ACTIONSCRIPT® 3.0
Developer's Guide

Contents

Chapter 1: Working with dates and times

Flash Player 9 and later, Adobe AIR 1.0 and later

Timing might not be everything, but it's usually a key factor in software applications. ActionScript 3.0 provides powerful ways to manage calendar dates, times, and time intervals. Two main classes provide most of this timing functionality: the Date class and the new Timer class in the flash.utils package.

Dates and times are a common type of information used in ActionScript programs. For instance, you might need to know the current day of the week or to measure how much time a user spends on a particular screen, among many other possibilities. In ActionScript, you can use the Date class to represent a single moment in time, including date and time information. Within a Date instance are values for the individual date and time units, including year, month, date, day of the week, hour, minutes, seconds, milliseconds, and time zone. For more advanced uses, ActionScript also includes the Timer class, which you can use to perform actions after a certain delay or at repeated intervals.

More Help topics

Date

flash.utils.Timer

Managing calendar dates and times

Flash Player 9 and later, Adobe AIR 1.0 and later

All of the calendar date and time management functions in ActionScript 3.0 are concentrated in the top-level Date class. The Date class contains methods and properties that let you handle dates and times in either Coordinated Universal Time (UTC) or in local time specific to a time zone. UTC is a standard time definition that is essentially the same as Greenwich Mean Time (GMT).

Creating Date objects

Flash Player 9 and later, Adobe AIR 1.0 and later

The Date class boasts one of the most versatile constructor methods of all the core classes. You can invoke it four different ways.

First, if given no parameters, the `Date()` constructor returns a Date object containing the current date and time, in local time based on your time zone. Here's an example:

```
var now:Date = new Date();
```

Second, if given a single numeric parameter, the `Date()` constructor treats that as the number of milliseconds since January 1, 1970, and returns a corresponding Date object. Note that the millisecond value you pass in is treated as milliseconds since January 1, 1970, in UTC. However, the Date object shows values in your local time zone, unless you use the UTC-specific methods to retrieve and display them. If you create a new Date object using a single milliseconds parameter, make sure you account for the time zone difference between your local time and UTC. The following statements create a Date object set to midnight on the day of January 1, 1970, in UTC:

```
var millisecondsPerDay:int = 1000 * 60 * 60 * 24;
// gets a Date one day after the start date of 1/1/1970
var startTime:Date = new Date(millisecondsPerDay);
```

Third, you can pass multiple numeric parameters to the `Date()` constructor. It treats those parameters as the year, month, day, hour, minute, second, and millisecond, respectively, and returns a corresponding Date object. Those input parameters are assumed to be in local time rather than UTC. The following statements get a Date object set to midnight at the start of January 1, 2000, in local time:

```
var millenium:Date = new Date(2000, 0, 1, 0, 0, 0, 0);
```

Fourth, you can pass a single string parameter to the `Date()` constructor. It will try to parse that string into date or time components and then return a corresponding Date object. If you use this approach, it's a good idea to enclose the `Date()` constructor in a `try..catch` block to trap any parsing errors. The `Date()` constructor accepts a number of different string formats (which are listed in the ActionScript 3.0 Reference for the Adobe Flash Platform). The following statement initializes a new Date object using a string value:

```
var nextDay:Date = new Date("Mon May 1 2006 11:30:00 AM");
```

If the `Date()` constructor cannot successfully parse the string parameter, it will not raise an exception. However, the resulting Date object will contain an invalid date value.

Getting time unit values

Flash Player 9 and later, Adobe AIR 1.0 and later

You can extract the values for various units of time within a Date object using properties or methods of the Date class. Each of the following properties gives you the value of a time unit in the Date object:

- The `fullYear` property
- The `month` property, which is in a numeric format with 0 for January up to 11 for December
- The `date` property, which is the calendar number of the day of the month, in the range of 1 to 31
- The `day` property, which is the day of the week in numeric format, with 0 standing for Sunday
- The `hours` property, in the range of 0 to 23
- The `minutes` property
- The `seconds` property
- The `milliseconds` property

  In fact, the Date class gives you a number of ways to get each of these values. For example, you can get the month value of a Date object in four different ways:

- The `month` property
- The `getMonth()` method
- The `monthUTC` property
- The `getMonthUTC()` method

  All four ways are essentially equivalent in terms of efficiency, so you can use whichever approach suits your application best.

  The properties just listed all represent components of the total date value. For example, the milliseconds property will never be greater than 999, since when it reaches 1000 the seconds value increases by 1 and the milliseconds property resets to 0.

If you want to get the value of the Date object in terms of milliseconds since January 1, 1970 (UTC), you can use the `getTime()` method. Its counterpart, the `setTime()` method, lets you change the value of an existing Date object using milliseconds since January 1, 1970 (UTC).

Performing date and time arithmetic

Flash Player 9 and later, Adobe AIR 1.0 and later

You can perform addition and subtraction on dates and times with the Date class. Date values are kept internally in terms of milliseconds, so you should convert other values to milliseconds before adding them to or subtracting them from Date objects.

If your application will perform a lot of date and time arithmetic, you might find it useful to create constants that hold common time unit values in terms of milliseconds, like the following:

```
public static const millisecondsPerMinute:int = 1000 * 60;
public static const millisecondsPerHour:int = 1000 * 60 * 60;
public static const millisecondsPerDay:int = 1000 * 60 * 60 * 24;
```

Now it is easy to perform date arithmetic using standard time units. The following code sets a date value to one hour from the current time using the `getTime()` and `setTime()` methods:

```
var oneHourFromNow:Date = new Date();
oneHourFromNow.setTime(oneHourFromNow.getTime() + millisecondsPerHour);
```

Another way to set a date value is to create a new Date object using a single milliseconds parameter. For example, the following code adds 30 days to one date to calculate another:

```
// sets the invoice date to today's date
var invoiceDate:Date = new Date();

// adds 30 days to get the due date
var dueDate:Date = new Date(invoiceDate.getTime() + (30 * millisecondsPerDay));
```

Next, the `millisecondsPerDay` constant is multiplied by 30 to represent 30 days' time and the result is added to the `invoiceDate` value and used to set the `dueDate` value.

Converting between time zones

Flash Player 9 and later, Adobe AIR 1.0 and later

Date and time arithmetic comes in handy when you want to convert dates from one time zone to another. So does the `getTimezoneOffset()` method, which returns the value in minutes by which the Date object's time zone differs from UTC. It returns a value in minutes because not all time zones are set to even-hour increments—some have half-hour offsets from neighboring zones.

The following example uses the time zone offset to convert a date from local time to UTC. It does the conversion by first calculating the time zone value in milliseconds and then adjusting the Date value by that amount:

```
// creates a Date in local time
var nextDay:Date = new Date("Mon May 1 2006 11:30:00 AM");

// converts the Date to UTC by adding or subtracting the time zone offset
var offsetMilliseconds:Number = nextDay.getTimezoneOffset() * 60 * 1000;
nextDay.setTime(nextDay.getTime() + offsetMilliseconds);
```

Controlling time intervals

Flash Player 9 and later, Adobe AIR 1.0 and later

When you develop applications using Adobe Flash CS4 Professional, you have access to the timeline, which provides a steady, frame-by-frame progression through your application. In pure ActionScript projects, however, you must rely on other timing mechanisms.

Loops versus timers

Flash Player 9 and later, Adobe AIR 1.0 and later

In some programming languages, you must devise your own timing schemes using loop statements like `for` or `do..while.`

Loop statements generally execute as fast as the local machine allows, which means that the application runs faster on some machines and slower on others. If your application needs a consistent timing interval, you need to tie it to an actual calendar or clock time. Many applications, such as games, animations, and real-time controllers, need regular, time-driven ticking mechanisms that are consistent from machine to machine.

The ActionScript 3.0 Timer class provides a powerful solution. Using the ActionScript 3.0 event model, the Timer class dispatches timer events whenever a specified time interval is reached.

The Timer class

Flash Player 9 and later, Adobe AIR 1.0 and later

The preferred way to handle timing functions in ActionScript 3.0 is to use the Timer class (flash.utils.Timer), which can be used to dispatch events whenever an interval is reached.

To start a timer, you first create an instance of the Timer class, telling it how often to generate a timer event and how many times to do so before stopping.

For example, the following code creates a Timer instance that dispatches an event every second and continues for 60 seconds:

```
var oneMinuteTimer:Timer = new Timer(1000, 60);
```

The Timer object dispatches a TimerEvent object each time the given interval is reached. A TimerEvent object's event type is `timer` (defined by the constant `TimerEvent.TIMER`). A TimerEvent object contains the same properties as a standard Event object.

If the Timer instance is set to a fixed number of intervals, it will also dispatch a `timerComplete` event (defined by the constant `TimerEvent.TIMER_COMPLETE`) when it reaches the final interval.

Here is a small sample application showing the Timer class in action:

```
package
{
    import flash.display.Sprite;
    import flash.events.TimerEvent;
    import flash.utils.Timer;

    public class ShortTimer extends Sprite
    {
        public function ShortTimer()
        {
            // creates a new five-second Timer
            var minuteTimer:Timer = new Timer(1000, 5);

            // designates listeners for the interval and completion events
            minuteTimer.addEventListener(TimerEvent.TIMER, onTick);
            minuteTimer.addEventListener(TimerEvent.TIMER_COMPLETE, onTimerComplete);

            // starts the timer ticking
            minuteTimer.start();
        }

        public function onTick(event:TimerEvent):void
        {
            // displays the tick count so far
            // The target of this event is the Timer instance itself.
            trace("tick " + event.target.currentCount);
        }

        public function onTimerComplete(event:TimerEvent):void
        {
            trace("Time's Up!");
        }
    }
}
```

When the ShortTimer class is created, it creates a Timer instance that will tick once per second for five seconds. Then it adds two listeners to the timer: one that listens to each tick, and one that listens for the `timerComplete` event.

Next, it starts the timer ticking, and from that point forward, the `onTick()` method executes at one-second intervals.

The `onTick()` method simply displays the current tick count. After five seconds have passed, the `onTimerComplete()` method executes, telling you that the time is up.

When you run this sample, you should see the following lines appear in your console or trace window at the rate of one line per second:

```
tick 1
tick 2
tick 3
tick 4
tick 5
Time's Up!
```

Timing functions in the flash.utils package

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 contains a number of timing functions similar to those that were available in ActionScript 2.0. These functions are provided as package-level functions in the flash.utils package, and they operate just as they did in ActionScript 2.0.

Function	Description
`clearInterval(id:uint):void`	Cancels a specified `setInterval()` call.
`clearTimeout(id:uint):void`	Cancels a specified `setTimeout()` call.
`getTimer():int`	Returns the number of milliseconds that have elapsed since Adobe® Flash® Player or Adobe® AIR™ was initialized.
`setInterval(closure:Function, delay:Number, ... arguments):uint`	Runs a function at a specified interval (in milliseconds).
`setTimeout(closure:Function, delay:Number, ... arguments):uint`	Runs a specified function after a specified delay (in milliseconds).

These functions remain in ActionScript 3.0 for backward compatibility. Adobe does not recommend that you use them in new ActionScript 3.0 applications. In general, it is easier and more efficient to use the Timer class in your applications.

Date and time example: Simple analog clock

Flash Player 9 and later, Adobe AIR 1.0 and later

A simple analog clock example illustrates these two date and time concepts:

- Getting the current date and time and extracting values for the hours, minutes, and seconds
- Using a Timer to set the pace of an application

  To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The SimpleClock application files can be found in the folder Samples/SimpleClock. The application consists of the following files:

File	Description
SimpleClockApp.mxml or SimpleClockApp.fla	The main application file in Flash (FLA) or Flex (MXML).
com/example/programmingas3/simpleclock/SimpleClock.as	The main application file.
com/example/programmingas3/simpleclock/AnalogClockFace.as	Draws a round clock face and hour, minute, and seconds hands based on the time.

Defining the SimpleClock class

Flash Player 9 and later, Adobe AIR 1.0 and later

The clock example is simple, but it's a good idea to organize even simple applications well so you could easily expand them in the future. To that end, the SimpleClock application uses the SimpleClock class to handle the startup and time-keeping tasks, and then uses another class named AnalogClockFace to actually display the time.

Here is the code that defines and initializes the SimpleClock class (note that in the Flash version, SimpleClock extends the Sprite class instead):

```
public class SimpleClock extends UIComponent
{
    /**
     * The time display component.
     */
    private var face:AnalogClockFace;

    /**
     * The Timer that acts like a heartbeat for the application.
     */
    private var ticker:Timer;
```

The class has two important properties:

- `The face` property, which is an instance of the AnalogClockFace class
- `The ticker` property, which is an instance of the Timer class

  The SimpleClock class uses a default constructor. The `initClock()` method takes care of the real setup work, creating the clock face and starting the Timer instance ticking.

Creating the clock face

Flash Player 9 and later, Adobe AIR 1.0 and later

The next lines in the SimpleClock code create the clock face that is used to display the time:

```
    /**
     * Sets up a SimpleClock instance.
     */
    public function initClock(faceSize:Number = 200)
    {
        // creates the clock face and adds it to the display list
        face = new AnalogClockFace(Math.max(20, faceSize));
        face.init();
        addChild(face);

        // draws the initial clock display
        face.draw();
```

The size of the face can be passed in to the `initClock()` method. If no `faceSize` value is passed, a default size of 200 pixels is used.

Next, the application initializes the face and then adds it to the display list using the `addChild()` method inherited from the DisplayObjectContainer class. Then it calls the `AnalogClockFace.draw()` method to display the clock face once, showing the current time.

Starting the timer

Flash Player 9 and later, Adobe AIR 1.0 and later

After creating the clock face, the `initClock()` method sets up a timer:

```
        // creates a Timer that fires an event once per second
        ticker = new Timer(1000);

        // designates the onTick() method to handle Timer events
        ticker.addEventListener(TimerEvent.TIMER, onTick);

        // starts the clock ticking
        ticker.start();
```

First this method instantiates a Timer instance that will dispatch an event once per second (every 1000 milliseconds). Since no second `repeatCount` parameter is passed to the `Timer()` constructor, the Timer will keep repeating indefinitely.

The `SimpleClock.onTick()` method will execute once per second when the `timer` event is received:

```
    public function onTick(event:TimerEvent):void
    {
        // updates the clock display
        face.draw();
    }
```

The `AnalogClockFace.draw()` method simply draws the clock face and hands.

Displaying the current time

Flash Player 9 and later, Adobe AIR 1.0 and later

Most of the code in the AnalogClockFace class involves setting up the clock face's display elements. When the AnalogClockFace is initialized, it draws a circular outline, places a numeric text label at each hour mark, and then creates three Shape objects, one each for the hour hand, the minute hand, and the second hand on the clock.

Once the SimpleClock application is running, it calls the `AnalogClockFace.draw()` method each second, as follows:

```
    /**
     * Called by the parent container when the display is being drawn.
     */
    public override function draw():void
    {
        // stores the current date and time in an instance variable
        currentTime = new Date();
        showTime(currentTime);
    }
```

This method saves the current time in a variable, so the time can't change in the middle of drawing the clock hands. Then it calls the `showTime()` method to display the hands, as the following shows:

```
/**
 * Displays the given Date/Time in that good old analog clock style.
 */
public function showTime(time:Date):void
{
    // gets the time values
    var seconds:uint = time.getSeconds();
    var minutes:uint = time.getMinutes();
    var hours:uint = time.getHours();

    // multiplies by 6 to get degrees
    this.secondHand.rotation = 180 + (seconds * 6);
    this.minuteHand.rotation = 180 + (minutes * 6);

    // Multiply by 30 to get basic degrees, then
    // add up to 29.5 degrees (59 * 0.5)
    // to account for the minutes.
    this.hourHand.rotation = 180 + (hours * 30) + (minutes * 0.5);
}
```

First, this method extracts the values for the hours, minutes, and seconds of the current time. Then it uses these values to calculate the angle for each hand. Since the second hand makes a full rotation in 60 seconds, it rotates 6 degrees each second (360/60). The minute hand rotates the same amount each minute.

The hour hand updates every minute, too, so it can show some progress as the minutes tick by. It rotates 30 degrees each hour (360/12), but it also rotates half a degree each minute (30 degrees divided by 60 minutes).

Chapter 2: Working with strings

Flash Player 9 and later, Adobe AIR 1.0 and later

The String class contains methods that let you work with text strings. Strings are important in working with many objects. The methods described here are useful for working with strings used in objects such as TextField, StaticText, XML, ContextMenu, and FileReference objects.

Strings are sequences of characters. ActionScript 3.0 supports ASCII and Unicode characters.

More Help topics

String

RegExp

parseFloat()

parseInt()

Basics of strings

Flash Player 9 and later, Adobe AIR 1.0 and later

In programming parlance, a string is a text value—a sequence of letters, numbers, or other characters strung together into a single value. For instance, this line of code creates a variable with the data type String and assigns a literal string value to that variable:

```
var albumName:String = "Three for the money";
```

As this example shows, in ActionScript you can denote a string value by surrounding text with double or single quotation marks. Here are several more examples of strings:

```
"Hello"
"555-7649"
"http://www.adobe.com/"
```

Any time you manipulate a piece of text in ActionScript, you are working with a string value. The ActionScript String class is the data type you can use to work with text values. String instances are frequently used for properties, method parameters, and so forth in many other ActionScript classes.

Important concepts and terms

The following reference list contains important terms related to strings that you will encounter:

ASCII A system for representing text characters and symbols in computer programs. The ASCII system supports the 26-letter English alphabet, plus a limited set of additional characters.

Character The smallest unit of text data (a single letter or symbol).

Concatenation Joining multiple string values together by adding one to the end of the other, creating a new string value.

Empty string A string that contains no text, white space, or other characters, written as `""`. An empty string value is different from a String variable with a null value—a null String variable is a variable that does not have a String instance assigned to it, whereas an empty string has an instance with a value that contains no characters.

String A textual value (sequence of characters).

String literal (or "literal string") A string value written explicitly in code, written as a text value surrounded by double quotation marks or single quotation marks.

Substring A string that is a portion of another string.

Unicode A standard system for representing text characters and symbols in computer programs. The Unicode system allows for the use of any character in any writing system.

Creating strings

Flash Player 9 and later, Adobe AIR 1.0 and later

The String class is used to represent string (textual) data in ActionScript 3.0. ActionScript strings support both ASCII and Unicode characters. The simplest way to create a string is to use a string literal. To declare a string literal, use straight double quotation mark (`"`) or single quotation mark (`'`) characters. For example, the following two strings are equivalent:

```
var str1:String = "hello";
var str2:String = 'hello';
```

You can also declare a string by using the `new` operator, as follows:

```
var str1:String = new String("hello");
var str2:String = new String(str1);
var str3:String = new String();       // str3 == ""
```

The following two strings are equivalent:

```
var str1:String = "hello";
var str2:String = new String("hello");
```

To use single quotation marks (`'`) within a string literal defined with single quotation mark (`'`) delimiters, use the backslash escape character (\). Similarly, to use double quotation marks (`"`) within a string literal defined with double quotation marks (`"`) delimiters, use the backslash escape character (\). The following two strings are equivalent:

```
var str1:String = "That's \"A-OK\"";
var str2:String = 'That\'s "A-OK"';
```

You may choose to use single quotation marks or double quotation marks based on any single or double quotation marks that exist in a string literal, as in the following:

```
var str1:String = "ActionScript <span class='heavy'>3.0</span>";
var str2:String = '<item id="155">banana</item>';
```

Keep in mind that ActionScript distinguishes between a straight single quotation mark (`'`) and a left or right single quotation mark (`‘` or `’`). The same is true for double quotation marks. Use straight quotation marks to delineate string literals. When pasting text from another source into ActionScript, be sure to use the correct characters.

As the following table shows, you can use the backslash escape character (\) to define other characters in string literals:

Escape sequence	**Character**
`\b`	Backspace
`\f`	Form feed
`\n`	Newline
`\r`	Carriage return
`\t`	Tab
`\u`***`nnnn`***	The Unicode character with the character code specified by the hexadecimal number *nnnn*; for example, `\u263a` is the smiley character.
`\\x`***`nn`***	The ASCII character with the character code specified by the hexadecimal number *nn*
`\'`	Single quotation mark
`\"`	Double quotation mark
`\\`	Single backslash character

The length property

Flash Player 9 and later, Adobe AIR 1.0 and later

Every string has a `length` property, which is equal to the number of characters in the string:

```
var str:String = "Adobe";
trace(str.length);            // output: 5
```

An empty string and a null string both have a length of 0, as the following example shows:

```
var str1:String = new String();
trace(str1.length);           // output: 0

str2:String = '';
trace(str2.length);           // output: 0
```

Working with characters in strings

Flash Player 9 and later, Adobe AIR 1.0 and later

Every character in a string has an index position in the string (an integer). The index position of the first character is 0. For example, in the following string, the character `y` is in position 0 and the character `w` is in position 5:

```
"yellow"
```

You can examine individual characters in various positions in a string using the `charAt()` method and the `charCodeAt()` method, as in this example:

```
var str:String = "hello world!";
for (var i:int = 0; i < str.length; i++)
{
    trace(str.charAt(i), "-", str.charCodeAt(i));
}
```

When you run this code, the following output is produced:

```
h - 104
e - 101
l - 108
l - 108
o - 111
- 32
w - 119
o - 111
r - 114
l - 108
d - 100
! - 33
```

You can also use character codes to define a string using the `fromCharCode()` method, as the following example shows:

```
var myStr:String = String.fromCharCode(104,101,108,108,111,32,119,111,114,108,100,33);
        // Sets myStr to "hello world!"
```

Comparing strings

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the following operators to compare strings: `<`, `<=`, `!=`, `==`, `=>`, and `>`. These operators can be used with conditional statements, such as `if` and `while`, as the following example shows:

```
var str1:String = "Apple";
var str2:String = "apple";
if (str1 < str2)
{
    trace("A < a, B < b, C < c, ...");
}
```

When using these operators with strings, ActionScript considers the character code value of each character in the string, comparing characters from left to right, as in the following:

```
trace("A" < "B"); // true
trace("A" < "a"); // true
trace("Ab" < "az"); // true
trace("abc" < "abza"); // true
```

Use the `==` and `!=` operators to compare strings with each other and to compare strings with other types of objects, as the following example shows:

```
var str1:String = "1";
var str1b:String = "1";
var str2:String = "2";
trace(str1 == str1b); // true
trace(str1 == str2); // false
var total:uint = 1;
trace(str1 == total); // true
```

Obtaining string representations of other objects

Flash Player 9 and later, Adobe AIR 1.0 and later

You can obtain a String representation for any kind of object. All objects have a `toString()` method for this purpose:

```
var n:Number = 99.47;
var str:String = n.toString();
    // str == "99.47"
```

When using the `+` concatenation operator with a combination of String objects and objects that are not strings, you do not need to use the `toString()` method. For details on concatenation, see the next section.

The `String()` global function returns the same value for a given object as the value returned by the object calling the `toString()` method.

Concatenating strings

Flash Player 9 and later, Adobe AIR 1.0 and later

Concatenation of strings means taking two strings and joining them sequentially into one. For example, you can use the `+` operator to concatenate two strings:

```
var str1:String = "green";
var str2:String = "ish";
var str3:String = str1 + str2; // str3 == "greenish"
```

You can also use the `+=` operator to the produce the same result, as the following example shows:

```
var str:String = "green";
str += "ish"; // str == "greenish"
```

Additionally, the String class includes a `concat()` method, which can be used as follows:

```
var str1:String = "Bonjour";
var str2:String = "from";
var str3:String = "Paris";
var str4:String = str1.concat(" ", str2, " ", str3);
// str4 == "Bonjour from Paris"
```

If you use the `+` operator (or the `+=` operator) with a String object and an object that is *not* a string, ActionScript automatically converts the nonstring object to a String object in order to evaluate the expression, as shown in this example:

```
var str:String = "Area = ";
var area:Number = Math.PI * Math.pow(3, 2);
str = str + area; // str == "Area = 28.274333882308138"
```

However, you can use parentheses for grouping to provide context for the `+` operator, as the following example shows:

```
trace("Total: $" + 4.55 + 1.45); // output: Total: $4.551.45
trace("Total: $" + (4.55 + 1.45)); // output: Total: $6
```

Finding substrings and patterns in strings

Flash Player 9 and later, Adobe AIR 1.0 and later

Substrings are sequential characters within a string. For example, the string `"abc"` has the following substrings: `""`, `"a"`, `"ab"`, `"abc"`, `"b"`, `"bc"`, `"c"`. You can use ActionScript methods to locate substrings of a string.

Patterns are defined in ActionScript by strings or by regular expressions. For example, the following regular expression defines a specific pattern—the letters A, B, and C followed by a digit character (the forward slashes are regular expression delimiters):

```
/ABC\d/
```

ActionScript includes methods for finding patterns in strings and for replacing found matches with replacement substrings. These methods are described in the following sections.

Regular expressions can define intricate patterns. For more information, see "Using regular expressions" on page 76.

Finding a substring by character position

Flash Player 9 and later, Adobe AIR 1.0 and later

The `substr()` and `substring()` methods are similar. Both return a substring of a string. Both take two parameters. In both methods, the first parameter is the position of the starting character in the given string. However, in the `substr()` method, the second parameter is the *length* of the substring to return, and in the `substring()` method, the second parameter is the position of the character at the *end* of the substring (which is not included in the returned string). This example shows the difference between these two methods:

```
var str:String = "Hello from Paris, Texas!!!";
trace(str.substr(11,15)); // output: Paris, Texas!!!
trace(str.substring(11,15)); // output: Pari
```

The `slice()` method functions similarly to the `substring()` method. When given two non-negative integers as parameters, it works exactly the same. However, the `slice()` method can take negative integers as parameters, in which case the character position is taken from the end of the string, as shown in the following example:

```
var str:String = "Hello from Paris, Texas!!!";
trace(str.slice(11,15)); // output: Pari
trace(str.slice(-3,-1)); // output: !!
trace(str.slice(-3,26)); // output: !!!
trace(str.slice(-3,str.length)); // output: !!!
trace(str.slice(-8,-3)); // output: Texas
```

You can combine non-negative and negative integers as the parameters of the `slice()` method.

Finding the character position of a matching substring

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `indexOf()` and `lastIndexOf()` methods to locate matching substrings within a string, as the following example shows:

```
var str:String = "The moon, the stars, the sea, the land";
trace(str.indexOf("the")); // output: 10
```

Notice that the `indexOf()` method is case-sensitive.

You can specify a second parameter to indicate the index position in the string from which to start the search, as follows:

```
var str:String = "The moon, the stars, the sea, the land"
trace(str.indexOf("the", 11)); // output: 21
```

The `lastIndexOf()` method finds the last occurrence of a substring in the string:

```
var str:String = "The moon, the stars, the sea, the land"
trace(str.lastIndexOf("the")); // output: 30
```

If you include a second parameter with the `lastIndexOf()` method, the search is conducted from that index position in the string working backward (from right to left):

```
var str:String = "The moon, the stars, the sea, the land"
trace(str.lastIndexOf("the", 29)); // output: 21
```

Creating an array of substrings segmented by a delimiter

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `split()` method to create an array of substrings, which is divided based on a delimiter. For example, you can segment a comma-delimited or tab-delimited string into multiple strings.

The following example shows how to split an array into substrings with the ampersand (&) character as the delimiter:

```
var queryStr:String = "first=joe&last=cheng&title=manager&StartDate=3/6/65";
var params:Array = queryStr.split("&", 2); // params == ["first=joe","last=cheng"]
```

The second parameter of the `split()` method, which is optional, defines the maximum size of the array that is returned.

You can also use a regular expression as the delimiter character:

```
var str:String = "Give me\t5."
var a:Array = str.split(/\s+/); // a == ["Give","me","5."]
```

For more information, see "Using regular expressions" on page 76 and the ActionScript 3.0 Reference for the Adobe Flash Platform.

Finding patterns in strings and replacing substrings

Flash Player 9 and later, Adobe AIR 1.0 and later

The String class includes the following methods for working with patterns in strings:

- Use the `match()` and `search()` methods to locate substrings that match a pattern.
- Use the `replace()` method to find substrings that match a pattern and replace them with a specified substring.

These methods are described in the following sections.

You can use strings or regular expressions to define patterns used in these methods. For more information on regular expressions, see "Using regular expressions" on page 76.

Finding matching substrings

The `search()` method returns the index position of the first substring that matches a given pattern, as shown in this example:

```
var str:String = "The more the merrier.";
// (This search is case-sensitive.)
trace(str.search("the")); // output: 9
```

You can also use regular expressions to define the pattern to match, as this example shows:

```
var pattern:RegExp = /the/i;
var str:String = "The more the merrier.";
trace(str.search(pattern)); // 0
```

The output of the `trace()` method is 0, because the first character in the string is index position 0. The `i` flag is set in the regular expression, so the search is not case-sensitive.

The `search()` method finds only one match and returns its starting index position, even if the `g` (global) flag is set in the regular expression.

The following example shows a more intricate regular expression, one that matches a string in double quotation marks:

```
var pattern:RegExp = /"[^"]*"/;
var str:String = "The \"more\" the merrier.";
trace(str.search(pattern)); // output: 4

str = "The \"more the merrier.";
trace(str.search(pattern)); // output: -1
// (Indicates no match, since there is no closing double quotation mark.)
```

The `match()` method works similarly. It searches for a matching substring. However, when you use the global flag in a regular expression pattern, as in the following example, `match()` returns an array of matching substrings:

```
var str:String = "bob@example.com, omar@example.org";
var pattern:RegExp = /\w*@\w*\.[org|com]+/g;
var results:Array = str.match(pattern);
```

The `results` array is set to the following:

```
["bob@example.com","omar@example.org"]
```

For more information on regular expressions, see "Using regular expressions" on page 76.

Replacing matched substrings

You can use the `replace()` method to search for a specified pattern in a string and replace matches with the specified replacement string, as the following example shows:

```
var str:String = "She sells seashells by the seashore.";
var pattern:RegExp = /sh/gi;
trace(str.replace(pattern, "sch")); //sche sells seaschells by the seaschore.
```

Note that in this example, the matched strings are not case-sensitive because the `i` (`ignoreCase`) flag is set in the regular expression, and multiple matches are replaced because the `g` (`global`) flag is set. For more information, see "Using regular expressions" on page 76.

You can include the following `$` replacement codes in the replacement string. The replacement text shown in the following table is inserted in place of the `$` replacement code:

$ Code	**Replacement Text**
`$$`	$
`$&`	The matched substring.
`` $` ``	The portion of the string that precedes the matched substring. This code uses the straight left single quotation mark character (`` ` ``), not the straight single quotation mark (`'`) or the left curly single quotation mark (`'`).
`$'`	The portion of the string that follows the matched substring. This code uses the straight single quotation mark (`'`).
`$`*n*	The *n*th captured parenthetical group match, where n is a single digit, 1-9, and $n is not followed by a decimal digit.
`$`*nn*	The *nn*th captured parenthetical group match, where *nn* is a two-digit decimal number, 01–99. If the *nn*th capture is undefined, the replacement text is an empty string.

For example, the following shows the use of the `$2` and `$1` replacement codes, which represent the first and second capturing group matched:

```
var str:String = "flip-flop";
var pattern:RegExp = /(\w+)-(\w+)/g;
trace(str.replace(pattern, "$2-$1")); // flop-flip
```

You can also use a function as the second parameter of the `replace()` method. The matching text is replaced by the returned value of the function.

```
var str:String = "Now only $9.95!";
var price:RegExp = /\$([\d,]+.\d+)+/i;
trace(str.replace(price, usdToEuro));

function usdToEuro(matchedSubstring:String,  capturedMatch1:String,  index:int,
str:String):String
{
    var usd:String = capturedMatch1;
    usd = usd.replace(",", "");
    var exchangeRate:Number = 0.853690;
    var euro:Number = parseFloat(usd) * exchangeRate;
    const euroSymbol:String = String.fromCharCode(8364);
    return euro.toFixed(2) + " " + euroSymbol;
}
```

When you use a function as the second parameter of the `replace()` method, the following arguments are passed to the function:

- The matching portion of the string.
- Any capturing parenthetical group matches. The number of arguments passed this way will vary depending on the number of parenthetical matches. You can determine the number of parenthetical matches by checking `arguments.length - 3` within the function code.
- The index position in the string where the match begins.
- The complete string.

Converting strings between uppercase and lowercase

Flash Player 9 and later, Adobe AIR 1.0 and later

As the following example shows, the `toLowerCase()` method and the `toUpperCase()` method convert alphabetical characters in the string to lowercase and uppercase, respectively:

```
var str:String = "Dr. Bob Roberts, #9."
trace(str.toLowerCase()); // dr. bob roberts, #9.
trace(str.toUpperCase()); // DR. BOB ROBERTS, #9.
```

After these methods are executed, the source string remains unchanged. To transform the source string, use the following code:

```
str = str.toUpperCase();
```

These methods work with extended characters, not simply a–z and A–Z:

```
var str:String = "José Barça";
trace(str.toUpperCase(), str.toLowerCase()); // JOSÉ BARÇA josé barça
```

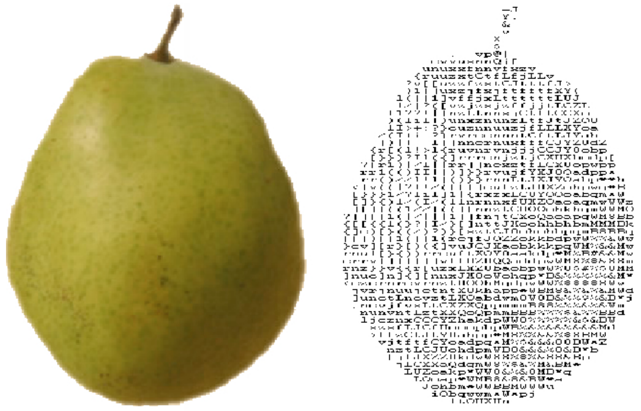
Strings example: ASCII art

Flash Player 9 and later, Adobe AIR 1.0 and later

This ASCII Art example shows a number of features of working with the String class in ActionScript 3.0, including the following:

- The `split()` method of the String class is used to extract values from a character-delimited string (image information in a tab-delimited text file).
- Several string-manipulation techniques, including `split()`, concatenation, and extracting a portion of the string using `substring()` and `substr()`, are used to capitalize the first letter of each word in the image titles.
- The `getCharAt()` method is used to get a single character from a string (to determine the ASCII character corresponding to a grayscale bitmap value).
- String concatenation is used to build up the ASCII art representation of an image one character at a time.

The term *ASCII art* refers to a text representations of an image, in which a grid of monospaced font characters, such as Courier New characters, plots the image. The following image shows an example of ASCII art produced by the application:



The ASCII art version of the graphic is shown on the right.

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The ASCIIArt application files can be found in the folder Samples/AsciiArt. The application consists of the following files:

File	Description
AsciiArtApp.mxml or AsciiArtApp.fla	The main application file in Flash (FLA) or Flex (MXML)
com/example/programmingas3/asciiArt/AsciiArtBuilder.as	The class that provides the main functionality of the application, including extracting image metadata from a text file, loading the images, and managing the image-to-text conversion process.
com/example/programmingas3/asciiArt/BitmapToAsciiConverter.as	A class that provides the `parseBitmapData()` method for converting image data into a String version.
com/example/programmingas3/asciiArt/Image.as	A class which represents a loaded bitmap image.
com/example/programmingas3/asciiArt/ImageInfo.as	A class representing metadata for an ASCII art image (such as title, image file URL, and so on).
image/	A folder containing images used by the application.
txt/ImageData.txt	A tab-delimited text file, containing information on the images to be loaded by the application.

Extracting tab-delimited values

Flash Player 9 and later, Adobe AIR 1.0 and later

This example uses the common practice of storing application data separate from the application itself; that way, if the data changes (for example, if another image is added or an image's title changes), there is no need to recreate the SWF file. In this case, the image metadata, including the image title, the URL of the actual image file, and some values that are used to manipulate the image, are stored in a text file (the txt/ImageData.txt file in the project). The contents of the text file are as follows:

```
FILENAMETITLEWHITE_THRESHHOLDBLACK_THRESHHOLD
FruitBasket.jpgPear, apple, orange, and bananad810
Banana.jpgA picture of a bananaC820
Orange.jpgorangeFF20
Apple.jpgpicture of an apple6E10
```

The file uses a specific tab-delimited format. The first line (row) is a heading row. The remaining lines contain the following data for each bitmap to be loaded:

- The filename of the bitmap.
- The display name of the bitmap.
- The white-threshold and black-threshold values for the bitmaps. These are hex values above which and below which a pixel is to be considered completely white or completely black.

As soon as the application starts, the AsciiArtBuilder class loads and parses the contents of the text file in order to create the "stack" of images that it will display, using the following code from the AsciiArtBuilder class's `parseImageInfo()` method:

```
var lines:Array = _imageInfoLoader.data.split("\n");
var numLines:uint = lines.length;
for (var i:uint = 1; i < numLines; i++)
{
    var imageInfoRaw:String = lines[i];
    ...
    if (imageInfoRaw.length > 0)
    {
        // Create a new image info record and add it to the array of image info.
        var imageInfo:ImageInfo = new ImageInfo();

        // Split the current line into values (separated by tab (\t)
        // characters) and extract the individual properties:
        var imageProperties:Array = imageInfoRaw.split("\t");
        imageInfo.fileName = imageProperties[0];
        imageInfo.title = normalizeTitle(imageProperties[1]);
        imageInfo.whiteThreshold = parseInt(imageProperties[2], 16);
        imageInfo.blackThreshold = parseInt(imageProperties[3], 16);
        result.push(imageInfo);
    }
}
```

The entire contents of the text file are contained in a single String instance, the `_imageInfoLoader.data` property. Using the `split()` method with the newline character (`"\n"`) as a parameter, the String instance is divided into an Array (`lines`) whose elements are the individual lines of the text file. Next, the code uses a loop to work with each of the lines (except the first, because it contains only headers rather than actual content). Inside the loop, the `split()` method is used once again to divide the contents of the single line into a set of values (the Array object named `imageProperties`). The parameter used with the `split()` method in this case is the tab (`"\t"`) character, because the values in each line are delineated by tab characters.

Using String methods to normalize image titles

Flash Player 9 and later, Adobe AIR 1.0 and later

One of the design decisions for this application is that all the image titles are displayed using a standard format, with the first letter of each word capitalized (except for a few words that are commonly not capitalized in English titles). Rather than assume that the text file contains properly formatted titles, the application formats the titles while they're being extracted from the text file.

In the previous code listing, as part of extracting individual image metadata values, the following line of code is used:

```
imageInfo.title = normalizeTitle(imageProperties[1]);
```

In that code, the image's title from the text file is passed through the `normalizeTitle()` method before it is stored in the ImageInfo object:

```
private function normalizeTitle(title:String):String
{
    var words:Array = title.split(" ");
    var len:uint = words.length;
    for (var i:uint; i < len; i++)
    {
        words[i] = capitalizeFirstLetter(words[i]);
    }

    return words.join(" ");
}
```

This method uses the `split()` method to divide the title into individual words (separated by the space character), passes each word through the `capitalizeFirstLetter()` method, and then uses the Array class's `join()` method to combine the words back into a single string again.

As its name suggests, the `capitalizeFirstLetter()` method actually does the work of capitalizing the first letter of each word:

```
/**
 * Capitalizes the first letter of a single word, unless it's one of
 * a set of words that are normally not capitalized in English.
 */
private function capitalizeFirstLetter(word:String):String
{
    switch (word)
    {
        case "and":
        case "the":
        case "in":
        case "an":
        case "or":
        case "at":
        case "of":
        case "a":
            // Don't do anything to these words.
            break;
        default:
            // For any other word, capitalize the first character.
            var firstLetter:String = word.substr(0, 1);
            firstLetter = firstLetter.toUpperCase();
            var otherLetters:String = word.substring(1);
            word = firstLetter + otherLetters;
    }
    return word;
}
```

In English, the initial character of each word in a title is *not* capitalized if it is one of the following words: "and," "the," "in," "an," "or," "at," "of," or "a." (This is a simplified version of the rules.) To execute this logic, the code first uses a `switch` statement to check if the word is one of the words that should not be capitalized. If so, the code simply jumps out of the `switch` statement. On the other hand, if the word should be capitalized, that is done in several steps, as follows:

1 The first letter of the word is extracted using `substr(0, 1)`, which extracts a substring starting with the character at index 0 (the first letter in the string, as indicated by the first parameter `0`). The substring will be one character in length (indicated by the second parameter `1`).

2 That character is capitalized using the `toUpperCase()` method.

3 The remaining characters of the original word are extracted using `substring(1)`, which extracts a substring starting at index 1 (the second letter) through the end of the string (indicated by leaving off the second parameter of the `substring()` method).

4 The final word is created by combining the newly capitalized first letter with the remaining letters using string concatenation: `firstLetter + otherLetters`.

Generating the ASCII art text

Flash Player 9 and later, Adobe AIR 1.0 and later

The BitmapToAsciiConverter class provides the functionality of converting a bitmap image to its ASCII text representation. This process is performed by the `parseBitmapData()` method, which is partially shown here:

```
    var result:String = "";

    // Loop through the rows of pixels top to bottom:
    for (var y:uint = 0; y < _data.height; y += verticalResolution)
    {
        // Within each row, loop through pixels left to right:
        for (var x:uint = 0; x < _data.width; x += horizontalResolution)
        {
            ...

            // Convert the gray value in the 0-255 range to a value
            // in the 0-64 range (since that's the number of "shades of
            // gray" in the set of available characters):
            index = Math.floor(grayVal / 4);
            result += palette.charAt(index);
        }
        result += "\n";
    }
    return result;
```

This code first defines a String instance named `result` that will be used to build up the ASCII art version of the bitmap image. Next, it loops through individual pixels of the source bitmap image. Using several color-manipulation techniques (omitted here for brevity), it converts the red, green, and blue color values of an individual pixel to a single grayscale value (a number from 0 to 255). The code then divides that value by 4 (as shown) to convert it to a value in the 0-63 scale, which is stored in the variable `index`. (The 0-63 scale is used because the "palette" of available ASCII characters used by this application contains 64 values.) The palette of characters is defined as a String instance in the BitmapToAsciiConverter class:

```
// The characters are in order from darkest to lightest, so that their
// position (index) in the string corresponds to a relative color value
// (0 = black).
private static const palette:String =
"@#$%&8BMW*mwqpdbkhaoQ0OZXYUJCLtfjzxnuvcr[]{}1()|/?Il!i><+_~-;,. ";
```

Since the `index` variable defines which ASCII character in the palette corresponds to the current pixel in the bitmap image, that character is retrieved from the `palette` String using the `charAt()` method. It is then appended to the `result` String instance using the concatenation assignment operator (`+=`). In addition, at the end of each row of pixels, a newline character is concatenated to the end of the `result` String, forcing the line to wrap to create a new row of character "pixels."

Chapter 3: Working with arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

Arrays allow you to store multiple values in a single data structure. You can use simple indexed arrays that store values using fixed ordinal integer indexes or complex associative arrays that store values using arbitrary keys. Arrays can also be multidimensional, containing elements that are themselves arrays. Finally, you can use a Vector for an array whose elements are all instances of the same data type.

More Help topics

Array

Vector

Basics of arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

Often in programming you'll need to work with a set of items rather than a single object. For example, in a music player application, you might want to have a list of songs waiting to be played. You wouldn't want to have to create a separate variable for each song on that list. It would be preferable to have all the Song objects together in a bundle, and be able to work with them as a group.

An array is a programming element that acts as a container for a set of items, such as a list of songs. Most commonly all the items in an array are instances of the same class, but that is not a requirement in ActionScript. The individual items in an array are known as the array's *elements*. You can think of an array as a file drawer for variables. Variables can be added as elements in the array, which is like placing a folder into the file drawer. You can work with the array as a single variable (like carrying the whole drawer to a different location). You can work with the variables as a group (like flipping through the folders one by one searching for a piece of information). You can also access them individually (like opening the drawer and selecting a single folder).

For example, imagine you're creating a music player application where a user can select multiple songs and add them to a playlist. In your ActionScript code, you have a method named `addSongsToPlaylist()`, which accepts a single array as a parameter. No matter how many songs you want to add to the list (a few, a lot, or even only one), you call the `addSongsToPlaylist()` method only one time, passing it the array containing the Song objects. Inside the `addSongsToPlaylist()` method, you can use a loop to go through the array's elements (the songs) one by one and actually add them to the playlist.

The most common type of ActionScript array is an *indexed array*. In an indexed array each item is stored in a numbered slot (known as an *index*). Items are accessed using the number, like an address. Indexed arrays work well for most programming needs. The Array class is one common class that's used to represent an indexed array.

Often, an indexed array is used to store multiple items of the same type (objects that are instances of the same class). The Array class doesn't have any means for restricting the type of items it contains. The Vector class is a type of indexed array in which all the items in a single array are the same type. Using a Vector instance instead of an Array instance can also provide performance improvements and other benefits. The Vector class is available starting with Flash Player 10 and Adobe AIR 1.5.

A special use of an indexed array is a *multidimensional array*. A multidimensional array is an indexed array whose elements are indexed arrays (which in turn contain other elements).

Another type of array is an *associative array*, which uses a string *key* instead of a numeric index to identify individual elements. Finally, ActionScript 3.0 also includes the Dictionary class, which represents a *dictionary*. A dictionary is an array that allows you to use any type of object as a key to distinguish between elements.

Important concepts and terms

The following reference list contains important terms that you will encounter when programming array and vector handling routines:

Array An object that serves as a container to group multiple objects.

Array access ([]) operator A pair of square brackets surrounding an index or key that uniquely identifies an array element. This syntax is used after an array variable name to specify a single element of the array rather than the entire array.

Associative array An array that uses string keys to identify individual elements.

Base type The data type of the objects that a Vector instance is allowed to store.

Dictionary An array whose items consist of pairs of objects, known as the key and the value. The key is used instead of a numeric index to identify a single element.

Element A single item in an array.

Index The numeric "address" used to identify a single element in an indexed array.

Indexed array The standard type of array that stores each element in a numbered position, and uses the number (index) to identify individual elements.

Key The string or object used to identify a single element in an associative array or a dictionary.

Multidimensional array An array containing items that are arrays rather than single values.

T The standard convention that's used in this documentation to represent the base type of a Vector instance, whatever that base type happens to be. The T convention is used to represent a class name, as shown in the Type parameter description. ("T" stands for "type," as in "data type.").

Type parameter The syntax that's used with the Vector class name to specify the Vector's base type (the data type of the objects that it stores). The syntax consists of a period (`.`), then the data type name surrounded by angle brackets (`<>`). Put together, it looks like this: `Vector.<T>`. In this documentation, the class specified in the type parameter is represented generically as `T`.

Vector A type of array whose elements are all instances of the same data type.

Indexed arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

Indexed arrays store a series of one or more values organized such that each value can be accessed using an unsigned integer value. The first index is always the number 0, and the index increments by 1 for each subsequent element added to the array. In ActionScript 3.0, two classes are used as indexed arrays: the Array class and the Vector class.

Indexed arrays use an unsigned 32-bit integer for the index number. The maximum size of an indexed array is $2^{32} - 1$ or 4,294,967,295. An attempt to create an array that is larger than the maximum size results in a run-time error.

To access an individual element of an indexed array, you use the array access (`[]`) operator to specify the index position of the element you wish to access. For example, the following code represents the first element (the element at index 0) in an indexed array named `songTitles`:

```
songTitles[0]
```

The combination of the array variable name followed by the index in square brackets functions as a single identifier. (In other words, it can be used in any way a variable name can). You can assign a value to an indexed array element by using the name and index on the left side of an assignment statement:

```
songTitles[1] = "Symphony No. 5 in D minor";
```

Likewise, you can retrieve the value of an indexed array element by using the name and index on the right side of an assignment statement:

```
var nextSong:String = songTitles[2];
```

You can also use a variable in the square brackets rather than providing an explicit value. (The variable must contain a non-negative integer value such as a uint, a positive int, or a positive integer Number instance). This technique is commonly used to "loop over" the elements in an indexed array and perform an operation on some or all the elements. The following code listing demonstrates this technique. The code uses a loop to access each value in an Array object named `oddNumbers`. It uses the `trace()` statement to print each value in the form "oddNumber[*index*] = *value*":

```
var oddNumbers:Array = [1, 3, 5, 7, 9, 11];
var len:uint = oddNumbers.length;
for (var i:uint = 0; i < len; i++)
{
    trace("oddNumbers[" + i.toString() + "] = " + oddNumbers[i].toString());
}
```

The Array class

The first type of indexed array is the Array class. An Array instance can hold a value of any data type. The same Array object can hold objects that are of different data types. For example, a single Array instance can have a String value in index 0, a Number instance in index 1, and an XML object in index 2.

The Vector class

Another type of indexed array that's available in ActionScript 3.0 is the Vector class. A Vector instance is a *typed array*, which means that all the elements in a Vector instance always have the same data type.

***Note:** The Vector class is available starting with Flash Player 10 and Adobe AIR 1.5.*

When you declare a Vector variable or instantiate a Vector object, you explicitly specify the data type of the objects that the Vector can contain. The specified data type is known as the Vector's *base type*. At run time and at compile time (in strict mode), any code that sets the value of a Vector element or retrieves a value from a Vector is checked. If the data type of the object being added or retrieved doesn't match the Vector's base type, an error occurs.

In addition to the data type restriction, the Vector class has other restrictions that distinguish it from the Array class:

- A Vector is a dense array. An Array object may have values in indices 0 and 7 even if it has no values in positions 1 through 6. However, a Vector must have a value (or `null`) in each index.
- A Vector can optionally be fixed-length. This means that the number of elements the Vector contains can't change.
- Access to a Vector's elements is bounds-checked. You can never read a value from an index greater than the final element (`length` - 1). You can never set a value with an index more than one beyond the current final index. (In other words, you can only set a value at an existing index or at index `[length]`.)

As a result of its restrictions, a Vector has three primary benefits over an Array instance whose elements are all instances of a single class:

- Performance: array element access and iteration are much faster when using a Vector instance than when using an Array instance.
- Type safety: in strict mode the compiler can identify data type errors. Examples of such errors include assigning a value of the incorrect data type to a Vector or expecting the wrong data type when reading a value from a Vector. At run time, data types are also checked when adding data to or reading data from a Vector object. Note, however, that when you use the `push()` method or `unshift()` method to add values to a Vector, the arguments' data types are not checked at compile time. When using those methods the values are still checked at run time.
- Reliability: runtime range checking (or fixed-length checking) increases reliability significantly over Arrays.

Aside from the additional restrictions and benefits, the Vector class is very much like the Array class. The properties and methods of a Vector object are similar—for the most part identical—to the properties and methods of an Array. In most situations where you would use an Array in which all the elements have the same data type, a Vector instance is preferable.

Creating arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use several techniques to create an Array instance or a Vector instance. However, the techniques to create each type of array are somewhat different.

Creating an Array instance

Flash Player 9 and later, Adobe AIR 1.0 and later

You create an Array object by calling the `Array()` constructor or by using Array literal syntax.

The `Array()` constructor function can be used in three ways. First, if you call the constructor with no arguments, you get an empty array. You can use the `length` property of the Array class to verify that the array has no elements. For example, the following code calls the `Array()` constructor with no arguments:

```
var names:Array = new Array();
trace(names.length); // output: 0
```

Second, if you use a number as the only parameter to the `Array()` constructor, an array of that length is created, with each element's value set to `undefined`. The argument must be an unsigned integer between the values 0 and 4,294,967,295. For example, the following code calls the `Array()` constructor with a single numeric argument:

```
var names:Array = new Array(3);
trace(names.length); // output: 3
trace(names[0]); // output: undefined
trace(names[1]); // output: undefined
trace(names[2]); // output: undefined
```

Third, if you call the constructor and pass a list of elements as parameters, an array is created, with elements corresponding to each of the parameters. The following code passes three arguments to the `Array()` constructor:

```
var names:Array = new Array("John", "Jane", "David");
trace(names.length); // output: 3
trace(names[0]); // output: John
trace(names[1]); // output: Jane
trace(names[2]); // output: David
```

You can also create arrays with Array literals. An Array literal can be assigned directly to an array variable, as shown in the following example:

```
var names:Array = ["John", "Jane", "David"];
```

Creating a Vector instance

Flash Player 10 and later, Adobe AIR 1.5 and later

You create a Vector instance by calling the `Vector.<T>()` constructor. You can also create a Vector by calling the `Vector.<T>()` global function. That function converts a specified object to a Vector instance. In Flash Professional CS5 and later, Flash Builder 4 and later, and Flex 4 and later, you can also create a vector instance by using Vector literal syntax.

Any time you declare a Vector variable (or similarly, a Vector method parameter or method return type) you specify the base type of the Vector variable. You also specify the base type when you create a Vector instance by calling the `Vector.<T>()` constructor. Put another way, any time you use the term `Vector` in ActionScript, it is accompanied by a base type.

You specify the Vector's base type using type parameter syntax. The type parameter immediately follows the word `Vector` in the code. It consists of a dot (`.`), then the base class name surrounded by angle brackets (`<>`), as shown in this example:

```
var v:Vector.<String>;
v = new Vector.<String>();
```

In the first line of the example, the variable `v` is declared as a `Vector.<String>` instance. In other words, it represents an indexed array that can only hold String instances. The second line calls the `Vector()` constructor to create an instance of the same Vector type (that is, a Vector whose elements are all String objects). It assigns that object to `v`.

Using the Vector.<T>() constructor

If you use the `Vector.<T>()` constructor without any arguments, it creates an empty Vector instance. You can test that a Vector is empty by checking its `length` property. For example, the following code calls the `Vector.<T>()` constructor with no arguments:

```
var names:Vector.<String> = new Vector.<String>();
trace(names.length); // output: 0
```

If you know ahead of time how many elements a Vector initially needs, you can pre-define the number of elements in the Vector. To create a Vector with a certain number of elements, pass the number of elements as the first parameter (the `length` parameter). Because Vector elements can't be empty, the elements are filled with instances of the base type. If the base type is a reference type that allows `null` values, the elements all contain `null`. Otherwise, the elements all contain the default value for the class. For example, a uint variable can't be `null`. Consequently, in the following code listing the Vector named `ages` is created with seven elements, each containing the value 0:

```
var ages:Vector.<uint> = new Vector.<uint>(7);
trace(ages); // output: 0,0,0,0,0,0,0
```

Finally, using the `Vector.<T>()` constructor you can also create a fixed-length Vector by passing `true` for the second parameter (the `fixed` parameter). In that case the Vector is created with the specified number of elements and the number of elements can't be changed. Note, however, that you can still change the values of the elements of a fixed-length Vector.

Using the Vector literal syntax constructor

In Flash Professional CS5 and later, Flash Builder 4 and later, and Flex 4 and later, you can pass a list of values to the `Vector.<T>()` constructor to specify the Vector's initial values:

```
// var v:Vector.<T> = new <T>[E0, ..., En-1 ,];
// For example:
var v:Vector.<int> = new <int>[0,1,2,];
```

The following information applies to this syntax:

- The trailing comma is optional.
- Empty items in the array are not supported; a statement such as `var v:Vector.<int> = new <int>[0,,2,]` throws a compiler error.
- You can't specify a default length for the Vector instance. Instead, the length is the same as the number of elements in the initialization list.
- You can't specify whether the Vector instance has a fixed length. Instead, use the `fixed` property.
- Data loss or errors can occur if items passed as values don't match the specified type. For example:

  ```
  var v:Vector.<int> = new <int>[4.2]; // compiler error when running in strict mode
  trace(v[0]); //returns 4 when not running in strict mode
  ```

Using the Vector.<T>() global function

In addition to the `Vector.<T>()` and Vector literal syntax constructors, you can also use the `Vector.<T>()` global function to create a Vector object. The `Vector.<T>()` global function is a conversion function. When you call the `Vector.<T>()` global function you specify the base type of the Vector that the method returns. You pass a single indexed array (Array or Vector instance) as an argument. The method then returns a Vector with the specified base type, containing the values in the source array argument. The following code listing shows the syntax for calling the `Vector.<T>()` global function:

```
var friends:Vector.<String> = Vector.<String>(["Bob", "Larry", "Sarah"]);
```

The `Vector.<T>()` global function performs data type conversion on two levels. First, when an Array instance is passed to the function, a Vector instance is returned. Second, whether the source array is an Array or Vector instance the function attempts to convert the source array's elements to values of the base type. The conversion uses standard ActionScript data type conversion rules. For example, the following code listing converts the String values in the source Array to integers in the result Vector. The decimal portion of the first value (`"1.5"`) is truncated, and the non-numeric third value (`"Waffles"`) is converted to 0 in the result:

```
var numbers:Vector.<int> = Vector.<int>(["1.5", "17", "Waffles"]);
trace(numbers); // output: 1,17,0
```

If any of the source elements can't be converted, an error occurs.

When code calls the `Vector.<T>()` global function, if an element in the source array is an instance of a subclass of the specified base type, the element is added to the result Vector (no error occurs). Using the `Vector.<T>()` global function is the only way to convert a Vector with base type `T` to a Vector with a base type that's a superclass of `T`.

Inserting array elements

Flash Player 9 and later, Adobe AIR 1.0 and later

The most basic way to add an element to an indexed array is to use the array access (`[]`) operator. To set the value of an indexed array element, use the Array or Vector object name and index number on the left side of an assignment statement:

```
songTitles[5] = "Happy Birthday";
```

If the Array or Vector doesn't already have an element at that index, the index is created and the value is stored there. If a value exists at that index, the new value replaces the existing one.

An Array object allows you to create an element at any index. However, with a Vector object you can only assign a value to an existing index or to the next available index. The next available index corresponds to the Vector object's `length` property. The safest way to add a new element to a Vector object is to use code like this listing:

```
myVector[myVector.length] = valueToAdd;
```

Three of the Array and Vector class methods—`push()`, `unshift()`, and `splice()`—allow you to insert elements into an indexed array. The `push()` method appends one or more elements to the end of an array. In other words, the last element inserted into the array using the `push()` method will have the highest index number. The `unshift()` method inserts one or more elements at the beginning of an array, which is always at index number 0. The `splice()` method will insert any number of items at a specified index in the array.

The following example demonstrates all three methods. An array named `planets` is created to store the names of the planets in order of proximity to the Sun. First, the `push()` method is called to add the initial item, `Mars`. Second, the `unshift()` method is called to insert the item that belongs at the front of the array, `Mercury`. Finally, the `splice()` method is called to insert the items `Venus` and `Earth` after `Mercury`, but before `Mars`. The first argument sent to `splice()`, the integer 1, directs the insertion to begin at index 1. The second argument sent to `splice()`, the integer 0, indicates that no items should be deleted. Finally, the third and fourth arguments sent to `splice()`, `Venus` and `Earth`, are the items to be inserted.

```
var planets:Array = new Array();
planets.push("Mars"); // array contents: Mars
planets.unshift("Mercury"); // array contents: Mercury,Mars
planets.splice(1, 0, "Venus", "Earth");
trace(planets); // array contents: Mercury,Venus,Earth,Mars
```

The `push()` and `unshift()` methods both return an unsigned integer that represents the length of the modified array. The `splice()` method returns an empty array when used to insert elements, which may seem strange, but makes more sense in light of the `splice()` method's versatility. You can use the `splice()` method not only to insert elements into an array, but also to remove elements from an array. When used to remove elements, the `splice()` method returns an array containing the elements removed.

***Note:** If a Vector object's `fixed` property is `true`, the total number of elements in the Vector can't change. If you try to add a new element to a fixed-length Vector using the techniques described here, an error occurs.*

Retrieving values and removing array elements

Flash Player 9 and later, Adobe AIR 1.0 and later

The simplest way to retrieve the value of an element from an indexed array is to use the array access (`[]`) operator. To retrieve the value of an indexed array element, use the Array or Vector object name and index number on the right side of an assignment statement:

```
var myFavoriteSong:String = songTitles[3];
```

It's possible to attempt to retrieve a value from an Array or Vector using an index where no element exists. In that case, an Array object returns the value undefined and a Vector throws a RangeError exception.

Three methods of the Array and Vector classes—`pop()`, `shift()`, and `splice()`—allow you to remove elements. The `pop()` method removes an element from the end of the array. In other words, it removes the element at the highest index number. The `shift()` method removes an element from the beginning of the array, which means that it always removes the element at index number 0. The `splice()` method, which can also be used to insert elements, removes an arbitrary number of elements starting at the index number specified by the first argument sent to the method.

The following example uses all three methods to remove elements from an Array instance. An Array named `oceans` is created to store the names of large bodies of water. Some of the names in the Array are lakes rather than oceans, so they need to be removed.

First, the `splice()` method is used to remove the items `Aral` and `Superior`, and insert the items `Atlantic` and `Indian`. The first argument sent to `splice()`, the integer 2, indicates that the operation should start with the third item in the list, which is at index 2. The second argument, 2, indicates that two items should be removed. The remaining arguments, `Atlantic` and `Indian`, are values to be inserted at index 2.

Second, the `pop()` method is used to remove last element in the array, `Huron`. And third, the `shift()` method is used to remove the first item in the array, `Victoria`.

```
var oceans:Array = ["Victoria", "Pacific", "Aral", "Superior", "Indian", "Huron"];
oceans.splice(2, 2, "Arctic", "Atlantic"); // replaces Aral and Superior
oceans.pop(); // removes Huron
oceans.shift(); // removes Victoria
trace(oceans);// output: Pacific,Arctic,Atlantic,Indian
```

The `pop()` and `shift()` methods both return the item that was removed. For an Array instance, the data type of the return value is Object because arrays can hold values of any data type. For a Vector instance, the data type of the return value is the base type of the Vector. The `splice()` method returns an Array or Vector containing the values removed. You can change the `oceans` Array example so that the call to `splice()` assigns the returned Array to a new Array variable, as shown in the following example:

```
var lakes:Array = oceans.splice(2, 2, "Arctic", "Atlantic");
trace(lakes); // output: Aral,Superior
```

You may come across code that uses the `delete` operator on an Array object element. The `delete` operator sets the value of an Array element to `undefined`, but it does not remove the element from the Array. For example, the following code uses the `delete` operator on the third element in the `oceans` Array, but the length of the Array remains 5:

```
var oceans:Array = ["Arctic", "Pacific", "Victoria", "Indian", "Atlantic"];
delete oceans[2];
trace(oceans);// output: Arctic,Pacific,,Indian,Atlantic
trace(oceans[2]); // output: undefined
trace(oceans.length); // output: 5
```

You can truncate an Array or Vector using an array's `length` property. If you set the `length` property of an indexed array to a length that is less than the current length of the array, the array is truncated, removing any elements stored at index numbers higher than the new value of `length` minus 1. For example, if the `oceans` array were sorted such that all valid entries were at the beginning of the array, you could use the `length` property to remove the entries at the end of the array, as shown in the following code:

```
var oceans:Array = ["Arctic", "Pacific", "Victoria", "Aral", "Superior"];
oceans.length = 2;
trace(oceans); // output: Arctic,Pacific
```

***Note:** If a Vector object's `fixed` property is `true`, the total number of elements in the Vector can't change. If you try to remove an element from or truncate a fixed-length Vector using the techniques described here, an error occurs.*

Sorting an array

Flash Player 9 and later, Adobe AIR 1.0 and later

There are three methods—`reverse()`, `sort()`, and `sortOn()`—that allow you to change the order of an indexed array, either by sorting or reversing the order. All of these methods modify the existing array. The following table summarizes these methods and their behavior for Array and Vector objects:

Method	Array behavior	Vector behavior
`reverse()`	Changes the order of the elements so that the last element becomes the first element, the penultimate element becomes the second, and so on	Identical to Array behavior
`sort()`	Allows you to sort the Array's elements in a variety of predefined ways, such as alphabetical or numeric order. You can also specify a custom sorting algorithm.	Sorts the elements according to the custom sorting algorithm that you specify
`sortOn()`	Allows you to sort objects that have one or more common properties, specifying the property or properties to use as the sort keys	Not available in the Vector class

The reverse() method

The `reverse()` method takes no parameters and does not return a value, but allows you to toggle the order of your array from its current state to the reverse order. The following example reverses the order of the oceans listed in the `oceans` array:

```
var oceans:Array = ["Arctic", "Atlantic", "Indian", "Pacific"];
oceans.reverse();
trace(oceans); // output: Pacific,Indian,Atlantic,Arctic
```

Basic sorting with the sort() method (Array class only)

For an Array instance, the `sort()` method rearranges the elements in an array using the *default sort order*. The default sort order has the following characteristics:

- The sort is case-sensitive, which means that uppercase characters precede lowercase characters. For example, the letter D precedes the letter b.
- The sort is ascending, which means that lower character codes (such as A) precede higher character codes (such as B).
- The sort places identical values adjacent to each other but in no particular order.
- The sort is string-based, which means that elements are converted to strings before they are compared (for example, 10 precedes 3 because the string `"1"` has a lower character code than the string `"3"` has).

You may find that you need to sort your Array without regard to case, or in descending order, or perhaps your array contains numbers that you want to sort numerically instead of alphabetically. The Array class's `sort()` method has an `options` parameter that allows you to alter each characteristic of the default sort order. The options are defined by a set of static constants in the Array class, as shown in the following list:

- `Array.CASEINSENSITIVE`: This option makes the sort disregard case. For example, the lowercase letter b precedes the uppercase letter D.
- `Array.DESCENDING:` This reverses the default ascending sort. For example, the letter B precedes the letter A.
- `Array.UNIQUESORT:` This causes the sort to abort if two identical values are found.
- `Array.NUMERIC:` This causes numerical sorting, so that 3 precedes 10.

The following example highlights some of these options. An Array named `poets` is created that is sorted using several different options.

```
var poets:Array = ["Blake", "cummings", "Angelou", "Dante"];
poets.sort(); // default sort
trace(poets); // output: Angelou,Blake,Dante,cummings

poets.sort(Array.CASEINSENSITIVE);
trace(poets); // output: Angelou,Blake,cummings,Dante

poets.sort(Array.DESCENDING);
trace(poets); // output: cummings,Dante,Blake,Angelou

poets.sort(Array.DESCENDING | Array.CASEINSENSITIVE); // use two options
trace(poets); // output: Dante,cummings,Blake,Angelou
```

Custom sorting with the sort() method (Array and Vector classes)

In addition to the basic sorting that's available for an Array object, you can also define a custom sorting rule. This technique is the only form of the `sort()` method that is available for the Vector class. To define a custom sort, you write a custom sort function and pass it as an argument to the `sort()` method.

For example, if you have a list of names in which each list element contains a person's full name, but you want to sort the list by last name, you must use a custom sort function to parse each element and use the last name in the sort function. The following code shows how this can be done with a custom function that is used as a parameter to the `Array.sort()` method:

```
var names:Array = new Array("John Q. Smith", "Jane Doe", "Mike Jones");
function orderLastName(a, b):int
{
    var lastName:RegExp = /\b\S+$/;
    var name1 = a.match(lastName);
    var name2 = b.match(lastName);
    if (name1 < name2)
    {
        return -1;
    }
    else if (name1 > name2)
    {
        return 1;
    }
    else
    {
        return 0;
    }
}
trace(names); // output: John Q. Smith,Jane Doe,Mike Jones
names.sort(orderLastName);
trace(names); // output: Jane Doe,Mike Jones,John Q. Smith
```

The custom sort function `orderLastName()` uses a regular expression to extract the last name from each element to use for the comparison operation. The function identifier `orderLastName` is used as the sole parameter when calling the `sort()` method on the `names` array. The sort function accepts two parameters, `a` and `b`, because it works on two array elements at a time. The sort function's return value indicates how the elements should be sorted:

- A return value of -1 indicates that the first parameter, `a`, precedes the second parameter, `b`.
- A return value of 1 indicates that the second parameter, `b`, precedes the first, `a`.
- A return value of 0 indicates that the elements have equal sorting precedence.

The sortOn() method (Array class only)

The `sortOn()` method is designed for Array objects with elements that contain objects. These objects are expected to have at least one common property that can be used as the sort key. The use of the `sortOn()` method for arrays of any other type yields unexpected results.

***Note:** The Vector class does not include a `sortOn()` method. This method is only available for Array objects.*

The following example revises the `poets` Array so that each element is an object instead of a string. Each object holds both the poet's last name and year of birth.

```
var poets:Array = new Array();
poets.push({name:"Angelou", born:"1928"});
poets.push({name:"Blake", born:"1757"});
poets.push({name:"cummings", born:"1894"});
poets.push({name:"Dante", born:"1265"});
poets.push({name:"Wang", born:"701"});
```

You can use the `sortOn()` method to sort the Array by the `born` property. The `sortOn()` method defines two parameters, `fieldName` and `options`. The `fieldName` argument must be specified as a string. In the following example, `sortOn()` is called with two arguments, "`born"` and `Array.NUMERIC`. The `Array.NUMERIC` argument is used to ensure that the sort is done numerically instead of alphabetically. This is a good practice even when all the numbers have the same number of digits because it ensures that the sort will continue to behave as expected if a number with fewer or more digits is later added to the array.

```
poets.sortOn("born", Array.NUMERIC);
for (var i:int = 0; i < poets.length; ++i)
{
    trace(poets[i].name, poets[i].born);
}
/* output:
Wang 701
Dante 1265
Blake 1757
cummings 1894
Angelou 1928
*/
```

Sorting without modifying the original array (Array class only)

Generally, the `sort()` and `sortOn()` methods modify an Array. If you wish to sort an Array without modifying the existing array, pass the `Array.RETURNINDEXEDARRAY` constant as part of the `options` parameter. This option directs the methods to return a new Array that reflects the sort and to leave the original Array unmodified. The Array returned by the methods is a simple Array of index numbers that reflects the new sort order and does not contain any elements from the original Array. For example, to sort the `poets` Array by birth year without modifying the Array, include the `Array.RETURNINDEXEDARRAY` constant as part of the argument passed for the `options` parameter.

The following example stores the returned index information in an Array named `indices` and uses the `indices` array in conjunction with the unmodified `poets` array to output the poets in order of birth year:

```
var indices:Array;
indices = poets.sortOn("born", Array.NUMERIC | Array.RETURNINDEXEDARRAY);
for (var i:int = 0; i < indices.length; ++i)
{
    var index:int = indices[i];
    trace(poets[index].name, poets[index].born);
}
/* output:
Wang 701
Dante 1265
Blake 1757
cummings 1894
Angelou 1928
*/
```

Querying an array

Flash Player 9 and later, Adobe AIR 1.0 and later

Four methods of the Array and Vector classes—`concat()`, `join()`, `slice()`, and `toString()`—all query the array for information, but do not modify the array. The `concat()` and `slice()` methods both return new arrays, while the `join()` and `toString()` methods both return strings. The `concat()` method takes a new array or list of elements as arguments and combines it with the existing array to create a new array. The `slice()` method has two parameters, aptly named `startIndex` and an `endIndex`, and returns a new array containing a copy of the elements "sliced" from the existing array. The slice begins with the element at `startIndex` and ends with the element just before `endIndex`. That bears repeating: the element at `endIndex` is not included in the return value.

The following example uses `concat()` and `slice()` to create new arrays using elements of other arrays:

```
var array1:Array = ["alpha", "beta"];
var array2:Array = array1.concat("gamma", "delta");
trace(array2); // output: alpha,beta,gamma,delta

var array3:Array = array1.concat(array2);
trace(array3); // output: alpha,beta,alpha,beta,gamma,delta

var array4:Array = array3.slice(2,5);
trace(array4); // output: alpha,beta,gamma
```

You can use the `join()` and `toString()` methods to query the array and return its contents as a string. If no parameters are used for the `join()` method, the two methods behave identically—they return a string containing a comma-delimited list of all elements in the array. The `join()` method, unlike the `toString()` method, accepts a parameter named `delimiter`, which allows you to choose the symbol to use as a separator between each element in the returned string.

The following example creates an Array called `rivers` and calls both `join()` and `toString()` to return the values in the Array as a string. The `toString()` method is used to return comma-separated values (`riverCSV`), while the `join()` method is used to return values separated by the `+` character.

```
var rivers:Array = ["Nile", "Amazon", "Yangtze", "Mississippi"];
var riverCSV:String = rivers.toString();
trace(riverCSV); // output: Nile,Amazon,Yangtze,Mississippi
var riverPSV:String = rivers.join("+");
trace(riverPSV); // output: Nile+Amazon+Yangtze+Mississippi
```

One issue to be aware of with the `join()` method is that any nested Array or Vector instances are always returned with comma-separated values, no matter what separator you specify for the main array elements, as the following example shows:

```
var nested:Array = ["b","c","d"];
var letters:Array = ["a",nested,"e"];
var joined:String = letters.join("+");
trace(joined); // output: a+b,c,d+e
```

Associative arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

An associative array, sometimes called a *hash* or *map*, uses *keys* instead of a numeric index to organize stored values. Each key in an associative array is a unique string that is used to access a stored value. An associative array is an instance of the Object class, which means that each key corresponds to a property name. Associative arrays are unordered collections of key and value pairs. Your code should not expect the keys of an associative array to be in a specific order.

ActionScript 3.0 also includes an advanced type of associative array called a *dictionary*. Dictionaries, which are instances of the Dictionary class in the flash.utils package, use keys that can be of any data type. In other words, dictionary keys are not limited to values of type String.

Associative arrays with string keys

Flash Player 9 and later, Adobe AIR 1.0 and later

There are two ways to create associative arrays in ActionScript 3.0. The first way is to use an Object instance. By using an Object instance you can initialize your array with an object literal. An instance of the Object class, also called a *generic object*, is functionally identical to an associative array. Each property name of the generic object serves as the key that provides access to a stored value.

The following example creates an associative array named `monitorInfo`, using an object literal to initialize the array with two key and value pairs:

```
var monitorInfo:Object = {type:"Flat Panel", resolution:"1600 x 1200"};
trace(monitorInfo["type"], monitorInfo["resolution"]);
// output: Flat Panel 1600 x 1200
```

If you do not need to initialize the array at declaration time, you can use the Object constructor to create the array, as follows:

```
var monitorInfo:Object = new Object();
```

After the array is created using either an object literal or the Object class constructor, you can add new values to the array using either the array access (`[]`) operator or the dot operator (`.`). The following example adds two new values to `monitorArray`:

```
monitorInfo["aspect ratio"] = "16:10"; // bad form, do not use spaces
monitorInfo.colors = "16.7 million";
trace(monitorInfo["aspect ratio"], monitorInfo.colors);
// output: 16:10 16.7 million
```

Note that the key named `aspect ratio` contains a space character. This is possible with the array access (`[]`) operator, but generates an error if attempted with the dot operator. Using spaces in your key names is not recommended.

The second way to create an associative array is to use the Array constructor (or the constructor of any dynamic class) and then use either the array access (`[]`) operator or the dot operator (`.`) to add key and value pairs to the array. If you declare your associative array to be of type Array, you cannot use an object literal to initialize the array. The following example creates an associative array named `monitorInfo` using the Array constructor and adds a key called `type` and a key called `resolution`, along with their values:

```
var monitorInfo:Array = new Array();
monitorInfo["type"] = "Flat Panel";
monitorInfo["resolution"] = "1600 x 1200";
trace(monitorInfo["type"], monitorInfo["resolution"]);
// output: Flat Panel 1600 x 1200
```

There is no advantage in using the Array constructor to create an associative array. You cannot use the `Array.length` property or any of the methods of the Array class with associative arrays, even if you use the Array constructor or the Array data type. The use of the Array constructor is best left for the creation of indexed arrays.

Associative arrays with object keys (Dictionaries)

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the Dictionary class to create an associative array that uses objects for keys rather than strings. Such arrays are sometimes called dictionaries, hashes, or maps. For example, consider an application that determines the location of a Sprite object based on its association with a specific container. You can use a Dictionary object to map each Sprite object to a container.

The following code creates three instances of the Sprite class that serve as keys for the Dictionary object. Each key is assigned a value of either `GroupA` or `GroupB`. The values can be of any data type, but in this example both `GroupA` and `GroupB` are instances of the Object class. Subsequently, you can access the value associated with each key with the array access (`[]`) operator, as shown in the following code:

```
import flash.display.Sprite;
import flash.utils.Dictionary;

var groupMap:Dictionary = new Dictionary();

// objects to use as keys
var spr1:Sprite = new Sprite();
var spr2:Sprite = new Sprite();
var spr3:Sprite = new Sprite();

// objects to use as values
var groupA:Object = new Object();
var groupB:Object = new Object();

// Create new key-value pairs in dictionary.
groupMap[spr1] = groupA;
groupMap[spr2] = groupB;
groupMap[spr3] = groupB;

if (groupMap[spr1] == groupA)
{
    trace("spr1 is in groupA");
}
if (groupMap[spr2] == groupB)
{
    trace("spr2 is in groupB");
}
if (groupMap[spr3] == groupB)
{
    trace("spr3 is in groupB");
}
```

Iterating with object keys

You can iterate through the contents of a Dictionary object with either a `for..in` loop or a `for each..in` loop. A `for..in` loop allows you to iterate based on the keys, whereas a `for each..in` loop allows you to iterate based on the values associated with each key.

Use the `for..in` loop for direct access to the object keys of a Dictionary object. You can also access the values of the Dictionary object with the array access (`[]`) operator. The following code uses the previous example of the `groupMap` dictionary to show how to iterate through a Dictionary object with the `for..in` loop:

```
for (var key:Object in groupMap)
{
    trace(key, groupMap[key]);
}
/* output:
[object Sprite] [object Object]
[object Sprite] [object Object]
[object Sprite] [object Object]
*/
```

Use the `for each..in` loop for direct access to the values of a Dictionary object. The following code also uses the `groupMap` dictionary to show how to iterate through a Dictionary object with the `for each..in` loop:

```
for each (var item:Object in groupMap)
{
    trace(item);
}
/* output:
[object Object]
[object Object]
[object Object]
*/
```

Object keys and memory management

Adobe® Flash® Player and Adobe® AIR™ use a garbage collection system to recover memory that is no longer used. When an object has no references pointing to it, the object becomes eligible for garbage collection, and the memory is recovered the next time the garbage collection system executes. For example, the following code creates a new object and assigns a reference to the object to the variable `myObject`:

```
var myObject:Object = new Object();
```

As long as any reference to the object exists, the garbage collection system will not recover the memory that the object occupies. If the value of `myObject` is changed such that it points to a different object or is set to the value `null`, the memory occupied by the original object becomes eligible for garbage collection, but only if there are no other references to the original object.

If you use `myObject` as a key in a Dictionary object, you are creating another reference to the original object. For example, the following code creates two references to an object—the `myObject` variable, and the key in the `myMap` object:

```
import flash.utils.Dictionary;

var myObject:Object = new Object();
var myMap:Dictionary = new Dictionary();
myMap[myObject] = "foo";
```

To make the object referenced by `myObject` eligible for garbage collection, you must remove all references to it. In this case, you must change the value of `myObject` and delete the `myObject` key from `myMap`, as shown in the following code:

```
myObject = null;
delete myMap[myObject];
```

Alternatively, you can use the `useWeakReference` parameter of the Dictionary constructor to make all of the dictionary keys *weak references*. The garbage collection system ignores weak references, which means that an object that has only weak references is eligible for garbage collection. For example, in the following code, you do not need to delete the `myObject` key from `myMap` in order to make the object eligible for garbage collection:

```
import flash.utils.Dictionary;

var myObject:Object = new Object();
var myMap:Dictionary = new Dictionary(true);
myMap[myObject] = "foo";
myObject = null; // Make object eligible for garbage collection.
```

Multidimensional arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

Multidimensional arrays contain other arrays as elements. For example, consider a list of tasks that is stored as an indexed array of strings:

```
var tasks:Array = ["wash dishes", "take out trash"];
```

If you want to store a separate list of tasks for each day of the week, you can create a multidimensional array with one element for each day of the week. Each element contains an indexed array, similar to the `tasks` array, that stores the list of tasks. You can use any combination of indexed or associative arrays in multidimensional arrays. The examples in the following sections use either two indexed arrays or an associative array of indexed arrays. You might want to try the other combinations as exercises.

Two indexed arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

When you use two indexed arrays, you can visualize the result as a table or spreadsheet. The elements of the first array represent the rows of the table, while the elements of the second array represent the columns.

For example, the following multidimensional array uses two indexed arrays to track task lists for each day of the week. The first array, `masterTaskList`, is created using the Array class constructor. Each element of the array represents a day of the week, with index 0 representing Monday, and index 6 representing Sunday. These elements can be thought of as the rows in the table. You can create each day's task list by assigning an array literal to each of the seven elements that you create in the `masterTaskList` array. The array literals represent the columns in the table.

```
var masterTaskList:Array = new Array();
masterTaskList[0] = ["wash dishes", "take out trash"];
masterTaskList[1] = ["wash dishes", "pay bills"];
masterTaskList[2] = ["wash dishes", "dentist", "wash dog"];
masterTaskList[3] = ["wash dishes"];
masterTaskList[4] = ["wash dishes", "clean house"];
masterTaskList[5] = ["wash dishes", "wash car", "pay rent"];
masterTaskList[6] = ["mow lawn", "fix chair"];
```

You can access individual items on any of the task lists using the array access (`[]`) operator. The first set of brackets represents the day of the week, and the second set of brackets represents the task list for that day. For example, to retrieve the second task from Wednesday's list, first use index 2 for Wednesday, and then use index 1 for the second task in the list.

```
trace(masterTaskList[2][1]); // output: dentist
```

To retrieve the first task from Sunday's list, use index 6 for Sunday and index 0 for the first task on the list.

```
trace(masterTaskList[6][0]); // output: mow lawn
```

Associative array with an indexed array

Flash Player 9 and later, Adobe AIR 1.0 and later

To make the individual arrays easier to access, you can use an associative array for the days of the week and an indexed array for the task lists. Using an associative array allows you to use dot syntax when referring to a particular day of the week, but at the cost of extra run-time processing to access each element of the associative array. The following example uses an associative array as the basis of a task list, with a key and value pair for each day of the week:

```
var masterTaskList:Object = new Object();
masterTaskList["Monday"] = ["wash dishes", "take out trash"];
masterTaskList["Tuesday"] = ["wash dishes", "pay bills"];
masterTaskList["Wednesday"] = ["wash dishes", "dentist", "wash dog"];
masterTaskList["Thursday"] = ["wash dishes"];
masterTaskList["Friday"] = ["wash dishes", "clean house"];
masterTaskList["Saturday"] = ["wash dishes", "wash car", "pay rent"];
masterTaskList["Sunday"] = ["mow lawn", "fix chair"];
```

Dot syntax makes the code more readable by making it possible to avoid multiple sets of brackets.

```
trace(masterTaskList.Wednesday[1]); // output: dentist
trace(masterTaskList.Sunday[0]);// output: mow lawn
```

You can iterate through the task list using a `for..in` loop, but you must use the array access (`[]`) operator instead of dot syntax to access the value associated with each key. Because `masterTaskList` is an associative array, the elements are not necessarily retrieved in the order that you may expect, as the following example shows:

```
for (var day:String in masterTaskList)
{
    trace(day + ": " + masterTaskList[day])
}
/* output:
Sunday: mow lawn,fix chair
Wednesday: wash dishes,dentist,wash dog
Friday: wash dishes,clean house
Thursday: wash dishes
Monday: wash dishes,take out trash
Saturday: wash dishes,wash car,pay rent
Tuesday: wash dishes,pay bills
*/
```

Cloning arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

The Array class has no built-in method for making copies of arrays. You can create a *shallowcopy* of an array by calling either the `concat()` or `slice()` methods with no arguments. In a shallow copy, if the original array has elements that are objects, only the references to the objects are copied rather than the objects themselves. The copy points to the same objects as the original does. Any changes made to the objects are reflected in both arrays.

In a *deep copy*, any objects found in the original array are also copied so that the new array does not point to the same objects as does the original array. Deep copying requires more than one line of code, which usually calls for the creation of a function. Such a function could be created as a global utility function or as a method of an Array subclass.

The following example defines a function named `clone()` that does deep copying. The algorithm is borrowed from a common Java programming technique. The function creates a deep copy by serializing the array into an instance of the ByteArray class, and then reading the array back into a new array. This function accepts an object so that it can be used with both indexed arrays and associative arrays, as shown in the following code:

```
import flash.utils.ByteArray;

function clone(source:Object):*
{
    var myBA:ByteArray = new ByteArray();
    myBA.writeObject(source);
    myBA.position = 0;
    return(myBA.readObject());
}
```

Extending the Array class

Flash Player 9 and later, Adobe AIR 1.0 and later

The Array class is one of the few core classes that is not final, which means that you can create your own subclass of Array. This section provides an example of how to create a subclass of Array and discusses some of the issues that can arise during the process.

As mentioned previously, arrays in ActionScript are not typed, but you can create a subclass of Array that accepts elements of only a specific data type. The example in the following sections defines an Array subclass named TypedArray that limits its elements to values of the data type specified in the first parameter. The TypedArray class is presented merely as an example of how to extend the Array class and may not be suitable for production purposes for several reasons. First, type checking occurs at run time rather than at compile time. Second, when a TypedArray method encounters a mismatch, the mismatch is ignored and no exception is thrown, although the methods can be easily modified to throw exceptions. Third, the class cannot prevent the use of the array access operator to insert values of any type into the array. Fourth, the coding style favors simplicity over performance optimization.

***Note:** You can use the technique described here to create a typed array. However, a better approach is to use a Vector object. A Vector instance is a true typed array, and provides performance and other improvements over the Array class or any subclass. The purpose of this discussion is to demonstrate how to create an Array subclass.*

Declaring the subclass

Use the `extends` keyword to indicate that a class is a subclass of Array. A subclass of Array should use the `dynamic` attribute, just as the Array class does. Otherwise, your subclass will not function properly.

The following code shows the definition of the TypedArray class, which contains a constant to hold the data type, a constructor method, and the four methods that are capable of adding elements to the array. The code for each method is omitted in this example, but is delineated and explained fully in the sections that follow:

```
public dynamic class TypedArray extends Array
{
    private const dataType:Class;

    public function TypedArray(...args) {}

    AS3 override function concat(...args):Array {}

    AS3 override function push(...args):uint {}

    AS3 override function splice(...args) {}

    AS3 override function unshift(...args):uint {}
}
```

The four overridden methods all use the AS3 namespace instead of the `public` attribute because this example assumes that the compiler option `-as3` is set to `true` and the compiler option `-es` is set to `false`. These are the default settings for Adobe Flash Builder and for AdobeFlashProfessional.

If you are an advanced developer who prefers to use prototype inheritance, you can make two minor changes to the TypedArray class to make it compile with the compiler option `-es` set to `true`. First, remove all occurrences of the `override` attribute and replace the AS3 namespace with the `public` attribute. Second, substitute `Array.prototype` for all four occurrences of `super`.

TypedArray constructor

The subclass constructor poses an interesting challenge because the constructor must accept a list of arguments of arbitrary length. The challenge is how to pass the arguments on to the superconstructor to create the array. If you pass the list of arguments as an array, the superconstructor considers it a single argument of type Array and the resulting array is always 1 element long. The traditional way to handle pass-through argument lists is to use the `Function.apply()` method, which takes an array of arguments as its second parameter but converts it to a list of arguments when executing the function. Unfortunately, the `Function.apply()` method cannot be used with constructors.

The only option left is to recreate the logic of the Array constructor in the TypedArray constructor. The following code shows the algorithm used in the Array class constructor, which you can reuse in your Array subclass constructor:

```
public dynamic class Array
{
    public function Array(...args)
    {
        var n:uint = args.length
        if (n == 1 && (args[0] is Number))
        {
            var dlen:Number = args[0];
            var ulen:uint = dlen;
            if (ulen != dlen)
            {
                throw new RangeError("Array index is not a 32-bit unsigned integer ("+dlen+")");
            }
            length = ulen;
        }
        else
        {
            length = n;
            for (var i:int=0; i < n; i++)
            {
                this[i] = args[i]
            }
        }
    }
}
```

The TypedArray constructor shares most of the code from the Array constructor, with only four changes to the code. First, the parameter list includes a new required parameter of type Class that allows specification of the array's data type. Second, the data type passed to the constructor is assigned to the `dataType` variable. Third, in the `else` statement, the value of the `length` property is assigned after the `for` loop so that `length` includes only arguments that are the proper type. Fourth, the body of the `for` loop uses the overridden version of the `push()` method so that only arguments of the correct data type are added to the array. The following example shows the TypedArray constructor function:

```
public dynamic class TypedArray extends Array
{
    private var dataType:Class;
    public function TypedArray(typeParam:Class, ...args)
    {
        dataType = typeParam;
        var n:uint = args.length
        if (n == 1 && (args[0] is Number))
        {
            var dlen:Number = args[0];
            var ulen:uint = dlen
            if (ulen != dlen)
            {
                throw new RangeError("Array index is not a 32-bit unsigned integer ("+dlen+")")
            }
            length = ulen;
        }
        else
        {
            for (var i:int=0; i < n; i++)
            {
                // type check done in push()
                this.push(args[i])
            }
            length = this.length;
        }
    }
}
```

TypedArray overridden methods

The TypedArray class overrides the four methods of the Array class that are capable of adding elements to an array. In each case, the overridden method adds a type check that prevents the addition of elements that are not the correct data type. Subsequently, each method calls the superclass version of itself.

The `push()` method iterates through the list of arguments with a `for..in` loop and does a type check on each argument. Any argument that is not the correct type is removed from the `args` array with the `splice()` method. After the `for..in` loop ends, the `args` array contains values only of type `dataType`. The superclass version of `push()` is then called with the updated `args` array, as the following code shows:

```
    AS3 override function push(...args):uint
    {
        for (var i:* in args)
        {
            if (!(args[i] is dataType))
            {
                args.splice(i,1);
            }
        }
        return (super.push.apply(this, args));
    }
```

The `concat()` method creates a temporary TypedArray named `passArgs` to store the arguments that pass the type check. This allows the reuse of the type check code that exists in the `push()` method. A `for..in` loop iterates through the `args` array, and calls `push()` on each argument. Because `passArgs` is typed as TypedArray, the TypedArray version of `push()` is executed. The `concat()` method then calls its own superclass version, as the following code shows:

```
    AS3 override function concat(...args):Array
    {
        var passArgs:TypedArray = new TypedArray(dataType);
        for (var i:* in args)
        {
            // type check done in push()
            passArgs.push(args[i]);
        }
        return (super.concat.apply(this, passArgs));
    }
```

The `splice()` method takes an arbitrary list of arguments, but the first two arguments always refer to an index number and the number of elements to delete. This is why the overridden `splice()` method does type checking only for `args` array elements in index positions 2 or higher. One point of interest in the code is that there appears to be a recursive call to `splice()` inside the `for` loop, but this is not a recursive call because `args` is of type Array rather than TypedArray, which means that the call to `args.splice()` is a call to the superclass version of the method. After the `for..in` loop concludes, the `args` array contains only values of the correct type in index positions 2 or higher, and `splice()` calls its own superclass version, as shown in the following code:

```
    AS3 override function splice(...args):*
    {
        if (args.length > 2)
        {
            for (var i:int=2; i< args.length; i++)
            {
                if (!(args[i] is dataType))
                {
                    args.splice(i,1);
                }
            }
        }
        return (super.splice.apply(this, args));
    }
```

The `unshift()` method, which adds elements to the beginning of an array, also accepts an arbitrary list of arguments. The overridden `unshift()` method uses an algorithm very similar to that used by the `push()` method, as shown in the following example code:

```
    AS3 override function unshift(...args):uint
    {
        for (var i:* in args)
        {
            if (!(args[i] is dataType))
            {
                args.splice(i,1);
            }
        }
        return (super.unshift.apply(this, args));
    }
}
```

Arrays example: PlayList

Flash Player 9 and later, Adobe AIR 1.0 and later

The PlayList example demonstrates techniques for working with arrays, in the context of a music playlist application that manages a list of songs. These techniques are:

- Creating an indexed array
- Adding items to an indexed array
- Sorting an array of objects by different properties, using different sorting options
- Converting an array to a character-delimited string

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The PlayList application files can be found in the Samples/PlayList folder. The application consists of the following files:

File	Description
PlayList.mxml or PlayList.fla	The main application file in Flash (FLA) or Flex (MXML).
com/example/programmingas3/playlist/PlayList.as	A class representing a list of songs. It uses an Array to store the list, and manages the sorting of the list's items..
com/example/programmingas3/playlist/Song.as	A value object representing information about a single song. The items that are managed by the PlayList class are Song instances.
com/example/programmingas3/playlist/SortProperty.as	A pseudo-enumeration whose available values represent the properties of the Song class by which a list of Song objects can be sorted.

PlayList class overview

Flash Player 9 and later, Adobe AIR 1.0 and later

The PlayList class manages a set of Song objects. It has public methods with functionality for adding a song to the playlist (the `addSong()` method) and sorting the songs in the list (the `sortList()` method). In addition, the class includes a read-only accessor property, `songList`, which provides access to the actual set of songs in the playlist. Internally, the PlayList class keeps track of its songs using a private Array variable:

```
public class PlayList
{
    private var _songs:Array;
    private var _currentSort:SortProperty = null;
    private var _needToSort:Boolean = false;
    ...
}
```

In addition to the `_songs` Array variable, which is used by the PlayList class to keep track of its list of songs, two other private variables keep track of whether the list needs to be sorted (`_needToSort`) and which property the song list is sorted by at a given time (`_currentSort`).

As with all objects, declaring an Array instance is only half the job of creating an Array. Before accessing an Array instance's properties or methods, it must be instantiated, which is done in the PlayList class's constructor.

```
public function PlayList()
{
    this._songs = new Array();
    // Set the initial sorting.
    this.sortList(SortProperty.TITLE);
}
```

The first line of the constructor instantiates the `_songs` variable, so that it is ready to be used. In addition, the `sortList()` method is called to set the initial sort-by property.

Adding a song to the list

Flash Player 9 and later, Adobe AIR 1.0 and later

When a user enters a new song into the application, the code in the data entry form calls the PlayList class's `addSong()` method.

```
/**
 * Adds a song to the playlist.
 */
public function addSong(song:Song):void
{
    this._songs.push(song);
    this._needToSort = true;
}
```

Inside `addSong()`, the `_songs` array's `push()` method is called, adding the Song object that was passed to `addSong()` as a new element in that array. With the `push()` method, the new element is added to the end of the array, regardless of any sorting that might have been applied previously. This means that after the `push()` method has been called, the list of songs is likely to no longer be sorted correctly, so the `_needToSort` variable is set to `true`. In theory, the `sortList()` method could be called immediately, removing the need to keep track of whether the list is sorted or not at a given time. In practice, however, there is no need for the list of songs to be sorted until immediately before it is retrieved. By deferring the sorting operation, the application doesn't perform sorting that is unnecessary if, for example, several songs are added to the list before it is retrieved.

Sorting the list of songs

Flash Player 9 and later, Adobe AIR 1.0 and later

Because the Song instances that are managed by the playlist are complex objects, users of the application may wish to sort the playlist according to different properties, such as song title or year of publication. In the PlayList application, the task of sorting the list of songs has three parts: identifying the property by which the list should be sorted, indicating what sorting options need to be used when sorting by that property, and performing the actual sort operation.

Properties for sorting

A Song object keeps track of several properties, including song title, artist, publication year, filename, and a user-selected set of genres in which the song belongs. Of these, only the first three are practical for sorting. As a matter of convenience for developers, the example includes the SortProperty class, which acts as an enumeration with values representing the properties available for sorting.

```
public static const TITLE:SortProperty = new SortProperty("title");
public static const ARTIST:SortProperty = new SortProperty("artist");
public static const YEAR:SortProperty = new SortProperty("year");
```

The SortProperty class contain three constants, `TITLE`, `ARTIST`, and `YEAR`, each of which stores a String containing the actual name of the associated Song class property that can be used for sorting. Throughout the rest of the code, whenever a sort property is indicated, it is done using the enumeration member. For instance, in the PlayList constructor, the list is sorted initially by calling the `sortList()` method, as follows:

```
// Set the initial sorting.
this.sortList(SortProperty.TITLE);
```

Because the property for sorting is specified as `SortProperty.TITLE`, the songs are sorted according to their title.

Sorting by property and specifying sort options

The work of actually sorting the list of songs is performed by the PlayList class in the `sortList()` method, as follows:

```
/**
 * Sorts the list of songs according to the specified property.
 */
public function sortList(sortProperty:SortProperty):void
{
    ...
    var sortOptions:uint;
    switch (sortProperty)
    {
        case SortProperty.TITLE:
            sortOptions = Array.CASEINSENSITIVE;
            break;
        case SortProperty.ARTIST:
            sortOptions = Array.CASEINSENSITIVE;
            break;
        case SortProperty.YEAR:
            sortOptions = Array.NUMERIC;
            break;
    }

    // Perform the actual sorting of the data.
    this._songs.sortOn(sortProperty.propertyName, sortOptions);

    // Save the current sort property.
    this._currentSort = sortProperty;

    // Record that the list is sorted.
    this._needToSort = false;
}
```

When sorting by title or artist, it makes sense to sort alphabetically, but when sorting by year, it's most logical to perform a numeric sort. The `switch` statement is used to define the appropriate sorting option, stored in the variable `sortOptions`, according to the value specified in the `sortProperty` parameter. Here again the named enumeration members are used to distinguish between properties, rather than hard-coded values.

With the sort property and sort options determined, the `_songs` array is actually sorted by calling its `sortOn()` method, passing those two values as parameters. The current sort property is recorded, as is the fact that the song list is currently sorted.

Combining array elements into a character-delimited string

Flash Player 9 and later, Adobe AIR 1.0 and later

In addition to using an array to maintain the song list in the PlayList class, in this example arrays are also used in the Song class to help manage the list of genres to which a given song belongs. Consider this snippet from the Song class's definition:

```
private var _genres:String;

public function Song(title:String, artist:String, year:uint, filename:String, genres:Array)
{
    ...
    // Genres are passed in as an array
    // but stored as a semicolon-separated string.
    this._genres = genres.join(";");
}
```

When creating a new Song instance, the `genres` parameter that is used to specify the genre (or genres) the song belongs to is defined as an Array instance. This makes it convenient to group multiple genres together into a single variable that can be passed to the constructor. However, internally the Song class maintains the genres in the private `_genres` variable as a semicolon-separated String instance. The Array parameter is converted into a semicolon-separated string by calling its `join()` method with the literal string value `";"` as the specified delimiter.

By the same token, the `genres` accessors allow genres to be set or retrieved as an Array:

```
    public function get genres():Array
    {
        // Genres are stored as a semicolon-separated String,
        // so they need to be transformed into an Array to pass them back out.
        return this._genres.split(";");
    }
    public function set genres(value:Array):void
    {
        // Genres are passed in as an array,
        // but stored as a semicolon-separated string.
        this._genres = value.join(";");
    }
```

The `genresset` accessor behaves exactly the same as the constructor; it accepts an Array and calls the `join()` method to convert it to a semicolon-separated String. The `get` accessor performs the opposite operation: the `_genres` variable's `split()` method is called, splitting the String into an array of values using the specified delimiter (the literal string value `";"` as before).

Chapter 4: Handling errors

Flash Player 9 and later, Adobe AIR 1.0 and later

To “handle” an error means that you build logic into your application to respond to, or fix, an error. Errors are generated either when an application is compiled or when a compiled application is running. When your application handles errors, *something* occurs as a response when the error is encountered, as opposed to no response (when whatever process created the error fails silently). Used correctly, error handling helps shield your application and its users from otherwise unexpected behavior.

However, error handling is a broad category that includes responding to many kinds of errors that are thrown during compilation or while an application is running. This discussion focuses on how to handle run-time errors (thrown while an application is running), the different types of errors that can be generated, and the advantages of the error-handling system in ActionScript 3.0.

Basics of error handling

Flash Player 9 and later, Adobe AIR 1.0 and later

A run-time error is something that goes wrong in your ActionScript code that stops the ActionScript content from running as intended. To ensure that your ActionScript code runs smoothly for users, write code in your application that handles the error—that fixes it, works around it, or at least lets the user know that it has happened. This process is called *error handling*.

Error handling is a broad category that includes responding to many kinds of errors that are thrown during compilation or while an application is running. Errors that happen at compile time are often easier to identify— fix them to complete the process of creating a SWF file.

Run-time errors can be more difficult to detect, because in order for them to occur the erroneous code must actually be run. If a segment of your program has several branches of code, like an `if..then..else` statement, test every possible condition, with all the possible input values that real users might use, to confirm that your code is error-free.

Run-time errors can be divided into two categories: *program errors* are mistakes in your ActionScript code, such as specifying the wrong data type for a method parameter; *logical errors* are mistakes in the logic (the data checking and value manipulation) of your program, such as using the wrong formula to calculate interest rates in a banking application. Again, both of these types of errors can often be detected and corrected ahead of time by diligently testing your application.

Ideally, you’ll want to identify and remove all errors from your application before it is released to end users. However, not all errors can be foreseen or prevented. For example, suppose your ActionScript application loads information from a particular website that is outside your control. If at some point that website isn’t available, the part of your application that depends on that external data won’t behave correctly. The most important aspect of error handling involves preparing for these unknown cases and handling them gracefully. Users need to continue to use your application, or at least get a friendly error message explaining why it isn’t working.

Run-time errors are represented in two ways in ActionScript:

- Error classes: Many errors have an error class associated with them. When an error occurs, the Flash runtime (such as Flash Player or Adobe AIR) creates an instance of the specific error class that is associated with that particular error. Your code can use the information contained in that error object to make an appropriate response to the error.
- Error events: Sometimes an error occurs when the Flash runtime would normally trigger an event. In those cases, an error event is triggered instead. Each error event has a class associated with it, and the Flash runtime passes an instance of that class to the methods that are subscribed to the error event.

To determine whether a particular method can trigger an error or error event, see the method's entry in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Important concepts and terms

The following reference list contains important terms for programming error handling routines:

Asynchronous A program command such as a method call that doesn't provide an immediate result; instead it gives a result (or error) in the form of an event.

Catch When an exception (a run-time error) occurs and your code becomes aware of the exception, that code is said to *catch* the exception. Once an exception is caught, the Flash runtime stops notifying other ActionScript code of the exception.

Debugger version A special version of the Flash runtime, such as the Flash Player dubugger version or the AIR Debug Launcher (ADL), that contains code for notifying users of run-time errors. In the standard version of Flash Player or Adobe AIR (the one that most users have), errors that aren't handled by your ActionScript code are ignored. In the debugger versions (which are included with Adobe Flash CS4 Professional and Adobe Flash Builder), a warning message appears when an unhandled error happens.

Exception An error that happens while an application is running and that the Flash runtime can't resolve on its own.

Re-throw When your code catches an exception, the Flash runtime no longer notifies other objects of the exception. If it's important for other objects to receive the exception, your code must *re-throw* the exception to start the notification process again.

Synchronous A program command, such as a method call, that provides an immediate result (or immediately throws an error), meaning that the response can be used within the same code block.

Throw The act of notifying a Flash runtime (and consequently, notifying other objects and ActionScript code) that an error has occurred is known as *throwing* an error.

Types of errors

Flash Player 9 and later, Adobe AIR 1.0 and later

When you develop and run applications, you encounter different types of errors and error terminology. The following list introduces the major error types and terms:

- *Compile-time errors* are raised by the ActionScript compiler during code compilation. Compile-time errors occur when syntactical problems in your code prevent your application from being built.

- *Run-time errors* occur when you run your application after you compile it. Run-time errors represent errors that are caused while a SWF file plays in a Flash runtime (such as Adobe Flash Player or Adobe AIR). In most cases, you handle run-time errors as they occur, reporting them to the user and taking steps to keep your application running. If the error is a fatal error, such as not being able to connect to a remote website or load required data, you can use error handling to allow your application to finish, gracefully.
- *Synchronous errors* are run-time errors that occur at the time a function is called—for example, when you try to use a specific method and the argument you pass to the method is invalid, so the Flash runtime throws an exception. Most errors occur synchronously—at the time the statement executes—and the flow of control passes immediately to the most applicable `catch` statement.

  For example, the following code excerpt throws a run-time error because the `browse()` method is not called before the program attempts to upload a file:

```
var fileRef:FileReference = new FileReference();
try
{
    fileRef.upload(new URLRequest("http://www.yourdomain.com/fileupload.cfm"));
}
catch (error:IllegalOperationError)
{
    trace(error);
    // Error #2037: Functions called in incorrect sequence, or earlier
    // call was unsuccessful.
}
```

  In this case, a run-time error is thrown synchronously because Flash Player determined that the `browse()` method was not called before the file upload was attempted.

  For detailed information on synchronous error handling, see "Handling synchronous errors in an application" on page 58.
- *Asynchronouserrors* are run-time errors that occur outside of the normal program flow. They generate events and event listeners catch them. An asynchronous operation is one in which a function initiates an operation, but doesn't wait for it to complete. You can create an error event listener to wait for the application or user to try some operation. If the operation fails, you catch the error with an event listener and respond to the error event. Then, the event listener calls an event handler function to respond to the error event in a useful manner. For example, the event handler could launch a dialog box that prompts the user to resolve the error.

  Consider the file-upload synchronous error example presented earlier. If you successfully call the `browse()` method before beginning a file upload, Flash Player would dispatch several events. For example, when an upload starts, the `open` event is dispatched. When the file upload operation completes successfully, the `complete` event is dispatched. Because event handling is asynchronous (that is, it does not occur at specific, known, predesignated times), use the `addEventListener()` method to listen for these specific events, as the following code shows:

```
var fileRef:FileReference = new FileReference();
fileRef.addEventListener(Event.SELECT, selectHandler);
fileRef.addEventListener(Event.OPEN, openHandler);
fileRef.addEventListener(Event.COMPLETE, completeHandler);
fileRef.browse();

function selectHandler(event:Event):void
{
    trace("...select...");
    var request:URLRequest = new URLRequest("http://www.yourdomain.com/fileupload.cfm");
    request.method = URLRequestMethod.POST;
    event.target.upload(request);
}
function openHandler(event:Event):void
{
    trace("...open...");
}
function completeHandler(event:Event):void
{
    trace("...complete...");
}
```

For detailed information on asynchronous error handling, see "Responding to error events and status" on page 63.

- *Uncaught exceptions* are errors thrown with no corresponding logic (like a `catch` statement) to respond to them. If your application throws an error, and no appropriate `catch` statement or event handler can be found at the current or higher level to handle the error, the error is considered an uncaught exception.

  When an uncaught error happens, the runtime dispatches an `uncaughtError` event. This event is also known as a "global error handler." This event is dispatched by the SWF's UncaughtErrorEvents object, which is available through the `LoaderInfo.uncaughtErrorEvents` property. If no listeners are registered for the `uncaughtError` event, the runtime ignores uncaught errors and tries to continue running, as long as the error doesn't stop the SWF.

  In addition to dispatching the `uncaughtError` event, debugger versions of the Flash runtime respond to uncaught errors by terminating the current script. Then, they display the uncaught error in `trace` statement output or writing the error message to a log file. If the exception object is an instance of the Error class or one of its subclasses, stack trace information is also displayed in the output. For more information about using the debugger version of Flash runtimes, see "Working with the debugger versions of Flash runtimes" on page 57.

  ***Note:** While processing an uncaughtError event, if an error event is thrown from an uncaughtError handler, the event handler is called multiple times. This results in an infinite loop of exceptions. It is recommended that you avoid such a scenario.*

Error handling in ActionScript 3.0

Flash Player 9 and later, Adobe AIR 1.0 and later

Since many applications can run without building the logic to handle errors, developers are tempted to postpone building error handling into their applications. However, without error handling, an application can easily stall or frustrate the user if something doesn't work as expected. ActionScript 2.0 has an Error class that allows you to build logic into custom functions to throw an exception with a specific message. Because error handling is critical for making a user-friendly application, ActionScript 3.0 includes an expanded architecture for catching errors.

***Note:** While the ActionScript 3.0 Reference for the Adobe Flash Platform documents the exceptions thrown by many methods, it might not include all possible exceptions for each method. A method might throw an exception for syntax errors or other problems that are not noted explicitly in the method description, even when the description does list some of the exceptions a method throws.*

ActionScript 3.0 error-handling elements

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 includes many tools for error handling, including:

- Error classes. ActionScript 3.0 includes a broad range of Error classes to expand the scope of situations that can produce error objects. Each Error class helps applications handle and respond to specific error conditions, whether they are related to system errors (like a MemoryError condition), coding errors (like an ArgumentError condition), networking and communication errors (like a URIError condition), or other situations. For more information on each class, see "Comparing the Error classes" on page 66.
- Fewer silent failures. In earlier versions of Flash Player, errors were generated and reported only if you explicitly used the `throw` statement. For Flash Player 9 and later Flash runtimes, native ActionScript methods and properties throw run-time errors. These errors allow you to handle these exceptions more effectively when they occur, then react to each exception, individually.
- Clear error messages displayed during debugging. When you are using the debugger version of a Flash runtime, problematic code or situations generate robust error messages, which help you easily identify reasons why a particular block of code fails. These messages make fixing errors more efficient. For more information, see "Working with the debugger versions of Flash runtimes" on page 57.
- Precise errors allow for clear error messages displayed to users. In previous versions of Flash Player, the `FileReference.upload()` method returned a Boolean value of `false` if the `upload()` call was unsuccessful, indicating one of five possible errors. If an error occurs when you call the `upload()` method in ActionScript 3.0, four specific errors help you display more accurate error messages to end users.
- Refined error handling. Distinct errors are thrown for many common situations. For example, in ActionScript 2.0, before a FileReference object has been populated, the `name` property has the value `null` (so, before you can use or display the `name` property, ensure that the value is set and not `null`). In ActionScript 3.0, if you attempt to access the `name` property before it has been populated, Flash Player or AIR throws an IllegalOperationError, which informs you that the value has not been set, and you can use `try..catch..finally` blocks to handle the error. For more information see "Using try..catch..finally statements" on page 58.
- No significant performance drawbacks. Using `try..catch..finally` blocks to handle errors takes little or no additional resources compared to previous versions of ActionScript.
- An ErrorEvent class that allows you to build listeners for specific asynchronous error events. For more information see "Responding to error events and status" on page 63.

Error-handling strategies

Flash Player 9 and later, Adobe AIR 1.0 and later

As long as your application doesn't encounter a problematic condition, it can still run successfully if you don't build error-handling logic into your code. However, if you don't actively handle errors and your application does encounter a problem, your users will never know why your application fails when it does.

There are different ways you can approach error handling in your application. The following list summarizes the three major options for handling errors:

- Use `try..catch..finally` statements. These statements catch synchronous errors as they occur. You can nest your statements into a hierarchy to catch exceptions at various levels of code execution. For more information, see "Using try..catch..finally statements" on page 58.
- Create your own custom error objects. You can use the Error class to create your own custom error objects to track specific operations in your application that are not covered by built-in error types. Then you can use `try..catch..finally` statements on your custom error objects. For more information see "Creating custom error classes" on page 62.
- Write event listeners and handlers to respond to error events. By using this strategy, you can create global error handlers that let you handle similar events without duplicating much code in `try..catch..finally` blocks. You are also more likely to catch asynchronous errors using this approach. For more information, see "Responding to error events and status" on page 63.

Working with the debugger versions of Flash runtimes

Flash Player 9 and later, Adobe AIR 1.0 and later

Adobe provides developers with special editions of the Flash runtimes to assist debugging efforts. You obtain a copy of the debugger version of Flash Player when you install Adobe Flash Professional or Adobe Flash Builder. You also obtain a utility for the debugging of Adobe AIR applications, which is called ADL, when you install either of those tools, or as part of the Adobe AIR SDK.

There is a notable difference in how the debugger versions and the release versions of Flash Player and Adobe AIR indicate errors. The debugger versions shows the error type (such as a generic Error, IOError, or EOFError), error number, and a human-readable error message. The release versions shows only the error type and error number. For example, consider the following code:

```
try
{
    tf.text = myByteArray.readBoolean();
}
catch (error:EOFError)
{
    tf.text = error.toString();
}
```

If the `readBoolean()` method throws an EOFError in the debugger version of Flash Player, the following message displays in the `tf` text field: "EOFError: Error #2030: End of file was encountered."

The same code in a release version of Flash Player or Adobe AIR would display the following text: "EOFError: Error #2030."

Note: *The debugger players broadcast an event named "allComplete"; avoid creating custom events with the name "allComplete". Otherwise, you will encounter unpredictable behavior when debugging.*

To keep resources and size to a minimum in the release versions, error message strings are not present. You can look up the error number in the documentation (the appendixes of the ActionScript 3.0 Reference for the Adobe Flash Platform) to correlate to an error message. Alternatively, you can reproduce the error using the debugger versions of Flash Player and AIR to see the full message.

Handling synchronous errors in an application

Flash Player 9 and later, Adobe AIR 1.0 and later

The most common error handling is synchronous error-handling logic, where you insert statements into your code to catch synchronous errors while an application is running. This type of error handling lets your application notice and recover from run-time errors when functions fail. The logic for catching a synchronous error includes `try..catch..finally` statements, which literally try an operation, catch any error response from the Flash runtime, and finally execute some other operation to handle the failed operation.

Using try..catch..finally statements

Flash Player 9 and later, Adobe AIR 1.0 and later

When you work with synchronous run-time errors, use the `try..catch..finally` statements to catch errors. When a run-time error occurs, the Flash runtime throws an exception, which means that it suspends normal execution and creates a special object of type Error. The Error object is then thrown to the first available `catch` block.

The `try` statement encloses statements that have the potential to create errors. You always use the `catch` statement with a `try` statement. If an error is detected in one of the statements in the `try` statement block, the `catch` statements that are attached to that `try` statement run.

The `finally` statement encloses statements that run whether an error occurs in the `try` block. If there is no error, the statements within the `finally` block execute after the `try` block statements complete. If there is an error, the appropriate `catch` statement executes first, followed by the statements in the `finally` block.

The following code demonstrates the syntax for using the `try..catch..finally` statements:

```
try
{
    // some code that could throw an error
}
catch (err:Error)
{
    // code to react to the error
}
finally
{
    // Code that runs whether an error was thrown. This code can clean
    // up after the error, or take steps to keep the application running.
}
```

Each `catch` statement identifies a specific type of exception that it handles. The `catch` statement can specify only error classes that are subclasses of the Error class. Each `catch` statement is checked in order. Only the first `catch` statement that matches the type of error thrown runs. In other words, if you first check the higher-level Error class and then a subclass of the Error class, only the higher-level Error class matches. The following code illustrates this point:

```
try
{
    throw new ArgumentError("I am an ArgumentError");
}
catch (error:Error)
{
    trace("<Error> " + error.message);
}
catch (error:ArgumentError)
{
    trace("<ArgumentError> " + error.message);
}
```

The previous code displays the following output:

```
<Error> I am an ArgumentError
```

To correctly catch the ArgumentError, make sure that the most specific error types are listed first and the more generic error types are listed later, as the following code shows:

```
try
{
    throw new ArgumentError("I am an ArgumentError");
}
catch (error:ArgumentError)
{
    trace("<ArgumentError> " + error.message);
}
catch (error:Error)
{
    trace("<Error> " + error.message);
}
```

Several methods and properties in the ActionScript API throw run-time errors if they encounter errors while they execute. For example, the `close()` method in the Sound class throws an IOError if the method is unable to close the audio stream, as demonstrated in the following code:

```
var mySound:Sound = new Sound();
try
{
    mySound.close();
}
catch (error:IOError)
{
    // Error #2029: This URLStream object does not have an open stream.
}
```

As you become more familiar with the ActionScript 3.0 Reference for the Adobe Flash Platform, you'll notice which methods throw exceptions, as detailed in each method's description.

The throw statement

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash runtimes throw exceptions when they encounter errors in your running application. In addition, you can explicitly throw exceptions yourself using the `throw` statement. When explicitly throwing errors, Adobe recommends that you throw instances of the Error class or its subclasses. The following code demonstrates a `throw` statement that throws an instance of the Error class, `MyErr`, and eventually calls a function, `myFunction()`, to respond after the error is thrown:

```
var MyError:Error = new Error("Encountered an error with the numUsers value", 99);
var numUsers:uint = 0;
try
{
    if (numUsers == 0)
    {
        trace("numUsers equals 0");
    }
}
catch (error:uint)
{
    throw MyError; // Catch unsigned integer errors.
}
catch (error:int)
{
    throw MyError; // Catch integer errors.
}
catch (error:Number)
{
    throw MyError; // Catch number errors.
}
catch (error:*)
{
    throw MyError; // Catch any other error.
}
finally
{
    myFunction(); // Perform any necessary cleanup here.
}
```

Notice that the `catch` statements are ordered so that the most specific data types are listed first. If the `catch` statement for the Number data type is listed first, neither the catch statement for the uint data type nor the catch statement for the int data type is ever run.

***Note:** In the Java programming language, each function that can throw an exception must declare this fact, listing the exception classes it can throw in a `throws` clause attached to the function declaration. ActionScript does not require you to declare the exceptions thrown by a function.*

Displaying a simple error message

Flash Player 9 and later, Adobe AIR 1.0 and later

One of the biggest benefits of the new exception and error event model is that it allows you to tell users when and why an action has failed. Your part is to write the code to display the message and offer options in response.

The following code shows a simple `try..catch` statement to display the error in a text field:

```
package
{
    import flash.display.Sprite;
    import flash.text.TextField;

    public class SimpleError extends Sprite
    {
        public var employee:XML =
            <EmpCode>
                <costCenter>1234</costCenter>
                <costCenter>1-234</costCenter>
            </EmpCode>;

        public function SimpleError()
        {
            try
            {
                if (employee.costCenter.length() != 1)
                {
                    throw new Error("Error, employee must have exactly one cost center assigned.");
                }
            }
            catch (error:Error)
            {
                var errorMessage:TextField = new TextField();
                errorMessage.autoSize = TextFieldAutoSize.LEFT;
                errorMessage.textColor = 0xFF0000;
                errorMessage.text = error.message;
                addChild(errorMessage);
            }
        }
    }
}
```

Using a wider range of error classes and built-in compiler errors, ActionScript 3.0 offers more information than previous versions of ActionScript about why something has failed. This information enables you to build more stable applications with better error handling.

Rethrowing errors

Flash Player 9 and later, Adobe AIR 1.0 and later

When you build applications, there are several occasions in which you need to rethrow an error if you are unable to handle the error properly. For example, the following code shows a nested `try..catch` block, which rethrows a custom ApplicationError if the nested `catch` block is unable to handle the error:

```
try
{
    try
    {
        trace("<< try >>");
        throw new ApplicationError("some error which will be rethrown");
    }
    catch (error:ApplicationError)
    {
        trace("<< catch >> " + error);
        trace("<< throw >>");
        throw error;
    }
    catch (error:Error)
    {
        trace("<< Error >> " + error);
    }
}
catch (error:ApplicationError)
{
    trace("<< catch >> " + error);
}
```

The output from the previous snippet would be the following:

```
<< try >>
<< catch >> ApplicationError: some error which will be rethrown
<< throw >>
<< catch >> ApplicationError: some error which will be rethrown
```

The nested `try` block throws a custom ApplicationError error that is caught by the subsequent `catch` block. This nested `catch` block can try to handle the error, and if unsuccessful, throw the ApplicationError object to the enclosing `try..catch` block.

Creating custom error classes

Flash Player 9 and later, Adobe AIR 1.0 and later

You can extend one of the standard Error classes to create your own specialized error classes in ActionScript. There are a number of reasons to create your own error classes:

- To identify specific errors or groups of errors that are unique to your application.

  For example, take different actions for errors thrown by your own code, in addition to those errors trapped by a Flash runtime. You can create a subclass of the Error class to track the new error data type in `try..catch` blocks.

- To provide unique error display capabilities for errors generated by your application.

  For example, you can create a new `toString()` method that formats your error messages in a certain way. You can also define a `lookupErrorString()` method that takes an error code and retrieves the proper message based on the user's language preference.

A specialized error class must extend the core ActionScript Error class. Here is an example of a specialized AppError class that extends the Error class:

```
public class AppError extends Error
{
    public function AppError(message:String, errorID:int)
    {
        super(message, errorID);
    }
}
```

The following shows an example of using AppError in your project:

```
try
{
    throw new AppError("Encountered Custom AppError", 29);
}
catch (error:AppError)
{
    trace(error.errorID + ": " + error.message)
}
```

***Note:** If you want to override the `Error.toString()` method in your subclass, give it one `...`(rest) parameter. The ECMAScript language specification on which ActionScript 3.0 is based defines the `Error.toString()` method that way, and ActionScript 3.0 defines it the same way for backward compatibility. Therefore, when you override the `Error.toString()` method, match the parameters exactly. You do not want to pass any parameters to your `toString()` method at runtime, because those parameters are ignored.*

Responding to error events and status

Flash Player 9 and later, Adobe AIR 1.0 and later

One of the most noticeable improvements to error handling in ActionScript 3.0 is the support for error event handling for responding to asynchronous errors while an application is running. (For a definition of asynchronous errors, see "Types of errors" on page 53.)

You can create event listeners and event handlers to respond to the error events. Many classes dispatch error events the same way they dispatch other events. For example, an instance of the XMLSocket class normally dispatches three types of events: `Event.CLOSE`, `Event.CONNECT`, and `DataEvent.DATA`. However, when a problem occurs, the XMLSocket class can dispatch the `IOErrorEvent.IOError` or the `SecurityErrorEvent.SECURITY_ERROR`. For more information about event listeners and event handlers, see "Handling events" on page 125.

Error events fit into one of two categories:

- Error events that extend the ErrorEvent class

  The flash.events.ErrorEvent class contains the properties and methods for managing errors related to networking and communication operations in a running application. The AsyncErrorEvent, IOErrorEvent, and SecurityErrorEvent classes extend the ErrorEvent class. If you're using the debugger version of a Flash runtime, a dialog box informs you at run-time of any error events without listener functions that the player encounters.

- Status-based error events

  The status-based error events are related to the `netStatus` and `status` properties of the networking and communication classes. If a Flash runtime encounters a problem when reading or writing data, the value of the `netStatus.info.level` or `status.level` properties (depending on the class object you're using) is set to the value `"error"`. You respond to this error by checking if the `level` property contains the value `"error"` in your event handler function.

Working with error events

Flash Player 9 and later, Adobe AIR 1.0 and later

The ErrorEvent class and its subclasses contain error types for handling errors dispatched by Flash runtimes as they try to read or write data.

The following example uses both a `try..catch` statement and error event handlers to display any errors detected while trying to read a local file. You can add more sophisticated handling code to provide a user with options or otherwise handle the error automatically in the places indicated by the comment "your error-handling code here":

```
package
{
    import flash.display.Sprite;
    import flash.errors.IOError;
    import flash.events.IOErrorEvent;
    import flash.events.TextEvent;
    import flash.media.Sound;
    import flash.media.SoundChannel;
    import flash.net.URLRequest;
    import flash.text.TextField;
    import flash.text.TextFieldAutoSize;

    public class LinkEventExample extends Sprite
    {
        private var myMP3:Sound;
        public function LinkEventExample()
        {
            myMP3 = new Sound();
            var list:TextField = new TextField();
            list.autoSize = TextFieldAutoSize.LEFT;
            list.multiline = true;
            list.htmlText = "<a href=\"event:track1.mp3\">Track 1</a><br>";
            list.htmlText += "<a href=\"event:track2.mp3\">Track 2</a><br>";
            addEventListener(TextEvent.LINK, linkHandler);
            addChild(list);
        }

        private function playMP3(mp3:String):void
        {
            try
            {
                myMP3.load(new URLRequest(mp3));
                myMP3.play();
            }
            catch (err:Error)
            {
                trace(err.message);
                // your error-handling code here
            }
            myMP3.addEventListener(IOErrorEvent.IO_ERROR, errorHandler);
        }

        private function linkHandler(linkEvent:TextEvent):void
        {
            playMP3(linkEvent.text);
            // your error-handling code here
        }

        private function errorHandler(errorEvent:IOErrorEvent):void
        {
            trace(errorEvent.text);
            // your error-handling code here
        }
    }
}
```

Working with status change events

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash runtimes dynamically change the value of the `netStatus.info.level` or `status.level` properties for the classes that support the `level` property while an application is running. The classes that have the `netStatus.info.level` property are NetConnection, NetStream, and SharedObject. The classes that have the `status.level` property are HTTPStatusEvent, Camera, Microphone, and LocalConnection. You can write a handler function to respond to the change in `level` value and track communication errors.

The following example uses a `netStatusHandler()` function to test the value of the `level` property. If the `level` property indicates that an error has been encountered, the code traces the message “Video stream failed”.

```
package
{
    import flash.display.Sprite;
    import flash.events.NetStatusEvent;
    import flash.events.SecurityErrorEvent;
    import flash.media.Video;
    import flash.net.NetConnection;
    import flash.net.NetStream;

    public class VideoExample extends Sprite
    {
        private var videoUrl:String = "Video.flv";
        private var connection:NetConnection;
        private var stream:NetStream;

        public function VideoExample()
        {
            connection = new NetConnection();
            connection.addEventListener(NetStatusEvent.NET_STATUS, netStatusHandler);
            connection.addEventListener(SecurityErrorEvent.SECURITY_ERROR, securityErrorHandler);
            connection.connect(null);
        }
        private function netStatusHandler(event:NetStatusEvent):void
        {
            if (event.info.level == "error")
            {
                trace("Video stream failed")
            }
            else
            {
                connectStream();
            }
        }

        private function securityErrorHandler(event:SecurityErrorEvent):void
        {
            trace("securityErrorHandler: " + event);
        }

        private function connectStream():void
        {
            var stream:NetStream = new NetStream(connection);
            var video:Video = new Video();
            video.attachNetStream(stream);
            stream.play(videoUrl);
            addChild(video);
        }
    }
}
```

Comparing the Error classes

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript provides a number of predefined Error classes. But, you can also use the same Error classes in your own code. There are two main types of Error classes in ActionScript 3.0: ActionScript core Error classes and flash.error package Error classes. The flash.error package contains additional classes to aid ActionScript 3.0 application development and debugging.

Core Error classes

Flash Player 9 and later, Adobe AIR 1.0 and later

The core error classes include the Error, ArgumentError, EvalError, RangeError, ReferenceError, SecurityError, SyntaxError, TypeError, URIError, and VerifyError classes. Each of these classes are located in the top-level namespace.

Class name	**Description**	**Notes**
Error	The Error class is for throwing exceptions, and is the base class for the other exception classes defined in ECMAScript: EvalError, RangeError, ReferenceError, SyntaxError, TypeError, and URIError.	The Error class serves as the base class for all run-time errors, and is the recommended base class for any custom error classes.
ArgumentError	The ArgumentError class represents an error that occurs when the parameter values supplied during a function call do not match the parameters defined for that function.	Some examples of argument errors include the following: • Too few or too many arguments are supplied to a method. • An argument was expected to be a member of an enumeration and was not.
EvalError	An EvalError exception is thrown if any parameters are passed to the Function class's constructor or if user code calls the `eval()` function.	In ActionScript 3.0, support for the `eval()` function has been removed and attempts to use the function result in an error. Earlier versions of Flash Player used the `eval()` function to access variables, properties, objects, or movie clips by name.
RangeError	A RangeError exception is thrown if a numeric value falls outside an acceptable range.	For example, a RangeError is thrown by the Timer class if a delay was either negative or was not finite. A RangeError could also be thrown if you attempted to add a display object at an invalid depth.
ReferenceError	A ReferenceError exception is thrown when a reference to an undefined property is attempted on a sealed (nondynamic) object. Versions of the ActionScript compiler before ActionScript 3.0 did not throw an error when access was attempted to a property that was `undefined`. However ActionScript 3.0 throws the ReferenceError exception in this condition.	Exceptions for undefined variables point to potential bugs, helping you improve software quality. However, if you are not used to having to initialize your variables, this new ActionScript behavior requires some changes in your coding habits.
SecurityError	The SecurityError exception is thrown when a security violation takes place and access is denied.	Some examples of security errors include the following: • An unauthorized property access or method call is made across a security sandbox boundary. • An attempt was made to access a URL not permitted by the security sandbox. • A socket connection was attempted to a port but the necessary socket policy file wasn't present. • An attempt was made to access the user's camera or microphone, and the user denide the access to the device .
SyntaxError	A SyntaxError exception is thrown when a parsing error occurs in your ActionScript code.	A SyntaxError can be thrown under the following circumstances: • ActionScript throws SyntaxError exceptions when the RegExp class parses an invalid regular expression. • ActionScript throws SyntaxError exceptions when the XMLDocument class parses invalid XML.

Class name	**Description**	**Notes**
TypeError	The TypeError exception is thrown when the actual type of an operand is different from the expected type.	A TypeError can be thrown under the following circumstances: • An actual parameter of a function or method could not be coerced to the formal parameter type. • A value is assigned to a variable and cannot be coerced to the variable's type. • The right side of the `is` or `instanceof` operator is not a valid type. • The `super` keyword is used illegally. • A property lookup results in more than one binding, and is therefore ambiguous. • A method is called on an incompatible object. For example, a TypeError exception is thrown if a method in the RegExp class is "grafted" onto a generic object and then called.
URIError	The URIError exception is thrown when one of the global URI handling functions is used in a way that is incompatible with its definition.	A URIError can be thrown under the following circumstances: An invalid URI is specified for a Flash Player API function that expects a valid URI, such as `Socket.connect()`.
VerifyError	A VerifyError exception is thrown when a malformed or corrupted SWF file is encountered.	When a SWF file loads another SWF file, the parent SWF file can catch a VerifyError generated by the loaded SWF file.

flash.error package Error classes

Flash Player 9 and later, Adobe AIR 1.0 and later

The flash.error package contains Error classes that are considered part of the Flash runtime API. In contrast to the Error classes described, the flash.error package communicates errors events that are specific to Flash runtimes (such as Flash Player and Adobe AIR).

Class name	**Description**	**Notes**
EOFError	An EOFError exception is thrown when you attempt to read past the end of the available data.	For example, an EOFError is thrown when one of the read methods in the IDataInput interface is called and there is insufficient data to satisfy the read request.
IllegalOperationError	An IllegalOperationError exception is thrown when a method is not implemented or the implementation doesn't cover the current usage.	Examples of illegal operation error exceptions include the following: • A base class, such as DisplayObjectContainer, provides more functionality than the Stage can support. For example, if you attempt to get or set a mask on the Stage (using `stage.mask`), the Flash runtime throws an IllegalOperationError with the message "The Stage class does not implement this property or method." • A subclass inherits a method it does not require and does not want to support. • Certain accessibility methods are called when Flash Player is compiled without accessibility support. • Authoring-only features are called from a run-time version of Flash Player. • You attempt to set the name of an object placed on the timeline.
IOError	An IOError exception is thrown when some type of I/O exception occurs.	You get this error, for example, when a read-write operation is attempted on a socket that is not connected or that has become disconnected.
MemoryError	A MemoryError exception is thrown when a memory allocation request fails.	By default, ActionScript Virtual Machine 2 does not impose a limit on how much memory an ActionScript program allocates. On a desktop system, memory allocation failures are infrequent. You see an error thrown when the system is unable to allocate the memory required for an operation. So, on a desktop system, this exception is rare unless an allocation request is extremely large; for example, a request for 3 billion bytes is impossible because a 32-bit Microsoft® Windows® program can access only 2 GB of address space.
ScriptTimeoutError	A ScriptTimeoutError exception is thrown when a script timeout interval of 15 seconds is reached. By catching a ScriptTimeoutError exception, you can handle the script timeout more gracefully. If there is no exception handler, the uncaught exception handler displays a dialog box with an error message.	To prevent a malicious developer from catching the exception and staying in an infinite loop, only the first ScriptTimeoutError exception thrown in the course of a particular script can be caught. A subsequent ScriptTimeoutError exception cannot be caught by your code and immediately goes to the uncaught exception handler.
StackOverflowError	The StackOverflowError exception is thrown when the stack available to the script has been exhausted.	A StackOverflowError exception might indicate that infinite recursion has occurred.

Handling errors example: CustomErrors application

Flash Player 9 and later, Adobe AIR 1.0 and later

The CustomErrors application demonstrates techniques for working with custom errors when building an application. These techniques are:

- Validating an XML packet
- Writing a custom error
- Throwing custom errors
- Notifying users when an error is thrown

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The CustomErrors application files can be found in the Samples/CustomError folder. The application consists of the following files:

File	Description
CustomErrors.mxml or CustomErrors.fla	The main application file in Flash (FLA) or Flex (MXML)
com/example/programmingas3/errors/ApplicationError.as	A class that serves as the base error class for both the FatalError and WarningError classes.
com/example/programmingas3/errors/FatalError.as	A class that defines a FatalError errorthrown by the application. This class extends the custom ApplicationError class.
com/example/programmingas3/errors/Validator.as	A class that defines a single method that validates a user-supplied employee XML packet.
com/example/programmingas3/errors/WarningError.as	A class that defines a WarningError error thrown by the application. This class extends the custom ApplicationError class.

CustomErrors application overview

Flash Player 9 and later, Adobe AIR 1.0 and later

When the application loads, the `initApp()` method is called for Flex applications or the timeline (non-function) code is executed for Flash Professional applications. This code defines a sample XML packet to be verified by the Validator class. The following code is run:

```
employeeXML = 
    <employee id="12345">
        <firstName>John</firstName>
        <lastName>Doe</lastName>
        <costCenter>12345</costCenter>
        <costCenter>67890</costCenter>
    </employee>;
}
```

The XML packet is later displayed in a TextArea component instance on the Stage. This step allows you to modify the XML packet before attempting to revalidate it.

When the user clicks the Validate button, the `validateData()` method is called. This method validates the employee XML packet using the `validateEmployeeXML()` method in the Validator class. The following code shows the `validateData()` method:

```
function validateData():void
{
    try
    {
        var tempXML:XML = XML(xmlText.text);
        Validator.validateEmployeeXML(tempXML);
        status.text = "The XML was successfully validated.";
    }
    catch (error:FatalError)
    {
        showFatalError(error);
    }
    catch (error:WarningError)
    {
        showWarningError(error);
    }
    catch (error:Error)
    {
        showGenericError(error);
    }
}
```

First, a temporary XML object is created using the contents of the TextArea component instance `xmlText`. Next, the `validateEmployeeXML()` method in the custom Validator class (com.example.programmingas3/errors/Validator.as) is called and passes the temporary XML object as a parameter. If the XML packet is valid, the `status` Label component instance displays a success message and the application exits. If the `validateEmployeeXML()` method throws a custom error (that is, a FatalError, WarningError, or a generic Error occurs), the appropriate `catch` statement executes and calls either the `showFatalError()`, `showWarningError()`, or `showGenericError()` methods. Each of these methods displays an appropriate message in a text area named `statusText` to notify the user of the specific error that occurred. Each method also updates the `status` Label component instance with a specific message.

If a fatal error occurs during an attempt to validate the employee XML packet, the error message is displayed in the `statusText` text area, and the `xmlText` TextArea component instance and `validateBtn` Button component instance are disabled, as the following code shows:

```
function showFatalError(error:FatalError):void
{
    var message:String = error.message + "\n\n";
    var title:String = error.getTitle();
    statusText.text = message + " " + title + "\n\nThis application has ended.";
    this.xmlText.enabled = false;
    this.validateBtn.enabled = false;
    hideButtons();
}
```

If a warning error instead of a fatal error occurs, the error message is displayed in the `statusText` TextArea instance, but the `xmlText` TextField and Button component instances aren't disabled. The `showWarningError()` method displays the custom error message in the `statusText` text area. The message also asks the user to decide if they want to proceed with validating the XML or cancel the script. The following excerpt shows the `showWarningError()` method:

```
function showWarningError(error:WarningError):void
{
    var message:String = error.message + "\n\n" + "Do you want to exit this application?";
    showButtons();
    var title:String = error.getTitle();
    statusText.text = message;
}
```

When the user clicks either the Yes or No button, the `closeHandler()` method is called. The following excerpt shows the `closeHandler()` method:

```
function closeHandler(event:CloseEvent):void
{
    switch (event.detail)
    {
        case yesButton:
            showFatalError(new FatalError(9999));
            break;
        case noButton:
            statusText.text = "";
            hideButtons();
            break;
    }
}
```

If the user chooses to cancel the script by clicking Yes, a FatalError is thrown, causing the application to terminate.

Building a custom validator

Flash Player 9 and later, Adobe AIR 1.0 and later

The custom Validator class contains a single method, `validateEmployeeXML()`. The `validateEmployeeXML()` method takes a single argument, `employee`, which is the XML packet that you want to validate. The `validateEmployeeXML()` method is as follows:

```
public static function validateEmployeeXML(employee:XML):void
{
    // checks for the integrity of items in the XML
    if (employee.costCenter.length() < 1)
    {
        throw new FatalError(9000);
    }
    if (employee.costCenter.length() > 1)
    {
        throw new WarningError(9001);
    }
    if (employee.ssn.length() != 1)
    {
        throw new FatalError(9002);
    }
}
```

To be validated, an employee must belong to one (and only one) cost center. If the employee doesn't belong to any cost centers, the method throws a FatalError, which bubbles up to the `validateData()` method in the main application file. If the employee belongs to more than one cost center, a WarningError is thrown. The final check in the XML validator is that the user has exactly one social security number defined (the `ssn` node in the XML packet). If there is not exactly one `ssn` node, a FatalError error is thrown.

You can add additional checks to the `validateEmployeeXML()` method—for example, to ensure that the `ssn` node contains a valid number, or that the employee has at least one phone number and e-mail address defined, and that both values are valid. You can also modify the XML so that each employee has a unique ID and specifies the ID of their manager.

Defining the ApplicationError class

Flash Player 9 and later, Adobe AIR 1.0 and later

The ApplicationError class serves as the base class for both the FatalError and WarningError classes. The ApplicationError class extends the Error class, and defines its own custom methods and properties, including defining an error ID, severity, and an XML object that contains the custom error codes and messages. This class also defines two static constants that are used to define the severity of each error type.

The ApplicationError class's constructor method is as follows:

```
public function ApplicationError()
{
    messages =
        <errors>
            <error code="9000">
                <![CDATA[Employee must be assigned to a cost center.]]>
            </error>
            <error code="9001">
                <![CDATA[Employee must be assigned to only one cost center.]]>
            </error>
            <error code="9002">
                <![CDATA[Employee must have one and only one SSN.]]>
            </error>
            <error code="9999">
                <![CDATA[The application has been stopped.]]>
            </error>
        </errors>;
}
```

Each error node in the XML object contains a unique numeric code and an error message. Error messages can be easily looked up by their error code using E4X, as seen in the following `getMessageText()` method:

```
public function getMessageText(id:int):String
{
    var message:XMLList = messages.error.(@code == id);
    return message[0].text();
}
```

The `getMessageText()` method takes a single integer argument, `id`, and returns a string. The `id` argument is the error code for the error to look up. For example, passing an `id` of 9001 retrieves the error saying that employees must be assigned to only one cost center. If more than one error has the same error code, ActionScript returns the error message only for the first result found (`message[0]` in the returned XMLList object).

The next method in this class, `getTitle()`, doesn't take any parameters and returns a string value that contains the error ID for this specific error. This value is used to help you easily identify the exact error that occurred during validation of the XML packet. The following excerpt shows the `getTitle()` method:

```
public function getTitle():String
{
    return "Error #" + id;
}
```

The final method in the ApplicationError class is `toString()`. This method overrides the function defined in the Error class so that you can customize the presentation of the error message. The method returns a string that identifies the specific error number and message that occurred.

```
public override function toString():String
{
    return "[APPLICATION ERROR #" + id + "] " + message;
}
```

Defining the FatalError class

Flash Player 9 and later, Adobe AIR 1.0 and later

The FatalError class extends the custom ApplicationError class and defines three methods: the FatalError constructor, `getTitle()`, and `toString()`. The first method, the FatalError constructor, takes a single integer argument, `errorID`, and sets the error's severity using the static constant values defined in the ApplicationError class, and gets the specific error's error message by calling the `getMessageText()` method in the ApplicationError class. The FatalError constructor is as follows:

```
public function FatalError(errorID:int)
{
    id = errorID;
    severity = ApplicationError.FATAL;
    message = getMessageText(errorID);
}
```

The next method in the FatalError class, `getTitle()`, overrides the `getTitle()` method defined earlier in the ApplicationError class, and appends the text "-- FATAL" in the title to inform the user that a fatal error has occurred. The `getTitle()` method is as follows:

```
public override function getTitle():String
{
    return "Error #" + id + " -- FATAL";
}
```

The final method in this class, `toString()`, overrides the `toString()` method defined in the ApplicationError class. The `toString()` method is

```
public override function toString():String
{
    return "[FATAL ERROR #" + id + "] " + message;
}
```

Defining the WarningError class

Flash Player 9 and later, Adobe AIR 1.0 and later

The WarningError class extends the ApplicationError class and is nearly identical to the FatalError class, except for a couple minor string changes and sets the error severity to ApplicationError.WARNING instead of ApplicationError.FATAL, as seen in the following code:

```
public function WarningError(errorID:int)
{
    id = errorID;
    severity = ApplicationError.WARNING;
    message = super.getMessageText(errorID);
}
```

Chapter 5: Using regular expressions

Flash Player 9 and later, Adobe AIR 1.0 and later

A regular expression describes a pattern that is used to find and manipulate matching text in strings. Regular expressions resemble strings, but they can include special codes to describe patterns and repetition. For example, the following regular expression matches a string that starts with the character A followed by one or more sequential digits:

```
/A\d+/
```

The following topics describe the basic syntax for constructing regular expressions. However, regular expressions can have many complexities and nuances. You can find detailed resources on regular expressions on the web and in bookstores. Keep in mind that different programming environments implement regular expressions in different ways. ActionScript 3.0 implements regular expressions as defined in the ECMAScript edition 3 language specification (ECMA-262).

More Help topics

RegExp

Basics of regular expressions

Flash Player 9 and later, Adobe AIR 1.0 and later

A regular expression describes a pattern of characters. Regular expressions are typically used to verify that a text value conforms to a particular pattern (such as verifying that a user-entered phone number has the proper number of digits) or to replace portions of a text value that matches a particular pattern.

Regular expressions can be simple. For example, suppose you wanted to confirm that a particular string matches "ABC," or wanted to replace every occurrence of "ABC" in a string with some other text. In that case, you could use the following regular expression, which defines the pattern consisting of the letters A, B, and C in sequence:

```
/ABC/
```

Note that the regular expression literal is delineated with the forward slash (`/`) character.

Regular expression patterns can also be complex, and sometimes cryptic in appearance, such as the following expression to match a valid e-mail address:

```
/([0-9a-zA-Z]+[-._+&])*[0-9a-zA-Z]+@([-0-9a-zA-Z]+[.])+[a-zA-Z]{2,6}/
```

Most commonly you will use regular expressions to search for patterns in strings and to replace characters. In those cases, you will create a regular expression object and use it as a parameter for one of several String class methods. The following methods of the String class take regular expressions as parameters: `match()`, `replace()`, `search()`, and `split()`. For more information on these methods, see "Finding patterns in strings and replacing substrings" on page 16.

The RegExp class includes the following methods: `test()` and `exec()`. For more information, see "Methods for using regular expressions with strings" on page 90.

Important concepts and terms

The following reference list contains important terms that are relevant to this feature:

Escape character A character indicating that the character that follows should be treated as a metacharacter rather than a literal character. In regular expression syntax, the backslash character (\) is the escape character, so a backslash followed by another character is a special code rather than just the character itself.

Flag A character that specifies some option about how the regular expression pattern should be used, such as whether to distinguish between uppercase and lowercase characters.

Metacharacter A character that has special meaning in a regular expression pattern, as opposed to literally representing that character in the pattern.

Quantifier A character (or several characters) indicating how many times a part of the pattern should repeat. For example, a quantifier would be used to designate that a United States postal code should contain five or nine numbers.

Regular expression A program statement defining a pattern of characters that can be used to confirm whether other strings match that pattern or to replace portions of a string.

Regular expression syntax

Flash Player 9 and later, Adobe AIR 1.0 and later

This section describes all of the elements of ActionScript regular expression syntax. As you'll see, regular expressions can have many complexities and nuances. You can find detailed resources on regular expressions on the web and in bookstores. Keep in mind that different programming environments implement regular expressions in different ways. ActionScript 3.0 implements regular expressions as defined in the ECMAScript edition 3 language specification (ECMA-262).

Generally, you use regular expressions that match more complicated patterns than a simple string of characters. For example, the following regular expression defines the pattern consisting of the letters A, B, and C in sequence followed by any digit:

```
/ABC\d/
```

The `\d` code represents "any digit." The backslash (`\`) character is called the escape character, and combined with the character that follows it (in this case the letter d), it has special meaning in the regular expression.

The following regular expression defines the pattern of the letters ABC followed by any number of digits (note the asterisk):

```
/ABC\d*/
```

The asterisk character (`*`) is a *metacharacter*. A metacharacter is a character that has special meaning in regular expressions. The asterisk is a specific type of metacharacter called a *quantifier,* which is used to quantify the amount of repetition of a character or group of characters. For more information, see "Quantifiers" on page 82.

In addition to its pattern, a regular expression can contain flags, which specify how the regular expression is to be matched. For example, the following regular expression uses the `i` flag, which specifies that the regular expression ignores case sensitivity in matching strings:

```
/ABC\d*/i
```

For more information, see "Flags and properties" on page 87.

You can use regular expressions with the following methods of the String class: `match()`, `replace()`, and `search()`. For more information on these methods, see "Finding patterns in strings and replacing substrings" on page 16.

Creating an instance of a regular expression

Flash Player 9 and later, Adobe AIR 1.0 and later

There are two ways to create a regular expression instance. One way uses forward slash characters (`/`) to delineate the regular expression; the other uses the `new` constructor. For example, the following regular expressions are equivalent:

```
var pattern1:RegExp = /bob/i;
var pattern2:RegExp = new RegExp("bob", "i");
```

Forward slashes delineate a regular expression literal in the same way as quotation marks delineate a string literal. The part of the regular expression within the forward slashes defines the *pattern*. The regular expression can also include *flags* after the final delineating slash. These flags are considered to be part of the regular expression, but they are separate from its pattern.

When using the `new` constructor, you use two strings to define the regular expression. The first string defines the pattern, and the second string defines the flags, as in the following example:

```
var pattern2:RegExp = new RegExp("bob", "i");
```

When including a forward slash *within* a regular expression that is defined by using the forward slash delineators, you must precede the forward slash with the backslash (`\`) escape character. For example, the following regular expression matches the pattern `1/2`:

```
var pattern:RegExp = /1\/2/;
```

To include quotation marks *within* a regular expression that is defined with the `new` constructor, you must add backslash (`\`) escape character before the quotation marks (just as you would when defining any String literal). For example, the following regular expressions match the pattern `eat at "joe's"`:

```
var pattern1:RegExp = new RegExp("eat at \"joe's\"", "");
var pattern2:RegExp = new RegExp('eat at "joe\'s"', "");
```

Do not use the backslash escape character with quotation marks in regular expressions that are defined by using the forward slash delineators. Similarly, do not use the escape character with forward slashes in regular expressions that are defined with the `new` constructor. The following regular expressions are equivalent, and they define the pattern `1/2 "joe's"`:

```
var pattern1:RegExp = /1\/2 "joe's"/;
var pattern2:RegExp = new RegExp("1/2 \"joe's\"", "");
var pattern3:RegExp = new RegExp('1/2 "joe\'s"', '');
```

Also, in a regular expression that is defined with the `new` constructor, to use a metasequence that begins with the backslash (`\`) character, such as `\d` (which matches any digit), type the backslash character twice:

```
var pattern:RegExp = new RegExp("\\d+", ""); // matches one or more digits
```

You must type the backlash character twice in this case, because the first parameter of the `RegExp()` constructor method is a string, and in a string literal you must type a backslash character twice to have it recognized as a single backslash character.

The sections that follow describe syntax for defining regular expression patterns.

For more information on flags, see "Flags and properties" on page 87.

Characters, metacharacters, and metasequences

Flash Player 9 and later, Adobe AIR 1.0 and later

The simplest regular expression is one that matches a sequence of characters, as in the following example:

```
var pattern:RegExp = /hello/;
```

However, the following characters, known as metacharacters, have special meanings in regular expressions:

```
^ $ \ . * + ? ( ) [ ] { } |
```

For example, the following regular expression matches the letter A followed by zero or more instances of the letter B (the asterisk metacharacter indicates this repetition), followed by the letter C:

```
/AB*C/
```

To include a metacharacter without its special meaning in a regular expression pattern, you must use the backslash (\) escape character. For example, the following regular expression matches the letter A followed by the letter B, followed by an asterisk, followed by the letter C:

```
var pattern:RegExp = /AB\*C/;
```

A *metasequence*, like a metacharacter, has special meaning in a regular expression. A metasequence is made up of more than one character. The following sections provide details on using metacharacters and metasequences.

About metacharacters

The following table summarizes the metacharacters that you can use in regular expressions:

Metacharacter	Description
`^` (caret)	Matches at the start of the string. With the `m` (`multiline`) flag set, the caret matches the start of a line as well (see "Flags and properties" on page 87). Note that when used at the start of a character class, the caret indicates negation, not the start of a string. For more information, see "Character classes" on page 81.
`$`(dollar sign)	Matches at the end of the string. With the `m` (`multiline`) flag set, `$` matches the position before a newline (`\n`) character as well. For more information, see "Flags and properties" on page 87.
`\` (backslash)	Escapes the special metacharacter meaning of special characters. Also, use the backslash character if you want to use a forward slash character in a regular expression literal, as in `/1\/2/` (to match the character 1, followed by the forward slash character, followed by the character 2).
`.` (dot)	Matches any single character. A dot matches a newline character (`\n`) only if the `s` (`dotall`) flag is set. For more information, see "Flags and properties" on page 87.
`*` (star)	Matches the previous item repeated zero or more times. For more information, see "Quantifiers" on page 82.
`+` (plus)	Matches the previous item repeated one or more times. For more information, see "Quantifiers" on page 82.
`?` (question mark)	Matches the previous item repeated zero times or one time. For more information, see "Quantifiers" on page 82.

Metacharacter	Description
`(` and `)`	Defines groups within the regular expression. Use groups for the following: • To confine the scope of the | alternator: `/(a|b|c)d/` • To define the scope of a quantifier: `/(walla.){1,2}/` • In backreferences. For example, the `\1` in the following regular expression matches whatever matched the first parenthetical group of the pattern: • `/(\w*) is repeated: \1/` For more information, see "Groups" on page 84.
`[` and `]`	Defines a character class, which defines possible matches for a single character: `/[aeiou]/` matches any one of the specified characters. Within character classes, use the hyphen (`-`) to designate a range of characters: `/[A-Z0-9]/` matches uppercase A through Z or 0 through 9. Within character classes, insert a backslash to escape the] and - characters: `/[+\-]\d+/` matches either `+` or `-` before one or more digits. Within character classes, other characters, which are normally metacharacters, are treated as normal characters (not metacharacters), without the need for a backslash: `/[$]/`£ matches either `$`or £. For more information, see "Character classes" on page 81.
| *(pipe)*	Used for alternation, to match either the part on the left side or the part on the right side: `/abc|xyz/` matches either `abc` or `xyz`.

About metasequences

Metasequences are sequences of characters that have special meaning in a regular expression pattern. The following table describes these metasequences:

Metasequence	Description

`{`***n***`}`
`{`***n***`,}`
and
`{`***n***`,`***n***`}`
	Specifies a numeric quantifier or quantifier range for the previous item:
	`/A{27}/` matches the character `A` repeated `27` times.
	`/A{3,}/` matches the character `A` repeated `3` or more times.
	`/A{3,5}/` matches the character `A` repeated `3` to `5` times.
	For more information, see "Quantifiers" on page 82.

`\b`	Matches at the position between a word character and a nonword character. If the first or last character in the string is a word character, also matches the start or end of the string.
`\B`	Matches at the position between two word characters. Also matches the position between two nonword characters.
`\d`	Matches a decimal digit.
`\D`	Matches any character other than a digit.
`\f`	Matches a form feed character.
`\n`	Matches the newline character.

Metasequence	**Description**
`\r`	Matches the return character.
`\s`	Matches any white-space character (a space, tab, newline, or return character).
`\S`	Matches any character other than a white-space character.
`\t`	Matches the tab character.
`\unnnn`	Matches the Unicode character with the character code specified by the hexadecimal number *nnnn*. For example, `\u263a` is the smiley character.
`\v`	Matches a vertical feed character.
`\w`	Matches a word character (`AZ–`, `az–`, `0-9`, or `_`). Note that `\w` does not match non-English characters, such as `é` , `ñ` , or `ç` .
`\W`	Matches any character other than a word character.
`\\xnn`	Matches the character with the specified ASCII value, as defined by the hexadecimal number *nn*.

Character classes

Flash Player 9 and later, Adobe AIR 1.0 and later

You use character classes to specify a list of characters to match one position in the regular expression. You define character classes with square brackets (`[` and `]`). For example, the following regular expression defines a character class that matches `bag`, `beg`, `big`, `bog`, or `bug`:

```
/b[aeiou]g/
```

Escape sequences in character classes

Most metacharacters and metasequences that normally have special meanings in a regular expression *do not* have those same meanings inside a character class. For example, in a regular expression, the asterisk is used for repetition, but this is not the case when the asterisk appears in a character class. The following character class matches the asterisk literally, along with any of the other characters listed:

```
/[abc*123]/
```

However, the three characters listed in the following table do function as metacharacters, with special meaning, in character classes:

Metacharacter	**Meaning in character classes**
`]`	Defines the end of the character class.
`-`	Defines a range of characters (see the following section "Ranges of characters in character classes").
`\`	Defines metasequences and undoes the special meaning of metacharacters.

For any of these characters to be recognized as literal characters (without the special metacharacter meaning), you must precede the character with the backslash escape character. For example, the following regular expression includes a character class that matches any one of four symbols (`$`, `\`, `]`, or `-`):

```
/[$\\\]\-]/
```

In addition to the metacharacters that retain their special meanings, the following metasequences function as metasequences within character classes:

Metasequence	**Meaning in character classes**
`\n`	Matches a newline character.
`\r`	Matches a return character.
`\t`	Matches a tab character.
`\unnnn`	Matches the character with the specified Unicode code point value (as defined by the hexadecimal number *nnnn*).
`\\xnn`	Matches the character with the specified ASCII value (as defined by the hexadecimal number *nn*).

Other regular expression metasequences and metacharacters are treated as normal characters within a character class.

Ranges of characters in character classes

Use the hyphen to specify a range of characters, such as `A-Z`, `a-z`, or `0-9`. These characters must constitute a valid range in the character set. For example, the following character class matches any one of the characters in the range `a-z` or any digit:

```
/[a-z0-9]/
```

You can also use the `\\x`*nn* ASCII character code to specify a range by ASCII value. For example, the following character class matches any character from a set of extended ASCII characters (such as `é` and `ê`):

```
\\x
```

Negated character classes

When you use a caret (`^`) character at the beginning of a character class, it negates that class—any character not listed is considered a match. The following character class matches any character *except* for a lowercase letter (`az`–) or a digit:

```
/[^a-z0-9]/
```

You must type the caret (`^`) character at the *beginning* of a character class to indicate negation. Otherwise, you are simply adding the caret character to the characters in the character class. For example, the following character class matches any one of a number of symbol characters, including the caret:

```
/[!.,#+*%$&^]/
```

Quantifiers

Flash Player 9 and later, Adobe AIR 1.0 and later

You use quantifiers to specify repetitions of characters or sequences in patterns, as follows:

Quantifier metacharacter	**Description**
`*` (star)	Matches the previous item repeated zero or more times.
`+` (plus)	Matches the previous item repeated one or more times.
`?` (question mark)	Matches the previous item repeated zero times or one time.

`{n}`
`{n,}`
and
`{n,n}`
	Specifies a numeric quantifier or quantifier range for the previous item:
	`/A{27}/` matches the character A repeated 27 times.
	`/A{3,}/` matches the character A repeated 3 or more times.
	`/A{3,5}/` matches the character A repeated 3 to 5 times.

You can apply a quantifier to a single character, to a character class, or to a group:

- `/a+/` matches the character `a` repeated one or more times.
- `/\d+/` matches one or more digits.
- `/[abc]+/` matches a repetition of one or more character, each of which is either `a`, `b`, or `c`.
- `/(very, )*/` matches the word `very` followed by a comma and a space repeated zero or more times.

You can use quantifiers within parenthetical groupings that have quantifiers applied to them. For example, the following quantifier matches strings such as `word` and `word-word-word`:

```
/\w+(-\w+)*/
```

By default, regular expressions perform what is known as *greedy matching.* Any subpattern in the regular expression (such as `.*`) tries to match as many characters in the string as possible before moving forward to the next part of the regular expression. For example, consider the following regular expression and string:

```
var pattern:RegExp = /<p>.*<\/p>/;
str:String = "<p>Paragraph 1</p> <p>Paragraph 2</p>";
```

The regular expression matches the entire string:

```
<p>Paragraph 1</p> <p>Paragraph 2</p>
```

Suppose, however, that you want to match only one `<p>...</p>` grouping. You can do this with the following:

```
<p>Paragraph 1</p>
```

Add a question mark (`?`) after any quantifier to change it to what is known as a *lazy quantifier*. For example, the following regular expression, which uses the lazy `*?` quantifier, matches `<p>` followed by the minimum number of characters possible (lazy), followed by `</p>`:

```
/<p>.*?<\/p>/
```

Keep in mind the following points about quantifiers:

- The quantifiers `{0}` and `{0,0}` do not exclude an item from a match.
- Do not combine multiple quantifiers, as in `/abc+*/`.
- The dot (.) does not span lines unless the `s` (`dotall`) flag is set, even if it is followed by a `*` quantifier. For example, consider the following code:

  ```
  var str:String = "<p>Test\n";
  str += "Multiline</p>";
  var re:RegExp = /<p>.*<\/p>/;
  trace(str.match(re)); // null;

  re = /<p>.*<\/p>/s;
  trace(str.match(re));
      // output: <p>Test
      //                 Multiline</p>
  ```

For more information, see "Flags and properties" on page 87.

Alternation

Flash Player 9 and later, Adobe AIR 1.0 and later

Use the `|` (pipe) character in a regular expression to have the regular expression engine consider alternatives for a match. For example, the following regular expression matches any one of the words `cat, dog, pig, rat`:

```
var pattern:RegExp = /cat|dog|pig|rat/;
```

You can use parentheses to define groups to restrict the scope of the | alternator. The following regular expression matches `cat` followed by `nap` or `nip`:

```
var pattern:RegExp = /cat(nap|nip)/;
```

For more information, see "Groups" on page 84.

The following two regular expressions, one using the `|` alternator, the other using a character class (defined with `[` and `]`), are equivalent:

```
/1|3|5|7|9/
/[13579]/
```

For more information, see "Character classes" on page 81.

Groups

Flash Player 9 and later, Adobe AIR 1.0 and later

You can specify a group in a regular expression by using parentheses, as follows:

```
/class-(\d*)/
```

A group is a subsection of a pattern. You can use groups to do the following things:

- Apply a quantifier to more than one character.
- Delineate subpatterns to be applied with alternation (by using the `|` character).
- Capture substring matches (for example, by using `\1` in a regular expression to match a previously matched group, or by using `$1` similarly in the `replace()` method of the String class).

The following sections provide details on these uses of groups.

Using groups with quantifiers

If you do not use a group, a quantifier applies to the character or character class that precedes it, as the following shows:

```
var pattern:RegExp = /ab*/ ;
// matches the character a followed by
// zero or more occurrences of the character b

pattern = /a\d+/;
// matches the character a followed by
// one or more digits

pattern = /a[123]{1,3}/;
// matches the character a followed by
// one to three occurrences of either 1, 2, or 3
```

However, you can use a group to apply a quantifier to more than one character or character class:

```
var pattern:RegExp = /(ab)*/;
// matches zero or more occurrences of the character a
// followed by the character b, such as ababab

pattern = /(a\d)+/;
// matches one or more occurrences of the character a followed by
// a digit, such as a1a5a8a3

pattern = /(spam ){1,3}/;
// matches 1 to 3 occurrences of the word spam followed by a space
```

For more information on quantifiers, see "Quantifiers" on page 82.

Using groups with the alternator (|) character

You can use groups to define the group of characters to which you want to apply an alternator (`|`) character, as follows:

```
var pattern:RegExp = /cat|dog/;
// matches cat or dog

pattern = /ca(t|d)og/;
// matches catog or cadog
```

Using groups to capture substring matches

When you define a standard parenthetical group in a pattern, you can later refer to it in the regular expression. This is known as a *backreference*, and these sorts of groups are known as *capturing groups*. For example, in the following regular expression, the sequence `\1` matches whatever substring matched the capturing parenthetical group:

```
var pattern:RegExp = /(\d+)-by-\1/;
// matches the following: 48-by-48
```

You can specify up to 99 of these backreferences in a regular expression by typing `\1`, `\2`, ... , `\99`.

Similarly, in the `replace()` method of the String class, you can use `$1$99`– to insert captured group substring matches in the replacement string:

```
var pattern:RegExp = /Hi, (\w+)\./;
var str:String = "Hi, Bob.";
trace(str.replace(pattern, "$1, hello."));
    // output: Bob, hello.
```

Also, if you use capturing groups, the `exec()` method of the RegExp class and the `match()` method of the String class return substrings that match the capturing groups:

```
var pattern:RegExp = /(\w+)@(\w+).(\w+)/;
var str:String = "bob@example.com";
trace(pattern.exec(str));
    // bob@example.com,bob,example,com
```

Using noncapturing groups and lookahead groups

A noncapturing group is one that is used for grouping only; it is not "collected," and it does not match numbered backreferences. Use `(?:` and `)` to define noncapturing groups, as follows:

```
var pattern = /(?:com|org|net);
```

For example, note the difference between putting `(com|org)` in a capturing versus a noncapturing group (the `exec()` method lists capturing groups after the complete match):

```
var pattern:RegExp = /(\w+)@(\w+).(com|org)/;
var str:String = "bob@example.com";
trace(pattern.exec(str));
// bob@example.com,bob,example,com

//noncapturing:
var pattern:RegExp = /(\w+)@(\w+).(?:com|org)/;
var str:String = "bob@example.com";
trace(pattern.exec(str));
    // bob@example.com,bob,example
```

A special type of noncapturing group is the *lookahead group,* of which there are two types: the *positive lookahead group* and the *negative lookahead group.*

Use `(?=` and `)` to define a positive lookahead group, which specifies that the subpattern in the group must match at the position. However, the portion of the string that matches the positive lookahead group can match remaining patterns in the regular expression. For example, because `(?=e)` is a positive lookahead group in the following code, the character `e` that it matches can be matched by a subsequent part of the regular expression—in this case, the capturing group, `\w*)`:

```
var pattern:RegExp = /sh(?=e)(\w*)/i;
var str:String = "Shelly sells seashells by the seashore";
trace(pattern.exec(str));
// Shelly,elly
```

Use `(?!` and `)` to define a negative lookahead group that specifies that the subpattern in the group must *not* match at the position. For example:

```
var pattern:RegExp = /sh(?!e)(\w*)/i;
var str:String = "She sells seashells by the seashore";
trace(pattern.exec(str));
// shore,ore
```

Using named groups

A named group is a type of group in a regular expression that is given a named identifier. Use `(?P<name>` and `)` to define the named group. For example, the following regular expression includes a named group with the identifier named `digits`:

```
var pattern = /[a-z]+(?P<digits>\d+)[a-z]+/;
```

When you use the `exec()` method, a matching named group is added as a property of the `result` array:

```
var myPattern:RegExp = /([a-z]+)(?P<digits>\d+)[a-z]+/;
var str:String = "a123bcd";
var result:Array = myPattern.exec(str);
trace(result.digits); // 123
```

Here is another example, which uses two named groups, with the identifiers `name` and `dom`:

```
var emailPattern:RegExp =
    /(?P<name>(\w|[_.\-])+)@(?P<dom>((\w|-)+))+\.\w{2,4}+/;
var address:String = "bob@example.com";
var result:Array = emailPattern.exec(address);
trace(result.name); // bob
trace(result.dom); // example
```

Note: *Named groups are not part of the ECMAScript language specification. They are an added feature in ActionScript 3.0.*

Flags and properties

Flash Player 9 and later, Adobe AIR 1.0 and later

The following table lists the five flags that you can set for regular expressions. Each flag can be accessed as a property of the regular expression object.

Flag	Property	Description
`g`	`global`	Matches more than one match.
`i`	`ignoreCase`	Case-insensitive matching. Applies to the `A`—`Z` and `a`—`z` characters, but not to extended characters such as `É` and `é` .
`m`	`multiline`	With this flag set, `$` and `^` can match the beginning of a line and end of a line, respectively.
`s`	`dotall`	With this flag set, `.` (dot) can match the newline character (`\n`).
`x`	`extended`	Allows extended regular expressions. You can type spaces in the regular expression, which are ignored as part of the pattern. This lets you type regular expression code more legibly.

Note that these properties are read-only. You can set the flags (`g`, `i`, `m`, `s`, `x`) when you set a regular expression variable, as follows:

```
var re:RegExp = /abc/gimsx;
```

However, you cannot directly set the named properties. For instance, the following code results in an error:

```
var re:RegExp = /abc/;
re.global = true; // This generates an error.
```

By default, unless you specify them in the regular expression declaration, the flags are not set, and the corresponding properties are also set to `false`.

Additionally, there are two other properties of a regular expression:

- The `lastIndex` property specifies the index position in the string to use for the next call to the `exec()` or `test()` method of a regular expression.
- The `source` property specifies the string that defines the pattern portion of the regular expression.

The g (global) flag

When the `g` (`global`) flag is *not* included, a regular expression matches no more than one match. For example, with the `g` flag not included in the regular expression, the `String.match()` method returns only one matching substring:

```
var str:String = "she sells seashells by the seashore.";
var pattern:RegExp = /sh\w*/;
trace(str.match(pattern)) // output: she
```

When the `g` flag is set, the `Sting.match()` method returns multiple matches, as follows:

```
var str:String = "she sells seashells by the seashore.";
var pattern:RegExp = /sh\w*/g;
// The same pattern, but this time the g flag IS set.
trace(str.match(pattern)); // output: she,shells,shore
```

The i (ignoreCase) flag

By default, regular expression matches are case-sensitive. When you set the `i` (`ignoreCase`) flag, case sensitivity is ignored. For example, the lowercase `s` in the regular expression does not match the uppercase letter `S`, the first character of the string:

```
var str:String = "She sells seashells by the seashore.";
trace(str.search(/sh/)); // output: 13 -- Not the first character
```

With the `i` flag set, however, the regular expression does match the capital letter `S`:

```
var str:String = "She sells seashells by the seashore.";
trace(str.search(/sh/i)); // output: 0
```

The `i` flag ignores case sensitivity only for the `A–Z` and `a–z` characters, but not for extended characters such as `É` and `é` .

The m (multiline) flag

If the `m` (`multiline`) flag is not set, the `^` matches the beginning of the string and the `$` matches the end of the string. If the `m` flag is set, these characters match the beginning of a line and end of a line, respectively. Consider the following string, which includes a newline character:

```
var str:String = "Test\n";
str += "Multiline";
trace(str.match(/^\w*/g)); // Match a word at the beginning of the string.
```

Even though the `g` (`global`) flag is set in the regular expression, the `match()` method matches only one substring, since there is only one match for the `^`—the beginning of the string. The output is:

```
Test
```

Here is the same code with the `m` flag set:

```
var str:String = "Test\n";
str += "Multiline";
trace(str.match(/^\w*/gm)); // Match a word at the beginning of lines.
```

This time, the output includes the words at the beginning of both lines:

```
Test,Multiline
```

Note that only the `\n` character signals the end of a line. The following characters do not:

- Return (`\r`) character
- Unicode line-separator (`\u2028`) character
- Unicode paragraph-separator (`\u2029`) character

The s (dotall) flag

If the `s` (`dotall` or "dot all") flag is not set, a dot (`.`) in a regular expression pattern does not match a newline character (`\n`). So for the following example, there is no match:

```
var str:String = "<p>Test\n";
str += "Multiline</p>";
var re:RegExp = /<p>.*?<\/p>/;
trace(str.match(re));
```

However, if the `s` flag is set, the dot matches the newline character:

```
var str:String = "<p>Test\n";
str += "Multiline</p>";
var re:RegExp = /<p>.*?<\/p>/s;
trace(str.match(re));
```

In this case, the match is the entire substring within the `<p>` tags, including the newline character:

```
<p>Test
Multiline</p>
```

The x (extended) flag

Regular expressions can be difficult to read, especially when they include a lot of metasymbols and metasequences. For example:

```
/<p(>|(\s*[^>]*>)).*?<\/p>/gi
```

When you use the `x` (`extended`) flag in a regular expression, any blank spaces that you type in the pattern are ignored. For example, the following regular expression is identical to the previous example:

```
/     <p    (>  |  (\s*  [^>]*  >))    .*?    <\/p>  /gix
```

If you have the `x` flag set and do want to match a blank space character, precede the blank space with a backslash. For example, the following two regular expressions are equivalent:

```
/foo bar/
/foo \ bar/x
```

The lastIndex property

The `lastIndex` property specifies the index position in the string at which to start the next search. This property affects the `exec()` and `test()` methods called on a regular expression that has the `g` flag set to `true`. For example, consider the following code:

```
var pattern:RegExp = /p\w*/gi;
var str:String = "Pedro Piper picked a peck of pickled peppers.";
trace(pattern.lastIndex);
var result:Object = pattern.exec(str);
while (result != null)
{
    trace(pattern.lastIndex);
    result = pattern.exec(str);
}
```

The `lastIndex` property is set to 0 by default (to start searches at the beginning of the string). After each match, it is set to the index position following the match. Therefore, the output for the preceding code is the following:

```
0
5
11
18
25
36
44
```

If the `global` flag is set to `false`, the `exec()` and `test()` methods do not use or set the `lastIndex` property.

The `match()`, `replace()`, and `search()` methods of the String class start all searches from the beginning of the string, regardless of the setting of the `lastIndex` property of the regular expression used in the call to the method. (However, the `match()` method does set `lastIndex` to 0.)

You can set the `lastIndex` property to adjust the starting position in the string for regular expression matching.

The source property

The `source` property specifies the string that defines the pattern portion of a regular expression. For example:

```
var pattern:RegExp = /foo/gi;
trace(pattern.source); // foo
```

Methods for using regular expressions with strings

Flash Player 9 and later, Adobe AIR 1.0 and later

The RegExp class includes two methods: `exec()` and `test()`.

In addition to the `exec()` and `test()` methods of the RegExp class, the String class includes the following methods that let you match regular expressions in strings: `match()`, `replace()`, `search()`, and `splice()`.

The test() method

Flash Player 9 and later, Adobe AIR 1.0 and later

The `test()` method of the RegExp class simply checks the supplied string to see if it contains a match for the regular expression, as the following example shows:

```
var pattern:RegExp = /Class-\w/;
var str = "Class-A";
trace(pattern.test(str)); // output: true
```

The exec() method

Flash Player 9 and later, Adobe AIR 1.0 and later

The `exec()` method of the RegExp class checks the supplied string for a match of the regular expression and returns an array with the following:

- The matching substring
- Substring matches for any parenthetical groups in the regular expression

The array also includes an `index` property, indicating the index position of the start of the substring match.

For example, consider the following code:

```
var pattern:RegExp = /\d{3}\-\d{3}-\d{4}/; //U.S phone number
var str:String = "phone: 415-555-1212";
var result:Array = pattern.exec(str);
trace(result.index, " - ", result);
// 7-415-555-1212
```

Use the `exec()` method multiple times to match multiple substrings when the `g` (`global`) flag is set for the regular expression:

```
var pattern:RegExp = /\w*sh\w*/gi;
var str:String = "She sells seashells by the seashore";
var result:Array = pattern.exec(str);

while (result != null)
{
    trace(result.index, "\t", pattern.lastIndex, "\t", result);
    result = pattern.exec(str);
}
//output:
// 0  3  She
// 10  19  seashells
// 27  35  seashore
```

String methods that use RegExp parameters

Flash Player 9 and later, Adobe AIR 1.0 and later

The following methods of the String class take regular expressions as parameters: `match()`, `replace()`, `search()`, and `split()`. For more information on these methods, see "Finding patterns in strings and replacing substrings" on page 16.

Regular expressions example: A Wiki parser

Flash Player 9 and later, Adobe AIR 1.0 and later

This simple Wiki text conversion example illustrates a number of uses for regular expressions:

- Converting lines of text that match a source Wiki pattern to the appropriate HTML output strings.
- Using a regular expression to convert URL patterns to HTML `<a>` hyperlink tags.
- Using a regular expression to convert U.S. dollar strings (such as `"$9.95"`) to euro strings (such as `"8.24 €"`).

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The WikiEditor application files can be found in the folder Samples/WikiEditor. The application consists of the following files:

File	Description
WikiEditor.mxml or WikiEditor.fla	The main application file in Flash (FLA) or Flex (MXML).
com/example/programmingas3/regExpExamples/WikiParser.as	A class that includes methods that use regular expressions to convert Wiki input text patterns to the equivalent HTML output.
com/example/programmingas3/regExpExamples/URLParser.as	A class that includes methods that use regular expressions to convert URL strings to HTML `<a>` hyperlink tags.
com/example/programmingas3/regExpExamples/CurrencyConverter.as	A class that includes methods that use regular expressions to convert U.S. dollar strings to euro strings.

Defining the WikiParser class

Flash Player 9 and later, Adobe AIR 1.0 and later

The WikiParser class includes methods that convert Wiki input text into the equivalent HTML output. This is not a very robust Wiki conversion application, but it does illustrate some good uses of regular expressions for pattern matching and string conversion.

The constructor function, along with the `setWikiData()` method, simply initializes a sample string of Wiki input text, as follows:

```
public function WikiParser()
{
    wikiData = setWikiData();
}
```

When the user clicks the Test button in the sample application, the application invokes the `parseWikiString()` method of the WikiParser object. This method calls a number of other methods, which in turn assemble the resulting HTML string.

```
public function parseWikiString(wikiString:String):String
{
    var result:String = parseBold(wikiString);
    result = parseItalic(result);
    result = linesToParagraphs(result);
    result = parseBullets(result);
    return result;
}
```

Each of the methods called—`parseBold()`, `parseItalic()`, `linesToParagraphs()`, and `parseBullets()`—uses the `replace()` method of the string to replace matching patterns, defined by a regular expression, in order to transform the input Wiki text into HTML-formatted text.

Converting boldface and italic patterns

The `parseBold()` method looks for a Wiki boldface text pattern (such as `'''foo'''`) and transforms it into its HTML equivalent (such as `<b>foo</b>`), as follows:

```
private function parseBold(input:String):String
{
    var pattern:RegExp = /'''(.*?)'''/g;
    return input.replace(pattern, "<b>$1</b>");
}
```

Note that the `(.?*)` portion of the regular expression matches any number of characters (`*`) between the two defining `'''` patterns. The `?` quantifier makes the match nongreedy, so that for a string such as `'''aaa''' bbb '''ccc'''`, the first matched string will be `'''aaa'''` and not the entire string (which starts and ends with the `'''` pattern).

The parentheses in the regular expression define a capturing group, and the `replace()` method refers to this group by using the `$1` code in the replacement string. The `g` (`global`) flag in the regular expression ensures that the `replace()` method replaces all matches in the string (not simply the first one).

The `parseItalic()` method works similarly to the `parseBold()` method, except that it checks for two apostrophes (`''`) as the delimiter for italic text (not three):

```
private function parseItalic(input:String):String
{
    var pattern:RegExp = /''(.*?)''/g;
    return input.replace(pattern, "<i>$1</i>");
}
```

Converting bullet patterns

As the following example shows, the `parseBullet()` method looks for the Wiki bullet line pattern (such as `* foo`) and transforms it into its HTML equivalent (such as `<li>foo</li>`):

```
private function parseBullets(input:String):String
{
    var pattern:RegExp = /^\*(.*)/gm;
    return input.replace(pattern, "<li>$1</li>");
}
```

The ^ symbol at the beginning of the regular expression matches the beginning of a line. The `m` (`multiline`) flag in the regular expression causes the regular expression to match the ^ symbol against the start of a line, not simply the start of the string.

The `\*` pattern matches an asterisk character (the backslash is used to signal a literal asterisk instead of a `*` quantifier).

The parentheses in the regular expression define a capturing group, and the `replace()` method refers to this group by using the `$1` code in the replacement string. The `g` (`global`) flag in the regular expression ensures that the `replace()` method replaces all matches in the string (not simply the first one).

Converting paragraph Wiki patterns

The `linesToParagraphs()` method converts each line in the input Wiki string to an HTML `<p>` paragraph tag. These lines in the method strip out empty lines from the input Wiki string:

```
var pattern:RegExp = /^$/gm;
var result:String = input.replace(pattern, "");
```

The `^` and `$` symbols the regular expression match the beginning and end of a line. The `m` (`multiline`) flag in the regular expression causes the regular expression to match the ^ symbol against the start of a line, not simply the start of the string.

The `replace()` method replaces all matching substrings (empty lines) with an empty string (`""`). The `g` (`global`) flag in the regular expression ensures that the `replace()` method replaces all matches in the string (not simply the first one).

Converting URLs to HTML <a> tags

Flash Player 9 and later, Adobe AIR 1.0 and later

When the user clicks the Test button in the sample application, if the user selected the `urlToATag` check box, the application calls the `URLParser.urlToATag()` static method to convert URL strings from the input Wiki string into HTML `<a>` tags.

```
var protocol:String = "((?:http|ftp)://)";
var urlPart:String = "([a-z0-9_-]+\.[a-z0-9_-]+)";
var optionalUrlPart:String = "(\.[a-z0-9_-]*)";
var urlPattern:RegExp = new RegExp(protocol + urlPart + optionalUrlPart, "ig");
var result:String = input.replace(urlPattern, "<a href='$1$2$3'><u>$1$2$3</u></a>");
```

The `RegExp()` constructor function is used to assemble a regular expression (`urlPattern`) from a number of constituent parts. These constituent parts are each strings that define part of the regular expression pattern.

The first part of the regular expression pattern, defined by the `protocol` string, defines an URL protocol: either `http://` or `ftp://`. The parentheses define a noncapturing group, indicated by the `?` symbol. This means that the parentheses are simply used to define a group for the `|` alternation pattern; the group will not match backreference codes (`$1`, `$2`, `$3`) in the replacement string of the `replace()` method.

The other constituent parts of the regular expression each use capturing groups (indicated by parentheses in the pattern), which are then used in the backreference codes (`$1`, `$2`, `$3`) in the replacement string of the `replace()` method.

The part of the pattern defined by the `urlPart` string matches *at least* one of the following characters: `a-z`, `0-9`, `_`, or `-`. The `+` quantifier indicates that at least one character is matched. The `\.` indicates a required dot (`.`) character. And the remainder matches another string of at least one of these characters: `a-z`, `0-9`, `_`, or `-`.

The part of the pattern defined by the `optionalUrlPart` string matches *zero or more* of the following: a dot (`.`) character followed by any number of alphanumeric characters (including `_` and `-`). The `*` quantifier indicates that zero or more characters are matched.

The call to the `replace()` method employs the regular expression and assembles the replacement HTML string, using backreferences.

The `urlToATag()` method then calls the `emailToATag()` method, which uses similar techniques to replace e-mail patterns with HTML `<a>` hyperlink strings. The regular expressions used to match HTTP, FTP, and e-mail URLs in this sample file are fairly simple, for the purposes of exemplification; there are much more complicated regular expressions for matching such URLs more correctly.

Converting U.S. dollar strings to euro strings

Flash Player 9 and later, Adobe AIR 1.0 and later

When the user clicks the Test button in the sample application, if the user selected the `dollarToEuro` check box, the application calls the `CurrencyConverter.usdToEuro()` static method to convert U.S. dollar strings (such as `"$9.95"`) to euro strings (such as `"8.24 €"`), as follows:

```
var usdPrice:RegExp = /\$([\d,]+.\d+)+/g;
return input.replace(usdPrice, usdStrToEuroStr);
```

The first line defines a simple pattern for matching U.S. dollar strings. Notice that the `$` character is preceded with the backslash (`\`) escape character.

The `replace()` method uses the regular expression as the pattern matcher, and it calls the `usdStrToEuroStr()` function to determine the replacement string (a value in euros).

When a function name is used as the second parameter of the `replace()` method, the following are passed as parameters to the called function:

- The matching portion of the string.
- Any captured parenthetical group matches. The number of arguments passed this way varies depending on the number of captured parenthetical group matches. You can determine the number of captured parenthetical group matches by checking `arguments.length - 3` within the function code.
- The index position in the string where the match begins.
- The complete string.

The `usdStrToEuroStr()` method converts U.S. dollar string patterns to euro strings, as follows:

```
private function usdToEuro(...args):String
{
    var usd:String = args[1];
    usd = usd.replace(",", "");
    var exchangeRate:Number = 0.828017;
    var euro:Number = Number(usd) * exchangeRate;
    trace(usd, Number(usd), euro);
    const euroSymbol:String = String.fromCharCode(8364); // €
    return euro.toFixed(2) + " " + euroSymbol;
}
```

Note that `args[1]` represents the captured parenthetical group matched by the `usdPrice` regular expression. This is the numerical portion of the U.S. dollar string: that is, the dollar amount without the `$` sign. The method applies an exchange rate conversion and returns the resulting string (with a trailing € symbol instead of a leading $ symbol).

Chapter 6: Working with XML

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 includes a group of classes based on the ECMAScript for XML (E4X) specification (ECMA-357 edition 2). These classes include powerful and easy-to-use functionality for working with XML data. Using E4X, you will be able to develop code with XML data faster than was possible with previous programming techniques. As an added benefit, the code you produce will be easier to read.

More Help topics

XML class

ECMA-357 specification

Basics of XML

Flash Player 9 and later, Adobe AIR 1.0 and later

XML is a standard way of representing structured information so that it is easy for computers to work with and reasonably easy for people to write and understand. XML is an abbreviation for eXtensible Markup Language. The XML standard is available at www.w3.org/XML/.

XML offers a standard and convenient way to categorize data, to make it easier to read, access, and manipulate. XML uses a tree structure and tag structure that is similar to HTML. Here is a simple example of XML data:

```
<song>
    <title>What you know?</title>
    <artist>Steve and the flubberblubs</artist>
    <year>1989</year>
    <lastplayed>2006-10-17-08:31</lastplayed>
</song>
```

XML data can also be more complex, with tags nested in other tags as well as attributes and other structural components. Here is a more complex example of XML data:

```
<album>
    <title>Questions, unanswered</title>
    <artist>Steve and the flubberblubs</artist>
    <year>1989</year>
    <tracks>
        <song tracknumber="1" length="4:05">
            <title>What do you know?</title>
            <artist>Steve and the flubberblubs</artist>
            <lastplayed>2006-10-17-08:31</lastplayed>
        </song>
        <song tracknumber="2" length="3:45">
            <title>Who do you know?</title>
            <artist>Steve and the flubberblubs</artist>
            <lastplayed>2006-10-17-08:35</lastplayed>
        </song>
        <song tracknumber="3" length="5:14">
            <title>When do you know?</title>
            <artist>Steve and the flubberblubs</artist>
            <lastplayed>2006-10-17-08:39</lastplayed>
        </song>
        <song tracknumber="4" length="4:19">
            <title>Do you know?</title>
            <artist>Steve and the flubberblubs</artist>
            <lastplayed>2006-10-17-08:44</lastplayed>
        </song>
    </tracks>
</album>
```

Notice that this XML document contains other complete XML structures within it (such as the `song` tags with their children). It also demonstrates other XML structures such as attributes (`tracknumber` and `length` in the `song` tags), and tags that contain other tags rather than containing data (such as the `tracks` tag).

Getting started with XML

If you have little or no experience with XML, here is a brief description of the most common aspects of XML data. XML data is written in plain-text form, with a specific syntax for organizing the information into a structured format. Generally, a single set of XML data is known as an *XML document*. In XML format, data is organized into *elements* (which can be single data items or containers for other elements) using a hierarchical structure. Every XML document has a single element as the top level or main item; inside this root element there may be a single piece of information, although there are more likely to be other elements, which in turn contain other elements, and so forth. For example, this XML document contains the information about a music album:

```
<song tracknumber="1" length="4:05">
    <title>What do you know?</title>
    <artist>Steve and the flubberblubs</artist>
    <mood>Happy</mood>
    <lastplayed>2006-10-17-08:31</lastplayed>
</song>
```

Each element is distinguished by a set of *tags*—the element's name wrapped in angle brackets (less-than and greater-than signs). The opening tag, indicating the start of the element, has the element name:

```
<title>
```

The closing tag, which marks the end of the element, has a forward slash before the element's name:

```
</title>
```

If an element contains no content, it can be written as an empty element (sometimes called a self-closing element). In XML, this element:

```
<lastplayed/>
```

is identical to this element:

```
<lastplayed></lastplayed>
```

In addition to the element's content contained between the opening and closing tags, an element can also include other values, known as *attributes*, defined in the element's opening tag. For example, this XML element defines a single attribute named `length`, with the value `"4:19"` :

```
<song length="4:19"></song>
```

Each XML element has content, which is either a single value, one or more XML elements, or nothing (for an empty element).

Learning more about XML

To learn more about working with XML, there are a number of additional books and resources for learning more about XML, including these web sites:

- W3Schools XML Tutorial: http://w3schools.com/xml/
- XMLpitstop tutorials, discussion lists, and more: http://xmlpitstop.com/

ActionScript classes for working with XML

ActionScript 3.0 includes several classes that are used for working with XML-structured information. The two main classes are as follows:

- XML: Represents a single XML element, which can be an XML document with multiple children or a single-value element within a document.
- XMLList: Represents a set of XML elements. An XMLList object is used when there are multiple XML elements that are "siblings" (at the same level, and contained by the same parent, in the XML document's hierarchy). For instance, an XMLList instance would be the easiest way to work with this set of XML elements (presumably contained in an XML document):

  ```
  <artist type="composer">Fred Wilson</artist>
  <artist type="conductor">James Schmidt</artist>
  <artist type="soloist">Susan Harriet Thurndon</artist>
  ```

For more advanced uses involving XML namespaces, ActionScript also includes the Namespace and QName classes. For more information, see "Using XML namespaces" on page 110.

In addition to the built-in classes for working with XML, ActionScript 3.0 also includes several operators that provide specific functionality for accessing and manipulating XML data. This approach to working with XML using these classes and operators is known as ECMAScript for XML (E4X), as defined by the ECMA-357 edition 2 specification.

Important concepts and terms

The following reference list contains important terms you will encounter when programming XML handling routines:

Element A single item in an XML document, identified as the content contained between a starting tag and an ending tag (including the tags). XML elements can contain text data or other elements, or can be empty.

Empty element An XML element that contains no child elements. Empty elements are often written as self-closing tags (such as `<element/>`).

Document A single XML structure. An XML document can contain any number of elements (or can consist only of a single empty element); however, an XML document must have a single top-level element that contains all the other elements in the document.

Node Another name for an XML element.

Attribute A named value associated with an element that is written into the opening tag of the element in `attributename="value"` format, rather than being written as a separate child element nested inside the element.

The E4X approach to XML processing

Flash Player 9 and later, Adobe AIR 1.0 and later

The ECMAScript for XML specification defines a set of classes and functionality for working with XML data. These classes and functionality are known collectively as *E4X*. ActionScript 3.0 includes the following E4X classes: XML, XMLList, QName, and Namespace.

The methods, properties, and operators of the E4X classes are designed with the following goals:

- Simplicity—Where possible, E4X makes it easier to write and understand code for working with XML data.
- Consistency—The methods and reasoning behind E4X are internally consistent and consistent with other parts of ActionScript.
- Familiarity—You manipulate XML data with well-known operators, such as the dot (`.`) operator.

***Note:** There is a different XML class in ActionScript 2.0. In ActionScript 3.0 that class has been renamed as XMLDocument, so that the name does not conflict with the ActionScript 3.0 XML class that is part of E4X. In ActionScript 3.0, the legacy classes—XMLDocument, XMLNode, XMLParser, and XMLTag—are included in the flash.xml package primarily for legacy support. The new E4X classes are core classes; you need not import a package to use them. For details on the legacy ActionScript 2.0 XML classes, see the flash.xml packagein the ActionScript 3.0 Reference for the Adobe Flash Platform.*

Here is an example of manipulating data with E4X:

```
var myXML:XML =
    <order>
        <item id='1'>
            <menuName>burger</menuName>
            <price>3.95</price>
        </item>
        <item id='2'>
            <menuName>fries</menuName>
            <price>1.45</price>
        </item>
    </order>
```

Often, your application will load XML data from an external source, such as a web service or a RSS feed. However, for clarity, the code examples provided here assign XML data as literals.

As the following code shows, E4X includes some intuitive operators, such as the dot (`.`) and attribute identifier (`@`) operators, for accessing properties and attributes in the XML:

```
trace(myXML.item[0].menuName); // Output: burger
trace(myXML.item.(@id==2).menuName); // Output: fries
trace(myXML.item.(menuName=="burger").price); // Output: 3.95
```

Use the `appendChild()` method to assign a new child node to the XML, as the following snippet shows:

```
var newItem:XML =
    <item id="3">
        <menuName>medium cola</menuName>
        <price>1.25</price>
    </item>

myXML.appendChild(newItem);
```

Use the `@` and `.` operators not only to read data, but also to assign data, as in the following:

```
myXML.item[0].menuName="regular burger";
myXML.item[1].menuName="small fries";
myXML.item[2].menuName="medium cola";

myXML.item.(menuName=="regular burger").@quantity = "2";
myXML.item.(menuName=="small fries").@quantity = "2";
myXML.item.(menuName=="medium cola").@quantity = "2";
```

Use a `for` loop to iterate through nodes of the XML, as follows:

```
var total:Number = 0;
for each (var property:XML in myXML.item)
{
    var q:int = Number(property.@quantity);
    var p:Number = Number(property.price);
    var itemTotal:Number = q * p;
    total += itemTotal;
    trace(q + " " + property.menuName + " $" + itemTotal.toFixed(2))
}
trace("Total: $", total.toFixed(2));
```

XML objects

Flash Player 9 and later, Adobe AIR 1.0 and later

An XML object may represent an XML element, attribute, comment, processing instruction, or text element.

An XML object is classified as having either *simple content* or *complex content*. An XML object that has child nodes is classified as having complex content. An XML object is said to have simple content if it is any one of the following: an attribute, a comment, a processing instruction, or a text node.

For example, the following XML object contains complex content, including a comment and a processing instruction:

```
XML.ignoreComments = false;
XML.ignoreProcessingInstructions = false;
var x1:XML =
    <order>
        <!--This is a comment. -->
        <?PROC_INSTR sample ?>
        <item id='1'>
            <menuName>burger</menuName>
            <price>3.95</price>
        </item>
        <item id='2'>
            <menuName>fries</menuName>
            <price>1.45</price>
        </item>
    </order>
```

As the following example shows, you can now use the `comments()` and `processingInstructions()` methods to create new XML objects, a comment and a processing instruction:

```
var x2:XML = x1.comments()[0];
var x3:XML = x1.processingInstructions()[0];
```

XML properties

Flash Player 9 and later, Adobe AIR 1.0 and later

The XML class has five static properties:

- The `ignoreComments` and `ignoreProcessingInstructions` properties determine whether comments or processing instructions are ignored when the XML object is parsed.
- The `ignoreWhitespace` property determines whether white space characters are ignored in element tags and embedded expressions that are separated only by white space characters.
- The `prettyIndent`and `prettyPrinting` properties are used to format the text that is returned by the `toString()` and `toXMLString()` methods of the XML class.

For details on these properties, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

XML methods

Flash Player 9 and later, Adobe AIR 1.0 and later

The following methods allow you to work with the hierarchical structure of XML objects:

- `appendChild()`
- `child()`
- `childIndex()`
- `children()`
- `descendants()`
- `elements()`
- `insertChildAfter()`
- `insertChildBefore()`

- `parent()`
- `prependChild()`

The following methods allow you to work with XML object attributes:

- `attribute()`
- `attributes()`

The following methods allow you to you work with XML object properties:

- `hasOwnProperty()`
- `propertyIsEnumerable()`
- `replace()`
- `setChildren()`

The following methods are for working with qualified names and namespaces:

- `addNamespace()`
- `inScopeNamespaces()`
- `localName()`
- `name()`
- `namespace()`
- `namespaceDeclarations()`
- `removeNamespace()`
- `setLocalName()`
- `setName()`
- `setNamespace()`

The following methods are for working with and determining certain types of XML content:

- `comments()`
- `hasComplexContent()`
- `hasSimpleContent()`
- `nodeKind()`
- `processingInstructions()`
- `text()`

The following methods are for conversion to strings and for formatting XML objects:

- `defaultSettings()`
- `setSettings()`
- `settings()`
- `normalize()`
- `toString()`
- `toXMLString()`

There are a few additional methods:

- `contains()`
- `copy()`
- `valueOf()`
- `length()`

For details on these methods, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

XMLList objects

Flash Player 9 and later, Adobe AIR 1.0 and later

An XMLList instance represents an arbitrary collection of XML objects. It can contain full XML documents, XML fragments, or the results of an XML query.

The following methods allow you to work with the hierarchical structure of XMLList objects:

- `child()`
- `children()`
- `descendants()`
- `elements()`
- `parent()`

The following methods allow you to work with XMLList object attributes:

- `attribute()`
- `attributes()`

The following methods allow you to you work with XMLList properties:

- `hasOwnProperty()`
- `propertyIsEnumerable()`

The following methods are for working with and determining certain types of XML content:

- `comments()`
- `hasComplexContent()`
- `hasSimpleContent()`
- `processingInstructions()`
- `text()`

The following are for conversion to strings and for formatting the XMLList object:

- `normalize()`
- `toString()`
- `toXMLString()`

There are a few additional methods:

- `contains()`

- `copy()`
- `length()`
- `valueOf()`

For details on these methods, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

For an XMLList object that contains exactly one XML element, you can use all properties and methods of the XML class, because an XMLList with one XML element is treated the same as an XML object. For example, in the following code, because `doc.div` is an XMLList object containing one element, you can use the `appendChild()` method from the XML class:

```
var doc:XML = 
        <body>
            <div>
                <p>Hello</p>
            </div>
        </body>;
doc.div.appendChild(<p>World</p>);
```

For a list of XML properties and methods, see "XML objects" on page 99.

Initializing XML variables

Flash Player 9 and later, Adobe AIR 1.0 and later

You can assign an XML literal to an XML object, as follows:

```
var myXML:XML = 
    <order>
        <item id='1'>
            <menuName>burger</menuName>
            <price>3.95</price>
        </item>
        <item id='2'>
            <menuName>fries</menuName>
            <price>1.45</price>
        </item>
    </order>
```

As the following snippet shows, you can also use the `new` constructor to create an instance of an XML object from a string that contains XML data:

```
var str:String = "<order><item id='1'><menuName>burger</menuName>"
                            + "<price>3.95</price></item></order>";
var myXML:XML = new XML(str);
```

If the XML data in the string is not well formed (for example, if a closing tag is missing), you will see a run-time error.

You can also pass data by reference (from other variables) into an XML object, as the following example shows:

```
var tagname:String = "item";
var attributename:String = "id";
var attributevalue:String = "5";
var content:String = "Chicken";
var x:XML = <{tagname} {attributename}={attributevalue}>{content}</{tagname}>;
trace(x.toXMLString())
    // Output: <item id="5">Chicken</item>
```

To load XML data from a URL, use the URLLoader class, as the following example shows:

```
import flash.events.Event;
import flash.net.URLLoader;
import flash.net.URLRequest;

var externalXML:XML;
var loader:URLLoader = new URLLoader();
var request:URLRequest = new URLRequest("xmlFile.xml");
loader.load(request);
loader.addEventListener(Event.COMPLETE, onComplete);

function onComplete(event:Event):void
{
    var loader:URLLoader = event.target as URLLoader;
    if (loader != null)
    {
        externalXML = new XML(loader.data);
        trace(externalXML.toXMLString());
    }
    else
    {
        trace("loader is not a URLLoader!");
    }
}
```

To read XML data from a socket connection, use the XMLSocket class. For more information, see the XMLSocket class in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Assembling and transforming XML objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Use the `prependChild()` method or the `appendChild()` method to add a property to the beginning or end of an XML object's list of properties, as the following example shows:

```
var x1:XML = <p>Line 1</p>
var x2:XML = <p>Line 2</p>
var x:XML = <body></body>
x = x.appendChild(x1);
x = x.appendChild(x2);
x = x.prependChild(<p>Line 0</p>);
    // x == <body><p>Line 0</p><p>Line 1</p><p>Line 2</p></body>
```

Use the `insertChildBefore()` method or the `insertChildAfter()` method to add a property before or after a specified property, as follows:

```
var x:XML =
    <body>
        <p>Paragraph 1</p>
        <p>Paragraph 2</p>
    </body>
var newNode:XML = <p>Paragraph 1.5</p>
x = x.insertChildAfter(x.p[0], newNode)
x = x.insertChildBefore(x.p[2], <p>Paragraph 1.75</p>)
```

As the following example shows, you can also use curly brace operators ({ and }) to pass data by reference (from other variables) when constructing XML objects:

```
var ids:Array = [121, 122, 123];
var names:Array = [["Murphy","Pat"], ["Thibaut","Jean"], ["Smith","Vijay"]]
var x:XML = new XML("<employeeList></employeeList>");

for (var i:int = 0; i < 3; i++)
{
    var newnode:XML = new XML();
    newnode =
        <employee id={ids[i]}>
            <last>{names[i][0]}</last>
            <first>{names[i][1]}</first>
        </employee>;

    x = x.appendChild(newnode)
}
```

You can assign properties and attributes to an XML object by using the = operator, as in the following:

```
var x:XML =
    <employee>
        <lastname>Smith</lastname>
    </employee>
x.firstname = "Jean";
x.@id = "239";
```

This sets the XML object `x` to the following:

```
<employee id="239">
    <lastname>Smith</lastname>
    <firstname>Jean</firstname>
</employee>
```

You can use the + and += operators to concatenate XMLList objects:

```
var x1:XML = <a>test1</a>
var x2:XML = <b>test2</b>
var xList:XMLList = x1 + x2;
xList += <c>test3</c>
```

This sets the XMLList object `xList` to the following:

```
<a>test1</a>
<b>test2</b>
<c>test3</c>
```

Traversing XML structures

Flash Player 9 and later, Adobe AIR 1.0 and later

One of the powerful features of XML is its ability to provide complex, nested data via a linear string of text characters. When you load data into an XML object, ActionScript parses the data and loads its hierarchical structure into memory (or it sends a run-time error if the XML data is not well formed).

The operators and methods of the XML and XMLList objects make it easy to traverse the structure of XML data.

Use the dot (.) operator and the descendent accessor (..) operator to access child properties of an XML object. Consider the following XML object:

```
var myXML:XML =
    <order>
        <book ISBN="0942407296">
            <title>Baking Extravagant Pastries with Kumquats</title>
            <author>
                <lastName>Contino</lastName>
                <firstName>Chuck</firstName>
            </author>
            <pageCount>238</pageCount>
        </book>
        <book ISBN="0865436401">
            <title>Emu Care and Breeding</title>
            <editor>
                <lastName>Case</lastName>
                <firstName>Justin</firstName>
            </editor>
            <pageCount>115</pageCount>
        </book>
    </order>
```

The object `myXML.book` is an XMLList object containing child properties of the `myXML` object that have the name `book`. These are two XML objects, matching the two `book` properties of the `myXML` object.

The object `myXML..lastName` is an XMLList object containing any descendent properties with the name `lastName`. These are two XML objects, matching the two `lastName` of the `myXML` object.

The object `myXML.book.editor.lastName` is an XMLList object containing any children with the name `lastName` of children with the name `editor` of children with the name `book` of the `myXML` object: in this case, an XMLList object containing only one XML object (the `lastName` property with the value "`Case`").

Accessing parent and child nodes

Flash Player 9 and later, Adobe AIR 1.0 and later

The `parent()` method returns the parent of an XML object.

You can use the ordinal index values of a child list to access specific child objects. For example, consider an XML object `myXML` that has two child properties named `book`. Each child property named `book` has an index number associated with it:

```
myXML.book[0]
myXML.book[1]
```

To access a specific grandchild, you can specify index numbers for both the child and grandchild names:

```
myXML.book[0].title[0]
```

However, if there is only one child of `x.book[0]` that has the name `title`, you can omit the index reference, as follows:

```
myXML.book[0].title
```

Similarly, if there is only one book child of the object `x`, and if that child object has only one title object, you can omit both index references, like this:

```
myXML.book.title
```

You can use the `child()` method to navigate to children with names based on a variable or expression, as the following example shows:

```
var myXML:XML =
        <order>
            <book>
                <title>Dictionary</title>
            </book>
        </order>;

var childName:String = "book";

trace(myXML.child(childName).title) // output: Dictionary
```

Accessing attributes

Flash Player 9 and later, Adobe AIR 1.0 and later

Use the `@` symbol (the attribute identifier operator) to access attributes in an XML or XMLList object, as shown in the following code:

```
var employee:XML =
    <employee id="6401" code="233">
        <lastName>Wu</lastName>
        <firstName>Erin</firstName>
    </employee>;
trace(employee.@id); // 6401
```

You can use the `*` wildcard symbol with the `@` symbol to access all attributes of an XML or XMLList object, as in the following code:

```
var employee:XML =
    <employee id="6401" code="233">
        <lastName>Wu</lastName>
        <firstName>Erin</firstName>
    </employee>;
trace(employee.@*.toXMLString());
// 6401
// 233
```

You can use the `attribute()` or `attributes()` method to access a specific attribute or all attributes of an XML or XMLList object, as in the following code:

```
var employee:XML =
    <employee id="6401" code="233">
        <lastName>Wu</lastName>
        <firstName>Erin</firstName>
    </employee>;
trace(employee.attribute("id")); // 6401
trace(employee.attribute("*").toXMLString());
// 6401
// 233
trace(employee.attributes().toXMLString());
// 6401
// 233
```

Note that you can also use the following syntax to access attributes, as the following example shows:

```
employee.attribute("id")
employee["@id"]
employee.@["id"]
```

These are each equivalent to `employee.@id`. However, the syntax `employee.@id` is the preferred approach.

Filtering by attribute or element value

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the parentheses operators— `(` and `)` —to filter elements with a specific element name or attribute value. Consider the following XML object:

```
var x:XML =
    <employeeList>
        <employee id="347">
            <lastName>Zmed</lastName>
            <firstName>Sue</firstName>
            <position>Data analyst</position>
        </employee>
        <employee id="348">
            <lastName>McGee</lastName>
            <firstName>Chuck</firstName>
            <position>Jr. data analyst</position>
        </employee>
    </employeeList>
```

The following expressions are all valid:

- `x.employee.(lastName == "McGee")`—This is the second `employee` node.
- `x.employee.(lastName == "McGee").firstName`—This is the `firstName` property of the second `employee` node.
- `x.employee.(lastName == "McGee").@id`—This is the value of the `id` attribute of the second `employee` node.
- `x.employee.(@id == 347)`—The first `employee` node.
- `x.employee.(@id == 347).lastName`—This is the `lastName` property of the first `employee` node.
- `x.employee.(@id > 300)`—This is an XMLList with both `employee` properties.
- `x.employee.(position.toString().search("analyst") > -1)`—This is an XMLList with both `position` properties.

If you try to filter on attributes or elements that do not exist, an exception is thrown. For example, the final line of the following code generates an error, because there is no `id` attribute in the second `p` element:

```
var doc:XML = 
            <body>
                <p id='123'>Hello, <b>Bob</b>.</p>
                <p>Hello.</p>
            </body>;
trace(doc.p.(@id == '123'));
```

Similarly, the final line of following code generates an error because there is no `b` property of the second `p` element:

```
var doc:XML = 
            <body>
                <p id='123'>Hello, <b>Bob</b>.</p>
                <p>Hello.</p>
            </body>;
trace(doc.p.(b == 'Bob'));
```

To avoid these errors, you can identify the properties that have the matching attributes or elements by using the `attribute()` and `elements()` methods, as in the following code:

```
var doc:XML = 
            <body>
                <p id='123'>Hello, <b>Bob</b>.</p>
                <p>Hello.</p>
            </body>;
trace(doc.p.(attribute('id') == '123'));
trace(doc.p.(elements('b') == 'Bob'));
```

You can also use the `hasOwnProperty()` method, as in the following code:

```
var doc:XML = 
            <body>
                <p id='123'>Hello, <b>Bob</b>.</p>
                <p>Hello.</p>
            </body>;
trace(doc.p.(hasOwnProperty('@id') && @id == '123'));
trace(doc.p.(hasOwnProperty('b') && b == 'Bob'));
```

Using the for..in and the for each..in statements

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 includes the `for..in` statement and the `for each..in` statement for iterating through XMLList objects. For example, consider the following XML object, `myXML`, and the XMLList object, `myXML.item`. The XMLList object, `myXML.item,` consists of the two `item` nodes of the XML object.

```
var myXML:XML = 
    <order>
        <item id='1' quantity='2'>
            <menuName>burger</menuName>
            <price>3.95</price>
        </item>
        <item id='2' quantity='2'>
            <menuName>fries</menuName>
            <price>1.45</price>
        </item>
    </order>;
```

The `for..in` statement lets you iterate over a set of property names in an XMLList:

```
var total:Number = 0;
for (var pname:String in myXML.item)
{
    total += myXML.item.@quantity[pname] * myXML.item.price[pname];
}
```

The `for each..in` statement lets you iterate through the properties in the XMLList:

```
var total2:Number = 0;
for each (var prop:XML in myXML.item)
{
    total2 += prop.@quantity * prop.price;
}
```

Using XML namespaces

Flash Player 9 and later, Adobe AIR 1.0 and later

Namespaces in an XML object (or document) identify the type of data that the object contains. For example, in sending and delivering XML data to a web service that uses the SOAP messaging protocol, you declare the namespace in the opening tag of the XML:

```
var message:XML = 
    <soap:Envelope xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/"
    soap:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
        <soap:Body xmlns:w="http://www.test.com/weather/">
            <w:getWeatherResponse>
                <w:tempurature >78</w:tempurature>
            </w:getWeatherResponse>
        </soap:Body>
    </soap:Envelope>;
```

The namespace has a prefix, `soap`, and a URI that defines the namespace, `http://schemas.xmlsoap.org/soap/envelope/`.

ActionScript 3.0 includes the Namespace class for working with XML namespaces. For the XML object in the previous example, you can use the Namespace class as follows:

```
var soapNS:Namespace = message.namespace("soap");
trace(soapNS); // Output: http://schemas.xmlsoap.org/soap/envelope/

var wNS:Namespace = new Namespace("w", "http://www.test.com/weather/");
message.addNamespace(wNS);
var encodingStyle:XMLList = message.@soapNS::encodingStyle;
var body:XMLList = message.soapNS::Body;

message.soapNS::Body.wNS::GetWeatherResponse.wNS::tempurature = "78";
```

The XML class includes the following methods for working with namespaces: `addNamespace()`, `inScopeNamespaces()`, `localName()`, `name()`, `namespace()`, `namespaceDeclarations()`, `removeNamespace()`, `setLocalName()`, `setName()`, and `setNamespace()`.

The `default xml namespace` directive lets you assign a default namespace for XML objects. For example, in the following, both `x1` and `x2` have the same default namespace:

```
var ns1:Namespace = new Namespace("http://www.example.com/namespaces/");
default xml namespace = ns1;
var x1:XML = <test1 />;
var x2:XML = <test2 />;
```

XML type conversion

Flash Player 9 and later, Adobe AIR 1.0 and later

You can convert XML objects and XMLList objects to String values. Similarly, you can convert strings to XML objects and XMLList objects. Also, keep in mind that all XML attribute values, names, and text values are strings. The following sections discuss all these forms of XML type conversion.

Converting XML and XMLList objects to strings

Flash Player 9 and later, Adobe AIR 1.0 and later

The XML and XMLList classes include a `toString()` method and a `toXMLString()` method. The `toXMLString()` method returns a string that includes all tags, attributes, namespace declarations, and content of the XML object. For XML objects with complex content (child elements), the `toString()` method does exactly the same as the `toXMLString()` method. For XML objects with simple content (those that contain only one text element), the `toString()` method returns only the text content of the element, as the following example shows:

```
var myXML:XML = 
    <order>
        <item id='1' quantity='2'>
            <menuName>burger</menuName>
            <price>3.95</price>
        </item>
    <order>;

trace(myXML.item[0].menuName.toXMLString()); 
    // <menuName>burger</menuName>
trace(myXML.item[0].menuName.toString());
    // burger
```

If you use the `trace()` method without specifying `toString()` or `toXMLString()`, the data is converted using the `toString()` method by default, as this code shows:

```
var myXML:XML = 
    <order>
        <item id='1' quantity='2'>
            <menuName>burger</menuName>
            <price>3.95</price>
        </item>
    <order>;

trace(myXML.item[0].menuName); 
    // burger
```

When using the `trace()` method to debug code, you will often want to use the `toXMLString()` method so that the `trace()` method outputs more complete data.

Converting strings to XML objects

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `new XML()` constructor to create an XML object from a string, as follows:

```
var x:XML = new XML("<a>test</a>");
```

If you attempt to convert a string to XML from a string that represents invalid XML or XML that is not well formed, a run-time error is thrown, as follows:

```
var x:XML = new XML("<a>test"); // throws an error
```

Converting attribute values, names, and text values from strings

Flash Player 9 and later, Adobe AIR 1.0 and later

All XML attribute values, names, and text values are String data types, and you may need to convert these to other data types. For example, the following code uses the `Number()` function to convert text values to numbers:

```
var myXML:XML = 
                        <order>
                            <item>
                                <price>3.95</price>
                            </item>
                            <item>
                                <price>1.00</price>
                            </item>
                        </order>;

var total:XML = <total>0</total>;
myXML.appendChild(total);

for each (var item:XML in myXML.item)
{
    myXML.total.children()[0] = Number(myXML.total.children()[0])
                                                + Number(item.price.children()[0]);
}
trace(myXML.total); // 4.95;
```

If this code did not use the `Number()` function, the code would interpret the + operator as the string concatenation operator, and the `trace()` method in the last line would output the following:

```
01.003.95
```

Reading external XML documents

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the URLLoader class to load XML data from a URL. To use the following code in your applications, replace the `XML_URL` value in the example with a valid URL:

```
import flash.events.Event;
import flash.net.URLLoader;

var myXML:XML = new XML();
var XML_URL:String = "http://www.example.com/Sample3.xml";
var myXMLURL:URLRequest = new URLRequest(XML_URL);
var myLoader:URLLoader = new URLLoader(myXMLURL);
myLoader.addEventListener(Event.COMPLETE, xmlLoaded);

function xmlLoaded(event:Event):void
{
    myXML = XML(myLoader.data);
    trace("Data loaded.");
}
```

You can also use the XMLSocket class to set up an asynchronous XML socket connection with a server. For more information, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

XML in ActionScript example: Loading RSS data from the Internet

Flash Player 9 and later, Adobe AIR 1.0 and later

The RSSViewer sample application shows a number of features of working with XML in ActionScript, including the following:

- Using XML methods to traverse XML data in the form of an RSS feed.
- Using XML methods to assemble XML data in the form of HTML to use in a text field.

The RSS format is widely used to syndicate news via XML. A simple RSS data file may look like the following:

```
<?xml version="1.0" encoding="UTF-8" ?>
<rss version="2.0" xmlns:dc="http://purl.org/dc/elements/1.1/">
<channel>
    <title>Alaska - Weather</title>
    <link>http://www.nws.noaa.gov/alerts/ak.html</link>
    <description>Alaska - Watches, Warnings and Advisories</description>

    <item>
        <title>
            Short Term Forecast - Taiya Inlet, Klondike Highway (Alaska)
        </title>
        <link>
            http://www.nws.noaa.gov/alerts/ak.html#A18.AJKNK.1900
        </link>
        <description>
            Short Term Forecast Issued At: 2005-04-11T19:00:00
            Expired At: 2005-04-12T01:00:00 Issuing Weather Forecast Office
            Homepage: http://pajk.arh.noaa.gov
        </description>
</item>
    <item>
        <title>
            Short Term Forecast - Haines Borough (Alaska)
        </title>
            <link>
            http://www.nws.noaa.gov/alerts/ak.html#AKZ019.AJKNOWAJK.190000
        </link>
        <description>
            Short Term Forecast Issued At: 2005-04-11T19:00:00
            Expired At: 2005-04-12T01:00:00 Issuing Weather Forecast Office
            Homepage: http://pajk.arh.noaa.gov
        </description>
    </item>
</channel>
</rss>
```

The SimpleRSS application reads RSS data from the Internet, parses the data for headlines (titles), links, and descriptions, and returns that data. The SimpleRSSUI class provides the UI and calls the SimpleRSS class, which does all of the XML processing.

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The RSSViewer application files can be found in the folder Samples/RSSViewer. The application consists of the following files:

File	Description
RSSViewer.mxml or RSSViewer.fla	The main application file in Flash (FLA) or Flex (MXML).
com/example/programmingas3/rssViewer/RSSParser.as	A class that contains methods that use E4X to traverse RSS (XML) data and generate a corresponding HTML representation.
RSSData/ak.rss	A sample RSS file. The application is set up to read RSS data from the web, at a Flex RSS feed hosted by Adobe. However, you can easily change the application to read RSS data from this document, which uses a slightly different schema than that of the Flex RSS feed.

Reading and parsing XML data

Flash Player 9 and later, Adobe AIR 1.0 and later

The RSSParser class includes an `xmlLoaded()` method that converts the input RSS data, stored in the `rssXML` variable, into an string containing HTML-formatted output, `rssOutput`.

Near the beginning of the method, code sets the default XML namespace if the source RSS data includes a default namespace:

```
if (rssXML.namespace("") != undefined)
{
    default xml namespace = rssXML.namespace("");
}
```

The next lines then loop through the contents of the source XML data, examining each descendant property named `item`:

```
for each (var item:XML in rssXML..item)
{
    var itemTitle:String = item.title.toString();
    var itemDescription:String = item.description.toString();
    var itemLink:String = item.link.toString();
    outXML += buildItemHTML(itemTitle,
                            itemDescription,
                            itemLink);
}
```

The first three lines simply set string variables to represent the title, description and link properties of the `item` property of the XML data. The next line then calls the `buildItemHTML()` method to get HTML data in the form of an XMLList object, using the three new string variables as parameters.

Assembling XMLList data

Flash Player 9 and later, Adobe AIR 1.0 and later

The HTML data (an XMLList object) is of the following form:

```
<b>itemTitle</b>
<p>
    itemDescription
    <br />
    <a href="link">
        <font color="#008000">More...</font>
    </a>
</p>
```

The first lines of the method clear the default xml namespace:

```
default xml namespace = new Namespace();
```

The `default xml namespace` directive has function block-level scope. This means that the scope of this declaration is the `buildItemHTML()` method.

The lines that follow assemble the XMLList, based on the string arguments passed to the function:

```
var body:XMLList = new XMLList();
body += new XML("<b>" + itemTitle + "</b>");
var p:XML = new XML("<p>" + itemDescription + "</p>");

var link:XML = <a></a>;
link.@href = itemLink; // <link href="itemLinkString"></link>
link.font.@color = "#008000";
        // <font color="#008000"></font></a>
        // 0x008000 = green
link.font = "More...";

p.appendChild(<br/>);
p.appendChild(link);
body += p;
```

This XMLList object represents string data suitable for an ActionScript HTML text field.

The `xmlLoaded()` method uses the return value of the `buildItemHTML()` method and converts it to a string:

```
XML.prettyPrinting = false;
rssOutput = outXML.toXMLString();
```

Extracting the title of the RSS feed and sending a custom event

Flash Player 9 and later, Adobe AIR 1.0 and later

The `xmlLoaded()` method sets a `rssTitle` string variable, based on information in the source RSS XML data:

```
rssTitle = rssXML.channel.title.toString();
```

Finally, the `xmlLoaded()` method generates an event, which notifies the application that the data is parsed and available:

```
            dataWritten = new Event("dataWritten", true);
```

Chapter 7: Using native JSON functionality

ActionScript 3.0 provides a native API for encoding and decoding ActionScript objects using JavaScript Object Notation (JSON) format. The JSON class and supporting member functions follow the ECMA-262 5th edition specification with few variances.

Community member Todd Anderson provides a comparison of the native JSON API and the third-party as3corelib JSON class. See Working with Native JSON in Flash Player 11.

More Help topics

JSON

Overview of the JSON API

The ActionScript JSON API consists of the JSON class and `toJSON()` member functions on a few native classes. For applications that require a custom JSON encoding for any class, the ActionScript framework provides ways to override the default encoding.

The JSON class internally handles import and export for any ActionScript class that does not provide a `toJSON()` member. For such cases, JSON traverses the public properties of each object it encounters. If an object contains other objects, JSON recurses into the nested objects and performs the same traversal. If any object provides a `toJSON()` method, JSON uses that custom method instead of its internal algorithm.

The JSON interface consists of an encoding method, `stringify()`, and a decoding method, `parse()`. Each of these methods provides a parameter that lets you insert your own logic into the JSON encoding or decoding workflow. For `stringify()`, this parameter is named `replacer`; for `parse()`, it is `reviver`. These parameters take a function definition with two arguments using the following signature:

```
function(k, v):*
```

toJSON() methods

The signature for `toJSON()` methods is

```
public function toJSON(k:String):*
```

`JSON.stringify()` calls `toJSON()`, if it exists, for each public property that it encounters during its traversal of an object. A property consists of a key-value pair. When `stringify()` calls `toJSON()`, it passes in the key, `k`, of the property that it is currently examining. A typical `toJSON()` implementation evaluates each property name and returns the desired encoding of its value.

The `toJSON()` method can return a value of any type (denoted as *)—not just a String. This variable return type allows `toJSON()` to return an object if appropriate. For example, if a property of your custom class contains an object from another third-party library, you can return that object when `toJSON()` encounters your property. JSON then recurses into the third-party object. The encoding process flow behaves as follows:

- If `toJSON()` returns an object that doesn't evaluate to a string, `stringify()` recurses into that object.

- If `toJSON()` returns a string, `stringify()` wraps that value in another string, returns the wrapped string, and then moves to the next value.

In many cases, returning an object is preferable to returning a JSON string created by your application. Returning an object takes leverages the built-in JSON encoding algorithm and also allows JSON to recurse into nested objects.

The `toJSON()`method is not defined in the Object class or in most other native classes. Its absence tells JSON to perform its standard traversal over the object's public properties. If you like, you can also use `toJSON()` to expose your object's private properties.

A few native classes pose challenges that the ActionScript libraries can't solve effectively for all use cases. For these classes, ActionScript provides a trivial implementation that clients can reimplement to suit their needs. The classes that provide trivial `toJSON()` members include:

- ByteArray
- Date
- Dictionary
- XML

You can subclass the ByteArray class to override its `toJSON()` method, or you can redefine its prototype. The Date and XML classes, which are declared final, require you to use the class prototype to redefine `toJSON()`. The Dictionary class is declared dynamic, which gives you extra freedom in overriding `toJSON()`.

Defining custom JSON behavior

To implement your own JSON encoding and decoding for native classes, you can choose from several options:

- Defining or overriding `toJSON()`on your custom subclass of a non-final native class
- Defining or redefining `toJSON()` on the class prototype
- Defining a `toJSON` property on a dynamic class
- Using the `JSON.stringify() replacer` and `JSON.parser() reviver` parameters

More Help topics

ECMA-262, 5th Edition

Defining toJSON() on the prototype of a built-in class

The native JSON implementation in ActionScript mirrors the ECMAScript JSON mechanism defined in ECMA-262, 5th edition. Since ECMAScript doesn't support classes, ActionScript defines JSON behavior in terms of prototype-based dispatch. Prototypes are precursors to ActionScript 3.0 classes that allow simulated inheritance as well as member additions and redefinitions.

ActionScript allows you to define or redefine `toJSON()` on the prototype of any class. This privilege applies even to classes that are marked final. When you define `toJSON()` on a class prototype, your definition becomes current for all instances of that class within the scope of your application. For example, here's how you can define a `toJSON()` method on the MovieClip prototype:

```
MovieClip.prototype.toJSON = function(k):* {
    trace("prototype.toJSON() called.");
    return "toJSON";
}
```

When your application then calls `stringify()` on any MovieClip instance, `stringify()` returns the output of your `toJSON()` method:

```
var mc:MovieClip = new MovieClip();
var js:String = JSON.stringify(mc); //"prototype toJSON() called."
trace("js: " + js); //"js: toJSON"
```

You can also override `toJSON()` in native classes that define the method. For example, the following code overrides `Date.toJSON()`:

```
Date.prototype.toJSON = function (k):* {
    return "any date format you like via toJSON: "+
        "this.time:"+this.time + " this.hours:"+this.hours;
}
var dt:Date = new Date();
trace(JSON.stringify(dt));
// "any date format you like via toJSON: this.time:1317244361947 this.hours:14"
```

Defining or overriding toJSON() at the class level

Applications aren't always required to use prototypes to redefine `toJSON()`. You can also define `toJSON()` as a member of a subclass if the parent class is not marked final. For example, you can extend the ByteArray class and define a public `toJSON()` function:

```
package {

    import flash.utils.ByteArray;
    public class MyByteArray extends ByteArray
    {
        public function MyByteArray() {
        }

        public function toJSON(s:String):*
        {
            return "MyByteArray";
        }

    }
}


var ba:ByteArray = new ByteArray();
trace(JSON.stringify(ba)); //"ByteArray"
var mba:MyByteArray = new MyByteArray(); //"MyByteArray"
trace(JSON.stringify(mba)); //"MyByteArray"
```

If a class is dynamic, you can add a `toJSON` property to an object of that class and assign a function to it as follows:

```
var d:Dictionary = new Dictionary();
trace(JSON.stringify((d))); // "Dictionary"
d.toJSON = function(){return {c : "toJSON override."};} // overrides existing function
trace(JSON.stringify((d))); // {"c":"toJSON override."}
```

You can override, define, or redefine `toJSON()` on any ActionScript class. However, most built-in ActionScript classes don't define `toJSON()`. The Object class does not define `toJSON` in its default prototype or declare it as a class member. Only a handful of native classes define the method as a prototype function. Thus, in most classes you can't override `toJSON()` in the traditional sense.

Native classes that don't define `toJSON()` are serialized to JSON by the internal JSON implementation. Avoid replacing this built-in functionality if possible. If you define a `toJSON()` member, the JSON class uses your logic instead of its own functionality.

Using the JSON.stringify() replacer parameter

Overriding `toJSON()` on the prototype is useful for changing a class's JSON export behavior throughout an application. In some cases, though, your export logic might apply only to special cases under transient conditions. To accommodate such small-scope changes, you can use the `replacer` parameter of the `JSON.stringify()` method.

The `stringify()` method applies the function passed through the `replacer` parameter to the object being encoded. The signature for this function is similar to that of `toJSON()`:

```
function (k,v):*
```

Unlike `toJSON()`, the `replacer` function requires the value, `v`, as well as the key, `k`. This difference is necessary because `stringify()` is defined on the static JSON object instead of the object being encoded. When `JSON.stringify()` calls `replacer(k,v)`, it is traversing the original input object. The implicit `this` parameter passed to the `replacer` function refers to the object that holds the key and value. Because `JSON.stringify()` does not modify the original input object, that object remains unchanged in the container being traversed. Thus, you can use the code `this[k]` to query the key on the original object. The `v` parameter holds the value that `toJSON()` converts.

Like `toJSON()`, the `replacer` function can return any type of value. If `replacer` returns a string, the JSON engine escapes the contents in quotes and then wraps those escaped contents in quotes as well. This wrapping guarantees that `stringify()` receives a valid JSON string object that remains a string in a subsequent call to `JSON.parse()`.

The following code uses the `replacer` parameter and the implicit `this` parameter to return the `time` and `hours` values of a Date object:

```
JSON.stringify(d, function (k,v):* {
    return "any date format you like via replacer: "+
        "holder[k].time:"+this[k].time + " holder[k].hours:"+this[k].hours;
});
```

Using the JSON.parse() reviver parameter

The `reviver` parameter of the `JSON.parse()` method does the opposite of the `replacer` function: It converts a JSON string into a usable ActionScript object. The `reviver` argument is a function that takes two parameters and returns any type:

```
function (k,v):*
```

In this function, `k` is a key, and `v` is the value of `k`. Like `stringify()`, `parse()` traverses the JSON key-value pairs and applies the `reviver` function—if one exists—to each pair. A potential problem is the fact that the JSON class does not output an object's ActionScript class name. Thus, it can be challenging to know which type of object to revive. This problem can be especially troublesome when objects are nested. In designing `toJSON()`, `replacer`, and `reviver` functions, you can devise ways to identify the ActionScript objects that are exported while keeping the original objects intact.

Parsing example

The following example shows a strategy for reviving objects parsed from JSON strings. This example defines two classes: JSONGenericDictExample and JSONDictionaryExtnExample. Class JSONGenericDictExample is a custom dictionary class. Each record contains a person's name and birthday, as well as a unique ID. Each time the JSONGenericDictExample constructor is called, it adds the newly created object to an internal static array with a statically incrementing integer as its ID. Class JSONGenericDictExample also defines a `revive()` method that extracts just the integer portion from the longer `id` member. The `revive()` method uses this integer to look up and return the correct revivable object.

Class JSONDictionaryExtnExample extends the ActionScript Dictionary class. Its records have no set structure and can contain any data. Data is assigned after a JSONDictionaryExtnExample object is constructed, rather than as class-defined properties. JSONDictionaryExtnExample records use JSONGenericDictExample objects as keys. When a JSONDictionaryExtnExample object is revived, the `JSONGenericDictExample.revive()` function uses the ID associated with JSONDictionaryExtnExample to retrieve the correct key object.

Most importantly, the `JSONDictionaryExtnExample.toJSON()` method returns a marker string in addition to the JSONDictionaryExtnExample object. This string identifies the JSON output as belonging to the JSONDictionaryExtnExample class. This marker leaves no doubt as to which object type is being processed during `JSON.parse()`.

```
package {
    // Generic dictionary example:
    public class JSONGenericDictExample {
        static var revivableObjects = [];
        static var nextId = 10000;
        public var id;
        public var dname:String;
        public var birthday;

        public function JSONGenericDictExample(name, birthday) {
            revivableObjects[nextId] = this;
            this.id       = "id_class_JSONGenericDictExample_" + nextId;
            this.dname     = name;
            this.birthday = birthday;
            nextId++;
        }
        public function toString():String { return this.dname; }
        public static function revive(id:String):JSONGenericDictExample {
            var r:RegExp = /^id_class_JSONGenericDictExample_([0-9]*)$/;
            var res = r.exec(id);
            return JSONGenericDictExample.revivableObjects[res[1]];
        }
    }
}

package {
    import flash.utils.Dictionary;
    import flash.utils.ByteArray;

    // For this extension of dictionary, we serialize the contents of the
    // dictionary by using toJSON
    public final class JSONDictionaryExtnExample extends Dictionary {
        public function toJSON(k):* {
            var contents = {};
            for (var a in this) {
                contents[a.id] = this[a];
            }

            // We also wrap the contents in an object so that we can
            // identify it by looking for the marking property "class E"
            // while in the midst of JSON.parse.
            return {"class JSONDictionaryExtnExample": contents};
        }

        // This is just here for debugging and for illustration
        public function toString():String {
            var retval = "[JSONDictionaryExtnExample <";
            var printed_any = false;
            for (var k in this) {
                retval += k.toString() + "=" +
                "[e="+this[k].earnings +
                ",v="+this[k].violations + "], "
                printed_any = true;
            }
            if (printed_any)
                retval = retval.substring(0, retval.length-2);
            retval += ">]"
            return retval;
        }
    }
}
```

When the following runtime script calls `JSON.parse()` on a JSONDictionaryExtnExample object, the `reviver` function calls `JSONGenericDictExample.revive()` on each object in JSONDictionaryExtnExample. This call extracts the ID that represents the object key. The `JSONGenericDictExample.revive()`function uses this ID to retrieve and return the stored JSONDictionaryExtnExample object from a private static array.

```
import flash.display.MovieClip;
import flash.text.TextField;

var a_bob1:JSONGenericDictExample = new JSONGenericDictExample("Bob", new
Date(Date.parse("01/02/1934")));
var a_bob2:JSONGenericDictExample = new JSONGenericDictExample("Bob", new
Date(Date.parse("05/06/1978")));
var a_jen:JSONGenericDictExample = new JSONGenericDictExample("Jen", new
Date(Date.parse("09/09/1999")));

var e = new JSONDictionaryExtnExample();
e[a_bob1] = {earnings: 40, violations: 2};
e[a_bob2] = {earnings: 10, violations: 1};
e[a_jen]  = {earnings: 25, violations: 3};

trace("JSON.stringify(e): " + JSON.stringify(e)); // {"class JSONDictionaryExtnExample":
                        //{"id_class_JSONGenericDictExample_10001":
                        //{"earnings":10,"violations":1},
                        //"id_class_JSONGenericDictExample_10002":
                        //{"earnings":25,"violations":3},
                        //"id_class_JSONGenericDictExample_10000":
                        // {"earnings":40,"violations":2}}}

var e_result = JSON.stringify(e);
var e1 = new JSONDictionaryExtnExample();
var e2 = new JSONDictionaryExtnExample();

// It's somewhat easy to convert the string from JSON.stringify(e) back
// into a dictionary (turn it into an object via JSON.parse, then loop
// over that object's properties to construct a fresh dictionary).
//
// The harder exercise is to handle situations where the dictionaries
// themselves are nested in the object passed to JSON.stringify and
// thus does not occur at the topmost level of the resulting string.
//
// (For example: consider roundtripping something like
//   var tricky_array = [e1, [[4, e2, 6]], {table:e3}]
// where e1, e2, e3 are all dictionaries.  Furthermore, consider
// dictionaries that contain references to dictionaries.)
//
// This parsing (or at least some instances of it) can be done via
// JSON.parse, but it's not necessarily trivial.  Careful consideration
// of how toJSON, replacer, and reviver can work together is
// necessary.

var e_roundtrip =
    JSON.parse(e_result,
           // This is a reviver that is focused on rebuilding JSONDictionaryExtnExample objects.
               function (k, v) {
                    if ("class JSONDictionaryExtnExample" in v) { // special marker tag;
                        //see JSONDictionaryExtnExample.toJSON().
                       var e = new JSONDictionaryExtnExample();
                       var contents = v["class JSONDictionaryExtnExample"];
                       for (var i in contents) {
                          // Reviving JSONGenericDictExample objects from string
                          // identifiers is also special;
                          // see JSONGenericDictExample constructor and
                          // JSONGenericDictExample's revive() method.
                           e[JSONGenericDictExample.revive(i)] = contents[i];
                       }
                       return e;
                   } else {
                       return v;
                   }
               });

trace("// == Here is an extended Dictionary that has been round-tripped  ==");
trace("// == Note that we have revived Jen/Jan during the roundtrip.    ==");
trace("e:           " + e); //[JSONDictionaryExtnExample <Bob=[e=40,v=2], Bob=[e=10,v=1],
                           //Jen=[e=25,v=3]>]
trace("e_roundtrip: " + e_roundtrip); //[JSONDictionaryExtnExample <Bob=[e=40,v=2],
                                     //Bob=[e=10,v=1], Jen=[e=25,v=3]>]
trace("Is e_roundtrip a JSONDictionaryExtnExample? " + (e_roundtrip is
JSONDictionaryExtnExample)); //true
trace("Name change: Jen is now Jan");
a_jen.dname = "Jan"

trace("e:           " + e); //[JSONDictionaryExtnExample <Bob=[e=40,v=2], Bob=[e=10,v=1],
                           //Jan=[e=25,v=3]>]
trace("e_roundtrip: " + e_roundtrip); //[JSONDictionaryExtnExample <Bob=[e=40,v=2],
                                     //Bob=[e=10,v=1], Jan=[e=25,v=3]>]
```

Chapter 8: Handling events

Flash Player 9 and later, Adobe AIR 1.0 and later

An event-handling system allows programmers to respond to user input and system events in a convenient way. The ActionScript 3.0 event model is not only convenient, but also standards-compliant, and well integrated with the display list. Based on the Document Object Model (DOM) Level 3 Events Specification, an industry-standard event-handling architecture, the new event model provides a powerful yet intuitive event-handling tool for ActionScript programmers.

The ActionScript 3.0 event-handling system interacts closely with the display list. To gain a basic understanding of the display list, read “Display programming” on page 151.

More Help topics

flash.events package

Document Object Model (DOM) Level 3 Events Specification

Basics of handling events

Flash Player 9 and later, Adobe AIR 1.0 and later

You can think of events as occurrences of any kind in your SWF file that are of interest to you as a programmer. For example, most SWF files support user interaction of some sort—whether it's something as simple as responding to a mouse click or something more complex, such as accepting and processing data entered into a form. Any such user interaction with your SWF file is considered an event. Events can also occur without any direct user interaction, such as when data has finished loading from a server or when an attached camera has become active.

In ActionScript 3.0, each event is represented by an event object, which is an instance of the Event class or one of its subclasses. An event object not only stores information about a specific event, but also contains methods that facilitate manipulation of the event object. For example, when Flash Player or AIR detects a mouse click, it creates an event object (an instance of the MouseEvent class) to represent that particular mouse click event.

After creating an event object, Flash Player or AIR *dispatches* it, which means that the event object is passed to the object that is the target of the event. An object that serves as the destination for a dispatched event object is called an *event target*. For example, when an attached camera becomes active, Flash Player dispatches an event object directly to the event target, which in this case is the object that represents the camera. If the event target is on the display list, however, the event object is passed down through the display list hierarchy until it reaches the event target. In some cases, the event object then “bubbles” back up the display list hierarchy along the same route. This traversal of the display list hierarchy is called the *event flow*.

You can “listen” for event objects in your code using event listeners. *Event listeners* are the functions or methods that you write to respond to specific events. To ensure that your program responds to events, you must add event listeners either to the event target or to any display list object that is part of an event object’s event flow.

Any time you write event listener code, it follows this basic structure (elements in bold are placeholders you’d fill in for your specific case):

```
function eventResponse(eventObject:EventType):void
{
    // Actions performed in response to the event go here.
}

eventTarget.addEventListener(EventType.EVENT_NAME, eventResponse);
```

This code does two things. First, it defines a function, which is the way to specify the actions that will be performed in response to the event. Next, it calls the `addEventListener()` method of the source object, in essence "subscribing" the function to the specified event so that when the event happens, the function's actions are carried out. When the event actually happens, the event target checks its list of all the functions and methods that are registered as event listeners. It then calls each one in turn, passing the event object as a parameter.

You need to alter four things in this code to create your own event listener. First, you must change the name of the function to the name you want to use (this must be changed in two places, where the code says **eventResponse**). Second, you must specify the appropriate class name of the event object that is dispatched by the event you want to listen for (**EventType** in the code), and you must specify the appropriate constant for the specific event (**EVENT_NAME** in the listing). Third, you must call the `addEventListener()` method on the object that will dispatch the event (**eventTarget** in this code). Optionally, you can change the name of the variable used as the function's parameter (**eventObject** in this code).

Important concepts and terms

The following reference list contains important terms that you will encounter when writing event-handling routines:

Bubbling Bubbling occurs for some events so that a parent display object can respond to events dispatched by its children.

Bubbling phase The part of the event flow in which an event propagates up to parent display objects. The bubbling phase occurs after the capture and target phases.

Capture phase The part of the event flow in which an event propagates down from the most general target to the most specific target object. The capture phase occurs before the target and bubbling phases.

Default behavior Some events include a behavior that normally happens along with the event, known as the default behavior. For example, when a user types text in a text field, a text input event is raised. The default behavior for that event is to actually display the character that was typed into the text field—but you can override that default behavior (if for some reason you don't want the typed character to be displayed).

Dispatch To notify event listeners that an event has occurred.

Event Something that happens to an object that the object can tell other objects about.

Event flow When events happen to an object on the display list (an object displayed on the screen), all the objects that contain the object are notified of the event and notify their event listeners in turn. This process starts with the Stage and proceeds through the display list to the actual object where the event occurred, and then proceeds back to the Stage again. This process is known as the event flow.

Event object An object that contains information about a particular event's occurrence, which is sent to all listeners when an event is dispatched.

Event target The object that actually dispatches an event. For example, if the user clicks a button that is inside a Sprite that is in turn inside the Stage, all those objects dispatch events, but the event target is the one where the event actually happened—in this case, the clicked button.

Listener An object or function that has registered itself with an object, to indicate that it should be notified when a specific event takes place.

Target phase The point of the event flow at which an event has reached the most specific possible target. The target phase occurs between the capture and the bubbling phases.

How ActionScript 3.0 event handling differs from earlier versions

Flash Player 9 and later, Adobe AIR 1.0 and later

The most noticeable difference between event handling in ActionScript 3.0 and event handling in previous versions of ActionScript is that in ActionScript 3.0 there is only one system for event handling, whereas in previous versions of ActionScript there are several different event-handling systems. This section begins with an overview of how event handling worked in previous versions of ActionScript, and then discusses how event handling has changed for ActionScript 3.0.

Event handling in previous versions of ActionScript

Flash Player 9 and later, Adobe AIR 1.0 and later

Versions of ActionScript before ActionScript 3.0 provided a number of different ways to handle events:

- `on()` event handlers that can be placed directly on Button and MovieClip instances
- `onClipEvent()` handlers that can be placed directly on MovieClip instances
- Callback function properties, such as `XML.onload` and `Camera.onActivity`
- Event listeners that you register using the `addListener()` method
- The UIEventDispatcher class that partially implemented the DOM event model.

Each of these mechanisms presents its own set of advantages and limitations. The `on()` and `onClipEvent()` handlers are easy to use, but make subsequent maintenance of projects more difficult because code placed directly on buttons and movie clips can be difficult to find. Callback functions are also simple to implement, but limit you to only one callback function for any given event. Event listeners are more difficult to implement—they require not only the creation of a listener object and function, but also the registration of the listener with the object that generates the event. This increased overhead, however, enables you to create several listener objects and register them all for the same event.

The development of components for ActionScript 2.0 engendered yet another event model. This new model, embodied in the UIEventDispatcher class, was based on a subset of the DOM Events Specification. Developers who are familiar with component event handling will find the transition to the new ActionScript 3.0 event model relatively painless.

Unfortunately, the syntax used by the various event models overlap in various ways, and differ in others. For example, in ActionScript 2.0, some properties, such as `TextField.onChanged`, can be used as either a callback function or an event listener. However, the syntax for registering listener objects differs depending on whether you are using one of the six classes that support listeners or the UIEventDispatcher class. For the Key, Mouse, MovieClipLoader, Selection, Stage, and TextField classes, you use the `addListener()` method, but for components event handling, you use a method called `addEventListener()`.

Another complexity introduced by the different event-handling models was that the scope of the event handler function varied widely depending on the mechanism used. In other words, the meaning of the `this` keyword was not consistent among the event-handling systems.

Event handling in ActionScript 3.0

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 introduces a single event-handling model that replaces the many different event-handling mechanisms that existed in previous versions of the language. The new event model is based on the Document Object Model (DOM) Level 3 Events Specification. Although the SWF file format does not adhere specifically to the Document Object Model standard, there are sufficient similarities between the display list and the structure of the DOM to make implementation of the DOM event model possible. An object on the display list is analogous to a node in the DOM hierarchical structure, and the terms *display list object* and *node* are used interchangeably throughout this discussion.

The Flash Player and AIR implementation of the DOM event model includes a concept named default behaviors. A *default behavior* is an action that Flash Player or AIR executes as the normal consequence of certain events.

Default behaviors

Developers are usually responsible for writing code that responds to events. In some cases, however, a behavior is so commonly associated with an event that Flash Player or AIR automatically executes the behavior unless the developer adds code to cancel it. Because Flash Player or AIR automatically exhibits the behavior, such behaviors are called default behaviors.

For example, when a user enters text into a TextField object, the expectation that the text will be displayed in that TextField object is so common that the behavior is built into Flash Player and AIR. If you do not want this default behavior to occur, you can cancel it using the new event-handling system. When a user inputs text into a TextField object, Flash Player or AIR creates an instance of the TextEvent class to represent that user input. To prevent Flash Player or AIR from displaying the text in the TextField object, you must access that specific TextEvent instance and call that instance's `preventDefault()` method.

Not all default behaviors can be prevented. For example, Flash Player and AIR generate a MouseEvent object when a user double-clicks a word in a TextField object. The default behavior, which cannot be prevented, is that the word under the cursor is highlighted.

Many types of event objects do not have associated default behaviors. For example, Flash Player dispatches a connect event object when a network connection is established, but there is no default behavior associated with it. The API documentation for the Event class and its subclasses lists each type of event and describes any associated default behavior, and whether that behavior can be prevented.

It is important to understand that default behaviors are associated only with event objects dispatched by Flash Player or AIR, and do not exist for event objects dispatched programmatically through ActionScript. For example, you can use the methods of the EventDispatcher class to dispatch an event object of type `textInput`, but that event object will not have a default behavior associated with it. In other words, Flash Player and AIR will not display a character in a TextField object as a result of a `textInput` event that you dispatched programmatically.

What's new for event listeners in ActionScript 3.0

For developers with experience using the ActionScript 2.0 `addListener()` method, it may be helpful to point out the differences between the ActionScript 2.0 event listener model and the ActionScript 3.0 event model. The following list describes a few major differences between the two event models:

- To add event listeners in ActionScript 2.0, you use `addListener()` in some cases and `addEventListener()` in others, whereas in ActionScript 3.0, you use `addEventListener()` in all situations.
- There is no event flow in ActionScript 2.0, which means that the `addListener()` method can be called only on the object that broadcasts the event, whereas in ActionScript 3.0, the `addEventListener()` method can be called on any object that is part of the event flow.

- In ActionScript 2.0, event listeners can be either functions, methods, or objects, whereas in ActionScript 3.0, only functions or methods can be event listeners.

The event flow

Flash Player 9 and later, Adobe AIR 1.0 and later

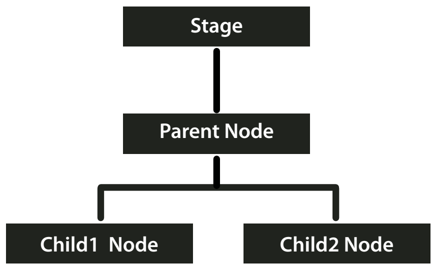
Flash Player or AIR dispatches event objects whenever an event occurs. If the event target is not on the display list, Flash Player or AIR dispatches the event object directly to the event target. For example, Flash Player dispatches the progress event object directly to a URLStream object. If the event target is on the display list, however, Flash Player dispatches the event object into the display list, and the event object travels through the display list to the event target.

The *event flow* describes how an event object moves through the display list. The display list is organized in a hierarchy that can be described as a tree. At the top of the display list hierarchy is the Stage, which is a special display object container that serves as the root of the display list. The Stage is represented by the flash.display.Stage class and can only be accessed through a display object. Every display object has a property named `stage` that refers to the Stage for that application.

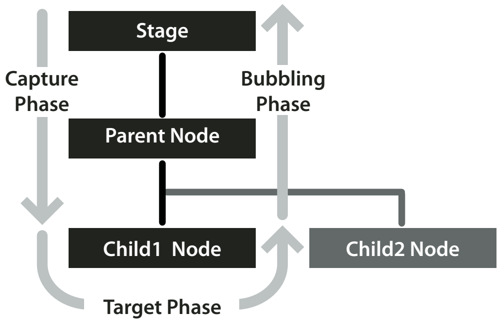
When Flash Player or AIR dispatches an event object for a display list-related event, that event object makes a round-trip journey from the Stage to the *target node*. The DOM Events Specification defines the target node as the node representing the event target. In other words, the target node is the display list object where the event occurred. For example, if a user clicks on a display list object named `child1`, Flash Player or AIR will dispatch an event object using `child1` as the target node.

The event flow is conceptually divided into three parts. The first part is called the capture phase; this phase comprises all of the nodes from the Stage to the parent of the target node. The second part is called the target phase, which consists solely of the target node. The third part is called the bubbling phase. The bubbling phase comprises the nodes encountered on the return trip from the parent of the target node back to the Stage.

The names of the phases make more sense if you conceive of the display list as a vertical hierarchy with the Stage at the top, as shown in the following diagram:



If a user clicks on `Child1 Node`, Flash Player or AIR dispatches an event object into the event flow. As the following image shows, the object's journey starts at `Stage`, moves down to `Parent Node`, then moves to `Child1 Node,` and then "bubbles" back up to `Stage`, moving through `Parent Node` again on its journey back to `Stage`.



In this example, the capture phase comprises `Stage` and `Parent Node` during the initial downward journey. The target phase comprises the time spent at `Child1 Node`. The bubbling phase comprises `Parent Node` and `Stage` as they are encountered during the upward journey back to the root node.

The event flow contributes to a more powerful event-handling system than that previously available to ActionScript programmers. In previous versions of ActionScript, the event flow does not exist, which means that event listeners can be added only to the object that generates the event. In ActionScript 3.0, you can add event listeners not only to a target node, but also to any node along the event flow.

The ability to add event listeners along the event flow is useful when a user interface component comprises more than one object. For example, a button object often contains a text object that serves as the button's label. Without the ability to add a listener to the event flow, you would have to add a listener to both the button object and the text object to ensure that you receive notification about click events that occur anywhere on the button. The existence of the event flow, however, allows you to place a single event listener on the button object that handles click events that occur either on the text object or on the areas of the button object that are not obscured by the text object.

Not every event object, however, participates in all three phases of the event flow. Some types of events, such as the `enterFrame` and `init` event types, are dispatched directly to the target node and participate in neither the capture phase nor the bubbling phase. Other events may target objects that are not on the display list, such as events dispatched to an instance of the Socket class. These event objects will also flow directly to the target object, without participating in the capture and bubbling phases.

To find out how a particular event type behaves, you can either check the API documentation or examine the event object's properties. Examining the event object's properties is described in the following section.

Event objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Event objects serve two main purposes in the new event-handling system. First, event objects represent actual events by storing information about specific events in a set of properties. Second, event objects contain a set of methods that allow you to manipulate event objects and affect the behavior of the event-handling system.

To facilitate access to these properties and methods, the Flash Player API defines an Event class that serves as the base class for all event objects. The Event class defines a fundamental set of properties and methods that are common to all event objects.

This section begins with a discussion of the Event class properties, continues with a description of the Event class methods, and concludes with an explanation of why subclasses of the Event class exist.

Understanding Event class properties

Flash Player 9 and later, Adobe AIR 1.0 and later

The Event class defines a number of read-only properties and constants that provide important information about an event object.The following are especially important:

- Event object types are represented by constants and stored in the `Event.type` property.
- Whether an event's default behavior can be prevented is represented by a Boolean value and stored in the `Event.cancelable` property.
- Event flow information is contained in the remaining properties.

Event object types

Every event object has an associated event type. Event types are stored in the `Event.type` property as string values. It is useful to know the type of an event object so that your code can distinguish objects of different types from one another. For example, the following code specifies that the `clickHandler()` listener function should respond to any mouse click event objects that are passed to `myDisplayObject`:

```
myDisplayObject.addEventListener(MouseEvent.CLICK, clickHandler);
```

Some two dozen event types are associated with the Event class itself and are represented by Event class constants, some of which are shown in the following excerpt from the Event class definition:

```
package flash.events
{
    public class Event
    {
        // class constants
        public static const ACTIVATE:String = "activate";
        public static const ADDED:String= "added";
        // remaining constants omitted for brevity
    }
}
```

These constants provide an easy way to refer to specific event types. You should use these constants instead of the strings they represent. If you misspell a constant name in your code, the compiler will catch the mistake, but if you instead use strings, a typographical error may not manifest at compile time and could lead to unexpected behavior that could be difficult to debug. For example, when adding an event listener, use the following code:

```
myDisplayObject.addEventListener(MouseEvent.CLICK, clickHandler);
```

rather than:

```
myDisplayObject.addEventListener("click", clickHandler);
```

Default behavior information

Your code can check whether the default behavior for any given event object can be prevented by accessing the `cancelable` property. The `cancelable` property holds a Boolean value that indicates whether or not a default behavior can be prevented. You can prevent, or cancel, the default behavior associated with a small number of events using the `preventDefault()` method. For more information, see Canceling default event behavior under "Understanding Event class methods" on page 133.

Event flow information

The remaining Event class properties contain important information about an event object and its relationship to the event flow, as described in the following list:

- The `bubbles` property contains information about the parts of the event flow in which the event object participates.
- The `eventPhase` property indicates the current phase in the event flow.
- The `target` property stores a reference to the event target.
- The `currentTarget` property stores a reference to the display list object that is currently processing the event object.

The bubbles property

An event is said to bubble if its event object participates in the bubbling phase of the event flow, which means that the event object is passed from the target node back through its ancestors until it reaches the Stage. The `Event.bubbles` property stores a Boolean value that indicates whether the event object participates in the bubbling phase. Because all events that bubble also participate in the capture and target phases, any event that bubbles participates in all three of the event flow phases. If the value is `true`, the event object participates in all three phases. If the value is `false`, the event object does not participate in the bubbling phase.

The eventPhase property

You can determine the event phase for any event object by investigating its `eventPhase` property. The `eventPhase` property contains an unsigned integer value that represents one of the three phases of the event flow. The Flash Player API defines a separate EventPhase class that contains three constants that correspond to the three unsigned integer values, as shown in the following code excerpt:

```
package flash.events
{
    public final class EventPhase
    {
        public static const CAPTURING_PHASE:uint = 1;
        public static const AT_TARGET:uint = 2;
        public static const BUBBLING_PHASE:uint= 3;
    }
}
```

These constants correspond to the three valid values of the `eventPhase` property. You can use these constants to make your code more readable. For example, if you want to ensure that a function named `myFunc()` is called only if the event target is in the target stage, you can use the following code to test for this condition:

```
if (event.eventPhase == EventPhase.AT_TARGET)
{
    myFunc();
}
```

The target property

The `target` property holds a reference to the object that is the target of the event. In some cases, this is straightforward, such as when a microphone becomes active, the target of the event object is the Microphone object. If the target is on the display list, however, the display list hierarchy must be taken into account. For example, if a user inputs a mouse click on a point that includes overlapping display list objects, Flash Player and AIR always choose the object that is farthest away from the Stage as the event target.

For complex SWF files, especially those in which buttons are routinely decorated with smaller child objects, the `target` property may not be used frequently because it will often point to a button's child object instead of the button. In these situations, the common practice is to add event listeners to the button and use the `currentTarget` property because it points to the button, whereas the `target` property may point to a child of the button.

The currentTarget property

The `currentTarget` property contains a reference to the object that is currently processing the event object. Although it may seem odd not to know which node is currently processing the event object that you are examining, keep in mind that you can add a listener function to any display object in that event object's event flow, and the listener function can be placed in any location. Moreover, the same listener function can be added to different display objects. As a project increases in size and complexity, the `currentTarget` property becomes more and more useful.

Understanding Event class methods

Flash Player 9 and later, Adobe AIR 1.0 and later

There are three categories of Event class methods:

- Utility methods, which can create copies of an event object or convert it to a string
- Event flow methods, which remove event objects from the event flow
- Default behavior methods, which prevent default behavior or check whether it has been prevented

Event class utility methods

There are two utility methods in the Event class. The `clone()` method allows you to create copies of an event object. The `toString()` method allows you to generate a string representation of the properties of an event object along with their values. Both of these methods are used internally by the event model system, but are exposed to developers for general use.

For advanced developers creating subclasses of the Event class, you must override and implement versions of both utility methods to ensure that the event subclass will work properly.

Stopping event flow

You can call either the `Event.stopPropagation()` method or the `Event.stopImmediatePropagation()` method to prevent an event object from continuing on its way through the event flow. The two methods are nearly identical and differ only in whether the current node's other event listeners are allowed to execute:

- The `Event.stopPropagation()` method prevents the event object from moving on to the next node, but only after any other event listeners on the current node are allowed to execute.
- The `Event.stopImmediatePropagation()` method also prevents the event object from moving on to the next node, but does not allow any other event listeners on the current node to execute.

Calling either of these methods has no effect on whether the default behavior associated with an event occurs. Use the default behavior methods of the Event class to prevent default behavior.

Canceling default event behavior

The two methods that pertain to canceling default behavior are the `preventDefault()` method and the `isDefaultPrevented()` method. Call the `preventDefault()` method to cancel the default behavior associated with an event. To check whether `preventDefault()` has already been called on an event object, call the `isDefaultPrevented()` method, which returns a value of `true` if the method has already been called and `false` otherwise.

The `preventDefault()` method will work only if the event's default behavior can be cancelled. You can check whether this is the case by referring to the API documentation for that event type, or by using ActionScript to examine the `cancelable` property of the event object.

Canceling the default behavior has no effect on the progress of an event object through the event flow. Use the event flow methods of the Event class to remove an event object from the event flow.

Subclasses of the Event class

Flash Player 9 and later, Adobe AIR 1.0 and later

For many events, the common set of properties defined in the Event class is sufficient. Other events, however, have unique characteristics that cannot be captured by the properties available in the Event class. For these events, ActionScript 3.0 defines several subclasses of the Event class.

Each subclass provides additional properties and event types that are unique to that category of events. For example, events related to mouse input have several unique characteristics that cannot be captured by the properties defined in the Event class. The MouseEvent class extends the Event class by adding ten properties that contain information such as the location of the mouse event and whether specific keys were pressed during the mouse event.

An Event subclass also contains constants that represent the event types that are associated with the subclass. For example, the MouseEvent class defines constants for several mouse event types, include the `click`, `doubleClick`, `mouseDown`, and `mouseUp` event types.

As described in the section on Event class utility methods under "Event objects" on page 130, when creating an Event subclass you must override the `clone()` and `toString()` methods to provide functionality specific to the subclass.

Event listeners

Flash Player 9 and later, Adobe AIR 1.0 and later

Event listeners, which are also called event handlers, are functions that Flash Player and AIR execute in response to specific events. Adding an event listener is a two-step process. First, you create a function or class method for Flash Player or AIR to execute in response to the event. This is sometimes called the listener function or the event handler function. Second, you use the `addEventListener()` method to register your listener function with the target of the event or any display list object that lies along the appropriate event flow.

Creating a listener function

Flash Player 9 and later, Adobe AIR 1.0 and later

The creation of listener functions is one area where the ActionScript 3.0 event model deviates from the DOM event model. In the DOM event model, there is a clear distinction between an event listener and a listener function: an event listener is an instance of a class that implements the EventListener interface, whereas a listener function is a method of that class named `handleEvent()`. In the DOM event model, you register the class instance that contains the listener function rather than the actual listener function.

In the ActionScript 3.0 event model, there is no distinction between an event listener and a listener function. ActionScript 3.0 does not have an EventListener interface, and listener functions can be defined outside a class or as part of a class. Moreover, listener functions do not have to be named `handleEvent()`—they can be named with any valid identifier. In ActionScript 3.0, you register the name of the actual listener function.

Listener function defined outside of a class

The following code creates a simple SWF file that displays a red square shape. A listener function named `clickHandler()`, which is not part of a class, listens for mouse click events on the red square.

```
package
{
    import flash.display.Sprite;

    public class ClickExample extends Sprite
    {
        public function ClickExample()
        {
            var child:ChildSprite = new ChildSprite();
            addChild(child);
        }
    }
}

import flash.display.Sprite;
import flash.events.MouseEvent;

class ChildSprite extends Sprite
{
    public function ChildSprite()
    {
        graphics.beginFill(0xFF0000);
        graphics.drawRect(0,0,100,100);
        graphics.endFill();
        addEventListener(MouseEvent.CLICK, clickHandler);
    }
}

function clickHandler(event:MouseEvent):void
{
    trace("clickHandler detected an event of type: " + event.type);
    trace("the this keyword refers to: " + this);
}
```

When a user interacts with the resulting SWF file by clicking on the square, Flash Player or AIR generates the following trace output:

```
clickHandler detected an event of type: click
the this keyword refers to: [object global]
```

Notice that the event object is passed as an argument to `clickHandler()`. This allows your listener function to examine the event object. In this example, you use the event object's `type` property to ascertain that the event is a click event.

The example also checks the value of the `this` keyword. In this case, `this` represents the global object, which makes sense because the function is defined outside of any custom class or object.

Listener function defined as a class method

The following example is identical to the previous example that defines the ClickExample class except that the `clickHandler()` function is defined as a method of the ChildSprite class:

```
package
{
    import flash.display.Sprite;

    public class ClickExample extends Sprite
    {
        public function ClickExample()
        {
            var child:ChildSprite = new ChildSprite();
            addChild(child);
        }
    }
}

import flash.display.Sprite;
import flash.events.MouseEvent;

class ChildSprite extends Sprite
{
    public function ChildSprite()
    {
        graphics.beginFill(0xFF0000);
        graphics.drawRect(0,0,100,100);
        graphics.endFill();
        addEventListener(MouseEvent.CLICK, clickHandler);
    }
    private function clickHandler(event:MouseEvent):void
    {
        trace("clickHandler detected an event of type: " + event.type);
        trace("the this keyword refers to: " + this);
    }
}
```

When a user interacts with the resulting SWF file by clicking on the red square, Flash Player or AIR generates the following trace output:

```
clickHandler detected an event of type: click
the this keyword refers to: [object ChildSprite]
```

Note that the `this` keyword refers to the ChildSprite instance named `child`. This is a change in behavior from ActionScript 2.0. If you used components in ActionScript 2.0, you may remember that when a class method was passed in to `UIEventDispatcher.addEventListener()`, the scope of the method was bound to the component that broadcast the event instead of the class in which the listener method was defined. In other words, if you used this technique in ActionScript 2.0, the `this` keyword would refer to the component broadcasting the event instead of the ChildSprite instance.

This was a significant issue for some programmers because it meant that they could not access other methods and properties of the class containing the listener method. As a workaround, ActionScript 2.0 programmers could use the `mx.util.Delegate` class to change the scope of the listener method. This is no longer necessary, however, because ActionScript 3.0 creates a bound method when `addEventListener()` is called. As a result, the `this` keyword refers to the ChildSprite instance named `child`, and the programmer has access to the other methods and properties of the ChildSprite class.

Event listener that should not be used

There is a third technique in which you create a generic object with a property that points to a dynamically assigned listener function, but it is not recommended. It is discussed here because it was commonly used in ActionScript 2.0, but should not be used in ActionScript 3.0. This technique is not recommended because the `this` keyword will refer to the global object instead of your listener object.

The following example is identical to the previous ClickExample class example, except that the listener function is defined as part of a generic object named `myListenerObj`:

```
package
{
    import flash.display.Sprite;

    public class ClickExample extends Sprite
    {
        public function ClickExample()
        {
            var child:ChildSprite = new ChildSprite();
            addChild(child);
        }
    }
}

import flash.display.Sprite;
import flash.events.MouseEvent;

class ChildSprite extends Sprite
{
    public function ChildSprite()
    {
        graphics.beginFill(0xFF0000);
        graphics.drawRect(0,0,100,100);
        graphics.endFill();
        addEventListener(MouseEvent.CLICK, myListenerObj.clickHandler);
    }
}

var myListenerObj:Object = new Object();
myListenerObj.clickHandler = function (event:MouseEvent):void
{
        trace("clickHandler detected an event of type: " + event.type);
        trace("the this keyword refers to: " + this);
}
```

The results of the trace will look like this:

```
clickHandler detected an event of type: click
the this keyword refers to: [object global]
```

You would expect that `this` would refer to `myListenerObj` and that the trace output would be `[object Object]`, but instead it refers to the global object. When you pass in a dynamic property name as an argument to `addEventListener()`, Flash Player or AIR is unable to create a bound method. This is because what you are passing as the `listener` parameter is nothing more than the memory address of your listener function, and Flash Player and AIR have no way to link that memory address with the `myListenerObj` instance.

Managing event listeners

Flash Player 9 and later, Adobe AIR 1.0 and later

You can manage your listener functions using the methods of the IEventDispatcher interface. The IEventDispatcher interface is the ActionScript 3.0 version of the EventTarget interface of the DOM event model. Although the name IEventDispatcher may seem to imply that its main purpose is to send (or dispatch) event objects, the methods of this class are actually used much more frequently to register event listeners, check for event listeners, and remove event listeners. The IEventDispatcher interface defines five methods, as shown in the following code:

```
package flash.events
{
    public interface IEventDispatcher
    {
        function addEventListener(eventName:String,
                        listener:Object,
                        useCapture:Boolean=false,
                        priority:Integer=0,
                        useWeakReference:Boolean=false):Boolean;

        function removeEventListener(eventName:String,
                    listener:Object,
                    useCapture:Boolean=false):Boolean;

        function dispatchEvent(eventObject:Event):Boolean;

        function hasEventListener(eventName:String):Boolean;
        function willTrigger(eventName:String):Boolean;
    }
}
```

The Flash Player API implements the IEventDispatcher interface with the EventDispatcher class, which serves as a base class for all classes that can be event targets or part of an event flow. For example, the DisplayObject class inherits from the EventDispatcher class. This means that any object on the display list has access to the methods of the IEventDispatcher interface.

Adding event listeners

The `addEventListener()` method is the workhorse of the IEventDispatcher interface. You use it to register your listener functions. The two required parameters are `type` and `listener`. You use the `type` parameter to specify the type of event. You use the `listener` parameter to specify the listener function that will execute when the event occurs. The `listener` parameter can be a reference to either a function or a class method.

Do not use parentheses when you specify the `listener` parameter. For example, the `clickHandler()` function is specified without parentheses in the following call to the `addEventListener()` method:

```
addEventListener(MouseEvent.CLICK, clickHandler)
```

The `useCapture` parameter of the `addEventListener()` method allows you to control the event flow phase on which your listener will be active. If `useCapture` is set to `true`, your listener will be active during the capture phase of the event flow. If `useCapture` is set to `false`, your listener will be active during the target and bubbling phases of the event flow. To listen for an event during all phases of the event flow, you must call `addEventListener()` twice, once with `useCapture` set to `true`, and then again with `useCapture` set to `false`.

The `priority` parameter of the `addEventListener()` method is not an official part of the DOM Level 3 event model. It is included in ActionScript 3.0 to provide you with more flexibility in organizing your event listeners. When you call `addEventListener()`, you can set the priority for that event listener by passing an integer value as the `priority` parameter. The default value is 0, but you can set it to negative or positive integer values. The higher the number, the sooner that event listener will be executed. Event listeners with the same priority are executed in the order that they were added, so the earlier a listener is added, the sooner it will be executed.

The `useWeakReference` parameter allows you to specify whether the reference to the listener function is weak or normal. Setting this parameter to `true` allows you to avoid situations in which listener functions persist in memory even though they are no longer needed. Flash Player and AIR use a technique called *garbage collection* to clear objects from memory that are no longer in use. An object is considered no longer in use if no references to it exist. The garbage collector disregards weak references, which means that a listener function that has only a weak reference pointing to it is eligible for garbage collection.

Removing event listeners

You can use the `removeEventListener()` method to remove an event listener that you no longer need. It is a good idea to remove any listeners that will no longer be used. Required parameters include the `eventName` and `listener` parameters, which are the same as the required parameters for the `addEventListener()` method. Recall that you can listen for events during all event phases by calling `addEventListener()` twice, once with `useCapture` set to `true`, and then again with it set to `false`. To remove both event listeners, you would need to call `removeEventListener()` twice, once with `useCapture` set to `true`, and then again with it set to `false`.

Dispatching events

The `dispatchEvent()` method can be used by advanced programmers to dispatch a custom event object into the event flow. The only parameter accepted by this method is a reference to an event object, which must be an instance of the Event class or a subclass of the Event class. Once dispatched, the `target` property of the event object is set to the object on which `dispatchEvent()` was called.

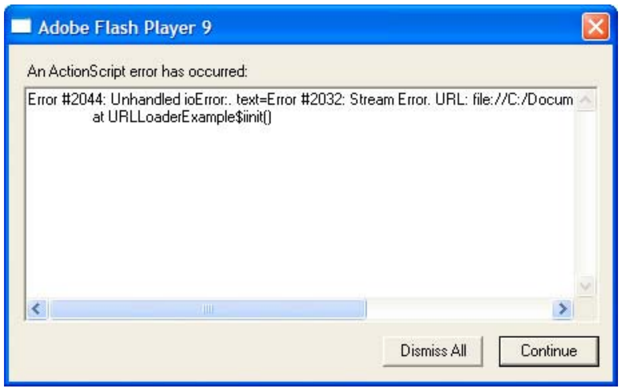
Checking for existing event listeners

The final two methods of the IEventDispatcher interface provide useful information about the existence of event listeners. The `hasEventListener()` method returns `true` if an event listener is found for a specific event type on a particular display list object. The `willTrigger()` method also returns `true` if a listener is found for a particular display list object, but `willTrigger()` checks for listeners not only on that display object, but also on all of that display list object's ancestors for all phases of the event flow.

Error events without listeners

Flash Player 9 and later, Adobe AIR 1.0 and later

Exceptions, rather than events, are the primary mechanism for error handling in ActionScript 3.0, but exception handling does not work for asynchronous operations such as loading files. If an error occurs during such an asynchronous operation, Flash Player and AIR dispatch an error event object. If you do not create a listener for the error event, the debugger versions of Flash Player and AIR will bring up a dialog box with information about the error. For example, the debugger version of Flash Player produces the following dialog box describing the error when the application attempts to load a file from an invalid URL:



An ActionScript error has occurred:

```
Error #2044: Unhandled ioError:. text=Error #2032: Stream Error. URL: file://C:/Docum
	at URLLoaderExample$iinit()
```

Most error events are based on the ErrorEvent class, and as such will have a property named `text` that is used to store the error message that Flash Player or AIR displays. The two exceptions are the StatusEvent and NetStatusEvent classes. Both of these classes have a `level` property (`StatusEvent.level` and `NetStatusEvent.info.level`). When the value of the `level` property is "`error`", these event types are considered to be error events.

An error event will not cause a SWF file to stop running. It will manifest only as a dialog box on the debugger versions of the browser plug-ins and stand-alone players, as a message in the output panel in the authoring player, and as an entry in the log file for Adobe Flash Builder. It will not manifest at all in the release versions of Flash Player or AIR.

Event handling example: Alarm Clock

Flash Player 9 and later, Adobe AIR 1.0 and later

The Alarm Clock example consists of a clock that allows the user to specify a time at which an alarm will go off, as well as a message to be displayed at that time. The Alarm Clock example builds on the SimpleClock application from "Working with dates and times" on page 1 Alarm Clock illustrates several aspects of working with events in ActionScript 3.0, including:

- Listening and responding to an event
- Notifying listeners of an event
- Creating a custom event type

To get the Flash Professional application files for this sample, see http://www.adobe.com/go/learn_programmingAS3samples_flash. To get the Flex application files for this sample, see http://www.adobe.com/go/as3examples. The Alarm Clock application files can be found in the Samples/AlarmClock folder. The application includes these files:

File	**Description**
AlarmClockApp.mxml or AlarmClockApp.fla	The main application file in Flash (FLA) or Flex (MXML).
com/example/programmingas3/clock/AlarmClock.as	A class which extends the SimpleClock class, adding alarm clock functionality.
com/example/programmingas3/clock/AlarmEvent.as	A custom event class (a subclass of flash.events.Event) which serves as the event object for the AlarmClock class's `alarm` event.
com/example/programmingas3/clock/AnalogClockFace.as	Draws a round clock face and hour, minute, and seconds hands based on the time (described in the SimpleClock example).
com/example/programmingas3/clock/SimpleClock.as	A clock interface component with simple timekeeping functionality (described in the SimpleClock example).

Alarm Clock overview

Flash Player 9 and later, Adobe AIR 1.0 and later

The primary functionality of the clock in this example, including tracking the time and displaying the clock face, reuses the SimpleClock application code, which is described in "Date and time example: Simple analog clock" on page 6. The AlarmClock class extends the SimpleClock class from that example by adding the functionality required for an alarm clock, including setting the alarm time and providing notification when the alarm "goes off."

Providing notification when something happens is the job that events are made for. The AlarmClock class exposes the Alarm event, which other objects can listen for in order to perform desired actions. In addition, the AlarmClock class uses an instance of the Timer class to determine when to trigger its alarm. Like the AlarmClock class, the Timer class provides an event to notify other objects (an AlarmClock instance, in this case) when a certain amount of time has passed. As with most ActionScript applications, events form an important part of the functionality of the Alarm Clock sample application.

Triggering the alarm

Flash Player 9 and later, Adobe AIR 1.0 and later

As mentioned previously, the only functionality that the AlarmClock class actually provides relates to setting and triggering the alarm. The built-in Timer class (flash.utils.Timer) provides a way for a developer to define code that will be executed after a specified amount of time. The AlarmClock class uses a Timer instance to determine when to set off the alarm.

```
import flash.events.TimerEvent;
import flash.utils.Timer;

/**
 * The Timer that will be used for the alarm.
 */
public var alarmTimer:Timer;
...
/**
 * Instantiates a new AlarmClock of a given size.
 */
public override function initClock(faceSize:Number = 200):void
{
    super.initClock(faceSize);
    alarmTimer = new Timer(0, 1);
    alarmTimer.addEventListener(TimerEvent.TIMER, onAlarm);
}
```

The Timer instance defined in the AlarmClock class is named `alarmTimer`. The `initClock()` method, which performs necessary setup operations for the AlarmClock instance, does two things with the `alarmTimer` variable. First, the variable is instantiated with parameters instructing the Timer instance to wait 0 milliseconds and only trigger its timer event one time. After instantiating `alarmTimer`, the code calls that variable's `addEventListener()` method to indicate that it wants to listen to that variable's `timer` event. A Timer instance works by dispatching its `timer` event after a specified amount of time has passed. The AlarmClock class will need to know when the `timer` event is dispatched in order to set off its own alarm. By calling `addEventListener()`, the AlarmClock code registers itself as a listener with `alarmTimer`. The two parameters indicate that the AlarmClock class wants to listen for the `timer` event (indicated by the constant `TimerEvent.TIMER`), and that when the event happens, the AlarmClock class's `onAlarm()` method should be called in response to the event.

In order to actually set the alarm, the AlarmClock class's `setAlarm()` method is called, as follows:

```
/**
 * Sets the time at which the alarm should go off.
 * @param hour The hour portion of the alarm time.
 * @param minutes The minutes portion of the alarm time.
 * @param message The message to display when the alarm goes off.
 * @return The time at which the alarm will go off.
 */
public function setAlarm(hour:Number = 0, minutes:Number = 0, message:String = "Alarm!"):Date
{
    this.alarmMessage = message;
    var now:Date = new Date();
    // Create this time on today's date.
    alarmTime = new Date(now.fullYear, now.month, now.date, hour, minutes);

    // Determine if the specified time has already passed today.
    if (alarmTime <= now)
    {
        alarmTime.setTime(alarmTime.time + MILLISECONDS_PER_DAY);
    }

    // Stop the alarm timer if it's currently set.
    alarmTimer.reset();
    // Calculate how many milliseconds should pass before the alarm should
    // go off (the difference between the alarm time and now) and set that
    // value as the delay for the alarm timer.
    alarmTimer.delay = Math.max(1000, alarmTime.time - now.time);
    alarmTimer.start();

    return alarmTime;
}
```

This method does several things, including storing the alarm message and creating a Date object (`alarmTime`) representing the actual moment in time when the alarm is to go off. Of most relevance to the current discussion, in the final several lines of the method, the `alarmTimer` variable's timer is set and activated. First, its `reset()` method is called, stopping the timer and resetting it in case it is already running. Next, the current time (represented by the `now` variable) is subtracted from the `alarmTime` variable's value to determine how many milliseconds need to pass before the alarm goes off. The Timer class doesn't trigger its `timer` event at an absolute time, so it is this relative time difference that is assigned to the `delay` property of `alarmTimer`. Finally, the `start()` method is called to actually start the timer.

Once the specified amount of time has passed, `alarmTimer` dispatches the `timer` event. Because the AlarmClock class registered its `onAlarm()` method as a listener for that event, when the `timer` event happens, `onAlarm()` is called.

```
/**
 * Called when the timer event is dispatched.
 */
public function onAlarm(event:TimerEvent):void
{
    trace("Alarm!");
    var alarm:AlarmEvent = new AlarmEvent(this.alarmMessage);
    this.dispatchEvent(alarm);
}
```

A method that is registered as an event listener must be defined with the appropriate signature (that is, the set of parameters and return type of the method). To be a listener for the Timer class's `timer` event, a method must define one parameter whose data type is TimerEvent (flash.events.TimerEvent), a subclass of the Event class. When the Timer instance calls its event listeners, it passes a TimerEvent instance as the event object.

Notifying others of the alarm

Flash Player 9 and later, Adobe AIR 1.0 and later

Like the Timer class, the AlarmClock class provides an event that allows other code to receive notifications when the alarm goes off. For a class to use the event-handling framework built into ActionScript, that class must implement the flash.events.IEventDispatcher interface. Most commonly, this is done by extending the flash.events.EventDispatcher class, which provides a standard implementation of IEventDispatcher (or by extending one of EventDispatcher's subclasses). As described previously, the AlarmClock class extends the SimpleClock class, which (through a chain of inheritance) extends the EventDispatcher class. All of this means that the AlarmClock class already has built-in functionality to provide its own events.

Other code can register to be notified of the AlarmClock class's `alarm` event by calling the `addEventListener()` method that AlarmClock inherits from EventDispatcher. When an AlarmClock instance is ready to notify other code that its `alarm` event has been raised, it does so by calling the `dispatchEvent()` method, which is also inherited from EventDispatcher.

```
var alarm:AlarmEvent = new AlarmEvent(this.alarmMessage);
this.dispatchEvent(alarm);
```

These lines of code are taken from the AlarmClock class's `onAlarm()` method (shown in its entirety previously). The AlarmClock instance's `dispatchEvent()` method is called, which in turn notifies all the registered listeners that the AlarmClock instance's `alarm` event has been triggered. The parameter that is passed to `dispatchEvent()` is the event object that will be passed along to the listener methods. In this case, it is an instance of the AlarmEvent class, an Event subclass created specifically for this example.

Providing a custom alarm event

Flash Player 9 and later, Adobe AIR 1.0 and later

All event listeners receive an event object parameter with information about the particular event being triggered. In many cases, the event object is an instance of the Event class. However, in some cases it is useful to provide additional information to event listeners. A common way to accomplish this is to define a new class, a subclass of the Event class, and use an instance of that class as the event object. In this example, an AlarmEvent instance is used as the event object when the AlarmClock class's `alarm` event is dispatched. The AlarmEvent class, shown here, provides additional information about the `alarm` event, specifically the alarm message:

```
import flash.events.Event;

/**
 * This custom Event class adds a message property to a basic Event.
 */
public class AlarmEvent extends Event
{
    /**
     * The name of the new AlarmEvent type.
     */
    public static const ALARM:String = "alarm";

    /**
     * A text message that can be passed to an event handler
     * with this event object.
     */
    public var message:String;

    /**
     *Constructor.
     *@param message The text to display when the alarm goes off.
     */
    public function AlarmEvent(message:String = "ALARM!")
    {
        super(ALARM);
        this.message = message;
    }
    ...
}
```

The best way to create a custom event object class is to define a class that extends the Event class, as shown in the preceding example. To supplement the inherited functionality, the AlarmEvent class defines a property `message` that contains the text of the alarm message associated with the event; the `message` value is passed in as a parameter in the AlarmEvent constructor. The AlarmEvent class also defines the constant `ALARM`, which can be used to refer to the specific event (`alarm`) when calling the AlarmClock class's `addEventListener()` method.

In addition to adding custom functionality, every Event subclass must override the inherited `clone()` method as part of the ActionScript event-handling framework. Event subclasses can also optionally override the inherited `toString()` method to include the custom event's properties in the value returned when the `toString()` method is called.

```
    /**
     * Creates and returns a copy of the current instance.
     * @return A copy of the current instance.
     */
    public override function clone():Event
    {
        return new AlarmEvent(message);
    }

    /**
     * Returns a String containing all the properties of the current
     * instance.
     * @return A string representation of the current instance.
     */
    public override function toString():String
    {
        return formatToString("AlarmEvent", "type", "bubbles", "cancelable", "eventPhase",
"message");
    }
```

The overridden `clone()` method needs to return a new instance of the custom Event subclass, with all the custom properties set to match the current instance. In the overridden `toString()` method, the utility method `formatToString()` (inherited from Event) is used to provide a string with the name of the custom type, as well as the names and values of all its properties.

Chapter 9: Working with application domains

Flash Player 9 and later, Adobe AIR 1.0 and later

The purpose of the ApplicationDomain class is to store a table of ActionScript 3.0 definitions. All code in a SWF file is defined to exist in an application domain. You use application domains to partition classes that are in the same security domain. This allows multiple definitions of the same class to exist and also lets children reuse parent definitions.

You can use application domains when loading an external SWF file written in ActionScript 3.0 using the Loader class API. (Note that you cannot use application domains when loading an image or SWF file written in ActionScript 1.0 or ActionScript 2.0.) All ActionScript 3.0 definitions contained in the loaded class are stored in the application domain. When loading the SWF file, you can specify that the file be included in the same application domain as that of the Loader object, by setting the `applicationDomain` parameter of the LoaderContext object to `ApplicationDomain.currentDomain`. By putting the loaded SWF file in the same application domain, you can access its classes directly. This can be useful if you are loading a SWF file that contains embedded media, which you can access via their associated class names, or if you want to access the loaded SWF file's methods.

The following example assumes it has access to a separate Greeter.swf file that defines a public method named welcome():

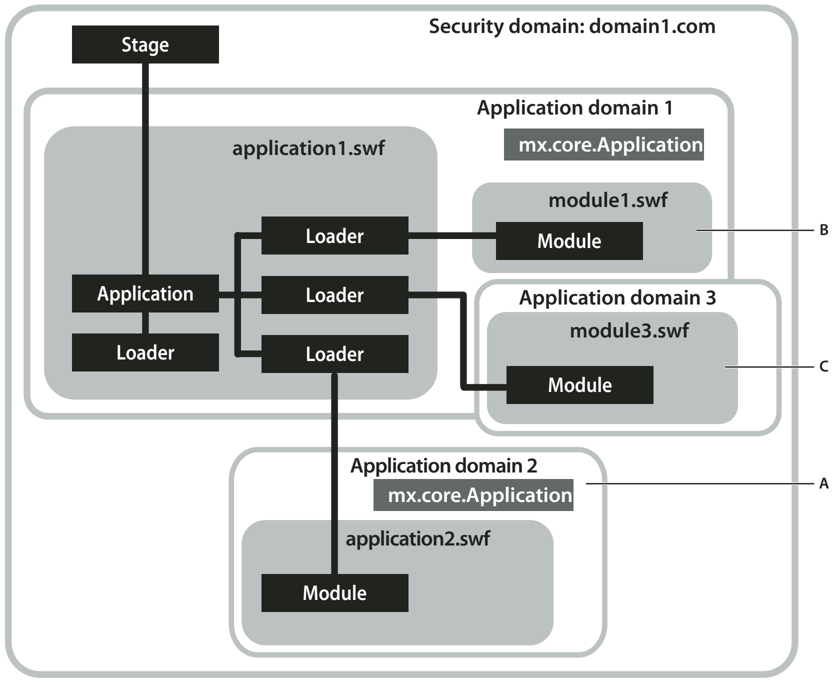
```
package
{
    import flash.display.Loader;
    import flash.display.Sprite;
    import flash.events.*;
    import flash.net.URLRequest;
    import flash.system.ApplicationDomain;
    import flash.system.LoaderContext;

    public class ApplicationDomainExample extends Sprite
    {
        private var ldr:Loader;
        public function ApplicationDomainExample()
        {
            ldr = new Loader();
            var req:URLRequest = new URLRequest("Greeter.swf");
            var ldrContext:LoaderContext = new LoaderContext(false,
ApplicationDomain.currentDomain);
            ldr.contentLoaderInfo.addEventListener(Event.COMPLETE, completeHandler);
            ldr.load(req, ldrContext);
        }
        private function completeHandler(event:Event):void
        {
            var myGreeter:Class = ApplicationDomain.currentDomain.getDefinition("Greeter") as
Class;
            var myGreeter:Greeter = Greeter(event.target.content);
            var message:String = myGreeter.welcome("Tommy");
            trace(message); // Hello, Tommy
        }
    }
}
```

Also see the ApplicationDomain class example of the ActionScript 3.0 Reference for the Adobe Flash Platform.

Other things to keep in mind when you work with application domains include the following:

- All code in a SWF file is defined to exist in an application domain. The *current domain* is where your main application runs. The *system domain* contains all application domains, including the current domain, which means that it contains all Flash Player classes.
- All application domains, except the system domain, have an associated parent domain. The parent domain for your main application's application domain is the system domain. Loaded classes are defined only when their parent doesn't already define them. You cannot override a loaded class definition with a newer definition.

The following diagram shows an application that loads content from various SWF files within a single domain, domain1.com. Depending on the content you load, different application domains can be used. The text that follows describes the logic used to set the appropriate application domain for each SWF file in the application.



A. *Usage A* ***B.*** *Usage B* ***C.*** *Usage C*

The main application file is application1.swf. It contains Loader objects that load content from other SWF files. In this scenario, the current domain is Application domain 1. Usage A, usage B, and usage C illustrate different techniques for setting the appropriate application domain for each SWF file in an application.

Usage A Partition the child SWF file by creating a child of the system domain. In the diagram, Application domain 2 is created as a child of the system domain.The application2.swf file is loaded in Application domain 2, and its class definitions are thus partitioned from the classes defined in application1.swf.

One use of this technique is to have an old application dynamically loading a newer version of the same application without conflict. There is no conflict because although the same class names are used, they are partitioned into different application domains.

The following code creates an application domain that is a child of the system domain, and starts loading a SWF using that application domain:

```
var appDomainA:ApplicationDomain = new ApplicationDomain();

var contextA:LoaderContext = new LoaderContext(false, appDomainA);
var loaderA:Loader = new Loader();
loaderA.load(new URLRequest("application2.swf"), contextA);
```

Usage B: Add new class definitions to current class definitions. The application domain of module1.swf is set to the current domain (Application domain 1). This lets you add to the application's current set of class definitions with new class definitions. This could be used for a run-time shared library of the main application. The loaded SWF is treated as a remote shared library (RSL). Use this technique to load RSLs by a preloader before the application starts.

The following code loads a SWF, setting its application domain to the current domain:

```
var appDomainB:ApplicationDomain = ApplicationDomain.currentDomain;

var contextB:LoaderContext = new LoaderContext(false, appDomainB);
var loaderB:Loader = new Loader();
loaderB.load(new URLRequest("module1.swf"), contextB);
```

Usage C: Use the parent's class definitions by creating a new child domain of the current domain. The application domain of module3.swf is a child of the current domain, and the child uses the parent's versions of all classes. One use of this technique might be a module of a multiple-screen rich Internet application (RIA), loaded as a child of the main application, that uses the main application's types. If you can ensure that all classes are always updated to be backward compatible, and that the loading application is always newer than the things it loads, the children will use the parent versions. Having a new application domain also allows you to unload all the class definitions for garbage collection, if you can ensure that you do not continue to have references to the child SWF.

This technique lets loaded modules share the loader's singleton objects and static class members.

The following code creates a new child domain of the current domain, and starts loading a SWF using that application domain:

```
var appDomainC:ApplicationDomain = new ApplicationDomain(ApplicationDomain.currentDomain);

var contextC:LoaderContext = new LoaderContext(false, appDomainC);
var loaderC:Loader = new Loader();
loaderC.load(new URLRequest("module3.swf"), contextC);
```

Chapter 10: Display programming

Flash Player 9 and later, Adobe AIR 1.0 and later

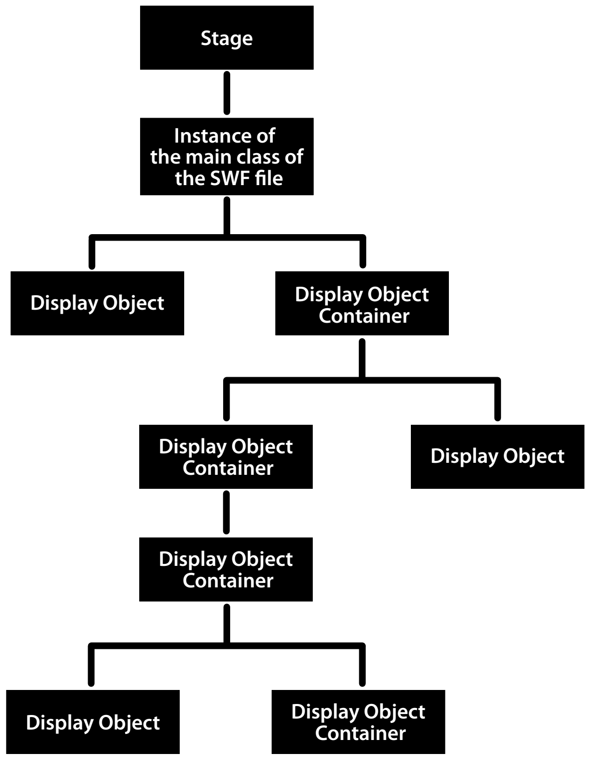
Visual elements are programmed in Adobe® ActionScript® 3.0 by working with display objects on the display stage. For example, you can add, move, remove, and order display objects, apply filters and masks, draw vector and bitmap graphics, and perform three-dimensional transformations using the ActionScript display programming API. The primary classes used for display programming are part of the flash.display package.

***Note:** Adobe® AIR™ provides the HTMLoader object for rendering and displaying HTML content. The HTMLLoader renders the visual elements of the HTML DOM as a single display object. You cannot access the individual elements of the DOM directly through the ActionScript display list hierarchy. Instead, you access these DOM elements using the separate DOM API provided by the HTMLLoader.*

Basics of display programming

Flash Player 9 and later, Adobe AIR 1.0 and later

Each application built with ActionScript 3.0 has a hierarchy of displayed objects known as the *display list*, illustrated below. The display list contains all the visible elements in the application.



As the illustration shows, display elements fall into one or more of the following groups:

- The Stage

  The Stage is the base container of display objects. Each application has one Stage object, which contains all on-screen display objects. The Stage is the top-level container and is at the top of the display list hierarchy:

  Each SWF file has an associated ActionScript class, known as *the main class of the SWF file*. When a SWF file opens in Flash Player or Adobe AIR, Flash Player or AIR calls the constructor function for that class and the instance that is created (which is always a type of display object) is added as a child of the Stage object. The main class of a SWF file always extends the Sprite class (for more information, see "Advantages of the display list approach" on page 156).

  You can access the Stage through the `stage` property of any DisplayObject instance. For more information, see "Setting Stage properties" on page 164.

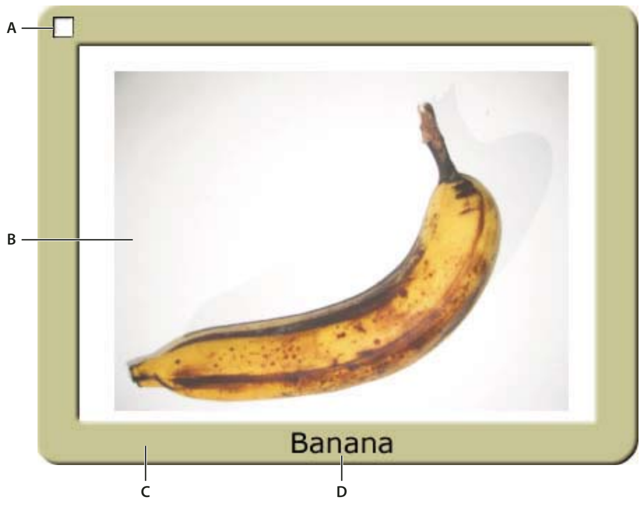
- Display objects

  In ActionScript 3.0, all elements that appear on screen in an application are types of *display objects*. The flash.display package includes a DisplayObject class, which is a base class extended by a number of other classes. These different classes represent different types of display objects, such as vector shapes, movie clips, and text fields, to name a few. For an overview of these classes, see "Advantages of the display list approach" on page 156.

- Display object containers

  Display object containers are special types of display objects that, in addition to having their own visual representation, can also contain child objects that are also display objects.

  The DisplayObjectContainer class is a subclass of the DisplayObject class. A DisplayObjectContainer object can contain multiple display objects in its *childlist*. For example, the following illustration shows a type of DisplayObjectContainer object known as a Sprite that contains various display objects:



__A.__ A SimpleButton object. This type of display object has different "up," "down," and "over" states. __B.__ A Bitmap object. In this case, the Bitmap object was loaded from an external JPEG through a Loader object. __C.__ A Shape object. The "picture frame" contains a rounded rectangle that is drawn in ActionScript. This Shape object has a Drop Shadow filter applied to it. __D.__ A TextField object.

In the context of discussing display objects, DisplayObjectContainer objects are also known as *display object containers* or simply *containers*. As noted earlier, the Stage is a display object container.

Although all visible display objects inherit from the DisplayObject class, the type of each is of a specific subclass of DisplayObject class. For example, there is a constructor function for the Shape class or the Video class, but there is no constructor function for the DisplayObject class.

Important concepts and terms

The following reference list contains important terms that you will encounter when programming ActionScript graphics:

Alpha The color value representing the amount of transparency (or more correctly, the amount of opacity) in a color. For example, a color with an alpha channel value of 60% only shows 60% of its full strength, and is 40% transparent.

Bitmap graphic A graphic that is defined in the computer as a grid (rows and columns) of colored pixels. Commonly bitmap graphics include digital photos and similar images.

Blending mode A specification of how the contents of two overlapping images should interact. Commonly an opaque image on top of another image simply blocks the image underneath so that it isn't visible at all; however, different blending modes cause the colors of the images to blend together in different ways so the resulting content is some combination of the two images.

Display list The hierarchy of display objects that will be rendered as visible screen content by Flash Player and AIR. The Stage is the root of the display list, and all the display objects that are attached to the Stage or one of its children form the display list (even if the object isn't actually rendered, for example if it's outside the boundaries of the Stage).

Display object An object which represents some type of visual content in Flash Player or AIR. Only display objects can be included in the display list, and all display object classes are subclasses of the DisplayObject class.

Display object container A special type of display object which can contain child display objects in addition to (generally) having its own visual representation.

Main class of the SWF file The class that defines the behavior for the outermost display object in a SWF file, which conceptually is the class for the SWF file itself. For instance, in a SWF created in Flash authoring, the main class is the document class. It has a "main timeline" which contains all other timelines; the main class of the SWF file is the class of which the main timeline is an instance.

Masking A technique of hiding from view certain parts of an image (or conversely, only allowing certain parts of an image to display). The portions of the mask image become transparent, so content underneath shows through. The term is related to painter's masking tape that is used to prevent paint from being applied to certain areas.

Stage The visual container that is the base or background of all visual content in a SWF.

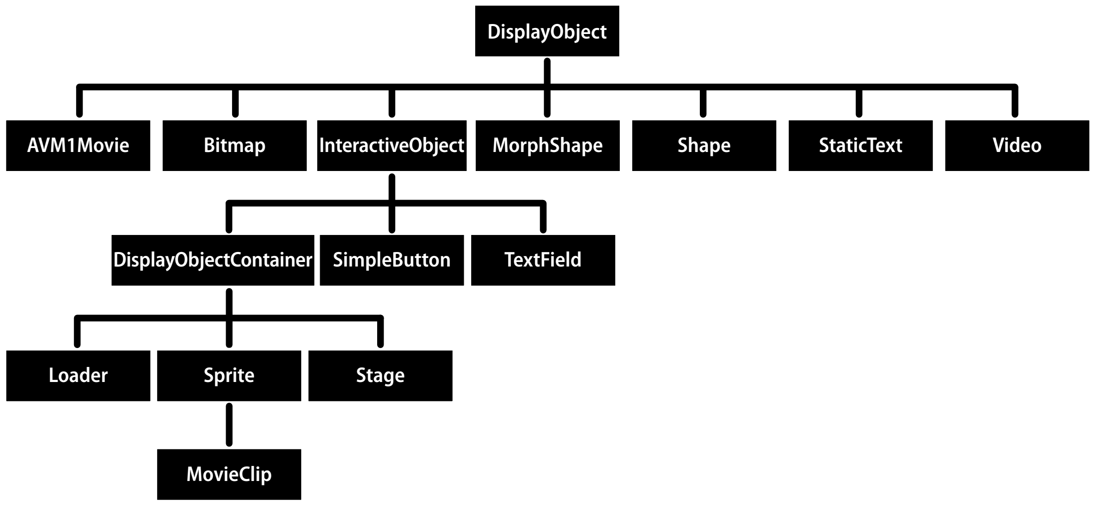
Transformation An adjustment to a visual characteristic of a graphic, such as rotating the object, altering its scale, skewing or distorting its shape, or altering its color.

Vector graphic A graphic that is defined in the computer as lines and shapes drawn with particular characteristics (such as thickness, length, size, angle, and position).

Core display classes

Flash Player 9 and later, Adobe AIR 1.0 and later

The ActionScript 3.0 flash.display package includes classes for visual objects that can appear in Flash Player or AIR. The following illustration shows the subclass relationships of these core display object classes.



The illustration shows the class inheritance of display object classes. Note that some of these classes, specifically StaticText, TextField, and Video, are not in the flash.display package, but they still inherit from the DisplayObject class.

All classes that extend the DisplayObject class inherit its methods and properties. For more information, see "Properties and methods of the DisplayObject class" on page 158.

You can instantiate objects of the following classes contained in the flash.display package:

- Bitmap—You use the Bitmap class to define bitmap objects, either loaded from external files or rendered through ActionScript. You can load bitmaps from external files through the Loader class. You can load GIF, JPG, or PNG files. You can also create a BitmapData object with custom data and then create a Bitmap object that uses that data. You can use the methods of the BitmapData class to alter bitmaps, whether they are loaded or created in ActionScript. For more information, see "Loading display objects" on page 198 and "Working with bitmaps" on page 242.
- Loader—You use the Loader class to load external assets (either SWF files or graphics). For more information, see "Loading display content dynamically" on page 198.
- Shape—You use the Shape class to create vector graphics, such as rectangles, lines, circles, and so on. For more information, see "Using the drawing API" on page 222.
- SimpleButton—A SimpleButton object is the ActionScript representation of a button symbol created in the Flash authoring tool. A SimpleButton instance has four button states: up, down, over, and hit test (the area that responds to mouse and keyboard events).
- Sprite—A Sprite object can contain graphics of its own, and it can contain child display objects. (The Sprite class extends the DisplayObjectContainer class). For more information, see "Working with display object containers" on page 159 and "Using the drawing API" on page 222.

- MovieClip—A MovieClip object is the ActionScript form of a movie clip symbol created in the Flash authoring tool. In practice, a MovieClip is similar to a Sprite object, except that it also has a timeline. For more information, see "Working with movie clips" on page 322.

The following classes, which are not in the flash.display package, are subclasses of the DisplayObject class:

- The TextField class, included in the flash.text package, is a display object for text display and input. For more information, see "Basics of Working with text" on page 371.
- The TextLine class, included in the flash.text.engine package, is the display object used to display lines of text composed by the Flash Text Engine and the Text Layout Framework. For more information, see "Using the Flash Text Engine" on page 397 and "Using the Text Layout Framework" on page 426.
- The Video class, included in the flash.media package, is the display object used for displaying video files. For more information, see "Working with video" on page 474.

The following classes in the flash.display package extend the DisplayObject class, but you cannot create instances of them. Instead, they serve as parent classes for other display objects, combining common functionality into a single class.

- AVM1Movie—The AVM1Movie class is used to represent loaded SWF files that are authored in ActionScript 1.0 and 2.0.
- DisplayObjectContainer—The Loader, Stage, Sprite, and MovieClip classes each extend the DisplayObjectContainer class. For more information, see "Working with display object containers" on page 159.
- InteractiveObject—InteractiveObject is the base class for all objects used to interact with the mouse and keyboard. SimpleButton, TextField, Loader, Sprite, Stage, and MovieClip objects are all subclasses of the InteractiveObject class. For more information on creating mouse and keyboard interaction, see "Basics of user interaction" on page 556.
- MorphShape—These objects are created when you create a shape tween in the Flash authoring tool. You cannot instantiate them using ActionScript, but they can be accessed from the display list.
- Stage—The Stage class extends the DisplayObjectContainer class. There is one Stage instance for an application, and it is at the top of the display list hierarchy. To access the Stage, use the `stage` property of any DisplayObject instance. For more information, see "Setting Stage properties" on page 164.

Also, the StaticText class, in the flash.text package, extends the DisplayObject class, but you cannot create an instance of it in code. Static text fields are created only in Flash.

The following classes are not display objects or display object containers, and do not appear in the display list, but do display graphics on the stage. These classes draw into a rectangle, called a viewport, positioned relative to the stage.

- StageVideo—The StageVideo class displays video content, using hardware acceleration, when possible. This class is available starting in Flash Player 10.2. For more information, see "Using the StageVideo class for hardware accelerated presentation" on page 512.
- StageWebView—The StageWebView class displays HTML content. This class is available starting in AIR 2.5. For more information, see "StageWebView objects" on page 1026.

The following fl.display classes provide functionality that parallels the flash.display.Loader and LoaderInfo classes. Use these classes instead of their flash.display counterparts if you are developing in the Flash Professional environment (CS5.5 or later). In that environment, these classes help solve issues involving TLF with RSL preloading. For more information, see "Using the ProLoader and ProLoaderInfo classes" on page 202.

- fl.display.ProLoader—Analogous to flash.display.Loader
- fl.display.ProLoaderInfo—Analogous to flash.display.LoaderInfo

Advantages of the display list approach

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 3.0, there are separate classes for different types of display objects. In ActionScript 1.0 and 2.0, many of the same types of objects are all included in one class: the MovieClip class.

This individualization of classes and the hierarchical structure of display lists have the following benefits:

- More efficient rendering and reduced memory usage
- Improved depth management
- Full traversal of the display list
- Off-list display objects
- Easier subclassing of display objects

More efficient rendering and smaller file sizes

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 1.0 and 2.0, you could draw shapes only in a MovieClip object. In ActionScript 3.0, there are simpler display object classes in which you can draw shapes. Because these ActionScript 3.0 display object classes do not include the full set of methods and properties that a MovieClip object includes, they are less taxing on memory and processor resources.

For example, each MovieClip object includes properties for the timeline of the movie clip, whereas a Shape object does not. The properties for managing the timeline can use a lot of memory and processor resources. In ActionScript 3.0, using the Shape object results in better performance. The Shape object has less overhead than the more complex MovieClip object. Flash Player and AIR do not need to manage unused MovieClip properties, which improves speed and reduces the memory footprint the object uses.

Improved depth management

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 1.0 and 2.0, depth was managed through a linear depth management scheme and methods such as `getNextHighestDepth()`.

ActionScript 3.0 includes the DisplayObjectContainer class, which has more convenient methods and properties for managing the depth of display objects.

In ActionScript 3.0, when you move a display object to a new position in the child list of a DisplayObjectContainer instance, the other children in the display object container are repositioned automatically and assigned appropriate child index positions in the display object container.

Also, in ActionScript 3.0 it is always possible to discover all of the child objects of any display object container. Every DisplayObjectContainer instance has a `numChildren` property, which lists the number of children in the display object container. And since the child list of a display object container is always an indexed list, you can examine every object in the list from index position 0 through the last index position (`numChildren - 1`). This was not possible with the methods and properties of a MovieClip object in ActionScript 1.0 and 2.0.

In ActionScript 3.0, you can easily traverse the display list sequentially; there are no gaps in the index numbers of a child list of a display object container. Traversing the display list and managing the depth of objects is much easier than was possible in ActionScript 1.0 and 2.0. In ActionScript 1.0 and 2.0, a movie clip could contain objects with intermittent gaps in the depth order, which could make it difficult to traverse the list of object. In ActionScript 3.0, each child list of a display object container is cached internally as an array, resulting in very fast lookups (by index). Looping through all children of a display object container is also very fast.

In ActionScript 3.0, you can also access children in a display object container by using the `getChildByName()` method of the DisplayObjectContainer class.

Full traversal of the display list

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 1.0 and 2.0, you could not access some objects, such as vector shapes, that were drawn in the Flash authoring tool. In ActionScript 3.0, you can access all objects on the display list—both those created using ActionScript and all display objects created in the Flash authoring tool. For details, see "Traversing the display list" on page 163.

Off-list display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 3.0, you can create display objects that are not on the visible display list. These are known as *off-list* display objects. A display object is added to the visible display list only when you call the `addChild()` or `addChildAt()` method of a DisplayObjectContainer instance that has already been added to the display list.

You can use off-list display objects to assemble complex display objects, such as those that have multiple display object containers containing multiple display objects. By keeping display objects off-list, you can assemble complicated objects without using the processing time to render these display objects. You can then add an off-list display object to the display list when it is needed. Also, you can move a child of a display object container on and off the display list and to any desired position in the display list at will.

Easier subclassing of display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 1.0 and 2.0, you would often have to add new MovieClip objects to a SWF file to create basic shapes or to display bitmaps. In ActionScript 3.0, the DisplayObject class includes many built-in subclasses, including Shape and Bitmap. Because the classes in ActionScript 3.0 are more specialized for specific types of objects, it is easier to create basic subclasses of the built-in classes.

For example, in order to draw a circle in ActionScript 2.0, you could create a CustomCircle class that extends the MovieClip class when an object of the custom class is instantiated. However, that class would also include a number of properties and methods from the MovieClip class (such as `totalFrames`) that do not apply to the class. In ActionScript 3.0, however, you can create a CustomCircle class that extends the Shape object, and as such does not include the unrelated properties and methods that are contained in the MovieClip class. The following code shows an example of a CustomCircle class:

```
import flash.display.*;

public class CustomCircle extends Shape
{
    var xPos:Number;
    var yPos:Number;
    var radius:Number;
    var color:uint;
    public function CustomCircle(xInput:Number,
                                    yInput:Number,
                                    rInput:Number,
                                    colorInput:uint)
    {
        xPos = xInput;
        yPos = yInput;
        radius = rInput;
        color = colorInput;
        this.graphics.beginFill(color);
        this.graphics.drawCircle(xPos, yPos, radius);
    }
}
```

Working with display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Now that you understand the basic concepts of the Stage, display objects, display object containers, and the display list, this section provides you with some more specific information about working with display objects in ActionScript 3.0.

Properties and methods of the DisplayObject class

Flash Player 9 and later, Adobe AIR 1.0 and later

All display objects are subclasses of the DisplayObject class, and as such they inherit the properties and methods of the DisplayObject class. The properties inherited are basic properties that apply to all display objects. For example, each display object has an `x` property and a `y` property that specifies the object's position in its display object container.

You cannot create a DisplayObject instance using the DisplayObject class constructor. You must create another type of object (an object that is a subclass of the DisplayObject class), such as a Sprite, to instantiate an object with the `new` operator. Also, if you want to create a custom display object class, you must create a subclass of one of the display object subclasses that has a usable constructor function (such as the Shape class or the Sprite class). For more information, see the DisplayObject class description in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Adding display objects to the display list

Flash Player 9 and later, Adobe AIR 1.0 and later

When you instantiate a display object, it will not appear on-screen (on the Stage) until you add the display object instance to a display object container that is on the display list. For example, in the following code, the `myText` TextField object would not be visible if you omitted the last line of code. In the last line of code, the `this` keyword must refer to a display object container that is already added to the display list.

```
import flash.display.*;
import flash.text.TextField;
var myText:TextField = new TextField();
myText.text = "Buenos dias.";
this.addChild(myText);
```

When you add any visual element to the Stage, that element becomes a *child* of the Stage object. The first SWF file loaded in an application (for example, the one that you embed in an HTML page) is automatically added as a child of the Stage. It can be an object of any type that extends the Sprite class.

Any display objects that you create *without* using ActionScript—for example, by adding an MXML tag in a Flex MXML file or by placing an item on the Stage in Flash Professional—are added to the display list. Although you do not add these display objects through ActionScript, you can access them through ActionScript. For example, the following code adjusts the width of an object named `button1` that was added in the authoring tool (not through ActionScript):

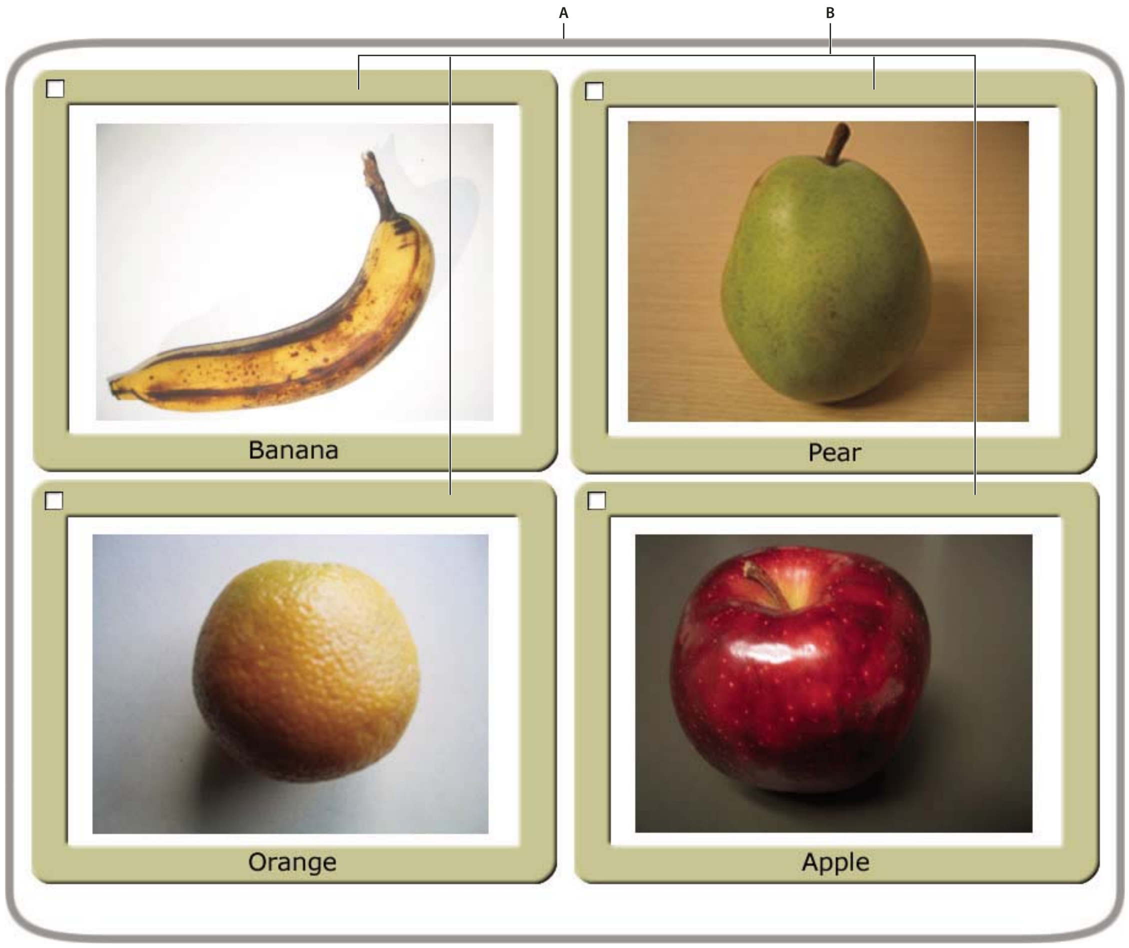
```
button1.width = 200;
```

Working with display object containers

Flash Player 9 and later, Adobe AIR 1.0 and later

If a DisplayObjectContainer object is deleted from the display list, or if it is moved or transformed in some other way, each display object in the DisplayObjectContainer is also deleted, moved, or transformed.

A display object container is itself a type of display object—it can be added to another display object container. For example, the following image shows a display object container, `pictureScreen`, that contains one outline shape and four other display object containers (of type PictureFrame):



***A.** A shape defining the border of the pictureScreen display object container* ***B.** Four display object containers that are children of the pictureScreen object*

In order to have a display object appear in the display list, you must add it to a display object container that is on the display list. You do this by using the `addChild()` method or the `addChildAt()` method of the container object. For example, without the final line of the following code, the `myTextField` object would not be displayed:

```
var myTextField:TextField = new TextField();
myTextField.text = "hello";
this.root.addChild(myTextField);
```

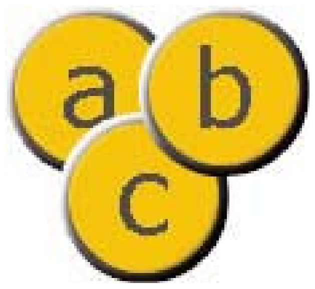
In this code sample, `this.root` points to the MovieClip display object container that contains the code. In your actual code, you may specify a different container.

Use the `addChildAt()` method to add the child to a specific position in the child list of the display object container. These zero-based index positions in the child list relate to the layering (the front-to-back order) of the display objects. For example, consider the following three display objects. Each object was created from a custom class called Ball.

The layering of these display objects in their container can be adjusted using the `addChildAt()` method. For example, consider the following code:

```
ball_A = new Ball(0xFFCC00, "a");
ball_A.name = "ball_A";
ball_A.x = 20;
ball_A.y = 20;
container.addChild(ball_A);

ball_B = new Ball(0xFFCC00, "b");
ball_B.name = "ball_B";
ball_B.x = 70;
ball_B.y = 20;
container.addChild(ball_B);

ball_C = new Ball(0xFFCC00, "c");
ball_C.name = "ball_C";
ball_C.x = 40;
ball_C.y = 60;
container.addChildAt(ball_C, 1);
```

After executing this code, the display objects are positioned as follows in the `container` DisplayObjectContainer object. Notice the layering of the objects.



To reposition an object to the top of the display list, simply re-add it to the list. For example, after the previous code, to move `ball_A` to the top of the stack, use this line of code:

```
container.addChild(ball_A);
```

This code effectively removes `ball_A` from its location in `container`'s display list, and re-adds it to the top of the list—which has the end result of moving it to the top of the stack.

You can use the `getChildAt()` method to verify the layer order of the display objects. The `getChildAt()` method returns child objects of a container based on the index number you pass it. For example, the following code reveals names of display objects at different positions in the child list of the `container` DisplayObjectContainer object:

```
trace(container.getChildAt(0).name); // ball_A
trace(container.getChildAt(1).name); // ball_C
trace(container.getChildAt(2).name); // ball_B
```

If you remove a display object from the parent container's child list, the higher elements on the list each move down a position in the child index. For example, continuing with the previous code, the following code shows how the display object that was at position 2 in the `container` DisplayObjectContainer moves to position 1 if a display object that is lower in the child list is removed:

```
container.removeChild(ball_C);
trace(container.getChildAt(0).name); // ball_A
trace(container.getChildAt(1).name); // ball_B
```

The `removeChild()` and `removeChildAt()` methods do not delete a display object instance entirely. They simply remove it from the child list of the container. The instance can still be referenced by another variable. (Use the `delete` operator to completely remove an object.)

Because a display object has only one parent container, you can add an instance of a display object to only one display object container. For example, the following code shows that the display object `tf1` can exist in only one container (in this case, a Sprite, which extends the DisplayObjectContainer class):

```
tf1:TextField = new TextField();
tf2:TextField = new TextField();
tf1.name = "text 1";
tf2.name = "text 2";

container1:Sprite = new Sprite();
container2:Sprite = new Sprite();

container1.addChild(tf1);
container1.addChild(tf2);
container2.addChild(tf1);

trace(container1.numChildren); // 1
trace(container1.getChildAt(0).name); // text 2
trace(container2.numChildren); // 1
trace(container2.getChildAt(0).name); // text 1
```

If you add a display object that is contained in one display object container to another display object container, it is removed from the first display object container's child list.

In addition to the methods described above, the DisplayObjectContainer class defines several methods for working with child display objects, including the following:

- `contains()`: Determines whether a display object is a child of a DisplayObjectContainer.
- `getChildByName()`: Retrieves a display object by name.
- `getChildIndex()`: Returns the index position of a display object.
- `setChildIndex()`: Changes the position of a child display object.
- `removeChildren()`: Removes multiple child display objects.
- `swapChildren()`: Swaps the front-to-back order of two display objects.
- `swapChildrenAt()`: Swaps the front-to-back order of two display objects, specified by their index values.

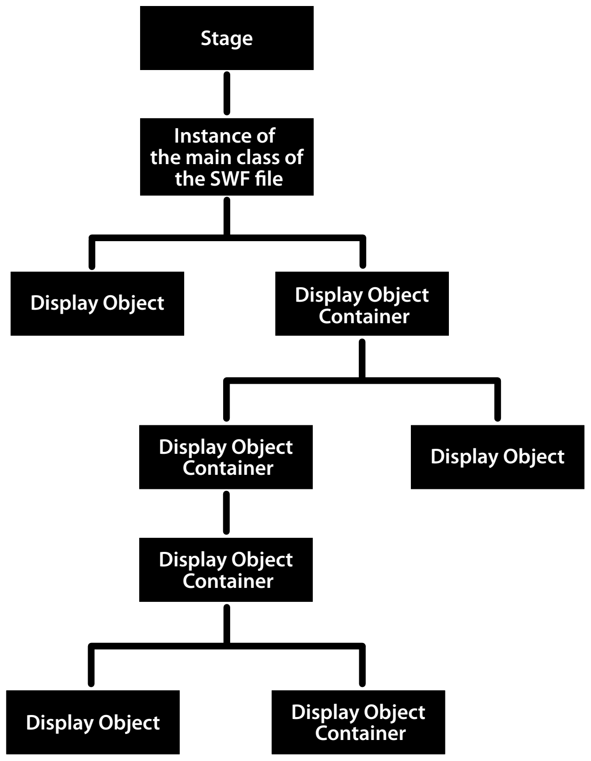
For more information, see the relevant entries in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Recall that a display object that is off the display list—one that is not included in a display object container that is a child of the Stage—is known as an *off-list* display object.

Traversing the display list

Flash Player 9 and later, Adobe AIR 1.0 and later

As you've seen, the display list is a tree structure. At the top of the tree is the Stage, which can contain multiple display objects. Those display objects that are themselves display object containers can contain other display objects, or display object containers.



The DisplayObjectContainer class includes properties and methods for traversing the display list, by means of the child lists of display object containers. For example, consider the following code, which adds two display objects, `title` and `pict`, to the `container` object (which is a Sprite, and the Sprite class extends the DisplayObjectContainer class):

```
var container:Sprite = new Sprite();
var title:TextField = new TextField();
title.text = "Hello";
var pict:Loader = new Loader();
var url:URLRequest = new URLRequest("banana.jpg");
pict.load(url);
pict.name = "banana loader";
container.addChild(title);
container.addChild(pict);
```

The `getChildAt()` method returns the child of the display list at a specific index position:

```
trace(container.getChildAt(0) is TextField); // true
```

You can also access child objects by name. Each display object has a name property, and if you don't assign it, Flash Player or AIR assigns a default value, such as `"instance1"`. For example, the following code shows how to use the `getChildByName()` method to access a child display object with the name `"banana loader"`:

```
trace(container.getChildByName("banana loader") is Loader); // true
```

Using the `getChildByName()` method can result in slower performance than using the `getChildAt()` method.

Since a display object container can contain other display object containers as child objects in its display list, you can traverse the full display list of the application as a tree. For example, in the code excerpt shown earlier, once the load operation for the `pict` Loader object is complete, the `pict` object will have one child display object, which is the bitmap, loaded. To access this bitmap display object, you can write `pict.getChildAt(0)`. You can also write `container.getChildAt(0).getChildAt(0)` (since `container.getChildAt(0) == pict`).

The following function provides an indented `trace()` output of the display list from a display object container:

```
function traceDisplayList(container:DisplayObjectContainer,indentString:String = ""):void
{
    var child:DisplayObject;
    for (var i:uint=0; i < container.numChildren; i++)
    {
        child = container.getChildAt(i);
        trace(indentString, child, child.name);
        if (container.getChildAt(i) is DisplayObjectContainer)
        {
            traceDisplayList(DisplayObjectContainer(child), indentString + "")
        }
    }
}
```

Adobe Flex

If you use Flex, you should know that Flex defines many component display object classes, and these classes override the display list access methods of the DisplayObjectContainer class. For example, the Container class of the mx.core package overrides the `addChild()` method and other methods of the DisplayObjectContainer class (which the Container class extends). In the case of the `addChild()` method, the class overrides the method in such a way that you cannot add all types of display objects to a Container instance in Flex. The overridden method, in this case, requires that the child object that you are adding be a type of mx.core.UIComponent object.

Setting Stage properties

Flash Player 9 and later, Adobe AIR 1.0 and later

The Stage class overrides most properties and methods of the DisplayObject class. If you call one of these overridden properties or methods, Flash Player and AIR throw an exception. For example, the Stage object does not have `x` or `y` properties, since its position is fixed as the main container for the application. The `x` and `y` properties refer to the position of a display object relative to its container, and since the Stage is not contained in another display object container, these properties do not apply.

***Note:** Some properties and methods of the Stage class are only available to display objects that are in the same security sandbox as the first SWF file loaded. For details, see "Stage security" on page 1064.*

Controlling the playback frame rate

Flash Player 9 and later, Adobe AIR 1.0 and later

The `frameRate` property of the Stage class is used to set the frame rate for all SWF files loaded into the application. For more information, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

Controlling Stage scaling

Flash Player 9 and later, Adobe AIR 1.0 and later

When the portion of the screen representing Flash Player or AIR is resized, the runtime automatically adjusts the Stage contents to compensate. The Stage class's `scaleMode` property determines how the Stage contents are adjusted. This property can be set to four different values, defined as constants in the flash.display.StageScaleMode class:

- `StageScaleMode.EXACT_FIT` scales the SWF to fill the new stage dimensions without regard for the original content aspect ratio. The scale factors might not be the same for width and height, so the content can appear squeezed or stretched if the aspect ratio of the stage is changed.
- `StageScaleMode.SHOW_ALL` scales the SWF to fit entirely within the new stage dimensions without changing the content aspect ratio. This scale mode displays all of the content, but can result in "letterbox" borders, like the black bars that appear when viewing a wide-screen movie on a standard television.
- `StageScaleMode.NO_BORDER` scales the SWF to entirely fill the new stage dimensions without changing the aspect ratio of the content. This scale mode makes full use of the stage display area, but can result in cropping.
- `StageScaleMode.NO_SCALE` — does not scale the SWF. If the new stage dimensions are smaller, the content is cropped; if larger, the added space is blank.

  In the `StageScaleMode.NO_SCALE` scale mode only, the stage`Width` and stage`Height` properties of the Stage class can be used to determine the actual pixel dimensions of the resized stage. (In the other scale modes, the `stageWidth` and `stageHeight` properties always reflect the original width and height of the SWF.) In addition, when `scaleMode` is set to `StageScaleMode.NO_SCALE` and the SWF file is resized, the Stage class's `resize` event is dispatched, allowing you to make adjustments accordingly.

  Consequently, having `scaleMode` set to `StageScaleMode.NO_SCALE` allows you to have greater control over how the screen contents adjust to the window resizing if you desire. For example, in a SWF containing a video and a control bar, you might want to make the control bar stay the same size when the Stage is resized, and only change the size of the video window to accommodate the Stage size change. This is demonstrated in the following example:

```
// mainContent is a display object containing the main content;
// it is positioned at the top-left corner of the Stage, and
// it should resize when the SWF resizes.

// controlBar is a display object (e.g. a Sprite) containing several
// buttons; it should stay positioned at the bottom-left corner of the
// Stage (below mainContent) and it should not resize when the SWF
// resizes.

import flash.display.Stage;
import flash.display.StageAlign;
import flash.display.StageScaleMode;
import flash.events.Event;

var swfStage:Stage = mainContent.stage;
swfStage.scaleMode = StageScaleMode.NO_SCALE;
swfStage.align = StageAlign.TOP_LEFT;
swfStage.addEventListener(Event.RESIZE, resizeDisplay);

function resizeDisplay(event:Event):void
{
    var swfWidth:int = swfStage.stageWidth;
    var swfHeight:int = swfStage.stageHeight;

    // Resize the main content area
    var newContentHeight:Number = swfHeight - controlBar.height;
    mainContent.height = newContentHeight;
    mainContent.scaleX = mainContent.scaleY;

    // Reposition the control bar.
    controlBar.y = newContentHeight;
}
```

Setting the stage scale mode for AIR windows

The stage `scaleMode` property determines how the stage scales and clips child display objects when a window is resized. Only the `noScale` mode should be used in AIR. In this mode, the stage is not scaled. Instead, the size of the stage changes directly with the bounds of the window. Objects may be clipped if the window is resized smaller.

The stage scale modes are designed for use in a environments such as a web browser where you don't always have control over the size or aspect ratio of the stage. The modes let you choose the least bad compromise when the stage does not match the ideal size or aspect ratio of your application. In AIR, you always have control of the stage, so in most cases re-laying out your content or adjusting the dimensions of your window will give you better results than enabling stage scaling.

In the browser and for the initial AIR window, the relationship between the window size and the initial scale factor is read from the loaded SWF file. However, when you create a NativeWindow object, AIR chooses an arbitrary relationship between the window size and the scale factor of 72:1. Thus, if your window is 72x72 pixels, a 10x10 rectangle added to the window is drawn the correct size of 10x10 pixels. However, if the window is 144x144 pixels, then a 10x10 pixel rectangle is scaled to 20x20 pixels. If you insist on using a `scaleMode` other than `noScale` for a window stage, you can compensate by setting the scale factor of any display objects in the window to the ratio of 72 pixels to the current width and height of the stage. For example, the following code calculates the required scale factor for a display object named `client`:

```
if(newWindow.stage.scaleMode != StageScaleMode.NO_SCALE){
client.scaleX = 72/newWindow.stage.stageWidth;
client.scaleY = 72/newWindow.stage.stageHeight;
}
```

***Note:** Flex and HTML windows automatically set the stage `scaleMode` to `noScale`. Changing the `scaleMode` disturbs the automatic layout mechanisms used in these types of windows.*

Working with full-screen mode

Flash Player 9 and later, Adobe AIR 1.0 and later

Full-screen mode allows you to set a movie's stage to fill a viewer's entire monitor without any container borders or menus. The Stage class's `displayState` property is used to toggle full-screen mode on and off for a SWF. The `displayState` property can be set to one of the values defined by the constants in the flash.display.StageDisplayState class. To turn on full-screen mode, set the `displayState` property to `StageDisplayState.FULL_SCREEN`:

```
stage.displayState = StageDisplayState.FULL_SCREEN;
```

To turn on full-screen interactive mode (new in Flash Player 11.3), set the `displayState` property to `StageDisplayState.FULL_SCREEN_INTERACTIVE`:

```
stage.displayState = StageDisplayState.FULL_SCREEN_INTERACTIVE;
```

In Flash Player, full-screen mode can only be initiated through ActionScript in response to a mouse click (including right-click) or keypress. AIR content running in the application security sandbox does not require that full-screen mode be entered in response to a user gesture.

To exit full-screen mode, set the `displayState` property to `StageDisplayState.NORMAL`.

```
stage.displayState = StageDisplayState.NORMAL;
```

In addition, a user can choose to leave full-screen mode by switching focus to a different window or by using one of several key combinations: the Esc key (all platforms), Control-W (Windows), Command-W (Mac), or Alt-F4 (Windows).

Enabling full-screen mode in Flash Player

To enable full-screen mode for a SWF file embedded in an HTML page, the HTML code to embed Flash Player must include a `param` tag and `embed` attribute with the name `allowFullScreen` and value `true`, like this:

```
<object>
    ...
    <param name="allowFullScreen" value="true" />
    <embed ... allowFullScreen="true" />
</object>
```

In the Flash authoring tool, select File -> Publish Settings and in the Publish Settings dialog box, on the HTML tab, select the Flash Only - Allow Full Screen template.

In Flex, ensure that the HTML template includes `<object>` and `<embed>` tags that support full screen.

If you are using JavaScript in a web page to generate the SWF-embedding tags, you must alter the JavaScript to add the `allowFullScreen param` tag and attribute. For example, if your HTML page uses the `AC_FL_RunContent()` function (which is used in HTML pages generated by Flash Professional and Flash Builder), you should add the `allowFullScreen` parameter to that function call as follows:

```
AC_FL_RunContent(
    ...
    'allowFullScreen','true',
    ...
    ); //end AC code
```

This does not apply to SWF files running in the stand-alone Flash Player.

***Note:** If you set the Window Mode (wmode in the HTML) to Opaque Windowless (opaque) or Transparent Windowless (transparent), the full-screen window is always opaque*

There are also security-related restrictions for using full-screen mode with Flash Player in a browser. These restrictions are described in "Security" on page 1042.

Enabling full-screen interactive mode in Flash Player 11.3 and higher

Flash Player 11.3 and higher support full-screen interactive mode, which enables full support for all keyboard keys (except for **Esc**, which exits full-screen interactive mode). Full-screen interactive mode is useful for gaming (for example, to enable chat in a multi-player game or WASD keyboard controls in a first-person shooter game.)

To enable full-screen interactive mode for a SWF file embedded in an HTML page, the HTML code to embed Flash Player must include a `param` tag and `embed` attribute with the name `allowFullScreenInteractive` and value `true`, like this:

```
<object>
    ...
    <param name="allowFullScreenInteractive" value="true" />
    <embed ... allowFullScreenInteractive="true" />
</object>
```

In the Flash authoring tool, select File -> Publish Settings and in the Publish Settings dialog box, on the HTML tab, select the Flash Only - Allow Full Screen Interactive template.

In Flash Builder and Flex, ensure that the HTML templates include `<object>` and `<embed>` tags that support full screen interactive mode.

If you are using JavaScript in a web page to generate the SWF-embedding tags, you must alter the JavaScript to add the `allowFullScreenInteractive param` tag and attribute. For example, if your HTML page uses the `AC_FL_RunContent()` function (which is used in HTML pages generated by Flash Professional and Flash Builder), you should add the `allowFullScreenInteractive` parameter to that function call as follows:

```
AC_FL_RunContent(
    ...
    'allowFullScreenInteractive','true',
    ...
    ); //end AC code
```

This does not apply to SWF files running in the stand-alone Flash Player.

Full screen stage size and scaling

The `Stage.fullScreenHeight` and `Stage.fullScreenWidth` properties return the height and the width of the monitor that's used when going to full-screen size, if that state is entered immediately. These values can be incorrect if the user has the opportunity to move the browser from one monitor to another after you retrieve these values but before entering full-screen mode. If you retrieve these values in the same event handler where you set the `Stage.displayState` property to `StageDisplayState.FULL_SCREEN`, the values are correct.For users with multiple monitors, the SWF content expands to fill only one monitor. Flash Player and AIR use a metric to determine which monitor contains the greatest portion of the SWF, and uses that monitor for full-screen mode. The fullScreenHeight and fullScreenWidth properties only reflect the size of the monitor that is used for full-screen mode. For more information, see `Stage.fullScreenHeight` and `Stage.fullScreenWidth` in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Stage scaling behavior for full-screen mode is the same as under normal mode; the scaling is controlled by the Stage class's `scaleMode` property. If the `scaleMode` property is set to `StageScaleMode.NO_SCALE`, the Stage's `stageWidth` and `stageHeight` properties change to reflect the size of the screen area occupied by the SWF (the entire screen, in this case); if viewed in the browser the HTML parameter for this controls the setting.

You can use the Stage class's `fullScreen` event to detect and respond when full-screen mode is turned on or off. For example, you might want to reposition, add, or remove items from the screen when entering or leaving full-screen mode, as in this example:

```
import flash.events.FullScreenEvent;

function fullScreenRedraw(event:FullScreenEvent):void
{
    if (event.fullScreen)
    {
        // Remove input text fields.
        // Add a button that closes full-screen mode.
    }
    else
    {
        // Re-add input text fields.
        // Remove the button that closes full-screen mode.
    }
}

mySprite.stage.addEventListener(FullScreenEvent.FULL_SCREEN, fullScreenRedraw);
```

As this code shows, the event object for the `fullScreen` event is an instance of the flash.events.FullScreenEvent class, which includes a `fullScreen` property indicating whether full-screen mode is enabled (`true`) or not (`false`).

Keyboard support in full-screen mode

When Flash Player runs in a browser, all keyboard-related ActionScript, such as keyboard events and text entry in TextField instances, is disabled in full-screen mode. The exceptions (the keys that are enabled) are:

- Selected non-printing keys, specifically the arrow keys, space bar, and tab key
- Keyboard shortcuts that terminate full-screen mode: Esc (Windows and Mac), Control-W (Windows), Command-W (Mac), and Alt-F4

These restrictions are not present for SWF content running in the stand-alone Flash Player or in AIR. AIR supports an interactive full-screen mode that allows keyboard input.

Mouse support in full-screen mode

By default, mouse events in full-screen mode work the same way as when not in full-screen mode. However, in full-screen mode, you can optionally set the `Stage.mouseLock` property to enable mouse locking. Mouse locking disables the cursor and enables unbounded mouse movement.

***Note:** You can only enable mouse locking in full-screen mode for desktop applications. Setting it on applications not in full-screen mode, or for applications on mobile devices, throws an exception.*

Mouse locking is disabled automatically and the mouse cursor is made visible again when:

- The user exits full-screen mode by using the Escape key (all platforms), Control-W (Windows), Command-W (Mac), or Alt-F4 (Windows).
- The application window loses focus.
- Any settings UI is visible, including all privacy dialog boxes.
- A native dialog box is shown, such as a file upload dialog box.

Events associated with mouse movement, such as the `mouseMove` event, use the MouseEvent class to represent the event object. When mouse locking is disabled, use the `MouseEvent.localX` and `MouseEvent.localY` properties to determine the location of the mouse.When mouse locking is enabled, use the `MouseEvent.movementX` and `MouseEvent.movementY` properties to determine the location of the mouse. The `movementX` and `movementY` properties contain changes in the position of the mouse since the last event, instead of absolute coordinates of the mouse location.

Hardware scaling in full-screen mode

You can use the Stage class's `fullScreenSourceRect` property to set Flash Player or AIR to scale a specific region of the stage to full-screen mode. Flash Player and AIR scale in hardware, if available, using the graphics and video card on a user's computer, and generally display content more quickly than software scaling.

To take advantage of hardware scaling, you set the whole stage or part of the stage to full-screen mode. The following ActionScript 3.0 code sets the whole stage to full-screen mode:

```
import flash.geom.*;
{
    stage.fullScreenSourceRect = new Rectangle(0,0,320,240);
    stage.displayState = StageDisplayState.FULL_SCREEN;
}
```

When this property is set to a valid rectangle and the `displayState` property is set to full-screen mode, Flash Player and AIR scale the specified area. The actual Stage size in pixels within ActionScript does not change. Flash Player and AIR enforce a minimum limit for the size of the rectangle to accommodate the standard "Press Esc to exit full-screen mode" message. This limit is usually around 260 by 30 pixels but can vary depending on platform and Flash Player version.

The `fullScreenSourceRect` property can only be set when Flash Player or AIR is not in full-screen mode. To use this property correctly, set this property first, then set the `displayState` property to full-screen mode.

To enable scaling, set the `fullScreenSourceRect` property to a rectangle object.

```
stage.fullScreenSourceRect = new Rectangle(0,0,320,240);
```

To disable scaling, set the `fullScreenSourceRect` property to `null`.

```
stage.fullScreenSourceRect = null;
```

To take advantage of all hardware acceleration features with Flash Player, enable it through the Flash Player Settings dialog box. To load the dialog box, right-click (Windows) or Control-click (Mac) inside Flash Player content in your browser. Select the Display tab, which is the first tab, and click the checkbox: Enable hardware acceleration.

Direct and GPU-compositing window modes

Flash Player 10 introduces two window modes, direct and GPU compositing, which you can enable through the publish settings in the Flash authoring tool. These modes are not supported in AIR. To take advantage of these modes, you must enable hardware acceleration for Flash Player.

Direct mode uses the fastest, most direct path to push graphics to the screen, which is advantageous for video playback.

GPU Compositing uses the graphics processing unit on the video card to accelerate compositing. Video compositing is the process of layering multiple images to create a single video image. When compositing is accelerated with the GPU it can improve the performance of YUV conversion, color correction, rotation or scaling, and blending. YUV conversion refers to the color conversion of composite analog signals, which are used for transmission, to the RGB (red, green, blue) color model that video cameras and displays use. Using the GPU to accelerate compositing reduces the memory and computational demands that are otherwise placed on the CPU. It also results in smoother playback for standard-definition video.

Be cautious in implementing these window modes. Using GPU compositing can be expensive for memory and CPU resources. If some operations (such as blend modes, filtering, clipping or masking) cannot be carried out in the GPU, they are done by the software. Adobe recommends limiting yourself to one SWF file per HTML page when using these modes and you should not enable these modes for banners. The Flash Test Movie facility does not use hardware acceleration but you can use it through the Publish Preview option.

Setting a frame rate in your SWF file that is higher than 60, the maximum screen refresh rate, is useless. Setting the frame rate from 50 through 55 allows for dropped frames, which can occur for various reasons from time to time.

Using direct mode requires Microsoft DirectX 9 with VRAM 128 MB on Windows and OpenGL for Apple Macintosh, Mac OS X v10.2 or higher. GPU compositing requires Microsoft DirectX 9 and Pixel Shader 2.0 support on Windows with 128 MB of VRAM. On Mac OS X and Linux, GPU compositing requires OpenGL 1.5 and several OpenGL extensions (framebuffer object, multitexture, shader objects, shading language, fragment shader).

You can activate `direct` and `gpu` acceleration modes on a per-SWF basis through the Flash Publish Settings dialog box, using the Hardware Acceleration menu on the Flash tab. If you choose None, the window mode reverts to `default`, `transparent`, or `opaque`, as specified by the Window Mode setting on the HTML tab.

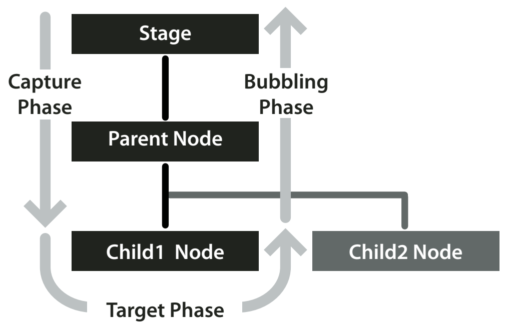
Handling events for display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

The DisplayObject class inherits from the EventDispatcher class. This means that every display object can participate fully in the event model (described in "Handling events" on page 125). Every display object can use its `addEventListener()` method—inherited from the EventDispatcher class—to listen for a particular event, but only if the listening object is part of the event flow for that event.

When Flash Player or AIR dispatches an event object, that event object makes a round-trip journey from the Stage to the display object where the event occurred. For example, if a user clicks on a display object named `child1`, Flash Player dispatches an event object from the Stage through the display list hierarchy down to the `child1` display object.

The event flow is conceptually divided into three phases, as illustrated in this diagram:



For more information, see “Handling events” on page 125.

One important issue to keep in mind when working with display object events is the effect that event listeners can have on whether display objects are automatically removed from memory (garbage collected) when they're removed from the display list. If a display object has objects subscribed as listeners to its events, that display object will not be removed from memory even when it's removed from the display list, because it will still have references to those listener objects. For more information, see “Managing event listeners” on page 138.

Choosing a DisplayObject subclass

Flash Player 9 and later, Adobe AIR 1.0 and later

With several options to choose from, one of the important decisions you'll make when you're working with display objects is which display object to use for what purpose. Here are some guidelines to help you decide. These same suggestions apply whether you need an instance of a class or you're choosing a base class for a class you're creating:

- If you don't need an object that can be a container for other display objects (that is, you just need one that serves as a stand-alone screen element), choose one of these DisplayObject or InteractiveObject subclasses, depending on what it will be used for:
  - Bitmap for displaying a bitmap image.
  - TextField for adding text.
  - Video for displaying video.
  - Shape for a “canvas” for drawing content on-screen. In particular, if you want to create an instance for drawing shapes on the screen, and it won't be a container for other display objects, you'll gain significant performance benefits using Shape instead of Sprite or MovieClip.
  - MorphShape, StaticText, or SimpleButton for items created by the Flash authoring tool. (You can't create instances of these classes programmatically, but you can create variables with these data types to refer to items created using the Flash authoring tool.)
- If you need a variable to refer to the main Stage, use the Stage class as its data type.
- If you need a container for loading an external SWF file or image file, use a Loader instance. The loaded content will be added to the display list as a child of the Loader instance. Its data type will depend on the nature of the loaded content, as follows:
  - A loaded image will be a Bitmap instance.
  - A loaded SWF file written in ActionScript 3.0 will be a Sprite or MovieClip instance (or an instance of a subclass of those classes, as specified by the content creator).
  - A loaded SWF file written in ActionScript 1.0 or ActionScript 2.0 will be an AVM1Movie instance.
- If you need an object to serve as a container for other display objects (whether or not you'll also be drawing onto the display object using ActionScript), choose one of the DisplayObjectContainer subclasses:
  - Sprite if the object will be created using only ActionScript, or as the base class for a custom display object that will be created and manipulated solely with ActionScript.
  - MovieClip if you're creating a variable to refer to a movie clip symbol created in the Flash authoring tool.
- If you are creating a class that will be associated with a movie clip symbol in the Flash library, choose one of these DisplayObjectContainer subclasses as your class's base class:
  - MovieClip if the associated movie clip symbol has content on more than one frame
  - Sprite if the associated movie clip symbol has content only on the first frame

Manipulating display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Regardless of which display object you choose to use, there are a number of manipulations that all display objects have in common as elements that are displayed on the screen. For example, they can all be positioned on the screen, moved forward or backward in the stacking order of display objects, scaled, rotated, and so forth. Because all display objects inherit this functionality from their common base class (DisplayObject), this functionality behaves the same whether you're manipulating a TextField instance, a Video instance, a Shape instance, or any other display object. The following sections detail several of these common display object manipulations.

Changing position

Flash Player 9 and later, Adobe AIR 1.0 and later

The most basic manipulation to any display object is positioning it on the screen. To set a display object's position, change the object's `x` and `y` properties.

```
myShape.x = 17;
myShape.y = 212;
```

The display object positioning system treats the Stage as a Cartesian coordinate system (the common grid system with a horizontal x axis and vertical y axis). The origin of the coordinate system (the 0,0 coordinate where the x and y axes meet) is at the top-left corner of the Stage. From there, x values are positive going right and negative going left, while (in contrast to typical graphing systems) y values are positive going down and negative going up. For example, the previous lines of code move the object `myShape` to the x coordinate 17 (17 pixels to the right of the origin) and y coordinate 212 (212 pixels below the origin).

By default, when a display object is created using ActionScript, the `x` and `y` properties are both set to 0, placing the object at the top-left corner of its parent content.

Changing position relative to the Stage

It's important to remember that the `x` and `y` properties always refer to the position of the display object relative to the 0,0 coordinate of its parent display object's axes. So for a Shape instance (such as a circle) contained inside a Sprite instance, setting the Shape object's `x` and `y` properties to 0 will place the circle at the top-left corner of the Sprite, which is not necessarily the top-left corner of the Stage. To position an object relative to the global Stage coordinates, you can use the `globalToLocal()` method of any display object to convert coordinates from global (Stage) coordinates to local (display object container) coordinates, like this:

```
// Position the shape at the top-left corner of the Stage,
// regardless of where its parent is located.

// Create a Sprite, positioned at x:200 and y:200.
var mySprite:Sprite = new Sprite();
mySprite.x = 200;
mySprite.y = 200;
this.addChild(mySprite);

// Draw a dot at the Sprite's 0,0 coordinate, for reference.
mySprite.graphics.lineStyle(1, 0x000000);
mySprite.graphics.beginFill(0x000000);
mySprite.graphics.moveTo(0, 0);
mySprite.graphics.lineTo(1, 0);
mySprite.graphics.lineTo(1, 1);
mySprite.graphics.lineTo(0, 1);
mySprite.graphics.endFill();

// Create the circle Shape instance.
var circle:Shape = new Shape();
mySprite.addChild(circle);

// Draw a circle with radius 50 and center point at x:50, y:50 in the Shape.
circle.graphics.lineStyle(1, 0x000000);
circle.graphics.beginFill(0xff0000);
circle.graphics.drawCircle(50, 50, 50);
circle.graphics.endFill();

// Move the Shape so its top-left corner is at the Stage's 0, 0 coordinate.
var stagePoint:Point = new Point(0, 0);
var targetPoint:Point = mySprite.globalToLocal(stagePoint);
circle.x = targetPoint.x;
circle.y = targetPoint.y;
```

You can likewise use the DisplayObject class's `localToGlobal()` method to convert local coordinates to Stage coordinates.

Moving display objects with the mouse

You can let a user move display objects with mouse using two different techniques in ActionScript. In both cases, two mouse events are used: when the mouse button is pressed down, the object is told to follow the mouse cursor, and when it's released, the object is told to stop following the mouse cursor.

***Note:** Flash Player 11.3 and higher, AIR 3.3 and higher: You can also use the MouseEvent.RELEASE_OUTSIDE event to cover the case of a user releasing the mouse button outside the bounds of the containing Sprite.*

The first technique, using the `startDrag()` method, is simpler, but more limited. When the mouse button is pressed, the `startDrag()` method of the display object to be dragged is called. When the mouse button is released, the `stopDrag()` method is called. The Sprite class defines these two functions, so the object moved must be a Sprite or one of its subclasses.

```
// This code creates a mouse drag interaction using the startDrag()
// technique.
// square is a MovieClip or Sprite instance).

import flash.events.MouseEvent;

// This function is called when the mouse button is pressed.
function startDragging(event:MouseEvent):void
{
    square.startDrag();
}

// This function is called when the mouse button is released.
function stopDragging(event:MouseEvent):void
{
    square.stopDrag();
}

square.addEventListener(MouseEvent.MOUSE_DOWN, startDragging);
square.addEventListener(MouseEvent.MOUSE_UP, stopDragging);
```

This technique suffers from one fairly significant limitation: only one item at a time can be dragged using `startDrag()`. If one display object is being dragged and the `startDrag()` method is called on another display object, the first display object stops following the mouse immediately. For example, if the `startDragging()` function is changed as shown here, only the `circle` object will be dragged, in spite of the `square.startDrag()` method call:

```
function startDragging(event:MouseEvent):void
{
    square.startDrag();
    circle.startDrag();
}
```

As a consequence of the fact that only one object can be dragged at a time using `startDrag()`, the `stopDrag()` method can be called on any display object and it stops whatever object is currently being dragged.

If you need to drag more than one display object, or to avoid the possibility of conflicts where more than one object might potentially use `startDrag()`, it's best to use the mouse-following technique to create the dragging effect. With this technique, when the mouse button is pressed, a function is subscribed as a listener to the `mouseMove` event of the Stage. This function, which is then called every time the mouse moves, causes the dragged object to jump to the x, y coordinate of the mouse. Once the mouse button is released, the function is unsubscribed as a listener, meaning it is no longer called when the mouse moves and the object stops following the mouse cursor. Here is some code that demonstrates this technique:

```
// This code moves display objects using the mouse-following
// technique.
// circle is a DisplayObject (e.g. a MovieClip or Sprite instance).

import flash.events.MouseEvent;

var offsetX:Number;
var offsetY:Number;

// This function is called when the mouse button is pressed.
function startDragging(event:MouseEvent):void
{
    // Record the difference (offset) between where
    // the cursor was when the mouse button was pressed and the x, y
    // coordinate of the circle when the mouse button was pressed.
    offsetX = event.stageX - circle.x;
    offsetY = event.stageY - circle.y;

    // tell Flash Player to start listening for the mouseMove event
    stage.addEventListener(MouseEvent.MOUSE_MOVE, dragCircle);
}

// This function is called when the mouse button is released.
function stopDragging(event:MouseEvent):void
{
    // Tell Flash Player to stop listening for the mouseMove event.
    stage.removeEventListener(MouseEvent.MOUSE_MOVE, dragCircle);
}

// This function is called every time the mouse moves,
// as long as the mouse button is pressed down.
function dragCircle(event:MouseEvent):void
{
    // Move the circle to the location of the cursor, maintaining
    // the offset between the cursor's location and the
    // location of the dragged object.
    circle.x = event.stageX - offsetX;
    circle.y = event.stageY - offsetY;

    // Instruct Flash Player to refresh the screen after this event.
    event.updateAfterEvent();
}

circle.addEventListener(MouseEvent.MOUSE_DOWN, startDragging);
circle.addEventListener(MouseEvent.MOUSE_UP, stopDragging);
```

In addition to making a display object follow the mouse cursor, it is often desirable to move the dragged object to the front of the display, so that it appears to be floating above all the other objects. For example, suppose you have two objects, a circle and a square, that can both be moved with the mouse. If the circle happens to be below the square on the display list, and you click and drag the circle so that the cursor is over the square, the circle will appear to slide behind the square, which breaks the drag-and-drop illusion. Instead, you can make it so that when the circle is clicked, it moves to the top of the display list, and thus always appears on top of any other content.

The following code (adapted from the previous example) allows two display objects, a circle and a square, to be moved with the mouse. Whenever the mouse button is pressed over either one, that item is moved to the top of the Stage's display list, so that the dragged item always appears on top. (Code that is new or changed from the previous listing appears in boldface.)

```
// This code creates a drag-and-drop interaction using the mouse-following
// technique.
// circle and square are DisplayObjects (e.g. MovieClip or Sprite
// instances).

import flash.display.DisplayObject;
import flash.events.MouseEvent;

var offsetX:Number;
var offsetY:Number;
var draggedObject:DisplayObject;

// This function is called when the mouse button is pressed.
function startDragging(event:MouseEvent):void
{
    // remember which object is being dragged
    draggedObject = DisplayObject(event.target);

    // Record the difference (offset) between where the cursor was when
    // the mouse button was pressed and the x, y coordinate of the
    // dragged object when the mouse button was pressed.
    offsetX = event.stageX - draggedObject.x;
    offsetY = event.stageY - draggedObject.y;

    // move the selected object to the top of the display list
    stage.addChild(draggedObject);

    // Tell Flash Player to start listening for the mouseMove event.
    stage.addEventListener(MouseEvent.MOUSE_MOVE, dragObject);
}

// This function is called when the mouse button is released.
function stopDragging(event:MouseEvent):void
{
    // Tell Flash Player to stop listening for the mouseMove event.
    stage.removeEventListener(MouseEvent.MOUSE_MOVE, dragObject);
}
```

```
// This function is called every time the mouse moves,
// as long as the mouse button is pressed down.
function dragObject(event:MouseEvent):void
{
    // Move the dragged object to the location of the cursor, maintaining
    // the offset between the cursor's location and the location
    // of the dragged object.
    draggedObject.x = event.stageX - offsetX;
    draggedObject.y = event.stageY - offsetY;

    // Instruct Flash Player to refresh the screen after this event.
    event.updateAfterEvent();
}

circle.addEventListener(MouseEvent.MOUSE_DOWN, startDragging);
circle.addEventListener(MouseEvent.MOUSE_UP, stopDragging);

square.addEventListener(MouseEvent.MOUSE_DOWN, startDragging);
square.addEventListener(MouseEvent.MOUSE_UP, stopDragging);
```

To extend this effect further, such as for a game where tokens or cards are moved among piles, you could add the dragged object to the Stage's display list when it's "picked up," and then add it to another display list—such as the "pile" where it is dropped—when the mouse button is released.

Finally, to enhance the effect, you could apply a drop shadow filter to the display object when it is clicked (when you start dragging it) and remove the drop shadow when the object is released. For details on using the drop shadow filter and other display object filters in ActionScript, see "Filtering display objects" on page 267.

Panning and scrolling display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

If you have a display object that is too large for the area in which you want it to display it, you can use the `scrollRect` property to define the viewable area of the display object. In addition, by changing the `scrollRect` property in response to user input, you can cause the content to pan left and right or scroll up and down.

The `scrollRect` property is an instance of the Rectangle class, which is a class that combines the values needed to define a rectangular area as a single object. To initially define the viewable area of the display object, create a new Rectangle instance and assign it to the display object's `scrollRect` property. Later, to scroll or pan, you read the `scrollRect` property into a separate Rectangle variable, and change the desired property (for instance, change the Rectangle instance's `x` property to pan or `y` property to scroll). Then you reassign that Rectangle instance to the `scrollRect` property to notify the display object of the changed value.

For example, the following code defines the viewable area for a TextField object named `bigText` that is too tall to fit in the SWF file's boundaries. When the two buttons named `up` and `down` are clicked, they call functions that cause the contents of the TextField object to scroll up or down by modifying the `y` property of the `scrollRect` Rectangle instance.

```
import flash.events.MouseEvent;
import flash.geom.Rectangle;

// Define the initial viewable area of the TextField instance:
// left: 0, top: 0, width: TextField's width, height: 350 pixels.
bigText.scrollRect = new Rectangle(0, 0, bigText.width, 350);

// Cache the TextField as a bitmap to improve performance.
bigText.cacheAsBitmap = true;

// called when the "up" button is clicked
function scrollUp(event:MouseEvent):void
{
    // Get access to the current scroll rectangle.
    var rect:Rectangle = bigText.scrollRect;
    // Decrease the y value of the rectangle by 20, effectively
    // shifting the rectangle down by 20 pixels.
    rect.y -= 20;
    // Reassign the rectangle to the TextField to "apply" the change.
    bigText.scrollRect = rect;
}

// called when the "down" button is clicked
function scrollDown(event:MouseEvent):void
{
    // Get access to the current scroll rectangle.
    var rect:Rectangle = bigText.scrollRect;
    // Increase the y value of the rectangle by 20, effectively
    // shifting the rectangle up by 20 pixels.
    rect.y += 20;
    // Reassign the rectangle to the TextField to "apply" the change.
    bigText.scrollRect = rect;
}

up.addEventListener(MouseEvent.CLICK, scrollUp);
down.addEventListener(MouseEvent.CLICK, scrollDown);
```

As this example illustrates, when you work with the `scrollRect` property of a display object, it's best to specify that Flash Player or AIR should cache the display object's content as a bitmap, using the `cacheAsBitmap` property. When you do so, Flash Player and AIR don't have to re-draw the entire contents of the display object each time it is scrolled, and can instead use the cached bitmap to render the necessary portion directly to the screen. For details, see "Caching display objects" on page 182.

Manipulating size and scaling objects

Flash Player 9 and later, Adobe AIR 1.0 and later

You can measure and manipulate the size of a display object in two ways, using either the dimension properties (`width` and `height`) or the scale properties (`scaleX` and `scaleY`).

Every display object has a `width` property and a `height` property, which are initially set to the size of the object in pixels. You can read the values of those properties to measure the size of the display object. You can also specify new values to change the size of the object, as follows:

```
// Resize a display object.
square.width = 420;
square.height = 420;

// Determine the radius of a circle display object.
var radius:Number = circle.width / 2;
```

Changing the `height` or `width` of a display object causes the object to scale, meaning its contents stretch or squeeze to fit in the new area. If the display object contains only vector shapes, those shapes will be redrawn at the new scale, with no loss in quality. Any bitmap graphic elements in the display object will be scaled rather than redrawn. So, for example, a digital photo whose width and height are increased beyond the actual dimensions of the pixel information in the image will be pixelated, making it look jagged.

When you change the `width` or `height` properties of a display object, Flash Player and AIR update the `scaleX` and `scaleY` properties of the object as well.

***Note:** TextField objects are an exception to this scaling behavior. Text fields need to resize themselves to accommodate text wrapping and font sizes, so they reset their scaleX or scaleY values to 1 after resizing. However, if you adjust the scaleX or scaleY values of a TextField object, the width and height values change to accommodate the scaling values you provide.*

These properties represent the relative size of the display object compared to its original size. The `scaleX` and `scaleY` properties use fraction (decimal) values to represent percentage. For example, if a display object's `width` has been changed so that it's half as wide as its original size, the object's `scaleX` property will have the value `.5`, meaning 50 percent. If its height has been doubled, its `scaleY` property will have the value `2`, meaning 200 percent.

```
// circle is a display object whose width and height are 150 pixels.
// At original size, scaleX and scaleY are 1 (100%).
trace(circle.scaleX); // output: 1
trace(circle.scaleY); // output: 1

// When you change the width and height properties,
// Flash Player changes the scaleX and scaleY properties accordingly.
circle.width = 100;
circle.height = 75;
trace(circle.scaleX); // output: 0.6622516556291391
trace(circle.scaleY); // output: 0.4966887417218543
```

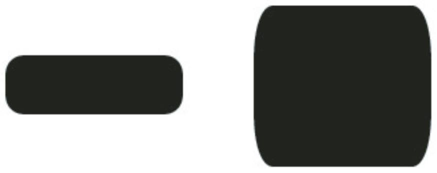
Size changes are not proportional. In other words, if you change the `height` of a square but not its `width`, its proportions will no longer be the same, and it will be a rectangle instead of a square. If you want to make relative changes to the size of a display object, you can set the values of the `scaleX` and `scaleY` properties to resize the object, as an alternative to setting the `width` or `height` properties. For example, this code changes the `width` of the display object named `square`, and then alters the vertical scale (`scaleY`) to match the horizontal scale, so that the size of the square stays proportional.

```
// Change the width directly.
square.width = 150;

// Change the vertical scale to match the horizontal scale,
// to keep the size proportional.
square.scaleY = square.scaleX;
```

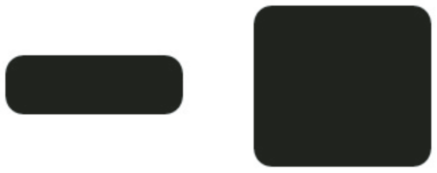
Controlling distortion when scaling

Flash Player 9 and later, Adobe AIR 1.0 and later

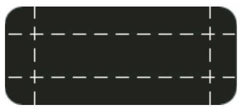
Normally when a display object is scaled (for example, stretched horizontally), the resulting distortion is spread equally across the object, so that each part is stretched the same amount. For graphics and design elements, this is probably what you want. However, sometimes it's preferable to have control over which portions of the display object stretch and which portions remain unchanged. One common example of this is a button that's a rectangle with rounded corners. With normal scaling, the corners of the button will stretch, making the corner radius change as the button resizes.



However, in this case it would be preferable to have control over the scaling—to be able to designate certain areas which should scale (the straight sides and middle) and areas which shouldn't (the corners)—so that scaling happens without visible distortion.



You can use 9-slice scaling (Scale-9) to create display objects where you have control over how the objects scale. With 9-slice scaling, the display object is divided into nine separate rectangles (a 3 by 3 grid, like the grid of a tic-tac-toe board). The rectangles aren't necessarily the same size—you designate where the grid lines are placed. Any content that lies in the four corner rectangles (such as the rounded corners of a button) will not be stretched or compressed when the display object scales. The top-center and bottom-center rectangles will scale horizontally but not vertically, while the left-middle and right-middle rectangles will scale vertically but not horizontally. The center rectangle will scale both horizontally and vertically.

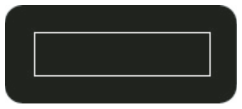


Keeping this in mind, if you're creating a display object and you want certain content to never scale, you just have to make sure that the dividing lines of the 9-slice scaling grid are placed so that the content ends up in one of the corner rectangles.

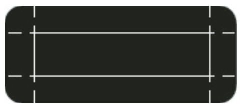
In ActionScript, setting a value for the `scale9Grid` property of a display object turns on 9-slice scaling for the object and defines the size of the rectangles in the object's Scale-9 grid. You use an instance of the Rectangle class as the value for the `scale9Grid` property, as follows:

```
myButton.scale9Grid = new Rectangle(32, 27, 71, 64);
```

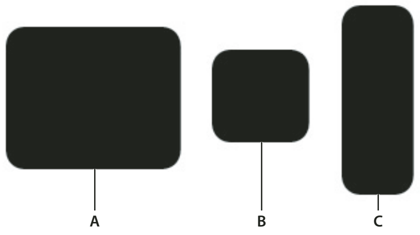
The four parameters of the Rectangle constructor are the x coordinate, y coordinate, width, and height. In this example, the rectangle's top-left corner is placed at the point x: 32, y: 27 on the display object named `myButton`. The rectangle is 71 pixels wide and 64 pixels tall (so its right edge is at the x coordinate 103 on the display object and its bottom edge is at the y coordinate 92 on the display object).



The actual area contained in the region defined by the Rectangle instance represents the center rectangle of the Scale-9 grid. The other rectangles are calculated by Flash Player and AIR by extending the sides of the Rectangle instance, as shown here:



In this case, as the button scales up or down, the rounded corners will not stretch or compress, but the other areas will adjust to accommodate the scaling.



A. *myButton.width = 131;myButton.height = 106;* ***B.*** *myButton.width = 73;myButton.height = 69;* ***C.*** *myButton.width = 54;myButton.height = 141;*

Caching display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

As your designs in Flash grow in size, whether you are creating an application or complex scripted animations, you need to consider performance and optimization. When you have content that remains static (such as a rectangle Shape instance), Flash Player and AIR do not optimize the content. Therefore, when you change the position of the rectangle, Flash Player or AIR redraws the entire Shape instance.

You can cache specified display objects to improve the performance of your SWF file. The display object is a *surface*, essentially a bitmap version of the instance's vector data, which is data that you do not intend to change much over the course of your SWF file. Therefore, instances with caching turned on are not continually redrawn as the SWF file plays, letting the SWF file render quickly.

Note: *You can update the vector data, at which time the surface is recreated. Therefore, the vector data cached in the surface does not need to remain the same for the entire SWF file.*

Setting a display object's `cacheAsBitmap` property to `true` makes the display object cache a bitmap representation of itself. Flash Player or AIR creates a surface object for the instance, which is a cached bitmap instead of vector data. If you change the bounds of the display object, the surface is recreated instead of resized. Surfaces can nest within other surfaces. The child surface copies its bitmap onto its parent surface. For more information, see "Enabling bitmap caching" on page 184.

The DisplayObject class's `opaqueBackground` property and `scrollRect` property are related to bitmap caching using the `cacheAsBitmap` property. Although these three properties are independent of each other, the `opaqueBackground` and `scrollRect` properties work best when an object is cached as a bitmap—you see performance benefits for the `opaqueBackground` and `scrollRect` properties only when you set `cacheAsBitmap` to `true`. For more information about scrolling display object content, see "Panning and scrolling display objects" on page 178. For more information about setting an opaque background, see "Setting an opaque background color" on page 185.

For information on alpha channel masking, which requires you to set the `cacheAsBitmap` property to `true`, see "Masking display objects" on page 190.

When to enable caching

Flash Player 9 and later, Adobe AIR 1.0 and later

Enabling caching for a display object creates a surface, which has several advantages, such as helping complex vector animations to render fast. There are several scenarios in which you will want to enable caching. It might seem as though you would always want to enable caching to improve the performance of your SWF files; however, there are situations in which enabling caching does not improve performance, or can even decrease it. This section describes scenarios in which caching should be used, and when to use regular display objects.

Overall performance of cached data depends on how complex the vector data of your instances are, how much of the data you change, and whether or not you set the `opaqueBackground` property. If you are changing small regions, the difference between using a surface and using vector data could be negligible. You might want to test both scenarios with your work before you deploy the application.

When to use bitmap caching

The following are typical scenarios in which you might see significant benefits when you enable bitmap caching.

- Complex background image: An application that contains a detailed and complex background image of vector data (perhaps an image where you applied the trace bitmap command, or artwork that you created in Adobe Illustrator®). You might animate characters over the background, which slows the animation because the background needs to continuously regenerate the vector data. To improve performance, you can set the `opaqueBackground` property of the background display object to `true`. The background is rendered as a bitmap and can be redrawn quickly, so that your animation plays much faster.
- Scrolling text field: An application that displays a large amount of text in a scrolling text field. You can place the text field in a display object that you set as scrollable with scrolling bounds (the `scrollRect` property). This enables fast pixel scrolling for the specified instance. When a user scrolls the display object instance, Flash Player or AIR shifts the scrolled pixels up and generates the newly exposed region instead of regenerating the entire text field.
- Windowing system: An application with a complex system of overlapping windows. Each window can be open or closed (for example, web browser windows). If you mark each window as a surface (by setting the `cacheAsBitmap` property to `true`), each window is isolated and cached. Users can drag the windows so that they overlap each other, and each window doesn't need to regenerate the vector content.
- Alpha channel masking: When you are using alpha channel masking, you must set the `cacheAsBitmap` property to `true`. For more information, see "Masking display objects" on page 190.

Enabling bitmap caching in all of these scenarios improves the responsiveness and interactivity of the application by optimizing the vector graphics.

In addition, whenever you apply a filter to a display object, `cacheAsBitmap` is automatically set to `true`, even if you explicitly set it to `false`. If you clear all the filters from the display object, the `cacheAsBitmap` property returns to the value it was last set to.

When to avoid using bitmap caching

Using this feature in the wrong circumstances can negatively affect the performance of your SWF file. When you use bitmap caching, remember the following guidelines:

- Do not overuse surfaces (display objects with caching enabled). Each surface uses more memory than a regular display object, which means that you should only enable surfaces when you need to improve rendering performance.

  A cached bitmap can use significantly more memory than a regular display object. For example, if a Sprite instance on the Stage is 250 pixels by 250 pixels in size, when cached it might use 250 KB instead of 1 KB when it's a regular (un-cached) Sprite instance.
- Avoid zooming into cached surfaces. If you overuse bitmap caching, a large amount of memory is consumed (see previous bullet), especially if you zoom in on the content.
- Use surfaces for display object instances that are largely static (non-animating). You can drag or move the instance, but the contents of the instance should not animate or change a lot. (Animation or changing content are more likely with a MovieClip instance containing animation or a Video instance.) For example, if you rotate or transform an instance, the instance changes between the surface and vector data, which is difficult to process and negatively affects your SWF file.
- If you mix surfaces with vector data, it increases the amount of processing that Flash Player and AIR (and sometimes the computer) need to do. Group surfaces together as much as possible—for example, when you create windowing applications.
- Do not cache objects whose graphics change frequently. Every time you scale, skew, rotate the display object, change the alpha or color transform, move child display objects, or draw using the graphics property, the bitmap cache is redrawn. If this happens every frame, the runtime must draw the object into a bitmap and then copy that bitmap onto the stage—which results in extra work compared to just drawing the uncached object to the stage. The performance tradeoff of caching versus update frequency depends on the complexity and size of the display object and can only be determined by testing the specific content.

Enabling bitmap caching

Flash Player 9 and later, Adobe AIR 1.0 and later

To enable bitmap caching for a display object, you set its `cacheAsBitmap` property to `true`:

```
mySprite.cacheAsBitmap = true;
```

After you set the `cacheAsBitmap` property to `true`, you might notice that the display object automatically pixel-snaps to whole coordinates. When you test the SWF file, you should notice that any animation performed on a complex vector image renders much faster.

A surface (cached bitmap) is not created, even if `cacheAsBitmap` is set to `true`, if one or more of the following occurs:

- The bitmap is greater than 2880 pixels in height or width.
- The bitmap fails to allocate (because of an out-of-memory error).

Cached bitmap transform matrices

Adobe AIR 2.0 and later (mobile profile)

In AIR applications for mobile devices, you should set the `cacheAsBitmapMatrix` property whenever you set the `cacheAsBitmap` property. Setting this property allows you to apply a wider range of transformations to the display object without triggering rerendering.

```
mySprite.cacheAsBitmap = true;
mySprite.cacheAsBitmapMatrix = new Matrix();
```

When you set this matrix property, you can apply the following additional transformation to the display object without recaching the object:

- Move or translate without pixel-snapping
- Rotate
- Scale
- Skew
- Change alpha (between 0 and 100% transparency)

These transformations are applied directly to the cached bitmap.

Setting an opaque background color

Flash Player 9 and later, Adobe AIR 1.0 and later

You can set an opaque background for a display object. For example, when your SWF has a background that contains complex vector art, you can set the `opaqueBackground` property to a specified color (typically the same color as the Stage). The color is specified as a number (commonly a hexadecimal color value). The background is then treated as a bitmap, which helps optimize performance.

When you set `cacheAsBitmap` to `true`, and also set the `opaqueBackground` property to a specified color, the `opaqueBackground` property allows the internal bitmap to be opaque and rendered faster. If you do not set `cacheAsBitmap` to `true`, the `opaqueBackground` property adds an opaque vector-square shape to the background of the display object. It does not create a bitmap automatically.

The following example shows how to set the background of a display object to optimize performance:

```
myShape.cacheAsBitmap = true;
myShape.opaqueBackground = 0xFF0000;
```

In this case, the background color of the Shape named `myShape` is set to red (`0xFF0000`). Assuming the Shape instance contains a drawing of a green triangle, on a Stage with a white background, this would show up as a green triangle with red in the empty space in the Shape instance's bounding box (the rectangle that completely encloses the Shape).

Of course, this code would make more sense if it were used with a Stage with a solid red background. On another colored background, that color would be specified instead. For example, in a SWF with a white background, the `opaqueBackground` property would most likely be set to `0xFFFFFF`, or pure white.

Applying blending modes

Flash Player 9 and later, Adobe AIR 1.0 and later

Blending modes involve combining the colors of one image (the base image) with the colors of another image (the blend image) to produce a third image—the resulting image is the one that is actually displayed on the screen. Each pixel value in an image is processed with the corresponding pixel value of the other image to produce a pixel value for that same position in the result.

Every display object has a `blendMode` property that can be set to one of the following blending modes. These are constants defined in the BlendMode class. Alternatively, you can use the String values (in parentheses) that are the actual values of the constants.

- `BlendMode.ADD` (`"add"`): Commonly used to create an animated lightening dissolve effect between two images.
- `BlendMode.ALPHA` (`"alpha"`): Commonly used to apply the transparency of the foreground on the background. (Not supported under GPU rendering.)
- `BlendMode.DARKEN` (`"darken"`): Commonly used to superimpose type. (Not supported under GPU rendering.)
- `BlendMode.DIFFERENCE` (`"difference"`): Commonly used to create more vibrant colors.
- `BlendMode.ERASE` (`"erase"`): Commonly used to cut out (erase) part of the background using the foreground alpha. (Not supported under GPU rendering.)
- `BlendMode.HARDLIGHT` (`"hardlight"`): Commonly used to create shading effects. (Not supported under GPU rendering.)
- `BlendMode.INVERT` (`"invert"`): Used to invert the background.
- `BlendMode.LAYER` (`"layer"`): Used to force the creation of a temporary buffer for precomposition for a particular display object. (Not supported under GPU rendering.)
- `BlendMode.LIGHTEN` (`"lighten"`): Commonly used to superimpose type. (Not supported under GPU rendering.)
- `BlendMode.MULTIPLY` (`"multiply"`): Commonly used to create shadows and depth effects.
- `BlendMode.NORMAL` (`"normal"`): Used to specify that the pixel values of the blend image override those of the base image.
- `BlendMode.OVERLAY` (`"overlay"`): Commonly used to create shading effects. (Not supported under GPU rendering.)
- `BlendMode.SCREEN` (`"screen"`): Commonly used to create highlights and lens flares.
- `BlendMode.SHADER` (`"shader"`): Used to specify that a Pixel Bender shader is used to create a custom blending effect. For more information about using shaders, see "Working with Pixel Bender shaders" on page 300. (Not supported under GPU rendering.)
- `BlendMode.SUBTRACT` (`"subtract"`): Commonly used to create an animated darkening dissolve effect between two images.

Adjusting DisplayObject colors

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the methods of the ColorTransform class (flash.geom.ColorTransform) to adjust the color of a display object. Each display object has a `transform` property, which is an instance of the Transform class, and contains information about various transformations that are applied to the display object (such as rotation, changes in scale or position, and so forth). In addition to its information about geometric transformations, the Transform class also includes a `colorTransform` property, which is an instance of the ColorTransform class, and provides access to make color adjustments to the display object. To access the color transformation information of a display object, you can use code such as this:

```
var colorInfo:ColorTransform = myDisplayObject.transform.colorTransform;
```

Once you've created a ColorTransform instance, you can read its property values to find out what color transformations have already been applied, or you can set those values to make color changes to the display object. To update the display object after any changes, you must reassign the ColorTransform instance back to the `transform.colorTransform` property.

```
var colorInfo:ColorTransform = myDisplayObject.transform.colorTransform;

// Make some color transformations here.

// Commit the change.
myDisplayObject.transform.colorTransform = colorInfo;
```

Setting color values with code

Flash Player 9 and later, Adobe AIR 1.0 and later

The `color` property of the ColorTransform class can be used to assign a specific red, green, blue (RGB) color value to the display object. The following example uses the `color` property to change the color of the display object named `square` to blue, when the user clicks a button named `blueBtn`:

```
// square is a display object on the Stage.
// blueBtn, redBtn, greenBtn, and blackBtn are buttons on the Stage.

import flash.events.MouseEvent;
import flash.geom.ColorTransform;

// Get access to the ColorTransform instance associated with square.
var colorInfo:ColorTransform = square.transform.colorTransform;

// This function is called when blueBtn is clicked.
function makeBlue(event:MouseEvent):void
{
    // Set the color of the ColorTransform object.
    colorInfo.color = 0x003399;
    // apply the change to the display object
    square.transform.colorTransform = colorInfo;
}

blueBtn.addEventListener(MouseEvent.CLICK, makeBlue);
```

Note that when you change a display object's color using the `color` property, it completely changes the color of the entire object, regardless of whether the object previously had multiple colors. For example, if there is a display object containing a green circle with black text on top, setting the `color` property of that object's associated ColorTransform instance to a shade of red will make the entire object, circle and text, turn red (so the text will no longer be distinguishable from the rest of the object).

Altering color and brightness effects with code

Flash Player 9 and later, Adobe AIR 1.0 and later

Suppose you have a display object with multiple colors (for example, a digital photo) and you don't want to completely recolor the object; you just want to adjust the color of a display object based on the existing colors. In this scenario, the ColorTransform class includes a series of multiplier and offset properties that you can use to make this type of adjustment. The multiplier properties, named `redMultiplier`, `greenMultiplier`, `blueMultiplier`, and `alphaMultiplier`, work like colored photographic filters (or colored sunglasses), amplifying or diminishing certain colors in the display object. The offset properties (`redOffset`, `greenOffset`, `blueOffset`, and `alphaOffset`) can be used to add extra amounts of a certain color to the object, or to specify the minimum value that a particular color can have.

These multiplier and offset properties are identical to the advanced color settings that are available for movie clip symbols in the Flash authoring tool when you choose Advanced from the Color pop-up menu on the Property inspector.

The following code loads a JPEG image and applies a color transformation to it, which adjusts the red and green channels as the mouse pointer moves along the x axis and y axis. In this case, because no offset values are specified, the color value of each color channel displayed on screen will be a percentage of the original color value in the image—meaning that the most red or green displayed in any given pixel will be the original amount of red or green in that pixel.

```
import flash.display.Loader;
import flash.events.MouseEvent;
import flash.geom.Transform;
import flash.geom.ColorTransform;
import flash.net.URLRequest;

// Load an image onto the Stage.
var loader:Loader = new Loader();
var url:URLRequest = new URLRequest("http://www.helpexamples.com/flash/images/image1.jpg");
loader.load(url);
this.addChild(loader);

// This function is called when the mouse moves over the loaded image.
function adjustColor(event:MouseEvent):void
{
    // Access the ColorTransform object for the Loader (containing the image)
    var colorTransformer:ColorTransform = loader.transform.colorTransform;

    // Set the red and green multipliers according to the mouse position.
    // The red value ranges from 0% (no red) when the cursor is at the left
    // to 100% red (normal image appearance) when the cursor is at the right.
    // The same applies to the green channel, except it's controlled by the
    // position of the mouse in the y axis.
    colorTransformer.redMultiplier = (loader.mouseX / loader.width) * 1;
    colorTransformer.greenMultiplier = (loader.mouseY / loader.height) * 1;

    // Apply the changes to the display object.
    loader.transform.colorTransform = colorTransformer;
}

loader.addEventListener(MouseEvent.MOUSE_MOVE, adjustColor);
```

Rotating objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Display objects can be rotated using the `rotation` property. You can read this value to find out whether an object has been rotated, or to rotate the object you can set this property to a number (in degrees) representing the amount of rotation to be applied to the object. For instance, this line of code rotates the object named `square` 45 degrees (one eighth of one complete revolution):

```
square.rotation = 45;
```

Alternatively, you can rotate a display object using a transformation matrix, described in "Working with geometry" on page 210.

Fading objects

Flash Player 9 and later, Adobe AIR 1.0 and later

You can control the transparency of a display object to make it partially (or completely transparent), or change the transparency to make the object appear to fade in or out. The DisplayObject class's `alpha` property defines the transparency (or more accurately, the opacity) of a display object. The `alpha` property can be set to any value between 0 and 1, where 0 is completely transparent, and 1 is completely opaque. For example, these lines of code make the object named `myBall` partially (50 percent) transparent when it is clicked with the mouse:

```
function fadeBall(event:MouseEvent):void
{
    myBall.alpha = .5;
}
myBall.addEventListener(MouseEvent.CLICK, fadeBall);
```

You can also alter the transparency of a display object using the color adjustments available through the ColorTransform class. For more information, see "Adjusting DisplayObject colors" on page 187.

Masking display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use a display object as a mask to create a hole through which the contents of another display object are visible.

Defining a mask

To indicate that a display object will be the mask for another display object, set the mask object as the `mask` property of the display object to be masked:

```
// Make the object maskSprite be a mask for the object mySprite.
mySprite.mask = maskSprite;
```

The masked display object is revealed under all opaque (nontransparent) areas of the display object acting as the mask. For instance, the following code creates a Shape instance containing a red 100 by 100 pixel square and a Sprite instance containing a blue circle with a radius of 25 pixels. When the circle is clicked, it is set as the mask for the square, so that the only part of the square that shows is the part that is covered by the solid part of the circle. In other words, only a red circle will be visible.

```
// This code assumes it's being run within a display object container
// such as a MovieClip or Sprite instance.

import flash.display.Shape;

// Draw a square and add it to the display list.
var square:Shape = new Shape();
square.graphics.lineStyle(1, 0x000000);
square.graphics.beginFill(0xff0000);
square.graphics.drawRect(0, 0, 100, 100);
square.graphics.endFill();
this.addChild(square);

// Draw a circle and add it to the display list.
var circle:Sprite = new Sprite();
circle.graphics.lineStyle(1, 0x000000);
circle.graphics.beginFill(0x0000ff);
circle.graphics.drawCircle(25, 25, 25);
circle.graphics.endFill();
this.addChild(circle);

function maskSquare(event:MouseEvent):void
{
    square.mask = circle;
    circle.removeEventListener(MouseEvent.CLICK, maskSquare);
}

circle.addEventListener(MouseEvent.CLICK, maskSquare);
```

The display object that is acting as a mask can be draggable, animated, resized dynamically, and can use separate shapes within a single mask. The mask display object doesn't necessarily need to be added to the display list. However, if you want the mask object to scale when the Stage is scaled or if you want to enable user interaction with the mask (such as user-controlled dragging and resizing), the mask object must be added to the display list. The actual z-index (front-to-back order) of the display objects doesn't matter, as long as the mask object is added to the display list. (The mask object will not appear on the screen except as a mask.) If the mask object is a MovieClip instance with multiple frames, it plays all the frames in its timeline, the same as it would if it were not serving as a mask. You can remove a mask by setting the `mask` property to `null`:

```
// remove the mask from mySprite
mySprite.mask = null;
```

You cannot use a mask to mask another mask. You cannot set the `alpha` property of a mask display object. Only fills are used in a display object that is used as a mask; strokes are ignored.

AIR 2

If a masked display object is cached by setting the `cacheAsBitmap` and `cacheAsBitmapMatrix` properties, the mask must be a child of the masked display object. Similarly, if the masked display object is a descendent of a display object container that is cached, both the mask and the display object must be descendents of that container. If the masked object is a descendent of more than one cached display object container, the mask must be a descendent of the cached container closest to the masked object in the display list.

About masking device fonts

You can use a display object to mask text that is set in a device font. When you use a display object to mask text set in a device font, the rectangular bounding box of the mask is used as the masking shape. That is, if you create a non-rectangular display object mask for device font text, the mask that appears in the SWF file is the shape of the rectangular bounding box of the mask, not the shape of the mask itself.

Alpha channel masking

Alpha channel masking is supported if both the mask and the masked display objects use bitmap caching, as shown here:

```
// maskShape is a Shape instance which includes a gradient fill.
mySprite.cacheAsBitmap = true;
maskShape.cacheAsBitmap = true;
mySprite.mask = maskShape;
```

For instance, one application of alpha channel masking is to use a filter on the mask object independently of a filter that is applied to the masked display object.

In the following example, an external image file is loaded onto the Stage. That image (or more accurately, the Loader instance it is loaded into) will be the display object that is masked. A gradient oval (solid black center fading to transparent at the edges) is drawn over the image; this will be the alpha mask. Both display objects have bitmap caching turned on. The oval is set as a mask for the image, and it is then made draggable.

```
// This code assumes it's being run within a display object container
// such as a MovieClip or Sprite instance.

import flash.display.GradientType;
import flash.display.Loader;
import flash.display.Sprite;
import flash.geom.Matrix;
import flash.net.URLRequest;

// Load an image and add it to the display list.
var loader:Loader = new Loader();
var url:URLRequest = new URLRequest("http://www.helpexamples.com/flash/images/image1.jpg");
loader.load(url);
this.addChild(loader);

// Create a Sprite.
var oval:Sprite = new Sprite();
// Draw a gradient oval.
var colors:Array = [0x000000, 0x000000];
var alphas:Array = [1, 0];
var ratios:Array = [0, 255];
var matrix:Matrix = new Matrix();
matrix.createGradientBox(200, 100, 0, -100, -50);
oval.graphics.beginGradientFill(GradientType.RADIAL,
                                colors,
                                alphas,
                                ratios,
                                matrix);
oval.graphics.drawEllipse(-100, -50, 200, 100);
oval.graphics.endFill();
// add the Sprite to the display list
this.addChild(oval);

// Set cacheAsBitmap = true for both display objects.
loader.cacheAsBitmap = true;
oval.cacheAsBitmap = true;
// Set the oval as the mask for the loader (and its child, the loaded image)
loader.mask = oval;

// Make the oval draggable.
oval.startDrag(true);
```

Animating objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Animation is the process of making something move, or alternatively, of making something change over time. Scripted animation is a fundamental part of video games, and is often used to add polish and useful interaction clues to other applications.

The fundamental idea behind scripted animation is that a change needs to take place, and that change needs to be divided into increments over time. It's easy to make something repeat in ActionScript, using a common looping statement. However, a loop will run through all its iterations before updating the display. To create scripted animation, you need to write ActionScript that performs some action repeatedly over time and also updates the screen each time it runs.

For example, imagine you want to create a simple animation, such as making a ball travel across the screen. ActionScript includes a simple mechanism that allows you to track the passage of time and update the screen accordingly—meaning you could write code that moves the ball a small amount each time, until it reaches its destination. After each move the screen would update, making the cross-Stage motion visible to the viewer.

From a practical standpoint, it makes sense to synchronize scripted animation with the SWF file's frame rate (in other words, make one animation change each time a new frame displays or would display), since that defines how frequently Flash Player or AIR updates the screen. Each display object has an `enterFrame` event that is dispatched according to the frame rate of the SWF file—one event per frame. Most developers who create scripted animation use the `enterFrame` event as a way to create actions that repeat over time. You could write code that listens to the `enterFrame` event, moving the animated ball a certain amount each frame, and as the screen is updated (each frame), the ball would be redrawn in its new location, creating motion.

***Note:** Another way to perform an action repeatedly over time is to use the Timer class. A Timer instance triggers an event notification each time a specified amount of time has past. You could write code that performs animation by handling the Timer class's timer event, setting the time interval to a small one (some fraction of a second). For more information about using the Timer class, see "Controlling time intervals" on page 4.*

In the following example, a circle Sprite instance, named `circle`, is created on the Stage. When the user clicks the circle, a scripted animation sequence begins, causing `circle` to fade (its `alpha` property is decreased) until it is completely transparent:

```
import flash.display.Sprite;
import flash.events.Event;
import flash.events.MouseEvent;

// draw a circle and add it to the display list
var circle:Sprite = new Sprite();
circle.graphics.beginFill(0x990000);
circle.graphics.drawCircle(50, 50, 50);
circle.graphics.endFill();
addChild(circle);

// When this animation starts, this function is called every frame.
// The change made by this function (updated to the screen every
// frame) is what causes the animation to occur.
function fadeCircle(event:Event):void
{
    circle.alpha -= .05;

    if (circle.alpha <= 0)
    {
        circle.removeEventListener(Event.ENTER_FRAME, fadeCircle);
    }
}

function startAnimation(event:MouseEvent):void
{
    circle.addEventListener(Event.ENTER_FRAME, fadeCircle);
}

circle.addEventListener(MouseEvent.CLICK, startAnimation);
```

When the user clicks the circle, the function `fadeCircle()` is subscribed as a listener of the `enterFrame` event, meaning it begins to be called once per frame. That function fades `circle` by changing its `alpha` property, so once per frame the circle's `alpha` decreases by .05 (5 percent) and the screen is updated. Eventually, when the `alpha` value is 0 (`circle` is completely transparent), the `fadeCircle()` function is removed as an event listener, ending the animation.

The same code could be used, for example, to create animated motion instead of fading. By substituting a different property for `alpha` in the function that is an `enterFrame` event listener, that property will be animated instead. For example, changing this line

```
    circle.alpha -= .05;
```

to this code

```
    circle.x += 5;
```

will animate the `x` property, causing the circle to move to the right across the Stage. The condition that ends the animation could be changed to end the animation (that is, unsubscribe the `enterFrame` listener) when the desired x coordinate is reached.

Stage orientation

AIR 2.0 and later

Mobile devices typically re-orient the user interface to keep the display upright when the user rotates the device. If you enable auto-orientation in your application, the device keeps the display properly oriented, but it is up to you to make sure that your content looks okay when the aspect ratio of the stage changes. If you disable auto-orientation, then the device display remains fixed unless you change the orientation manually.

AIR applications run on a number of different mobile devices and operating systems. The underlying orientation behavior can vary across operating systems, and even across different devices on the same operating system. A simple design strategy, that works well across all devices and operating systems, is to enable auto-orientation and to listen for Stage `resize` events to determine when you need to refresh the application layout.

Alternately, if your application only supports the portrait aspect ratio or only supports the landscape aspect ratio, you can turn off auto-orientation and set the supported aspect ratio in the AIR application descriptor. This design strategy provides consistent behavior and selects the "best" orientation for the selected aspect ratio. For example, if you specify the landscape aspect ratio, the orientation chosen is appropriate for devices with landscape-mode, slide-out keyboards.

Getting the current Stage orientation and aspect ratio

Orientation is reported relative to the normal position of the device. On most devices there is a clear, upright position. This position is considered the *default* orientation. The other three possible orientations are then: *rotated left*, *rotated right*, and *upside down*. The StageOrientation class defines string constants to use when setting or comparing orientation values.

The Stage class defines two properties that report orientation:

- Stage.deviceOrientation — Reports the physical orientation of the device relative to the default position.

  Note: *The deviceOrientation is not always available when your application first starts up or when the device is lying flat. In these cases, the device orientation is reported as unknown.*

- Stage.orientation — Reports the orientation of the Stage relative to the default position. When auto-orientation is enabled, the stage rotates in the opposite direction as the device to remain upright. Thus, the right and left positions reported by the `orientation` property are the opposite of those reported by the `deviceOrientation` property. For example, when `deviceRotation` reports *rotated right*, `orientation` reports *rotated left*.

The aspect ratio of the stage can be derived by simply comparing the current width and height of the stage:

```
var aspect:String = this.stage.stageWidth >= this.stage.stageHeight ?
StageAspectRatio.LANDSCAPE : StageAspectRatio.PORTRAIT;
```

Automatic orientation

When auto-orientation is on and a user rotates their device, the operating system re-orients the entire user interface, including the system taskbar and your application. As a result, the aspect ratio of the stage changes from portrait to landscape or landscape to portrait. When the aspect ratio changes, the stage dimensions also change.

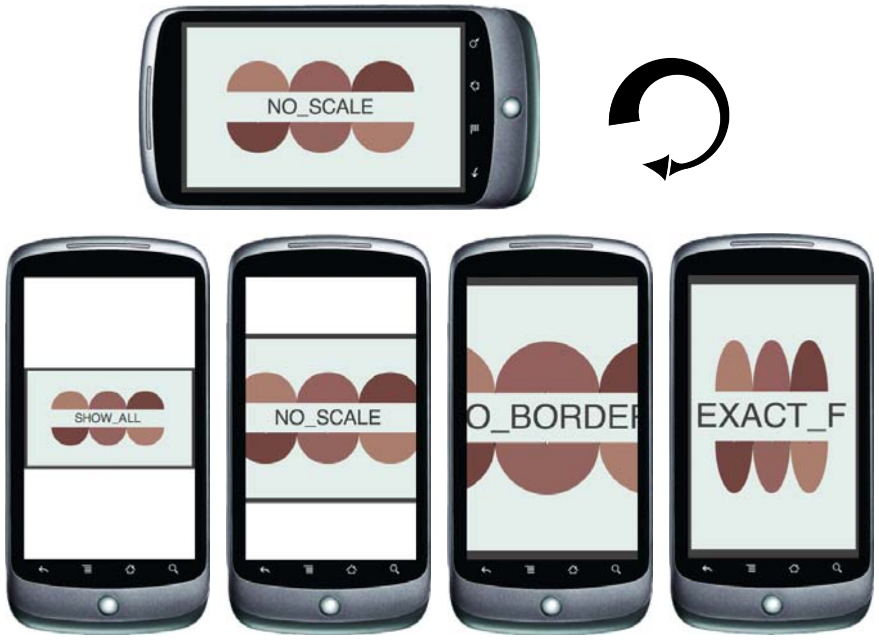
Enable or disable auto-orientation at runtime, by setting the Stage `autoOrients` property to `true` or `false`. You can set the initial value of this property in the AIR application descriptor with the `<autoOrients>` element. (Note that prior to AIR 2.6, `autoOrients` is a read-only property and can only be set in the application descriptor.)

If you specify an aspect ratio of landscape or portrait and also enable auto-orientation, AIR constrains auto-orientation to the specified aspect ratio.

Stage dimension changes

When the stage dimensions change, the stage contents are scaled and repositioned as specified by the `scaleMode` and `align` properties of the Stage object. In most cases, relying on the automatic behavior provided by the Stage `scaleMode` settings does not produce good results. Instead you must re-layout or redraw your graphics and components to support more than one aspect ratio. (Providing flexible layout logic also means that your application will work better across devices with different screen sizes and aspect ratios.)

The following illustration demonstrates the effects of the different `scaleMode` settings when rotating a typical mobile device:



Rotation from landscape to portrait aspect ratio

The illustration demonstrates the scaling behavior that occurs when rotating from a landscape aspect ratio to a portrait aspect ratio with different scale modes. Rotating from portrait to landscape causes a similar set of effects.

Orientation change events

The Stage object dispatches two types of events that you can use to detect and react to orientation changes. Both stage `resize` and `orientationChange` events are dispatched when auto-orientation is enabled.

The *resize* event is the best event to use when you are relying on auto-orientation to keep the display upright. When the stage dispatches a `resize` event, relayout or redraw your content, as needed. The `resize` event is only dispatched when the stage scale mode is set to `noScale`.

The `orientationChange` event can also be used to detect orientation changes. The `orientationChange` event is only dispatched when auto-orientation is enabled.

Note: *On some mobile platforms, the stage dispatches a cancelable `orientationChanging` event before dispatching the resize or orientationChange events. Since the event is not supported on all platforms, avoid relying on it.*

Manual orientation

AIR 2.6 and later

You can control the stage orientation using the Stage `setOrientation()` or `setAspectRatio()` methods.

Setting the stage orientation

You can set the stage orientation at runtime using the `setOrientation()` method of the Stage object. Use the string constants defined by the StageOrientation class to specify the desired orientation:

```
this.stage.setOrientation( StageOrientation.ROTATED_RIGHT );
```

Not every device and operating system supports every possible orientation. For example, Android 2.2 does not support programmatically choosing the rotated-left orientation on portrait-standard devices and does not support the upside-down orientation at all. The `supportedOrientations` property of the stage provides a list of the orientations that can be passed to the `setOrientation()` method:

```
var orientations:Vector.<String> = this.stage.supportedOrientations;
for each( var orientation:String in orientations )
{
    trace( orientation );
}
```

Setting the stage aspect ratio

If you are primarily concerned about the aspect ratio of the stage, you can set the aspect ratio to portrait or landscape. You can set the aspect ratio in either the AIR application descriptor or, at run time, using the Stage `setAspectRatio()` method:

```
this.stage.setAspectRatio( StageAspectRatio.LANDSCAPE );
```

The runtime chooses one of the two possible orientations for the specified aspect ratio. This may not match the current device orientation. For example, the default orientation is chosen in preference to the upside-down orientation (AIR 3.2 and earlier) and the orientation appropriate for the slide-out keyboard is chosen in preference to the opposite orientation.

(AIR 3.3 and higher) Starting with AIR 3.3 (SWF version 16), you can also use the `StageAspectRatio.ANY` constant. If `Stage.autoOrients` is set to `true` and you call `setAspectRatio(StageAspectRatio.ANY)`, your application has the capability to re-orient to all orientations (landscape-left, landscape-right, portait, and portrait-upside-down). Also new in AIR 3.3, the aspect ratio is persistent, and further rotation of the device is constrained to the specified orientation.

Example: Setting the stage orientation to match the device orientation

The following example illustrates a function that updates the stage orientation to match the current device orientation. The stage `deviceOrientation` property indicates the physical orientation of the device, even when auto-orientation is turned off.

```
function refreshOrientation( theStage:Stage ):void
{
    switch ( theStage.deviceOrientation )
    {
        case StageOrientation.DEFAULT:
            theStage.setOrientation( StageOrientation.DEFAULT );
            break;
        case StageOrientation.ROTATED_RIGHT:
            theStage.setOrientation( StageOrientation.ROTATED_LEFT );
            break;
        case StageOrientation.ROTATED_LEFT:
            theStage.setOrientation( StageOrientation.ROTATED_RIGHT );
            break;
        case StageOrientation.UPSIDE_DOWN:
            theStage.setOrientation( StageOrientation.UPSIDE_DOWN );
            break;
        default:
            //No change
    }
}
```

The orientation change is asynchronous. You can listen for the `orientationChange` event dispatched by the stage to detect the completion of the change. If an orientation is not supported on a device, the `setOrientation()` call fails without throwing an error.

Loading display content dynamically

Flash Player 9 and later, Adobe AIR 1.0 and later

You can load any of the following external display assets into an ActionScript 3.0 application:

- A SWF file authored in ActionScript 3.0—This file can be a Sprite, MovieClip, or any class that extends Sprite. In AIR applications on iOS, only SWF files that do not contain ActionScript bytecode can be loaded. This means that SWF files containing embedded data, such as images and sound can be loaded, but not SWF files containing executable code.
- An image file—This includes JPG, PNG, and GIF files.
- An AVM1 SWF file—This is a SWF file written in ActionScript 1.0 or 2.0. (not supported in mobile AIR applications)

You load these assets by using the Loader class.

Loading display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Loader objects are used to load SWF files and graphics files into an application. The Loader class is a subclass of the DisplayObjectContainer class. A Loader object can contain only one child display object in its display list—the display object representing the SWF or graphic file that it loads. When you add a Loader object to the display list, as in the following code, you also add the loaded child display object to the display list once it loads:

```
var pictLdr:Loader = new Loader();
var pictURL:String = "banana.jpg"
var pictURLReq:URLRequest = new URLRequest(pictURL);
pictLdr.load(pictURLReq);
this.addChild(pictLdr);
```

Once the SWF file or image is loaded, you can move the loaded display object to another display object container, such as the `container` DisplayObjectContainer object in this example:

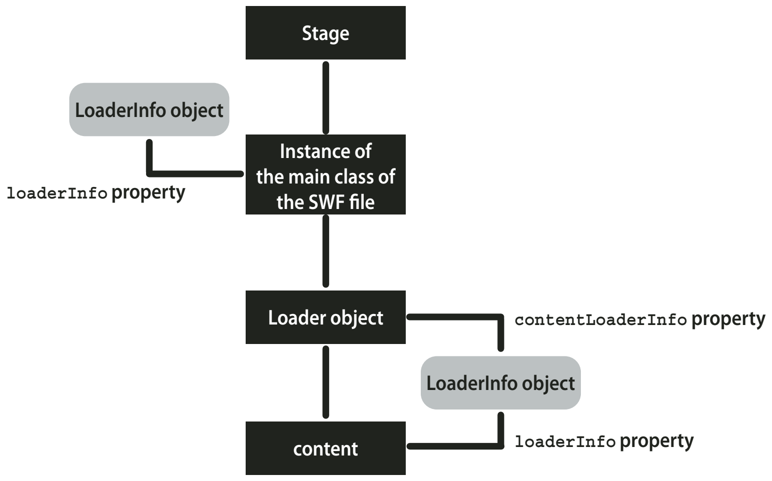
```
import flash.display.*;
import flash.net.URLRequest;
import flash.events.Event;
var container:Sprite = new Sprite();
addChild(container);
var pictLdr:Loader = new Loader();
var pictURL:String = "banana.jpg"
var pictURLReq:URLRequest = new URLRequest(pictURL);
pictLdr.load(pictURLReq);
pictLdr.contentLoaderInfo.addEventListener(Event.COMPLETE, imgLoaded);
function imgLoaded(event:Event):void
{
    container.addChild(pictLdr.content);
}
```

Monitoring loading progress

Flash Player 9 and later, Adobe AIR 1.0 and later

Once the file has started loading, a LoaderInfo object is created. A LoaderInfo object provides information such as load progress, the URLs of the loader and loadee, the number of bytes total for the media, and the nominal height and width of the media. A LoaderInfo object also dispatches events for monitoring the progress of the load.

The following diagram shows the different uses of the LoaderInfo object—for the instance of the main class of the SWF file, for a Loader object, and for an object loaded by the Loader object:



The LoaderInfo object can be accessed as a property of both the Loader object and the loaded display object. As soon as loading begins, the LoaderInfo object can be accessed through the `contentLoaderInfo` property of the Loader object. Once the display object has finished loading, the LoaderInfo object can also be accessed as a property of the loaded display object through the display object's `loaderInfo` property. The `loaderInfo` property of the loaded display object refers to the same LoaderInfo object as the `contentLoaderInfo` property of the Loader object. In other words, a LoaderInfo object is shared between a loaded object and the Loader object that loaded it (between loader and loadee).

In order to access properties of loaded content, you will want to add an event listener to the LoaderInfo object, as in the following code:

```
import flash.display.Loader;
import flash.display.Sprite;
import flash.events.Event;

var ldr:Loader = new Loader();
var urlReq:URLRequest = new URLRequest("Circle.swf");
ldr.load(urlReq);
ldr.contentLoaderInfo.addEventListener(Event.COMPLETE, loaded);
addChild(ldr);

function loaded(event:Event):void
{
    var content:Sprite = event.target.content;
    content.scaleX = 2;
}
```

For more information, see "Handling events" on page 125.

Specifying loading context

Flash Player 9 and later, Adobe AIR 1.0 and later

When you load an external file into Flash Player or AIR through the `load()` or `loadBytes()` method of the Loader class, you can optionally specify a `context` parameter. This parameter is a LoaderContext object.

The LoaderContext class includes three properties that let you define the context of how the loaded content can be used:

- `checkPolicyFile`: Use this property only when loading an image file (not a SWF file). If you set this property to `true`, the Loader checks the origin server for a policy file (see "Website controls (policy files)" on page 1051). This is necessary only for content originating from domains other than that of the SWF file containing the Loader object. If the server grants permission to the Loader domain, ActionScript from SWF files in the Loader domain can access data in the loaded image; in other words, you can use the `BitmapData.draw()` command to access data in the loaded image.

  Note that a SWF file from other domains than that of the Loader object can call `Security.allowDomain()` to permit a specific domain.

- `securityDomain`: Use this property only when loading a SWF file (not an image). Specify this for a SWF file from a domain other than that of the file containing the Loader object. When you specify this option, Flash Player checks for the existence of a policy file, and if one exists, SWF files from the domains permitted in the cross-policy file can cross-script the loaded SWF content. You can specify `flash.system.SecurityDomain.currentDomain` as this parameter.

- `applicationDomain`: Use this property only when loading a SWF file written in ActionScript 3.0 (not an image or a SWF file written in ActionScript 1.0 or 2.0). When loading the file, you can specify that the file be included in the same application domain as that of the Loader object, by setting the `applicationDomain` parameter to `flash.system.ApplicationDomain.currentDomain`. By putting the loaded SWF file in the same application domain, you can access its classes directly. This can be useful if you are loading a SWF file that contains embedded media, which you can access via their associated class names. For more information, see "Working with application domains" on page 147.

Here's an example of checking for a policy file when loading a bitmap from another domain:

```
var context:LoaderContext = new LoaderContext();
context.checkPolicyFile = true;
var urlReq:URLRequest = new URLRequest("http://www.[your_domain_here].com/photo11.jpg");
var ldr:Loader = new Loader();
ldr.load(urlReq, context);
```

Here's an example of checking for a policy file when loading a SWF from another domain, in order to place the file in the same security sandbox as the Loader object. Additionally, the code adds the classes in the loaded SWF file to the same application domain as that of the Loader object:

```
var context:LoaderContext = new LoaderContext();
context.securityDomain = SecurityDomain.currentDomain;
context.applicationDomain = ApplicationDomain.currentDomain;
var urlReq:URLRequest = new URLRequest("http://www.[your_domain_here].com/library.swf");
var ldr:Loader = new Loader();
ldr.load(urlReq, context);
```

For more information, see the LoaderContext class in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Loading SWF files in AIR for iOS

Adobe AIR 3.6 and later, iOS only

On iOS devices, there are restrictions on loading and compiling code at runtime. Because of these restrictions, there are some necessary differences in the task of loading external SWF files into your application:

- All SWF files that contain ActionScript code must be included in the application package. No SWF containing code can be loaded from an external source such as over a network. As part of packaging the application, all ActionScript code in all SWF files in the application package is compiled to native code for iOS devices.
- You can't load, unload, and then re-load a SWF file. If you attempt to do this, an error occurs.
- The behavior of loading into memory and then unloading it is the same as with desktop platforms. If you load a SWF file then unload it, all visual assets contained in the SWF are unloaded from memory. However, any class references to an ActionScript class in the loaded SWF remain in memory and can be accessed in ActionScript code.
- All loaded SWF files must be loaded in the same application domain as the main SWF file. This is not the default behavior, so for each SWF you load you must create a LoaderContext object specifying the main application domain, and pass that LoaderContext object to the Loader.load() method call. If you attempt to load a SWF in an application domain other than the main SWF application domain, an error occurs. This is true even if the loaded SWF only contains visual assets and no ActionScript code.

  The following example shows the code to use to load a SWF from the application package into the main SWF's application domain:

```
var loader:Loader = new Loader();
var url:URLRequest = new URLRequest("swfs/SecondarySwf.swf");
var loaderContext:LoaderContext = new LoaderContext(false, ApplicationDomain.currentDomain,
null);
loader.load(url, loaderContext);
```

A SWF file containing only assets and no code can be loaded from the application package or over a network. In either case, the SWF file must still be loaded into the main application domain.

For AIR versions prior to AIR 3.6, all code is stripped from SWFs other than the main application SWF during the compilation process. SWF files containing only visual assets can be included in the application package and loaded at runtime, but no code. If you attempt to load a SWF that contains ActionScript code, an error occurs. The error causes an "Uncompiled ActionScript" error dialog to appear in the application.

See also

Packaging and loading multiple SWFs in AIR apps on iOS

Using the ProLoader and ProLoaderInfo classes

Flash Player 9 and later, Adobe AIR 1.0 and later, and requires Flash Professional CS5.5

To help with remote shared library (RSL) preloading, Flash Professional CS5.5 introduces the fl.display.ProLoader and fl.display.ProLoaderInfo classes. These classes mirror the flash.display.Loader and flash.display.LoaderInfo classes but provide a more consistent loading experience.

In particular, ProLoader helps you load SWF files that use the Text Layout Framework (TLF) with RSL preloading. At runtime, SWF files that preload other SWF files or SWZ files, such as TLF, require an internal-only SWF wrapper file. The extra layer of complexity imposed by the SWF wrapper file can result in unwanted behavior. ProLoader solves this complexity to load these files as though they were ordinary SWF files. The solution used by the ProLoader class is transparent to the user and requires no special handling in ActionScript. In addition, ProLoader loads ordinary SWF content correctly.

In Flash Professional CS5.5 and later, you can safely replace all usages of the Loader class with the ProLoader class. Then, export your application to Flash Player 10.2 or higher so that ProLoader can access the required ActionScript functionality. You can also use ProLoader while targeting earlier versions of Flash Player that support ActionScript 3.0. However, you get full advantage of ProLoader features only with Flash Player 10.2 or higher. Always use ProLoader when you use TLF in Flash Professional CS5.5 or later. ProLoader is not needed in environments other than Flash Professional.

Important: *For SWF files published in Flash Professional CS5.5 and later, you can always use the fl.display.ProLoader and fl.display.ProLoaderInfo classes instead of flash.display.Loader and flash.display.LoaderInfo.*

Issues addressed by the ProLoader class

The ProLoader class addresses issues that the legacy Loader class was not designed to handle. These issues stem from RSL preloading of TLF libraries. Specifically, they apply to SWF files that use a Loader object to load other SWF files. Addressed issues include the following:

- **Scripting between the loading file and the loaded file does not behave as expected.** The ProLoader class automatically sets the loading SWF file as the parent of the loaded SWF file. Thus, communications from the loading SWF file go directly to the loaded SWF file.
- **The SWF application must actively manage the loading process.** Doing so requires implementation of extra events, such as `added`, `removed`, `addedToStage`, and `removedFromStage`. If your application targets Flash Player 10.2 or later, ProLoader removes the need for this extra work.

Updating code to use ProLoader instead of Loader

Because ProLoader mirrors the Loader class, you can easily switch the two classes in your code. The following example shows how to update existing code to use the new class:

```
import flash.display.Loader;
import flash.events.Event;
var l:Loader = new Loader();

addChild(l);
l.contentLoaderInfo.addEventListener(Event.COMPLETE, loadComplete);
l.load("my.swf");
function loadComplete(e:Event) {
    trace('load complete!');
}
```

This code can be updated to use ProLoader as follows:

```
import fl.display.ProLoader;
import flash.events.Event;
var l:ProLoader = new ProLoader();

addChild(l);
l.contentLoaderInfo.addEventListener(Event.COMPLETE, loadComplete);
l.load("my.swf");
function loadComplete(e:Event) {
    trace('load complete!');
}
```

Display object example: SpriteArranger

Flash Player 9 and later, Adobe AIR 1.0 and later

The SpriteArranger sample application builds upon the Geometric Shapes sample application described separately in *Learning ActionScript 3.0*.

The SpriteArranger sample application illustrates a number of concepts for dealing with display objects:

- Extending display object classes
- Adding objects to the display list
- Layering display objects and working with display object containers
- Responding to display object events
- Using properties and methods of display objects

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The SpriteArranger application files can be found in the folder Examples/SpriteArranger. The application consists of the following files:

File	**Description**
SpriteArranger.mxml or SpriteArranger.fla	The main application file in Flash (FLA) or Flex (MXML).
com/example/programmingas3/SpriteArranger/CircleSprite.as	A class defining a type of Sprite object that renders a circle on-screen.
com/example/programmingas3/SpriteArranger/DrawingCanvas.as	A class defining the canvas, which is a display object container that contains GeometricSprite objects.
com/example/programmingas3/SpriteArranger/SquareSprite.as	A class defining a type of Sprite object that renders a square on-screen.
com/example/programmingas3/SpriteArranger/TriangleSprite.as	A class defining a type of Sprite object that renders a triangle on-screen.
com/example/programmingas3/SpriteArranger/GeometricSprite.as	A class that extends the Sprite object, used to define an on-screen shape. The CircleSprite, SquareSprite, and TriangleSprite each extend this class.
com/example/programmingas3/geometricshapes/IGeometricShape.as	The base interface defining methods to be implemented by all geometric shape classes.
com/example/programmingas3/geometricshapes/IPolygon.as	An interface defining methods to be implemented by geometric shape classes that have multiple sides.
com/example/programmingas3/geometricshapes/RegularPolygon.as	A type of geometric shape that has sides of equal length positioned symmetrically around the shape's center.
com/example/programmingas3/geometricshapes/Circle.as	A type of geometric shape that defines a circle.
com/example/programmingas3/geometricshapes/EquilateralTriangle.as	A subclass of RegularPolygon that defines a triangle with all sides the same length.
com/example/programmingas3/geometricshapes/Square.as	A subclass of RegularPolygon defining a rectangle with all four sides the same length.
com/example/programmingas3/geometricshapes/GeometricShapeFactory.as	A class containing a "factory method" for creating shapes given a shape type and size.

Defining the SpriteArranger classes

Flash Player 9 and later, Adobe AIR 1.0 and later

The SpriteArranger application lets the user add a variety of display objects to the on-screen "canvas."

The DrawingCanvas class defines a drawing area, a type of display object container, to which the user can add on-screen shapes. These on-screen shapes are instances of one of the subclasses of the GeometricSprite class.

The DrawingCanvas class

In Flex, all child display objects added to a Container object must be of a class that descends from the mx.core.UIComponent class. This application adds an instance of the DrawingCanvas class as a child of an mx.containers.VBox object, as defined in MXML code in the SpriteArranger.mxml file. This inheritance is defined in the DrawingCanvas class declaration, as follows:

```
public class DrawingCanvas extends UIComponent
```

The UIComponent class inherits from the DisplayObject, DisplayObjectContainer, and Sprite classes, and the code in the DrawingCanvas class uses methods and properties of those classes.

The DrawingCanvas class extends the Sprite class, and this inheritance is defined in the DrawingCanvas class declaration, as follows:

```
public class DrawingCanvas extends Sprite
```

The Sprite class is a subclass of the DisplayObjectContainer and DisplayObject classes, and the DrawingCanvas class uses methods and properties of those classes.

The `DrawingCanvas()` constructor method sets up a Rectangle object, `bounds`, which is property that is later used in drawing the outline of the canvas. It then calls the `initCanvas()` method, as follows:

```
this.bounds = new Rectangle(0, 0, w, h);
initCanvas(fillColor, lineColor);
```

AS the following example shows, the `initCanvas()` method defines various properties of the DrawingCanvas object, which were passed as arguments to the constructor function:

```
this.lineColor = lineColor;
this.fillColor = fillColor;
this.width = 500;
this.height = 200;
```

The `initCanvas()` method then calls the `drawBounds()` method, which draws the canvas using the DrawingCanvas class's `graphics` property. The `graphics` property is inherited from the Shape class.

```
this.graphics.clear();
this.graphics.lineStyle(1.0, this.lineColor, 1.0);
this.graphics.beginFill(this.fillColor, 1.0);
this.graphics.drawRect(bounds.left - 1,
                        bounds.top - 1,
                        bounds.width + 2,
                        bounds.height + 2);
this.graphics.endFill();
```

The following additional methods of the DrawingCanvas class are invoked based on user interactions with the application:

- The `addShape()` and `describeChildren()` methods, which are described in "Adding display objects to the canvas" on page 206
- The `moveToBack()`, `moveDown()`, `moveToFront()`, and `moveUp()` methods, which are described in "Rearranging display object layering" on page 208
- The `onMouseUp()` method, which is described in "Clicking and dragging display objects" on page 207

The GeometricSprite class and its subclasses

Each display object the user can add to the canvas is an instance of one of the following subclasses of the GeometricSprite class:

- CircleSprite
- SquareSprite
- TriangleSprite

The GeometricSprite class extends the flash.display.Sprite class:

```
public class GeometricSprite extends Sprite
```

The GeometricSprite class includes a number of properties common to all GeometricSprite objects. These are set in the constructor function based on parameters passed to the function. For example:

```
this.size = size;
this.lineColor = lColor;
this.fillColor = fColor;
```

The `geometricShape` property of the GeometricSprite class defines an IGeometricShape interface, which defines the mathematical properties, but not the visual properties, of the shape. The classes that implement the IGeometricShape interface are defined in the GeometricShapes sample application described in *Learning ActionScript 3.0*.

The GeometricSprite class defines the `drawShape()` method, which is further refined in the override definitions in each subclass of GeometricSprite. For more information, see the "Adding display objects to the canvas" section, which follows.

The GeometricSprite class also provides the following methods:

- The `onMouseDown()` and `onMouseUp()` methods, which are described in "Clicking and dragging display objects" on page 207
- The `showSelected()` and `hideSelected()` methods, which are described in "Clicking and dragging display objects" on page 207

Adding display objects to the canvas

Flash Player 9 and later, Adobe AIR 1.0 and later

When the user clicks the Add Shape button, the application calls the `addShape()` method of the DrawingCanvas class. It instantiates a new GeometricSprite by calling the appropriate constructor function of one of the GeometricSprite subclasses, as the following example shows:

```
public function addShape(shapeName:String, len:Number):void
{
    var newShape:GeometricSprite;
    switch (shapeName)
    {
        case "Triangle":
            newShape = new TriangleSprite(len);
            break;

        case "Square":
            newShape = new SquareSprite(len);
            break;

        case "Circle":
            newShape = new CircleSprite(len);
            break;
    }
    newShape.alpha = 0.8;
    this.addChild(newShape);
}
```

Each constructor method calls the `drawShape()` method, which uses the `graphics` property of the class (inherited from the Sprite class) to draw the appropriate vector graphic. For example, the `drawShape()` method of the CircleSprite class includes the following code:

```
this.graphics.clear();
this.graphics.lineStyle(1.0, this.lineColor, 1.0);
this.graphics.beginFill(this.fillColor, 1.0);
var radius:Number = this.size / 2;
this.graphics.drawCircle(radius, radius, radius);
```

The second to last line of the `addShape()` function sets the `alpha` property of the display object (inherited from the DisplayObject class), so that each display object added to the canvas is slightly transparent, letting the user see the objects behind it.

The final line of the `addChild()` method adds the new display object to the child list of the instance of the DrawingCanvas class, which is already on the display list. This causes the new display object to appear on the Stage.

The interface for the application includes two text fields, `selectedSpriteTxt` and `outputTxt`. The text properties of these text fields are updated with information about the GeometricSprite objects that have been added to the canvas or selected by the user. The GeometricSprite class handles this information-reporting task by overriding the `toString()` method, as follows:

```
public override function toString():String
{
    return this.shapeType + " of size " + this.size + " at " + this.x + ", " + this.y;
}
```

The `shapeType` property is set to the appropriate value in the constructor method of each GeometricSprite subclass. For example, the `toString()` method might return the following value for a CircleSprite instance recently added to the DrawingCanvas instance:

```
Circle of size 50 at 0, 0
```

The `describeChildren()` method of the DrawingCanvas class loops through the canvas's child list, using the `numChildren` property (inherited from the DisplayObjectContainer class) to set the limit of the `for` loop. It generates a string listing each child, as follows:

```
var desc:String = "";
var child:DisplayObject;
for (var i:int=0; i < this.numChildren; i++)
{
child = this.getChildAt(i);
desc += i + ": " + child + '\n';
}
```

The resulting string is used to set the `text` property of the `outputTxt` text field.

Clicking and dragging display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

When the user clicks on a GeometricSprite instance, the application calls the `onMouseDown()` event handler. As the following shows, this event handler is set to listen for mouse down events in the constructor function of the GeometricSprite class:

```
this.addEventListener(MouseEvent.MOUSE_DOWN, onMouseDown);
```

The `onMouseDown()` method then calls the `showSelected()` method of the GeometricSprite object. If it is the first time this method has been called for the object, the method creates a new Shape object named `selectionIndicator` and it uses the `graphics` property of the Shape object to draw a red highlight rectangle, as follows:

```
this.selectionIndicator = new Shape();
this.selectionIndicator.graphics.lineStyle(1.0, 0xFF0000, 1.0);
this.selectionIndicator.graphics.drawRect(-1, -1, this.size + 1, this.size + 1);
this.addChild(this.selectionIndicator);
```

If this is not the first time the `onMouseDown()` method is called, the method simply sets the `selectionIndicator` shape's `visible` property (inherited from the DisplayObject class), as follows:

```
this.selectionIndicator.visible = true;
```

The `hideSelected()` method hides the `selectionIndicator` shape of the previously selected object by setting its `visible` property to `false`.

The `onMouseDown()` event handler method also calls the `startDrag()` method (inherited from the Sprite class), which includes the following code:

```
var boundsRect:Rectangle = this.parent.getRect(this.parent);
boundsRect.width -= this.size;
boundsRect.height -= this.size;
this.startDrag(false, boundsRect);
```

This lets the user drag the selected object around the canvas, within the boundaries set by the `boundsRect` rectangle.

When the user releases the mouse button, the `mouseUp` event is dispatched. The constructor method of the DrawingCanvas sets up the following event listener:

```
this.addEventListener(MouseEvent.MOUSE_UP, onMouseUp);
```

This event listener is set for the DrawingCanvas object, rather than for the individual GeometricSprite objects. This is because when the GeometricSprite object is dragged, it could end up behind another display object (another GeometricSprite object) when the mouse is released. The display object in the foreground would receive the mouse up event but the display object the user is dragging would not. Adding the listener to the DrawingCanvas object ensures that the event is always handled.

The `onMouseUp()` method calls the `onMouseUp()` method of the GeometricSprite object, which in turn calls the `stopDrag()` method of the GeometricSprite object.

Rearranging display object layering

Flash Player 9 and later, Adobe AIR 1.0 and later

The user interface for the application includes buttons labeled Move Back, Move Down, Move Up, and Move to Front. When the user clicks one of these buttons, the application calls the corresponding method of the DrawingCanvas class: `moveToBack()`, `moveDown()`, `moveUp()`, or `moveToFront()`. For example, the `moveToBack()` method includes the following code:

```
public function moveToBack(shape:GeometricSprite):void
{
    var index:int = this.getChildIndex(shape);
    if (index > 0)
    {
        this.setChildIndex(shape, 0);
    }
}
```

The method uses the `setChildIndex()` method (inherited from the DisplayObjectContainer class) to position the display object in index position 0 in the child list of the DrawingCanvas instance (`this`).

The `moveDown()` method works similarly, except that it decrements the index position of the display object by 1 in the child list of the DrawingCanvas instance:

```
public function moveDown(shape:GeometricSprite):void
{
    var index:int = this.getChildIndex(shape);
    if (index > 0)
    {
        this.setChildIndex(shape, index - 1);
    }
}
```

The `moveUp()` and `moveToFront()` methods work similarly to the `moveToBack()` and `moveDown()` methods.

Chapter 11: Working with geometry

Flash Player 9 and later, Adobe AIR 1.0 and later

The flash.geom package contains classes that define geometric objects such as points, rectangles, and transformation matrixes. You use these classes to define the properties of objects that are used in other classes.

More Help topics

flash.geom package

Basics of geometry

Flash Player 9 and later, Adobe AIR 1.0 and later

The flash.geom package contains classes that define geometric objects such as points, rectangles, and transformation matrixes. These classes don't necessarily provide functionality by themselves; however, they are used to define the properties of objects that are used in other classes.

All the geometry classes are based around the notion that locations on the screen are represented as a two-dimensional plane. The screen is treated like a flat graph with a horizontal (x) axis and a vertical (y) axis. Any location (or *point*) on the screen can be represented as a pair of x and y values—the *coordinates* of that location.

Every display object, including the Stage, has its own *coordinate space*. The coordinate space is an object's own graph for plotting the locations of child display objects, drawings, and so on. The *origin* is at coordinate location 0, 0 (where the x and y-axes meet), and is placed at the upper-left corner of the display object. While this origin location is always true for the Stage, it is not necessarily true for other display objects. Values on the x-axis get bigger going toward the right, and smaller going toward the left. For locations to the left of the origin, the x coordinate is negative. However, contrary to traditional coordinate systems, Flash runtime coordinate values on the y-axis get bigger going down the screen and smaller going up the screen. Values above the origin have a negative y coordinate value). Since the upper-left corner of the Stage is the origin of its coordinate space, most objects on the Stage have an x coordinate greater than 0 and smaller than the Stage width. And the same object has a y coordinate larger than 0 and smaller than the Stage height.

You can use Point class instances to represent individual points in a coordinate space. You can create a Rectangle instance to represent a rectangular region in a coordinate space. For advanced users, you can use a Matrix instance to apply multiple or complex transformations to a display object. Many simple transformations, such as rotation, position, and scale changes, can be applied directly to a display object using that object's properties. For more information on applying transformations using display object properties, see "Manipulating display objects" on page 173.

Important concepts and terms

The following reference list contains important geometry terms:

Cartesian coordinates Coordinates are commonly written as a pair of number (like 5, 12 or 17, -23). The two numbers are the x coordinate and the y coordinate, respectively.

Coordinate space The graph of coordinates contained in a display object, on which its child elements are positioned.

Origin The point in a coordinate space where the x-axis meets the y-axis. This point has the coordinate 0, 0.

Point A single location in a coordinate space. In the 2-d coordinate system used in ActionScript, the location along the x-axis and the y-axis (the point's coordinates) define the point.

Registration point In a display object, the origin (0, 0 coordinate) of its coordinate space.

Scale The size of an object relative to its original size. When used as a verb, to scale an object means to change its size by stretching or shrinking the object.

Translate To change a point's coordinates from one coordinate space to another.

Transformation An adjustment to a visual characteristic of a graphic, such as rotating the object, altering its scale, skewing or distorting its shape, or altering its color.

X-axis The horizontal axis in the 2-d coordinate system used in ActionScript.

Y-axis The vertical axis in the 2-d coordinate system used in ActionScript.

Using Point objects

Flash Player 9 and later, Adobe AIR 1.0 and later

A Point object defines a Cartesian pair of coordinates. It represents location in a two-dimensional coordinate system, where *x* represents the horizontal axis and *y* represents the vertical axis.

To define a Point object, you set its `x` and `y` properties, as follows:

```
import flash.geom.*;
var pt1:Point = new Point(10, 20); // x == 10; y == 20
var pt2:Point = new Point();
pt2.x = 10;
pt2.y = 20;
```

Finding the distance between two points

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `distance()` method of the Point class to find the distance between two points in a coordinate space. For example, the following code finds the distance between the registration points of two display objects, `circle1` and `circle2`, in the same display object container:

```
import flash.geom.*;
var pt1:Point = new Point(circle1.x, circle1.y);
var pt2:Point = new Point(circle2.x, circle2.y);
var distance:Number = Point.distance(pt1, pt2);
```

Translating coordinate spaces

Flash Player 9 and later, Adobe AIR 1.0 and later

If two display objects are in different display object containers, they can be in different coordinate spaces. You can use the `localToGlobal()` method of the DisplayObject class to translate the coordinates to the same (global) coordinate space, that of the Stage. For example, the following code finds the distance between the registration points of two display objects, `circle1` and `circle2`, in the different display object containers:

```
import flash.geom.*;
var pt1:Point = new Point(circle1.x, circle1.y);
pt1 = circle1.localToGlobal(pt1);
var pt2:Point = new Point(circle2.x, circle2.y);
pt2 = circle2.localToGlobal(pt2);
var distance:Number = Point.distance(pt1, pt2);
```

Similarly, to find the distance of the registration point of a display object named `target` from a specific point on the Stage, use the `localToGlobal()` method of the DisplayObject class:

```
import flash.geom.*;
var stageCenter:Point = new Point();
stageCenter.x = this.stage.stageWidth / 2;
stageCenter.y = this.stage.stageHeight / 2;
var targetCenter:Point = new Point(target.x, target.y);
targetCenter = target.localToGlobal(targetCenter);
var distance:Number = Point.distance(stageCenter, targetCenter);
```

Moving a display object by a specified angle and distance

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `polar()` method of the Point class to move a display object a specific distance by a specific angle. For example, the following code moves the `myDisplayObject` object 100 pixels by 60°:

```
import flash.geom.*;
var distance:Number = 100;
var angle:Number = 2 * Math.PI * (90 / 360);
var translatePoint:Point = Point.polar(distance, angle);
myDisplayObject.x += translatePoint.x;
myDisplayObject.y += translatePoint.y;
```

Other uses of the Point class

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use Point objects with the following methods and properties:

Class	Methods or properties	Description
DisplayObjectContainer	`areInaccessibleObjectsUnderPoint()getObjectsUnderPoint()`	Used to return a list of objects under a point in a display object container.
BitmapData	`hitTest()`	Used to define the pixel in the BitmapData object as well as the point that you are checking for a hit.

Class	Methods or properties	Description

BitmapData	`applyFilter()`
	`copyChannel()`
	`merge()`
	`paletteMap()`
	`pixelDissolve()`
	`threshold()`
		Used to define the positions of rectangles that define the operations.

Matrix	`deltaTransformPoint()`
	`transformPoint()`
		Used to define points for which you want to apply a transformation.

Rectangle	`bottomRight`
	`size`
	`topLeft`
		Used to define these properties.

Using Rectangle objects

Flash Player 9 and later, Adobe AIR 1.0 and later

A Rectangle object defines a rectangular area. A Rectangle object has a position, defined by the *x* and *y* coordinates of its upper-left corner, a `width` property, and a `height` property. You can define these properties for a new Rectangle object by calling the `Rectangle()` constructor function, as follows:

```
import flash.geom.Rectangle;
var rx:Number = 0;
var ry:Number = 0;
var rwidth:Number = 100;
var rheight:Number = 50;
var rect1:Rectangle = new Rectangle(rx, ry, rwidth, rheight);
```

Resizing and repositioning Rectangle objects

Flash Player 9 and later, Adobe AIR 1.0 and later

There are a number of ways to resize and reposition Rectangle objects.

You can directly reposition the Rectangle object by changing its `x` and `y` properties. This change has no effect on the width or height of the Rectangle object.

```
import flash.geom.Rectangle;
var x1:Number = 0;
var y1:Number = 0;
var width1:Number = 100;
var height1:Number = 50;
var rect1:Rectangle = new Rectangle(x1, y1, width1, height1);
trace(rect1) // (x=0, y=0, w=100, h=50)
rect1.x = 20;
rect1.y = 30;
trace(rect1); // (x=20, y=30, w=100, h=50)
```

As the following code shows, when you change the `left` or `top` property of a Rectangle object, the rectangle is repositioned. The rectangle's `x` and `y` properties match the `left` and `top` properties, respectively. However, the position of the lower-left corner of the Rectangle object does not change, so it is resized.

```
import flash.geom.Rectangle;
var x1:Number = 0;
var y1:Number = 0;
var width1:Number = 100;
var height1:Number = 50;
var rect1:Rectangle = new Rectangle(x1, y1, width1, height1);
trace(rect1) // (x=0, y=0, w=100, h=50)
rect1.left = 20;
rect1.top = 30;
trace(rect1); // (x=20, y=30, w=80, h=20)
```

Similarly, as the following example shows, if you change the `bottom` or `right` property of a Rectangle object, the position of its upper-left corner does not change. The rectangle is resized accordingly:

```
import flash.geom.Rectangle;
var x1:Number = 0;
var y1:Number = 0;
var width1:Number = 100;
var height1:Number = 50;
var rect1:Rectangle = new Rectangle(x1, y1, width1, height1);
trace(rect1) // (x=0, y=0, w=100, h=50)
rect1.right = 60;
trect1.bottom = 20;
trace(rect1); // (x=0, y=0, w=60, h=20)
```

You can also reposition a Rectangle object by using the `offset()` method, as follows:

```
import flash.geom.Rectangle;
var x1:Number = 0;
var y1:Number = 0;
var width1:Number = 100;
var height1:Number = 50;
var rect1:Rectangle = new Rectangle(x1, y1, width1, height1);
trace(rect1) // (x=0, y=0, w=100, h=50)
rect1.offset(20, 30);
trace(rect1); // (x=20, y=30, w=100, h=50)
```

The `offsetPt()` method works similarly, except that it takes a Point object as its parameter, rather than *x* and *y* offset values.

You can also resize a Rectangle object by using the `inflate()` method, which includes two parameters, `dx` and `dy`. The `dx` parameter represents the number of pixels that the left and right sides of the rectangle moves from the center. The `dy` parameter represents the number of pixels that the top and bottom of the rectangle moves from the center:

```
import flash.geom.Rectangle;
var x1:Number = 0;
var y1:Number = 0;
var width1:Number = 100;
var height1:Number = 50;
var rect1:Rectangle = new Rectangle(x1, y1, width1, height1);
trace(rect1) // (x=0, y=0, w=100, h=50)
rect1.inflate(6,4);
trace(rect1); // (x=-6, y=-4, w=112, h=58)
```

The `inflatePt()` method works similarly, except that it takes a Point object as its parameter, rather than `dx` and `dy` values.

Finding unions and intersections of Rectangle objects

Flash Player 9 and later, Adobe AIR 1.0 and later

You use the `union()` method to find the rectangular region formed by the boundaries of two rectangles:

```
import flash.display.*;
import flash.geom.Rectangle;
var rect1:Rectangle = new Rectangle(0, 0, 100, 100);
trace(rect1); // (x=0, y=0, w=100, h=100)
var rect2:Rectangle = new Rectangle(120, 60, 100, 100);
trace(rect2); // (x=120, y=60, w=100, h=100)
trace(rect1.union(rect2)); // (x=0, y=0, w=220, h=160)
```

You use the `intersection()` method to find the rectangular region formed by the overlapping region of two rectangles:

```
import flash.display.*;
import flash.geom.Rectangle;
var rect1:Rectangle = new Rectangle(0, 0, 100, 100);
trace(rect1); // (x=0, y=0, w=100, h=100)
var rect2:Rectangle = new Rectangle(80, 60, 100, 100);
trace(rect2); // (x=120, y=60, w=100, h=100)
trace(rect1.intersection(rect2)); // (x=80, y=60, w=20, h=40)
```

You use the `intersects()` method to find out whether two rectangles intersect. You can also use the `intersects()` method to find out whether a display object is in a certain region of the Stage. For the following code example, assume the coordinate space of the display object container that contains the `circle` object is the same as that of the Stage. The example shows how to use the `intersects()` method to determine if a display object, `circle`, intersects specified regions of the Stage, defined by the `target1` and `target2` Rectangle objects:

```
import flash.display.*;
import flash.geom.Rectangle;
var circle:Shape = new Shape();
circle.graphics.lineStyle(2, 0xFF0000);
circle.graphics.drawCircle(250, 250, 100);
addChild(circle);
var circleBounds:Rectangle = circle.getBounds(stage);
var target1:Rectangle = new Rectangle(0, 0, 100, 100);
trace(circleBounds.intersects(target1)); // false
var target2:Rectangle = new Rectangle(0, 0, 300, 300);
trace(circleBounds.intersects(target2)); // true
```

Similarly, you can use the `intersects()` method to find out whether the bounding rectangles of two display objects overlap. Use the `getRect()` method of the DisplayObject class to include any additional space that the strokes of a display object add to a bounding region.

Other uses of Rectangle objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Rectangle objects are used in the following methods and properties:

Class	Methods or properties	Description
BitmapData	`applyFilter()`, `colorTransform()`, `copyChannel()`, `copyPixels()`, `draw()`, `drawWithQuality()`, `encode()`, `fillRect()`, `generateFilterRect()`, `getColorBoundsRect()`, `getPixels()`, `merge()`, `paletteMap()`, `pixelDissolve()`, `setPixels()`, and `threshold()`	Used as the type for some parameters to define a region of the BitmapData object.
DisplayObject	`getBounds()`, `getRect()`, `scrollRect`, `scale9Grid`	Used as the data type for the property or the data type returned.
PrintJob	`addPage()`	Used to define the `printArea` parameter.
Sprite	`startDrag()`	Used to define the `bounds` parameter.
TextField	`getCharBoundaries()`	Used as the return value type.
Transform	`pixelBounds`	Used as the data type.

Using Matrix objects

Flash Player 9 and later, Adobe AIR 1.0 and later

The Matrix class represents a transformation matrix that determines how to map points from one coordinate space to another. You can perform various graphical transformations on a display object by setting the properties of a Matrix object, applying that Matrix object to the `matrix` property of a Transform object, and then applying that Transform object as the `transform` property of the display object. These transformation functions include translation (*x* and *y* repositioning), rotation, scaling, and skewing.

Although you could define a matrix by directly adjusting the properties (`a`, `b`, `c`, `d`, `tx`, `ty`) of a Matrix object, it is easier to use the `createBox()` method. This method includes parameters that let you directly define the scaling, rotation, and translation effects of the resulting matrix. For example, the following code creates a Matrix object that scales an object horizontally by 2.0, scales it vertically by 3.0, rotates it by 45°, moving (translating) it 10 pixels to the right, and moving it 20 pixels down:

```
var matrix:Matrix = new Matrix();
var scaleX:Number = 2.0;
var scaleY:Number = 3.0;
var rotation:Number = 2 * Math.PI * (45 / 360);
var tx:Number = 10;
var ty:Number = 20;
matrix.createBox(scaleX, scaleY, rotation, tx, ty);
```

You can also adjust the scaling, rotation, and translation effects of a Matrix object by using the `scale()`, `rotate()`, and `translate()` methods. Note that these methods combine with the values of the existing Matrix object. For example, the following code sets a Matrix object that scales an object by a factor of 4 and rotates it 60°, since the `scale()` and `rotate()` methods are called twice:

```
var matrix:Matrix = new Matrix();
var rotation:Number = 2 * Math.PI * (30 / 360); // 30°
var scaleFactor:Number = 2;
matrix.scale(scaleFactor, scaleFactor);
matrix.rotate(rotation);
matrix.scale(scaleX, scaleY);
matrix.rotate(rotation);

myDisplayObject.transform.matrix = matrix;
```

To apply a skew transformation to a Matrix object, adjust its `b` or `c` property. Adjusting the `b` property skews the matrix vertically, and adjusting the `c` property skews the matrix horizontally. The following code skews the `myMatrix` Matrix object vertically by a factor of 2:

```
var skewMatrix:Matrix = new Matrix();
skewMatrix.b = Math.tan(2);
myMatrix.concat(skewMatrix);
```

You can apply a Matrix transformation to the `transform` property of a display object. For example, the following code applies a matrix transformation to a display object named `myDisplayObject`:

```
var matrix:Matrix = myDisplayObject.transform.matrix;
var scaleFactor:Number = 2;
var rotation:Number = 2 * Math.PI * (60 / 360); // 60°
matrix.scale(scaleFactor, scaleFactor);
matrix.rotate(rotation);

myDisplayObject.transform.matrix = matrix;
```

The first line sets a Matrix object to the existing transformation matrix used by the `myDisplayObject` display object (the `matrix` property of the `transformation` property of the `myDisplayObject` display object). This way, the Matrix class methods that you call have a cumulative effect on the display object's existing position, scale, and rotation.

***Note:** The ColorTransform class is also included in the flash.geometry package. This class is used to set the* `colorTransform` *property of a Transform object. Since it does not apply any geometrical transformation, it is not discussed, in detail, here. For more information, see the ColorTransform class in the ActionScript 3.0 Reference for the Adobe Flash Platform.*

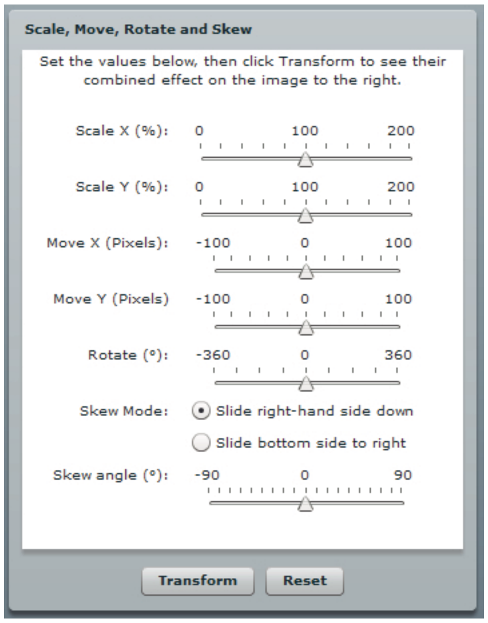
Geometry example: Applying a matrix transformation to a display object

Flash Player 9 and later, Adobe AIR 1.0 and later

The DisplayObjectTransformer sample application shows a number of features of using the Matrix class to transform a display object, including the following:

- Rotating the display object
- Scaling the display object
- Translating (repositioning) the display object
- Skewing the display object

The application provides an interface for adjusting the parameters of the matrix transformation, as follows:


Scale, Move, Rotate and Skew
Set the values below, then click Transform to see their combined effect on the image to the right.
Scale X (%): 0 100 200
Scale Y (%): 0 100 200
Move X (Pixels): -100 0 100
Move Y (Pixels) -100 0 100
Rotate (°): -360 0 360
Skew Mode: Slide right-hand side down
Slide bottom side to right
Skew angle (°): -90 0 90
Transform
Reset

When the user clicks the Transform button, the application applies the appropriate transformation.

The original display object, and the display object rotated by -45° and scaled by 50%

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The DisplayObjectTransformer application files can be found in the folder Samples/DisplayObjectTransformer. The application consists of the following files:

File	Description
DisplayObjectTransformer.mxml or DisplayObjectTransformer.fla	The main application file in Flash (FLA) or Flex (MXML)
com/example/programmingas3/geometry/MatrixTransformer.as	A class that contains methods for applying matrix transformations.
img/	A directory containing sample image files used by the application.

Defining the MatrixTransformer class

Flash Player 9 and later, Adobe AIR 1.0 and later

The MatrixTransformer class includes static methods that apply geometric transformations of Matrix objects.

The transform() method

The `transform()` method includes parameters for each of the following:

- `sourceMatrix`—The input matrix, which the method transforms
- `xScale` and `yScale`—The *x* and *y* scale factor
- `dx` and `dy`—The *x* and *y* translation amounts, in pixels
- `rotation`—The rotation amount, in degrees
- `skew`—The skew factor, as a percentage
- `skewType`—The direction in which the skew, either `"right"` or `"left"`

The return value is the resulting matrix.

The `transform()` method calls the following static methods of the class:

- `skew()`
- `scale()`
- `translate()`
- `rotate()`

Each returns the source matrix with the applied transformation.

The skew() method

The `skew()` method skews the matrix by adjusting the `b` and `c` properties of the matrix. An optional parameter, `unit`, determines the units used to define the skew angle, and if necessary, the method converts the `angle` value to radians:

```
if (unit == "degrees")
{
    angle = Math.PI * 2 * angle / 360;
}
if (unit == "gradients")
{
    angle = Math.PI * 2 * angle / 100;
}
```

A `skewMatrix` Matrix object is created and adjusted to apply the skew transformation. Initially, it is the identity matrix, as follows:

```
var skewMatrix:Matrix = new Matrix();
```

The `skewSide` parameter determines the side to which the skew is applied. If it is set to `"right"`, the following code sets the `b` property of the matrix:

```
skewMatrix.b = Math.tan(angle);
```

Otherwise, the bottom side is skewed by adjusting the `c` property of the Matrix, as follows:

```
skewMatrix.c = Math.tan(angle);
```

The resulting skew is then applied to the existing matrix by concatenating the two matrixes, as the following example shows:

```
sourceMatrix.concat(skewMatrix);
return sourceMatrix;
```

The scale() method

The following example shows the `scale()` method adjusts the scale factor if it is provided as a percentage, first, and then uses the `scale()` method of the matrix object:

```
if (percent)
{
    xScale = xScale / 100;
    yScale = yScale / 100;
}
sourceMatrix.scale(xScale, yScale);
return sourceMatrix;
```

The translate() method

The `translate()` method simply applies the `dx` and `dy` translation factors by calling the `translate()` method of the matrix object, as follows:

```
sourceMatrix.translate(dx, dy);
return sourceMatrix;
```

The rotate() method

The `rotate()` method converts the input rotation factor to radians (if it is provided in degrees or gradients), and then calls the `rotate()` method of the matrix object:

```
if (unit == "degrees")
{
    angle = Math.PI * 2 * angle / 360;
}
if (unit == "gradients")
{
    angle = Math.PI * 2 * angle / 100;
}
sourceMatrix.rotate(angle);
return sourceMatrix;
```

Calling the MatrixTransformer.transform() method from the application

Flash Player 9 and later, Adobe AIR 1.0 and later

The application contains a user interface for getting the transformation parameters from the user. It then passes these values, along with the `matrix` property of the `transform` property of the display object, to the `Matrix.transform()` method, as follows:

```
tempMatrix = MatrixTransformer.transform(tempMatrix,
    xScaleSlider.value,
    yScaleSlider.value,
    dxSlider.value,
    dySlider.value,
    rotationSlider.value,
    skewSlider.value,
    skewSide );
```

The application then applies the return value to the `matrix` property of the `transform` property of the display object, triggering the transformation:

```
img.content.transform.matrix = tempMatrix;
```

Chapter 12: Using the drawing API

Flash Player 9 and later, Adobe AIR 1.0 and later

Although imported images and artwork are important, the functionality known as the drawing API, which allows you to draw lines and shapes in ActionScript, gives you the freedom to start an application with the computer equivalent of a blank canvas, on which you can create whatever images you wish. The ability to create your own graphics opens up broad possibilities for your applications. With the techniques covered here you can create a drawing program, make animated, interactive art, or programmatically create your own user interface elements, among many possibilities.

More Help topics

flash.display.Graphics

Basics of the drawing API

Flash Player 9 and later, Adobe AIR 1.0 and later

The drawing API is the name for the functionality built into ActionScript that allows you to create vector graphics—lines, curves, shapes, fills, and gradients—and display them on the screen using ActionScript. The flash.display.Graphics class provides this functionality. You can draw with ActionScript on any Shape, Sprite, or MovieClip instance, using the `graphics` property defined in each of those classes. (Each of those classes' `graphics` property is in fact an instance of the Graphics class.)

If you're just getting started with drawing with code, the Graphics class includes several methods that make it easy to draw common shapes like circles, ellipses, rectangles, and rectangles with rounded corners. You can draw them as empty lines or filled shapes. When you need more advanced functionality, the Graphics class also includes methods for drawing lines and quadratic Bézier curves, which you can use in conjunction with the trigonometry functions in the Math class to create any shape you need.

Flash runtimes (such as Flash Player 10 and Adobe AIR 1.5 and later versions) add an additional API for drawing, which allow you to programmatically draw entire shapes with a single command. Once you're familiar with the Graphics class and tasks covered in "Basics of using the drawing API", continue to "Advanced use of the drawing API" on page 235 to learn more about these drawing API features.

Important concepts and terms

The following reference list contains important terms that you will encounter while using the drawing API:

Anchor point One of the two end points of a quadratic Bézier curve.

Control point The point that defines the direction and amount of curve of a quadratic Bézier curve. The curved line never reaches the control point; however, the line curves as though being drawn toward the control point.

Coordinate space The graph of coordinates contained in a display object, on which its child elements are positioned.

Fill The solid inner portion of a shape that has a line filled in with color, or all of a shape that has no outline.

Gradient A color that consists of a gradual transition from one color to one or more other colors (as opposed to a solid color).

Point A single location in a coordinate space. In the 2-d coordinate system used in ActionScript, a point is defined by its location along the x axis and the y axis (the point's coordinates).

Quadratic Bézier curve A type of curve defined by a particular mathematical formula. In this type of curve, the shape of the curve is calculated based on the positions of the anchor points (the end points of the curve) and a control point that defines the amount and direction of the curve.

Scale The size of an object relative to its original size. When used as a verb, to scale an object means to change its size by stretching or shrinking the object.

Stroke The outline portion of a shape that has a line filled in with color, or the lines of an un-filled shape.

Translate To change a point's coordinates from one coordinate space to another.

X axis The horizontal axis in the 2-d coordinate system used in ActionScript.

Y axis The vertical axis in the 2-d coordinate system used in ActionScript.

The Graphics class

Flash Player 9 and later, Adobe AIR 1.0 and later

Each Shape, Sprite, and MovieClip object has a `graphics` property, which is an instance of the Graphics class. The Graphics class includes properties and methods for drawing lines, fills, and shapes. If you want a display object to use solely as a canvas for drawing content, you can use a Shape instance. A Shape instance will perform better than other display objects for drawing, because it doesn't have the overhead of the additional functionality in the Sprite and MovieClip classes. If you want a display object on which you can draw graphical content and also want that object to contain other display objects, you can use a Sprite instance. For more information on determining which display object to use for various tasks, see "Choosing a DisplayObject subclass" on page 172.

Drawing lines and curves

Flash Player 9 and later, Adobe AIR 1.0 and later

All drawing that you do with a Graphics instance is based on basic drawing with lines and curves. Consequently, all ActionScript drawing must be performed using the same series of steps:

- Define line and fill styles
- Set the initial drawing position
- Draw lines, curves, and shapes (optionally moving the drawing point)
- If necessary, finish creating a fill

Defining line and fill styles

Flash Player 9 and later, Adobe AIR 1.0 and later

To draw with the `graphics` property of a Shape, Sprite, or MovieClip instance, you must first define the style (line size and color, fill color) to use when drawing. Just like when you use the drawing tools in Adobe® Flash® Professional or another drawing application, when you're using ActionScript to draw you can draw with or without a stroke, and with or without a fill color. You specify the appearance of the stroke using the `lineStyle()` or `lineGradientStyle()` method. To create a solid line, use the `lineStyle()` method. When calling this method, the most common values you'll specify are the first three parameters: line thickness, color, and alpha. For example, this line of code tells the Shape named `myShape` to draw lines that are 2 pixels thick, red (0x990000), and 75% opaque:

```
myShape.graphics.lineStyle(2, 0x990000, .75);
```

The default value for the alpha parameter is 1.0 (100%), so you can leave that parameter off if you want a completely opaque line. The `lineStyle()` method also accepts two additional parameters for pixel hinting and scale mode; for more information about using those parameters see the description of the `Graphics.lineStyle()` method in the ActionScript 3.0 Reference for the Adobe Flash Platform.

To create a gradient line, use the `lineGradientStyle()` method. This method is described in "Creating gradient lines and fills" on page 227.

If you want to create a filled shape, you call the `beginFill()`, `beginGradientFill()`, `beginBitmapFill()`, or `beginShaderFill()` methods before starting the drawing. The most basic of these, the `beginFill()` method, accepts two parameters: the fill color, and (optionally) an alpha value for the fill color. For example, if you want to draw a shape with a solid green fill, you would use the following code (assuming you're drawing on an object named `myShape`):

```
myShape.graphics.beginFill(0x00FF00);
```

Calling any fill method implicitly ends any previous fill before starting a new one. Calling any method that specifies a stroke style replaces the previous stroke, but does not alter a previously specified fill, and vice versa.

Once you have specified the line style and fill properties, the next step is to indicate the starting point for your drawing. The Graphics instance has a drawing point, like the tip of a pen on a piece of paper. Wherever the drawing point is located, that is where the next drawing action will begin. Initially a Graphics object begins with its drawing point at the point 0, 0 in the coordinate space of the object on which it's drawing. To start the drawing at a different point, you can first call the `moveTo()` method before calling one of the drawing methods. This is analogous to lifting the pen tip off of the paper and moving it to a new position.

With the drawing point in place you draw using a series of calls to the drawing methods `lineTo()` (for drawing straight lines) and `curveTo()` (for drawing curved lines).

While you are drawing, you can call the `moveTo()` method at any time to move the drawing point to a new position without drawing.

While drawing, if you have specified a fill color, you can close off the fill by calling the `endFill()` method. If you have not drawn a closed shape (in other words, if at the time you call `endFill()` the drawing point is not at the starting point of the shape), when you call the `endFill()` method the Flash runtime automatically closes the shape by drawing a straight line from the current drawing point to the location specified in the most recent `moveTo()` call. If you have started a fill and not called `endFill()`, calling `beginFill()` (or one of the other fill methods) closes the current fill and starts the new one.

Drawing straight lines

Flash Player 9 and later, Adobe AIR 1.0 and later

When you call the `lineTo()` method, the Graphics object draws a straight line from the current drawing point to the coordinates you specify as the two parameters in the method call, drawing with the line style you have specified. For example, this line of code puts the drawing point at the point 100, 100 then draws a line to the point 200, 200:

```
myShape.graphics.moveTo(100, 100);
myShape.graphics.lineTo(200, 200);
```

The following example draws red and green triangles with a height of 100 pixels:

```
var triangleHeight:uint = 100;
var triangle:Shape = new Shape();

// red triangle, starting at point 0, 0
triangle.graphics.beginFill(0xFF0000);
triangle.graphics.moveTo(triangleHeight / 2, 0);
triangle.graphics.lineTo(triangleHeight, triangleHeight);
triangle.graphics.lineTo(0, triangleHeight);
triangle.graphics.lineTo(triangleHeight / 2, 0);

// green triangle, starting at point 200, 0
triangle.graphics.beginFill(0x00FF00);
triangle.graphics.moveTo(200 + triangleHeight / 2, 0);
triangle.graphics.lineTo(200 + triangleHeight, triangleHeight);
triangle.graphics.lineTo(200, triangleHeight);
triangle.graphics.lineTo(200 + triangleHeight / 2, 0);

this.addChild(triangle);
```

Drawing curves

Flash Player 9 and later, Adobe AIR 1.0 and later

The `curveTo()` method draws a quadratic Bézier curve. This draws an arc that connects two points (called anchor points) while bending toward a third point (called the control point). The Graphics object uses the current drawing position as the first anchor point. When you call the `curveTo()` method, you pass four parameters: the x and y coordinates of the control point, followed by the x and y coordinates of the second anchor point. For example, the following code draws a curve starting at point 100, 100 and ending at point 200, 200. Because the control point is at point 175, 125, this creates a curve that moves to the right and then downward:

```
myShape.graphics.moveTo(100, 100);
myShape.graphics.curveTo(175, 125, 200, 200);
```

The following example draws red and green circular objects with a width and height of 100 pixels. Note that due to the nature of the quadratic Bézier equation, these are not perfect circles:

```
var size:uint = 100;
var roundObject:Shape = new Shape();

// red circular shape
roundObject.graphics.beginFill(0xFF0000);
roundObject.graphics.moveTo(size / 2, 0);
roundObject.graphics.curveTo(size, 0, size, size / 2);
roundObject.graphics.curveTo(size, size, size / 2, size);
roundObject.graphics.curveTo(0, size, 0, size / 2);
roundObject.graphics.curveTo(0, 0, size / 2, 0);

// green circular shape
roundObject.graphics.beginFill(0x00FF00);
roundObject.graphics.moveTo(200 + size / 2, 0);
roundObject.graphics.curveTo(200 + size, 0, 200 + size, size / 2);
roundObject.graphics.curveTo(200 + size, size, 200 + size / 2, size);
roundObject.graphics.curveTo(200, size, 200, size / 2);
roundObject.graphics.curveTo(200, 0, 200 + size / 2, 0);

this.addChild(roundObject);
```

Drawing shapes using built-in methods

Flash Player 9 and later, Adobe AIR 1.0 and later

For convenience when drawing common shapes such as circles, ellipses, rectangles, and rectangles with rounded corners, ActionScript 3.0 has methods that draw these common shapes for you. These are the `drawCircle()`, `drawEllipse()`, `drawRect()`, and `drawRoundRect()` methods of the Graphics class. These methods may be used in place of the `lineTo()` and `curveTo()` methods. Note, however, that you must still specify line and fill styles before calling these methods.

The following example recreates the example of drawing red, green, and blue squares with width and height of 100 pixels. This code uses the `drawRect()` method, and additionally specifies that the fill color has an alpha of 50% (0.5):

```
var squareSize:uint = 100;
var square:Shape = new Shape();
square.graphics.beginFill(0xFF0000, 0.5);
square.graphics.drawRect(0, 0, squareSize, squareSize);
square.graphics.beginFill(0x00FF00, 0.5);
square.graphics.drawRect(200, 0, squareSize, squareSize);
square.graphics.beginFill(0x0000FF, 0.5);
square.graphics.drawRect(400, 0, squareSize, squareSize);
square.graphics.endFill();
this.addChild(square);
```

In a Sprite or MovieClip object, the drawing content created with the `graphics` property always appears behind all child display objects that are contained by the object. Also, the `graphics` property content is not a separate display object so it does not appear in the list of a Sprite or MovieClip object's children. For example, the following Sprite object has a circle drawn with its `graphics` property, and it has a TextField object in its list of child display objects:

```
var mySprite:Sprite = new Sprite();
mySprite.graphics.beginFill(0xFFCC00);
mySprite.graphics.drawCircle(30, 30, 30);
var label:TextField = new TextField();
label.width = 200;
label.text = "They call me mellow yellow...";
label.x = 20;
label.y = 20;
mySprite.addChild(label);
this.addChild(mySprite);
```

Note that the TextField appears on top of the circle drawn with the graphics object.

Creating gradient lines and fills

Flash Player 9 and later, Adobe AIR 1.0 and later

The graphics object can also draw strokes and fills with gradients rather than solid colors. A gradient stroke is created with the `lineGradientStyle()` method and a gradient fill is created with the `beginGradientFill()` method.

Both methods accept the same parameters. The first four are required: type, colors, alphas, and ratios. The remaining four are optional but are useful for advanced customizing.

- The first parameter specifies the type of gradient you are creating. Acceptable values are `GradientType.LINEAR` or `GradientType.RADIAL`.
- The second parameter specifies the array of the color values to use. In a linear gradient, the colors will be arranged from left to right. In a radial gradient, they will be arranged from inside to outside. The order of the colors of the array represents the order that the colors will be drawn in the gradient.
- The third parameter specifies the alpha transparency values of the corresponding colors in the previous parameter.
- The fourth parameter specifies ratios, or the emphasis each color has within the gradient. Acceptable values range from 0-255. These values do not represent any width or height, but rather the position within the gradient; 0 represents the beginning of the gradient, 255 represents the end of the gradient. The array of ratios must increase sequentially and have the same number of entries as both the color and alpha arrays specified in the second and third parameters.

Although the fifth parameter, the transformation matrix, is optional, it is commonly used because it provides an easy and powerful way to control the gradient's appearance. This parameter accepts a Matrix instance. The easiest way to create a Matrix object for a gradient is to use the Matrix class's `createGradientBox()` method.

Defining a Matrix object for use with a gradient

Flash Player 9 and later, Adobe AIR 1.0 and later

You use the `beginGradientFill()` and `lineGradientStyle()` methods of the flash.display.Graphics class to define gradients for use in shapes. When you define a gradient, you supply a matrix as one of the parameters of these methods.

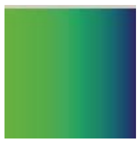
The easiest way to define the matrix is by using the Matrix class's `createGradientBox()` method, which creates a matrix that is used to define the gradient. You define the scale, rotation, and position of the gradient using the parameters passed to the `createGradientBox()` method. The `createGradientBox()` method accepts the following parameters:

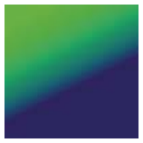
- Gradient box width: the width (in pixels) to which the gradient will spread
- Gradient box height: the height (in pixels) to which the gradient will spread
- Gradient box rotation: the rotation (in radians) that will be applied to the gradient
- Horizontal translation: how far (in pixels) the gradient is shifted horizontally
- Vertical translation: how far (in pixels) the gradient is shifted vertically

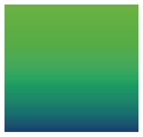
For example, consider a gradient with the following characteristics:

- `GradientType.LINEAR`
- Two colors, green and blue, with the `ratios` array set to `[0, 255]`
- `SpreadMethod.PAD`
- `InterpolationMethod.LINEAR_RGB`

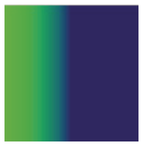
The following examples show gradients in which the `rotation` parameter of the `createGradientBox()` method differs as indicated, but all other settings stay the same:

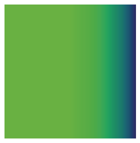
`width = 100;`
`height = 100;`
`rotation = 0;`
`tx = 0;`
`ty = 0;`
	

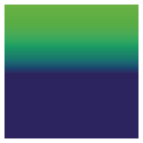
`width = 100;`
`height = 100;`
`rotation = Math.PI/4; // 45°`
`tx = 0;`
`ty = 0;`
	

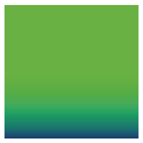
`width = 100;`
`height = 100;`
`rotation = Math.PI/2; // 90°`
`tx = 0;`
`ty = 0;`
	

The following examples show the effects on a green-to-blue linear gradient in which the `rotation`, `tx`, and `ty` parameters of the `createGradientBox()` method differ as indicated, but all other settings stay the same:

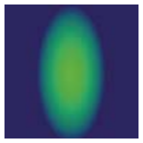
`width = 50;`
`height = 100;`
`rotation = 0;`
`tx = 0;`
`ty = 0;`
	

`width = 50;`
`height = 100;`
`rotation = 0`
`tx = 50;`
`ty = 0;`
	

`width = 100;`
`height = 50;`
`rotation = Math.PI/2; // 90°`
`tx = 0;`
`ty = 0;`
	

`width = 100;`
`height = 50;`
`rotation = Math.PI/2; // 90°`
`tx = 0;`
`ty = 50;`
	

The `width`, `height`, `tx`, and `ty` parameters of the `createGradientBox()` method affect the size and position of a *radial* gradient fill as well, as the following example shows:

`width = 50;`
`height = 100;`
`rotation = 0;`
`tx = 25;`
`ty = 0;`
	

The following code produces the last radial gradient illustrated:

```
import flash.display.Shape;
import flash.display.GradientType;
import flash.geom.Matrix;

var type:String = GradientType.RADIAL;
var colors:Array = [0x00FF00, 0x000088];
var alphas:Array = [1, 1];
var ratios:Array = [0, 255];
var spreadMethod:String = SpreadMethod.PAD;
var interp:String = InterpolationMethod.LINEAR_RGB;
var focalPtRatio:Number = 0;

var matrix:Matrix = new Matrix();
var boxWidth:Number = 50;
var boxHeight:Number = 100;
var boxRotation:Number = Math.PI/2; // 90°
var tx:Number = 25;
var ty:Number = 0;
matrix.createGradientBox(boxWidth, boxHeight, boxRotation, tx, ty);

var square:Shape = new Shape;
square.graphics.beginGradientFill(type,
                            colors,
                            alphas,
                            ratios,
                            matrix,
                            spreadMethod,
                            interp,
                            focalPtRatio);
square.graphics.drawRect(0, 0, 100, 100);
addChild(square);
```

Note that the width and height of the gradient fill is determined by the width and height of the gradient matrix rather than the width or height that is drawn using the Graphics object. When drawing with the Graphics object, you draw what exists at those coordinates in the gradient matrix. Even if you use one of the shape methods of a Graphics object such as `drawRect()`, the gradient does not stretch itself to the size of the shape that is drawn—the gradient's size must be specified in the gradient matrix itself.

The following illustrates the visual difference between the dimensions of the gradient matrix and the dimensions of the draw itself:

```
var myShape:Shape = new Shape();
var gradientBoxMatrix:Matrix = new Matrix();
gradientBoxMatrix.createGradientBox(100, 40, 0, 0, 0);
myShape.graphics.beginGradientFill(GradientType.LINEAR, [0xFF0000, 0x00FF00, 0x0000FF], [1,
1, 1], [0, 128, 255], gradientBoxMatrix);
myShape.graphics.drawRect(0, 0, 50, 40);
myShape.graphics.drawRect(0, 50, 100, 40);
myShape.graphics.drawRect(0, 100, 150, 40);
myShape.graphics.endFill();
this.addChild(myShape);
```

This code draws three gradients with the same fill style, specified with an equal distribution of red, green, and blue. The gradients are drawn using the `drawRect()` method with pixel widths of 50, 100, and 150 respectively. The gradient matrix which is specified in the `beginGradientFill()` method is created with a width of 100 pixels. This means that the first gradient will encompass only half of the gradient spectrum, the second will encompass all of it, and the third will encompass all of it and have an additional 50 pixels of blue extending to the right.

The `lineGradientStyle()` method works similarly to `beginGradientFill()` except that in addition to defining the gradient, you must specify the thickness of the stroke using the `lineStyle()` method before drawing. The following code draws a box with a red, green, and blue gradient stroke:

```
var myShape:Shape = new Shape();
var gradientBoxMatrix:Matrix = new Matrix();
gradientBoxMatrix.createGradientBox(200, 40, 0, 0, 0);
myShape.graphics.lineStyle(5, 0);
myShape.graphics.lineGradientStyle(GradientType.LINEAR, [0xFF0000, 0x00FF00, 0x0000FF], [1,
1, 1], [0, 128, 255], gradientBoxMatrix);
myShape.graphics.drawRect(0, 0, 200, 40);
this.addChild(myShape);
```

For more information on the Matrix class, see "Using Matrix objects" on page 216.

Using the Math class with drawing methods

Flash Player 9 and later, Adobe AIR 1.0 and later

A Graphics object draws circles and squares, but can also draw more complex forms, particularly when the drawing methods are used in combination with the properties and methods of the Math class. The Math class contains constants of common mathematical interest, such as `Math.PI` (approximately 3.14159265...), a constant for the ratio of the circumference of a circle to its diameter. It also contains methods for trigonometry functions, including `Math.sin()`, `Math.cos()`, and `Math.tan()` among others. Drawing shapes using these methods and constants create more dynamic visual effects, particularly when used with repetition or recursion.

Many methods of the Math class expect circular measurements in units of radians rather than degrees. Converting between these two types of units is a common use of the Math class:

```
var degrees = 121;
var radians = degrees * Math.PI / 180;
trace(radians) // 2.111848394913139
```

The following example creates a sine wave and a cosine wave, to highlight the difference between the `Math.sin()` and `Math.cos()` methods for a given value.

```
var sinWavePosition = 100;
var cosWavePosition = 200;
var sinWaveColor:uint = 0xFF0000;
var cosWaveColor:uint = 0x00FF00;
var waveMultiplier:Number = 10;
var waveStretcher:Number = 5;

var i:uint;
for(i = 1; i < stage.stageWidth; i++)
{
    var sinPosY:Number = Math.sin(i / waveStretcher) * waveMultiplier;
    var cosPosY:Number = Math.cos(i / waveStretcher) * waveMultiplier;

    graphics.beginFill(sinWaveColor);
    graphics.drawRect(i, sinWavePosition + sinPosY, 2, 2);
    graphics.beginFill(cosWaveColor);
    graphics.drawRect(i, cosWavePosition + cosPosY, 2, 2);
}
```

Animating with the drawing API

Flash Player 9 and later, Adobe AIR 1.0 and later

One advantage of creating content with the drawing API is that you are not limited to positioning your content once. What you draw can be modified by maintaining and modifying the variables you use to draw. You can convey animation by changing variables and redrawing, either over a period of frames or with a timer.

For example, the following code changes the display with each passing frame (by listening to the `Event.ENTER_FRAME` event), incrementing the current degree count, and directs the graphics object to clear and redraw with the updated position.

```
stage.frameRate = 31;

var currentDegrees:Number = 0;
var radius:Number = 40;
var satelliteRadius:Number = 6;

var container:Sprite = new Sprite();
container.x = stage.stageWidth / 2;
container.y = stage.stageHeight / 2;
addChild(container);
var satellite:Shape = new Shape();
container.addChild(satellite);

addEventListener(Event.ENTER_FRAME, doEveryFrame);

function doEveryFrame(event:Event):void
{
    currentDegrees += 4;
    var radians:Number = getRadians(currentDegrees);
    var posX:Number = Math.sin(radians) * radius;
    var posY:Number = Math.cos(radians) * radius;
    satellite.graphics.clear();
    satellite.graphics.beginFill(0);
    satellite.graphics.drawCircle(posX, posY, satelliteRadius);
}
function getRadians(degrees:Number):Number
{
return degrees * Math.PI / 180;
}
```

To produce a significantly different result, you can experiment by modifying the initial seed variables at the beginning of the code, `currentDegrees`, `radius`, and `satelliteRadius`. For example, try shrinking the radius variable and/or increasing the totalSatellites variable. This is only one example of how the drawing API can create a visual display whose complexity conceals the simplicity of its creation.

Drawing API example: Algorithmic Visual Generator

Flash Player 9 and later, Adobe AIR 1.0 and later

The Algorithmic Visual Generator example dynamically draws to the stage several "satellites", or circles moving in a circular orbit. Among the features explored are:

- Using the drawing API to draw a basic shape with dynamic appearances
- Connecting user interaction with the properties that are used in a draw
- Conveying animation by clearing the stage on each frame and redrawing

The example in the previous subsection animated a solitary "satellite" using the `Event.ENTER_FRAME` event. This example expands upon this, building a control panel with series of sliders that immediately update the visual display of several satellites. This example formalizes the code into external classes and wraps the satellite creation code into a loop, storing a reference to each satellite in a `satellites` array.

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The application files can be found in the folder Samples/AlgorithmicVisualGenerator. This folder contains the following files:

File	Description
AlgorithmicVisualGenerator.fla	The main application file in Flash Professional (FLA).
com/example/programmingas3/algorithmic/AlgorithmicVisualGenerator.as	The class that provides the main functionality of the application, including drawing satellites on the stage and responding to events from the control panel to update the variables that affect the drawing of satellites.
com/example/programmingas3/algorithmic/ControlPanel.as	A class that manages user interaction with several sliders and dispatching events when this occurs.
com/example/programmingas3/algorithmic/Satellite.as	A class which represents the display object that rotates in an orbit around a central point and contains properties related to its current draw state.

Setting the listeners

Flash Player 9 and later, Adobe AIR 1.0 and later

The application first creates three listeners. The first listens for a dispatched event from the control panel that a rebuild of the satellites is necessary. The second listens to changes to the size of the SWF file's stage. The third listens for each passing frame in the SWF file and to redraw using the `doEveryFrame()` function.

Creating the satellites

Flash Player 9 and later, Adobe AIR 1.0 and later

Once these listeners are set, the `build()` function is called. This function first calls the `clear()` function, which empties the `satellites` array and clears any previous draws to the stage. This is necessary since the `build()` function could be recalled whenever the control panel sends an event to do so, such as when the color settings have been changed. In such a case, the satellites must be removed and recreated.

The function then creates the satellites, setting the initial properties needed for creation, such as a the `position` variable, which starts at a random position in the orbit, and the `color` variable, which in this example does not change once the satellite has been created.

As each satellite is created, a reference to it is added to the `satellites` array. When the `doEveryFrame()` function is called, it will update to all satellites in this array.

Updating the satellite position

Flash Player 9 and later, Adobe AIR 1.0 and later

The `doEveryFrame()` function is the heart of the application's animation process. It is called for every frame, at a rate equal the framerate of the SWF file. Because the variables of the draw change slightly, this conveys the appearance of animation.

The function first clears all previous draws and redraws the background. Then, it loops through each satellite container and increments the `position` property of each satellite, and updates the `radius` and `orbitRadius` properties that may have changed from user interaction with the control panel. Finally, the satellite updates to its new position by calling the `draw()` method of the Satellite class.

Note that the counter, `i`, only increments up to the `visibleSatellites` variable. This is because if the user has limited the amount of satellites that are displayed through the control panel, the remaining satellites in the loop should not be redrawn but should instead be hidden. This occurs in a loop which immediately follows the loop responsible for drawing.

When the doEveryFrame() function completes, the number of `visibleSatellites` update in position across the screen.

Responding to user interaction

Flash Player 9 and later, Adobe AIR 1.0 and later

User interaction occurs via the control panel, which is managed by the ControlPanel class. This class sets a listener along with the individual minimum, maximum, and default values of each slider. As the user moves these sliders, the `changeSetting()` function is called. This function updates the properties of the control panel. If the change requires a rebuild of the display, an event is dispatched which is then handled in the main application file. As the control panel settings change, the `doEveryFrame()` function draws each satellite with the updated variables.

Customizing further

Flash Player 9 and later, Adobe AIR 1.0 and later

This example is only a basic schematic of how to generate visuals using the drawing API. It uses relatively few lines of code to create an interactive experience that appears quite complex. Even so, this example could be extended with minor changes. A few ideas:

- The `doEveryFrame()` function could increment the color value of the satellite.
- The `doEveryFrame()` function could shrink or expand the satellite radius over time.
- The satellite radius does not have to be circular; it could use the Math class to move according to a sine wave, for example.
- Satellites could use hit detection with other satellites.

The drawing API can be used as an alternative to creating visual effects in the Flash authoring environment, drawing basic shapes at run time. But it can also be used to create visual effects of a variety and scope that are not possible to create by hand. Using the drawing API and a bit of mathematics, the ActionScript author can give life to many unexpected creations.

Advanced use of the drawing API

Flash Player 10 and later, Adobe AIR 1.5 and later

Flash Player 10, Adobe AIR 1.5, and later Flash runtimes, support an advanced set of drawing features. The drawing API enhancements for these runtimes expand upon the drawing methods from previous releases so you can establish data sets to generate shapes, alter shapes at runtime, and create three-dimensional effects. The drawing API enhancements consolidate existing methods into alternative commands. These commands leverage vector arrays and enumeration classes to provide data sets for drawing methods. Using vector arrays allows for more complex shapes to render quickly and for developers to change the array values programmatically for dynamic shape rendering at runtime.

The drawing features introduced in Flash Player 10 are described in the following sections: "Drawing Paths" on page 236, "Defining winding rules" on page 237, "Using graphics data classes" on page 239, and "About using drawTriangles()" on page 241.

The following tasks are things you'll likely want to accomplish using the advanced drawing API in ActionScript:

- Using Vector objects to store data for drawing methods
- Defining paths for drawing shapes programmatically in a single operation
- Defining winding rules to determine how overlapping shapes are filled
- Reading the vector graphics content of a display object, such as to serialize and save the graphics data, to generate a spritesheet at runtime, or to draw a copy of the vector graphics content
- Using triangles and drawing methods for three-dimensional effects

Important concepts and terms

The following reference list contains important terms that you will encounter in this section:

- Vector: An array of values all of the same data type. A Vector object can store an array of values that drawing methods use to construct lines and shapes with a single command. For more information on Vector objects, see "Indexed arrays" on page 26.
- Path: A path is made up of one or more straight or curved segments. The beginning and end of each segment are marked by coordinates, which work like pins holding a wire in place. A path can be closed (for example, a circle), or open, with distinct endpoints (for example, a wavy line).
- Winding: The direction of a path as interpreted by the renderer; either positive (clockwise) or negative (counter-clockwise).
- GraphicsStroke: A class for setting the line style. While the term "stroke" isn't part of the drawing API enhancements, the use of a class to designate a line style with its own fill property is part of the new drawing API. You can dynamically adjust a line's style using the GraphicsStroke class.

- Fill object: Objects created using display classes like flash.display.GraphicsBitmapFill and flash.display.GraphicsGradientFill that are passed to the drawing command `Graphics.drawGraphicsData()`. Fill objects and the enhanced drawing commands introduce a more object-oriented programming approach to replicating `Graphics.beginBitmapFill()` and `Graphics.beginGradientFill()`.

Drawing Paths

Flash Player 10 and later, Adobe AIR 1.5 and later

The section on drawing lines and curves (see "Drawing lines and curves" on page 223) introduced the commands for drawing a single line (`Graphics.lineTo()`) or curve (`Graphics.curveTo()`) and then moving the line to another point (`Graphics.moveTo()`) to form a shape. The `Graphics.drawPath()` and `Graphics.drawTriangles()` methods accept a set of objects representing those same drawing commands as a parameter. With these methods, you can provide a series of `Graphics.lineTo()`, `Graphics.curveTo()`, or `Graphics.moveTo()` commands for the Flash runtime to execute in a single statement.

The GraphicsPathCommand enumeration class defines a set of constants that correspond to drawing commands. You pass a series of these constants (wrapped in a Vector instance) as a parameter for the `Graphics.drawPath()` method. Then with a single command you can render an entire shape, or several shapes. You can also alter the values passed to these methods to change an existing shape.

In addition to the Vector of drawing commands, the `drawPath()` method needs a set of coordinates that correspond to the coordinates for each drawing command. Create a Vector instance containing coordinates (Number instances) and pass it to the `drawPath()` method as the second (`data`) argument.

Note: *The values in the vector are not Point objects; the vector is a series of numbers where each group of two numbers represents an x/y coordinate pair.*

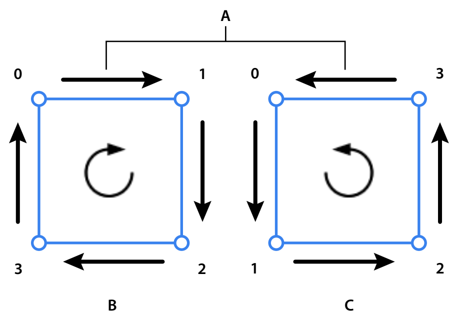
The `Graphics.drawPath()` method matches each command with its respective point values (a collection of two or four numbers) to generate a path in the Graphics object:

```
package
{
    import flash.display.*;

    public class DrawPathExample extends Sprite
    {
        public function DrawPathExample(){

            var squareCommands:Vector.<int> = new Vector.<int>(5, true);
            squareCommands[0] = GraphicsPathCommand.MOVE_TO;
            squareCommands[1] = GraphicsPathCommand.LINE_TO;
            squareCommands[2] = GraphicsPathCommand.LINE_TO;
            squareCommands[3] = GraphicsPathCommand.LINE_TO;
            squareCommands[4] = GraphicsPathCommand.LINE_TO;

            var squareCoord:Vector.<Number> = new Vector.<Number>(10, true);
            squareCoord[0] = 20; //x
            squareCoord[1] = 10; //y
            squareCoord[2] = 50;
            squareCoord[3] = 10;
            squareCoord[4] = 50;
            squareCoord[5] = 40;
            squareCoord[6] = 20;
            squareCoord[7] = 40;
            squareCoord[8] = 20;
            squareCoord[9] = 10;

            graphics.beginFill(0x442266);//set the color
            graphics.drawPath(squareCommands, squareCoord);
        }
    }
}
```

Defining winding rules

Flash Player 10 and later, Adobe AIR 1.5 and later

The enhanced drawing API also introduces the concept of path "winding": the direction for a path. The winding for a path is either positive (clockwise) or negative (counter-clockwise). The order in which the renderer interprets the coordinates provided by the vector for the data parameter determines the winding.



Positive and negative winding
***A.** Arrows indicate drawing direction **B.** Positively wound (clockwise) **C.** Negatively wound (counter-clockwise)*

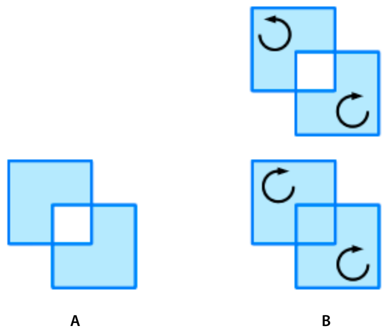
Additionally, notice that the `Graphics.drawPath()` method has an optional third parameter called "winding":

```
drawPath(commands:Vector.<int>, data:Vector.<Number>, winding:String = "evenOdd"):void
```

In this context, the third parameter is a string or a constant that specifies the winding or fill rule for intersecting paths. (The constant values are defined in the GraphicsPathWinding class as `GraphicsPathWinding.EVEN_ODD` or `GraphicsPathWinding.NON_ZERO`.) The winding rule is important when paths intersect.

The even-odd rule is the standard winding rule and is the rule used by the legacy drawing API. The Even-odd rule is also the default rule for the `Graphics.drawPath()` method. With the even-odd winding rule, any intersecting paths alternate between open and closed fills. If two squares drawn with the same fill intersect, the area in which the intersection occurs is filled. Generally, adjacent areas are neither both filled nor both unfilled.

The non-zero rule, on the other hand, depends on winding (drawing direction) to determine whether areas defined by intersecting paths are filled. When paths of opposite winding intersect, the area defined is unfilled, much like with even-odd. For paths of the same winding, the area that would be unfilled is filled:

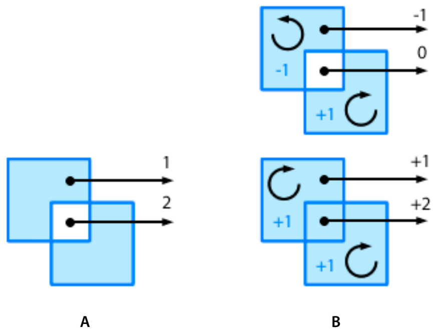


Winding rules for intersecting areas
***A.** Even-odd winding rule* ***B.** Non-zero winding rule*

Winding rule names

Flash Player 10 and later, Adobe AIR 1.5 and later

The names refer to a more specific rule that defines how these fills are managed. Positively wound paths are assigned a value of +1; negatively wound paths are assigned a value of -1. Starting from a point within an enclosed area of a shape, draw a line from that point extending out indefinitely. The number of times that line crosses a path, and the combined values of those paths, are used to determine the fill. For even-odd winding, the count of times the line crosses a path is used. When the count is odd, the area is filled. For even counts, the area is unfilled. For non-zero winding, the values assigned to the paths are used. When the combined values of the path are not 0, the area is filled. When the combined value is 0, the area is unfilled.



Winding rule counts and fills
***A.** Even-odd winding rule* ***B.** Non-zero winding rule*

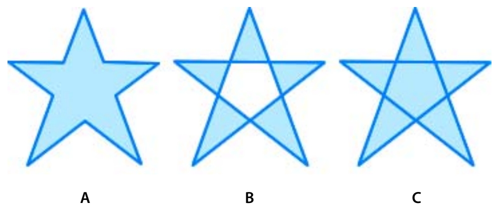
Using winding rules

Flash Player 10 and later, Adobe AIR 1.5 and later

These fill rules are complicated, but in some situations they are necessary. For example, consider drawing a star shape. With the standard even-odd rule, the shape would require ten different lines. With the non-zero winding rule, those ten lines are reduced to five. Here is the ActionScript for a star with five lines and a non-zero winding rule:

```
graphics.beginFill(0x60A0FF);
graphics.drawPath( Vector.<int>([1,2,2,2,2]),  Vector.<Number>([66,10, 23,127, 122,50, 10,49,
109,127]),   GraphicsPathWinding.NON_ZERO);
```

And here is the star shape:



A star shape using different winding rules
***A.** Even-odd 10 lines* ***B.** Even-odd 5 lines* ***C.** Non-zero 5 lines*

And, as images are animated or used as textures on three-dimensional objects and overlap, the winding rules become more important.

Using graphics data classes

Flash Player 10 and later, Adobe AIR 1.5 and later

The enhanced drawing API includes a set of classes in the flash.display package that implement the IGraphicsData interface. These classes act as value objects (data containers) that represent the drawing methods of the drawing API.

The following classes implement the IGraphicsData interface:

- GraphicsBitmapFill
- GraphicsEndFill
- GraphicsGradientFill
- GraphicsPath
- GraphicsShaderFill
- GraphicsSolidFill
- GraphicsStroke
- GraphicsTrianglePath

With these classes, you can store a complete drawing in a Vector object of IGraphicsData type (Vector.<IGraphicsData>). You can then reuse the graphics data as the data source for other shape instances or to store drawing information for later use.

Notice you have multiple fill classes for each style of fill, but only one stroke class. ActionScript has only one stroke IGraphicsData class because the stroke class uses the fill classes to define its style. So every stroke is actually defined by a combination of the stroke class and a fill class. Otherwise, the API for these graphics data classes mirror the methods they represent in the flash.display.Graphics class:

Graphics Method	Corresponding Class
beginBitmapFill()	GraphicsBitmapFill
beginFill()	GraphicsSolidFill
beginGradientFill()	GraphicsGradientFill
beginShaderFill()	GraphicsShaderFill
lineBitmapStyle()	GraphicsStroke + GraphicsBitmapFill
lineGradientStyle()	GraphicsStroke + GraphicsGradientFill
lineShaderStyle()	GraphicsStroke + GraphicsShaderFill
lineStyle()	GraphicsStroke + GraphicsSolidFill

moveTo()
lineTo()
curveTo()
drawPath()
	GraphicsPath

drawTriangles()	GraphicsTrianglePath

In addition, the GraphicsPath class has its own `GraphicsPath.moveTo()`, `GraphicsPath.lineTo()`, `GraphicsPath.curveTo()`, `GraphicsPath.wideLineTo()`, and `GraphicsPath.wideMoveTo()` utility methods to easily define those commands for a GraphicsPath instance. These utility methods simplify the task of defining or updating the commands and data values directly.

Drawing with vector graphics data

Once you have a collection of IGraphicsData instances, use the Graphics class's `drawGraphicsData()` method to render the graphics. The `drawGraphicsData()` method carries out a set of drawing instructions from a vector of IGraphicsData instances in sequential order:

```
// stroke object
var stroke:GraphicsStroke = new GraphicsStroke(3);
stroke.joints = JointStyle.MITER;
stroke.fill = new GraphicsSolidFill(0x102020);// solid stroke

// fill object
var fill:GraphicsGradientFill = new GraphicsGradientFill();
fill.colors = [0x0000FF, 0xEEFFEE];
fill.matrix = new Matrix();
fill.matrix.createGradientBox(70, 70, Math.PI/2);
// path object
var path:GraphicsPath = new GraphicsPath(new Vector.<int>(), new Vector.<Number>());
path.commands.push(GraphicsPathCommand.MOVE_TO, GraphicsPathCommand.LINE_TO,
GraphicsPathCommand.LINE_TO);
path.data.push(125,0, 50,100, 175,0);

// combine objects for complete drawing
var drawing:Vector.<IGraphicsData> = new Vector.<IGraphicsData>();
drawing.push(stroke, fill, path);

// draw the drawing
graphics.drawGraphicsData(drawing);
```

By modifying one value in the path used by the drawing in the example, the shape can be redrawn multiple times for a more complex image:

```
// draw the drawing multiple times
// change one value to modify each variation
graphics.drawGraphicsData(drawing);
path.data[2] += 200;
graphics.drawGraphicsData(drawing);
path.data[2] -= 150;
graphics.drawGraphicsData(drawing);
path.data[2] += 100;
graphics.drawGraphicsData(drawing);
path.data[2] -= 50;graphicsS.drawGraphicsData(drawing);
```

Though IGraphicsData objects can define fill and stroke styles, the fill and stroke styles are not a requirement. In other words, Graphics class methods can be used to set styles while IGraphicsData objects can be used to draw a saved collection of paths, or vice-versa.

***Note:** Use the `Graphics.clear()` method to clear out a previous drawing before starting a new one; unless you're adding on to the original drawing, as seen in the example above. As you change a single portion of a path or collection of IGraphicsData objects, redraw the entire drawing to see the changes.*

When using graphics data classes, the fill is rendered whenever three or more points are drawn, because the shape is inherently closed at that point. Even though the fill closes, the stroke does not, and this behavior is different than when using multiple `Graphics.lineTo()` or `Graphics.moveTo()` commands.

Reading vector graphics data

Flash Player 11.6 and later, Adobe AIR 3.6 and later

In addition to drawing vector content to a display object, in Flash Player 11.6 and Adobe AIR 3.6 and later you can use the Graphics class's `readGraphicsData()` method to obtain a data representation of the vector graphics content of a display object. This can be used to create a snapshot of a graphic to save, copy, create a spritesheet at run time, and more.

Calling the `readGraphicsData()` method returns a Vector instance containing IGraphicsData objects. These are the same objects used to draw vector graphics with the `drawGraphicsData()` method.

There are several limitations to reading vector graphics with the `readGraphicsData()` method. For more information, see the readGraphicsData() entry in the ActionScript Language Reference.

About using drawTriangles()

Flash Player 10 and later, Adobe AIR 1.5 and later

Another advanced method introduced in Flash Player 10 and Adobe AIR 1.5, `Graphics.drawTriangles()`, is like the `Graphics.drawPath()` method. The `Graphics.drawTriangles()` method also uses a Vector.<Number> object to specify point locations for drawing a path.

However, the real purpose for the `Graphics.drawTriangles()` method is to facilitate three-dimensional effects through ActionScript. For information about using `Graphics.drawTriangles()` to produce three-dimensional effects, see "Using triangles for 3D effects" on page 363.

Chapter 13: Working with bitmaps

Flash Player 9 and later, Adobe AIR 1.0 and later

In addition to its vector drawing capabilities, ActionScript 3.0 includes the ability to create bitmap images or manipulate the pixel data of external bitmap images that are loaded into a SWF. With the ability to access and change individual pixel values, you can create your own filter-like image effects and use the built-in noise functions to create textures and random noise.

- Renaun Erickson: Rendering game assets in ActionScript using blitting techniques
- Bitmap programming: Chapter 26 of Essential ActionScript 3 by Colin Moock (O'Reilly Media, 2007)
- Mike Jones: Working with Sprites in Pushbutton Engine
- Flash & Math: Pixel Particles Made Simple
- Flixel

Basics of working with bitmaps

Flash Player 9 and later, Adobe AIR 1.0 and later

When you work with digital images, you're likely to encounter two main types of graphics: bitmap and vector. Bitmap graphics, also known as raster graphics, are composed of tiny squares (pixels) that are arranged in a rectangular grid formation. Vector graphics are composed of mathematically generated geometric shapes such as lines, curves, and polygons.

Bitmap images are defined by the width and height of the image, measured in pixels, and the number of bits contained in each pixel, which represents the number of colors a pixel can contain. In the case of a bitmap image that utilizes the RGB color model, the pixels are made up of three bytes: red, green, and blue. Each of these bytes contains a value ranging from 0 to 255. When the bytes are combined within the pixel, they produce a color similar to an artist mixing paint colors. For example, a pixel containing byte values of red-255, green-102 and blue-0 would produce a vibrant orange color.

The quality of a bitmap image is determined by combining the resolution of the image with its color depth bit value. *Resolution* relates to the number of pixels contained within an image. The greater the number of pixels, the higher the resolution and the finer the image appears. *Color depth* relates to the amount of information a pixel can contain. For example, an image that has a color depth value of 16 bits per pixel cannot represent the same number of colors as an image that has a color depth of 48 bits. As a result, the 48-bit image will have smoother degrees of shading than its 16-bit counterpart.

Because bitmap graphics are resolution-dependent, they don't scale very well. This is most noticeable when bitmap images are scaled up in size. Scaling up a bitmap usually results in a loss of detail and quality.

Bitmap file formats

Bitmap images are grouped into a number of common file formats. These formats use different types of compression algorithms to reduce file size, as well as optimize image quality based on the end purpose of the image. The bitmap image formats supported by Adobe runtimes are BMP, GIF, JPG, PNG, and TIFF.

BMP

The BMP (bit mapped) format is a default image format used by the Microsoft Windows operating system. It does not use any form of compression algorithm and as such usually results in large file sizes.

GIF

The Graphics Interchange Format (GIF) was originally developed by CompuServe in 1987 as a means to transmit images with 256 colors (8-bit color). The format provides small file sizes and is ideal for web-based images. Because of this format's limited color palette, GIF images are generally not suitable for photographs, which typically require high degrees of shading and color gradients. GIF images permit single-bit transparency, which allows colors to be mapped as clear (or transparent). This results in the background color of a web page showing through the image where the transparency has been mapped.

JPEG

Developed by the Joint Photographic Experts Group (JPEG), the JPEG (often written JPG) image format uses a lossy compression algorithm to allow 24-bit color depth with a small file size. Lossy compression means that each time the image is saved, the image loses quality and data but results in a smaller file size. The JPEG format is ideal for photographs because it is capable of displaying millions of colors. The ability to control the degree of compression applied to an image allows you to manipulate image quality and file size.

PNG

The Portable Network Graphics (PNG) format was produced as an open-source alternative to the patented GIF file format. PNGs support up to 64-bit color depth, allowing for up to 16 million colors. Because PNG is a relatively new format, some older browsers don't support PNG files. Unlike JPGs, PNGs use lossless compression, which means that none of the image data is lost when the image is saved. PNG files also support alpha transparency, which allows for up to 256 levels of transparency.

TIFF

The Tagged Image File Format (TIFF) was the cross-platform format of choice before the PNG was introduced. The drawback with the TIFF format is that because of the many different varieties of TIFF, there is no single reader that can handle every version. In addition, no web browsers currently support the format. TIFF can use either lossy or lossless compression, and is able to handle device-specific color spaces (such as CMYK).

Transparent bitmaps and opaque bitmaps

Bitmap images that use either the GIF or PNG formats can have an extra byte (alpha channel) added to each pixel. This extra pixel byte represents the transparency value of the pixel.

GIF images allow single-bit transparency, which means that you can specify a single color, from a 256-color palette, to be transparent. PNG images, on the other hand, can have up to 256 levels of transparency. This function is especially beneficial when images or text are required to blend into backgrounds.

ActionScript 3.0 replicates this extra transparency pixel byte within the BitmapData class. Similar to the PNG transparency model, ActionScript offers up to 256 levels of transparency.

Important concepts and terms

The following list contains important terms that you will encounter when learning about bitmap graphics:

Alpha The level of transparency (or more accurately, opacity) in a color or an image. The amount of alpha is often described as the *alpha channel* value.

ARGB color A color scheme where each pixel's color is a mixture of red, green, and blue color values, and its transparency is specified as an alpha value.

Color channel Commonly, colors are represented as a mixture of a few basic colors—usually (for computer graphics) red, green, and blue. Each basic color is considered a color channel; the amount of color in each color channel, mixed together, determines the final color.

Color depth Also known as *bit depth*, this refers to the amount of computer memory that is devoted to each pixel, which in turn determines the number of possible colors that can be represented in the image.

Pixel The smallest unit of information in a bitmap image—essentially a dot of color.

Resolution The pixel dimensions of an image, which determines the level of fine-grained detail contained in the image. Resolution is often expressed in terms of width and height in number of pixels.

RGB color A color scheme where each pixel's color is represented as a mixture of red, green, and blue color values.

The Bitmap and BitmapData classes

Flash Player 9 and later, Adobe AIR 1.0 and later

The main ActionScript 3.0 classes for working with bitmap images are the Bitmap class, which is used to display bitmap images on the screen, and the BitmapData class, which is used to access and manipulate the raw image data of a bitmap.

More Help topics

flash.display.Bitmap

flash.display.BitmapData

Understanding the Bitmap class

Flash Player 9 and later, Adobe AIR 1.0 and later

As a subclass of the DisplayObject class, the Bitmap class is the main ActionScript 3.0 class used for displaying bitmap images. These images may have been loaded via the flash.display.Loader class or created dynamically using the `Bitmap()` constructor. When loading an image from an external source, a Bitmap object can only use GIF, JPEG, or PNG format images. Once instantiated, the Bitmap instance can be considered a wrapper for a BitmapData object that needs to be rendered to the Stage. Because a Bitmap instance is a display object, all the characteristics and functionality of display objects can be used to manipulate a Bitmap instance as well. For more information about working with display objects, see "Display programming" on page 151.

Pixel snapping and smoothing

Flash Player 9 and later, Adobe AIR 1.0 and later

In addition to the functionality common to all display objects, the Bitmap class provides some additional features that are specific to bitmap images.

The `pixelSnapping` property of the Bitmap class determines whether or not a Bitmap object snaps to its nearest pixel. This property accepts one of three constants defined in the PixelSnapping class: `ALWAYS`, `AUTO`, and `NEVER`.

The syntax for applying pixel snapping is as follows:

```
myBitmap.pixelSnapping = PixelSnapping.ALWAYS;
```

Often, when bitmap images are scaled, they become blurred and distorted. To help reduce this distortion, use the `smoothing` property of the BitmapData class. This Boolean property, when set to `true`, smooths, or anti-aliases, the pixels within the image when it is scaled. This gives the image a clearer and more natural appearance.

Understanding the BitmapData class

Flash Player 9 and later, Adobe AIR 1.0 and later

The BitmapData class, which is in the flash.display package, can be likened to a photographic snapshot of the pixels contained within a loaded or dynamically created bitmap image. This snapshot is represented by an array of pixel data within the object. The BitmapData class also contains a series of built-in methods that are useful for creation and manipulation of pixel data.

To instantiate a BitmapData object, use the following code:

```
var myBitmap:BitmapData = new BitmapData(width:Number, height:Number, transparent:Boolean, 
fillColor:uinit);
```

The `width` and `height` parameters specify the size of the bitmap. Starting with AIR 3 and Flash player 11, the size limits for a BitmapData object have been removed. The maximum size of a bitmap is dependent on the operating system.

In AIR 1.5 and Flash Player 10, the maximum size for a BitmapData object is 8,191 pixels in width or height, and the total number of pixels cannot exceed 16,777,215 pixels. (So, if a BitmapData object is 8,191 pixels wide, it can only be 2,048 pixels high.) In Flash Player 9 and earlier and AIR 1.1 and earlier, the limitation is 2,880 pixels in height and 2,880 in width.

The `transparent` parameter specifies whether the bitmap data includes an alpha channel (`true`) or not (`false`). The `fillColor` parameter is a 32-bit color value that specifies the background color, as well as the transparency value (if it has been set to `true`). The following example creates a BitmapData object with an orange background that is 50 percent transparent:

```
var myBitmap:BitmapData = new BitmapData(150, 150, true, 0x80FF3300);
```

To render a newly created BitmapData object to the screen, assign it to or wrap it in a Bitmap instance. To do this, you can either pass the BitmapData object as a parameter of the Bitmap object's constructor, or you can assign it to the `bitmapData` property of an existing Bitmap instance. You must also add the Bitmap instance to the display list by calling the `addChild()` or `addChildAt()` methods of the display object container that will contain the Bitmap instance. For more information on working with the display list, see "Adding display objects to the display list" on page 158.

The following example creates a BitmapData object with a red fill, and displays it in a Bitmap instance:

```
var myBitmapDataObject:BitmapData = new BitmapData(150, 150, false, 0xFF0000);
var myImage:Bitmap = new Bitmap(myBitmapDataObject);
addChild(myImage);
```

Manipulating pixels

Flash Player 9 and later, Adobe AIR 1.0 and later

The BitmapData class contains a set of methods that allow you to manipulate pixel data values.

Manipulating individual pixels

Flash Player 9 and later, Adobe AIR 1.0 and later

When changing the appearance of a bitmap image at a pixel level, you first need to get the color values of the pixels contained within the area you wish to manipulate. You use the `getPixel()` method to read these pixel values.

The `getPixel()` method retrieves an RGB value from a set of x, y (pixel) coordinates that are passed as a parameter. If any of the pixels that you want to manipulate include transparency (alpha channel) information, you need to use the `getPixel32()` method. This method also retrieves an RGB value, but unlike with `getPixel()`, the value returned by `getPixel32()` contains additional data that represents the alpha channel (transparency) value of the selected pixel.

Alternatively, if you simply want to change the color or transparency of a pixel contained within a bitmap, you can use the `setPixel()` or `setPixel32()` method. To set a pixel's color, simply pass in the x, y coordinates and the color value to one of these methods.

The following example uses `setPixel()` to draw a cross on a green BitmapData background. It then uses `getPixel()` to retrieve the color value from the pixel at the coordinate 50, 50 and traces the returned value.

```
import flash.display.Bitmap;
import flash.display.BitmapData;

var myBitmapData:BitmapData = new BitmapData(100, 100, false, 0x009900);

for (var i:uint = 0; i < 100; i++)
{
    var red:uint = 0xFF0000;
    myBitmapData.setPixel(50, i, red);
    myBitmapData.setPixel(i, 50, red);
}

var myBitmapImage:Bitmap = new Bitmap(myBitmapData);
addChild(myBitmapImage);

var pixelValue:uint = myBitmapData.getPixel(50, 50);
trace(pixelValue.toString(16));
```

If you want to read the value of a group of pixels, as opposed to a single pixel, use the `getPixels()` method. This method generates a byte array from a rectangular region of pixel data that is passed as a parameter. Each of the elements of the byte array (in other words, the pixel values) are unsigned integers—32-bit, unmultiplied pixel values.

Conversely, to change (or set) the value of a group of pixels, use the `setPixels()` method. This method expects two parameters (`rect` and `inputByteArray`), which are combined to output a rectangular region (`rect`) of pixel data (`inputByteArray`).

As data is read (and written) out of the `inputByteArray`, the `ByteArray.readUnsignedInt()` method is called for each of the pixels in the array. If, for some reason, the `inputByteArray` doesn't contain a full rectangle worth of pixel data, the method stops processing the image data at that point.

It's important to remember that, for both getting and setting pixel data, the byte array expects 32-bit alpha, red, green, blue (ARGB) pixel values.

The following example uses the `getPixels()` and `setPixels()` methods to copy a group of pixels from one BitmapData object to another:

```
import flash.display.Bitmap;
import flash.display.BitmapData;
import flash.utils.ByteArray;
import flash.geom.Rectangle;

var bitmapDataObject1:BitmapData = new BitmapData(100, 100, false, 0x006666FF);
var bitmapDataObject2:BitmapData = new BitmapData(100, 100, false, 0x00FF0000);

var rect:Rectangle = new Rectangle(0, 0, 100, 100);
var bytes:ByteArray = bitmapDataObject1.getPixels(rect);

bytes.position = 0;
bitmapDataObject2.setPixels(rect, bytes);

var bitmapImage1:Bitmap = new Bitmap(bitmapDataObject1);
addChild(bitmapImage1);
var bitmapImage2:Bitmap = new Bitmap(bitmapDataObject2);
addChild(bitmapImage2);
bitmapImage2.x = 110;
```

Pixel-level collision detection

Flash Player 9 and later, Adobe AIR 1.0 and later

The `BitmapData.hitTest()` method performs pixel-level collision detection between the bitmap data and another object or point.

The `BitmapData.hitTest()` method accepts five parameters:

- `firstPoint` (Point): This parameter refers to the pixel position of the upper-left corner of the first BitmapData upon which the hit test is being performed.
- `firstAlphaThreshold` (uint): This parameter specifies the highest alpha channel value that is considered opaque for this hit test.
- `secondObject` (Object): This parameter represents the area of impact. The `secondObject` object can be a Rectangle, Point, Bitmap, or BitmapData object. This object represents the hit area on which the collision detection is being performed.
- `secondBitmapDataPoint` (Point): This optional parameter is used to define a pixel location in the second BitmapData object. This parameter is used only when the value of `secondObject` is a BitmapData object. The default is `null`.
- `secondAlphaThreshold` (uint): This optional parameter represents the highest alpha channel value that is considered opaque in the second BitmapData object. The default value is 1. This parameter is only used when the value of `secondObject` is a BitmapData object and both BitmapData objects are transparent.

When performing collision detection on opaque images, keep in mind that ActionScript treats the image as though it were a fully opaque rectangle (or bounding box). Alternatively, when performing pixel-level hit testing on images that are transparent, both of the images are required to be transparent. In addition to this, ActionScript uses the alpha threshold parameters to determine at what point the pixels change from being transparent to opaque.

The following example creates three bitmap images and checks for pixel collision using two different collision points (one returns false, the other true):

```
import flash.display.Bitmap;
import flash.display.BitmapData;
import flash.geom.Point;

var bmd1:BitmapData = new BitmapData(100, 100, false, 0x000000FF);
var bmd2:BitmapData = new BitmapData(20, 20, false, 0x00FF3300);

var bm1:Bitmap = new Bitmap(bmd1);
this.addChild(bm1);

// Create a red square.
var redSquare1:Bitmap = new Bitmap(bmd2);
this.addChild(redSquare1);
redSquare1.x = 0;

// Create a second red square.
var redSquare2:Bitmap = new Bitmap(bmd2);
this.addChild(redSquare2);
redSquare2.x = 150;
redSquare2.y = 150;

// Define the point at the top-left corner of the bitmap.
var pt1:Point = new Point(0, 0);
// Define the point at the center of redSquare1.
var pt2:Point = new Point(20, 20);
// Define the point at the center of redSquare2.
var pt3:Point = new Point(160, 160);

trace(bmd1.hitTest(pt1, 0xFF, pt2)); // true
trace(bmd1.hitTest(pt1, 0xFF, pt3)); // false
```

Copying bitmap data

Flash Player 9 and later, Adobe AIR 1.0 and later

To copy bitmap data from one image to another, you can use several methods: `clone()`, `copyPixels()`, `copyChannel()`, `draw()`, and `drawWithQuality()`(`drawWithQuality` method available in Flash Player 11.3 and higher; AIR 3.3 and higher).

As its name suggests, the `clone()` method lets you clone, or sample, bitmap data from one BitmapData object to another. When called, the method returns a new BitmapData object that is an exact clone of the original instance it was copied from.

The following example clones a copy of an orange (parent) square and places the clone beside the original parent square:

```
import flash.display.Bitmap;
import flash.display.BitmapData;

var myParentSquareBitmap:BitmapData = new BitmapData(100, 100, false, 0x00ff3300);
var myClonedChild:BitmapData = myParentSquareBitmap.clone();

var myParentSquareContainer:Bitmap = new Bitmap(myParentSquareBitmap);
this.addChild(myParentSquareContainer);

var myClonedChildContainer:Bitmap = new Bitmap(myClonedChild);
this.addChild(myClonedChildContainer);
myClonedChildContainer.x = 110;
```

The `copyPixels()` method is a quick and easy way of copying pixels from one BitmapData object to another. The method takes a rectangular snapshot (defined by the `sourceRect` parameter) of the source image and copies it to another rectangular area (of equal size). The location of the newly "pasted" rectangle is defined within the `destPoint` parameter.

The `copyChannel()` method samples a predefined color channel value (alpha, red, green, or blue) from a source BitmapData object and copies it into a channel of a destination BitmapData object. Calling this method does not affect the other channels in the destination BitmapData object.

The `draw()` and `drawWithQuality()` methods draw, or render, the graphical content from a source sprite, movie clip, or other display object on to a new bitmap. Using the `matrix`, `colorTransform`, `blendMode`, and destination `clipRect` parameters, you can modify the way in which the new bitmap is rendered. This method uses the vector renderer in Flash Player and AIR to generate the data.

When you call `draw()` or `drawWithQuality()`, you pass the source object (sprite, movie clip, or other display object) as the first parameter, as demonstrated here:

```
myBitmap.draw(movieClip);
```

If the source object has had any transformations (color, matrix, and so forth) applied to it after it was originally loaded, these transformations are not copied across to the new object. If you want to copy the transformations to the new bitmap, then you need to copy the value of the `transform` property from the original object to the `transform` property of the Bitmap object that uses the new BitmapData object.

Compressing bitmap data

Flash Player 11.3 and later, AIR 3.3 and later

The `flash.display.BitmapData.encode()` method lets you natively compress bitmap data into one of the following image compression formats:

- **PNG** - Uses PNG compression, optionally using fast compression, which emphasizes compression speed over file size. To use PNG compression, pass a new `flash.display.PNGEncoderOptions` object as the second parameter of the `BitmapData.encode()` method.
- **JPEG** - Uses JPEG compression, optionally specifying image quality. To use JPEG compression, pass a new `flash.display.JPEGEncoderOptions` object as the second parameter of the `BitmapData.encode()` method.
- **JPEGXR** - Uses JPEG Extended Range (XR) compression, optionally specifying color channel, lossy, and entropy settings. To use JPEGXR compression, pass a new `flash.display.JPEGXREncoderOptions` object as the second parameter of the `BitmapData.encode()` method.

You can use this feature for image processing as part of a server upload or download workflow.

The following example snippet compresses a BitmapData object using `JPEGEncoderOptions`:

```
// Compress a BitmapData object as a JPEG file.
var bitmapData:BitmapData = new BitmapData(640,480,false,0x00FF00);
var byteArray:ByteArray = new ByteArray();
bitmapData.encode(new Rectangle(0,0,640,480), new flash.display.JPEGEncoderOptions(),
byteArray);
```

Making textures with noise functions

Flash Player 9 and later, Adobe AIR 1.0 and later

To modify the appearance of a bitmap, you can apply a noise effect to it, using either the `noise()` method or the `perlinNoise()` methods. A noise effect can be likened to the static that appears on an untuned television screen.

To apply a noise effect to a a bitmap, use the `noise()` method. This method applies a random color value to pixels within a specified area of a bitmap image.

This method accepts five parameters:

- `randomSeed` (int): The random seed number that determines the pattern. Despite its name, this number actually creates the same results if the same number is passed. To get a true random result, use the `Math.random()` method to pass a random number for this parameter.
- `low` (uint): This parameter refers to the lowest value to be generated for each pixel (0 to 255). The default value is 0. Setting this value lower results in a darker noise pattern, while setting it to a higher value results in a brighter pattern.
- `high` (uint): This parameter refers to the highest value to be generated for each pixel (0 to 255). The default value is 255. Setting this value lower results in a darker noise pattern, while setting it to a higher value results in a brighter pattern.
- `channelOptions` (uint): This parameter specifies to which color channel of the bitmap object the noise pattern will be applied. The number can be a combination of any of the four color channel ARGB values. The default value is 7.
- `grayScale` (Boolean): When set to `true`, this parameter applies the `randomSeed` value to the bitmap pixels, effectively washing all color out of the image. The alpha channel is not affected by this parameter. The default value is `false`.

The following example creates a bitmap image and applies a blue noise pattern to it:

```
package
{
    import flash.display.Sprite;
    import flash.display.Bitmap;
    import flash.display.BitmapData;
    import flash.display.BitmapDataChannel;

    public class BitmapNoise1 extends Sprite
    {
        public function BitmapNoise1()
        {
            var myBitmap:BitmapData = new BitmapData(250, 250,false, 0xff000000);
            myBitmap.noise(500, 0, 255, BitmapDataChannel.BLUE,false);
            var image:Bitmap = new Bitmap(myBitmap);
            addChild(image);
        }
    }
}
```

If you want to create a more organic-looking texture, use the `perlinNoise()` method. The `perlinNoise()` method produces realistic, organic textures that are ideal for smoke, clouds, water, fire, or even explosions.

Because it is generated by an algorithm, the `perlinNoise()` method uses less memory than bitmap-based textures. However, it can still have an impact on processor usage, slowing down your content and causing the screen to be redrawn more slowly than the frame rate, especially on older computers. This is mainly due to the floating-point calculations that need to occur to process the perlin noise algorithms.

The method accepts nine parameters (the first six are required):

- `baseX` (Number): Determines the x (size) value of patterns created.
- `baseY` (Number): Determines the y (size) value of the patterns created.
- `numOctaves` (uint): Number of octaves or individual noise functions to combine to create this noise. Larger numbers of octaves create images with greater detail but also require more processing time.
- `randomSeed` (int): The random seed number works exactly the same way as it does in the `noise()` function. To get a true random result, use the `Math.random()` method to pass a random number for this parameter.
- `stitch` (Boolean): If set to `true`, this method attempts to stitch (or smooth) the transition edges of the image to create seamless textures for tiling as a bitmap fill.
- `fractalNoise` (Boolean): This parameter relates to the edges of the gradients being generated by the method. If set to `true`, the method generates fractal noise that smooths the edges of the effect. If set to `false`, it generates turbulence. An image with turbulence has visible discontinuities in the gradient that can make it better approximate sharper visual effects, like flames and ocean waves.
- `channelOptions` (uint): The `channelOptions` parameter works exactly the same way as it does in the `noise()` method. It specifies to which color channel (of the bitmap) the noise pattern is applied. The number can be a combination of any of the four color channel ARGB values. The default value is 7.
- `grayScale` (Boolean): The `grayScale` parameter works exactly the same way as it does in the `noise()` method. If set to `true`, it applies the `randomSeed` value to the bitmap pixels, effectively washing all color out of the image. The default value is `false`.
- `offsets` (Array): An array of points that correspond to x and y offsets for each octave. By manipulating the offset values, you can smoothly scroll the layers of the image. Each point in the offset array affects a specific octave noise function. The default value is `null`.

The following example creates a 150 x 150 pixel BitmapData object that calls the `perlinNoise()` method to generate a green and blue cloud effect:

```
package
{
    import flash.display.Sprite;
    import flash.display.Bitmap;
    import flash.display.BitmapData;
    import flash.display.BitmapDataChannel;

    public class BitmapNoise2 extends Sprite
    {
        public function BitmapNoise2()
        {
            var myBitmapDataObject:BitmapData =
                new BitmapData(150, 150, false, 0x00FF0000);

            var seed:Number = Math.floor(Math.random() * 100);
            var channels:uint = BitmapDataChannel.GREEN | BitmapDataChannel.BLUE
            myBitmapDataObject.perlinNoise(100, 80, 6, seed, false, true, channels, false, null);

            var myBitmap:Bitmap = new Bitmap(myBitmapDataObject);
            addChild(myBitmap);
        }
    }
}
```

Scrolling bitmaps

Flash Player 9 and later, Adobe AIR 1.0 and later

Imagine you have created a street mapping application where each time the user moves the map you are required to update the view (even if the map has been moved by just a few pixels).

One way to create this functionality would be to re-render a new image containing the updated map view each time the user moves the map. Alternatively, you could create a large single image and use the `scroll()` method.

The `scroll()` method copies an on-screen bitmap and then pastes it to a new offset location—specified by (`x`, `y`) parameters. If a portion of the bitmap happens to reside off-stage, this gives the effect that the image has shifted. When combined with a timer function (or an `enterFrame` event), you can make the image appear to be animating or scrolling.

The following example takes the previous perlin noise example and generates a larger bitmap image (three-fourths of which is rendered off-stage). The `scroll()` method is then applied, along with an `enterFrame` event listener that offsets the image by one pixel in a diagonally downward direction. This method is called each time the frame is entered and as a result, the off screen portions of the image are rendered to the Stage as the image scrolls down.

```
import flash.display.Bitmap;
import flash.display.BitmapData;

var myBitmapDataObject:BitmapData = new BitmapData(1000, 1000, false, 0x00FF0000);
var seed:Number = Math.floor(Math.random() * 100);
var channels:uint = BitmapDataChannel.GREEN | BitmapDataChannel.BLUE;
myBitmapDataObject.perlinNoise(100, 80, 6, seed, false, true, channels, false, null);

var myBitmap:Bitmap = new Bitmap(myBitmapDataObject);
myBitmap.x = -750;
myBitmap.y = -750;
addChild(myBitmap);

addEventListener(Event.ENTER_FRAME, scrollBitmap);

function scrollBitmap(event:Event):void
{
    myBitmapDataObject.scroll(1, 1);
}
```

Taking advantage of mipmapping

Flash Player 9 and later, Adobe AIR 1.0 and later

MIP maps (also known as *mipmaps*), are bitmaps grouped together and associated with a texture to increase runtime rendering quality and performance. Each bitmap image in the MIP map is a version of the main bitmap image, but at a reduced level of detail from the main image.

For example, you can have a MIP map that includes at the highest quality a main image at 64 × 64 pixels. Lower quality images in the MIP map would be 32 × 32, 16 × 16, 8 × 8, 4 × 4, 2 × 2, and 1 × 1 pixels.

Texture streaming is the ability to load the lowest quality bitmap first, and then to progressively display higher quality bitmaps as the bitmaps are loaded. Because lower quality bitmaps are small, they load faster than the main image. Therefore, application users can view image in an application before the main, high quality bitmap loads.

Flash Player 9.115.0 and later versions and AIR implement this technology (the process is called *mipmapping*), by creating optimized versions of varying scale of each bitmap (starting at 50%).

Flash Player 11.3 and AIR 3.3 support texture streaming through the `streamingLevels` parameter of the `Context3D.createCubeTexture()` and `Context3D.createTexture()` methods.

Texture compression lets you store texture images in compressed format directly on the GPU, which saves GPU memory and memory bandwidth. Typically, compressed textures are compressed offline and uploaded to the GPU in compressed format. However, Flash Player 11.4 and AIR 3.4 support runtime texture compression, which is useful in certain situations, such as when rendering dynami textures from vector art. To use runtime texture compression, perform the following steps:

- Create the texture object by calling the `Context3D.createTexture()` method, passing either `flash.display3D.Context3DTextureFormat.COMPRESSED` or `flash.display3D.Context3DTextureFormat.COMPRESSED_ALPHA` in the third parameter.

- Using the `flash.display3D.textures.Texture` instance returned by `createTexture()`, call either `flash.display3D.textures.Texture.uploadFromBitmapData()` or `flash.display3D.textures.Texture.uploadFromByteArray()`. These methods upload and compress the texture in one step.

MIP maps are created for the following types of bitmaps:

- a bitmap (JPEG, GIF, or PNG files) displayed using the ActionScript 3.0 Loader class
- a bitmap in the library of a Flash Professional document
- a BitmapData object
- a bitmap displayed using the ActionScript 2.0 `loadMovie()` function

MIP maps are not applied to filtered objects or bitmap-cached movie clips. However, MIP maps are applied if you have bitmap transformations within a filtered display object, even if the bitmap is within masked content.

Mipmapping happens automatically, but you can follow a few guidelines to make sure your images take advantage of this optimization:

- For video playback, set the `smoothing` property to `true` for the Video object (see the Video class).
- For bitmaps, the `smoothing` property does not have to be set to `true`, but the quality improvements are more visible when bitmaps use smoothing.
- Use bitmap sizes that are divisible by 4 or 8 for two-dimensional images (such as 640 x 128, which can be reduced as follows: 320 x 64 > 160 x 32 > 80 x 16 > 40 x 8 > 20 x 4 > 10 x 2 > 5 x 1).

  For three-dimensional textures, use MIP maps where each image is at a resolution that is a power of 2 (meaning 2^n). For example, the main image is at a resolution of 1024 x 1024 pixels. The lower quality images in the MIP map would then be at 512 x 512, 256 x 256, 128 x 128 down to 1 x 1 pixels for a total of 11 images in the MIP map.

  Note that mipmapping does not occur for bitmap content with an odd width or height.

Bitmap example: Animated spinning moon

Flash Player 9 and later, Adobe AIR 1.0 and later

The Animated spinning moon example demonstrates techniques for working with Bitmap objects and bitmap image data (BitmapData objects). The example creates an animation of a spinning, spherical moon using a flat image of the moon's surface as the raw image data. The following techniques are demonstrated:

- Loading an external image and accessing its raw image data
- Creating animation by repeatedly copying pixels from different parts of a source image
- Creating a bitmap image by setting pixel values

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The Animated spinning moon application files can be found in the Samples/SpinningMoon folder. The application consists of the following files:

File	Description
SpinningMoon.mxml or SpinningMoon.fla	The main application file in Flex (MXML) or Flash (FLA).
com/example/programmingas3/moon/MoonSphere.as	Class that performs the functionality of loading, displaying, and animating the moon.
moonMap.png	Image file containing a photograph of the moon's surface, which is loaded and used to create the animated, spinning moon.

Loading an external image as bitmap data

Flash Player 9 and later, Adobe AIR 1.0 and later

The first main task this sample performs is loading an external image file, which is a photograph of the moon's surface. The loading operation is handled by two methods in the MoonSphere class: the `MoonSphere()` constructor, where the loading process is initiated, and the `imageLoadComplete()` method, which is called when the external image is completely loaded.

Loading an external image is similar to loading an external SWF; both use an instance of the flash.display.Loader class to perform the loading operation. The actual code in the `MoonSphere()` method that starts loading the image is as follows:

```
var imageLoader:Loader = new Loader();
imageLoader.contentLoaderInfo.addEventListener(Event.COMPLETE, imageLoadComplete);
imageLoader.load(new URLRequest("moonMap.png"));
```

The first line declares the Loader instance named `imageLoader`. The third line actually starts the loading process by calling the Loader object's `load()` method, passing a URLRequest instance representing the URL of the image to load. The second line sets up the event listener that will be triggered when the image has completely loaded. Notice that the `addEventListener()` method is not called on the Loader instance itself; instead, it's called on the Loader object's `contentLoaderInfo` property. The Loader instance itself doesn't dispatch events relating to the content being loaded. Its `contentLoaderInfo` property, however, contains a reference to the LoaderInfo object that's associated with the content being loaded into the Loader object (the external image in this case). That LoaderInfo object does provide several events relating to the progress and completion of loading the external content, including the `complete` event (`Event.COMPLETE`) that will trigger a call to the `imageLoadComplete()` method when the image has completely loaded.

While starting the external image loading is an important part of the process, it's equally important to know what to do when it finishes loading. As shown in the code above, the `imageLoadComplete()` function is called when the image is loaded. That function does several things with the loaded image data, described subsequently. However, to use the image data, it needs to access that data. When a Loader object is used to load an external image, the loaded image becomes a Bitmap instance, which is attached as a child display object of the Loader object. In this case, the Loader instance is available to the event listener method as part of the event object that's passed to the method as a parameter. The first lines of the `imageLoadComplete()` method are as follows:

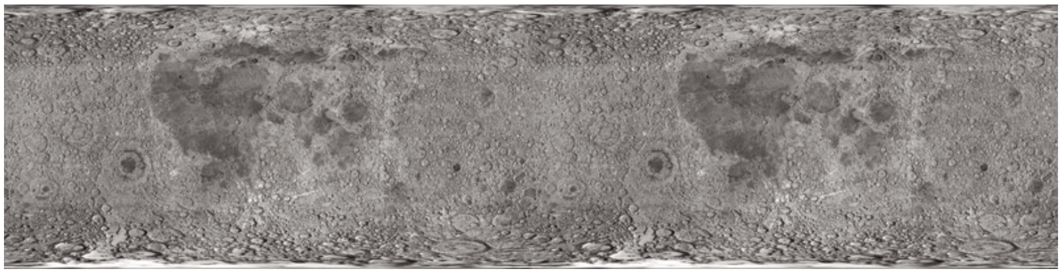
```
private function imageLoadComplete(event:Event):void
{
    textureMap = event.target.content.bitmapData;
    ...
}
```

Notice that the event object parameter is named `event`, and it's an instance of the Event class. Every instance of the Event class has a `target` property, which refers to the object triggering the event (in this case, the LoaderInfo instance on which the `addEventListener()` method was called, as described previously). The LoaderInfo object, in turn, has a `content` property that (once the loading process is complete) contains the Bitmap instance with the loaded bitmap image. If you want to display the image directly on the screen, you can attach this Bitmap instance (`event.target.content`) to a display object container. (You could also attach the Loader object to a display object container). However, in this sample, the loaded content is used as a source of raw image data rather than being displayed on the screen. Consequently, the first line of the `imageLoadComplete()` method reads the `bitmapData` property of the loaded Bitmap instance (`event.target.content.bitmapData`) and stores it in the instance variable named `textureMap`, which is used as a source of the image data to create the animation of the rotating moon. This is described next.

Creating animation by copying pixels

Flash Player 9 and later, Adobe AIR 1.0 and later

A basic definition of animation is the illusion of motion, or change, created by changing an image over time. In this sample, the goal is to create the illusion of a spherical moon rotating around its vertical axis. However, for the purposes of the animation, you can ignore the spherical distortion aspect of the sample. Consider the actual image that's loaded and used as the source of the moon image data:



As you can see, the image is not one or several spheres; it's a rectangular photograph of the surface of the moon. Because the photo was taken exactly at the moon's equator, the parts of the image that are closer to the top and bottom of the image are stretched and distorted. To remove the distortion from the image and make it appear spherical, we will use a displacement map filter, as described later. However, because this source image is a rectangle, to create the illusion that the sphere is rotating, the code simply needs to slide the moon surface photo horizontally.

Notice that the image actually contains two copies of the moon surface photograph next to each other. This image is the source image from which image data is copied repeatedly to create the appearance of motion. By having two copies of the image next to each other, a continuous, uninterrupted scrolling effect can more easily be created. Let's walk through the process of the animation step-by-step to see how this works.

The process actually involves two separate ActionScript objects. First, there is the loaded source image, which in the code is represented by the BitmapData instance named `textureMap`. As described previously, `textureMap` is populated with image data as soon as the external image loads, using this code:

```
textureMap = event.target.content.bitmapData;
```

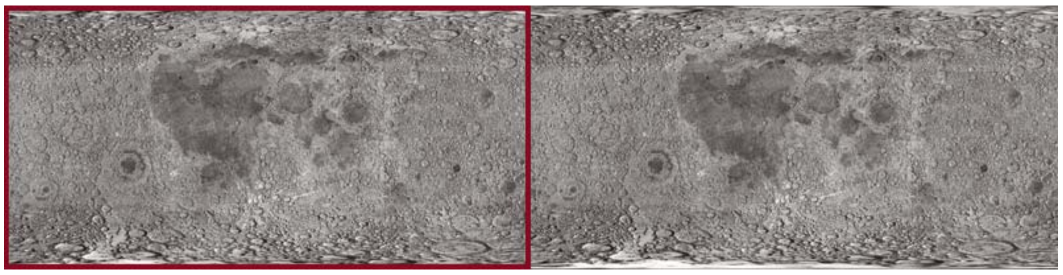
The content of `textureMap` is the rectangle moon image. In addition, to create the animated rotation, the code uses a Bitmap instance named `sphere`, which is the actual display object that shows the moon image onscreen. Like `textureMap`, the `sphere` object is created and populated with its initial image data in the `imageLoadComplete()` method, using the following code:

```
sphere = new Bitmap();
sphere.bitmapData = new BitmapData(textureMap.width / 2, textureMap.height);
sphere.bitmapData.copyPixels(textureMap,
                             new Rectangle(0, 0, sphere.width, sphere.height),
                             new Point(0, 0));
```

As the code shows, `sphere` is instantiated. Its `bitmapData` property (the raw image data that is displayed by `sphere`) is created with the same height and half the width of `textureMap`. In other words, the content of `sphere` will be the size of one moon photo (since the `textureMap` image contains two moon photos side-by-side). Next the `bitmapData` property is filled with image data using its `copyPixels()` method. The parameters in the `copyPixels()` method call indicate several things:

- The first parameter indicates that the image data is copied from `textureMap`.
- The second parameter, a new Rectangle instance, specifies from which part of `textureMap` the image snapshot should be taken; in this case the snapshot is a rectangle starting from the top left corner of `textureMap` (indicated by the first two `Rectangle()` parameters: `0, 0`) and the rectangle snapshot's width and height match the `width` and `height` properties of `sphere`.
- The third parameter, a new Point instance with x and y values of `0`, defines the destination of the pixel data—in this case, the top-left corner (0, 0) of `sphere.bitmapData`.

Represented visually, the code copies the pixels from `textureMap` outlined in the following image and pastes them onto `sphere`. In other words, the BitmapData content of `sphere` is the portion of `textureMap` highlighted here:



Remember, however, that this is just the initial state of `sphere`—the first image content that's copied onto `sphere`.

With the source image loaded and `sphere` created, the final task performed by the `imageLoadComplete()` method is to set up the animation. The animation is driven by a Timer instance named `rotationTimer`, which is created and started by the following code:

```
var rotationTimer:Timer = new Timer(15);
rotationTimer.addEventListener(TimerEvent.TIMER, rotateMoon);
rotationTimer.start();
```

The code first creates the Timer instance named `rotationTimer`; the parameter passed to the `Timer()` constructor indicates that `rotationTimer` should trigger its `timer` event every 15 milliseconds. Next, the `addEventListener()` method is called, specifying that when the `timer` event (`TimerEvent.TIMER`) occurs, the method `rotateMoon()` is called. Finally, the timer is actually started by calling its `start()` method.

Because of the way `rotationTimer` is defined, approximately every 15 milliseconds Flash Player calls the `rotateMoon()` method in the MoonSphere class, which is where the animation of the moon happens. The source code of the `rotateMoon()` method is as follows:

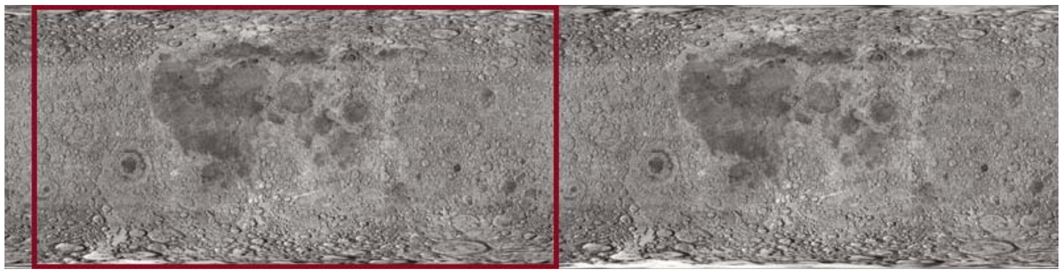
```
private function rotateMoon(event:TimerEvent):void
{
    sourceX += 1;
    if (sourceX > textureMap.width / 2)
    {
        sourceX = 0;
    }

    sphere.Data.copyPixels(textureMap,
                                new Rectangle(sourceX, 0, sphere.width, sphere.height),
                                new Point(0, 0));

    event.updateAfterEvent();
}
```

The code does three things:

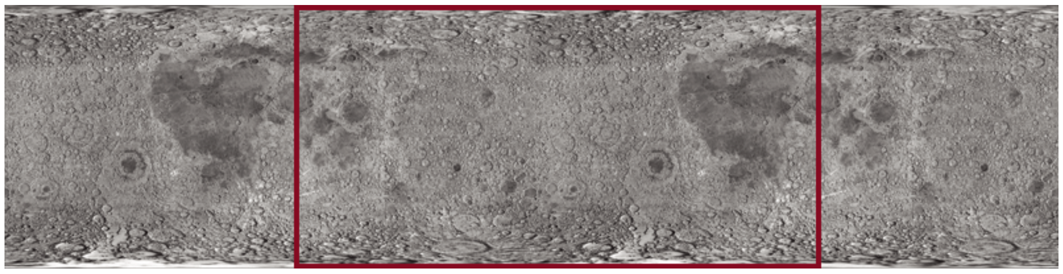
1 The value of the variable `sourceX` (initially set to 0) increments by 1.

```
sourceX += 1;
```

As you'll see, `sourceX` is used to determine the location in `textureMap` from which the pixels will be copied onto `sphere`, so this code has the effect of moving the rectangle one pixel to the right on `textureMap`. Going back to the visual representation, after several cycles of animation the source rectangle will have moved several pixels to the right, like this:

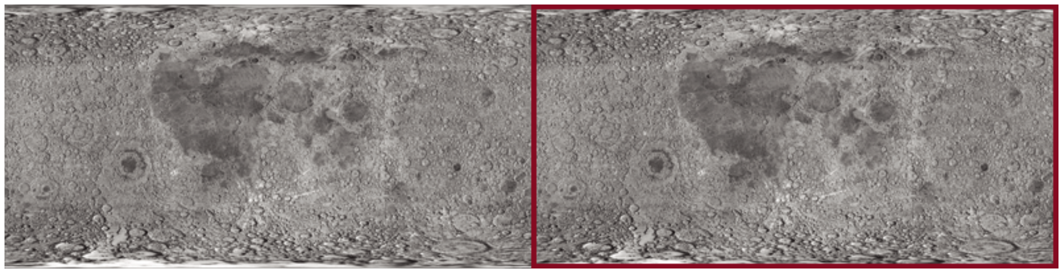


After several more cycles, the rectangle will have moved even farther:



This gradual, steady shift in the location from which the pixels are copied is the key to the animation. By slowly and continuously moving the source location to the right, the image that is displayed on the screen in `sphere` appears to continuously slide to the left. This is the reason why the source image (`textureMap`) needs to have two copies of the moon surface photo. Because the rectangle is continually moving to the right, most of the time it is not over one single moon photo but rather overlaps the two moon photos.

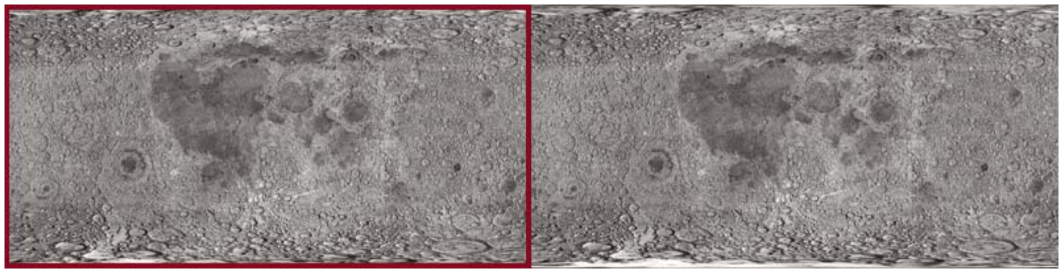
2 With the source rectangle slowly moving to the right, there is one problem. Eventually the rectangle will reach the right edge of `textureMap` and it will run out of moon photo pixels to copy onto `sphere`:



The next lines of code address this issue:

```
if (sourceX >= textureMap.width / 2)
{
    sourceX = 0;
}
```

The code checks if `sourceX` (the left edge of the rectangle) has reached the middle of `textureMap`. If so, it resets `sourceX` back to 0, moving it back to the left edge of `textureMap` and starting the cycle over again:



3 With the appropriate `sourceX` value calculated, the final step in creating the animation is to actually copy the new source rectangle pixels onto `sphere`. The code that does this is very similar to the code that initially populated `sphere` (described previously); the only difference is that in this case, in the `new Rectangle()` constructor call, the left edge of the rectangle is placed at `sourceX`:

```
sphere.bitmapData.copyPixels(textureMap,
                            new Rectangle(sourceX, 0, sphere.width, sphere.height),
                            new Point(0, 0));
```

Remember that this code is called repeatedly, every 15 milliseconds. As the source rectangle's location is continuously shifted, and the pixels are copied onto `sphere`, the appearance on the screen is that the moon photo image represented by `sphere` continuously slides. In other words, the moon appears to rotate continuously.

Creating the spherical appearance

Flash Player 9 and later, Adobe AIR 1.0 and later

The moon, of course, is a sphere and not a rectangle. Consequently, the sample needs to take the rectangular moon surface photo, as it continuously animates, and convert it into a sphere. This involves two separate steps: a mask is used to hide all the content except for a circular region of the moon surface photo, and a displacement map filter is used to distort the appearance of the moon photo to make it look three-dimensional.

First, a circle-shaped mask is used to hide all the content of the MoonSphere object except for the sphere created by the filter. The following code creates the mask as a Shape instance and applies it as the mask of the MoonSphere instance:

```
moonMask = new Shape();
moonMask.graphics.beginFill(0);
moonMask.graphics.drawCircle(0, 0, radius);
this.addChild(moonMask);
this.mask = moonMask;
```

Note that since MoonSphere is a display object (it is based on the Sprite class), the mask can be applied directly to the MoonSphere instance using its inherited `mask` property.

Simply hiding parts of the photo using a circle-shaped mask isn't enough to create a realistic-looking rotating-sphere effect. Because of the way the photo of the moon's surface was taken, its dimensions aren't proportional; the portions of the image that are more toward the top or bottom of the image are more distorted and stretched compared to the portions in the equator. To distort the appearance of the moon photo to make it look three-dimensional, we'll use a displacement map filter.

A displacement map filter is a type of filter that is used to distort an image. In this case, the moon photo will be "distorted" to make it look more realistic, by squeezing the top and bottom of the image horizontally, while leaving the middle unchanged. Assuming the filter operates on a square-shaped portion of the photo, squeezing the top and bottom but not the middle will turn the square into a circle. A side effect of animating this distorted image is that the middle of the image seems to move farther in actual pixel distance than the areas close to the top and bottom, which creates the illusion that the circle is actually a three-dimensional object (a sphere).

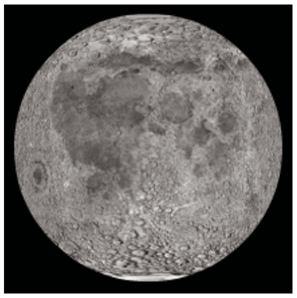
The following code is used to create the displacement map filter, named `displaceFilter`:

```
var displaceFilter:DisplacementMapFilter;
displaceFilter = new DisplacementMapFilter(fisheyeLens,
                                new Point(radius, 0),
                                BitmapDataChannel.RED,
                                BitmapDataChannel.GREEN,
                                radius, 0);
```

The first parameter, `fisheyeLens`, is known as the map image; in this case it is a BitmapData object that is created programmatically. The creation of that image is described in "Creating a bitmap image by setting pixel values" on page 261. The other parameters describe the position in the filtered image at which the filter should be applied, which color channels will be used to control the displacement effect, and to what extent they will affect the displacement. Once the displacement map filter is created, it is applied to `sphere`, still within the `imageLoadComplete()` method:

```
sphere.filters = [displaceFilter];
```

The final image, with mask and displacement map filter applied, looks like this:



With every cycle of the rotating moon animation, the BitmapData content of sphere is overwritten by a new snapshot of the source image data. However, the filter does not need to be re-applied each time. This is because the filter is applied to the Bitmap instance (the display object) rather than to the bitmap data (the raw pixel information). Remember, the Bitmap instance is not the actual bitmap data; it is a display object that displays the bitmap data on the screen. To use an analogy, a Bitmap instance is like the slide projector that is used to display photographic slides on a screen, and a BitmapData object is like the actual photographic slide that can be presented through a slide projector. A filter can be applied directly to a BitmapData object, which would be comparable to drawing directly onto a photographic slide to alter the image. A filter can also be applied to any display object, including a Bitmap instance; this would be like placing a filter in front of the slide projector's lens to distort the output shown on the screen (without altering the original slide at all). Because the raw bitmap data is accessible through a Bitmap instance's bitmapData property, the filter could have been applied directly to the raw bitmap data. However, in this case, it makes sense to apply the filter to the Bitmap display object rather than to the bitmap data.

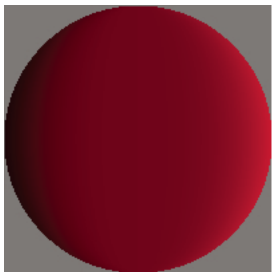
For detailed information about using the displacement map filter in ActionScript, see "Filtering display objects" on page 267.

Creating a bitmap image by setting pixel values

Flash Player 9 and later, Adobe AIR 1.0 and later

One important aspect of a displacement map filter is that it actually involves two images. One image, the source image, is the image that is actually altered by the filter. In this sample, the source image is the Bitmap instance named `sphere`. The other image used by the filter is known as the map image. The map image is not actually displayed on the screen. Instead, the color of each of its pixels is used as an input to the displacement function—the color of the pixel at a certain x, y coordinate in the map image determines how much displacement (physical shift in position) is applied to the pixel at that x, y coordinate in the source image.

Consequently, to use the displacement map filter to create a sphere effect, the sample needs the appropriate map image—one that has a gray background and a circle that's filled with a gradient of a single color (red) going horizontally from dark to light, as shown here:



Because only one map image and filter are used in this sample, the map image is only created once, in the `imageLoadComplete()` method (in other words, when the external image finishes loading). The map image, named `fisheyeLens`, is created by calling the MoonSphere class's `createFisheyeMap()` method:

```
var fisheyeLens:BitmapData = createFisheyeMap(radius);
```

Inside the `createFisheyeMap()` method, the map image is actually drawn one pixel at a time using the BitmapData class's `setPixel()` method. The complete code for the `createFisheyeMap()` method is listed here, followed by a step-by-step discussion of how it works:

```
private function createFisheyeMap(radius:int):BitmapData
{
    var diameter:int = 2 * radius;

    var result:BitmapData = new BitmapData(diameter,
                                    diameter,
                                    false,
                                    0x808080);

    // Loop through the pixels in the image one by one
    for (var i:int = 0; i < diameter; i++)
    {
        for (var j:int = 0; j < diameter; j++)
        {
            // Calculate the x and y distances of this pixel from
            // the center of the circle (as a percentage of the radius).
            var pctX:Number = (i - radius) / radius;
            var pctY:Number = (j - radius) / radius;

            // Calculate the linear distance of this pixel from
            // the center of the circle (as a percentage of the radius).
            var pctDistance:Number = Math.sqrt(pctX * pctX + pctY * pctY);

            // If the current pixel is inside the circle,
            // set its color.
            if (pctDistance < 1)
            {
                // Calculate the appropriate color depending on the
                // distance of this pixel from the center of the circle.
                var red:int;
                var green:int;
                var blue:int;
                var rgb:uint;
                red = 128 * (1 + 0.75 * pctX * pctX * pctX / (1 - pctY * pctY));
                green = 0;
                blue = 0;
                rgb = (red << 16 | green << 8 | blue);
                // Set the pixel to the calculated color.
                result.setPixel(i, j, rgb);
            }
        }
    }
    return result;
}
```

First, when the method is called it receives a parameter, `radius`, indicating the radius of the circle-shaped image to create. Next, the code creates the BitmapData object on which the circle will be drawn. That object, named `result`, is eventually passed back as the return value of the method. As shown in the following code snippet, the `result` BitmapData instance is created with a width and height as big as the diameter of the circle, without transparency (`false` for the third parameter), and pre-filled with the color `0x808080` (middle gray):

```
var result:BitmapData = new BitmapData(diameter,
                                    diameter,
                                    false,
                                    0x808080);
```

Next, the code uses two loops to iterate over each pixel of the image. The outer loop goes through each column of the image from left to right (using the variable `i` to represent the horizontal position of the pixel currently being manipulated), while the inner loop goes through each pixel of the current column from top to bottom (with the variable `j` representing the vertical position of the current pixel). The code for the loops (with the inner loop's contents omitted) is shown here:

```
for (var i:int = 0; i < diameter; i++)
{
    for (var j:int = 0; j < diameter; j++)
    {
        ...
    }
}
```

As the loops cycle through the pixels one by one, at each pixel a value (the color value of that pixel in the map image) is calculated. This process involves four steps:

1 The code calculates the distance of the current pixel from the center of the circle along the x axis (`i - radius`). That value is divided by the radius to make it a percentage of the radius rather than an absolute distance (`(i - radius) / radius`). That percentage value is stored in a variable named `pctX`, and the equivalent value for the y axis is calculated and stored in the variable `pctY`, as shown in this code:

```
var pctX:Number = (i - radius) / radius;
var pctY:Number = (j - radius) / radius;
```

2 Using a standard trigonometric formula, the Pythagorean theorem, the linear distance between the center of the circle and the current point is calculated from `pctX` and `pctY`. That value is stored in a variable named `pctDistance`, as shown here:

```
var pctDistance:Number = Math.sqrt(pctX * pctX + pctY * pctY);
```

3 Next, the code checks whether the distance percentage is less than 1 (meaning 100% of the radius, or in other words, if the pixel being considered is within the radius of the circle). If the pixel falls inside the circle, it is assigned a calculated color value (omitted here, but described in step 4); if not, nothing further happens with that pixel so its color is left as the default middle gray:

```
if (pctDistance < 1)
{
    ...
}
```

4 For those pixels that fall inside the circle, a color value is calculated for the pixel. The final color will be a shade of red ranging from black (0% red) at the left edge of the circle to bright (100%) red at the right edge of the circle. The color value is initially calculated in three parts (red, green, and blue), as shown here:

```
red = 128 * (1 + 0.75 * pctX * pctX * pctX / (1 - pctY * pctY));
green = 0;
blue = 0;
```

Notice that only the red portion of the color (the variable `red`) actually has a value. The green and blue values (the variables `green` and `blue`) are shown here for clarity, but could be omitted. Since the purpose of this method is to create a circle that contains a red gradient, no green or blue values are needed.

Once the three individual color values are determined, they are combined into a single integer color value using a standard bit-shifting algorithm, shown in this code:

```
rgb = (red << 16 | green << 8 | blue);
```

Finally, with the color value calculated, that value is actually assigned to the current pixel using the `setPixel()` method of the `result` BitmapData object, shown here:

```
result.setPixel(i, j, rgb);
```

Asynchronous decoding of bitmap images

Flash Player 11 and later, Adobe AIR 2.6 and later

When you work with bitmap images, you can asynchronously decode and load the bitmap images to improve your application's perceived performance. Decoding a bitmap image asynchronously can take the same time as decoding the image synchronously in many cases. However, the bitmap image gets decoded in a separate thread before the associated `Loader` object sends the `COMPLETE` event. Hence, you can asynchronously decode larger images after loading them.

The `ImageDecodingPolicy` class in the `flash.system` package, allows you to specify the bitmap loading scheme. The default loading scheme is synchronous.

Bitmap Decoding Policy	Bitmap Loading Scheme	Description
`ImageDecodingPolicy.ON_DEMAND`	Synchronous	Loaded images are decoded when the image data is accessed. Use this policy to decode smaller images. You can also use this policy when your application does not rely on complex effects and transitions.
`ImageDecodingPolicy.ON_LOAD`	Asynchronous	Loaded images are decoded on load, before the `COMPLETE` event is dispatched. Ideal for larger images (greater than 10 MP). When you are developing AIR-based mobile applications with page transitions, use this bitmap loading policy to improve your application's perceived performance.

***Note:** If the file being loaded is a bitmap image and the decoding policy used is `ON_LOAD`, the image is decoded asynchronously before the `COMPLETE` event is dispatched.*

The following code shows the usage of the `ImageDecodingPolicy` class:

```
var loaderContext:LoaderContext = new LoaderContext();
loaderContext.imageDecodingPolicy = ImageDecodingPolicy.ON_LOAD
var loader:Loader = new Loader();
loader.load(new URLRequest("http://www.adobe.com/myimage.png"), loaderContext);
```

You can still use `ON_DEMAND` decoding with `Loader.load()` and `Loader.loadBytes()` methods. However, all the other methods that take a `LoaderContext` object as an argument, ignore any `ImageDecodingPolicy` value passed.

The following example shows the difference in decoding a bitmap image synchronously and asynchronously:

```
package
{
    import flash.display.Loader;
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.net.URLRequest;
    import flash.system.ImageDecodingPolicy;
    import flash.system.LoaderContext;

    public class AsyncTest extends Sprite
    {
        private var loaderContext:LoaderContext;
        private var loader:Loader;
        private var urlRequest:URLRequest;
        public function AsyncTest()
        {
            //Load the image synchronously
            loaderContext = new LoaderContext();
            //Default behavior.
            loaderContext.imageDecodingPolicy = ImageDecodingPolicy.ON_DEMAND;
            loader = new Loader();
            loadImageSync();

            //Load the image asynchronously
            loaderContext = new LoaderContext();
            loaderContext.imageDecodingPolicy = ImageDecodingPolicy.ON_LOAD;
            loader = new Loader();
            loadImageASync();
        }

        private function loadImageASync():void{
            trace("Loading image asynchronously...");
            urlRequest = new URLRequest("http://www.adobe.com/myimage.png");
            urlRequest.useCache = false;
            loader.load(urlRequest, loaderContext);
            loader.contentLoaderInfo.addEventListener
                (Event.COMPLETE, onAsyncLoadComplete);
        }

        private function onAsyncLoadComplete(event:Event):void{
            trace("Async. Image Load Complete");
        }

        private function loadImageSync():void{
            trace("Loading image synchronously...");
            urlRequest = new URLRequest("http://www.adobe.com/myimage.png");
            urlRequest.useCache = false;
            loader.load(urlRequest, loaderContext);
            loader.contentLoaderInfo.addEventListener
                (Event.COMPLETE, onSyncLoadComplete);
        }

        private function onSyncLoadComplete(event:Event):void{
            trace("Sync. Image Load Complete");
        }
    }
}
```

For a demonstration of the effect of the different decoding policies, see Thibaud Imbert: Asynchronous bitmap decoding in the Adobe Flash runtimes

Chapter 14: Filtering display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Historically, the application of filter effects to bitmap images has been the domain of specialized image-editing software such as Adobe Photoshop® and Adobe Fireworks®. ActionScript 3.0 includes the flash.filters package, which contains a series of bitmap effect filter classes. These effects allow developers to programmatically apply filters to bitmaps and display objects and achieve many of the same effects that are available in graphics manipulation applications.

Basics of filtering display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

One of the ways to add polish to an application is to add simple graphic effects. You can add a drop shadow behind a photo to create the illusion of 3-d, or a glow around a button to show that it is active. ActionScript 3.0 includes ten filters that you can apply to any display object or to a BitmapData instance. The built-in filters range from basic, such as the drop shadow and glow filters, to complex, such as the displacement map filter and the convolution filter.

Note: *In addition to the built-in filters, you can also program custom filters and effects using Pixel Bender. See "Working with Pixel Bender shaders" on page 300.*

Important concepts and terms

The following reference list contains important terms that you might encounter when creating filters:

Bevel An edge created by lightening pixels on two sides and darkening pixels on the opposite two sides. This effect creates the appearance of a three-dimensional border. The effect is commonly used for raised or indented buttons and similar graphics.

Convolution Distorting pixels in an image by combining each pixel's value with the values of some or all of its neighboring pixels, using various ratios.

Displacement Shifting or moving pixels in an image to a new position.

Matrix A grid of numbers used to perform certain mathematical calculations by applying the numbers in the grid to various values, then combining the results.

More Help topics

flash.filters package

flash.display.DisplayObject.filters

flash.display.BitmapData.applyFilter()

Creating and applying filters

Flash Player 9 and later, Adobe AIR 1.0 and later

Filters allow you to apply a range of effects to bitmap and display objects, ranging from drop shadows to bevels and blurs. Each filter is defined as a class, so applying filters involves creating instances of filter objects, which is no different from constructing any other object. Once you've created an instance of a filter object, it can easily be applied to a display object by using the object's `filters` property, or in the case of a BitmapData object, by using the `applyFilter()` method.

Creating a filter

Flash Player 9 and later, Adobe AIR 1.0 and later

To create a filter object, simply call the constructor method of your selected filter class. For example, to create a DropShadowFilter object, use the following code:

```
import flash.filters.DropShadowFilter;
var myFilter:DropShadowFilter = new DropShadowFilter();
```

Although not shown here, the `DropShadowFilter()` constructor (like all the filter classes' constructors) accepts several optional parameters that can be used to customize the appearance of the filter effect.

Applying a filter

Flash Player 9 and later, Adobe AIR 1.0 and later

Once you've constructed a filter object, you can apply it to a display object or a BitmapData object; how you apply the filter depends on the object to which you're applying it.

Applying a filter to a display object

When you apply filter effects to a display object, you apply them through the `filters` property. The `filters` property of a display object is an Array instance, whose elements are the filter objects applied to the display object. To apply a single filter to a display object, create the filter instance, add it to an Array instance, and assign that Array object to the display object's `filters` property:

```
import flash.display.Bitmap;
import flash.display.BitmapData;
import flash.filters.DropShadowFilter;

// Create a bitmapData object and render it to screen
var myBitmapData:BitmapData = new BitmapData(100,100,false,0xFFFF3300);
var myDisplayObject:Bitmap = new Bitmap(myBitmapData);
addChild(myDisplayObject);

// Create a DropShadowFilter instance.
var dropShadow:DropShadowFilter = new DropShadowFilter();

// Create the filters array, adding the filter to the array by passing it as
// a parameter to the Array() constructor.
var filtersArray:Array = new Array(dropShadow);

// Assign the filters array to the display object to apply the filter.
myDisplayObject.filters = filtersArray;
```

If you want to assign multiple filters to the object, simply add all the filters to the Array instance before assigning it to the `filters` property. You can add multiple objects to an Array by passing them as parameters to its constructor. For example, this code applies a bevel filter and a glow filter to the previously created display object:

```
import flash.filters.BevelFilter;
import flash.filters.GlowFilter;

// Create the filters and add them to an array.
var bevel:BevelFilter = new BevelFilter();
var glow:GlowFilter = new GlowFilter();
var filtersArray:Array = new Array(bevel, glow);

// Assign the filters array to the display object to apply the filter.
myDisplayObject.filters = filtersArray;
```

When you're creating the array containing the filters, you can create it using the `new Array()` constructor (as shown in the previous examples) or you can use Array literal syntax, wrapping the filters in square brackets (`[]`). For instance, this line of code:

```
var filters:Array = new Array(dropShadow, blur);
```

does the same thing as this line of code:

```
var filters:Array = [dropShadow, blur];
```

If you apply multiple filters to display objects, they are applied in a cumulative, sequential manner. For example, if a filters array has two elements, a bevel filter added first and a drop shadow filter added second, the drop shadow filter is applied to both the bevel filter and the display object. This is because of the drop shadow filter's second position in the filters array. If you want to apply filters in a noncumulative manner, apply each filter to a new copy of the display object.

If you're only assigning one or a few filters to a display object, you can create the filter instance and assign it to the object in a single statement. For example, the following line of code applies a blur filter to a display object called `myDisplayObject`:

```
myDisplayObject.filters = [new BlurFilter()];
```

The previous code creates an Array instance using Array literal syntax (square braces), creates a BlurFilter instance as an element in the Array, and assigns that Array to the `filters` property of the display object named `myDisplayObject`.

Removing filters from a display object

Removing all filters from a display object is as simple as assigning a null value to the `filters` property:

```
myDisplayObject.filters = null;
```

If you've applied multiple filters to an object and want to remove only one of the filters, you must go through several steps to change the `filters` property array. For more information, see "Potential issues for working with filters" on page 270.

Applying a filter to a BitmapData object

Applying a filter to a BitmapData object requires the use of the BitmapData object's `applyFilter()` method:

```
var rect:Rectangle = new Rectangle();
var origin:Point = new Point();
myBitmapData.applyFilter(sourceBitmapData, rect, origin, new BlurFilter());
```

The `applyFilter()` method applies a filter to a source BitmapData object, producing a new, filtered image. This method does not modify the original source image; instead, the result of the filter being applied to the source image is stored in the BitmapData instance on which the `applyFilter()` method is called.

How filters work

Flash Player 9 and later, Adobe AIR 1.0 and later

Display object filtering works by caching a copy of the original object as a transparent bitmap.

Once a filter has been applied to a display object, the runtime caches the object as a bitmap for as long as the object has a valid filter list. This source bitmap is then used as the original image for all subsequently applied filter effects.

Each display object usually contains two bitmaps: one with the original unfiltered source display object and another for the final image after filtering. The final image is used when rendering. As long as the display object does not change, the final image does not need updating.

Potential issues for working with filters

Flash Player 9 and later, Adobe AIR 1.0 and later

There are several potential sources of confusion or trouble to keep in mind when you're working with filters.

Filters and bitmap caching

To apply a filter to a display object, bitmap caching must be enabled for that object. When you apply a filter to a display object whose `cacheAsBitmap` property is set to `false`, the object's `cacheAsBitmap` property is automatically set to `true`. If you later remove all the filters from the display object, the `cacheAsBitmap` property is reset to the last value it was set to.

Changing filters at run time

If a display object already has one or more filters applied to it, you can't change the set of filters by adding additional filters to or removing filters from the `filters` property array. Instead, to add to or change the set of filters being applied, you must make your changes to a separate array, then assign that array to the filters property of the display object for the filters to be applied to the object. The simplest way to do this is to read the `filters` property array into an Array variable and make your modifications to this temporary array. You then reassign this array back to the `filters` property of the display object. In more complex cases, you might need to keep a separate master array of filters. You make any changes to that master filter array, and reassign the master array to the display object's `filters` property after each change.

Adding an additional filter

The following code demonstrates the process of adding an additional filter to a display object that already has one or more filters applied to it. Initially, a glow filter is applied to the display object named `myDisplayObject`; later, when the display object is clicked, the `addFilters()` function is called. In this function, two additional filters are applied to `myDisplayObject`:

```
import flash.events.MouseEvent;
import flash.filters.*;

myDisplayObject.filters = [new GlowFilter()];

function addFilters(event:MouseEvent):void
{
    // Make a copy of the filters array.
    var filtersCopy:Array = myDisplayObject.filters;

    // Make desired changes to the filters (in this case, adding filters).
    filtersCopy.push(new BlurFilter());
    filtersCopy.push(new DropShadowFilter());

    // Apply the changes by reassigning the array to the filters property.
    myDisplayObject.filters = filtersCopy;
}

myDisplayObject.addEventListener(MouseEvent.CLICK, addFilters);
```

Removing one filter from a set of filters

If a display object has multiple filters applied to it, and you want to remove one of the filters while the other filters continue to be applied to the object, you copy the filters into a temporary array, remove the unwanted filter from that array, and reassign the temporary array to the display object's `filters` property. Several ways to remove one or more elements from any array are described in "Retrieving values and removing array elements" on page 31.

The most straightforward situation is to remove the top-most filter on the object (the last filter applied to the object). You use the Array class's `pop()` method to remove the filter from the array:

```
// Example of removing the top-most filter from a display object
// named "filteredObject".

var tempFilters:Array = filteredObject.filters;

// Remove the last element from the Array (the top-most filter).
tempFilters.pop();

// Apply the new set of filters to the display object.
filteredObject.filters = tempFilters;
```

Similarly, to remove the bottom-most filter (the first one applied to the object) you use the same code, substituting the Array class's `shift()` method in place of the `pop()` method.

To remove a filter from the middle of an array of filters (assuming that the array has more than two filters) you can use the `splice()` method. You must know the index (the position in the array) of the filter you want to remove. For example, the following code removes the second filter (the filter at index 1) from a display object:

```
// Example of removing a filter from the middle of a stack of filters
// applied to a display object named "filteredObject".

var tempFilters:Array = filteredObject.filters;

// Remove the second filter from the array. It's the item at index 1
// because Array indexes start from 0.
// The first "1" indicates the index of the filter to remove; the
// second "1" indicates how many elements to remove.
tempFilters.splice(1, 1);

// Apply the new set of filters to the display object.
filteredObject.filters = tempFilters;
```

Determining a filter's index

You need to know which filter to remove from the array, so that you know the index of the filter. You must either know (by virtue of the way the application is designed), or calculate the index of the filter to remove.

The best approach is to design your application so that the filter you want to remove is always in the same position in the set of filters. For example, if you have a single display object with a convolution filter and a drop-shadow filter applied to it (in that order), and you want to remove the drop-shadow filter but keep the convolution filter, the filter is in a known position (the top-most filter) so that you can know ahead of time which Array method to use (in this case `Array.pop()` to remove the drop-shadow filter).

If the filter you want to remove is always a certain type, but not necessarily always in the same position in the set of filters, you can check the data type of each filter in the array to determine which one to remove. For example, the following code determines which of a set of filters is a glow filter, and removes that filter from the set.

```
// Example of removing a glow filter from a set of filters, where the
//filter you want to remove is the only GlowFilter instance applied
// to the filtered object.

var tempFilters:Array = filteredObject.filters;

// Loop through the filters to find the index of the GlowFilter instance.
var glowIndex:int;
var numFilters:int = tempFilters.length;
for (var i:int = 0; i < numFilters; i++)
{
    if (tempFilters[i] is GlowFilter)
    {
        glowIndex = i;
        break;
    }
}

// Remove the glow filter from the array.
tempFilters.splice(glowIndex, 1);

// Apply the new set of filters to the display object.
filteredObject.filters = tempFilters;
```

In a more complex case, such as if the filter to remove is selected at runtime, the best approach is to keep a separate, persistent copy of the filter array that serves as the master list of filters. Any time you make a change to the set of filters, change the master list then apply that filter array as the `filters` property of the display object.

For example, in the following code listing, multiple convolution filters are applied to a display object to create different visual effects, and at a later point in the application one of those filters is removed while the others are retained. In this case, the code keeps a master copy of the filters array, as well as a reference to the filter to remove. Finding and removing the specific filter is similar to the preceding approach, except that instead of making a temporary copy of the filters array, the master copy is manipulated and then applied to the display object.

```
// Example of removing a filter from a set of
// filters, where there may be more than one
// of that type of filter applied to the filtered
// object, and you only want to remove one.

// A master list of filters is stored in a separate,
// persistent Array variable.
var masterFilterList:Array;

// At some point, you store a reference to the filter you
// want to remove.
var filterToRemove:ConvolutionFilter;

// ... assume the filters have been added to masterFilterList,
// which is then assigned as the filteredObject.filters:
filteredObject.filters = masterFilterList;

// ... later, when it's time to remove the filter, this code gets called:

// Loop through the filters to find the index of masterFilterList.
var removeIndex:int = -1;
var numFilters:int = masterFilterList.length;
for (var i:int = 0; i < numFilters; i++)
{
    if (masterFilterList[i] == filterToRemove)
    {
        removeIndex = i;
        break;
    }
}

if (removeIndex >= 0)
{
    // Remove the filter from the array.
    masterFilterList.splice(removeIndex, 1);

    // Apply the new set of filters to the display object.
    filteredObject.filters = masterFilterList;
}
```

In this approach (when you're comparing a stored filter reference to the items in the filters array to determine which filter to remove), you *must* keep a separate copy of the filters array—the code does not work if you compare the stored filter reference to the elements in a temporary array copied from the display object's `filters` property. This is because internally, when you assign an array to the `filters` property, the runtime makes a copy of each filter object in the array. Those copies (rather than the original objects) are applied to the display object, and when you read the `filters` property into a temporary array, the temporary array contains references to the copied filter objects rather than references to the original filter objects. Consequently, if in the preceding example you try to determine the index of `filterToRemove` by comparing it to the filters in a temporary filters array, no match is found.

Filters and object transformations

No filtered region—a drop shadow, for example—outside of a display object's bounding box rectangle is considered to be part of the surface for the purposes of hit detection (determining if an instance overlaps or intersects with another instance). Because the DisplayObject class's hit detection methods are vector-based, you cannot perform a hit detection on the bitmap result. For example, if you apply a bevel filter to a button instance, hit detection is not available on the beveled portion of the instance.

Scaling, rotating, and skewing are not supported by filters; if the filtered display object itself is scaled (if `scaleX` and `scaleY` are not 100%), the filter effect does not scale with the instance. This means that the original shape of the instance rotates, scales, or skews; however, the filter does not rotate, scale, or skew with the instance.

You can animate an instance with a filter to create realistic effects, or nest instances and use the BitmapData class to animate filters to achieve this effect.

Filters and Bitmap objects

When you apply any filter to a BitmapData object, the `cacheAsBitmap` property is automatically set to `true`. In this way, the filter is actually applied to the copy of the object rather than to the original.

This copy is then placed on the main display (over the original object) as close as possible to the nearest pixel. If the bounds of the original bitmap change, the filtered copy bitmap is recreated from the original, rather than being stretched or distorted.

If you clear all filters for a display object, the `cacheAsBitmap` property is reset to what it was before the filter was applied.

Available display filters

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 includes ten filter classes that you can apply to display objects and BitmapData objects:

- Bevel filter (BevelFilter class)
- Blur filter (BlurFilter class)
- Drop shadow filter (DropShadowFilter class)
- Glow filter (GlowFilter class)
- Gradient bevel filter (GradientBevelFilter class)
- Gradient glow filter (GradientGlowFilter class)
- Color matrix filter (ColorMatrixFilter class)
- Convolution filter (ConvolutionFilter class)
- Displacement map filter (DisplacementMapFilter class)
- Shader filter (ShaderFilter class)

The first six filters are simple filters that can be used to create one specific effect, with some customization of the effect available. Those six filters can be applied using ActionScript, and can also be applied to objects in Flash Professional using the Filters panel. Consequently, even if you're applying filters using ActionScript, if you have Flash Professional you can use the visual interface to quickly try out different filters and settings to figure out how to create a desired effect.

The final four filters are available in ActionScript only. Those filters, the color matrix filter, convolution filter, displacement map filter, and shader filter, are much more flexible in the types of effects that they can be used to create. Rather than being optimized for a single effect, they provide power and flexibility. For example, by selecting different values for its matrix, the convolution filter can be used to create effects such as blurring, embossing, sharpening, finding color edges, transformations, and more.

Each of the filters, whether simple or complex, can be customized using their properties. Generally, you have two choices for setting filter properties. All the filters let you set the properties by passing parameter values to the filter object's constructor. Alternatively, whether or not you set the filter properties by passing parameters, you can adjust the filters later by setting values for the filter object's properties. Most of the example code listings set the properties directlyto make the example easier to follow. Nevertheless, you could usually achieve the same result in fewer lines of code by passing the values as parameters in the filter object's constructor. For more details on the specifics of each filter, its properties and its constructor parameters, see the listings for the flash.filters package in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Bevel filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The BevelFilter class allows you to add a 3D beveled edge to the filtered object. This filter makes the hard corners or edges of your object look like they have been chiseled, or beveled, away.

The BevelFilter class properties allow you to customize the appearance of the bevel. You can set highlight and shadow colors, bevel edge blurs, bevel angles, and bevel edge placement; you can even create a knockout effect.

The following example loads an external image and applies a bevel filter to it.

```
import flash.display.*;
import flash.filters.BevelFilter;
import flash.filters.BitmapFilterQuality;
import flash.filters.BitmapFilterType;
import flash.net.URLRequest;

// Load an image onto the Stage.
var imageLoader:Loader = new Loader();
var url:String = "http://www.helpexamples.com/flash/images/image3.jpg";
var urlReq:URLRequest = new URLRequest(url);
imageLoader.load(urlReq);
addChild(imageLoader);

// Create the bevel filter and set filter properties.
var bevel:BevelFilter = new BevelFilter();

bevel.distance = 5;
bevel.angle = 45;
bevel.highlightColor = 0xFFFF00;
bevel.highlightAlpha = 0.8;
bevel.shadowColor = 0x666666;
bevel.shadowAlpha = 0.8;
bevel.blurX = 5;
bevel.blurY = 5;
bevel.strength = 5;
bevel.quality = BitmapFilterQuality.HIGH;
bevel.type = BitmapFilterType.INNER;
bevel.knockout = false;

// Apply filter to the image.
imageLoader.filters = [bevel];
```

Blur filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The BlurFilter class smears, or blurs, a display object and its contents. Blur effects are useful for giving the impression that an object is out of focus or for simulating fast movement, as in a motion blur. By setting the `quality` property of the blur filter too low, you can simulate a softly out-of-focus lens effect. Setting the `quality` property to high results in a smooth blur effect similar to a Gaussian blur.

The following example creates a circle object using the `drawCircle()` method of the Graphics class and applies a blur filter to it:

```
import flash.display.Sprite;
import flash.filters.BitmapFilterQuality;
import flash.filters.BlurFilter;

// Draw a circle.
var redDotCutout:Sprite = new Sprite();
redDotCutout.graphics.lineStyle();
redDotCutout.graphics.beginFill(0xFF0000);
redDotCutout.graphics.drawCircle(145, 90, 25);
redDotCutout.graphics.endFill();

// Add the circle to the display list.
addChild(redDotCutout);

// Apply the blur filter to the rectangle.
var blur:BlurFilter = new BlurFilter();
blur.blurX = 10;
blur.blurY = 10;
blur.quality = BitmapFilterQuality.MEDIUM;
redDotCutout.filters = [blur];
```

Drop shadow filter

Flash Player 9 and later, Adobe AIR 1.0 and later

Drop shadows give the impression that there is a separate light source situated above a target object. The position and intensity of this light source can be modified to produce a variety of different drop shadow effects.

The DropShadowFilter class uses an algorithm that is similar to the blur filter's algorithm. The main difference is that the drop shadow filter has a few more properties that you can modify to simulate different light-source attributes (such as alpha, color, offset and brightness).

The drop shadow filter also allows you to apply custom transformation options on the style of the drop shadow, including inner or outer shadow and knockout (also known as cutout) mode.

The following code creates a square box sprite and applies a drop shadow filter to it:

```
import flash.display.Sprite;
import flash.filters.DropShadowFilter;

// Draw a box.
var boxShadow:Sprite = new Sprite();
boxShadow.graphics.lineStyle(1);
boxShadow.graphics.beginFill(0xFF3300);
boxShadow.graphics.drawRect(0, 0, 100, 100);
boxShadow.graphics.endFill();
addChild(boxShadow);

// Apply the drop shadow filter to the box.
var shadow:DropShadowFilter = new DropShadowFilter();
shadow.distance = 10;
shadow.angle = 25;

// You can also set other properties, such as the shadow color,
// alpha, amount of blur, strength, quality, and options for
// inner shadows and knockout effects.

boxShadow.filters = [shadow];
```

Glow filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The GlowFilter class applies a lighting effect to display objects, making it appear that a light is being shined up from underneath the object to create a soft glow.

Similar to the drop shadow filter, the glow filter includes properties to modify the distance, angle, and color of the light source to produce varying effects. The GlowFilter also has several options for modifying the style of the glow, including inner or outer glow and knockout mode.

The following code creates a cross using the Sprite class and applies a glow filter to it:

```
import flash.display.Sprite;
import flash.filters.BitmapFilterQuality;
import flash.filters.GlowFilter;

// Create a cross graphic.
var crossGraphic:Sprite = new Sprite();
crossGraphic.graphics.lineStyle();
crossGraphic.graphics.beginFill(0xCCCC00);
crossGraphic.graphics.drawRect(60, 90, 100, 20);
crossGraphic.graphics.drawRect(100, 50, 20, 100);
crossGraphic.graphics.endFill();
addChild(crossGraphic);

// Apply the glow filter to the cross shape.
var glow:GlowFilter = new GlowFilter();
glow.color = 0x009922;
glow.alpha = 1;
glow.blurX = 25;
glow.blurY = 25;
glow.quality = BitmapFilterQuality.MEDIUM;

crossGraphic.filters = [glow];
```

Gradient bevel filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The GradientBevelFilter class lets you apply an enhanced bevel effect to display objects or BitmapData objects. Using a gradient color on the bevel greatly improves the spatial depth of the bevel, giving edges a more realistic, 3D appearance.

The following code creates a rectangle object using the `drawRect()` method of the Shape class and applies a gradient bevel filter to it.

```
import flash.display.Shape;
import flash.filters.BitmapFilterQuality;
import flash.filters.GradientBevelFilter;

// Draw a rectangle.
var box:Shape = new Shape();
box.graphics.lineStyle();
box.graphics.beginFill(0xFEFE78);
box.graphics.drawRect(100, 50, 90, 200);
box.graphics.endFill();

// Apply a gradient bevel to the rectangle.
var gradientBevel:GradientBevelFilter = new GradientBevelFilter();

gradientBevel.distance = 8;
gradientBevel.angle = 225; // opposite of 45 degrees
gradientBevel.colors = [0xFFFFCC, 0xFEFE78, 0x8F8E01];
gradientBevel.alphas = [1, 0, 1];
gradientBevel.ratios = [0, 128, 255];
gradientBevel.blurX = 8;
gradientBevel.blurY = 8;
gradientBevel.quality = BitmapFilterQuality.HIGH;

// Other properties let you set the filter strength and set options
// for inner bevel and knockout effects.

box.filters = [gradientBevel];

// Add the graphic to the display list.
addChild(box);
```

Gradient glow filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The GradientGlowFilter class lets you apply an enhanced glow effect to display objects or BitmapData objects. The effect gives you greater color control of the glow, and in turn produces a more realistic glow effect. Additionally, the gradient glow filter allows you to apply a gradient glow to the inner, outer, or upper edges of an object.

The following example draws a circle on the Stage, and applies a gradient glow filter to it. As you move the mouse further to the right and down, the amount of blur increases in the horizontal and vertical directions respectively. In addition, any time you click on the Stage, the strength of the blur increases.

```
import flash.events.MouseEvent;
import flash.filters.BitmapFilterQuality;
import flash.filters.BitmapFilterType;
import flash.filters.GradientGlowFilter;

// Create a new Shape instance.
var shape:Shape = new Shape();

// Draw the shape.
shape.graphics.beginFill(0xFF0000, 100);
shape.graphics.moveTo(0, 0);
shape.graphics.lineTo(100, 0);
shape.graphics.lineTo(100, 100);
shape.graphics.lineTo(0, 100);
shape.graphics.lineTo(0, 0);
shape.graphics.endFill();

// Position the shape on the Stage.
addChild(shape);
shape.x = 100;
shape.y = 100;

// Define a gradient glow.
var gradientGlow:GradientGlowFilter = new GradientGlowFilter();
gradientGlow.distance = 0;
gradientGlow.angle = 45;
gradientGlow.colors = [0x000000, 0xFF0000];
gradientGlow.alphas = [0, 1];
gradientGlow.ratios = [0, 255];
gradientGlow.blurX = 10;
gradientGlow.blurY = 10;
gradientGlow.strength = 2;
gradientGlow.quality = BitmapFilterQuality.HIGH;
gradientGlow.type = BitmapFilterType.OUTER;

// Define functions to listen for two events.
function onClick(event:MouseEvent):void
{
    gradientGlow.strength++;
    shape.filters = [gradientGlow];
}

function onMouseMove(event:MouseEvent):void
{
    gradientGlow.blurX = (stage.mouseX / stage.stageWidth) * 255;
    gradientGlow.blurY = (stage.mouseY / stage.stageHeight) * 255;
    shape.filters = [gradientGlow];
}
stage.addEventListener(MouseEvent.CLICK, onClick);
stage.addEventListener(MouseEvent.MOUSE_MOVE, onMouseMove);
```

Example: Combining basic filters

Flash Player 9 and later, Adobe AIR 1.0 and later

The following code example uses several basic filters, combined with a Timer for creating repeating actions, to create an animated traffic light simulation.

```
import flash.display.Shape;
import flash.events.TimerEvent;
import flash.filters.BitmapFilterQuality;
import flash.filters.BitmapFilterType;
import flash.filters.DropShadowFilter;
import flash.filters.GlowFilter;
import flash.filters.GradientBevelFilter;
import flash.utils.Timer;

var count:Number = 1;
var distance:Number = 8;
var angleInDegrees:Number = 225; // opposite of 45 degrees
var colors:Array = [0xFFFFCC, 0xFEFE78, 0x8F8E01];
var alphas:Array = [1, 0, 1];
var ratios:Array = [0, 128, 255];
var blurX:Number = 8;
var blurY:Number = 8;
var strength:Number = 1;
var quality:Number = BitmapFilterQuality.HIGH;
var type:String = BitmapFilterType.INNER;
var knockout:Boolean = false;

// Draw the rectangle background for the traffic light.
var box:Shape = new Shape();
box.graphics.lineStyle();
box.graphics.beginFill(0xFEFE78);
box.graphics.drawRect(100, 50, 90, 200);
box.graphics.endFill();

// Draw the 3 circles for the three lights.
var stopLight:Shape = new Shape();
stopLight.graphics.lineStyle();
stopLight.graphics.beginFill(0xFF0000);
stopLight.graphics.drawCircle(145,90,25);
stopLight.graphics.endFill();

var cautionLight:Shape = new Shape();
cautionLight.graphics.lineStyle();
cautionLight.graphics.beginFill(0xFF9900);
cautionLight.graphics.drawCircle(145,150,25);
cautionLight.graphics.endFill();

var goLight:Shape = new Shape();
goLight.graphics.lineStyle();
goLight.graphics.beginFill(0x00CC00);
goLight.graphics.drawCircle(145,210,25);
goLight.graphics.endFill();

// Add the graphics to the display list.
addChild(box);
addChild(stopLight);
addChild(cautionLight);
addChild(goLight);

// Apply a gradient bevel to the traffic light rectangle.
var gradientBevel:GradientBevelFilter = new GradientBevelFilter(distance, angleInDegrees,
colors, alphas, ratios, blurX, blurY, strength, quality, type, knockout);
box.filters = [gradientBevel];

// Create the inner shadow (for lights when off) and glow
// (for lights when on).
var innerShadow:DropShadowFilter = new DropShadowFilter(5, 45, 0, 0.5, 3, 3, 1, 1, true,
false);
var redGlow:GlowFilter = new GlowFilter(0xFF0000, 1, 30, 30, 1, 1, false, false);
var yellowGlow:GlowFilter = new GlowFilter(0xFF9900, 1, 30, 30, 1, 1, false, false);
var greenGlow:GlowFilter = new GlowFilter(0x00CC00, 1, 30, 30, 1, 1, false, false);

// Set the starting state of the lights (green on, red/yellow off).
stopLight.filters = [innerShadow];
cautionLight.filters = [innerShadow];
goLight.filters = [greenGlow];

// Swap the filters based on the count value.
function trafficControl(event:TimerEvent):void
{
    if (count == 4)
    {
        count = 1;
    }

    switch (count)
    {
        case 1:
            stopLight.filters = [innerShadow];
            cautionLight.filters = [yellowGlow];
            goLight.filters = [innerShadow];
            break;
        case 2:
            stopLight.filters = [redGlow];
            cautionLight.filters = [innerShadow];
            goLight.filters = [innerShadow];
            break;
        case 3:
            stopLight.filters = [innerShadow];
            cautionLight.filters = [innerShadow];
            goLight.filters = [greenGlow];
            break;
    }

    count++;
}

// Create a timer to swap the filters at a 3 second interval.
var timer:Timer = new Timer(3000, 9);
timer.addEventListener(TimerEvent.TIMER, trafficControl);
timer.start();
```

Color matrix filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The ColorMatrixFilter class is used to manipulate the color and alpha values of the filtered object. This allows you to create saturation changes, hue rotation (shifting a palette from one range of colors to another), luminance-to-alpha changes, and other color manipulation effects using values from one color channel and potentially applying them to other channels.

Conceptually, the filter goes through the pixels in the source image one by one and separates each pixel into its red, green, blue, and alpha components. It then multiplies values provided in the color matrix by each of these values, adding the results together to determine the resulting color value that will be displayed on the screen for that pixel. The `matrix` property of the filter is an array of 20 numbers that are used in calculating the final color. For details of the specific algorithm used to calculate the color values, see the entry describing the ColorMatrixFilter class's `matrix` property in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Convolution filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The ConvolutionFilter class can be used to apply a wide range of imaging transformations to BitmapData objects or display objects, such as blurring, edge detection, sharpening, embossing, and beveling.

The convolution filter conceptually goes through each pixel in the source image one by one and determines the final color of that pixel using the value of the pixel and its surrounding pixels. A matrix, specified as an array of numeric values, indicates to what degree the value of each particular neighboring pixel affects the final resulting value.

Consider the most commonly used type of matrix, which is a three by three matrix. The matrix includes nine values:

```
N    N    N
N    P    N
N    N    N
```

When the convolution filter is applied to a certain pixel, it will look at the color value of the pixel itself ("P" in the example), as well as the values of the surrounding pixels (labeled "N" in the example). However, by setting values in the matrix, you specify how much priority certain pixels have in affecting the resulting image.

For example, the following matrix, applied using a convolution filter, will leave an image exactly as it was:

```
0    0    0
0    1    0
0    0    0
```

The reason the image is unchanged is because the original pixel's value has a relative strength of 1 in determining the final pixel color, while the surrounding pixels' values have relative strength of 0—meaning their colors don't affect the final image.

Similarly, this matrix will cause the pixels of an image to shift one pixel to the left:

```
0    0    0
0    0    1
0    0    0
```

Notice that in this case, the pixel itself has no effect on the final value of the pixel displayed in that location on the final image—only the value of the pixel to the right is used to determine the pixel's resulting value.

In ActionScript, you create the matrix as a combination of an Array instance containing the values and two properties specifying the number of rows and columns in the matrix. The following example loads an image and, when the image finishes loading, applies a convolution filter to the image using the matrix in the previous listing:

```
// Load an image onto the Stage.
var loader:Loader = new Loader();
var url:URLRequest = new URLRequest("http://www.helpexamples.com/flash/images/image1.jpg");
loader.load(url);
this.addChild(loader);

function applyFilter(event:MouseEvent):void
{
    // Create the convolution matrix.
    var matrix:Array = [0, 0, 0,
                                     0, 0, 1,
                                     0, 0, 0];

    var convolution:ConvolutionFilter = new ConvolutionFilter();
    convolution.matrixX = 3;
    convolution.matrixY = 3;
    convolution.matrix = matrix;
    convolution.divisor = 1;

    loader.filters = [convolution];
}

loader.addEventListener(MouseEvent.CLICK, applyFilter);
```

Something that isn't obvious in this code is the effect of using values other than 1 or 0 in the matrix. For example, the same matrix, with the number 8 instead of 1 in the right-hand position, performs the same action (shifting the pixels to the left). In addition, it affects the colors of the image, making them 8 times brighter. This is because the final pixel color values are calculated by multiplying the matrix values by the original pixel colors, adding the values together, and dividing by the value of the filter's `divisor` property. Notice that in the example code, the `divisor` property is set to 1. As a general rule, if you want the brightness of the colors to stay about the same as in the original image, you should make the divisor equal to the sum of the matrix values. So with a matrix where the values add up to 8, and a divisor of 1, the resulting image is going to be roughly 8 times brighter than the original image.

Although the effect of this matrix isn't very noticeable, other matrix values can be used to create various effects. Here are several standard sets of matrix values for different effects using a three by three matrix:

- Basic blur (divisor 5):

  ```
   0 1 0
   1 1 1
   0 1 0
  ```

- Sharpening (divisor 1):

  ```
   0, -1, 0
  -1, 5, -1
   0, -1, 0
  ```

- Edge detection (divisor 1):

  ```
   0, -1, 0
  -1, 4, -1
   0, -1, 0
  ```

- Embossing effect (divisor 1):

```
-2, -1, 0
-1, 1, 1
 0, 1, 2
```

Notice that with most of these effects, the divisor is 1. This is because the negative matrix values added to the positive matrix values result in 1 (or 0 in the case of edge detection, but the `divisor` property's value cannot be 0).

Displacement map filter

Flash Player 9 and later, Adobe AIR 1.0 and later

The DisplacementMapFilter class uses pixel values from a BitmapData object (known as the displacement map image) to perform a displacement effect on a new object. The displacement map image is typically different than the actual display object or BitmapData instance to which the filter is being applied. A displacement effect involves displacing pixels in the filtered image—in other words, shifting them away from their original location to some extent. This filter can be used to create a shifted, warped, or mottled effect.

The location and amount of displacement applied to a given pixel is determined by the color value of the displacement map image. When working with the filter, in addition to specifying the map image, you specify the following values to control how the displacement is calculated from the map image:

- Map point: The location on the filtered image at which the upper-left corner of the displacement filter will be applied. You can use this if you only want to apply the filter to part of an image.
- X component: Which color channel of the map image affects the x position of pixels.
- Y component: Which color channel of the map image affects the y position of pixels.
- X scale: A multiplier value that specifies how strong the x axis displacement is.
- Y scale: A multiplier value that specifies how strong the y axis displacement is.
- Filter mode: Determines what to do in any empty spaces created by pixels being shifted away. The options, defined as constants in the DisplacementMapFilterMode class, are to display the original pixels (filter mode `IGNORE`), to wrap the pixels around from the other side of the image (filter mode `WRAP`, which is the default), to use the nearest shifted pixel (filter mode `CLAMP`), or to fill in the spaces with a color (filter mode `COLOR`).

To understand how the displacement map filter works, consider a basic example. In the following code, an image is loaded, and when it finishes loading it is centered on the Stage and a displacement map filter is applied to it, causing the pixels in the entire image to shift horizontally to the left.

```
import flash.display.BitmapData;
import flash.display.Loader;
import flash.events.MouseEvent;
import flash.filters.DisplacementMapFilter;
import flash.geom.Point;
import flash.net.URLRequest;

// Load an image onto the Stage.
var loader:Loader = new Loader();
var url:URLRequest = new URLRequest("http://www.helpexamples.com/flash/images/image3.jpg");
loader.load(url);
this.addChild(loader);

var mapImage:BitmapData;
var displacementMap:DisplacementMapFilter;

// This function is called when the image finishes loading.
function setupStage(event:Event):void
{
    // Center the loaded image on the Stage.
    loader.x = (stage.stageWidth - loader.width) / 2;
    loader.y = (stage.stageHeight - loader.height) / 2;

    // Create the displacement map image.
    mapImage = new BitmapData(loader.width, loader.height, false, 0xFF0000);

    // Create the displacement filter.
    displacementMap = new DisplacementMapFilter();
    displacementMap.mapBitmap = mapImage;
    displacementMap.mapPoint = new Point(0, 0);
    displacementMap.componentX = BitmapDataChannel.RED;
    displacementMap.scaleX = 250;
    loader.filters = [displacementMap];
}

loader.contentLoaderInfo.addEventListener(Event.COMPLETE, setupStage);
```

The properties used to define the displacement are as follows:

- Map bitmap: The displacement bitmap is a new BitmapData instance created by the code. Its dimensions match the dimensions of the loaded image (so the displacement is applied to the entire image). It is filled with solid red pixels.
- Map point: This value is set to the point 0, 0—again, causing the displacement to be applied to the entire image.
- X component: This value is set to the constant `BitmapDataChannel.RED`, meaning the red value of the map bitmap will determine how much the pixels are displaced (how much they move) along the x axis.
- X scale: This value is set to 250. The full amount of displacement (from the map image being completely red) only displaces the image by a small amount (roughly one-half of a pixel), so if this value was set to 1 the image would only shift .5 pixels horizontally. By setting it to 250, the image shifts by approximately 125 pixels.

These settings cause the filtered image's pixels to shift 250 pixels to the left. The direction (left or right) and amount of shift is based on the color value of the pixels in the map image. Conceptually, the filter goes through the pixels of the filtered image one by one (at least, the pixels in the region where the filter is applied, which in this case means all the pixels), and does the following with each pixel:

1. It finds the corresponding pixel in the map image. For example, when the filter calculates the displacement amount for the pixel in the upper-left corner of the filtered image, it looks at the pixel in the upper-left corner of the map image.
2. It determines the value of the specified color channel in the map pixel. In this case, the x component color channel is the red channel, so the filter looks to see what the value of the red channel of the map image is at the pixel in question. Since the map image is solid red, the pixel's red channel is 0xFF, or 255. This is used as the displacement value.
3. It compares the displacement value to the "middle" value (127, which is halfway between 0 and 255). If the displacement value is lower than the middle value, the pixel shifts in a positive direction (to the right for x displacement; down for y displacement). On the other hand, if the displacement value is higher than the middle value (as in this example), the pixel shifts in a negative direction (to the left for x displacement; up for y displacement). To be more precise, the filter subtracts the displacement value from 127, and the result (positive or negative) is the relative amount of displacement that is applied.
4. Finally, it determines the actual amount of displacement by determining what percentage of full displacement the relative displacement value represents. In this case, full red means 100% displacement. That percentage is then multiplied by the x scale or y scale value to determine the number of pixels of displacement that will be applied. In this example, 100% times a multiplier of 250 determines the amount of displacement—roughly 125 pixels to the left.

Because no values are specified for y component and y scale, the defaults (which cause no displacement) are used—that's why the image doesn't shift at all in the vertical direction.

The default filter mode setting, `WRAP`, is used in the example, so as the pixels shift to the left the empty space on the right is filled in by the pixels that shifted off the left edge of the image. You can experiment with this value to see the different effects. For example, if you add the following line to the portion of code where the displacement properties are being set (before the line `loader.filters = [displacementMap]`), it will make the image look as though it has been smeared across the Stage:

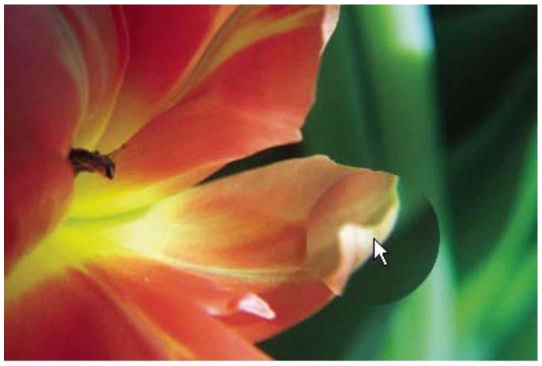
```
displacementMap.mode = DisplacementMapFilterMode.CLAMP;
```

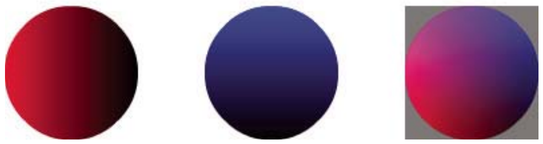
For a more complex example, the following listing uses a displacement map filter to create a magnifying glass effect on an image:

```
import flash.display.Bitmap;
import flash.display.BitmapData;
import flash.display.BitmapDataChannel;
import flash.display.GradientType;
import flash.display.Loader;
import flash.display.Shape;
import flash.events.MouseEvent;
import flash.filters.DisplacementMapFilter;
import flash.filters.DisplacementMapFilterMode;
import flash.geom.Matrix;
import flash.geom.Point;
import flash.net.URLRequest;

// Create the gradient circles that will together form the
// displacement map image
var radius:uint = 50;

var type:String = GradientType.LINEAR;
var redColors:Array = [0xFF0000, 0x000000];
var blueColors:Array = [0x0000FF, 0x000000];
var alphas:Array = [1, 1];
var ratios:Array = [0, 255];
var xMatrix:Matrix = new Matrix();
xMatrix.createGradientBox(radius * 2, radius * 2);
var yMatrix:Matrix = new Matrix();
yMatrix.createGradientBox(radius * 2, radius * 2, Math.PI / 2);

var xCircle:Shape = new Shape();
xCircle.graphics.lineStyle(0, 0, 0);
xCircle.graphics.beginGradientFill(type, redColors, alphas, ratios, xMatrix);
xCircle.graphics.drawCircle(radius, radius, radius);

var yCircle:Shape = new Shape();
yCircle.graphics.lineStyle(0, 0, 0);
yCircle.graphics.beginGradientFill(type, blueColors, alphas, ratios, yMatrix);
yCircle.graphics.drawCircle(radius, radius, radius);

// Position the circles at the bottom of the screen, for reference.
this.addChild(xCircle);
xCircle.y = stage.stageHeight - xCircle.height;
this.addChild(yCircle);
yCircle.y = stage.stageHeight - yCircle.height;
yCircle.x = 200;

// Load an image onto the Stage.
var loader:Loader = new Loader();
var url:URLRequest = new URLRequest("http://www.helpexamples.com/flash/images/image1.jpg");
loader.load(url);
this.addChild(loader);

// Create the map image by combining the two gradient circles.
var map:BitmapData = new BitmapData(xCircle.width, xCircle.height, false, 0x7F7F7F);
map.draw(xCircle);
var yMap:BitmapData = new BitmapData(yCircle.width, yCircle.height, false, 0x7F7F7F);
yMap.draw(yCircle);
map.copyChannel(yMap, yMap.rect, new Point(0, 0), BitmapDataChannel.BLUE,
BitmapDataChannel.BLUE);
```

```
yMap.dispose();

// Display the map image on the Stage, for reference.
var mapBitmap:Bitmap = new Bitmap(map);
this.addChild(mapBitmap);
mapBitmap.x = 400;
mapBitmap.y = stage.stageHeight - mapBitmap.height;

// This function creates the displacement map filter at the mouse location.
function magnify():void
{
    // Position the filter.
    var filterX:Number = (loader.mouseX) - (map.width / 2);
    var filterY:Number = (loader.mouseY) - (map.height / 2);
    var pt:Point = new Point(filterX, filterY);
    var xyFilter:DisplacementMapFilter = new DisplacementMapFilter();
    xyFilter.mapBitmap = map;
    xyFilter.mapPoint = pt;
    // The red in the map image will control x displacement.
    xyFilter.componentX = BitmapDataChannel.RED;
    // The blue in the map image will control y displacement.
    xyFilter.componentY = BitmapDataChannel.BLUE;
    xyFilter.scaleX = 35;
    xyFilter.scaleY = 35;
    xyFilter.mode = DisplacementMapFilterMode.IGNORE;
    loader.filters = [xyFilter];
}

// This function is called when the mouse moves. If the mouse is
// over the loaded image, it applies the filter.
function moveMagnifier(event:MouseEvent):void
{
    if (loader.hitTestPoint(loader.mouseX, loader.mouseY))
    {
        magnify();
    }
}
loader.addEventListener(MouseEvent.MOUSE_MOVE, moveMagnifier);
```

The code first generates two gradient circles, which are combined together to form the displacement map image. The red circle creates the x axis displacement (`xyFilter.componentX = BitmapDataChannel.RED`), and the blue circle creates the y axis displacement (`xyFilter.componentY = BitmapDataChannel.BLUE`). To help you understand what the displacement map image looks like, the code adds the original circles as well as the combined circle that serves as the map image to the bottom of the screen.





The code then loads an image and, as the mouse moves, applies the displacement filter to the portion of the image that's under the mouse. The gradient circles used as the displacement map image causes the displaced region to spread out away from the pointer. Notice that the gray regions of the displacement map image don't cause any displacement. The gray color is `0x7F7F7F`. The blue and red channels of that shade of gray exactly match the middle shade of those color channels, so there is no displacement in a gray area of the map image. Likewise, in the center of the circle there is no displacement. Although the color there isn't gray, that color's blue channel and red channel are identical to the blue channel and red channel of medium gray, and since blue and red are the colors that cause displacement, no displacement happens there.

Shader filter

Flash Player 10 and later, Adobe AIR 1.5 and later

The ShaderFilter class lets you use a custom filter effect defined as a Pixel Bender shader. Because the filter effect is written as a Pixel Bender shader, the effect can be completely customized. The filtered content is passed in to the shader as an image input, and the result of the shader operation becomes the filter result.

Note: *The Shader filter is available in ActionScript starting with Flash Player 10 and Adobe AIR 1.5.*

To apply a shader filter to an object, you first create a Shader instance representing the Pixel Bender shader that you are using. For details on the procedure for creating a Shader instance and on how to specify input image and parameter values, see "Working with Pixel Bender shaders" on page 300.

When using a shader as a filter, there are three important things to keep in mind:

- The shader must be defined to accept at least one input image.
- The filtered object (the display object or BitmapData object to which the filter is applied) is passed to the shader as the first input image value. Because of this, do not manually specify a value for the first image input.

- If the shader defines more that one input image, the additional inputs must be specified manually (that is, by setting the `input` property of any ShaderInput instance that belongs to the Shader instance).

Once you have a Shader object for your shader, you create a ShaderFilter instance. This is the actual filter object that you use like any other filter. To create a ShaderFilter that uses a Shader object, call the `ShaderFilter()` constructor and pass the Shader object as an argument, as shown in this listing:

```
var myFilter:ShaderFilter = new ShaderFilter(myShader);
```

For a complete example of using a shader filter, see "Using a shader as a filter" on page 318.

Filtering display objects example: Filter Workbench

Flash Player 9 and later, Adobe AIR 1.0 and later

The Filter Workbench provides a user interface to apply different filters to images and other visual content and see the resulting code that can be used to generate the same effect in ActionScript. In addition to providing a tool for experimenting with filters, this application demonstrates the following techniques:

- Creating instances of various filters
- Applying multiple filters to a display object

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The Filter Workbench application files can be found in the Samples/FilterWorkbench folder. The application consists of the following files:

File	Description
com/example/programmingas3/filterWorkbench/FilterWorkbenchController.as	Class that provides the main functionality of the application, including switching content to which filters are applied, and applying filters to content.
com/example/programmingas3/filterWorkbench/IFilterFactory.as	Interface defining common methods that are implemented by each of the filter factory classes. This interface defines the common functionality that the FilterWorkbenchController class uses to interact with the individual filter factory classes.
in folder com/example/programmingas3/filterWorkbench/: BevelFactory.as BlurFactory.as ColorMatrixFactory.as ConvolutionFactory.as DropShadowFactory.as GlowFactory.as GradientBevelFactory.as GradientGlowFactory.as	Set of classes, each of which implements the IFilterFactory interface. Each of these classes provides the functionality of creating and setting values for a single type of filter. The filter property panels in the application use these factory classes to create instances of their particular filters, which the FilterWorkbenchController class retrieves and applies to the image content.
com/example/programmingas3/filterWorkbench/IFilterPanel.as	Interface defining common methods that are implemented by classes that define the user interface panels that are used to manipulate filter values in the application.

File	**Description**
com/example/programmingas3/filterWorkbench/ColorStringFormatter.as	Utility class that includes a method to convert a numeric color value to hexadecimal String format
com/example/programmingas3/filterWorkbench/GradientColor.as	Class that serves as a value object, combining into a single object the three values (color, alpha, and ratio) that are associated with each color in the GradientBevelFilter and GradientGlowFilter
User interface (Flex)	
FilterWorkbench.mxml	The main file defining the application's user interface.
flexapp/FilterWorkbench.as	Class that provides the functionality for the main application's user interface; this class is used as the code-behind class for the application MXML file.
In folder flexapp/filterPanels: BevelPanel.mxml BlurPanel.mxml ColorMatrixPanel.mxml ConvolutionPanel.mxml DropShadowPanel.mxml GlowPanel.mxml GradientBevelPanel.mxml GradientGlowPanel.mxml	Set of MXML components that provide the functionality for each panel that is used to set options for a single filter.
flexapp/ImageContainer.as	A display object that serves as a container for the loaded image on the screen
flexapp/controls/BGColorCellRenderer.as	Custom cell renderer used to change the background color of a cell in the DataGrid component
flexapp/controls/QualityComboBox.as	Custom control defining a combo box that can be used for the Quality setting in several filter panels.
flexapp/controls/TypeComboBox.as	Custom control defining a combo box that can be used for the Type setting in several filter panels.
User interface (Flash)	
FilterWorkbench.fla	The main file defining the application's user interface.
flashapp/FilterWorkbench.as	Class that provides the functionality for the main application's user interface; this class is used as the document class for the application FLA file.

File	Description
In folder flashapp/filterPanels: BevelPanel.as BlurPanel.as ColorMatrixPanel.as ConvolutionPanel.as DropShadowPanel.as GlowPanel.as GradientBevelPanel.as GradientGlowPanel.as	Set of classes that provide the functionality for each panel that is used to set options for a single filter. For each class, there is also an associated MovieClip symbol in the library of the main application FLA file, whose name matches the name of the class (for example, the symbol "BlurPanel" is linked to the class defined in BlurPanel.as). The components that make up the user interface are positioned and named within those symbols.
flashapp/ImageContainer.as	A display object that serves as a container for the loaded image on the screen
flashapp/BGColorCellRenderer.as	Custom cell renderer used to change the background color of a cell in the DataGrid component
flashapp/ButtonCellRenderer.as	Custom cell renderer used to include a button component in a cell in the DataGrid component
Filtered image content	
com/example/programmingas3/filterWorkbench/ImageType.as	This class serves as a value object containing the type and URL of a single image file to which the application can load and apply filters. The class also includes a set of constants representing the actual image files available.
images/sampleAnimation.swf, images/sampleImage1.jpg, images/sampleImage2.jpg	Images and other visual content to which filters are applied in the application.

Experimenting with ActionScript filters

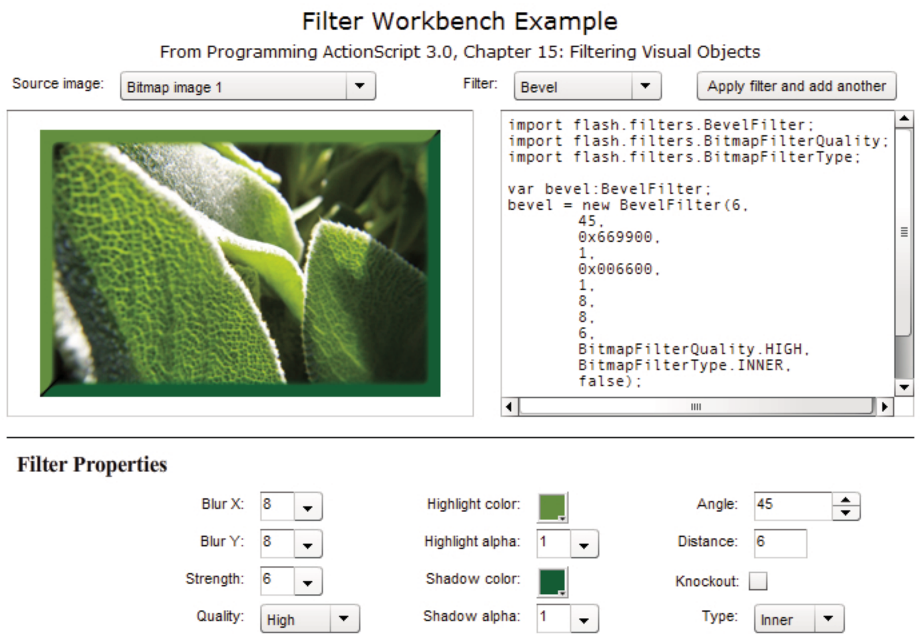
Flash Player 9 and later, Adobe AIR 1.0 and later

The Filter Workbench application is designed to help you experiment with various filter effects and generate the relevant ActionScript code for that effect. The application lets you select from three different files containing visual content, including bitmap images and an animation created by Flash, and apply eight different ActionScript filters to the selected image, either individually or in combination with other filters. The application includes the following filters:

- Bevel (flash.filters.BevelFilter)
- Blur (flash.filters.BlurFilter)
- Color matrix (flash.filters.ColorMatrixFilter)
- Convolution (flash.filters.ConvolutionFilter)
- Drop shadow (flash.filters.DropShadowFilter)
- Glow (flash.filters.GlowFilter)
- Gradient bevel (flash.filters.GradientBevelFilter)

- Gradient glow (flash.filters.GradientGlowFilter)

Once a user has selected an image and a filter to apply to that image, the application displays a panel with controls for setting the specific properties of the selected filter. For example, the following image shows the application with the Bevel filter selected:


Filter Workbench Example

From Programming ActionScript 3.0, Chapter 15: Filtering Visual Objects

Source image: Bitmap image 1 Filter: Bevel Apply filter and add another

```
import flash.filters.BevelFilter;
import flash.filters.BitmapFilterQuality;
import flash.filters.BitmapFilterType;

var bevel:BevelFilter;
bevel = new BevelFilter(6,
        45,
        0x669900,
        1,
        0x006600,
        1,
        8,
        8,
        6,
        BitmapFilterQuality.HIGH,
        BitmapFilterType.INNER,
        false);
```

Filter Properties

Blur X:	8	Highlight color:	🟩	Angle:	45
Blur Y:	8	Highlight alpha:	1	Distance:	6
Strength:	6	Shadow color:	🟩	Knockout:	☐
Quality:	High	Shadow alpha:	1	Type:	Inner

As the user adjusts the filter properties, the preview updates in real time. The user can also apply multiple filters by customizing one filter, clicking the Apply button, customizing another filter, clicking the Apply button, and so forth.

There are a few features and limitations in the application's filter panels:

- The color matrix filter includes a set of controls for directly manipulating common image properties including brightness, contrasts, saturation, and hue. In addition, custom color matrix values can be specified.
- The convolution filter, which is only available using ActionScript, includes a set of commonly used convolution matrix values, or custom values can be specified. However, while the ConvolutionFilter class accepts a matrix of any size, the Filter Workbench application uses a fixed 3 x 3 matrix, the most commonly used filter size.
- The displacement map filter and shader filter, which are only available in ActionScript, are not available in the Filter Workbench application.

Creating filter instances

Flash Player 9 and later, Adobe AIR 1.0 and later

The Filter Workbench application includes a set of classes, one for each of the available filters, which are used by the individual panels to create the filters. When a user selects a filter, the ActionScript code associated with the filter panel creates an instance of the appropriate filter factory class. (These classes are known as *factory classes* because their purpose is to create instances of other objects, much like a real-world factory creates individual products.)

Whenever the user changes a property value on the panel, the panel's code calls the appropriate method in the factory class. Each factory class includes specific methods that the panel uses to create the appropriate filter instance. For example, if the user selects the Blur filter, the application creates a BlurFactory instance. The BlurFactory class includes a `modifyFilter()` method that accepts three parameters: `blurX`, `blurY`, and `quality`, which together are used to create the desired BlurFilter instance:

```
private var _filter:BlurFilter;

public function modifyFilter(blurX:Number = 4, blurY:Number = 4, quality:int = 1):void
{
    _filter = new BlurFilter(blurX, blurY, quality);
    dispatchEvent(new Event(Event.CHANGE));
}
```

On the other hand, if the user selects the Convolution filter, that filter allows for much greater flexibility and consequently has a larger set of properties to control. In the ConvolutionFactory class, the following code is called when the user selects a different value on the filter panel:

```
private var _filter:ConvolutionFilter;

public function modifyFilter(matrixX:Number = 0,
                                                matrixY:Number = 0,
                                                matrix:Array = null,
                                                divisor:Number = 1.0,
                                                bias:Number = 0.0,
                                                preserveAlpha:Boolean = true,
                                                clamp:Boolean = true,
                                                color:uint = 0,
                                                alpha:Number = 0.0):void
{
    _filter = new ConvolutionFilter(matrixX, matrixY, matrix, divisor, bias, preserveAlpha,
clamp, color, alpha);
    dispatchEvent(new Event(Event.CHANGE));
}
```

Notice that in each case, when the filter values are changed, the factory object dispatches an `Event.CHANGE` event to notify listeners that the filter's values have changed. The FilterWorkbenchController class, which does the work of actually applying filters to the filtered content, listens for that event to ascertain when it needs to retrieve a new copy of the filter and re-apply it to the filtered content.

The FilterWorkbenchController class doesn't need to know specific details of each filter factory class—it just needs to know that the filter has changed and to be able to access a copy of the filter. To support this, the application includes an interface, IFilterFactory, that defines the behavior a filter factory class needs to provide so the application's FilterWorkbenchController instance can do its job. The IFilterFactory defines the `getFilter`() method that's used in the FilterWorkbenchController class:

```
function getFilter():BitmapFilter;
```

Notice that the `getFilter()` interface method definition specifies that it returns a BitmapFilter instance rather than a specific type of filter. The BitmapFilter class does not define a specific type of filter. Rather, BitmapFilter is the base class on which all the filter classes are built. Each filter factory class defines a specific implementation of the `getFilter()` method in which it returns a reference to the filter object it has built. For example, here is an abbreviated version of the ConvolutionFactory class's source code:

```
public class ConvolutionFactory extends EventDispatcher implements IFilterFactory
{
    // ------- Private vars -------
    private var _filter:ConvolutionFilter;
    ...
    // ------- IFilterFactory implementation -------
    public function getFilter():BitmapFilter
    {
        return _filter;
    }
    ...
}
```

In the ConvolutionFactory class's implementation of the `getFilter()` method, it returns a ConvolutionFilter instance, although any object that calls `getFilter()` doesn't necessarily know that—according to the definition of the `getFilter()` method that ConvolutionFactory follows, it must return any BitmapFilter instance, which could be an instance of any of the ActionScript filter classes.

Applying filters to display objects

Flash Player 9 and later, Adobe AIR 1.0 and later

As explained previously, the Filter Workbench application uses an instance of the FilterWorkbenchController class (hereafter referred to as the "controller instance"), which performs the actual task of applying filters to the selected visual object. Before the controller instance can apply a filter, it first needs to know what image or visual content the filter should be applied to. When the user selects an image, the application calls the `setFilterTarget()` method in the FilterWorkbenchController class, passing in one of the constants defined in the ImageType class:

```
public function setFilterTarget(targetType:ImageType):void
{
    ...
    _loader = new Loader();
    ...
    _loader.contentLoaderInfo.addEventListener(Event.COMPLETE, targetLoadComplete);
    ...
}
```

Using that information the controller instance loads the designated file, storing it in an instance variable named `_currentTarget` once it loads:

```
private var _currentTarget:DisplayObject;

private function targetLoadComplete(event:Event):void
{
    ...
    _currentTarget = _loader.content;
    ...
}
```

When the user selects a filter, the application calls the controller instance's `setFilter()` method, giving the controller a reference to the relevant filter factory object, which it stores in an instance variable named `_filterFactory`.

```
private var _filterFactory:IFilterFactory;

public function setFilter(factory:IFilterFactory):void
{
    ...

    _filterFactory = factory;
    _filterFactory.addEventListener(Event.CHANGE, filterChange);
}
```

Notice that, as described previously, the controller instance doesn't know the specific data type of the filter factory instance that it is given; it only knows that the object implements the IFilterFactory instance, meaning it has a `getFilter()` method and it dispatches a `change` (`Event.CHANGE`) event when the filter changes.

When the user changes a filter's properties in the filter's panel, the controller instance finds out that the filter has changed through the filter factory's `change` event, which calls the controller instance's `filterChange()` method. That method, in turn, calls the `applyTemporaryFilter()` method:

```
private function filterChange(event:Event):void
{
    applyTemporaryFilter();
}

private function applyTemporaryFilter():void
{
    var currentFilter:BitmapFilter = _filterFactory.getFilter();

    // Add the current filter to the set temporarily
    _currentFilters.push(currentFilter);

    // Refresh the filter set of the filter target
    _currentTarget.filters = _currentFilters;

    // Remove the current filter from the set
    // (This doesn't remove it from the filter target, since
    // the target uses a copy of the filters array internally.)
    _currentFilters.pop();
}
```

The work of applying the filter to the display object occurs within the `applyTemporaryFilter()` method. First, the controller retrieves a reference to the filter object by calling the filter factory's `getFilter()` method.

```
var currentFilter:BitmapFilter = _filterFactory.getFilter();
```

The controller instance has an Array instance variable named `_currentFilters`, in which it stores all the filters that have been applied to the display object. The next step is to add the newly updated filter to that array:

```
_currentFilters.push(currentFilter);
```

Next, the code assigns the array of filters to the display object's `filters` property, which actually applies the filters to the image:

```
_currentTarget.filters = _currentFilters;
```

Finally, since this most recently added filter is still the "working" filter, it shouldn't be permanently applied to the display object, so it is removed from the `_currentFilters` array:

```
_currentFilters.pop();
```

Removing this filter from the array doesn't affect the filtered display object, because a display object makes a copy of the filters array when it is assigned to the `filters` property, and it uses that internal array rather than the original one. For this reason, any changes that are made to the array of filters don't affect the display object until the array is assigned to the display object's `filters` property again.

Chapter 15: Working with Pixel Bender shaders

Flash Player 10 and later, Adobe AIR 1.5 and later

Adobe Pixel Bender Toolkit allows developers to write shaders that create graphical effects and perform other image and data processing. The Pixel Bender bytecode can be executed in ActionScript to apply the effect to image data or visual content. Using Pixel Bender shaders in ActionScript gives you the capability to create custom visual effects and perform data processing beyond the built-in capabilities in ActionScript.

***Note:** Pixel Bender support is available starting in Flash Player 10 and Adobe AIR 1.5. Pixel Bender blends, filters, and fills are not supported under GPU rendering.*

More Help topics

Adobe Pixel Bender Technology Center

Pixel Bender Developer's Guide

Pixel Bender Reference

flash.display.Shader

flash.filters.ShaderFilter

Pixel Bender basics for Flash

Pixel Bender basics for Flex

Basics of Pixel Bender shaders

Flash Player 10 and later, Adobe AIR 1.5 and later

Adobe Pixel Bender is a programming language that is used to create or manipulate image content. Using Pixel Bender you create a kernel, also known as a shader. The shader defines a single function that executes on each of the pixels of an image individually. The result of each call to the function is the output color at that pixel coordinate in the image. Input images and parameter values can be specified to customize the operation. In a single execution of a shader, input and parameter values are constant. The only thing that varies is the coordinate of the pixel whose color is the result of the function call.

Where possible, the shader function is called for multiple output pixel coordinates in parallel. This improves shader performance and can provide high-performance processing.

In ActionScript, three types of effects can be easily created using a shader:

- drawing fill
- blend mode
- filter

A shader can also be executed in stand-alone mode. Using stand-alone mode a shader's result is accessed directly rather than pre-specifying its intended use. The result can be accessed as image data or as binary or number data. The data need not be image data at all. In this way you can give a shader a set of data as an input. The shader processes the data, and you can access the result data returned by the shader.

Pixel Bender support is available starting in Flash Player 10 and Adobe AIR 1.5. Pixel Bender blends, filters, and fills are not supported under GPU rendering. On mobile devices, Pixel Bender shaders do run under CPU rendering. However, performance is not at the same level as on a desktop computer. Many shader programs may only execute at a few frames per second.

Important concepts and terms

The following reference list contains important terms that you will encounter when creating and using Pixel Bender shaders:

Kernel For Pixel Bender, a kernel is the same thing as a shader. Using Pixel Bender your code defines a kernel, which defines a single function that executes on each of the pixels of an image individually.

Pixel Bender bytecode When a Pixel Bender kernel is compiled it is transformed into Pixel Bender bytecode. The bytecode is accessed and executed at run time.

Pixel Bender language The programming language used to create a Pixel Bender kernel.

Pixel Bender Toolkit The application that is used to create a Pixel Bender bytecode file from Pixel Bender source code. The toolkit allows you to write, test, and compile Pixel Bender source code.

Shader For the purposes of this document, a shader is a set of functionality written in the Pixel Bender language. A shader's code creates a visual effect or performs a calculation. In either case, the shader returns a set of data (usually the pixels of an image). The shader performs the same operation on each data point, with the only difference being the coordinates of the output pixel.The shader is not written in ActionScript. It is written in the Pixel Bender language and compiled into Pixel Bender bytecode. It can be embedded into a SWF file at compile time or loaded as an external file at run time. In either case it is accessed in ActionScript by creating a Shader object and linking that object to the shader bytecode.

Shader input A complex input, usually bitmap image data, that is provided to a shader to use in its calculations. For each input variable defined in a shader, a single value (that is, a single image or set of binary data) is used for the entire execution of the shader.

Shader parameter A single value (or limited set of values) that is provided to a shader to use in its calculations. Each parameter value is defined for a single shader execution, and the same value is used throughout the shader execution.

Working through the code examples

You may want to test the example code listings that are provided. Testing the code involves running the code and viewing the results in the SWF that's created. All the examples create content using the drawing API which uses or is modified by the shader effect.

Most of the example code listings include two parts. One part is the Pixel Bender source code for the shader used in the example. You must first use the Pixel Bender Toolkit to compile the source code to a Pixel Bender bytecode file. Follow these steps to create the Pixel Bender bytecode file:

1. Open Adobe Pixel Bender Toolkit. If necessary, from the Build menu choose "Turn on Flash Player warnings and errors."
2. Copy the Pixel Bender code listing and paste it into the code editor pane of the Pixel Bender Toolkit.
3. From the File menu, choose "Export kernel filter for Flash Player."

4 Save the Pixel Bender bytecode file in the same directory as the Flash document. The file's name should match the name specified in the example description.

The ActionScript part of each example is written as a class file. To test the example in Flash Professional:

1 Create an empty Flash document and save it to your computer.

2 Create a new ActionScript file and save it in the same directory as the Flash document. The file's name should match the name of the class in the code listing. For instance, if the code listing defines a class named MyApplication, use the name MyApplication.as to save the ActionScript file.

3 Copy the code listing into the ActionScript file and save the file.

4 In the Flash document, click a blank part of the Stage or work space to activate the document Property inspector.

5 In the Property inspector, in the Document Class field, enter the name of the ActionScript class you copied from the text.

6 Run the program using Control > Test Movie

   You will see the results of the example in the preview window.

These techniques for testing example code listings are explained in more detail in "How to Use ActionScript Examples" on page 1096.

Loading or embedding a shader

Flash Player 10 and later, Adobe AIR 1.5 and later

The first step in using a Pixel Bender shader in ActionScript is to get access to the shader in your ActionScript code. Because a shader is created using the Adobe Pixel Bender Toolkit, and written in the Pixel Bender language, it cannot be directly accessed in ActionScript. Instead, you create an instance of the Shader class that represents the Pixel Bender shader to ActionScript. The Shader object allows you to find out information about the shader, such as whether it expects parameters or input image values. You pass the Shader object to other objects to actually use the shader. For example, to use the shader as a filter you assign the Shader object to a ShaderFilter object's `shader` property. Alternatively, to use the shader as a drawing fill, you pass the Shader object as an argument to the `Graphics.beginShaderFill()` method.

Your ActionScript code can access a shader created by Adobe Pixel Bender Toolkit (a .pbj file) in two ways:

- Loaded at run time: the shader file can be loaded as an external asset using a URLLoader object. This technique is like loading an external asset such as a text file. The following example demonstrates loading a shader bytecode file at run time and linking it to a Shader instance:

```
var loader:URLLoader = new URLLoader();
loader.dataFormat = URLLoaderDataFormat.BINARY;
loader.addEventListener(Event.COMPLETE, onLoadComplete);
loader.load(new URLRequest("myShader.pbj"));

var shader:Shader;

function onLoadComplete(event:Event):void {
    // Create a new shader and set the loaded data as its bytecode
    shader = new Shader();
    shader.byteCode = loader.data;

    // You can also pass the bytecode to the Shader() constructor like this:
    // shader = new Shader(loader.data);

     // do something with the shader
}
```

- Embedded in the SWF file: the shader file can be embedded in the SWF file at compile time using the `[Embed]` metadata tag. The `[Embed]` metadata tag is only available if you use the Flex SDK to compile the SWF file. The `[Embed]` tag's `source` parameter points to the shader file, and its `mimeType` parameter is `"application/octet-stream"`, as in this example:

```
[Embed(source="myShader.pbj", mimeType="application/octet-stream")]
var MyShaderClass:Class;

// ...

// create a shader and set the embedded shader as its bytecode
var shader:Shader = new Shader();
shader.byteCode = new MyShaderClass();

// You can also pass the bytecode to the Shader() constructor like this:
// var shader:Shader = new Shader(new MyShaderClass());

// do something with the shader
```

In either case, you link the raw shader bytecode (the `URLLoader.data` property or an instance of the `[Embed]` data class) to the Shader instance. As the previous examples demonstrate, you can assign the bytecode to the Shader instance in two ways. You can pass the shader bytecode as an argument to the `Shader()` constructor. Alternatively, you can set it as the Shader instance's `byteCode` property.

Once a Pixel Bender shader has been created and linked to a Shader object, you can use the shader to create effects in several ways. You can use it as a filter, a blend mode, a bitmap fill, or for stand-alone processing of bitmap or other data. You can also use the Shader object's `data` property to access the shader's metadata, specify input images, and set parameter values.

Accessing shader metadata

Flash Player 10 and later, Adobe AIR 1.5 and later

While creating a Pixel Bender shader kernel, the author can specify metadata about the shader in the Pixel Bender source code. While using a shader in ActionScript, you can examine the shader and extract its metadata.

When you create a Shader instance and link it to a Pixel Bender shader, a ShaderData object containing data about the shader is created and stored in the Shader object's `data` property. The ShaderData class doesn't define any properties of its own. However, at run time a property is dynamically added to the ShaderData object for each metadata value defined in the shader source code. The name given to each property is the same as the name specified in the metadata. For example, suppose the source code of a Pixel Bender shader includes the following metadata definition:

```
namespace : "Adobe::Example";
vendor : "Bob Jones";
version : 1;
description : "Creates a version of the specified image with the specified brightness.";
```

The ShaderData object created for that shader is created with the following properties and values:

- `namespace` (String): `"Adobe::Example"`
- `vendor` (String): `"Bob Jones"`
- `version` (String): `"1"`
- `description` (String): `"Creates a version of the specified image with the specified brightness"`

Because metadata properties are dynamically added to the ShaderData object, you can use a `for..in` loop to examine the ShaderData object. Using this technique you can find out whether the shader has any metadata and what the metadata values are. In addition to metadata properties, a ShaderData object can have properties representing inputs and parameters that are defined in the shader. When you use a `for..in` loop to examine a ShaderData object, check the data type of each property to determine whether the property is an input (a ShaderInput instance), a parameter (a ShaderParameter instance), or a metadata value (a String instance). The following example shows how to use a `for..in` loop to examine the dynamic properties of a shader's `data` property. Each metadata value is added to a Vector instance named `metadata`. Note that this example assumes a Shader instance named `myShader` is already created:

```
var shaderData:ShaderData = myShader.data;
var metadata:Vector.<String> = new Vector.<String>();

for (var prop:String in shaderData)
{
    if (!(shaderData[prop] is ShaderInput) && !(shaderData[prop] is ShaderParameter))
    {
        metadata[metadata.length] = shaderData[prop];
    }
}

// do something with the metadata
```

For a version of this example that also extracts shader inputs and parameters, see "Identifying shader inputs and parameters" on page 305. For more information about input and parameter properties, see "Specifying shader input and parameter values" on page 305.

Specifying shader input and parameter values

Flash Player 10 and later, Adobe AIR 1.5 and later

Many Pixel Bender shaders are defined to use one or more input images that are used in the shader processing. For example, it's common for a shader to accept a source image and output that image with a particular effect applied to it. Depending on how the shader is used the input value may be specified automatically or you may need to explicitly provide a value. Similarly, many shaders specify parameters that are used to customize the output of the shader. You must also explicitly set a value for each parameter before using the shader.

You use the Shader object's `data` property to set shader inputs and parameters and to determine whether a particular shader expects inputs or parameters. The `data` property is a ShaderData instance.

Identifying shader inputs and parameters

Flash Player 10 and later, Adobe AIR 1.5 and later

The first step in specifying shader input and parameter values is to find out whether the particular shader you're using expects any input images or parameters. Each Shader instance has a `data` property containing a ShaderData object. If the shader defines any inputs or parameters, they are accessed as properties of that ShaderData object. The properties' names match the names specified for the inputs and parameters in the shader source code. For example, if a shader defines an input named `src`, the ShaderData object has a property named `src` representing that input. Each property that represents an input is a ShaderInput instance, and each property that represents a parameter is a ShaderParameter instance.

Ideally, the author of the shader provides documentation for the shader, indicating what input image values and parameters the shader expects, what they represent, the appropriate values, and so forth.

However, if the shader isn't documented (and you don't have its source code) you can inspect the shader data to identify the inputs and parameters. The properties representing inputs and parameters are dynamically added to the ShaderData object. Consequently, you can use a `for..in` loop to examine the ShaderData object to find out whether its associated shader defines any inputs or parameters. As described in "Accessing shader metadata" on page 303, any metadata value defined for a shader is also accessed as a dynamic property added to the `Shader.data` property. When you use this technique to identify shader inputs and parameters, check the data type of the dynamic properties. If a property is a ShaderInput instance it represents an input. If it is a ShaderParameter instance it represents a parameter. Otherwise, it is a metadata value. The following example shows how to use a `for..in` loop to examine the dynamic properties of a shader's `data` property. Each input (ShaderInput object) is added to a Vector instance named `inputs`. Each parameter (ShaderParameter object) is added to a Vector instance named `parameters`. Finally, any metadata properties are added to a Vector instance named `metadata`. Note that this example assumes a Shader instance named `myShader` is already created:

```
var shaderData:ShaderData = myShader.data;
var inputs:Vector.<ShaderInput> = new Vector.<ShaderInput>();
var parameters:Vector.<ShaderParameter> = new Vector.<ShaderParameter>();
var metadata:Vector.<String> = new Vector.<String>();

for (var prop:String in shaderData)
{
    if (shaderData[prop] is ShaderInput)
    {
        inputs[inputs.length] = shaderData[prop];
    }
    else if (shaderData[prop] is ShaderParameter)
    {
        parameters[parameters.length] = shaderData[prop];
    }
    else
    {
        metadata[metadata.length] = shaderData[prop];
    }
}

// do something with the inputs or properties
```

Specifying shader input values

Flash Player 10 and later, Adobe AIR 1.5 and later

Many shaders expect one or more input images that are used in the shader processing. However, in many cases an input is specified automatically when the Shader object is used. For example, suppose a shader requires one input, and that shader is used as a filter. When the filter is applied to a display object or BitmapData object, that object is automatically set as the input. In that case you do not explicitly set an input value.

However, in some cases, especially if a shader defines multiple inputs, you do explicitly set a value for an input. Each input that is defined in a shader is represented in ActionScript by a ShaderInput object. The ShaderInput object is a property of the ShaderData instance in the Shader object's `data` property, as described in "Identifying shader inputs and parameters" on page 305. For example, suppose a shader defines an input named `src`, and that shader is linked to a Shader object named `myShader`. In that case you access the ShaderInput object corresponding to the `src` input using the following identifier:

```
myShader.data.src
```

Each ShaderInput object has an `input` property that is used to set the value for the input. You set the `input` property to a BitmapData instance to specify image data. You can also set the `input` property to a BitmapData or Vector.<Number> instance to specify binary or number data. For details and restrictions on using a BitmapData or Vector.<Number> instance as an input, see the `ShaderInput.input` listing in the ActionScript 3.0 Reference for the Adobe Flash Platform.

In addition to the `input` property, a ShaderInput object has properties that can be used to determine what type of image the input expects. These properties include the `width`, `height`, and `channels` properties. Each ShaderInput object also has an `index` property that is useful for determining whether an explicit value must be provided for the input. If a shader expects more inputs than the number that are automatically set, then you set values for those inputs. For details on the different ways to use a shader, and whether input values are automatically set, see "Using a shader" on page 310.

Specifying shader parameter values

Flash Player 10 and later, Adobe AIR 1.5 and later

Some shaders define parameter values that the shader uses in creating its result. For example, a shader that alters the brightness of an image might specify a brightness parameter that determines how much the operation affects the brightness. A single parameter defined in a shader can expect a single value or multiple values, according to the parameter definition in the shader. Each parameter that is defined in a shader is represented in ActionScript by a ShaderParameter object. The ShaderParameter object is a property of the ShaderData instance in the Shader object's data property, as described in "Identifying shader inputs and parameters" on page 305. For example, suppose a shader defines a parameter named `brightness`, and that shader is represented by a Shader object named `myShader`. In that case you access the ShaderParameter corresponding to the `brightness` parameter using the following identifier:

```
myShader.data.brightness
```

To set a value (or values) for the parameter, create an ActionScript array containing the value or values and assign that array to the ShaderParameter object's `value` property. The `value` property is defined as an Array instance because it's possible that a single shader parameter requires multiple values. Even if the shader parameter only expects a single value, you must wrap the value in an Array object to assign it to the `ShaderParameter.value` property. The following listing demonstrates setting a single value as the `value` property:

```
myShader.data.brightness.value = [75];
```

If the Pixel Bender source code for the shader defines a default value for the parameter, an array containing the default value or values is created and assigned to the ShaderParameter object's `value` property when the Shader object is created. Once an array has been assigned to the `value` property (including if it's the default array) the parameter value can be changed by changing the value of the array element. You do not need to create a new array and assign it to the `value` property.

The following example demonstrates setting a shader's parameter value in ActionScript. In this example the shader defines a parameter named `color`. The `color` parameter is declared as a `float4` variable in the Pixel Bender source code, which means it is an array of four floating point numbers. In the example, the `color` parameter value is changed continuously, and each time it changes the shader is used to draw a colored rectangle on the screen. The result is an animated color change.

Note: *The code for this example was written by Ryan Taylor. Thank you Ryan for sharing this example. You can see Ryan's portfolio and read his writing at www.boostworthy.com/.*

The ActionScript code centers around three methods:

- `init()`: In the `init()` method the code loads the Pixel Bender bytecode file containing the shader. When the file loads, the `onLoadComplete()` method is called.
- `onLoadComplete()`: In the `onLoadComplete()` method the code creates the Shader object named `shader`. It also creates a Sprite instance named `texture`. In the `renderShader()` method, the code draws the shader result into `texture` once per frame.
- `onEnterFrame()`: The `onEnterFrame()` method is called once per frame, creating the animation effect. In this method, the code sets the shader parameter value to the new color, then calls the `renderShader()` method to draw the shader result as a rectangle.
- `renderShader()`: In the `renderShader()` method, the code calls the `Graphics.beginShaderFill()` method to specify a shader fill. It then draws a rectangle whose fill is defined by the shader output (the generated color) For more information on using a shader in this way, see "Using a shader as a drawing fill" on page 310.

The following is the ActionScript code for this example. Use this class as the main application class for an ActionScript-only project in Flash Builder, or as the document class for the FLA file in Flash Professional:

```
package
{
    import flash.display.Shader;
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.net.URLLoader;
    import flash.net.URLLoaderDataFormat;
    import flash.net.URLRequest;

    public class ColorFilterExample extends Sprite
    {
        private const DELTA_OFFSET:Number = Math.PI * 0.5;
        private var loader:URLLoader;
        private var shader:Shader;
        private var texture:Sprite;
        private var delta:Number = 0;

        public function ColorFilterExample()
        {
            init();
        }

        private function init():void
        {
            loader = new URLLoader();
            loader.dataFormat = URLLoaderDataFormat.BINARY;
            loader.addEventListener(Event.COMPLETE, onLoadComplete);
            loader.load(new URLRequest("ColorFilter.pbj"));
        }

        private function onLoadComplete(event:Event):void
        {
            shader = new Shader(loader.data);

            texture = new Sprite();

            addChild(texture);

            addEventListener(Event.ENTER_FRAME, onEnterFrame);
        }
        private function onEnterFrame(event:Event):void
        {
            shader.data.color.value[0] = 0.5 + Math.cos(delta - DELTA_OFFSET) * 0.5;
            shader.data.color.value[1] = 0.5 + Math.cos(delta) * 0.5;
            shader.data.color.value[2] = 0.5 + Math.cos(delta + DELTA_OFFSET) * 0.5;
            // The alpha channel value (index 3) is set to 1 by the kernel's default
            // value. This value doesn't need to change.

            delta += 0.1;

            renderShader();
        }

        private function renderShader():void
        {
            texture:graphics.clear();
            texture.graphics.beginShaderFill(shader);
            texture.graphics.drawRect(0, 0, stage.stageWidth, stage.stageHeight);
            texture.graphics.endFill();
        }
    }
}
```

The following is the source code for the ColorFilter shader kernel, used to create the "ColorFilter.pbj" Pixel Bender bytecode file:

```
<languageVersion : 1.0;>
kernel ColorFilter
<
    namespace : "boostworthy::Example";
    vendor : "Ryan Taylor";
    version : 1;
    description : "Creates an image where every pixel has the specified color value.";
>
{
    output pixel4 result;

    parameter float4 color
    <
        minValue:float4(0, 0, 0, 0);
        maxValue:float4(1, 1, 1, 1);
        defaultValue:float4(0, 0, 0, 1);
    >;

    void evaluatePixel()
    {
        result = color;
    }
}
```

If you're using a shader whose parameters aren't documented, you can figure out how many elements of what type must be included in the array by checking the ShaderParameter object's `type` property. The `type` property indicates the data type of the parameter as defined in the shader itself. For a list of the number and type of elements expected by each parameter type, see the `ShaderParameter.value` property listing in the ActionScript 3.0 Reference.

Each ShaderParameter object also has an `index` property that indicates where the parameter fits in the order of the shader's parameters. In addition to these properties, a ShaderParameter object can have additional properties containing metadata values provided by the shader's author. For example, the author can specify metadata values such as minimum, maximum, and default values for a parameter. Any metadata values that the author specifies are added to the ShaderParameter object as dynamic properties. To examine those properties, use a `for..in` loop to loop over the ShaderParameter object's dynamic properties to identify its metadata. The following example shows how to use a `for..in` loop to identify a ShaderParameter object's metadata. Each metadata value is added to a Vector instance named `metadata`. Note that this example assumes a Shader instance named `myShader` is already created, and that it is known to have a parameter named `brightness`:

```
var brightness:ShaderParameter = myShader.data.brightness;
var metadata:Vector.<String> = new Vector.<String>();

for (var prop:String in brightness)
{
    if (brightness[prop] is String)
    {
        metadata[metadata.length] = brightness[prop];
    }
}

// do something with the metadata
```

Using a shader

Flash Player 10 and later, Adobe AIR 1.5 and later

Once a Pixel Bender shader is available in ActionScript as a Shader object, it can be used in several ways:

- Shader drawing fill: The shader defines the fill portion of a shape drawn using the drawing api
- Blend mode: The shader defines the blend between two overlapping display objects
- Filter: The shader defines a filter that modifies the appearance of visual content
- Stand-alone shader processing: The shader processing runs without specifying the intended use of the output. The shader can optionally run in the background, with the result is available when the processing completes. This technique can be used to generate bitmap data and also to process non-visual data.

Using a shader as a drawing fill

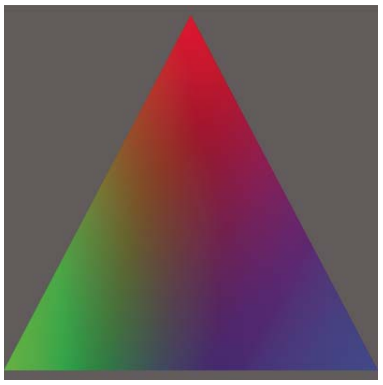
Flash Player 10 and later, Adobe AIR 1.5 and later

When you use a shader to create a drawing fill, you use the drawing api methods to create a vector shape. The shader's output is used to fill in the shape, in the same way that any bitmap image can be used as a bitmap fill with the drawing api. To create a shader fill, at the point in your code at which you want to start drawing the shape, call the Graphics object's `beginShaderFill()` method. Pass the Shader object as the first argument to the `beginShaderFill()` method, as shown in this listing:

```
var canvas:Sprite = new Sprite();
canvas.graphics.beginShaderFill(myShader);
canvas.graphics.drawRect(10, 10, 150, 150);
canvas.graphics.endFill();
// add canvas to the display list to see the result
```

When you use a shader as a drawing fill, you set any input image values and parameter values that the shader requires.

The following example demonstrates using a shader as a drawing fill. In this example, the shader creates a three-point gradient. This gradient has three colors, each at the point of a triangle, with a gradient blend between them. In addition, the colors rotate to create an animated spinning color effect.



Note: *The code for this example was written by Petri Leskinen. Thank you Petri for sharing this example. You can see more of Petri's examples and tutorials at http://pixelero.wordpress.com/.*

The ActionScript code is in three methods:

- `init()`: The `init()` method is called when the application loads. In this method the code sets the initial values for the Point objects representing the points of the triangle. The also code creates a Sprite instance named `canvas`. Later, in the `updateShaderFill()`, the code draws the shader result into `canvas` once per frame. Finally, the code loads the shader bytecode file.
- `onLoadComplete()`: In the `onLoadComplete()` method the code creates the Shader object named `shader`. It also sets the initial parameter values. Finally, the code adds the `updateShaderFill()` method as a listener for the `enterFrame` event, meaning that it is called once per frame to create an animation effect.
- `updateShaderFill()`: The `updateShaderFill()` method is called once per frame, creating the animation effect. In this method, the code calculates and sets the shader parameters' values. The code then calls the `beginShaderFill()` method to create a shader fill and calls other drawing api methods to draw the shader result in a triangle.

The following is the ActionScript code for this example. Use this class as the main application class for an ActionScript-only project in Flash Builder, or as the document class for a FLA file in Flash Professional:

```
package
{
    import flash.display.Shader;
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.geom.Point;
    import flash.net.URLLoader;
    import flash.net.URLLoaderDataFormat;
    import flash.net.URLRequest;

    public class ThreePointGradient extends Sprite
    {
        private var canvas:Sprite;
        private var shader:Shader;
        private var loader:URLLoader;

        private var topMiddle:Point;
        private var bottomLeft:Point;
        private var bottomRight:Point;

        private var colorAngle:Number = 0.0;
        private const d120:Number = 120 / 180 * Math.PI; // 120 degrees in radians


        public function ThreePointGradient()
        {
            init();
        }

        private function init():void
        {
            canvas = new Sprite();
            addChild(canvas);

            var size:int = 400;
            topMiddle = new Point(size / 2, 10);
            bottomLeft = new Point(0, size - 10);
            bottomRight = new Point(size, size - 10);

            loader = new URLLoader();
            loader.dataFormat = URLLoaderDataFormat.BINARY;
            loader.addEventListener(Event.COMPLETE, onLoadComplete);
            loader.load(new URLRequest("ThreePointGradient.pbj"));
        }

        private function onLoadComplete(event:Event):void
        {
            shader = new Shader(loader.data);

            shader.data.point1.value = [topMiddle.x, topMiddle.y];
            shader.data.point2.value = [bottomLeft.x, bottomLeft.y];
            shader.data.point3.value = [bottomRight.x, bottomRight.y];

            addEventListener(Event.ENTER_FRAME, updateShaderFill);
        }

        private function updateShaderFill(event:Event):void
        {
            colorAngle += .06;

            var c1:Number = 1 / 3 + 2 / 3 * Math.cos(colorAngle);
            var c2:Number = 1 / 3 + 2 / 3 * Math.cos(colorAngle + d120);
            var c3:Number = 1 / 3 + 2 / 3 * Math.cos(colorAngle - d120);

            shader.data.color1.value = [c1, c2, c3, 1.0];
            shader.data.color2.value = [c3, c1, c2, 1.0];
            shader.data.color3.value = [c2, c3, c1, 1.0];

            canvas.graphics.clear();
            canvas.graphics.beginShaderFill(shader);

            canvas.graphics.moveTo(topMiddle.x, topMiddle.y);
            canvas.graphics.lineTo(bottomLeft.x, bottomLeft.y);
            canvas.graphics.lineTo(bottomRight.x, bottomLeft.y);

            canvas.graphics.endFill();
        }
    }
}
```

The following is the source code for the ThreePointGradient shader kernel, used to create the "ThreePointGradient.pbj" Pixel Bender bytecode file:

```
<languageVersion : 1.0;>
kernel ThreePointGradient
<
    namespace : "Petri Leskinen::Example";
    vendor : "Petri Leskinen";
    version : 1;
    description : "Creates a gradient fill using three specified points and colors.";
>
{
    parameter float2 point1 // coordinates of the first point
    <
        minValue:float2(0, 0);
        maxValue:float2(4000, 4000);
        defaultValue:float2(0, 0);
    >;

    parameter float4 color1 // color at the first point, opaque red by default
    <
        defaultValue:float4(1.0, 0.0, 0.0, 1.0);
    >;

    parameter float2 point2 // coordinates of the second point
    <
        minValue:float2(0, 0);
        maxValue:float2(4000, 4000);
        defaultValue:float2(0, 500);
    >;

    parameter float4 color2 // color at the second point, opaque green by default
    <
        defaultValue:float4(0.0, 1.0, 0.0, 1.0);
    >;

    parameter float2 point3 // coordinates of the third point
    <
        minValue:float2(0, 0);
        maxValue:float2(4000, 4000);
        defaultValue:float2(0, 500);
    >;

    parameter float4 color3 // color at the third point, opaque blue by default
    <
        defaultValue:float4(0.0, 0.0, 1.0, 1.0);
    >;

    output pixel4 dst;

    void evaluatePixel()
    {
        float2 d2 = point2 - point1;
        float2 d3 = point3 - point1;

        // transformation to a new coordinate system
        // transforms point 1 to origin, point2 to (1, 0), and point3 to (0, 1)
        float2x2 mtrx = float2x2(d3.y, -d2.y, -d3.x, d2.x) / (d2.x * d3.y - d3.x * d2.y);
        float2 pNew = mtrx * (outCoord() - point1);

        // repeat the edge colors on the outside
        pNew.xy = clamp(pNew.xy, 0.0, 1.0); // set the range to 0.0 ... 1.0

        // interpolating the output color or alpha value
        dst = mix(mix(color1, color2, pNew.x), color3, pNew.y);
    }
}
```

***Note:** If you use a shader fill when rendering under the graphics processing unit (GPU), the filled area will be colored cyan.*

For more information about drawing shapes using the drawing api, see "Using the drawing API" on page 222.

Using a shader as a blend mode

Flash Player 10 and later, Adobe AIR 1.5 and later

Using a shader as a blend mode is like using other blend modes. The shader defines the appearance resulting from two display objects being blended together visually. To use a shader as a blend mode, assign your Shader object to the `blendShader` property of the foreground display object. Assigning a value other than `null` to the `blendShader` property automatically sets the display object's `blendMode` property to `BlendMode.SHADER`. The following listing demonstrates using a shader as a blend mode. Note that this example assumes that there is a display object named `foreground` contained in the same parent on the display list as other display content, with `foreground` overlapping the other content:

```
foreground.blendShader = myShader;
```

When you use a shader as a blend mode, the shader must be defined with at least two inputs. As the example shows, you do not set the input values in your code. Instead, the two blended images are automatically used as shader inputs. The foreground image is set as the second image. (This is the display object to which the blend mode is applied.) A background image is created by taking the composite of all the pixels behind the foreground image's bounding box. This background image is set as the first input image. If you use a shader that expects more than two inputs, you provide a value for any input beyond the first two.

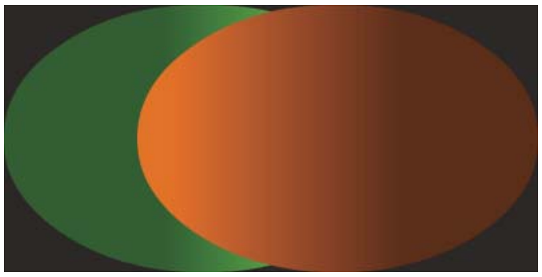
The following example demonstrates using a shader as a blend mode. This example uses a lighten blend mode based on luminosity. The result of the blend is that the lightest pixel value from either of the blended objects becomes the pixel that's displayed.

Note: *The code for this example was written by Mario Klingemann. Thank you Mario for sharing this example. You can see more of Mario's work and read his writing at www.quasimondo.com/.*

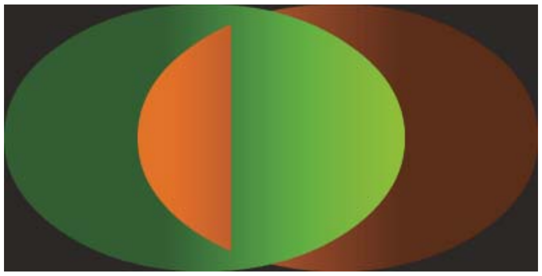
The important ActionScript code is in these two methods:

- `init()`: The `init()` method is called when the application loads. In this method the code loads the shader bytecode file.
- `onLoadComplete()`: In the `onLoadComplete()` method the code creates the Shader object named `shader`. It then draws three objects. The first, `backdrop`, is a dark gray background behind the blended objects. The second, `backgroundShape`, is a green gradient ellipse. The third object, `foregroundShape`, is an orange gradient ellipse.

  The `foregroundShape` ellipse is the foreground object of the blend. The background image of the blend is formed by the part of `backdrop` and the part of `backgroundShape` that are overlapped by the `foregroundShape` object's bounding box. The `foregroundShape` object is the front-most object in the display list. It partially overlaps `backgroundShape` and completely overlaps `backdrop`. Because of this overlap, without a blend mode applied, the orange ellipse (`foregroundShape`) shows completely and part of the green ellipse (`backgroundShape`) is hidden by it:

  However, with the blend mode applied, the brighter part of the green ellipse "shows through" because it is lighter than the portion of `foregroundShape` that overlaps it:

The following is the ActionScript code for this example. Use this class as the main application class for an ActionScript-only project in Flash Builder, or as the document class for the FLA file in Flash Professional:

```
package
{
    import flash.display.BlendMode;
    import flash.display.GradientType;
    import flash.display.Graphics;
    import flash.display.Shader;
    import flash.display.Shape;
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.geom.Matrix;
    import flash.net.URLLoader;
    import flash.net.URLLoaderDataFormat;
    import flash.net.URLRequest;

    public class LumaLighten extends Sprite
    {
        private var shader:Shader;
        private var loader:URLLoader;

        public function LumaLighten()
        {
            init();
        }

        private function init():void
        {
            loader = new URLLoader();
            loader.dataFormat = URLLoaderDataFormat.BINARY;
            loader.addEventListener(Event.COMPLETE, onLoadComplete);
            loader.load(new URLRequest("LumaLighten.pbj"));
        }


        private function onLoadComplete(event:Event):void
        {
            shader = new Shader(loader.data);

            var backdrop:Shape = new Shape();
            var g0:Graphics = backdrop.graphics;
            g0.beginFill(0x303030);
            g0.drawRect(0, 0, 400, 200);
            g0.endFill();
            addChild(backdrop);

            var backgroundShape:Shape = new Shape();
            var g1:Graphics = backgroundShape.graphics;
            var c1:Array = [0x336600, 0x80ff00];
            var a1:Array = [255, 255];
            var r1:Array = [100, 255];
            var m1:Matrix = new Matrix();
            m1.createGradientBox(300, 200);
            g1.beginGradientFill(GradientType.LINEAR, c1, a1, r1, m1);
            g1.drawEllipse(0, 0, 300, 200);
            g1.endFill();
            addChild(backgroundShape);

            var foregroundShape:Shape = new Shape();
            var g2:Graphics = foregroundShape.graphics;
            var c2:Array = [0xff8000, 0x663300];
            var a2:Array = [255, 255];
            var r2:Array = [100, 255];
            var m2:Matrix = new Matrix();
            m2.createGradientBox(300, 200);
            g2.beginGradientFill(GradientType.LINEAR, c2, a2, r2, m2);
            g2.drawEllipse(100, 0, 300, 200);
            g2.endFill();
            addChild(foregroundShape);

            foregroundShape.blendShader = shader;
            foregroundShape.blendMode = BlendMode.SHADER;
        }
    }
}
```

The following is the source code for the LumaLighten shader kernel, used to create the "LumaLighten.pbj" Pixel Bender bytecode file:

```
<languageVersion : 1.0;>
kernel LumaLighten
<
    namespace : "com.quasimondo.blendModes";
    vendor : "Quasimondo.com";
    version : 1;
    description : "Luminance based lighten blend mode";
>
{
    input image4 background;
    input image4 foreground;

    output pixel4 dst;

    const float3 LUMA = float3(0.212671, 0.715160, 0.072169);

    void evaluatePixel()
    {
        float4 a = sampleNearest(foreground, outCoord());
        float4 b = sampleNearest(background, outCoord());
        float luma_a = a.r * LUMA.r + a.g * LUMA.g + a.b * LUMA.b;
        float luma_b = b.r * LUMA.r + b.g * LUMA.g + b.b * LUMA.b;

        dst = luma_a > luma_b ? a : b;
    }
}
```

For more information on using blend modes, see "Applying blending modes" on page 186.

***Note:** When a Pixel Bender shader program is run as a blend in Flash Player or AIR, the sampling and* `outCoord()` *functions behave differently than in other contexts.In a blend, a sampling function will always return the current pixel being evaluated by the shader. You cannot, for example, use add an offset to* `outCoord()` *in order to sample a neighboring pixel. Likewise, if you use the* `outCoord()` *function outside a sampling function, its coordinates always evaluate to 0. You cannot, for example, use the position of a pixel to influence how the blended images are combined.*

Using a shader as a filter

Flash Player 10 and later, Adobe AIR 1.5 and later

Using a shader as a filter is like using any of the other filters in ActionScript. When you use a shader as a filter, the filtered image (a display object or BitmapData object) is passed to the shader. The shader uses the input image to create the filter output, which is usually a modified version of the original image. If the filtered object is a display object the shader's output is displayed on the screen in place of the filtered display object. If the filtered object is a BitmapData object, the shader's output becomes the content of the BitmapData object whose `applyFilter()` method is called.

To use a shader as a filter, you first create the Shader object as described in "Loading or embedding a shader" on page 302. Next you create a ShaderFilter object linked to the Shader object. The ShaderFilter object is the filter that is applied to the filtered object. You apply it to an object in the same way that you apply any filter. You pass it to the `filters` property of a display object or you call the `applyFilter()` method on a BitmapData object. For example, the following code creates a ShaderFilter object and applies the filter to a display object named `homeButton`.

```
var myFilter:ShaderFilter = new ShaderFilter(myShader);
homeButton.filters = [myFilter];
```

When you use a shader as a filter, the shader must be defined with at least one input. As the example shows, you do not set the input value in your code. Instead, the filtered display object or BitmapData object is set as the input image. If you use a shader that expects more than one input, you provide a value for any input beyond the first one.

In some cases, a filter changes the dimensions of the original image. For example, a typical drop shadow effect adds extra pixels containing the shadow that's added to the image. When you use a shader that changes the image dimensions, set the `leftExtension`, `rightExtension`, `topExtension`, and `bottomExtension` properties to indicate by how much you want the image size to change.

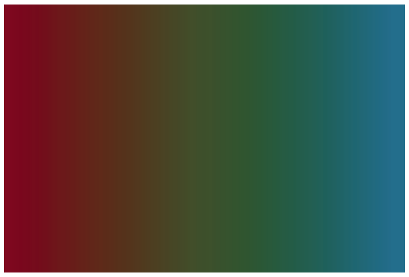
The following example demonstrates using a shader as a filter. The filter in this example inverts the red, green, and blue channel values of an image. The result is the "negative" version of the image.

***Note:** The shader that this example uses is the invertRGB.pbk Pixel Bender kernel that is included with the Pixel Bender Toolkit. You can load the source code for the kernel from the Pixel Bender Toolkit installation directory. Compile the source code and save the bytecode file in the same directory as the source code.*

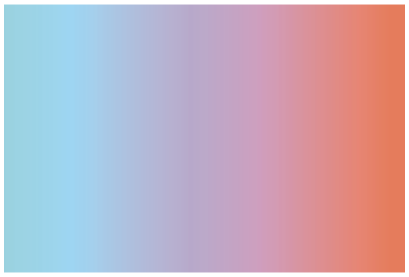
The important ActionScript code is in these two methods:

- `init()`: The `init()` method is called when the application loads. In this method the code loads the shader bytecode file.

- `onLoadComplete()`: In the `onLoadComplete()` method the code creates the Shader object named `shader`. It then creates and draws the contents of an object named `target`. The `target` object is a rectangle filled with a linear gradient color that is red on the left, yellow-green in the middle, and light blue on the right. The unfiltered object looks like this:

  With the filter applied the colors are inverted, making the rectangle look like this:

The shader that this example uses is the "invertRGB.pbk" sample Pixel Bender kernel that is included with the Pixel Bender Toolkit. The source code is available in the file "invertRGB.pbk" in the Pixel Bender Toolkit installation directory. Compile the source code and save the bytecode file with the name "invertRGB.pbj" in the same directory as your ActionScript source code.

The following is the ActionScript code for this example. Use this class as the main application class for an ActionScript-only project in Flash Builder, or as the document class for the FLA file in Flash Professional:

```
package
{
    import flash.display.GradientType;
    import flash.display.Graphics;
    import flash.display.Shader;
    import flash.display.Shape;
    import flash.display.Sprite;
    import flash.filters.ShaderFilter;
    import flash.events.Event;
    import flash.geom.Matrix;
    import flash.net.URLLoader;
    import flash.net.URLLoaderDataFormat;
    import flash.net.URLRequest;

    public class InvertRGB extends Sprite
    {
        private var shader:Shader;
        private var loader:URLLoader;

        public function InvertRGB()
        {
            init();
        }

        private function init():void
        {
            loader = new URLLoader();
            loader.dataFormat = URLLoaderDataFormat.BINARY;
            loader.addEventListener(Event.COMPLETE, onLoadComplete);
            loader.load(new URLRequest("invertRGB.pbj"));
        }


        private function onLoadComplete(event:Event):void
        {
            shader = new Shader(loader.data);

            var target:Shape = new Shape();
            addChild(target);

            var g:Graphics = target.graphics;
            var c:Array = [0x990000, 0x445500, 0x007799];
            var a:Array = [255, 255, 255];
            var r:Array = [0, 127, 255];
            var m:Matrix = new Matrix();
            m.createGradientBox(w, h);
            g.beginGradientFill(GradientType.LINEAR, c, a, r, m);
            g.drawRect(10, 10, w, h);
            g.endFill();

            var invertFilter:ShaderFilter = new ShaderFilter(shader);
            target.filters = [invertFilter];
        }
    }
}
```

For more information on applying filters, see "Creating and applying filters" on page 268.

Using a shader in stand-alone mode

Flash Player 10 and later, Adobe AIR 1.5 and later

When you use a shader in stand-alone mode, the shader processing runs independent of how you intend to use the output. You specify a shader to execute, set input and parameter values, and designate an object into which the result data is placed. You can use a shader in stand-alone mode for two reasons:

- Processing non-image data: In stand-alone mode, you can choose to pass arbitrary binary or number data to the shader rather than bitmap image data. You can choose to have the shader result be returned as binary data or number data in addition to bitmap image data.
- Background processing: When you run a shader in stand-alone mode, by default the shader executes asynchronously. This means that the shader runs in the background while your application continues to run, and your code is notified when the shader processing finishes. You can use a shader that takes a long time to run and it doesn't freeze up the application user interface or other processing while the shader is running.

You use a ShaderJob object to execute a shader in stand-alone mode. First you create the ShaderJob object and link it to the Shader object representing the shader to execute:

```
var job:ShaderJob = new ShaderJob(myShader);
```

Next, you set any input or parameter values that the shader expects. If you are executing the shader in the background, you also register a listener for the ShaderJob object's `complete` event. Your listener is called when the shader finishes its work:

```
function completeHandler(event:ShaderEvent):void
{
    // do something with the shader result
}

job.addEventListener(ShaderEvent.COMPLETE, completeHandler);
```

Next, you create an object into which the shader operation result is written when the operation finishes. You assign that object to the ShaderJob object's `target` property:

```
var jobResult:BitmapData = new BitmapData(100, 75);
job.target = jobResult;
```

Assign a BitmapData instance to the `target` property if you are using the ShaderJob to perform image processing. If you are processing binary or number data, assign a ByteArray object or Vector.<Number> instance to the `target` property. In that case, you must set the ShaderJob object's `width` and `height` properties to specify the amount of data to output to the `target` object.

***Note:** You can set the ShaderJob object's `shader`, `target`, `width`, and `height` properties in one step by passing arguments to the `ShaderJob()` constructor, like this: `var job:ShaderJob = new ShaderJob(myShader, myTarget, myWidth, myHeight);`*

When you are ready to execute the shader, you call the ShaderJob object's `start()` method:

```
job.start();
```

By default calling `start()` causes the ShaderJob to execute asynchronously. In that case program execution continues immediately with the next line of code rather than waiting for the shader to finish. When the shader operation finishes, the ShaderJob object calls its `complete` event listeners, notifying them that it is done. At that point (that is, in the body of your `complete` event listener) the `target` object contains the shader operation result.

***Note:** Instead of using the `target` property object, you can retrieve the shader result directly from the event object that's passed to your listener method. The event object is a ShaderEvent instance. The ShaderEvent object has three properties that can be used to access the result, depending on the data type of the object you set as the `target` property: `ShaderEvent.bitmapData`, `ShaderEvent.byteArray`, and `ShaderEvent.vector`.*

Alternatively, you can pass a `true` argument to the `start()` method. In that case the shader operation executes synchronously. All code (including interaction with the user interface and any other events) pauses while the shader executes. When the shader finishes, the `target` object contains the shader result and the program continues with the next line of code.

```
job.start(true);
```

Chapter 16: Working with movie clips

Flash Player 9 and later, Adobe AIR 1.0 and later

The MovieClip class is the core class for animation and movie clip symbols that you create in your Adobe® Flash® development environment. It has all the behaviors and functionality of display objects, but with additional properties and methods for controlling its timeline.

Basics of movie clips

Flash Player 9 and later, Adobe AIR 1.0 and later

Movie clips are a key element for people who create animated content with the Flash authoring tool and want to control that content with ActionScript. Whenever you create a movie clip symbol in Flash, Flash adds the symbol to the library of that Flash document. By default, this symbol becomes an instance of the MovieClip class, and as such has the properties and methods of the MovieClip class.

When an instance of a movie clip symbol is placed on the Stage, the movie clip automatically progresses through its timeline (if it has more than one frame) unless its playback is altered using ActionScript. It is this timeline that distinguishes the MovieClip class, allowing you to create animation through motion or shape tweens through the Flash authoring tool. By contrast, with a display object that is an instance of the Sprite class, you can create animation only by programmatically changing the object's values.

In previous versions of ActionScript, the MovieClip class was the base class of all instances on the Stage. In ActionScript 3.0, a movie clip is only one of many display objects that can appear on the screen. If a timeline is not necessary for the function of a display object, using the Shape class or Sprite class in lieu of the MovieClip class may improve rendering performance. For more information on choosing the appropriate display object for a task, see "Choosing a DisplayObject subclass" on page 172.

Important concepts and terms

The following reference list contains important terms related to movie clips:

AVM1 SWF A SWF file created using ActionScript 1.0 or ActionScript 2.0, usually targeting Flash Player 8 or earlier.

AVM2 SWF A SWF file created using ActionScript 3.0 for Adobe Flash Player 9 or later or Adobe AIR.

External SWF A SWF file that is created separately from the project SWF file and is intended to be loaded into the project SWF file and played back within that SWF file.

Frame The smallest division of time on the timeline. As with a motion picture filmstrip, each frame is like a snapshot of the animation in time, and when frames are played quickly in sequence, the effect of animation is created.

Timeline The metaphorical representation of the series of frames that make up a movie clip's animation sequence. The timeline of a MovieClip object is equivalent to the timeline in the Flash authoring tool.

Playhead A marker identifying the location (frame) in the timeline that is being displayed at a given moment.

Working with MovieClip objects

Flash Player 9 and later, Adobe AIR 1.0 and later

When you publish a SWF file, Flash converts all movie clip symbol instances on the Stage to MovieClip objects. You can make a movie clip symbol available to ActionScript by giving it an instance name in the Instance Name field of the Property inspector. When the SWF file is created, Flash generates the code that creates the MovieClip instance on the Stage and declares a variable using the instance name. If you have named movie clips that are nested inside other named movie clips, those child movie clips are treated like properties of the parent movie clip—you can access the child movie clip using dot syntax. For example, if a movie clip with the instance name `childClip` is nested within another clip with the instance name `parentClip`, you can make the child clip's timeline animation play by calling this code:

```
parentClip.childClip.play();
```

Note: *: Children instances placed on the Stage in the Flash authoring tool cannot be accessed by code from within the constructor of a parent instance since they have not been created at that point in code execution. Before accessing the child, the parent must instead either create the child instance by code or delay access to a callback function that listens for the child to dispatch its* `Event.ADDED_TO_STAGE` *event.*

While some legacy methods and properties of the ActionScript 2.0 MovieClip class remain the same, others have changed. All properties prefixed with an underscore have been renamed. For example, `_width` and `_height` properties are now accessed as `width` and `height`, while `_xscale` and `_yscale` are now accessed as `scaleX` and `scaleY`. For a complete list of the properties and methods of the MovieClip class, consult the ActionScript 3.0 Reference for the Adobe Flash Platform .

Controlling movie clip playback

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash uses the metaphor of a timeline to convey animation or a change in state. Any visual element that employs a timeline must be either a MovieClip object or extend from the MovieClip class. While ActionScript can direct any movie clip to stop, play, or go to another point on the timeline, it cannot be used to dynamically create a timeline or add content at specific frames; this is only possible using the Flash authoring tool.

When a MovieClip is playing, it progresses along its timeline at a speed dictated by the frame rate of the SWF file. Alternatively, you can override this setting by setting the `Stage.frameRate` property in ActionScript.

Playing movie clips and stopping playback

Flash Player 9 and later, Adobe AIR 1.0 and later

The `play()` and `stop()` methods allow basic control of a movie clip across its timeline. For example, suppose you have a movie clip symbol on the Stage which contains an animation of a bicycle moving across the screen, with its instance name set to `bicycle`. If the following code is attached to a keyframe on the main timeline,

```
bicycle.stop();
```

the bicycle will not move (its animation will not play). The bicycle's movement could start through some other user interaction. For example, if you had a button named `startButton`, the following code on a keyframe on the main timeline would make it so that clicking the button causes the animation to play:

```
// This function will be called when the button is clicked. It causes the
// bicycle animation to play.
function playAnimation(event:MouseEvent):void
{
    bicycle.play();
}
// Register the function as a listener with the button.
startButton.addEventListener(MouseEvent.CLICK, playAnimation);
```

Fast-forwarding and rewinding

Flash Player 9 and later, Adobe AIR 1.0 and later

The `play()` and `stop()` methods are not the only way of controlling playback in a movie clip. You can also move the playhead forward or backward along the timeline manually by using the `nextFrame()` and `prevFrame()` methods. Calling either of these methods stops playback and moves the playhead one frame forward or backward, respectively.

Using the `play()` method is analogous to calling `nextFrame()` every time the movie clip object's `enterFrame` event is triggered. Along these lines, you could make the `bicycle` movie clip play backwards by creating an event listener for the `enterFrame` event and telling `bicycle` to go to its previous frame in the listener function, as follows:

```
// This function is called when the enterFrame event is triggered, meaning
// it's called once per frame.
function everyFrame(event:Event):void
{
    if (bicycle.currentFrame == 1)
    {
        bicycle.gotoAndStop(bicycle.totalFrames);
    }
    else
    {
        bicycle.prevFrame();
    }
}
bicycle.addEventListener(Event.ENTER_FRAME, everyFrame);
```

In normal playback, if a movie clip contains more than a single frame, it will loop indefinitely when playing; that is, it will return to Frame 1 if it progresses past its final frame. When you use `prevFrame()` or `nextFrame()`, this behavior does not happen automatically (calling `prevFrame()` when the playhead is on Frame 1 doesn't move the playhead to the last frame). The `if` condition in the example above checks to see if the playhead has progressed backwards to the first frame, and sets the playhead ahead to its final frame, effectively creating a continuous loop of the movie clip playing backwards.

Jumping to a different frame and using frame labels

Flash Player 9 and later, Adobe AIR 1.0 and later

Sending a movie clip to a new frame is a simple affair. Calling either `gotoAndPlay()` or `gotoAndStop()` will jump the movie clip to the frame number specified as a parameter. Alternatively, you can pass a string that matches the name of a frame label. Any frame on the timeline can be assigned a label. To do this, select a frame on the timeline and then enter a name in the Frame Label field on the Property inspector.

The advantages of using frame labels instead of numbers are particularly evident when creating a complex movie clip. When the number of frames, layers, and tweens in an animation becomes large, consider labeling important frames with explanatory descriptions that represent shifts in the behavior of the movie clip (for example, "off," "walking," or "running"). This improves code readability and also provides flexibility, since ActionScript calls that go to a labeled frame are pointers to a single reference—the label—rather than a specific frame number. If later on you decide to move a particular segment of the animation to a different frame, you will not need to change your ActionScript code as long as you keep the same label for the frames in the new location.

To represent frame labels in code, ActionScript 3.0 includes the FrameLabel class. Each instance of this class represents a single frame label, and has a `name` property representing the name of the frame label as specified in the Property inspector, and a `frame` property representing the frame number of the frame where the label is placed on the timeline.

In order to get access to the FrameLabel instances associated with a movie clip instance, the MovieClip class includes two properties that directly return FrameLabel objects. The `currentLabels` property returns an array that consists of all FrameLabel objects across the entire timeline of a movie clip. The `currentLabel` property returns a string containing the name of the frame label encountered most recently along the timeline.

Suppose you were creating a movie clip named `robot` and had labeled the various states of its animation. You could set up a condition that checks the `currentLabel` property to access the current state of `robot`, as in the following code:

```
if (robot.currentLabel == "walking")
{
    // do something
}
```

Flash Player 11.3 and AIR 3.3 added the `frameLabel` event to the FrameLabel class. You can assign an event handler to the FrameLabel instance that represents a frame label. The event is dispatched when the playhead enters the frame.

The following example creates a FrameLabel instance for the second frame label in the Array of frame labels for the MovieClip. It then registers an event handler for the `frameLabel` event:

```
var myFrameLabel:FrameLabel = robot.currentLabels[1];
myFrameLabel.addEventListener(Event.FRAME_LABEL, onFrameLabel);

function onFrameLabel(e:Event):void {
    //do something
}
```

Working with scenes

Flash Player 9 and later, Adobe AIR 1.0 and later

In the Flash authoring environment, you can use scenes to demarcate a series of timelines that a SWF file will progress through. Using the second parameter of the `gotoAndPlay()` or `gotoAndStop()` methods, you can specify a scene to send the playhead to. All FLA files start with only the initial scene, but you can create new scenes.

Using scenes is not always the best approach because scenes have a number of drawbacks. A Flash document that contains multiple scenes can be difficult to maintain, particularly in multiauthor environments. Multiple scenes can also be inefficient in bandwidth, because the publishing process merges all scenes into a single timeline. This causes a progressive download of all scenes, even if they are never played. For these reasons, use of multiple scenes is often discouraged except for organizing lengthy multiple timeline-based animations.

The `scenes` property of the MovieClip class returns an array of Scene objects representing all the scenes in the SWF file. The `currentScene` property returns a Scene object that represents the scene that is currently playing.

The Scene class has several properties that give information about a scene. The `labels` property returns an array of FrameLabel objects representing the frame labels in that scene. The `name` property returns the scene's name as a string. The `numFrames` property returns an int representing the total number of frames in the scene.

Creating MovieClip objects with ActionScript

Flash Player 9 and later, Adobe AIR 1.0 and later

One way of adding content to the screen in Flash is by dragging assets from the library onto the Stage, but that is not the only workflow. For complex projects, experienced developers commonly prefer to create movie clips programatically. This approach brings several advantages: easier re-use of code, faster compile-time speed, and more sophisticated modifications that are available only to ActionScript.

The display list API of ActionScript 3.0 streamlines the process of dynamically creating MovieClip objects. The ability to instantiate a MovieClip instance directly, separate from the process of adding it to the display list, provides flexibility and simplicity without sacrificing control.

In ActionScript 3.0, when you create a movie clip (or any other display object) instance programatically, it is not visible on the screen until it is added to the display list by calling the `addChild()` or the `addChildAt()` method on a display object container. This allows you to create a movie clip, set its properties, and even call methods before it is rendered to the screen. For more information on working with the display list, see "Working with display object containers" on page 159.

Exporting library symbols for ActionScript

Flash Player 9 and later, Adobe AIR 1.0 and later

By default, instances of movie clip symbols in a Flash document's library cannot be dynamically created (that is, created using only ActionScript). This is because each symbol that is exported for use in ActionScript adds to the size of your SWF file, and it's recognized that some symbols might not be intended for use on the stage. For this reason, in order to make a symbol available in ActionScript, you must specify that the symbol should be exported for ActionScript.

To export a symbol for ActionScript:

1 Select the symbol in the Library panel and open its Symbol Properties dialog box.

2 If necessary, activate the Advanced settings.

3 In the Linkage section, activate the Export for ActionScript checkbox.

   This will activate the Class and Base Class fields.

   By default, the Class field is populated with the symbol name, with spaces removed (for example, a symbol named "Tree House" would become "TreeHouse"). To specify that the symbol should use a custom class for its behavior, enter the full name of the class including its package in this field. If you want to be able to create instances of the symbol in ActionScript, but don't need to add any additional behavior, you can leave the class name as-is.

   The Base Class field's value defaults to `flash.display.MovieClip`. If you want your symbol to extend the functionality of another customer class, you can specify that class's name instead, as long as that class extends the Sprite (or MovieClip) class.

4 Press the OK button to save the changes.

At this point, if Flash can't find a linked SWC file or an external ActionScript file with a definition for the specified class (for instance, if you didn't need to add additional behavior for the symbol), a warning is displayed:

A definition for this class could not be found in the classpath, so one will be automatically generated in the SWF file upon export.

You can disregard this warning if your library symbol does not require unique functionality beyond the functionality of the MovieClip class.

If you do not provide a class for your symbol, Flash will create a class for your symbol equivalent to this one:

```
package
{
    import flash.display.MovieClip;

    public class ExampleMovieClip extends MovieClip
    {
        public function ExampleMovieClip()
        {
        }
    }
}
```

If you do want to add extra ActionScript functionality to your symbol, add the appropriate properties and methods to the code structure below. For example, suppose you have a movie clip symbol containing a circle of 50 pixels width and 50 pixels height, and the symbol is specified to be exported for ActionScript with a class named Circle. The following code, when placed in a Circle.as file, extends the MovieClip class and provides the symbol with the additional methods `getArea()` and `getCircumference()`:

```
package
{
    import flash.display.MovieClip;

    public class Circle extends MovieClip
    {
        public function Circle()
        {
        }

        public function getArea():Number
        {
        // The formula is Pi times the radius squared.
        return Math.PI * Math.pow((width / 2), 2);
        }

        public function getCircumference():Number
        {
        // The formula is Pi times the diameter.
        return Math.PI * width;
        }
    }
}
```

The following code, placed on a keyframe on Frame 1 of the Flash document, will create an instance of the symbol and display it on the screen:

```
var c:Circle = new Circle();
addChild(c);
trace(c.width);
trace(c.height);
trace(c.getArea());
trace(c.getCircumference());
```

This code demonstrates ActionScript-based instantiation as an alternative to dragging individual assets onto the Stage. It creates a circle that has all of the properties of a movie clip and also has the custom methods defined in the Circle class. This is a very basic example—your library symbol can specify any number of properties and methods in its class.

ActionScript-based instantiation is powerful, because it allows you to dynamically create large quantities of instances that would be tedious to arrange manually. It is also flexible, because you can customize each instance's properties as it is created. You can get a sense of both of these benefits by using a loop to dynamically create several Circle instances. With the Circle symbol and class described previously in your Flash document's library, place the following code on a keyframe on Frame 1:

```
import flash.geom.ColorTransform;

var totalCircles:uint = 10;
var i:uint;
for (i = 0; i < totalCircles; i++)
{
    // Create a new Circle instance.
    var c:Circle = new Circle();
    // Place the new Circle at an x coordinate that will space the circles
    // evenly across the Stage.
    c.x = (stage.stageWidth / totalCircles) * i;
    // Place the Circle instance at the vertical center of the Stage.
    c.y = stage.stageHeight / 2;
    // Change the Circle instance to a random color
    c.transform.colorTransform = getRandomColor();
    // Add the Circle instance to the current timeline.
    addChild(c);
}

function getRandomColor():ColorTransform
{
    // Generate random values for the red, green, and blue color channels.
    var red:Number = (Math.random() * 512) - 255;
    var green:Number = (Math.random() * 512) - 255;
    var blue:Number = (Math.random() * 512) - 255;

    // Create and return a ColorTransform object with the random colors.
    return new ColorTransform(1, 1, 1, 1, red, green, blue, 0);
}
```

This demonstrates how you can create and customize multiple instances of a symbol quickly using code. Each instance is positioned based on the current count within the loop, and each instance is given a random color by setting its `transform` property (which Circle inherits by extending the MovieClip class).

Loading an external SWF file

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 3.0, SWF files are loaded using the Loader class. To load an external SWF file, your ActionScript needs to do four things:

1 Create a new URLRequest object with the url of the file.

2 Create a new Loader object.

3 Call the Loader object's `load()` method, passing the URLRequest instance as a parameter.

4 Call the `addChild()` method on a display object container (such as the main timeline of a Flash document) to add the Loader instance to the display list.

Ultimately, the code looks like this:

```
var request:URLRequest = new URLRequest("http://www.[yourdomain].com/externalSwf.swf");
var loader:Loader = new Loader()
loader.load(request);
addChild(loader);
```

This same code can be used to load an external image file such as a JPEG, GIF, or PNG image, by specifying the image file's url rather than a SWF file's url. A SWF file, unlike an image file, may contain ActionScript. Thus, although the process of loading a SWF file may be identical to loading an image, when loading an external SWF file both the SWF file doing the loading and the SWF file being loaded must reside in the same security sandbox if Flash Player or AIR is playing the SWF and you plan to use ActionScript to communicate in any way to the external SWF file. Additionally, if the external SWF file contains classes that share the same namespace as classes in the loading SWF file, you may need to create a new application domain for the loaded SWF file in order to avoid namespace conflicts. For more information on security and application domain considerations, see "Working with application domains" on page 147 and "Loading content" on page 1060.

When the external SWF file is successfully loaded, it can be accessed through the `Loader.content` property. If the external SWF file is published for ActionScript 3.0, this will be either a movie clip or a sprite, depending on which class it extends.

There are a few differences for loading a SWF file in Adobe AIR for iOS versus other platforms. For more information, see "Loading SWF files in AIR for iOS" on page 201.

Considerations for loading an older SWF file

Flash Player 9 and later, Adobe AIR 1.0 and later

If the external SWF file has been published with an older version of ActionScript, there are important limitations to consider. Unlike an ActionScript 3.0 SWF file that runs in AVM2 (ActionScript Virtual Machine 2), a SWF file published for ActionScript 1.0 or 2.0 runs in AVM1 (ActionScript Virtual Machine 1).

There are important differences when loading an ActionScript 1.0 or 2.0 SWF file into an ActionScript 3.0 SWF file (compared to loading an ActionScript 3.0 SWF file). Flash Player provides full backward compatibility with previously published content. Any content that runs in previous versions of Flash Player runs in Flash Player versions that support ActionScript 3.0. However, the following limitations apply:

- ActionScript 3.0 code can load a SWF file written in ActionScript 1.0 or 2.0. When an ActionScript 1.0 or 2.0 SWF file is successfully loaded, the loaded object (the `Loader.content` property) is an AVM1Movie object. An AVM1Movie instance is not the same as a MovieClip instance. It is a display object, but unlike a movie clip, it does not include timeline-related methods or properties. The parent AVM2 SWF file cannot access the properties, methods, or objects of the loaded AVM1Movie object.
- SWF files written in ActionScript 1.0 or 2.0 cannot load SWF files written in ActionScript 3.0. This means that SWF files authored in Flash 8 or Flex Builder 1.5 or earlier versions cannot load ActionScript 3.0 SWF files.

  The only exception to this rule is that an ActionScript 2.0 SWF file can replace itself with an ActionScript 3.0 SWF file, as long as the ActionScript 2.0 SWF file hasn't previously loaded anything into any of its levels. An ActionScript 2.0 SWF file can do this through a call to `loadMovieNum()`, passing a value of 0 to the `level` parameter.
- In general, SWF files written in ActionScript 1.0 or 2.0 must be migrated if they are to work together with SWF files written in ActionScript 3.0. For example, suppose you created a media player using ActionScript 2.0. The media player loads various content that was also created using ActionScript 2.0. You cannot create new content in ActionScript 3.0 and load it in the media player. You must migrate the video player to ActionScript 3.0.

  If, however, you create a media player in ActionScript 3.0, that media player can perform simple loads of your ActionScript 2.0 content.

The following tables summarize the limitations of previous versions of Flash Player in relation to loading newer content and executing code, as well as the limitations for cross-scripting between SWF files written in different versions of ActionScript.

Supported functionality	**Flash Player 7**	**Flash Player 8**	**Flash Player 9 and 10**
Can load SWFs published for	7 and earlier	8 and earlier	9 (or 10) and earlier
Contains this AVM	AVM1	AVM1	AVM1 and AVM2
Runs SWFs written in ActionScript	1.0 and 2.0	1.0 and 2.0	1.0 and 2.0, and 3.0

In the following table, “Supported functionality” refers to content running in Flash Player 9 or later. Content running in Flash Player 8 or earlier can load, display, execute, and cross-script only ActionScript 1.0 and 2.0.

Supported functionality	**Content created in ActionScript 1.0 and 2.0**	**Content created in ActionScript 3.0**
Can load content and execute code in content created in	ActionScript 1.0 and 2.0 only	ActionScript 1.0 and 2.0, and ActionScript 3.0
Can cross script content created in	ActionScript 1.0 and 2.0 only (ActionScript 3.0 through Local Connection)	ActionScript 1.0 and 2.0 through LocalConnection. ActionScript 3.0

Movie clip example: RuntimeAssetsExplorer

Flash Player 9 and later, Adobe AIR 1.0 and later

The Export for ActionScript functionality can be especially advantageous for libraries that may be useful across more than one project. If Flash Player or AIR executes a SWF file, symbols that have been exported to ActionScript are available to any SWF file within the same security sandbox as the SWF that loads it. In this way, a single Flash document can generate a SWF file that is designated for the sole purpose of holding graphical assets. This technique is particularly useful for larger projects where designers working on visual assets can work in parallel with developers who create a "wrapper" SWF file that then loads the graphical assets SWF file at run time. You can use this method to maintain a series of versioned files where graphical assets are not dependent upon the progress of programming development.

The RuntimeAssetsExplorer application loads any SWF file that is a subclass of RuntimeAsset and allows you to browse the available assets of that SWF file. The example illustrates the following:

- Loading an external SWF file using `Loader.load()`
- Dynamic creation of a library symbol exported for ActionScript
- ActionScript control of MovieClip playback

Before beginning, note that each of the SWF files to run in Flash Player must be located in the same security sandbox. For more information, see "Security sandboxes" on page 1044.

To get the application files for this sample, download the Flash Professional Samples. The RuntimeAssetsExplorer application files can be found in the folder Samples/RuntimeAssetsExplorer. The application consists of the following files:

File	Description
RuntimeAssetsExample.mxml or RuntimeAssetsExample.fla	The user interface for the application for Flex (MXML) or Flash (FLA).
RuntimeAssetsExample.as	Document class for the Flash (FLA) application.
GeometricAssets.as	An example class that implements the RuntimeAsset interface.
GeometricAssets.fla	A FLA file linked to the GeometricAssets class (the document class of the FLA) containing symbols that are exported for ActionScript.
com/example/programmingas3/runtimeassetexplorer/RuntimeLibrary.as	An interface that defines the required methods expected of all run-time asset SWF files that will be loaded into the explorer container.
com/example/programmingas3/runtimeassetexplorer/AnimatingBox.as	The class of the library symbol in the shape of a rotating box.
com/example/programmingas3/runtimeassetexplorer/AnimatingStar.as	The class of the library symbol in the shape of a rotating star.

Establishing a run-time library interface

Flash Player 9 and later, Adobe AIR 1.0 and later

In order for the explorer to properly interact with a SWF library, the structure of the run-time asset libraries must be formalized. We will accomplish this by creating an interface, which is similar to a class in that it's a blueprint of methods that demarcate an expected structure, but unlike a class it includes no method bodies. The interface provides a way for both the run-time library and the explorer to communicate to one another. Each SWF of run-time assets that is loaded in our browser will implement this interface. For more information about interfaces and how they can be useful, see Interfaces in *Learning ActionScript 3.0*.

The RuntimeLibrary interface will be very simple—we merely require a function that can provide the explorer with an array of classpaths for the symbols to be exported and available in the run-time library. To this end, the interface has a single method: `getAssets()`.

```
package com.example.programmingas3.runtimeassetexplorer
{
    public interface RuntimeLibrary
    {
        function getAssets():Array;
    }
}
```

Creating the asset library SWF file

Flash Player 9 and later, Adobe AIR 1.0 and later

By defining the RuntimeLibrary interface, it's possible to create multiple asset library SWF files that can be loaded into another SWF file. Making an individual SWF library of assets involves four tasks:

- Creating a class for the asset library SWF file
- Creating classes for individual assets contained in the library
- Creating the actual graphic assets
- Associating graphic elements with classes and publishing the library SWF

Creating a class to implement the RuntimeLibrary interface

Next, we'll create the GeometricAssets class that will implement the RuntimeLibrary interface. This will be the document class of the FLA. The code for this class is very similar to the RuntimeLibrary interface—the difference between them is that in the class definition the `getAssets()` method has a method body.

```
package
{
    import flash.display.Sprite;
    import com.example.programmingas3.runtimeassetexplorer.RuntimeLibrary;

    public class GeometricAssets extends Sprite implements RuntimeLibrary
    {
        public function GeometricAssets() {

        }
        public function getAssets():Array {
            return [ "com.example.programmingas3.runtimeassetexplorer.AnimatingBox",
                     "com.example.programmingas3.runtimeassetexplorer.AnimatingStar" ];
        }
    }
}
```

If we were to create a second run-time library, we could create another FLA based upon another class (for example, AnimationAssets) that provides its own `getAssets()` implementation.

Creating classes for each MovieClip asset

For this example, we'll merely extend the MovieClip class without adding any functionality to the custom assets. The following code for AnimatingStar is analogous to that of AnimatingBox:

```
package com.example.programmingas3.runtimeassetexplorer
{
    import flash.display.MovieClip;

    public class AnimatingStar extends MovieClip
    {
        public function AnimatingStar() {
        }
    }
}
```

Publishing the library

We'll now connect the MovieClip-based assets to the new class by creating a new FLA and entering GeometricAssets into the Document Class field of the Property inspector. For the purposes of this example, we'll create two very basic shapes that use a timeline tween to make one clockwise rotation over 360 frames. Both the `animatingBox` and `animatingStar` symbols are set to Export for ActionScript and have the Class field set to the respective classpaths specified in the `getAssets()` implementation. The default base class of `flash.display.MovieClip` remains, as we want to subclass the standard MovieClip methods.

After setting up your symbol's export settings, publish the FLA. You now have your first run-time library. This SWF file could be loaded into another AVM2 SWF file and the AnimatingBox and AnimatingStar symbols would be available to the new SWF file.

Loading the library into another SWF file

Flash Player 9 and later, Adobe AIR 1.0 and later

The last functional piece to deal with is the user interface for the asset explorer. In this example, the path to the run-time library is hard-coded as a variable named `ASSETS_PATH`. Alternatively, you could use the FileReference class—for example, to create an interface that browses for a particular SWF file on your hard drive.

When the run-time library is successfully loaded, Flash Player calls the `runtimeAssetsLoadComplete()` method:

```
private function runtimeAssetsLoadComplete(event:Event):void
{
    var rl:* = event.target.content;
    var assetList:Array = rl.getAssets();
    populateDropdown(assetList);
    stage.frameRate = 60;
}
```

In this method, the variable rl represents the loaded SWF file. The code calls the `getAssets()` method of the loaded SWF file, obtaining the list of assets that are available, and uses them to populate a ComboBox component with a list of available assets by calling the `populateDropDown()` method. That method in turn stores the full classpath of each asset. Clicking the Add button on the user interface triggers the `addAsset()` method:

```
private function addAsset():void
{
    var className:String = assetNameCbo.selectedItem.data;
    var AssetClass:Class = getDefinitionByName(className) as Class;
    var mc:MovieClip = new AssetClass();
    ...
}
```

which gets the classpath of whichever asset is currently selected in the ComboBox (`assetNameCbo.selectedItem.data`), and uses the `getDefinitionByName()` function (from the flash.utils package) to obtain an actual reference to the asset's class in order to create a new instance of that asset.

Chapter 17: Working with motion tweens

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

"Animating objects" on page 192 describes how to implement scripted animation in ActionScript.

Here we describe a different technique for creating animation: motion tweens. This technique lets you create movement by setting up motion interactively in a document using Adobe® Flash® Professional. Then you can use that motion in your dynamic ActionScript-based animation at runtime.

Flash Professional automatically generates the ActionScript that implements the motion tween and makes it available for you to copy and reuse.

To create motion tweens, you must have a license for Flash Professional.

More Help topics

fl.motion package

Basics of Motion Tweens

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

Motion tweens provide an easy way to create animation.

A motion tween modifies display object properties, such as position or rotation, on a frame-to-frame basis. A motion tween can also change the appearance of a display object while it moves by applying various filters and other properties. You create the motion tween interactively with Flash Professional, which generates the ActionScript for the motion tween. From within Flash, use the Copy Motion as ActionScript 3.0 command to copy the ActionScript that created the motion tween. Then you can reuse the ActionScript to create movement in your own dynamic animation at runtime.

See the Motion Tweens section in *Using Flash Professional* for information about creating a motion tween.

Important concepts and terms

The following is an important term that is relevant to this feature:

Motion tween A construct that generates intermediate frames of a display object in different states at different times; gives the appearance that the first state evolves smoothly into the second. Used to move a display object across the stage, as well as make it grow, shrink, rotate, fade, or change color over time.

Copying motion tween scripts in Flash

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

A tween generates intermediate frames that show a display object in different states in two different frames on a timeline. It creates the appearance that the image in the first frame evolves smoothly into the image in the second. In a motion tween, the change in appearance typically involves changing the position of the display object, thus creating movement. In addition to repositioning the display object, a motion tween can also rotate, skew, resize, or apply filters to it.

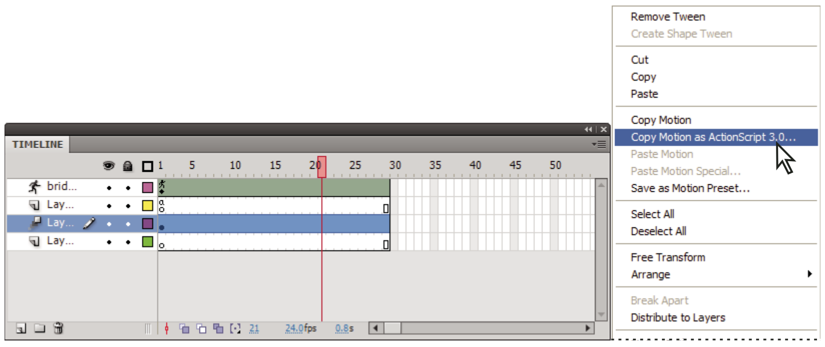
Create a motion tween in Flash by moving a display object between keyframes along the timeline. Flash automatically generates the ActionScript code that describes the tween, which you can copy and save in a file. See the Motion Tweens section in *Using Flash Professional* for information about creating a motion tween.

You can access the Copy Motion as ActionScript 3.0 command in Flash two ways. The first way is from a tween context menu on the stage:

1 Select the motion tween on the stage.

2 Right-click (Windows) or Control-click (Macintosh).

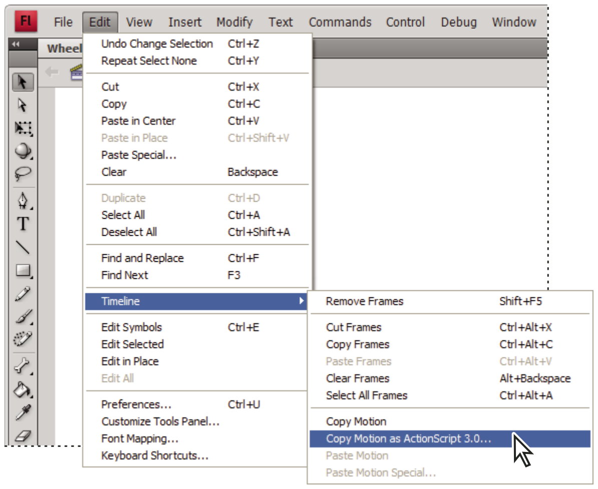
3 Choose Copy Motion as ActionScript 3.0 . . .



The second way is to choose the command directly from the Flash Edit menu:

1 Select the motion tween on the stage.

2 Select Edit > Timeline >Copy Motion as ActionScript 3.0.



After copying the script, paste it into a file and save it.

After creating a motion tween and copying and saving the script, you can reuse it as is or modify it in your own dynamic ActionScript-based animation.

Incorporating motion tween scripts

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

The header in the ActionScript code that you copy from Flash lists all the modules required to support the motion tween.

Motion tween classes

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

The essential motion tween classes are the AnimatorFactory, MotionBase, and Motion classes from the `fl.motion` package. You could need additional classes, depending on the properties that the motion tween manipulates. For example, if the motion tween transforms or rotates the display object, import the appropriate `flash.geom` classes. If it applies filters, import the `flash.filter` classes. In ActionScript, a motion tween is an instance of the Motion class. The Motion class stores a keyframe animation sequence that can be applied to a visual object. The animation data includes position, scale, rotation, skew, color, filters, and easing.

The following ActionScript was copied from a motion tween that was created in Flash to animate a display object whose instance name is `Symbol1_2`. It declares a variable for a MotionBase object named `__motion_Symbol1_2`. The MotionBase class is the parent of the Motion class.

```
var __motion_Symbol1_2:MotionBase;
```

Then the script creates the Motion object:

```
__motion_Symbol1_2 = new Motion();
```

Motion object names

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

In the previous case, Flash automatically generated the name `__motion_Symbol1_2` for the Motion object. It attached the prefix `__motion_` to the display object name. Thus, the automatically generated name is based on the instance name of the target object of the motion tween in Flash. The `duration` property of the Motion object indicates the total number of frames in the motion tween:

```
__motion_Symbol1_2.duration = 200;
```

By default, Flash automatically names the display object instance whose motion tween is copied, if it does not already have an instance name.

When you reuse ActionScript created by Flash in your own animation, you can keep the name that Flash automatically generates for the tween or you can substitute a different name. If you change the tween name, make sure that you change it throughout the script.

Alternately, in Flash you can assign a name of your choosing to the target object of the motion tween. Then create the motion tween and copy the script. Whichever naming approach you use, make sure that each Motion object in your ActionScript code has a unique name.

Describing the animation

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

The `addPropertyArray()` method of the MotionBase class adds an array of values to describe every tweened property.

Potentially the array contains one array item for every keyframe in the motion tween. Often some of these arrays contain fewer items than the total number of keyframes in the motion tween. This situation occurs when the last value in the array does not change for the remaining frames.

If the length of the array argument is greater than the `duration` property of the Motion object, `addPropertyArray()` adjusts the value of the `duration` property accordingly. It does not add keyframes for the properties that were previously added. The newly added keyframes persist for the extra frames of the animation.

The `x` and `y` properties of the Motion object describe the changing position of the tweened object as the animation is running. These coordinates are the values that are most likely to change in every keyframe, if the position of the display object changes. You can add additional motion properties with the `addPropertyArray()` method. For example, add the `scaleX` and `scaleY` values if the tweened object is resized. Add the `scewX` and `skewY` values if it is skewed. Add the `rotationConcat` property if it rotates.

Use the `addPropertyArray()` method to define the following tween properties:

`x`	horizontal position of the transformation point of the object in the coordinate space of its parent
`y`	vertical position of the transformation point of the object in the coordinate space of its parent
`z`	depth (z-axis) position of the transformation point of the object in the coordinate space of its parent
`scaleX`	horizontal scale as a percentage of the object as applied from the transformation point
`scaleY`	vertical scale as a percentage of the object as applied from the transformation point

`skewX`	horizontal skew angle of the object in degrees as applied from the transformation point
`skewY`	vertical skew angle of the object in degrees as applied from the transformation point
`rotationX`	rotation of the object around the x-axis from its original orientation
`rotationY`	rotation of the object around the y-axis from its original orientation
`rotationConcat`	rotation (z-axis) values of the object in the motion relative to previous orientation as applied from the transformation point
`useRotationConcat`	If set, causes the target object to rotate when `addPropertyArray()` supplies data for motion
`blendMode`	BlendMode class value specifying mixture the colors of the object with graphics underneath
`matrix3D`	matrix3D property if one exists for the keyframe; used for 3D tweens; if used, all the previous transform properties are ignored
`rotationZ`	z-axis rotation of the object, in degrees, from its original orientation relative to the 3D parent container; used for 3D tweens instead of rotationConcat

The properties that are added in the automatically generated script depend on the properties that were assigned to the motion tween in Flash. You can add, remove, or modify some of these properties when customizing your own version of the script.

The following code assigns values to the properties of a motion tween named `__motion_Wheel`. In this case, the tweened display object does not change location but rather spins in place throughout the 29 frames in the motion tween. The multiple values assigned to the `rotationConcat` array define the rotation. The other property values of this motion tween do not change.

```
__motion_Wheel = new Motion();
__motion_Wheel.duration = 29;
__motion_Wheel.addPropertyArray("x", [0]);
__motion_Wheel.addPropertyArray("y", [0]);
__motion_Wheel.addPropertyArray("scaleX", [1.00]);
__motion_Wheel.addPropertyArray("scaleY", [1.00]);
__motion_Wheel.addPropertyArray("skewX", [0]);
__motion_Wheel.addPropertyArray("skewY", [0]);
__motion_Wheel.addPropertyArray("rotationConcat",
    [
        0,-13.2143,-26.4285,-39.6428,-52.8571,-66.0714,-79.2857,-92.4999,-105.714,
        -118.929,-132.143,-145.357,-158.571,-171.786,-185,-198.214,-211.429,-224.643,
        -237.857,-251.071,-264.286,-277.5,-290.714,-303.929,-317.143,-330.357,
        -343.571,-356.786,-370
    ]
);
__motion_Wheel.addPropertyArray("blendMode", ["normal"]);
```

In the next example, the display object named `Leaf_1` moves across the stage. Its `x` and `y` property arrays contain different values for each of the 100 frames of the animation. In addition, the object rotates on its `z` axis as it moves across the stage. The multiple items in the `rotationZ` property array determine the rotation.

```
__motion_Leaf_1 = new MotionBase();
__motion_Leaf_1.duration = 100;
__motion_Symbol1_4.addPropertyArray("y",
    [
        0,5.91999,11.84,17.76,23.68,29.6,35.52,41.44,47.36,53.28,59.2,65.12,71.04,
        76.96,82.88,88.8,94.72,100.64,106.56,112.48,118.4,124.32,130.24,136.16,142.08,
        148,150.455,152.909,155.364,157.818,160.273,162.727,165.182,167.636,170.091,
        172.545,175,177.455,179.909,182.364,184.818,187.273,189.727,192.182,194.636,
        197.091,199.545,202,207.433,212.865,218.298,223.73,229.163,234.596,240.028,
        245.461,250.893,256.326,261.759,267.191,272.624,278.057,283.489,
        288.922,294.354,299.787,305.22,310.652,316.085,321.517,326.95,330.475,334,
        337.525,341.05,344.575,348.1,351.625,355.15,358.675,362.2,365.725,369.25,
        372.775,376.3,379.825,383.35,386.875,390.4,393.925,397.45,400.975,404.5,
        407.5,410.5,413.5,416.5,419.5,422.5,425.5
    ]
);
__motion_Symbol1_4.addPropertyArray("scaleX", [1.00]);
__motion_Symbol1_4.addPropertyArray("scaleY", [1.00]);
__motion_Symbol1_4.addPropertyArray("skewX", [0]);
__motion_Symbol1_4.addPropertyArray("skewY", [0]);
__motion_Symbol1_4.addPropertyArray("z",
    [
        0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
        0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
        0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
    ]
);
__motion_Symbol1_4.addPropertyArray("rotationX", [64.0361]);
__motion_Symbol1_4.addPropertyArray("rotationY", [41.9578]);
__motion_Symbol1_4.addPropertyArray("rotationZ",
    [
        -18.0336,-17.5536,-17.0736,-16.5936,-16.1136,-15.6336,-15.1536,-14.6736,
        -14.1936,-13.7136,-13.2336,-12.7536,-12.2736,-11.7936,-11.3136,-10.8336,
        -10.3536,-9.8736,-9.3936,-8.9136,-8.4336,-7.9536,-7.4736,-6.9936,-6.5136,
        -6.0336,-7.21542,-8.39723,-9.57905,-10.7609,-11.9427,-13.1245,-14.3063,
        -15.4881,-16.67,-17.8518,-19.0336,-20.2154,-21.3972,-22.5791,-23.7609,
        -24.9427,-26.1245,-27.3063,-28.4881,-29.67,-30.8518,-32.0336,-31.0771,
        -30.1206,-29.164,-28.2075,-27.251,-26.2945,-25.338,-24.3814,-23.4249,
        -22.4684,-21.5119,-20.5553,-19.5988,-18.6423,-17.6858,-16.7293,-15.7727
        -14.8162,-13.8597,-12.9032,-11.9466,-10.9901,-10.0336,-10.9427,-11.8518,
        -12.7609,-13.67,-14.5791,-15.4881,-16.3972,-17.3063,-18.2154,-19.1245,
        -20.0336,-20.9427,-21.8518,-22.7609,-23.67,-24.5791,-25.4881,-26.3972,
        -27.3063,-28.2154,-29.1245,-30.0336,-28.3193,-26.605,-24.8907,-23.1765,
        -21.4622,-19.7479,-18.0336
    ]
);
__motion_Symbol1_4.addPropertyArray("blendMode", ["normal"]);
```

Adding filters

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

If the target object of a motion tween contains filters, those filters are added using the `initFilters()` and `addFilterPropertyArray()` methods of the Motion class.

Initializing the filters array

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

The `initFilters()` method initializes the filters. Its first argument is an array of the fully qualified class names of all the filters applied to the display object. This array of filter names is generated from the filters list for the motion tween in Flash. In your copy of the script, you can remove or add any of the filters in the `flash.filters` package to this array. The following call initializes the filters list for the target display object. It applies the `DropShadowFilter`, `GlowFilter`, and `BevelFilter` and copies the list to each keyframe in the Motion object.

```
__motion_Box.initFilters(["flash.filters.DropShadowFilter", "flash.filters.GlowFilter",
"flash.filters.BevelFilter"], [0, 0, 0]);
```

Adding filters

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

The `addFilterPropertyArray()` method describes the properties of an initialized filter with the following arguments:

1 Its first argument identifies a filter by index. The index refers to the position of the filter name in the filter class names array passed in a previous call to `initFilters()`.
2 Its second argument is the filter property to store for that filter in each keyframe.
3 Its third argument is the value of the specified filter property.

Given the previous call to `initFilters()`, the following calls to `addFilterPropertyArray()` assign a value of 5 to the `blurX` and `blurY` properties of the `DropShadowFilter`. The `DropShadowFilter` is the first (index 0) item in the initialized filters array:

```
__motion_Box.addFilterPropertyArray(0, "blurX", [5]);
__motion_Box.addFilterPropertyArray(0, "blurY", [5]);
```

The next three calls assign values to the quality, alpha, and color properties of the `GlowFilter,` the second item (index 1) in the initialized filter array:

```
__motion_Box.addFilterPropertyArray(1, "quality", [BitmapFilterQuality.LOW]);
__motion_Box.addFilterPropertyArray(1, "alpha", [1.00]);
__motion_Box.addFilterPropertyArray(1, "color", [0xff0000]);
```

The next four calls assign values to the `shadowAlpha`, `shadowColor`, `highlightAlpha`, and `highlightColor` of the `BevelFilter`, the third (index 2) item in the initialized filters array:

```
__motion_Box.addFilterPropertyArray(2, "shadowAlpha", [1.00]);
__motion_Box.addFilterPropertyArray(2, "shadowColor", [0x000000]);
__motion_Box.addFilterPropertyArray(2, "highlightAlpha", [1.00]);
__motion_Box.addFilterPropertyArray(2, "highlightColor", [0xffffff]);
```

Adjusting color with the ColorMatrixFilter

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

After the `ColorMatrixFilter` has been initialized, you can set the appropriate `AdjustColor` properties to adjust the brightness, contrast, saturation, and hue of the tweened display object. Typically, the `AdjustColor` filter is applied when the motion tween is created in Flash; you can fine-tune it in your copy of the ActionScript. The following example transforms the hue and saturation of the display object as it moves.

```
__motion_Leaf_1.initFilters(["flash.filters.ColorMatrix"], [0], -1, -1);
__motion_Leaf_1.addFilterPropertyArray(0, "adjustColorBrightness", [0], -1, -1);
__motion_Leaf_1.addFilterPropertyArray(0, "adjustColorContrast", [0], -1, -1);
__motion_Leaf_1.addFilterPropertyArray(0, "adjustColorSaturation",
    [
        0,-0.589039,1.17808,-1.76712,-2.35616,-2.9452,-3.53424,-4.12328,
        -4.71232,-5.30136,-5.89041, 6.47945,-7.06849,-7.65753,-8.24657,
        -8.83561,-9.42465,-10.0137,-10.6027,-11.1918,11.7808,-12.3699,
        -12.9589,-13.5479,-14.137,-14.726,-15.3151,-15.9041,-16.4931,
        17.0822,-17.6712,-18.2603,-18.8493,-19.4383,-20.0274,-20.6164,
        -21.2055,-21.7945,22.3836,-22.9726,-23.5616,-24.1507,-24.7397,
        -25.3288,-25.9178,-26.5068,-27.0959,27.6849,-28.274,-28.863,-29.452,
        -30.0411,-30.6301,-31.2192,-31.8082,-32.3973,32.9863,-33.5753,
        -34.1644,-34.7534,-35.3425,-35.9315,-36.5205,-37.1096,-37.6986,
        38.2877,-38.8767,-39.4657,-40.0548,-40.6438,-41.2329,-41.8219,
        -42.411,-43
    ],
    -1, -1);
__motion_Leaf_1.addFilterPropertyArray(0, "adjustColorHue",
    [
        0,0.677418,1.35484,2.03226,2.70967,3.38709,4.06451,4.74193,5.41935,
        6.09677,6.77419,7.45161,8.12903,8.80645,9.48387,10.1613,10.8387,11.5161,
        12.1935,12.871,13.5484,14.2258,14.9032,15.5806,16.2581,16.9355,17.6129,
        18.2903,18.9677,19.6452,20.3226,21,22.4286,23.8571,25.2857,26.7143,28.1429,
        29.5714,31,32.4286,33.8571,35.2857,36.7143,38.1429,39.5714,41,42.4286,43.8571,
        45.2857,46.7143,48.1429,49.5714,51,54,57,60,63,66,69,72,75,78,81,84,87,
        90,93,96,99,102,105,108,111,114
    ],
    -1, -1);
```

Associating a motion tween with its display objects

Flash Player 9 and later, Adobe AIR 1.0 and later, requires Flash CS3 or later

The last task is to associate the motion tween with the display object or objects that it manipulates.

The AnimatorFactory class manages the association between a motion tween and its target display objects. The argument to the AnimatorFactory constructor is the Motion object:

```
var __animFactory_Wheel:AnimatorFactory = new AnimatorFactory(__motion_Wheel);
```

Use the `addTarget()` method of the AnimatorFactory class to associate the target display object with its motion tween. The ActionScript copied from Flash comments out the `addTarget()` line and does not specify an instance name:

```
// __animFactory_Wheel.addTarget(<instance name goes here>, 0);
```

In your copy, specify the display object to associate with the motion tween. In the following example, the targets are specified as `greenWheel` and `redWheel`:

```
__animFactory_Wheel.AnimatorFactory.addTarget(greenWheel, 0);
__animFactory_Wheel.AnimationFactory.addTarget(redWheel, 0);
```

You can associate multiple display objects with the same motion tween using multiple calls to `addTarget()`.

Chapter 18: Working with inverse kinematics

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS4 or later

Inverse kinematics (IK) is a great technique for creating realistic motion.

IK lets you create coordinated movements within a chain of connected parts called an IK armature, so that the parts move together in a lifelike way. The parts of the armature are its bones and joints. Given the end point of the armature, IK calculates the angles for the joints that are required to reach that end point.

Calculating those angles manually yourself would be challenging. The beauty of this feature is that you can create armatures interactively using Adobe® Flash® Professional. Then animate them using ActionScript. The IK engine included with Flash Professional performs the calculations to describe the movement of the armature. You can limit the movement to certain parameters in your ActionScript code.

New to the Flash Professional CS5 version of IK is the concept of bone spring, typically associated with high-end animation applications. Used with the new dynamic Physics Engine, this feature lets you configure life-like movement. And, this effect is visible both at runtime and during authoring.

To create inverse kinematics armatures, you must have a license for Flash Professional.

More Help topics

fl.ik package

Basics of Inverse Kinematics

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS4 or later

Inverse kinematics (IK) lets you create life-like animation by linking parts so they move in relation to one another in a realistic manner.

For example, using IK you can move a leg to a certain position by articulating the movements of the joints in the leg required to achieve the desired pose. IK uses a framework of bones chained together in a structure called an IK armature. The `fl.ik` package helps you create animations resembling natural motion. It lets you animate multiple IK armatures seamlessly without having to know a lot about the physics behind the IK algorithms.

Create the IK armature with its ancillary bones and joints with Flash Professional. Then you can access the IK classes to animate them at runtime.

See the Using inverse kinematics section in *Using Flash Professional* for detailed instructions on how to create an IK armature.

Important concepts and terms

The following reference list contains important terms that are relevant to this feature:

Armature A kinematic chain, consisting of bones and joints, used in computer animation to simulate realistic motion.

Bone A rigid segment in an armature, analogous to a bone in an animal skeleton.

Inverse Kinematics (IK) Process of determining the parameters of a jointed flexible object called a kinematic chain or armature.

Joint The location at which two bones make contact, constructed to enable movement of the bones; analogous to a joint in an animal.

Physics Engine A package of physics-related algorithms used to provide life-like actions to animation.

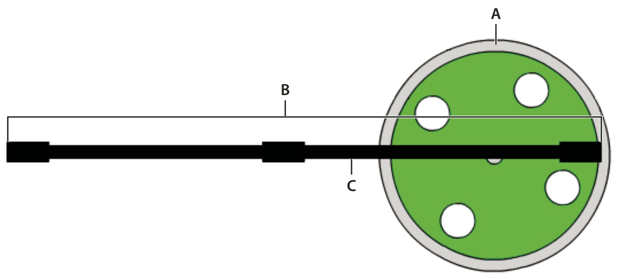
Spring The quality of a bone that moves and reacts when the parent bone is moved and then incrementally diminishes over time.

Animating IK Armatures Overview

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS4 or later

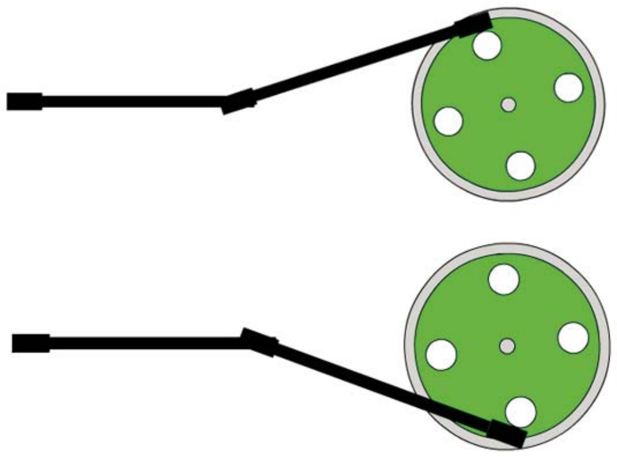
After creating an IK armature in Flash Professional, use the `fl.ik` classes to limit its movement, track its events, and animate it at runtime.

The following figure shows a movie clip named `Wheel`. The axle is an instance of an IKArmature named `Axle`. The IKMover class moves the armature in synchronization with the rotation of wheel. The IKBone, `ikBone2`, in the armature is attached to the wheel at its tail joint.



***A.** Wheel* ***B.** Axle* ***C.** ikBone2*

At runtime, the wheel spins in association with the `__motion_Wheel` motion tween discussed in "Describing the animation" on page 338. An IKMover object initiates and controls the movement of the axle. The following figure shows two snapshots of the axle armature attached to the spinning wheel at different frames in the rotation.



At runtime, the following ActionScript:

- Gets information about the armature and its components
- Instantiates an IKMover object
- Moves the axle in conjunction with the rotation of the wheel

```
import fl.ik.*

var tree:IKArmature = IKManager.getArmatureByName("Axle");
var bone:IKBone = tree.getBoneByName("ikBone2");
var endEffector:IKJoint = bone.tailJoint;
var pos:Point = endEffector.position;

var ik:IKMover = new IKMover(endEffector, pos);
ik.limitByDistance = true;
ik.distanceLimit = 0.1;
ik.limitByIteration = true;
ik.iterationLimit = 10;

Wheel.addEventListener(Event.ENTER_FRAME, frameFunc);

function frameFunc(event:Event)
{
    if (Wheel != null)
    {
        var mat:Matrix = Wheel.transform.matrix;
        var pt = new Point(90, 0);
        pt = mat.transformPoint(pt);

        ik.moveTo(pt);
    }
}
```

The IK classes used to move the axle are:

- IKArmature: describes the armature, a tree structure consisting of bones and joints; must be created with Flash Professional
- IKManager: container class for all the IK armatures in the document; must be created with Flash Professional
- IKBone: a segment of an IK armature
- IKJoint: a connection between two IK bones
- IKMover: initiates and controls IK movement of armatures

For complete and detailed descriptions of these classes, see the ik package.

Getting information about an IK armature

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS4 or later

First, declare variables for the armature, the bone, and the joint that make up the parts that you want to move.

The following code uses the `getArmatureByName()` method of the IKManager class to assign the value of the Axle armature to the IKArmature variable `tree`. The Axle armature was previously created with Flash Professional.

```
var tree:IKArmature = IKManager.getArmatureByName("Axle");
```

Similarly, the following code uses the `getBoneByName()` method of the IKArmature class to assign to the IKBone variable the value of the `ikBone2` bone.

```
var bone:IKBone = tree.getBoneByName("ikBone2");
```

The tail joint of the `ikBone2` bone is the part of the armature that attaches to the spinning wheel.

The following line declares the variable `endEffector` and assigns to it the `tailjoint` property of the `ikBone2` bone:

```
var endEffector:IKJoint = home.tailjoint;
```

The variable `pos` is a point that stores the current position of the `endEffector` joint.

```
var pos:Point = endEffector.position;
```

In this example, `pos` is the position of the joint at the end of the axle where it connects to the wheel. The original value of this variable is obtained from the `position` property of the IKJoint.

Instantiating an IK Mover and Limiting Its Movement

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS4 or later

An instance of the IKMover class moves the axle.

The following line instantiates the IKMover object `ik`, passing to its constructor the element to move and the starting point for the movement:

```
var ik:IKMover = new IKMover(endEffector, pos);
```

The properties of the IKMover class let you limit the movement of an armature. You can limit movement based on the distance, iterations, and time of the movement.

The following pairs of properties enforce these limits. The pairs consist of a Boolean value that indicates whether the movement is limited and an integer that specifies the limit:

Boolean property	Integer property	Limit set
`limitByDistance:Boolean`	`distanceLimit:int`	Sets the maximum distance in pixels that the IK engine moves for each iteration.
`limitByIteration:Boolean`	`iterationLimit:int`	Sets the maximum number of iterations the IK engine performs for each movement.
`limitByTime:Boolean`	`timeLimit:int`	Sets the maximum time in milliseconds allotted to the IK engine to perform the movement.

By default, all the Boolean values are set to `false`, so movement is not limited unless you explicitly set a Boolean value to `true`. To enforce a limit, set the appropriate property to `true` and then specify a value for the corresponding integer property. If you set the limit to a value without setting its corresponding Boolean property, the limit is ignored. In this case, the IK engine continues to move the object until another limit or the target position of the IKMover is reached.

In the following example, the maximum distance of the armature movement is set to 0.1 pixels per iteration. The maximum number of iterations for every movement is set to ten.

```
ik.limitByDistance = true;
ik.distanceLimit = 0.1;
ik.limitByIteration = true;
ik.iterationLimit = 10;
```

Moving an IK Armature

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS4 or later

The IKMover moves the axle inside the event listener for the wheel. On each enterFrame event of the wheel, a new target position for the armature is calculated. Using its `moveTo()` method, the IKMover moves the tail joint to its target position or as far as it can within the constraints set by its `limitByDistance`, `limitByIteration`, and `limitByTime` properties.

```
Wheel.addEventListener(Event.ENTER_FRAME, frameFunc);

function frameFunc(event:Event)
{
    if (Wheel != null)
    {
        var mat:Matrix = Wheel.transform.matrix;
        var pt = new Point(90,0);
        pt = mat.transformPoint(pt);

        ik.moveTo(pt);
    }
}
```

Using Springs

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS5 or later

Inverse kinematics in Flash Professional CS5 supports bone spring. Bone spring can be set during authoring, and bone spring attributes can be added or modified at runtime. Spring is a property of a bone and its joints. It has two attributes: `IKJoint.springStrength`, which sets the amount of spring, and `IKJoint.springDamping`, which adds resistance to the strength value and changes the rate of decay of the spring.

Spring strength is a percent value from the default 0 (completely rigid) to 100 (very loose and controlled by physics). Bones with spring react to the movement of their joint. If no other translation (rotation, x, or y) is enabled, the spring settings have no effect.

Spring damping is a percent value from the default 0 (no resistance) to 100 (heavily damped). Damping changes the amount of time between a bone's initial movement and its return to a rest position.

You can check to see if springs are enabled for an IKArmature object by checking its `IKArmature.springsEnabled` property. The other spring properties and methods belong to individual IKJoint objects. A joint can be enabled for angular rotation and translation along the x- and y-axes. You can position a rotational joint's spring angle with `IKJoint.setSpringAngle` and a translational joint's spring position with `IKJoint.setSpringPt`.

This example selects a bone by name and identifies its tailJoint. The code tests the parent armature to see if springs are enabled and then sets spring properties for the joint.

```
var arm:IKArmature = IKManager.getArmatureAt(0);
var bone:IKBone = arm.getBoneByName("c");
var joint:IKJoint = bone.tailJoint;
if (arm.springsEnabled) {
    joint.springStrength = 50; //medium spring strength
    joint.springDamping = 10; //light damping resistance
    if (joint.hasSpringAngle) {
        joint.setSpringAngle(30); //set angle for rotational spring
    }
}
```

Using IK Events

Flash Player 10 and later, Adobe AIR 1.5 and later, requires Flash CS4 or later

The IKEvent class lets you create an event object that contains information about IK Events. IKEvent information describes motion that has terminated because the specified time, distance, or iteration limit was exceeded.

The following code shows an event listener and handler for tracking time limit events. This event handler reports on the time, distance, iteration count, and joint properties of an event that fires when the time limit of the IKMover is exceeded.

```
var ikmover:IKMover = new IKMover(endjoint, pos);
ikMover.limitByTime = true;
ikMover.timeLimit = 1000;

ikmover.addEventListener(IKEvent.TIME_LIMIT, timeLimitFunction);

function timeLimitFunction(evt:IKEvent):void
{
    trace("timeLimit hit");
    trace("time is " + evt.time);
    trace("distance is " + evt.distance);
    trace("iterationCount is " + evt.iterationCount);
    trace("IKJoint is " + evt.joint.name);
}
```

Chapter 19: Working in three dimensions (3D)

Flash Player 10 and later, Adobe AIR 1.5 and later

The Flash Player and AIR runtimes support 3D graphics in two ways. You can use three-dimensional display objects on the Flash display list. This is appropriate for adding three-dimensional effects to Flash content and for low polygon-count objects. In Flash Player 11and AIR 3, or later, you can render complex 3D scenes using the Stage3D API.

A Stage3D viewport is not a display object. Instead, the 3D graphics are rendered to a viewport that is displayed underneath the Flash display list (and above any StageVideo viewport planes). Rather than using the Flash DisplayObject classes to create a scene, you use a programmable 3D-pipeline (similar to OpenGL and Direct3D). This pipeline takes triangle data and textures as input and renders the scene using shader programs that you provide. Hardware acceleration is used when a compatible graphics processing unit (GPU) with supported drivers, is available on the client computer.

Stage3D provides a very low-level API. In an application, you are encouraged to use a 3D framework that supports Stage3D. You can create your own framework or use one of several commercial and open source frameworks already available.

For more information about developing 3D applications using Stage3D and about available 3D frameworks, visit the Flash Player Developer Center: Stage 3D.

Basics of 3D display objects

Flash Player 10 and later, Adobe AIR 1.5 and later

The main difference between a two-dimensional (2D) object and a three-dimensional (3D) object projected on a two-dimensional screen is the addition of a third dimension to the object. The third dimension allows the object to move toward and away from viewpoint of the user.

When you explicitly set the `z` property of a display object to a numeric value, the object automatically creates a 3D transformation matrix. You can alter this matrix to modify the 3D transformation settings of that object.

In addition, 3D rotation differs from 2D rotation. In 2D the axis of rotation is always perpendicular to the x/y plane - in other words, on the z-axis. In 3D the axis of rotation can be around any of the x, y, or z axes. Setting the rotation and scaling properties of a display object enable it to move in 3D space.

Important concepts and terms

The following reference list contains important terms that you will encounter when programming 3-dimensional graphics:

Perspective In a 2D plane, representation of parallel lines as converging on a vanishing point to give the illusion of depth and distance.

Projection The production of a 2D image of a higher-dimensional object; 3D projection maps 3D points to a 2D plane.

Rotation Changing the orientation (and often the position) of an object by moving every point included in the object in a circular motion.

Transformation Altering 3D points or sets of points by translation, rotation, scale, skew, or a combination of these actions.

Translation Changing the position of an object by moving every point included in the object by the same amount in the same direction.

Vanishing point Point at which receding parallel lines seem to meet when represented in linear perspective.

Vector A 3D vector represents a point or a location in the three-dimensional space using the Cartesian coordinates x, y, and z.

Vertex A corner point.

Textured mesh Any point defining an object in 3D space.

UV mapping A way to apply a texture or bitmap to a 3D surface. UV mapping assigns values to coordinates on an image as percentages of the horizontal (U) axis and vertical (V) axis.

T value The scaling factor for determining the size of a 3D object as the object moves toward, or away from, the current point of view.

Culling Rendering, or not, surfaces with specific winding. Using culling you can hide surfaces that are not visible to the current point of view.

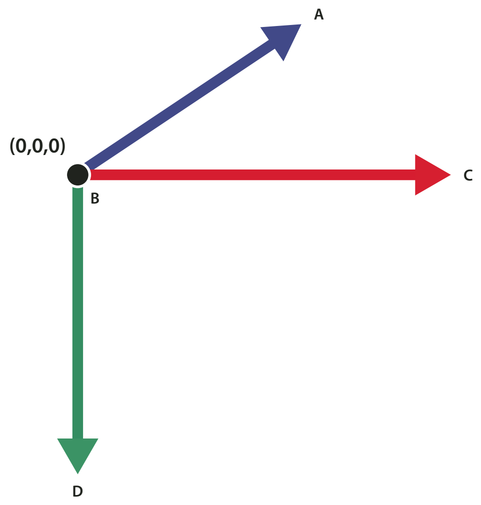
Understanding 3D display objects in Flash Player and the AIR runtime

Flash Player 10 and later, Adobe AIR 1.5 and later

In Flash Player versions prior to Flash Player 10 and Adobe AIR versions prior to Adobe AIR 1.5, display objects have two properties, `x` and `y`, for positioning them on a 2D plane. Starting with Flash Player 10 and Adobe AIR 1.5, every ActionScript display object has a `z` property that lets you position it along the z-axis, which is generally used to indicate depth or distance.

Flash Player 10 and Adobe AIR 1.5 introduced support for 3D effects. However, display objects are inherently flat. Each display object, such as a MovieClip object or a Sprite object, ultimately renders itself in two dimensions, on a single plane. The 3D features let you place, move, rotate, and otherwise transform these planar objects in all three dimensions. They also let you manage 3D points and convert them to 2D x, y coordinates, so you can project 3D objects onto a 2D view. You can simulate many kinds of 3D experiences using these features.

The 3D coordinate system used by ActionScript differs from other systems. When you use 2D coordinates in ActionScript, the value of x increases as you move to the right along the x-axis, and the value of y increases as you move down along the y-axis. The 3D coordinate system retains those conventions and adds a z-axis whose value increases as you move away from the viewpoint.



The positive directions of the x, y, and z axes in the ActionScript 3D coordinate system.
A. *+ Z axis* ***B.*** *Origin* ***C.*** *+X axis* ***D.*** *+Y axis*

Note: *Be aware that Flash Player and AIR always represent 3D in layers. This means that if object A is in front of object B on the display list, Flash Player or AIR always renders A in front of B regardless of the z-axis values of the two objects. To resolve this conflict between the display list order and the z-axis order, use the* `transform.getRelativeMatrix3D()` *method to save and then re-order the layers of 3D display objects. For more information, see "Using Matrix3D objects for reordering display" on page 362.*

The following ActionScript classes support the new 3D-related features:

1 The flash.display.DisplayObject class contains the `z` property and new rotation and scaling properties for manipulating display objects in 3D space. The `DisplayObject.local3DToGlobal()` method offers a simple way to project 3D geometry onto a 2D plane.

2 The flash.geom.Vector3D class can be used as a data structure for managing 3D points. It also supports vector mathematics.

3 The flash.geom.Matrix3D class supports complex transformations of 3D geometry, such as rotation, scaling, and translation.

4 The flash.geom.PerspectiveProjection class controls the parameters for mapping 3D geometry onto a 2D view.

There are two different approaches to simulating 3D images in ActionScript:

1 Arranging and animating planar objects in 3D space. This approach involves animating display objects using the x, y and z properties of display objects, or setting rotation and scaling properties using the DisplayObject class. More complex motion can be achieved using the DisplayObject.transform.matrix3D object. The DisplayObject.transform.perspectiveProjection object customizes how the display objects are drawn in 3D perspective. Use this approach when you want to animate 3D objects that consist primarily of planes. Examples of this approach include 3D image galleries or 2D animation objects arranged in 3D space.

2 Generating 2D triangles from 3D geometry, and rendering those triangles with textures. To use this approach you must first define and manage data about 3D objects and then convert that data into 2D triangles for rendering. Bitmap textures can be mapped to these triangles, and then the triangles are drawn to a graphics object using the `Graphics.drawTriangles()` method. Examples of this approach include loading 3D model data from a file and rendering the model on the screen, or generating and drawing 3D terrain as triangle meshes.

Creating and moving 3D display objects

Flash Player 10 and later, Adobe AIR 1.5 and later

To convert a 2D display object into a 3D display object, you can explicitly set its `z` property to a numeric value. When you assign a value to the `z` property, a new Transform object is created for the display object. Setting the `DisplayObject.rotationX` or `DisplayObject.rotationY` properties also creates a new Transform object. The Transform object contains a `Matrix3D` property that governs how the display object is represented in 3D space.

The following code sets the coordinates for a display object called "leaf":

```
leaf.x = 100; leaf.y = 50; leaf.z = -30;
```

You can see these values, as well as properties derived from these values, in the `matrix3D` property of the Transform object of the leaf:

```
var leafMatrix:Matrix3D  = leaf.transform.matrix3D;

trace(leafMatrix.position.x);
trace(leafMatrix.position.y);
trace(leafMatrix.position.z);
trace(leafMatrix.position.length);
trace(leafMatrix.position.lengthSquared);
```

For information about the properties of the Transform object, see the Transformclass. For information about the properties of the Matrix3D object, see the Matrix3D class.

Moving an object in 3D space

Flash Player 10 and later, Adobe AIR 1.5 and later

You can move an object in 3D space by changing the values of its `x, y, or z` properties. When you change the value of the `z` property the object appears to move closer or farther away from the viewer.

The following code moves two ellipses back and forth along their z-axes by changing the value of their `z` properties in response to an event. `ellipse2` moves faster than `ellipse1`: its `z` property is increased by a multiple of 20 on each Frame event while the `z` property of `ellipse1` is increased by a multiple of 10:

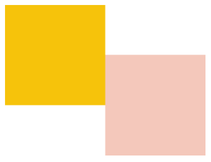
```
var depth:int = 1000;

function ellipse1FrameHandler(e:Event):void
{
    ellipse1Back = setDepth(e, ellipse1Back);
    e.currentTarget.z += ellipse1Back * 10;
}
function ellipse2FrameHandler(e:Event):void
{
    ellipse2Back = setDepth(e, ellipse1Back);
    e.currentTarget.z += ellipse1Back * 20;
}
function setDepth(e:Event, d:int):int
{
    if(e.currentTarget.z > depth)
    {
        e.currentTarget.z = depth;
        d = -1;
    }
    else if (e.currentTarget.z <  0)
    {
        e.currentTarget.z = 0;
        d = 1;
    }
}
```

Rotating an object in 3D space

Flash Player 10 and later, Adobe AIR 1.5 and later

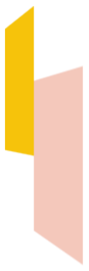
You can rotate an object in three different ways, depending on how you set the object's rotation properties: `rotationX`, `rotationY`, and `rotationZ`.

The figure below shows two squares that are not rotated:

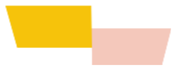


The next figure shows the two squares when you increment the `rotationY` property of the container of the squares to rotate them on the y- axis. Rotating the container, or parent display object, of the two squares rotates both squares:

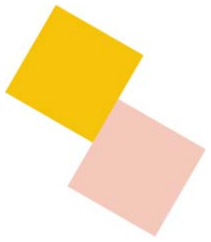
```
container.rotationY += 10;
```



The next figure shows what happens when you set the `rotationX` property of the container for the squares. This rotates the squares on the x- axis.



The next figure shows what happens when you increment the `rotationZ` property of the container of the squares.This rotates the squares on the z-axis.



A display object can simultaneously move and rotate in 3D space.

Projecting 3D objects onto a 2D view

Flash Player 10 and later, Adobe AIR 1.5 and later

The PerspectiveProjection class in the `flash.geom` package provides a simple way of applying rudimentary perspective when moving display objects through 3D space.

If you do not explicitly create a perspective projection for your 3D space, the 3D engine uses a default PerspectiveProjection object that exists on the root and is propagated to all its children.

The three properties that define how a PerspectiveProjection object displays 3D space are:

- `fieldOfView`
- `projectionCenter`
- `focalLength`

Modifying the value of the `fieldOfView` automatically modifies the value of the `focalLength` and vice-versa, since they are interdependent.

The formula used to calculate the `focalLength` given the `fieldOfView` value is:

```
focalLength = stageWidth/2 * (cos(fieldOfView/2) / sin(fieldOfView/2)
```

Typically you would modify the `fieldOfView` property explicitly.

Field of view

Flash Player 10 and later, Adobe AIR 1.5 and later

By manipulating the `fieldOfView` property of the PerspectiveProjection class, you can make a 3D display object approaching the viewer appear larger and an object receding from the viewer appear smaller.

The `fieldOfView` property specifies an angle *between* 0 and 180 degrees that determines the strength of the perspective projection. The greater the value, the stronger the distortion applied to a display object moving along its z-axis. A low `fieldOfView` value results in very little scaling and causes objects to appear to move only slightly back in space. A high `fieldOfView` value causes more distortion and the appearance of greater movement. The maximum value of 179.9999... degrees results in an extreme fish-eye camera lens effect. The maximum value of `fieldOfView` is 179.9999... and the minimum is 0.00001... Exactly 0 and 180 are illegal values.

Projection center

Flash Player 10 and later, Adobe AIR 1.5 and later

The `projectionCenter` property represents the vanishing point in the perspective projection. It is applied as an offset to the default registration point (0,0) in the upper-left corner of the stage.

As an object appears to move further from the viewer, it skews towards the vanishing point and eventually vanishes. Imagine an infinitely long hall. As you look down the hall, the edges of the walls converge to a vanishing point far down the hall.

If the vanishing point is at the center of the stage, the hall disappears towards a point in the center. The default value for the `projectionCenter` property is the center of the stage. If, for example, you want elements to appear on the left of the stage and a 3D area to appear on the right, set the `projectionCenter` to a point on the right of the stage to make that the vanishing point of your 3D viewing area.

Focal length

Flash Player 10 and later, Adobe AIR 1.5 and later

The `focalLength` property represents the distance between the origin of the viewpoint (0,0,0) and the location of the display object on its z-axis.

A long focal length is like a telephoto lens with a narrow view and compressed distances between objects. A short focal length is like a wide angle lens, with which you get a wide view with a lot of distortion. A medium focal length approximates what the human eye sees.

Typically the `focalLength` is re-calculated dynamically during perspective transformation as the display object moves, but you can set it explicitly.

Default perspective projection values

Flash Player 10 and later, Adobe AIR 1.5 and later

The default PerspectiveProjection object created on the root has the following values:

- `fieldOfView: 55`
- `perspectiveCenter: stagewidth/2, stageHeight/2`
- `focalLength: stageWidth/ 2 * ( cos(fieldOfView/2) / sin(fieldOfView/2) )`

These are the values that are used if you do not create your own PerspectiveProjection object.

You can instantiate your own PerspectiveProjection object with the intention of modifying the `projectionCenter` and `fieldOfView` yourself. In this case, the default values of the newly created object are the following, based on a default stage size of 500 by 500:

- `fieldOfView: 55`
- `perspectiveCenter: 250,250`
- `focalLength: 480.24554443359375`

Example: Perspective projection

Flash Player 10 and later, Adobe AIR 1.5 and later

The following example demonstrates the use of perspective projection to create 3D space. It shows how you can modify the vanishing point and change the perspective projection of the space through the `projectionCenter` property. This modification forces the recalculation of the `focalLength` and `fieldOfView` with its concomitant distortion of the 3D space.

This example:

1. Creates a sprite named `center`, as a circle with cross hairs
2. Assigns the coordinates of the `center` sprite to the `projectionCenter` property of the `perspectiveProjection` property of the `transform` property of the root
3. Adds event listeners for mouse events that call handlers that modify the `projectionCenter` so that it follows the location of the `center` object
4. Creates four accordion-style boxes that form the walls of the perspective space

When you test this example, ProjectionDragger.swf, drag the circle around to different locations. The vanishing point follows the circle, landing wherever you drop it. Watch the boxes that enclose the space stretch and become distorted when you move the projection center far from the center of the stage.

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The ProjectionDragger application files are in the Samples/ProjectionDragger folder.

```
package
{
    import flash.display.Sprite;
    import flash.display.Shape;
    import flash.geom.Point;
    import flash.events.*;
    public class ProjectionDragger extends Sprite
    {
        private var center : Sprite;
        private var boxPanel:Shape;
        private var inDrag:Boolean = false;

        public function ProjectionDragger():void
        {
            createBoxes();
            createCenter();
        }
        public function createCenter():void
        {
            var  centerRadius:int = 20;

            center = new Sprite();

            // circle
            center.graphics.lineStyle(1, 0x000099);
            center.graphics.beginFill(0xCCCCCC, 0.5);
            center.graphics.drawCircle(0, 0, centerRadius);
            center.graphics.endFill();
            // cross hairs
            center.graphics.moveTo(0, centerRadius);
            center.graphics.lineTo(0, -centerRadius);
            center.graphics.moveTo(centerRadius, 0);
            center.graphics.lineTo(-centerRadius, 0);
            center.x = 175;
            center.y = 175;
            center.z = 0;
            this.addChild(center);

            center.addEventListener(MouseEvent.MOUSE_DOWN, startDragProjectionCenter);
            center.addEventListener(MouseEvent.MOUSE_UP, stopDragProjectionCenter);
            center.addEventListener( MouseEvent.MOUSE_MOVE, doDragProjectionCenter);
            root.transform.perspectiveProjection.projectionCenter = new Point(center.x, 
center.y);
        }
        public function createBoxes():void
        {
            // createBoxPanel();
            var boxWidth:int = 50;
            var boxHeight:int = 50;
            var numLayers:int = 12;
            var depthPerLayer:int = 50;

            // var boxVec:Vector.<Shape> = new Vector.<Shape>(numLayers);
            for (var i:int = 0; i < numLayers; i++)
            {
                this.addChild(createBox(150, 50, (numLayers - i) * depthPerLayer, boxWidth, 
boxHeight, 0xCCCCFF));
```

```
                this.addChild(createBox(50, 150, (numLayers - i) * depthPerLayer, boxWidth, 
boxHeight, 0xFFCCCC));
                this.addChild(createBox(250, 150, (numLayers - i) * depthPerLayer, boxWidth, 
boxHeight, 0xCCFFCC));
                this.addChild(createBox(150, 250, (numLayers - i) * depthPerLayer, boxWidth, 
boxHeight, 0xDDDDDD));
            }
        }

        public function createBox(xPos:int = 0, yPos:int = 0, zPos:int = 100, w:int = 50, h:int 
= 50, color:int = 0xDDDDDD):Shape
        {
            var box:Shape = new Shape();
            box.graphics.lineStyle(2, 0x666666);
            box.graphics.beginFill(color, 1.0);
            box.graphics.drawRect(0, 0, w, h);
            box.graphics.endFill();
            box.x = xPos;
            box.y = yPos;
            box.z = zPos;
            return box;
        }
        public function startDragProjectionCenter(e:Event)
        {
            center.startDrag();
            inDrag = true;
        }

        public function doDragProjectionCenter(e:Event)
        {
            if (inDrag)
            {
                root.transform.perspectiveProjection.projectionCenter = new Point(center.x, 
center.y);
            }
        }

        public function stopDragProjectionCenter(e:Event)
        {
            center.stopDrag();
            root.transform.perspectiveProjection.projectionCenter = new Point(center.x, 
center.y);
            inDrag = false;
        }
    }
}
```

For more complex perspective projection, use the Matrix3D class.

Performing complex 3D transformations

Flash Player 10 and later, Adobe AIR 1.5 and later

The Matrix3D class lets you transform 3D points within a coordinate space or map 3D points from one coordinate space to another.

You don't need to understand matrix mathematics to use the Matrix3D class. Most of the common transformation operations can be handled using the methods of the class. You don't have to worry about explicitly setting or calculating the values of each element in the matrix.

After you set the `z` property of a display object to a numeric value, you can retrieve the object's transformation matrix using the Matrix3D property of the display object's Transform object:

```
var leafMatrix:Matrix3D = this.transform.matrix3D;
```

You can use the methods of the Matrix3D object to perform translation, rotation, scaling, and perspective projection on the display object.

Use the Vector3D class with its `x`, `y`, and `z` properties for managing 3D points. It can also represent a spatial vector in physics, which has a direction and a magnitude. The methods of the Vector3D class let you perform common calculations with spatial vectors, such as addition, dot product, and cross product calculations.

***Note:** The Vector3D class is not related to the ActionScript Vector class. The Vector3D class contains properties and methods for defining and manipulating 3D points, while the Vector class supports arrays of typed objects.*

Creating Matrix3D objects

Flash Player 10 and later, Adobe AIR 1.5 and later

There are three main ways of creating or retrieving `Matrix3D` objects:

- Use the `Matrix3D()` constructor method to instantiate a new matrix. The `Matrix3D()` constructor takes a `Vector` object containing 16 numeric values and places each value into a cell of the matrix. For example:

  ```
  var rotateMatrix:Matrix3D = new Matrix3D(1,0,0,1, 0,1,0,1, 0,0,1,1, 0,0,0,1);
  ```

- Set the value the `z` property of a display object. Then retrieve the transformation matrix from the `transform.matrix3D` property of that object.
- Retrieve the Matrix3D object that controls the display of 3D objects on the stage by calling the `perspectiveProjection.toMatrix3D()` method on the root display object.

Applying multiple 3D transformations

Flash Player 10 and later, Adobe AIR 1.5 and later

You can apply many 3D transformations at once using a Matrix3D object. For example if you wanted to rotate, scale, and then move a cube, you could apply three separate transformations to each point of the cube. However it is much more efficient to precalculate multiple transformations in one Matrix3D object and then perform one matrix transformation on each of the points.

***Note:** The order in which matrix transformations are applied is important. Matrix calculations are not commutative. For example, applying a rotation followed by a translation gives a different result than applying the same translation followed by the same rotation.*

The following example shows two ways of performing multiple 3D transformations.

```
package {
    import flash.display.Sprite;
    import flash.display.Shape;
    import flash.display.Graphics;
    import flash.geom.*;

public class Matrix3DTransformsExample extends Sprite
    {
        private var rect1:Shape;
        private var rect2:Shape;

public function Matrix3DTransformsExample():void
        {
            var pp:PerspectiveProjection = this.transform.perspectiveProjection;
            pp.projectionCenter = new Point(275,200);
            this.transform.perspectiveProjection = pp;

            rect1 = new Shape();
            rect1.x = -70;
            rect1.y = -40;
            rect1.z = 0;
            rect1.graphics.beginFill(0xFF8800);
            rect1.graphics.drawRect(0,0,50,80);
            rect1.graphics.endFill();
            addChild(rect1);

            rect2 = new Shape();
            rect2.x = 20;
            rect2.y = -40;
            rect2.z = 0;
            rect2.graphics.beginFill(0xFF0088);
            rect2.graphics.drawRect(0,0,50,80);
            rect2.graphics.endFill();
            addChild(rect2);

            doTransforms();
        }

        private function doTransforms():void
        {
            rect1.rotationX = 15;
            rect1.scaleX = 1.2;
            rect1.x += 100;
            rect1.y += 50;
            rect1.rotationZ = 10;

            var matrix:Matrix3D = rect2.transform.matrix3D;
            matrix.appendRotation(15, Vector3D.X_AXIS);
            matrix.appendScale(1.2, 1, 1);
            matrix.appendTranslation(100, 50, 0);
            matrix.appendRotation(10, Vector3D.Z_AXIS);
            rect2.transform.matrix3D = matrix;
        }
    }
}
```

In the `doTransforms()` method the first block of code uses the DisplayObject properties to change the rotation, scaling, and position of a rectangle shape. The second block of code uses the methods of the Matrix3D class to do the same transformations.

The main advantage of using the `Matrix3D` methods is that all of the calculations are performed in the matrix first,. Then they are applied to the display object only once, when its `transform.matrix3D` property is set. Setting DisplayObject properties make the source code a bit simpler to read. However each time a rotation or scaling property is set, it causes multiple calculations and changes multiple display object properties.

If your code will apply the same complex transformations to display objects more than once, save the Matrix3D object as a variable and then reapply it over and over.

Using Matrix3D objects for reordering display

Flash Player 10 and later, Adobe AIR 1.5 and later

As mentioned previously, the layering order of display objects in the display list determines the display layering order, regardless of their relative z-axes. If your animation transforms the properties of display objects into an order that differs from the display list order, the viewer might see display object layering that does not correspond to the z-axis layering. So, an object that should appear further away from the viewer might appear in front of an object that is closer to the viewer.

To ensure that the layering of 3D display objects corresponds to the relative depths of the objects, use an approach like the following:

1 Use the `getRelativeMatrix3D()` method of the Transform object to get the relative `z-axes` of the child 3D display objects.

2 Use the `removeChild()` method to remove the objects from the display list.

3 Sort the display objects based on their relative z-axis values.

4 Use the `addChild()` method to add the children back to the display list in reverse order.

This reordering ensures that your objects display in accordance with their relative z-axes.

The following code enforces the correct display of the six faces of a 3D box. It reorders the faces of the box after rotations have been applied to the it:

```
public var faces:Array; . . .

public function ReorderChildren()
{
    for(var ind:uint = 0; ind < 6; ind++)
    {
        faces[ind].z = faces[ind].child.transform.getRelativeMatrix3D(root).position.z;
        this.removeChild(faces[ind].child);
    }
    faces.sortOn("z", Array.NUMERIC | Array.DESCENDING);
    for (ind = 0; ind < 6; ind++)
    {
        this.addChild(faces[ind].child);
    }
}
```

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The application files are in the Samples/ReorderByZ folder.

Using triangles for 3D effects

Flash Player 10 and later, Adobe AIR 1.5 and later

In ActionScript, you perform bitmap transformations using the `Graphics.drawTriangles()` method, because 3D models are represented by a collection of triangles in space. (However, Flash Player and AIR do not support a depth buffer, so display objects are still inherently flat, or 2D. This is described in "Understanding 3D display objects in Flash Player and the AIR runtime" on page 351.) The `Graphics.drawTriangles()` method is like the `Graphics.drawPath()` method, as it takes a set of coordinates to draw a triangle path.

To familiarize yourself with using `Graphics.drawPath()`, see "Drawing Paths" on page 236.

The `Graphics.drawTriangles()` method uses a Vector.<Number> to specify the point locations for the triangle path:

```
drawTriangles(vertices:Vector.<Number>, indices:Vector.<int> = null, uvtData:Vector.<Number>
= null, culling:String = "none"):void
```

The first parameter of `drawTriangles()` is the only required parameter: the `vertices` parameter. This parameter is a vector of numbers defining the coordinates through which your triangles are drawn. Every three sets of coordinates (six numbers) represents a triangle path. Without the `indices` parameter, the length of the vector should always be a factor of six, since each triangle requires three coordinate pairs (three sets of two x/y values). For example:

```
graphics.beginFill(0xFF8000);
graphics.drawTriangles(
    Vector.<Number>([
        10,10,  100,10,  10,100,
        110,10, 110,100, 20,100]));
```

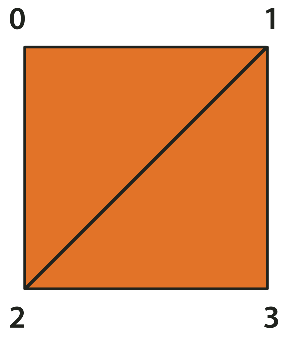
Neither of these triangles share any points, but if they did, the second `drawTriangles()` parameter, `indices`, could be used to reuse values in the `vertices` vector for more than one triangle.

When using the `indices` parameter, be aware that the `indices` values are point indices, not indices that relate directly to the `vertices` array elements. In other words, an index in the `vertices` vector as defined by `indices` is actually the real index divided by 2. For the third point of a `vertices` vector, for example, use an `indices` value of 2, even though the first numeric value of that point starts at the vector index of 4.

For example, merge two triangles to share the diagonal edge using the `indices` parameter:

```
graphics.beginFill(0xFF8000);
graphics.drawTriangles(
    Vector.<Number>([10,10, 100,10, 10,100, 100,100]),
    Vector.<int>([0,1,2, 1,3,2]));
```

Notice that though a square has now been drawn using two triangles, only four points were specified in the `vertices` vector. Using `indices`, the two points shared by the two triangles are reused for each triangle. This reduces the overall vertices count from 6 (12 numbers) to 4 (8 numbers):



A square drawn with two triangles using the vertices parameter

This technique becomes useful with larger triangle meshes where most points are shared by multiple triangles.

All fills can be applied to triangles. The fills are applied to the resulting triangle mesh as they would to any other shape.

Transforming bitmaps

Flash Player 10 and later, Adobe AIR 1.5 and later

Bitmap transformations provide the illusion of perspective or "texture" on a three-dimensional object. Specifically, you can distort a bitmap toward a vanishing point so the image appears to shrink as it moves toward the vanishing point. Or, you can use a two-dimensional bitmap to create a surface for a three-dimensional object, providing the illusion of texture or "wrapping" on that three-dimensional object.

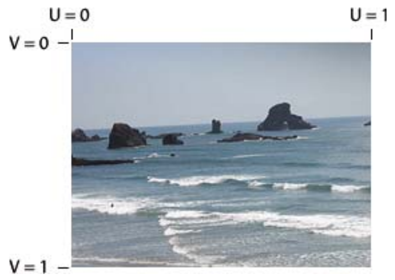
A two-dimensional surface using a vanishing point and a three-dimensional object wrapped with a bitmap.

UV mapping

Flash Player 10 and later, Adobe AIR 1.5 and later

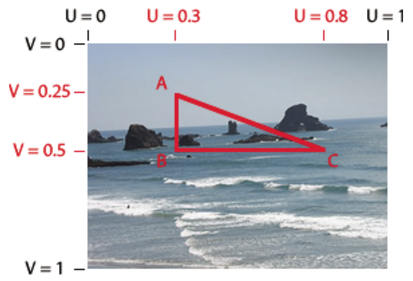
Once you start working with textures, you'll want to make use of the uvtData parameter of `drawTriangles()`. This parameter allows you to set up UV mapping for bitmap fills.

UV mapping is a method for texturing objects. It relies on two values, a U horizontal (x) value and a V vertical (y) value. Rather than being based on pixel values, they are based on percentages. 0 U and 0 V is the upper-left of an image and 1 U and 1 V is the lower-right:



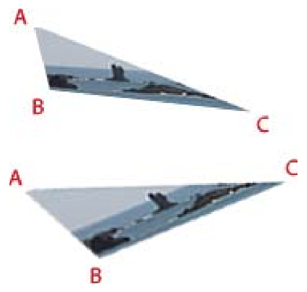
The UV 0 and 1 locations on a bitmap image

Vectors of a triangle can be given UV coordinates to associate themselves with the respective locations on an image:



The UV coordinates of a triangular area of a bitmap image

The UV values stay consistent with the points of the triangle:



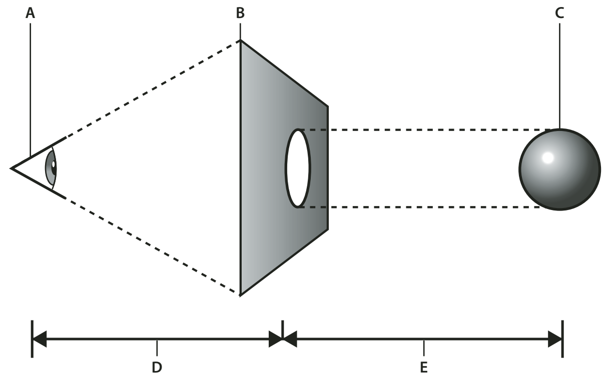
The vertices of the triangle move and the bitmap distorts to keep the UV values for an individual point the same

As ActionScript 3D transformations are applied to the triangle associated with the bitmap, the bitmap image is applied to the triangle based on the UV values. So, instead of using matrix calculations, set or adjust the UV values to create a three-dimensional effect.

The `Graphics.drawTriangles()` method also accepts an optional piece of information for three-dimensional transformations: the T value. The T value in uvtData represents the 3D perspective, or more specifically, the scale factor of the associated vertex. UVT mapping adds perspective correction to UV mapping. For example, if an object is positioned in 3D space away from the viewpoint so that it appears to be 50% its "original" size, the T value of that object would be 0.5. Since triangles are drawn to represent objects in 3D space, their locations along the z-axis determine their T values. The equation that determines the T value is:

```
T = focalLength/(focalLength + z);
```

In this equation, focalLength represents a focal length or calculated "screen" location which dictates the amount of perspective provided in the view.



The focal length and z value
***A.** viewpoint **B.** screen **C.** 3D object **D.** focalLength value **E.** z value*

The value of T is used to scale basic shapes to make them seem further in the distance. It is usually the value used to convert 3D points to 2D points. In the case of UVT data, it is also used to scale a bitmap between the points within a triangle with perspective.

When you define UVT values, the T value directly follows the UV values defined for a vertex. With the inclusion of T, every three values in the `uvtData` parameter (U, V, and T) match up with every two values in the `vertices` parameter (x, and y). With UV values alone, uvtData.length == vertices.length. With the inclusion of a T value, uvtData.length = 1.5*vertices.length.

The following example shows a plane being rotated in 3D space using UVT data. This example uses an image called ocean.jpg and a "helper" class, ImageLoader, to load the ocean.jpg image so it can be assigned to the BitmapData object.

Here is the ImageLoader class source (save this code into a file named ImageLoader.as):

```
package {
    import flash.display.*
    import flash.events.*;
    import flash.net.URLRequest;
    public class ImageLoader extends Sprite {
        public var url:String;
        public var bitmap:Bitmap;
    public function ImageLoader(loc:String = null) {
        if (loc != null){
            url = loc;
            loadImage();
        }
    }
    public function loadImage():void{
        if (url != null){
            var loader:Loader = new Loader();
            loader.contentLoaderInfo.addEventListener(Event.COMPLETE, onComplete);
            loader.contentLoaderInfo.addEventListener(IOErrorEvent.IO_ERROR, onIoError);

                var req:URLRequest = new URLRequest(url);
                loader.load(req);
            }
        }

    private function onComplete(event:Event):void {
            var loader:Loader = Loader(event.target.loader);
            var info:LoaderInfo = LoaderInfo(loader.contentLoaderInfo);
            this.bitmap = info.content as Bitmap;
            this.dispatchEvent(new Event(Event.COMPLETE));
    }

    private function onIoError(event:IOErrorEvent):void {
            trace("onIoError: " + event);
    }
    }
}
```

And here is the ActionScript that uses triangles, UV mapping, and T values to make the image appear as if it is shrinking toward a vanishing point and rotating. Save this code in a file named Spinning3dOcean.as:

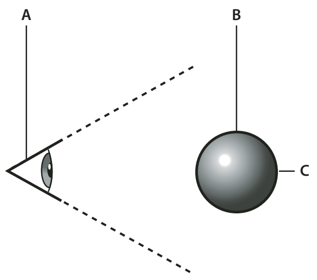
```
package {
    import flash.display.*
    import flash.events.*;
    import flash.utils.getTimer;

    public class Spinning3dOcean extends Sprite {
        // plane vertex coordinates (and t values)
        var x1:Number = -100,y1:Number = -100,z1:Number = 0,t1:Number = 0;
        var x2:Number = 100,y2:Number = -100,z2:Number = 0,t2:Number = 0;
        var x3:Number = 100,y3:Number = 100,z3:Number = 0,t3:Number = 0;
        var x4:Number = -100,y4:Number = 100,z4:Number = 0,t4:Number = 0;
        var focalLength:Number = 200;
        // 2 triangles for 1 plane, indices will always be the same
        var indices:Vector.<int>;

        var container:Sprite;

        var bitmapData:BitmapData; // texture
        var imageLoader:ImageLoader;
        public function Spinning3dOcean():void {
            indices =  new Vector.<int>();
            indices.push(0,1,3, 1,2,3);

            container = new Sprite(); // container to draw triangles in
            container.x = 200;
            container.y = 200;
            addChild(container);

            imageLoader = new ImageLoader("ocean.jpg");
            imageLoader.addEventListener(Event.COMPLETE, onImageLoaded);
        }
        function onImageLoaded(event:Event):void {
            bitmapData = imageLoader.bitmap.bitmapData;
            // animate every frame
            addEventListener(Event.ENTER_FRAME, rotatePlane);
        }
        function rotatePlane(event:Event):void {
            // rotate vertices over time
            var ticker = getTimer()/400;
            z2 = z3 = -(z1 = z4 = 100*Math.sin(ticker));
            x2 = x3 = -(x1 = x4 = 100*Math.cos(ticker));

            // calculate t values
            t1 = focalLength/(focalLength + z1);
            t2 = focalLength/(focalLength + z2);
            t3 = focalLength/(focalLength + z3);
            t4 = focalLength/(focalLength + z4);

            // determine triangle vertices based on t values
            var vertices:Vector.<Number> = new Vector.<Number>();
            vertices.push(x1*t1,y1*t1, x2*t2,y2*t2, x3*t3,y3*t3, x4*t4,y4*t4);
            // set T values allowing perspective to change
            // as each vertex moves around in z space
            var uvtData:Vector.<Number> = new Vector.<Number>();
            uvtData.push(0,0,t1, 1,0,t2, 1,1,t3, 0,1,t4);

            // draw
            container.graphics.clear();
            container.graphics.beginBitmapFill(bitmapData);
            container.graphics.drawTriangles(vertices, indices, uvtData);
        }
    }
}
```

To test this example, save these two class files in the same directory as an image named "ocean.jpg". You can see how the original bitmap is transformed to appear as if it is vanishing in the distance and rotating in 3D space.

Culling

Flash Player 10 and later, Adobe AIR 1.5 and later

Culling is the process that determines which surfaces of a three-dimensional object the renderer should not render because they are hidden from the current viewpoint. In 3D space, the surface on the "back" of a three-dimensional object is hidden from the viewpoint:



The back of a 3D object is hidden from the viewpoint.
***A.** viewpoint **B.** 3D object **C.** the back of a three dimensional object*

Inherently all triangles are always rendered no matter their size, shape, or position. Culling insures that Flash Player or AIR renders your 3D object correctly. In addition, to save on rendering cycles, sometimes you want some triangles to be skipped by the render. Consider a cube rotating in space. At any given time, you'll never see more than three sides of that cube since the sides not in view would be facing the other direction on the other side of the cube. Since those sides are not going to be seen, the renderer shouldn't draw them. Without culling, Flash Player or AIR renders both the front and back sides.

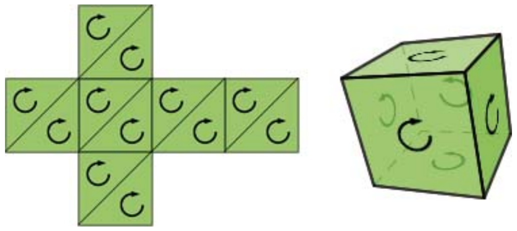
A cube has sides not visible from the current viewpoint

So, the `Graphics.drawTriangles()` method has a fourth parameter to establish a culling value:

```
public function drawTriangles(vertices:Vector.<Number>, indices:Vector.<int> = null,
uvtData:Vector.<Number> = null, culling:String = "none"):void
```

The culling parameter is a value from the `TriangleCulling` enumeration class: `TriangleCulling.NONE`, `TriangleCulling.POSITIVE`, and `TriangleCulling.NEGATIVE`. These values are dependent upon the direction of the triangle path defining the surface of the object. The ActionScript API for determining the culling assumes that all out-facing triangles of a 3D shape are drawn with the same path direction. Once a triangle face is turned around, the path direction also changes. At that point, the triangle can be culled (removed from rendering).

So, a `TriangleCulling` value of `POSITIVE` removes triangles with positive path direction (clockwise). A `TriangleCulling` value of `NEGATIVE` removes triangles with a negative (counterclockwise) path direction. In the case of a cube, while the front facing surfaces have a positive path direction, the back facing surfaces have a negative path direction:



A cube "unwrapped" to show the path direction. When "wrapped", the back side path direction is reversed.

To see how culling works, start with the earlier example from "UV mapping" on page 364, set the culling parameter of the `drawTriangles()` method to `TriangleCulling.NEGATIVE`:

```
container.graphics.drawTriangles(vertices, indices, uvtData, TriangleCulling.NEGATIVE);
```

Notice the "back" side of the image is not rendered as the object rotates.

Chapter 20: Basics of Working with text

Flash Player 9 and later, Adobe AIR 1.0 and later

To display text on the screen in Adobe® Flash® Player or Adobe® AIR™, use an instance of the TextField class or use the Flash Text Engine classes. These classes allow you to create, display, and format text. Alternatively, you can use the Text Layout Framework (TLF) — a component library based on the Flash Text Engine classes, but designed for ease of use. On mobile devices, you can use the StageText class for text input.

You can establish specific content for text fields, or designate the source for the text, and then set the appearance of that text. You can also respond to user events as the user inputs text or clicks a hypertext link.

Both the TextField class and the Flash Text Engine classes allow you to display and manage text in Flash Player and AIR.You can use the TextField class to create text objects for display and input. The TextField class provides the basis for other text-based components, such as TextArea and TextInput. You can use the TextFormat class to set character and paragraph formatting for TextField objects and you can apply Cascading Style Sheets (CSS) using the Textfield.styleSheet property and the StyleSheet class. You can assign HTML-formatted text, which can contain embedded media (movie clips, SWF files, GIF files, PNG files, and JPEG files), directly to a text field.

The Flash Text Engine, available starting with Flash Player 10 and Adobe AIR 1.5, provides low-level support for sophisticated control of text metrics, formatting, and bi-directional text. It also offers improved text flow and enhanced language support. While you can use the Flash Text Engine to create and manage text elements, it is primarily designed as the foundation for creating text-handling components and requires greater programming expertise.The Text Layout Framework, which includes a text-handling component based on the Flash Text Engine, provides an easier way to use the advanced features of the new text engine. The Text Layout Framework is an extensible library built entirely in ActionScript 3.0. You can use the existing TLF component, or use the framework to build your own text component.

The StageText class, available starting in AIR 3, provides a native text input field. Because this field is provided by the device operating system, it provides the experience with which users of a device are most familiar. A StageText instance is not a display object. Instead of adding it to the display list, you assign an instance a stage and a display area on that stage called a viewport. The StageText instance displays in front of any display objects.

For more information on these topics, see:

- "Using the TextField class" on page 373
- "Using the Flash Text Engine" on page 397
- "Using the Text Layout Framework" on page 426
- Native text input with StageText

Important concepts and terms

The following reference list contains important terms involved with text handling:

Cascading style sheets A standard syntax for specifying styles and formatting for content that's structured in XML (or HTML) format.

Device font A font that is installed on the user's machine.

Dynamic text field A text field whose contents can be changed by ActionScript but not by user input.

Embedded font A font that has its character outline data stored in the application SWF file.

HTML text Text content entered into a text field using ActionScript that includes HTML formatting tags along with actual text content.

Input text field A text field whose contents can be changed either by user input or by ActionScript.

Kerning An adjustment of the spacing between pairs of characters to make the spacing in words more proportional and the text easier to read.

Static text field A text field created in the authoring tool, whose content cannot change when the SWF file is running.

Text line metrics Measurements of the size of various parts of the text content in a text field, such as the baseline of the text, the height of the top of the characters, size of descenders (the part of some lowercase letters that extends below the baseline), and so on.

Tracking An adjustment of spacing between groups of letters or blocks of text to increase or decrease the density and make the text more readable.

Chapter 21: Using the TextField class

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use an instance of the TextField class to display text or create a text input field on the screen in Adobe® Flash® Player or Adobe® AIR™. The TextField class is the basis for other text-based components, such as the TextArea components or the TextInput components.

Text field content can be pre-specified in the SWF file, loaded from a text file or database, or entered by a user interacting with your application. Within a text field, the text can appear as rendered HTML content, with images embedded in the rendered HTML. After you create an instance of a text field, you can use flash.text classes, such as TextFormat and StyleSheet, to control the appearance of the text. The flash.text package contains nearly all the classes related to creating, managing, and formatting text in ActionScript.

You can format text by defining the formatting with a TextFormat object and assigning that object to the text field. If your text field contains HTML text, you can apply a StyleSheet object to the text field to assign styles to specific pieces of the text field content. The TextFormat object or StyleSheet object contains properties defining the appearance of the text, such as color, size, and weight. The TextFormat object assigns the properties to all the content within a text field or to a range of text. For example, within the same text field, one sentence can be bold red text and the next sentence can be blue italic text.

In addition to the classes in the flash.text package, you can use the flash.events.TextEvent class to respond to user actions related to text.

More Help topics

"Assigning text formats" on page 380

"Displaying HTML text" on page 375

"Applying cascading style sheets" on page 380

Displaying text

Flash Player 9 and later, Adobe AIR 1.0 and later

Although authoring tools like Adobe Flash Builder and Flash Professional provide several options for displaying text, including text-related components or text tools, the simplest way to display text programmatically is through a text field.

Types of text

Flash Player 9 and later, Adobe AIR 1.0 and later

The type of text within a text field is characterized by its source:

- Dynamic text

  Dynamic text includes content that is loaded from an external source, such as a text file, an XML file, or even a remote web service.

- Input text

  Input text is any text entered by a user or dynamic text that a user can edit. You can set up a style sheet to format input text, or use the flash.text.TextFormat class to assign properties to the text field for the input content. For more information, see "Capturing text input" on page 378.

- Static text

  Static text is created through Flash Professional only. You cannot create a static text instance using ActionScript 3.0. However, you can use ActionScript classes like StaticText and TextSnapshot to manipulate an existing static text instance. For more information, see "Working with static text" on page 386.

Modifying the text field contents

Flash Player 9 and later, Adobe AIR 1.0 and later

You can define dynamic text by assigning a string to the `flash.text.TextField.text` property. You assign a string directly to the property, as follows:

```
myTextField.text = "Hello World";
```

You can also assign the `text` property a value from a variable defined in your script, as in the following example:

```
package
{
    import flash.display.Sprite;
    import flash.text.*;

    public class TextWithImage extends Sprite
    {
        private var myTextBox:TextField = new TextField();
        private var myText:String = "Hello World";

        public function TextWithImage()
        {
            addChild(myTextBox);
            myTextBox.text = myText;
        }
    }
}
```

Alternatively, you can assign the `text` property a value from a remote variable. You have three options for loading text values from remote sources:

- The flash.net.URLLoader and flash.net.URLRequest classes load variables for the text from a local or remote location.
- The `FlashVars` attribute is embedded in the HTML page hosting the SWF file and can contain values for text variables.
- The flash.net.SharedObject class manages persistent storage of values. For more information, see "Storing local data" on page 701.

Displaying HTML text

Flash Player 9 and later, Adobe AIR 1.0 and later

The flash.text.TextField class has an `htmlText` property that you can use to identify your text string as one containing HTML tags for formatting the content. As in the following example, you must assign your string value to the `htmlText` property (not the `text` property) for Flash Player or AIR to render the text as HTML:

```
var myText:String = "<p>This is <b>some</b> content to <i>render</i> as <u>HTML</u> text.</p>";
myTextBox.htmlText = myText;
```

Flash Player and AIR support a subset of HTML tags and entities for the `htmlText` property. The `flash.text.TextField.htmlText` property description in the ActionScript 3.0 Reference provides detailed information about the supported HTML tags and entities.

Once you designate your content using the `htmlText` property, you can use style sheets or the `textformat` tag to manage the formatting of your content. For more information, see "Formatting text" on page 380.

Using images in text fields

Flash Player 9 and later, Adobe AIR 1.0 and later

Another advantage to displaying your content as HTML text is that you can include images in the text field. You can reference an image, local or remote, using the `img` tag and have it appear within the associated text field.

The following example creates a text field named `myTextBox` and includes a JPG image of an eye, stored in the same directory as the SWF file, within the displayed text:

```
package
{
    import flash.display.Sprite;
    import flash.text.*;

    public class TextWithImage extends Sprite
    {
        private var myTextBox:TextField;
        private var myText:String = "<p>This is <b>some</b> content to <i>test</i> and
<i>see</i></p><p><img src='eye.jpg' width='20' height='20'></p><p>what can be
rendered.</p><p>You should see an eye image and some <u>HTML</u> text.</p>";

        public function TextWithImage()
        {
            myTextBox.width = 200;
            myTextBox.height = 200;
            myTextBox.multiline = true;
            myTextBox.wordWrap = true;
            myTextBox.border = true;

            addChild(myTextBox);
            myTextBox.htmlText = myText;
        }
    }
}
```

The `img` tag supports JPEG, GIF, PNG, and SWF files.

Scrolling text in a text field

Flash Player 9 and later, Adobe AIR 1.0 and later

In many cases, your text can be longer than the text field displaying the text. Or you may have an input field that allows a user to input more text than can be displayed at one time. You can use the scroll-related properties of the flash.text.TextField class to manage lengthy content, either vertically or horizontally.

The scroll-related properties include `TextField.scrollV`, `TextField.scrollH` and `maxScrollV` and `maxScrollH`. Use these properties to respond to events, like a mouse click or a keypress.

The following example creates a text field that is a set size and contains more text than the field can display at one time. As the user clicks the text field, the text scrolls vertically.

```
package
{
    import flash.display.Sprite;
    import flash.text.*;
    import flash.events.MouseEvent;

    public class TextScrollExample extends Sprite
    {
        private var myTextBox:TextField = new TextField();
        private var myText:String = "Hello world and welcome to the show. It's really nice to
meet you. Take your coat off and stay a while. OK, show is over. Hope you had fun. You can go
home now. Don't forget to tip your waiter. There are mints in the bowl by the door. Thank you.
Please come again.";

        public function TextScrollExample()
        {
            myTextBox.text = myText;
            myTextBox.width = 200;
            myTextBox.height = 50;
            myTextBox.multiline = true;
            myTextBox.wordWrap = true;
            myTextBox.background = true;
            myTextBox.border = true;

            var format:TextFormat = new TextFormat();
            format.font = "Verdana";
            format.color = 0xFF0000;
            format.size = 10;

            myTextBox.defaultTextFormat = format;
            addChild(myTextBox);
            myTextBox.addEventListener(MouseEvent.MOUSE_DOWN, mouseDownScroll);
        }

        public function mouseDownScroll(event:MouseEvent):void
        {
            myTextBox.scrollV++;
        }
    }
}
```

Selecting and manipulating text

Flash Player 9 and later, Adobe AIR 1.0 and later

You can select dynamic or input text. Since the text selection properties and methods of the TextField class use index positions to set the range of text to manipulate, you can programmatically select dynamic or input text even if you don't know the content.

***Note:** In Flash Professional, if you choose the selectable option on a static text field, the text field that is exported and placed on the display list is a regular, dynamic text field.*

Selecting text

Flash Player 9 and later, Adobe AIR 1.0 and later

The `flash.text.TextField.selectable` property is `true` by default, and you can programmatically select text using the `setSelection()` method.

For example, you can set specific text within a text field to be selected when the user clicks the text field:

```
var myTextField:TextField = new TextField();
myTextField.text = "No matter where you click on this text field the TEXT IN ALL CAPS is selected.";
myTextField.autoSize = TextFieldAutoSize.LEFT;
addChild(myTextField);
addEventListener(MouseEvent.CLICK, selectText);

function selectText(event:MouseEvent):void
{
    myTextField.setSelection(49, 65);
}
```

Similarly, if you want text within a text field to be selected as the text is initially displayed, create an event handler function that is called as the text field is added to the display list.

Capturing user-selected text

Flash Player 9 and later, Adobe AIR 1.0 and later

The TextField `selectionBeginIndex` and `selectionEndIndex` properties, which are "read-only" so they can't be set to programmatically select text, can be used to capture whatever the user has currently selected. Additionally, input text fields can use the `caretIndex` property.

For example, the following code traces the index values of user-selected text:

```
var myTextField:TextField = new TextField();
myTextField.text = "Please select the TEXT IN ALL CAPS to see the index values for the first
and last letters.";
myTextField.autoSize = TextFieldAutoSize.LEFT;
addChild(myTextField);
addEventListener(MouseEvent.MOUSE_UP, selectText);

function selectText(event:MouseEvent):void
{
    trace("First letter index position: " + myTextField.selectionBeginIndex);
    trace("Last letter index position: " + myTextField.selectionEndIndex);
}
```

You can apply a collection of TextFormat object properties to the selection to change the text appearance. For more information about applying a collection of TextFormat properties to selected text, see "Formatting ranges of text within a text field" on page 383.

Capturing text input

Flash Player 9 and later, Adobe AIR 1.0 and later

By default, the `type` property of a text field is set to `dynamic`. If you set the `type` property to `input` using the TextFieldType class, you can collect user input and save the value for use in other parts of your application. Input text fields are useful for forms and any application that wants the user to define a text value for use elsewhere in the program.

For example, the following code creates an input text field called `myTextBox`. As the user enters text in the field, the `textInput` event is triggered. An event handler called `textInputCapture` captures the string of text entered and assigns it a variable. Flash Player or AIR displays the new text in another text field, called `myOutputBox`.

```
package
{
    import flash.display.Sprite;
    import flash.display.Stage;
    import flash.text.*;
    import flash.events.*;

    public class CaptureUserInput extends Sprite
    {
        private var myTextBox:TextField = new TextField();
        private var myOutputBox:TextField = new TextField();
        private var myText:String = "Type your text here.";

        public function CaptureUserInput()
        {
            captureText();
        }

        public function captureText():void
        {
            myTextBox.type = TextFieldType.INPUT;
            myTextBox.background = true;
            addChild(myTextBox);
            myTextBox.text = myText;
            myTextBox.addEventListener(TextEvent.TEXT_INPUT, textInputCapture);
        }

        public function textInputCapture(event:TextEvent):void
        {
            var str:String = myTextBox.text;
            createOutputBox(str);
        }

        public function createOutputBox(str:String):void
        {
            myOutputBox.background = true;
            myOutputBox.x = 200;
            addChild(myOutputBox);
            myOutputBox.text = str;
        }

    }
}
```

Restricting text input

Flash Player 9 and later, Adobe AIR 1.0 and later

Since input text fields are often used for forms or dialog boxes in applications, you may want to limit the types of characters a user can enter in a text field, or even keep the text hidden —for example, for a password. The flash.text.TextField class has a `displayAsPassword` property and a `restrict` property that you can set to control user input.

The `displayAsPassword` property simply hides the text (displaying it as a series of asterisks) as the user types it. When `displayAsPassword` is set to `true`, the Cut and Copy commands and their corresponding keyboard shortcuts do not function. As the following example shows, you assign the `displayAsPassword` property just as you would other properties, such as background and color:

```
myTextBox.type = TextFieldType.INPUT;
myTextBox.background = true;
myTextBox.displayAsPassword = true;
addChild(myTextBox);
```

The `restrict` property is a little more complicated since you must specify which characters the user is allowed to type in an input text field. You can allow specific letters, numbers, or ranges of letters, numbers, and characters. The following code allows the user to enter only uppercase letters (and not numbers or special characters) in the text field:

```
myTextBox.restrict = "A-Z";
```

ActionScript 3.0 uses hyphens to define ranges, and carets to define excluded characters. For more information about defining what is restricted in an input text field, see the `flash.text.TextField.restrict` property entry in the ActionScript 3.0 Reference.

***Note:** If you use the `flash.text.TextField.restrict` property, the runtime automatically converts restricted letters to the allowed case. If you use the `fl.text.TLFTextField.restrict` property (that is, if you use a TLF text field), the runtime ignores restricted letters.*

Formatting text

Flash Player 9 and later, Adobe AIR 1.0 and later

You have several options for programmatically formatting the display of text. You can set properties directly on the TextField instance—for example, the `TextFIeld.thickness`, `TextField.textColor`, and `TextField.textHeight` properties.Or you can designate the content of the text field using the `htmlText` property and use the supported HTML tags, such as `b`, `i`, and `u`. But you can also apply TextFormat objects to text fields containing plain text, or StyleSheet objects to text fields containing the `htmlText` property. Using TextFormat and StyleSheet objects provides the most control and consistency over the appearance of text throughout your application. You can define a TextFormat or StyleSheet object and apply it to many or all text fields in your application.

Assigning text formats

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the TextFormat class to set a number of different text display properties and to apply them to the entire contents of a TextField object, or to a range of text.

The following example applies one TextFormat object to an entire TextField object and applies a second TextFormat object to a range of text within that TextField object:

```
var tf:TextField = new TextField();
tf.text = "Hello Hello";

var format1:TextFormat = new TextFormat();
format1.color = 0xFF0000;

var format2:TextFormat = new TextFormat();
format2.font = "Courier";

tf.setTextFormat(format1);
var startRange:uint = 6;
tf.setTextFormat(format2, startRange);

addChild(tf);
```

The `TextField.setTextFormat()` method only affects text that is already displayed in the text field. If the content in the TextField changes, your application might need to call the `TextField.setTextFormat()` method again to reapply the formatting. You can also set the TextField `defaultTextFormat` property to specify the format to be used for user-entered text.

Applying cascading style sheets

Flash Player 9 and later, Adobe AIR 1.0 and later

Text fields can contain either plain text or HTML-formatted text. Plain text is stored in the `text` property of the instance, and HTML text is stored in the `htmlText` property.

You can use CSS style declarations to define text styles that you can apply to many different text fields. CSS style declarations can be created in your application code or loaded in at run time from an external CSS file.

The flash.text.StyleSheet class handles CSS styles. The StyleSheet class recognizes a limited set of CSS properties. For a detailed list of the style properties that the StyleSheet class supports, see the flash.textStylesheet entry in the ActionScript 3.0 Reference.

As the following example shows, you can create CSS in your code and apply those styles to HTML text by using a StyleSheet object:

```
var style:StyleSheet = new StyleSheet();

var styleObj:Object = new Object();
styleObj.fontSize = "bold";
styleObj.color = "#FF0000";
style.setStyle(".darkRed", styleObj);

var tf:TextField = new TextField();
tf.styleSheet = style;
tf.htmlText = "<span class = 'darkRed'>Red</span> apple";

addChild(tf);
```

After creating a StyleSheet object, the example code creates a simple object to hold a set of style declaration properties. Then it calls the `StyleSheet.setStyle()` method, which adds the new style to the style sheet with the name ".darkred". Next, it applies the style sheet formatting by assigning the StyleSheet object to the TextField `styleSheet` property.

For CSS styles to take effect, the style sheet should be applied to the TextField object before the `htmlText` property is set.

By design, a text field with a style sheet is not editable. If you have an input text field and assign a style sheet to it, the text field shows the properties of the style sheet, but the text field does not allow users to enter new text into it. Also, you cannot use the following ActionScript APIs on a text field with an assigned style sheet:

- The `TextField.replaceText()` method
- The `TextField.replaceSelectedText()` method
- The `TextField.defaultTextFormat` property
- The `TextField.setTextFormat()` method

If a text field has a style sheet assigned to it, but later the `TextField.styleSheet` property is set to `null`, the contents of both `TextField.text` and `TextField.htmlText` properties add tags and attributes to their content to incorporate the formatting from the previously assigned style sheet. To preserve the original `htmlText` property, save it in a variable before setting the style sheet to `null`.

Loading an external CSS file

Flash Player 9 and later, Adobe AIR 1.0 and later

The CSS approach to formatting is more powerful when you can load CSS information from an external file at run time. When the CSS data is external to the application itself, you can change the visual style of text in your application without having to change your ActionScript 3.0 source code. After your application has been deployed, you can change an external CSS file to change the look of the application, without having to redeploy the application SWF file.

The `StyleSheet.parseCSS()` method converts a string that contains CSS data into style declarations in the StyleSheet object. The following example shows how to read an external CSS file and apply its style declarations to a TextField object.

First, here is the content of the CSS file to be loaded, which is named example.css:

```
p {
    font-family: Times New Roman, Times, _serif;
    font-size: 14;
}

h1 {
    font-family: Arial, Helvetica, _sans;
    font-size: 20;
    font-weight: bold;
}

.bluetext {
    color: #0000CC;
}
```

Next is the ActionScript code for a class that loads the example.css file and applies the styles to TextField content:

```
package
{
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.net.URLLoader;
    import flash.net.URLRequest;
    import flash.text.StyleSheet;
    import flash.text.TextField;
    import flash.text.TextFieldAutoSize;

    public class CSSFormattingExample extends Sprite
    {
        var loader:URLLoader;
        var field:TextField;
        var exampleText:String = "<h1>This is a headline</h1>" +
            "<p>This is a line of text. <span class='bluetext'>" +
            "This line of text is colored blue.</span></p>";

        public function CSSFormattingExample():void
        {
            field = new TextField();
            field.width = 300;
            field.autoSize = TextFieldAutoSize.LEFT;
            field.wordWrap = true;
            addChild(field);

            var req:URLRequest = new URLRequest("example.css");

            loader = new URLLoader();
            loader.addEventListener(Event.COMPLETE, onCSSFileLoaded);
            loader.load(req);
        }

        public function onCSSFileLoaded(event:Event):void
        {
            var sheet:StyleSheet = new StyleSheet();
            sheet.parseCSS(loader.data);
            field.styleSheet = sheet;
            field.htmlText = exampleText;
        }
    }
}
```

When the CSS data is loaded, the `onCSSFileLoaded()` method executes and calls the `StyleSheet.parseCSS()` method to transfer the style declarations to the StyleSheet object.

Formatting ranges of text within a text field

Flash Player 9 and later, Adobe AIR 1.0 and later

A useful method of the flash.text.TextField class is the `setTextFormat()` method. Using `setTextFormat()`, you can assign specific properties to the contents of a part of a text field to respond to user input, such as forms that need to remind users that certain entries are required or to change the emphasis of a subsection of a passage of text within a text field as a user selects parts of the text.

The following example uses `TextField.setTextFormat()` on a range of characters to change the appearance of part of the content of `myTextField` when the user clicks the text field:

```
var myTextField:TextField = new TextField();
myTextField.text = "No matter where you click on this text field the TEXT IN ALL CAPS changes 
format.";
myTextField.autoSize = TextFieldAutoSize.LEFT;
addChild(myTextField);
addEventListener(MouseEvent.CLICK, changeText);

var myformat:TextFormat = new TextFormat();
myformat.color = 0xFF0000;
myformat.size = 18;
myformat.underline = true;

function changeText(event:MouseEvent):void
{
    myTextField.setTextFormat(myformat, 49, 65);
}
```

Advanced text rendering

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 provides a variety of classes in the flash.text package to control the properties of displayed text, including embedded fonts, anti-aliasing settings, alpha channel control, and other specific settings. The ActionScript 3.0 Reference provides detailed descriptions of these classes and properties, including the CSMSettings, Font, and TextRenderer classes.

Using embedded fonts

Flash Player 9 and later, Adobe AIR 1.0 and later

When you specify a specific font for a TextField in your application, Flash Player or AIR look for a device font (a font that resides on the user's computer) with the same name. If it doesn't find that font on the system, or if the user has a slightly different version of a font with that name, the text display could look very different from what you intend. By default, the text appears in a Times Roman font.

To make sure the user sees exactly the right font, you can embed that font in your application SWF file. Embedded fonts have a number of benefits:

- Embedded font characters are anti-aliased, making their edges appear smoother, especially for larger text.
- You can rotate text that uses embedded fonts.
- Embedded font text can be made transparent or semitransparent.
- You can use the `kerning` CSS style with embedded fonts.

The biggest limitation to using embedded fonts is that they increase the file size or download size of your application.

The exact method of embedding a font file into your application SWF file varies according to your development environment.

Once you have embedded a font you can make sure a TextField uses the correct embedded font:

- Set the `embedFonts` property of the TextField to `true`.
- Create a TextFormat object, set its `fontFamily` property to the name of the embedded font, and apply the TextFormat object to the TextField. When specifying an embedded font, the `fontFamily` property should only contain a single name; it cannot use a comma-delimited list of multiple font names.
- If using CSS styles to set fonts for TextFields or components, set the `font-family` CSS property to the name of the embedded font. The `font-family` property must contain a single name and not a list of names if you want to specify an embedded font.

Embedding a font in Flash

Flash Professional lets you embed almost any font you have installed on your system, including TrueType fonts and Type 1 Postscript fonts.

You can embed fonts in an application in many ways, including:

- Setting the font and style properties of a TextField on the Stage and clicking the Embed Fonts checkbox
- Creating and referencing a font symbol
- Creating and using a run-time shared library containing embedded font symbols

For more details about how to embed fonts in applications, see "Embedded fonts for dynamic or input text fields" in *Using Flash*.

Embedding a font in Flex

You can embed fonts in a Flex application in many ways, including:

- Using the `[Embed]` metadata tag in a script
- Using the `@font-face` style declaration
- Establish a class for the font and use the `[Embed]` tag to embed it.

You can only embed TrueType fonts directly in a Flex application. Fonts in other formats, such as Type 1 Postscript fonts, can first be embedded in a SWF file using Flash Professional and then that SWF file can be used in your Flex application. For more details about using embedded fonts from SWF files in Flex, see "Embedding fonts from SWF files" in *Using Flex 4*.

More Help topics

Embed fonts for consistent text appearance

Peter deHaan: Embedding fonts

Divillysausages.com: AS3 Font embedding masterclass

Controlling sharpness, thickness, and anti-aliasing

Flash Player 9 and later, Adobe AIR 1.0 and later

By default, Flash Player or AIR determines the settings for text display controls like sharpness, thickness, and anti-aliasing as text resizes, changes color, or is displayed on various backgrounds. In some cases, like when you have very small or very large text, or text on a variety of unique backgrounds, you might want to maintain control over these settings. You can override Flash Player or AIR settings using the `flash.text.TextRenderer` class and its associated classes, like the CSMSettings class. These classes give you precise control over the rendering quality of embedded text. For more information about embedded fonts, see "Using embedded fonts" on page 384.

Note: *The* `flash.text.TextField`*.antiAliasType property must have the value* `AntiAliasType.ADVANCED` *in order for you to set the sharpness, thickness, or the gridFitType property, or to use the* `TextRenderer.setAdvancedAntiAliasingTable()` *method.*

The following example applies custom continuous stroke modulation (CSM) properties and formatting to displayed text using an embedded font called `myFont`. When the user clicks the displayed text, Flash Player or Adobe AIR applies the custom settings:

```
var format:TextFormat = new TextFormat();
format.color = 0x336699;
format.size = 48;
format.font = "myFont";

var myText:TextField = new TextField();
myText.embedFonts = true;
myText.autoSize = TextFieldAutoSize.LEFT;
myText.antiAliasType = AntiAliasType.ADVANCED;
myText.defaultTextFormat = format;
myText.selectable = false;
myText.mouseEnabled = true;
myText.text = "Hello World";
addChild(myText);
myText.addEventListener(MouseEvent.CLICK, clickHandler);

function clickHandler(event:Event):void
{
    var myAntiAliasSettings = new CSMSettings(48, 0.8, -0.8);
    var myAliasTable:Array = new Array(myAntiAliasSettings);
    TextRenderer.setAdvancedAntiAliasingTable("myFont", FontStyle.ITALIC, 
TextColorType.DARK_COLOR, myAliasTable);
}
```

Working with static text

Flash Player 9 and later, Adobe AIR 1.0 and later

Static text is created only within Flash Professional. You cannot programmatically instantiate static text using ActionScript. Static text is useful if the text is short and is not intended to change (as dynamic text can). Think of static text as similar to a graphic element like a circle or square drawn on the Stage in Flash Professional. While static text is more limited than dynamic text, ActionScript 3.0 does allow you to read the property values of static text using the StaticText class. You can also use the TextSnapshot class to read values out of the static text.

Accessing static text fields with the StaticText class

Flash Player 9 and later, Adobe AIR 1.0 and later

Typically, you use the flash.text.StaticText class in the Actions panel of Flash Professional to interact with a static text instance placed on the Stage. You may also work in ActionScript files that interact with a SWF file containing static text. In either case, you can't instantiate a static text instance programmatically. Static text is created in Flash Professional.

To create a reference to an existing static text field, iterate over the items in the display list and assign a variable. For example:

```
for (var i = 0; i < this.numChildren; i++) {
var displayitem:DisplayObject = this.getChildAt(i);
if (displayitem instanceof StaticText) {
trace("a static text field is item " + i + " on the display list");
        var myFieldLabel:StaticText = StaticText(displayitem);
        trace("and contains the text: " + myFieldLabel.text);
}
}
```

Once you have a reference to a static text field, you can use the properties of that field in ActionScript 3.0. The following code is attached to a frame in the Timeline, and assumes that a variable named `myFieldLabel` is assigned to a static text reference. A dynamic text field named `myField` is positioned relative to the `x` and `y` values of `myFieldLabel` and displays the value of `myFieldLabel` again.

```
var myField:TextField = new TextField();
addChild(myField);
myField.x = myFieldLabel.x;
myField.y = myFieldLabel.y + 20;
myField.autoSize = TextFieldAutoSize.LEFT;
myField.text = "and " + myFieldLabel.text
```

Using the TextSnapshot class

Flash Player 9 and later, Adobe AIR 1.0 and later

If you want to programmatically work with an existing static text instance, you can use the flash.text.TextSnapshot class to work with the `textSnapshot` property of a flash.display.DisplayObjectContainer. In other words, you create a TextSnapshot instance from the `DisplayObjectContainer.textSnapshot` property. You can then apply methods to that instance to retrieve values or select parts of the static text.

For example, place a static text field that contains the text "TextSnapshot Example" on the Stage. Add the following ActionScript to Frame 1 of the Timeline:

```
var mySnap:TextSnapshot = this.textSnapshot;
var count:Number = mySnap.charCount;
mySnap.setSelected(0, 4, true);
mySnap.setSelected(1, 2, false);
var myText:String = mySnap.getSelectedText(false);
trace(myText);
```

The TextSnapshot class is useful for getting the text out of static text fields in a loaded SWF file, if you want to use the text as a value in another part of an application.

TextField Example: Newspaper-style text formatting

Flash Player 9 and later, Adobe AIR 1.0 and later

The News Layout example formats text to look something like a story in a printed newspaper. The input text can contain a headline, a subtitle, and the body of the story. Given a display width and height, this News Layout example formats the headline and the subtitle to take the full width of the display area. The story text is distributed across two or more columns.

This example illustrates the following ActionScript programming techniques:

- Extending the TextField class
- Loading and applying an external CSS file
- Converting CSS styles into TextFormat objects
- Using the TextLineMetrics class to get information about text display size

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The News Layout application files can be found in the folder Samples/NewsLayout. The application consists of the following files:

File	Description
NewsLayout.mxml or NewsLayout.fla	The user interface for the application for Flex (MXML) or Flash (FLA).
com/example/programmingas3/newslayout/StoryLayoutComponent.as	A Flex UIComponent class that places the StoryLayout instance.
com/example/programmingas3/newslayout/StoryLayout.as	The main ActionScript class that arranges all the components of a news story for display.
com/example/programmingas3/newslayout/FormattedTextField.as	A subclass of the TextField class that manages its own TextFormat object.
com/example/programmingas3/newslayout/HeadlineTextField.as	A subclass of the FormattedTextField class that adjusts font sizes to fit a desired width.
com/example/programmingas3/newslayout/MultiColumnTextField.as	An ActionScript class that splits text across two or more columns.
story.css	A CSS file that defines text styles for the layout.

Reading the external CSS file

Flash Player 9 and later, Adobe AIR 1.0 and later

The News Layout application starts by reading story text from a local XML file. Then it reads an external CSS file that provides the formatting information for the headline, subtitle, and main text.

The CSS file defines three styles, a standard paragraph style for the story, and the h1 and h2 styles for the headline and subtitle respectively.

```
p {
    font-family: Georgia, "Times New Roman", Times, _serif;
    font-size: 12;
    leading: 2;
    text-align: justify;
    indent: 24;
}

h1 {
    font-family: Verdana, Arial, Helvetica, _sans;
    font-size: 20;
    font-weight: bold;
    color: #000099;
    text-align: left;
}

h2 {
    font-family: Verdana, Arial, Helvetica, _sans;
    font-size: 16;
    font-weight: normal;
    text-align: left;
}
```

The technique used to read the external CSS file is the same as the technique described in "Loading an external CSS file" on page 381. When the CSS file has been loaded the application executes the `onCSSFileLoaded()` method, shown below.

```
public function onCSSFileLoaded(event:Event):void
{
    this.sheet = new StyleSheet();
    this.sheet.parseCSS(loader.data);

    h1Format = getTextStyle("h1", this.sheet);
    if (h1Format == null)
    {
        h1Format = getDefaultHeadFormat();
    }
    h2Format = getTextStyle("h2", this.sheet);
    if (h2Format == null)
    {
        h2Format = getDefaultHeadFormat();
        h2Format.size = 16;
    }
    pFormat = getTextStyle("p", this.sheet);
    if (pFormat == null)
    {
        pFormat = getDefaultTextFormat();
        pFormat.size = 12;
    }
    displayText();
}
```

The `onCSSFileLoaded()` method creates a StyleSheet object and has it parse the input CSS data. The main text for the story is displayed in a MultiColumnTextField object, which can use a StyleSheet object directly. However, the headline fields use the HeadlineTextField class, which uses a TextFormat object for its formatting.

The `onCSSFileLoaded()` method calls the `getTextStyle()` method twice to convert a CSS style declaration into a TextFormat object for use with each of the two HeadlineTextField objects.

```
public function getTextStyle(styleName:String, ss:StyleSheet):TextFormat
{
    var format:TextFormat = null;

    var style:Object = ss.getStyle(styleName);
    if (style != null)
    {
        var colorStr:String = style.color;
        if (colorStr != null && colorStr.indexOf("#") == 0)
        {
            style.color = colorStr.substr(1);
        }
        format = new TextFormat(style.fontFamily,
                        style.fontSize,
                        style.color,
                        (style.fontWeight == "bold"),
                        (style.fontStyle == "italic"),
                        (style.textDecoration == "underline"),
                        style.url,
                        style.target,
                        style.textAlign,
                        style.marginLeft,
                        style.marginRight,
                        style.indent,
                        style.leading);

        if (style.hasOwnProperty("letterSpacing"))
        {
            format.letterSpacing = style.letterSpacing;
        }
    }
    return format;
}
```

The property names and the meaning of the property values differ between CSS style declarations and TextFormat objects. The `getTextStyle()` method translates CSS property values into the values expected by the TextFormat object.

Arranging story elements on the page

Flash Player 9 and later, Adobe AIR 1.0 and later

The StoryLayout class formats and lays out the headline, subtitle, and main text fields into a newspaper-style arrangement. The `displayText()` method initially creates and places the various fields.

```
public function displayText():void
{
    headlineTxt = new HeadlineTextField(h1Format);
    headlineTxt.wordWrap = true;
    headlineTxt.x = this.paddingLeft;
    headlineTxt.y = this.paddingTop;
    headlineTxt.width = this.preferredWidth;
    this.addChild(headlineTxt);

    headlineTxt.fitText(this.headline, 1, true);

    subtitleTxt = new HeadlineTextField(h2Format);
    subtitleTxt.wordWrap = true;
    subtitleTxt.x = this.paddingLeft;
    subtitleTxt.y = headlineTxt.y + headlineTxt.height;
    subtitleTxt.width = this.preferredWidth;
    this.addChild(subtitleTxt);

    subtitleTxt.fitText(this.subtitle, 2, false);

    storyTxt = new MultiColumnText(this.numColumns, 20,
                    this.preferredWidth, 400, true, this.pFormat);
    storyTxt.x = this.paddingLeft;
    storyTxt.y = subtitleTxt.y + subtitleTxt.height + 10;
    this.addChild(storyTxt);

    storyTxt.text = this.content;
...
```

Each field is placed below the previous field by setting its `y` property to equal the `y` property of the previous field plus its height. This dynamic placement calculation is needed because HeadlineTextField objects and MultiColumnTextField objects can change their height to fit their contents.

Altering font size to fit the field size

Flash Player 9 and later, Adobe AIR 1.0 and later

Given a width in pixels and a maximum number of lines to display, the HeadlineTextField alters the font size to make the text fit the field. If the text is short, the font size is large, creating a tabloid-style headline. If the text is long, the font size is smaller.

The `HeadlineTextField.fitText()` method shown below does the font sizing work:

```
public function fitText(msg:String, maxLines:uint = 1, toUpper:Boolean = false, 
targetWidth:Number = -1):uint
{
    this.text = toUpper ? msg.toUpperCase() : msg;

    if (targetWidth == -1)
    {
        targetWidth = this.width;
    }

    var pixelsPerChar:Number = targetWidth / msg.length;

    var pointSize:Number = Math.min(MAX_POINT_SIZE, Math.round(pixelsPerChar * 1.8 * maxLines));

    if (pointSize < 6)
    {
        // the point size is too small
        return pointSize;
    }

    this.changeSize(pointSize);

    if (this.numLines > maxLines)
    {
        return shrinkText(--pointSize, maxLines);
    }
    else
    {
        return growText(pointSize, maxLines);
    }
}

public function growText(pointSize:Number, maxLines:uint = 1):Number
{
    if (pointSize >= MAX_POINT_SIZE)
    {
        return pointSize;
    }

    this.changeSize(pointSize + 1);

    if (this.numLines > maxLines)
    {
        // set it back to the last size
        this.changeSize(pointSize);
        return pointSize;
    }
    else
    {
        return growText(pointSize + 1, maxLines);
    }
}

public function shrinkText(pointSize:Number, maxLines:uint=1):Number
{
    if (pointSize <= MIN_POINT_SIZE)
    {
        return pointSize;
    }

    this.changeSize(pointSize);

    if (this.numLines > maxLines)
    {
        return shrinkText(pointSize - 1, maxLines);
    }
    else
    {
        return pointSize;
    }
}
```

The `HeadlineTextField.fitText()` method uses a simple recursive technique to size the font. First it guesses an average number of pixels per character in the text and from there calculates a starting point size. Then it changes the font size and checks whether the text has word wrapped to create more than the maximum number of text lines. If there are too many lines it calls the `shrinkText()` method to decrease the font size and try again. If there are not too many lines it calls the `growText()` method to increase the font size and try again. The process stops at the point where incrementing the font size by one more point would create too many lines.

Splitting text across multiple columns

Flash Player 9 and later, Adobe AIR 1.0 and later

The MultiColumnTextField class spreads text among multiple TextField objects which are then arranged like newspaper columns.

The `MultiColumnTextField()` constructor first creates an array of TextField objects, one for each column, as shown here:

```
    for (var i:int = 0; i < cols; i++)
    {
        var field:TextField = new TextField();
        field.multiline = true;
        field.autoSize = TextFieldAutoSize.NONE;
        field.wordWrap = true;
        field.width = this.colWidth;
        field.setTextFormat(this.format);
        this.fieldArray.push(field);
        this.addChild(field);
    }
```

Each TextField object is added to the array and added to the display list with the `addChild()` method.

Whenever the StoryLayout `text` property or `styleSheet` property changes, it calls the `layoutColumns()` method to redisplay the text. The `layoutColumns()` method calls the `getOptimalHeight()` method, to figure out the correct pixel height that is needed to fit all of the text within the given layout width.

```
public function getOptimalHeight(str:String):int
{
    if (field.text == "" || field.text == null)
    {
        return this.preferredHeight;
    }
    else
    {
        this.linesPerCol = Math.ceil(field.numLines / this.numColumns);

        var metrics:TextLineMetrics = field.getLineMetrics(0);
        this.lineHeight = metrics.height;
        var prefHeight:int = linesPerCol * this.lineHeight;

        return prefHeight + 4;
    }
}
```

First the `getOptimalHeight()` method calculates the width of each column. Then it sets the width and `htmlText` property of the first TextField object in the array. The `getOptimalHeight()` method uses that first TextField object to discover the total number of word-wrapped lines in the text, and from that it identifies how many lines should be in each column. Next it calls the `TextField.getLineMetrics()` method to retrieve a TextLineMetrics object that contains details about size of the text in the first line. The `TextLineMetrics.height` property represents the full height of a line of text, in pixels, including the ascent, descent, and leading. The optimal height for the MultiColumnTextField object is then the line height multiplied by the number of lines per column, plus 4 to account for the two-pixel border at the top and the bottom of a TextField object.

Here is the code for the full `layoutColumns()` method:

```
public function layoutColumns():void
{
    if (this._text == "" || this._text == null)
    {
        return;
    }

    var field:TextField = fieldArray[0] as TextField;
    field.text = this._text;
    field.setTextFormat(this.format);

    this.preferredHeight = this.getOptimalHeight(field);

    var remainder:String = this._text;
    var fieldText:String = "";
    var lastLineEndedPara:Boolean = true;

    var indent:Number = this.format.indent as Number;

    for (var i:int = 0; i < fieldArray.length; i++)
    {
        field = this.fieldArray[i] as TextField;

        field.height = this.preferredHeight;
        field.text = remainder;

        field.setTextFormat(this.format);
        var lineLen:int;
        if (indent > 0 && !lastLineEndedPara && field.numLines > 0)
        {
            lineLen = field.getLineLength(0);
            if (lineLen > 0)
            {
                field.setTextFormat(this.firstLineFormat, 0, lineLen);
                }
            }

        field.x = i * (colWidth + gutter);
        field.y = 0;

        remainder = "";
        fieldText = "";

        var linesRemaining:int = field.numLines;
        var linesVisible:int = Math.min(this.linesPerCol, linesRemaining);

        for (var j:int = 0; j < linesRemaining; j++)
        {
            if (j < linesVisible)
            {
                fieldText += field.getLineText(j);
            }
            else
            {
                remainder +=field.getLineText(j);
            }
        }

        field.text = fieldText;

        field.setTextFormat(this.format);

        if (indent > 0 && !lastLineEndedPara)
        {
            lineLen = field.getLineLength(0);
            if (lineLen > 0)
            {
                field.setTextFormat(this.firstLineFormat, 0, lineLen);
            }
        }

        var lastLine:String = field.getLineText(field.numLines - 1);
        var lastCharCode:Number = lastLine.charCodeAt(lastLine.length - 1);
        if (lastCharCode == 10 || lastCharCode == 13)
        {
        lastLineEndedPara = true;
        }
        else
        {
        lastLineEndedPara = false;
        }

        if ((this.format.align == TextFormatAlign.JUSTIFY) &&
                (i < fieldArray.length - 1))
        {
        if (!lastLineEndedPara)
        {
            justifyLastLine(field, lastLine);
        }
    }
    }
}
```

After the `preferredHeight` property has been set by calling the `getOptimalHeight()` method, the `layoutColumns()` method iterates through the TextField objects, setting the height of each to the `preferredHeight` value. The `layoutColumns()` method then distributes just enough lines of text to each field so that no scrolling occurs in any individual field, and the text in each successive field begins where the text in the previous field ended. If the text alignment style has been set to "justify" then the `justifyLastLine()` method is called to justify the final line of text in a field. Otherwise that last line would be treated as an end-of-paragraph line and not justified.

Chapter 22: Using the Flash Text Engine

Flash Player 10 and later, Adobe AIR 1.5 and later

The Adobe® Flash® Text Engine (FTE), available starting with Flash Player 10 and Adobe® AIR™1.5, provides low-level support for sophisticated control of text metrics, formatting, and bi-directional text. It offers improved text flow and enhanced language support. While it can be used to create and manage simple text elements, the FTE is primarily designed as a foundation for developers to create text-handling components. As such, Flash Text Engine assumes a more advanced level of programming expertise. To display simple text elements, see "Using the TextField class" on page 373.

The Text Layout Framework, which includes a text-handling component based on the FTE, provides an easier way to use its advanced features. The Text Layout Framework is an extensible library built entirely in ActionScript 3.0. You can use the existing TLF component, or use the framework to build your own text component. For more information, see "Using the Text Layout Framework" on page 426.

More Help topics

flash.text.engine package

Creating and displaying text

Flash Player 10 and later, Adobe AIR 1.5 and later

The classes that make up the Flash Text Engine enable you to create, format, and control text. The following classes are the basic building blocks for creating and displaying text with the Flash Text Engine:

- TextElement/GraphicElement/GroupElement - contain the content of a TextBlock instance
- ElementFormat - specifies formatting attributes for the content of a TextBlock instance
- TextBlock - the factory for building a paragraph of text
- TextLine - a line of text created from the TextBlock

To display text, create a TextElement object from a String, using an ElementFormat object to specify the formatting characteristics. Assign the TextElement to the `content` property of a TextBlock object. Create the lines of text for display by calling the `TextBlock.createTextLine()` method. The `createTextLine()` method returns a TextLine object containing as much of the string as will fit in the specified width. Call the method repeatedly until the entire string has been formatted into lines. When there are no more lines to be created, the textLineCreationResult property of the TextBlock object is assigned the value: `TextLineCreationResult.COMPLETE`. To show the lines, add them to the display list (with appropriate `x` and `y` position values).

The following code, for example, uses these FTE classes to display, "Hello World! This is Flash Text Engine!", using default format and font values. In this simple example, only a single line of text is created.

```
package
{
    import flash.text.engine.*;
    import flash.display.Sprite;

    public class HelloWorldExample extends Sprite
    {
        public function HelloWorldExample()
        {
            var str = "Hello World! This is Flash Text Engine!";
            var format:ElementFormat = new ElementFormat();
            var textElement:TextElement = new TextElement(str, format);
            var textBlock:TextBlock = new TextBlock();
            textBlock.content = textElement;

            var textLine1:TextLine = textBlock.createTextLine(null, 300);
            addChild(textLine1);
            textLine1.x = 30;
            textLine1.y = 30;
        }
    }
}
```

The parameters for `createTextLine()` specify the line from which to begin the new line and the width of the line in pixels. The line from which to begin the new line is usually the previous line but, in the case of the first line, it is `null`.

Adding GraphicElement and GroupElement objects

Flash Player 10 and later, Adobe AIR 1.5 and later

You can assign a GraphicElement object to a TextBlock object to display an image or a graphic element. Simply create an instance of the GraphicElement class from a graphic or an image and assign the instance to the `TextBlock.content` property. Create the text line by calling `TextBlock.createTextline()` as you normally would. The following example creates two text lines, one with a GraphicElement object and one with a TextElement object.

```
package
{
    import flash.text.engine.*;
    import flash.display.Sprite;
    import flash.display.Shape;
    import flash.display.Graphics;

    public class GraphicElementExample extends Sprite
    {
        public function GraphicElementExample()
        {
            var str:String = "Beware of Dog!";

            var triangle:Shape = new Shape();
            triangle.graphics.beginFill(0xFF0000, 1);
            triangle.graphics.lineStyle(3);
            triangle.graphics.moveTo(30, 0);
            triangle.graphics.lineTo(60, 50);
            triangle.graphics.lineTo(0, 50);
            triangle.graphics.lineTo(30, 0);
            triangle.graphics.endFill();
            var format:ElementFormat = new ElementFormat();
            format.fontSize = 20;

            var graphicElement:GraphicElement = new GraphicElement(triangle, triangle.width, 
triangle.height, format);
            var textBlock:TextBlock = new TextBlock();
            textBlock.content = graphicElement;
            var textLine1:TextLine = textBlock.createTextLine(null, triangle.width);
            textLine1.x = 50;
            textLine1.y = 110;
            addChild(textLine1);

            var textElement:TextElement = new TextElement(str, format);
            textBlock.content = textElement;
            var textLine2 = textBlock.createTextLine(null, 300);
            addChild(textLine2);
            textLine2.x = textLine1.x - 30;
            textLine2.y = textLine1.y + 15;
        }
    }
}
```

You can create a GroupElement object to create a group of TextElement, GraphicElement, and other GroupElement objects. A GroupElement can be assigned to the `content` property of a TextBlock object. The parameter to the `GroupElement()` constructor is a Vector, which points to the text, graphic, and group elements that make up the group. The following example groups two graphic elements and a text element and assigns them as a unit to a text block.

```
package
{
    import flash.text.engine.*;
    import flash.display.Sprite;
    import flash.display.Shape;
    import flash.display.Graphics;

    public class GroupElementExample extends Sprite
    {
        public function GroupElementExample()
        {
            var str:String = "Beware of Alligators!";

            var triangle1:Shape = new Shape();
            triangle1.graphics.beginFill(0xFF0000, 1);
            triangle1.graphics.lineStyle(3);
            triangle1.graphics.moveTo(30, 0);
            triangle1.graphics.lineTo(60, 50);
            triangle1.graphics.lineTo(0, 50);
            triangle1.graphics.lineTo(30, 0);
            triangle1.graphics.endFill();

            var triangle2:Shape = new Shape();
            triangle2.graphics.beginFill(0xFF0000, 1);
            triangle2.graphics.lineStyle(3);
            triangle2.graphics.moveTo(30, 0);
            triangle2.graphics.lineTo(60, 50);
            triangle2.graphics.lineTo(0, 50);
            triangle2.graphics.lineTo(30, 0);
            triangle2.graphics.endFill();

            var format:ElementFormat = new ElementFormat();
            format.fontSize = 20;
            var graphicElement1:GraphicElement = new GraphicElement(triangle1,
triangle1.width, triangle1.height, format);
            var textElement:TextElement = new TextElement(str, format);
            var graphicElement2:GraphicElement = new GraphicElement(triangle2,
triangle2.width, triangle2.height, format);
            var groupVector:Vector.<ContentElement> = new Vector.<ContentElement>();
            groupVector.push(graphicElement1, textElement, graphicElement2);
            var groupElement = new GroupElement(groupVector);
            var textBlock:TextBlock = new TextBlock();
            textBlock.content = groupElement;
            var textLine:TextLine = textBlock.createTextLine(null, 800);
            addChild(textLine);
            textLine.x = 100;
            textLine.y = 200;
        }
    }
}
```

Replacing text

Flash Player 10 and later, Adobe AIR 1.5 and later

You can replace text in a TextBlock instance by calling `TextElement.replaceText()` to replace text in the TextElement that you assigned to the `TextBlock.content` property.

The following example uses `replaceText()` to first, insert text at the beginning of the line, then, to append text to the end of the line, and, finally, to replace text in the middle of the line.

```
package
{
    import flash.text.engine.*;
    import flash.display.Sprite;

    public class ReplaceTextExample extends Sprite
    {
        public function ReplaceTextExample()
        {

            var str:String = "Lorem ipsum dolor sit amet";
            var fontDescription:FontDescription = new FontDescription("Arial");
            var format:ElementFormat = new ElementFormat(fontDescription);
            format.fontSize = 14;
            var textElement:TextElement = new TextElement(str, format);
            var textBlock:TextBlock = new TextBlock();
            textBlock.content = textElement;
            createLine(textBlock, 10);
            textElement.replaceText(0, 0, "A text fragment: ");
            createLine(textBlock, 30);
            textElement.replaceText(43, 43, "...");
            createLine(textBlock, 50);
            textElement.replaceText(23, 28, "(ipsum)");
            createLine(textBlock, 70);
        }

        function createLine(textBlock:TextBlock, y:Number):void {
            var textLine:TextLine = textBlock.createTextLine(null, 300);
            textLine.x = 10;
            textLine.y = y;
            addChild(textLine);
        }
    }
}
```

The `replaceText()` method replaces the text specified by the `beginIndex` and `endIndex` parameters with the text specified by the `newText` parameter. If the values of the `beginIndex` and `endIndex` parameters are the same, `replaceText()` inserts the specified text at that location. Otherwise it replaces the characters specified by `beginIndex` and `endIndex` with the new text.

Handling Events in FTE

Flash Player 10 and later, Adobe AIR 1.5 and later

You can add event listeners to a TextLine instance just as you can to other display objects. For example, you can detect when a user rolls the mouse over a text line or a user clicks the line. The following example detects both of these events. When you roll the mouse over the line, the cursor changes to a button cursor and when you click the line, it changes color.

```
package
{
    import flash.text.engine.*;
    import flash.ui.Mouse;
    import flash.display.Sprite
    import flash.events.MouseEvent;
    import flash.events.EventDispatcher;

    public class EventHandlerExample extends Sprite
    {
        var textBlock:TextBlock = new TextBlock();

        public function EventHandlerExample():void
        {
            var str:String = "I'll change color if you click me.";
            var fontDescription:FontDescription = new FontDescription("Arial");
            var format:ElementFormat = new ElementFormat(fontDescription, 18);
            var textElement = new TextElement(str, format);
            textBlock.content = textElement;
            createLine(textBlock);
        }

        private function createLine(textBlock:TextBlock):void
        {
            var textLine:TextLine = textBlock.createTextLine(null, 500);
            textLine.x = 30;
            textLine.y = 30;
            addChild(textLine);
            textLine.addEventListener("mouseOut", mouseOutHandler);
            textLine.addEventListener("mouseOver", mouseOverHandler);
            textLine.addEventListener("click", clickHandler);
        }

        private function mouseOverHandler(event:MouseEvent):void
        {
            Mouse.cursor = "button";
        }

        private function mouseOutHandler(event:MouseEvent):void
        {
            Mouse.cursor = "arrow";
        }

        function clickHandler(event:MouseEvent):void {
            if(textBlock.firstLine)
                removeChild(textBlock.firstLine);
            var newFormat:ElementFormat = textBlock.content.elementFormat.clone();
            switch(newFormat.color)
            {
                case 0x000000:
                    newFormat.color = 0xFF0000;
                    break;
                case 0xFF0000:
                    newFormat.color = 0x00FF00;
                    break;
                case 0x00FF00:
                    newFormat.color = 0x0000FF;
                    break;
                case 0x0000FF:
                    newFormat.color = 0x000000;
                    break;
            }
            textBlock.content.elementFormat = newFormat;
            createLine(textBlock);
        }
    }
}
```

Mirroring events

Flash Player 10 and later, Adobe AIR 1.5 and later

You can also mirror events on a text block, or on a portion of a text block, to an event dispatcher. First, create an EventDispatcher instance and then assign it to the `eventMirror` property of a TextElement instance. If the text block consists of a single text element, the text engine mirrors events for the entire text block. If the text block consists of multiple text elements, the text engine mirrors events only for the TextElement instances that have the `eventMirror` property set. The text in the following example consists of three elements: the word "Click", the word "here", and the string "to see me in italic". The example assigns an event dispatcher to the second text element, the word "here", and adds an event listener, the `clickHandler()` method. The `clickHandler()` method changes the text to italic. It also replaces the content of the third text element to read, "Click here to see me in normal font!".

```
package
{
    import flash.text.engine.*;
    import flash.ui.Mouse;
    import flash.display.Sprite;
    import flash.events.MouseEvent;
    import flash.events.EventDispatcher;

    public class EventMirrorExample extends Sprite
    {
        var fontDescription:FontDescription = new FontDescription("Helvetica", "bold");
        var format:ElementFormat = new ElementFormat(fontDescription, 18);
        var textElement1 = new TextElement("Click ", format);
        var textElement2 = new TextElement("here ", format);
        var textElement3 = new TextElement("to see me in italic! ", format);
        var textBlock:TextBlock = new TextBlock();

        public function EventMirrorExample()
        {
            var myEvent:EventDispatcher = new EventDispatcher();
            myEvent.addEventListener("click", clickHandler);
            myEvent.addEventListener("mouseOut", mouseOutHandler);
            myEvent.addEventListener("mouseOver", mouseOverHandler);

            textElement2.eventMirror=myEvent;

            var groupVector:Vector.<ContentElement> = new Vector.<ContentElement>;
            groupVector.push(textElement1, textElement2, textElement3);
            var groupElement:GroupElement = new GroupElement(groupVector);

            textBlock.content = groupElement;
            createLines(textBlock);
        }

        private function clickHandler(event:MouseEvent):void
        {
            var newFont:FontDescription = new FontDescription();
            newFont.fontWeight = "bold";

            var newFormat:ElementFormat = new ElementFormat();
            newFormat.fontSize = 18;
            if(textElement3.text == "to see me in italic! ") {
                newFont.fontPosture = FontPosture.ITALIC;
                textElement3.replaceText(0,21, "to see me in normal font! ");
            }
            else {
                newFont.fontPosture = FontPosture.NORMAL;
                textElement3.replaceText(0, 26, "to see me in italic! ");
            }
            newFormat.fontDescription = newFont;
            textElement1.elementFormat = newFormat;
            textElement2.elementFormat = newFormat;
            textElement3.elementFormat = newFormat;
            createLines(textBlock);
        }

        private function mouseOverHandler(event:MouseEvent):void
        {
            Mouse.cursor = "button";
        }

        private function mouseOutHandler(event:MouseEvent):void
        {
                Mouse.cursor = "arrow";
        }

        private function createLines(textBlock:TextBlock):void
        {
            if(textBlock.firstLine)
                removeChild (textBlock.firstLine);
            var textLine:TextLine = textBlock.createTextLine (null, 300);
            textLine.x = 15;
            textLine.y = 20;
            addChild (textLine);
        }
    }
}
```

The `mouseOverHandler()` and `mouseOutHandler()` functions set the cursor to a button cursor when it's over the word "here" and back to an arrow when it's not.

Formatting text

Flash Player 10 and later, Adobe AIR 1.5 and later

A `TextBlock` object is a factory for creating lines of text. The content of a `TextBlock` is assigned via the `TextElement` object. An `ElementFormat` object handles the formatting for the text. The ElementFormat class defines such properties as baseline alignment, kerning, tracking, text rotation, and font size, color, and case. It also includes a `FontDescription`, which is covered in detail in "Working with fonts" on page 409.

Using the ElementFormat object

Flash Player 10 and later, Adobe AIR 1.5 and later

The constructor for the `ElementFormat` object takes any of a long list of optional parameters, including a `FontDescription`. You can also set these properties outside the constructor. The following example shows the relationship of the various objects in defining and displaying a simple text line:

```
package
{
    import flash.display.Sprite;
    import flash.text.*;

    public class ElementFormatExample extends Sprite
    {
        private var tb:TextBlock = new TextBlock();
        private var te:TextElement;
        private var ef:ElementFormat;
        private var fd:FontDescription = new FontDescription();
        private var str:String;
        private var tl:TextLine;

        public function ElementFormatExample()
        {
            fd.fontName = "Garamond";
            ef = new ElementFormat(fd);
            ef.fontSize = 30;
            ef.color = 0xFF0000;
            str = "This is flash text";
            te = new TextElement(str, ef);
            tb.content = te;
            tl = tb.createTextLine(null,600);
            addChild(tl);
        }
    }
}
```

Font color and transparency (alpha)

Flash Player 10 and later, Adobe AIR 1.5 and later

The `color` property of the `ElementFormat` object sets the font color. The value is an integer representing the RGB components of the color; for example, 0xFF0000 for red and 0x00FF00 for green. The default is black (0x000000).

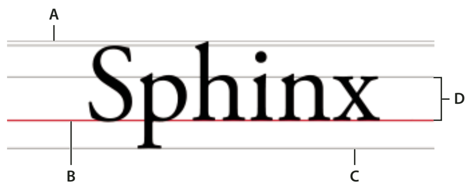
The `alpha` property sets the alpha transparency value for an element (both `TextElement` and `GraphicElement`). Values can range from 0 (fully transparent) to 1 (fully opaque, which is the default). Elements with an `alpha` of 0 are invisible, but still active. This value is multiplied by any inherited alpha values, thus making the element more transparent.

```
var ef:ElementFormat = new ElementFormat();
ef.alpha = 0.8;
ef.color = 0x999999;
```

Baseline alignment and shift

Flash Player 10 and later, Adobe AIR 1.5 and later

The font and size of the largest text in a line determine its dominant baseline. You can override these values by setting `TextBlock.baselineFontDescription` and `TextBlock.baselineFontSize`. You can align the dominant baseline with one of several baselines within the text. These baselines include the ascent line and the descent line or the ideographic top, center, or bottom.



A. *Ascent* ***B.*** *Baseline* ***C.*** *Descent* ***D.*** *x-height*

In the `ElementFormat` object, three properties determine baseline and alignment characteristics. The `alignmentBaseline` property sets the main baseline of a `TextElement` or `GraphicElement`. This baseline is the "snap-to" line for the element, and it's to this position that the dominant baseline of all text aligns.

The `dominantBaseline` property specifies which of the various baselines of the element to use, which determines the vertical position of the element on the line. The default value is `TextBaseline.ROMAN`, but it can also be set to have the `IDEOGRAPHIC_TOP` or `IDEOGRAPHIC_BOTTOM` baselines be dominant.

The `baselineShift` property moves the baseline by a set number of pixels on the y-axis. In normal (non-rotated) text, a positive value moves the baseline down and a negative value moves it up.

Typographic Case

Flash Player 10 and later, Adobe AIR 1.5 and later

The `TypographicCase` property of `ElementFormat` specifies text case, such as uppercase, lowercase, or small caps.

```
var ef_Upper:ElementFormat = new ElementFormat();
ef_Upper.typographicCase = TypographicCase.UPPERCASE;

var ef_SmallCaps:ElementFormat = new ElementFormat();
ef_SmallCaps.typographicCase = TypographicCase.SMALL_CAPS;
```

Rotating text

Flash Player 10 and later, Adobe AIR 1.5 and later

You can rotate a block of text or the glyphs within a segment of text in increments of 90°. The TextRotation class defines the following constants for setting both text block and glyph rotation:

Constant	Value	Description
AUTO	"auto"	Specifies 90 degree counter-clockwise rotation. Typically used with vertical Asian text to rotate only glyphs that require rotation.
ROTATE_0	"rotate_0"	Specifies no rotation.
ROTATE_180	"rotate_180"	Specifies 180 degree rotation.
ROTATE_270	"rotate_270"	Specifies 270 degree rotation.
ROTATE_90	"rotate_90"	Specifies 90 degree clockwise rotation.

To rotate the lines of text in a text block, set the `TextBlock.lineRotation` property before calling the `TextBlock.createTextLine()` method to create the text line.

To rotate the glyphs within a block of text or a segment, set the `ElementFormat.textRotation` property to the number of degrees that you want the glyphs to rotate. A glyph is the shape that makes up a character, or a part of a character that consists of multiple glyphs. The letter "a" and the dot on an "i", for example, are glyphs.

Rotating glyphs is relevant in some Asian languages in which you want to rotate the lines to vertical but not rotate the characters within the lines. For more information on rotating Asian text, see "Justifying East Asian text" on page 413.

Here is an example of rotating both a block of text and the glyphs within, as you would with Asian text. The example also uses a Japanese font:

```
package
{
    import flash.display.Sprite;
    import flash.text.*;

    public class RotationExample extends Sprite
    {
        private var tb:TextBlock = new TextBlock();
        private var te:TextElement;
        private var ef:ElementFormat;
        private var fd:FontDescription = new FontDescription();
        private var str:String;
        private var tl:TextLine;

        public function RotationExample()
        {
            fd.fontName = "MS Mincho";
            ef = new ElementFormat(fd);
            ef.textRotation = TextRotation.AUTO;
            str = "This is rotated Japanese text";
            te = new TextElement(str, ef);
            tb.lineRotation = TextRotation.ROTATE_90;
            tb.content = te;
            tl = tb.createTextLine(null,600);
            addChild(tl);
        }
    }
}
```

Locking and cloning ElementFormat

Flash Player 10 and later, Adobe AIR 1.5 and later

When an `ElementFormat` object is assigned to any type of `ContentElement`, its `locked` property is automatically set to `true`. Attempting to modify a locked `ElementFormat` object throws an `IllegalOperationError`. The best practice is to fully define such an object before assigning it to a `TextElement` instance.

If you want to modify an existing `ElementFormat` instance, first check its `locked` property. If it's `true`, use the `clone()` method to create an unlocked copy of the object. The properties of this unlocked object can be changed, and it can then be assigned to the `TextElement` instance. Any new lines created from it have the new formatting. Previous lines created from this same object and using the old format are unchanged.

```
package
{
    import flash.display.Sprite;
    import flash.text.*;

    public class ElementFormatCloneExample extends Sprite
    {
        private var tb:TextBlock = new TextBlock();
        private var te:TextElement;
        private var ef1:ElementFormat;
        private var ef2:ElementFormat;
        private var fd:FontDescription = new FontDescription();

        public function ElementFormatCloneExample()
        {
            fd.fontName = "Garamond";
            ef1 = new ElementFormat(fd);
            ef1.fontSize = 24;
            var str:String = "This is flash text";
            te = new TextElement(str, ef);
            tb.content = te;
            var tx1:TextLine = tb.createTextLine(null,600);
            addChild(tx1);

            ef2 = (ef1.locked) ? ef1.clone() : ef1;
            ef2.fontSize = 32;
            tb.content.elementFormat = ef2;
            var tx2:TextLine = tb.createTextLine(null,600);
            addChild(tx2);
        }
    }
}
```

Working with fonts

Flash Player 10 and later, Adobe AIR 1.5 and later

The `FontDescription` object is used in conjunction with `ElementFormat` to identify a font face and define some of its characteristics. These characteristics include the font name, weight, posture, rendering, and how to find the font (device versus embedded).

Note: *FTE does not support Type 1 fonts or bitmap fonts such as Type 3, ATC, sfnt-wrapped CID, or Naked CID.*

Defining font characteristics (FontDescription object)

Flash Player 10 and later, Adobe AIR 1.5 and later

The `fontName` property of the `FontDescription` object can be a single name or a comma-separated list of names. For example, in a list such as "Arial, Helvetica, _sans", the text engine looks for "Arial" first, then "Helvetica", and finally "_sans", if it can't find either of the first two fonts. The set of font names include three generic device font names: "_sans", "_serif", and "_typewriter". They map to specific device fonts, depending on the playback system. It is good practice to specify default names such as these in all font descriptions that use device fonts. If no `fontName` is specified, "_serif" is used as the default.

The `fontPosture` property can either be set to the default (`FontPosture.NORMAL`) or to italics (`FontPosture.ITALIC`). The `fontWeight` property can be set to the default (`FontWeight.NORMAL`) or to bold (`FontWeight.BOLD`).

```
var fd1:FontDescription = new FontDescription();
fd1.fontName = "Arial, Helvetica, _sans";
fd1.fontPosture = FontPosture.NORMAL;
fd1.fontWeight = FontWeight.BOLD;
```

Embedded versus device fonts

Flash Player 10 and later, Adobe AIR 1.5 and later

The `fontLookup` property of the `FontDescription` object specifies whether the text engine looks for a device font or embedded font to render text. If a device font (`FontLookup.DEVICE`) is specified, the runtime looks for the font on the playback system. Specifying an embedded font (`FontLookup.EMBEDDED_CFF`) causes the runtime to look for an embedded font with the specified name in the SWF file. Only embedded CFF (Compact Font Format) fonts work with this setting. If the specified font is not found, a fallback device font is used.

Device fonts result in a smaller SWF file size. Embedded fonts give you greater fidelity across platforms.

```
var fd1:FontDescription = new FontDescription();
fd1.fontLookup = FontLookup.EMBEDDED_CFF;
fd1.fontName = "Garamond, _serif";
```

Rendering mode and hinting

Flash Player 10 and later, Adobe AIR 1.5 and later

CFF (Compact Font Format) rendering is available starting with Flash Player 10 and Adobe AIR 1.5. This type of font rendering makes text more legible, and permits higher-quality display of fonts at small sizes. This setting only applies to embedded fonts. `FontDescription` defaults to this setting (`RenderingMode.CFF`) for the `renderingMode` property. You can set this property to `RenderingMode.NORMAL` to match the type of rendering used by Flash Player 7 or earlier versions.

When CFF rendering is selected, a second property, `cffHinting`, controls how a font's horizontal stems are fit to the subpixel grid. The default value, `CFFHinting.HORIZONTAL_STEM`, uses CFF hinting. Setting this property to `CFFHinting.NONE` removes hinting, which is appropriate for animation or for large font sizes.

```
var fd1:FontDescription = new FontDescription();
fd1.renderingMode = RenderingMode.CFF;
fd1.cffHinting = CFFHinting.HORIZONTAL_STEM;
```

Locking and cloning FontDescription

Flash Player 10 and later, Adobe AIR 1.5 and later

When a `FontDescription` object is assigned to an `ElementFormat`, its `locked` property is automatically set to `true`. Attempting to modify a locked `FontDescription` object throws an `IllegalOperationError`. The best practice is to fully define such an object before assigning it to a `ElementFormat`.

If you want to modify an existing `FontDescription`, first check its `locked` property. If it's `true`, use the `clone()` method to create an unlocked copy of the object. The properties of this unlocked object can be changed, and it can then be assigned to the `ElementFormat`. Any new lines created from this `TextElement` have the new formatting. Previous lines created from this same object are unchanged.

```
package
{
    import flash.display.Sprite;
    import flash.text.*;

    public class FontDescriptionCloneExample extends Sprite
    {
        private var tb:TextBlock = new TextBlock();
        private var te:TextElement;
        private var ef1:ElementFormat;
        private var ef2:ElementFormat;
        private var fd1:FontDescription = new FontDescription();
        private var fd2:FontDescription;

        public function FontDescriptionCloneExample()
        {
            fd1.fontName = "Garamond";
            ef1 = new ElementFormat(fd);
            var str:String = "This is flash text";
            te = new TextElement(str, ef);
            tb.content = te;
            var tx1:TextLine = tb.createTextLine(null,600);
            addChild(tx1);

            fd2 = (fd1.locked) ? fd1.clone() : fd1;
            fd2.fontName = "Arial";
            ef2 = (ef1.locked) ? ef1.clone() : ef1;
            ef2.fontDescription = fd2;
            tb.content.elementFormat = ef2;
            var tx2:TextLine = tb.createTextLine(null,600);
            addChild(tx2);
        }
    }
}
```

Controlling text

Flash Player 10 and later, Adobe AIR 1.5 and later

FTE gives you a new set of text formatting controls to handle justification and character spacing (kerning and tracking). There are also properties for controlling that way lines are broken and for setting tab stops within lines.

Justifying text

Flash Player 10 and later, Adobe AIR 1.5 and later

Justifying text makes all lines in a paragraph the same length by adjusting the spacing between words and sometimes between letters. The effect is to align the text on both sides, while the spacing between words and letters varies. Columns of text in newspapers and magazines are frequently justified.

The `lineJustfication` property in the SpaceJustifier class allows you to control the justification of lines in a block of text. The LineJustification class defines constants that you can use to specify a justification option: `ALL_BUT_LAST` justifies all but the last line of text; `ALL_INCLUDING_LAST` justifies all text, including the last line; `UNJUSTIFIED`, which is the default, leaves the text unjustified.

To justify text, set the `lineJustification` property to an instance of the SpaceJustifier class and assign that instance to the `textJustifier` property of a TextBlock instance. The following example creates a paragraph in which all but the last line of text is justified.

```
package
{
    import flash.text.engine.*;
    import flash.display.Sprite;

    public class JustifyExample extends Sprite
    {
        public function JustifyExample()
        {
            var str:String = "Lorem ipsum dolor sit amet, consectetur adipisicing elit, " +
            "sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut " +
            "enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut " +
            "aliquip ex ea commodo consequat.";

            var format:ElementFormat = new ElementFormat();
            var textElement:TextElement=new TextElement(str,format);
            var spaceJustifier:SpaceJustifier=new
SpaceJustifier("en",LineJustification.ALL_BUT_LAST);

            var textBlock:TextBlock = new TextBlock();
            textBlock.content=textElement;
            textBlock.textJustifier=spaceJustifier;
            createLines(textBlock);
        }

        private function createLines(textBlock:TextBlock):void {
            var yPos=20;
            var textLine:TextLine=textBlock.createTextLine(null,150);

            while (textLine) {
                addChild(textLine);
                textLine.x=15;
                yPos+=textLine.textHeight+2;
                textLine.y=yPos;
                textLine=textBlock.createTextLine(textLine,150);
            }
        }
    }
}
```

To vary spacing between letters as well as between words, set the `SpaceJustifier.letterspacing` property to `true`. Turning on letterspacing can reduce the occurrences of unsightly gaps between words, which can sometimes occur with simple justification.

Justifying East Asian text

Flash Player 10 and later, Adobe AIR 1.5 and later

Justifying East Asian text entails additional considerations. It can be written from top to bottom and some characters, known as kinsoku, cannot appear at the beginning or end of a line. The JustificationStyle class defines the following constants, which specify the options for handling these characters. `PRIORITIZE_LEAST_ADJUSTMENT` bases justification on either expanding or compressing the line, depending on which one produces the most desirable result. `PUSH_IN_KINSOKU` bases justification on compressing kinsoku at the end of the line, or expanding it if no kinsoku occurs, or if that space is insufficient.

`PUSH_OUT_ONLY` bases justification on expanding the line. To create a block of vertical Asian text, set the `TextBlock.lineRotation` property to `TextRotation.ROTATE_90` and set the `ElementFormat.textRotation` property to `TextRotation.AUTO`, which is the default. Setting the `textRotation` property to `AUTO` causes the glyphs in the text to remain vertical instead of turning on their side when the line is rotated. The `AUTO` setting rotates 90° counter-clockwise for full width and wide glyphs only, as determined by the Unicode properties of the glyph. The following example displays a vertical block of Japanese text and justifies it using the `PUSH_IN_KINSOKU` option.

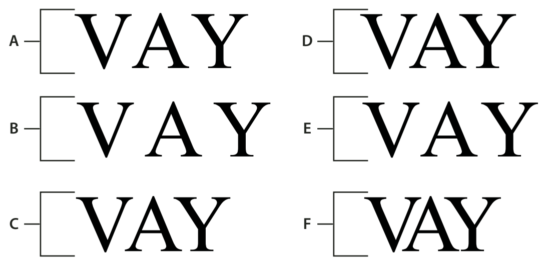
```
package
{
    import flash.text.engine.*;
    import flash.display.Stage;
    import flash.display.Sprite;
    import flash.system.Capabilities;

    public class EastAsianJustifyExample extends Sprite
    {
        public function EastAsianJustifyExample()
        {
            var Japanese_txt:String = String.fromCharCode(
            0x5185, 0x95A3, 0x5E9C, 0x304C, 0x300C, 0x653F, 0x5E9C, 0x30A4,
            0x30F3, 0x30BF, 0x30FC, 0x30CD, 0x30C3, 0x30C8, 0x30C6, 0x30EC,
            0x30D3, 0x300D, 0x306E, 0x52D5, 0x753B, 0x914D, 0x4FE1, 0x5411,
            0x3051, 0x306B, 0x30A2, 0x30C9, 0x30D3, 0x30B7, 0x30B9, 0x30C6,
            0x30E0, 0x30BA, 0x793E, 0x306E)
            var textBlock:TextBlock = new TextBlock();
            var font:FontDescription = new FontDescription();
            var format:ElementFormat = new ElementFormat();
            format.fontSize = 12;
            format.color = 0xCC0000;
            format.textRotation = TextRotation.AUTO;
            textBlock.baselineZero = TextBaseline.IDEOGRAPHIC_CENTER;
            var eastAsianJustifier:EastAsianJustifier = new EastAsianJustifier("ja",
LineJustification.ALL_BUT_LAST);
            eastAsianJustifier.justificationStyle = JustificationStyle.PUSH_IN_KINSOKU;
            textBlock.textJustifier = eastAsianJustifier;
            textBlock.lineRotation = TextRotation.ROTATE_90;
            var linePosition:Number = this.stage.stageWidth - 75;
            if (Capabilities.os.search("Mac OS") > -1)
                // set fontName: Kozuka Mincho Pro R
                font.fontName = String.fromCharCode(0x5C0F, 0x585A, 0x660E, 0x671D) + " Pro R";
            else
                font.fontName = "Kozuka Mincho Pro R";
            textBlock.content = new TextElement(Japanese_txt, format);
            var previousLine:TextLine = null;

            while (true)
            {
                var textLine:TextLine = textBlock.createTextLine(previousLine, 200);
                if (textLine == null)
                    break;
                textLine.y = 20;
                textLine.x = linePosition;
                linePosition -= 25;
                addChild(textLine);
                previousLine = textLine;
            }
        }
    }
}
```

Kerning and tracking

Flash Player 10 and later, Adobe AIR 1.5 and later

Kerning and tracking affect the distance between adjacent pairs of characters in a text block. Kerning controls how character pairs "fit" together, such as the pairs "WA" or "Va". Kerning is set in the `ElementFormat` object. It is enabled by default (`Kerning.ON`), and can be set to OFF or AUTO, in which case kerning is only applied between characters if neither is Kanji, Hiragana, or Katakana.

Tracking adds or subtracts a set number of pixels between all characters in a text block, and is also set in the `ElementFormat` object. It works with both embedded and device fonts. FTE supports two tracking properties, `trackingLeft`, which adds/subtracts pixels from the left side of a character, and `trackingRight`, which adds/subtracts from the right side. If kerning is being used, the tracking value is added to or subtracted from kerning values for each character pair.



A. Kerning.OFF *B. TrackingRight=5, Kerning.OFF* *C. TrackingRight=-5, Kerning.OFF* *D. Kerning.ON* *E. TrackingRight=-5, Kerning.ON* *F. TrackingRight=-5, Kerning.ON*

```
var ef1:ElementFormat = new ElementFormat();
ef1.kerning = Kerning.OFF;

var ef2:ElementFormat = new ElementFormat();
ef2.kerning = Kerning.ON;
ef2.trackingLeft = 0.8;
ef2.trackingRight = 0.8;

var ef3:ElementFormat = new ElementFormat();
ef3.trackingRight = -0.2;
```

Line breaks for wrapped text

Flash Player 10 and later, Adobe AIR 1.5 and later

The `breakOpportunity` property of the `ElementFormat` object determines which characters can be used for breaking when wrapping text is broken into multiple lines. The default, `BreakOpportunity.AUTO`, uses standard Unicode properties, such as breaking between words and on hyphens. Using `BreakOpportunity.ALL` allows any character to be treated as a line break opportunity, which is useful for creating effects like text along a path.

```
var ef:ElementFormat = new ElementFormat();
ef.breakOpportunity = BreakOpportunity.ALL;
```

Tab stops

Flash Player 10 and later, Adobe AIR 1.5 and later

To set tab stops in a text block, define the tab stops by creating instances of the TabStop class. The parameters to the `TabStop()` constructor specify how the text aligns with the tab stop. These parameters specify the position of the tab stop, and for decimal alignment, the value on which to align, expressed as a string. Typically, this value is a decimal point but it could also be a comma, a dollar sign, or the symbol for the Yen or the Euro, for example. The following line of code creates a tab stop called tab1.

```
var tab1:TabStop = new TabStop(TabAlignment.DECIMAL, 50, ".");
```

Once you've created the tab stops for a text block, assign them to the `tabStops` property of a TextBlock instance. Because the `tabStops` property requires a Vector, though, first create a Vector and add the tab stops to it. The Vector allows you to assign a set of tab stops to the text block. The following example creates a `Vector<TabStop>` instance and adds a set of TabStop objects to it. Then it assigns the tab stops to the `tabStops` property of a TextBlock instance.

```
var tabStops:Vector.<TabStop> = new Vector.<TabStop>();
tabStops.push(tab1, tab2, tab3, tab4);
textBlock.tabStops = tabStops
```

For more information on Vectors, see "Working with arrays" on page 25.

The following example shows the effect of each of the TabStop alignment options.

```
package {

    import flash.text.engine.*;
    import flash.display.Sprite;

    public class TabStopExample extends Sprite
    {
        public function TabStopExample()
        {
            var format:ElementFormat = new ElementFormat();
            format.fontDescription = new FontDescription("Arial");
            format.fontSize = 16;

            var tabStops:Vector.<TabStop> = new Vector.<TabStop>();
            tabStops.push(
                new TabStop(TabAlignment.START, 20),
                new TabStop(TabAlignment.CENTER, 140),
                new TabStop(TabAlignment.DECIMAL, 260, "."),
                new TabStop(TabAlignment.END, 380));
            var textBlock:TextBlock = new TextBlock();
            textBlock.content = new TextElement(
                "\tt1\tt2\tt3\tt4\n" +
                "\tThis line aligns on 1st tab\n" +
                "\t\t\t\tThis is the end\n" +
                "\tThe following fragment centers on the 2nd tab:\t\t\n" +
                "\t\tit's on me\t\t\n" +
                "\tThe following amounts align on the decimal point:\n" +
                "\t\t\t45.00\t\n" +
                "\t\t\t75,320.00\t\n" +
                "\t\t\t6,950.00\t\n" +
                "\t\t\t7.01\t\n", format);

            textBlock.tabStops = tabStops;
            var yPosition:Number = 60;
            var previousTextLine:TextLine = null;
            var textLine:TextLine;
            var i:int;
            for (i = 0; i < 10; i++) {
                textLine = textBlock.createTextLine(previousTextLine, 1000, 0);
                textLine.x = 20;
                textLine.y = yPosition;
                addChild(textLine);
                yPosition += 25;
                previousTextLine = textLine;
            }
        }
    }
}
```

Flash Text Engine example: News layout

Flash Player 10 and later, Adobe AIR 1.5 and later

This programming example shows the Flash Text Engine in use laying out a simple newspaper page. The page includes a large headline, a subhead, and a multicolumn body section.

First, create an FLA file, and attach the following code to frame #2 of the default layer:

```
import com.example.programmingas3.newslayout.StoryLayout ;
// frame sc ript - create  a 3-columned arti cle layout
var story:StoryLayout = new StoryLayout(720, 500, 3, 10);
story.x = 20;
story.y = 80;
addChild(story);
stop();
```

StoryLayout.as is the controller script for this example. It sets the content, reads in style information from an external style sheet, and assigns those styles to ElementFormat objects. It then creates the headline, subhead and multicolumn text elements.

```
package com.example.programmingas3.newslayout
{
    import flash.display.Sprite;
    import flash.text.StyleSheet;
    import flash.text.engine.*;

    import flash.events.Event;
    import flash.net.URLRequest;
    import flash.net.URLLoader;
    import flash.display.Sprite;
    import flash.display.Graphics;

    public class StoryLayout extends Sprite
    {
        public var headlineTxt:HeadlineTextField;
        public var subtitleTxt:HeadlineTextField;
        public var storyTxt:MultiColumnText;
        public var sheet:StyleSheet;
        public var h1_ElFormat:ElementFormat;
        public var h2_ElFormat:ElementFormat;
        public var p_ElFormat:ElementFormat;

        private var loader:URLLoader;

        public var paddingLeft:Number;
        public var paddingRight:Number;
        public var paddingTop:Number;
        public var paddingBottom:Number;

        public var preferredWidth:Number;
        public var preferredHeight:Number;

        public var numColumns:int;

        public var bgColor:Number = 0xFFFFFF;
        public var headline:String = "News Layout Example";
        public var subtitle:String = "This example formats text like a newspaper page using the 
Flash Text Engine API. ";

        public var rawTestData:String = 
        "From the part Mr. Burke took in the American Revolution, it was natural that I should 
consider him a friend to mankind; and as our acquaintance commenced on that ground, it would 
have been more agreeable to me to have had cause to continue in that opinion than to change it. " +
        "At the time Mr. Burke made his violent speech last winter in the English Parliament 
against the French Revolution and the National Assembly, I was in Paris, and had written to him 
but a short time before to inform him how prosperously matters were going on. Soon after this I 
saw his advertisement of the Pamphlet he intended to publish: As the attack was to be made in a 
language but little studied, and less understood in France, and as everything suffers by 
translation, I promised some of the friends of the Revolution in that country that whenever Mr. 
Burke's Pamphlet came forth, I would answer it. This appeared to me the more necessary to be 
done, when I saw the flagrant misrepresentations which Mr. Burke's Pamphlet contains; and that 
while it is an outrageous abuse on the French Revolution, and the principles of Liberty, it is 
an imposition on the rest of the world. " +
        "I am the more astonished and disappointed at this conduct in Mr. Burke, as (from the 
circumstances I am going to mention) I had formed other expectations. " +
        "I had seen enough of the miseries of war, to wish it might never more have existence 
in the world, and that some other mode might be found out to settle the differences that should 
occasionally arise in the neighbourhood of nations. This certainly might be done if Courts were 
disposed to set honesty about it, or if countries were enlightened enough not to be made the 
dupes of Courts. The people of America had been bred up in the same prejudices against France, 
which at that time characterised the people of England; but experience and an acquaintance with 
the French Nation have most effectually shown to the Americans the falsehood of those prejudices; 
and I do not believe that a more cordial and confidential intercourse exists between any two 
countries than between America and France. ";

        public function StoryLayout(w:int = 400, h:int = 200, cols:int = 3, padding:int = 
10):void
        {
            this.preferredWidth = w;
            this.preferredHeight = h;

            this.numColumns = cols;

            this.paddingLeft = padding;
            this.paddingRight = padding;
            this.paddingTop = padding;
            this.paddingBottom = padding;

            var req:URLRequest = new URLRequest("story.css");
            loader = new URLLoader();
            loader.addEventListener(Event.COMPLETE, onCSSFileLoaded);
            loader.load(req);
        }

        public function onCSSFileLoaded(event:Event):void
        {
            this.sheet = new StyleSheet();
            this.sheet.parseCSS(loader.data);

            // convert headline styles to ElementFormat objects
            h1_ElFormat = getElFormat("h1", this.sheet);
```

```
    h1_ElFormat.typographicCase = TypographicCase.UPPERCASE;
    h2_ElFormat = getElFormat("h2", this.sheet);
    p_ElFormat = getElFormat("p", this.sheet);
    displayText();
}

public function drawBackground():void
{
    var h:Number = this.storyTxt.y + this.storyTxt.height +
                    this.paddingTop + this.paddingBottom;
    var g:Graphics = this.graphics;
    g.beginFill(this.bgColor);
    g.drawRect(0, 0, this.width + this.paddingRight + this.paddingLeft, h);
    g.endFill();
}

/**
 * Reads a set of style properties for a named style and then creates
 * a TextFormat object that uses the same properties.
 */
public function getElFormat(styleName:String, ss:StyleSheet):ElementFormat
{
var style:Object = ss.getStyle(styleName);
if (style != null)
{
var colorStr:String = style.color;
if (colorStr != null && colorStr.indexOf("#") == 0)
{
    style.color = colorStr.substr(1);
}
        var fd:FontDescription = new FontDescription(
                            style.fontFamily,
                            style.fontWeight,
                            FontPosture.NORMAL,
                            FontLookup.DEVICE,
                            RenderingMode.NORMAL,
                            CFFHinting.NONE);
var format:ElementFormat = new ElementFormat(fd,
                      style.fontSize,
                      style.color,
                      1,
                      TextRotation.AUTO,
                      TextBaseline.ROMAN,
                      TextBaseline.USE_DOMINANT_BASELINE,
                      0.0,
                      Kerning.ON,
                      0.0,
                      0.0,
                      "en",
                              BreakOpportunity.AUTO,
                              DigitCase.DEFAULT,
                              DigitWidth.DEFAULT,
                      LigatureLevel.NONE,
                              TypographicCase.DEFAULT);

if (style.hasOwnProperty("letterSpacing"))
{
```

```
            format.trackingRight = style.letterSpacing;
        }
        }
        return format;
        }

        public function displayText():void
        {
        headlineTxt = new HeadlineTextField(h1_ElFormat,headline,this.preferredWidth);
        headlineTxt.x = this.paddingLeft;
        headlineTxt.y = 40 + this.paddingTop;
            headlineTxt.fitText(1);
            this.addChild(headlineTxt);

        subtitleTxt = new HeadlineTextField(h2_ElFormat,subtitle,this.preferredWidth);
        subtitleTxt.x = this.paddingLeft;
        subtitleTxt.y = headlineTxt.y + headlineTxt.height;
            subtitleTxt.fitText(2);
        this.addChild(subtitleTxt);

        storyTxt = new MultiColumnText(rawTestData, this.numColumns,
                        20, this.preferredWidth, this.preferredHeight, p_ElFormat);
        storyTxt.x = this.paddingLeft;
        storyTxt.y = subtitleTxt.y + subtitleTxt.height + 10;
        this.addChild(storyTxt);

            drawBackground();
        }
    }
}
```

FormattedTextBlock.as is used as a base class for creating blocks of text. It also includes utility functions for changing font size and case.

```
package com.example.programmingas3.newslayout
{
    import flash.text.engine.*;
    import flash.display.Sprite;

    public class FormattedTextBlock extends Sprite
    {
        public var tb:TextBlock;
        private var te:TextElement;
        private var ef1:ElementFormat;
        private var textWidth:int;
        public var totalTextLines:int;
        public var blockText:String;
        public var leading:Number = 1.25;
        public var preferredWidth:Number = 720;
        public var preferredHeight:Number = 100;

        public function FormattedTextBlock(ef:ElementFormat,txt:String, colW:int = 0)
        {
            this.textWidth = (colW==0) ? preferredWidth : colW;
            blockText = txt;
            ef1 = ef;
            tb = new TextBlock();
            tb.textJustifier = new SpaceJustifier("en",LineJustification.UNJUSTIFIED,false);
            te = new TextElement(blockText,this.ef1);
            tb.content = te;
            this.breakLines();
        }

        private function breakLines()
        {
            var textLine:TextLine = null;
            var y:Number = 0;
            var lineNum:int = 0;
            while (textLine = tb.createTextLine(textLine,this.textWidth,0,true))
            {
                textLine.x = 0;
                textLine.y = y;
                y += this.leading*textLine.height;
                this.addChild(textLine);
            }
            for (var i:int = 0; i < this.numChildren; i++)
            {
                TextLine(this.getChildAt(i)).validity = TextLineValidity.STATIC;
            }
            this.totalTextLines = this.numChildren;
        }

        private function rebreakLines()
        {
            this.clearLines();
            this.breakLines();
        }

        private function clearLines()
        {
            while(this.numChildren)
            {
                this.removeChildAt(0);
            }
        }
```

```
        public function changeSize(size:uint=12):void
        {
            if (size > 5)
            {
                var ef2:ElementFormat = ef1.clone();
                ef2.fontSize = size;
                te.elementFormat = ef2;
                this.rebreakLines();
            }
        }

        public function changeCase(newCase:String = "default"):void
        {
            var ef2:ElementFormat = ef1.clone();
            ef2.typographicCase = newCase;
            te.elementFormat = ef2;
        }
    }
}
```

HeadlineTextBlock.as extends the FormattedTextBlock class and is used for creating headlines. It includes a function for fitting text within a defined space on the page.

```
package com.example.programmingas3.newslayout
{
    import flash.text.engine.*;
    public class HeadlineTextField extends FormattedTextBlock
    {

        public static var MIN_POINT_SIZE:uint = 6;
        public static var MAX_POINT_SIZE:uint = 128;

        public function HeadlineTextField(te:ElementFormat,txt:String,colW:int = 0)
        {
            super(te,txt);
        }

        public function fitText(maxLines:uint = 1, targetWidth:Number = -1):uint
        {
            if (targetWidth == -1)
            {
                targetWidth = this.width;
            }

            var pixelsPerChar:Number = targetWidth / this.blockText.length;
            var pointSize:Number = Math.min(MAX_POINT_SIZE,
                            Math.round(pixelsPerChar * 1.8 * maxLines));

            if (pointSize < 6)
            {
                // the point size is too small
                return pointSize;
            }

            this.changeSize(pointSize);
            if (this.totalTextLines > maxLines)
            {
                return shrinkText(--pointSize, maxLines);
            }
            else
            {
                return growText(pointSize, maxLines);
            }
        }

        public function growText(pointSize:Number, maxLines:uint = 1):Number
        {
            if (pointSize >= MAX_POINT_SIZE)
            {
                return pointSize;
            }

            this.changeSize(pointSize + 1);
            if (this.totalTextLines > maxLines)
            {
                // set it back to the last size
                this.changeSize(pointSize);
                return pointSize;
            }
            else
            {
                return growText(pointSize + 1, maxLines);
            }
        }

        public function shrinkText(pointSize:Number, maxLines:uint=1):Number
        {
            if (pointSize <= MIN_POINT_SIZE)
            {
                return pointSize;
            }
            this.changeSize(pointSize);

            if (this.totalTextLines > maxLines)
            {
                return shrinkText(pointSize - 1, maxLines);
            }
            else
            {
                return pointSize;
            }
        }
    }
}
```

MultiColumnText.as handles formatting text within a multicolumn design. It demonstrates the flexible use a TextBlock object as a factory for creating, formatting, and placing text lines.

```
package com.example.programmingas3.newslayout
{
    import flash.display.Sprite;
    import flash.text.engine.*;

    public class MultiColumnText extends Sprite
    {
        private var tb:TextBlock;
        private var te:TextElement;
        private var numColumns:uint = 2;
        private var gutter:uint = 10;
        private var leading:Number = 1.25;
        private var preferredWidth:Number = 400;
        private var preferredHeight:Number = 100;
        private var colWidth:int = 200;

        public function MultiColumnText(txt:String = "",cols:uint = 2,
            gutter:uint = 10, w:Number = 400, h:Number = 100,
            ef:ElementFormat = null):void
        {
            this.numColumns = Math.max(1, cols);
            this.gutter = Math.max(1, gutter);

            this.preferredWidth = w;
            this.preferredHeight = h;

            this.setColumnWidth();

            var field:FormattedTextBlock = new FormattedTextBlock(ef,txt,this.colWidth);
            var totLines:int = field.totalTextLines;
            field = null;
            var linesPerCol:int = Math.ceil(totLines/cols);

            tb = new TextBlock();
            te = new TextElement(txt,ef);
            tb.content = te;
            var textLine:TextLine = null;
            var x:Number = 0;
            var y:Number = 0;
            var i:int = 0;
            var j:int = 0;
            while (textLine = tb.createTextLine(textLine,this.colWidth,0,true))
            {
                textLine.x = Math.floor(i/(linesPerCol+1))*(this.colWidth+this.gutter);
                textLine.y = y;
                y += this.leading*textLine.height;
                j++;
                if(j>linesPerCol)
                {
                    y = 0;
                    j = 0;
                }
                i++;

                this.addChild(textLine);
            }
        }

        private function setColumnWidth():void
        {
        this.colWidth = Math.floor( (this.preferredWidth -
            ((this.numColumns - 1) * this.gutter)) / this.numColumns);
        }

    }
}
```

Chapter 23: Using the Text Layout Framework

Flash Player 10 and later, Adobe AIR 1.5 and later

Overview of the Text Layout Framework

Flash Player 10 and later, Adobe AIR 1.5 and later

The Text Layout Framework (TLF) is an extensible ActionScript library. The TLF is built on the text engine in Adobe® Flash® Player 10 and Adobe® AIR® 1.5. The TLF provides advanced typographic and text layout features for innovative typography on the web. The framework can be used with Adobe® Flex® or Adobe® Flash® Professional. Developers can use or extend existing components, or they can use the framework to create their own text components.

The TLF includes the following capabilities:

- Bidirectional text, vertical text, and over 30 writing scripts including Arabic, Hebrew, Chinese, Japanese, Korean, Thai, Lao, Vietnamese, and others
- Selection, editing, and flowing text across multiple columns and linked containers
- Vertical text, Tate-Chu-Yoko (horizontal within vertical text) and justifier for East Asian typography
- Rich typographical controls, including kerning, ligatures, typographic case, digit case, digit width, and discretionary hyphens
- Cut, copy, paste, undo, and standard keyboard and mouse gestures for editing
- Rich developer APIs to manipulate text content, layout, and markup and create custom text components
- Robust list support including custom markers and numbering formats
- Inline images and positioning rules

The TLF is an ActionScript 3.0 library built on the Flash Text Engine (FTE) introduced in Flash Player 10. FTE can be accessed through the `flash.text.engine` package, which is part of the Flash Player 10 Application Programming Interface (API).

The Flash Player API, however, provides low-level access to the text engine, which means that some tasks can require a relatively large amount of code. The TLF encapsulates the low-level code into simpler APIs. The TLF also provides a conceptual architecture that organizes the basic building blocks defined by FTE into a system that is easier to use.

Unlike FTE, the TLF is not built in to Flash Player. Rather, it is an independent component library written entirely in ActionScript 3.0. Because the framework is extensible, it can be customized for specific environments. Both Flash Professional and the Flex SDK include components that are based on the TLF framework.

More Help topics

"Flow" TLF markup application

Complex script support

Flash Player 10 and later, Adobe AIR 1.5 and later

The TLF provides complex script support. Complex script support includes the ability to display and edit right-to-left scripts. The TLF also provides the ability to display and edit a mixture of left-to-right and right-to-left scripts such as Arabic and Hebrew. The framework not only supports vertical text layout for Chinese, Japanese, and Korean, but also supports tate-chu-yoko (TCY elements). TCY elements are blocks of horizontal text embedded into vertical runs of text. The following scripts are supported:

- Latin (English, Spanish, French, Vietnamese, and so on)
- Greek, Cyrillic, Armenian, Georgian, and Ethiopic
- Arabic and Hebrew
- Han ideographs and Kana (Chinese, Japanese, and Korean) and Hangul Johab (Korean)
- Thai, Lao, and Khmer
- Devanagari, Bengali, Gurmukhi, Malayalam, Telugu, Tamil, Gujarati, Oriya, Kannada, and Tibetan
- Tifinagh, Yi, Cherokee, Canadian Syllabics, Deseret, Shavian, Vai, Tagalog, Hanunoo, Buhid, and Tagbanwa

Using the Text Layout Framework in Flash Professional and Flex

You can use the TLF classes directly to create custom components in Flash. In addition, Flash Professional CS5 provides a new class, fl.text.TLFTextField, that encapsulates the TLF functionality. Use the TLFTextField class to create text fields in ActionScript that use the advanced text display features of the TLF. Create a TLFTextField object the same way you create a text field with the TextField class. Then, use the `textFlow` property to assign advanced formatting from the TLF classes.

You can also use Flash Professional to create the TLFTextField instance on the stage using the text tool. Then you can use ActionScript to control the formatting and layout of the text field content using the TLF classes. For more information, see TLFTextField in the ActionScript 3.0 Reference for the Adobe Flash Platform.

If you are working in Flex, use the TLF classes. For more information, see "Using the Text Layout Framework" on page 427.

Using the Text Layout Framework

Flash Player 10 and later, Adobe AIR 1.5 and later

If you are working in Flex or are building custom text components, use the TLF classes. The TLF is an ActionScript 3.0 library contained entirely within the textLayout.swc library. The TLF library contains about 100 ActionScript 3.0 classes and interfaces organized into ten packages. These packages are subpackages of the flashx.textLayout package.

The Text Layout Framework classes

Flash Player 10 and later, Adobe AIR 1.5 and later

The TLF classes can be grouped into three categories:

- Data structures and formatting classes

- Rendering classes
- User interaction classes

Data structures and formatting classes

The following packages contain the data structures and formatting classes for the TLF:

- flashx.textLayout.elements
- flashx.textLayout.formats
- flashx.textLayout.conversion

The main data structure of the TLF is the text flow hierarchy, which is defined in the elements package. Within this structure, you can assign styles and attributes to runs of text with the formats package. You can also control how text is imported to, and exported from, the data structure with the conversion package.

Rendering classes

The following packages contain the rendering classes for the TLF:

- flashx.textLayout.factory
- flashx.textLayout.container
- flashx.textLayout.compose

The classes in these packages facilitate the rendering of text for display by Flash Player. The factory package provides a simple way to display static text. The container package includes classes and interfaces that define display containers for dynamic text. The compose package defines techniques for positioning and displaying dynamic text in containers.

User interaction classes

The following packages contain the user interaction classes for the TLF:

- flashx.textLayout.edit
- flashx.textLayout.operations
- flashx.textLayout.events

The edit and operations packages define classes that you can use to allow editing of text stored in the data structures. The events package contains event handling classes.

General steps for creating text with the Text Layout Framework

The following steps describe the general process for creating text with the Text Layout Format:

1. Import formatted text into the TLF data structures. For more information, see "Structuring text with TLF" on page 432 and "Formatting text with TLF" on page 436.
2. Create one or more linked display object containers for the text. For more information, see "Managing text containers with TLF" on page 437.
3. Associate the text in the data structures with the containers and set editing and scrolling options. For more information, see "Enabling text selection, editing, and undo with TLF" on page 438.
4. Create an event handler to reflow the text in response to resize (or other) events. For more information, see "Event handling with TLF" on page 439.

Text Layout Framework example: News layout

Flash Player 10 and later, Adobe AIR 1.5 and later

The following example demonstrates using the TLF to lay out a simple newspaper page. The page includes a large headline, a subhead, and a multicolumn body section:

```
package
{
    import flash.display.Sprite;
    import flash.display.StageAlign;
    import flash.display.StageScaleMode;
    import flash.events.Event;
    import flash.geom.Rectangle;

    import flashx.textLayout.compose.StandardFlowComposer;
    import flashx.textLayout.container.ContainerController;
    import flashx.textLayout.container.ScrollPolicy;
    import flashx.textLayout.conversion.TextConverter;
    import flashx.textLayout.elements.TextFlow;
    import flashx.textLayout.formats.TextLayoutFormat;

    public class TLFNewsLayout extends Sprite
    {
        private var hTextFlow:TextFlow;
        private var headContainer:Sprite;
        private var headlineController:ContainerController;
        private var hContainerFormat:TextLayoutFormat;

        private var bTextFlow:TextFlow;
        private var bodyTextContainer:Sprite;
        private var bodyController:ContainerController;
        private var bodyTextContainerFormat:TextLayoutFormat;

        private const headlineMarkup:String = "<flow:TextFlow 
xmlns:flow='http://ns.adobe.com/textLayout/2008'><flow:p textAlign='center'><flow:span 
fontFamily='Helvetica' fontSize='18'>TLF News Layout Example</flow:span><flow:br/><flow:span 
fontFamily='Helvetica' fontSize='14'>This example formats text like a newspaper page with a 
headline, a subtitle, and multiple columns</flow:span></flow:p></flow:TextFlow>";

        private const bodyMarkup:String = "<flow:TextFlow 
xmlns:flow='http://ns.adobe.com/textLayout/2008' fontSize='12' textIndent='10' marginBottom='15' 
paddingTop='4' paddingLeft='4'><flow:p marginBottom='inherit'><flow:span>There are many 
</flow:span><flow:span fontStyle='italic'>such</flow:span><flow:span> lime-kilns in that tract 
of country, for the purpose of burning the white marble which composes a large part of the 
substance of the hills. Some of them, built years ago, and long deserted, with weeds growing in 
the vacant round of the interior, which is open to the sky, and grass and wild-flowers rooting 
themselves into the chinks of the stones, look already like relics of antiquity, and may yet be 
overspread with the lichens of centuries to come. Others, where the lime-burner still feeds his 
daily and nightlong fire, afford points of interest to the wanderer among the hills, who seats 
himself on a log of wood or a fragment of marble, to hold a chat with the solitary man. It is a 
lonesome, and, when the character is inclined to thought, may be an intensely thoughtful 
occupation; as it proved in the case of Ethan Brand, who had mused to such strange purpose, in 
days gone by, while the fire in this very kiln was burning.</flow:span></flow:p><flow:p 
marginBottom='inherit'><flow:span>The man who now watched the fire was of a different order, and 
troubled himself with no thoughts save the very few that were requisite to his business. At 
frequent intervals, he flung back the clashing weight of the iron door, and, turning his face
```

```
from the insufferable glare, thrust in huge logs of oak, or stirred the immense brands with a
long pole. Within the furnace were seen the curling and riotous flames, and the burning marble,
almost molten with the intensity of heat; while without, the reflection of the fire quivered on
the dark intricacy of the surrounding forest, and showed in the foreground a bright and ruddy
little picture of the hut, the spring beside its door, the athletic and coal-begrimed figure of
the lime-burner, and the half-frightened child, shrinking into the protection of his father's
shadow. And when again the iron door was closed, then reappeared the tender light of the half-
full moon, which vainly strove to trace out the indistinct shapes of the neighboring mountains;
and, in the upper sky, there was a flitting congregation of clouds, still faintly tinged with the
rosy sunset, though thus far down into the valley the sunshine had vanished long and long
ago.</flow:span></flow:p></flow:TextFlow>";

        public function TLFNewsLayout()
        {
            //wait for stage to exist
            addEventListener(Event.ADDED_TO_STAGE, onAddedToStage);
        }

        private function onAddedToStage(evtObj:Event):void
        {
            removeEventListener(Event.ADDED_TO_STAGE, onAddedToStage);
            stage.scaleMode = StageScaleMode.NO_SCALE;
            stage.align = StageAlign.TOP_LEFT;

            // Headline text flow and flow composer
            hTextFlow = TextConverter.importToFlow(headlineMarkup,
TextConverter.TEXT_LAYOUT_FORMAT);

            // initialize the headline container and controller objects
            headContainer = new Sprite();
            headlineController = new ContainerController(headContainer);
            headlineController.verticalScrollPolicy = ScrollPolicy.OFF;
            hContainerFormat = new TextLayoutFormat();
            hContainerFormat.paddingTop = 4;
            hContainerFormat.paddingRight = 4;
            hContainerFormat.paddingBottom = 4;
            hContainerFormat.paddingLeft = 4;

            headlineController.format = hContainerFormat;
            hTextFlow.flowComposer.addController(headlineController);
            addChild(headContainer);
            stage.addEventListener(flash.events.Event.RESIZE, resizeHandler);

            // Body text TextFlow and flow composer
            bTextFlow = TextConverter.importToFlow(bodyMarkup,
TextConverter.TEXT_LAYOUT_FORMAT);

            // The body text container is below, and has three columns
            bodyTextContainer = new Sprite();
            bodyController = new ContainerController(bodyTextContainer);
            bodyTextContainerFormat = new TextLayoutFormat();
            bodyTextContainerFormat.columnCount = 3;
            bodyTextContainerFormat.columnGap = 30;

            bodyController.format = bodyTextContainerFormat;
            bTextFlow.flowComposer.addController(bodyController);
            addChild(bodyTextContainer);
            resizeHandler(null);
        }

        private function resizeHandler(event:Event):void
        {
            const verticalGap:Number = 25;
            const stagePadding:Number = 16;
            var stageWidth:Number = stage.stageWidth - stagePadding;
            var stageHeight:Number = stage.stageHeight - stagePadding;
            var headlineWidth:Number = stageWidth;
            var headlineContainerHeight:Number = stageHeight;

            // Initial compose to get height of headline after resize
            headlineController.setCompositionSize(headlineWidth,
headlineContainerHeight);
            hTextFlow.flowComposer.compose();
            var rect:Rectangle = headlineController.getContentBounds();
            headlineContainerHeight = rect.height;

            // Resize and place headline text container
            // Call setCompositionSize() again with updated headline height
            headlineController.setCompositionSize(headlineWidth, headlineContainerHeight );
            headlineController.container.x = stagePadding / 2;
            headlineController.container.y = stagePadding / 2;
            hTextFlow.flowComposer.updateAllControllers();

            // Resize and place body text container
            var bodyContainerHeight:Number = (stageHeight - verticalGap -
headlineContainerHeight);
            bodyController.format = bodyTextContainerFormat;
            bodyController.setCompositionSize(stageWidth, bodyContainerHeight );
            bodyController.container.x = (stagePadding/2);
            bodyController.container.y = (stagePadding/2) + headlineContainerHeight +
verticalGap;
            bTextFlow.flowComposer.updateAllControllers();
        }
    }
}
```

The TLFNewsLayout class uses two text containers. One container displays a headline and subhead, and the other displays three-column body text. For simplicity, the text is hard-coded into the example as TLF Markup text. The `headlineMarkup` variable contains both the headline and the subhead, and the `bodyMarkup` variable contains the body text. For more information on TLF Markup, see "Structuring text with TLF" on page 432.

After some initialization, the `onAddedToStage()` function imports the headline text into a TextFlow object, which is the main data structure of the TLF:

```
hTextFlow = TextConverter.importToFlow(headlineMarkup, TextConverter.TEXT_LAYOUT_FORMAT);
```

Next, a Sprite object is created for the container, and a controller is created and associated with the container:

```
headContainer = new Sprite();
headlineController = new ContainerController(headContainer);
```

The controller is initialized to set formatting, scrolling, and other options. The controller contains geometry that defines the bounds of the container that the text flows into. A TextLayoutFormat object contains the formatting options:

```
hContainerFormat = new TextLayoutFormat();
```

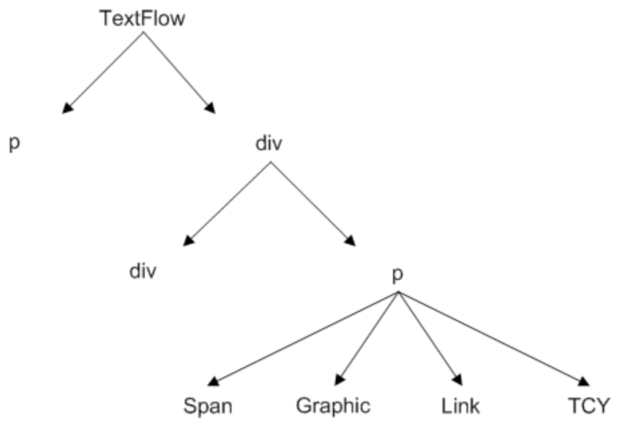
The controller is assigned to the flow composer and the function adds the container to the display list. The actual composition and display of the containers is deferred to the `resizeHandler()` method. The same sequence of steps is performed to initialize the body TextFlow object.

The `resizeHandler()` method measures the space available for rendering the containers and sizes the containers accordingly. An initial call to the `compose()` method allows for the calculation of the proper height of the headline container. The `resizeHandler()` method can then place and display the headline container with the `updateAllControllers()` method. Finally, the `resizeHandler()` method uses the size of the headline container to determine the placement of the body text container.

Structuring text with TLF

The TLF uses a hierarchical tree to represent text. Each node in the tree is an instance of a class defined in the elements package. For example, the root node of the tree is always an instance of the TextFlow class. The TextFlow class represents an entire story of text. A story is a collection of text and other elements that is treated as one unit, or flow. A single story can require more than one column or text container to display.

Apart from the root node, the remaining elements are loosely based on XHTML elements. The following diagram shows the hierarchy of the framework:



TextFlow Hierarchy

Text Layout Framework markup

Understanding the structure of the TLF is also helpful when dealing with TLF Markup. TLF Markup is an XML representation of text that is part of the TLF. Although the framework also supports other XML formats, TLF Markup is unique in that it is based specifically on the structure of the TextFlow hierarchy. If you export XML from a TextFlow using this markup format, the XML is exported with this hierarchy intact.

TLF Markup provides the highest fidelity representation of text in a TextFlow hierarchy. The markup language provides tags for each of the TextFlow hierarchy's basic elements, and also provides attributes for all formatting properties available in the TextLayoutFormat class.

The following table contains the tags that can be used in TLF Markup.

Element	**Description**	**Children**	**Class**
textflow	The root element of the markup.	div, p	TextFlow
div	A division within a TextFlow. May contain a group of paragraphs.	div, list, p	DivElement
p	A paragraph.	a, tcy, span, img, tab, br, g	ParagraphElement
a	A link.	tcy, span, img, tab, br, g	LinkElement
tcy	A run of horizontal text (used in a vertical TextFlow).	a, span, img, tab, br, g	TCYElement
span	A run of text within a paragraph.		SpanElement
img	An image in a paragraph.		InlineGraphicElement
tab	A tab character.		TabElement
br	A break character. Used for ending a line within a paragraph; text continues on the next line, but remains in the same paragraph.		BreakElement
linkNormalFormat	Defines the formatting attributes used for links in normal state.	TextLayoutFormat	TextLayoutFormat
linkActiveFormat	Defines the formatting attributes used for links in active state, when the mouse is down on a link.	TextLayoutFormat	TextLayoutFormat
linkHoverFormat	Defines the formatting attributes used for links in hover state, when the mouse is within the bounds (rolling over) a link.	TextLayoutFormat	TextLayoutFormat
li	A list item element. Must be inside a list element.	div, li, list, p	ListItemElement
list	A list. Lists can be nested, or placed adjacent to each other. Different labeling or numbering schemes can be applied to the list items.	div, li, list, p	ListElement
g	A group element. Used for grouping elements in a paragraph. The lets you nest elements below the paragraph level.	a, tcy, span, img, tab, br, g	SubParagraphGroupElement

More Help topics

TLF 2.0 Lists Markup

TLF 2.0 SubParagraphGroupElements and typeName

Using numbered and bulleted lists

You can use the ListElement and ListItemElement classes to add bulleted lists to your text controls. The bulleted lists can be nested and can be customized to use different bullets (or markers) and auto-numbering, as well as outline-style numbering.

To create lists in your text flows, use the `<list>` tag. You then use `<li>` tags within the `<list>` tag for each list item in the list. You can customize the appearance of the bullets by using the ListMarkerFormat class.

The following example creates simple lists:

```
<flow:list paddingRight="24" paddingLeft="24">
    <flow:li>Item 1</flow:li>
    <flow:li>Item 2</flow:li>
    <flow:li>Item 3</flow:li>
</flow:list>
```

You can nest lists within other lists, as the following example shows:

```
<flow:list paddingRight="24" paddingLeft="24">
    <flow:li>Item 1</flow:li>
    <flow:list paddingRight="24" paddingLeft="24">
        <flow:li>Item 1a</flow:li>
        <flow:li>Item 1b</flow:li>
        <flow:li>Item 1c</flow:li>
    </flow:list>
    <flow:li>Item 2</flow:li>
    <flow:li>Item 3</flow:li>
</flow:list>
```

To customize the type of marker in the list, use the `listStyleType` property of the ListElement. This property can be any value defined by the ListStyleType class (such as `check`, `circle`, `decimal`, and `box`). The following example creates lists with various marker types and a custom counter increment:

```
<flow:list paddingRight="24" paddingLeft="24" listStyleType="upperAlpha">
<flow:li>upperAlpha item</flow:li> <flow:li>another</flow:li> </flow:list> <flow:list
paddingRight="24" paddingLeft="24" listStyleType="lowerAlpha"> <flow:li>lowerAlpha
item</flow:li> <flow:li>another</flow:li> </flow:list> <flow:list paddingRight="24"
paddingLeft="24" listStyleType="upperRoman"> <flow:li>upperRoman item</flow:li>
<flow:li>another</flow:li> </flow:list> <flow:list paddingRight="24" paddingLeft="24"
listStyleType="lowerRoman"> <flow:listMarkerFormat> <!-- Increments the list by 2s rather than
1s. --> <flow:ListMarkerFormat counterIncrement="ordered 2"/> </flow:listMarkerFormat>
<flow:li>lowerRoman item</flow:li> <flow:li>another</flow:li> </flow:list>
```

You use the ListMarkerFormat class to define the counter. In addition to defining the increment of a counter, you can also customize the counter by resetting it with the `counterReset` property.

You can further customize the appearance of the markers in your lists by using the `beforeContent` and `afterContent` properties of the ListMarkerFormat. These properties apply to content that appears before and after the content of the marker.

The following example adds the string "XX" before the marker, and the string "YY" after the marker:

```
<flow:list listStyleType="upperRoman" paddingLeft="36" paddingRight="24">
    <flow:listMarkerFormat>
        <flow:ListMarkerFormat fontSize="16"
            beforeContent="XX"
            afterContent="YY"
            counterIncrement="ordered -1"/>
        </flow:listMarkerFormat>
    <flow:li>Item 1</flow:li>
    <flow:li>Item 2</flow:li>
    <flow:li>Item 3</flow:li>
</flow:list>
```

The `content` property itself can define further customizations of the marker format. The following example displays an ordered, uppercase Roman numeral marker:

```
<flow:list listStyleType="disc"  paddingLeft="96" paddingRight="24">
    <flow:listMarkerFormat>
        <flow:ListMarkerFormat fontSize="16"
            beforeContent="Section "
            content="counters(ordered,&quot;*&quot;,upperRoman)"
            afterContent=": "/>
    </flow:listMarkerFormat>
    <flow:li>Item 1</li>
    <flow:li>Item 2</li>
    <flow:li>Item 3</li>
</flow:list>
```

As the previous example shows, the `content` property can also insert a suffix: a string that appears after the marker, but before the `afterContent`. To insert this string when providing XML content to the flow, wrap the string in `&quote;` HTML entities rather than quotation marks (`"<string>"`).

More Help topics

TLF 2.0 Lists Markup

Using padding in TLF

Each FlowElement supports padding properties that you use to control the position of each element's content area, and the space between the content areas.

The total width of an element is the sum of its content's width, plus the `paddingLeft` and `paddingRight` properties. The total height of an element is the sum of its content's height, plus the `paddingTop` and `paddingBottom` properties.

The padding is the space between the border and the content. The padding properties are `paddingBottom`, `paddingTop`, `paddingLeft`, and `paddingRight`. Padding can be applied to the TextFlow object, as well as the following child elements:

- div
- img
- li
- list
- p

Padding properties cannot be applied to span elements.

The following example sets padding properties on the TextFlow:

```
<flow:TextFlow version="2.0.0" xmlns:flow="http://ns.adobe.com/textLayout/2008" fontSize="14"
textIndent="15" paddingTop="4" paddingLeft="4" fontFamily="Times New Roman">
```

Valid values for the padding properties are a number (in pixels), "auto", or "inherit". The default value is "auto", which means it is calculated automatically and set to 0, for all elements except the ListElement. For ListElements, "auto" is 0 except on the start side of the list where the value of the `listAutoPadding` property is used. The default value of `listAutoPadding` is 40, which gives lists a default indent.

The padding properties do not, by default, inherit. The "auto" and "inherit" values are constants defined by the FormatValue class.

Padding properties can be negative values.

More Help topics

Padding changes in TLF 2.0

Formatting text with TLF

Flash Player 10 and later, Adobe AIR 1.5 and later

The flashx.textLayout.formats package contains interfaces and classes that allow you to assign formats to any FlowElement in the text flow hierarchy tree. There are two ways to apply formatting. You can assign a specific format individually or assign a group of formats simultaneously with a special formatting object.

The ITextLayoutFormat interface contains all of the formats that can be applied to a FlowElement. Some formats apply to an entire container or paragraph of text, but do not logically apply to individual characters. For example, formats such as justification and tab stops apply to whole paragraphs, but are not applicable to individual characters.

Assigning formats to a FlowElement with properties

Flash Player 10 and later, Adobe AIR 1.5 and later

You can set formats on any FlowElement through property assignment. The FlowElement class implements the ITextLayoutFormat interface, so any subclass of the FlowElement class must also implement that interface.

For example, the following code shows how to assign individual formats to an instance of ParagraphElement:

```
var p:ParagraphElement = new ParagraphElement();
p.fontSize = 18;
p.fontFamily = "Arial";
```

Assigning formats to a FlowElement with the TextLayoutFormat class

Flash Player 10 and later, Adobe AIR 1.5 and later

You can apply formats to a FlowElement with the TextLayoutFormat class. You use this class to create a special formatting object that contains all of the formatting values you want. You can then assign that object to the `format` property of any FlowElement object. Both TextLayoutFormat and FlowElement implement the ITextLayoutFormat interface. This arrangement ensures that both classes contain the same format properties.

For more information, see TextLayoutFormat in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Format inheritance

Flash Player 10 and later, Adobe AIR 1.5 and later

Formats are inherited through the text flow hierarchy. If you assign an instance of TextLayoutFormat to a FlowElement instance with children, the framework initiates a process called a *cascade*. During a cascade, the framework recursively examines each node in the hierarchy that inherits from your FlowElement. It then determines whether to assign the inherited values to each formatting property. The following rules are applied during the cascade:

1 Property values are inherited only from an immediate ancestor (sometimes called the parent).

2 Property values are inherited only if a property does not already have a value (that is, the value is `undefined`).

3 Some attributes do not inherit values when undefined, unless the attribute's value is set to "inherit" or the constant `flashx.textLayout.formats.FormatValue.INHERIT`.

For example, if you set the `fontSize` value at the TextFlow level, the setting applies to all elements in the TextFlow. In other words, the values cascade down the text flow hierarchy. You can, however, override the value in a given element by assigning a new value directly to the element. As a counter-example, if you set the `backgroundColor` value for at the TextFlow level, the children of the TextFlow do not inherit that value. The `backgroundColor` property is one that does not inherit from its parent during a cascade. You can override this behavior by setting the `backgroundColor` property on each child to `flashx.textLayout.formats.FormatValue.INHERIT`.

For more information, see TextLayoutFormat in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Importing and exporting text with TLF

Flash Player 10 and later, Adobe AIR 1.5 and later

The TextConverter class in the flashx.textLayout.conversion.* package lets you import text to, and export text from, the TLF. Use this class if you plan to load text at runtime instead of compiling the text into the SWF file. You can also use this class to export text that is stored in a TextFlow instance into a String or XML object.

Both import and export are straightforward procedures. You call either the `export()` method or the `importToFlow()` method, both of which are part of the TextConverter class. Both methods are static, which means that you call the methods on the TextConverter class rather than on an instance of the TextConverter class.

The classes in the flashx.textLayout.conversion package provide considerable flexibility in where you choose to store your text. For example, if you store your text in a database, you can import the text into the framework for display. You can then use the classes in the flashx.textLayout.edit package to change the text, and export the changed text back to your database.

For more information, see flashx.textLayout.conversion in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Managing text containers with TLF

Flash Player 10 and later, Adobe AIR 1.5 and later

Once text is stored in the TLF data structures, Flash Player can display it. The text that is stored in the flow hierarchy must be converted into a format that Flash Player can display. The TLF offers two ways to create display objects from a flow. The first, more simple approach is suitable for displaying static text. The second, more complicated approach lets you create dynamic text that can be selected and edited. In both cases, the text is ultimately converted into instances of the TextLine class, which is part of the flash.text.engine.* package in Flash Player 10.

Creating static text

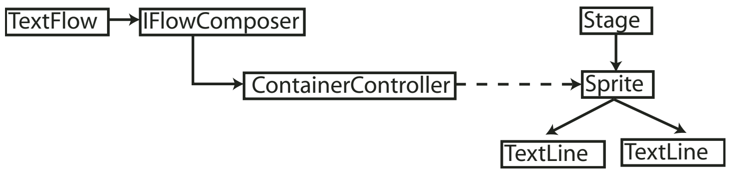
The simple approach uses the TextFlowTextLineFactory class, which can be found in the flashx.textLayout.factory package. The advantage of this approach, beyond its simplicity, is that it has a smaller memory footprint than does the FlowComposer approach. This approach is advisable for static text that the user does not need to edit, select, or scroll.

For more information, see TextFlowTextLineFactory in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Creating dynamic text and containers

Use a flow composer if you want to have more control over the display of text than that provided by TextFlowTextLineFactory. For example, with a flow composer, your users can select and edit the text. For more information, see "Enabling text selection, editing, and undo with TLF" on page 438.

A flow composer is an instance of the StandardFlowComposer class in the flashx.textLayout.compose package. A flow composer manages the conversion of TextFlow into TextLine instances, and also the placement of those TextLine instances into one or more containers.



An IFlowComposer has zero or more ContainerControllers

Every TextFlow instance has a corresponding object that implements the IFlowComposer interface. This IFlowComposer object is accessible through the `TextFlow.flowComposer` property. You can call methods defined by the IFlowComposer interface through this property. These methods allow you to associate the text with one or more containers and prepare the text for display within a container.

A container is an instance of the Sprite class, which is a subclass of the DisplayObjectContainer class. Both of these classes are part of the Flash Player display list API. A container is a more advanced form of the bounding rectangle used in with TextLineFactory class. Like the bounding rectangle, a container defines the area where TextLine instances appear. Unlike a bounding rectangle, a container has a corresponding "controller" object. The controller manages scrolling, composition, linking, formatting, and event handling for a container or set of containers. Each container has a corresponding controller object that is an instance of the ContainerController class in the flashx.textLayout.container package.

To display text, create a controller object to manage the container and associate it with the flow composer. Once you have the container associated, compose the text so that it can be displayed. Accordingly, containers have two states: composition and display. Composition is the process of converting the text from the text flow hierarchy into TextLine instances and calculating whether those instances fit into the container. Display is the process of updating the Flash Player display list.

For more information, see IFlowComposer, StandardFlowComposer, and ContainerController in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Enabling text selection, editing, and undo with TLF

Flash Player 9.0 and later, Adobe AIR 1.0 and later

The ability to select or edit text is controlled at the text flow level. Every instance of the TextFlow class has an associated interaction manager. You can access a TextFlow object's interaction manager through the object's `TextFlow.interactionManager` property. To enable text selection, assign an instance of the SelectionManager class to the `interactionManager` property. To enable both text selection and editing, assign an instance of the EditManager class instead of an instance of the SelectionManager class. To enable undo operations, create an instance of the UndoManager class and include it as an argument when calling the constructor for EditManager. The UndoManager class maintains a history of the user's most recent editing activities and lets the user undo or redo specific edits. All three of these classes are part of the edit package.

For more information, see SelectionManager, EditManager, and UndoManager in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Event handling with TLF

Flash Player 10 and later, Adobe AIR 1.5 and later

TextFlow objects dispatch events in many circumstances, including:

- When the text or layout changes
- Before an operation begins and after an operation completes
- When the status of a FlowElement object changes
- When a compose operation completes

For more information, see flashx.textLayout.events in the ActionScript 3.0 Reference for the Adobe Flash Platform.

More Help topics

TLF FlowElement and LinkElement Events and EventMirrors

Positioning images within text

To position the InlineGraphicElement within the text, you use the following properties:

- `float` property of the InlineGraphicElement class
- `clearFloats` property of the FlowElement

The `float` property controls the placement of the graphic and the text around it. The `clearFloats` property controls the placement of the paragraph elements relative to the `float`.

To control the location of an image within a text element, you use the `float` property. The following example adds an image to a paragraph and aligns it to the left so the text wraps around the right:

```
<flow:p paragraphSpaceAfter="15" >Images in a flow are a good thing. For example, here is a
float. It should show on the left: <flow:img float="left" height="50" width="19"
source="../assets/bulldog.jpg"></flow:img> Don't you agree? Another sentence here. Another
sentence here. Another sentence here. Another sentence here. Another sentence here. Another
sentence here. Another sentence here. Another sentence here.</flow:p>
```

Valid values for the `float` property are "left", "right", "start", "end", and "none". The Float class defines these constants. The default value is "none".

The `clearFloats` property is useful in cases where you want to adjust the starting position of subsequent paragraphs that would normally wrap around the image. For example, assume that you have an image that is larger than the first paragraph. To be sure the second paragraph starts *after* the image, set the `clearFloats` property.

The following example uses an image that is taller than the text in the first paragraph. To get the second paragraph to start after the image in the text block, this example sets the `clearFloats` property on the second paragraph to "end".

```
<flow:p paragraphSpaceAfter="15" >Here is another float, it should show up on the right:
<flow:img float="right" height="50" elementHeight="200" width="19"
source="../assets/bulldog.jpg"></flow:img>We'll add another paragraph that should clear past
it.</flow:p><flow:p clearFloats="end" >This should appear after the previous float on the
right.</flow:p>
```

Valid values for the `clearFloats` property are “left”, “right”, “end”, “start”, “none”, and “both”. The ClearFloats class defines these constants. You can also set the `clearFloats` property to “inherit”, which is a constant defined by the FormatValue class. The default value is “none”.

More Help topics

TLF Floats

Chapter 24: Working with sound

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript is made for immersive, interactive applications—and one often overlooked element of powerfully immersive applications is sound. You can add sound effects to a video game, audio feedback to an application user interface, or even make a program that analyzes mp3 files loaded over the Internet, with sound at the core of the application.

You can load external audio files and work with audio that's embedded in a SWF. You can control the audio, create visual representations of the sound information, and capture sound from a user's microphone.

More Help topics

flash.media package

flash.events.SampleDataEvent

Basics of working with sound

Flash Player 9 and later, Adobe AIR 1.0 and later

Computers can capture and encode digital audio—computer representation of sound information—and can store it and retrieve it to play back over speakers. You can play back sound using either Adobe® Flash® Player or Adobe® AIR™ and ActionScript.

When sound data is converted to digital form, it has various characteristics, such as the sound's volume and whether it is stereo or mono sound. When you play back a sound in ActionScript, you can adjust these characteristics as well—make the sound louder, or make it seem to be coming from a certain direction, for instance.

Before you can control a sound in ActionScript, you need to have the sound information loaded into Flash Player or AIR. There are five ways you can get audio data into Flash Player or AIR so that you can work with it using ActionScript.

- Load an external sound file such as an mp3 file into the SWF.
- Embed the sound information into the SWF file directly when it's being created.
- Capture audio from a microphone attached to a user's computer.
- Stream audio from a server.
- Dynamically generate and play audio.

When you load sound data from an external sound file, you can begin playing back the start of the sound file while the rest of the sound data is still loading.

Although there are various sound file formats used to encode digital audio, ActionScript 3.0, Flash Player and AIR support sound files that are stored in the mp3 format. They cannot directly load or play sound files in other formats like WAV or AIFF.

While you're working with sound in ActionScript, you'll likely work with several classes from the flash.media package. The Sound class is the class you use to get access to audio information by loading a sound file or assigning a function to an event that samples sound data and then starting playback. Once you start playing a sound, Flash Player and AIR give you access to a SoundChannel object. Since an audio file that you've loaded may only be one of several sounds that you play on a user's computer, each individual sound that's playing uses its own SoundChannel object; the combined output of all the SoundChannel objects mixed together is what actually plays over the computer's speakers. You use this SoundChannel instance to control properties of the sound and to stop its playback. Finally, if you want to control the combined audio, the SoundMixer class gives you control over the mixed output.

You can also use several other classes to perform more specific tasks when you're working with sound in ActionScript; for more information on all the sound-related classes, see "Understanding the sound architecture" on page 442.

Important concepts and terms

The following reference list contains important terms that you may encounter:

Amplitude The distance of a point on the sound waveform from the zero or equilibrium line.

Bit rate The amount of data that is encoded or streamed for each second of a sound file. For mp3 files, the bit rate is usually stated in terms of thousands of bits per second (kbps). A higher bit rate generally means a higher quality sound wave.

Buffering The receiving and storing of sound data before it is played back.

mp3 MPEG-1 Audio Layer 3, or mp3, is a popular sound compression format.

Panning The positioning of an audio signal between the left and right channels in a stereo soundfield.

Peak The highest point in a waveform.

Sampling rate Defines the number of samples per second taken from an analog audio signal to make a digital signal. The sampling rate of standard compact disc audio is 44.1 kHz or 44,100 samples per second.

Streaming The process of playing the early portions of a sound file or video file while later portions of that file are still being loaded from a server.

Volume The loudness of a sound.

Waveform The shape of a graph of the varying amplitudes of a sound signal over time.

Understanding the sound architecture

Flash Player 9 and later, Adobe AIR 1.0 and later

Your applications can load sound data from five main sources:

- External sound files loaded at run time
- Sound resources embedded within the application's SWF file
- Sound data from a microphone attached to the user's system
- Sound data streamed from a remote media server, such as Flash Media Server
- Sound data being generated dynamically through the use of the `sampleData` event handler

Sound data can be fully loaded before it is played back, or it can be streamed, meaning that it is played back while it is still loading.

The ActionScript 3.0 sound classes support sound files that are stored in the mp3 format. They cannot directly load or play sound files in other formats, such as WAV or AIFF. However, starting with Flash Player 9.0.115.0, AAC audio files can be loaded and played using the NetStream class. This is the same technique as is used for loading and playing video content. For more information on this technique, see "Working with video" on page 474.

Using Adobe Flash Professional, you can import WAV or AIFF sound files and then embed them into your application's SWF files in the mp3 format. The Flash Authoring tool also lets you compress embedded sound files to reduce their file size, though this size reduction comes at the expense of sound quality. For more information see "Importing Sounds" in *Using Flash*.

The ActionScript 3.0 sound architecture makes use of the following classes in the flash.media package.

Class	Description
flash.media.Sound	The Sound class handles the loading of sound, manages basic sound properties, and starts a sound playing.
flash.media.SoundChannel	When an application plays a Sound object, a new SoundChannel object is created to control the playback. The SoundChannel object controls the volume of both the left and right playback channels of the sound. Each sound that plays has its own SoundChannel object.
flash.media.SoundLoaderContext	The SoundLoaderContext class specifies how many seconds of buffering to use when loading a sound, and whether Flash Player or AIR looks for a policy file from the server when loading a file. A SoundLoaderContext object is used as a parameter to the `Sound.load()` method.
flash.media.SoundMixer	The SoundMixer class controls playback and security properties that pertain to all sounds in an application. In effect, multiple sound channels are mixed through a common SoundMixer object, so property values in the SoundMixer object will affect all SoundChannel objects that are currently playing.
flash.media.SoundTransform	The SoundTransform class contains values that control sound volume and panning. A SoundTransform object can be applied to an individual SoundChannel object, to the global SoundMixer object, or to a Microphone object, among others.
flash.media.ID3Info	An ID3Info object contains properties that represent ID3 metadata information that is often stored in mp3 sound files.
flash.media.Microphone	The Microphone class represents a microphone or other sound input device attached to the user's computer. Audio input from a microphone can be routed to local speakers or sent to a remote server. The Microphone object controls the gain, sampling rate, and other characteristics of its own sound stream.
flash.media.AudioPlaybackMode	The AudioPlaybackMode class defines constants for the `audioPlaybackMode` property of the SoundMixer class.

Each sound that is loaded and played needs its own instance of the Sound class and the SoundChannel class. The output from multiple SoundChannel instances is then mixed together by the global SoundMixer class during playback,

The Sound, SoundChannel, and SoundMixer classes are not used for sound data obtained from a microphone or from a streaming media server like Flash Media Server.

Loading external sound files

Flash Player 9 and later, Adobe AIR 1.0 and later

Each instance of the Sound class exists to load and trigger the playback of a specific sound resource. An application can't reuse a Sound object to load more than one sound. If it wants to load a new sound resource, it should create a new Sound object.

If you are loading a small sound file, such as a click sound to be attached to a button, your application can create a new Sound and have it automatically load the sound file, as shown below:

```
var req:URLRequest = new URLRequest("click.mp3");
var s:Sound = new Sound(req);
```

The `Sound()` constructor accepts a URLRequest object as its first parameter. When a value for the URLRequest parameter is supplied, the new Sound object starts loading the specified sound resource automatically.

In all but the simplest cases, your application should pay attention to the sound's loading progress and watch for errors during loading. For example, if the click sound is fairly large, it might not be completely loaded by the time the user clicks the button that triggers the sound. Trying to play an unloaded sound could cause a run-time error. It's safer to wait for the sound to load completely before letting users take actions that might start sounds playing.

A Sound object dispatches a number of different events during the sound loading process. Your application can listen for these events to track loading progress and make sure that the sound loads completely before playing. The following table lists the events that can be dispatched by a Sound object.

Event	Description
open (`Event.OPEN`)	Dispatched right before the sound loading operation begins.
progress (`ProgressEvent.PROGRESS`)	Dispatched periodically during the sound loading process when data is received from the file or stream.
id3 (`Event.ID3`)	Dispatched when ID3 data is available for an mp3 sound.
complete (`Event.COMPLETE`)	Dispatched when all of the sound resource's data has been loaded.
ioError (`IOErrorEvent.IO_ERROR`)	Dispatched when a sound file cannot be located or when the loading process is interrupted before all sound data can be received.

The following code illustrates how to play a sound after it has finished loading:

```
import flash.events.Event;
import flash.media.Sound;
import flash.net.URLRequest;

var s:Sound = new Sound();
s.addEventListener(Event.COMPLETE, onSoundLoaded);
var req:URLRequest = new URLRequest("bigSound.mp3");
s.load(req);

function onSoundLoaded(event:Event):void
{
    var localSound:Sound = event.target as Sound;
    localSound.play();
}
```

First, the code sample creates a new Sound object without giving it an initial value for the URLRequest parameter. Then, it listens for the `Event.COMPLETE` event from the Sound object, which causes the `onSoundLoaded()` method to execute when all the sound data is loaded. Next, it calls the `Sound.load()` method with a new URLRequest value for the sound file.

The `onSoundLoaded()` method executes when the sound loading is complete. The `target` property of the Event object is a reference to the Sound object. Calling the `play()` method of the Sound object then starts the sound playback.

Monitoring the sound loading process

Flash Player 9 and later, Adobe AIR 1.0 and later

Sound files can be very large and take a long time to load. While Flash Player and AIR let your application play sounds even before they are fully loaded, you might want to give the user an indication of how much of the sound data has been loaded and how much of the sound has already been played.

The Sound class dispatches two events that make it relatively easy to display the loading progress of a sound: `ProgressEvent.PROGRESS` and `Event.COMPLETE`. The following example shows how to use these events to display progress information about the sound being loaded:

```
import flash.events.Event;
import flash.events.ProgressEvent;
import flash.media.Sound;
import flash.net.URLRequest;

var s:Sound = new Sound();
s.addEventListener(ProgressEvent.PROGRESS, onLoadProgress);
s.addEventListener(Event.COMPLETE, onLoadComplete);
s.addEventListener(IOErrorEvent.IO_ERROR, onIOError);

var req:URLRequest = new URLRequest("bigSound.mp3");
s.load(req);

function onLoadProgress(event:ProgressEvent):void
{
    var loadedPct:uint = Math.round(100 * (event.bytesLoaded / event.bytesTotal));
    trace("The sound is " + loadedPct + "% loaded.");
}

function onLoadComplete(event:Event):void
{
    var localSound:Sound = event.target as Sound;
    localSound.play();
}
function onIOError(event:IOErrorEvent)
{
    trace("The sound could not be loaded: " + event.text);
}
```

This code first creates a Sound object and then adds listeners to that object for the `ProgressEvent.PROGRESS` and `Event.COMPLETE` events. After the `Sound.load()` method has been called and the first data is received from the sound file, a `ProgressEvent.PROGRESS` event occurs and triggers the `onSoundLoadProgress()` method.

The percentage of the sound data that has been loaded is equal to the value of the `bytesLoaded` property of the ProgressEvent object divided by the value of the `bytesTotal` property. The same `bytesLoaded` and `bytesTotal` properties are available on the Sound object as well. The example above simply shows messages about the sound loading progress, but you can easily use the `bytesLoaded` and `bytesTotal` values to update progress bar components, such as the ones that come with the Adobe Flex framework or the Adobe Flash authoring tool.

This example also shows how an application can recognize and respond to an error when loading sound files. For example, if a sound file with the given filename cannot be located, an `Event.IO_ERROR` event is dispatched by the Sound object. In the previous code, the `onIOError()` method executes and displays a brief error message when an error occurs.

Working with embedded sounds

Flash Player 9 and later, Adobe AIR 1.0 and later

Using embedded sounds, instead of loading sound from an external file, is most useful for small sounds that are used as indicators within your application's user interface, such as sounds that play when buttons are clicked.

When you embed a sound file in your application, the size of the resulting SWF file increases by the size of the sound file. In other words, embedding large sound files in your application can increase the size of your SWF file to an undesirable size.

The exact method of embedding a sound file into your application's SWF file varies according to your development environment.

Using an embedded sound file in Flash

Flash Player 9 and later, Adobe AIR 1.0 and later

The Flash authoring tool lets you import sounds in a number of sound formats and store them as symbols in the Library. You can then assign them to frames in the timeline or to the frames of a button state, use them with Behaviors, or use them directly in ActionScript code. This section describes how to use embedded sounds in ActionScript code with the Flash authoring tool. For information about the other ways to use embedded sounds in Flash, see "Importing Sounds" in *Using Flash*.

To embed a sound file using the Flash authoring tool:

1 Select File > Import > Import to Library, and then select a sound file and import it.

2 Right-click the name of the imported file in the Library panel, and select Properties. Click the Export for ActionScript checkbox.

3 In the Class field, enter a name to use when referring to this embedded sound in ActionScript. By default, it will use the name of the sound file in this field. If the filename includes a period, as in the name "DrumSound.mp3", you must change it to something like "DrumSound"; ActionScript does not allow a period character in a class name. The Base Class field should still show flash.media.Sound.

4 Click OK. You might see a dialog box saying that a definition for this class could not be found in the classpath. Click OK and continue. If you entered a class name that doesn't match the name of any of the classes in your application's classpath, a new class that inherits from the flash.media.Sound class is automatically generated for you.

5 To use the embedded sound, you reference the class name for that sound in ActionScript. For example, the following code starts by creating a new instance of the automatically generated DrumSound class:

```
var drum:DrumSound = new DrumSound();
var channel:SoundChannel = drum.play();
```

DrumSound is a subclass of the flash.media.Sound class so it inherits the Sound class's methods and properties, including the `play()` method as shown above.

Using an embedded sound file in Flex

Flash Player 9 and later, Adobe AIR 1.0 and later

There are many ways to embed sound assets in a Flex application, including:

- Using the `[Embed]` metadata tag in a script

- Using the `@Embed` directive in MXML to assign an embedded asset as a property of a component like a Button or a SoundEffect.
- Using the `@Embed` directive within a CSS file

This section describes the first option: how to embed sounds in ActionScript code within a Flex application using the `[Embed]` metadata tag.

To embed an asset in ActionScript code, use the `[Embed]` metadata tag.

Place the sound file in the main source folder or another folder that is in your project's build path. When the compiler encounters an Embed metadata tag, it creates the embedded asset class for you. You can access the class through a variable of data type Class that you declare immediately after the `[Embed]` metadata tag.

The following code embeds a sound named smallSound.mp3 and uses a variable named `soundClass` to store a reference to the embedded asset class associated with that sound. The code then creates an instance of the embedded asset class, casts it as an instance of the Sound class, and calls the `play()` method on that instance:

```
package
{
    import flash.display.Sprite;
    import flash.media.Sound;
    import flash.media.SoundChannel;

    public class EmbeddedSoundExample extends Sprite
    {
        [Embed(source="smallSound.mp3")]
        public var soundClass:Class;

        public function EmbeddedSoundExample()
        {
            var smallSound:Sound = new soundClass() as Sound;
            smallSound.play();
        }
    }
}
```

To use the embedded sound to set a property of a Flex component, it should be cast as an instance of the mx.core.SoundAsset class instead of as an instance of the Sound class. For a similar example that uses the SoundAsset class see "Embedded asset classes" in Learning ActionScript 3.0.

Working with streaming sound files

Flash Player 9 and later, Adobe AIR 1.0 and later

When a sound file or video file is playing back while its data is still being loaded, it is said to be *streaming*. External sound files that are loaded from a remote server are often streamed so that the user doesn't have to wait for all the sound data to load before listening to the sound.

The `SoundMixer.bufferTime` property represents the number of milliseconds of sound data that Flash Player or AIR should gather before letting the sound play. In other words, if the `bufferTime` property is set to 5000, Flash Player or AIR loads at least 5000 milliseconds worth of data from the sound file before the sound begins to play. The default `SoundMixer.bufferTime` value is 1000.

Your application can override the global `SoundMixer.bufferTime` value for an individual sound by explicitly specifying a new `bufferTime` value when loading the sound. To override the default buffer time, first create a new instance of the SoundLoaderContext class, set its `bufferTime` property, and then pass it as a parameter to the `Sound.load()` method, as shown below:

```
import flash.media.Sound;
import flash.media.SoundLoaderContext;
import flash.net.URLRequest;

var s:Sound = new Sound();
var req:URLRequest = new URLRequest("bigSound.mp3");
var context:SoundLoaderContext = new SoundLoaderContext(8000, true);
s.load(req, context);
s.play();
```

As playback continues, Flash Player and AIR try to keep the sound buffer at the same size or greater. If the sound data loads faster than the playback speed, playback will continue without interruption. However, if the data loading rate slows down because of network limitations, the playhead could reach the end of the sound buffer. If this happens, playback is suspended, though it automatically resumes once more sound data has been loaded.

To find out if playback is suspended because Flash Player or AIR is waiting for data to load, use the `Sound.isBuffering` property.

Working with dynamically generated audio

Flash Player 10 and later, Adobe AIR 1.5 and later

Note: *The ability to dynamically generate audio is available starting with Flash Player 10 and Adobe AIR 1.5.*

Instead of loading or streaming an existing sound, you can generate audio data dynamically. You can generate audio data when you assign an event listener for the `sampleData` event of a Sound object. (The `sampleData` event is defined in the SampleDataEvent class in the flash.events package.) In this environment, the Sound object doesn't load sound data from a file. Instead, it acts as a socket for sound data that is being streamed to it through the use of the function you assign to this event.

When you add a `sampleData` event listener to a Sound object, the object periodically requests data to add to the sound buffer. This buffer contains data for the Sound object to play. When you call the `play()` method of the Sound object, it dispatches the `sampleData` event when requesting new sound data. (This is true only when the Sound object has not loaded mp3 data from a file.)

The SampleDataEvent object includes a `data` property. In your event listener, you write ByteArray objects to this `data` object. The byte arrays you write to this object add to buffered sound data that the Sound object plays. The byte array in the buffer is a stream of floating-point values from -1 to 1. Each floating-point value represents the amplitude of one channel (left or right) of a sound sample. Sound is sampled at 44,100 samples per second. Each sample contains a left and right channel, interleaved as floating-point data in the byte array.

In your handler function, you use the `ByteArray.writeFloat()` method to write to the `data` property of the `sampleData` event. For example, the following code generates a sine wave:

```
var mySound:Sound = new Sound();
mySound.addEventListener(SampleDataEvent.SAMPLE_DATA, sineWaveGenerator);
mySound.play();
function sineWaveGenerator(event:SampleDataEvent):void
{
    for (var i:int = 0; i < 8192; i++)
    {
        var n:Number = Math.sin((i + event.position) / Math.PI / 4);
        event.data.writeFloat(n);
        event.data.writeFloat(n);
    }
}
```

When you call `Sound.play()`, the application starts calling your event handler, requesting sound sample data. The application continues to send events as the sound plays back until you stop providing data, or until you call `SoundChannel.stop()`.

The latency of the event varies from platform to platform, and could change in future versions of Flash Player and AIR. Do not depend on a specific latency; calculate it instead. To calculate the latency, use the following formula:

```
(SampleDataEvent.position / 44.1) - SoundChannelObject.position
```

Provide from 2048 through 8192 samples to the `data` property of the SampleDataEvent object (for each call to the event listener). For best performance, provide as many samples as possible (up to 8192). The fewer samples you provide, the more likely it is that clicks and pops will occur during playback. This behavior can differ on various platforms and can occur in various situations—for example, when resizing the browser. Code that works on one platform when you provide only 2048 sample might not work as well when run on a different platform. If you require the lowest latency possible, consider making the amount of data user-selectable.

If you provide fewer than 2048 samples (per call to the `sampleData` event listener), the application stops after playing the remaining samples. The SoundChannel object then dispatches a SoundComplete event.

Modifying sound from mp3 data

Flash Player 10 and later, Adobe AIR 1.5 and later

You use the `Sound.extract()` method to extract data from a Sound object. You can use (and modify) that data to write to the dynamic stream of another Sound object for playback. For example, the following code uses the bytes of a loaded MP3 file and passes them through a filter function, `upOctave()`:

```
var mySound:Sound = new Sound();
var sourceSnd:Sound = new Sound();
var urlReq:URLRequest = new URLRequest("test.mp3");
sourceSnd.load(urlReq);
sourceSnd.addEventListener(Event.COMPLETE, loaded);
function loaded(event:Event):void
{
    mySound.addEventListener(SampleDataEvent.SAMPLE_DATA, processSound);
    mySound.play();
}
function processSound(event:SampleDataEvent):void
{
        var bytes:ByteArray = new ByteArray();
        sourceSnd.extract(bytes, 8192);
        event.data.writeBytes(upOctave(bytes));
}
function upOctave(bytes:ByteArray):ByteArray
{
    var returnBytes:ByteArray = new ByteArray();
    bytes.position = 0;
    while(bytes.bytesAvailable > 0)
    {
        returnBytes.writeFloat(bytes.readFloat());
        returnBytes.writeFloat(bytes.readFloat());
        if (bytes.bytesAvailable > 0)
        {
            bytes.position += 8;
        }
    }
    return returnBytes;
}
```

Limitations on generated sounds

Flash Player 10 and later, Adobe AIR 1.5 and later

When you use a `sampleData` event listener with a Sound object, the only other Sound methods that are enabled are `Sound.extract()` and `Sound.play()`. Calling any other methods or properties results in an exception. All methods and properties of the SoundChannel object are still enabled.

Playing sounds

Flash Player 9 and later, Adobe AIR 1.0 and later

Playing a loaded sound can be as simple as calling the `Sound.play()` method for a Sound object, as follows:

```
var snd:Sound = new Sound(new URLRequest("smallSound.mp3"));
snd.play();
```

When playing back sounds using ActionScript 3.0, you can perform the following operations:

- Play a sound from a specific starting position
- Pause a sound and resume playback from the same position later

- Know exactly when a sound finishes playing
- Track the playback progress of a sound
- Change volume or panning while a sound plays

To perform these operations during playback, use the SoundChannel, SoundMixer, and SoundTransform classes.

The SoundChannel class controls the playback of a single sound. The `SoundChannel.position` property can be thought of as a playhead, indicating the current point in the sound data that's being played.

When an application calls the `Sound.play()` method, a new instance of the SoundChannel class is created to control the playback.

Your application can play a sound from a specific starting position by passing that position, in terms of milliseconds, as the `startTime` parameter of the `Sound.play()` method. It can also specify a fixed number of times to repeat the sound in rapid succession by passing a numeric value in the `loops` parameter of the `Sound.play()` method.

When the `Sound.play()` method is called with both a `startTime` parameter and a `loops` parameter, the sound is played back repeatedly from the same starting point each time, as shown in the following code:

```
var snd:Sound = new Sound(new URLRequest("repeatingSound.mp3"));
snd.play(1000, 3);
```

In this example, the sound is played from a point one second after the start of the sound, three times in succession.

Pausing and resuming a sound

Flash Player 9 and later, Adobe AIR 1.0 and later

If your application plays long sounds, like songs or podcasts, you probably want to let users pause and resume the playback of those sounds. A sound cannot literally be paused during playback in ActionScript; it can only be stopped. However, a sound can be played starting from any point. You can record the position of the sound at the time it was stopped, and then replay the sound starting at that position later.

For example, let's say your code loads and plays a sound file like this:

```
var snd:Sound = new Sound(new URLRequest("bigSound.mp3"));
var channel:SoundChannel = snd.play();
```

While the sound plays, the `SoundChannel.position` property indicates the point in the sound file that is currently being played. Your application can store the position value before stopping the sound from playing, as follows:

```
var pausePosition:int = channel.position;
channel.stop();
```

To resume playing the sound, pass the previously stored position value to restart the sound from the same point it stopped at before.

```
channel = snd.play(pausePosition);
```

Monitoring playback

Flash Player 9 and later, Adobe AIR 1.0 and later

Your application might want to know when a sound stops playing so it can start playing another sound, or clean up some resources used during the previous playback. The SoundChannel class dispatches an `Event.SOUND_COMPLETE` event when its sound finishes playing. Your application can listen for this event and take appropriate action, as shown below:

```
import flash.events.Event;
import flash.media.Sound;
import flash.net.URLRequest;

var snd:Sound = new Sound();
var req:URLRequest = new URLRequest("smallSound.mp3");
snd.load(req);

var channel:SoundChannel = snd.play();
channel.addEventListener(Event.SOUND_COMPLETE, onPlaybackComplete);

public function onPlaybackComplete(event:Event)
{
    trace("The sound has finished playing.");
}
```

The SoundChannel class does not dispatch progress events during playback. To report on playback progress, your application can set up its own timing mechanism and track the position of the sound playhead.

To calculate what percentage of a sound has been played, you can divide the value of the `SoundChannel.position` property by the length of the sound data that's being played:

```
var playbackPercent:uint = 100 * (channel.position / snd.length);
```

However, this code only reports accurate playback percentages if the sound data was fully loaded before playback began. The `Sound.length` property shows the size of the sound data that is currently loaded, not the eventual size of the entire sound file. To track the playback progress of a streaming sound that is still loading, your application should estimate the eventual size of the full sound file and use that value in its calculations. You can estimate the eventual length of the sound data using the `bytesLoaded` and `bytesTotal` properties of the Sound object, as follows:

```
var estimatedLength:int =
    Math.ceil(snd.length / (snd.bytesLoaded / snd.bytesTotal));
var playbackPercent:uint = 100 * (channel.position / estimatedLength);
```

The following code loads a larger sound file and uses the `Event.ENTER_FRAME` event as its timing mechanism for showing playback progress. It periodically reports on the playback percentage, which is calculated as the current position value divided by the total length of the sound data:

```
import flash.events.Event;
import flash.media.Sound;
import flash.net.URLRequest;

var snd:Sound = new Sound();
var req:URLRequest = new
    URLRequest("http://av.adobe.com/podcast/csbu_dev_podcast_epi_2.mp3");
snd.load(req);

var channel:SoundChannel;
channel = snd.play();
addEventListener(Event.ENTER_FRAME, onEnterFrame);
channel.addEventListener(Event.SOUND_COMPLETE, onPlaybackComplete);

function onEnterFrame(event:Event):void
{
    var estimatedLength:int =
        Math.ceil(snd.length / (snd.bytesLoaded / snd.bytesTotal));
    var playbackPercent:uint =
        Math.round(100 * (channel.position / estimatedLength));
    trace("Sound playback is " + playbackPercent + "% complete.");
}

function onPlaybackComplete(event:Event)
{
    trace("The sound has finished playing.");
    removeEventListener(Event.ENTER_FRAME, onEnterFrame);
}
```

After the sound data starts loading, this code calls the `snd.play()` method and stores the resulting SoundChannel object in the `channel` variable. Then it adds an event listener to the main application for the `Event.ENTER_FRAME` event and another event listener to the SoundChannel object for the `Event.SOUND_COMPLETE` event that occurs when playback is complete.

Each time the application reaches a new frame in its animation, the `onEnterFrame()` method is called. The `onEnterFrame()` method estimates the total length of the sound file based on the amount of data that has already been loaded, and then it calculates and displays the current playback percentage.

When the entire sound has been played, the `onPlaybackComplete()` method executes, removing the event listener for the `Event.ENTER_FRAME` event so that it doesn't try to display progress updates after playback is done.

The `Event.ENTER_FRAME` event can be dispatched many times per second. In some cases, you won't want to display playback progress that frequently. In those cases, your application can set up its own timing mechanism using the flash.util.Timer class; see "Working with dates and times" on page 1.

Stopping streaming sounds

Flash Player 9 and later, Adobe AIR 1.0 and later

There is a quirk in the playback process for sounds that are streaming—that is, for sounds that are still loading while they are being played. When your application calls the `SoundChannel.stop()` method on a SoundChannel instance that is playing back a streaming sound, the sound playback stops for one frame, and then on the next frame, it restarts from the beginning of the sound. This occurs because the sound loading process is still underway. To stop both the loading and the playback of a streaming sound, call the `Sound.close()` method.

Security considerations when loading and playing sounds

Flash Player 9 and later, Adobe AIR 1.0 and later

Your application's ability to access sound data can be limited according to the Flash Player or AIR security model. Each sound is subject to the restrictions of two different security sandboxes, the sandbox for the content itself (the "content sandbox"), and the sandbox for the application or object that loads and plays the sound (the "owner sandbox"). For AIR application content in the application security sandbox, all sounds, including those loaded from other domains, are accessible to content in the application security sandbox. However, content in other security security sandboxes observe the same rules as content running in Flash Player. For more information about the Flash Player security model in general, and the definition of sandboxes, see "Security" on page 1042.

The content sandbox controls whether detailed sound data can be extracted from the sound using the `id3` property or the `SoundMixer.computeSpectrum()` method. It doesn't restrict the loading or playing of the sound file itself.

The domain of origin of the sound file defines the security limitations of the content sandbox. Generally, if a sound file is located in the same domain or folder as the SWF file of the application or object that loads it, the application or object will have full access to that sound file. If the sound comes from a different domain than the application does, it can still be brought within the content sandbox by using a policy file.

Your application can pass a SoundLoaderContext object with a `checkPolicyFile` property as a parameter to the `Sound.load()` method. Setting the `checkPolicyFile` property to `true` tells Flash Player or AIR to look for a policy file on the server from which the sound is loaded. If a policy file exists, and it grants access to the domain of the loading SWF file, the SWF file can load the sound file, access the `id3` property of the Sound object, and call the `SoundMixer.computeSpectrum()` method for loaded sounds.

The owner sandbox controls local playback of the sounds. The application or object that starts playing a sound defines the owner sandbox.

The `SoundMixer.stopAll()` method silences the sounds in all SoundChannel objects that are currently playing, as long as they meet the following criteria:

- The sounds were started by objects within the same owner sandbox.
- The sounds are from a source with a policy file that grants access to the domain of the application or object that calls the `SoundMixer.stopAll()` method.

However, in an AIR application, content in the application security sandbox (content installed with the AIR application) are not restricted by these security limitations.

To find out if the `SoundMixer.stopAll()` method will indeed stop all playing sounds, your application can call the `SoundMixer.areSoundsInaccessible()` method. If that method returns a value of `true`, some of the sounds being played are outside the control of the current owner sandbox and will not be stopped by the `SoundMixer.stopAll()` method.

The `SoundMixer.stopAll()` method also stops the playhead from continuing for all sounds that were loaded from external files. However, sounds that are embedded in FLA files and attached to frames in the timeline using the Flash Authoring tool might start playing again if the animation moves to a new frame.

Controlling sound volume and panning

Flash Player 9 and later, Adobe AIR 1.0 and later

An individual SoundChannel object controls both the left and the right stereo channels for a sound. If an mp3 sound is a monaural sound, the left and right stereo channels of the SoundChannel object will contain identical waveforms.

You can find out the amplitude of each stereo channel of the sound being played using the `leftPeak` and `rightPeak` properties of the SoundChannel object. These properties show the peak amplitude of the sound waveform itself. They do not represent the actual playback volume. The actual playback volume is a function of the amplitude of the sound wave and the volume values set in the SoundChannel object and the SoundMixer class.

The pan property of a SoundChannel object can be used to specify a different volume level for each of the left and right channels during playback. The pan property can have a value ranging from -1 to 1, where -1 means the left channel plays at top volume while the right channel is silent, and 1 means the right channel plays at top volume while the left channel is silent. Numeric values in between -1 and 1 set proportional values for the left and right channel values, and a value of 0 means that both channels play at a balanced, mid-volume level.

The following code example creates a SoundTransform object with a volume value of 0.6 and a pan value of -1 (top left channel volume and no right channel volume). It passes the SoundTransform object as a parameter to the `play()` method, which applies that SoundTransform object to the new SoundChannel object that is created to control the playback.

```
var snd:Sound = new Sound(new URLRequest("bigSound.mp3"));
var trans:SoundTransform = new SoundTransform(0.6, -1);
var channel:SoundChannel = snd.play(0, 1, trans);
```

You can alter the volume and panning while a sound is playing by setting the `pan` or `volume` properties of a SoundTransform object and then applying that object as the `soundTransform` property of a SoundChannel object.

You can also set global volume and pan values for all sounds at once using the `soundTransform` property of the SoundMixer class, as the following example shows:

```
SoundMixer.soundTransform = new SoundTransform(1, -1);
```

You can also use a SoundTransform object to set volume and pan values for a Microphone object (see "Capturing sound input" on page 461) and for Sprite objects and SimpleButton objects.

The following example alternates the panning of the sound from the left channel to the right channel and back while the sound plays.

```
import flash.events.Event;
import flash.media.Sound;
import flash.media.SoundChannel;
import flash.media.SoundMixer;
import flash.net.URLRequest;

var snd:Sound = new Sound();
var req:URLRequest = new URLRequest("bigSound.mp3");
snd.load(req);

var panCounter:Number = 0;

var trans:SoundTransform;
trans = new SoundTransform(1, 0);
var channel:SoundChannel = snd.play(0, 1, trans);
channel.addEventListener(Event.SOUND_COMPLETE, onPlaybackComplete);

addEventListener(Event.ENTER_FRAME, onEnterFrame);

function onEnterFrame(event:Event):void
{
    trans.pan = Math.sin(panCounter);
    channel.soundTransform = trans; // or SoundMixer.soundTransform = trans;
    panCounter += 0.05;
}

function onPlaybackComplete(event:Event):void
{
    removeEventListener(Event.ENTER_FRAME, onEnterFrame);
}
```

This code starts by loading a sound file and then creating a new SoundTransform object with volume set to 1 (full volume) and pan set to 0 (evenly balanced between left and right). Then it calls the `snd.play()` method, passing the SoundTransform object as a parameter.

While the sound plays, the `onEnterFrame()` method executes repeatedly. The `onEnterFrame()` method uses the `Math.sin()` function to generate a value between -1 and 1, a range that corresponds to the acceptable values of the `SoundTransform.pan` property. The SoundTransform object's `pan` property is set to the new value, and then the channel's `soundTransform` property is set to use the altered SoundTransform object.

To run this example, replace the filename bigSound.mp3 with the name of a local mp3 file. Then run the example. You should hear the left channel volume getting louder while the right channel volume gets softer, and vice versa.

In this example, the same effect could be achieved by setting the `soundTransform` property of the SoundMixer class. However, that would affect the panning of all sounds currently playing, not just the single sound being played by this SoundChannel object.

Working with sound metadata

Flash Player 9 and later, Adobe AIR 1.0 and later

Sound files that use the mp3 format can contain additional data about the sound in the form of ID3 tags.

Not every mp3 file contains ID3 metadata. When a Sound object loads an mp3 sound file, it dispatches an `Event.ID3` event if the sound file contains ID3 metadata. To prevent run-time errors, your application should wait to receive the `Event.ID3` event before accessing the `Sound.id3` property for a loaded sound.

The following code shows how to recognize when the ID3 metadata for a sound file has been loaded:

```
import flash.events.Event;
import flash.media.ID3Info;
import flash.media.Sound;

var s:Sound = new Sound();
s.addEventListener(Event.ID3, onID3InfoReceived);
s.load("mySound.mp3");

function onID3InfoReceived(event:Event)
{
    var id3:ID3Info = event.target.id3;

    trace("Received ID3 Info:");
    for (var propName:String in id3)
    {
        trace(propName + " = " + id3[propName]);
    }
}
```

This code starts by creating a Sound object and telling it to listen for the `Event.ID3` event. When the sound file's ID3 metadata is loaded, the `onID3InfoReceived()` method is called. The target of the Event object that is passed to the `onID3InfoReceived()` method is the original Sound object, so the method then gets the Sound object's `id3` property and then iterates through all of its named properties to trace their values.

Accessing raw sound data

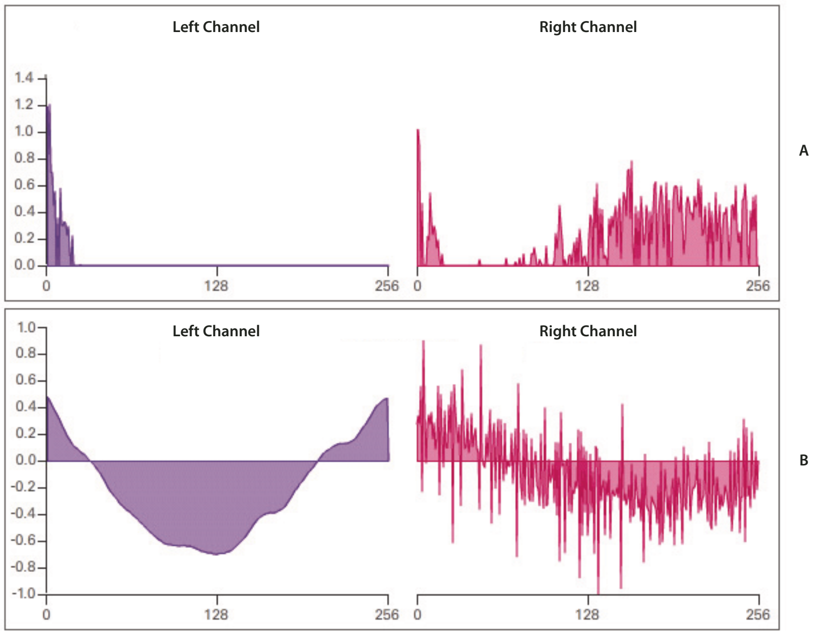
Flash Player 9 and later, Adobe AIR 1.0 and later

The `SoundMixer.computeSpectrum()` method lets an application read the raw sound data for the waveform that is currently being played. If more than one SoundChannel object is currently playing the `SoundMixer.computeSpectrum()` method shows the combined sound data of every SoundChannel object mixed together.

The sound data is returned as a ByteArray object containing 512 bytes of data, each of which contains a floating point value between -1 and 1. These values represent the amplitude of the points in the sound waveform being played. The values are delivered in two groups of 256, the first group for the left stereo channel and the second group for the right stereo channel.

The `SoundMixer.computeSpectrum()` method returns frequency spectrum data rather than waveform data if the `FFTMode` parameter is set to `true`. The frequency spectrum shows amplitude arranged by sound frequency, from lowest frequency to highest. A Fast Fourier Transform (FFT) is used to convert the waveform data into frequency spectrum data. The resulting frequency spectrum values range from 0 to roughly 1.414 (the square root of 2).

The following diagram compares the data returned from the `computeSpectrum()` method when the `FFTMode` parameter is set to `true` and when it is set to `false`. The sound whose data was used for this diagram contains a loud bass sound in the left channel and a drum hit sound in the right channel.



Values returned by the SoundMixer.computeSpectrum() method
***A.** fftMode=true **B.** fftMode=false*

The `computeSpectrum()` method can also return data that has been resampled at a lower bit rate. Generally, this results in smoother waveform data or frequency data at the expense of detail. The `stretchFactor` parameter controls the rate at which the `computeSpectrum()` method data is sampled. When the `stretchFactor` parameter is set to 0, the default, the sound data is sampled at a rate of 44.1 kHz. The rate is halved at each successive value of the stretchFactor parameter, so a value of 1 specifies a rate of 22.05 kHz, a value of 2 specifies a rate of 11.025 kHz, and so on. The `computeSpectrum()` method still returns 256 bytes per stereo channel when a higher `stretchFactor` value is used.

The `SoundMixer.computeSpectrum()` method has some limitations:

- Because sound data from a microphone or from RTMP streams do not pass through the global SoundMixer object, the `SoundMixer.computeSpectrum()` method will not return data from those sources.
- If one or more of the sounds being played come from sources outside the current content sandbox, security restrictions will cause the `SoundMixer.computeSpectrum()` method to throw an error. For more detail about the security limitations of the `SoundMixer.computeSpectrum()` method please see "Security considerations when loading and playing sounds" on page 454and "Accessing loaded media as data" on page 1066.

However, in an AIR application, content in the application security sandbox (content installed with the AIR application) are not restricted by these security limitations.

Building a simple sound visualizer

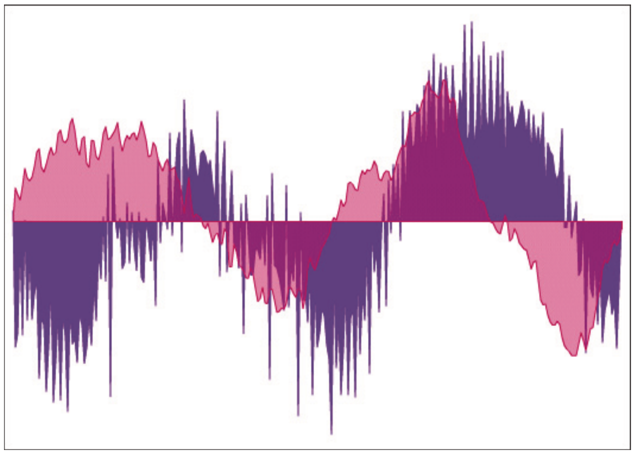
Flash Player 9 and later, Adobe AIR 1.0 and later

The following example uses the `SoundMixer.computeSpectrum()` method to show a chart of the sound waveform that animates with each frame:

```
import flash.display.Graphics;
import flash.events.Event;
import flash.media.Sound;
import flash.media.SoundChannel;
import flash.media.SoundMixer;
import flash.net.URLRequest;

const PLOT_HEIGHT:int = 200;
const CHANNEL_LENGTH:int = 256;

var snd:Sound = new Sound();
var req:URLRequest = new URLRequest("bigSound.mp3");
snd.load(req);

var channel:SoundChannel;
channel = snd.play();
addEventListener(Event.ENTER_FRAME, onEnterFrame);
snd.addEventListener(Event.SOUND_COMPLETE, onPlaybackComplete);

var bytes:ByteArray = new ByteArray();

function onEnterFrame(event:Event):void
{
    SoundMixer.computeSpectrum(bytes, false, 0);

    var g:Graphics = this.graphics;

    g.clear();
    g.lineStyle(0, 0x6600CC);
    g.beginFill(0x6600CC);
    g.moveTo(0, PLOT_HEIGHT);

    var n:Number = 0;

    // left channel
    for (var i:int = 0; i < CHANNEL_LENGTH; i++)
    {
        n = (bytes.readFloat() * PLOT_HEIGHT);
        g.lineTo(i * 2, PLOT_HEIGHT - n);
    }
    g.lineTo(CHANNEL_LENGTH * 2, PLOT_HEIGHT);
    g.endFill();

    // right channel
    g.lineStyle(0, 0xCC0066);
    g.beginFill(0xCC0066, 0.5);
    g.moveTo(CHANNEL_LENGTH * 2, PLOT_HEIGHT);

    for (i = CHANNEL_LENGTH; i > 0; i--)
    {
        n = (bytes.readFloat() * PLOT_HEIGHT);
        g.lineTo(i * 2, PLOT_HEIGHT - n);
    }
    g.lineTo(0, PLOT_HEIGHT);
    g.endFill();
}

function onPlaybackComplete(event:Event)
{
    removeEventListener(Event.ENTER_FRAME, onEnterFrame);
}
```

This example first loads and plays a sound file and then listens for the `Event.ENTER_FRAME` event which will trigger the `onEnterFrame()` method while the sound plays. The `onEnterFrame()` method starts by calling the `SoundMixer.computeSpectrum()` method, which stores the sound wave data in the `bytes` ByteArray object.

The sound waveform is plotted using the vector drawing API. A `for` loop cycles through the first 256 data values, representing the left stereo channel, and draws a line from each point to the next using the `Graphics.lineTo()` method. A second `for` loop cycles through the next set of 256 values, plotting them in reverse order this time, from right to left. The resulting waveform plots can produce an interesting mirror-image effect, as shown in the following image.



Capturing sound input

Flash Player 9 and later, Adobe AIR 1.0 and later

The Microphone class lets your application connect to a microphone or other sound input device on the user's system and broadcast the input audio to that system's speakers or send the audio data to a remote server, such as Flash Media Server. You can access the raw audio data from the microphone and record or process it; you can also send the audio directly to the system's speakers or send compressed audio data to a remote server. You can use either Speex or Nellymoser codec for data sent to a remote server. (The Speex codec is supported starting with Flash Player 10 and Adobe AIR 1.5.)

More Help topics

Michael Chaize: AIR, Android, and the Microphone

Christophe Coenraets: Voice Notes for Android

Accessing a microphone

Flash Player 9 and later, Adobe AIR 1.0 and later

The Microphone class does not have a constructor method. Instead, you use the static `Microphone.getMicrophone()` method to obtain a new Microphone instance, as shown below:

```
var mic:Microphone = Microphone.getMicrophone();
```

Calling the `Microphone.getMicrophone()` method without a parameter returns the first sound input device discovered on the user's system.

A system can have more than one sound input device attached to it. Your application can use the `Microphone.names` property to get an array of the names of all available sound input devices. Then it can call the `Microphone.getMicrophone()` method with an `index` parameter that matches the index value of a device's name in the array.

A system might not have a microphone or other sound input device attached to it. You can use the `Microphone.names` property or the `Microphone.getMicrophone()` method to check whether the user has a sound input device installed. If the user doesn't have a sound input device installed, the `names` array has a length of zero, and the `getMicrophone()` method returns a value of `null`.

When your application calls the `Microphone.getMicrophone()` method, Flash Player displays the Flash Player Settings dialog box, which prompts the user to either allow or deny Flash Player access to the camera and microphone on the system. After the user clicks on either the Allow button or the Deny button in this dialog, a StatusEvent is dispatched. The `code` property of that StatusEvent instance indicates whether microphone access was allowed or denied, as shown in this example:

```
import flash.media.Microphone;

var mic:Microphone = Microphone.getMicrophone();
mic.addEventListener(StatusEvent.STATUS, this.onMicStatus);

function onMicStatus(event:StatusEvent):void
{
    if (event.code == "Microphone.Unmuted")
    {
        trace("Microphone access was allowed.");
    }
    else if (event.code == "Microphone.Muted")
    {
        trace("Microphone access was denied.");
    }
}
```

The `StatusEvent.code` property will contain "Microphone.Unmuted" if access was allowed, or "Microphone.Muted" if access was denied.

The `Microphone.muted` property is set to `true` or `false` when the user allows or denies microphone access, respectively. However, the `muted` property is not set on the Microphone instance until the StatusEvent has been dispatched, so your application should also wait for the `StatusEvent.STATUS` event to be dispatched before checking the `Microphone.muted` property.

In order for Flash Player to display the settings dialog, the application window must be large enough to display it (at least 215 by 138 pixels). Otherwise, access is denied automatically.

Content running in the AIR application sandbox does not need the permission of the user to access the microphone. Thus, status events for muting and unmuting the microphone are never dispatched. Content running in AIR outside the application sandbox does require permission from the user, so these status events can be dispatched.

Routing microphone audio to local speakers

Flash Player 9 and later, Adobe AIR 1.0 and later

Audio input from a microphone can be routed to the local system speakers by calling the `Microphone.setLoopback()` method with a parameter value of `true`.

When sound from a local microphone is routed to local speakers, there is a risk of creating an audio feedback loop, which can cause loud squealing sounds and can potentially damage sound hardware. Calling the `Microphone.setUseEchoSuppression()` method with a parameter value of `true` reduces, but does not completely eliminate, the risk that audio feedback will occur. Adobe recommends you always call `Microphone.setUseEchoSuppression(true)` before calling `Microphone.setLoopback(true)`, unless you are certain that the user is playing back the sound using headphones or something other than speakers.

The following code shows how to route the audio from a local microphone to the local system speakers:

```
var mic:Microphone = Microphone.getMicrophone();
mic.setUseEchoSuppression(true);
mic.setLoopBack(true);
```

Altering microphone audio

Flash Player 9 and later, Adobe AIR 1.0 and later

Your application can alter the audio data that comes from a microphone in two ways. First, it can change the gain of the input sound, which effectively multiplies the input values by a specified amount to create a louder or quieter sound. The `Microphone.gain` property accepts numeric values between 0 and 100 inclusive. A value of 50 acts like a multiplier of one and specifies normal volume. A value of zero acts like a multiplier of zero and effectively silences the input audio. Values above 50 specify higher than normal volume.

Your application can also change the sample rate of the input audio. Higher sample rates increase sound quality, but they also create denser data streams that use more resources for transmission and storage. The `Microphone.rate` property represents the audio sample rate measured in kilohertz (kHz). The default sample rate is 8 kHz. You can set the `Microphone.rate` property to a value higher than 8 kHz if your microphone supports the higher rate. For example, setting the `Microphone.rate` property to a value of 11 sets the sample rate to 11 kHz; setting it to 22 sets the sample rate to 22 kHz, and so on. The sample rates available depend on the selected codec. When you use the Nellymoser codec, you can specify 5, 8, 11, 16, 22 and 44 kHz as the sample rate. When you use Speex codec (available starting in Flash Player 10 and Adobe AIR 1.5), you can only use 16 kHz.

Detecting microphone activity

Flash Player 9 and later, Adobe AIR 1.0 and later

To conserve bandwidth and processing resources, Flash Player tries to detect when no sound is being transmitted by a microphone. When the microphone's activity level stays below the silence level threshold for a period of time, Flash Player stops transmitting the audio input and dispatches a simple ActivityEvent instead. If you use the Speex codec (available in Flash Player 10 or later and Adobe AIR 1.5 or later), set the silence level to 0, to ensure that the application continuously transmits audio data. Speex voice activity detection automatically reduces bandwidth.

***Note:** A Microphone object only dispatches Activity events when your application is monitoring the microphone. Thus, if you do not call `setLoopBack( true )`, add a listener for sample data events, or attach the microphone to a NetStream object, then no activity events are dispatched.*

Three properties of the Microphone class monitor and control the detection of activity:

- The read-only `activityLevel` property indicates the amount of sound the microphone is detecting, on a scale from 0 to 100.
- The `silenceLevel` property specifies the amount of sound needed to activate the microphone and dispatch an `ActivityEvent.ACTIVITY` event. The `silenceLevel` property also uses a scale from 0 to 100, and the default value is 10.
- The `silenceTimeout` property describes the number of milliseconds that the activity level must stay below the silence level, until an `ActivityEvent.ACTIVITY` event is dispatched to indicate that the microphone is now silent. The default `silenceTimeout` value is 2000.

Both the `Microphone.silenceLevel` property and the `Microphone.silenceTimeout` property are read only, but their values can be changed by using the `Microphone.setSilenceLevel()` method.

In some cases, the process of activating the microphone when new activity is detected can cause a short delay. Keeping the microphone active at all times can remove such activation delays. Your application can call the `Microphone.setSilenceLevel()` method with the `silenceLevel` parameter set to zero to tell Flash Player to keep the microphone active and keep gathering audio data, even when no sound is being detected. Conversely, setting the `silenceLevel` parameter to 100 prevents the microphone from being activated at all.

The following example displays information about the microphone and reports on activity events and status events dispatched by a Microphone object:

```
import flash.events.ActivityEvent;
import flash.events.StatusEvent;
import flash.media.Microphone;

var deviceArray:Array = Microphone.names;
trace("Available sound input devices:");
for (var i:int = 0; i < deviceArray.length; i++)
{
    trace(" " + deviceArray[i]);
}

var mic:Microphone = Microphone.getMicrophone();
mic.gain = 60;
mic.rate = 11;
mic.setUseEchoSuppression(true);
mic.setLoopBack(true);
mic.setSilenceLevel(5, 1000);

mic.addEventListener(ActivityEvent.ACTIVITY, this.onMicActivity);
mic.addEventListener(StatusEvent.STATUS, this.onMicStatus);

var micDetails:String = "Sound input device name: " + mic.name + '\n';
micDetails += "Gain: " + mic.gain + '\n';
micDetails += "Rate: " + mic.rate + " kHz" + '\n';
micDetails += "Muted: " + mic.muted + '\n';
micDetails += "Silence level: " + mic.silenceLevel + '\n';
micDetails += "Silence timeout: " + mic.silenceTimeout + '\n';
micDetails += "Echo suppression: " + mic.useEchoSuppression + '\n';
trace(micDetails);

function onMicActivity(event:ActivityEvent):void
{
    trace("activating=" + event.activating + ", activityLevel=" +
        mic.activityLevel);
}

function onMicStatus(event:StatusEvent):void
{
    trace("status: level=" + event.level + ", code=" + event.code);
}
```

When you run the above example, speak or makes noises into your system microphone and watch the resulting trace statements appear in a console or debug window.

Sending audio to and from a media server

Flash Player 9 and later, Adobe AIR 1.0 and later

Additional audio capabilities are available when using ActionScript with a streaming media server such as Flash Media Server.

In particular, your application can attach a Microphone object to a NetStream object and transmit data directly from the user's microphone to the server. Audio data can also be streamed from the server to an application and played back as part of a MovieClip or by using a Video object.

The Speex codec is available starting with Flash Player 10 and Adobe AIR 1.5. To set the codec used for compressed audio sent to the media server, set the `codec` property of the Microphone object. This property can have two values, which are enumerated in the SoundCodec class. Setting the codec property to `SoundCodec.SPEEX` selects the Speex codec for compressing audio. Setting the property to `SoundCodec.NELLYMOSER` (the default) selects the Nellymoser codec for compressing audio.

For more information, see the Flash Media Server documentation online at www.adobe.com/go/learn_fms_docs_en.

Capturing microphone sound data

Flash Player 10.1 and later, Adobe AIR 2 and later

In Flash Player 10.1 and AIR 2, or later, you can capture data from a microphone data as a byte array of floating point values. Each value represents a sample of monophonic audio data.

To get microphone data, set an event listener for the `sampleData` event of the Microphone object. The Microphone object dispatches `sampleData` events periodically as the microphone buffer is filled with sound samples. The SampleDataEvent object has a `data` property that is a byte array of sound samples. The samples are each represented as floating point values, each representing a monophonic sound sample.

The following code captures microphone sound data into a ByteArray object named `soundBytes`:

```
var mic:Microphone = Microphone.getMicrophone();
mic.setSilenceLevel(0, DELAY_LENGTH);
mic.addEventListener(SampleDataEvent.SAMPLE_DATA, micSampleDataHandler);
function micSampleDataHandler(event:SampleDataEvent):void {
    while(event.data.bytesAvailable) {
        var sample:Number = event.data.readFloat();
        soundBytes.writeFloat(sample);
    }
}
```

You can reuse the sample bytes as playback audio for a Sound object. If you do, you should set the `rate` property of the Microphone object to 44, which is the sample rate used by Sound objects. (You can also convert microphone samples captured at a lower rate to 44 kHz rate required by the Sound object.) Also, keep in mind that the Microphone object captures monophonic samples, whereas the Sound object uses stereo sound; so you should write each of the bytes captured by the Microphone object to the Sound object twice. The following example captures 4 seconds of microphone data and plays it back using a Sound object:

```
const DELAY_LENGTH:int = 4000;
var mic:Microphone = Microphone.getMicrophone();
mic.setSilenceLevel(0, DELAY_LENGTH);
mic.gain = 100;
mic.rate = 44;
mic.addEventListener(SampleDataEvent.SAMPLE_DATA, micSampleDataHandler);

var timer:Timer = new Timer(DELAY_LENGTH);
timer.addEventListener(TimerEvent.TIMER, timerHandler);
timer.start();

function micSampleDataHandler(event:SampleDataEvent):void
{
    while(event.data.bytesAvailable)
    {
        var sample:Number = event.data.readFloat();
        soundBytes.writeFloat(sample);
    }
}
var sound:Sound = new Sound();
var channel:SoundChannel;
function timerHandler(event:TimerEvent):void
{
    mic.removeEventListener(SampleDataEvent.SAMPLE_DATA, micSampleDataHandler);
    timer.stop();
    soundBytes.position = 0;
    sound.addEventListener(SampleDataEvent.SAMPLE_DATA, playbackSampleHandler);
    channel.addEventListener( Event.SOUND_COMPLETE, playbackComplete );
    channel = sound.play();
}

function playbackSampleHandler(event:SampleDataEvent):void
{
    for (var i:int = 0; i < 8192 && soundBytes.bytesAvailable > 0; i++)
    {
        trace(sample);
        var sample:Number = soundBytes.readFloat();
        event.data.writeFloat(sample);
        event.data.writeFloat(sample);
    }
}

function playbackComplete( event:Event ):void
{
    trace( "Playback finished.");
}
```

For more information on playing back sounds from sound sample data, see "Working with dynamically generated audio" on page 448.

Sound example: Podcast Player

Flash Player 9 and later, Adobe AIR 1.0 and later

A podcast is a sound file that is distributed over the Internet, on demand or by subscription. Podcasts are usually published as part of a series, which is also called a podcast channel. Because podcast episodes can last anywhere from one minute to many hours, they are usually streamed while playing. Podcast episodes, which are also called items, are usually delivered in the mp3 file format. Video podcasts are also popular, but this sample application plays only audio podcasts that use mp3 files.

This example is not a full-featured podcast aggregator application. For example, it does not manage subscriptions to specific podcasts or remember which podcasts the user has listened to the next time the application is run. It could serve as a starting point for a more full-featured podcast aggregator.

The Podcast Player example illustrates the following ActionScript programming techniques:

- Reading an external RSS feed and parsing its XML content
- Creating a SoundFacade class to simplify loading and playback of sound files
- Displaying sound playback progress
- Pausing and resuming sound playback

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The Podcast Player application files can be found in the folder Samples/PodcastPlayer. The application consists of the following files:

File	Description
PodcastPlayer.mxml or PodcastPlayer.fla	The user interface for the application for Flex (MXML) or Flash (FLA).
comp/example/programmingas3/podcastplayer/PodcastPlayer.as	Document class containing the user interface logic for the podcast player (Flash only).
SoundPlayer.mxml	An MXML component that displays playback buttons and progress bars and controls sound playback, for Flex only.
main.css	Styles for the application user interface (Flex only).
images/	Icons for styling the buttons (Flex only).
comp/example/programmingas3/podcastplayer/SoundPlayer.as	Class for the SoundPlayer movie clip symbol containing the user interface logic for the sound player (Flash only).
comp/example/programmingas3/podcastplayer/PlayButtonRenderer.as	Custom cell renderer for displaying a play button in a data grid cell (Flash only).
com/example/programmingas3/podcastplayer/RSSBase.as	A base class that provides common properties and methods for the RSSChannel class and the RSSItem class.
com/example/programmingas3/podcastplayer/RSSChannel.as	An ActionScript class that holds data about an RSS channel.

File	Description
com/example/programmingas3/podcastplayer/RSSItem.as	An ActionScript class that holds data about an RSS item.
com/example/programmingas3/podcastplayer/SoundFacade.as	The main ActionScript class for the application. It encapsulates the methods and events of the Sound class and the SoundChannel class and adds support for pausing and resuming playback.
com/example/programmingas3/podcastplayer/URLService.as	An ActionScript class that retrieves data from a remote URL.
playerconfig.xml	An XML file containing a list of RSS feeds that represent podcast channels.
comp/example/programmingas3/utils/DateUtil.as	Class that is used for easy date formatting (Flash only).

Reading RSS data for a podcast channel

Flash Player 9 and later, Adobe AIR 1.0 and later

The Podcast Player application starts by reading information about a number of podcast channels and their episodes:

1. First, the application reads an XML configuration file that contains a list of podcast channels and displays the list of channels to the user.

2. When the user selects one of the podcast channels, it reads the RSS feed for the channel and displays a list of the channel episodes.

This example uses the URLLoader utility class to retrieve text-based data from a remote location or a local file. The Podcast Player first creates a URLLoader object to get a list of RSS feeds in XML format from the playerconfig.xml file. Next, when the user selects a specific feed from the list, a new URLLoader object is created to read the RSS data from that feed's URL.

Simplifying sound loading and playback using the SoundFacade class

Flash Player 9 and later, Adobe AIR 1.0 and later

The ActionScript 3.0 sound architecture is powerful but complex. Applications that only need basic sound loading and playback features can use a class that hides some of the complexity by providing a simpler set of method calls and events. In the world of software design patterns, such a class is called a *facade*.

The SoundFacade class presents a single interface for performing the following tasks:

- Loading sound files using a Sound object, a SoundLoaderContext object, and the SoundMixer class
- Playing sound files using the Sound object and the SoundChannel object
- Dispatching playback progress events
- Pausing and resuming playback of the sound using the Sound object and the SoundChannel object

The SoundFacade class tries to offer most of the functionality of the ActionScript sound classes with less complexity.

The following code shows the class declaration, the class properties, and the `SoundFacade()` constructor method:

```
public class SoundFacade extends EventDispatcher
{
    public var s:Sound;
    public var sc:SoundChannel;
    public var url:String;
    public var bufferTime:int = 1000;

    public var isLoaded:Boolean = false;
    public var isReadyToPlay:Boolean = false;
    public var isPlaying:Boolean = false;
    public var isStreaming:Boolean = true;
    public var autoLoad:Boolean = true;
    public var autoPlay:Boolean = true;

    public var pausePosition:int = 0;

    public static const PLAY_PROGRESS:String = "playProgress";
    public var progressInterval:int = 1000;
    public var playTimer:Timer;

    public function SoundFacade(soundUrl:String, autoLoad:Boolean = true,
                                autoPlay:Boolean = true, streaming:Boolean = true,
                                bufferTime:int = -1):void
    {
        this.url = soundUrl;

        // Sets Boolean values that determine the behavior of this object
        this.autoLoad = autoLoad;
        this.autoPlay = autoPlay;
        this.isStreaming = streaming;

        // Defaults to the global bufferTime value
        if (bufferTime < 0)
        {
            bufferTime = SoundMixer.bufferTime;
        }

        // Keeps buffer time reasonable, between 0 and 30 seconds
        this.bufferTime = Math.min(Math.max(0, bufferTime), 30000);

        if (autoLoad)
        {
            load();
        }
    }
```

The SoundFacade class extends the EventDispatcher class so that it can dispatch its own events. The class code first declares properties for a Sound object and a SoundChannel object. The class also stores the value of the URL of the sound file and a `bufferTime` property to use when streaming the sound. In addition, it accepts some Boolean parameter values that affect the loading and playback behavior:

- The `autoLoad` parameter tells the object that sound loading should start as soon as this object is created.
- The `autoPlay` parameter indicates that sound playing should start as soon as enough sound data has been loaded. If this is a streaming sound, playback will begin as soon as enough data, as specified by the `bufferTime` property, has loaded.

- The `streaming` parameter indicates that this sound file can start playing before loading has completed.

The `bufferTime` parameter defaults to a value of -1. If the constructor method detects a negative value in the `bufferTime` parameter, it sets the `bufferTime` property to the value of `SoundMixer.bufferTime`. This lets the application default to the global `SoundMixer.bufferTime` value as desired.

If the `autoLoad` parameter is set to `true`, the constructor method immediately calls the following `load()` method to start loading the sound file:

```
public function load():void
{
    if (this.isPlaying)
    {
        this.stop();
        this.s.close();
    }
    this.isLoaded = false;

    this.s = new Sound();

    this.s.addEventListener(ProgressEvent.PROGRESS, onLoadProgress);
    this.s.addEventListener(Event.OPEN, onLoadOpen);
    this.s.addEventListener(Event.COMPLETE, onLoadComplete);
    this.s.addEventListener(Event.ID3, onID3);
    this.s.addEventListener(IOErrorEvent.IO_ERROR, onIOError);
    this.s.addEventListener(SecurityErrorEvent.SECURITY_ERROR, onIOError);

    var req:URLRequest = new URLRequest(this.url);

    var context:SoundLoaderContext = new SoundLoaderContext(this.bufferTime, true);
    this.s.load(req, context);
}
```

The `load()` method creates a new Sound object and then adds listeners for all of the important sound events. Then it tells the Sound object to load the sound file, using a SoundLoaderContext object to pass in the `bufferTime` value.

Because the `url` property can be changed, a SoundFacade instance can be used to play different sound files in succession: simply change the `url` property and call the `load()` method, and the new sound file will be loaded.

The following three event listener methods show how the SoundFacade object tracks loading progress and decides when to start playing the sound:

```
public function onLoadOpen(event:Event):void
{
    if (this.isStreaming)
    {
        this.isReadyToPlay = true;
        if (autoPlay)
        {
            this.play();
        }
    }
    this.dispatchEvent(event.clone());
}

public function onLoadProgress(event:ProgressEvent):void
{
    this.dispatchEvent(event.clone());
}

public function onLoadComplete(event:Event):void
{
    this.isReadyToPlay = true;
    this.isLoaded = true;
    this.dispatchEvent(evt.clone());

    if (autoPlay && !isPlaying)
    {
        play();
    }
}
```

The `onLoadOpen()` method executes when sound loading starts. If the sound can be played in streaming mode, the `onLoadComplete()` method sets the `isReadyToPlay` flag to `true` right away. The `isReadyToPlay` flag determines whether the application can start the sound playing, perhaps in response to a user action like clicking a Play button. The SoundChannel class manages the buffering of sound data, so there is no need to explicitly check whether enough data has been loaded before calling the `play()` method.

The `onLoadProgress()` method executes periodically during the loading process. It simply dispatches a clone of its ProgressEvent object for use by code that uses this SoundFacade object.

When the sound data has been fully loaded the `onLoadComplete()` method executes, calling the `play()` method for non-streaming sounds if needed. The `play`() method itself is shown below.

```
public function play(pos:int = 0):void
{
    if (!this.isPlaying)
    {
        if (this.isReadyToPlay)
        {
            this.sc = this.s.play(pos);
            this.sc.addEventListener(Event.SOUND_COMPLETE, onPlayComplete);
            this.isPlaying = true;

            this.playTimer = new Timer(this.progressInterval);
            this.playTimer.addEventListener(TimerEvent.TIMER, onPlayTimer);
            this.playTimer.start();
        }
    }
}
```

The `play()` method calls the `Sound.play()` method if the sound is ready to play. The resulting SoundChannel object is stored in the `sc` property. The `play()` method then creates a Timer object that will be used to dispatch playback progress events at regular intervals.

Displaying playback progress

Flash Player 9 and later, Adobe AIR 1.0 and later

Creating a Timer object to drive playback monitoring is complex operation that you should only have to code once. Encapsulating this Timer logic in a reusable class like the SoundFacade class lets applications listen to the same kinds of progress events when a sound is loading and when it is playing.

The Timer object that is created by the `SoundFacade.play()` method dispatches a TimerEvent instance every second. The following `onPlayTimer()` method executes whenever a new TimerEvent arrives:

```
public function onPlayTimer(event:TimerEvent):void
{
    var estimatedLength:int =
        Math.ceil(this.s.length / (this.s.bytesLoaded / this.s.bytesTotal));
    var progEvent:ProgressEvent =
        new ProgressEvent(PLAY_PROGRESS, false, false, this.sc.position, estimatedLength);
    this.dispatchEvent(progEvent);
}
```

The `onPlayTimer()` method implements the size estimation technique described in the section "Monitoring playback" on page 451. Then it creates a new ProgressEvent instance with an event type of `SoundFacade.PLAY_PROGRESS`, with the `bytesLoaded` property set to the current position of the SoundChannel object and the `bytesTotal` property set to the estimated length of the sound data.

Pausing and resuming playback

Flash Player 9 and later, Adobe AIR 1.0 and later

The `SoundFacade.play()` method shown previously accepts a `pos` parameter corresponding to a starting position in the sound data. If the `pos` value is zero, the sound starts playing from the beginning.

The `SoundFacade.stop()` method also accepts a `pos` parameter as shown here:

```
public function stop(pos:int = 0):void
{
    if (this.isPlaying)
    {
        this.pausePosition = pos;
        this.sc.stop();
        this.playTimer.stop();
        this.isPlaying = false;
    }
}
```

Whenever the `SoundFacade.stop()` method is called, it sets the `pausePosition` property so that the application knows where to position the playhead if the user wants to resume playback of the same sound.

The `SoundFacade.pause()` and `SoundFacade.resume()` methods shown below invoke the `SoundFacade.stop()` and `SoundFacade.play()` methods respectively, passing a `pos` parameter value each time.

```
public function pause():void
{
    stop(this.sc.position);
}

public function resume():void
{
    play(this.pausePosition);
}
```

The `pause()` method passes the current `SoundChannel.position` value to the `play()` method, which stores that value in the `pausePosition` property. The `resume()` method starts playing the same sound again using the `pausePosition` value as the starting point.

Extending the Podcast Player example

Flash Player 9 and later, Adobe AIR 1.0 and later

This example presents a bare-bones Podcast Player that showcases the use of the reusable SoundFacade class. You could add other features to enhance the usefulness of this application, including the following:

- Store the list of feeds and usage information about each episode in a SharedObject instance that can be used the next time the user runs the application.
- Let the user add his or her own RSS feeds to the list of podcast channels.
- Remember the position of the playhead when the user stops or leaves an episode, so it can be restarted from that point next time the user runs the application.
- Download mp3 files of episodes for listening offline, when the user is not connected to the Internet.
- Add subscription features that periodically check for new episodes in a podcast channel and update the episode list automatically.
- Add podcast searching and browsing functionality using an API from a podcast hosting service like Odeo.com.

Chapter 25: Working with video

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash video is one of the standout technologies on the Internet. However, the traditional presentation of video—in a rectangular screen with a progress bar and control buttons underneath—is only one possible use of video. Through ActionScript, you have fine-tuned access to and control over video loading, presentation, and playback.

Basics of video

Flash Player 9 and later, Adobe AIR 1.0 and later

One important capability of Adobe® Flash® Player and Adobe® AIR™ is the ability to display and manipulate video information with ActionScript in the same way that you can manipulate other visual content such as images, animation, text, and so on. When you create a Flash Video (FLV) file in Adobe Flash CS4 Professional, you have the option to select a skin that includes common playback controls. However, there is no reason you need to limit yourself to the options available. Using ActionScript, you have fine-tuned control over loading, displaying, and playback of video—meaning you could create your own video player skin, or use your video in any less traditional way that you want. Working with video in ActionScript involves working with a combination of several classes:

- Video class: The classic video content box on the Stage is an instance of the Video class. The Video class is a display object, so it can be manipulated using the same techniques that can be applied to other display objects, such as positioning, applying transformations, applying filters and blending modes, and so forth.
- StageVideo class: The Video class typically uses software decoding and rendering. When GPU hardware acceleration is available on a device, your application can take best advantage of hardware accelerated presentation by switching to the StageVideo class. The StageVideo API includes a set of events that tell your code when to switch between StageVideo and Video objects. Stage video imposes some minor restrictions on video playback. If your application accepts those limitations, implement the StageVideo API. See “Guidelines and limitations” on page 514.
- NetStream class: When you’re loading a video file to be controlled by ActionScript, a NetStream instance represents the source of the video content—in this case, a stream of video data. Using a NetStream instance also involves using a NetConnection object, which is the connection to the video file—like the tunnel that the video data is fed through.
- Camera class: When you’re working with video data from a camera connected to the user’s computer, a Camera instance represents the source of the video content—the user’s camera and the video data it makes available. New in Flash Player 11.4 and AIR 3.4, you can use a camera to feed StageVideo.

When you’re loading external video, you can load the file from a standard web server for progressive download, or you can work with streaming video delivered by a specialized server such as Adobe’s Flash® Media Server.

Important concepts and terms

Cue point A marker that can be placed at a specific moment in time in a video file, for example to act like a bookmark for locating that point in time, or to provide additional data that is associated with that moment in time.

Encoding The process of taking video data in one format and converting it to another video data format; for example, taking a high-resolution source video and converting it to a format that’s suitable for Internet delivery.

Frame A single segment of video information; each frame is like a still image representing a snapshot of a moment in time. By playing frames in sequence at high speed, the illusion of motion is created.

Keyframe A video frame which contains the full information for the frame. Other frames that follow a keyframe only contain information about how they differ from the keyframe, rather than containing the full frame's worth of information.

Metadata Information about a video file that is embedded within the video file and retrieved when the video has loaded.

Progressive download When a video file is delivered from a standard web server, the video data is loaded using progressive download, meaning the video information loads in sequence. This has the benefit that the video can begin playing before the entire file is downloaded; however, it prevents you from jumping ahead to a part of the video that hasn't loaded.

Streaming As an alternative to progressive download, a special video server can be used to deliver video over the Internet using a technique known as streaming (sometimes called "true streaming"). With streaming, the viewer's computer never downloads the entire video at one time. To speed up download times, at any moment the computer only needs a portion of the total video information. Because a special server controls the delivery of the video content, any part of the video can be accessed at any time, rather than needing to wait for it to download before accessing it.

Understanding video formats

Flash Player 9 and later, Adobe AIR 1.0 and later

In addition to the Adobe FLV video format, Flash Player and Adobe AIR support video and audio encoded in H.264 and HE-AAC from within MPEG-4 standard file formats. These formats stream high quality video at lower bit rates. Developers can leverage industry standard tools, including Adobe Premiere Pro and Adobe After Effects, to create and deliver compelling video content.

Type	Format	Container
Video	H.264	MPEG-4: MP4, M4V, F4V, 3GPP
Video	Sorenson Spark	FLV file
Video	ON2 VP6	FLV file
Audio	AAC+ / HE-AAC / AAC v1 / AAC v2	MPEG-4:MP4, M4V, F4V, 3GPP
Audio	Mp3	Mp3
Audio	Nellymoser	FLV file
Audio	Speex	FLV file

More Help topics

Flash Media Server: Supported codecs

Adobe HTTP Dynamic Streaming

Encoding video for mobile devices

AIR on Android can decode a wide range of H.264 videos. However, only a small subset of H.264 videos is suited to have a smooth playback on mobile phones. It is because many mobile phones are constrained for processing power. Adobe Flash Player for mobile can decode H.264 videos using in-built hardware acceleration. This decoding assures better quality at lower power consumption.

H.264 standard supports several encoding techniques. Only high-end devices smoothly play videos with complex profiles and levels. However, a majority of devices can play video encoded in baseline profile. On mobile devices, hardware acceleration is available for a subset of these techniques. The profile and the level parameters define this subset of encoding techniques and settings used by the encoder. For developers, it translates into encoding the video in selected resolution which plays well on most devices.

Though resolutions that benefit from hardware acceleration vary from device to device, but most devices support the following standard resolutions.

Aspect ratio	Recommended resolutions		
4:3	640 × 480	512 × 384	480 × 360
16:9	640 × 360	512 x 288	480 × 272

***Note:** Flash Player supports every level and profile of the H.264 standard. Adhering to these recommendations ensures hardware acceleration and better user experience on most devices. These recommendations are not mandatory.*

For a detailed discussion and encoding settings in Adobe Media Encoder CS5, see Recommendations for encoding H.264 video for Flash Player 10.1 on mobile devices.

***Note:** On iOS, only video encoded with the Sorenson Spark and On2 VP6 codecs can be played back using the Video class. You can play back H.264 encoded video in the device video player by launching the URL to the video using the* `flash.net.navigateToURL()` *function. You can also play back H.264 video using the <video> tag in an html page displayed in a StageWebView object.*

Flash Player and AIR compatibility with encoded video files

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player 7 supports FLV files that are encoded with the Sorenson™ Spark™ video codec. Flash Player 8 supports FLV files encoded with Sorenson Spark or On2 VP6 encoder in Flash Professional 8. The On2 VP6 video codec supports an alpha channel.

Flash Player 9.0.115.0 and later versions support files derived from the standard MPEG-4 container format. These files include F4V, MP4, M4A, MOV, MP4V, 3GP, and 3G2, if they contain H.264 video or HE-AAC v2 encoded audio, or both. H.264 delivers higher quality video at lower bit rates when compared to the same encoding profile in Sorenson or On2. HE-AAC v2 is an extension of AAC, a standard audio format defined in the MPEG-4 video standard. HE-AAC v2 uses spectral band replication (SBR) and parametric stereo (PS) techniques to increase coding efficiency at low bit rates.

The following table lists the supported codecs. It also shows the corresponding SWF file format and the versions of Flash Player and AIR that are required to play them:

Codec	SWF file format version (earliest supported publish version)	Flash Player and AIR (earliest version required for playback)
Sorenson Spark	6	Flash Player 6, Flash Lite 3
On2 VP6	6	Flash Player 8, Flash Lite 3. Only Flash Player 8 and later versions support publish and playback of On2 VP6 video.
H.264 (MPEG-4 Part 10)	9	Flash Player 9 Update 3, AIR 1.0
ADPCM	6	Flash Player 6, Flash Lite 3

Codec	**SWF file format version (earliest supported publish version)**	**Flash Player and AIR (earliest version required for playback)**
Mp3	6	Flash Player 6, Flash Lite 3
AAC (MPEG-4 Part 3)	9	Flash Player 9 Update 3, AIR 1.0
Speex (audio)	10	Flash Player 10, AIR 1.5
Nellymoser	6	Flash Player 6

Understanding the Adobe F4V and FLV video file formats

Flash Player 9 and later, Adobe AIR 1.0 and later

Adobe provides the F4V and FLV video file formats for streaming content to Flash Player and AIR. For a complete description of these video file formats, see www.adobe.com/go/video_file_format.

The F4V video file format

Flash Player 9 and later, Adobe AIR 1.0 and later

Beginning with Flash Player Update 3 (9.0.115.0) and AIR 1.0, Flash Player and AIR support the Adobe F4V video format, which is based on the ISO MP4 format, Subsets of the format support different features. Flash Player expects a valid F4V file to begin with one of the following top-level boxes:

- ftyp

  The ftyp box identifies the features that a program must support to play a particular file format.

- moov

  The moov box is effectively the header of an F4V file. It contains one or more other boxes that in turn contain other boxes that define the structure of the F4V data. An F4V file must contain one and only one moov box.

- mdat

  An mdat box contains the data payload for the F4V file. An FV file contains only one mdat box. A moov box also must be present in the file because the mdat box cannot be understood on its own.

F4V files support multibyte integers in big-endian byte order, in which the most significant byte occurs first, at the lowest address.

The FLV video file format

Flash Player 9 and later, Adobe AIR 1.0 and later

The Adobe FLV file format contains encoded audio and video data for delivery by Flash Player. You can use an encoder, such as Adobe Media Encoder or Sorenson™ Squeeze, to convert a QuickTime or Windows Media video file to an FLV file.

***Note:** You can create FLV files by importing video into Flash and exporting it as an FLV file. You can use the FLV Export plug-in to export FLV files from supported video-editing applications. To load FLV files from a web server, register the filename extension and MIME type with your web server. Check your web server documentation. The MIME type for FLV files is `video/x-flv`. For more information, see "About configuring FLV files for hosting on a server" on page 506.*

For more information on FLV files, see "Advanced topics for video files" on page 505.

External vs embedded video

Flash Player 9 and later, Adobe AIR 1.0 and later

Using external video files provides certain capabilities that are not available when you use imported video:

- Longer video clips can be used in your application without slowing down playback. External video files use cached memory, which means that large files are stored in small pieces and accessed dynamically. For this reason, external F4V and FLV files require less memory than embedded video files.
- An external video file can have a different frame rate than the SWF file in which it plays. For example, you can set the SWF file frame rate to 30 frames per second (fps) and the video frame rate to 21 fps. This setting gives you better control of the video than embedded video, to ensure smooth video playback. It also allows you to play video files at different frame rates without the need to alter existing SWF file content.
- With external video files, playback of the SWF content is not interrupted while the video file is loading. Imported video files can sometimes interrupt document playback to perform certain functions, such as accessing a CD-ROM drive. Video files can perform functions independently of the SWF content, without interrupting playback.
- Captioning video content is easier with external FLV files because you can access the video metadata using event handlers.

Understanding the Video class

Flash Player 9 and later, Adobe AIR 1.0 and later

The Video class enables you to display live streaming video in an application without embedding it in your SWF file. You can capture and play live video using the `Camera.getCamera()` method. You can also use the Video class to play back video files over HTTP or from the local file system. There are several different ways to use Video in your projects:

- Load a video file dynamically using the NetConnection and NetStream classes and display the video in a Video object.
- Capture input from the user's camera. For more information, see "Working with cameras" on page 521.
- Use the FLVPlayback component.
- Use the VideoDisplay control.

Note: *Instances of a Video object on the Stage are instances of the Video class.*

Even though the Video class is in the flash.media package, it inherits from the flash.display.DisplayObject class. Therefore, all display object functionality, such as matrix transformations and filters, also applies to Video instances.

For more information see "Manipulating display objects" on page 173, "Working with geometry" on page 210, and "Filtering display objects" on page 267.

Loading video files

Flash Player 9 and later, Adobe AIR 1.0 and later

Loading videos using the NetStream and NetConnection classes is a multistep process. As a best practice, the steps of adding the Video object to the display list, attaching the NetStream object to the Video instance, and calling the NetStream object's `play()` method should be performed in the specified order:

1 Create a NetConnection object. If you are connecting to a local video file or one that is not using a server such as Adobe's Flash Media Server 2, pass `null` to the `connect()` method to play the video files from either an HTTP address or a local drive. If you are connecting to a server, set the parameter to the URI of the application that contains the video file on the server.

```
var nc:NetConnection = new NetConnection();
nc.connect(null);
```

2 Create a new Video object that display the video and add it to the stage display list, as shown in the following snippet:

```
var vid:Video = new Video();
addChild(vid);
```

3 Create a NetStream object, passing the NetConnection object as an argument to the constructor. The following snippet connects a NetStream object to the NetConnection instance and sets up the event handlers for the stream:

```
var ns:NetStream = new NetStream(nc);
ns.addEventListener(NetStatusEvent.NET_STATUS,netStatusHandler);
ns.addEventListener(AsyncErrorEvent.ASYNC_ERROR, asyncErrorHandler);

function netStatusHandler(event:NetStatusEvent):void
{
    // handle netStatus events, described later
}

function asyncErrorHandler(event:AsyncErrorEvent):void
{
    // ignore error
}
```

4 Attach the NetStream object to the Video object using the Video object's `attachNetStream()` method, as seen in the following snippet:

```
vid.attachNetStream(ns);
```

5 Call the NetStream object's `play()` method with the video file url as an argument to start the video playing. The following snippet loads and plays a video file named "video.mp4" in the same directory as the SWF file:

```
ns.play("video.mp4");
```

More Help topics

Flex: Spark VideoPlayer control

spark.components.VideoDisplay

Controlling video playback

Flash Player 9 and later, Adobe AIR 1.0 and later

The NetStream class offers four main methods for controlling video playback:

`pause()`: Pauses playback of a video stream. If the video is already paused, calling this method does nothing.

`resume()`: Resumes playback of a video stream that is paused. If the video is already playing, calling this method does nothing.

`seek()`: Seeks the keyframe closest to the specified location (an offset, in seconds, from the beginning of the stream).

`togglePause()`: Pauses or resumes playback of a stream.

Note: *There is no* `stop()` *method. In order to stop a stream you must pause playback and seek to the beginning of the video stream.*

Note: *The* `play()` *method does not resume playback, it is used for loading video files.*

The following example demonstrates how to control a video using several different buttons. To run the following example, create a new document and add four button instances to your workspace (`pauseBtn`, `playBtn`, `stopBtn`, and `togglePauseBtn`):

```
var nc:NetConnection = new NetConnection();
nc.connect(null);

var ns:NetStream = new NetStream(nc);
ns.addEventListener(AsyncErrorEvent.ASYNC_ERROR, asyncErrorHandler);
ns.play("video.flv");
function asyncErrorHandler(event:AsyncErrorEvent):void
{
    // ignore error
}

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);

pauseBtn.addEventListener(MouseEvent.CLICK, pauseHandler);
playBtn.addEventListener(MouseEvent.CLICK, playHandler);
stopBtn.addEventListener(MouseEvent.CLICK, stopHandler);
togglePauseBtn.addEventListener(MouseEvent.CLICK, togglePauseHandler);

function pauseHandler(event:MouseEvent):void
{
    ns.pause();
}
function playHandler(event:MouseEvent):void
{
    ns.resume();
}
function stopHandler(event:MouseEvent):void
{
    // Pause the stream and move the playhead back to
    // the beginning of the stream.
    ns.pause();
    ns.seek(0);
}
function togglePauseHandler(event:MouseEvent):void
{
    ns.togglePause();
}
```

Clicking on the `pauseBtn` button instance while the video is playing causes the video file to pause. If the video is already paused, clicking this button has no effect. Clicking on the `playBtn` button instance resumes video playback if playback was previously paused, otherwise the button has no effect if the video was already playing.

Detecting the end of a video stream

Flash Player 9 and later, Adobe AIR 1.0 and later

In order to listen for the beginning and end of a video stream, you need to add an event listener to the NetStream instance to listen for the `netStatus` event. The following code demonstrates how to listen for the various codes throughout the video's playback:

```
ns.addEventListener(NetStatusEvent.NET_STATUS, statusHandler);
function statusHandler(event:NetStatusEvent):void
{
    trace(event.info.code)
}
```

The previous code generates the following output:

```
NetStream.Play.Start
NetStream.Buffer.Empty
NetStream.Buffer.Full
NetStream.Buffer.Empty
NetStream.Buffer.Full
NetStream.Buffer.Empty
NetStream.Buffer.Full
NetStream.Buffer.Flush
NetStream.Play.Stop
NetStream.Buffer.Empty
NetStream.Buffer.Flush
```

The two codes that you want to specifically listen for are "NetStream.Play.Start" and "NetStream.Play.Stop" which signal the beginning and end of the video's playback. The following snippet uses a switch statement to filter these two codes and trace a message:

```
function statusHandler(event:NetStatusEvent):void
{
    switch (event.info.code)
    {
        case "NetStream.Play.Start":
            trace("Start [" + ns.time.toFixed(3) + " seconds]");
            break;
        case "NetStream.Play.Stop":
            trace("Stop [" + ns.time.toFixed(3) + " seconds]");
            break;
    }
}
```

By listening for the `netStatus` event (`NetStatusEvent.NET_STATUS`), you can build a video player which loads the next video in a playlist once the current video has finished playing.

Playing video in full-screen mode

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player and AIR allow you to create a full-screen application for your video playback, and support scaling video to full screen.

For AIR content running in full-screen mode on the desktop, the system screen saver and power-saving options are disabled during play until either the video input stops or the user exits full-screen mode.

For full details on using full-screen mode, see "Working with full-screen mode" on page 167.

Enabling full-screen mode for Flash Player in a browser

Before you can implement full-screen mode for Flash Player in a browser, enable it through the Publish template for your application. Templates that allow full screen include `<object>` and `<embed>` tags that contain an `allowFullScreen` parameter. The following example shows the `allowFullScreen` parameter in an `<embed>` tag.

```
<object classid="clsid:D27CDB6E-AE6D-11cf-96B8-444553540000"
    id="fullScreen" width="100%" height="100%"
    codebase="http://fpdownload.macromedia.com/get/flashplayer/current/swflash.cab">
    ...
    <param name="allowFullScreen" value="true" />
    <embed src="fullScreen.swf" allowFullScreen="true" quality="high" bgcolor="#869ca7"
        width="100%" height="100%" name="fullScreen" align="middle"
        play="true"
        loop="false"
        quality="high"
        allowScriptAccess="sameDomain"
        type="application/x-shockwave-flash"
        pluginspage="http://www.adobe.com/go/getflashplayer">
    </embed>
    ...
</object>
```

In Flash, select File -> Publish Settings and in the Publish Settings dialog box, on the HTML tab, select the Flash Only - Allow Full Screen template.

In Flex, ensure that the HTML template includes `<object>` and `<embed>` tags that support full screen.

Initiating full-screen mode

For Flash Player content running in a browser, you initiate full-screen mode for video in response to either a mouse click or a keypress. For example, you can initiate full-screen mode when the user clicks a button labeled Full Screen or selects a Full Screen command from a context menu. To respond to the user, add an event listener to the object on which the action occurs. The following code adds an event listener to a button that the user clicks to enter full-screen mode:

```
var fullScreenButton:Button = new Button();
fullScreenButton.label = "Full Screen";
addChild(fullScreenButton);
fullScreenButton.addEventListener(MouseEvent.CLICK, fullScreenButtonHandler);

function fullScreenButtonHandler(event:MouseEvent)
{
    stage.displayState = StageDisplayState.FULL_SCREEN;

}
```

The code initiates full-screen mode by setting the `Stage.displayState` property to `StageDisplayState.FULL_SCREEN`. This code scales the entire stage to full screen with the video scaling in proportion to the space it occupies on the stage.

The `fullScreenSourceRect` property allows you to specify a particular area of the stage to scale to full screen. First, define the rectangle that you want to scale to full screen. Then assign it to the `Stage.fullScreenSourceRect` property. This version of the `fullScreenButtonHandler()` function adds two additional lines of code that scale just the video to full screen.

```
private function fullScreenButtonHandler(event:MouseEvent)
{
    var screenRectangle:Rectangle = new Rectangle(video.x, video.y, video.width, video.height);
    stage.fullScreenSourceRect = screenRectangle;
    stage.displayState = StageDisplayState.FULL_SCREEN;
}
```

Though this example invokes an event handler in response to a mouse click, the technique of going to full-screen mode is the same for both Flash Player and AIR. Define the rectangle that you want to scale and then set the `Stage.displayState` property. For more information, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

The complete example, which follows, adds code that creates the connection and the NetStream object for the video and begins to play it.

```
package
{
    import flash.net.NetConnection;
    import flash.net.NetStream;
    import flash.media.Video;
    import flash.display.StageDisplayState;
    import fl.controls.Button;
    import flash.display.Sprite;
    import flash.events.MouseEvent;
    import flash.events.FullScreenEvent;
    import flash.geom.Rectangle;

    public class FullScreenVideoExample extends Sprite
    {
        var fullScreenButton:Button = new Button();
        var video:Video = new Video();

        public function FullScreenVideoExample()
        {
            var videoConnection:NetConnection = new NetConnection();
            videoConnection.connect(null);

            var videoStream:NetStream = new NetStream(videoConnection);
            videoStream.client = this;

            addChild(video);

            video.attachNetStream(videoStream);

            videoStream.play("http://www.helpexamples.com/flash/video/water.flv");

            fullScreenButton.x = 100;
            fullScreenButton.y = 270;
            fullScreenButton.label = "Full Screen";
            addChild(fullScreenButton);
            fullScreenButton.addEventListener(MouseEvent.CLICK, fullScreenButtonHandler);
        }

        private function fullScreenButtonHandler(event:MouseEvent)
        {
            var screenRectangle:Rectangle = new Rectangle(video.x, video.y, video.width, 
video.height);
            stage.fullScreenSourceRect = screenRectangle;
            stage.displayState = StageDisplayState.FULL_SCREEN;
        }

        public function onMetaData(infoObject:Object):void
        {
            // stub for callback function
        }
    }
}
```

The `onMetaData()` function is a callback function for handling video metadata, if any exists. A callback function is a function that the runtime calls in response to some type of occurrence or event. In this example, the `onMetaData()` function is a stub that satisfies the requirement to provide the function. For more information, see "Writing callback methods for metadata and cue points" on page 487

Leaving full-screen mode

A user can leave full-screen mode by entering one of the keyboard shortcuts, such as the Escape key. You can end full-screen mode in ActionScript by setting the `Stage.displayState` property to `StageDisplayState.NORMAL`. The code in the following example ends full-screen mode when the NetStream.Play.Stop `netStatus` event occurs.

```
videoStream.addEventListener(NetStatusEvent.NET_STATUS, netStatusHandler);

private function netStatusHandler(event:NetStatusEvent)
{
    if(event.info.code == "NetStream.Play.Stop")
        stage.displayState = StageDisplayState.NORMAL;
}
```

Full-screen hardware acceleration

When you rescale a rectangular area of the stage to full-screen mode, Flash Player or AIR uses hardware acceleration, if it's available and enabled. The runtime uses the video adapter on the computer to speed up scaling of the video, or a portion of the stage, to full-screen size. Under these circumstances, Flash Player applications can often profit by switching to the StageVideo class from the Video class (or Camera class; Flash Player 11.4/AIR 3.4 and higher).

For more information on hardware acceleration in full-screen mode, see "Working with full-screen mode" on page 167. For more information on StageVideo, see "Using the StageVideo class for hardware accelerated presentation" on page 512.

Streaming video files

Flash Player 9 and later, Adobe AIR 1.0 and later

To stream files from Flash Media Server, you can use the NetConnection and NetStream classes to connect to a remote server instance and play a specified stream. To specify a Real-Time Messaging Protocol (RTMP) server, you pass the desired RTMP URL, such as "rtmp://localhost/appName/appInstance", to the `NetConnection.connect()` method instead of passing `null`. To play a specific live or recorded stream from the specified Flash Media Server, you pass an identifying name for live data published by `NetStream.publish()`, or a recorded filename for playback to the `NetStream.play()` method.

Sending video to a server

Flash Player 9 and later, Adobe AIR 1.0 and later

If you want to build more complex applications involving video or camera objects, Flash Media Server offers a combination of streaming media capabilities and a development environment for creating and delivering media applications to a wide audience. This combination enables developers to create applications such as Video on Demand, live web-event broadcasts, and Mp3 streaming as well as video blogging, video messaging, and multimedia chat environments. For more information, see the Flash Media Server documentation online at www.adobe.com/go/learn_fms_docs_en.

Understanding cue points

Flash Player 9 and later, Adobe AIR 1.0 and later

You can embed cue points in an Adobe F4V or FLV video file during encoding. Historically, cue points were embedded in movies to give the projectionist a visual signal that indicated the reel of film was nearing the end. In Adobe F4V and FLV video formats, a cue point allows you to trigger one or more other actions in your application at the time that it occurs in the video stream.

You can use several different kinds of cue points with Flash video. You can use ActionScript to interact with cue points that you embed in a video file when you create it.

- Navigation cue points: You embed navigation cue points in the video stream and metadata packet when you encode the video file. You use navigation cue points to let users seek to a specified part of a file.
- Event cue points: You embed event cue points in the video stream and metadata packet when you encode the video file. You can write code to handle the events that are triggered at specified points during video playback.
- ActionScript cue points: ActionScript cue points are available only to the Flash FLVPlayback component. ActionScript cue points are external cue points that you create and access with ActionScript code. You can write code to trigger these cue points in relation to the video's playback. These cue points are less accurate than embedded cue points (up to a tenth of a second), because the video player tracks them separately. If you plan to create an application in which you want users to navigate to a cue point, you should create and embed cue points when you encode the file instead of using ActionScript cue points. You should embed the cue points in the FLV file, because they are more accurate.

Navigation cue points create a keyframe at the specified cue point location, so you can use code to move a video player's playhead to that location. You can set particular points in a video file where you might want users to seek. For example, your video might have multiple chapters or segments, and you can control the video by embedding navigation cue points in the video file.

For more information on encoding Adobe video files with cue points, see "Embed cue points" in *Using Flash*.

You can access cue point parameters by writing ActionScript. Cue point parameters are a part of the event object received by the callback handler.

To trigger certain actions in your code when an FLV file reaches a specific cue point, use the `NetStream.onCuePoint` event handler.

To synchronize an action for a cue point in an F4V video file, you must retrieve the cue point data from either the `onMetaData()` or the `onXMPData()` callback functions and trigger the cue point using the Timer class in ActionScript 3.0. For more information on F4V cue points, see "Using onXMPData()" on page 498.

For more information on handling cue points and metadata, see "Writing callback methods for metadata and cue points" on page 487.

Writing callback methods for metadata and cue points

Flash Player 9 and later, Adobe AIR 1.0 and later

You can trigger actions in your application when specific metadata is received by the player or when specific cue points are reached. When these events occur, you must use specific callback methods as event handlers. The NetStream class specifies the following metadata events that can occur during playback: `onCuePoint` (FLV files only), `onImageData`, `onMetaData`, `onPlayStatus`, `onTextData`, and `onXMPData`.

You must write callback methods for these handlers, or the Flash runtime may throw errors. For example, the following code plays an FLV file named video.flv in the same folder where the SWF file resides:

```
var nc:NetConnection = new NetConnection();
nc.connect(null);

var ns:NetStream = new NetStream(nc);
ns.addEventListener(AsyncErrorEvent.ASYNC_ERROR, asyncErrorHandler);
ns.play("video.flv");
function asyncErrorHandler(event:AsyncErrorEvent):void
{
    trace(event.text);
}

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);
```

The previous code loads a local video file named video.flv and listens for the `asyncError` (`AsyncErrorEvent.ASYNC_ERROR`) to be dispatched. This event is dispatched when an exception is thrown from native asynchronous code. In this case, it is dispatched when the video file contains metadata or cue point information, and the appropriate listeners have not been defined. The previous code handles the `asyncError` event and ignores the error if you are not interested in the video file's metadata or cue point information. If you had an FLV with metadata and several cue points, the `trace()` function would display the following error messages:

```
Error #2095: flash.net.NetStream was unable to invoke callback onMetaData.
Error #2095: flash.net.NetStream was unable to invoke callback onCuePoint.
Error #2095: flash.net.NetStream was unable to invoke callback onCuePoint.
Error #2095: flash.net.NetStream was unable to invoke callback onCuePoint.
```

The errors occur because the NetStream object was unable to find an `onMetaData` or `onCuePoint` callback method. There are several ways to define these callback methods within your applications.

More Help topics

Flash Media Server: Handling metadata in streams

Set the NetStream object's client property to an Object

Flash Player 9 and later, Adobe AIR 1.0 and later

By setting the `client` property to either an Object or a subclass of NetStream, you can reroute the `onMetaData` and `onCuePoint` callback methods or ignore them completely. The following example demonstrates how you can use an empty Object to ignore the callback methods without listening for the `asyncError` event:

```
var nc:NetConnection = new NetConnection();
nc.connect(null);

var customClient:Object = new Object();

var ns:NetStream = new NetStream(nc);
ns.client = customClient;
ns.play("video.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);
```

If you wanted to listen for either the `onMetaData` or `onCuePoint` callback methods, you would need to define methods to handle those callback methods, as shown in the following snippet:

```
var customClient:Object = new Object();
customClient.onMetaData = metaDataHandler;
function metaDataHandler(infoObject:Object):void
{
    trace("metadata");
}
```

The previous code listens for the `onMetaData` callback method and calls the `metaDataHandler()` method, which traces a string. If the Flash runtime encountered a cue point, no errors would be generated even though no `onCuePoint` callback method is defined.

Create a custom class and define methods to handle the callback methods

Flash Player 9 and later, Adobe AIR 1.0 and later

The following code sets the NetStream object's `client` property to a custom class, CustomClient, which defines handlers for the callback methods:

```
var nc:NetConnection = new NetConnection();
nc.connect(null);

var ns:NetStream = new NetStream(nc);
ns.client = new CustomClient();
ns.play("video.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);
```

The CustomClient class is as follows:

```
package
{
    public class CustomClient
    {
        public function onMetaData(infoObject:Object):void
        {
            trace("metadata");
        }
    }
}
```

The CustomClient class defines a handler for the `onMetaData` callback handler. If a cue point was encountered and the `onCuePoint` callback handler was called, an `asyncError` event (`AsyncErrorEvent.ASYNC_ERROR`) would be dispatched saying "flash.net.NetStream was unable to invoke callback onCuePoint." To prevent this error, you would either need to define an `onCuePoint` callback method in your CustomClient class, or define an event handler for the `asyncError` event.

Extend the NetStream class and add methods to handle the callback methods

Flash Player 9 and later, Adobe AIR 1.0 and later

The following code creates an instance of the CustomNetStream class, which is defined in a later code listing:

```
var ns:CustomNetStream = new CustomNetStream();
ns.play("video.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);
```

The following code listing defines the CustomNetStream class that extends the NetStream class, handles the creation of the necessary NetConnection object, and handles the `onMetaData` and `onCuePoint` callback handler methods:

```
package
{
    import flash.net.NetConnection;
    import flash.net.NetStream;
    public class CustomNetStream extends NetStream
    {
        private var nc:NetConnection;
        public function CustomNetStream()
        {
            nc = new NetConnection();
            nc.connect(null);
            super(nc);
        }
        public function onMetaData(infoObject:Object):void
        {
            trace("metadata");
        }
        public function onCuePoint(infoObject:Object):void
        {
            trace("cue point");
        }
    }
}
```

If you want to rename the `onMetaData()` and `onCuePoint()` methods in the CustomNetStream class, you could use the following code:

```
package
{
    import flash.net.NetConnection;
    import flash.net.NetStream;
    public class CustomNetStream extends NetStream
    {
        private var nc:NetConnection;
        public var onMetaData:Function;
        public var onCuePoint:Function;
        public function CustomNetStream()
        {
            onMetaData = metaDataHandler;
            onCuePoint = cuePointHandler;
            nc = new NetConnection();
            nc.connect(null);
            super(nc);
        }
        private function metaDataHandler(infoObject:Object):void
        {
            trace("metadata");
        }
        private function cuePointHandler(infoObject:Object):void
        {
            trace("cue point");
        }
    }
}
```

Extend the NetStream class and make it dynamic

Flash Player 9 and later, Adobe AIR 1.0 and later

You can extend the NetStream class and make the subclass dynamic so that `onCuePoint` and `onMetaData` callback handlers can be added dynamically. This is demonstrated in the following listing:

```
var ns:DynamicCustomNetStream = new DynamicCustomNetStream();
ns.play("video.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);
```

The DynamicCustomNetStream class is as follows:

```
package
{
    import flash.net.NetConnection;
    import flash.net.NetStream;
    public dynamic class DynamicCustomNetStream extends NetStream
    {
        private var nc:NetConnection;
        public function DynamicCustomNetStream()
        {
            nc = new NetConnection();
            nc.connect(null);
            super(nc);
        }
    }
}
```

Even with no handlers for the `onMetaData` and `onCuePoint` callback handlers, no errors are thrown since the DynamicCustomNetStream class is dynamic. If you want to define methods for the `onMetaData` and `onCuePoint` callback handlers, you could use the following code:

```
var ns:DynamicCustomNetStream = new DynamicCustomNetStream();
ns.onMetaData = metaDataHandler;
ns.onCuePoint = cuePointHandler;
ns.play("http://www.helpexamples.com/flash/video/cuepoints.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);

function metaDataHandler(infoObject:Object):void
{
    trace("metadata");
}
function cuePointHandler(infoObject:Object):void
{
    trace("cue point");
}
```

Set the NetStream object's client property to this

Flash Player 9 and later, Adobe AIR 1.0 and later

By setting the `client` property to `this`, the application looks in the current scope for `onMetaData()` and `onCuePoint()` methods. You can see this in the following example:

```
var nc:NetConnection = new NetConnection();
nc.connect(null);

var ns:NetStream = new NetStream(nc);
ns.client = this;
ns.play("video.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);
```

If the `onMetaData` or `onCuePoint` callback handlers are called and no methods exist to handle the callback, no errors are generated. To handle these callback handlers, create an `onMetaData()` and `onCuePoint()` method in your code, as seen in the following snippet:

```
function onMetaData(infoObject:Object):void
{
    trace("metadata");
}
function onCuePoint(infoObject:Object):void
{
    trace("cue point");
}
```

Using cue points and metadata

Flash Player 9 and later, Adobe AIR 1.0 and later

Use the NetStream callback methods to capture and process cue point and metadata events as the video plays.

Using cue points

Flash Player 9 and later, Adobe AIR 1.0 and later

The following table describes the callback methods that you can use to capture F4V and FLV cue points in Flash Player and AIR.

Runtime	F4V	FLV
Flash Player 9/ AIR1.0		OnCuePoint
		OnMetaData
Flash Player 10		OnCuePoint
	OnMetaData	OnMetaData
	OnXMPData	OnXMPData

The following example uses a simple `for..in` loop to iterate over each of the properties in the `infoObject` parameter that the `onCuePoint()` function receives. It calls the trace() function to display a message when it receives cue point data:

```
var nc:NetConnection = new NetConnection();
nc.connect(null);

var ns:NetStream = new NetStream(nc);
ns.client = this;
ns.play("video.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);

function onCuePoint(infoObject:Object):void
{
    var key:String;
    for (key in infoObject)
    {
        trace(key + ": " + infoObject[key]);
    }
}
```

The following output appears:

```
parameters:
name: point1
time: 0.418
type: navigation
```

This code uses one of several techniques to set the object on which the callback method runs. You can use other techniques; for more information, see "Writing callback methods for metadata and cue points" on page 487.

Using video metadata

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `OnMetaData()` and `OnXMPData()` functions to access the metadata information in your video file, including cue points.

Using OnMetaData()

Flash Player 9 and later, Adobe AIR 1.0 and later

Metadata includes information about your video file, such as duration, width, height, and frame rate. The metadata information that is added to your video file depends on the software you use to encode the video file.

```
var nc:NetConnection = new NetConnection();
nc.connect(null);

var ns:NetStream = new NetStream(nc);
ns.client = this;
ns.play("video.flv");

var vid:Video = new Video();
vid.attachNetStream(ns);
addChild(vid);

function onMetaData(infoObject:Object):void
{
    var key:String;
    for (key in infoObject)
    {
        trace(key + ": " + infoObject[key]);
    }
}
```

The previous code generates output like the following:

```
width: 320
audiodelay: 0.038
canSeekToEnd: true
height: 213
cuePoints: ,,
audiodatarate: 96
duration: 16.334
videodatarate: 400
framerate: 15
videocodecid: 4
audiocodecid: 2
```

If your video does not have audio, the audio-related metadata information (such as `audiodatarate`) returns `undefined` because no audio information is added to the metadata during encoding.

In the previous code, the cue point information was not displaying. To display the cue point metadata, you can use the following function which recursively displays the items in an Object:

```
function traceObject(obj:Object, indent:uint = 0):void
{
    var indentString:String = "";
    var i:uint;
    var prop:String;
    var val:*;
    for (i = 0; i < indent; i++)
    {
        indentString += "\t";
    }
    for (prop in obj)
    {
        val = obj[prop];
        if (typeof(val) == "object")
        {
            trace(indentString + " " + prop + ": [Object]");
            traceObject(val, indent + 1);
        }
        else
        {
            trace(indentString + " " + prop + ": " + val);
        }
    }
}
```

Using the previous code snippet to trace the `infoObject` parameter in the `onMetaData()` method creates the following output:

```
width: 320
audiodatarate: 96
audiocodecid: 2
videocodecid: 4
videodatarate: 400
canSeekToEnd: true
duration: 16.334
audiodelay: 0.038
height: 213
framerate: 15
cuePoints: [Object]
    0: [Object]
        parameters: [Object]
            lights: beginning
        name: point1
        time: 0.418
        type: navigation
    1: [Object]
        parameters: [Object]
            lights: middle
        name: point2
        time: 7.748
        type: navigation
    2: [Object]
        parameters: [Object]
            lights: end
        name: point3
        time: 16.02
        type: navigation
```

The following example displays the metadata for an MP4 video. It assumes that there is a TextArea object called `metaDataOut`, to which it writes the metadata.

```
package
{
    import flash.net.NetConnection;
    import flash.net.NetStream;
    import flash.events.NetStatusEvent;
    import flash.media.Video;
    import flash.display.StageDisplayState;
    import flash.display.Loader;
    import flash.display.Sprite;
    import flash.events.MouseEvent;

    public class onMetaDataExample extends Sprite
    {
        var video:Video = new Video();

        public function onMetaDataExample():void
        {
            var videoConnection:NetConnection = new NetConnection();
            videoConnection.connect(null);

            var videoStream:NetStream = new NetStream(videoConnection);
            videoStream.client = this;

            addChild(video);
            video.x = 185;
            video.y = 5;

            video.attachNetStream(videoStream);

            videoStream.play("video.mp4");

            videoStream.addEventListener(NetStatusEvent.NET_STATUS, netStatusHandler);
        }

        public function onMetaData(infoObject:Object):void
        {
            for(var propName:String in infoObject)
            {
                metaDataOut.appendText(propName + "=" + infoObject[propName] + "\n");
            }
        }

        private function netStatusHandler(event:NetStatusEvent):void
        {
            if(event.info.code == "NetStream.Play.Stop")
                stage.displayState = StageDisplayState.NORMAL;
        }
    }
}
```

The `onMetaData()` function produced the following output for this video:

```
moovposition=731965
height=352
avclevel=21
videocodecid=avc1
duration=2.36
width=704
videoframerate=25
avcprofile=88
trackinfo=[object Object]
```

Using the information object

The following table shows the possible values for video metadata that are passed to the `onMetaData()` callback function in the Object that they receive:

Parameter	Description
aacaot	AAC audio object type; 0, 1, or 2 are supported.
avclevel	AVC IDC level number such as 10, 11, 20, 21, and so on.
avcprofile	AVC profile number such as 55, 77, 100, and so on.
audiocodecid	A string that indicates the audio codec (code/decode technique) that was used - for example ".Mp3" or "mp4a"
audiodatarate	A number that indicates the rate at which audio was encoded, in kilobytes per second.
audiodelay	A number that indicates what time in the FLV file "time 0" of the original FLV file exists. The video content needs to be delayed by a small amount to properly synchronize the audio.
canSeekToEnd	A Boolean value that is `true` if the FLV file is encoded with a keyframe on the last frame, which allows seeking to the end of a progressive -download video file. It is `false` if the FLV file is not encoded with a keyframe on the last frame.
cuePoints	An array of objects, one for each cue point embedded in the FLV file. Value is undefined if the FLV file does not contain any cue points. Each object has the following properties: • `type`: a string that specifies the type of cue point as either "navigation" or "event". • `name`: a string that is the name of the cue point. • `time`: a number that is the time of the cue point in seconds with a precision of three decimal places (milliseconds). • `parameters`: an optional object that has name-value pairs that are designated by the user when creating the cue points.
duration	A number that specifies the duration of the video file, in seconds.
framerate	A number that is the frame rate of the FLV file.
height	A number that is the height of the FLV file, in pixels.
seekpoints	An array that lists the available keyframes as timestamps in milliseconds. Optional.
tags	An array of key-value pairs that represent the information in the "ilst" atom, which is the equivalent of ID3 tags for MP4 files. iTunes uses these tags. Can be used to display artwork, if available.
trackinfo	Object that provides information on all the tracks in the MP4 file, including their sample description ID.
videocodecid	A string that is the codec version that was used to encode the video. - for example, "avc1" or "VP6F"

Parameter	Description
videodatarate	A number that is the video data rate of the FLV file.
videoframerate	Framerate of the MP4 video.
width	A number that is the width of the FLV file, in pixels.

The following table shows the possible values for the `videocodecid` parameter:

videocodecid	Codec name
2	Sorenson H.263
3	Screen video (SWF version 7 and later only)
4	VP6 (SWF version 8 and later only)
5	VP6 video with alpha channel (SWF version 8 and later only)

The following table shows the possible values for the `audiocodecid` parameter:

audiocodecid	Codec Name
0	uncompressed
1	ADPCM
2	Mp3
4	Nellymoser @ 16 kHz mono
5	Nellymoser, 8kHz mono
6	Nellymoser
10	AAC
11	Speex

Using onXMPData()

Flash Player 10 and later, Adobe AIR 1.5 and later

The `onXMPData()` callback function receives information specific to Adobe Extensible Metadata Platform (XMP) that is embedded in the Adobe F4V or FLV video file. The XMP metadata includes cue points as well as other video metadata. XMP metadata support is introduced with Flash Player 10 and Adobe AIR 1.5 and supported by subsequent versions.

The following example processes cue point data in the XMP metadata:

```
package
{
    import flash.display.*;
    import flash.net.*;
    import flash.events.NetStatusEvent;
    import flash.media.Video;

    public class onXMPDataExample extends Sprite
    {
        public function onXMPDataExample():void
        {
            var videoConnection:NetConnection = new NetConnection();
            videoConnection.connect(null);

            var videoStream:NetStream = new NetStream(videoConnection);
            videoStream.client = this;
            var video:Video = new Video();

            addChild(video);

            video.attachNetStream(videoStream);

            videoStream.play("video.f4v");
        }

        public function onMetaData(info:Object):void {
            trace("onMetaData fired");
        }

        public function onXMPData(infoObject:Object):void
        {
            trace("onXMPData Fired\n");
            //trace("raw XMP =\n");
            //trace(infoObject.data);
            var cuePoints:Array = new Array();
            var cuePoint:Object;
            var strFrameRate:String;
            var nTracksFrameRate:Number;
            var strTracks:String = "";
            var onXMPXML = new XML(infoObject.data);
            // Set up namespaces to make referencing easier
            var xmpDM:Namespace = new Namespace("http://ns.adobe.com/xmp/1.0/DynamicMedia/");
            var rdf:Namespace = new Namespace("http://www.w3.org/1999/02/22-rdf-syntax-ns#");
            for each (var it:XML in onXMPXML..xmpDM::Tracks)
            {
                 var strTrackName:String = 
it.rdf::Bag.rdf::li.rdf::Description.@xmpDM::trackName; 
                 var strFrameRateXML:String = 
it.rdf::Bag.rdf::li.rdf::Description.@xmpDM::frameRate; 
                 strFrameRate = strFrameRateXML.substr(1,strFrameRateXML.length); 

                 nTracksFrameRate = Number(strFrameRate); 

                 strTracks += it; 
            } 
            var onXMPTracksXML:XML = new XML(strTracks); 
            var strCuepoints:String = ""; 
            for each (var item:XML in onXMPTracksXML..xmpDM::markers) 
            { 
                strCuepoints += item; 
            } 
            trace(strCuepoints); 
        } 
    } 
}
```

For a short video file called startrekintro.f4v, this example produces the following trace lines. The lines show the cue point data for navigation and event cue points in the XMP meta data:

```
onMetaData fired
onXMPData Fired

<xmpDM:markers xmlns:xmp="http://ns.adobe.com/xap/1.0/"
xmlns:xmpDM="http://ns.adobe.com/xmp/1.0/DynamicMedia/"
xmlns:stDim="http://ns.adobe.com/xap/1.0/sType/Dimensions#"
xmlns:xmpMM="http://ns.adobe.com/xap/1.0/mm/"
xmlns:stEvt="http://ns.adobe.com/xap/1.0/sType/ResourceEvent#"
xmlns:dc="http://purl.org/dc/elements/1.1/" xmlns:rdf="http://www.w3.org/1999/02/22-rdf-
syntax-ns#" xmlns:x="adobe:ns:meta/">
  <rdf:Seq>
    <rdf:li>
      <rdf:Description xmpDM:startTime="7695905817600" xmpDM:name="Title1"
xmpDM:type="FLVCuePoint" xmpDM:cuePointType="Navigation">
        <xmpDM:cuePointParams>
          <rdf:Seq>
            <rdf:li xmpDM:key="Title" xmpDM:value="Star Trek"/>
            <rdf:li xmpDM:key="Color" xmpDM:value="Blue"/>
          </rdf:Seq>
        </xmpDM:cuePointParams>
      </rdf:Description>
    </rdf:li>
    <rdf:li>
      <rdf:Description xmpDM:startTime="10289459980800" xmpDM:name="Title2"
xmpDM:type="FLVCuePoint" xmpDM:cuePointType="Event">
        <xmpDM:cuePointParams>
          <rdf:Seq>
            <rdf:li xmpDM:key="William Shatner" xmpDM:value="First Star"/>
            <rdf:li xmpDM:key="Color" xmpDM:value="Light Blue"/>
          </rdf:Seq>
        </xmpDM:cuePointParams>
      </rdf:Description>
    </rdf:li>
  </rdf:Seq>
</xmpDM:markers>
onMetaData fired
```

***Note:** In XMP data, time is stored as DVA Ticks rather than seconds. To compute the cue point time, divide the start time by the framerate. For example, the start time of 7695905817600 divided by a framerate of 254016000000 equals 30:30.*

To see the complete raw XMP metadata, which includes the framerate, remove the comment identifiers (//'s) preceding the second and third `trace()` statements at the beginning of the `onXMPData()` function.

For more information on XMP, see:

- partners.adobe.com/public/developer/xmp/topic.html
- www.adobe.com/devnet/xmp/

Using image metadata

Flash Player 9 and later, Adobe AIR 1.0 and later

The `onImageData` event sends image data as a byte array through an AMF0 data channel. The data can be in JPEG, PNG, or GIF formats. Define an `onImageData()` callback method to process this information, in the same way that you would define callback methods for `onCuePoint` and `onMetaData`. The following example accesses and displays image data using an `onImageData()` callback method:

```
public function onImageData(imageData:Object):void
{
    // display track number
    trace(imageData.trackid);
    var loader:Loader = new Loader();
    //imageData.data is a ByteArray object
    loader.loadBytes(imageData.data);
    addChild(loader);
}
```

Using text metadata

Flash Player 9 and later, Adobe AIR 1.0 and later

The `onTextData` event sends text data through an AMF0 data channel. The text data is in UTF-8 format and contains additional information about formatting, based on the 3GP timed-text specification. This specification defines a standardized subtitle format. Define an `onTextData()` callback method to process this information, in the same way that you would define callback methods for `onCuePoint` or `onMetaData`. In the following example, the `onTextData()` method displays the track ID number and corresponding track text.

```
public function onTextData(textData:Object):void
{
    // display the track number
    trace(textData.trackid);
    // displays the text, which can be a null string, indicating old text
    // that should be erased
    trace(textData.text);
}
```

Monitoring NetStream activity

Flash Player 10.3 and later, Adobe AIR 2.7 and later

You can monitor NetStream activity to collect the information required to support media usage analysis and reporting. The monitoring features discussed in this section allow you to create media measurement libraries that collect data without close coupling to the particular video player displaying the media. This allows your client developers to choose their favorite video players when using your library. Use the NetMonitor class to monitor the creation and activity of NetStream objects in an application. The NetMonitor class provides a list of the active NetStreams existing at any given time and also dispatches an event whenever a NetStream object is created.

A NetStream object dispatches the events listed in the following table, depending on the type of media being played:

Event	Progressive download	RTMP streaming	HTTP streaming
NetStream.Play.Start	Yes	Yes	No
NetStream.Play.Stop	Yes	Yes	No
NetStream.Play.Complete	Yes	Yes	No
NetStream.SeekStart.Notify	Yes	Yes	Yes
NetStream.Seek.Notify	Yes	Yes	Yes
NetStream.Unpause.Notify	Yes	Yes	Yes
NetStream.Unpause.Notify	Yes	Yes	Yes
NetStream.Play.Transition	Not applicable	Yes	Not applicable
NetStream.Play.TransitionComplete	Not applicable	Yes	Not applicable
NetStream.Buffer.Full	Yes	Yes	Yes
NetStream.Buffer.Flush	Yes	Yes	Yes
NetStream.Buffer.Empty	Yes	Yes	Yes

The NetStreamInfo object associated with a NetStream instance also stores the last metadata and XMP data objects that were encountered in the media.

When media is played via HTTP streaming, the NetStream.Play.Start, NetStream.Play.Stop, and NetStream.Play.Complete are not dispatched since the application has complete control of the media stream. A video player should synthesize and dispatch these events for HTTP streams.

Likewise, NetStream.Play.Transition and NetStream.Play.TransitionComplete are not dispatched for either progressive download or HTTP media. Dynamic bitrate switching is an RTMP feature. If a video player using an HTTP stream supports a similar feature, the player can synthesize and dispatch transition events.

More Help topics

Adobe Developer Connection: Measuring video consumption in Flash

Monitoring NetStream events

Two types of events provide valuable usage data: `netStatus` and `mediaTypeData`. In addition, a timer can be used to periodically log the position of the NetStream playhead.

`netStatus` events provide information you can use to determine how much of a stream a user viewed. Buffer and RTMFP stream transition events also result in a `netStatus` event.

`mediaTypeData` events provide meta and XMP data information. The Netstream.Play.Complete event is dispatched as a `mediaTypeData` event. Other data embedded in the stream are also available through `mediaTypeData` events, including cue points, text, and images.

The following example illustrates how to create a class that monitors status and data events from any active NetStreams in an application. Typically, such a class would upload the data it was interested in analyzing to a server for collection.

```
package com.adobe.example
{
    import flash.events.NetDataEvent;
    import flash.events.NetMonitorEvent;
    import flash.events.NetStatusEvent;
    import flash.net.NetMonitor;
    import flash.net.NetStream;

    public class NetStreamEventMonitor
    {
        private var netmon:NetMonitor;
        private var heartbeat:Timer = new Timer( 5000 );

        public function NetStreamEventMonitor()
        {
            //Create NetMonitor object
            netmon = new NetMonitor();
            netmon.addEventListener( NetMonitorEvent.NET_STREAM_CREATE, newNetStream );

            //Start the heartbeat timer
            heartbeat.addEventListener( TimerEvent.TIMER, onHeartbeat );
            heartbeat.start();
        }

        //On new NetStream
        private function newNetStream( event:NetMonitorEvent ):void
        {
            trace( "New Netstream object");
            var stream:NetStream = event.netStream;
            stream.addEventListener(NetDataEvent.MEDIA_TYPE_DATA, onStreamData);
            stream.addEventListener(NetStatusEvent.NET_STATUS, onStatus);
        }

        //On data events from a NetStream object
        private function onStreamData( event:NetDataEvent ):void
        {

            var netStream:NetStream = event.target as NetStream;
            trace( "Data event from " + netStream.info.uri + " at " + event.timestamp );
            switch( event.info.handler )
            {
                case "onMetaData":
                    //handle metadata;
                    break;
                case "onXMPData":
                    //handle XMP;
                    break;
                case "onPlayStatus":
                    //handle NetStream.Play.Complete
                case "onImageData":
                    //handle image
                    break;
                case "onTextData":
                    //handle text
                    break;
                default:
                    //handle other events
            }
        }

        //On status events from a NetStream object
        private function onStatus( event:NetStatusEvent ):void
        {
            trace( "Status event from " + event.target.info.uri + " at " + event.target.time );
            //handle status events
        }
        //On heartbeat timer
        private function onHeartbeat( event:TimerEvent ):void
        {
            var streams:Vector.<NetStream> = netmon.listStreams();
            for( var i:int = 0; i < streams.length; i++ )
            {
                trace( "Heartbeat on " + streams[i].info.uri + " at " + streams[i].time );
                //handle heartbeat event
            }
        }

    }
}
```

Detecting player domain

The URL and domain of the web page on which a user is viewing media content is not always readily available. If allowed by the hosting web site, you can use the ExternalInterface class to get the exact URL. However, some web sites that allow third-party video players do not allow the ExternalInterface to be used. In such cases, you can get the domain of the current web page from the `pageDomain` property of the Security class. The full URL is not divulged for user security and privacy reasons.

The page domain is available from the static `pageDomain` property of the Security class:

```
var domain:String = Security.pageDomain;
```

Advanced topics for video files

Flash Player 9 and later, Adobe AIR 1.0 and later

The following topics address some special issues for working with FLV files.

About configuring FLV files for hosting on a server

Flash Player 9 and later, Adobe AIR 1.0 and later

When you work with FLV files, you might have to configure your server to work with the FLV file format. Multipurpose Internet Mail Extensions (MIME) is a standardized data specification that lets you send non-ASCII files over Internet connections. Web browsers and e-mail clients are configured to interpret numerous MIME types so that they can send and receive video, audio, graphics, and formatted text. To load FLV files from a web server, you might need to register the file extension and MIME type with your web server, so you should check your web server documentation. The MIME type for FLV files is `video/x-flv`. The full information for the FLV file type is as follows:

- Mime Type: video/x-flv
- File extension: .flv
- Required parameters: none
- Optional parameters: none
- Encoding considerations: FLV files are binary files; some applications might require the application/octet-stream subtype to be set
- Security issues: none
- Published specification: www.adobe.com/go/video_file_format

Microsoft changed the way streaming media is handled in Microsoft Internet Information Services (IIS) 6.0 web server from earlier versions. Earlier versions of IIS do not require any modification to stream Flash Video. In IIS 6.0, the default web server that comes with Windows 2003, the server requires a MIME type to recognize that FLV files are streaming media.

When SWF files that stream external FLV files are placed on Microsoft Windows Server® 2003 and are viewed in a browser, the SWF file plays correctly, but the FLV video does not stream. This issue affects all FLV files placed on Windows Server 2003, including files you make with earlier versions of the Flash authoring tool, and the Macromedia Flash Video Kit for Dreamweaver MX 2004 from Adobe. These files work correctly if you test them on other operating systems.

For information about configuring Microsoft Windows 2003 and Microsoft IIS Server 6.0 to stream FLV video, see www.adobe.com/go/tn_19439.

About targeting local FLV files on the Macintosh

Flash Player 9 and later, Adobe AIR 1.0 and later

If you attempt to play a local FLV from a non-system drive on an Apple® Macintosh® computer by using a path that uses a relative slash (/), the video will not play. Non-system drives include, but are not limited to, CD-ROMs, partitioned hard disks, removable storage media, and connected storage devices.

***Note:** The reason for this failure is a limitation of the operating system, not a limitation in Flash Player or AIR.*

For an FLV file to play from a non-system drive on a Macintosh, refer to it with an absolute path using a colon-based notation (:) rather than slash-based notation (/). The following list shows the difference in the two kinds of notation:

- Slash-based notation: myDrive/myFolder/myFLV.flv
- Colon-based notation: (Mac OS®) myDrive:myFolder:myFLV.flv

Video example: Video Jukebox

Flash Player 9 and later, Adobe AIR 1.0 and later

The following example builds a simple video jukebox which dynamically loads a list of videos to play back in a sequential order. This allows you to build an application that lets a user browse through a series of video tutorials, or perhaps specifies which advertisements should be played back before delivering the user's requested video. This example demonstrates the following features of ActionScript 3.0:

- Updating a playhead based on a video file's playback progress
- Listening for and parsing a video file's metadata
- Handling specific codes in a net stream
- Loading, playing, pausing, and stopping a dynamically loaded FLV
- Resizing a video object on the display list based on the net stream's metadata

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The Video Jukebox application files can be found in the folder Samples/VideoJukebox. The application consists of the following files:

File	Description
VideoJukebox.fla or VideoJukebox.mxml	The main application file for Flex (MXML) or Flash (FLA).
VideoJukebox.as	The class that provides the main functionality of the application.
playlist.xml	A file that lists which video files will be loaded into the video jukebox.

Loading an external video playlist file

Flash Player 9 and later, Adobe AIR 1.0 and later

The external playlist.xml file specifies which videos to load, and the order to play them back in. In order to load the XML file, you need to use a URLLoader object and a URLRequest object, as seen in the following code:

```
uldr = new URLLoader();
uldr.addEventListener(Event.COMPLETE, xmlCompleteHandler);
uldr.load(new URLRequest(PLAYLIST_XML_URL));
```

This code is placed in the VideoJukebox class's constructor so the file is loaded before any other code is run. As soon as the XML file has finished loading, the `xmlCompleteHandler()` method is called which parses the external file into an XML object, as seen in the following code:

```
private function xmlCompleteHandler(event:Event):void
{
    playlist = XML(event.target.data);
    videosXML = playlist.video;
    main();
}
```

The `playlist` XML object contains the raw XML from the external file, whereas the videos XML is an XMLList object which contains just the video nodes. A sample playlist.xml file can be seen in the following snippet:

```
<videos>
    <video url="video/caption_video.flv" />
    <video url="video/cuepoints.flv" />
    <video url="video/water.flv" />
</videos>
```

Finally, the `xmlCompleteHandler()` method calls the `main()` method which sets up the various component instances on the display list, as well as the NetConnection and NetStream objects which are used to load the external FLV files.

Creating the user interface

Flash Player 9 and later, Adobe AIR 1.0 and later

To build the user interface you need to drag five Button instances onto the display list and give them the following instance names: `playButton`, `pauseButton`, `stopButton`, `backButton`, and `forwardButton`.

For each of these Button instances, you'll need to assign a handler for the `click` event, as seen in the following snippet:

```
playButton.addEventListener(MouseEvent.CLICK, buttonClickHandler);
pauseButton.addEventListener(MouseEvent.CLICK, buttonClickHandler);
stopButton.addEventListener(MouseEvent.CLICK, buttonClickHandler);
backButton.addEventListener(MouseEvent.CLICK, buttonClickHandler);
forwardButton.addEventListener(MouseEvent.CLICK, buttonClickHandler);
```

The `buttonClickHandler()` method uses a switch statement to determine which button instance was clicked, as seen in the following code:

```
private function buttonClickHandler(event:MouseEvent):void
{
    switch (event.currentTarget)
    {
        case playButton:
            ns.resume();
            break;
        case pauseButton:
            ns.togglePause();
            break;
        case stopButton:
            ns.pause();
            ns.seek(0);
            break;
        case backButton:
            playPreviousVideo();
            break;
        case forwardButton:
            playNextVideo();
            break;
    }
}
```

Next, add a Slider instance to the display list and give it an instance name of `volumeSlider`. The following code sets the slider instance's `liveDragging` property to `true` and defines an event listener for the slider instance's `change` event:

```
volumeSlider.value = volumeTransform.volume;
volumeSlider.minimum = 0;
volumeSlider.maximum = 1;
volumeSlider.snapInterval = 0.1;
volumeSlider.tickInterval = volumeSlider.snapInterval;
volumeSlider.liveDragging = true;
volumeSlider.addEventListener(SliderEvent.CHANGE, volumeChangeHandler);
```

Add a ProgressBar instance to the display list and give it an instance name of `positionBar`. Set its `mode` property to manual, as seen in the following snippet:

```
positionBar.mode = ProgressBarMode.MANUAL;
```

Finally add a Label instance to the display list and give it an instance name of `positionLabel`. This Label instance's value will be set by the timer instance

Listening for a video object's metadata

Flash Player 9 and later, Adobe AIR 1.0 and later

When Flash Player encounters metadata for each of the loaded videos, the `onMetaData()` callback handler is called on the NetStream object's `client` property. The following code initializes an Object and sets up the specified callback handler:

```
client = new Object();
client.onMetaData = metadataHandler;
```

The `metadataHandler()` method copies its data to the meta property defined earlier in the code. This allows you to access the metadata for the current video anytime throughout the entire application. Next, the video object on the Stage is resized to match the dimensions returned from the metadata. Finally, the positionBar progress bar instance is moved and resized based on the size of the currently playing video. The following code contains the entire `metadataHandler()` method:

```
private function metadataHandler(metadataObj:Object):void
{
    meta = metadataObj;
    vid.width = meta.width;
    vid.height = meta.height;
    positionBar.move(vid.x, vid.y + vid.height);
    positionBar.width = vid.width;
}
```

Dynamically loading a video

Flash Player 9 and later, Adobe AIR 1.0 and later

To dynamically load each of the videos, the application uses a NetConnection and a NetStream object. The following code creates a NetConnection object and passes `null` to the `connect()` method. By specifying `null`, Flash Player connects to a video on the local server instead of connecting to a server, such as a Flash Media Server.

The following code creates both the NetConnection and NetStream instances, defines an event listener for the `netStatus` event, and assigns the `client` Object to the `client` property:

```
nc = new NetConnection();
nc.connect(null);

ns = new NetStream(nc);
ns.addEventListener(NetStatusEvent.NET_STATUS, netStatusHandler);
ns.client = client;
```

The `netStatusHandler()` method is called whenever the status of the video is changed. This includes when a video starts or stops playback, is buffering or if a video stream cannot be found. The following code lists the `netStatusHandler()` event:

```
private function netStatusHandler(event:NetStatusEvent):void
{
    try
    {
        switch (event.info.code)
        {
            case "NetStream.Play.Start":
                t.start();
                break;
            case "NetStream.Play.StreamNotFound":
            case "NetStream.Play.Stop":
                t.stop();
                playNextVideo();
                break;
        }
    }
    catch (error:TypeError)
    {
        // Ignore any errors.
    }
}
```

The previous code evaluates the code property of the info object and filters whether the code is "NetStream.Play.Start", "NetStream.Play.StreamNotFound", or "NetStream.Play.Stop". All other codes will be ignored. If the net stream is starting the code starts the Timer instance which updates the playhead. If the net stream cannot be found or is stopped, the Timer instance is stopped and the application attempts to play the next video in the playlist.

Every time the Timer executes, the `positionBar` progress bar instance updates its current position by calling the `setProgress()` method of the ProgressBar class and the `positionLabel` Label instance is updated with the time elapsed and total time of the current video.

```
private function timerHandler(event:TimerEvent):void
{
    try
    {
        positionBar.setProgress(ns.time, meta.duration);
        positionLabel.text = ns.time.toFixed(1) + " of " meta.duration.toFixed(1) + " seconds";
    }
    catch (error:Error)
    {
        // Ignore this error.
    }
}
```

Controlling the volume of the video

Flash Player 9 and later, Adobe AIR 1.0 and later

You can control the volume for the dynamically loaded video by setting the `soundTransform` property on the NetStream object. The video jukebox application allows you to modify the volume level by changing the value of the `volumeSlider` Slider instance. The following code shows how you can change the volume level by assigning the value of the Slider component to a SoundTransform object which is set to the `soundTransform` property on the NetStream object:

```
private function volumeChangeHandler(event:SliderEvent):void
{
    volumeTransform.volume = event.value;
    ns.soundTransform = volumeTransform;
}
```

Controlling video playback

Flash Player 9 and later, Adobe AIR 1.0 and later

The rest of the application controls video playback when the video reaches the end of the video stream or the user skips to the previous or next video.

The following method retrieves the video URL from the XMLList for the currently selected index:

```
private function getVideo():String
{
    return videosXML[idx].@url;
}
```

The `playVideo()` method calls the `play()` method on the NetStream object to load the currently selected video:

```
private function playVideo():void
{
    var url:String = getVideo();
    ns.play(url);
}
```

The `playPreviousVideo()` method decrements the current video index, calls the `playVideo()` method to load the new video file and sets the progress bar to visible:

```
private function playPreviousVideo():void
{
    if (idx > 0)
    {
        idx--;
        playVideo();
        positionBar.visible = true;
    }
}
```

The final method, `playNextVideo()`, increments the video index and calls the `playVideo()` method. If the current video is the last video in the playlist, the `clear()` method is called on the Video object and the progress bar instance's `visible` property is set to `false`:

```
private function playNextVideo():void
{
    if (idx < (videosXML.length() - 1))
    {
        idx++;
        playVideo();
        positionBar.visible = true;
    }
    else
    {
        idx++;
        vid.clear();
        positionBar.visible = false;
    }
}
```

Using the StageVideo class for hardware accelerated presentation

Flash Player 10.2 and later

Flash Player optimizes video performance by using hardware acceleration for H.264 decoding. You can enhance performance further by using the StageVideo API. Stage video lets your application take advantage of hardware accelerated presentation.

Runtimes that support the StageVideo API include:

- Flash Player 10.2 and later

***Note:** In Flash Player 11.4/AIR 3.4 and higher, you can use camera input with StageVideo.*

Downloadable source code and additional details for the stage video feature are available at Getting Started with Stage Video.

For a StageVideo quick start tutorial, see Working with Stage Video.

About hardware acceleration using StageVideo

Hardware accelerated presentation—which includes video scaling, color conversion, and blitting—enhances the performance benefits of hardware accelerated decoding. On devices that offer GPU (hardware) acceleration, you can use a flash.media.StageVideo object to process video directly on the device hardware. Direct processing frees the CPU to perform other tasks while the GPU handles video. The legacy Video class, on the other hand, typically uses software presentation. Software presentation occurs in the CPU and can consume a significant share of system resources.

Currently, few devices provide full GPU acceleration. However, stage video lets applications take maximum advantage of whatever hardware acceleration is available.

The StageVideo class does not make the Video class obsolete. Working together, these two classes provide the optimal video display experience allowed by device resources at any given time. Your application takes advantage of hardware acceleration by listening to the appropriate events and switching between StageVideo and Video as necessary.

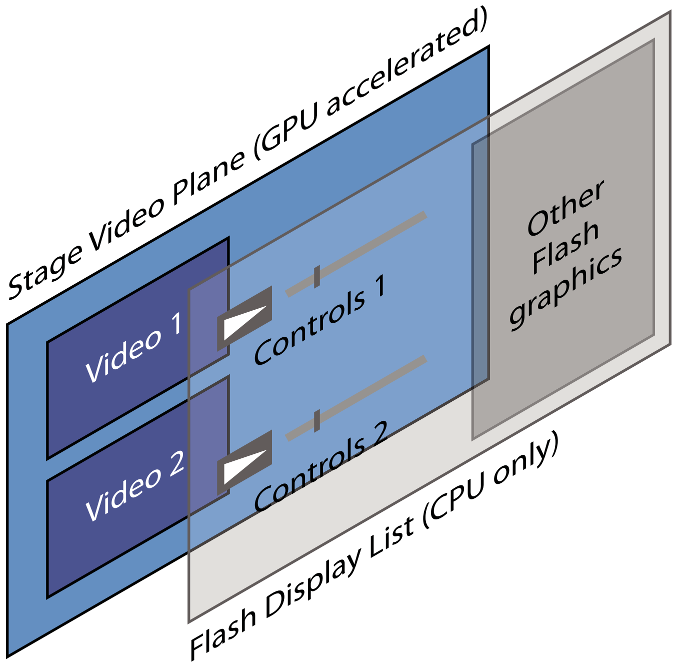
The StageVideo class imposes certain restrictions on video usage. Before implementing StageVideo, review the guidelines and make sure your application can accept them. If you accept the restrictions, use the StageVideo class whenever Flash Player detects that hardware accelerated presentation is available. See "Guidelines and limitations" on page 514.

Parallel planes: Stage video and the Flash display list

With the stage video model, Flash Player can separate video from the display list. Flash Player divides the composite display between two Z-ordered planes:

Stage video plane The stage video plane sits in the background. It displays only hardware accelerated video. Because of this design, this plane is not available if hardware acceleration is not supported or not available on the device. In ActionScript, StageVideo objects handle videos played on the stage video plane.

Flash display list plane Flash display list entities are composited on a plane in front of the stage video plane. Display list entities include anything that the runtime renders, including playback controls. When hardware acceleration is not available, videos can be played only on this plane, using the Video class object. Stage video always displays behind Flash display list graphics.


Stage Video Plane (GPU accelerated)
Video 1
Video 2
Controls 1
Controls 2
Other Flash graphics
Flash Display List (CPU only)

Video display planes

The StageVideo object appears in a non-rotated, window-aligned rectangular region of the screen. You cannot layer objects behind the stage video plane. However, you can use the Flash display list plane to layer other graphics on top of the stage video plane. Stage video runs concurrently with the display list. Thus, you can use the two mechanisms together to create a unified visual effect that uses two discreet planes. For example, you can use the front plane for playback controls that operate on the stage video running in the background.

Stage video and H.264 codec

In Flash Player applications, implementing video hardware acceleration involves two steps:

1 Encoding the video as H.264

2 Implementing the StageVideo API

For best results, perform both steps. The H.264 codec lets you take maximum advantage of hardware acceleration, from video decoding to presentation.

Stage video eliminates GPU-to-CPU read-back. In other words, the GPU no longer sends decoded frames back to the CPU for compositing with display list objects. Instead, the GPU blits decoded and rendered frames directly to the screen, behind the display list objects. This technique reduces CPU and memory usage and also provides better pixel fidelity.

More Help topics

"Understanding video formats" on page 475

Guidelines and limitations

When video is running in full screen mode, stage video is always available if the device supports hardware acceleration. Flash Player, however, also runs within a browser. In the browser context, the `wmode` setting affects stage video availability. Try to use `wmode="direct"` at all times if you want to use stage video. Stage video is not compatible with other `wmode` settings when not in full screen mode. This restriction means that, at run time, stage video can vacillate unpredictably between being available and unavailable. For example, if the user exits full screen mode while stage video is running, the video context reverts to the browser. If the browser `wmode` parameter is not set to `"direct"`, stage video can suddenly become unavailable. Flash Player communicates playback context changes to applications through a set of events. If you implement the StageVideo API, maintain a Video object as a backup when stage video becomes unavailable.

Because of its direct relationship to hardware, stage video restricts some video features. Stage video enforces the following constraints:

- For each SWF file, Flash Player limits the number of StageVideo objects that can concurrently display videos to four. However, the actual limit can be lower, depending on device hardware resources.
- The video timing is not synchronized with the timing of content that the runtime displays.
- The video display area can only be a rectangle. You cannot use more advanced display areas, such as elliptical or irregular shapes.
- You cannot rotate the video.
- You cannot bitmap cache the video or use BitmapData object to access it.
- You cannot apply filters to the video.
- You cannot apply color transforms to the video.
- You cannot apply an alpha value to the video.
- Blend modes that you apply to objects in the display list plane do not apply to stage video.
- You can place the video only on full pixel boundaries.
- Though GPU rendering is the best available for the given device hardware, it is not 100% "pixel identical" across devices. Slight variations occur due to driver and platform differences.
- A few devices do not support all required color spaces. For example, some devices do not support BT.709, the H.264 standard. In such cases, you can use BT.601 for fast display.
- You cannot use stage video with WMODE settings such as normal, opaque, or transparent. Stage video supports only `WMODE=direct` when not in full screen mode. WMODE has no effect in Safari 4 or higher and IE 9 or higher.

In most cases, these limitations do not affect video player applications. If you can accept these limitations, use stage video whenever possible.

More Help topics

"Working with full-screen mode" on page 167

Using the StageVideo APIs

Stage video is a mechanism within the runtime that enhances video playback and device performance. The runtime creates and maintains this mechanism; as a developer, your role is to configure your application to take advantage of it.

To use stage video, you implement a framework of event handlers that detect when stage video is and isn't available. When you receive notification that stage video is available, you retrieve a StageVideo object from the `Stage.stageVideos` property. The runtime populates this Vector object with one or more StageVideo objects. You can then use one of the provided StageVideo objects, rather than a Video object, to display streaming video.

On Flash Player, when you receive notification that stage video is no longer available, switch your video stream back to a Video object.

Note: *You cannot create StageVideo objects.*

Stage.stageVideos property

The `Stage.stageVideos` property is a Vector object that gives you access to StageVideo instances. This vector can contain up to four StageVideo objects, depending on hardware and system resources. Mobile devices can be limited to one, or none.

When stage video is not available, this vector contains no objects. To avoid run time errors, be sure that you access members of this vector only when the most recent `StageVideoAvailability` event indicates that stage video is available.

StageVideo events

The StageVideo API framework provides the following events:

StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY Sent when the `Stage.stageVideos` property changes. The `StageVideoAvailabilityEvent.availability` property indicates either `AVAILABLE` or `UNAVAILABLE`. Use this event to determine whether the `stageVideos` property contains any StageVideo objects, rather than directly checking the length of the `Stage.stageVideos` vector.

StageVideoEvent.RENDER_STATE Sent when a NetStream or Camera object has been attached to a StageVideo object and is playing. Indicates the type of decoding currently in use: hardware, software, or unavailable (nothing is displayed). The event target contains `videoWidth` and `videoHeight` properties that are safe to use for resizing the video viewport.

Important: *Coordinates obtained from the StageVideo target object use Stage coordinates, since they are not part of the standard display list.*

VideoEvent.RENDER_STATE Sent when a Video object is being used. Indicates whether software or hardware accelerated decoding is in use. If this event indicates hardware accelerated decoding, switch to a StageVideo object if possible. The Video event target contains `videoWidth` and `videoHeight` properties that are safe to use for resizing the video viewport.

Workflow for implementing the StageVideo feature

Follow these top-level steps to implement the StageVideo feature:

1. Listen for the `StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY` event to find out when the `Stage.stageVideos` vector has changed. See "Using the StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY event" on page 517.
2. If the `StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY` event reports that stage video is available, use the `Stage.stageVideos` Vector object within the event handler to access a StageVideo object.
3. Attach a NetStream object using `StageVideo.attachNetStream()` or attach a Camera object using `StageVideo.attachCamera()`.
4. Play the video using `NetStream.play()`.
5. Listen for the `StageVideoEvent.RENDER_STATE` event on the StageVideo object to determine the status of playing the video. Receipt of this event also indicates that the width and height properties of the video have been initialized or changed. See "Using the StageVideoEvent.RENDER_STATE and VideoEvent.RENDER_STATE events" on page 519.
6. Listen for the `VideoEvent.RENDER_STATE` event on the Video object. This event provides the same statuses as `StageVideoEvent.RENDER_STATE`, so you can also use it to determine whether GPU acceleration is available. Receipt of this event also indicates that the width and height properties of the video have been initialized or changed. See "Using the StageVideoEvent.RENDER_STATE and VideoEvent.RENDER_STATE events" on page 519.

Initializing StageVideo event listeners

Set up your StageVideoAvailabilityEvent and VideoEvent listeners during application initialization. For example, you can initialize these listeners in the `flash.events.Event.ADDED_TO_STAGE` event handler. This event guarantees that your application is visible on the stage:

```
public class SimpleStageVideo extends Sprite
    private var nc:NetConnection;
    private var ns:NetStream;

    public function SimpleStageVideo()
    {
        // Constructor for SimpleStageVideo class
        // Make sure the app is visible and stage available
        addEventListener(Event.ADDED_TO_STAGE, onAddedToStage);
    }

    private function onAddedToStage(event:Event):void
    {
        //...
        // Connections
        nc = new NetConnection();
        nc.connect(null);
        ns = new NetStream(nc);
        ns.addEventListener(NetStatusEvent.NET_STATUS, onNetStatus);
        ns.client = this;

        // Screen
        video = new Video();
        video.smoothing = true;

        // Video Events
        // the StageVideoEvent.STAGE_VIDEO_STATE informs you whether
        // StageVideo is available
        stage.addEventListener(StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY,
            onStageVideoState);
        // in case of fallback to Video, listen to the VideoEvent.RENDER_STATE
        // event to handle resize properly and know about the acceleration mode running
        video.addEventListener(VideoEvent.RENDER_STATE, videoStateChange);
        //...
    }
```

Using the StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY event

In the `StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY` handler, decide whether to use a Video or StageVideo object based on the availability of StageVideo. If the `StageVideoAvailabilityEvent.availability` property is set to `StageVideoAvailability.AVAILABLE`, use StageVideo. In this case, you can rely on the Stage.stageVideos vector to contain one or more StageVideo objects. Obtain a StageVideo object from the `Stage.stageVideos` property and attach the NetStream object to it. Because StageVideo objects always appear in the background, remove any existing Video object (always in the foreground). You also use this event handler to add a listener for the `StageVideoEvent.RENDER_STATE` event.

If the `StageVideoAvailabilityEvent.availability` property is set to `StageVideoAvailability.UNAVAILABLE`, do not use StageVideo or access the `Stage.stageVideos` vector. In this case, attach the NetStream object to a Video object. Finally, add the StageVideo or Video object to the stage and call `NetStream.play()`.

The following code shows how to handle the `StageVideoAvailabilityEvent.STAGE_VIDEO_AVAILABILITY` event:

```
private var sv:StageVideo;
private var video:Video;

private function onStageVideoState(event:StageVideoAvailabilityEvent):void
{
    // Detect if StageVideo is available and decide what to do in toggleStageVideo
    toggleStageVideo(event.availability == StageVideoAvailability.AVAILABLE);
}

private function toggleStageVideo(on:Boolean):void
{
    // To choose StageVideo attach the NetStream to StageVideo
    if (on)
    {
        stageVideoInUse = true;
        if ( sv == null )
        {
            sv = stage.stageVideos[0];
            sv.addEventListener(StageVideoEvent.RENDER_STATE, stageVideoStateChange);
                sv.attachNetStream(ns);
        }

        if (classicVideoInUse)
        {
            // If you use StageVideo, remove from the display list the
            // Video object to avoid covering the StageVideo object
            // (which is always in the background)
            stage.removeChild ( video );
            classicVideoInUse = false;
        }
    } else
    {
        // Otherwise attach it to a Video object
        if (stageVideoInUse)
            stageVideoInUse = false;
        classicVideoInUse = true;
        video.attachNetStream(ns);
        stage.addChildAt(video, 0);
    }

    if ( !played )
    {
        played = true;
        ns.play(FILE_NAME);
    }
}
```

Important: *The first time an application accesses the vector element at Stage.stageVideos[0], the default rect is set to 0,0,0,0, and pan and zoom properties use default values. Always reset these values to your preferred settings. You can use the* `videoWidth` *and* `videoHeight` *properties of the* `StageVideoEvent.RENDER_STATE` *or* `VideoEvent.RENDER_STATE` *event target for calculating the video viewport dimensions.*

Download the full source code for this sample application at Getting Started with Stage Video.

Using the StageVideoEvent.RENDER_STATE and VideoEvent.RENDER_STATE events

StageVideo and Video objects send events that inform applications when the display environment changes. These events are `StageVideoEvent.RENDER_STATE` and `VideoEvent.RENDER_STATE`.

A StageVideo or Video object dispatches a render state event when a NetStream object is attached and begins playing. It also sends this event when the display environment changes; for example, when the video viewport is resized. Use these notifications to reset your viewport to the current `videoHeight` and `videoWidth` values of the event target object.

Reported render states include:

- `RENDER_STATUS_UNAVAILABLE`
- `RENDER_STATUS_SOFTWARE`
- `RENDER_STATUS_ACCELERATED`

Render states indicate when hardware accelerated decoding is in use, regardless of which class is currently playing video. Check the `StageVideoEvent.status` property to learn whether the necessary decoding is available. If this property is set to "unavailable", the StageVideo object cannot play the video. This status requires that you immediately reattach the NetStream object to a Video object. Other statuses inform your application of the current rendering conditions.

The following table describes the implications of all render status values for StageVideoEvent and VideoEvent objects in Flash Player:

	VideoStatus.ACCELERATED	**VideoStatus.SOFTWARE**	**VideoStatus.UNAVAILABLE**
StageVideoEvent	Decoding and presentation both occur in hardware. (Best performance.)	Presentation in hardware, decoding in software. (Acceptable performance.)	No GPU resources are available to handle video, and nothing is displayed. **Fall back to a Video object.**
VideoEvent	Presentation in software, decoding in hardware. (Acceptable performance on a modern desktop system only. Degraded full-screen performance.)	Presentation in software, decoding in software. (Worst case performance-wise. Degraded full-screen performance.)	(N/A)

Color spaces

Stage video uses underlying hardware capabilities to support color spaces. SWF content can provide metadata indicating its preferred color space. However, the device graphics hardware determines whether that color space can be used. One device can support several color spaces, while another supports none. If the hardware does not support the requested color space, Flash Player attempts to find the closest match among the supported color spaces.

To query which color spaces the hardware supports, use the `StageVideo.colorSpaces` property. This property returns the list of supported color spaces in a String vector:

```
var colorSpace:Vector.<String> = stageVideo.colorSpaces();
```

To learn which color space the currently playing video is using, check the `StageVideoEvent.colorSpace` property. Check this property in your event handler for the `StageVideoEvent.RENDER_STATE` event:

```
var currColorSpace:String;

//StageVideoEvent.RENDER_STATE event handler
private function stageVideoRenderState(event:Object):void
{
    //...
    currColorSpace = (event as StageVideoEvent).colorSpace;
    //...
}
```

If Flash Player cannot find a substitute for an unsupported color space, stage video uses the default color space BT.601. For example, video streams with H.264 encoding typically use the BT.709 color space. If the device hardware does not support BT.709, the `colorSpace` property returns `"BT601"`. A `StageVideoEvent.colorSpace` value of `"unknown"` indicates that the hardware does not provide a means of querying the color space.

If your application deems the current color space unacceptable, you can choose to switch from a StageVideo object to a Video object. The Video class supports all color spaces through software compositing.

Chapter 26: Working with cameras

Flash Player 9 and later, Adobe AIR 1.0 and later

A camera attached to a user's computer can serve as a source of video data that you can display and manipulate using ActionScript. The Camera class is the mechanism built into ActionScript for working with a computer or device camera.

On mobile devices, you can also use the CameraUI class. The CameraUI class launches a separate camera application to allow the user to capture a still image or video. When the user is finished, your application can access the image or video through a MediaPromise object.

More Help topics

Christian Cantrell: How to use CameraUI in a Cross-platform Way

Michaël CHAIZE: Android, AIR and the Camera

Understanding the Camera class

Flash Player 9 and later, Adobe AIR 1.0 and later

The Camera object allows you to connect to the user's local camera and broadcast the video either locally (back to the user) or remotely to a server (such as Flash Media Server).

Using the Camera class, you can access the following kinds of information about the user's camera:

- Which cameras installed on the user's computer or device are available
- Whether a camera is installed
- Whether Flash Player is allowed or denied access to the user's camera
- Which camera is currently active
- The width and height of the video being captured

The Camera class includes several useful methods and properties for working with camera objects. For example, the static `Camera.names` property contains an array of camera names currently installed on the user's computer. You can also use the `name` property to display the name of the currently active camera.

***Note:** When streaming camera video across the network, you should always handle network interruptions. Network interruptions can occur for many reasons, particularly on mobile devices.*

Displaying camera content on screen

Flash Player 9 and later, Adobe AIR 1.0 and later

Connecting to a camera can require less code than using the NetConnection and NetStream classes to load a video. The camera class can also quickly become tricky because with Flash Player, you need a user's permission to connect to their camera before you can access it.

The following code demonstrates how you can use the Camera class to connect to a user's local camera:

```
var cam:Camera = Camera.getCamera();
var vid:Video = new Video();
vid.attachCamera(cam);
addChild(vid);
```

***Note:** The Camera class does not have a constructor method. In order to create a new Camera instance you use the static* `Camera.getCamera()` *method.*

Designing your camera application

Flash Player 9 and later, Adobe AIR 1.0 and later

When writing an application that connects to a user's camera, you need to account for the following in your code:

- Check if the user has a camera currently installed. Handle the case where no camera is available.
- For Flash Player only, check if the user has explicitly allowed access to the camera. For security reasons the player displays the Flash Player Settings dialog which lets the user allow or deny access to their camera. This prevents Flash Player from connecting to a user's camera and broadcasting a video stream without their permission. If a user clicks allow, your application can connect to the user's camera. If the user clicks deny, your application will be unable to access the user's camera. Your applications should always handle both cases gracefully.
- For AIR only, check whether the Camera class is supported for the device profiles supported by your application.
- The Camera class is not supported in mobile browsers.
- The Camera class is not supported in mobile AIR apps that use the GPU rendering mode.
- On mobile devices, only one camera can be active at a time.

More Help topics

Christophe Coenraets: Multi-User Video Tic-Tac-Toe

Mark Doherty: Android Radar app (source)

Connecting to a user's camera

Flash Player 9 and later, Adobe AIR 1.0 and later

The first step when connecting to a user's camera is to create a new camera instance by creating a variable of type Camera and initializing it to the return value of the static `Camera.getCamera()` method.

The next step is to create a new video object and attach the Camera object to it.

The third step is to add the video object to the display list. You need to perform steps 2 and 3 because the Camera class does not extend the DisplayObject class so it cannot be added directly to the display list. To display the camera's captured video, you create a new video object and call the `attachCamera()` method.

The following code shows these three steps:

```
var cam:Camera = Camera.getCamera();
var vid:Video = new Video();
vid.attachCamera(cam);
addChild(vid);
```

Note that if a user does not have a camera installed, the application does not display anything.

In real life, you need to perform additional steps for your application. See "Verifying that cameras are installed" on page 523 and "Detecting permissions for camera access" on page 524 for further information.

More Help topics

Lee Brimelow: How to access the camera on Android devices

Verifying that cameras are installed

Flash Player 9 and later, Adobe AIR 1.0 and later

Before you attempt to use any methods or properties on a camera instance, you'll want to verify that the user has a camera installed. There are two ways to check whether the user has a camera installed:

- Check the static `Camera.names` property which contains an array of camera names which are available. Typically this array will have one or fewer strings, as most users will not likely have more than one camera installed at a time. The following code demonstrates how you could check the `Camera.names` property to see if the user has any available cameras:

  ```
  if (Camera.names.length > 0)
  {
      trace("User has at least one camera installed.");
      var cam:Camera = Camera.getCamera(); // Get default camera.
  }
  else
  {
      trace("User has no cameras installed.");
  }
  ```

- Check the return value of the static `Camera.getCamera()` method. If no cameras are available or installed, this method returns `null`, otherwise it returns a reference to a Camera object. The following code demonstrates how you could check the `Camera.getCamera()` method to see if the user has any available cameras:

```
var cam:Camera = Camera.getCamera();
if (cam == null)
{
    trace("User has no cameras installed.");
}
else
{
    trace("User has at least 1 camera installed.");
}
```

Since the Camera class doesn't extend the DisplayObject class, it cannot be directly added to the display list using the `addChild()` method. In order to display the camera's captured video, you need to create a new Video object and call the `attachCamera()` method on the Video instance.

This snippet shows how you can attach the camera if one exists; if not, the application simply displays nothing:

```
var cam:Camera = Camera.getCamera();
if (cam != null)
{
    var vid:Video = new Video();
    vid.attachCamera(cam);
    addChild(vid);
}
```

Mobile device cameras

The Camera class is not supported in the Flash Player runtime in mobile browsers.

In AIR applications on mobile devices you can access the camera or cameras on the device. On mobile devices, you can use both the front- and the back-facing camera, but only one camera output can be displayed at any given time. (Attaching a second camera will detach the first.) The front-facing camera is horizontally mirrored on iOS, on Android, it is not.

Detecting permissions for camera access

Flash Player 9 and later, Adobe AIR 1.0 and later

In the AIR application sandbox, the application can access any camera without the user's permission. On Android, however, the application must specify the Android CAMERA permission in the application descriptor.

Before Flash Player can display a camera's output, the user must explicitly allow Flash Player to access the camera. When the `attachCamera()` method gets called Flash Player displays the Flash Player Settings dialog box which prompts the user to either allow or deny Flash Player access to the camera and microphone. If the user clicks the Allow button, Flash Player displays the camera's output in the Video instance on the Stage. If the user clicks the Deny button, Flash Player is unable to connect to the camera and the Video object does not display anything.

If you want to detect whether the user allowed Flash Player access to the camera, you can listen for the camera's `status` event (`StatusEvent.STATUS`), as seen in the following code:

```
var cam:Camera = Camera.getCamera();
if (cam != null)
{
    cam.addEventListener(StatusEvent.STATUS, statusHandler);
    var vid:Video = new Video();
    vid.attachCamera(cam);
    addChild(vid);
}
function statusHandler(event:StatusEvent):void
{
    // This event gets dispatched when the user clicks the "Allow" or "Deny"
    // button in the Flash Player Settings dialog box.
    trace(event.code); // "Camera.Muted" or "Camera.Unmuted"
}
```

The `statusHandler()` function gets called as soon as the user clicks either Allow or Deny. You can detect which button the user clicked, using one of two methods:

- The `event` parameter of the `statusHandler()` function contains a code property which contains the string "Camera.Muted" or "Camera.Unmuted". If the value is "Camera.Muted" the user clicked the Deny button and Flash Player is unable to access the camera. You can see an example of this in the following snippet:

  ```
  function statusHandler(event:StatusEvent):void
  {
      switch (event.code)
      {
          case "Camera.Muted":
              trace("User clicked Deny.");
              break;
          case "Camera.Unmuted":
              trace("User clicked Accept.");
              break;
      }
  }
  ```

- The Camera class contains a read-only property named `muted` which specifies whether the user has denied access to the camera (`true`) or allowed access (`false`) in the Flash Player Privacy panel. You can see an example of this in the following snippet:

  ```
  function statusHandler(event:StatusEvent):void
  {
      if (cam.muted)
      {
          trace("User clicked Deny.");
      }
      else
      {
          trace("User clicked Accept.");
      }
  }
  ```

By checking for the status event to be dispatched, you can write code that handles the user accepting or denying access to the camera and clean up appropriately. For example, if the user clicks the Deny button, you could display a message to the user stating that they need to click Allow if they want to participate in a video chat, or you could instead make sure the Video object on the display list is deleted to free up system resources.

In AIR, a Camera object does not dispatch status events since permission to use the camera is not dynamic.

Maximizing camera video quality

Flash Player 9 and later, Adobe AIR 1.0 and later

By default, new instances of the Video class are 320 pixels wide by 240 pixels high. In order to maximize video quality you should always ensure that your video object matches the same dimensions as the video being returned by the camera object. You can get the camera object's width and height by using the Camera class's `width` and `height` properties, you can then set the video object's `width` and `height` properties to match the camera objects dimensions, or you can pass the camera's width and height to the Video class's constructor method, as seen in the following snippet:

```
var cam:Camera = Camera.getCamera();
if (cam != null)
{
    var vid:Video = new Video(cam.width, cam.height);
    vid.attachCamera(cam);
    addChild(vid);
}
```

Since the `getCamera()` method returns a reference to a camera object (or `null` if no cameras are available) you can access the camera's methods and properties even if the user denies access to their camera. This allows you to set the size of the video instance using the camera's native height and width.

```
var vid:Video;
var cam:Camera = Camera.getCamera();

if (cam == null)
{
    trace("Unable to locate available cameras.");
}
else
{
    trace("Found camera: " + cam.name);
    cam.addEventListener(StatusEvent.STATUS, statusHandler);
    vid = new Video();
    vid.attachCamera(cam);
}
function statusHandler(event:StatusEvent):void
{
    if (cam.muted)
    {
        trace("Unable to connect to active camera.");
    }
    else
    {
        // Resize Video object to match camera settings and
        // add the video to the display list.
        vid.width = cam.width;
        vid.height = cam.height;
        addChild(vid);
    }
    // Remove the status event listener.
    cam.removeEventListener(StatusEvent.STATUS, statusHandler);
}
```

For information about full-screen mode, see the full-screen mode section under "Setting Stage properties" on page 164.

Monitoring camera status

Flash Player 9 and later, Adobe AIR 1.0 and later

The camera class contains several properties which allow you to monitor the Camera object's current status. For example, the following code displays several of the camera's properties using a Timer object and a text field instance on the display list:

```
var vid:Video;
var cam:Camera = Camera.getCamera();
var tf:TextField = new TextField();
tf.x = 300;
tf.autoSize = TextFieldAutoSize.LEFT;
addChild(tf);

if (cam != null)
{
    cam.addEventListener(StatusEvent.STATUS, statusHandler);
    vid = new Video();
    vid.attachCamera(cam);
}
function statusHandler(event:StatusEvent):void
{
    if (!cam.muted)
    {
        vid.width = cam.width;
        vid.height = cam.height;
        addChild(vid);
        t.start();
    }
    cam.removeEventListener(StatusEvent.STATUS, statusHandler);
}

var t:Timer = new Timer(100);
t.addEventListener(TimerEvent.TIMER, timerHandler);
function timerHandler(event:TimerEvent):void
{
    tf.text = "";
    tf.appendText("activityLevel: " + cam.activityLevel + "\n");
    tf.appendText("bandwidth: " + cam.bandwidth + "\n");
    tf.appendText("currentFPS: " + cam.currentFPS + "\n");
    tf.appendText("fps: " + cam.fps + "\n");
    tf.appendText("keyFrameInterval: " + cam.keyFrameInterval + "\n");
    tf.appendText("loopback: " + cam.loopback + "\n");
    tf.appendText("motionLevel: " + cam.motionLevel + "\n");
    tf.appendText("motionTimeout: " + cam.motionTimeout + "\n");
    tf.appendText("quality: " + cam.quality + "\n");
}
```

Every 1/10 of a second (100 milliseconds) the Timer object's `timer` event is dispatched and the `timerHandler()` function updates the text field on the display list.

Chapter 27: Using digital rights management

Flash Player 10.1 and later, Adobe AIR 1.5 and later

Adobe® Access™ is a content protection solution. It lets content owners, distributors, and advertisers realize new sources of revenue by providing seamless access to premium content. Publishers use Adobe Access to encrypt content, create policies, and issue licenses. Adobe Flash Player and Adobe AIR incorporate a DRM library, the Adobe Access module. This module enables the runtime to communicate with the Adobe Access license server and play back protected content. The runtime thus completes the life cycle of content protected by Adobe Access and distributed by Flash Media Server.

With Adobe Access, content providers can provide both free content and premium content. For example, a consumer wants to view a television program without advertisements. The consumer registers and pays the content publisher. The consumer can then enter their user credentials to gain access and play the program without the ads.

In another example, a consumer wants to view content offline while traveling with no Internet access. This offline workflow is supported in AIR applications. After registering and paying the publisher for the content, the user can access and download the content and associated AIR application from the publisher's website. Using the AIR application, the user can view the content offline during the permitted period. The content can also be shared with other devices in the same device group using domains (**New in 3.0**).

Adobe Access also supports anonymous access, which does not require user authentication. For example, a publisher can use anonymous access to distribute ad-supported content. Anonymous access also lets a publisher allow free access to the current content for a specified number of days. The content provider can also specify and restrict the type and version of the player needed for their content.

When a user tries to play protected content in Flash Player or Adobe AIR, your application must call the DRM APIs. The DRM APIs initiate the workflow for playback of protected content. The runtime, through the Adobe Access module, contacts the license server. The license server authenticates the user, if necessary, and issues a license to allow playback of protected content. The runtime receives the license and decrypts the content for playback.

How to enable your application to play content protected by Adobe Access is described here. It is not necessary to understand how to encrypt content or maintain policies using Adobe Access. However, it is assumed that you are communicating with the Adobe Access license server to authenticate the user and retrieve the license. It is also assumed that you are designing an application to specifically play content protected by Adobe Access.

For an overview of Adobe Access, including creating policies, see the documentation included with Adobe Access.

More Help topics

flash.net.drm package

flash.net.NetConnection

flash.net.NetStream

Understanding the protected content workflow

Flash Player 10.1 and later, Adobe AIR 2.0 and later

Important: Flash Player 11.5 and above integrates the Adobe Access module, so the update step (calling `SystemUpdater.update(SystemUpdaterType.DRM)`) is unnecessary. This includes the following browsers and platforms:

- Flash Player 11.5 ActiveX control, for all platforms except Internet Explorer on Windows 8 on Intel processors
- Flash Player 11.5 plugin, for all browsers
- Adobe AIR (desktop and mobile)

This means that the update step is *still required* in the following cases:

- Internet Explorer on Windows 8 on Intel processors
- Flash Player 11.4 and below, except on Google Chrome 22 and above (all platforms) or 21 and above (Windows)

Note: *You can still safely call* `SystemUpdater.update(SystemUpdaterType.DRM)` *on a system with Flash Player 11.5 or higher, but nothing is downloaded.*

The following high-level workflow shows that how an application can retrieve and play protected content. The workflow assumes that the application is designed specifically to play content protected by Adobe Access:

1 Get the content metadata.
2 Handle updates to Flash Player, if needed.
3 Check if a license is available locally. If so, load it and go to step 7. If not, go to step 4.
4 Check if authentication is required. If not, you can go to step 7.
5 If authentication is required, get the authentication credentials from the user and pass them to the license server.
6 If domain registration is required, join the domain (AIR 3.0 and higher).
7 Once authentication succeeds, download the license from the server.
8 Play the content.

If an error has not occurred and the user was successfully authorized to view the content, the NetStream object dispatches a DRMStatusEvent object. The application then begins playback. The DRMStatusEvent object holds the related voucher information, which identifies the user's policy and permissions. For example, it holds information regarding whether the content can be made available offline or when the license expires. The application can use this data to inform the user of the status of their policy. For example, the application can display the number of remaining days the user has for viewing the content in a status bar.

If the user is allowed offline access, the voucher is cached, and the encrypted content is downloaded to the user's machine. The content is made accessible for the duration defined in the license caching duration. The `detail` property in the event contains `"DRM.voucherObtained"`. The application decides where to store the content locally in order for it to be available offline. You can also preload vouchers using the DRMManager class.

Note: *Caching and pre-loading of vouchers is supported in both AIR and Flash Player. However, downloading and storing encrypted content is supported only in AIR.*

It is the application's responsibility to explicitly handle the error events. These events include cases where the user inputs valid credentials, but the voucher protecting the encrypted content restricts the access to the content. For example, an authenticated user cannot access content if the rights have not been paid for. This case can also occur when two registered members of the same publisher attempt to share content that only one of them has paid for. The application must inform the user of the error and provide an alternative suggestion. A typical alternative suggestion is instructions in how to register and pay for viewing rights.

Detailed API workflow

Flash Player 10.1 and later, AIR 2.0 and later

This workflow provides a more detailed view of the protected-content workflow. This workflow describes the specific APIs used to play content protected by Adobe Access.

1. Using a URLLoader object, load the bytes of the protected content's metadata file. Set this object to a variable, such as `metadata_bytes`.

   All content controlled by Adobe Access has Adobe Access metadata. When the content is packaged, this metadata can be saved as a separate metadata file (.metadata) alongside the content. For more information, see the Adobe Access documentation.

2. Create a DRMContentData instance. Put this code into a try-catch block:

   ```
   new DRMContentData(metadata_bytes)
   ```

   where *`metadata_bytes`* is the URLLoader object obtained in step 1.

3. (Flash Player only) The runtime checks for the Adobe Access module. If not found, an IllegalOperationError with DRMErrorEvent error code 3344 or DRMErrorEvent error code 3343 is thrown.

   To handle this error, download the Adobe Access module using the SystemUpdater API. After this module is downloaded, the SystemUpdater object dispatches a COMPLETE event. Include an event listener for this event that returns to step 2 when this event is dispatched. The following code demonstrates these steps:

   ```
   flash.system.SystemUpdater.addEventListener(Event.COMPLETE, updateCompleteHandler);
   flash.system.SystemUpdater.update(flash.system.SystemUpdaterType.DRM)

   private function updateCompleteHandler (event:Event):void {
       /*redo step 2*/
       drmContentData = new DRMContentData(metadata_bytes);
   }
   ```

   If the player itself must be updated, a status event is dispatched. For more information on handling this event, see "Listening for an update event" on page 545.

   ***Note:** In AIR applications, the AIR installer handles updating the Adobe Access module and required runtime updates.*

4. Create listeners to listen for the DRMStatusEvent and DRMErrorEvent dispatched from the DRMManager object:

   ```
   DRMManager.addEventListener(DRMStatusEvent.DRM_STATUS, onDRMStatus);
   DRMManager.addEventListener(DRMErrorEvent.DRM_ERROR, onDRMError);
   ```

   In the DRMStatusEvent listener, check that the voucher is valid (not null). In the DRMErrorEvent listener, handle DRMErrorEvents. See "Using the DRMStatusEvent class" on page 537 and "Using the DRMErrorEvent class" on page 541.

5. Load the voucher (license) that is required to play the content.

   First, try to load a locally stored license to play the content:

```
DRMManager.loadvoucher(drmContentData, LoadVoucherSetting.LOCAL_ONLY)
```

After loading completes, the DRMManager object dispatches `DRMStatusEvent.DRM_Status`.

6 If the DRMVoucher object is not null, the voucher is valid. Skip to step 13.

7 If the DRMVoucher object is null, check the authentication method required by the policy for this content. Use the `DRMContentData.authenticationMethod` property.

8 If the authentication method is `ANONYMOUS`, go to step 13.

9 If the authentication method is `USERNAME_AND_PASSWORD`, your application must provide a mechanism to let the user enter credentials. Pass these credentials to the license server to authenticate the user:

```
DRMManager.authenticate(metadata.serverURL, metadata.domain, username, password)
```

The DRMManager dispatches a `DRMAuthenticationErrorEvent` if authentication fails or a `DRMAuthenticationCompleteEvent` if authentication succeeds. Create listeners for these events.

10 If the authentication method is `UNKNOWN`, a custom authentication method must be used. In this case, the content provider has arranged for authentication to be done in an out-of-band manner by not using the ActionScript 3.0 APIs. The custom authentication procedure must produce an authentication token that can be passed to the `DRMManager.setAuthenticationToken()` method.

11 If authentication fails, your application must return to step 9. Ensure that your application has a mechanism to handle and limit repeated authentication failures. For example, after three attempts, you display a message to the user indicating the authentication has failed and content cannot be played.

12 To use the stored token instead of prompting the user to enter credentials, set the token with `DRMManager.setAuthenticationToken()` method. You then download the license from the license server and play content as in step 8.

13 (optional) If authentication succeeds, you can capture the authentication token, which is a byte array cached in memory. Get this token with the `DRMAuthenticationCompleteEvent.token` property. You can store and use the authentication token so that the user does not have to repeatedly enter credentials for this content. The license server determines the valid period of the authentication token.

14 If authentication succeeds, download the license from the license server:

```
DRMManager.loadvoucher(drmContentData, LoadVoucherSetting.FORCE_REFRESH)
```

After loading completes, the DRMManager object dispatches DRMStatusEvent.DRM_STATUS. Listen for this event, and when it is dispatched, you can play the content.

15 Play the video by creating a NetStream object and then calling its `play()` method:

```
stream = new NetStream(connection);
stream.addEventListener(DRMStatusEvent.DRM _STATUS, drmStatusHandler);
stream.addEventListener(DRMErrorEvent.DRM_ERROR, drmErrorHandler);
stream.addEventListener(NetStatusEvent.NET_STATUS, netStatusHandler);
stream.client = new CustomClient();
video.attachNetStream(stream);
stream.play(videoURL);
```

DRMContentData and session objects

When `DRMContentData` is created, it will be used as a session object that refers to the Flash Player DRM module. All the `DRMManager` APIs that receives this `DRMContentData` will use that particular DRM module. However, there are 2 `DRMManager` APIs that does not use `DRMContentData`. They are:

1 `authenticate()`

2 `setAuthenticationToken()`

Since there is no `DRMContentData` associated, invoking these `DRMManager` APIs will use the latest DRM module from the disk. This may become a problem if an update of the DRM module happens in the middle of the application's DRM workflow. Consider the following scenario:

1 The application creates a `DRMContentData` object `contentData1`, which uses *AdobeCP1* as the DRM module.

2 The application invokes the `DRMManager.authenticate(contentData1.serverURL,...)` method.

3 The application invokes the `DRMManager.loadVoucher(contentData1, ...)` method.

If an update happens for the DRM module before the application can get to step 2, then the `DRMManager.authenticate()` method will end up authenticating using *AdobeCP2* as the DRM module. The `loadVoucher()` method in step 3 will fail since it is still using *AdobeCP1* as the DRM module. The update may have happened due to another application invoking the DRM module update.You can avoid this scenario by invoking the DRM module update on application startup.

DRM-related events

The runtime dispatches numerous events when an application attempts to play protected content:

- DRMDeviceGroupErrorEvent (AIR only), dispatched by DRMManager
- DRMAuthenticateEvent (AIR only), dispatched by NetStream
- DRMAuthenticationCompleteEvent, dispatched by DRMManager
- DRMAuthenticationErrorEvent, dispatched by DRMManager
- DRMErrorEvent, dispatched by NetStream and DRMManager
- DRMStatusEvent, dispatched by NetStream and DRMManager
- StatusEvent
- NetStatusEvent. See "Listening for an update event" on page 545

To support content protected by Adobe Access, add event listeners for handling the DRM events.

Pre-loading vouchers for offline playback

Adobe AIR 1.5 and later

You can preload the vouchers (licenses) required to play content protected by Adobe Access. Pre-loaded vouchers allow users to view the content whether they have an active Internet connection. (The preload process itself requires an Internet connection.) You can use the NetStream class `preloadEmbeddedMetadata()` method and the DRMManager class to preload vouchers. In AIR 2.0 and later, you can use a DRMContentData object to preload vouchers directly. This technique is preferable because it lets you update the DRMContentData object independent of the content. (The `preloadEmbeddedData()` method fetches DRMContentData from the content.)

Using DRMContentData

Adobe AIR 2.0 and later

The following steps describe the workflow for pre-loading the voucher for a protected media file using a DRMContentData object.

1 Get the binary metadata for the packaged content. If using the Adobe Access Java Reference Packager, this metadata file is automatically generated with a *.metadata* extension. You could, for example, download this metadata using the URLLoader class.

2 Create a DRMContentData object, passing the metadata to the constructor function:

```
var drmData:DRMContentData = new DRMContentData( metadata );
```

3 The rest of the steps are identical to the workflow described in "Understanding the protected content workflow" on page 529.

Using preloadEmbeddedMetadata()

Adobe AIR 1.5 and later

The following steps describe the workflow for pre-loading the voucher for a DRM-protected media file using `preloadEmbeddedMetadata()`:

1 Download and store the media file. (DRM metadata can only be pre-loaded from locally stored files.)

2 Create the NetConnection and NetStream objects, supplying implementations for the `onDRMContentData()` and `onPlayStatus()` callback functions of the NetStream client object.

3 Create a NetStreamPlayOptions object and set the `stream` property to the URL of the local media file.

4 Call the NetStream `preloadEmbeddedMetadata()`, passing in the NetStreamPlayOptions object identifying the media file to parse.

5 If the media file contains DRM metadata, then the `onDRMContentData()` callback function is invoked. The metadata is passed to this function as a DRMContentData object.

6 Use the DRMContentData object to obtain the voucher using the DRMManager `loadVoucher()` method.

   If the value of the `authenticationMethod` property of the `DRMContentData` object is `flash.net.drm.AuthenticationMethod.USERNAME_AND_PASSWORD`, authenticate the user on the media rights server before loading the voucher. The `serverURL` and `domain` properties of the DRMContentData object can be passed to the DRMManager `authenticate()` method, along with the user's credentials.

7 The `onPlayStatus()` callback function is invoked when file parsing is complete. If the `onDRMContentData()` function has not been called, the file does not contain the metadata required to obtain a voucher. This missing call also possibly means that Adobe Access does not protect this file.

The following code example for AIR illustrates how to preload a voucher for a local media file:

```
package
{
import flash.display.Sprite;
import flash.events.DRMAuthenticationCompleteEvent;
import flash.events.DRMAuthenticationErrorEvent;
import flash.events.DRMErrorEvent;
import flash.ev ents.DRMStatusEvent;
import flash.events.NetStatusEvent;
import flash.net.NetConnection;
import flash.net.NetStream;
import flash.net.NetStreamPlayOptions;
import flash.net.drm.AuthenticationMethod;
import flash.net.drm.DRMContentData;
import flash.net.drm.DRMManager;
import flash.net.drm.LoadVoucherSetting;
public class DRMPreloader extends Sprite
{
    private var videoURL:String = "app-storage:/video.flv";
    private var userName:String = "user";
    private var password:String = "password";
    private var preloadConnection:NetConnection;
    private var preloadStream:NetStream;
    private var drmManager:DRMManager = DRMManager.getDRMManager();
    private var drmContentData:DRMContentData;
    public function DRMPreloader():void {
        drmManager.addEventListener(
            DRMAuthenticationCompleteEvent.AUTHENTICATION_COMPLETE,
            onAuthenticationComplete);
        drmManager.addEventListener(DRMAuthenticationErrorEvent.AUTHENTICATION_ERROR,
            onAuthenticationError);
        drmManager.addEventListener(DRMStatusEvent.DRM_STATUS, onDRMStatus);
        drmManager.addEventListener(DRMErrorEvent.DRM_ERROR, onDRMError);
        preloadConnection = new NetConnection();
        preloadConnection.addEventListener(NetStatusEvent.NET_STATUS, onConnect);
        preloadConnection.connect(null);
    }

    private function onConnect( event:NetStatusEvent ):void
    {
        preloadMetadata();
    }
    private function preloadMetadata():void
    {
        preloadStream = new NetStream( preloadConnection );
        preloadStream.client = this;
        var options:NetStreamPlayOptions = new NetStreamPlayOptions();
        options.streamName = videoURL;
        preloadStream.preloadEmbeddedData( options );
    }
    public function onDRMContentData( drmMetadata:DRMContentData ):void
    {
        drmContentData = drmMetadata;
        if ( drmMetadata.authenticationMethod == AuthenticationMethod.USERNAME_AND_PASSWORD )
        {
            authenticateUser();
        }
        else
```

```
            {
                getVoucher();
            }
    }
    private function getVoucher():void
    {
        drmManager.loadVoucher( drmContentData, LoadVoucherSetting.ALLOW_SERVER );
    }

    private function authenticateUser():void
    {
        drmManager.authenticate( drmContentData.serverURL, drmContentData.domain, userName, 
password );
    }
    private function onAuthenticationError( event:DRMAuthenticationErrorEvent ):void
    {
        trace( "Authentication error: " + event.errorID + ", " + event.subErrorID );
    }

    private function onAuthenticationComplete( event:DRMAuthenticationCompleteEvent ):void
    {
        trace( "Authenticated to: " + event.serverURL + ", domain: " + event.domain );
        getVoucher();
    }
    private function onDRMStatus( event:DRMStatusEvent ):void
    {
        trace( "DRM Status: " + event.detail);
        trace("--Voucher allows offline playback = " + event.isAvailableOffline );
        trace("--Voucher already cached          = " + event.isLocal );
        trace("--Voucher required authentication = " + !event.isAnonymous );
    }
    private function onDRMError( event:DRMErrorEvent ):void
    {
        trace( "DRM error event: " + event.errorID + ", " + event.subErrorID + ", " + event.text );
    }
    public function onPlayStatus( info:Object ):void
    {
        preloadStream.close();
    }
}
}
```

DRM-related members and events of the NetStream class

Flash Player 10.1 and later, Adobe AIR 1.0 and later

The NetStream class provides a one-way streaming connection between Flash Player or an AIR application, and either Flash Media Server or the local file system. (The NetStream class also supports progressive download.) A NetStream object is a channel within a NetConnection object. The NetStream class dispatches four DRM-related events:

Event	Description
drmAuthenticate (AIR only)	Defined in the DRMAuthenticateEvent class. This event is dispatched when a NetStream object tries to play protected content that requires a user credential for authentication before playback. The properties of this event include header, usernamePrompt, passwordPrompt, and urlPrompt properties that can be used in obtaining and setting the user's credentials. This event occurs repeatedly until the NetStream object receives valid user credentials.
drmError	Defined in the DRMErrorEvent class and dispatched when a NetStream object tries to play protected content and encounters a DRM-related error. For example, DRM error event object is dispatched when the user authorization fails. This error could occur because the user has not purchased the rights to view the content. It could also occur because the content provider does not support the viewing application.
drmStatus	Defined in the DRMStatusEvent class. This event is dispatched when the protected content begins playing (when the user is authenticated and authorized to play the content). The DRMStatusEvent object contains information related to the voucher. Voucher information includes whether the content can be made available offline or when the voucher expires and the content can no longer be viewed.
status	Defined in events.StatusEvent and only dispatched when the application attempts to play protected content, by invoking the NetStream.play() method. The value of the status code property is "DRM.encryptedFLV".

The NetStream class includes the following DRM-specific methods, for use in AIR only:

Method	Description
resetDRMVouchers()	Deletes all the locally cached digital rights management (DRM) voucher data. The application must download the vouchers again for the user to be able to access the encrypted content. For example, the following code removes all vouchers from the cache: NetStream.resetDRMVouchers();
setDRMAuthenticationCredentials()	Passes a set of authentication credentials, namely user name, password, and authentication type, to the NetStream object for authentication. Valid authentication types are `"drm"` and `"proxy"`. With `"drm"` authentication type, the credentials provided are authenticated against Adobe Access. With `"proxy"` authentication type, the credentials authenticate against the proxy server and must match the credentials required by the proxy server. For example, an enterprise can require the application to authenticate against a proxy server before the user can access the Internet. The proxy option allows this type of authentication. Unless anonymous authentication is used, after the proxy authentication, the user must still authenticate against Adobe Access to obtain the voucher and play the content. You can use `setDRMAuthenticationCredentials()` a second time, with "`drm`" option, to authenticate against Adobe Access.
preloadEmbeddedMetadata()	Parses a local media file for embedded metadata. When DRM-related metadata is found, AIR calls the `onDRMContentData()` callback function.

In addition, in AIR, a NetStream object calls the `onDRMContentData()` and `onPlayStatus()` callback functions as a result of a call to the `preloadEmbeddedMetaData()` method. The `onDRMContentData()` function is called when DRM metadata is encountered in a media file. The `onPlayStatus()` function is called when the file has been parsed. The `onDRMContentData()` and `onPlayStatus()` functions must be defined on the `client` object assigned to the NetStream instance. If you use the same NetStream object to preload vouchers and play content, wait for the `onPlayStatus()` call generated by `preloadEmbeddedMetaData()` before starting playback.

In the following code for AIR, user name ("administrator"), password ("password") and the "drm" authentication type are set for authenticating the user. The setDRMAuthenticationCredentials() method must provide credentials that match credentials known and accepted by the content provider. These credentials are the same user credentials that permit the user to view the content. The code for playing the video and making sure that a successful connection to the video stream has been made is not included here.

```
var connection:NetConnection = new NetConnection();
connection.connect(null);

var videoStream:NetStream = new NetStream(connection);

videoStream.addEventListener(DRMAuthenticateEvent.DRM_AUTHENTICATE,
                            drmAuthenticateEventHandler)

private function drmAuthenticateEventHandler(event:DRMAuthenticateEvent):void
{
    videoStream.setDRMAuthenticationCredentials("administrator", "password", "drm");
}
```

Using the DRMStatusEvent class

Flash Player 10.1, Adobe AIR 1.0 and later

A NetStream object dispatches a DRMStatusEvent object when the content protected by Adobe Access begins playing successfully. (Success implies that the license is verified and that the user is authenticated and authorized to view the content). The DRMStatusEvent is also dispatched for anonymous users if they are permitted access. The license is checked to verify whether anonymous users, who do not require authentication, are allowed access to play the content. Anonymous users maybe denied access for various reasons. For example, an anonymous user does not have access to the content when the license has expired.

The DRMStatusEvent object contains information related to the license. Such information includes whether the license can be made available offline or when the voucher expires and the content can no longer be viewed. The application can use this data to convey the user's policy status and its permissions.

DRMStatusEvent properties

Flash Player 10.1, Adobe AIR 1.0 and later

The DRMStatusEvent class includes the following properties. Some properties became available in versions of AIR later than 1.0. For complete version information, see the *ActionScript 3.0 Reference*.

For properties that aren't supported in Flash Player 10.1, the DRMVoucher class provides similar properties for Flash Player.

Property	Description
contentData	A DRMContentData object containing the DRM metadata embedded in the content.
detail (AIR only)	A string explaining the context of the status event. In DRM 1.0, the only valid value is DRM.voucherObtained.
isAnonymous (AIR only)	Indicates whether the content, protected with Adobe Access, is available without requiring a user to provide authentication credentials (true) or not (false). A false value means that the user must provide a user name and password that matches the one known and expected by the content provider.
isAvailableOffline (AIR only)	Indicates whether the content, protected with Adobe Access, can be made available offline (true) or not (false). In order for digitally protected content to be available offline, its voucher must be cached to the user's local machine.
isLocal	Indicates whether the voucher that is required to play the content is cached locally.

Property	Description
offlineLeasePeriod (AIR only)	The remaining number of days that content can be viewed offline.
policies (AIR only)	A custom object that can contain custom DRM properties.
voucher	The DRMVoucher.
voucherEndDate (AIR only)	The absolute date on which the voucher expires and the content is no longer viewable.

Creating a DRMStatusEvent handler

Flash Player 10.1, Adobe AIR 1.0 and later

The following example creates an event handler that outputs the DRM content status information for the NetStream object that originated the event. Add this event handler to a NetStream object that points to protected content.

```
function drmStatusEventHandler(event:DRMStatusEvent):void
{
    trace(event);
}
function drmStatusEventHandler(event:DRMStatusEvent):void
{
    trace(event);
}
```

Using the DRMAuthenticateEvent class

Adobe AIR 1.0 and later

The DRMAuthenticateEvent object is dispatched when a NetStream object tries to play protected content that requires a user credential for authentication before playback.

The DRMAuthenticateEvent handler is responsible for gathering the required credentials (user name, password, and type) and passing the values to the `NetStream.setDRMAuthenticationCredentials()` method for validation. Each AIR application must provide some mechanism for obtaining user credentials. For example, the application could provide a user with a simple user interface to enter the user name and password values. Also, provide a mechanism for handling and limiting repeated authentication attempts.

DRMAuthenticateEvent properties

Adobe AIR 1.0 and later

The DRMAuthenticateEvent class includes the following properties:

Property	**Description**
authenticationType	Indicates whether the supplied credentials are for authenticating against Adobe Access ("drm") or a proxy server ("proxy"). For example, the "proxy" option allows the application to authenticate against a proxy server if necessary before the user can access the Internet. Unless anonymous authentication is used, after the proxy authentication, the user must still authenticate against Adobe Access to obtain the voucher and play the content. You can use setDRMAuthenticationcredentials() a second time, with "drm" option, to authenticate against Adobe Access.
header	The encrypted content file header provided by the server. It contains information about the context of the encrypted content. This header string can be passed on to the Flash application to enable the application to construct a user name-password dialog box. The header string can be used as the dialog box's instructions. For example, the header can be "Please type in your user name and password".
netstream	The NetStream object that initiated this event.
passwordPrompt	A prompt for a password credential, provided by the server. The string can include instruction for the type of password required.
urlPrompt	A prompt for a URL string, provided by the server. The string can provide the location where the user name and password are sent.
usernamePrompt	A prompt for a user name credential, provided by the server. The string can include instruction for the type of user name required. For example, a content provider can require an e-mail address as the user name.

The previously mentioned strings are supplied by the FMRMS server only. Adobe Access Server does not use these strings.

Creating a DRMAuthenticateEvent handler

Adobe AIR 1.0 and later

The following example creates an event handler that passes a set of hard-coded authentication credentials to the NetStream object that originated the event. (The code for playing the video and making sure that a successful connection to the video stream has been made is not included here.)

```
var connection:NetConnection = new NetConnection();
connection.connect(null);

var videoStream:NetStream = new NetStream(connection);

videoStream.addEventListener(DRMAuthenticateEvent.DRM_AUTHENTICATE,
                            drmAuthenticateEventHandler)

private function drmAuthenticateEventHandler(event:DRMAuthenticateEvent):void
{
    videoStream.setDRMAuthenticationCredentials("administrator", "password", "drm");
}
```

Creating an interface for retrieving user credentials

Adobe AIR 1.0 and later

In the case where protected content requires user authentication, the AIR application must usually retrieve the user's authentication credentials via a user interface.

The following is a Flex example of a simple user interface for retrieving user credentials. It consists of a panel object containing two TextInput objects, one for each of the user name and password credentials. The panel also contains a button that launches the `credentials()` method.

```
<mx:Panel x="236.5" y="113" width="325" height="204" layout="absolute" title="Login">
    <mx:TextInput x="110" y="46" id="uName"/>
    <mx:TextInput x="110" y="76" id="pWord" displayAsPassword="true"/>
    <mx:Text x="35" y="48" text="Username:"/>
    <mx:Text x="35" y="78" text="Password:"/>
    <mx:Button x="120" y="115" label="Login" click="credentials()"/>
</mx:Panel>
```

The `credentials()` method is a user-defined method that passes the user name and password values to the `setDRMAuthenticationCredentials()` method. Once the values are passed, the `credentials()` method resets the values of the TextInput objects.

```
<mx:Script>
    <![CDATA[
        public function credentials():void
        {
            videoStream.setDRMAuthenticationCredentials(uName, pWord, "drm");
            uName.text = "";
            pWord.text = "";
        }
    ]]>
</mx:Script>
```

One way to implement this type of simple interface is to include the panel as part of a new state. The new state originates from the base state when the DRMAuthenticateEvent object is thrown. The following example contains a VideoDisplay object with a source attribute that points to a protected FLV file. In this case, the `credentials()` method is modified so that it also returns the application to the base state. This method does so after passing the user credentials and resetting the TextInput object values.

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml"
    layout="absolute"
    width="800"
    height="500"
    title="DRM FLV Player"
    creationComplete="initApp()" >

    <mx:states>
        <mx:State name="LOGIN">
            <mx:AddChild position="lastChild">
                    <mx:Panel x="236.5" y="113" width="325" height="204" layout="absolute"
                            title="Login">
                    <mx:TextInput x="110" y="46" id="uName"/>
                    <mx:TextInput x="110" y="76" id="pWord" displayAsPassword="true"/>
                    <mx:Text x="35" y="48" text="Username:"/>
                    <mx:Text x="35" y="78" text="Password:"/>
                    <mx:Button x="120" y="115" label="Login" click="credentials()"/>
                    <mx:Button x="193" y="115" label="Reset" click="uName.text='';
                            pWord.text='';"/>
                </mx:Panel>
            </mx:AddChild>
        </mx:State>
    </mx:states>
    <mx:Script>
        <![CDATA[
                import flash.events.DRMAuthenticateEvent;
            private function initApp():void
            {
                videoStream.addEventListener(DRMAuthenticateEvent.DRM_AUTHENTICATE,
                                        drmAuthenticateEventHandler);
            }

            public function credentials():void
            {
                videoStream.setDRMAuthenticationCredentials(uName, pWord, "drm");
                uName.text = "";
                pWord.text = "";
                currentState='';
            }

            private function drmAuthenticateEventHandler(event:DRMAuthenticateEvent):void
            {
                currentState='LOGIN';
            }
        ]]>
    </mx:Script>

    <mx:VideoDisplay id="video" x="50" y="25" width="700" height="350"
        autoPlay="true"
        bufferTime="10.0"
        source="http://www.example.com/flv/Video.flv" />
</mx:WindowedApplication>
```

Using the DRMErrorEvent class

Flash Player 10.1 and later, Adobe AIR 1.0 and later

Adobe Flash Player and Adobe AIR dispatch a DRMErrorEvent object when a NetStream object, trying to play protected content, encounters a DRM-related error. If user credentials are invalid in an AIR application, the DRMAuthenticateEvent object repeatedly dispatches until the user enters valid credentials or the application denies further attempts. The application is responsible for listening to any other DRM error events to detect, identify, and handle the DRM-related errors.

Even with valid user credentials, the terms of the content's voucher can still prevent a user from viewing the encrypted content. For example, a user can be denied access for attempting to view content in an unauthorized application. An unauthorized application is one that the publisher of the encrypted content has not validated. In this case, a DRMErrorEvent object is dispatched.

The error events can also be fired if the content is corrupted or if the application's version does not match what the voucher specifies. The application must provide appropriate mechanism for handling errors.

DRMErrorEvent properties

Flash Player 10.1 and later, Adobe AIR 1.0 and later

For a complete list of errors, see the Runtime Error Codes in the ActionScript 3.0 Reference. The DRM-related errors start at error 3300.

Creating a DRMErrorEvent handler

Flash Player 10.1 and later, Adobe AIR 1.0 and later

The following example creates an event handler for the NetStream object that originated the event. It is called when the NetStream encounters an error while attempting to play protected content. Normally, when an application encounters an error, it performs any number of clean-up tasks. It then informs the user of the error and provides options for solving the problem.

```
private function drmErrorEventHandler(event:DRMErrorEvent):void
{
    trace(event.toString());
}
```

Using the DRMManager class

Flash Player 10.1 and later, Adobe AIR 1.5 and later

Use the DRMManager class to manage vouchers and media rights server sessions in applications.

Voucher management (AIR only)

Whenever a user plays protected content, the runtime obtains and caches the license required to view the content. If the application saves the file locally, and the license allows offline playback, the user can view the content in the AIR application. Such local offline playback succeeds even if a connection to the media rights server is not available. Using the DRMManager and the NetStream `preloadEmbeddedMetadata()` method, you can pre-cache the voucher. The application does not have to obtain the license necessary to view the content. For example, your application could download the media file and then obtain the voucher while the user is still online.

To preload a voucher, use the NetStream `preloadEmbeddedMetadata()` method to obtain a DRMContentData object. The DRMContentData object contains the URL and domain of the media rights server that can provide the license and describes whether user authentication is required. With this information, you can call the DRMManager `loadVoucher()` method to obtain and cache the voucher. The workflow for pre-loading vouchers is described in more detail in "Pre-loading vouchers for offline playback" on page 532.

Session management

You can also use the DRMManager to authenticate the user to a media rights server and to manage persistent sessions.

Call the DRMManager `authenticate()` method to establish a session with the media rights server. When authentication is completed successfully, the DRMManager dispatches a DRMAuthenticationCompleteEvent object. This object contains a session token. You can save this token to establish future sessions so that the user does not have to provide their account credentials. Pass the token to the `setAuthenticationToken()` method to establish a new authenticated session. (The settings of the server that generated the token determine the token expiration and other attributes. AIR application code should not interpret the token data structure, because the structure may change in future AIR updates.)

Authentication tokens can be transferred to other computers. To protect tokens, you can store them in the AIR Encrypted Local Store. See "Encrypted local storage" on page 710 for more information.

DRMStatus Events

Flash Player 10.1 and later, Adobe AIR 1.5 and later

The DRMManager dispatches a DRMStatusEvent object after a call to the `loadVoucher()` method completes successfully.

If a voucher is obtained, then the `detail` property (AIR only) of the event object has the value: "DRM.voucherObtained", and the `voucher` property contains the DRMVoucher object.

If a voucher is not obtained, then the `detail` property (AIR only) still has the value: "DRM.voucherObtained"; however, the `voucher` property is `null`. A voucher cannot be obtained if, for example, you use the LoadVoucherSetting of *localOnly* and there is no locally cached voucher.

If the `loadVoucher()` call does not complete successfully, perhaps because of an authentication or communication error, then the DRMManager dispatches a DRMErrorEvent or DRMAuthenticationErrorEvent object instead.

DRMAuthenticationComplete events

Flash Player 10.1 and later, Adobe AIR 1.5 and later

The DRMManager dispatches a DRMAuthenticationCompleteEvent object when a user is successfully authenticated through a call to the `authenticate()` method.

The DRMAuthenticationCompleteEvent object contains a reusable token that can be used to persist user authentication across application sessions. Pass this token to DRMManager `setAuthenticationToken()` method to re-establish the session. (The token creator sets token attributes such as expiration. Adobe does not provide an API for examining token attributes.)

DRMAuthenticationError events

Flash Player 10.1 and later, Adobe AIR 1.5 and later

The DRMManager dispatches a DRMAuthenticationErrorEvent object when a user cannot be successfully authenticated through a call to the `authenticate()` or `setAuthenticationToken()` methods.

Using the DRMContentData class

Flash Player 10.1 and later, Adobe AIR 1.5 and later

The DRMContentData object contains the metadata properties of content protected by Adobe Access. The DRMContentData properties contain the information necessary to obtain a license voucher for viewing the content. You can use the DRMContentData class to get the metadata file associated with content, as described in the "Detailed API workflow" on page 530.

For more information, see the DRMContentData class in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Updating Flash Player to support Adobe Access

Flash Player 10.1 and later

Important: Flash Player 11.5 and above integrates the Adobe Access module, so the update step (calling `SystemUpdater.update(SystemUpdaterType.DRM)`) is unnecessary. This includes the following browsers and platforms:

- Flash Player 11.5 ActiveX control, for all platforms except Internet Explorer on Windows 8
- Flash Player 11.5 plugin, for all browsers
- Adobe AIR (desktop and mobile)

This means that the update step is *still required* in the following cases:

- Internet Explorer on Windows 8
- Flash Player 11.4 and below, except on Google Chrome 22 and above (all platforms) or 21 and above (Windows)

Note: *You can still safely call* `SystemUpdater.update(SystemUpdaterType.DRM)` *on a system with Flash Player 11.5 or higher, but nothing is downloaded.*

To support Adobe Access, Flash Player requires the Adobe Access module. When Flash Player tries to play protected content, the runtime indicates if the module or a new version of Flash Player must be downloaded. In this way, Flash Player allows SWF developers the option of not updating if desired.

In most cases, to play protected content, SWF developers update to the required Adobe Access module or player. To update, you can use the SystemUpdater API to get the latest version of the Adobe Access module or of Flash Player.

The SystemUpdater API permits only one update at a time. The error code 2202 indicates that an update is already occurring in the current runtime instance or another instance. For example, if an update is occurring in a Flash Player instance in Internet Explorer, an update cannot proceed in a Flash Player instance running in Firefox.

The SystemUpdater API is supported for desktop platforms only.

Note: *For versions of Flash Player earlier than 10.1, use the update mechanism supported in earlier player versions (manual download and install from www.adobe.com or ExpressInstall). Also, the AIR installer handles necessary updates for Adobe Access and does not support the SystemUpdater API.*

Listening for an update event

Flash Player 10.1 and later

When an update of the Adobe Access module is required, the NetStream object dispatches a NetStatusEvent with a code value of `DRM.UpdateNeeded`. This value indicates that the NetStream object cannot play back the protected stream with any of the currently installed Adobe Access modules. Listen for this event and call the following code:

```
SystemUpdater.update(flash.system.SystemUpdaterType.DRM)
```

This code updates the Adobe Access module installed in the player. User consent for this module update is not required.

If the Adobe Access module is not found, an error is thrown. See step 3 of the "Detailed API workflow" on page 530.

***Note:** If play() is called on an encrypted stream in players earlier than 10.1, a NetStatusEvent with code value of NetStream.Play.StreamNotFound is dispatched. For earlier players, use the update mechanism supported for those players (manual download and install from www.adobe.com or ExpressInstall).*

When an update of the player itself is required, the SystemUpdater object dispatches a StatusEvent with a code value of `DRM.UpdateNeededButIncompatible` is dispatched. For an update of the player, user consent is required. In your application, provide an interface for the user to agree to and initiate the update of the player. Listen for the StatusEvent event and call the following code:

```
SystemUpdater.update(flash.system.SystemUpdaterType.SYSTEM);
```

This code initiates the update of the player.

Additional events for the SystemUpdater class are documented in the ActionScript 3.0 Reference for the Adobe Flash Platform.

After the player update completes, the user is redirected to the page where the update began. The Adobe Access module is downloaded, and the stream can begin playing.

Out-of-band Licenses

Flash Player 11 and later, Adobe AIR 3.0 and later

Licenses can also be obtained out-of-band (without contacting a Adobe Access License Server) by storing the voucher (license) on disk and in memory using the `storeVoucher` method.

To play encrypted videos in Flash Player and AIR, the respective runtime needs to obtain the DRM voucher for that video. The DRM voucher contains the video's decryption key and is generated by the Adobe Access License Server that the customer has deployed.

The Flash Player/AIR runtime generally obtains this voucher by sending a voucher request to the Adobe Access License Server indicated in the video's DRM metadata (`DRMContentData` class). The Flash/AIR application can trigger this license request by calling the `DRMManager.loadVoucher()` method. Or, the Flash Player/AIR runtime will automatically request a license at the start of the encrypted video playback if there is no license for the content on disk or in memory. In either case, the Flash/AIR application's performance gets impacted by communicating with the Adobe Access License Server.

`DRMManager.storeVoucher()` allows the Flash/AIR application to send DRM vouchers that it has obtained out-of-band to the Flash Player/AIR runtime. The runtime can then skip the license request process and use the forwarded vouchers for playing encrypted videos. The DRM voucher still needs to be generated by the Adobe Access License Server before it can be obtained out-of-band. However, you have the option of hosting the vouchers on any HTTP server, instead of a public-facing Adobe Access license server.

`DRMManager.storeVoucher()` is also used to support DRM voucher sharing between multiple devices. In Adobe Access 3.0, this feature is referred to as "Domain Support". If your deployment supports this use case, you can register multiple machines to a device group using the `DRMManager.addToDeviceGroup()` method. If there is a machine with a valid domain-bound voucher for a given content, the AIR application can then extract the serialized DRM vouchers using the `DRMVoucher.toByteArray()` method and on your other machines you can import the vouchers using the `DRMManager.storeVoucher()`method.

Device registration

The DRM vouchers are bound to the end user's machine. Hence Flash /AIR applications will need a unique ID for the user's machine to refer to the right serialized DRM voucher object. The following scenario depicts a device registration process:

Assuming that you have performed the following tasks:

- You have set up the Adobe Access Server SDK.
- You have set up an HTTP server for obtaining pre-generated licenses.
- You have created a Flash application to view the protected content.

The device registration phase involves the following actions:

1. The Flash application creates a randomly generated ID.
2. The Flash application invokes the `DRMManager.authenticate()` method. The application must include the randomly generated ID in the authentication request. For instance, include the ID in the username field.
3. The action mentioned in Step 2 will result in Adobe Access sending an authentication request to the customer's server. This request includes the device certificate.
   - a The server extracts the device certificate and the generated ID from the request and stores.
   - b The customer sub-system pre-generates licenses for this device certificate, stores them and grants access to them in a way that associates them with the generated ID.
4. The server responds to the request with a "success" message.
5. The Flash application stores the generated ID locally in a Local Shared Object (LSO).

After the device registration, the Flash application uses the generated ID in the same way as it would have used the device ID in the previous scheme:

1. The Flash application will try to locate the generated ID in LSO.
2. If the generated ID is found, the Flash application will use the generated ID while downloading the pre-generated licenses. The Flash application will send the licenses to the Adobe Access client for consumption using the `DRMManager.storeVoucher()` method.
3. If the generated ID is not found, the Flash application will go through the device registration procedure.

Factory reset

When the user of the device invokes the factory reset option, the device certificate will be purged. To continue playing the protected content, the Flash application will need to go through the device registration procedure again. If the Flash application sends an outdated pre-generated license, the Adobe Access client will reject it since the license was encrypted for an older device ID.

Domain support

Flash Player 11 and later, Adobe AIR 3.0 and later

If the content metadata specifies that domain registration is required, the AIR application can invoke an API to join a device group. This action triggers a domain registration request to be sent to the domain server. Once a license is issued to a device group, the license can be exported and shared with other devices that have joined the device group.

The device group information is then used in the `DRMContentData`'s `VoucherAccessInfo` object, which will then be used to present the information that is required to successfully retrieve and consume a voucher.

Playing encrypted content using domain support

To play encrypted content using Adobe Access, perform the following steps:

1 Using `VoucherAccessInfo.deviceGroup`, check if device group registration is required.

2 If authentication is required:

   a Use the `DeviceGroupInfo.authenticationMethod` property find out if authentication is required.

   b If authentication is required, authenticate the user by performing ONE of the following steps:

   - Obtain user's username and password. Invoke `DRMManager.authenticate(deviceGroup.serverURL, deviceGroup.domain, username, password).`
   - Obtain a cached/pre-generated authentication token and invoke `DRMManager.setAuthenticationToken().`

   c Invoke `DRMManager.addToDeviceGroup().`

3 Get the voucher for the content by performing one of the following tasks:

   a Use the `DRMManager.loadVoucher()` method.

   b Obtain the voucher from a different device registered in the same device group. Provide the voucher to the `DRMManager` through the `DRMManager.storeVoucher()` method.

4 Play the encrypted content using the `NetStream.play()` method.

To export the license for the content, any of the devices can provide the license's raw bytes using the `DRMVoucher.toByteArray()` method after obtaining the license from the Adobe Access License Server. Content providers typically limit the number of devices in a device group. If the limit is reached, you may need to call the `DRMManager.removeFromDeviceGroup()` method on an unused device before registering the current device.

License preview

The Flash application can send a license preview request, meaning that the application can carry out a preview operation before asking the user to buy the content in order to determine whether the user's machine actually meets all the criteria required for playback. License preview refers to the client's ability to preview the license (to see what rights the license allows) as opposed to previewing the content (viewing a small portion of the content before deciding to buy). Some of the parameters that are unique to each machine are: outputs available and their protection status, the runtime/DRM version available, and the DRM client security level. The license preview mode allows the runtime/DRM client to test the license server business logic and provide information back to the user so he can make an informed decision. Thus the client can see what a valid license looks like but would not actually receive the key to decrypt the content. Support for license preview is optional, and only necessary if you implement a custom application that uses this functionality.

Delivering content

Adobe Access is agnostic to the delivery mechanism of the content as the Flash Player abstracts out the networking layer and simply provides the protected content to the Adobe Access subsystem. Hence, content can be delivered through HTTP, HTTP Dynamic Streaming, RTMP, or RTMPE.

However, you may get some issues due to the necessity of the protected content's metadata (usually in the form of a '.metadata' file) before Adobe Access can acquire a license to decrypt the content. Specifically, with the RTMP/RTMPE protocol, only FLV and F4V data can be delivered to the client through the Flash Media Server (FMS). Because of this, the client must retrieve the metadata blob by other ways. One option to solve this problem is to host the metadata on an HTTP web server, and implement the client video player to retrieve the appropriate metadata, depending on the content being played back.

```
private function getMetadata():void{

    extrapolated-path-to-metadata = "http://metadatas.mywebserver.com/" + videoname;
    var urlRequest : URLRequest = new URLRequest(extrapolated-path-to-the-metadata + ".metadata");
    var urlStream : URLStream = new URLStream();
    urlStream.addEventListener(Event.COMPLETE, handleMetadata);
    urlStream.addEventListener(IOErrorEvent.NETWORK_ERROR, handleIOError);
    urlStream.addEventListener(IOErrorEvent.IO_ERROR, handleIOError);
    urlStream.addEventListener(IOErrorEvent.VERIFY_ERROR, handleIOError);
    try{
        urlStream.load(urlRequest);
     }catch(se:SecurityError){
        videoLog.text += se.toString() + "\n";
     }catch(e:Error){
        videoLog.text += e.toString() + "\n";
     }
}
```

Open Source Media Framework

Open Source Media Framework (OSMF) is an ActionScript-based framework that gives you complete flexibility and control in creating your own rich media experiences. For more information on OSMF, visit the OSMF Developer Site.

Workflow for playing protected content

1 Create a `MediaPlayer` instance.

```
player = new MediaPlayer();
```

2 Register `MediaPlayerCapabilityChangeEvent.HAS_DRM_CHANGE` event to the player. This event will be dispatched if the content is DRM protected.

```
player.addEventListener(MediaPlayerCapabilityChangeEvent.HAS_DRM_CHANGE,
onDRMCapabilityChange);
```

3 In the event handler, obtain the `DRMTrait` instance. `DRMTrait` is the interface through which you invoke DRM-related methods, such as `authenticate()`. When loading a DRM-protected content, OSMF performs the DRM validating actions and dispatches state events. Add a `DRMEvent.DRM_STATE_CHANGE` event handler to the `DRMTrait`.

```
private function onDRMCapabilityChange
    (event :MediaPlayerCapabilityChangeEvent) :void
        {
            if (event.type == MediaPlayerCapabilityChangeEvent.HAS_DRM_CHANGE
                && event.enabled)
            {
                drmTrait = player.media.getTrait(MediaTraitType.DRM) as DRMTrait;
                drmTrait.addEventListener
                    (DRMEvent.DRM_STATE_CHANGE, onDRMStateChange);
            }
        }
```

4 Handle the DRM events in the `onDRMStateChange()` method.

```
        private function onDRMStateChange(event :DRMEvent) :void
        {
            trace ( "DRMState: ",event.drmState);
            switch(event.drmState)
            {
                case DRMState.AUTHENTICATION_NEEDED:
                    // Identity-based content
                    var authPopup :AuthWindow = AuthWindow.create(_parentWin);
                    authPopup.serverURL = event.serverURL;
                    authPopup.addEventListener("dismiss", function () :void {
                        trace ("Authentication dismissed");
                        if(_drmTrait != null)
                        {
                            //Ignore authentication. Just
                            //try to acquire a license.
                            _drmTrait.authenticate(null, null);
                        }
                    });
                    authPopup.addEventListener("authenticate",
                                    function (event :AuthWindowEvent) :void {
                        if(_drmTrait != null)
                        {
                            _drmTrait.authenticate(event.username, event.password);
                        }
                    });
                    authPopup.show();
                    break;
                case DRMState.AUTHENTICATING:
                    //Display any authentication message.
                    trace("Authenticating...");
                    break;
                case DRMState.AUTHENTICATION_COMPLETE:
                    // Start to retrieve voucher and playback.
                    // You can display the voucher information at this point.
                    if(event.token)
                    // You just received the authentication token.
                    {
                        trace("Authentication success. Token: \n", event.token);
                    }
                    else
                    // You have got the voucher.
                    {
                        trace("DRM License:");
                        trace("Playback window period: ",
                            !isNaN(event.period) ? event.period == 0 ?
                            "<unlimited>" : event.period : "<none>");
                        trace("Playback window end date: ",
                            event.endDate != null ? event.endDate : "<none>");
                        trace("Playback window start date: ",
                            event.startDate != null ? event.startDate : "<none>");
                    }
                    break;
                case DRMState.AUTHENTICATION_ERROR:
                    trace ("DRM Error:", event.mediaError.errorID +
                        "[" + DRMErrorEventRef.getDRMErrorMnemonic
                        (event.mediaError.errorID) + "]");
                    //Stop everything.
                    player.media = null;
                    break;
                case DRMState.DRM_SYSTEM_UPDATING:
                    Logger.log("Downloading DRM module...");
                    break;
                case DRMState.UNINITIALIZED:
                    break;
            }
        }
```

Chapter 28: Adding PDF content in AIR

Adobe AIR 1.0 and later

Applications running in Adobe® AIR® can render not only SWF and HTML content, but also PDF content. AIR applications render PDF content using the HTMLLoader class, the WebKit engine, and the Adobe® Reader® browser plug-in. In an AIR application, PDF content can either stretch across the full height and width of your application or alternatively as a portion of the interface. The Adobe Reader browser plug-in controls display of PDF files in an AIR application. modifications to the Reader toolbar interface (such as controls for position, anchoring, and visibility) persist in subsequent viewing of PDF files in both AIR applications and the browser.

Important: *To render PDF content in AIR, the user must have Adobe Reader or Adobe® Acrobat® version 8.1 or higher installed.*

Detecting PDF Capability

Adobe AIR 1.0 and later

If the user does not have Adobe Reader or Adobe Acrobat 8.1 or higher, PDF content is not displayed in an AIR application. To detect if a user can render PDF content, first check the `HTMLLoader.pdfCapability` property. This property is set to one of the following constants of the HTMLPDFCapability class:

Constant	Description
HTMLPDFCapability.STATUS_OK	A sufficient version (8.1 or greater) of Adobe Reader is detected and PDF content can be loaded into an HTMLLoader object.
HTMLPDFCapability.ERROR_INSTALLED_READER_NOT_FOUND	No version of Adobe Reader is detected. An HTMLLoader object cannot display PDF content.
HTMLPDFCapability.ERROR_INSTALLED_READER_TOO_OLD	Adobe Reader has been detected, but the version is too old. An HTMLLoader object cannot display PDF content.
HTMLPDFCapability.ERROR_PREFERRED_READER_TOO_OLD	A sufficient version (8.1 or later) of Adobe Reader is detected, but the version of Adobe Reader that is set up to handle PDF content is older than Reader 8.1. An HTMLLoader object cannot display PDF content.

On Windows, if Adobe Acrobat or Adobe Reader version 7.x or above is running on the user's system, that version is used even if a later version that supports loading PDF is installed. In this case, if the value of the `pdfCapability` property is `HTMLPDFCapability.STATUS_OK`, when an AIR application attempts to load PDF content, the older version of Acrobat or Reader displays an alert (and no exception is thrown in the AIR application). If this is a possible situation for your end users, consider providing them with instructions to close Acrobat while running your application. You may want to display these instructions if the PDF content does not load within an acceptable time frame.

On Linux, AIR looks for Adobe Reader in the PATH exported by the user (if it contains the acroread command) and in the /opt/Adobe/Reader directory.

The following code detects whether a user can display PDF content in an AIR application. If the user cannot display PDF, the code traces the error code that corresponds to the HTMLPDFCapability error object:

```
 if(HTMLLoader.pdfCapability == HTMLPDFCapability.STATUS_OK)
{
    trace("PDF content can be displayed");
}
else
{
    trace("PDF cannot be displayed. Error code:", HTMLLoader.pdfCapability);
}
```

Loading PDF content

Adobe AIR 1.0 and later

You can add a PDF to an AIR application by creating an HTMLLoader instance, setting its dimensions, and loading the path of a PDF.

The following example loads a PDF from an external site. Replace the URLRequest with the path to an available external PDF.

```
 var request:URLRequest = new URLRequest("http://www.example.com/test.pdf");
pdf = new HTMLLoader();
pdf.height = 800;
pdf.width = 600;
pdf.load(request);
container.addChild(pdf);
```

You can also load content from file URLs and AIR-specific URL schemes, such as app and app-storage. For example, the following code loads the test.pdf file in the PDFs subdirectory of the application directory:

app:/js_api_reference.pdf

For more information on AIR URL schemes, see "URI schemes" on page 813.

Scripting PDF content

Adobe AIR 1.0 and later

You can use JavaScript to control PDF content just as you can in a web page in the browser.

JavaScript extensions to Acrobat provide the following features, among others:

- Controlling page navigation and magnification
- Processing forms within the document
- Controlling multimedia events

Full details on JavaScript extensions for Adobe Acrobat are provided at the Adobe Acrobat Developer Connection at http://www.adobe.com/devnet/acrobat/javascript.html.

HTML-PDF communication basics

Adobe AIR 1.0 and later

JavaScript in an HTML page can send a message to JavaScript in PDF content by calling the `postMessage()` method of the DOM object representing the PDF content. For example, consider the following embedded PDF content:

```
<object id="PDFObj" data="test.pdf" type="application/pdf" width="100%" height="100%"/>
```

The following JavaScript code in the containing HTML content sends a message to the JavaScript in the PDF file:

```
pdfObject = document.getElementById("PDFObj");
pdfObject.postMessage(["testMsg", "hello"]);
```

The PDF file can include JavaScript for receiving this message. You can add JavaScript code to PDF files in some contexts, including the document-, folder-, page-, field-, and batch-level contexts. Only the document-level context, which defines scripts that are evaluated when the PDF document opens, is discussed here.

A PDF file can add a `messageHandler` property to the `hostContainer` object. The `messageHandler` property is an object that defines handler functions to respond to messages. For example, the following code defines the function to handle messages received by the PDF file from the host container (which is the HTML content embedding the PDF file):

```
this.hostContainer.messageHandler = {onMessage: myOnMessage};

function myOnMessage(aMessage)
{
    if(aMessage[0] == "testMsg")
    {
        app.alert("Test message: " + aMessage[1]);
    }
    else
    {
        app.alert("Error");
    }
}
```

JavaScript code in the HTML page can call the `postMessage()` method of the PDF object contained in the page. Calling this method sends a message (`"Hello from HTML"`) to the document-level JavaScript in the PDF file:

```
 <html>
    <head>
    <title>PDF Test</title>
    <script>
        function init()
        {
            pdfObject = document.getElementById("PDFObj");
            try {
                 pdfObject.postMessage(["alert", "Hello from HTML"]);
            }
            catch (e)
            {
                alert( "Error: \n name = " + e.name + "\n message = " + e.message );
            }
        }
    </script>
    </head>
    <body onload='init()'>
        <object
            id="PDFObj"
            data="test.pdf"
            type="application/pdf"
            width="100%" height="100%"/>
    </body>
</html>
```

For a more advanced example, and for information on using Acrobat 8 to add JavaScript to a PDF file, see Cross-scripting PDF content in Adobe AIR.

Scripting PDF content from ActionScript

Adobe AIR 1.0 and later

ActionScript code (in SWF content) cannot directly communicate with JavaScript in PDF content. However, ActionScript can communicate with the JavaScript in the HTML page loaded in an HTMLLoader object that loads PDF content, and that JavaScript code can communicate with the JavaScript in the loaded PDF file. For more information, see "Programming HTML and JavaScript in AIR" on page 981.

Known limitations for PDF content in AIR

Adobe AIR 1.0 and later

PDF content in Adobe AIR has the following limitations:

- PDF content does not display in a window (a NativeWindow object) that is transparent (where the `transparent` property is set to `true`).
- The display order of a PDF file operates differently than other display objects in an AIR application. Although PDF content clips correctly according to HTML display order, it will always sit on top of content in the AIR application's display order.

- If certain visual properties of an HTMLLoader object that contains a PDF document are changed, the PDF document will become invisible. These properties include the `filters`, `alpha`, `rotation`, and `scaling` properties. Changing these properties renders the PDF content invisible until the properties are reset. The PDF content is also invisible if you change these properties of display object containers that contain the HTMLLoader object.
- PDF content is visible only when the `scaleMode` property of the Stage object of the NativeWindow object containing the PDF content is set to `StageScaleMode.NO_SCALE`. When it is set to any other value, the PDF content is not visible.
- Clicking links to content within the PDF file update the scroll position of the PDF content. Clicking links to content outside the PDF file redirect the HTMLLoader object that contains the PDF (even if the target of a link is a new window).
- PDF commenting workflows do not function in AIR.

Chapter 29: Basics of user interaction

Flash Player 9 and later, Adobe AIR 1.0 and later

Your application can create interactivity by using ActionScript 3.0 to respond to user activity. Note that this section assumes that you are already familiar with the ActionScript 3.0 event model. For more information, see "Handling events" on page 125.

Capturing user input

Flash Player 9 and later, Adobe AIR 1.0 and later

User interaction, whether by keyboard, mouse, camera, or a combination of these devices, is the foundation of interactivity. In ActionScript 3.0, identifying and responding to user interaction primarily involves listening to events.

The InteractiveObject class, a subclass of the DisplayObject class, provides the common structure of events and functionality necessary for handling user interaction. You do not directly create an instance of the InteractiveObject class. Instead, display objects such as SimpleButton, Sprite, TextField, and various Flash authoring tool and Flex components inherit their user interaction model from this class and therefore share a common structure. This means that the techniques you learn and the code you write to handle user interaction in an object derived from InteractiveObject are applicable to all the others.

Important concepts and terms

It's important to familiarize yourself with the following key user interaction terms before proceeding:

Character code A numeric code representing a character in the current character set (associated with a key being pressed on the keyboard). For example, "D" and "d" have different character codes even though they're created by the same key on a U.S. English keyboard.

Context menu The menu that appears when a user right-clicks or uses a particular keyboard-mouse combination. Context menu commands typically apply directly to what has been clicked. For example, a context menu for an image may contain a command to show the image in a separate window and a command to download it.

Focus The indication that a selected element is active and that it is the target of keyboard or mouse interaction.

Key code A numeric code corresponding to a physical key on the keyboard.

More Help topics

InteractiveObject

Keyboard

Mouse

ContextMenu

Managing focus

Flash Player 9 and later, Adobe AIR 1.0 and later

An interactive object can receive focus, either programmatically or through a user action. Additionally, if the `tabEnabled` property is set to `true`, the user can pass focus from one object to another by pressing the Tab key. Note that the `tabEnabled` value is `false` by default, except in the following cases:

- For a SimpleButton object, the value is `true`.
- For a input text field, the value is `true`.
- For a Sprite or MovieClip object with `buttonMode` set to `true,` the value is `true`.

In each of these situations, you can add a listener for `FocusEvent.FOCUS_IN` or `FocusEvent.FOCUS_OUT` to provide additional behavior when focus changes. This is particularly useful for text fields and forms, but can also be used on sprites, movie clips, or any object that inherits from the InteractiveObject class. The following example shows how to enable focus cycling with the Tab key and how to respond to the subsequent focus event. In this case, each square changes color as it receives focus.

Note: *Flash Professional uses keyboard shortcuts to manage focus; therefore, to properly simulate focus management, SWF files should be tested in a browser or AIR rather than within Flash.*

```
var rows:uint = 10;
var cols:uint = 10;
var rowSpacing:uint = 25;
var colSpacing:uint = 25;
var i:uint;
var j:uint;
for (i = 0; i < rows; i++)
{
    for (j = 0; j < cols; j++)
    {
        createSquare(j * colSpacing, i * rowSpacing, (i * cols) + j);
    }
}

function createSquare(startX:Number, startY:Number, tabNumber:uint):void
{
    var square:Sprite = new Sprite();
    square.graphics.beginFill(0x000000);
    square.graphics.drawRect(0, 0, colSpacing, rowSpacing);
    square.graphics.endFill();
    square.x = startX;
    square.y = startY;
    square.tabEnabled = true;
    square.tabIndex = tabNumber;
    square.addEventListener(FocusEvent.FOCUS_IN, changeColor);
    addChild(square);
}
function changeColor(event:FocusEvent):void
{
    event.target.transform.colorTransform = getRandomColor();
}
function getRandomColor():ColorTransform
{
    // Generate random values for the red, green, and blue color channels.
    var red:Number = (Math.random() * 512) - 255;
    var green:Number = (Math.random() * 512) - 255;
    var blue:Number = (Math.random() * 512) - 255;

    // Create and return a ColorTransform object with the random colors.
    return new ColorTransform(1, 1, 1, 1, red, green, blue, 0);
}
```

Discovering input types

Flash Player 10.1 and later, Adobe AIR 2 and later

The Flash Player 10.1 and Adobe AIR 2 releases introduced the ability to test the runtime environment for support of specific input types. You can use ActionScript to test if the device on which the runtime is currently deployed:

- Supports stylus or finger input (or no touch input at all).
- Has a virtual or physical keyboard for the user (or no keyboard at all).
- Displays a cursor (if not, then features that are dependent upon having a cursor hover over an object do not work).

The input discovery ActionScript APIs include:

- flash.system.Capabilities.touchscreenType property: A value provided at runtime indicating what input type is supported in the current environment.
- flash.system.TouchscreenType class: A class of enumeration value constants for the Capabilities.touchscreenType property.
- flash.ui.Mouse.supportsCursor property: A value provided at runtime indicating if a persistent cursor is available or not.
- flash.ui.Keyboard.physicalKeyboardType property: A value provided at runtime indicating if a full physical keyboard is available or a numeric keypad, only, or no keyboard at all.
- flash.ui.KeyboardType class: A class of enumeration value constants for the flash.ui.Keyboard.physicalKeyboardType property.
- flash.ui.Keyboard.hasVirtualKeyboard property: A value provided at runtime indicating if a virtual keyboard is provided to the user (either in place of a physical keyboard, or in addition to a physical keyboard).

The input discovery APIs let you take advantage of a user's device capabilities, or provide alternatives when those capabilities are not present. These API are especially useful for developing mobile and touch-enabled applications. For example, if you have an interface for a mobile device that has small buttons for a stylus, you can provide an alternative interface with larger buttons for a user using finger touches for input. The following code is for an application that has a function called createStylusUI() that assigns one set of user interface elements appropriate for stylus interaction. Another function, called createTouchUI(), assigns another set of user interface elements appropriate for finger interaction:

```
if(Capabilities.touchscreenType == TouchscreenType.STYLUS ){
    //Construct the user interface using small buttons for a stylus
    //and allow more screen space for other visual content
    createStylusUI();
} else if(Capabilities.touchscreenType = TouchscreenType.FINGER){
    //Construct the user interface using larger buttons
    //to capture a larger point of contact with the device
    createTouchUI();
}
```

When developing applications for different input environments, consider the following compatibility chart:

Environment	supportsCursor	touchscreenType == FINGER	touchscreenType == STYLUS	touchscreenType == NONE
Traditional Desktop	true	false	false	true
Capacitive Touchscreen Devices (tablets, PDAs, and phones that detect subtle human touch, such as the Apple iPhone or Palm Pre)	false	true	false	false
Resistive Touchscreen devices (tablets, PDAs, and phones that detect precise, high-pressure contact, such as the HTC Fuze)	false	false	true	false
Non-Touchscreen devices (feature phones and devices that run applications but don't have screens that detect contact)	false	false	false	true

Note: *Different device platforms can support many combinations of input types. Use this chart as a general guide.*

Chapter 30: Keyboard input

Flash Player 9 and later, Adobe AIR 1.0 and later

Your application can capture and respond to keyboard input and can manipulate an IME to let users type non-ASCII text characters in multibyte languages. Note that this section assumes that you are already familiar with the ActionScript 3.0 event model. For more information, see “Handling events” on page 125.

For information on discovering what kind of keyboard support is available (such as physical, virtual, alphanumeric, or 12-button numeric) during runtime, see “Discovering input types” on page 558.

An Input Method Editor (IME) allows users to type complex characters and symbols using a standard keyboard. You can use the IME classes to enable users to take advantage of their system IME in your applications.

More Help topics

flash.events.KeyboardEvent

flash.system.IME

Capturing keyboard input

Flash Player 9 and later, Adobe AIR 1.0 and later

Display objects that inherit their interaction model from the InteractiveObject class can respond to keyboard events by using event listeners. For example, you can place an event listener on the Stage to listen for and respond to keyboard input. In the following code, an event listener captures a key press, and the key name and key code properties are displayed:

```
function reportKeyDown(event:KeyboardEvent):void
{
    trace("Key Pressed: " + String.fromCharCode(event.charCode) + " (character code: " +
event.charCode + ")");
}
stage.addEventListener(KeyboardEvent.KEY_DOWN, reportKeyDown);
```

Some keys, such as the Ctrl key, generate events even though they have no glyph representation.

In the previous code example, the keyboard event listener captured keyboard input for the entire Stage. You can also write an event listener for a specific display object on the Stage; this event listener is triggered when the object has the focus.

In the following example, keystrokes are reflected in the Output panel only when the user types inside the TextField instance. Holding the Shift key down temporarily changes the border color of the TextField to red.

This code assumes there is a TextField instance named `tf` on the Stage.

```
tf.border = true;
tf.type = "input";
tf.addEventListener(KeyboardEvent.KEY_DOWN,reportKeyDown);
tf.addEventListener(KeyboardEvent.KEY_UP,reportKeyUp);

function reportKeyDown(event:KeyboardEvent):void
{
    trace("Key Pressed: " + String.fromCharCode(event.charCode) + " (key code: " +
event.keyCode + " character code: " + event.charCode + ")");
    if (event.keyCode == Keyboard.SHIFT) tf.borderColor = 0xFF0000;
}

function reportKeyUp(event:KeyboardEvent):void
{
    trace("Key Released: " + String.fromCharCode(event.charCode) + " (key code: " +
event.keyCode + " character code: " + event.charCode + ")");
    if (event.keyCode == Keyboard.SHIFT)
    {
        tf.borderColor = 0x000000;
    }
}
```

The TextField class also reports a `textInput` event that you can listen for when a user enters text. For more information, see "Capturing text input" on page 378.

Note: *In the AIR runtime, a keyboard event can be canceled. In the Flash Player runtime, a keyboard event cannot be canceled.*

Key codes and character codes

Flash Player 9 and later, Adobe AIR 1.0 and later

You can access the `keyCode` and `charCode` properties of a keyboard event to determine what key was pressed and then trigger other actions. The `keyCode` property is a numeric value that corresponds to the value of a key on the keyboard. The `charCode` property is the numeric value of that key in the current character set. (The default character set is UTF-8, which supports ASCII.)

The primary difference between the key code and character values is that a key code value represents a particular key on the keyboard (the 1 on a keypad is different than the 1 in the top row, but the key that generates "1" and the key that generates "!" are the same key) and the character value represents a particular character (the R and r characters are different).

Note: *For the mappings between keys and their character code values in ASCII, see the flash.ui.Keyboard class in the ActionScript 3.0 Reference for the Adobe Flash Platform.*

The mappings between keys and their key codes is dependent on the device and the operating system. For this reason, you should not use key mappings to trigger actions. Instead, you should use the predefined constant values provided by the Keyboard class to reference the appropriate `keyCode` properties. For example, instead of using the key mapping for the Shift key, use the `Keyboard.SHIFT` constant (as shown in the preceding code sample).

KeyboardEvent precedence

Flash Player 9 and later, Adobe AIR 1.0 and later

As with other events, the keyboard event sequence is determined by the display object hierarchy and not the order in which `addEventListener()` methods are assigned in code.

For example, suppose you place a text field called `tf` inside a movie clip called `container` and add an event listener for a keyboard event to both instances, as the following example shows:

```
container.addEventListener(KeyboardEvent.KEY_DOWN,reportKeyDown);
container.tf.border = true;
container.tf.type = "input";
container.tf.addEventListener(KeyboardEvent.KEY_DOWN,reportKeyDown);

function reportKeyDown(event:KeyboardEvent):void
{
    trace(event.currentTarget.name + " hears key press: " + String.fromCharCode(event.charCode)
+ " (key code: " + event.keyCode + " character code: " + event.charCode + ")");
}
```

Because there is a listener on both the text field and its parent container, the `reportKeyDown()` function is called twice for every keystroke inside the TextField. Note that for each key pressed, the text field dispatches an event before the `container` movie clip dispatches an event.

The operating system and the web browser will process keyboard events before Adobe Flash Player or AIR. For example, in Microsoft Internet Explorer, pressing Ctrl+W closes the browser window before any contained SWF file dispatches a keyboard event.

Using the IME class

Flash Player 9 and later, Adobe AIR 1.0 and later

The IME class lets you manipulate the operating system's IME within Flash Player or Adobe AIR.

Using ActionScript, you can determine the following:

- If an IME is installed on the user's computer (`Capabilities.hasIME`)
- If the IME is enabled or disabled on the user's computer (`IME.enabled`)
- The conversion mode the current IME is using (`IME.conversionMode`)

You can associate an input text field with a particular IME context. When you switch between input fields, you can also switch the IME between Hiragana (Japanese), full-width numbers, half-width numbers, direct input, and so on.

An IME lets users type non-ASCII text characters in multibyte languages, such as Chinese, Japanese, and Korean.

For more information on working with IMEs, see the documentation for the operating system for which you are developing the application. For additional resources, see the following web sites:

- http://www.msdn.microsoft.com/goglobal/
- http://developer.apple.com/library/mac/navigation/
- http://www.java.sun.com/

***Note:** If an IME is not active on the user's computer, calls to IME methods or properties, other than `Capabilities.hasIME`, will fail. Once you manually activate an IME, subsequent ActionScript calls to IME methods and properties will work as expected. For example, if you are using a Japanese IME, you must activate it before you can call any IME method or property.*

Checking if an IME is installed and enabled

Flash Player 9 and later, Adobe AIR 1.0 and later

Before you call any of the IME methods or properties, you should always check to see if the user's computer currently has an IME installed and enabled. The following code illustrates how to check that the user has an IME both installed and active before you call any methods:

```
if (Capabilities.hasIME)
{
    if (IME.enabled)
    {
        trace("IME is installed and enabled.");
    }
    else
    {
        trace("IME is installed but not enabled. Please enable your IME and try again.");
    }
}
else
{
    trace("IME is not installed. Please install an IME and try again.");
}
```

The previous code first checks to see if the user has an IME installed using the `Capabilities.hasIME` property. If this property is set to `true,` the code then checks whether the user's IME is currently enabled, using the `IME.enabled` property.

Determining which IME conversion mode is currently enabled

Flash Player 9 and later, Adobe AIR 1.0 and later

When building multilingual applications, you may need to determine which conversion mode the user currently has active. The following code demonstrates how to check whether the user has an IME installed, and if so, which IME conversion mode is currently active:

```
if (Capabilities.hasIME)
{
    switch (IME.conversionMode)
    {
        case IMEConversionMode.ALPHANUMERIC_FULL:
            tf.text = "Current conversion mode is alphanumeric (full-width).";
            break;
        case IMEConversionMode.ALPHANUMERIC_HALF:
            tf.text = "Current conversion mode is alphanumeric (half-width).";
            break;
        case IMEConversionMode.CHINESE:
            tf.text = "Current conversion mode is Chinese.";
            break;
        case IMEConversionMode.JAPANESE_HIRAGANA:
            tf.text = "Current conversion mode is Japananese Hiragana.";
            break;
        case IMEConversionMode.JAPANESE_KATAKANA_FULL:
            tf.text = "Current conversion mode is Japanese Katakana (full-width).";
            break;
        case IMEConversionMode.JAPANESE_KATAKANA_HALF:
            tf.text = "Current conversion mode is Japanese Katakana (half-width).";
            break;
        case IMEConversionMode.KOREAN:
            tf.text = "Current conversion mode is Korean.";
            break;
        default:
            tf.text = "Current conversion mode is " + IME.conversionMode + ".";
            break;
    }
}
else
{
    tf.text = "Please install an IME and try again.";
}
```

The previous code first checks to see whether the user has an IME installed. Next it checks which conversion mode the current IME is using by comparing the `IME.conversionMode` property against each of the constants in the IMEConversionMode class.

Setting the IME conversion mode

Flash Player 9 and later, Adobe AIR 1.0 and later

When you change the conversion mode of the user's IME, you need to make sure that the code is wrapped in a `try..catch` block, because setting a conversion mode using the `conversionMode` property can throw an error if the IME is unable to set the conversion mode. The following code demonstrates how to use a `try..catch` block when setting the `IME.conversionMode` property:

```
var statusText:TextField = new TextField;
statusText.autoSize = TextFieldAutoSize.LEFT;
addChild(statusText);
if (Capabilities.hasIME)
{
    try
    {
        IME.enabled = true;
        IME.conversionMode = IMEConversionMode.KOREAN;
        statusText.text = "Conversion mode is " + IME.conversionMode + ".";
    }
    catch (error:Error)
    {
        statusText.text = "Unable to set conversion mode.\n" + error.message;
    }
}
```

The previous code first creates a text field, which is used to display a status message to the user. Next, if the IME is installed, the code enables the IME and sets the conversion mode to Korean. If the user's computer does not have a Korean IME installed, an error is thrown by Flash Player or AIR and is caught by the `try..catch` block. The `try..catch` block displays the error message in the previously created text field.

Disabling the IME for certain text fields

Flash Player 9 and later, Adobe AIR 1.0 and later

In some cases, you may want to disable the user's IME while they type characters. For example, if you had a text field that only accepts numeric input, you may not want the IME to come up and slow down data entry.

The following example demonstrates how you can listen for the `FocusEvent.FOCUS_IN` and `FocusEvent.FOCUS_OUT` events and disable the user's IME accordingly:

```
var phoneTxt:TextField = new TextField();
var nameTxt:TextField = new TextField();

phoneTxt.type = TextFieldType.INPUT;
phoneTxt.addEventListener(FocusEvent.FOCUS_IN, focusInHandler);
phoneTxt.addEventListener(FocusEvent.FOCUS_OUT, focusOutHandler);
phoneTxt.restrict = "0-9";
phoneTxt.width = 100;
phoneTxt.height = 18;
phoneTxt.background = true;
phoneTxt.border = true;
addChild(phoneTxt);

nameField.type = TextFieldType.INPUT;
nameField.x = 120;
nameField.width = 100;
nameField.height = 18;
nameField.background = true;
nameField.border = true;
addChild(nameField);

function focusInHandler(event:FocusEvent):void
{
    if (Capabilities.hasIME)
    {
        IME.enabled = false;
    }
}
function focusOutHandler(event:FocusEvent):void
{
    if (Capabilities.hasIME)
    {
        IME.enabled = true;
    }
}
```

This example creates two input text fields, `phoneTxt` and `nameTxt`, and then adds two event listeners to the `phoneTxt` text field. When the user sets focus to the `phoneTxt` text field, a `FocusEvent.FOCUS_IN` event is dispatched and the IME is disabled. When the `phoneTxt` text field loses focus, the `FocusEvent.FOCUS_OUT` event is dispatched to re-enable the IME.

Listening for IME composition events

Flash Player 9 and later, Adobe AIR 1.0 and later

IME composition events are dispatched when a composition string is being set. For example, if the user has their IME enabled and active and types a string in Japanese, the `IMEEvent.IME_COMPOSITION` event would dispatch as soon as the user selects the composition string. In order to listen for the `IMEEvent.IME_COMPOSITION` event, you need to add an event listener to the static `ime` property in the System class (`flash.system.System.ime.addEventListener(...)`), as shown in the following example:

```
var inputTxt:TextField;
var outputTxt:TextField;

inputTxt = new TextField();
inputTxt.type = TextFieldType.INPUT;
inputTxt.width = 200;
inputTxt.height = 18;
inputTxt.border = true;
inputTxt.background = true;
addChild(inputTxt);

outputTxt = new TextField();
outputTxt.autoSize = TextFieldAutoSize.LEFT;
outputTxt.y = 20;
addChild(outputTxt);

if (Capabilities.hasIME)
{
    IME.enabled = true;
    try
    {
        IME.conversionMode = IMEConversionMode.JAPANESE_HIRAGANA;
    }
    catch (error:Error)
    {
        outputTxt.text = "Unable to change IME.";
    }
    System.ime.addEventListener(IMEEvent.IME_COMPOSITION, imeCompositionHandler);
}
else
{
    outputTxt.text = "Please install IME and try again.";
}

function imeCompositionHandler(event:IMEEvent):void
{
    outputTxt.text = "you typed: " + event.text;
}
```

The previous code creates two text fields and adds them to the display list. The first text field, `inputTxt`, is an input text field that allows the user to enter Japanese text. The second text field, `outputTxt`, is a dynamic text field that displays error messages to the user, or echoes the Japanese string that the user types into the `inputTxt` text field.

Virtual keyboards

Flash Player 10.2 and later, AIR 2.6 and later

Mobile devices, such as phones and tablets, often provide a virtual, software keyboard instead of a physical one. The classes in the Flash API let you:

- Detect when the virtual keyboard is raised and when it closes.
- Prevent the keyboard from raising.
- Determine the area of the stage obscured by the virtual keyboard.

- Create interactive objects that raise the keyboard when they gain focus. (Not supported by AIR applications on iOS.)
- (AIR only) Disable the automatic panning behavior so that your application can modify its own display to accommodate the keyboard.

Controlling virtual keyboard behavior

The runtime automatically opens the virtual keyboard when the user taps inside a text field or a specially configured interactive object. When the keyboard opens, the runtime follows the native platform conventions in panning and resizing the application content so that the user can see the text as they type.

When the keyboard opens, the focused object dispatches the following events in sequence:

`softKeyboardActivating` event — dispatched immediately before the keyboard begins to rise over the stage. If you call the `preventDefault()` method of the dispatched event object, the virtual keyboard does not open.

`softKeyboardActivate` event — dispatched after `softKeyboardActivating` event handling has completed. When the focused object dispatches this event, the `softKeyboardRect` property of the Stage object has been updated to reflect the area of the stage obscured by the virtual keyboard. This event cannot be canceled.

***Note:** If the keyboard changes size, for example, when the user changes the keyboard type, the focused object dispatches a second softKeyboardActivate event.*

`softKeyboardDeactivate` event — dispatched when the virtual keyboard closes for any reason. This event cannot be canceled.

The following example adds two TextField objects on the stage. The upper TextField prevents the keyboard from raising when you tap the field and closes it if it is already raised. The lower TextField demonstrates the default behavior. The example reports the soft keyboard events dispatched by both text fields.

```
package
{
import flash.display.Sprite;
import flash.text.TextField;
import flash.text.TextFieldType;
import flash.events.SoftKeyboardEvent;
public class SoftKeyboardEventExample extends Sprite
{
    private var tf1:TextField = new TextField();
    private var tf2:TextField = new TextField();

    public function SoftKeyboardEventExample()
    {
        tf1.width = this.stage.stageWidth;
        tf1.type = TextFieldType.INPUT;
        tf1.border = true;
        this.addChild( tf1 );

        tf1.addEventListener( SoftKeyboardEvent.SOFT_KEYBOARD_ACTIVATING, preventSoftKe
yboard );
        tf1.addEventListener( SoftKeyboardEvent.SOFT_KEYBOARD_ACTIVATE, preventSoftKe
yboard );
        tf1.addEventListener( SoftKeyboardEvent.SOFT_KEYBOARD_DEACTIVATE, preventSoftKeyboard
);

        tf2.border = true;
        tf2.type = TextFieldType.INPUT;
        tf2.width = this.stage.stageWidth;
        tf2.y = tf1.y + tf1.height + 30;
        this.addChild( tf2 );

        tf2.addEventListener( SoftKeyboardEvent.SOFT_KEYBOARD_ACTIVATING, allowSoftKeyboard );
        tf2.addEventListener( SoftKeyboardEvent.SOFT_KEYBOARD_ACTIVATE, allowSoftKeyboard );
        tf2.addEventListener( SoftKeyboardEvent.SOFT_KEYBOARD_DEACTIVATE, allowSoftKeyboard);
    }

    private function preventSoftKeyboard( event:SoftKeyboardEvent ):void
    {
            event.preventDefault();
            this.stage.focus = null; //close the keyboard, if raised
            trace( "tf1 dispatched: " + event.type + " -- " + event.triggerType );
    }
    private function allowSoftKeyboard( event:SoftKeyboardEvent )    :void
    {
            trace( "tf2 dispatched: " + event.type + " -- " + event.triggerType );
    }
}
}
```

Adding virtual keyboard support for interactive objects

Flash Player 10.2 and later, AIR 2.6 and later (but not supported on iOS)

Normally, the virtual keyboard only opens when a TextField object is tapped. You can configure an instance of the InteractiveObject class to open the virtual keyboard when it receives focus.

To configure an InteractiveObject instance to open the soft keyboard, set its `needsSoftKeyboard` property to `true`. Whenever the object is assigned to the stage focus property, the soft keyboard automatically opens. In addition, you can raise the keyboard by calling the `requestSoftKeyboard()` method of the InteractiveObject.

The following example illustrates how you can program an InteractiveObject to act as a text entry field. The TextInput class shown in the example sets the `needsSoftKeyboard` property so that the keyboard is raised when needed. The object then listens for `keyDown` events and inserts the typed character into the field.

The example uses the Flash text engine to append and display any typed text and handles some important events. For simplicity, the example does not implement a full-featured text field.

```
package  {
    import flash.geom.Rectangle;
    import flash.display.Sprite;
    import flash.text.engine.TextElement;
    import flash.text.engine.TextBlock;
    import flash.events.MouseEvent;
    import flash.events.FocusEvent;
    import flash.events.KeyboardEvent;
    import flash.text.engine.TextLine;
    import flash.text.engine.ElementFormat;
    import flash.events.Event;

    public class TextInput extends Sprite
    {

        public var text:String = " ";
        public  var textSize:Number = 24;
        public var textColor:uint = 0x000000;
        private var _bounds:Rectangle = new Rectangle( 0, 0, 100, textSize );
        private var textElement: TextElement;
        private var textBlock:TextBlock = new  TextBlock();

        public function TextInput( text:String = "" )
        {
            this.text = text;
            this.scrollRect = _bounds;
            this.focusRect= false;

            //Enable keyboard support
            this.needsSoftKeyboard = true;
            this.addEventListener(MouseEvent.MOUSE_DOWN, onSelect);
            this.addEventListener(FocusEvent.FOCUS_IN, onFocusIn);
            this.addEventListener(FocusEvent.FOCUS_OUT, onFocusOut);

            //Setup text engine
            textElement = new TextElement( text, new ElementFormat( null, textSize, textColor ) );
            textBlock.content = textElement;
            var firstLine:TextLine = textBlock.createTextLine( null, _bounds.width - 8 );
            firstLine.x = 4;
            firstLine.y = 4 + firstLine.totalHeight;
            this.addChild( firstLine );

        }

        private function onSelect( event:MouseEvent ):void
        {
            stage.focus = this;
        }
        private function onFocusIn( event:FocusEvent ):void
        {
            this.addEventListener( KeyboardEvent.KEY_DOWN, onKey );
        }

        private function onFocusOut( event:FocusEvent ):void
        {
            this.removeEventListener( KeyboardEvent.KEY_UP, onKey );
        }
        private function onKey( event:KeyboardEvent ):void
        {
            textElement.replaceText( textElement.text.length, textElement.text.length, 
String.fromCharCode( event.charCode ) );
            updateText();
        }
        public function set bounds( newBounds:Rectangle ):void
        {
            _bounds = newBounds.clone();
            drawBackground();
            updateText();
            this.scrollRect = _bounds;
            
            //force update to focus rect, if needed
            if( this.stage!= null && this.focusRect && this.stage.focus == this )
                this.stage.focus = this;
        }
        
        private function updateText():void
        {
            //clear text lines
            while( this.numChildren > 0 ) this.removeChildAt( 0 );
            
            //and recreate them
            var textLine:TextLine = textBlock.createTextLine( null, _bounds.width - 8);
            while ( textLine)
            {
                textLine.x = 4;
                if( textLine.previousLine != null )
                {
                    textLine.y = textLine.previousLine.y + 
                                textLine.previousLine.totalHeight + 2;
                }
                              else
                {
                    textLine.y = 4 + textLine.totalHeight;
                }
                this.addChild(textLine);
                textLine = textBlock.createTextLine(textLine, _bounds.width - 8 ); 
            }
        }
        
        private function drawBackground():void
        {
            //draw background and border for the field
            this.graphics.clear();
            this.graphics.beginFill( 0xededed );
            this.graphics.lineStyle( 1, 0x000000 );
            this.graphics.drawRect( _bounds.x + 2, _bounds.y + 2, _bounds.width - 4, 
_bounds.height - 4);
            this.graphics.endFill();
        }
    }
}
```

The following main application class illustrates how to use the TextInput class and manage the application layout when the keyboard is raised or the device orientation changes. The main class creates a TextInput object and sets its bounds to fill the stage. The class adjusts the size of the TextInput object when either the soft keyboard is raised or the stage changes size. The class listens for soft keyboard events from the TextInput object and resize events from the stage. Irrespective of the cause of the event, the application determines the visible area of the stage and resizes the input control to fill it. Naturally, in a real application, you would need a more sophisticated layout algorithm.

```
package  {

    import flash.display.MovieClip;
    import flash.events.SoftKeyboardEvent;
    import flash.geom.Rectangle;
    import flash.events.Event;
    import flash.display.StageScaleMode;
    import flash.display.StageAlign;

    public class CustomTextField extends MovieClip {

        private var customField:TextInput = new TextInput("Input text: ");

        public function CustomTextField() {
            this.stage.scaleMode = StageScaleMode.NO_SCALE;
            this.stage.align = StageAlign.TOP_LEFT;
            this.addChild( customField );
            customField.bounds = new Rectangle( 0, 0, this.stage.stageWidth, 
this.stage.stageHeight );

            //track soft keyboard and stage resize events
            customField.addEventListener(SoftKeyboardEvent.SOFT_KEYBOARD_ACTIVATE, 
onDisplayAreaChange );
            customField.addEventListener(SoftKeyboardEvent.SOFT_KEYBOARD_DEACTIVATE, 
onDisplayAreaChange );
            this.stage.addEventListener( Event.RESIZE, onDisplayAreaChange );
        }

        private function onDisplayAreaChange( event:Event ):void
        {
            //Fill the stage if possible, but avoid the area covered by a keyboard
            var desiredBounds = new Rectangle( 0, 0, this.stage.stageWidth, 
this.stage.stageHeight );
            if( this.stage.stageHeight - this.stage.softKeyboardRect.height < 
desiredBounds.height )
                desiredBounds.height = this.stage.stageHeight - 
this.stage.softKeyboardRect.height;

            customField.bounds = desiredBounds;
        }
    }
}
```

***Note:** The stage only dispatches resize events in response to an orientation change when the `scaleMode` property is set to `noScale`. In other modes, the dimensions of the stage do not change; instead, the content is scaled to compensate.*

Handling application display changes

AIR 2.6 and later

In AIR, you can turn off the default panning and resizing behavior associated with raising a soft keyboard by setting the `softKeyboardBehavior` element in the application descriptor to `none`:

```
<softKeyboardBehavior>none</softKeyboardBehavior>
```

When you turn off the automatic behavior, it is your application's responsibility to make any necessary adjustments to the application display. A softKeyboardActivate event is dispatched when the keyboard opens. When the `softKeyboardActivate` event is dispatched, the `softKeyboardRect` property of the stage contains the dimensions of the area obscured by the open keyboard. Use these dimensions to move or resize your content so that it is displayed properly while the keyboard is open and the user is typing. (When the keyboard is closed, the dimensions of the softKeyboardRect rectangle are all zero.)

When the keyboard closes, a `softKeyboardDeactivate` event is dispatched, and you can return the application display to normal.

```
package  {
    import flash.display.MovieClip;
    import flash.events.SoftKeyboardEvent;
    import flash.events.Event;
    import flash.display.StageScaleMode;
    import flash.display.StageAlign;
    import flash.display.InteractiveObject;
    import flash.text.TextFieldType;
    import flash.text.TextField;

    public class PanningExample extends MovieClip {

        private var textField:TextField = new TextField();

        public function PanningExample() {
            this.stage.scaleMode = StageScaleMode.NO_SCALE;
            this.stage.align = StageAlign.TOP_LEFT;

            textField.y = this.stage.stageHeight - 201;
            textField.width = this.stage.stageWidth;
            textField.height = 200;
            textField.type = TextFieldType.INPUT;
            textField.border = true;
            textField.wordWrap = true;
            textField.multiline = true;

            this.addChild( textField );

            //track soft keyboard and stage resize events
            textField.addEventListener(SoftKeyboardEvent.SOFT_KEYBOARD_ACTIVATE,
onKeyboardChange );
            textField.addEventListener(SoftKeyboardEvent.SOFT_KEYBOARD_DEACTIVATE,
onKeyboardChange );
            this.stage.addEventListener( Event.RESIZE, onDisplayAreaChange );
        }

        private function onDisplayAreaChange( event:Event ):void
        {
            textField.y = this.stage.stageHeight - 201;
            textField.width = this.stage.stageWidth;
        }

        private function onKeyboardChange( event:SoftKeyboardEvent ):void
        {
            var field:InteractiveObject = textField;
            var offset:int = 0;

            //if the softkeyboard is open and the field is at least partially covered
            if( (this.stage.softKeyboardRect.y != 0) && (field.y + field.height > 
this.stage.softKeyboardRect.y) )
                offset = field.y + field.height - this.stage.softKeyboardRect.y;

            //but don't push the top of the field above the top of the screen
            if( field.y - offset < 0 ) offset += field.y - offset;

            this.y = -offset;
        }
    }
}
```

***Note:** On Android, there are circumstances, including fullscreen mode, in which the exact dimensions of the keyboard are not available from the operating system. In these cases, the size is estimated. Also, in landscape orientations, the native fullscreen IME keyboard is used for all text entry. This IME keyboard has a built-in text entry field and obscures the entire stage. There is no way to display a landscape keyboard that does not fill the screen.*

Chapter 31: Mouse input

Flash Player 9 and later, Adobe AIR 1.0 and later

Your application can create interactivity by capturing and responding to mouse input. Note that this section assumes that you are already familiar with the ActionScript 3.0 event model. For more information, see “Handling events” on page 125.

For information on discovering what kind of mouse support is available (such as persistent cursor, stylus or touch input) during runtime, see “Discovering input types” on page 558.

More Help topics

flash.ui.Mouse

flash.events.MouseEvent

“Touch, multitouch and gesture input” on page 581

Capturing mouse input

Flash Player 9 and later, Adobe AIR 1.0 and later

Mouse clicks create mouse events that can be used to trigger interactive functionality. You can add an event listener to the Stage to listen for mouse events that occur anywhere within the SWF file. You can also add event listeners to objects on the Stage that inherit from InteractiveObject (for example, Sprite or MovieClip); these listeners are triggered when the object is clicked.

As with keyboard events, mouse events bubble. In the following example, because `square` is a child of the Stage, the event dispatches both from the sprite `square` as well as from the Stage object when the square is clicked:

```
var square:Sprite = new Sprite();
square.graphics.beginFill(0xFF0000);
square.graphics.drawRect(0,0,100,100);
square.graphics.endFill();
square.addEventListener(MouseEvent.CLICK, reportClick);
square.x =
square.y = 50;
addChild(square);

stage.addEventListener(MouseEvent.CLICK, reportClick);

function reportClick(event:MouseEvent):void
{
    trace(event.currentTarget.toString() + " dispatches MouseEvent. Local coords [" +
event.localX + "," + event.localY + "] Stage coords [" + event.stageX + "," + event.stageY + "]");
}
```

In the previous example, notice that the mouse event contains positional information about the click. The `localX` and `localY` properties contain the location of the click on the lowest child in the display chain. For example, clicking at the top-left corner of `square` reports local coordinates of [0,0] because that is the registration point of `square`. Alternatively, the `stageX` and `stageY` properties refer to the global coordinates of the click on the Stage. The same click reports [50,50] for these coordinates, because `square` was moved to these coordinates. Both of these coordinate pairs can be useful depending on how you want to respond to user interaction.

***Note:** In full-screen mode, you can configure the application to use mouse locking. Mouse locking disables the cursor and enables unbounded mouse movement. For more information, see "Working with full-screen mode" on page 167.*

The MouseEvent object also contains `altKey`, `ctrlKey`, and `shiftKey` Boolean properties. You can use these properties to check if the Alt, Ctrl, or Shift key is also being pressed at the time of the mouse click.

Dragging Sprites around the stage

Flash Player 9 and later, Adobe AIR 1.0 and later

You can allow users to drag a Sprite object around the stage using the `startDrag()` method of the Sprite class. The following code shows an example of this:

```
import flash.display.Sprite;
import flash.events.MouseEvent;

var circle:Sprite = new Sprite();
circle.graphics.beginFill(0xFFCC00);
circle.graphics.drawCircle(0, 0, 40);

var target1:Sprite = new Sprite();
target1.graphics.beginFill(0xCCFF00);
target1.graphics.drawRect(0, 0, 100, 100);
target1.name = "target1";

var target2:Sprite = new Sprite();
target2.graphics.beginFill(0xCCFF00);
target2.graphics.drawRect(0, 200, 100, 100);
target2.name = "target2";

addChild(target1);
addChild(target2);
addChild(circle);

circle.addEventListener(MouseEvent.MOUSE_DOWN, mouseDown)

function mouseDown(event:MouseEvent):void
{
    circle.startDrag();
}
circle.addEventListener(MouseEvent.MOUSE_UP, mouseReleased);

function mouseReleased(event:MouseEvent):void
{
    circle.stopDrag();
    trace(circle.dropTarget.name);
}
```

For more details, see the section on creating mouse drag interaction in "Changing position" on page 173.

Drag-and-drop in AIR

In Adobe AIR, you can enable drag-and-drop support to allow users to drag data into and out of your application. For more details, see "Drag and drop in AIR" on page 608.

Customizing the mouse cursor

Flash Player 9 and later, Adobe AIR 1.0 and later

The mouse cursor (mouse pointer) can be hidden or swapped for any display object on the Stage. To hide the mouse cursor, call the `Mouse.hide()` method. Customize the cursor by calling `Mouse.hide()`, listening to the Stage for the `MouseEvent.MOUSE_MOVE` event, and setting the coordinates of a display object (your custom cursor) to the `stageX` and `stageY` properties of the event. The following example illustrates a basic execution of this task:

```
var cursor:Sprite = new Sprite();
cursor.graphics.beginFill(0x000000);
cursor.graphics.drawCircle(0,0,20);
cursor.graphics.endFill();
addChild(cursor);

stage.addEventListener(MouseEvent.MOUSE_MOVE,redrawCursor);
Mouse.hide();

function redrawCursor(event:MouseEvent):void
{
    cursor.x = event.stageX;
    cursor.y = event.stageY;
}
```

Mouse input example: WordSearch

Flash Player 9 and later, Adobe AIR 1.0 and later

This example demonstrates user interaction by handling mouse events. Users build as many words as possible from a random grid of letters, spelling by moving horizontally or vertically in the grid, but never using the same letter twice.This example demonstrates the following features of ActionScript 3.0:

- Building a grid of components dynamically
- Responding to mouse events
- Maintaining a score based on user interaction

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The WordSearch application files can be found in the folder Samples/WordSearch. The application consists of the following files:

File	Description
WordSearch.as	The class that provides the main functionality of the application.
WordSearch.fla or WordSearch.mxml	The main application file for Flex (MXML) or Flash (FLA).
dictionary.txt	A file used to determine if spelled words are scorable and spelled correctly.

Loading a dictionary

Flash Player 9 and later, Adobe AIR 1.0 and later

To create a game that involves finding words, a dictionary is needed. The example includes a text file called dictionary.txt that contains a list of words separated by carriage returns. After creating an array named `words`, the `loadDictionary()` function requests this file, and when it loads successfully, the file becomes a long string. You can parse this string into an array of words by using the `split()` method, breaking at each instance of a carriage return (character code 10) or new line (character code 13). This parsing occurs in the `dictionaryLoaded()` function:

```
words = dictionaryText.split(String.fromCharCode(13, 10));
```

Creating the user interface

Flash Player 9 and later, Adobe AIR 1.0 and later

After the words have been stored, you can set up the user interface. Create two Button instances: one for submitting a word, and another for clearing a word that is currently being spelled. In each case, you must respond to user input by listening to the `MouseEvent.CLICK` event that the button broadcasts and then calling a function. In the `setupUI()` function, this code creates the listeners on the two buttons:

```
submitWordButton.addEventListener(MouseEvent.CLICK,submitWord);
clearWordButton.addEventListener(MouseEvent.CLICK,clearWord);
```

Generating a game board

Flash Player 9 and later, Adobe AIR 1.0 and later

The game board is a grid of random letters. In the `generateBoard()` function, a two-dimensional grid is created by nesting one loop inside another. The first loop increments rows and the second increments the total number of columns per row. Each of the cells created by these rows and columns contains a button that represents a letter on the board.

```
private function generateBoard(startX:Number, startY:Number, totalRows:Number, 
totalCols:Number, buttonSize:Number):void 
{ 
    buttons = new Array(); 
    var colCounter:uint; 
    var rowCounter:uint; 
    for (rowCounter = 0; rowCounter < totalRows; rowCounter++) 
    { 
        for (colCounter = 0; colCounter < totalCols; colCounter++) 
        { 
            var b:Button = new Button(); 
            b.x = startX + (colCounter*buttonSize); 
            b.y = startY + (rowCounter*buttonSize); 
            b.addEventListener(MouseEvent.CLICK, letterClicked); 
            b.label = getRandomLetter().toUpperCase(); 
            b.setSize(buttonSize,buttonSize); 
            b.name = "buttonRow"+rowCounter+"Col"+colCounter; 
            addChild(b); 
             
            buttons.push(b); 
        } 
    } 
}
```

Although a listener is added for a `MouseEvent.CLICK` event on only one line, because it is in a `for` loop, it is assigned to each Button instance. Also, each button is assigned a name derived from its row and column position, which provides an easy way to reference the row and column of each button later in the code.

Building words from user input

Flash Player 9 and later, Adobe AIR 1.0 and later

Words can be spelled by selecting letters that are vertically or horizontally adjacent, but never using the same letter twice. Each click generates a mouse event, at which point the word the user is spelling must be checked to ensure it properly continues from letters that have previously been clicked. If it is not, the previous word is removed and a new one is started. This check occurs in the `isLegalContinuation()` method.

```
private function isLegalContinuation(prevButton:Button, currButton:Button):Boolean 
{ 
    var currButtonRow:Number = Number(currButton.name.charAt(currButton.name. indexOf("Row") + 
3)); 
    var currButtonCol:Number = Number(currButton.name.charAt(currButton.name.indexOf("Col") + 
3)); 
    var prevButtonRow:Number = Number(prevButton.name.charAt(prevButton.name.indexOf("Row") + 
3)); 
    var prevButtonCol:Number = Number(prevButton.name.charAt(prevButton.name.indexOf("Col") + 
3)); 
     
    return ((prevButtonCol == currButtonCol && Math.abs(prevButtonRow - currButtonRow) <= 1) || 
             (prevButtonRow == currButtonRow && Math.abs(prevButtonCol - currButtonCol) <= 1)); 
}
```

The `charAt()` and `indexOf()` methods of the String class retrieve the appropriate rows and columns from both the currently clicked button and the previously clicked button. The `isLegalContinuation()` method returns `true` if the row or column is unchanged and if the row or column that has been changed is within a single increment from the previous one. If you want to change the rules of the game and allow diagonal spelling, you can remove the checks for an unchanged row or column and the final line would look like this:

```
return (Math.abs(prevButtonRow - currButtonRow) <= 1) && Math.abs(prevButtonCol - 
currButtonCol) <= 1));
```

Checking word submissions

Flash Player 9 and later, Adobe AIR 1.0 and later

To complete the code for the game, mechanisms for checking word submissions and tallying the score are needed. The `searchForWord()` method contains both:

```
private function searchForWord(str:String):Number
{
    if (words && str)
    {
        var i:uint = 0
        for (i = 0; i < words.length; i++)
        {
            var thisWord:String = words[i];
            if (str == words[i])
            {
                return i;
            }
        }
        return -1;
    }
    else
    {
        trace("WARNING: cannot find words, or string supplied is null");
    }
    return -1;
}
```

This function loops through all of the words in the dictionary. If the user's word matches a word in the dictionary, its position in the dictionary is returned. The `submitWord()` method then checks the response and updates the score if the position is valid.

Customization

Flash Player 9 and later, Adobe AIR 1.0 and later

At the beginning of the class are several constants. You can modify this game by modifying these variables. For example, you can change the amount of time available to play by increasing the `TOTAL_TIME` variable. You can also increase the `PERCENT_VOWELS` variable slightly to increase the likelihood of finding words.

Chapter 32: Touch, multitouch and gesture input

Flash Player 10.1 and later, Adobe AIR 2 and later

The touch event handling features of the Flash Platform include input from a single point of contact or multiple points of contact on touch-enabled devices. And, the Flash runtimes handle events that combine multiple touch points with movement to create a gesture. In other words, Flash runtimes interpret two types of input:

Touch input with a single point device such as a finger, stylus, or other tool on a touch-enabled device. Some devices support multiple simultaneous points of contact with a finger or stylus.

Multitouch input with more than one simultaneous point of contact.

Gesture Input interpreted by a device or operating system in response to one or more touch events. For example, a user rotates two fingers simultaneously, and the device or operating system interprets that touch input as a rotation gesture. Some gestures are performed with one finger or touch point, and some gestures require multiple touch points. The device or operating system establishes the type of gesture to assign to the input.

Both touch and gesture input can be multitouch input depending on the user's device. ActionScript provides API for handling touch events, gesture events, and individually tracked touch events for multitouch input.

Note: *Listening for touch and gesture events can consume a significant amount of processing resources (equivalent to rendering several frames per second), depending on the computing device and operating system. It is often better to use mouse events when you do not actually need the extra functionality provided by touch or gestures. When you do use touch or gesture events, consider reducing the amount of graphical changes that can occur, especially when such events can be dispatched rapidly, as during a pan, rotate, or zoom operation. For example, you could stop animation within a component while the user resizes it using a zoom gesture.*

More Help topics

flash.ui.Multitouch

flash.events.TouchEvent

flash.events.GestureEvent

flash.events.TransformGestureEvent

flash.events.GesturePhase

flash.events.PressAndTapGestureEvent

Paul Trani: Touch Events and Gestures on Mobile

Mike Jones: Virtual Game Controllers

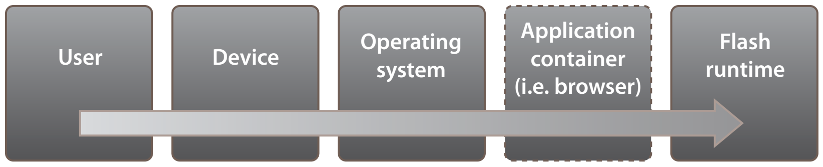
Basics of touch input

Flash Player 10.1 and later, Adobe AIR 2 and later

When the Flash Platform is running in an environment that supports touch input, InteractiveObject instances can listen for touch events and call handlers. Generally, you handle touch, multitouch, and gesture events as you would other events in ActionScript (see "Handling events" on page 125 for basic information about event handling with ActionScript).

However, for the Flash runtime to interpret a touch or gesture, the runtime must be running in a hardware and software environment that supports touch or multitouch input. See "Discovering input types" on page 558 for a chart comparing different touch screen types. Additionally, if the runtime is running within a container application (such as a browser), then that container passes the input to the runtime. In some cases, the current hardware and operating system environment support multitouch, but the browser containing the Flash runtime interprets the input and does not pass it on to the runtime. Or, it can simply ignore the input altogether.

The following diagram shows the flow of input from user to runtime:



Flow of input from user to the Flash Platform runtime

Fortunately, the ActionScript API for developing touch applications includes classes, methods, and properties to determine the support for touch or multitouch input in the runtime environment. The API you use to determine support for touch input are the "discovery API" for touch event handling.

Important concepts and terms

The following reference list contains important terms for writing touch event-handling applications:

Discovery API The methods and properties used to test the runtime environment for support of touch events and different modes of input.

Touch event An input action performed on a touch-enabled device using a single point of contact.

Touch point The point of contact for a single touch event. Even if a device does not support gesture input, it might support multiple simultaneous touch points.

Touch sequence The series of events representing the lifespan of a single touch. These events include one beginning, zero or more moves, and one end.

Multitouch event An input action performed on a touch-enabled device using several points of contact (such as more than one finger).

Gesture event An input action performed on a touch-enabled device tracing some complex movement. For example, one gesture is touching a screen with two fingers and moving them simultaneously around the perimeter of an abstract circle to indicate rotation.

Phases Distinct points of time in the event flow (such as begin and end).

Stylus An instrument for interacting with a touch-enabled screen. A stylus can provide more precision than the human finger. Some devices recognize only input from a specific type of stylus. Devices that do recognize stylus input might not recognize multiple, simultaneous points of contact or finger contact.

Press-and-tap A specific type of multitouch input gesture where the user pushes a finger against a touch-enabled device and then taps with another finger or pointing device. This gesture is often used to simulate a mouse right-click in multitouch applications.

The touch input API structure

The ActionScript touch input API is designed to address the fact that touch input handling depends on the hardware and software environment of the Flash runtime. The touch input API primarily addresses three needs of touch application development: discovery, events, and phases. Coordinate these API to produce a predictable and responsive experience for the user; even if the target device is unknown as you develop an application.

Discovery

The discovery API provides the ability to test the hardware and software environment at runtime. The values populated by the runtime determine the touch input available to the Flash runtime in its current context. Also, use the collection of discovery properties and methods to set your application to react to mouse events (instead of touch events in case some touch input is not supported by the environment). For more information, see "Touch support discovery" on page 584.

Events

ActionScript manages touch input events with event listeners and event handlers as it does other events. However, touch input event handling also must take into account:

- A touch can be interpreted in several ways by the device or operating system, either as a sequence of touches or, collectively, as a gesture.
- A single touch to a touch-enabled device (by a finger, stylus or pointing device) always dispatches a mouse event, too. You can handle the mouse event with the event types in the MouseEvent class. Or, you can design your application only to respond to touch events. Or, you can design an application that responds to both.
- An application can respond to multiple, simultaneous touch events, and handle each one separately.

Typically, use the discovery API to conditionally handle the events your application handles, and how they are handled. Once the application knows the runtime environment, it can call the appropriate handler or establish the correct event object when the user interacts with the application. Or, the application can indicate that specific input cannot be handled in the current environment and provide the user with an alternative or information. For more information, see "Touch event handling" on page 585 and "Gesture event handling" on page 589.

Phases

For touch and multitouch applications, touch event objects contain properties to track the phases of user interaction. Write ActionScript to handle phases like the begin, update, or end phase of user input to provide the user with feedback. Respond to event phases so visual objects change as the user touch and moves the point of touch on a screen. Or, use the phases to track specific properties of a gesture, as the gesture evolves.

For touch point events, track how long the user rests on a specific interactive object. An application can track multiple, simultaneous touch points' phases individually, and handle each accordingly.

For a gesture, interpret specific information about the transformation of the gesture as it occurs. Track the coordinates of the point of contact (or several) as they move across the screen.

Touch support discovery

Flash Player 10.1 and later, Adobe AIR 2 and later

Use the Multitouch class properties to set the scope of touch input your application handles. Then, test the environment to ensure that support exists for the events your ActionScript handles. Specifically, first establish the type of touch input for your application. The options are: touch point, gesture, or none (interpret all touch input as mouse clicks and use mouse event handlers, only). Then, use the properties and methods of the Multitouch class to make sure that the runtime is in an environment that supports the touch input your application requires. Test the runtime environment for support of the types of touch input (such as whether it can interpret gestures), and respond accordingly.

***Note:** The Multitouch class properties are static properties, and do not belong to instances of any class. Use them with the syntax Multitouch.property, for example:*

```
var touchSupport:Boolean = Multitouch.supportsTouchEvents;
```

Set the input type

The Flash runtime must know the type of touch input to interpret, because a touch event can have many elements or phases. If a finger simply touches a touch-enabled screen, does the runtime dispatch a touch event? Or does it wait for a gesture? Or does the runtime track the touch as a mouse-down event? An application that supports touch input must establish the type of touch events it handles for the Flash runtime. Use the `Multitouch.inputMode` property to establish the type of touch input for the runtime. The input mode can be one of three options:

None No special handling is provided for touch events. Set: `Multitouch.inputMode=MultitouchInputMode.NONE` and use the MouseEvent class to handle input.

Single touch points All touch input is interpreted, individually, and all touch points can be tracked and handled. Set: `Multitouch.inputMode=MultitouchInputMode.TOUCH_POINT` and use the TouchEvent class to handle input.

Gesture input The device or operating system interprets input as a complex form of finger movement across the screen. The device or operating system collectively assigns the movement to a single gesture input event. Set: `Multitouch.inputMode=MultitouchInputMode.GESTURE` and use the TransformGestureEvent, PressAndTapGestureEvent, or GestureEvent classes to handle input.

See "Touch event handling" on page 585 for an example that uses the `Multitouch.inputMode` property to set the input type before handling a touch event.

Test for touch input support

Other properties of the Multitouch class provide values for fine-tuning your application to the current environment's touch support. The Flash runtime populates values for the number of simultaneous touch points allowed or gestures available. If the runtime is in an environment that does not support the touch event handling your application needs, provide the user with an alternative. For example, provide mouse event handling or information about what features are available, or not, in the current environment.

You can also use the API for keyboard, touch, and mouse support, see "Discovering input types" on page 558.

For more information about compatibility testing, see "Troubleshooting" on page 593.

Touch event handling

Flash Player 10.1 and later, Adobe AIR 2 and later

Basic touch events are handled the same way you handle other events, like mouse events, in ActionScript. You can listen for a series of touch events defined by the event type constants in the TouchEvent class.

***Note:** For multiple touch point input (such as touching a device with more than one finger), the first point of contact dispatches a mouse event and a touch event.*

To handle a basic touch event:

1. Set your application to handle touch events by setting the `flash.ui.Multitouch.inputMode` property to `MultitouchInputMode.TOUCH_POINT`.
2. Attach an event listener to an instance of a class that inherits properties from the InteractiveObject class, such as Sprite or TextField.
3. Specify the type of touch event to handle.
4. Call an event handler function to do something in response to the event.

For example, the following code displays a message when the square drawn on mySprite is tapped on a touch-enabled screen:

```
Multitouch.inputMode=MultitouchInputMode.TOUCH_POINT;

var mySprite:Sprite = new Sprite();
var myTextField:TextField = new TextField();

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);

mySprite.addEventListener(TouchEvent.TOUCH_TAP, taphandler);

function taphandler(evt:TouchEvent): void {
    myTextField.text = "I've been tapped";
    myTextField.y = 50;
    addChild(myTextField);
}
```

Touch Event properties

When an event occurs, an event object is created. The TouchEvent object contains information about the location and conditions of the touch event. You can use the properties of the event object to retrieve that information.

For example, the following code creates a TouchEvent object *evt*, and then displays the `stageX` property of the event object (the x-coordinate of the point in the Stage space that the touch occurred) in the text field:

```
Multitouch.inputMode=MultitouchInputMode.TOUCH_POINT;

var mySprite:Sprite = new Sprite();
var myTextField:TextField = new TextField();

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);

mySprite.addEventListener(TouchEvent.TOUCH_TAP, taphandler);

function taphandler(evt:TouchEvent): void {
myTextField.text = evt.stageX.toString;
myTextField.y = 50;
addChild(myTextField);
}
```

See the TouchEvent class for the properties available through the event object.

Note: *Not all TouchEvent properties are supported in all runtime environments. For example, not all touch-enabled devices are capable or detecting the amount of pressure the user is applying to the touch screen. So, the `TouchEvent.pressure` property is not supported on those devices. Try testing for specific property support to ensure your application works, and see "Troubleshooting" on page 593 for more information.*

Touch event phases

Track touch events through various stages over and outside an InteractiveObject just as you do for mouse events. And, track touch events through the beginning, middle, and end of a touch interaction. The TouchEvent class provides values for handling `touchBegin`, `touchMove`, and `touchEnd` events.

For example, you could use `touchBegin`, `touchMove`, and `touchEnd` events to give the user visual feedback as they touch and move a display object:

```
Multitouch.inputMode = MultitouchInputMode.TOUCH_POINT;
var mySprite:Sprite = new Sprite();
mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);
var myTextField:TextField = new TextField();
myTextField.width = 200;
myTextField.height = 20;
addChild(myTextField);

mySprite.addEventListener(TouchEvent.TOUCH_BEGIN, onTouchBegin);
stage.addEventListener(TouchEvent.TOUCH_MOVE, onTouchMove);
stage.addEventListener(TouchEvent.TOUCH_END, onTouchEnd);
function onTouchBegin(event:TouchEvent) {
    myTextField.text = "touch begin" + event.touchPointID;
}
function onTouchMove(event:TouchEvent) {
    myTextField.text = "touch move" + event.touchPointID;
}
function onTouchEnd(event:TouchEvent) {
    myTextField.text = "touch end" + event.touchPointID;
}
```

***Note:** The initial touch listener is attached to mySprite, but the listeners for moving and ending the touch event are not. If the users's finger or pointing devices moves ahead of the display object, the Stage continues to listen for the touch event.*

Touch Point ID

The `TouchEvent.touchPointID` property is an essential part of writing applications that respond to touch input. The Flash runtime assigns each point of touch a unique `touchPointID` value. Whenever an application responds to the phases or movement of touch input, check the `touchPointID` before handling the event. The touch input dragging methods of the Sprite class use the `touchPointID` property as a parameter so the correct input instance is handled. The `touchPointID` property ensures that an event handler is responding to the correct touch point. Otherwise, the event handler responds to any instances of the touch event type (such as all `touchMove` events) on the device, producing unpredictable behavior. The property is especially important when the user is dragging objects.

Use the `touchPointID` property to manage an entire touch sequence. A touch sequence has one `touchBegin` event, zero or more `touchMove` events, and one `touchEnd` event that all have the same `touchPointID` value.

The following example establishes a variable *touchMoveID* to test for the correct `touchPointID` value before responding to a touch move event. Otherwise, other touch input triggers the event handler, too. Notice the listeners for the move and end phases are on the stage, not the display object. The stage listens for the move or end phases in case the user's touch moves beyond the display object boundaries.

```
Multitouch.inputMode = MultitouchInputMode.TOUCH_POINT;
var mySprite:Sprite = new Sprite();
mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);
var myTextField:TextField = new TextField();
addChild(myTextField);
myTextField.width = 200;
myTextField.height = 20;
var touchMoveID:int = 0;

mySprite.addEventListener(TouchEvent.TOUCH_BEGIN, onTouchBegin);
function onTouchBegin(event:TouchEvent) {
    if(touchMoveID != 0) {
        myTextField.text = "already moving. ignoring new touch";
        return;
    }
    touchMoveID = event.touchPointID;

    myTextField.text = "touch begin" + event.touchPointID;
    stage.addEventListener(TouchEvent.TOUCH_MOVE, onTouchMove);
    stage.addEventListener(TouchEvent.TOUCH_END, onTouchEnd);
}
function onTouchMove(event:TouchEvent) {
    if(event.touchPointID != touchMoveID) {
        myTextField.text = "ignoring unrelated touch";
        return;
    }
    mySprite.x = event.stageX;
    mySprite.y = event.stageY;
    myTextField.text = "touch move" + event.touchPointID;
}
function onTouchEnd(event:TouchEvent) {
    if(event.touchPointID != touchMoveID) {
        myTextField.text = "ignoring unrelated touch end";
        return;
    }
    touchMoveID = 0;
    stage.removeEventListener(TouchEvent.TOUCH_MOVE, onTouchMove);
    stage.removeEventListener(TouchEvent.TOUCH_END, onTouchEnd);
    myTextField.text = "touch end" + event.touchPointID;
}
```

Touch and drag

Flash Player 10.1 and later, Adobe AIR 2 and later

Two methods were added to the Sprite class to provide additional support for touch-enabled applications supporting touch-point input: `Sprite.startTouchDrag()` and `Sprite.stopTouchDrag()`. These methods behave the same as `Sprite.startDrag()` and `Sprite.stopDrag()` do for mouse events. However, notice the `Sprite.startTouchDrag()` and `Sprite.stopTouchDrag()` methods both take `touchPointID` values as parameters.

The runtime assigns the `touchPointID` value to the event object for a touch event. Use this value to respond to a specific touch point in the case the environment supports multiple, simultaneous, touch points (even if it does not handle gestures). For more information about the `touchPointID` property, see "Touch Point ID" on page 587.

The following code shows a simple start drag event handler and a stop drag event handler for a touch event. The variable *bg* is a display object that contains *mySprite*:

```
mySprite.addEventListener(TouchEvent.TOUCH_BEGIN, onTouchBegin);
mySprite.addEventListener(TouchEvent.TOUCH_END, onTouchEnd);

function onTouchBegin(e:TouchEvent) {
    e.target.startTouchDrag(e.touchPointID, false, bg.getRect(this));
    trace("touch begin");
}

function onTouchEnd(e:TouchEvent) {
    e.target.stopTouchDrag(e.touchPointID);
    trace("touch end");
}
```

And the following shows a more advanced example combining dragging with touch event phases:

```
Multitouch.inputMode = MultitouchInputMode.TOUCH_POINT;
var mySprite:Sprite = new Sprite();

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);

mySprite.addEventListener(TouchEvent.TOUCH_BEGIN, onTouchBegin);
mySprite.addEventListener(TouchEvent.TOUCH_MOVE, onTouchMove);
mySprite.addEventListener(TouchEvent.TOUCH_END, onTouchEnd);

function onTouchBegin(evt:TouchEvent) {
    evt.target.startTouchDrag(evt.touchPointID);
    evt.target.scaleX *= 1.5;
    evt.target.scaleY *= 1.5;
}

function onTouchMove(evt:TouchEvent) {
    evt.target.alpha = 0.5;
}

function onTouchEnd(evt:TouchEvent) {
    evt.target.stopTouchDrag(evt.touchPointID);
    evt.target.width = 40;
    evt.target.height = 40;
    evt.target.alpha = 1;
}
```

Gesture event handling

Flash Player 10.1 and later, Adobe AIR 2 and later

Handle gesture events in the same way as basic touch events. You can listen for a series of gesture events defined by the event type constants in the TransformGestureEvent class, the GestureEvent class and the PressAndTapGestureEvent class.

To handle a gesture touch event:

1. Set your application to handle gesture input by setting the `flash.ui.Multitouch.inputMode` property to `MultitouchInputMode.GESTURE`.
2. Attach an event listener to an instance of a class that inherits properties from the InteractiveObject class, such as Sprite or TextField.
3. Specify the type of gesture event to handle.
4. Call an event handler function to do something in response to the event.

For example, the following code displays a message when the square drawn on *mySprite* is swiped on a touch-enabled screen:

```
Multitouch.inputMode=MultitouchInputMode.GESTURE;

var mySprite:Sprite = new Sprite();
var myTextField:TextField = new TextField();

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);

mySprite.addEventListener(TransformGestureEvent.GESTURE_SWIPE, swipehandler);

function swipehandler(evt:TransformGestureEvent): void {
myTextField.text = "I've been swiped";
myTextField.y = 50;
addChild(myTextField);
}
```

Two-finger tap events are handled the same way, but use the GestureEvent class:

```
Multitouch.inputMode=MultitouchInputMode.GESTURE;

var mySprite:Sprite = new Sprite();
var myTextField:TextField = new TextField();

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);

mySprite.addEventListener(GestureEvent.GESTURE_TWO_FINGER_TAP, taphandler);

function taphandler(evt:GestureEvent): void {
myTextField.text = "I've been two-finger tapped";
myTextField.y = 50;
addChild(myTextField);
}
```

Press-and-tap events are also handled the same way, but use the PressAndTapGestureEvent class:

```
Multitouch.inputMode=MultitouchInputMode.GESTURE;

var mySprite:Sprite = new Sprite();
var myTextField:TextField = new TextField();

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);

mySprite.addEventListener(PressAndTapGestureEvent.GESTURE_PRESS_AND_TAP, taphandler);

function taphandler(evt:PressAndTapGestureEvent): void {
myTextField.text = "I've been press-and-tapped";
myTextField.y = 50;
addChild(myTextField);
}
```

***Note:** Not all GestureEvent, TransformGestureEvent, and PressAndTapGestureEvent event types are supported in all runtime environments. For example, not all touch-enabled devices are capable or detecting a multi-finger swipe. So, the InteractiveObject `gestureSwipe` events are not supported on those devices. Try testing for specific event support to ensure your application works, and see "Troubleshooting" on page 593 for more information.*

Gesture Event properties

Gesture events have a smaller scope of event properties than basic touch events. You access them the same way, through the event object in the event handler function.

For example, the following code rotates *mySprite* as the user performs a rotation gesture on it. The text field shows the amount of rotation since the last gesture (when testing this code, rotate it several times to see the values change):

```
Multitouch.inputMode=MultitouchInputMode.GESTURE;

var mySprite:Sprite = new Sprite();
var mySpriteCon:Sprite = new Sprite();
var myTextField:TextField = new TextField();
myTextField.y = 50;
addChild(myTextField);

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(-20,-20,40,40);
mySpriteCon.addChild(mySprite);
mySprite.x = 20;
mySprite.y = 20;
addChild(mySpriteCon);

mySprite.addEventListener(TransformGestureEvent.GESTURE_ROTATE, rothandler);

function rothandler(evt:TransformGestureEvent): void {
evt.target.parent.rotationZ += evt.target.rotation;
myTextField.text = evt.target.parent.rotation.toString();
}
```

***Note:** Not all TransformGestureEvent properties are supported in all runtime environments. For example, not all touch-enabled devices are capable or detecting the rotation of a gesture on the screen. So, the `TransformGestureEvent.rotation` property is not supported on those devices. Try testing for specific property support to ensure your application works, and see "Troubleshooting" on page 593 for more information.*

Gesture phases

Additionally, the gesture events can be tracked through phases, so you can track properties as the gesture is taking place. For example, you can track x-coordinates as an object is moved with a swipe gesture. Use those values to draw a line through all the points in its path after the swipe is complete. Or, visually change a display object as it is dragged across a screen using a pan gesture. Change the object again once the pan gesture is complete.

```
Multitouch.inputMode = MultitouchInputMode.GESTURE;
var mySprite = new Sprite();
mySprite.addEventListener(TransformGestureEvent.GESTURE_PAN , onPan);
mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0, 0, 40, 40);
var myTextField = new TextField();
myTextField.y = 200;
addChild(mySprite);
addChild(myTextField);

function onPan(evt:TransformGestureEvent):void {

    evt.target.localX++;

if (evt.phase==GesturePhase.BEGIN) {
    myTextField.text = "Begin";
    evt.target.scaleX *= 1.5;
    evt.target.scaleY *= 1.5;
}
if (evt.phase==GesturePhase.UPDATE) {
    myTextField.text = "Update";
    evt.target.alpha = 0.5;
}
if (evt.phase==GesturePhase.END) {
    myTextField.text = "End";
    evt.target.width = 40;
    evt.target.height = 40;
    evt.target.alpha = 1;
}
}
```

***Note:** The frequency of the update phase depends on the runtime's environment. Some operating system and hardware combinations do not relay updates at all.*

Gesture phase is "all" for simple gesture events

Some gesture event objects do not track individual phases of the gesture event, and instead populate the event object's phase property with the value all. The simple gestures swipe and two-finger tap do not track the event by multiple phases. The `phase` property of the event object for an InteractiveObject listening for the `gestureSwipe` or `gestureTwoFingerTap` events is always `all` once the event is dispatched:

```
Multitouch.inputMode = MultitouchInputMode.GESTURE;
var mySprite = new Sprite();
mySprite.addEventListener(TransformGestureEvent.GESTURE_SWIPE, onSwipe);
mySprite.addEventListener(GestureEvent.GESTURE_TWO_FINGER_TAP, onTwoTap);
mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0, 0, 40, 40);
var myTextField = new TextField();
myTextField.y = 200;
addChild(mySprite);
addChild(myTextField);

function onSwipe(swipeEvt:TransformGestureEvent):void {
    myTextField.text = swipeEvt.phase // Output is "all"
}
function onTwoTap(tapEvt:GestureEvent):void {
    myTextField.text = tapEvt.phase // Output is "all"
}
```

Troubleshooting

Flash Player 10.1 and later, Adobe AIR 2 and later

Hardware and software support for touch input is changing, rapidly. This reference does not maintain a list of every device an operating system and software combination that supports multitouch. However, it provides guidance on using the discovery API to determine if your application is deployed on a device that supports multitouch, and provides tips for troubleshooting your ActionScript code.

Flash runtimes respond to touch events based on information the device, operating system, or containing software (such as a browser) passes to the runtime. This dependency on the software environment complicates documenting multitouch compatibility. Some devices interpret a gesture or touch motion differently than another device. Is rotation defined by two fingers rotating at the same time? Is rotation one finger drawing a circle on a screen? Depending on the hardware and software environment, the rotation gesture could be either, or something entirely different. So, the device tells the operating system the user input, then the operating system passes that information to the runtime. If the runtime is inside a browser, the browser software sometimes interprets the gesture or touch event and does not pass the input to the runtime. This behavior is similar to the behavior of "hotkeys": you try to use a specific key combination to get Flash Player to do something inside the browser and the browser keeps opening a menu instead.

Individual API and classes mention if they're not compatible with specific operating systems. You can explore individual API entries here, starting with the Multitouch class:
http://help.adobe.com/en_US/FlashPlatform/reference/actionscript/3/flash/ui/Multitouch.html.

Here are some common gesture and touch descriptions:

Pan Move a finger left-to-right or right-to-left. Some devices require two fingers to pan.

Rotate Touch two fingers down, then move them around in a circle (as if they're both simultaneously tracing an imaginary circle on a surface). The pivot point is set at the midpoint between the two finger touch points.

Swipe Move three fingers left-to-right or right-to-left, top-to-bottom, or bottom-to-top, quickly.

Zoom Touch two fingers down, then move them away from each other to zoom in and toward each other to zoom out.

Press-and-tap Move or press one finger, then tap the surface with another.

Each device has its own documentation about the gestures the device supports and how to perform each gesture on that device. In general, the user must remove all fingers from contact with the device between gestures, depending upon the operating system.

If you find your application is not responding to touch events or gestures, test the following:

1 Do you have event listeners for touch or gesture events attached to an object class that inherits from the InteractiveObject class? Only InteractiveObject instances can listen for touch and gesture events

2 Are you testing your application within Flash Professional CS5? If so, try publishing and testing the application, because Flash Professional can intercept the interaction.

3 Start simple and see what does work, first (the following code example is from the API entry for `Multitouch.inputMode`:

```
Multitouch.inputMode=MultitouchInputMode.TOUCH_POINT;
var mySprite:Sprite = new Sprite();
var myTextField:TextField = new TextField()

mySprite.graphics.beginFill(0x336699);
mySprite.graphics.drawRect(0,0,40,40);
addChild(mySprite);

mySprite.addEventListener(TouchEvent.TOUCH_TAP, taplistener);

function taplistener(e:TouchEvent): void {
    myTextField.text = "I've been tapped";
    myTextField.y = 50;
    addChild(myTextField);
}
```

Tap the rectangle. If this example works, then you know your environment supports a simple tap. Then you can try more complicated handling.

Testing for gesture support is more complicated. An individual device or operating system supports any combination of gesture input, or none.

Here is a simple test for the zoom gesture:

```
Multitouch.inputMode = MultitouchInputMode.GESTURE;

stage.addEventListener(TransformGestureEvent.GESTURE_ZOOM , onZoom);
var myTextField = new TextField();
myTextField.y = 200;
myTextField.text = "Perform a zoom gesture";
addChild(myTextField);

function onZoom(evt:TransformGestureEvent):void {
    myTextField.text = "Zoom is supported";
}
```

Perform a zoom gesture on the device and see if the text field populates with the message `Zoom is supported`. The event listener is added to the stage so you can perform the gesture on any part of the test application.

Here is a simple test for the pan gesture:

```
Multitouch.inputMode = MultitouchInputMode.GESTURE;

stage.addEventListener(TransformGestureEvent.GESTURE_PAN , onPan);
var myTextField = new TextField();
myTextField.y = 200;
myTextField.text = "Perform a pan gesture";
addChild(myTextField);

function onPan(evt:TransformGestureEvent):void {
    myTextField.text = "Pan is supported";
}
```

Perform a pan gesture on the device and see if the text field populates with the message `Pan is supported`. The event listener is added to the stage so you can perform the gesture on any part of the test application.

Some operating system and device combinations support both gestures, some support only one, some none. Test your application's deployment environment to be sure.

Known Issues

The following are known issues related to touch input:

1. Mobile Internet Explorer on Windows Mobile operating system automatically zooms SWF file content:

   This Internet Explorer zoom behavior is overridden by adding the following to the HTML page hosting the SWF file:

   ```
   <head>
   <meta name="viewport" content="width=device-width, height=device-height, initial-
   scale=1.0">
   </head>
   ```

2. Windows 7 (and possibly other operating systems), the user must lift the pointing device (or fingers) off the screen between gestures. For example:, to rotate and zoom an image:
   - Perform the rotate gesture.
   - Lift your fingers off the screen.
   - Put your fingers back onto the screen and perform the zoom gesture.
3. Windows 7 (and possibly other operating systems), the rotate and zoom gestures don't always generate an "update" phase if the user performs the gesture very quickly.
4. Windows 7 Starter Edition does not support multitouch. See the AIR Labs Forum for details: http://forums.adobe.com/thread/579180?tstart=0
5. For Mac OS 10.5.3 and later, the `Multitouch.supportsGestureEvents` value is always `true`, even if the hardware does not support gesture events.

Chapter 33: Copy and paste

Flash Player 10 and later, Adobe AIR 1.0 and later

Use the classes in the clipboard API to copy information to and from the system clipboard. The data formats that can be transferred into or out of an application running in Adobe® Flash® Player or Adobe® AIR® include:

- Text
- HTML-formatted text
- Rich Text Format data
- Serialized objects
- Object references (valid only within the originating application)
- Bitmaps (AIR only)
- Files (AIR only)
- URL strings (AIR only)

Basics of copy-and-paste

Flash Player 10 and later, Adobe AIR 1.0 and later

The copy-and-paste API contains the following classes.

Package	Classes
flash.desktop	• Clipboard • ClipboardFormats • ClipboardTransferMode

The static `Clipboard.generalClipboard` property represents the operating system clipboard. The Clipboard class provides methods for reading and writing data to clipboard objects.

The HTMLLoader class (in AIR) and the TextField class implement default behavior for the normal copy and paste keyboard shortcuts. To implement copy and paste shortcut behavior for custom components, you can listen for these keystrokes directly. You can also use native menu commands along with key equivalents to respond to the keystrokes indirectly.

Different representations of the same information can be made available in a single Clipboard object to increase the ability of other applications to understand and use the data. For example, an image might be included as image data, a serialized Bitmap object, and as a file. Rendering of the data in a format can be deferred so that the format is not actually created until the data in that format is read.

Reading from and writing to the system clipboard

Flash Player 10 and later, Adobe AIR 1.0 and later

To read the operating system clipboard, call the `getData()` method of the `Clipboard.generalClipboard` object, passing in the name of the format to read:

```
import flash.desktop.Clipboard;
import flash.desktop.ClipboardFormats;

if(Clipboard.generalClipboard.hasFormat(ClipboardFormats.TEXT_FORMAT)){
    var text:String = Clipboard.generalClipboard.getData(ClipboardFormats.TEXT_FORMAT);
}
```

***Note:** Content running in Flash Player or in a non-application sandbox in AIR can call the `getData()` method only in an event handler for a `paste` event. In other words, only code running in the AIR application sandbox can call the `getData()` method outside of a `paste` event handler.*

To write to the clipboard, add the data to the `Clipboard.generalClipboard` object in one or more formats. Any existing data in the same format is overwritten automatically. Nevertheless, it is a good practice to also clear the system clipboard before writing new data to it to make sure that unrelated data in any other formats is also deleted.

```
import flash.desktop.Clipboard;
import flash.desktop.ClipboardFormats;

var textToCopy:String = "Copy to clipboard.";
Clipboard.generalClipboard.clear();
Clipboard.generalClipboard.setData(ClipboardFormats.TEXT_FORMAT, textToCopy, false);
```

***Note:** Content running in Flash Player or in a non-application sandbox in AIR can call the `setData()` method only in an event handler for a user event, such as a keyboard or mouse event, or a `copy` or `cut` event. In other words, only code running in the AIR application sandbox can call the `setData()` method outside of a user event handler.*

HTML copy and paste in AIR

Adobe AIR 1.0 and later

The HTML environment in Adobe AIR provides its own set of events and default behavior for copy and paste. Only code running in the application sandbox can access the system clipboard directly through the AIR `Clipboard.generalClipboard` object. JavaScript code in a non-application sandbox can access the clipboard through the event object dispatched in response to one of the copy or paste events dispatched by an element in an HTML document.

Copy and paste events include: `copy`, `cut`, and `paste`. The object dispatched for these events provides access to the clipboard through the `clipboardData` property.

Default behavior

Adobe AIR 1.0 and later

By default, AIR copies selected items in response to the copy command, which can be generated either by a keyboard shortcut or a context menu. Within editable regions, AIR cuts text in response to the cut command or pastes text to the cursor or selection in response to the paste command.

To prevent the default behavior, your event handler can call the `preventDefault()` method of the dispatched event object.

Using the clipboardData property of the event object

Adobe AIR 1.0 and later

The `clipboardData` property of the event object dispatched as a result of one of the copy or paste events allows you to read and write clipboard data.

To write to the clipboard when handling a copy or cut event, use the `setData()` method of the `clipboardData` object, passing in the data to copy and the MIME type:

```
function customCopy(event){
    event.clipboardData.setData("text/plain", "A copied string.");
}
```

To access the data that is being pasted, you can use the `getData()` method of the `clipboardData` object, passing in the MIME type of the data format. The available formats are reported by the `types` property.

```
function customPaste(event){
    var pastedData = event.clipboardData("text/plain");
}
```

The `getData()` method and the `types` property can only be accessed in the event object dispatched by the `paste` event.

The following example illustrates how to override the default copy and paste behavior in an HTML page. The `copy` event handler italicizes the copied text and copies it to the clipboard as HTML text. The `cut` event handler copies the selected data to the clipboard and removes it from the document. The `paste` handler inserts the clipboard contents as HTML and styles the insertion as bold text.

```
 <html>
<head>
    <title>Copy and Paste</title>
    <script language="javascript" type="text/javascript">
        function onCopy(event){
            var selection = window.getSelection();
            event.clipboardData.setData("text/html","<i>" + selection + "</i>");
            event.preventDefault();
        }

        function onCut(event){
             var selection = window.getSelection();
             event.clipboardData.setData("text/html","<i>" + selection + "</i>");
             var range = selection.getRangeAt(0);
             range.extractContents();

            event.preventDefault();
        }

        function onPaste(event){
            var insertion = document.createElement("b");
            insertion.innerHTML = event.clipboardData.getData("text/html");
             var selection = window.getSelection();
             var range = selection.getRangeAt(0);
             range.insertNode(insertion);
            event.preventDefault();
        }
    </script>
</head>
<body onCopy="onCopy(event)"
     onPaste="onPaste(event)"
     onCut="onCut(event)">
<p>Sed ut perspiciatis unde omnis iste natus error sit voluptatem accusantium
doloremque laudantium, totam rem aperiam, eaque ipsa quae ab illo inventore
veritatis et quasi architecto beatae vitae dicta sunt explicabo. Nemo enim ipsam
voluptatem quia voluptas sit aspernatur aut odit aut fugit, sed quia consequuntur
magni dolores eos qui ratione voluptatem sequi nesciunt.</p>
</body>
</html>
```

Clipboard data formats

Flash Player 10 and later, Adobe AIR 1.0 and later

Clipboard formats describe the data placed in a Clipboard object. Flash Player or AIR automatically translates the standard data formats between ActionScript data types and system clipboard formats. In addition, application objects can be transferred within and between ActionScript-based applications using application-defined formats.

A Clipboard object can contain representations of the same information in different formats. For example, a Clipboard object representing a Sprite could include a reference format for use within the same application, a serialized format for use by another application running in Flash Player or AIR, a bitmap format for use by an image editor, and a file list format, perhaps with deferred rendering to encode a PNG file, for copying or dragging a representation of the Sprite to the file system.

Standard data formats

Flash Player 10 and later, Adobe AIR 1.0 and later

The constants defining the standard format names are provided in the ClipboardFormats class:

Constant	**Description**
TEXT_FORMAT	Text-format data is translated to and from the ActionScript String class.
HTML_FORMAT	Text with HTML markup.
RICH_TEXT_FORMAT	Rich-text-format data is translated to and from the ActionScript ByteArray class. The RTF markup is not interpreted or translated in any way.
BITMAP_FORMAT	(AIR only) Bitmap-format data is translated to and from the ActionScript BitmapData class.
FILE_LIST_FORMAT	(AIR only) File-list-format data is translated to and from an array of ActionScript File objects.
URL_FORMAT	(AIR only) URL-format data is translated to and from the ActionScript String class.

When copying and pasting data in response to a `copy`, `cut`, or `paste` event in HTML content hosted in an AIR application, MIME types must be used instead of the ClipboardFormat strings. The valid data MIME types are:

MIME type	**Description**
Text	"text/plain"
URL	"text/uri-list"
Bitmap	"image/x-vnd.adobe.air.bitmap"
File list	"application/x-vnd.adobe.air.file-list"

Note: *Rich text format data is not available from the* `clipboardData` *property of the event object dispatched as a result of a* `paste` *event within HTML content.*

Custom data formats

Flash Player 10 and later, Adobe AIR 1.0 and later

You can use application-defined custom formats to transfer objects as references or as serialized copies. References are valid only within the same application. Serialized objects can be transferred between applications, but can be used only with objects that remain valid when serialized and deserialized. Objects can usually be serialized if their properties are either simple types or serializable objects.

To add a serialized object to a Clipboard object, set the *serializable* parameter to `true` when calling the `Clipboard.setData()` method. The format name can be one of the standard formats or an arbitrary string defined by your application.

Transfer modes

Flash Player 10 and later, Adobe AIR 1.0 and later

When an object is written to the clipboard using a custom data format, the object data can be read from the clipboard either as a reference or as a serialized copy of the original object. There are four transfer modes that determine whether objects are transferred as references or as serialized copies:

Transfer mode	Description
ClipboardTransferModes.ORIGINAL_ONLY	Only a reference is returned. If no reference is available, a null value is returned.
ClipboardTransferModes.ORIGINAL_PREFFERED	A reference is returned, if available. Otherwise a serialized copy is returned.
ClipboardTransferModes.CLONE_ONLY	Only a serialized copy is returned. If no serialized copy is available, a null value is returned.
ClipboardTransferModes.CLONE_PREFFERED	A serialized copy is returned, if available. Otherwise a reference is returned.

Reading and writing custom data formats

Flash Player 10 and later, Adobe AIR 1.0 and later

When writing an object to the clipboard, you can use any string that does not begin with the reserved prefixes `air:` or `flash:` for the *format* parameter. Use the same string as the format to read the object. The following examples illustrate how to read and write objects to the clipboard:

```
public function createClipboardObject(object:Object):Clipboard{
    var transfer:Clipboard = Clipboard.generalClipboard;
    transfer.setData("object", object, true);
}
```

To extract a serialized object from the clipboard object (after a drop or paste operation), use the same format name and the `CLONE_ONLY` or `CLONE_PREFFERED` transfer modes.

```
var transfer:Object = clipboard.getData("object", ClipboardTransferMode.CLONE_ONLY);
```

A reference is always added to the Clipboard object. To extract the reference from the clipboard object (after a drop or paste operation), instead of the serialized copy, use the `ORIGINAL_ONLY` or `ORIGINAL_PREFFERED` transfer modes:

```
var transferredObject:Object =
    clipboard.getData("object", ClipboardTransferMode.ORIGINAL_ONLY);
```

References are valid only if the Clipboard object originates from the current application. Use the `ORIGINAL_PREFFERED` transfer mode to access the reference when it is available, and the serialized clone when the reference is not available.

Deferred rendering

Flash Player 10 and later, Adobe AIR 1.0 and later

If creating a data format is computationally expensive, you can use deferred rendering by supplying a function that supplies the data on demand. The function is called only if a receiver of the drop or paste operation requests data in the deferred format.

The rendering function is added to a Clipboard object using the `setDataHandler()` method. The function must return the data in the appropriate format. For example, if you called `setDataHandler(ClipboardFormat.TEXT_FORMAT, writeText)`, then the `writeText()` function must return a string.

If a data format of the same type is added to a Clipboard object with the `setData()` method, that data takes precedence over the deferred version (the rendering function is never called). The rendering function may or may not be called again if the same clipboard data is accessed a second time.

***Note:** On Mac OS X, deferred rendering works only with custom data formats. With standard data formats, the rendering function is called immediately.*

Pasting text using a deferred rendering function

Flash Player 10 and later, Adobe AIR 1.0 and later

The following example illustrates how to implement a deferred rendering function.

When the user presses the Copy button, the application clears the system clipboard to ensure that no data is left over from previous clipboard operations. The `setDataHandler()` method then sets the `renderData()` function as the clipboard renderer.

When the user selects the Paste command from the context menu of the destination text field, the application accesses the clipboard and sets the destination text. Since the text data format on the clipboard has been set with a function rather than a string, the clipboard calls the `renderData()` function. The `renderData()` function returns the text in the source text, which is then assigned to the destination text.

Notice that if you edit the source text before pressing the Paste button, the edit will be reflected in the pasted text, even when the edit occurs after the copy button was pressed. This is because the rendering function doesn't copy the source text until the paste button is pressed. (When using deferred rendering in a real application, you might want to store or protect the source data in some way to prevent this problem.)

Flash example

```
package {
   import flash.desktop.Clipboard;
   import flash.desktop.ClipboardFormats;
   import flash.desktop.ClipboardTransferMode;
   import flash.display.Sprite;
   import flash.text.TextField;
   import flash.text.TextFormat;
   import flash.text.TextFieldType;
   import flash.events.MouseEvent;
   import flash.events.Event;
   public class DeferredRenderingExample extends Sprite
   {
       private var sourceTextField:TextField;
       private var destination:TextField;
       private var copyText:TextField;
       public function DeferredRenderingExample():void
       {
           sourceTextField = createTextField(10, 10, 380, 90);
           sourceTextField.text = "Neque porro quisquam est qui dolorem "
               + "ipsum quia dolor sit amet, consectetur, adipisci velit.";

           copyText = createTextField(10, 110, 35, 20);
           copyText.htmlText = "<a href='#'>Copy</a>";
           copyText.addEventListener(MouseEvent.CLICK, onCopy);

           destination = createTextField(10, 145, 380, 90);
           destination.addEventListener(Event.PASTE, onPaste);
       }
       private function createTextField(x:Number, y:Number, width:Number,
                       height:Number):TextField
       {
           var newTxt:TextField = new TextField();
           newTxt.x = x;
           newTxt.y = y;
           newTxt.height = height;
```

```
            newTxt.width = width;
            newTxt.border = true;
            newTxt.multiline = true;
            newTxt.wordWrap = true;
            newTxt.type = TextFieldType.INPUT;
            addChild(newTxt);
            return newTxt;
        }
        public function onCopy(event:MouseEvent):void
        {
            Clipboard.generalClipboard.clear();
            Clipboard.generalClipboard.setDataHandler(ClipboardFormats.TEXT_FORMAT,
                            renderData);
        }
        public function onPaste(event:Event):void
        {
            sourceTextField.text =
            Clipboard.generalClipboard.getData(ClipboardFormats.TEXT_FORMAT).toString;
        }
        public function renderData():String
        {
            trace("Rendering data");
            var sourceStr:String = sourceTextField.text;
            if (sourceTextField.selectionEndIndex >
                     sourceTextField.selectionBeginIndex)
            {
                return sourceStr.substring(sourceTextField.selectionBeginIndex,
                                    sourceTextField.selectionEndIndex);
            }
            else
            {
                return sourceStr;
            }
        }
    }
}
```

Flex example

```
<mx:Application xmlns:mx="http://www.adobe.com/2006/mxml" layout="absolute" width="326"
height="330" applicationComplete="init()">
    <mx:Script>
    <![CDATA[
    import flash.desktop.Clipboard;
    import flash.desktop.ClipboardFormats;

    public function init():void
    {
        destination.addEventListener("paste", doPaste);
    }

    public function doCopy():void
    {
        Clipboard.generalClipboard.clear();
        Clipboard.generalClipboard.setDataHandler(ClipboardFormats.TEXT_FORMAT, renderData);
    }
    public function doPaste(event:Event):void
    {
        destination.text =
Clipboard.generalClipboard.getData(ClipboardFormats.TEXT_FORMAT).toString;
    }

    public function renderData():String{
        trace("Rendering data");
        return source.text;
    }
    ]]>
    </mx:Script>
    <mx:Label x="10" y="10" text="Source"/>
    <mx:TextArea id="source" x="10" y="36" width="300" height="100">
        <mx:text>Neque porro quisquam est qui dolorem ipsum quia dolor sit amet, consectetur,
adipisci velit.</mx:text>
    </mx:TextArea>
    <mx:Label x="10" y="181" text="Destination"/>
    <mx:TextArea id="destination"  x="12" y="207" width="300" height="100"/>
    <mx:Button click="doCopy();" x="91" y="156" label="Copy"/>
</mx:Application>
```

Chapter 34: Accelerometer input

Flash Player 10.1 and later, Adobe AIR 2 and later

The Accelerometer class dispatches events based on activity detected by the device's motion sensor. This data represents the device's location or movement along a three-dimensional axis. When the device moves, the sensor detects this movement and returns the acceleration coordinates of the device. The Accelerometer class provides methods to query whether accelerometer is supported, and also to set the rate at which acceleration events are dispatched.

The accelerometer axes are normalized to the display orientation, not the physical orientation of the device. When the device re-orients the display, the accelerometer axes are re-oriented as well. Thus the y-axis is always roughly vertical when the user is holding the phone in a normal, upright viewing position — no matter which way the phone is rotated. If auto-orientation is off, for example, when SWF content in a browser is in full-screen mode, then the accelerometer axes are not re-oriented as the device is rotated.

More Help topics

flash.sensors.Accelerometer

flash.events.AccelerometerEvent

Checking accelerometer support

Use the `Accelerometer.isSupported` property to test the runtime environment for the ability to use this feature:

```
if (Accelerometer.isSupported)
{
    // Set up Accelerometer event listeners and code.
}
```

The Accelerometer class and its members are accessible to the runtime versions listed for each API entry. However the current environment at run time determines the availability of this feature. For example, you can compile code using the Accelerometer class properties for Flash Player 10.1, but you need to use the `Accelerometer.isSupported` property to test for the availability of the Accelerometer feature on the user's device. If `Accelerometer.isSupported` is `true` at runtime, then Accelerometer support currently exists.

Detecting accelerometer changes

To use the accelerometer sensor, instantiate an Accelerometer object and register for `update` events it dispatches. The `update` event is an Accelerometer event object. The event has four properties, and each are numbers:

- `accelerationX`—Acceleration along the x-axis, measured in g's. The x-axis runs from the left to the right of the device when it is in the upright position. (The device is upright when the top of the device is facing up.) The acceleration is positive if the device moves toward the right.

- `accelerationY`—Acceleration along the y-axis, measured in g's. The y-axis runs from the bottom to the top of the device when it is in the upright position. (The device is upright when the top of the device is facing up.) The acceleration is positive if the device moves up relative to this axis.
- `accelerationZ`—Acceleration along the z-axis, measured in g's. The Z axis runs perpendicular to the face of the device. The acceleration is positive if you move the device so that the face of the device points up. The acceleration is negative if the face of the device points towards the ground.
- `timestamp`—The number of milliseconds at the time of the event since the runtime was initialized.

1 g is the standard acceleration due to gravity, roughly 9.8 m/sec$^{2.}$.

Here is a basic example that displays accelerometer data in a text field:

```
var accl:Accelerometer;
if (Accelerometer.isSupported)
{
    accl = new Accelerometer();
    accl.addEventListener(AccelerometerEvent.UPDATE, updateHandler);
}
else
{
    accTextField.text = "Accelerometer feature not supported";
}
function updateHandler(evt:AccelerometerEvent):void
{
    accTextField.text = "acceleration X: " + evt.accelerationX.toString() + "\n"
            + "acceleration Y: " + evt.accelerationY.toString() + "\n"
            + "acceleration Z: " + evt.accelerationZ.toString()
}
```

To use this example, be sure to create the `accTextField` text field and add it to the display list before using this code.

You can adjust the desired time interval for accelerometer events by calling the `setRequestedUpdateInterval()` method of the Accelerometer object. This method takes one parameter, `interval`, which is the requested update interval in milliseconds:

```
var accl:Accelerometer;
accl = new Accelerometer();
accl.setRequestedUpdateInterval(1000);
```

The actual time between accelerometer updates may be greater or lesser than this value. Any change in the update interval affects all registered listeners. If you don't call the `setRequestedUpdateInterval()` method, the application receives updates based on the device's default interval.

Accelerometer data has some degree of inaccuracy. You can use a moving average of recent data to smooth out the data. For example, the following example factors recent accelerometer readings with the current reading to get a rounded result:

```
var accl:Accelerometer;
var rollingX:Number = 0;
var rollingY:Number = 0;
var rollingZ:Number = 0;
const FACTOR:Number = 0.25;

if (Accelerometer.isSupported)
{
    accl = new Accelerometer();
    accl.setRequestedUpdateInterval(200);
    accl.addEventListener(AccelerometerEvent.UPDATE, updateHandler);
}
else
{
    accTextField.text = "Accelerometer feature not supported";
}
function updateHandler(event:AccelerometerEvent):void
{
    accelRollingAvg(event);
    accTextField.text = rollingX + "\n" +  rollingY + "\n" + rollingZ + "\n";
}

function accelRollingAvg(event:AccelerometerEvent):void
{
    rollingX = (event.accelerationX * FACTOR) + (rollingX * (1 - FACTOR));
    rollingY = (event.accelerationY * FACTOR) + (rollingY * (1 - FACTOR));
    rollingZ = (event.accelerationZ * FACTOR) + (rollingZ * (1 - FACTOR));
}
```

However, this moving average is only desirable if the accelerometer update interval is small.

Chapter 35: Drag and drop in AIR

Adobe AIR 1.0 and later

Use the classes in the Adobe® AIR™ drag-and-drop API to support user-interface drag-and-drop gestures. A *gesture* in this sense is an action by the user, mediated by both the operating system and your application, expressing an intent to copy, move, or link information. A *drag-out* gesture occurs when the user drags an object out of a component or application. A *drag-in* gesture occurs when the user drags in an object from outside a component or application.

With the drag-and-drop API, you can allow a user to drag data between applications and between components within an application. Supported transfer formats include:

- Bitmaps
- Files
- HTML-formatted text
- Text
- Rich Text Format data
- URLs
- File promises
- Serialized objects
- Object references (only valid within the originating application)

Basics of drag and drop in AIR

Adobe AIR 1.0 and later

For a quick explanation and code examples of using drag and drop in an AIR application, see the following quick start articles on the Adobe Developer Connection:

- Supporting drag-and-drop and copy-and-paste (Flex)
- Supporting drag-and-drop and copy-and-paste (Flash)

The drag-and-drop API contains the following classes.

Package	**Classes**
flash.desktop	• NativeDragManager • NativeDragOptions • Clipboard • URLFilePromise • IFilePromise Constants used with the drag-and-drop API are defined in the following classes: • NativeDragActions • ClipboardFormat • ClipboardTransferModes
flash.events	NativeDragEvent

Drag-and-drop gesture stages

The drag-and-drop gesture has three stages:

Initiation *A user initiates a drag-and-drop operation by dragging from a component, or an item in a component, while holding down the mouse button.* The component that is the source of the dragged item is typically designated as the drag initiator and dispatches `nativeDragStart` and `nativeDragComplete` events. An Adobe AIR application starts a drag operation by calling the `NativeDragManager.doDrag()` method in response to a `mouseDown` or `mouseMove` event.

If the drag operation is initiated from outside an AIR application, there is no initiator object to dispatch `nativeDragStart` or `nativeDragComplete` events.

Dragging *While holding down the mouse button, the user moves the mouse cursor to another component, application, or to the desktop.* As long as the drag is underway, the initiator object dispatches `nativeDragUpdate` events. (However, this event is not dispatched in AIR for Linux.) When the user moves the mouse over a possible drop target in an AIR application, the drop target dispatches a `nativeDragEnter` event. The event handler can inspect the event object to determine whether the dragged data is available in a format that the target accepts and, if so, let the user drop the data onto it by calling the `NativeDragManager.acceptDragDrop()` method.

As long as the drag gesture remains over an interactive object, that object dispatches `nativeDragOver` events. When the drag gesture leaves the interactive object, it dispatches a `nativeDragExit` event.

Drop *The user releases the mouse over an eligible drop target.* If the target is an AIR application or component, then the target object dispatches a `nativeDragDrop` event. The event handler can access the transferred data from the event object. If the target is outside AIR, the operating system or another application handles the drop. In both cases, the initiating object dispatches a `nativeDragComplete` event (if the drag started from within AIR).

The NativeDragManager class controls both drag-in and drag-out gestures. All the members of the NativeDragManager class are static, do not create an instance of this class.

The Clipboard object

Data that is dragged into or out of an application or component is contained in a Clipboard object. A single Clipboard object can make available different representations of the same information to increase the likelihood that another application can understand and use the data. For example, an image could be included as image data, a serialized Bitmap object, and as a file. Rendering of the data in a format can be deferred to a rendering function that is not called until the data is read.

Once a drag gesture has started, the Clipboard object can only be accessed from within an event handler for the `nativeDragEnter`, `nativeDragOver`, and `nativeDragDrop` events. After the drag gesture has ended, the Clipboard object cannot be read or reused.

An application object can be transferred as a reference and as a serialized object. References are only valid within the originating application. Serialized object transfers are valid between AIR applications, but can only be used with objects that remain valid when serialized and deserialized. Objects that are serialized are converted into the Action Message Format for ActionScript 3 (AMF3), a string-based data-transfer format.

Working with the Flex framework
In most cases, it is better to use the Adobe® Flex™ drag-and-drop API when building Flex applications. The Flex framework provides an equivalent feature set when a Flex application is run in AIR (it uses the AIR NativeDragManager internally). Flex also maintains a more limited feature set when an application or component is running within the more restrictive browser environment. AIR classes cannot be used in components or applications that run outside the AIR run-time environment.

Supporting the drag-out gesture

Adobe AIR 1.0 and later

To support the drag-out gesture, you must create a Clipboard object in response to a `mouseDown` event and send it to the `NativeDragManager.doDrag()` method. Your application can then listen for the `nativeDragComplete` event on the initiating object to determine what action to take when the user completes or abandons the gesture.

Preparing data for transfer

Flash Player 9 and later, Adobe AIR 1.0 and later

To prepare data or an object for dragging, create a Clipboard object and add the information to be transferred in one or more formats. You can use the standard data formats to pass data that can be translated automatically to native clipboard formats, and application-defined formats to pass objects.

If it is computationally expensive to convert the information to be transferred into a particular format, you can supply the name of a handler function to perform the conversion. The function is called if and only if the receiving component or application reads the associated format.

For more information on clipboard formats, see "Clipboard data formats" on page 599.

The following example illustrates how to create a Clipboard object containing a bitmap in several formats: a Bitmap object, a native bitmap format, and a file list format containing the file from which the bitmap was originally loaded:

```
import flash.desktop.Clipboard;
import flash.display.Bitmap;
import flash.filesystem.File;
public function createClipboard(image:Bitmap, sourceFile:File):Clipboard{
    var transfer:Clipboard = new Clipboard();
    transfer.setData("CUSTOM_BITMAP", image, true); //Flash object by value and by reference
    transfer.setData(ClipboardFormats.BITMAP_FORMAT, image.bitmapData, false);
    transfer.setData(ClipboardFormats.FILE_LIST_FORMAT, new Array(sourceFile), false);
    return transfer;
}
```

Starting a drag-out operation

Adobe AIR 1.0 and later

To start a drag operation, call the `NativeDragManager.doDrag()` method in response to a mouse down event. The `doDrag()` method is a static method that takes the following parameters:

Parameter	Description
initiator	The object from which the drag originates, and which dispatches the `dragStart` and `dragComplete` events. The initiator must be an interactive object.
clipboard	The Clipboard object containing the data to be transferred. The Clipboard object is referenced in the NativeDragEvent objects dispatched during the drag-and-drop sequence.
dragImage	(Optional) A BitmapData object to display during the drag. The image can specify an `alpha` value. (Note: Microsoft Windows always applies a fixed alpha fade to drag images).
offset	(Optional) A Point object specifying the offset of the drag image from the mouse hotspot. Use negative coordinates to move the drag image up and left relative to the mouse cursor. If no offset is provided, the top, left corner of the drag image is positioned at the mouse hotspot.
actionsAllowed	(Optional) A NativeDragOptions object specifying which actions (copy, move, or link) are valid for the drag operation. If no argument is provided, all actions are permitted. The DragOptions object is referenced in NativeDragEvent objects to enable a potential drag target to check that the allowed actions are compatible with the purpose of the target component. For example, a "trash" component might only accept drag gestures that allow the move action.

The following example illustrates how to start a drag operation for a bitmap object loaded from a file. The example loads an image and, on a `mouseDown` event, starts the drag operation.

```
 package
{
import flash.desktop.NativeDragManager;
import mx.core.UIComponent;
import flash.display.Sprite;
import flash.display.Loader;
import flash.system.LoaderContext;
import flash.net.URLRequest;
import flash.geom.Point;
import flash.desktop.Clipboard;
import flash.display.Bitmap;
import flash.filesystem.File;
import flash.events.Event;
import flash.events.MouseEvent;

public class DragOutExample extends UIComponent Sprite {
    protected var fileURL:String = "app:/image.jpg";
    protected var display:Bitmap;

    private function init():void {
        loadImage();
    }
    private function onMouseDown(event:MouseEvent):void {
        var bitmapFile:File = new File(fileURL);
        var transferObject:Clipboard = createClipboard(display, bitmapFile);
        NativeDragManager.doDrag(this,
                             transferObject,
                             display.bitmapData,
                        new Point(-mouseX,-mouseY));
    }
    public function createClipboard(image:Bitmap, sourceFile:File):Clipboard {
        var transfer:Clipboard = new Clipboard();
        transfer.setData("bitmap",
                        image,
                        true);
                        // ActionScript 3 Bitmap object by value and by reference
        transfer.setData(ClipboardFormats.BITMAP_FORMAT,
                        image.bitmapData,
                        false);
                        // Standard BitmapData format
        transfer.setData(ClipboardFormats.FILE_LIST_FORMAT,
                        new Array(sourceFile),
                        false);
                        // Standard file list format
        return transfer;
    }
    private function loadImage():void {
        var url:URLRequest = new URLRequest(fileURL);
        var loader:Loader = new Loader();
        loader.load(url,new LoaderContext());
        loader.contentLoaderInfo.addEventListener(Event.COMPLETE, onLoadComplete);
    }
    private function onLoadComplete(event:Event):void {
        display = event.target.loader.content;
        var flexWrapper:UIComponent = new UIComponent();
        flexWrapper.addChild(event.target.loader.content);
        addChild(flexWrapper);
        flexWrapper.addEventListener(MouseEvent.MOUSE_DOWN, onMouseDown);
    }
}
}
```

Completing a drag-out transfer

Adobe AIR 1.0 and later

When a user drops the dragged item by releasing the mouse, the initiator object dispatches a `nativeDragComplete` event. You can check the `dropAction` property of the event object and then take the appropriate action. For example, if the action is `NativeDragAction.MOVE`, you could remove the source item from its original location. The user can abandon a drag gesture by releasing the mouse button while the cursor is outside an eligible drop target. The drag manager sets the `dropAction` property for an abandoned gesture to `NativeDragAction.NONE`.

Supporting the drag-in gesture

Adobe AIR 1.0 and later

To support the drag-in gesture, your application (or, more typically, a visual component of your application) must respond to `nativeDragEnter` or `nativeDragOver` events.

Steps in a typical drop operation

Adobe AIR 1.0 and later

The following sequence of events is typical for a drop operation:

1 The user drags a clipboard object over a component.

2 The component dispatches a `nativeDragEnter` event.

3 The `nativeDragEnter` event handler examines the event object to check the available data formats and allowed actions. If the component can handle the drop, it calls `NativeDragManager.acceptDragDrop()`.

4 The NativeDragManager changes the mouse cursor to indicate that the object can be dropped.

5 The user drops the object over the component.

6 The receiving component dispatches a `nativeDragDrop` event.

7 The receiving component reads the data in the desired format from the Clipboard object within the event object.

8 If the drag gesture originated within an AIR application, then the initiating interactive object dispatches a `nativeDragComplete` event. If the gesture originated outside AIR, no feedback is sent.

Acknowledging a drag-in gesture

Adobe AIR 1.0 and later

When a user drags a clipboard item into the bounds of a visual component, the component dispatches `nativeDragEnter` and `nativeDragOver` events. To determine whether the component can accept the clipboard item, the handlers for these events can check the `clipboard` and `allowedActions` properties of the event object. To signal that the component can accept the drop, the event handler must call the `NativeDragManager.acceptDragDrop()` method, passing a reference to the receiving component. If more than one registered event listener calls the `acceptDragDrop()` method, the last handler in the list takes precedence. The `acceptDragDrop()` call remains valid until the mouse leaves the bounds of the accepting object, triggering the `nativeDragExit` event.

If more than one action is permitted in the `allowedActions` parameter passed to `doDrag()`, the user can indicate which of the allowed actions they intend to perform by holding down a modifier key. The drag manager changes the cursor image to tell the user which action would occur if they completed the drop. The intended action is reported by the `dropAction` property of the NativeDragEvent object. The action set for a drag gesture is advisory only. The components involved in the transfer must implement the appropriate behavior. To complete a move action, for example, the drag initiator might remove the dragged item and the drop target might add it.

Your drag target can limit the drop action to one of the three possible actions by setting the `dropAction` property of NativeDragManager class. If a user tries to choose a different action using the keyboard, then the NativeDragManager displays the *unavailable* cursor. Set the `dropAction` property in the handlers for both the `nativeDragEnter` and the `nativeDragOver` events.

The following example illustrates an event handler for a `nativeDragEnter` or `nativeDragOver` event. This handler only accepts a drag-in gesture if the clipboard being dragged contains text-format data.

```
import flash.desktop.NativeDragManager;
import flash.events.NativeDragEvent;

public function onDragIn(event:NativeDragEvent):void{
    NativeDragManager.dropAction = NativeDragActions.MOVE;
    if(event.clipboard.hasFormat(ClipboardFormats.TEXT_FORMAT)){
        NativeDragManager.acceptDragDrop(this); //'this' is the receiving component
    }
}
```

Completing the drop

Adobe AIR 1.0 and later

When the user drops a dragged item on an interactive object that has accepted the gesture, the interactive object dispatches a `nativeDragDrop` event. The handler for this event can extract the data from the `clipboard` property of the event object.

When the clipboard contains an application-defined format, the `transferMode` parameter passed to the `getData()` method of the Clipboard object determines whether the drag manager returns a reference or a serialized version of the object.

The following example illustrates an event handler for the `nativeDragDrop` event:

```
 import flash.desktop.Clipboard;
import flash.events.NativeDragEvent;

public function onDrop(event:NativeDragEvent):void {
    if (event.clipboard.hasFormat(ClipboardFormats.TEXT_FORMAT)) {
    var text:String =
        String(event.clipboard.getData(ClipboardFormats.TEXT_FORMAT,
                                ClipboardTransferMode.ORIGINAL_PREFERRED));
}
```

Once the event handler exits, the Clipboard object is no longer valid. Any attempt to access the object or its data generates an error.

Updating the visual appearance of a component

Adobe AIR 1.0 and later

A component can update its visual appearance based on the NativeDragEvent events. The following table describes the types of changes that a typical component would make in response to the different events:

Event	Description
nativeDragStart	The initiating interactive object can use the `nativeDragStart` event to provide visual feedback that the drag gesture originated from that interactive object.
nativeDragUpdate	The initiating interactive object can use the nativeDragUpdate event to update its state during the gesture. (This event does not exist in AIR for Linux.)
nativeDragEnter	A potential receiving interactive object can use this event to take the focus, or indicate visually that it can or cannot accept the drop.

Event	Description
nativeDragOver	A potential receiving interactive object can use this event to respond to the movement of the mouse within the interactive object, such as when the mouse enters a "hot" region of a complex component such as a street map display.
nativeDragExit	A potential receiving interactive object can use this event to restore its state when a drag gesture moves outside its bounds.
nativeDragComplete	The initiating interactive object can use this event to update its associated data model, such as by removing an item from a list, and to restore its visual state.

Tracking mouse position during a drag-in gesture

Adobe AIR 1.0 and later

While a drag gesture remains over a component, that component dispatches `nativeDragOver` events. These events are dispatched every few milliseconds and also whenever the mouse moves. The `nativeDragOver` event object can be used to determine the position of the mouse over the component. Having access to the mouse position can be helpful in situations where the receiving component is complex, but is not made up of sub-components. For example, if your application displayed a bitmap containing a street map and you wanted to highlight zones on the map when the user dragged information into them, you could use the mouse coordinates reported in the `nativeDragOver` event to track the mouse position within the map.

Drag and drop in HTML

Adobe AIR 1.0 and later

To drag data into and out of an HTML-based application (or into and out of the HTML displayed in an HTMLLoader), you can use HTML drag and drop events. The HTML drag-and-drop API allows you to drag to and from DOM elements in the HTML content.

***Note:** You can also use the AIR NativeDragEvent and NativeDragManager APIs by listening for events on the HTMLLoader object containing the HTML content. However, the HTML API is better integrated with the HTML DOM and gives you control of the default behavior.*

Default drag-and-drop behavior

Adobe AIR 1.0 and later

The HTML environment provides default behavior for drag-and-drop gestures involving text, images, and URLs. Using the default behavior, you can always drag these types of data out of an element. However, you can only drag text into an element and only to elements in an editable region of a page. When you drag text between or within editable regions of a page, the default behavior performs a move action. When you drag text to an editable region from a non-editable region or from outside the application, then the default behavior performs a copy action.

You can override the default behavior by handling the drag-and-drop events yourself. To cancel the default behavior, you must call the `preventDefault()` methods of the objects dispatched for the drag-and-drop events. You can then insert data into the drop target and remove data from the drag source as necessary to perform the chosen action.

By default, the user can select and drag any text, and drag images and links. You can use the WebKit CSS property, `-webkit-user-select` to control how any HTML element can be selected. For example, if you set `-webkit-user-select` to `none`, then the element contents are not selectable and so cannot be dragged. You can also use the `-webkit-user-drag` CSS property to control whether an element as a whole can be dragged. However, the contents of the element are treated separately. The user could still drag a selected portion of the text. For more information, see "CSS in AIR" on page 977.

Drag-and-drop events in HTML

Adobe AIR 1.0 and later

The events dispatched by the initiator element from which a drag originates, are:

Event	Description
dragstart	Dispatched when the user starts the drag gesture. The handler for this event can prevent the drag, if necessary, by calling the preventDefault() method of the event object. To control whether the dragged data can be copied, linked, or moved, set the effectAllowed property. Selected text, images, and links are put onto the clipboard by the default behavior, but you can set different data for the drag gesture using the dataTransfer property of the event object.
drag	Dispatched continuously during the drag gesture.
dragend	Dispatched when the user releases the mouse button to end the drag gesture.

The events dispatched by a drag target are:

Event	Description
dragover	Dispatched continuously while the drag gesture remains within the element boundaries. The handler for this event should set the dataTransfer.dropEffect property to indicate whether the drop will result in a copy, move, or link action if the user releases the mouse.
dragenter	Dispatched when the drag gesture enters the boundaries of the element. If you change any properties of a dataTransfer object in a dragenter event handler, those changes are quickly overridden by the next dragover event. On the other hand, there is a short delay between a dragenter and the first dragover event that can cause the cursor to flash if different properties are set. In many cases, you can use the same event handler for both events.
dragleave	Dispatched when the drag gesture leaves the element boundaries.
drop	Dispatched when the user drops the data onto the element. The data being dragged can only be accessed within the handler for this event.

The event object dispatched in response to these events is similar to a mouse event. You can use mouse event properties such as (`clientX`, `clientY`) and (`screenX`, `screenY`), to determine the mouse position.

The most important property of a drag event object is `dataTransfer`, which contains the data being dragged. The `dataTransfer` object itself has the following properties and methods:

Property or Method	**Description**
effectAllowed	The effect allowed by the source of the drag. Typically, the handler for the dragstart event sets this value. See "Drag effects in HTML" on page 618.
dropEffect	The effect chosen by the target or the user. If you set the `dropEffect` in a `dragover` or `dragenter` event handler, then AIR updates the mouse cursor to indicate the effect that occurs if the user releases the mouse. If the `dropEffect` set does not match one of the allowed effects, no drop is allowed and the *unavailable* cursor is displayed. If you have not set a `dropEffect` in response to the latest `dragover` or `dragenter` event, then the user can choose from the allowed effects with the standard operating system modifier keys. The final effect is reported by the `dropEffect` property of the object dispatched for `dragend`. If the user abandons the drop by releasing the mouse outside an eligible target, then `dropEffect` is set to `none`.
types	An array containing the MIME type strings for each data format present in the `dataTransfer` object.
getData(mimeType)	Gets the data in the format specified by the `mimeType` parameter. The `getData()` method can only be called in response to the `drop` event.
setData(mimeType)	Adds data to the `dataTransfer` in the format specified by the mimeType parameter. You can add data in multiple formats by calling `setData()` for each MIME type. Any data placed in the `dataTransfer` object by the default drag behavior is cleared. The `setData()` method can only be called in response to the `dragstart` event.
clearData(mimeType)	Clears any data in the format specified by the `mimeType` parameter.
setDragImage(image, offsetX, offsetY)	Sets a custom drag image. The `setDragImage()` method can only be called in response to the dragstart event and only when an entire HTML element is dragged by setting its `-webkit-user-drag` CSS style to `element`. The `image` parameter can be a JavaScript Element or Image object.

MIME types for the HTML drag-and-drop

Adobe AIR 1.0 and later

The MIME types to use with the `dataTransfer` object of an HTML drag-and-drop event include:

Data format	**MIME type**
Text	"text/plain"
HTML	"text/html"
URL	"text/uri-list"
Bitmap	"image/x-vnd.adobe.air.bitmap"
File list	"application/x-vnd.adobe.air.file-list"

You can also use other MIME strings, including application-defined strings. However, other applications may not be able to recognize or use the transferred data. It is your responsibility to add data to the `dataTransfer` object in the expected format.

Important: *Only code running in the application sandbox can access dropped files. Attempting to read or set any property of a File object within a non-application sandbox generates a security error. See "Handling file drops in non-application HTML sandboxes" on page 622 for more information.*

Drag effects in HTML

Adobe AIR 1.0 and later

The initiator of the drag gesture can limit the allowed drag effects by setting the `dataTransfer.effectAllowed` property in the handler for the `dragstart` event. The following string values can be used:

String value	Description
"none"	No drag operations are allowed.
"copy"	The data will be copied to the destination, leaving the original in place.
"link"	The data will be shared with the drop destination using a link back to the original.
"move"	The data will be copied to the destination and removed from the original location.
"copyLink"	The data can be copied or linked.
"copyMove"	The data can be copied or moved.
"linkMove"	The data can be linked or moved.
"all"	The data can be copied, moved, or linked. *All* is the default effect when you prevent the default behavior.

The target of the drag gesture can set the `dataTransfer.dropEffect` property to indicate the action that is taken if the user completes the drop. If the drop effect is one of the allowed actions, then the system displays the appropriate copy, move, or link cursor. If not, then the system displays the *unavailable* cursor. If no drop effect is set by the target, the user can choose from the allowed actions with the modifier keys.

Set the `dropEffect` value in the handlers for both the `dragover` and `dragenter` events:

```
function doDragStart(event) {
    event.dataTransfer.setData("text/plain","Text to drag");
    event.dataTransfer.effectAllowed = "copyMove";
}

function doDragOver(event) {
    event.dataTransfer.dropEffect = "copy";
}

function doDragEnter(event) {
    event.dataTransfer.dropEffect = "copy";
}
```

***Note:** Although you should always set the `dropEffect` property in the handler for `dragenter`, be aware that the next `dragover` event resets the property to its default value. Set `dropEffect` in response to both events.*

Dragging data out of an HTML element

Adobe AIR 1.0 and later

The default behavior allows most content in an HTML page to be copied by dragging. You can control the content allowed to be dragged using CSS properties `-webkit-user-select` and `-webkit-user-drag`.

Override the default drag-out behavior in the handler for the `dragstart` event. Call the `setData()` method of the `dataTransfer` property of the event object to put your own data into the drag gesture.

To indicate which drag effects a source object supports when you are not relying on the default behavior, set the `dataTransfer.effectAllowed` property of the event object dispatched for the `dragstart` event. You can choose any combination of effects. For example, if a source element supports both *copy* and *link* effects, set the property to `"copyLink"`.

Setting the dragged data

Flash Player 9 and later, Adobe AIR 1.0 and later

Add the data for the drag gesture in the handler for the `dragstart` event with the `dataTransfer` property. Use the `dataTransfer.setData()` method to put data onto the clipboard, passing in the MIME type and the data to transfer.

For example, if you had an image element in your application, with the id *imageOfGeorge*, you could use the following dragstart event handler. This example adds representations of a picture of George in several data formats, which increases the likelihood that other applications can use the dragged data.

```
function dragStartHandler(event){
    event.dataTransfer.effectAllowed = "copy";

    var dragImage = document.getElementById("imageOfGeorge");
    var dragFile = new air.File(dragImage.src);
    event.dataTransfer.setData("text/plain","A picture of George");
    event.dataTransfer.setData("image/x-vnd.adobe.air.bitmap", dragImage);
    event.dataTransfer.setData("application/x-vnd.adobe.air.file-list",
                                new Array(dragFile));
}
```

Note: *When you call the* `setData()` *method of* `dataTransfer` *object, no data is added by the default drag-and-drop behavior.*

Dragging data into an HTML element

Adobe AIR 1.0 and later

The default behavior only allows text to be dragged into editable regions of the page. You can specify that an element and its children can be made editable by including the `contenteditable` attribute in the opening tag of the element. You can also make an entire document editable by setting the document object `designMode` property to `"on"`.

You can support alternate drag-in behavior on a page by handling the `dragenter`, `dragover`, and `drop` events for any elements that can accept dragged data.

Enabling drag-in

Adobe AIR 1.0 and later

To handle the drag-in gesture, you must first cancel the default behavior. Listen for the `dragenter` and `dragover` events on any HTML elements you want to use as drop targets. In the handlers for these events, call the `preventDefault()` method of the dispatched event object. Canceling the default behavior allows non-editable regions to receive a drop.

Getting the dropped data

Adobe AIR 1.0 and later

You can access the dropped data in the handler for the `ondrop` event:

```
 function doDrop(event){
    droppedText = event.dataTransfer.getData("text/plain");
}
```

Use the `dataTransfer.getData()` method to read the data onto the clipboard, passing in the MIME type of the data format to read. You can find out which data formats are available using the `types` property of the `dataTransfer` object. The `types` array contains the MIME type string of each available format.

When you cancel the default behavior in the dragenter or dragover events, you are responsible for inserting any dropped data into its proper place in the document. No API exists to convert a mouse position into an insertion point within an element. This limitation can make it difficult to implement insertion-type drag gestures.

Example: Overriding the default HTML drag-in behavior

Adobe AIR 1.0 and later

This example implements a drop target that displays a table showing each data format available in the dropped item.

The default behavior is used to allow text, links, and images to be dragged within the application. The example overrides the default drag-in behavior for the div element that serves as the drop target. The key step to enabling non-editable content to accept a drag-in gesture is to call the `preventDefault()` method of the event object dispatched for both the `dragenter` and `dragover` events. In response to a `drop` event, the handler converts the transferred data into an HTML row element and inserts the row into a table for display.

```
 <html>
<head>
<title>Drag-and-drop</title>
<script language="javascript" type="text/javascript" src="AIRAliases.js"></script>
<script language="javascript">
    function init(){
        var target = document.getElementById('target');
        target.addEventListener("dragenter", dragEnterOverHandler);
        target.addEventListener("dragover", dragEnterOverHandler);
        target.addEventListener("drop", dropHandler);

        var source = document.getElementById('source');
        source.addEventListener("dragstart", dragStartHandler);
        source.addEventListener("dragend", dragEndHandler);

        emptyRow = document.getElementById("emptyTargetRow");
    }

    function dragStartHandler(event){
        event.dataTransfer.effectAllowed = "copy";
    }

    function dragEndHandler(event){
        air.trace(event.type + ": " + event.dataTransfer.dropEffect);
    }

    function dragEnterOverHandler(event){
        event.preventDefault();
    }

    var emptyRow;
    function dropHandler(event){
        for(var prop in event){
            air.trace(prop + " = " + event[prop]);
        }
        var row = document.createElement('tr');
        row.innerHTML = "<td>" + event.dataTransfer.getData("text/plain") + "</td>" +
            "<td>" + event.dataTransfer.getData("text/html") + "</td>" +
            "<td>" + event.dataTransfer.getData("text/uri-list") + "</td>" +
            "<td>" + event.dataTransfer.getData("application/x-vnd.adobe.air.file-list") +
            "</td>";

        var imageCell = document.createElement('td');
        if((event.dataTransfer.types.toString()).search("image/x-vnd.adobe.air.bitmap") > -
1){
            imageCell.appendChild(event.dataTransfer.getData("image/x-
vnd.adobe.air.bitmap"));
        }
        row.appendChild(imageCell);
        var parent = emptyRow.parentNode;
        parent.insertBefore(row, emptyRow);
    }
</script>
</head>
<body onLoad="init()" style="padding:5px">
<div>
    <h1>Source</h1>
       <p>Items to drag:</p>
    <ul id="source">
        <li>Plain text.</li>
           <li>HTML <b>formatted</b> text.</li>
           <li>A <a href="http://www.adobe.com">URL.</a></li>
           <li><img src="icons/AIRApp_16.png" alt="An image"/></li>
           <li style="-webkit-user-drag:none;">
        Uses "-webkit-user-drag:none" style.
           </li>
           <li style="-webkit-user-select:none;">
        Uses "-webkit-user-select:none" style.
           </li>

       </ul>
</div>
<div id="target" style="border-style:dashed;">
    <h1 >Target</h1>
       <p>Drag items from the source list (or elsewhere).</p>
       <table id="displayTable" border="1">
        <tr><th>Plain text</th><th>Html text</th><th>URL</th><th>File list</th><th>Bitmap 
Data</th></tr>
           <tr 
id="emptyTargetRow"><td>&nbsp;</td><td>&nbsp;</td><td>&nbsp;</td><td>&nbsp;</td><td>&nbsp;</
td></tr>
       </table>
       </div>
</div>
</body>
</html>
```

Handling file drops in non-application HTML sandboxes

Adobe AIR 1.0 and later

Non-application content cannot access the File objects that result when files are dragged into an AIR application. Nor is it possible to pass one of these File objects to application content through a sandbox bridge. (The object properties must be accessed during serialization.) However, you can still drop files in your application by listening for the AIR nativeDragDrop events on the HTMLLoader object.

Normally, if a user drops a file into a frame that hosts non-application content, the drop event does not propagate from the child to the parent. However, since the events dispatched by the HTMLLoader (which is the container for all HTML content in an AIR application) are not part of the HTML event flow, you can still receive the drop event in application content.

To receive the event for a file drop, the parent document adds an event listener to the HTMLLoader object using the reference provided by `window.htmlLoader`:

```
 window.htmlLoader.addEventListener("nativeDragDrop",function(event){
    var filelist = event.clipboard.getData(air.ClipboardFormats.FILE_LIST_FORMAT);
    air.trace(filelist[0].url);
});
```

The following example uses a parent document that loads a child page into a remote sandbox (http://localhost/). The parent listens for the `nativeDragDrop` event on the HTMLLoader object and traces out the file url.

```
<html>
<head>
<title>Drag-and-drop in a remote sandbox</title>
<script language="javascript" type="text/javascript" src="AIRAliases.js"></script>
<script language="javascript">
    window.htmlLoader.addEventListener("nativeDragDrop",function(event){
        var filelist = event.clipboard.getData(air.ClipboardFormats.FILE_LIST_FORMAT);
        air.trace(filelist[0].url);
    });
</script>
</head>
<body>
       <iframe src="child.html"
               sandboxRoot="http://localhost/"
               documentRoot="app:/"
               frameBorder="0"  width="100%" height="100%">
       </iframe>
</body>
</html>
```

The child document must present a valid drop target by calling the Event object `preventDefault()` method in the HTML `dragenter` and `dragover` event handlers. Otherwise, the drop event can never occur.

```
<html>
<head>
    <title>Drag and drop target</title>
    <script language="javascript" type="text/javascript">
        function preventDefault(event){
            event.preventDefault();
        }
    </script>
</head>
<body ondragenter="preventDefault(event)" ondragover="preventDefault(event)">
<div>
<h1>Drop Files Here</h1>
</div>
</body>
</html>
```

Dropping file promises

Adobe AIR 2 and later

A file promise is a drag-and-drop clipboard format that allows a user to drag a file that does not yet exist out of an AIR application. For example, using file promises, your application could allow a user to drag a proxy icon to a desktop folder. The proxy icon represents a file or some data known to be available at a URL. After the user drops the icon, the runtime downloads the data and writes the file to the drop location.

You can use the URLFilePromise class in an AIR application to drag-and-drop files accessible at a URL. The URLFilePromise implementation is provided in the aircore library as part of the AIR 2 SDK. Use either the aircore.swc or aircore.swf file found in the SDK frameworks/libs/air directory.

Alternately, you can implement your own file promise logic using the IFilePromise interface (which is defined in the runtime flash.desktop package).

File promises are similar in concept to deferred rendering using a data handler function on the clipboard. Use file promises instead of deferred rendering when dragging and dropping files. The deferred rendering technique can lead to undesirable pauses in the drag gesture as the data is generated or downloaded. Use deferred rendering for copy and paste operations (for which file promises are not supported).

Limitations when using file promises

File promises have the following limitations compared to other data formats that you can put in a drag-and-drop clipboard:

- File promises can only be dragged out of an AIR application; they cannot be dropped into an AIR application.
- File promises are not supported on all operating systems. Use the `Clipboard.supportsFilePromise` property to test whether file promises are supported on the host system. On systems that do not support file promises, you should provide an alternative mechanism for downloading or generating the file data.
- File promises cannot be used with the copy-and-paste clipboard (`Clipboard.generalClipboard`).

More Help topics

flash.desktop.IFilePromise

air.desktop.URLFilePromise

Dropping remote files

Adobe AIR 2 and later

Use the URLFilePromise class to create file promise objects representing files or data available at a URL. Add one or more file promise objects to the clipboard using the `FILE_PROMISE_LIST` clipboard format. In the following example, a single file, available at http://www.example.com/foo.txt, is downloaded and saved to the drop location as bar.txt. (The remote and the local file names do not have to match.)

```
if( Clipboard.supportsFilePromise )
{
    var filePromise:URLFilePromise = new URLFilePromise();
    filePromise.request = new URLRequest("http://example.com/foo.txt");
    filePromise.relativePath = "bar.txt";

    var fileList:Array = new Array( filePromise );
    var clipboard:Clipboard = new Clipboard();
    clipboard.setData( ClipboardFormats.FILE_PROMISE_LIST_FORMAT, fileList );
    NativeDragManager.doDrag( dragSource, clipboard );
}
```

You can allow the user to drag more than one file at a time by adding more file promise objects to the array assigned to the clipboard. You can also specify subdirectories in the `relativePath` property so that some or all of the files included in the operation are placed in a subfolder relative to the drop location.

The following example illustrates how to initiate a drag operation that includes multiple file promises. In this example, an html page, *article.html*, is put on the clipboard as a file promise, along with its two linked image files. The images are copied into an *images* subfolder so that the relative links are maintained.

```
if( Clipboard.supportsFilePromise )
{   //Create the promise objects
    var filePromise:URLFilePromise = new URLFilePromise();
    filePromise.request = new URLRequest("http://example.com/article.html");
    filePromise.relativePath = "article.html";

    var image1Promise:URLFilePromise = new URLFilePromise();
    image1Promise.request = new URLRequest("http://example.com/images/img_1.jpg");
    image1Promise.relativePath = "images/img_1.html";
    var image2Promise:URLFilePromise = new URLFilePromise();
    image2Promise.request = new URLRequest("http://example.com/images/img_2.jpg");
    image2Promise.relativePath = "images/img_2.jpg";


    //Put the promise objects onto the clipboard inside an array
    var fileList:Array = new Array( filePromise, image1Promise, image2Promise );
    var clipboard:Clipboard = new Clipboard();
    clipboard.setData( ClipboardFormats.FILE_PROMISE_LIST_FORMAT, fileList );
    //Start the drag operation
    NativeDragManager.doDrag( dragSource, clipboard );
}
```

Implementing the IFilePromise interface

Adobe AIR 2 and later

To provide file promises for resources that cannot be accessed using a URLFilePromise object, you can implement the IFilePromise interface in a custom class. The IFilePromise interface defines the methods and properties used by the AIR runtime to access the data to be written to a file once the file promise is dropped.

An IFilePromise implementation passes another object to the AIR runtime that provides the data for the file promise. This object must implement the IDataInput interface, which the AIR runtime uses to read the data. For example, the URLFilePromise class, which implements IFilePromise, uses a URLStream object as the data provider.

AIR can read the data synchronously or asynchronously. The IFilePromise implementation reports which mode of access is supported by returning the appropriate value in the `isAsync` property. If asynchronous data access is provided, the data provider object must implement the IEventDispatcher interface and dispatch the necessary events, such as `open`, `progress` and `complete`.

You can use a custom class, or one of the following built-in classes, as a data provider for a file promise:

- ByteArray (synchronous)
- FileStream (synchronous or asynchronous)
- Socket (asynchronous)
- URLStream (asynchronous)

To implement the IFilePromise interface, you must provide code for the following functions and properties:

- `open():IDataInput` — Returns the data provider object from which the data for the promised file is read. The object must implement the IDataInput interface. If the data is provided asynchronously, the object must also implement the IEventDispatcher interface and dispatch the necessary events (see "Using an asynchronous data provider in a file promise" on page 627).

- `get relativePath():String` — Provides the path, including file name, for the created file. The path is resolved relative to the drop location chosen by the user in the drag-and-drop operation. To make sure that the path uses the proper separator character for the host operating system, use the `File.separator` constant when specifying paths containing directories. You can add a setter function or use a constructor parameter to allow the path to be set at runtime.
- `get isAsync():Boolean` — Informs the AIR runtime whether the data provider object provides it's data asynchronously or synchronously.
- `close():void` — Called by the runtime when the data is fully read (or an error prevents further reading). You can use this function to cleanup resources.
- `reportError( e:ErrorEvent ):void` — Called by the runtime when an error reading the data occurs.

All of the IFilePromise methods are called by the runtime during a drag-and-drop operation involving the file promise. Typically, your application logic should not call any of these methods directly.

Using a synchronous data provider in a file promise

Adobe AIR 2 and later

The simplest way to implement the IFilePromise interface is to use a synchronous data provider object, such as a ByteArray or a synchronous FileStream. In the following example, a ByteArray object is created, filled with data, and returned when the `open()` method is called.

```
package
{
    import flash.desktop.IFilePromise;
    import flash.events.ErrorEvent;
    import flash.utils.ByteArray;
    import flash.utils.IDataInput;

    public class SynchronousFilePromise implements IFilePromise
    {
        private const fileSize:int = 5000; //size of file data
        private var filePath:String = "SynchronousFile.txt";

        public function get relativePath():String
        {
            return filePath;
        }

        public function get isAsync():Boolean
        {
            return false;
        }

        public function open():IDataInput
        {
            var fileContents:ByteArray = new ByteArray();

            //Create some arbitrary data for the file
            for( var i:int = 0; i < fileSize; i++ )
            {
                fileContents.writeUTFBytes( 'S' );
            }

            //Important: the ByteArray is read from the current position
            fileContents.position = 0;
            return fileContents;
        }

        public function close():void
        {
            //Nothing needs to be closed in this case.
        }

        public function reportError(e:ErrorEvent):void
        {
            trace("Something went wrong: " + e.errorID + " - " + e.type + ", " + e.text );
        }
    }
}
```

In practice, synchronous file promises have limited utility. If the amount of data is small, you could just as easily create a file in a temporary directory and add a normal file list array to the drag-and-drop clipboard. On the other hand, if the amount of data is large or generating the data is computationally expensive, a long synchronous process is necessary. Long synchronous processes can block UI updates for a noticeable amount of time and make your application seem unresponsive. To avoid this problem, you can create an asynchronous data provider driven by a timer.

Using an asynchronous data provider in a file promise

Adobe AIR 2 and later

When you use an asynchronous data provider object, the IFilePromise `isAsync` property must be `true` and the object returned by the `open()` method must implement the IEventDispatcher interface. The runtime listens for several alternative events so that different built-in objects can be used as a data provider. For example, `progress` events are dispatched by FileStream and URLStream objects, whereas `socketData` events are dispatched by Socket objects. The runtime listens for the appropriate events from all of these objects.

The following events drive the process of reading the data from the data provider object:

- Event.OPEN — Informs the runtime that the data source is ready.
- ProgressEvent.PROGRESS — Informs the runtime that data is available. The runtime will read the amount of available data from the data provider object.
- ProgressEvent.SOCKET_DATA — Informs the runtime that data is available. The `socketData` event is dispatched by socket-based objects. For other object types, you should dispatch a `progress` event. (The runtime listens for both events to detect when data can be read.)
- Event.COMPLETE — Informs the runtime that the data has all been read.
- Event.CLOSE — Informs the runtime that the data has all been read. (The runtime listens for both `close` and `complete` for this purpose.)
- IOErrorEvent.IOERROR — Informs the runtime that an error reading the data has occurred. The runtime aborts file creation and calls the IFilePromise `close()` method.

- SecurityErrorEvent.SECURITY_ERROR — Informs the runtime that a security error has occurred. The runtime aborts file creation and calls the IFilePromise `close()` method.
- HTTPStatusEvent.HTTP_STATUS — Used, along with `httpResponseStatus`, by the runtime to make sure that the data available represents the desired content, rather than an error message (such as a 404 page). Objects based on the HTTP protocol should dispatch this event.
- HTTPStatusEvent.HTTP_RESPONSE_STATUS — Used, along with `httpStatus`, by the runtime to make sure that the data available represents the desired content. Objects based on the HTTP protocol should dispatch this event.

The data provider should dispatch these events in the following sequence:

1. `open` event
2. `progress` or `socketData` events
3. `complete` or `close` event

Note: *The built-in objects, FileStream, Socket, and URLStream, dispatch the appropriate events automatically.*

The following example creates a file promise using a custom, asynchronous data provider. The data provider class extends ByteArray (for the IDataInput support) and implements the IEventDispatcher interface. At each timer event, the object generates a chunk of data and dispatches a progress event to inform the runtime that the data is available. When enough data has been produced, the object dispatches a complete event.

```
package
{
import flash.events.Event;
import flash.events.EventDispatcher;
import flash.events.IEventDispatcher;
import flash.events.ProgressEvent;
import flash.events.TimerEvent;
import flash.utils.ByteArray;
import flash.utils.Timer;

[Event(name="open", type="flash.events.Event.OPEN")]
[Event(name="complete",  type="flash.events.Event.COMPLETE")]
[Event(name="progress", type="flash.events.ProgressEvent")]
[Event(name="ioError", type="flash.events.IOErrorEvent")]
[Event(name="securityError", type="flash.events.SecurityErrorEvent")]
public class AsyncDataProvider extends ByteArray implements IEventDispatcher
{
    private var dispatcher:EventDispatcher = new EventDispatcher();
    public var fileSize:int = 0; //The number of characters in the file
    private const chunkSize:int = 1000; //Amount of data written per event
    private var dispatchDataTimer:Timer = new Timer( 100 );
    private var opened:Boolean = false;

    public function AsyncDataProvider()
    {
        super();
        dispatchDataTimer.addEventListener( TimerEvent.TIMER, generateData );
    }

    public function begin():void{
        dispatchDataTimer.start();
    }
    public function end():void
    {
        dispatchDataTimer.stop();
    }
    private function generateData( event:Event ):void
    {
        if( !opened )
        {
            var open:Event = new Event( Event.OPEN );
            dispatchEvent( open );
            opened = true;
        }
        else if( position + chunkSize < fileSize )
        {
            for( var i:int = 0; i <= chunkSize; i++ )
            {
                writeUTFBytes( 'A' );
            }
            //Set position back to the start of the new data
            this.position -= chunkSize;
            var progress:ProgressEvent =
                new ProgressEvent( ProgressEvent.PROGRESS, false, false, bytesAvailable, 
bytesAvailable + chunkSize);
            dispatchEvent( progress )
        }
        else
        {
            var complete:Event = new Event( Event.COMPLETE );
            dispatchEvent( complete );
        }
    }
     //IEventDispatcher implementation
    public function addEventListener(type:String, listener:Function, 
useCapture:Boolean=false, priority:int=0, useWeakReference:Boolean=false):void
    {
        dispatcher.addEventListener( type, listener, useCapture, priority, useWeakReference );
    }

    public function removeEventListener(type:String, listener:Function, 
useCapture:Boolean=false):void
```

```
    {
        dispatcher.removeEventListener( type, listener, useCapture );
    }

    public function dispatchEvent(event:Event):Boolean
    {
        return dispatcher.dispatchEvent( event );
    }

    public function hasEventListener(type:String):Boolean
    {
        return dispatcher.hasEventListener( type );
    }

    public function willTrigger(type:String):Boolean
    {
        return dispatcher.willTrigger( type );
    }
}
}
```

***Note:** Because the AsyncDataProvider class in the example extends ByteArray, it cannot also extend EventDispatcher. To implement the IEventDispatcher interface, the class uses an internal EventDispatcher object and forwards the IEventDispatcher method calls to that internal object. You could also extend EventDispatcher and implement IDataInput (or implement both interfaces).*

The asynchronous IFilePromise implementation is almost identical to the synchronous implementation. The main differences are that `isAsync` returns `true` and that the `open()` method returns an asynchronous data object:

```
package
{
    import flash.desktop.IFilePromise;
    import flash.events.ErrorEvent;
    import flash.events.EventDispatcher;
    import flash.utils.IDataInput;

    public class AsynchronousFilePromise extends EventDispatcher implements IFilePromise
    {
        private var fileGenerator:AsyncDataProvider;
        private const fileSize:int = 5000; //size of file data
        private var filePath:String = "AsynchronousFile.txt";

        public function get relativePath():String
        {
            return filePath;
        }

        public function get isAsync():Boolean
        {
            return true;
        }
        public function open():IDataInput
        {
            fileGenerator = new AsyncDataProvider();
            fileGenerator.fileSize = fileSize;
            fileGenerator.begin();
            return fileGenerator;
        }

        public function close():void
        {
            fileGenerator.end();
        }

        public function reportError(e:ErrorEvent):void
        {
            trace("Something went wrong: " + e.errorID + " - " + e.type + ", " + e.text );
        }
    }
}
```

Chapter 36: Working with menus

Flash Player 9 and later, Adobe AIR 1.0 and later

Use the classes in the context menu API to modify the context menu in web-based Flex and Flash Player applications.

Use the classes in the native menu API to define application, window, context, and pop-up menus in Adobe® AIR®.

Menu basics

Flash Player 9 and later, Adobe AIR 1.0 and later

For a quick explanation and code examples of creating native menus in AIR applications, see the following quick start articles on the Adobe Developer Connection:

- Adding native menus to an AIR application (Flex)
- Adding native menus to an AIR application (Flash)

The native menu classes allow you to access the native menu features of the operating system on which your application is running. NativeMenu objects can be used for application menus (available on Mac OS X), window menus (available on Windows and Linux), context menus, and pop-up menus.

Outside of AIR, you can use the context menu classes to modify the context menu that Flash Player automatically displays when a user right-clicks or cmd-clicks on an object in your application. (An automatic context menu is not displayed for AIR applications.)

Menu classes

Flash Player 9 and later, Adobe AIR 1.0 and later

The menu classes include:

Package	Classes
flash.display	• NativeMenu • NativeMenuItem
flash.ui	• ContextMenu • ContextMenuItem
flash.events	• Event • ContextMenuEvent

Menu varieties

Flash Player 9 and later, Adobe AIR 1.0 and later

AIR supports the following types of menus:

Context menus Context menus open in response to a right-click or command-click on an interactive object in SWF content or a document element in HTML content.

In the Flash Player runtime, a context menu is automatically displayed. You can use the ContextMenu and ContextMenuItem classes to add your own commands to the menu. You can also remove some, but not all, of the built-in commands.

In the AIR runtime, you can create a context menu using either the NativeMenu or the ContextMenu class. In HTML content in AIR, you can use the Webkit HTML and JavaScript APIs to add context menus to HTML elements.

Application menus (AIR only) An application menu is a global menu that applies to the entire application. Application menus are supported on Mac OS X, but not on Windows or Linux. On Mac OS X, the operating system automatically creates an application menu. You can use the AIR menu API to add items and submenus to the standard menus. You can add listeners for handling the existing menu commands. Or you can remove existing items.

Window menus (AIR only) A window menu is associated with a single window and is displayed below the title bar. Menus can be added to a window by creating a NativeMenu object and assigning it to the `menu` property of the NativeWindow object. Window menus are supported on the Windows and Linux operating systems, but not on Mac OS X. Native window menus can only be used with windows that have system chrome.

Dock and system tray icon menus (AIR only) These icon menus are similar to context menus and are assigned to an application icon in the Mac OS X dock or the Windows and Linux notification areas on the taskbar. Dock and system tray icon menus use the NativeMenu class. On Mac OS X, the items in the menu are added above the standard operating system items. On Windows or Linux, there is no standard menu.

Pop-up menus (AIR only) An AIR pop-up menu is like a context menu, but is not necessarily associated with a particular application object or component. Pop-up menus can be displayed anywhere in a window by calling the `display()` method of any NativeMenu object.

Custom menus Native menus are drawn entirely by the operating system and, as such, exist outside the Flash and HTML rendering models. Instead of using native menus, you can always create your own custom, non-native menus using MXML, ActionScript, or JavaScript (in AIR). Such menus must be fully rendered inside application content.

Flex menus The Adobe® Flex™ framework provides a set of Flex menu components. The Flex menus are drawn by the runtime rather than the operating system and are not *native* menus. A Flex menu component can be used for Flex windows that do not have system chrome. Another benefit of using the Flex menu component is that you can specify menus declaratively in MXML format. If you are using the Flex Framework, use the Flex menu classes for window menus instead of the native classes.

Default menus (AIR only)

The following default menus are provided by the operating system or a built-in AIR class:

- Application menu on Mac OS X
- Dock icon menu on Mac OS X
- Context menu for selected text and images in HTML content
- Context menu for selected text in a TextField object (or an object that extends TextField)

About context menus

Flash Player 9 and later, Adobe AIR 1.0 and later

In SWF content, any object that inherits from InteractiveObject can be given a context menu by assigning a menu object to its `contextMenu` property. Several commands are included by default, including Forward, Back, Print, Quality, and Zoom. In the AIR runtime, the menu object assigned to `contextMenu` can either be of type NativeMenu or of type ContextMenu. In the Flash Player runtime, only the ContextMenu class is available.

You can listen for either native menu events or context menus events when using the ContextMenu and ContextMenuItem classes; both are dispatched. One benefit provided by the ContextMenuEvent object properties is that contextMenuOwner identifies the object to which the menu is attached and `mouseTarget` identifies the object that was clicked to open the menu. This information is not available from the NativeMenuEvent object.

The following example creates a Sprite and adds a simple edit context menu:

```
 var sprite:Sprite = new Sprite();
sprite.contextMenu = createContextMenu()
private function createContextMenu():ContextMenu{
    var editContextMenu:ContextMenu = new ContextMenu();
    var cutItem:ContextMenuItem = new ContextMenuItem("Cut")
    cutItem.addEventListener(ContextMenuEvent.MENU_ITEM_SELECT, doCutCommand);
    editContextMenu.customItems.push(cutItem);

    var copyItem:ContextMenuItem = new ContextMenuItem("Copy")
    copyItem.addEventListener(ContextMenuEvent.MENU_ITEM_SELECT, doCopyCommand);
    editContextMenu.customItems.push(copyItem);

    var pasteItem:ContextMenuItem = new ContextMenuItem("Paste")
    pasteItem.addEventListener(ContextMenuEvent.MENU_ITEM_SELECT, doPasteCommand);
    editContextMenu.customItems.push(pasteItem);

    return editContextMenu
}
private function doCutCommand(event:ContextMenuEvent):void{trace("cut");}
private function doCopyCommand(event:ContextMenuEvent):void{trace("copy");}
private function doPasteCommand(event:ContextMenuEvent):void{trace("paste");}
```

***Note:** In contrast to SWF content displayed in a browser environment, context menus in AIR do not have any built-in commands.*

Customizing a Flash Player context menu

In a browser or a projector, context menus in SWF content always have built-in items. You can remove all of these default commands from the menu, except for the Settings and About commands. Setting the Stage property `showDefaultContextMenu` to `false` removes these commands from the context menu.

To create a customized context menu for a specific display object, create a new instance of the ContextMenu class, call the `hideBuiltInItems()` method, and assign that instance to the `contextMenu` property of that DisplayObject instance. The following example provides a dynamically drawn square with a context menu command to change it to a random color:

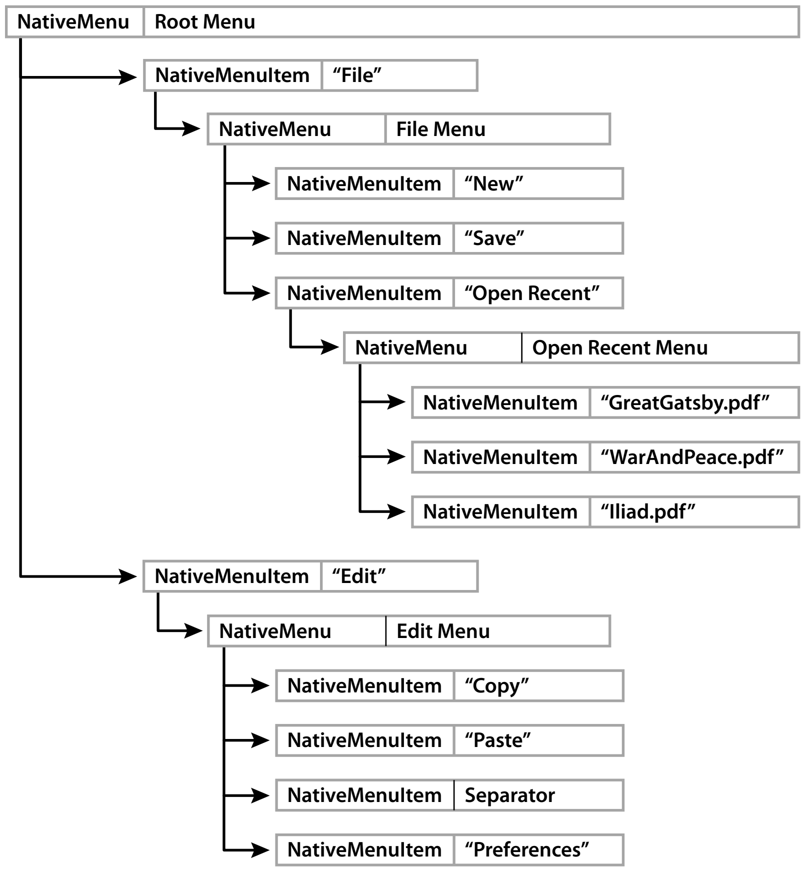
```
var square:Sprite = new Sprite();
square.graphics.beginFill(0x000000);
square.graphics.drawRect(0,0,100,100);
square.graphics.endFill();
square.x =
square.y = 10;
addChild(square);

var menuItem:ContextMenuItem = new ContextMenuItem("Change Color");
menuItem.addEventListener(ContextMenuEvent.MENU_ITEM_SELECT,changeColor);
var customContextMenu:ContextMenu = new ContextMenu();
customContextMenu.hideBuiltInItems();
customContextMenu.customItems.push(menuItem);
square.contextMenu = customContextMenu;

function changeColor(event:ContextMenuEvent):void
{
    square.transform.colorTransform = getRandomColor();
}
function getRandomColor():ColorTransform
{
    return new ColorTransform(Math.random(), Math.random(), Math.random(),1,(Math.random() * 
512) - 255, (Math.random() * 512) -255, (Math.random() * 512) - 255, 0);
}
```

Native menu structure (AIR)

Adobe AIR 1.0 and later

Native menus are hierarchical in nature. NativeMenu objects contain child NativeMenuItem objects. NativeMenuItem objects that represent submenus, in turn, can contain NativeMenu objects. The top- or root-level menu object in the structure represents the menu bar for application and window menus. (Context, icon, and pop-up menus don't have a menu bar).

The following diagram illustrates the structure of a typical menu. The root menu represents the menu bar and contains two menu items referencing a *File* submenu and an *Edit* submenu. The File submenu in this structure contains two command items and an item that references an *Open Recent Menu* submenu, which, itself, contains three items. The Edit submenu contains three commands and a separator.


NativeMenu | Root Menu
NativeMenuItem | "File"
NativeMenu | File Menu
NativeMenuItem | "New"
NativeMenuItem | "Save"
NativeMenuItem | "Open Recent"
NativeMenu | Open Recent Menu
NativeMenuItem | "GreatGatsby.pdf"
NativeMenuItem | "WarAndPeace.pdf"
NativeMenuItem | "Iliad.pdf"
NativeMenuItem | "Edit"
NativeMenu | Edit Menu
NativeMenuItem | "Copy"
NativeMenuItem | "Paste"
NativeMenuItem | Separator
NativeMenuItem | "Preferences"

Defining a submenu requires both a NativeMenu and a NativeMenuItem object. The NativeMenuItem object defines the label displayed in the parent menu and allows the user to open the submenu. The NativeMenu object serves as a container for items in the submenu. The NativeMenuItem object references the NativeMenu object through the NativeMenuItem `submenu` property.

To view a code example that creates this menu see "Native menu example: Window and application menu (AIR)" on page 644.

Menu events

Adobe AIR 1.0 and later

NativeMenu and NativeMenuItem objects both dispatch `preparing`, `displaying`, and `select` events:

Preparing: Whenever the object is about to begin a user interaction, the menu and its menu items dispatch a `preparing` event to any registered listeners. Interaction includes opening the menu or selecting an item with a keyboard shortcut.

***Note:** The `preparing` event is available only for Adobe AIR 2.6 and later.*

Displaying: Immediately before a menu is displayed, the menu and its menu items dispatch a `displaying` event to any registered listeners.

The `preparing` and `displaying` events give you an opportunity to update the menu contents or item appearance before it is shown to the user. For example, in the listener for the `displaying` event of an "Open Recent" menu, you could change the menu items to reflect the current list of recently viewed documents.

If you remove the menu item whose keyboard shortcut triggered a `preparing` event, the menu interaction is effectively canceled and a `select` event is not dispatched.

The `target` and `currentTarget` properties of the event are both the object on which the listener is registered: either the menu itself, or one of its items.

The `preparing` event is dispatched before the `displaying` event. You typically listen for one event or the other, not both.

Select: When a command item is chosen by the user, the item dispatches a `select` event to any registered listeners. Submenu and separator items cannot be selected and so never dispatch a `select` event.

A `select` event bubbles up from a menu item to its containing menu, on up to the root menu. You can listen for `select` events directly on an item and you can listen higher up in the menu structure. When you listen for the `select` event on a menu, you can identify the selected item using the event `target` property. As the event bubbles up through the menu hierarchy, the `currentTarget` property of the event object identifies the current menu object.

***Note:** ContextMenu and ContextMenuItem objects dispatch `menuItemSelect` and `menuSelect` events as well as `select`, `preparing`, and `displaying` events.*

Key equivalents for native menu commands (AIR)

Adobe AIR 1.0 and later

You can assign a key equivalent (sometimes called an accelerator) to a menu command. The menu item dispatches a `select` event to any registered listeners when the key, or key combination is pressed. The menu containing the item must be part of the menu of the application or the active window for the command to be invoked.

Key equivalents have two parts, a string representing the primary key and an array of modifier keys that must also be pressed. To assign the primary key, set the menu item `keyEquivalent` property to the single character string for that key. If you use an uppercase letter, the shift key is added to the modifier array automatically.

On Mac OS X, the default modifier is the command key (`Keyboard.COMMAND`). On Windows and Linux, it is the control key (`Keyboard.CONTROL`). These default keys are automatically added to the modifier array. To assign different modifier keys, assign a new array containing the desired key codes to the `keyEquivalentModifiers` property. The default array is overwritten. Whether you use the default modifiers or assign your own modifier array, the shift key is added if the string you assign to the `keyEquivalent` property is an uppercase letter. Constants for the key codes to use for the modifier keys are defined in the Keyboard class.

The assigned key equivalent string is automatically displayed beside the menu item name. The format depends on the user's operating system and system preferences.

***Note:** If you assign the `Keyboard.COMMAND` value to a key modifier array on the Windows operating system, no key equivalent is displayed in the menu. However, the control key must be used to activate the menu command.*

The following example assigns `Ctrl+Shift+G` as the key equivalent for a menu item:

```
 var item:NativeMenuItem = new NativeMenuItem("Ungroup");
item.keyEquivalent = "G";
```

This example assigns `Ctrl+Shift+G` as the key equivalent by setting the modifier array directly:

```
 var item:NativeMenuItem = new NativeMenuItem("Ungroup");
item.keyEquivalent = "G";
item.keyEquivalentModifiers = [Keyboard.CONTROL];
```

***Note:** Key equivalents are only triggered for application and window menus. If you add a key equivalent to a context or pop-up menu, the key equivalent is displayed in the menu label, but the associated menu command is never invoked.*

Mnemonics (AIR)

Adobe AIR 1.0 and later

Mnemonics are part of the operating system keyboard interface to menus. Linux, Mac OS X, and Windows allow users to open menus and select commands with the keyboard, but there are subtle differences.

On Mac OS X, the user types the first letter or two of the menu or command and then presses the return key. The `mnemonicIndex` property is ignored.

On Windows, only a single letter is significant. By default, the significant letter is the first character in the label, but if you assign a mnemonic to the menu item, then the significant character becomes the designated letter. If two items in a menu have the same significant character (whether or not a mnemonic has been assigned), then the user's keyboard interaction with the menu changes slightly. Instead of pressing a single letter to select the menu or command, the user must press the letter as many times as necessary to highlight the desired item and then press the enter key to complete the selection. To maintain a consistent behavior, you should assign a unique mnemonic to each item in a menu for window menus.

On Linux, no default mnemonic is provided. You must specify a value for the `mnemonicIndex` property of a menu item to provide a mnemonic.

Specify the mnemonic character as an index into the label string. The index of the first character in a label is 0. Thus, to use "r" as the mnemonic for a menu item labeled, "Format," you would set the `mnemonicIndex` property equal to 2.

```
 var item:NativeMenuItem = new NativeMenuItem("Format");
item.mnemonicIndex = 2;
```

Menu item state

Adobe AIR 1.0 and later

Menu items have the two state properties, `checked` and `enabled`:

checked Set to `true` to display a check mark next to the item label.

```
 var item:NativeMenuItem = new NativeMenuItem("Format");
item.checked = true;
```

enabled Toggle the value between `true` and `false` to control whether the command is enabled. Disabled items are visually "grayed-out" and do not dispatch `select` events.

```
 var item:NativeMenuItem = new NativeMenuItem("Format");
item.enabled = false;
```

Attaching an object to a menu item

Adobe AIR 1.0 and later

The `data` property of the NativeMenuItem class allows you to reference an arbitrary object in each item. For example, in an “Open Recent” menu, you could assign the File object for each document to each menu item.

```
 var file:File = File.applicationStorageDirectory.resolvePath("GreatGatsby.pdf")
var menuItem:NativeMenuItem = docMenu.addItem(new NativeMenuItem(file.name));
menuItem.data = file;
```

Creating native menus (AIR)

Adobe AIR 1.0 and later

This topic describes how to create the various types of native menu supported by AIR.

Creating a root menu object

Adobe AIR 1.0 and later

To create a NativeMenu object to serve as the root of the menu, use the NativeMenu constructor:

```
 var root:NativeMenu = new NativeMenu();
```

For application and window menus, the root menu represents the menu bar and should only contain items that open submenus. Context menu and pop-up menus do not have a menu bar, so the root menu can contain commands and separator lines as well as submenus.

After the menu is created, you can add menu items. Items appear in the menu in the order in which they are added, unless you add the items at a specific index using the `addItemAt()` method of a menu object.

Assign the menu as an application, window, icon, or context menu, or display it as a pop-up menu as shown in the following sections:

Setting the application menu or window menu

It’s important that your code accommodate both application menus (supported on Mac OS) and window menus (supported on other operating systems)

```
var root:NativeMenu = new NativeMenu();
if (NativeApplication.supportsMenu)
{
    NativeApplication.nativeApplication.menu = root;
}
else if (NativeWindow.supportsMenu)
{
    nativeWindow.menu = root;
}
```

***Note:** Mac OS defines a menu containing standard items for every application. Assigning a new NativeMenu object to the `menu` property of the NativeApplication object replaces the standard menu. You can also use the standard menu instead of replacing it.*

The Adobe Flex provides a FlexNativeMenu class for easily creating menus that work across platforms. If you are using the Flex Framework, use the FlexNativeMenu classes instead of the NativeMenu class.

Setting a context menu on an interactive object

```
 interactiveObject.contextMenu = root;
```

Setting a dock icon menu or system tray icon menu

It's important that your code accommodate both application menus (supported on Mac OS) and window menus (supported on other operating systems)

```
if (NativeApplication.supportsSystemTrayIcon)
{
    SystemTrayIcon(NativeApplication.nativeApplication.icon).menu = root;
}
else if (NativeApplication.supportsDockIcon)
{
    DockIcon(NativeApplication.nativeApplication.icon).menu = root;
}
```

***Note:** Mac OS X defines a standard menu for the application dock icon. When you assign a new NativeMenu to the menu property of the DockIcon object, the items in that menu are displayed above the standard items. You cannot remove, access, or modify the standard menu items.*

Displaying a menu as a pop-up

```
 root.display(stage, x, y);
```

More Help topics

Developing cross-platform AIR applications

Creating a submenu

Adobe AIR 1.0 and later

To create a submenu, you add a NativeMenuItem object to the parent menu and then assign the NativeMenu object defining the submenu to the item's `submenu` property. AIR provides two ways to create submenu items and their associated menu object:

You can create a menu item and its related menu object in one step with the `addSubmenu()` method:

```
 var editMenuItem:NativeMenuItem = root.addSubmenu(new NativeMenu(), "Edit");
```

You can also create the menu item and assign the menu object to its `submenu` property separately:

```
 var editMenuItem:NativeMenuItem = root.addItem("Edit", false);
editMenuItem.submenu = new NativeMenu();
```

Creating a menu command

Adobe AIR 1.0 and later

To create a menu command, add a NativeMenuItem object to a menu and add an event listener referencing the function implementing the menu command:

```
var copy:NativeMenuItem = new NativeMenuItem("Copy", false);
copy.addEventListener(Event.SELECT, onCopyCommand);
editMenu.addItem(copy);
```

You can listen for the `select` event on the command item itself (as shown in the example), or you can listen for the `select` event on a parent menu object.

***Note:** Menu items that represent submenus and separator lines do not dispatch `select` events and so cannot be used as commands.*

Creating a menu separator line

Adobe AIR 1.0 and later

To create a separator line, create a NativeMenuItem, setting the `isSeparator` parameter to `true` in the constructor. Then add the separator item to the menu in the correct location:

```
var separatorA:NativeMenuItem = new NativeMenuItem("A", true);
editMenu.addItem(separatorA);
```

The label specified for the separator, if any, is not displayed.

About context menus in HTML (AIR)

Adobe AIR 1.0 and later

In HTML content displayed using the HTMLLoader object, the `contextmenu` event can be used to display a context menu. By default, a context menu is displayed automatically when the user invokes the context menu event on selected text (by right-clicking or command-clicking the text). To prevent the default menu from opening, listen for the `contextmenu` event and call the event object's `preventDefault()` method:

```
function showContextMenu(event){
    event.preventDefault();
}
```

You can then display a custom context menu using DHTML techniques or by displaying an AIR native context menu. The following example displays a native context menu by calling the menu `display()` method in response to the HTML `contextmenu` event:

```
 <html>
<head>
<script src="AIRAliases.js" language="JavaScript" type="text/javascript"></script>
<script language="javascript" type="text/javascript">

function showContextMenu(event){
    event.preventDefault();
    contextMenu.display(window.nativeWindow.stage, event.clientX, event.clientY);
}

function createContextMenu(){
    var menu = new air.NativeMenu();
    var command = menu.addItem(new air.NativeMenuItem("Custom command"));
    command.addEventListener(air.Event.SELECT, onCommand);
    return menu;
}

function onCommand(){
    air.trace("Context command invoked.");
}

var contextMenu = createContextMenu();
</script>
</head>
<body>
<p oncontextmenu="showContextMenu(event)" style="-khtml-user-select:auto;">Custom context 
menu.</p>
</body>
</html>
```

Displaying pop-up native menus (AIR)

Adobe AIR 1.0 and later

You can display any NativeMenu object at an arbitrary time and location above a window, by calling the menu `display()` method. The method requires a reference to the stage; thus, only content in the application sandbox can display a menu as a pop-up.

The following method displays the menu defined by a NativeMenu object named `popupMenu` in response to a mouse click:

```
 private function onMouseClick(event:MouseEvent):void {
    popupMenu.display(event.target.stage, event.stageX, event.stageY);
}
```

***Note:** The menu does not need to be displayed in direct response to an event. Any method can call the `display()` function.*

Handling menu events

Flash Player 9 and later, Adobe AIR 1.0 and later

A menu dispatches events when the user selects the menu or when the user selects a menu item.

Events summary for menu classes

Flash Player 9 and later, Adobe AIR 1.0 and later

Add event listeners to menus or individual items to handle menu events.

Object	Events dispatched
NativeMenu (AIR)	Event.PREPARING (Adobe AIR 2.6 and later) Event.DISPLAYING Event.SELECT (propagated from child items and submenus)
NativeMenuItem (AIR)	Event.PREPARING (Adobe AIR 2.6 and later) Event.SELECT Event.DISPLAYING (propagated from parent menu)
ContextMenu	ContextMenuEvent.MENU_SELECT
ContextMenuItem	ContextMenuEvent.MENU_ITEM_SELECT Event.SELECT (AIR)

Select menu events

Adobe AIR 1.0 and later

To handle a click on a menu item, add an event listener for the `select` event to the NativeMenuItem object:

```
var menuCommandX:NativeMenuItem = new NativeMenuItem("Command X");
menuCommandX.addEventListener(Event.SELECT, doCommandX)
```

Because `select` events bubble up to the containing menus, you can also listen for select events on a parent menu. When listening at the menu level, you can use the event object `target` property to determine which menu command was selected. The following example traces the label of the selected command:

```
 var colorMenuItem:NativeMenuItem = new NativeMenuItem("Choose a color");
var colorMenu:NativeMenu = new NativeMenu();
colorMenuItem.submenu = colorMenu;

var red:NativeMenuItem = new NativeMenuItem("Red");
var green:NativeMenuItem = new NativeMenuItem("Green");
var blue:NativeMenuItem = new NativeMenuItem("Blue");
colorMenu.addItem(red);
colorMenu.addItem(green);
colorMenu.addItem(blue);

if(NativeApplication.supportsMenu){
    NativeApplication.nativeApplication.menu.addItem(colorMenuItem);
    NativeApplication.nativeApplication.menu.addEventListener(Event.SELECT, colorChoice);
} else if (NativeWindow.supportsMenu){
    var windowMenu:NativeMenu = new NativeMenu();
    this.stage.nativeWindow.menu = windowMenu;
    windowMenu.addItem(colorMenuItem);
    windowMenu.addEventListener(Event.SELECT, colorChoice);
}

function colorChoice(event:Event):void {
    var menuItem:NativeMenuItem = event.target as NativeMenuItem;
    trace(menuItem.label + " has been selected");
}
```

If you are using the ContextMenuItem class, you can listen for either the `select` event or the `menuItemSelect` event. The `menuItemSelect` event gives you additional information about the object owning the context menu, but does not bubble up to the containing menus.

Displaying menu events

Adobe AIR 1.0 and later

To handle the opening of a menu, you can add a listener for the `displaying` event, which is dispatched before a menu is displayed. You can use the displaying event to update the menu, for example by adding or removing items, or by updating the enabled or checked states of individual items. You can also listen for the `menuSelect` event from a ContextMenu object.

In AIR 2.6 and later, you can use the `preparing` event to update a menu in response to either displaying a menu or selecting an item with a keyboard shortcut.

Native menu example: Window and application menu (AIR)

Adobe AIR 1.0 and later

The following example creates the menu shown in "Native menu structure (AIR)" on page 635.

The menu is designed to work both on Windows, for which only window menus are supported, and on Mac OS X, for which only application menus are supported. To make the distinction, the MenuExample class constructor checks the static `supportsMenu` properties of the NativeWindow and NativeApplication classes. If `NativeWindow.supportsMenu` is `true`, then the constructor creates a NativeMenu object for the window and then creates and adds the File and Edit submenus. If `NativeApplication.supportsMenu` is `true`, then the constructor creates and adds the File and Edit menus to the existing menu provided by the Mac OS X operating system.

The example also illustrates menu event handling. The `select` event is handled at the item level and also at the menu level. Each menu in the chain from the menu containing the selected item to the root menu responds to the `select` event. The `displaying` event is used with the "Open Recent" menu. Just before the menu is opened, the items in the menu are refreshed from the recent Documents array (which doesn't actually change in this example). Although not shown in this example, you can also listen for `displaying` events on individual items.

```
 package {
    import flash.display.NativeMenu;
    import flash.display.NativeMenuItem;
    import flash.display.NativeWindow;
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.filesystem.File;
    import flash.desktop.NativeApplication;

    public class MenuExample extends Sprite
    {
        private var recentDocuments:Array =
            new Array(new File("app-storage:/GreatGatsby.pdf"),
                      new File("app-storage:/WarAndPeace.pdf"),
                      new File("app-storage:/Iliad.pdf"));

        public function MenuExample()
        {
            var fileMenu:NativeMenuItem;
            var editMenu:NativeMenuItem;

            if (NativeWindow.supportsMenu){
                stage.nativeWindow.menu = new NativeMenu();
                stage.nativeWindow.menu.addEventListener(Event.SELECT, selectCommandMenu);
                fileMenu = stage.nativeWindow.menu.addItem(new NativeMenuItem("File"));
                fileMenu.submenu = createFileMenu();
                editMenu = stage.nativeWindow.menu.addItem(new NativeMenuItem("Edit"));
                editMenu.submenu = createEditMenu();
            }

            if (NativeApplication.supportsMenu){
                NativeApplication.nativeApplication.menu.addEventListener(Event.SELECT,
selectCommandMenu);
                fileMenu = NativeApplication.nativeApplication.menu.addItem(new
NativeMenuItem("File"));
                fileMenu.submenu = createFileMenu();
                editMenu = NativeApplication.nativeApplication.menu.addItem(new
NativeMenuItem("Edit"));
                editMenu.submenu = createEditMenu();
            }
        }

        public function createFileMenu():NativeMenu {
            var fileMenu:NativeMenu = new NativeMenu();
            fileMenu.addEventListener(Event.SELECT, selectCommandMenu);

            var newCommand:NativeMenuItem = fileMenu.addItem(new NativeMenuItem("New"));
            newCommand.addEventListener(Event.SELECT, selectCommand);
            var saveCommand:NativeMenuItem = fileMenu.addItem(new NativeMenuItem("Save"));
            saveCommand.addEventListener(Event.SELECT, selectCommand);
            var openRecentMenu:NativeMenuItem =
                    fileMenu.addItem(new NativeMenuItem("Open Recent"));
            openRecentMenu.submenu = new NativeMenu();
            openRecentMenu.submenu.addEventListener(Event.DISPLAYING,
                                            updateRecentDocumentMenu);
            openRecentMenu.submenu.addEventListener(Event.SELECT, selectCommandMenu);

            return fileMenu;
        }

        public function createEditMenu():NativeMenu {
            var editMenu:NativeMenu = new NativeMenu();
            editMenu.addEventListener(Event.SELECT, selectCommandMenu);

            var copyCommand:NativeMenuItem = editMenu.addItem(new NativeMenuItem("Copy"));
            copyCommand.addEventListener(Event.SELECT, selectCommand);
            copyCommand.keyEquivalent = "c";
            var pasteCommand:NativeMenuItem =
                    editMenu.addItem(new NativeMenuItem("Paste"));
            pasteCommand.addEventListener(Event.SELECT, selectCommand);
            pasteCommand.keyEquivalent = "v";
            editMenu.addItem(new NativeMenuItem("", true));
            var preferencesCommand:NativeMenuItem =
                    editMenu.addItem(new NativeMenuItem("Preferences"));
            preferencesCommand.addEventListener(Event.SELECT, selectCommand);

            return editMenu;
        }

        private function updateRecentDocumentMenu(event:Event):void {
            trace("Updating recent document menu.");
            var docMenu:NativeMenu = NativeMenu(event.target);

            for each (var item:NativeMenuItem in docMenu.items) {
                docMenu.removeItem(item);
            }

            for each (var file:File in recentDocuments) {
                var menuItem:NativeMenuItem =
                        docMenu.addItem(new NativeMenuItem(file.name));
                menuItem.data = file;
                menuItem.addEventListener(Event.SELECT, selectRecentDocument);
            }
        }

        private function selectRecentDocument(event:Event):void {
            trace("Selected recent document: " + event.target.data.name);
        }

        private function selectCommand(event:Event):void {
            trace("Selected command: " + event.target.label);
        }

        private function selectCommandMenu(event:Event):void {
            if (event.currentTarget.parent != null) {
                var menuItem:NativeMenuItem =
                        findItemForMenu(NativeMenu(event.currentTarget));
                if (menuItem != null) {
                    trace("Select event for \"" +
                            event.target.label +
                            "\" command handled by menu: " +
                            menuItem.label);
                }
            } else {
                trace("Select event for \"" +
                        event.target.label +
                        "\" command handled by root menu.");
            }
        }

        private function findItemForMenu(menu:NativeMenu):NativeMenuItem {
            for each (var item:NativeMenuItem in menu.parent.items) {
                if (item != null) {
                    if (item.submenu == menu) {
                        return item;
                    }
                }
            }
            return null;
        }
    }
}
```

Chapter 37: Taskbar icons in AIR

Adobe AIR 1.0 and later

Many operating systems provide a taskbar, such as the Mac OS X dock, that can contain an icon to represent an application. Adobe® AIR® provides an interface for interacting with the application task bar icon through the `NativeApplication.nativeApplication.icon` property.

- Using the system tray and dock icons (Flex)
- Using the system tray and dock icons (Flash)

More Help topics

flash.desktop.NativeApplication

flash.desktop.DockIcon

flash.desktop.SystemTrayIcon

About taskbar icons

Adobe AIR 1.0 and later

AIR creates the `NativeApplication.nativeApplication.icon` object automatically. The object type is either DockIcon or SystemTrayIcon, depending on the operating system. You can determine which of these InteractiveIcon subclasses that AIR supports on the current operating system using the `NativeApplication.supportsDockIcon` and `NativeApplication.supportsSystemTrayIcon` properties. The InteractiveIcon base class provides the properties `width`, `height`, and `bitmaps`, which you can use to change the image used for the icon. However, accessing properties specific to DockIcon or SystemTrayIcon on the wrong operating system generates a runtime error.

To set or change the image used for an icon, create an array containing one or more images and assign it to the `NativeApplication.nativeApplication.icon.bitmaps` property. The size of taskbar icons can be different on different operating systems. To avoid image degradation due to scaling, you can add multiple sizes of images to the `bitmaps` array. If you provide more than one image, AIR selects the size closest to the current display size of the taskbar icon, scaling it only if necessary. The following example sets the image for a taskbar icon using two images:

```
NativeApplication.nativeApplication.icon.bitmaps =
            [bmp16x16.bitmapData, bmp128x128.bitmapData];
```

To change the icon image, assign an array containing the new image or images to the `bitmaps` property. You can animate the icon by changing the image in response to an `enterFrame` or `timer` event.

To remove the icon from the notification area on Windows and Linux, or to restore the default icon appearance on Mac OS X, set `bitmaps` to an empty array:

```
NativeApplication.nativeApplication.icon.bitmaps = [];
```

Dock icons

Adobe AIR 1.0 and later

AIR supports dock icons when `NativeApplication.supportsDockIcon` is `true`. The `NativeApplication.nativeApplication.icon` property represents the application icon on the dock (not a window dock icon).

***Note:** AIR does not support changing window icons on the dock under Mac OS X. Also, changes to the application dock icon only apply while an application is running — the icon reverts to its normal appearance when the application terminates.*

Dock icon menus

Adobe AIR 1.0 and later

You can add commands to the standard dock menu by creating a NativeMenu object containing the commands and assigning it to the `NativeApplication.nativeApplication.icon.menu` property. The items in the menu are displayed above the standard dock icon menu items.

Bouncing the dock

Adobe AIR 1.0 and later

You can bounce the dock icon by calling the `NativeApplication.nativeApplication.icon.bounce()` method. If you set the `bounce() priority` parameter to informational, then the icon bounces once. If you set it to critical, then the icon bounces until the user activates the application. Constants for the `priority` parameter are defined in the NotificationType class.

***Note:** The icon does not bounce if the application is already active.*

Dock icon events

Adobe AIR 1.0 and later

When the dock icon is clicked, the NativeApplication object dispatches an `invoke` event. If the application is not running, the system launches it. Otherwise, the `invoke` event is delivered to the running application instance.

System Tray icons

Adobe AIR 1.0 and later

AIR supports system tray icons when `NativeApplication.supportsSystemTrayIcon` is `true`, which is currently the case only on Windows and most Linux distributions. On Windows and Linux, system tray icons are displayed in the notification area of the taskbar. No icon is displayed by default. To show an icon, assign an array containing BitmapData objects to the icon `bitmaps` property. To change the icon image, assign an array containing the new images to `bitmaps`. To remove the icon, set `bitmaps` to `null`.

System tray icon menus

Adobe AIR 1.0 and later

You can add a menu to the system tray icon by creating a NativeMenu object and assigning it to the `NativeApplication.nativeApplication.icon.menu` property (no default menu is provided by the operating system). Access the system tray icon menu by right-clicking the icon.

System tray icon tooltips

Adobe AIR 1.0 and later

Add a tooltip to an icon by setting the tooltip property:

```
NativeApplication.nativeApplication.icon.tooltip = "Application name";
```

System tray icon events

Adobe AIR 1.0 and later

The SystemTrayIcon object referenced by the NativeApplication.nativeApplication.icon property dispatches a ScreenMouseEvent for `click`, `mouseDown`, `mouseUp`, `rightClick`, `rightMouseDown`, and `rightMouseUp` events. You can use these events, along with an icon menu, to allow users to interact with your application when it has no visible windows.

Example: Creating an application with no windows

Adobe AIR 1.0 and later

The following example creates an AIR application which has a system tray icon, but no visible windows. (The `visible` property of the application must not be set to `true` in the application descriptor, or the window will be visible when the application starts up.)

```
package
{
    import flash.display.Loader;
    import flash.display.NativeMenu;
    import flash.display.NativeMenuItem;
    import flash.display.NativeWindow;
    import flash.display.Sprite;
    import flash.desktop.DockIcon;
    import flash.desktop.SystemTrayIcon;
    import flash.events.Event;
    import flash.net.URLRequest;
    import flash.desktop.NativeApplication;

    public class SysTrayApp extends Sprite
    {
        public function SysTrayApp():void{
            NativeApplication.nativeApplication.autoExit = false;
            var icon:Loader = new Loader();
            var iconMenu:NativeMenu = new NativeMenu();
            var exitCommand:NativeMenuItem = iconMenu.addItem(new NativeMenuItem("Exit"));
                exitCommand.addEventListener(Event.SELECT, function(event:Event):void {
                    NativeApplication.nativeApplication.icon.bitmaps = [];
                    NativeApplication.nativeApplication.exit();
                });

            if (NativeApplication.supportsSystemTrayIcon) {
                NativeApplication.nativeApplication.autoExit = false;
                icon.contentLoaderInfo.addEventListener(Event.COMPLETE, iconLoadComplete);
                icon.load(new URLRequest("icons/AIRApp_16.png"));

                var systray:SystemTrayIcon =
                    NativeApplication.nativeApplication.icon as SystemTrayIcon;
                systray.tooltip = "AIR application";
                systray.menu = iconMenu;
            }

            if (NativeApplication.supportsDockIcon){
                icon.contentLoaderInfo.addEventListener(Event.COMPLETE,iconLoadComplete);
                icon.load(new URLRequest("icons/AIRApp_128.png"));
                var dock:DockIcon = NativeApplication.nativeApplication.icon as DockIcon;
                dock.menu = iconMenu;
            }
        }

        private function iconLoadComplete(event:Event):void
        {
            NativeApplication.nativeApplication.icon.bitmaps =
                [event.target.content.bitmapData];
        }
    }
}
```

***Note:** When using the Flex WindowedApplication component, you must set the `visible` attribute of the WindowedApplication tag to `false`. This attribute supercedes the setting in the application descriptor.*

***Note:** The example assumes that there are image files named `AIRApp_16.png` and `AIRApp_128.png` in an `icons` subdirectory of the application. (Sample icon files, which you can copy to your project folder, are included in the AIR SDK.)*

Window taskbar icons and buttons

Adobe AIR 1.0 and later

Iconified representations of windows are typically displayed in the window area of a taskbar or dock to allow users to easily access background or minimized windows. The Mac OS X dock displays an icon for your application as well as an icon for each minimized window. The Microsoft Windows and Linux taskbars display a button containing the progam icon and title for each normal-type window in your application.

Highlighting the taskbar window button

Adobe AIR 1.0 and later

When a window is in the background, you can notify the user that an event of interest related to the window has occurred. On Mac OS X, you can notify the user by bouncing the application dock icon (as described in "Bouncing the dock" on page 649). On Windows and Linux, you can highlight the window taskbar button by calling the `notifyUser()` method of the NativeWindow instance. The `type` parameter passed to the method determines the urgency of the notification:

- `NotificationType.CRITICAL`: the window icon flashes until the user brings the window to the foreground.
- `NotificationType.INFORMATIONAL`: the window icon highlights by changing color.

__Note:__ On Linux, only the informational type of notification is supported. Passing either type value to the `notifyUser()` function will create the same effect.

The following statement highlights the taskbar button of a window:

```
stage.nativeWindow.notifyUser(NotificationType.CRITICAL);
```

Calling the `NativeWindow.notifyUser()` method on an operating system that does not support window-level notification has no effect. Use the `NativeWindow.supportsNotification` property to determine if window notification is supported.

Creating windows without taskbar buttons or icons

Adobe AIR 1.0 and later

On the Windows operating system, windows created with the types *utility* or *lightweight* do not appear on the taskbar. Invisible windows do not appear on the taskbar, either.

Because the initial window is necessarily of type, *normal*, in order to create an application without any windows appearing in the taskbar, you must either close the initial window or leave it invisible. To close all windows in your application without terminating the application, set the `autoExit` property of the NativeApplication object to `false` before closing the last window. To simply prevent the initial window from ever becoming visible, add `<visible>false</visible>` to the `<initalWindow>` element of the application descriptor file (and do not set the `visible` property to `true` or call the `activate()` method of the window).

In new windows opened by the application, set the `type` property of the NativeWindowInitOption object passed to the window constructor to `NativeWindowType.UTILITY` or `NativeWindowType.LIGHTWEIGHT`.

On Mac OS X, windows that are minimized are displayed on the dock taskbar. You can prevent the minimized icon from being displayed by hiding the window instead of minimizing it. The following example listens for a `nativeWindowDisplayState` change event and cancels it if the window is being minimized. Instead the handler sets the window `visible` property to `false`:

```
private function preventMinimize(event:NativeWindowDisplayStateEvent):void{
    if(event.afterDisplayState == NativeWindowDisplayState.MINIMIZED){
        event.preventDefault();
        event.target.visible = false;
    }
}
```

If a window is minimized on the Mac OS X dock when you set the `visible` property to `false`, the dock icon is not removed. A user can still click the icon to make the window reappear.

Chapter 38: Working with the file system

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash® Player provides basic file reading and writing capabilities, via the FileReference class. For security reasons, when running in Flash Player, the user must always grant permission before you can read or write a file.

Adobe® AIR® provides more complete access to the file system of the host computer than is available in Flash Player. Using the AIR file system API, you can access and manage directories and files, create directories and files, write data to files, and so on.

More Help topics

flash.net.FileReference

flash.net.FileReferenceList

flash.filesystem.File

flash.filesystem.FileStream

Using the FileReference class

Flash Player 9 and later, Adobe AIR 1.0 and later

A FileReference object represents a data file on a client or server machine. The methods of the FileReference class let your application load and save data files locally, and transfer file data to and from remote servers.

The FileReference class offers two different approaches to loading, transferring, and saving data files. Since its introduction, the FileReference class has includedthe `browse()` method, the `upload()` method, and the `download()` method. Use the `browse()` method to let the user select a file. Use the `upload()` method to transfer the file data to a remote server. Use the `download()` method to retrieve that data from the server and save it in a local file. Starting with Flash Player 10 and Adobe AIR 1.5, the FileReference class includes the `load()` and `save()` methods. The `load()` and `save()` methods allow you to access and save local files directly as well. The use of those methods is similar to the equivalent-named methods in the URLLoader and Loader classes.

***Note:** The File class, which extends the FileReference class, and the FileStream class provide additional functions for working with files and the local file system. The File and FileStream classes are only supported in AIR and not in the Flash Player.*

FileReference class

Flash Player 9 and later, Adobe AIR 1.0 and later

Each FileReference object represents a single data file on the local machine. The properties of the FileReference class contain information about the file's size, type, name, filename extension, creator, creation date, and modification date.

***Note:** The `creator` property is supported on Mac OS only. All other platforms return `null`.*

***Note:** The `extension` property is only supported in Adobe AIR.*

You can create an instance of the FileReference class one of two ways:

- Use the `new` operator, as shown in the following code:

  ```
  import flash.net.FileReference;
  var fileRef:FileReference = new FileReference();
  ```

- Call the `FileReferenceList.browse()` method, which opens a dialog box and prompts the user to select one or more files to upload. It then creates an array of FileReference objects if the user successfully selects one or more files.

Once you have created a FileReference object, you can do the following:

- Call the `FileReference.browse()` method, which opens a dialog box and prompts the user to select a single file from the local file system. This is usually done before a subsequent call to the `FileReference.upload()` method or `FileReference.load()` method. Call the `FileReference.upload()` method to upload the file to a remote server. Call to the `FileReference.load()` method to open a local file.
- Call the `FileReference.download()` method. The `download()` method opens a dialog box to let the user select a location for saving a new file. Then it downloads data from the server and stores it in the new file.
- Call the `FileReference.load()` method. This method begins loading data from a file selected previously using the `browse()` method. The `load()` method can't be called until the `browse()` operation completes (the user selects a file).
- Call the `FileReference.save()` method. This method opens a dialog box and prompts the user to choose a single file location on the local file system. It then saves data to the specified location.

***Note:** You can only perform one `browse()`, `download()`, or `save()` action at a time, because only one dialog box can be open at any point.*

The FileReference object properties such as `name`, `size`, or `modificationDate` are not defined until one of the following happens:

- The `FileReference.browse()` method or `FileReferenceList.browse()` method has been called, and the user has selected a file using the dialog box.
- The `FileReference.download()` method has been called, and the user has specified a new file location using the dialog box.

***Note:** When performing a download, only the `FileReference.name` property is populated before the download is complete. After the file has been downloaded, all properties are available.*

While calls to the `FileReference.browse()`, `FileReferenceList.browse()`, `FileReference.download()`, `FileReference.load()`, or `FileReference.save()` methods are executing, most players continue SWF file playback including dispatching events and executing code.

For uploading and downloading operations, a SWF file can access files only within its own domain, including any domains specified by a policy file. You need to put a policy file on the server containing the file if that server is not in the same domain as the SWF file initiating the upload or download.

See FileReference.

Loading data from files

Flash Player 9 and later, Adobe AIR 1.0 and later

The `FileReference.load()` method lets you load data from a local file into memory.

***Note:** Your code must first call the `FileReference.browse()` method to let the user select a file to load. This restriction does not apply to content running in Adobe AIR in the application security sandbox*

The `FileReference.load()` method returns immediately after being called, but the data being loaded isn't available immediately. The FileReference object dispatches events to invoke listener methods at each step of the loading process.

The FileReference object dispatches the following events during the loading process.

- `open` event (`Event.OPEN`): Dispatched when the load operation starts.
- `progress` event (`ProgressEvent.PROGRESS`): Dispatched periodically as bytes of data are read from the file.
- `complete` event (`Event.COMPLETE`): Dispatched when the load operation completes successfully.
- `ioError` event (`IOErrorEvent.IO_ERROR`): Dispatched if the load process fails because an input/output error occurs while opening or reading data from the file.

Once the FileReference object dispatches the complete event, the loaded data can be accessed as a ByteArray in the FileReference object's `data` property.

The following example shows how to prompt the user to select a file and then load the data from that file into memory:

```
package
{
    import flash.display.Sprite;
    import flash.events.*;
    import flash.net.FileFilter;
    import flash.net.FileReference;
    import flash.net.URLRequest;
    import flash.utils.ByteArray;

    public class FileReferenceExample1 extends Sprite
    {
        private var fileRef:FileReference;
        public function FileReferenceExample1()
        {
            fileRef = new FileReference();
            fileRef.addEventListener(Event.SELECT, onFileSelected);
            fileRef.addEventListener(Event.CANCEL, onCancel);
            fileRef.addEventListener(IOErrorEvent.IO_ERROR, onIOError);
            fileRef.addEventListener(SecurityErrorEvent.SECURITY_ERROR,
                        onSecurityError);
            var textTypeFilter:FileFilter = new FileFilter("Text Files (*.txt, *.rtf)",
                        "*.txt;*.rtf");
            fileRef.browse([textTypeFilter]);
        }
        public function onFileSelected(evt:Event):void
        {
            fileRef.addEventListener(ProgressEvent.PROGRESS, onProgress);
            fileRef.addEventListener(Event.COMPLETE, onComplete);
            fileRef.load();
        }

        public function onProgress(evt:ProgressEvent):void
        {
            trace("Loaded " + evt.bytesLoaded + " of " + evt.bytesTotal + " bytes.");
        }

        public function onComplete(evt:Event):void
        {
            trace("File was successfully loaded.");
            trace(fileRef.data);
        }

        public function onCancel(evt:Event):void
        {
            trace("The browse request was canceled by the user.");
        }

        public function onIOError(evt:IOErrorEvent):void
        {
            trace("There was an IO Error.");
        }
        public function onSecurityError(evt:Event):void
        {
            trace("There was a security error.");
        }
    }
}
```

The example code first creates the FileReference object named `fileRef` and then calls its `browse()` method. The `browse()` method opens a dialog box that prompts the user to select a file. When a file is selected, the code invokes the `onFileSelected()` method. This method adds listeners for the `progress` and `complete` events and then calls the FileReference object's `load()` method. The other handler methods in the example simply output messages to report on the progress of the load operation. When the loading completes, the application displays the contents of the loaded file using the `trace()` method.

In Adobe AIR, the FileStream class provides additional functionality for reading data from a local file. See "Reading and writing files" on page 689.

Saving data to local files

Flash Player 9 and later, Adobe AIR 1.0 and later

The `FileReference.save()` method lets you save data to a local file. It starts by opening a dialog box to let the user enter a new filename and location to which to save a file. After the user selects the filename and location, the data is written to the new file. When the file is saved successfully, the properties of the FileReference object are populated with the properties of the local file.

***Note:** Your code can only call the `FileReference.save()` method in response to a user-initiated event such as a mouse click or a keypress event. Otherwise an error is thrown. This restriction does not apply to content running in Adobe AIR in the application security sandbox.*

The `FileReference.save()` method returns immediately after being called. The FileReference object then dispatches events to call listener methods at each step of the file saving process.

The FileReference object dispatches the following events during the file saving process:

- `select` event (`Event.SELECT`): Dispatched when the user specifies the location and file name for the new file to be saved.
- `cancel` event (`Event.CANCEL`): Dispatched when the user click the Cancel button in the dialog box.
- `open` event (`Event.OPEN`): Dispatched when the save operation starts.
- `progress` event (`ProgressEvent.PROGRESS`): Dispatched periodically as bytes of data are saved to the file.

- `complete` event (`Event.COMPLETE`): Dispatched when the save operation completes successfully.
- `ioError` event (`IOErrorEvent.IO_ERROR`): Dispatched if the saving process fails because an input/output error occurs while attempting to save data to the file.

The type of object passed in the `data` parameter of the `FileReference.save()` method determines how the data is written to the file:

- If it is a String value, then it is saved as a text file using UTF-8 encoding.
- If it is an XML object, then it is written to a file in XML format with all formatting preserved.
- If it is a ByteArray object, then its contents are written directly to the file with no conversion.
- If it is some other object, then the `FileReference.save()` method calls the object's `toString()` method and then saves the resulting String value to a UTF-8 text file. If the object's `toString()` method can't be called, then an error is thrown.

If the value of the `data` parameter is `null`, then an error is thrown.

The following code extends the previous example for the `FileReference.load()` method. After reading the data from the file, this example prompts the user for a filename and then saves the data in a new file:

```
package
{
    import flash.display.Sprite;
    import flash.events.*;
    import flash.net.FileFilter;
    import flash.net.FileReference;
    import flash.net.URLRequest;
    import flash.utils.ByteArray;

    public class FileReferenceExample2 extends Sprite
    {
        private var fileRef:FileReference;
        public function FileReferenceExample2()
        {
            fileRef = new FileReference();
            fileRef.addEventListener(Event.SELECT, onFileSelected);
            fileRef.addEventListener(Event.CANCEL, onCancel);
            fileRef.addEventListener(IOErrorEvent.IO_ERROR, onIOError);
            fileRef.addEventListener(SecurityErrorEvent.SECURITY_ERROR,
                        onSecurityError);
            var textTypeFilter:FileFilter = new FileFilter("Text Files (*.txt, *.rtf)",
                        "*.txt;*.rtf");
            fileRef.browse([textTypeFilter]);
        }
        public function onFileSelected(evt:Event):void
        {
            fileRef.addEventListener(ProgressEvent.PROGRESS, onProgress);
            fileRef.addEventListener(Event.COMPLETE, onComplete);
            fileRef.load();
        }

        public function onProgress(evt:ProgressEvent):void
        {
            trace("Loaded " + evt.bytesLoaded + " of " + evt.bytesTotal + " bytes.");
        }
        public function onCancel(evt:Event):void
        {
            trace("The browse request was canceled by the user.");
        }
        public function onComplete(evt:Event):void
        {
            trace("File was successfully loaded.");
            fileRef.removeEventListener(Event.SELECT, onFileSelected);
            fileRef.removeEventListener(ProgressEvent.PROGRESS, onProgress);
            fileRef.removeEventListener(Event.COMPLETE, onComplete);
            fileRef.removeEventListener(Event.CANCEL, onCancel);
            saveFile();
        }
        public function saveFile():void
        {
            fileRef.addEventListener(Event.SELECT, onSaveFileSelected);
            fileRef.save(fileRef.data,"NewFileName.txt");
        }

        public function onSaveFileSelected(evt:Event):void
        {
            fileRef.addEventListener(ProgressEvent.PROGRESS, onSaveProgress);
            fileRef.addEventListener(Event.COMPLETE, onSaveComplete);
            fileRef.addEventListener(Event.CANCEL, onSaveCancel);
        }

        public function onSaveProgress(evt:ProgressEvent):void
        {
            trace("Saved " + evt.bytesLoaded + " of " + evt.bytesTotal + " bytes.");
        }

        public function onSaveComplete(evt:Event):void
        {
            trace("File saved.");
            fileRef.removeEventListener(Event.SELECT, onSaveFileSelected);
            fileRef.removeEventListener(ProgressEvent.PROGRESS, onSaveProgress);
            fileRef.removeEventListener(Event.COMPLETE, onSaveComplete);
            fileRef.removeEventListener(Event.CANCEL, onSaveCancel);
        }

        public function onSaveCancel(evt:Event):void
        {
            trace("The save request was canceled by the user.");
        }

        public function onIOError(evt:IOErrorEvent):void
        {
            trace("There was an IO Error.");
        }
        public function onSecurityError(evt:Event):void
        {
            trace("There was a security error.");
        }
    }
}
```

When all of the data loads from the file, the code calls the `onComplete()` method. The `onComplete()` method removes the listeners for the loading events and then calls the `saveFile()` method. The `saveFile()` method calls the `FileReference.save()` method. The `FileReference.save()` method opens a new dialog box to let the user enter a new filename and location to save the file. The remaining event listener methods trace the progress of the file saving process until it is complete.

In Adobe AIR, the FileStream class provides additional functionality for writing data to a local file. See "Reading and writing files" on page 689.

Uploading files to a server

Flash Player 9 and later, Adobe AIR 1.0 and later

To upload files to a server, first call the `browse()` method to allow a user to select one or more files. Next, when the `FileReference.upload()` method is called, the selected file is transferred to the server. If the user selects multiple files using the `FileReferenceList.browse()` method, Flash Player creates an array of selected files called `FileReferenceList.fileList`. You can then use the `FileReference.upload()` method to upload each file individually.

Note: *Using the `FileReference.browse()` method allows you to upload single files only. To allow a user to upload multiple files, use the `FileReferenceList.browse()` method.*

By default, the system file picker dialog box allows users to pick any file type from the local computer. Developers can specify one or more custom file type filters by using the FileFilter class and passing an array of file filter instances to the `browse()` method:

```
var imageTypes:FileFilter = new FileFilter("Images (*.jpg, *.jpeg, *.gif, *.png)", "*.jpg;
*.jpeg; *.gif; *.png");
var textTypes:FileFilter = new FileFilter("Text Files (*.txt, *.rtf)", "*.txt; *.rtf");
var allTypes:Array = new Array(imageTypes, textTypes);
var fileRef:FileReference = new FileReference();
fileRef.browse(allTypes);
```

When the user has selected the files and clicked the Open button in the system file picker, the `Event.SELECT` event is dispatched. If the `FileReference.browse()` method is used to select a file to upload, the following code sends the file to a web server:

```
var fileRef:FileReference = new FileReference();
fileRef.addEventListener(Event.SELECT, selectHandler);
fileRef.addEventListener(Event.COMPLETE, completeHandler);
try
{
    var success:Boolean = fileRef.browse();
}
catch (error:Error)
{
    trace("Unable to browse for files.");
}
function selectHandler(event:Event):void
{
    var request:URLRequest = new URLRequest("http://www.[yourdomain].com/fileUploadScript.cfm")
    try
    {
        fileRef.upload(request);
    }
    catch (error:Error)
    {
        trace("Unable to upload file.");
    }
}
function completeHandler(event:Event):void
{
    trace("uploaded");
}
```

You can send data to the server with the `FileReference.upload()` method by using the `URLRequest.method` and `URLRequest.data` properties to send variables using the `POST` or `GET` methods.

When you attempt to upload a file using the `FileReference.upload()` method, the following events are dispatched:

- `open` event (`Event.OPEN`): Dispatched when the upload operation starts.
- `progress` event (`ProgressEvent.PROGRESS`): Dispatched periodically as bytes of data from the file are uploaded.
- `complete` event (`Event.COMPLETE`): Dispatched when the upload operation completes successfully.
- `httpStatus` event (`HTTPStatusEvent.HTTP_STATUS`): Dispatched when the upload process fails because of an HTTP error.
- `httpResponseStatus` event (`HTTPStatusEvent.HTTP_RESPONSE_STATUS`): Dispatched if a call to the `upload()` or `uploadUnencoded()` method attempts to access data over HTTP and Adobe AIR is able to detect and return the status code for the request.
- `securityError` event (`SecurityErrorEvent.SECURITY_ERROR`): Dispatched when an upload operation fails because of a security violation.
- `uploadCompleteData` event (`DataEvent.UPLOAD_COMPLETE_DATA`): Dispatched after data is received from the server after a successful upload.
- `ioError` event (`IOErrorEvent.IO_ERROR`): Dispatched if the upload process fails for any of the following reasons:
    - An input/output error occurred while Flash Player is reading, writing, or transmitting the file.
    - The SWF tried to upload a file to a server that requires authentication (such as a user name and password). During upload, Flash Player does not provide a means for users to enter passwords.
    - The `url` parameter contains an invalid protocol. The `FileReference.upload()` method must use either HTTP or HTTPS.

Flash Player does not offer complete support for servers that require authentication. Only SWF files that are running in a browser using the browser plug-in or Microsoft ActiveX® control can provide a dialog box to prompt the user to enter a user name and password for authentication, and then only for downloads. For uploads using the plug-in or ActiveX control or upload/download using either the stand-alone or external player, the file transfer fails.

To create a server script in ColdFusion to accept a file upload from Flash Player, you can use code similar to the following:

```
<cffile action="upload" filefield="Filedata" destination="#ExpandPath('./')#"
nameconflict="OVERWRITE" />
```

This ColdFusion code uploads the file sent by Flash Player and saves it to the same directory as the ColdFusion template, overwriting any file with the same name. The previous code shows the bare minimum amount of code necessary to accept a file upload; this script should not be used in a production environment. Ideally, add data validation to ensure that users upload only accepted file types, such as an image instead of a potentially dangerous server-side script.

The following code demonstrates file uploads using PHP, and it includes data validation. The script limits the number of uploaded files in the upload directory to 10, ensures that the file is less than 200 KB, and permits only JPEG, GIF, or PNG files to be uploaded and saved to the file system.

```
<?php
$MAXIMUM_FILESIZE = 1024 * 200; // 200KB
$MAXIMUM_FILE_COUNT = 10; // keep maximum 10 files on server
echo exif_imagetype($_FILES['Filedata']);
if ($_FILES['Filedata']['size'] <= $MAXIMUM_FILESIZE)
{
    move_uploaded_file($_FILES['Filedata']['tmp_name'],
"./temporary/".$_FILES['Filedata']['name']);
    $type = exif_imagetype("./temporary/".$_FILES['Filedata']['name']);
    if ($type == 1 || $type == 2 || $type == 3)
    {
        rename("./temporary/".$_FILES['Filedata']['name'],
"./images/".$_FILES['Filedata']['name']);
    }
    else
    {
        unlink("./temporary/".$_FILES['Filedata']['name']);
    }
}
$directory = opendir('./images/');
$files = array();
while ($file = readdir($directory))
{
    array_push($files, array('./images/'.$file, filectime('./images/'.$file)));
}
usort($files, sorter);
if (count($files) > $MAXIMUM_FILE_COUNT)
{
    $files_to_delete = array_splice($files, 0, count($files) - $MAXIMUM_FILE_COUNT);
    for ($i = 0; $i < count($files_to_delete); $i++)
    {
        unlink($files_to_delete[$i][0]);
    }
}
print_r($files);
closedir($directory);

function sorter($a, $b)
{
    if ($a[1] == $b[1])
    {
        return 0;
    }
    else
    {
        return ($a[1] < $b[1]) ? -1 : 1;
    }
}
?>
```

You can pass additional variables to the upload script using either the `POST` or `GET` request method. To send additional `POST` variables to your upload script, you can use the following code:

```
var fileRef:FileReference = new FileReference();
fileRef.addEventListener(Event.SELECT, selectHandler);
fileRef.addEventListener(Event.COMPLETE, completeHandler);
fileRef.browse();
function selectHandler(event:Event):void
{
    var params:URLVariables = new URLVariables();
    params.date = new Date();
    params.ssid = "94103-1394-2345";
    var request:URLRequest = new
URLRequest("http://www.yourdomain.com/FileReferenceUpload/fileupload.cfm");
    request.method = URLRequestMethod.POST;
    request.data = params;
    fileRef.upload(request, "Custom1");
}
function completeHandler(event:Event):void
{
    trace("uploaded");
}
```

The previous example creates a URLVariables object that you pass to the remote server- side script. In previous versions of ActionScript, you could pass variables to the server upload script by passing values in the query string. ActionScript 3.0 allows you to pass variables to the remote script using a URLRequest object, which allows you to pass data using either the `POST` or `GET` method; this, in turn, makes passing larger sets of data easier and cleaner. In order to specify whether the variables are passed using the `GET` or `POST` request method, you can set the `URLRequest.method` property to either `URLRequestMethod.GET` or `URLRequestMethod.POST`, respectively.

ActionScript 3.0 also lets you override the default `Filedata` upload file field name by providing a second parameter to the `upload()` method, as demonstrated in the previous example (which replaced the default value `Filedata` with `Custom1`).

By default, Flash Player does not attempt to send a test upload, although you can override this default by passing a value of `true` as the third parameter to the `upload()` method. The purpose of the test upload is to check whether the actual file upload will be successful and that server authentication, if required, will succeed.

***Note:** A test upload occurs only on Windows-based Flash Players at this time.*

The server script that handles the file upload should expect an HTTP `POST` request with the following elements:

- `Content-Type` with a value of `multipart/form-data`.
- `Content-Disposition` with a `name` attribute set to "`Filedata`" and a `filename` attribute set to the name of the original file. You can specify a custom `name` attribute by passing a value for the `uploadDataFieldName` parameter in the `FileReference.upload()` method.
- The binary contents of the file.

Here is a sample HTTP `POST` request:

```
POST /handler.asp HTTP/1.1
Accept: text/*
Content-Type: multipart/form-data;
boundary=----------Ij5ae0ae0KM7GI3KM7ei4cH2ei4gL6
User-Agent: Shockwave Flash
Host: www.mydomain.com
Content-Length: 421
Connection: Keep-Alive
Cache-Control: no-cache

------------Ij5ae0ae0KM7GI3KM7ei4cH2ei4gL6
Content-Disposition: form-data; name="Filename"

sushi.jpg
------------Ij5ae0ae0KM7GI3KM7ei4cH2ei4gL6
Content-Disposition: form-data; name="Filedata"; filename="sushi.jpg"
Content-Type: application/octet-stream

Test File
------------Ij5ae0ae0KM7GI3KM7ei4cH2ei4gL6
Content-Disposition: form-data; name="Upload"

Submit Query
------------Ij5ae0ae0KM7GI3KM7ei4cH2ei4gL6
(actual file data,,,)
```

The following sample HTTP `POST` request sends three `POST` variables: `api_sig`, `api_key`, and `auth_token`, and uses a custom upload data field name value of `"photo"`:

```
POST /handler.asp HTTP/1.1
Accept: text/*
Content-Type: multipart/form-data;
boundary=----------Ij5ae0ae0KM7GI3KM7ei4cH2ei4gL6
User-Agent: Shockwave Flash
Host: www.mydomain.com
Content-Length: 421
Connection: Keep-Alive
Cache-Control: no-cache

------------Ij5GI3GI3ei4GI3ei4KM7GI3KM7KM7
Content-Disposition: form-data; name="Filename"

sushi.jpg
------------Ij5GI3GI3ei4GI3ei4KM7GI3KM7KM7
Content-Disposition: form-data; name="api_sig"

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
------------Ij5GI3GI3ei4GI3ei4KM7GI3KM7KM7
Content-Disposition: form-data; name="api_key"

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
------------Ij5GI3GI3ei4GI3ei4KM7GI3KM7KM7
Content-Disposition: form-data; name="auth_token"

XXXXXXXXXXXXXXXXXXXXXXX
------------Ij5GI3GI3ei4GI3ei4KM7GI3KM7KM7
Content-Disposition: form-data; name="photo"; filename="sushi.jpg"
Content-Type: application/octet-stream

(actual file data,,,)
------------Ij5GI3GI3ei4GI3ei4KM7GI3KM7KM7
Content-Disposition: form-data; name="Upload"

Submit Query
------------Ij5GI3GI3ei4GI3ei4KM7GI3KM7KM7--
```

Downloading files from a server

Flash Player 9 and later, Adobe AIR 1.0 and later

You can let users download files from a server using the `FileReference.download()` method, which takes two parameters: `request` and `defaultFileName`. The first parameter is the URLRequest object that contains the URL of the file to download. The second parameter is optional—it lets you specify a default filename that appears in the download file dialog box. If you omit the second parameter, `defaultFileName`, the filename from the specified URL is used.

The following code downloads a file named index.xml from the same directory as the SWF file:

```
var request:URLRequest = new URLRequest("index.xml");
var fileRef:FileReference = new FileReference();
fileRef.download(request);
```

To set the default name to currentnews.xml instead of index.xml, specify the `defaultFileName` parameter, as the following snippet shows:

```
var request:URLRequest = new URLRequest("index.xml");
var fileToDownload:FileReference = new FileReference();
fileToDownload.download(request, "currentnews.xml");
```

Renaming a file can be useful if the server filename was not intuitive or was server-generated. It's also good to explicitly specify the `defaultFileName` parameter when you download a file using a server-side script, instead of downloading the file directly. For example, you need to specify the `defaultFileName` parameter if you have a server-side script that downloads specific files based on URL variables passed to it. Otherwise, the default name of the downloaded file is the name of your server-side script.

Data can be sent to the server using the `download()` method by appending parameters to the URL for the server script to parse. The following ActionScript 3.0 snippet downloads a document based on which parameters are passed to a ColdFusion script:

```
package
{
    import flash.display.Sprite;
    import flash.net.FileReference;
    import flash.net.URLRequest;
    import flash.net.URLRequestMethod;
    import flash.net.URLVariables;

    public class DownloadFileExample extends Sprite
    {
        private var fileToDownload:FileReference;
        public function DownloadFileExample()
        {
            var request:URLRequest = new URLRequest();
            request.url = "http://www.[yourdomain].com/downloadfile.cfm";
            request.method = URLRequestMethod.GET;
            request.data = new URLVariables("id=2");
            fileToDownload = new FileReference();
            try
            {
                fileToDownload.download(request, "file2.txt");
            }
            catch (error:Error)
            {
                trace("Unable to download file.");
            }
        }
    }
}
```

The following code demonstrates the ColdFusion script, download.cfm, that downloads one of two files from the server, depending on the value of a URL variable:

```
<cfparam name="URL.id" default="1" />
<cfswitch expression="#URL.id#">
    <cfcase value="2">
        <cfcontent type="text/plain" file="#ExpandPath('two.txt')#" deletefile="No" />
    </cfcase>
    <cfdefaultcase>
        <cfcontent type="text/plain" file="#ExpandPath('one.txt')#" deletefile="No" />
    </cfdefaultcase>
</cfswitch>
```

FileReferenceList class

Flash Player 9 and later, Adobe AIR 1.0 and later

The FileReferenceList class lets the user select one or more files to upload to a server-side script. The file upload is handled by the `FileReference.upload()` method, which must be called on each file that the user selects.

The following code creates two FileFilter objects (`imageFilter` and `textFilter`) and passes them in an array to the `FileReferenceList.browse()` method. This causes the operating system file dialog box to display two possible filters for file types.

```
var imageFilter:FileFilter = new FileFilter("Image Files (*.jpg, *.jpeg, *.gif, *.png)",
"*.jpg; *.jpeg; *.gif; *.png");
var textFilter:FileFilter = new FileFilter("Text Files (*.txt, *.rtf)", "*.txt; *.rtf");
var fileRefList:FileReferenceList = new FileReferenceList();
try
{
    var success:Boolean = fileRefList.browse(new Array(imageFilter, textFilter));
}
catch (error:Error)
{
    trace("Unable to browse for files.");
}
```

Allowing the user to select and upload one or more files by using the FileReferenceList class is the same as using `FileReference.browse()` to select files, although the FileReferenceList allows you to select more than one file. Uploading multiple files requires you to upload each of the selected files by using `FileReference.upload()`, as the following code shows:

```
var fileRefList:FileReferenceList = new FileReferenceList();
fileRefList.addEventListener(Event.SELECT, selectHandler);
fileRefList.browse();

function selectHandler(event:Event):void
{
    var request:URLRequest = new URLRequest("http://www.[yourdomain].com/fileUploadScript.cfm");
    var file:FileReference;
    var files:FileReferenceList = FileReferenceList(event.target);
    var selectedFileArray:Array = files.fileList;
    for (var i:uint = 0; i < selectedFileArray.length; i++)
    {
        file = FileReference(selectedFileArray[i]);
        file.addEventListener(Event.COMPLETE, completeHandler);
        try
        {
            file.upload(request);
        }
        catch (error:Error)
        {
            trace("Unable to upload files.");
        }
    }
}
function completeHandler(event:Event):void
{
    trace("uploaded");
}
```

Because the `Event.COMPLETE` event is added to each individual FileReference object in the array, Flash Player calls the `completeHandler()` method when each individual file finishes uploading.

Using the AIR file system API

Adobe AIR 1.0 and later

The Adobe AIR file system API includes the following classes:

- File
- FileMode
- FileStream

The file system API lets you do the following (and more):

- Copy, create, delete, and move files and directories
- Get information about files and directories
- Read and write files

AIR file basics

Adobe AIR 1.0 and later

For a quick explanation and code examples of working with the file system in AIR, see the following quick start articles on the Adobe Developer Connection:

- Building a text-file editor (Flash)
- Building a text-file editor (Flex)
- Building a directory search application (Flex)
- Reading and writing from an XML preferences file (Flex)
- Compressing files and data (Flex)

Adobe AIR provides classes that you can use to access, create, and manage both files and folders. These classes, contained in the flash.filesystem package, are used as follows:

File classes	Description
File	File object represents a path to a file or directory. You use a file object to create a pointer to a file or folder, initiating interaction with the file or folder.
FileMode	The FileMode class defines string constants used in the `fileMode` parameter of the `open()` and `openAsync()` methods of the FileStream class. The `fileMode` parameter of these methods determines the capabilities available to the FileStream object once the file is opened, which include writing, reading, appending, and updating.
FileStream	FileStream object is used to open files for reading and writing. Once you've created a File object that points to a new or existing file, you pass that pointer to the FileStream object so that you can open it and read or write data.

Some methods in the File class have both synchronous and asynchronous versions:

- `File.copyTo()` and `File.copyToAsync()`

- `File.deleteDirectory()` and `File.deleteDirectoryAsync()`
- `File.deleteFile()` and `File.deleteFileAsync()`
- `File.getDirectoryListing()` and `File.getDirectoryListingAsync()`
- `File.moveTo()` and `File.moveToAsync()`
- `File.moveToTrash()` and `File.moveToTrashAsync()`

Also, FileStream operations work synchronously or asynchronously depending on how the FileStream object opens the file: by calling the `open()` method or by calling the `openAsync()` method.

The asynchronous versions let you initiate processes that run in the background and dispatch events when complete (or when error events occur). Other code can execute while these asynchronous background processes are taking place. With asynchronous versions of the operations, you must set up event listener functions, using the `addEventListener()` method of the File or FileStream object that calls the function.

The synchronous versions let you write simpler code that does not rely on setting up event listeners. However, since other code cannot execute while a synchronous method is executing, important processes such as display object rendering and animation can be delayed.

Working with File objects in AIR

Adobe AIR 1.0 and later

A File object is a pointer to a file or directory in the file system.

The File class extends the FileReference class. The FileReference class, which is available in Adobe® Flash® Player as well as AIR, represents a pointer to a file. The File class adds properties and methods that are not exposed in Flash Player (in a SWF file running in a browser), due to security considerations.

About the File class

Adobe AIR 1.0 and later

You can use the File class for the following:

- Getting the path to special directories, including the user directory, the user's documents directory, the directory from which the application was launched, and the application directory
- Coping files and directories
- Moving files and directories
- Deleting files and directories (or moving them to the trash)
- Listing files and directories contained in a directory
- Creating temporary files and folders

Once a File object points to a file path, you can use it to read and write file data, using the FileStream class.

A File object can point to the path of a file or directory that does not yet exist. You can use such a File object in creating a file or directory.

Paths of File objects

Adobe AIR 1.0 and later

Each File object has two properties that each define its path:

Property	**Description**
`nativePath`	Specifies the platform-specific path to a file. For example, on Windows a path might be "c:\Sample directory\test.txt" whereas on Mac OS it could be "/Sample directory/test.txt". A `nativePath` property uses the backslash (\) character as the directory separator character on Windows, and it uses the forward slash (/) character on Mac OS and Linux.
`url`	This may use the file URL scheme to point to a file. For example, on Windows a path might be "file:///c:/Sample%20directory/test.txt" whereas on Mac OS it could be "file:///Sample%20directory/test.txt". The runtime includes other special URL schemes besides `file` and are described in "Supported AIR URL schemes" on page 677

The File class includes static properties for pointing to standard directories on Mac OS, Windows, and Linux. These properties include:

- `File.applicationStorageDirectory`—a storage directory unique to each installed AIR application. This directory is an appropriate place to store dynamic application assets and user preferences. Consider storing large amounts of data elsewhere.

  On Android and iOS, the application storage directory is removed when the application is uninstalled or the user chooses to clear application data, but this is not the case on other platforms.

- `File.applicationDirectory`—the directory where the application is installed (along with any installed assets). On some operating systems, the application is stored in a single package file rather than a physical directory. In this case, the contents may not be accessible using the native path. The application directory is read-only.
- `File.desktopDirectory`—the user's desktop directory. If a platform does not define a desktop directory, another location on the file system is used.
- `File.documentsDirectory`—the user's documents directory. If a platform does not define a documents directory, another location on the file system is used.
- `File.userDirectory`—the user directory. If a platform does not define a user directory, another location on the file system is used.

***Note:** When a platform does not define standard locations for desktop, documents, or user directories,* `File.documentsDirectory`*,* `File.desktopDirectory`*, and* `File.userDirectory` *can reference the same directory.*

These properties have different values on different operating systems. For example, Mac and Windows each have a different native path to the user's desktop directory. However, the `File.desktopDirectory` property points to an appropriate directory path on every platform. To write applications that work well across platforms, use these properties as the basis for referencing other directories and files used by the application. Then use the `resolvePath()` method to refine the path. For example, this code points to the preferences.xml file in the application storage directory:

```
var prefsFile:File = File.applicationStorageDirectory;
prefsFile = prefsFile.resolvePath("preferences.xml");
```

Although the File class lets you point to a specific file path, doing so can lead to applications that do not work across platforms. For example, the path C:\Documents and Settings\joe\ only works on Windows. For these reasons, it is best to use the static properties of the File class, such as `File.documentsDirectory`.

Common directory locations

Platform	Directory type	Typical file system location
Android	Application	`/data/data/`
	Application-storage	`/data/data/air.applicationID/filename/Local Store`
	Cache	/data/data/applicationID/cache
	Desktop	`/mnt/sdcard`
	Documents	`/mnt/sdcard`
	Temporary	`/data/data/applicationID/cache/FlashTmp.randomString`
	User	`/mnt/sdcard`
iOS	Application	`/var/mobile/Applications/uid/filename.app`
	Application-storage	`/var/mobile/Applications/uid/Library/Application Support/applicationID/Local Store`
	Cache	/var/mobile/Applications/uid/Library/Caches
	Desktop	not accessible
	Documents	`/var/mobile/Applications/uid/Documents`
	Temporary	`/private/var/mobile/Applications/uid/tmp/FlashTmpNNN`
	User	not accessible
Linux	Application	`/opt/filename/share`
	Application-storage	`/home/userName/.appdata/applicationID/Local Store`
	Desktop	`/home/userName/Desktop`
	Documents	`/home/userName/Documents`
	Temporary	`/tmp/FlashTmp.randomString`
	User	`/home/userName`
Mac	Application	`/Applications/filename.app/Contents/Resources`
	Application-storage	`/Users/`***`userName`***`/Library/Preferences/`***`applicationid`***`/Local Store` (AIR 3.2 and earlier) ***`path`***`/Library/Application Support/`***`applicationid`***`/Local Store` (AIR 3.3 and later), where path is is either `/Users/`***`userName`***`/Library/Containers/`***`bundle-id`***`/Data` (sandboxed environment) or `/Users/userName` (when running outside a sandboxed environment)
	Cache	/Users/userName/Library/Caches
	Desktop	`/Users/`***`userName`***`/Desktop`
	Documents	`/Users/`***`userName`***`/Documents`
	Temporary	`/private/var/folders/JY/randomString/TemporaryItems/FlashTmp`
	User	`/Users/`***`userName`***

Platform	Directory type	Typical file system location
Windows	Application	`C:\Program Files\filename`
	Application-storage	`C:\Documents and settings\userName\ApplicationData\applicationID\Local Store`
	Cache	C:\Documents and settings\userName\Local Settings\Temp
	Desktop	`C:\Documents and settings\userName\Desktop`
	Documents	`C:\Documents and settings\userName\My Documents`
	Temporary	`C:\Documents and settings\userName\Local Settings\Temp\randomString.tmp`
	User	`C:\Documents and settings\userName`

The actual native paths for these directories vary based on the operating system and computer configuration. The paths shown in this table are typical examples. You should always use the appropriate static File class properties to refer to these directories so that your application works correctly on any platform. In an actual AIR application, the values for `applicationID` and `filename` shown in the table are taken from the application descriptor. If you specify a publisher ID in the application descriptor, then the publisher ID is appended to the application ID in these paths. The value for `userName` is the account name of the installing user.

Pointing a File object to a directory

Adobe AIR 1.0 and later

There are different ways to set a File object to point to a directory.

Pointing to the user's home directory

Adobe AIR 1.0 and later

You can point a File object to the user's home directory. The following code sets a File object to point to an AIR Test subdirectory of the home directory:

```
var file:File = File.userDirectory.resolvePath("AIR Test");
```

Pointing to the user's documents directory

Adobe AIR 1.0 and later

You can point a File object to the user's documents directory. The following code sets a File object to point to an AIR Test subdirectory of the documents directory:

```
var file:File = File.documentsDirectory.resolvePath("AIR Test");
```

Pointing to the desktop directory

Adobe AIR 1.0 and later

You can point a File object to the desktop. The following code sets a File object to point to an AIR Test subdirectory of the desktop:

```
var file:File = File.desktopDirectory.resolvePath("AIR Test");
```

Pointing to the application storage directory

Adobe AIR 1.0 and later

You can point a File object to the application storage directory. For every AIR application, there is a unique associated path that defines the application storage directory. This directory is unique to each application and user. You can use this directory to store user-specific, application-specific data (such as user data or preferences files). For example, the following code points a File object to a preferences file, prefs.xml, contained in the application storage directory:

```
 var file:File = File.applicationStorageDirectory;
file = file.resolvePath("prefs.xml");
```

The application storage directory location is typically based on the user name and the application ID. The following file system locations are given here to help you debug your application. You should always use the `File.applicationStorage` property or `app-storage:` URI scheme to resolve files in this directory:

- On Mac OS — varies by AIR version:

  AIR 3.2 and earlier: `/Users/user name/Library/Preferences/`*`applicationID`*`/Local Store/`

  AIR 3.3 and later: *`path`*`/Library/Application Support/`*`applicationID`*`/Local Store`, where *`path`* is either `/Users/`*`username`*`/Library/Containers/`*`bundle-id`*`/Data` (sandboxed environment) or `/Users/`*`username`* (when running outside a sandboxed environment)

  For example (AIR 3.2):

  ```
  /Users/babbage/Library/Preferences/com.example.TestApp/Local Store
  ```

- On Windows—In the documents and Settings directory, in:

  C:\Documents and Settings\user name`\Application Data\`*applicationID*`\Local Store\`

  For example:

  ```
  C:\Documents and Settings\babbage\Application Data\com.example.TestApp\Local Store
  ```

- On Linux—In:

  `/home/`*user name*`/.appdata/`*applicationID*`/Local Store/`

  For example:

  ```
  /home/babbage/.appdata/com.example.TestApp/Local Store
  ```

- On Android—In:

  /data/data/`androidPackageID/applicationID/Local Store`

  For example:

  ```
  /data/data/air.com.example.TestApp/com.example.TestApp/Local Store
  ```

Note: *If an application has a publisher ID, then the publisher ID is also used as part of the path to the application storage directory.*

The URL (and `url` property) for a File object created with `File.applicationStorageDirectory` uses the `app-storage` URL scheme (see "Supported AIR URL schemes" on page 677), as in the following:

```
 var dir:File = File.applicationStorageDirectory;
dir = dir.resolvePath("preferences");
trace(dir.url); // app-storage:/preferences
```

Pointing to the application directory

Adobe AIR 1.0 and later

You can point a File object to the directory in which the application was installed, known as the application directory. You can reference this directory using the `File.applicationDirectory` property. You can use this directory to examine the application descriptor file or other resources installed with the application. For example, the following code points a File object to a directory named *images* in the application directory:

```
var dir:File = File.applicationDirectory;
dir = dir.resolvePath("images");
```

The URL (and `url` property) for a File object created with `File.applicationDirectory` uses the `app` URL scheme (see "Supported AIR URL schemes" on page 677), as in the following:

```
var dir:File = File.applicationDirectory;
dir = dir.resolvePath("images");
trace(dir.url); // app:/images
```

***Note:** On Android, the files in the application package are not accessible via the `nativePath`. The `nativePath` property is an empty string. Always use the URL to access files in the application directory rather than a native path.*

Pointing to the cache directory

Adobe AIR 3.6 and later

You can point a File object to the operating system's temporary or cache directory using the `File.cacheDirectory` property. This directory contains temporary files that are not required for the application to run and will not cause problems or data loss for the user if they are deleted.

In most operating systems the cache directory is a temporary directory. On iOS, the cache directory corresponds to the application library's Caches directory. Files in this directory are not backed up to online storage, and can potentially be deleted by the operating system if the device's available storage space is too low. For more information, see "Controlling file backup and caching" on page 677.

Pointing to the file system root

Adobe AIR 1.0 and later

The `File.getRootDirectories()` method lists all root volumes, such as C: and mounted volumes, on a Windows computer. On Mac OS and Linux, this method always returns the unique root directory for the machine (the "/" directory). The `StorageVolumeInfo.getStorageVolumes()` method provides more detailed information on mounted storage volumes (see "Working with storage volumes" on page 687).

***Note:** The root of the file system is not readable on Android. A File object referencing the directory with the native path, "/", is returned, but the properties of that object do not have accurate values. For example, `spaceAvailable` is always 0.*

Pointing to an explicit directory

Adobe AIR 1.0 and later

You can point the File object to an explicit directory by setting the `nativePath` property of the File object, as in the following example (on Windows):

```
var file:File = new File();
file.nativePath = "C:\\AIR Test";
```

Important: Pointing to an explicit path this way can lead to code that does not work across platforms. For example, the previous example only works on Windows. You can use the static properties of the File object, such as `File.applicationStorageDirectory`, to locate a directory that works cross-platform. Then use the `resolvePath()` method (see the next section) to navigate to a relative path.

Navigating to relative paths

Adobe AIR 1.0 and later

You can use the `resolvePath()` method to obtain a path relative to another given path. For example, the following code sets a File object to point to an "AIR Test" subdirectory of the user's home directory:

```
var file:File = File.userDirectory;
file = file.resolvePath("AIR Test");
```

You can also use the `url` property of a File object to point it to a directory based on a URL string, as in the following:

```
var urlStr:String = "file:///C:/AIR Test/";
var file:File = new File()
file.url = urlStr;
```

For more information, see "Modifying File paths" on page 676.

Letting the user browse to select a directory

Adobe AIR 1.0 and later

The File class includes the `browseForDirectory()` method, which presents a system dialog box in which the user can select a directory to assign to the object. The `browseForDirectory()` method is asynchronous. The File object dispatches a `select` event if the user selects a directory and clicks the Open button, or it dispatches a `cancel` event if the user clicks the Cancel button.

For example, the following code lets the user select a directory and outputs the directory path upon selection:

```
var file:File = new File();
file.addEventListener(Event.SELECT, dirSelected);
file.browseForDirectory("Select a directory");
function dirSelected(e:Event):void {
    trace(file.nativePath);
}
```

***Note:** On Android, the `browseForDirectory()` method is not supported. Calling this method has no effect; a cancel event is dispatched immediately. To allow users to select a directory, use a custom, application-defined dialog, instead.*

Pointing to the directory from which the application was invoked

Adobe AIR 1.0 and later

You can get the directory location from which an application is invoked, by checking the `currentDirectory` property of the InvokeEvent object dispatched when the application is invoked. For details, see "Capturing command line arguments" on page 879.

Pointing a File object to a file

Adobe AIR 1.0 and later

There are different ways to set the file to which a File object points.

Pointing to an explicit file path

Adobe AIR 1.0 and later

Important: Pointing to an explicit path can lead to code that does not work across platforms. For example, the path C:/foo.txt only works on Windows. You can use the static properties of the File object, such as `File.applicationStorageDirectory`, to locate a directory that works cross-platform. Then use the `resolvePath()` method (see "Modifying File paths" on page 676) to navigate to a relative path.

You can use the `url` property of a File object to point it to a file or directory based on a URL string, as in the following:

```
 var urlStr:String = "file:///C:/AIR Test/test.txt";
var file:File = new File()
file.url = urlStr;
```

You can also pass the URL to the `File()` constructor function, as in the following:

```
var urlStr:String = "file:///C:/AIR Test/test.txt";
var file:File = new File(urlStr);
```

The `url` property always returns the URI-encoded version of the URL (for example, blank spaces are replaced with `"%20`):

```
 file.url = "file:///c:/AIR Test";
trace(file.url); // file:///c:/AIR%20Test
```

You can also use the `nativePath` property of a File object to set an explicit path. For example, the following code, when run on a Windows computer, sets a File object to the test.txt file in the AIR Test subdirectory of the C: drive:

```
 var file:File = new File();
file.nativePath = "C:/AIR Test/test.txt";
```

You can also pass this path to the `File()` constructor function, as in the following:

```
 var file:File = new File("C:/AIR Test/test.txt");
```

Use the forward slash (/) character as the path delimiter for the `nativePath` property. On Windows, you can also use the backslash (\) character, but doing so leads to applications that do not work across platforms.

For more information, see "Modifying File paths" on page 676.

Enumerating files in a directory

Adobe AIR 1.0 and later

You can use the `getDirectoryListing()` method of a File object to get an array of File objects pointing to files and subdirectories at the root level of a directory. For more information, see "Enumerating directories" on page 683.

Letting the user browse to select a file

Adobe AIR 1.0 and later

The File class includes the following methods that present a system dialog box in which the user can select a file to assign to the object:

- `browseForOpen()`
- `browseForSave()`

- `browseForOpenMultiple()`

These methods are each asynchronous. The `browseForOpen()` and `browseForSave()` methods dispatch the select event when the user selects a file (or a target path, in the case of browseForSave()). With the `browseForOpen()` and `browseForSave()` methods, upon selection the target File object points to the selected files. The `browseForOpenMultiple`() method dispatches a `selectMultiple` event when the user selects files. The `selectMultiple` event is of type FileListEvent, which has a `files` property that is an array of File objects (pointing to the selected files).

For example, the following code presents the user with an "Open" dialog box in which the user can select a file:

```
 var fileToOpen:File = File.documentsDirectory;
selectTextFile(fileToOpen);

function selectTextFile(root:File):void
{
    var txtFilter:FileFilter = new FileFilter("Text", "*.as;*.css;*.html;*.txt;*.xml");
    root.browseForOpen("Open", [txtFilter]);
    root.addEventListener(Event.SELECT, fileSelected);
}

function fileSelected(event:Event):void
{
    trace(fileToOpen.nativePath);
}
```

If the application has another browser dialog box open when you call a browse method, the runtime throws an Error exception.

***Note:** On Android, only image, video, and audio files can be selected with the `browseForOpen()` and `browseForOpenMultiple()` methods. The browseForSave() dialog also displays only media files even though the user can enter an arbitrary filename. For opening and saving non-media files, you should consider using custom dialogs instead of these methods.*

Modifying File paths

Adobe AIR 1.0 and later

You can also modify the path of an existing File object by calling the `resolvePath()` method or by modifying the `nativePath` or `url` property of the object, as in the following examples (on Windows):

```
var file1:File = File.documentsDirectory;
file1 = file1.resolvePath("AIR Test");
trace(file1.nativePath); // C:\Documents and Settings\userName\My Documents\AIR Test
var file2:File = File.documentsDirectory;
file2 = file2.resolvePath("..");
trace(file2.nativePath); // C:\Documents and Settings\userName
var file3:File = File.documentsDirectory;
file3.nativePath += "/subdirectory";
trace(file3.nativePath); // C:\Documents and Settings\userName\My Documents\subdirectory
var file4:File = new File();
file4.url = "file:///c:/AIR Test/test.txt";
trace(file4.nativePath); // C:\AIR Test\test.txt
```

When using the `nativePath` property, use the forward slash (/) character as the directory separator character. On Windows, you can use the backslash (\) character as well, but you should not do so, as it leads to code that does not work cross-platform.

Supported AIR URL schemes

Adobe AIR 1.0 and later

In AIR, you can use any of the following URL schemes in defining the `url` property of a File object:

URL scheme	Description
file	Use to specify a path relative to the root of the file system. For example: `file:///c:/AIR Test/test.txt` The URL standard specifies that a file URL takes the form `file://<host>/<path>`. As a special case,`<host>` can be the empty string, which is interpreted as "the machine from which the URL is being interpreted." For this reason, file URLs often have three slashes (///).
app	Use to specify a path relative to the root directory of the installed application (the directory that contains the application.xml file for the installed application). For example, the following path points to an images subdirectory of the directory of the installed application: `app:/images`
app-storage	Use to specify a path relative to the application store directory. For each installed application, AIR defines a unique application store directory, which is a useful place to store data specific to that application. For example, the following path points to a prefs.xml file in a settings subdirectory of the application store directory: `app-storage:/settings/prefs.xml`

Controlling file backup and caching

Adobe AIR 3.6 and later, iOS and OS X only

Certain operating systems, most notably iOS and Mac OS X, provide users the ability to automatically back up application files to a remote storage. In addition, on iOS there are restrictions on whether files can be backed up and also where files of different purposes can be stored.

The following summarize how to comply with Apple's guidelines for file backup and storage. For further information see the next sections.

- To specify that a file does not need to be backed up and (iOS only) can be deleted by the operating system if device storage space runs low, save the file in the cache directory (`File.cacheDirectory`). This is the preferred storage location on iOS and should be used for most files that can be regenerated or re-downloaded.
- To specify that a file does not need to be backed up, but should not be deleted by the operating system, save the file in one of the application library directories such as the application storage directory (`File.applicationStorageDirectory`) or the documents directory (`File.documentsDirectory`). Set the File object's `preventBackup` property to `true`. This is required by Apple for content that can be regenerated or downloaded again, but which is required for proper functioning of your application during offline use.

Specifying files for backup

In order to save backup space and reduce network bandwidth use, Apple's guidelines for iOS and Mac applications specify that only files that contain user-entered data or data that otherwise can't be regenerated or re-downloaded should be designated for backup.

By default all files in the application library folders are backed up. On Mac OS X this is the application storage directory. On iOS, this includes the application storage directory, the application directory, the desktop directory, documents directory, and user directory (because those directories are mapped to application library folders on iOS). Consequently, any files in those directories are backed up to server storage by default.

If you are saving a file in one of those locations that can be re-created by your application, you should flag the file so the operating system knows not to back it up. To indicate that a file should not be backed up, set the File object's `preventBackup` property to `true`.

Note that on iOS, for a file in any of the application library folders, even if the file's `preventBackup` property is set to `true` the file is flagged as a persistent file that the operating system shouldn't delete.

Controlling file caching and deletion

Apple's guidelines for iOS applications specify that as much as possible, content that can be regenerated should be made available to the operating system to delete in case the device runs low on storage space.

On iOS, files in the application library folders (such as the application storage directory or the documents directory) are flagged as permanent and are not deleted by the operating system.

Save files that can be regenerated by the application and are safe to delete in case of low storage space in the application cache directory. You access the cache directory using the `File.cacheDirectory` static property.

On iOS the cache directory corresponds to the application's cache directory (<Application Home>/Library/Caches). On other operating systems, this directory is mapped to a comparable directory. For example, on Mac OS X it also maps to the Caches directory in the application library. On Android the cache directory maps to the application's cache directory. On Windows, the cache directory maps to the operating system temp directory. On both Android and Windows, this is the same directory that is accessed by a call to the File class's `createTempDirectory()` and `createTempFile()` methods.

Finding the relative path between two files

Adobe AIR 1.0 and later

You can use the `getRelativePath()` method to find the relative path between two files:

```
 var file1:File = File.documentsDirectory.resolvePath("AIR Test");
var file2:File = File.documentsDirectory
file2 = file2.resolvePath("AIR Test/bob/test.txt");

trace(file1.getRelativePath(file2)); // bob/test.txt
```

The second parameter of the `getRelativePath()` method, the `useDotDot` parameter, allows for `..` syntax to be returned in results, to indicate parent directories:

```
 var file1:File = File.documentsDirectory;
file1 = file1.resolvePath("AIR Test");
var file2:File = File.documentsDirectory;
file2 = file2.resolvePath("AIR Test/bob/test.txt");
var file3:File = File.documentsDirectory;
file3 = file3.resolvePath("AIR Test/susan/test.txt");

trace(file2.getRelativePath(file1, true)); // ../..
trace(file3.getRelativePath(file2, true)); // ../../bob/test.txt
```

Obtaining canonical versions of file names

Adobe AIR 1.0 and later

File and path names are not case sensitive on Windows and Mac OS. In the following, two File objects point to the same file:

```
 File.documentsDirectory.resolvePath("test.txt");
File.documentsDirectory.resolvePath("TeSt.TxT");
```

However, documents and directory names do include capitalization. For example, the following assumes that there is a folder named AIR Test in the documents directory, as in the following examples:

```
 var file:File = File.documentsDirectory.resolvePath("AIR test");
trace(file.nativePath); // ... AIR test
file.canonicalize();
trace(file.nativePath); // ... AIR Test
```

The `canonicalize()` method converts the `nativePath` object to use the correct capitalization for the file or directory name. On case sensitive file systems (such as Linux), when multiple files exists with names differing only in case, the `canonicalize()` method adjusts the path to match the first file found (in an order determined by the file system).

You can also use the `canonicalize()` method to convert short file names ("8.3" names) to long file names on Windows, as in the following examples:

```
var path:File = new File();
path.nativePath = "C:\\AIR~1";
path.canonicalize();
trace(path.nativePath); // C:\AIR Test
```

Working with packages and symbolic links

Adobe AIR 1.0 and later

Various operating systems support package files and symbolic link files:

Packages—On Mac OS, directories can be designated as packages and show up in the Mac OS Finder as a single file rather than as a directory.

Symbolic links—Mac OS, Linux, and Windows Vista support symbolic links. Symbolic links allow a file to point to another file or directory on disk. Although similar, symbolic links are not the same as aliases. An alias is always reported as a file (rather than a directory), and reading or writing to an alias or shortcut never affects the original file or directory that it points to. On the other hand, a symbolic link behaves exactly like the file or directory it points to. It can be reported as a file or a directory, and reading or writing to a symbolic link affects the file or directory that it points to, not the symbolic link itself. Additionally, on Windows the `isSymbolicLink` property for a File object referencing a junction point (used in the NTFS file system) is set to `true`.

The File class includes the `isPackage` and `isSymbolicLink` properties for checking if a File object references a package or symbolic link.

The following code iterates through the user's desktop directory, listing subdirectories that are *not* packages:

```
 var desktopNodes:Array = File.desktopDirectory.getDirectoryListing();
for (var i:uint = 0; i < desktopNodes.length; i++)
{
    if (desktopNodes[i].isDirectory && !desktopNodes[i].isPackage)
    {
        trace(desktopNodes[i].name);
    }
}
```

The following code iterates through the user's desktop directory, listing files and directories that are *not* symbolic links:

```
 var desktopNodes:Array = File.desktopDirectory.getDirectoryListing();
for (var i:uint = 0; i < desktopNodes.length; i++)
{
    if (!desktopNodes[i].isSymbolicLink)
    {
        trace(desktopNodes[i].name);
    }
}
```

The `canonicalize()` method changes the path of a symbolic link to point to the file or directory to which the link refers. The following code iterates through the user's desktop directory, and reports the paths referenced by files that are symbolic links:

```
 var desktopNodes:Array = File.desktopDirectory.getDirectoryListing();
for (var i:uint = 0; i < desktopNodes.length; i++)
{
    if (desktopNodes[i].isSymbolicLink)
    {
        var linkNode:File = desktopNodes[i] as File;
        linkNode.canonicalize();
        trace(linkNode.nativePath);
    }
}
```

Determining space available on a volume

Adobe AIR 1.0 and later

The `spaceAvailable` property of a File object is the space available for use at the File location, in bytes. For example, the following code checks the space available in the application storage directory:

```
trace(File.applicationStorageDirectory.spaceAvailable);
```

If the File object references a directory, the `spaceAvailable` property indicates the space in the directory that files can use. If the File object references a file, the `spaceAvailable` property indicates the space into which the file could grow. If the file location does not exist, the `spaceAvailable` property is set to 0. If the File object references a symbolic link, the `spaceAvailable` property is set to space available at the location the symbolic link points to.

Typically the space available for a directory or file is the same as the space available on the volume containing the directory or file. However, space available can take into account quotas and per-directory limits.

Adding a file or directory to a volume generally requires more space than the actual size of the file or the size of the contents of the directory. For example, the operating system may require more space to store index information. Or the disk sectors required may use additional space. Also, available space changes dynamically. So, you cannot expect to allocate all of the reported space for file storage. For information on writing to the file system, see "Reading and writing files" on page 689.

The `StorageVolumeInfo.getStorageVolumes()` method provides more detailed information on mounted storage volumes (see "Working with storage volumes" on page 687).

Opening files with the default system application

Adobe AIR 2 and later

In AIR 2, you can open a file using the application registered by the operating system to open it. For example, an AIR application can open a DOC file with the application registered to open it. Use the `openWithDefaultApplication()` method of a File object to open the file. For example, the following code opens a file named test.doc on the user's desktop and opens it with the default application for DOC files:

```
var file:File = File.deskopDirectory;
file = file.resolvePath("test.doc");
file.openWithDefaultApplication();
```

Note: *On Linux, the file's MIME type, not the filename extension, determines the default application for a file.*

The following code lets the user navigate to an mp3 file and open it in the default application for playing mp3 files:

```
var file:File = File.documentsDirectory;
var mp3Filter:FileFilter = new FileFilter("MP3 Files", "*.mp3");
file.browseForOpen("Open", [mp3Filter]);
file.addEventListener(Event.SELECT, fileSelected);

function fileSelected(e:Event):void
{
    file.openWithDefaultApplication();
}
```

You cannot use the `openWithDefaultApplication()` method with files located in the application directory.

AIR prevents you from using the `openWithDefaultApplication()` method to open certain files. On Windows, AIR prevents you from opening files that have certain filetypes, such as EXE or BAT. On Mac OS and Linux, AIR prevents you from opening files that will launch in certain application. (These include Terminal and AppletLauncher on Mac OS; and csh, bash, or ruby on Linux.) Attempting to open one of these files using the `openWithDefaultApplication()` method results in an exception. For a complete list of prevented filetypes, see the language reference entry for the `File.openWithDefaultApplication()` method.

Note: *This limitation does not exist for an AIR application installed using a native installer (an extended desktop application).*

Getting file system information

Adobe AIR 1.0 and later

The File class includes the following static properties that provide some useful information about the file system:

Property	**Description**
`File.lineEnding`	The line-ending character sequence used by the host operating system. On Mac OS and Linux, this is the line-feed character. On Windows, this is the carriage return character followed by the line-feed character.
`File.separator`	The host operating system's path component separator character. On Mac OS and Linux, this is the forward slash (/) character. On Windows, it is the backslash (\) character.
`File.systemCharset`	The default encoding used for files by the host operating system. This pertains to the character set used by the operating system, corresponding to its language.

The `Capabilities` class also includes useful system information that can be useful when working with files:

Property	**Description**
Capabilities.hasIME	Specifies whether the player is running on a system that does (`true`) or does not (`false`) have an input method editor (IME) installed.
Capabilities.language	Specifies the language code of the system on which the player is running.
Capabilities.os	Specifies the current operating system.

***Note:** Be careful when using `Capabilities.os` to determine system characteristics. If a more specific property exists to determine a system characteristic, use it. Otherwise, you run the risk of writing code that does not work correctly on all platforms. For example, consider the following code:*

```
var separator:String;
if (Capablities.os.indexOf("Mac") > -1)
{
    separator = "/";
}
else
{
    separator = "\\";
}
```

This code leads to problems on Linux. It is better to simply use the `File.separator` property.

Working with directories

Adobe AIR 1.0 and later

The runtime provides you with capabilities to work with directories on the local file system.

For details on creating File objects that point to directories, see "Pointing a File object to a directory" on page 671.

Creating directories

Adobe AIR 1.0 and later

The `File.createDirectory()` method lets you create a directory. For example, the following code creates a directory named AIR Test as a subdirectory of the user's home directory:

```
 var dir:File = File.userDirectory.resolvePath("AIR Test");
dir.createDirectory();
```

If the directory exists, the `createDirectory()` method does nothing.

Also, in some modes, a FileStream object creates directories when opening files. Missing directories are created when you instantiate a FileStream instance with the `fileMode` parameter of the `FileStream()` constructor set to `FileMode.APPEND` or `FileMode.WRITE`. For more information, see "Workflow for reading and writing files" on page 689.

Creating a temporary directory

Adobe AIR 1.0 and later

The File class includes a `createTempDirectory()` method, which creates a directory in the temporary directory folder for the System, as in the following example:

```
var temp:File = File.createTempDirectory();
```

The `createTempDirectory()` method automatically creates a unique temporary directory (saving you the work of determining a new unique location).

You can use a temporary directory to temporarily store temporary files used for a session of the application. Note that there is a `createTempFile()` method for creating new, unique temporary files in the System temporary directory.

You may want to delete the temporary directory before closing the application, as it is *not* automatically deleted on all devices.

Enumerating directories

Adobe AIR 1.0 and later

You can use the `getDirectoryListing()` method or the `getDirectoryListingAsync()` method of a File object to get an array of File objects pointing to files and subfolders in a directory.

For example, the following code lists the contents of the user's documents directory (without examining subdirectories):

```
var directory:File = File.documentsDirectory;
var contents:Array = directory.getDirectoryListing();
for (var i:uint = 0; i < contents.length; i++)
{
    trace(contents[i].name, contents[i].size);
}
```

When using the asynchronous version of the method, the `directoryListing` event object has a `files` property that is the array of File objects pertaining to the directories:

```
var directory:File = File.documentsDirectory;
directory.getDirectoryListingAsync();
directory.addEventListener(FileListEvent.DIRECTORY_LISTING, dirListHandler);

function dirListHandler(event:FileListEvent):void
{
    var contents:Array = event.files;
    for (var i:uint = 0; i < contents.length; i++)
    {
        trace(contents[i].name, contents[i].size);
    }
}
```

Copying and moving directories

Adobe AIR 1.0 and later

You can copy or move a directory, using the same methods as you would to copy or move a file. For example, the following code copies a directory synchronously:

```
 var sourceDir:File = File.documentsDirectory.resolvePath("AIR Test");
var resultDir:File = File.documentsDirectory.resolvePath("AIR Test Copy");
sourceDir.copyTo(resultDir);
```

When you specify true for the `overwrite` parameter of the `copyTo()` method, all files and folders in an existing target directory are deleted and replaced with the files and folders in the source directory (even if the target file does not exist in the source directory).

The directory that you specify as the `newLocation` parameter of the `copyTo()` method specifies the path to the resulting directory; it does *not* specify the *parent* directory that will contain the resulting directory.

For details, see "Copying and moving files" on page 685.

Deleting directory contents

Adobe AIR 1.0 and later

The File class includes a `deleteDirectory()` method and a `deleteDirectoryAsync()` method. These methods delete directories, the first working synchronously, the second working asynchronously (see "AIR file basics" on page 667). Both methods include a `deleteDirectoryContents` parameter (which takes a Boolean value); when this parameter is set to `true` (the default value is `false`) the call to the method deletes non-empty directories; otherwise, only empty directories are deleted.

For example, the following code synchronously deletes the AIR Test subdirectory of the user's documents directory:

```
 var directory:File = File.documentsDirectory.resolvePath("AIR Test");
directory.deleteDirectory(true);
```

The following code asynchronously deletes the AIR Test subdirectory of the user's documents directory:

```
 var directory:File = File.documentsDirectory.resolvePath("AIR Test");
directory.addEventListener(Event.COMPLETE, completeHandler)
directory.deleteDirectoryAsync(true);

function completeHandler(event:Event):void {
    trace("Deleted.")
}
```

Also included are the `moveToTrash()` and `moveToTrashAsync()` methods, which you can use to move a directory to the System trash. For details, see "Moving a file to the trash" on page 687.

Working with files

Adobe AIR 1.0 and later

Using the AIR file API, you can add basic file interaction capabilities to your applications. For example, you can read and write files, copy and delete files, and so on. Since your applications can access the local file system, refer to "AIR security" on page 1076, if you haven't already done so.

***Note:** You can associate a file type with an AIR application (so that double-clicking it opens the application). For details, see "Managing file associations" on page 888.*

Getting file information

Adobe AIR 1.0 and later

The File class includes the following properties that provide information about a file or directory to which a File object points:

File property	**Description**
creationDate	The creation date of the file on the local disk.
creator	Obsolete—use the `extension` property. (This property reports the Macintosh creator type of the file, which is only used in Mac OS versions prior to Mac OS X.)
downloaded	(AIR 2 and later) Indicates whether the referenced file or directory was downloaded (from the internet) or not. property is only meaningful on operating systems in which files can be flagged as downloaded: • Windows XP service pack 2 and later, and on Windows Vista • Mac OS 10.5 and later
exists	Whether the referenced file or directory exists.
extension	The file extension, which is the part of the name following (and not including) the final dot ("."). If there is no dot in the filename, the extension is `null`.
icon	An Icon object containing the icons defined for the file.
isDirectory	Whether the File object reference is to a directory.
modificationDate	The date that the file or directory on the local disk was last modified.
name	The name of the file or directory (including the file extension, if there is one) on the local disk.
nativePath	The full path in the host operating system representation. See "Paths of File objects" on page 668.
parent	The folder that contains the folder or file represented by the File object. This property is `null` if the File object references a file or directory in the root of the file system.
size	The size of the file on the local disk in bytes.
type	Obsolete—use the `extension` property. (On the Macintosh, this property is the four-character file type, which is only used in Mac OS versions prior to Mac OS X.)
url	The URL for the file or directory. See "Paths of File objects" on page 668.

For details on these properties, see the File class entry in the ActionScript 3.0 Reference for the Adobe Flash Platform.

Copying and moving files

Adobe AIR 1.0 and later

The File class includes two methods for copying files or directories: `copyTo()` and `copyToAsync()`. The File class includes two methods for moving files or directories: `moveTo()` and `moveToAsync()`. The `copyTo()` and `moveTo()` methods work synchronously, and the `copyToAsync()` and `moveToAsync()` methods work asynchronously (see "AIR file basics" on page 667).

To copy or move a file, you set up two File objects. One points to the file to copy or move, and it is the object that calls the copy or move method; the other points to the destination (result) path.

The following copies a test.txt file from the AIR Test subdirectory of the user's documents directory to a file named copy.txt in the same directory:

```
var original:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var newFile:File = File.resolvePath("AIR Test/copy.txt");
original.copyTo(newFile, true);
```

In this example, the value of `overwrite` parameter of the `copyTo()` method (the second parameter) is set to `true`. By setting `overwrite` to `true`, an existing target file is overwritten. This parameter is optional. If you set it to `false` (the default value), the operation dispatches an IOErrorEvent event if the target file exists (and the file is not copied).

The "Async" versions of the copy and move methods work asynchronously. Use the `addEventListener()` method to monitor completion of the task or error conditions, as in the following code:

```
var original = File.documentsDirectory;
original = original.resolvePath("AIR Test/test.txt");

var destination:File = File.documentsDirectory;
destination =  destination.resolvePath("AIR Test 2/copy.txt");

original.addEventListener(Event.COMPLETE, fileMoveCompleteHandler);
original.addEventListener(IOErrorEvent.IO_ERROR, fileMoveIOErrorEventHandler);
original.moveToAsync(destination);

function fileMoveCompleteHandler(event:Event):void {
    trace(event.target); // [object File]
}
function fileMoveIOErrorEventHandler(event:IOErrorEvent):void {
    trace("I/O Error.");
}
```

The File class also includes the `File.moveToTrash()` and `File.moveToTrashAsync()` methods, which move a file or directory to the system trash.

Deleting a file

Adobe AIR 1.0 and later

The File class includes a `deleteFile()` method and a `deleteFileAsync()` method. These methods delete files, the first working synchronously, the second working asynchronously (see "AIR file basics" on page 667).

For example, the following code synchronously deletes the test.txt file in the user's documents directory:

```
var file:File = File.documentsDirectory.resolvePath("test.txt");
file.deleteFile();
```

The following code asynchronously deletes the test.txt file of the user's documents directory:

```
var file:File = File.documentsDirectory.resolvePath("test.txt");
file.addEventListener(Event.COMPLETE, completeHandler)
file.deleteFileAsync();

function completeHandler(event:Event):void {
    trace("Deleted.")
}
```

Also included are the `moveToTrash()` and `moveToTrashAsync` methods, which you can use to move a file or directory to the System trash. For details, see "Moving a file to the trash" on page 687.

Moving a file to the trash

Adobe AIR 1.0 and later

The File class includes a `moveToTrash()` method and a `moveToTrashAsync()` method. These methods send a file or directory to the System trash, the first working synchronously, the second working asynchronously (see "AIR file basics" on page 667).

For example, the following code synchronously moves the test.txt file in the user's documents directory to the System trash:

```
 var file:File = File.documentsDirectory.resolvePath("test.txt");
file.moveToTrash();
```

***Note:** On operating systems that do not support the concept of a recoverable trash folder, the files are removed immediately.*

Creating a temporary file

Adobe AIR 1.0 and later

The File class includes a `createTempFile()` method, which creates a file in the temporary directory folder for the System, as in the following example:

```
 var temp:File = File.createTempFile();
```

The `createTempFile()` method automatically creates a unique temporary file (saving you the work of determining a new unique location).

You can use a temporary file to temporarily store information used in a session of the application. Note that there is also a `createTempDirectory()` method, for creating a unique temporary directory in the System temporary directory.

You may want to delete the temporary file before closing the application, as it is *not* automatically deleted on all devices.

Working with storage volumes

Adobe AIR 2 and later

In AIR 2, you can detect when mass storage volumes are mounted or unmounted. The StorageVolumeInfo class defines a singleton `storageVolumeInfo` object. The `StorageVolumeInfo.storageVolumeInfo` object dispatches a `storageVolumeMount` event when a storage volume is mounted. And it dispatches a `storageVolumeUnmount` event when a volume is unmounted. The StorageVolumeChangeEvent class defines these events.

***Note:** On modern Linux distributions, the StorageVolumeInfo object only dispatches `storageVolumeMount` and `storageVolumeUnmount` events for physical devices and network drives mounted at particular locations.*

The `storageVolume` property of the StorageVolumeChangeEvent class is a StorageVolume object. The StorageVolume class defines basic properties of the storage volume:

- `drive`—The volume drive letter on Windows (`null` on other operating systems)

- `fileSystemType`—The type of file system on the storage volume (such as "FAT", "NTFS", "HFS", or "UFS")
- `isRemoveable`—Whether a volume is removable (`true`) or not (`false`)
- `isWritable`—Whether a volume is writable (`true`) or not (`false`)
- `name`—The name of the volume
- `rootDirectory`—A File object corresponding to the root directory of the volume

The StorageVolumeChangeEvent class also includes a `rootDirectory` property. The `rootDirectory` property is a File object referencing the root directory of the storage volume that has been mounted or unmounted.

The `storageVolume` property of the StorageVolumeChangeEvent object is undefined (`null`) for an unmounted volume. However you can access the `rootDirectory` property of the event.

The following code outputs the name and file path of a storage volume when it is mounted:

```
StorageVolumeInfo.storageVolumeInfo.addEventListener(StorageVolumeChangeEvent.STORAGE_VOLUME
_MOUNT, onVolumeMount);
function onVolumeMount(event:StorageVolumeChangeEvent):void
{
    trace(event.storageVolume.name, event.rootDirectory.nativePath);
}
```

The following code outputs the file path of a storage volume when it is unmounted:

```
StorageVolumeInfo.storageVolumeInfo.addEventListener(StorageVolumeChangeEvent.STORAGE_VOLUME
_UNMOUNT, onVolumeUnmount);
function onVolumeUnmount(event:StorageVolumeChangeEvent):void
{
    trace(event.rootDirectory.nativePath);
}
```

The `StorageVolumeInfo.storageVolumeInfo` object includes a `getStorageVolumes()` method. This method returns a vector of StorageVolume objects corresponding to the currently mounted storage volumes. The following code shows how to list the names and root directories of all mounted storage volumes:

```
var volumes:Vector.<StorageVolume> = new Vector.<StorageVolume>;
volumes = StorageVolumeInfo.storageVolumeInfo.getStorageVolumes();
for (var i:int = 0; i < volumes.length; i++)
{
    trace(volumes[i].name, volumes[i].rootDirectory.nativePath);
}
```

***Note:** On modern Linux distributions, the `getStorageVolumes()` method returns objects corresponding to physical devices and network drives mounted at particular locations.*

The `File.getRootDirectories()` method lists the root directories (see "Pointing to the file system root" on page 673. However, the StorageVolume objects (enumerated by the `StorageVolumeInfo.getStorageVolumes()` method) provides more information about the storage volumes.

You can use the `spaceAvailable` property of the `rootDirectory` property of a StorageVolume object to get the space available on a storage volume. (See "Determining space available on a volume" on page 680.)

More Help topics

StorageVolume

StorageVolumeInfo

Reading and writing files

Adobe AIR 1.0 and later

The FileStream class lets AIR applications read and write to the file system.

Workflow for reading and writing files

Adobe AIR 1.0 and later

The workflow for reading and writing files is as follows.

Initialize a File object that points to the path.

The File object represents the path of the file that you want to work with (or a file that you will later create).

```
 var file:File = File.documentsDirectory;
file = file.resolvePath("AIR Test/testFile.txt");
```

This example uses the `File.documentsDirectory` property and the `resolvePath()` method of a File object to initialize the File object. However, there are many other ways to point a File object to a file. For more information, see "Pointing a File object to a file" on page 674.

Initialize a FileStream object.

Call the open() method or the openAsync() method of the FileStream object.

The method you call depends on whether you want to open the file for synchronous or asynchronous operations. Use the File object as the `file` parameter of the open method. For the `fileMode` parameter, specify a constant from the FileMode class that specifies the way in which you will use the file.

For example, the following code initializes a FileStream object that is used to create a file and overwrite any existing data:

```
 var fileStream:FileStream = new FileStream();
fileStream.open(file, FileMode.WRITE);
```

For more information, see "Initializing a FileStream object, and opening and closing files" on page 691 and "FileStream open modes" on page 690.

If you opened the file asynchronously (using the openAsync() method), add and set up event listeners for the FileStream object.

These event listener methods respond to events dispatched by the FileStream object in various situations. These situations include when data is read in from the file, when I/O errors are encountered, or when the complete amount of data to be written has been written.

For details, see "Asynchronous programming and the events generated by a FileStream object opened asynchronously" on page 695.

Include code for reading and writing data, as needed.

There are many methods of the FileStream class related to reading and writing. (They each begin with "read" or "write".) The method you choose to use to read or write data depends on the format of the data in the target file.

For example, if the data in the target file is UTF-encoded text, you may use the `readUTFBytes()` and `writeUTFBytes()` methods. If you want to deal with the data as byte arrays, you may use the `readByte()`, `readBytes()`, `writeByte()`, and `writeBytes()` methods. For details, see "Data formats, and choosing the read and write methods to use" on page 695.

If you opened the file asynchronously, then be sure that enough data is available before calling a read method. For details, see "The read buffer and the bytesAvailable property of a FileStream object" on page 693.

Before writing to a file, if you want to check the amount of disk space available, you can check the spaceAvailable property of the File object. For more information, see "Determining space available on a volume" on page 680.

Call the close() method of the FileStream object when you are done working with the file.
Calling the close() method makes the file available to other applications.

For details, see "Initializing a FileStream object, and opening and closing files" on page 691.

To see a sample application that uses the FileStream class to read and write files, see the following articles at the Adobe AIR Developer Center:

- Building a text-file editor
- Building a text-file editor
- Reading and writing from an XML preferences file

Working with FileStream objects

Adobe AIR 1.0 and later

The FileStream class defines methods for opening, reading, and writing files.

FileStream open modes

Adobe AIR 1.0 and later

The `open()` and `openAsync()` methods of a FileStream object each include a `fileMode` parameter, which defines some properties for a file stream, including the following:

- The ability to read from the file
- The ability to write to the file
- Whether data will always be appended past the end of the file (when writing)
- What to do when the file does not exist (and when its parent directories do not exist)

The following are the various file modes (which you can specify as the `fileMode` parameter of the `open()` and `openAsync()` methods):

File mode	Description
FileMode.READ	Specifies that the file is open for reading only.

File mode	Description
FileMode.WRITE	Specifies that the file is open for writing. If the file does not exist, it is created when the FileStream object is opened. If the file does exist, any existing data is deleted.
FileMode.APPEND	Specifies that the file is open for appending. The file is created if it does not exist. If the file exists, existing data is not overwritten, and all writing begins at the end of the file.
FileMode.UPDATE	Specifies that the file is open for reading and writing. If the file does not exist, it is created. Specify this mode for random read/write access to the file. You can read from any position in the file. When writing to the file, only the bytes written overwrite existing bytes (all other bytes remain unchanged).

Initializing a FileStream object, and opening and closing files

Adobe AIR 1.0 and later

When you open a FileStream object, you make it available to read and write data to a file. You open a FileStream object by passing a File object to the `open()` or `openAsync()` method of the FileStream object:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.open(myFile, FileMode.READ);
```

The `fileMode` parameter (the second parameter of the `open()` and `openAsync()` methods), specifies the mode in which to open the file: for read, write, append, or update. For details, see the previous section, "FileStream open modes" on page 690.

If you use the `openAsync()` method to open the file for asynchronous file operations, set up event listeners to handle the asynchronous events:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.addEventListener(Event.COMPLETE, completeHandler);
myFileStream.addEventListener(ProgressEvent.PROGRESS, progressHandler);
myFileStream.addEventListener(IOErrorEvent.IO_Error, errorHandler);
myFileStream.openAsync(myFile, FileMode.READ);

function completeHandler(event:Event):void {
    // ...
}

function progressHandler(event:ProgressEvent):void {
    // ...
}

function errorHandler(event:IOErrorEvent):void {
    // ...
}
```

The file is opened for synchronous or asynchronous operations, depending upon whether you use the `open()` or `openAsync()` method. For details, see "AIR file basics" on page 667.

If you set the `fileMode` parameter to `FileMode.READ` or `FileMode.UPDATE` in the open method of the FileStream object, data is read into the read buffer as soon as you open the FileStream object. For details, see "The read buffer and the bytesAvailable property of a FileStream object" on page 693.

You can call the `close()` method of a FileStream object to close the associated file, making it available for use by other applications.

The position property of a FileStream object

Adobe AIR 1.0 and later

The `position` property of a FileStream object determines where data is read or written on the next read or write method.

Before a read or write operation, set the `position` property to any valid position in the file.

For example, the following code writes the string `"hello"` (in UTF encoding) at position 8 in the file:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.open(myFile, FileMode.UPDATE);
myFileStream.position = 8;
myFileStream.writeUTFBytes("hello");
```

When you first open a FileStream object, the `position` property is set to 0.

Before a read operation, the value of `position` must be at least 0 and less than the number of bytes in the file (which are existing positions in the file).

The value of the `position` property is modified only in the following conditions:

- When you explicitly set the `position` property.
- When you call a read method.
- When you call a write method.

When you call a read or write method of a FileStream object, the `position` property is immediately incremented by the number of bytes that you read or write. Depending on the read method you use, the `position` property is either incremented by the number of bytes you specify to read or by the number of bytes available. When you call a read or write method subsequently, it reads or writes starting at the new position.

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.open(myFile, FileMode.UPDATE);
myFileStream.position = 4000;
trace(myFileStream.position); // 4000
myFileStream.writeBytes(myByteArray, 0, 200);
trace(myFileStream.position); // 4200
```

There is, however, one exception: for a FileStream opened in append mode, the `position` property is not changed after a call to a write method. (In append mode, data is always written to the end of the file, independent of the value of the `position` property.)

For a file opened for asynchronous operations, the write operation does not complete before the next line of code is executed. However, you can call multiple asynchronous methods sequentially, and the runtime executes them in order:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.openAsync(myFile, FileMode.WRITE);
myFileStream.writeUTFBytes("hello");
myFileStream.writeUTFBytes("world");
myFileStream.addEventListener(Event.CLOSE, closeHandler);
myFileStream.close();
trace("started.");

closeHandler(event:Event):void
{
    trace("finished.");
}
```

The trace output for this code is the following:

```
started.
finished.
```

You *can* specify the `position` value immediately after you call a read or write method (or at any time), and the next read or write operation will take place starting at that position. For example, note that the following code sets the `position` property right after a call to the `writeBytes()` operation, and the `position` is set to that value (300) even after the write operation completes:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.openAsync(myFile, FileMode.UPDATE);
myFileStream.position = 4000;
trace(myFileStream.position); // 4000
myFileStream.writeBytes(myByteArray, 0, 200);
myFileStream.position = 300;
trace(myFileStream.position); // 300
```

The read buffer and the bytesAvailable property of a FileStream object
Adobe AIR 1.0 and later

When a FileStream object with read capabilities (one in which the `fileMode` parameter of the `open()` or `openAsync()` method was set to `READ` or `UPDATE`) is opened, the runtime stores the data in an internal buffer. The FileStream object begins reading data into the buffer as soon as you open the file (by calling the `open()` or `openAsync()` method of the FileStream object).

For a file opened for synchronous operations (using the `open()` method), you can always set the `position` pointer to any valid position (within the bounds of the file) and begin reading any amount of data (within the bounds of the file), as shown in the following code (which assumes that the file contains at least 100 bytes):

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.open(myFile, FileMode.READ);
myFileStream.position = 10;
myFileStream.readBytes(myByteArray, 0, 20);
myFileStream.position = 89;
myFileStream.readBytes(myByteArray, 0, 10);
```

Whether a file is opened for synchronous or asynchronous operations, the read methods always read from the "available" bytes, represented by the `bytesAvalable` property. When reading synchronously, all of the bytes of the file are available all of the time. When reading asynchronously, the bytes become available starting at the position specified by the `position` property, in a series of asynchronous buffer fills signaled by `progress` events.

For files opened for *synchronous* operations, the `bytesAvailable` property is always set to represent the number of bytes from the `position` property to the end of the file (all bytes in the file are always available for reading).

For files opened for *asynchronous* operations, you need to ensure that the read buffer has consumed enough data before calling a read method. For a file opened asynchronously, as the read operation progresses, the data from the file, starting at the `position` specified when the read operation started, is added to the buffer, and the `bytesAvailable` property increments with each byte read. The `bytesAvailable` property indicates the number of bytes available starting with the byte at the position specified by the `position` property to the end of the buffer. Periodically, the FileStream object sends a `progress` event.

For a file opened asynchronously, as data becomes available in the read buffer, the FileStream object periodically dispatches the `progress` event. For example, the following code reads data into a ByteArray object, `bytes`, as it is read into the buffer:

```
 var bytes:ByteArray = new ByteArray();
var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.addEventListener(ProgressEvent.PROGRESS, progressHandler);
myFileStream.openAsync(myFile, FileMode.READ);

function progressHandler(event:ProgressEvent):void
{
    myFileStream.readBytes(bytes, myFileStream.position, myFileStream.bytesAvailable);
}
```

For a file opened asynchronously, only the data in the read buffer can be read. Furthermore, as you read the data, it is removed from the read buffer. For read operations, you need to ensure that the data exists in the read buffer before calling the read operation. For example, the following code reads 8000 bytes of data starting from position 4000 in the file:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.addEventListener(ProgressEvent.PROGRESS, progressHandler);
myFileStream.addEventListener(Event.COMPLETE, completed);
myFileStream.openAsync(myFile, FileMode.READ);
myFileStream.position = 4000;

var str:String = "";

function progressHandler(event:Event):void
{
    if (myFileStream.bytesAvailable > 8000 )
    {
        str += myFileStream.readMultiByte(8000, "iso-8859-1");
    }
}
```

During a write operation, the FileStream object does not read data into the read buffer. When a write operation completes (all data in the write buffer is written to the file), the FileStream object starts a new read buffer (assuming that the associated FileStream object was opened with read capabilities), and starts reading data into the read buffer, starting from the position specified by the `position` property. The `position` property may be the position of the last byte written, or it may be a different position, if the user specifies a different value for the `position` object after the write operation.

Asynchronous programming and the events generated by a FileStream object opened asynchronously
Adobe AIR 1.0 and later

When a file is opened asynchronously (using the `openAsync()` method), reading and writing files are done asynchronously. As data is read into the read buffer and as output data is being written, other ActionScript code can execute.

This means that you need to register for events generated by the FileStream object opened asynchronously.

By registering for the `progress` event, you can be notified as new data becomes available for reading, as in the following code:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.addEventListener(ProgressEvent.PROGRESS, progressHandler);
myFileStream.openAsync(myFile, FileMode.READ);
var str:String = "";

function progressHandler(event:ProgressEvent):void
{
    str += myFileStream.readMultiByte(myFileStream.bytesAvailable, "iso-8859-1");
}
```

You can read the entire data by registering for the `complete` event, as in the following code:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.addEventListener(Event.COMPLETE, completed);
myFileStream.openAsync(myFile, FileMode.READ);
var str:String = "";
function completeHandler(event:Event):void
{
    str = myFileStream.readMultiByte(myFileStream.bytesAvailable, "iso-8859-1");
}
```

In much the same way that input data is buffered to enable asynchronous reading, data that you write on an asynchronous stream is buffered and written to the file asynchronously. As data is written to a file, the FileStream object periodically dispatches an `OutputProgressEvent` object. An `OutputProgressEvent` object includes a `bytesPending` property that is set to the number of bytes remaining to be written. You can register for the `outputProgress` event to be notified as this buffer is actually written to the file, perhaps in order to display a progress dialog. However, in general, it is not necessary to do so. In particular, you may call the `close()` method without concern for the unwritten bytes. The FileStream object will continue writing data and the `close` event will be delivered after the final byte is written to the file and the underlying file is closed.

Data formats, and choosing the read and write methods to use
Adobe AIR 1.0 and later

Every file is a set of bytes on a disk. In ActionScript, the data from a file can always be represented as a ByteArray. For example, the following code reads the data from a file into a ByteArray object named `bytes`:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.addEventListener(Event.COMPLETE, completeHandler);
myFileStream.openAsync(myFile, FileMode.READ);
var bytes:ByteArray = new ByteArray();

function completeHandler(event:Event):void
{
    myFileStream.readBytes(bytes, 0, myFileStream.bytesAvailable);
}
```

Similarly, the following code writes data from a ByteArray named `bytes` to a file:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.open(myFile, FileMode.WRITE);
myFileStream.writeBytes(bytes, 0, bytes.length);
```

However, often you do not want to store the data in an ActionScript ByteArray object. And often the data file is in a specified file format.

For example, the data in the file may be in a text file format, and you may want to represent such data in a String object.

For this reason, the FileStream class includes read and write methods for reading and writing data to and from types other than ByteArray objects. For example, the `readMultiByte()` method lets you read data from a file and store it to a string, as in the following code:

```
 var myFile:File = File.documentsDirectory.resolvePath("AIR Test/test.txt");
var myFileStream:FileStream = new FileStream();
myFileStream.addEventListener(Event.COMPLETE, completed);
myFileStream.openAsync(myFile, FileMode.READ);
var str:String = "";

function completeHandler(event:Event):void
{
    str = myFileStream.readMultiByte(myFileStream.bytesAvailable, "iso-8859-1");
}
```

The second parameter of the `readMultiByte()` method specifies the text format that ActionScript uses to interpret the data ("iso-8859-1" in the example). Adobe AIR supports common character set encodings (see Supported character sets).

The FileStream class also includes the `readUTFBytes()` method, which reads data from the read buffer into a string using the UTF-8 character set. Since characters in the UTF-8 character set are of variable length, do not use `readUTFBytes()` in a method that responds to the `progress` event, since the data at the end of the read buffer may represent an incomplete character. (This is also true when using the `readMultiByte()` method with a variable-length character encoding.) For this reason, read the entire set of data when the FileStream object dispatches the `complete` event.

There are also similar write methods, `writeMultiByte()` and `writeUTFBytes()`, for working with String objects and text files.

The `readUTF()` and the `writeUTF()` methods (not to be confused with `readUTFBytes()` and `writeUTFBytes()`) also read and write the text data to a file, but they assume that the text data is preceded by data specifying the length of the text data, which is not a common practice in standard text files.

Some UTF-encoded text files begin with a "UTF-BOM" (byte order mark) character that defines the endianness as well as the encoding format (such as UTF-16 or UTF-32).

For an example of reading and writing to a text file, see "Example: Reading an XML file into an XML object" on page 698.

The `readObject()` and `writeObject()` are convenient ways to store and retrieve data for complex ActionScript objects. The data is encoded in AMF (ActionScript Message Format). Adobe AIR, Flash Player, Flash Media Server, and Flex Data Services include APIs for working with data in this format.

There are some other read and write methods (such as `readDouble()` and `writeDouble()`). However, if you use these, make sure that the file format matches the formats of the data defined by these methods.

File formats are often more complex than simple text formats. For example, an MP3 file includes compressed data that can only be interpreted with the decompression and decoding algorithms specific to MP3 files. MP3 files also may include ID3 tags that contain meta tag information about the file (such as the title and artist for a song). There are multiple versions of the ID3 format, but the simplest (ID3 version 1) is discussed in the "Example: Reading and writing data with random access" on page 699 section.

Other files formats (for images, databases, application documents, and so on) have different structures, and to work with their data in ActionScript, you must understand how the data is structured.

Using the load() and save() methods

Flash Player 10 and later, Adobe AIR 1.5 and later

Flash Player 10 added the `load()` and `save()` methods to the FileReference class. These methods are also in AIR 1.5, and the File class inherits the methods from the FileReference class. These methods were designed to provide a secure means for users to load and save file data in Flash Player. However, AIR applications can also use these methods as an easy way to load and save files asynchronously.

For example, the following code saves a string to a text file:

```
var file:File = File.applicationStorageDirectory.resolvePath("test.txt");
var str:String = "Hello.";
file.addEventListener(Event.COMPLETE, fileSaved);
file.save(str);
function fileSaved(event:Event):void
{
    trace("Done.");
}
```

The `data` parameter of the `save()` method can take a String, XML, or ByteArray value. When the argument is a String or XML value, the method saves the file as a UTF-8–encoded text file.

When this code sample executes, the application displays a dialog box in which the user selects the saved file destination.

The following code loads a string from a UTF-8–encoded text file:

```
var file:File = File.applicationStorageDirectory.resolvePath("test.txt");
file.addEventListener(Event.COMPLETE, loaded);
file.load();
var str:String;
function loaded(event:Event):void
{
    var bytes:ByteArray = file.data;
    str = bytes.readUTFBytes(bytes.length);
    trace(str);
}
```

The FileStream class provides more functionality than that provided by the `load()` and `save()` methods:

- Using the FileStream class, you can read and write data both synchronously and asynchronously.
- Using the FileStream class lets you write incrementally to a file.
- Using the FileStream class lets you open a file for random access (both reading from and writing to any section of the file).
- The FileStream class lets you specify the type of file access you have to the file, by setting the `fileMode` parameter of the `open()` or `openAsync()` method.
- The FileStream class lets you save data to files without presenting the user with an Open or Save dialog box.
- You can directly use types other than byte arrays when reading data with the FileStream class.

Example: Reading an XML file into an XML object

Adobe AIR 1.0 and later

The following examples demonstrate how to read and write to a text file that contains XML data.

To read from the file, initialize the File and FileStream objects, call the `readUTFBytes()` method of the FileStream and convert the string to an XML object:

```
 var file:File = File.documentsDirectory.resolvePath("AIR Test/preferences.xml");
var fileStream:FileStream = new FileStream();
fileStream.open(file, FileMode.READ);
var prefsXML:XML = XML(fileStream.readUTFBytes(fileStream.bytesAvailable));
fileStream.close();
```

Similarly, writing the data to the file is as easy as setting up appropriate File and FileStream objects, and then calling a write method of the FileStream object. Pass the string version of the XML data to the write method as in the following code:

```
 var prefsXML:XML = <prefs><autoSave>true</autoSave></prefs>;
var file:File = File.documentsDirectory.resolvePath("AIR Test/preferences.xml");
fileStream = new FileStream();
fileStream.open(file, FileMode.WRITE);

var outputString:String = '<?xml version="1.0" encoding="utf-8"?>\n';
outputString += prefsXML.toXMLString();

fileStream.writeUTFBytes(outputString);
fileStream.close();
```

These examples use the `readUTFBytes()` and `writeUTFBytes()` methods, because they assume that the files are in UTF-8 format. If not, you may need to use a different method (see "Data formats, and choosing the read and write methods to use" on page 695).

The previous examples use FileStream objects opened for synchronous operation. You can also open files for asynchronous operations (which rely on event listener functions to respond to events). For example, the following code shows how to read an XML file asynchronously:

```
var file:File = File.documentsDirectory.resolvePath("AIR Test/preferences.xml");
var fileStream:FileStream = new FileStream();
fileStream.addEventListener(Event.COMPLETE, processXMLData);
fileStream.openAsync(file, FileMode.READ);
var prefsXML:XML;

function processXMLData(event:Event):void
{
    prefsXML = XML(fileStream.readUTFBytes(fileStream.bytesAvailable));
    fileStream.close();
}
```

The `processXMLData()` method is invoked when the entire file is read into the read buffer (when the FileStream object dispatches the `complete` event). It calls the `readUTFBytes()` method to get a string version of the read data, and it creates an XML object, `prefsXML`, based on that string.

To see a sample application that shows these capabilities, see Reading and writing from an XML preferences file.

Example: Reading and writing data with random access

Adobe AIR 1.0 and later

MP3 files can include ID3 tags, which are sections at the beginning or end of the file that contain meta data identifying the recording. The ID3 tag format itself has different revisions. This example describes how to read and write from an MP3 file that contains the simplest ID3 format (ID3 version 1.0) using "random access to file data", which means that it reads from and writes to arbitrary locations in the file.

An MP3 file that contains an ID3 version 1 tag includes the ID3 data at the end of the file, in the final 128 bytes.

When accessing a file for random read/write access, it is important to specify `FileMode.UPDATE` as the `fileMode` parameter for the `open()` or `openAsync()` method:

```
var file:File = File.documentsDirectory.resolvePath("My Music/Sample ID3 v1.mp3");
var fileStr:FileStream = new FileStream();
fileStr.open(file, FileMode.UPDATE);
```

This lets you both read and write to the file.

Upon opening the file, you can set the `position` pointer to the position 128 bytes before the end of the file:

```
fileStr.position = file.size - 128;
```

This code sets the `position` property to this location in the file because the ID3 v1.0 format specifies that the ID3 tag data is stored in the last 128 bytes of the file. The specification also says the following:

- The first 3 bytes of the tag contain the string `"TAG"`.
- The next 30 characters contain the title for the MP3 track, as a string.
- The next 30 characters contain the name of the artist, as a string.

- The next 30 characters contain the name of the album, as a string.
- The next 4 characters contain the year, as a string.
- The next 30 characters contain the comment, as a string.
- The next byte contains a code indicating the track's genre.
- All text data is in ISO 8859-1 format.

The `id3TagRead()` method checks the data after it is read in (upon the `complete` event):

```
 function id3TagRead():void
{
    if (fileStr.readMultiByte(3, "iso-8859-1").match(/tag/i))
    {
        var id3Title:String = fileStr.readMultiByte(30, "iso-8859-1");
        var id3Artist:String = fileStr.readMultiByte(30, "iso-8859-1");
        var id3Album:String = fileStr.readMultiByte(30, "iso-8859-1");
        var id3Year:String = fileStr.readMultiByte(4, "iso-8859-1");
        var id3Comment:String = fileStr.readMultiByte(30, "iso-8859-1");
        var id3GenreCode:String =  fileStr.readByte().toString(10);
    }
}
```

You can also perform a random-access write to the file. For example, you could parse the `id3Title` variable to ensure that it is correctly capitalized (using methods of the String class), and then write a modified string, called `newTitle`, to the file, as in the following:

```
fileStr.position = file.length - 125;    // 128 - 3
fileStr.writeMultiByte(newTitle, "iso-8859-1");
```

To conform with the ID3 version 1 standard, the length of the `newTitle` string should be 30 characters, padded at the end with the character code 0 (`String.fromCharCode(0)`).

Chapter 39: Storing local data

Flash Player 9 and later, Adobe AIR 1.0 and later

You use the SharedObject class to store small amounts of data on the client computer. In Adobe AIR, you can also use the EncryptedLocalStore class to store small amounts of privacy-sensitive user data on the local computer in an AIR application.

You can also read and write files on the file system and (in Adobe AIR) access local database files. For more information, see "Working with the file system" on page 653 and "Working with local SQL databases in AIR" on page 714.

There are a number of security factors that relate to shared objects. For more information, see "Shared objects" on page 1074 in "Security" on page 1042.

Shared objects

Flash Player 9 and later, Adobe AIR 1.0 and later

A shared object, sometimes referred to as a "Flash cookie," is a data file that can be created on your computer by the sites that you visit. Shared objects are most often used to enhance your web-browsing experience—for example, by allowing you to personalize the look and feel of a website that you frequently visit.

About shared objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Shared objects function like browser cookies. You use the SharedObject class to store data on the user's local hard disk and call that data during the same session or in a later session. Applications can access only their own SharedObject data, and only if they are running on the same domain. The data is not sent to the server and is not accessible by other applications running on other domains, but can be made accessible by applications from the same domain.

Shared objects compared with cookies

Flash Player 9 and later, Adobe AIR 1.0 and later

Cookies and shared objects are very similar. Because most web programmers are familiar with how cookies work, it might be useful to compare cookies and local SharedObjects.

Cookies that adhere to the RFC 2109 standard generally have the following properties:

- They can expire, and often do at the end of a session by default.
- They can be disabled by the client on a site-specific basis.
- There is a limit of 300 cookies total, and 20 cookies maximum per site.
- They are usually limited to a size of 4 KB each.
- They are sometimes perceived to be a security threat, and as a result, they are sometimes disabled on the client.
- They are stored in a location specified by the client browser.

- They are transmitted from client to server through HTTP.

  In contrast, shared objects have the following properties:

- They do not expire by default.
- By default, they are limited to a size of 100 KB each.
- They can store simple data types (such as String, Array, and Date).
- They are stored in a location specified by the application (within the user's home directory).
- They are never transmitted between the client and server.

About the SharedObject class

Flash Player 9 and later, Adobe AIR 1.0 and later

Using the SharedObject class, you can create and delete shared objects, as well as detect the current size of a SharedObject object that you are using.

Creating a shared object

Flash Player 9 and later, Adobe AIR 1.0 and later

To create a SharedObject object, use the `SharedObject.getLocal()` method, which has the following syntax:

```
SharedObject.getLocal("objectName" [, pathname]): SharedObject
```

The following example creates a shared object called mySO:

```
public var mySO:SharedObject;
mySO = SharedObject.getLocal("preferences");
```

This creates a file on the client's machine called preferences.sol.

The term *local* refers to the location of the shared object. In this case, Adobe® Flash® Player stores the SharedObject file locally in the client's home directory.

When you create a shared object, Flash Player creates a new directory for the application and domain inside its sandbox. It also creates a *.sol file that stores the SharedObject data. The default location of this file is a subdirectory of the user's home directory. The following table shows the default locations of this directory:

Operating System	Location
Windows 95/98/ME/2000/XP	c:/Documents and Settings/*username*/Application Data/Macromedia/Flash Player/#SharedObjects
Windows Vista/Windows 7	c:/Users/*username*/AppData/Roaming/Macromedia/Flash Player/#SharedObjects
Macintosh OS X	/Users/*username*/Library/Preferences/Macromedia/Flash Player/#SharedObjects/*web_domain*/*path_to_application*/*application_name*/*object_name*.sol
Linux/Unix	/home/username/.macromedia/Flash_Player/#SharedObjects/*web_domain*/*path_to_application*/*application_name*/*object_name*.sol

Below the #SharedObjects directory is a randomly-named directory. Below that is a directory that matches the hostname, then the path to the application, and finally the *.sol file.

For example, if you request an application named MyApp.swf on the local host, and within a subdirectory named /sos, Flash Player stores the *.sol file in the following location on Windows XP:

```
c:/Documents and Settings/fred/Application Data/Macromedia/Flash 
Player/#SharedObjects/KROKWXRK/#localhost/sos/MyApp.swf/data.sol
```

***Note:** If you do not provide a name in the `SharedObject.getLocal()` method, Flash Player names the file undefined.sol.*

By default, Flash can save locally persistent SharedObject objects of up to 100 KB per domain. This value is user-configurable. When the application tries to save data to a shared object that would make it bigger than 100 KB, Flash Player displays the Local Storage dialog box, which lets the user allow or deny more local storage for the domain that is requesting access.

Specifying a path

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the optional *pathname* parameter to specify a location for the SharedObject file. This file must be a subdirectory of that domain's SharedObject directory. For example, if you request an application on the localhost and specify the following:

```
mySO = SharedObject.getLocal("myObjectFile","/");
```

Flash Player writes the SharedObject file in the /#localhost directory (or /localhost if the application is offline). This is useful if you want more than one application on the client to be able to access the same shared object. In this case, the client could run two Flex applications, both of which specify a path to the shared object that is the root of the domain; the client could then access the same shared object from both applications. To share data between more than application without persistence, you can use the LocalConnection object.

If you specify a directory that does not exist, Flash Player does not create a SharedObject file.

Adding data to a shared object

Flash Player 9 and later, Adobe AIR 1.0 and later

You add data to a SharedObject's *.sol file using the `data` property of the SharedObject object. To add new data to the shared object, use the following syntax:

```
sharedObject_name.data.variable = value;
```

The following example adds the `userName`, `itemNumbers`, and `adminPrivileges` properties and their values to a SharedObject:

```
public var currentUserName:String = "Reiner";
public var itemsArray:Array = new Array(101,346,483);
public var currentUserIsAdmin:Boolean = true;
mySO.data.userName = currentUserName;
mySO.data.itemNumbers = itemsArray;
mySO.data.adminPrivileges = currentUserIsAdmin;
```

After you assign values to the `data` property, you must instruct Flash Player to write those values to the SharedObject's file. To force Flash Player to write the values to the SharedObject's file, use the `SharedObject.flush()` method, as follows:

```
mySO.flush();
```

If you do not call the `SharedObject.flush()` method, Flash Player writes the values to the file when the application quits. However, this does not provide the user with an opportunity to increase the available space that Flash Player has to store the data if that data exceeds the default settings. Therefore, it is a good practice to call `SharedObject.flush()`.

When using the `flush()` method to write shared objects to a user's hard drive, you should be careful to check whether the user has explicitly disabled local storage using the Flash Player Settings Manager (www.macromedia.com/support/documentation/en/flashplayer/help/settings_manager07.html), as shown in the following example:

```
var so:SharedObject = SharedObject.getLocal("test");
trace("Current SharedObject size is " + so.size + " bytes.");
so.flush();
```

Storing objects in shared objects

You can store simple objects such as Arrays or Strings in a SharedObject's `data` property.

The following example is an ActionScript class that defines methods that control the interaction with the shared object. These methods let the user add and remove objects from the shared object. This class stores an ArrayCollection that contains simple objects.

```
package {
    import mx.collections.ArrayCollection;
    import flash.net.SharedObject;

    public class LSOHandler {

        private var mySO:SharedObject;
        private var ac:ArrayCollection;
        private var lsoType:String;

        // The parameter is "feeds" or "sites".
        public function LSOHandler(s:String) {
            init(s);
        }

        private function init(s:String):void {
            ac = new ArrayCollection();
            lsoType = s;
            mySO = SharedObject.getLocal(lsoType);
            if (getObjects()) {
                ac = getObjects();
            }
        }

        public function getObjects():ArrayCollection {
            return mySO.data[lsoType];
        }

        public function addObject(o:Object):void {
            ac.addItem(o);
            updateSharedObjects();
        }

        private function updateSharedObjects():void {
            mySO.data[lsoType] = ac;
            mySO.flush();
        }
    }

}
```

The following Flex application creates an instance of the ActionScript class for each of the types of shared objects it needs. It then calls methods on that class when the user adds or removes blogs or site URLs.

```
<?xml version="1.0"?>
<!-- lsos/BlogAggregator.mxml -->
<mx:Application
    xmlns:local="*"
    xmlns:mx="http://www.adobe.com/2006/mxml"
    creationComplete="initApp()"
    backgroundColor="#ffffff"
>
    <mx:Script>
        <![CDATA[
        import mx.collections.ArrayCollection;
        import mx.utils.ObjectUtil;
        import flash.net.SharedObject;

        [Bindable]
        public var welcomeMessage:String;

        [Bindable]
        public var localFeeds:ArrayCollection = new ArrayCollection();

        [Bindable]
        public var localSites:ArrayCollection = new ArrayCollection();

        public var lsofeeds:LSOHandler;
        public var lsosites:LSOHandler;

        private function initApp():void {
            lsofeeds = new LSOHandler("feeds");
            lsosites = new LSOHandler("sites");

            if (lsofeeds.getObjects()) {
                localFeeds = lsofeeds.getObjects();
            }
            if (lsosites.getObjects()) {
                localSites = lsosites.getObjects();
            }
        }

        // Adds a new feed to the feeds DataGrid.
        private function addFeed():void {
            // Construct an object you want to store in the
            // LSO. This object can contain any number of fields.
            var o:Object = {name:ti1.text, url:ti2.text, date:new Date()};
            lsofeeds.addObject(o);

            // Because the DataGrid's dataProvider property is
            // bound to the ArrayCollection, Flex updates the
            // DataGrid when you call this method.
            localFeeds = lsofeeds.getObjects();

            // Clear the text fields.
            ti1.text = '';
            ti2.text = '';
        }

        // Removes feeds from the feeds DataGrid.
        private function removeFeed():void {
            // Use a method of ArrayCollection to remove a feed.
            // Because the DataGrid's dataProvider property is
            // bound to the ArrayCollection, Flex updates the
            // DataGrid when you call this method. You do not need
            // to update it manually.
            if (myFeedsGrid.selectedIndex > -1) {

localFeeds.removeItemAt(myFeedsGrid.selectedIndex);
             }
        }

        private function addSite():void {
            var o:Object = {name:ti3.text, date:new Date()};
            lsosites.addObject(o);
            localSites = lsosites.getObjects();
            ti3.text = '';
        }

        private function removeSite():void {
            if (mySitesGrid.selectedIndex > -1) {

localSites.removeItemAt(mySitesGrid.selectedIndex);
            }
        }

        ]]>
    </mx:Script>

    <mx:Label text="Blog aggregator" fontSize="28"/>

    <mx:Panel title="Blogs">
        <mx:Form id="blogForm">
            <mx:HBox>
```

```
                <mx:FormItem label="Name:">
                    <mx:TextInput id="ti1" width="100"/>
                </mx:FormItem>
                <mx:FormItem label="Location:">
                    <mx:TextInput id="ti2" width="300"/>
                </mx:FormItem>
                <mx:Button id="b1" label="Add Feed" click="addFeed()"/>
            </mx:HBox>

            <mx:FormItem label="Existing Feeds:">
                <mx:DataGrid
                    id="myFeedsGrid"
                    dataProvider="{localFeeds}"
                    width="400"
                />
            </mx:FormItem>
            <mx:Button id="b2" label="Remove Feed" click="removeFeed()"/>
        </mx:Form>
    </mx:Panel>

    <mx:Panel title="Sites">
        <mx:Form id="siteForm">
            <mx:HBox>
                <mx:FormItem label="Site:">
                    <mx:TextInput id="ti3" width="400"/>
                </mx:FormItem>
                <mx:Button id="b3" label="Add Site" click="addSite()"/>
            </mx:HBox>

            <mx:FormItem label="Existing Sites:">
                <mx:DataGrid
                    id="mySitesGrid"
                    dataProvider="{localSites}"
                    width="400"
                />
            </mx:FormItem>
            <mx:Button id="b4" label="Remove Site" click="removeSite()"/>
        </mx:Form>
    </mx:Panel>

</mx:Application>
```

Storing typed objects in shared objects

You can store typed ActionScript instances in shared objects. You do this by calling the `flash.net.registerClassAlias()` method to register the class. If you create an instance of your class and store it in the data member of your shared object and later read the object out, you will get a typed instance. By default, the SharedObject `objectEncoding` property supports AMF3 encoding, and unpacks your stored instance from the SharedObject object; the stored instance retains the same type you specified when you called the `registerClassAlias()` method.

(iOS only) Prevent cloud backup of local shared objects

Adobe AIR 3.7 and later, iOS only

You can set the `SharedObject.preventBackup` property to control whether local shared objects will be backed up on the iOS cloud backup service. This is required by Apple for content that can be regenerated or downloaded again, but that is required for proper functioning of your application during offline use.

Creating multiple shared objects

You can create multiple shared objects for the same Flex application. To do this, you assign each of them a different instance name, as the following example shows:

```
public var mySO:SharedObject = SharedObject.getLocal("preferences");
public var mySO2:SharedObject = SharedObject.getLocal("history");
```

This creates a preferences.sol file and a history.sol file in the Flex application's local directory.

Creating a secure SharedObject

Flash Player 9 and later, Adobe AIR 1.0 and later

When you create either a local or remote SharedObject using `getLocal()` or `getRemote()`, there is an optional parameter named `secure` that determines whether access to this shared object is restricted to SWF files that are delivered over an HTTPS connection. If this parameter is set to `true` and your SWF file is delivered over HTTPS, Flash Player creates a new secure shared object or gets a reference to an existing secure shared object. This secure shared object can be read from or written to only by SWF files delivered over HTTPS that call `SharedObject.getLocal()` with the secure parameter set to `true`. If this parameter is set to `false` and your SWF file is delivered over HTTPS, Flash Player creates a new shared object or gets a reference to an existing shared object.

This shared object can be read from or written to by SWF files delivered over non-HTTPS connections. If your SWF file is delivered over a non-HTTPS connection and you try to set this parameter to `true`, the creation of a new shared object (or the access of a previously created secure shared object) fails, an error is thrown, and the shared object is set to `null`. If you attempt to run the following snippet from a non-HTTPS connection, the `SharedObject.getLocal()` method will throw an error:

```
try
{
    var so:SharedObject = SharedObject.getLocal("contactManager", null, true);
}
catch (error:Error)
{
    trace("Unable to create SharedObject.");
}
```

Regardless of the value of this parameter, the created shared objects count toward the total amount of disk space allowed for a domain.

Displaying contents of a shared object

Flash Player 9 and later, Adobe AIR 1.0 and later

Values are stored in shared objects within the `data` property. You can loop over each value within a shared object instance by using a `for..in` loop, as the following example shows:

```
var so:SharedObject = SharedObject.getLocal("test");
so.data.hello = "world";
so.data.foo = "bar";
so.data.timezone = new Date().timezoneOffset;
for (var i:String in so.data)
{
    trace(i + ":\t" + so.data[i]);
}
```

Destroying shared objects

Flash Player 9 and later, Adobe AIR 1.0 and later

To destroy a SharedObject on the client, use the `SharedObject.clear()` method. This does not destroy directories in the default path for the application's shared objects.

The following example deletes the SharedObject file from the client:

```
public function destroySharedObject():void {
    mySO.clear();
}
```

SharedObject example

Flash Player 9 and later, Adobe AIR 1.0 and later

The following example shows that you can store simple objects, such as a Date object, in a SharedObject object without having to manually serialize and deserialize those objects.

The following example begins by welcoming you as a first-time visitor. When you click Log Out, the application stores the current date in a shared object. The next time you launch this application or refresh the page, the application welcomes you back with a reminder of the time you logged out.

To see the application in action, launch the application, click Log Out, and then refresh the page. The application displays the date and time that you clicked the Log Out button on your previous visit. At any time, you can delete the stored information by clicking the Delete LSO button.

```
<?xml version="1.0"?>
<!-- lsos/WelcomeMessage.mxml -->
<mx:Application xmlns:mx="http://www.adobe.com/2006/mxml" initialize="initApp()">
  <mx:Script><![CDATA[
  public var mySO:SharedObject;
  [Bindable]
  public var welcomeMessage:String;

  public function initApp():void {
     mySO = SharedObject.getLocal("mydata");
     if (mySO.data.visitDate==null) {
        welcomeMessage = "Hello first-timer!"
     } else {
        welcomeMessage = "Welcome back. You last visited on " +
           getVisitDate();
     }
  }

  private function getVisitDate():Date {
     return mySO.data.visitDate;
  }

  private function storeDate():void {
     mySO.data.visitDate = new Date();
     mySO.flush();
  }

  private function deleteLSO():void {
     // Deletes the SharedObject from the client machine.
     // Next time they log in, they will be a 'first-timer'.
     mySO.clear();
  }

  ]]></mx:Script>
  <mx:Label id="label1" text="{welcomeMessage}"/>
  <mx:Button label="Log Out" click="storeDate()"/>
  <mx:Button label="Delete LSO" click="deleteLSO()"/>
</mx:Application>
```

Encrypted local storage

The EncryptedLocalStore class (ELS) provides an encrypted local storage mechanism that you can be use as a small cache for an application's private data. ELS data cannot be shared between applications. The intent of ELS is to allow an application to store easily recreated items such as login credentials and other private information. ELS data should not be considered as permanent, as outlined in "Limitations of the encrypted local store" and "Best practices," below.

Note: *In addition to the encrypted local store, AIR also provides encryption for content stored in SQL databases. For details, see "Using encryption with SQL databases" on page 758.*

You may want to use the encrypted local store to cache information that must be secured, such as login credentials for web services. The ELS is appropriate for storing information that must be kept private from other users. It does not, however, protect the data from other processes run under the same user account. It is thus not appropriate for protecting secret application data, such as DRM or encryption keys.

On desktop platforms, AIR uses DPAPI on Windows, KeyChain on Mac OS and iOS, and KeyRing or KWallet on Linux to associate the encrypted local store to each application and user. The encrypted local store uses AES-CBC 128-bit encryption.

On Android, the data stored by the EncryptedLocalStorage class are not encrypted. Instead the data is protected by the user-level security provided by the operating system. The Android operating system assigns every application a separate user ID. Applications can only access their own files and files created in public locations (such as the removable storage card). Note that on "rooted" Android devices, applications running with root privileges CAN access the files of other applications. Thus on a rooted device, the encrypted local store does not provide as high a level of data protection as it does on on a non-rooted device.

Information in the encrypted local store is only available to AIR application content in the application security sandbox.

If you update an AIR application, the updated version retains access to any existing data in the encrypted local store unless:

- The items were added with the `stronglyBound` parameter set to `true`
- The existing and update versions are both published prior to AIR 1.5.3 and the update is signed with a migration signature.

Limitations of the encrypted local store

The data in the encrypted local store is protected by the user's operating system account credentials. Other entities cannot access the data in the store unless they can login as that user. However, the data is not secure against access by other applications run by an authenticated user.

Because the user must be authenticated for these attacks to work, the user's private data is still protected (unless the user account itself is compromised). However, data that your application may want to keep secret from users, such as keys used for licensing or digital rights management, is not secure. Thus the ELS is not an appropriate location for storing such information. It is only an appropriate place for storing a user's private data, such as passwords.

Data in the ELS can be lost for a variety of reasons. For example, the user could uninstall the application and delete the encrypted file. Or, the publisher ID could be changed as a result of an update. Thus the ELS should be treated as a private cache, not a permanent data storage.

The `stronglyBound` parameter is deprecated and should not be set to `true`. Setting the parameter to `true` does not provide any additional protection for data. At the same time, access to the data is lost whenever the application is updated — even if the publisher ID stays the same.

The encrypted local store may perform more slowly if the stored data exceeds 10MB.

When you uninstall an AIR application, the uninstaller does not delete data stored in the encrypted local store.

Best practices

The best practices for using the ELS include:

- Use the ELS to store sensitive user data such as passwords (setting stronglyBound to false)
- Do not use the ELS to store applications secrets such as DRM keys or licensing tokens.
- Provide a way for your application to recreate the data stored in the ELS if the ELS data is lost. For example, by prompting the user to re-enter their account credentials when necessary.
- Do not use the `stronglyBound` parameter.
- If you do set `stronglyBound` to `true`, do not migrate stored items during an update. Recreate the data after the update instead.

- Only store relatively small amounts of data. For larger amounts of data, use an AIR SQL database with encryption.

More Help topics

flash.data.EncryptedLocalStore

Adding data to the encrypted local store

Use the `setItem()` static method of the EncryptedLocalStore class to store data in the local store. The data is stored in a hash table, using strings as keys, with the data stored as byte arrays.

For example, the following code stores a string in the encrypted local store:

```
var str:String = "Bob";
var bytes:ByteArray = new ByteArray();
bytes.writeUTFBytes(str);
EncryptedLocalStore.setItem("firstName", bytes);
```

The third parameter of the `setItem()` method, the `stronglyBound` parameter, is optional. When this parameter is set to `true`, the encrypted local store binds the stored item to the storing AIR application's digital signature and bits:

```
var str:String = "Bob";
var bytes:ByteArray = new ByteArray();
bytes.writeUTFBytes(str);
EncryptedLocalStore.setItem("firstName", bytes, false);
```

For an item that is stored with `stronglyBound` set to `true`, subsequent calls to `getItem()` only succeed if the calling AIR application is identical to the storing application (if no data in files in the application directory have changed). If the calling AIR application is different from the storing application, the application throws an Error exception when you call `getItem()` for a strongly bound item. If you update your application, it will not be able to read strongly bound data previously written to the encrypted local store. Setting `stronglyBound` to `true` on mobile devices is ignored; the parameter is always treated as `false`.

If the `stronglyBound` parameter is set to `false` (the default), only the publisher ID needs to stay the same for the application to read the data. The bits of the application may change (and they need to be signed by the same publisher), but they do not need to be the exact same bits as were in application that stored the data. Updated applications with the same publisher ID as the original can continue to access the data.

Note: *In practice, setting `stronglyBound` to `true` does not add any additional data protection. A "malicious" user could still alter an application to gain access to items stored in the ELS. Furthermore, data is protected from external, non-user threats just as strongly whether `stronglyBound` is set to `true` or `false`. For these reasons, setting `stronglyBound` to `true` is discouraged.*

Accessing data in the encrypted local store

Adobe AIR 1.0 and later

You can retrieve a value from the encrypted local store by using the `EncryptedLocalStore.getItem()` method, as in the following example:

```
var storedValue:ByteArray = EncryptedLocalStore.getItem("firstName");
trace(storedValue.readUTFBytes(storedValue.length)); // "Bob"
```

Removing data from the encrypted local store

Adobe AIR 1.0 and later

You can delete a value from the encrypted local store by using the `EncryptedLocalStore.removeItem()` method, as in the following example:

```
EncryptedLocalStore.removeItem("firstName");
```

You can clear all data from the encrypted local store by calling the `EncryptedLocalStore.reset()` method, as in the following example:

```
EncryptedLocalStore.reset();
```

Chapter 40: Working with local SQL databases in AIR

Adobe AIR 1.0 and later

Adobe® AIR® includes the capability of creating and working with local SQL databases. The runtime includes a SQL database engine with support for many standard SQL features, using the open source SQLite database system. A local SQL database can be used for storing local, persistent data. For example, it can be used for application data, application user settings, documents, or any other type of data that you want your application to save locally.

About local SQL databases

Adobe AIR 1.0 and later

For a quick explanation and code examples of using SQL databases, see the following quick start articles on the Adobe Developer Connection:

- Working asynchronously with a local SQL database (Flex)
- Working synchronously with a local SQL database (Flex)
- Using an encrypted database (Flex)
- Working asynchronously with a local SQL database (Flash)
- Working synchronously with a local SQL database (Flash)
- Using an encrypted database (Flash)

Adobe AIR includes a SQL-based relational database engine that runs within the runtime, with data stored locally in database files on the computer on which the AIR application runs (for example, on the computer's hard drive). Because the database runs and data files are stored locally, a database can be used by an AIR application regardless of whether a network connection is available. Thus, the runtime's local SQL database engine provides a convenient mechanism for storing persistent, local application data, particularly if you have experience with SQL and relational databases.

Uses for local SQL databases

Adobe AIR 1.0 and later

The AIR local SQL database functionality can be used for any purpose for which you might want to store application data on a user's local computer. Adobe AIR includes several mechanisms for storing data locally, each of which has different advantages. The following are some possible uses for a local SQL database in your AIR application:

- For a data-oriented application (for example an address book), a database can be used to store the main application data.
- For a document-oriented application, where users create documents to save and possibly share, each document could be saved as a database file, in a user-designated location. (Note, however, that unless the database is encrypted any AIR application would be able to open the database file. Encryption is recommended for potentially sensitive documents.)

- For a network-aware application, a database can be used to store a local cache of application data, or to store data temporarily when a network connection isn't available. You could create a mechanism for synchronizing the local database with the network data store.
- For any application, a database can be used to store individual users' application settings, such as user options or application information like window size and position.

More Help topics

Christophe Coenraets: Employee Directory on AIR for Android

Raymond Camden: jQuery and AIR - Moving from web page to application

About AIR databases and database files

Adobe AIR 1.0 and later

An individual Adobe AIR local SQL database is stored as a single file in the computer's file system. The runtime includes the SQL database engine that manages creation and structuring of database files and manipulation and retrieval of data from a database file. The runtime does not specify how or where database data is stored on the file system; rather, each database is stored completely within a single file. You specify the location in the file system where the database file is stored. A single AIR application can access one or many separate databases (that is, separate database files). Because the runtime stores each database as a single file on the file system, you can locate your database as needed by the design of your application and file access constraints of the operating system. Each user can have a separate database file for their specific data, or a database file can be accessed by all application users on a single computer for shared data. Because the data is local to a single computer, data is not automatically shared among users on different computers. The local SQL database engine doesn't provide any capability to execute SQL statements against a remote or server-based database.

About relational databases

Adobe AIR 1.0 and later

A relational database is a mechanism for storing (and retrieving) data on a computer. Data is organized into tables: rows represent records or items, and columns (sometimes called "fields") divide each record into individual values. For example, an address book application could contain a "friends" table. Each row in the table would represent a single friend stored in the database. The table's columns would represent data such as first name, last name, birth date, and so forth. For each friend row in the table, the database stores a separate value for each column.

Relational databases are designed to store complex data, where one item is associated with or related to items of another type. In a relational database, any data that has a one-to-many relationship—where a single record can be related to multiple records of a different type—should be divided among different tables. For example, suppose you want your address book application to store multiple phone numbers for each friend; this is a one-to-many relationship. The "friends" table would contain all the personal information for each friend. A separate "phone numbers" table would contain all the phone numbers for all the friends.

In addition to storing the data about friends and phone numbers, each table would need a piece of data to keep track of the relationship between the two tables—to match individual friend records with their phone numbers. This data is known as a primary key—a unique identifier that distinguishes each row in a table from other rows in that table. The primary key can be a "natural key," meaning it's one of the items of data that naturally distinguishes each record in a table. In the "friends" table, if you knew that none of your friends share a birth date, you could use the birth date column as the primary key (a natural key) of the "friends" table. If there isn't a natural key, you would create a separate primary key column such as a "friend id" —an artificial value that the application uses to distinguish between rows.

Using a primary key, you can set up relationships between multiple tables. For example, suppose the "friends" table has a column "friend id" that contains a unique number for each row (each friend). The related "phone numbers" table can be structured with two columns: one with the "friend id" of the friend to whom the phone number belongs, and one with the actual phone number. That way, no matter how many phone numbers a single friend has, they can all be stored in the "phone numbers" table and can be linked to the related friend using the "friend id" primary key. When a primary key from one table is used in a related table to specify the connection between the records, the value in the related table is known as a foreign key. Unlike many databases, the AIR local database engine does not allow you to create foreign key constraints, which are constraints that automatically check that an inserted or updated foreign key value has a corresponding row in the primary key table. Nevertheless, foreign key relationships are an important part of the structure of a relational database, and foreign keys should be used when creating relationships between tables in your database.

About SQL

Adobe AIR 1.0 and later

Structured Query Language (SQL) is used with relational databases to manipulate and retrieve data. SQL is a descriptive language rather than a procedural language. Instead of giving the computer instructions on how it should retrieve data, a SQL statement describes the set of data you want. The database engine determines how to retrieve that data.

The SQL language has been standardized by the American National Standards Institute (ANSI). The Adobe AIR local SQL database supports most of the SQL-92 standard.

For specific descriptions of the SQL language supported in Adobe AIR, see "SQL support in local databases" on page 1104.

About SQL database classes

Adobe AIR 1.0 and later

To work with local SQL databases in ActionScript 3.0, you use instances of these classes in the flash.data package:

Class	Description
flash.data.SQLConnection	Provides the means to create and open databases (database files), as well as methods for performing database-level operations and for controlling database transactions.
flash.data.SQLStatement	Represents a single SQL statement (a single query or command) that is executed on a database, including defining the statement text and setting parameter values.
flash.data.SQLResult	Provides a way to get information about or results from executing a statement, such as the result rows from a `SELECT` statement, the number of rows affected by an `UPDATE` or `DELETE` statement, and so forth.

To obtain schema information describing the structure of a database, you use these classes in the flash.data package:

Class	Description
flash.data.SQLSchemaResult	Serves as a container for database schema results generated by calling the `SQLConnection.loadSchema()` method.
flash.data.SQLTableSchema	Provides information describing a single table in a database.

Class	**Description**
flash.data.SQLViewSchema	Provides information describing a single view in a database.
flash.data.SQLIndexSchema	Provides information describing a single column of a table or view in a database.
flash.data.SQLTriggerSchem a	Provides information describing a single trigger in a database.

Other classes in the flash.data package provide constants that are used with the SQLConnection class and the SQLColumnSchema class:

Class	**Description**
flash.data.SQLMode	Defines a set of constants representing the possible values for the `openMode` parameter of the `SQLConnection.open()` and `SQLConnection.openAsync()` methods.
flash.data.SQLColumnNameStyle	Defines a set of constants representing the possible values for the `SQLConnection.columnNameStyle` property.
flash.data.SQLTransactionLockType	Defines a set of constants representing the possible values for the option parameter of the `SQLConnection.begin()` method.
flash.data.SQLCollationType	Defines a set of constants representing the possible values for the `SQLColumnSchema.defaultCollationType` property and the `defaultCollationType` parameter of the `SQLColumnSchema()` constructor.

In addition, the following classes in the flash.events package represent the events (and supporting constants) that you use:

Class	**Description**
flash.events.SQLEvent	Defines the events that a SQLConnection or SQLStatement instance dispatches when any of its operations execute successfully. Each operation has an associated event type constant defined in the SQLEvent class.
flash.events.SQLErrorEvent	Defines the event that a SQLConnection or SQLStatement instance dispatches when any of its operations results in an error.
flash.events.SQLUpdateEven t	Defines the event that a SQLConnection instances dispatches when table data in one of its connected databases changes as a result of an `INSERT`, `UPDATE`, or `DELETE` SQL statement being executed.

Finally, the following classes in the flash.errors package provide information about database operation errors:

Class	**Description**
flash.errors.SQLError	Provides information about a database operation error, including the operation that was being attempted and the cause of the failure.
flash.errors.SQLErrorOperati on	Defines a set of constants representing the possible values for the SQLError class's `operation` property, which indicates the database operation that resulted in an error.

About synchronous and asynchronous execution modes

Adobe AIR 1.0 and later

When you're writing code to work with a local SQL database, you specify that database operations execution in one of two execution modes: asynchronous or synchronous execution mode. In general, the code examples show how to perform each operation in both ways, so that you can use the example that's most appropriate for your needs.

In asynchronous execution mode, you give the runtime an instruction and the runtime dispatches an event when your requested operation completes or fails. First you tell the database engine to perform an operation. The database engine does its work in the background while the application continues running. Finally, when the operation is completed (or when it fails) the database engine dispatches an event. Your code, triggered by the event, carries out subsequent operations. This approach has a significant benefit: the runtime performs the database operations in the background while the main application code continues executing. If the database operation takes a notable amount of time, the application continues to run. Most importantly, the user can continue to interact with it without the screen freezing. Nevertheless, asynchronous operation code can be more complex to write than other code. This complexity is usually in cases where multiple dependent operations must be divided up among various event listener methods.

Conceptually, it is simpler to code operations as a single sequence of steps—a set of synchronous operations—rather than a set of operations split into several event listener methods. In addition to asynchronous database operations, Adobe AIR also allows you to execute database operations synchronously. In synchronous execution mode, operations don't run in the background. Instead they run in the same execution sequence as all other application code. You tell the database engine to perform an operation. The code then pauses at that point while the database engine does its work. When the operation completes, execution continues with the next line of your code.

Whether operations execute asynchronously or synchronously is set at the SQLConnection level. Using a single database connection, you can't execute some operations or statements synchronously and others asynchronously. You specify whether a SQLConnection operates in synchronous or asynchronous execution mode by calling a SQLConnection method to open the database. If you call `SQLConnection.open()` the connection operates in synchronous execution mode, and if you call `SQLConnection.openAsync()` the connection operates in asynchronous execution mode. Once a SQLConnection instance is connected to a database using `open()` or `openAsync()`, it is fixed to synchronous or asynchronous execution mode unless you close and reopen the connection to the database.

Each execution mode has benefits. While most aspects of each mode are similar, there are some differences you'll want to keep in mind when working in each mode. For more information on these topics, and suggestions for working in each mode, see "Using synchronous and asynchronous database operations" on page 753.

Creating and modifying a database

Adobe AIR 1.0 and later

Before your application can add or retrieve data, there must be a database with tables defined in it that your application can access. Described here are the tasks of creating a database and creating the data structure within a database. While these tasks are less frequently used than data insertion and retrieval, they are necessary for most applications.

More Help topics

Mind the Flex: Updating an existing AIR database

Creating a database

Adobe AIR 1.0 and later

To create a database file, you first create a SQLConnection instance. You call its `open()` method to open it in synchronous execution mode, or its `openAsync()` method to open it in asynchronous execution mode. The `open()` and `openAsync()` methods are used to open a connection to a database. If you pass a File instance that refers to a non-existent file location for the `reference` parameter (the first parameter), the `open()` or `openAsync()` method creates a database file at that file location and open a connection to the newly created database.

Whether you call the `open()` method or the `openAsync()` method to create a database, the database file's name can be any valid filename, with any filename extension. If you call the `open()` or `openAsync()` method with `null` for the `reference` parameter, a new in-memory database is created rather than a database file on disk.

The following code listing shows the process of creating a database file (a new database) using asynchronous execution mode. In this case, the database file is saved in the "Pointing to the application storage directory" on page 672, with the filename "DBSample.db":

```
import flash.data.SQLConnection;
import flash.events.SQLErrorEvent;
import flash.events.SQLEvent;
import flash.filesystem.File;

var conn:SQLConnection = new SQLConnection();

conn.addEventListener(SQLEvent.OPEN, openHandler);
conn.addEventListener(SQLErrorEvent.ERROR, errorHandler);

// The database file is in the application storage directory
var folder:File = File.applicationStorageDirectory;
var dbFile:File = folder.resolvePath("DBSample.db");

conn.openAsync(dbFile);

function openHandler(event:SQLEvent):void
{
    trace("the database was created successfully");
}

function errorHandler(event:SQLErrorEvent):void
{
    trace("Error message:", event.error.message);
    trace("Details:", event.error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.events.SQLErrorEvent;
            import flash.events.SQLEvent;
            import flash.filesystem.File;
            
            private function init():void
            {
                var conn:SQLConnection = new SQLConnection();
                
                conn.addEventListener(SQLEvent.OPEN, openHandler);
                conn.addEventListener(SQLErrorEvent.ERROR, errorHandler);
                
                // The database file is in the application storage directory
                var folder:File = File.applicationStorageDirectory;
                var dbFile:File = folder.resolvePath("DBSample.db");
                
                conn.openAsync(dbFile);
            }
            
            private function openHandler(event:SQLEvent):void
            {
                trace("the database was created successfully");
            }
            
            private function errorHandler(event:SQLErrorEvent):void
            {
                trace("Error message:", event.error.message);
                trace("Details:", event.error.details);
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

Note: *Although the File class lets you point to a specific native file path, doing so can lead to applications that will not work across platforms. For example, the path C:\Documents and Settings\joe\test.db only works on Windows. For these reasons, it is best to use the static properties of the File class such as `File.applicationStorageDirectory`, as well as the `resolvePath()` method (as shown in the previous example). For more information, see "Paths of File objects" on page 668.*

To execute operations synchronously, when you open a database connection with the SQLConnection instance, call the `open()` method. The following example shows how to create and open a SQLConnection instance that executes its operations synchronously:

```
import flash.data.SQLConnection;
import flash.errors.SQLError;
import flash.filesystem.File;

var conn:SQLConnection = new SQLConnection();

// The database file is in the application storage directory
var folder:File = File.applicationStorageDirectory;
var dbFile:File = folder.resolvePath("DBSample.db");

try
{
    conn.open(dbFile);
    trace("the database was created successfully");
}
catch (error:SQLError)
{
    trace("Error message:", error.message);
    trace("Details:", error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.errors.SQLError;
            import flash.filesystem.File;

            private function init():void
            {
                var conn:SQLConnection = new SQLConnection();

                // The database file is in the application storage directory
                var folder:File = File.applicationStorageDirectory;
                var dbFile:File = folder.resolvePath("DBSample.db");

                try
                {
                    conn.open(dbFile);
                    trace("the database was created successfully");
                }
                catch (error:SQLError)
                {
                    trace("Error message:", error.message);
                    trace("Details:", error.details);
                }
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

Creating database tables

Adobe AIR 1.0 and later

Creating a table in a database involves executing a SQL statement on that database, using the same process that you use to execute a SQL statement such as `SELECT`, `INSERT`, and so forth. To create a table, you use a `CREATE TABLE` statement, which includes definitions of columns and constraints for the new table. For more information about executing SQL statements, see "Working with SQL statements" on page 729.

The following example demonstrates creating a table named "employees" in an existing database file, using asynchronous execution mode. Note that this code assumes there is a SQLConnection instance named `conn` that is already instantiated and is already connected to a database.

```
import flash.data.SQLConnection;
import flash.data.SQLStatement;
import flash.events.SQLErrorEvent;
import flash.events.SQLEvent;

// ... create and open the SQLConnection instance named conn ...

var createStmt:SQLStatement = new SQLStatement();
createStmt.sqlConnection = conn;

var sql:String =
    "CREATE TABLE IF NOT EXISTS employees (" +
    "   empId INTEGER PRIMARY KEY AUTOINCREMENT, " +
    "   firstName TEXT, " +
    "   lastName TEXT, " +
    "   salary NUMERIC CHECK (salary > 0)" +
    ")";
createStmt.text = sql;

createStmt.addEventListener(SQLEvent.RESULT, createResult);
createStmt.addEventListener(SQLErrorEvent.ERROR, createError);

createStmt.execute();

function createResult(event:SQLEvent):void
{
    trace("Table created");
}

function createError(event:SQLErrorEvent):void
{
    trace("Error message:", event.error.message);
    trace("Details:", event.error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLStatement;
            import flash.events.SQLErrorEvent;
            import flash.events.SQLEvent;

            private function init():void
            {
                // ... create and open the SQLConnection instance named conn ...

                var createStmt:SQLStatement = new SQLStatement();
                createStmt.sqlConnection = conn;

                var sql:String =
                    "CREATE TABLE IF NOT EXISTS employees (" +
                    "    empId INTEGER PRIMARY KEY AUTOINCREMENT, " +
                    "    firstName TEXT, " +
                    "    lastName TEXT, " +
                    "    salary NUMERIC CHECK (salary > 0)" +
                    ")";
                createStmt.text = sql;

                createStmt.addEventListener(SQLEvent.RESULT, createResult);
                createStmt.addEventListener(SQLErrorEvent.ERROR, createError);

                createStmt.execute();
            }

            private function createResult(event:SQLEvent):void
            {
                trace("Table created");
            }

            private function createError(event:SQLErrorEvent):void
            {
                trace("Error message:", event.error.message);
                trace("Details:", event.error.details);
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

The following example demonstrates how to create a table named "employees" in an existing database file, using synchronous execution mode. Note that this code assumes there is a SQLConnection instance named `conn` that is already instantiated and is already connected to a database.

```
import flash.data.SQLConnection;
import flash.data.SQLStatement;
import flash.errors.SQLError;

// ... create and open the SQLConnection instance named conn ...

var createStmt:SQLStatement = new SQLStatement();
createStmt.sqlConnection = conn;

var sql:String =
    "CREATE TABLE IF NOT EXISTS employees (" +
    "   empId INTEGER PRIMARY KEY AUTOINCREMENT, " +
    "   firstName TEXT, " +
    "   lastName TEXT, " +
    "   salary NUMERIC CHECK (salary > 0)" +
    ")";
createStmt.text = sql;

try
{
    createStmt.execute();
    trace("Table created");
}
catch (error:SQLError)
{
    trace("Error message:", error.message);
    trace("Details:", error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLStatement;
            import flash.errors.SQLError;

            private function init():void
            {
                // ... create and open the SQLConnection instance named conn ...

                var createStmt:SQLStatement = new SQLStatement();
                createStmt.sqlConnection = conn;

                var sql:String =
                    "CREATE TABLE IF NOT EXISTS employees (" +
                    "    empId INTEGER PRIMARY KEY AUTOINCREMENT, " +
                    "    firstName TEXT, " +
                    "    lastName TEXT, " +
                    "    salary NUMERIC CHECK (salary > 0)" +
                    ")";
                createStmt.text = sql;

                try
                {
                    createStmt.execute();
                    trace("Table created");
                }
                catch (error:SQLError)
                {
                    trace("Error message:", error.message);
                    trace("Details:", error.details);
                }
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

Manipulating SQL database data

Adobe AIR 1.0 and later

There are some common tasks that you perform when you're working with local SQL databases. These tasks include connecting to a database, adding data to tables, and retrieving data from tables in a database. There are also several issues you'll want to keep in mind while performing these tasks, such as working with data types and handling errors.

Note that there are also several database tasks that are things you'll deal with less frequently, but will often need to do before you can perform these more common tasks. For example, before you can connect to a database and retrieve data from a table, you'll need to create the database and create the table structure in the database. Those less-frequent initial setup tasks are discussed in "Creating and modifying a database" on page 718.

You can choose to perform database operations asynchronously, meaning the database engine runs in the background and notifies you when the operation succeeds or fails by dispatching an event. You can also perform these operations synchronously. In that case the database operations are performed one after another and the entire application (including updates to the screen) waits for the operations to complete before executing other code. For more information on working in asynchronous or synchronous execution mode, see "Using synchronous and asynchronous database operations" on page 753.

Connecting to a database

Adobe AIR 1.0 and later

Before you can perform any database operations, first open a connection to the database file. A SQLConnection instance is used to represent a connection to one or more databases. The first database that is connected using a SQLConnection instance is known as the "main" database. This database is connected using the `open()` method (for synchronous execution mode) or the `openAsync()` method (for asynchronous execution mode).

If you open a database using the asynchronous `openAsync()` operation, register for the SQLConnection instance's `open` event in order to know when the `openAsync()` operation completes. Register for the SQLConnection instance's `error` event to determine if the operation fails.

The following example shows how to open an existing database file for asynchronous execution. The database file is named "DBSample.db" and is located in the user's "Pointing to the application storage directory" on page 672.

```
import flash.data.SQLConnection;
import flash.data.SQLMode;
import flash.events.SQLErrorEvent;
import flash.events.SQLEvent;
import flash.filesystem.File;

var conn:SQLConnection = new SQLConnection();

conn.addEventListener(SQLEvent.OPEN, openHandler);
conn.addEventListener(SQLErrorEvent.ERROR, errorHandler);

// The database file is in the application storage directory
var folder:File = File.applicationStorageDirectory;
var dbFile:File = folder.resolvePath("DBSample.db");

conn.openAsync(dbFile, SQLMode.UPDATE);

function openHandler(event:SQLEvent):void
{
    trace("the database opened successfully");
}

function errorHandler(event:SQLErrorEvent):void
{
    trace("Error message:", event.error.message);
    trace("Details:", event.error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLMode;
            import flash.events.SQLErrorEvent;
            import flash.events.SQLEvent;
            import flash.filesystem.File;

            private function init():void
            {
                var conn:SQLConnection = new SQLConnection();

                conn.addEventListener(SQLEvent.OPEN, openHandler);
                conn.addEventListener(SQLErrorEvent.ERROR, errorHandler);

                // The database file is in the application storage directory
                var folder:File = File.applicationStorageDirectory;
                var dbFile:File = folder.resolvePath("DBSample.db");

                conn.openAsync(dbFile, SQLMode.UPDATE);
            }

            private function openHandler(event:SQLEvent):void
            {
                trace("the database opened successfully");
            }

            private function errorHandler(event:SQLErrorEvent):void
            {
                trace("Error message:", event.error.message);
                trace("Details:", event.error.details);
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

The following example shows how to open an existing database file for synchronous execution. The database file is named "DBSample.db" and is located in the user's "Pointing to the application storage directory" on page 672.

```
import flash.data.SQLConnection;
import flash.data.SQLMode;
import flash.errors.SQLError;
import flash.filesystem.File;

var conn:SQLConnection = new SQLConnection();

// The database file is in the application storage directory
var folder:File = File.applicationStorageDirectory;
var dbFile:File = folder.resolvePath("DBSample.db");

try
{
    conn.open(dbFile, SQLMode.UPDATE);
    trace("the database opened successfully");
}
catch (error:SQLError)
{
    trace("Error message:", error.message);
    trace("Details:", error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLMode;
            import flash.errors.SQLError;
            import flash.filesystem.File;

            private function init():void
            {
                var conn:SQLConnection = new SQLConnection();

                // The database file is in the application storage directory
                var folder:File = File.applicationStorageDirectory;
                var dbFile:File = folder.resolvePath("DBSample.db");

                try
                {
                    conn.open(dbFile, SQLMode.UPDATE);
                    trace("the database opened successfully");
                }
                catch (error:SQLError)
                {
                    trace("Error message:", error.message);
                    trace("Details:", error.details);
                }
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

Notice that in the `openAsync()` method call in the asynchronous example, and the `open()` method call in the synchronous example, the second argument is the constant `SQLMode.UPDATE`. Specifying `SQLMode.UPDATE` for the second parameter (`openMode`) causes the runtime to dispatch an error if the specified file doesn't exist. If you pass `SQLMode.CREATE` for the `openMode` parameter (or if you leave the `openMode` parameter off), the runtime attempts to create a database file if the specified file doesn't exist. However, if the file exists it is opened, which is the same as if you use `SQLMode.Update`. You can also specify `SQLMode.READ` for the `openMode` parameter to open an existing database in a read-only mode. In that case data can be retrieved from the database but no data can be added, deleted, or changed.

Working with SQL statements

Adobe AIR 1.0 and later

An individual SQL statement (a query or command) is represented in the runtime as a SQLStatement object. Follow these steps to create and execute a SQL statement:

Create a SQLStatement instance.
The SQLStatement object represents the SQL statement in your application.

```
var selectData:SQLStatement = new SQLStatement();
```

Specify which database the query runs against.
To do this, set the SQLStatement object's `sqlConnection` property to the SQLConnection instance that's connected with the desired database.

```
// A SQLConnection named "conn" has been created previously
selectData.sqlConnection = conn;
```

Specify the actual SQL statement.
Create the statement text as a String and assign it to the SQLStatement instance's `text` property.

```
selectData.text = "SELECT col1, col2 FROM my_table WHERE col1 = :param1";
```

Define functions to handle the result of the execute operation (asynchronous execution mode only).
Use the `addEventListener()` method to register functions as listeners for the SQLStatement instance's `result` and `error` events.

```
// using listener methods and addEventListener()

selectData.addEventListener(SQLEvent.RESULT, resultHandler);
selectData.addEventListener(SQLErrorEvent.ERROR, errorHandler);

function resultHandler(event:SQLEvent):void
{
    // do something after the statement execution succeeds
}

function errorHandler(event:SQLErrorEvent):void
{
    // do something after the statement execution fails
}
```

Alternatively, you can specify listener methods using a Responder object. In that case you create the Responder instance and link the listener methods to it.

```
// using a Responder (flash.net.Responder)

var selectResponder = new Responder(onResult, onError);

function onResult(result:SQLResult):void
{
    // do something after the statement execution succeeds
}

function onError(error:SQLError):void
{
    // do something after the statement execution fails
}
```

If the statement text includes parameter definitions, assign values for those parameters.
To assign parameter values, use the SQLStatement instance's `parameters` associative array property.

```
selectData.parameters[":param1"] = 25;
```

Execute the SQL statement.
Call the SQLStatement instance's `execute()` method.

```
// using synchronous execution mode
// or listener methods in asynchronous execution mode
selectData.execute();
```

Additionally, if you're using a Responder instead of event listeners in asynchronous execution mode, pass the Responder instance to the `execute()` method.

```
// using a Responder in asynchronous execution mode
selectData.execute(-1, selectResponder);
```

For specific examples that demonstrate these steps, see the following topics:

"Retrieving data from a database" on page 733

"Inserting data" on page 743

"Changing or deleting data" on page 749

Using parameters in statements

Adobe AIR 1.0 and later

Using SQL statement parameters allows you to create a reusable SQL statement. When you use statement parameters, values within the statement can change (such as values being added in an `INSERT` statement) but the basic statement text remains unchanged. Consequently, using parameters provides performance benefits and makes it easier to code an application.

Understanding statement parameters

Adobe AIR 1.0 and later

Frequently an application uses a single SQL statement multiple times in an application, with slight variation. For example, consider an inventory-tracking application where a user can add new inventory items to the database. The application code that adds an inventory item to the database executes a SQL `INSERT` statement that actually adds the data to the database. However, each time the statement is executed there is a slight variation. Specifically, the actual values that are inserted in the table are different because they are specific to the inventory item being added.

In cases where you have a SQL statement that's used multiple times with different values in the statement, the best approach is to use a SQL statement that includes parameters rather than literal values in the SQL text. A parameter is a placeholder in the statement text that is replaced with an actual value each time the statement is executed. To use parameters in a SQL statement, you create the SQLStatement instance as usual. For the actual SQL statement assigned to the `text` property, use parameter placeholders rather than literal values. You then define the value for each parameter by setting the value of an element in the SQLStatement instance's `parameters` property. The `parameters` property is an associative array, so you set a particular value using the following syntax:

```
statement.parameters[parameter_identifier] = value;
```

The *parameter_identifier* is a string if you're using a named parameter, or an integer index if you're using an unnamed parameter.

Using named parameters

Adobe AIR 1.0 and later

A parameter can be a named parameter. A named parameter has a specific name that the database uses to match the parameter value to its placeholder location in the statement text. A parameter name consists of the ":" or "@" character followed by a name, as in the following examples:

```
:itemName
@firstName
```

The following code listing demonstrates the use of named parameters:

```
var sql:String =
    "INSERT INTO inventoryItems (name, productCode)" +
    "VALUES (:name, :productCode)";

var addItemStmt:SQLStatement = new SQLStatement();
addItemStmt.sqlConnection = conn;
addItemStmt.text = sql;

// set parameter values
addItemStmt.parameters[":name"] = "Item name";
addItemStmt.parameters[":productCode"] = "12345";

addItemStmt.execute();
```

Using unnamed parameters

Adobe AIR 1.0 and later

As an alternative to using named parameters, you can also use unnamed parameters. To use an unnamed parameter you denote a parameter in a SQL statement using a "?" character. Each parameter is assigned a numeric index, according to the order of the parameters in the statement, starting with index 0 for the first parameter. The following example demonstrates a version of the previous example, using unnamed parameters:

```
var sql:String =
    "INSERT INTO inventoryItems (name, productCode)" +
    "VALUES (?, ?)";

var addItemStmt:SQLStatement = new SQLStatement();
addItemStmt.sqlConnection = conn;
addItemStmt.text = sql;

// set parameter values
addItemStmt.parameters[0] = "Item name";
addItemStmt.parameters[1] = "12345";

addItemStmt.execute();
```

Benefits of using parameters

Adobe AIR 1.0 and later

Using parameters in a SQL statement provides several benefits:

Better performance A SQLStatement instance that uses parameters can execute more efficiently compared to one that dynamically creates the SQL text each time it executes. The performance improvement is because the statement is prepared a single time and can then be executed multiple times using different parameter values, without needing to recompile the SQL statement.

Explicit data typing Parameters are used to allow for typed substitution of values that are unknown at the time the SQL statement is constructed. The use of parameters is the only way to guarantee the storage class for a value passed in to the database. When parameters are not used, the runtime attempts to convert all values from their text representation to a storage class based on the associated column's type affinity.

For more information on storage classes and column affinity, see "Data type support" on page 1125.

Greater security The use of parameters helps prevent a malicious technique known as a SQL injection attack. In a SQL injection attack, a user enters SQL code in a user-accessible location (for example, a data entry field). If application code constructs a SQL statement by directly concatenating user input into the SQL text, the user-entered SQL code is executed against the database. The following listing shows an example of concatenating user input into SQL text. **Do not use this technique**:

```
// assume the variables "username" and "password"
// contain user-entered data

var sql:String =
    "SELECT userId " +
    "FROM users " +
    "WHERE username = '" + username + "' " +
    "    AND password = '" + password + "'";

var statement:SQLStatement = new SQLStatement();
statement.text = sql;
```

Using statement parameters instead of concatenating user-entered values into a statement's text prevents a SQL injection attack. SQL injection can't happen because the parameter values are treated explicitly as substituted values, rather than becoming part of the literal statement text. The following is the recommended alternative to the previous listing:

```
// assume the variables "username" and "password"
// contain user-entered data

var sql:String =
    "SELECT userId " +
    "FROM users " +
    "WHERE username = :username " +
    "    AND password = :password";

var statement:SQLStatement = new SQLStatement();
statement.text = sql;

// set parameter values
statement.parameters[":username"] = username;
statement.parameters[":password"] = password;
```

Retrieving data from a database

Adobe AIR 1.0 and later

Retrieving data from a database involves two steps. First, you execute a SQL `SELECT` statement, describing the set of data you want from the database. Next, you access the retrieved data and display or manipulate it as needed by your application.

Executing a SELECT statement

Adobe AIR 1.0 and later

To retrieve existing data from a database, you use a SQLStatement instance. Assign the appropriate SQL `SELECT` statement to the instance's `text` property, then call its `execute()` method.

For details on the syntax of the `SELECT` statement, see "SQL support in local databases" on page 1104.

The following example demonstrates executing a `SELECT` statement to retrieve data from a table named "products," using asynchronous execution mode:

```
var selectStmt:SQLStatement = new SQLStatement();

// A SQLConnection named "conn" has been created previously
selectStmt.sqlConnection = conn;

selectStmt.text = "SELECT itemId, itemName, price FROM products";

selectStmt.addEventListener(SQLEvent.RESULT, resultHandler);
selectStmt.addEventListener(SQLErrorEvent.ERROR, errorHandler);

selectStmt.execute();

function resultHandler(event:SQLEvent):void
{
    var result:SQLResult = selectStmt.getResult();

    var numResults:int = result.data.length;
    for (var i:int = 0; i < numResults; i++)
    {
        var row:Object = result.data[i];
        var output:String = "itemId: " + row.itemId;
        output += "; itemName: " + row.itemName;
        output += "; price: " + row.price;
        trace(output);
    }
}

function errorHandler(event:SQLErrorEvent):void
{
    // Information about the error is available in the
    // event.error property, which is an instance of
    // the SQLError class.
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLResult;
            import flash.data.SQLStatement;
            import flash.errors.SQLError;
            import flash.events.SQLErrorEvent;
            import flash.events.SQLEvent;

            private function init():void
            {
                var selectStmt:SQLStatement = new SQLStatement();

                // A SQLConnection named "conn" has been created previously
                selectStmt.sqlConnection = conn;

                selectStmt.text = "SELECT itemId, itemName, price FROM products";

                selectStmt.addEventListener(SQLEvent.RESULT, resultHandler);
                selectStmt.addEventListener(SQLErrorEvent.ERROR, errorHandler);
                selectStmt.execute();
            }
            
            private function resultHandler(event:SQLEvent):void
            {
                var result:SQLResult = selectStmt.getResult();
                
                var numResults:int = result.data.length;
                for (var i:int = 0; i < numResults; i++)
                {
                    var row:Object = result.data[i];
                    var output:String = "itemId: " + row.itemId;
                    output += "; itemName: " + row.itemName;
                    output += "; price: " + row.price;
                    trace(output);
                }
            }
            
            private function errorHandler(event:SQLErrorEvent):void
            {
                // Information about the error is available in the
                // event.error property, which is an instance of
                // the SQLError class.
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

The following example demonstrates executing a `SELECT` statement to retrieve data from a table named "products," using synchronous execution mode:

```
var selectStmt:SQLStatement = new SQLStatement();

// A SQLConnection named "conn" has been created previously
selectStmt.sqlConnection = conn;

selectStmt.text = "SELECT itemId, itemName, price FROM products";

try
{
    selectStmt.execute();

    var result:SQLResult = selectStmt.getResult();

    var numResults:int = result.data.length;
    for (var i:int = 0; i < numResults; i++)
    {
        var row:Object = result.data[i];
        var output:String = "itemId: " + row.itemId;
        output += "; itemName: " + row.itemName;
        output += "; price: " + row.price;
        trace(output);
    }
}
catch (error:SQLError)
{
    // Information about the error is available in the
    // error variable, which is an instance of
    // the SQLError class.
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLResult;
            import flash.data.SQLStatement;
            import flash.errors.SQLError;
            import flash.events.SQLErrorEvent;
            import flash.events.SQLEvent;

            private function init():void
            {
                var selectStmt:SQLStatement = new SQLStatement();

                // A SQLConnection named "conn" has been created previously
                selectStmt.sqlConnection = conn;

                selectStmt.text = "SELECT itemId, itemName, price FROM products";

                try
                {
                    selectStmt.execute();

                    var result:SQLResult = selectStmt.getResult();
                    var numResults:int = result.data.length;
                    for (var i:int = 0; i < numResults; i++)
                    {
                        var row:Object = result.data[i];
                        var output:String = "itemId: " + row.itemId;
                        output += "; itemName: " + row.itemName;
                        output += "; price: " + row.price;
                        trace(output);
                    }
                }
                catch (error:SQLError)
                {
                    // Information about the error is available in the
                    // error variable, which is an instance of
                    // the SQLError class.
                }
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

In asynchronous execution mode, when the statement finishes executing, the SQLStatement instance dispatches a `result` event (`SQLEvent.RESULT`) indicating that the statement was run successfully. Alternatively, if a Responder object is passed as an argument to the `execute()` method, the Responder object's result handler function is called. In synchronous execution mode, execution pauses until the `execute()` operation completes, then continues on the next line of code.

Accessing SELECT statement result data

Adobe AIR 1.0 and later

Once the `SELECT` statement has finished executing, the next step is to access the data that was retrieved. You retrieve the result data from executing a `SELECT` statement by calling the SQLStatement object's `getResult()` method:

```
var result:SQLResult = selectStatement.getResult();
```

The `getResult()` method returns a SQLResult object. The SQLResult object's `data` property is an Array containing the results of the `SELECT` statement:

```
var numResults:int = result.data.length;
for (var i:int = 0; i < numResults; i++)
{
    // row is an Object representing one row of result data
    var row:Object = result.data[i];
}
```

Each row of data in the `SELECT` result set becomes an Object instance contained in the `data` Array. That object has properties whose names match the result set's column names. The properties contain the values from the result set's columns. For example, suppose a `SELECT` statement specifies a result set with three columns named "itemId," "itemName," and "price." For each row in the result set, an Object instance is created with properties named `itemId`, `itemName`, and `price`. Those properties contain the values from their respective columns.

The following code listing defines a SQLStatement instance whose text is a `SELECT` statement. The statement retrieves rows containing the `firstName` and `lastName` column values of all the rows of a table named `employees`. This example uses asynchronous execution mode. When the execution completes, the `selectResult()` method is called, and the resulting rows of data are accessed using `SQLStatement.getResult()` and displayed using the `trace()` method. Note that this listing assumes there is a SQLConnection instance named `conn` that has already been instantiated and is already connected to the database. It also assumes that the "employees" table has already been created and populated with data.

```
import flash.data.SQLConnection;
import flash.data.SQLResult;
import flash.data.SQLStatement;
import flash.events.SQLErrorEvent;
import flash.events.SQLEvent;

// ... create and open the SQLConnection instance named conn ...

// create the SQL statement
var selectStmt:SQLStatement = new SQLStatement();
selectStmt.sqlConnection = conn;

// define the SQL text
var sql:String =
    "SELECT firstName, lastName " +
    "FROM employees";
selectStmt.text = sql;

// register listeners for the result and error events
selectStmt.addEventListener(SQLEvent.RESULT, selectResult);
selectStmt.addEventListener(SQLErrorEvent.ERROR, selectError);

// execute the statement
selectStmt.execute();

function selectResult(event:SQLEvent):void
{
    // access the result data
    var result:SQLResult = selectStmt.getResult();

    var numRows:int = result.data.length;
    for (var i:int = 0; i < numRows; i++)
    {
        var output:String = "";
        for (var columnName:String in result.data[i])
        {
            output += columnName + ": " + result.data[i][columnName] + "; ";
        }
        trace("row[" + i.toString() + "]\t", output);
    }
}

function selectError(event:SQLErrorEvent):void
{
    trace("Error message:", event.error.message);
    trace("Details:", event.error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLResult;
            import flash.data.SQLStatement;
            import flash.events.SQLErrorEvent;
            import flash.events.SQLEvent;

            private function init():void
            {
                // ... create and open the SQLConnection instance named conn ...

                // create the SQL statement
                var selectStmt:SQLStatement = new SQLStatement();
                selectStmt.sqlConnection = conn;

                // define the SQL text
                var sql:String =
                    "SELECT firstName, lastName " +
                    "FROM employees";
                selectStmt.text = sql;

                // register listeners for the result and error events
                selectStmt.addEventListener(SQLEvent.RESULT, selectResult);
                selectStmt.addEventListener(SQLErrorEvent.ERROR, selectError);

                // execute the statement
                selectStmt.execute();
            }

            private function selectResult(event:SQLEvent):void
            {
                // access the result data
                var result:SQLResult = selectStmt.getResult();

                var numRows:int = result.data.length;
                for (var i:int = 0; i < numRows; i++)
                {
                    var output:String = "";
                    for (var columnName:String in result.data[i])
                    {
                        output += columnName + ": " + result.data[i][columnName] + "; ";
                    }
                    trace("row[" + i.toString() + "]\t", output);
                }
            }

            private function selectError(event:SQLErrorEvent):void
            {
                trace("Error message:", event.error.message);
                trace("Details:", event.error.details);
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

The following code listing demonstrates the same techniques as the preceding one, but uses synchronous execution mode. The example defines a SQLStatement instance whose text is a `SELECT` statement. The statement retrieves rows containing the `firstName` and `lastName` column values of all the rows of a table named `employees`. The resulting rows of data are accessed using `SQLStatement.getResult()` and displayed using the `trace()` method. Note that this listing assumes there is a SQLConnection instance named `conn` that has already been instantiated and is already connected to the database. It also assumes that the "employees" table has already been created and populated with data.

```
import flash.data.SQLConnection;
import flash.data.SQLResult;
import flash.data.SQLStatement;
import flash.errors.SQLError;

// ... create and open the SQLConnection instance named conn ...

// create the SQL statement
var selectStmt:SQLStatement = new SQLStatement();
selectStmt.sqlConnection = conn;

// define the SQL text
var sql:String =
    "SELECT firstName, lastName " +
    "FROM employees";
selectStmt.text = sql;

try
{
    // execute the statement
    selectStmt.execute();

    // access the result data
    var result:SQLResult = selectStmt.getResult();

    var numRows:int = result.data.length;
    for (var i:int = 0; i < numRows; i++)
    {
        var output:String = "";
        for (var columnName:String in result.data[i])
        {
            output += columnName + ": " + result.data[i][columnName] + "; ";
        }
        trace("row[" + i.toString() + "]\t", output);
    }
}
catch (error:SQLError)
{
    trace("Error message:", error.message);
    trace("Details:", error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLResult;
            import flash.data.SQLStatement;
            import flash.errors.SQLError;

            private function init():void
            {
                // ... create and open the SQLConnection instance named conn ...

                // create the SQL statement
                var selectStmt:SQLStatement = new SQLStatement();
                selectStmt.sqlConnection = conn;

                // define the SQL text
                var sql:String =
                    "SELECT firstName, lastName " +
                    "FROM employees";
                selectStmt.text = sql;

                try
                {
                    // execute the statement
                    selectStmt.execute();

                    // access the result data
                    var result:SQLResult = selectStmt.getResult();

                    var numRows:int = result.data.length;
                    for (var i:int = 0; i < numRows; i++)
                    {
                        var output:String = "";
                        for (var columnName:String in result.data[i])
                        {
                            output += columnName + ": ";
                            output += result.data[i][columnName] + "; ";
                        }
                        trace("row[" + i.toString() + "]\t", output);
                    }
                }
                catch (error:SQLError)
                {
                    trace("Error message:", error.message);
                    trace("Details:", error.details);
                }
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

Defining the data type of SELECT result data

Adobe AIR 1.0 and later

By default, each row returned by a `SELECT` statement is created as an Object instance with properties named for the result set's column names and with the value of each column as the value of its associated property. However, before executing a SQL `SELECT` statement, you can set the `itemClass` property of the SQLStatement instance to a class. By setting the `itemClass` property, each row returned by the `SELECT` statement is created as an instance of the designated class. The runtime assigns result column values to property values by matching the column names in the `SELECT` result set to the names of the properties in the `itemClass` class.

Any class assigned as an `itemClass` property value must have a constructor that does not require any parameters. In addition, the class must have a single property for each column returned by the `SELECT` statement. It is considered an error if a column in the `SELECT` list does not have a matching property name in the `itemClass` class.

Retrieving SELECT results in parts

Adobe AIR 1.0 and later

By default, a `SELECT` statement execution retrieves all the rows of the result set at one time. Once the statement completes, you usually process the retrieved data in some way, such as creating objects or displaying the data on the screen. If the statement returns a large number of rows, processing all the data at once can be demanding for the computer, which in turn will cause the user interface to not redraw itself.

You can improve the perceived performance of your application by instructing the runtime to return a specific number of result rows at a time. Doing so causes the initial result data to return more quickly. It also allows you to divide the result rows into sets, so that the user interface is updated after each set of rows is processed. Note that it's only practical to use this technique in asynchronous execution mode.

To retrieve `SELECT` results in parts, specify a value for the `SQLStatement.execute()` method's first parameter (the `prefetch` parameter). The `prefetch` parameter indicates the number of rows to retrieve the first time the statement executes. When you call a SQLStatement instance's `execute()` method, specify a `prefetch` parameter value and only that many rows are retrieved:

```
var stmt:SQLStatement = new SQLStatement();
stmt.sqlConnection = conn;

stmt.text = "SELECT ...";

stmt.addEventListener(SQLEvent.RESULT, selectResult);

stmt.execute(20); // only the first 20 rows (or fewer) are returned
```

The statement dispatches the `result` event, indicating that the first set of result rows is available. The resulting SQLResult instance's `data` property contains the rows of data, and its `complete` property indicates whether there are additional result rows to retrieve. To retrieve additional result rows, call the SQLStatement instance's `next()` method. Like the `execute()` method, the `next()` method's first parameter is used to indicate how many rows to retrieve the next time the result event is dispatched.

```
function selectResult(event:SQLEvent):void
{
    var result:SQLResult = stmt.getResult();
    if (result.data != null)
    {
        // ... loop through the rows or perform other processing ...

        if (!result.complete)
        {
            stmt.next(20); // retrieve the next 20 rows
        }
        else
        {
            stmt.removeEventListener(SQLEvent.RESULT, selectResult);
        }
    }
}
```

The SQLStatement dispatches a `result` event each time the `next()` method returns a subsequent set of result rows. Consequently, the same listener function can be used to continue processing results (from `next()` calls) until all the rows are retrieved.

For more information, see the descriptions for the `SQLStatement.execute()` method (the `prefetch` parameter description) and the `SQLStatement.next()` method.

Inserting data

Adobe AIR 1.0 and later

Adding data to a database involves executing a SQL `INSERT` statement. Once the statement has finished executing, you can access the primary key for the newly inserted row if the key was generated by the database.

Executing an INSERT statement

Adobe AIR 1.0 and later

To add data to a table in a database, you create and execute a SQLStatement instance whose text is a SQL `INSERT` statement.

The following example uses a SQLStatement instance to add a row of data to the already-existing employees table. This example demonstrates inserting data using asynchronous execution mode. Note that this listing assumes that there is a SQLConnection instance named `conn` that has already been instantiated and is already connected to a database. It also assumes that the "employees" table has already been created.

```
import flash.data.SQLConnection;
import flash.data.SQLResult;
import flash.data.SQLStatement;
import flash.events.SQLErrorEvent;
import flash.events.SQLEvent;

// ... create and open the SQLConnection instance named conn ...

// create the SQL statement
var insertStmt:SQLStatement = new SQLStatement();
insertStmt.sqlConnection = conn;

// define the SQL text
var sql:String =
    "INSERT INTO employees (firstName, lastName, salary) " +
    "VALUES ('Bob', 'Smith', 8000)";
insertStmt.text = sql;

// register listeners for the result and failure (status) events
insertStmt.addEventListener(SQLEvent.RESULT, insertResult);
insertStmt.addEventListener(SQLErrorEvent.ERROR, insertError);

// execute the statement
insertStmt.execute();

function insertResult(event:SQLEvent):void
{
    trace("INSERT statement succeeded");
}

function insertError(event:SQLErrorEvent):void
{
    trace("Error message:", event.error.message);
    trace("Details:", event.error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLResult;
            import flash.data.SQLStatement;
            import flash.events.SQLErrorEvent;
            import flash.events.SQLEvent;

            private function init():void
            {
                // ... create and open the SQLConnection instance named conn ...

                // create the SQL statement
                var insertStmt:SQLStatement = new SQLStatement();
                insertStmt.sqlConnection = conn;

                // define the SQL text
                var sql:String =
                    "INSERT INTO employees (firstName, lastName, salary) " +
                    "VALUES ('Bob', 'Smith', 8000)";
                insertStmt.text = sql;

                // register listeners for the result and failure (status) events
                insertStmt.addEventListener(SQLEvent.RESULT, insertResult);
                insertStmt.addEventListener(SQLErrorEvent.ERROR, insertError);

                // execute the statement
                insertStmt.execute();
            }

            private function insertResult(event:SQLEvent):void
            {
                trace("INSERT statement succeeded");
            }

            private function insertError(event:SQLErrorEvent):void
            {
                trace("Error message:", event.error.message);
                trace("Details:", event.error.details);
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

The following example adds a row of data to the already-existing employees table, using synchronous execution mode. Note that this listing assumes that there is a SQLConnection instance named `conn` that has already been instantiated and is already connected to a database. It also assumes that the "employees" table has already been created.

```
import flash.data.SQLConnection;
import flash.data.SQLResult;
import flash.data.SQLStatement;
import flash.errors.SQLError;

// ... create and open the SQLConnection instance named conn ...

// create the SQL statement
var insertStmt:SQLStatement = new SQLStatement();
insertStmt.sqlConnection = conn;

// define the SQL text
var sql:String =
    "INSERT INTO employees (firstName, lastName, salary) " +
    "VALUES ('Bob', 'Smith', 8000)";
insertStmt.text = sql;

try
{
    // execute the statement
    insertStmt.execute();

    trace("INSERT statement succeeded");
}
catch (error:SQLError)
{
    trace("Error message:", error.message);
    trace("Details:", error.details);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" creationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.data.SQLConnection;
            import flash.data.SQLResult;
            import flash.data.SQLStatement;
            import flash.errors.SQLError;

            private function init():void
            {
                // ... create and open the SQLConnection instance named conn ...

                // create the SQL statement
                var insertStmt:SQLStatement = new SQLStatement();
                insertStmt.sqlConnection = conn;

                // define the SQL text
                var sql:String =
                    "INSERT INTO employees (firstName, lastName, salary) " +
                    "VALUES ('Bob', 'Smith', 8000)";
                insertStmt.text = sql;

                try
                {
                    // execute the statement
                    insertStmt.execute();
                    trace("INSERT statement succeeded");
                }
                catch (error:SQLError)
                {
                    trace("Error message:", error.message);
                    trace("Details:", error.details);
                }
            }
        ]]>
    </mx:Script>
</mx:WindowedApplication>
```

Retrieving a database-generated primary key of an inserted row

Adobe AIR 1.0 and later

Often after inserting a row of data into a table, your code needs to know a database-generated primary key or row identifier value for the newly inserted row. For example, once you insert a row in one table, you might want to add rows in a related table. In that case you would want to insert the primary key value as a foreign key in the related table. The primary key of a newly inserted row can be retrieved using the SQLResult object associated with the statement execution. This is the same object that's used to access result data after a `SELECT` statement is executed. As with any SQL statement, when the execution of an `INSERT` statement completes the runtime creates a SQLResult instance. You access the SQLResult instance by calling the SQLStatement object's `getResult()` method if you're using an event listener or if you're using synchronous execution mode. Alternatively, if you're using asynchronous execution mode and you pass a Responder instance to the `execute()` call, the SQLResult instance is passed as an argument to the result handler function. In any case, the SQLResult instance has a property, `lastInsertRowID`, that contains the row identifier of the most-recently inserted row if the executed SQL statement is an `INSERT` statement.

The following example demonstrates accessing the primary key of an inserted row in asynchronous execution mode:

```
insertStmt.text = "INSERT INTO ...";

insertStmt.addEventListener(SQLEvent.RESULT, resultHandler);

insertStmt.execute();

function resultHandler(event:SQLEvent):void
{
    // get the primary key
    var result:SQLResult = insertStmt.getResult();

    var primaryKey:Number = result.lastInsertRowID;
    // do something with the primary key
}
```

The following example demonstrates accessing the primary key of an inserted row in synchronous execution mode:

```
insertStmt.text = "INSERT INTO ...";

try
{
    insertStmt.execute();

    // get the primary key
    var result:SQLResult = insertStmt.getResult();

    var primaryKey:Number = result.lastInsertRowID;
    // do something with the primary key
}
catch (error:SQLError)
{
    // respond to the error
}
```

Note that the row identifier may or may not be the value of the column that is designated as the primary key column in the table definition, according to the following rules:

- If the table is defined with a primary key column whose affinity (column data type) is `INTEGER`, the `lastInsertRowID` property contains the value that was inserted into that row (or the value generated by the runtime if it's an `AUTOINCREMENT` column).
- If the table is defined with multiple primary key columns (a composite key) or with a single primary key column whose affinity is not `INTEGER`, behind the scenes the database generates an integer row identifier value for the row. That generated value is the value of the `lastInsertRowID` property.
- The value is always the row identifier of the most-recently inserted row. If an `INSERT` statement causes a trigger to fire which in turn inserts a row, the `lastInsertRowID` property contains the row identifier of the last row inserted by the trigger rather than the row created by the `INSERT` statement.

As a consequence of these rules, if you want to have an explicitly defined primary key column whose value is available after an `INSERT` command through the `SQLResult.lastInsertRowID` property, the column must be defined as an `INTEGER PRIMARY KEY` column. Even if your table does not include an explicit `INTEGER PRIMARY KEY` column, it is equally acceptable to use the database-generated row identifier as a primary key for your table in the sense of defining relationships with related tables. The row identifier column value is available in any SQL statement by using one of the special column names `ROWID`, `_ROWID_`, or `OID`. You can create a foreign key column in a related table and use the row identifier value as the foreign key column value just as you would with an explicitly declared `INTEGER PRIMARY KEY` column. In that sense, if you are using an arbitrary primary key rather than a natural key, and as long as you don't mind the runtime generating the primary key value for you, it makes little difference whether you use an `INTEGER PRIMARY KEY` column or the system-generated row identifier as a table's primary key for defining a foreign key relationship with between two tables.

For more information about primary keys and generated row identifiers, see "SQL support in local databases" on page 1104.

Changing or deleting data

Adobe AIR 1.0 and later

The process for executing other data manipulation operations is identical to the process used to execute a SQL `SELECT` or `INSERT` statement, as described in "Working with SQL statements" on page 729. Simply substitute a different SQL statement in the SQLStatement instance's `text` property:

- To change existing data in a table, use an `UPDATE` statement.
- To delete one or more rows of data from a table, use a `DELETE` statement.

For descriptions of these statements, see "SQL support in local databases" on page 1104.

Working with multiple databases

Adobe AIR 1.0 and later

Use the `SQLConnection.attach()` method to open a connection to an additional database on a SQLConnection instance that already has an open database. You give the attached database a name using the name parameter in the `attach()` method call. When writing statements to manipulate that database, you can then use that name in a prefix (using the form `database-name.table-name`) to qualify any table names in your SQL statements, indicating to the runtime that the table can be found in the named database.

You can execute a single SQL statement that includes tables from multiple databases that are connected to the same SQLConnection instance. If a transaction is created on the SQLConnection instance, that transaction applies to all SQL statements that are executed using the SQLConnection instance. This is true regardless of which attached database the statement runs on.

Alternatively, you can also create multiple SQLConnection instances in an application, each of which is connected to one or multiple databases. However, if you do use multiple connections to the same database keep in mind that a database transaction isn't shared across SQLConnection instances. Consequently, if you connect to the same database file using multiple SQLConnection instances, you can't rely on both connections' data changes being applied in the expected manner. For example, if two `UPDATE` or `DELETE` statements are run against the same database through different SQLConnection instances, and an application error occurs after one operation takes place, the database data could be left in an intermediate state that would not be reversible and might affect the integrity of the database (and consequently the application).

Handling database errors

Adobe AIR 1.0 and later

In general, database error handling is like other runtime error handling. You should write code that is prepared for errors that may occur, and respond to the errors rather than leave it up to the runtime to do so. In a general sense, the possible database errors can be divided into three categories: connection errors, SQL syntax errors, and constraint errors.

Connection errors

Adobe AIR 1.0 and later

Most database errors are connection errors, and they can occur during any operation. Although there are strategies for preventing connection errors, there is rarely a simple way to gracefully recover from a connection error if the database is a critical part of your application.

Most connection errors have to do with how the runtime interacts with the operating system, the file system, and the database file. For example, a connection error occurs if the user doesn't have permission to create a database file in a particular location on the file system. The following strategies help to prevent connection errors:

Use user-specific database files Rather than using a single database file for all users who use the application on a single computer, give each user their own database file. The file should be located in a directory that's associated with the user's account. For example, it could be in the application's storage directory, the user's documents folder, the user's desktop, and so forth.

Consider different user types Test your application with different types of user accounts, on different operating systems. Don't assume that the user has administrator permission on the computer. Also, don't assume that the individual who installed the application is the user who's running the application.

Consider various file locations If you allow a user to specify where to save a database file or select a file to open, consider the possible file locations that the users might use. In addition, consider defining limits on where users can store (or from where they can open) database files. For example, you might only allow users to open files that are within their user account's storage location.

If a connection error occurs, it most likely happens on the first attempt to create or open the database. This means that the user is unable to do any database-related operations in the application. For certain types of errors, such as read-only or permission errors, one possible recovery technique is to copy the database file to a different location. The application can copy the database file to a different location where the user does have permission to create and write to files, and use that location instead.

Syntax errors

Adobe AIR 1.0 and later

A syntax error occurs when a SQL statement is incorrectly formed, and the application attempts to execute the statement. Because local database SQL statements are created as strings, compile-time SQL syntax checking is not possible. All SQL statements must be executed to check their syntax. Use the following strategies to prevent SQL syntax errors:

Test all SQL statements thoroughly If possible, while developing your application test your SQL statements separately before encoding them as statement text in the application code. In addition, use a code-testing approach such as unit testing to create a set of tests that exercise every possible option and variation in the code.

Use statement parameters and avoid concatenating (dynamically generating) SQL Using parameters, and avoiding dynamically built SQL statements, means that the same SQL statement text is used each time a statement is executed. Consequently, it's much easier to test your statements and limit the possible variation. If you must dynamically generate a SQL statement, keep the dynamic parts of the statement to a minimum. Also, carefully validate any user input to make sure it won't cause syntax errors.

To recover from a syntax error, an application would need complex logic to be able to examine a SQL statement and correct its syntax. By following the previous guidelines for preventing syntax errors, your code can identify any potential run-time sources of SQL syntax errors (such as user input used in a statement). To recover from a syntax error, provide guidance to the user. Indicate what to correct to make the statement execute properly.

Constraint errors

Adobe AIR 1.0 and later

Constraint errors occur when an `INSERT` or `UPDATE` statement attempts to add data to a column. The error happens if the new data violates one of the defined constraints for the table or column. The set of possible constraints includes:

Unique constraint Indicates that across all the rows in a table, there cannot be duplicate values in one column. Alternatively, when multiple columns are combined in a unique constraint, the combination of values in those columns must not be duplicated. In other words, in terms of the specified unique column or columns, each row must be distinct.

Primary key constraint In terms of the data that a constraint allows and doesn't allow, a primary key constraint is identical to a unique constraint.

Not null constraint Specifies that a single column cannot store a `NULL` value and consequently that in every row, that column must have a value.

Check constraint Allows you to specify an arbitrary constraint on one or more tables. A common check constraint is a rule that define that a column's value must be within certain bounds (for example, that a numeric column's value must be larger than 0). Another common type of check constraint specifies relationships between column values (for example, that a column's value must be different from the value of another column in the same row).

Data type (column affinity) constraint The runtime enforces the data type of columns' values, and an error occurs if an attempt is made to store a value of the incorrect type in a column. However, in many conditions values are converted to match the column's declared data type. See "Working with database data types" on page 752 for more information.

The runtime does not enforce constraints on foreign key values. In other words, foreign key values aren't required to match an existing primary key value.

In addition to the predefined constraint types, the runtime SQL engine supports the use of triggers. A trigger is like an event handler. It is a predefined set of instructions that are carried out when a certain action happens. For example, a trigger could be defined that runs when data is inserted into or deleted from a particular table. One possible use of a trigger is to examine data changes and cause an error to occur if specified conditions aren't met. Consequently, a trigger can serve the same purpose as a constraint, and the strategies for preventing and recovering from constraint errors also apply to trigger-generated errors. However, the error id for trigger-generated errors is different from the error id for constraint errors.

The set of constraints that apply to a particular table is determined while you're designing an application. Consciously designing constraints makes it easier to design your application to prevent and recover from constraint errors. However, constraint errors are difficult to systematically predict and prevent. Prediction is difficult because constraint errors don't appear until application data is added. Constraint errors occur with data that is added to a database after it's created. These errors are often a result of the relationship between new data and data that already exists in the database. The following strategies can help you avoid many constraint errors:

Carefully plan database structure and constraints The purpose of constraints is to enforce application rules and help protect the integrity of the database's data. When you're planning your application, consider how to structure your database to support your application. As part of that process, identify rules for your data, such as whether certain values are required, whether a value has a default, whether duplicate values are allowed, and so forth. Those rules guide you in defining database constraints.

Explicitly specify column names An `INSERT` statement can be written without explicitly specifying the columns into which values are to be inserted, but doing so is an unnecessary risk. By explicitly naming the columns into which values are to be inserted, you can allow for automatically generated values, columns with default values, and columns that allow `NULL` values. In addition, by doing so you can ensure that all `NOT NULL` columns have an explicit value inserted.

Use default values Whenever you specify a `NOT NULL` constraint for a column, if at all possible specify a default value in the column definition. Application code can also provide default values. For example, your code can check if a String variable is `null` and assign it a value before using it to set a statement parameter value.

Validate user-entered data Check user-entered data ahead of time to make sure that it obeys limits specified by constraints, especially in the case of `NOT NULL` and `CHECK` constraints. Naturally, a `UNIQUE` constraint is more difficult to check for because doing so would require executing a `SELECT` query to determine whether the data is unique.

Use triggers You can write a trigger that validates (and possibly replaces) inserted data or takes other actions to correct invalid data. This validation and correction can prevent a constraint error from occurring.

In many ways constraint errors are more difficult to prevent than other types of errors. Fortunately, there are several strategies to recover from constraint errors in ways that don't make the application unstable or unusable:

Use conflict algorithms When you define a constraint on a column, and when you create an `INSERT` or `UPDATE` statement, you have the option of specifying a conflict algorithm. A conflict algorithm defines the action the database takes when a constraint violation occurs. There are several possible actions the database engine can take. The database engine can end a single statement or a whole transaction. It can ignore the error. It can even remove old data and replace it with the data that the code is attempting to store.

For more information see the section "ON CONFLICT (conflict algorithms)" in the "SQL support in local databases" on page 1104.

Provide corrective feedback The set of constraints that can affect a particular SQL command can be identified ahead of time. Consequently, you can anticipate constraint errors that a statement could cause. With that knowledge, you can build application logic to respond to a constraint error. For example, suppose an application includes a data entry form for entering new products. If the product name column in the database is defined with a `UNIQUE` constraint, the action of inserting a new product row in the database could cause a constraint error. Consequently, the application is designed to anticipate a constraint error. When the error happens, the application alerts the user, indicating that the specified product name is already in use and asking the user to choose a different name. Another possible response is to allow the user to view information about the other product with the same name.

Working with database data types

Adobe AIR 1.0 and later

When a table is created in a database, the SQL statement for creating the table defines the affinity, or data type, for each column in the table. Although affinity declarations can be omitted, it's a good idea to explicitly declare column affinity in your `CREATE TABLE` SQL statements.

As a general rule, any object that you store in a database using an `INSERT` statement is returned as an instance of the same data type when you execute a `SELECT` statement. However, the data type of the retrieved value can be different depending on the affinity of the database column in which the value is stored. When a value is stored in a column, if its data type doesn't match the column's affinity, the database attempts to convert the value to match the column's affinity. For example, if a database column is declared with `NUMERIC` affinity, the database attempts to convert inserted data into a numeric storage class (`INTEGER` or `REAL`) before storing the data. The database throws an error if the data can't be converted. According to this rule, if the String "12345" is inserted into a `NUMERIC` column, the database automatically converts it to the integer value 12345 before storing it in the database. When it's retrieved with a `SELECT` statement, the value is returned as an instance of a numeric data type (such as Number) rather than as a String instance.

The best way to avoid undesirable data type conversion is to follow two rules. First, define each column with the affinity that matches the type of data that it is intended to store. Next, only insert values whose data type matches the defined affinity. Following these rules provides two benefits. When you insert the data it isn't converted unexpectedly (possibly losing its intended meaning as a result). In addition, when you retrieve the data it is returned with its original data type.

For more information about the available column affinity types and using data types in SQL statements, see the "Data type support" on page 1125.

Using synchronous and asynchronous database operations

Adobe AIR 1.0 and later

Previous sections have described common database operations such as retrieving, inserting, updating, and deleting data, as well as creating a database file and tables and other objects within a database. The examples have demonstrated how to perform these operations both asynchronously and synchronously.

As a reminder, in asynchronous execution mode, you instruct the database engine to perform an operation. The database engine then works in the background while the application keeps running. When the operation finishes the database engine dispatches an event to alert you to that fact. The key benefit of asynchronous execution is that the runtime performs the database operations in the background while the main application code continues executing. This is especially valuable when the operation takes a notable amount of time to run.

On the other hand, in synchronous execution mode operations don't run in the background. You tell the database engine to perform an operation. The code pauses at that point while the database engine does its work. When the operation completes, execution continues with the next line of your code.

A single database connection can't execute some operations or statements synchronously and others asynchronously. You specify whether a SQLConnection operates in synchronous or asynchronous when you open the connection to the database. If you call `SQLConnection.open()` the connection operates in synchronous execution mode, and if you call `SQLConnection.openAsync()` the connection operates in asynchronous execution mode. Once a SQLConnection instance is connected to a database using `open()` or `openAsync()`, it is fixed to synchronous or asynchronous execution.

Using synchronous database operations

Adobe AIR 1.0 and later

There is little difference in the actual code that you use to execute and respond to operations when using synchronous execution, compared to the code for asynchronous execution mode. The key differences between the two approaches fall into two areas. The first is executing an operation that depends on another operation (such as `SELECT` result rows or the primary key of the row added by an `INSERT` statement). The second area of difference is in handling errors.

Writing code for synchronous operations

Adobe AIR 1.0 and later

The key difference between synchronous and asynchronous execution is that in synchronous mode you write the code as a single series of steps. In contrast, in asynchronous code you register event listeners and often divide operations among listener methods. When a database is connected in synchronous execution mode, you can execute a series of database operations in succession within a single code block. The following example demonstrates this technique:

```
var conn:SQLConnection = new SQLConnection();

// The database file is in the application storage directory
var folder:File = File.applicationStorageDirectory;
var dbFile:File = folder.resolvePath("DBSample.db");

// open the database
conn.open(dbFile, OpenMode.UPDATE);

// start a transaction
conn.begin();

// add the customer record to the database
var insertCustomer:SQLStatement = new SQLStatement();
insertCustomer.sqlConnection = conn;
insertCustomer.text =
    "INSERT INTO customers (firstName, lastName) " +
    "VALUES ('Bob', 'Jones')";
insertCustomer.execute();

var customerId:Number = insertCustomer.getResult().lastInsertRowID;

// add a related phone number record for the customer
var insertPhoneNumber:SQLStatement = new SQLStatement();
insertPhoneNumber.sqlConnection = conn;
insertPhoneNumber.text =
    "INSERT INTO customerPhoneNumbers (customerId, number) " +
    "VALUES (:customerId, '800-555-1234')";
insertPhoneNumber.parameters[":customerId"] = customerId;
insertPhoneNumber.execute();

// commit the transaction
conn.commit();
```

As you can see, you call the same methods to perform database operations whether you're using synchronous or asynchronous execution. The key differences between the two approaches are executing an operation that depends on another operation and handling errors.

Executing an operation that depends on another operation

Adobe AIR 1.0 and later

When you're using synchronous execution mode, you don't need to write code that listens for an event to determine when an operation completes. Instead, you can assume that if an operation in one line of code completes successfully, execution continues with the next line of code. Consequently, to perform an operation that depends on the success of another operation, simply write the dependent code immediately following the operation on which it depends. For instance, to code an application to begin a transaction, execute an `INSERT` statement, retrieve the primary key of the inserted row, insert that primary key into another row of a different table, and finally commit the transaction, the code can all be written as a series of statements. The following example demonstrates these operations:

```
var conn:SQLConnection = new SQLConnection();

// The database file is in the application storage directory
var folder:File = File.applicationStorageDirectory;
var dbFile:File = folder.resolvePath("DBSample.db");

// open the database
conn.open(dbFile, SQLMode.UPDATE);

// start a transaction
conn.begin();

// add the customer record to the database
var insertCustomer:SQLStatement = new SQLStatement();
insertCustomer.sqlConnection = conn;
insertCustomer.text =
    "INSERT INTO customers (firstName, lastName) " +
    "VALUES ('Bob', 'Jones')";
insertCustomer.execute();

var customerId:Number = insertCustomer.getResult().lastInsertRowID;

// add a related phone number record for the customer
var insertPhoneNumber:SQLStatement = new SQLStatement();
insertPhoneNumber.sqlConnection = conn;
insertPhoneNumber.text =
    "INSERT INTO customerPhoneNumbers (customerId, number) " +
    "VALUES (:customerId, '800-555-1234')";
insertPhoneNumber.parameters[":customerId"] = customerId;
insertPhoneNumber.execute();

// commit the transaction
conn.commit();
```

Handling errors with synchronous execution

Adobe AIR 1.0 and later

In synchronous execution mode, you don't listen for an error event to determine that an operation has failed. Instead, you surround any code that could trigger errors in a set of `try..catch..finally` code blocks. You wrap the error-throwing code in the `try` block. Write the actions to perform in response to each type of error in separate `catch` blocks. Place any code that you want to always execute regardless of success or failure (for example, closing a database connection that's no longer needed) in a `finally` block. The following example demonstrates using `try..catch..finally` blocks for error handling. It builds on the previous example by adding error handling code:

```
var conn:SQLConnection = new SQLConnection();

// The database file is in the application storage directory
var folder:File = File.applicationStorageDirectory;
var dbFile:File = folder.resolvePath("DBSample.db");

// open the database
conn.open(dbFile, SQLMode.UPDATE);

// start a transaction
conn.begin();

try
{
    // add the customer record to the database
    var insertCustomer:SQLStatement = new SQLStatement();
    insertCustomer.sqlConnection = conn;
    insertCustomer.text =
        "INSERT INTO customers (firstName, lastName)" +
        "VALUES ('Bob', 'Jones')";

    insertCustomer.execute();

    var customerId:Number = insertCustomer.getResult().lastInsertRowID;

    // add a related phone number record for the customer
    var insertPhoneNumber:SQLStatement = new SQLStatement();
    insertPhoneNumber.sqlConnection = conn;
    insertPhoneNumber.text =
        "INSERT INTO customerPhoneNumbers (customerId, number)" +
        "VALUES (:customerId, '800-555-1234')";
    insertPhoneNumber.parameters[":customerId"] = customerId;

    insertPhoneNumber.execute();

    // if we've gotten to this point without errors, commit the transaction
    conn.commit();
}
catch (error:SQLError)
{
    // rollback the transaction
    conn.rollback();
}
```

Understanding the asynchronous execution model

Adobe AIR 1.0 and later

One common concern about using asynchronous execution mode is the assumption that you can't start executing a SQLStatement instance if another SQLStatement is currently executing against the same database connection. In fact, this assumption isn't correct. While a SQLStatement instance is executing you can't change the `text` property of the statement. However, if you use a separate SQLStatement instance for each different SQL statement that you want to execute, you can call the `execute()` method of a SQLStatement while another SQLStatement instance is still executing, without causing an error.

Internally, when you're executing database operations using asynchronous execution mode, each database connection (each SQLConnection instance) has its own queue or list of operations that it is instructed to perform. The runtime executes each operation in sequence, in the order they are added to the queue. When you create a SQLStatement instance and call its `execute()` method, that statement execution operation is added to the queue for the connection. If no operation is currently executing on that SQLConnection instance, the statement begins executing in the background. Suppose that within the same block of code you create another SQLStatement instance and also call that method's `execute()` method. That second statement execution operation is added to the queue behind the first statement. As soon as the first statement finishes executing, the runtime moves to the next operation in the queue. The processing of subsequent operations in the queue happens in the background, even while the `result` event for the first operation is being dispatched in the main application code. The following code demonstrates this technique:

```
// Using asynchronous execution mode
var stmt1:SQLStatement = new SQLStatement();
stmt1.sqlConnection = conn;

// ... Set statement text and parameters, and register event listeners ...

stmt1.execute();

// At this point stmt1's execute() operation is added to conn's execution queue.

var stmt2:SQLStatement = new SQLStatement();
stmt2.sqlConnection = conn;

// ... Set statement text and parameters, and register event listeners ...

stmt2.execute();

// At this point stmt2's execute() operation is added to conn's execution queue.
// When stmt1 finishes executing, stmt2 will immediately begin executing
// in the background.
```

There is an important side effect of the database automatically executing subsequent queued statements. If a statement depends on the outcome of another operation, you can't add the statement to the queue (in other words, you can't call its `execute()` method) until the first operation completes. This is because once you've called the second statement's `execute()` method, you can't change the statement's `text` or `parameters` properties. In that case you must wait for the event indicating that the first operation completes before starting the next operation. For example, if you want to execute a statement in the context of a transaction, the statement execution depends on the operation of opening the transaction. After calling the `SQLConnection.begin()` method to open the transaction, you need to wait for the SQLConnection instance to dispatch its `begin` event. Only then can you call the SQLStatement instance's `execute()` method. In this example the simplest way to organize the application to ensure that the operations are executed properly is to create a method that's registered as a listener for the `begin` event. The code to call the `SQLStatement.execute()` method is placed within that listener method.

Using encryption with SQL databases

Adobe AIR 1.5 and later

All Adobe AIR applications share the same local database engine. Consequently, any AIR application can connect to, read from, and write to an unencrypted database file. Starting with Adobe AIR 1.5, AIR includes the capability of creating and connecting to encrypted database files. When you use an encrypted database, in order to connect to the database an application must provide the correct encryption key. If the incorrect encryption key (or no key) is provided, the application is not able to connect to the database. Consequently, the application can't read data from the database or write to or change data in the database.

To use an encrypted database, you must create the database as an encrypted database. With an existing encrypted database, you can open a connection to the database. You can also change the encryption key of an encrypted database. Other than creating and connecting to encrypted databases, the techniques for working with an encrypted database are the same as for working with an unencrypted one. In particular, executing SQL statements is the same regardless of whether a database is encrypted or not.

Uses for an encrypted database

Adobe AIR 1.5 and later

Encryption is useful any time you want to restrict access to the information stored in a database. The database encryption functionality of Adobe AIR can be used for several purposes. The following are some examples of cases where you would want to use an encrypted database:

- A read-only cache of private application data downloaded from a server
- A local application store for private data that is synchronized with a server (data is sent to and loaded from the server)
- Encrypted files used as the file format for documents created and edited by the application. The files could be private to one user, or could be designed to be shared among all users of the application.
- Any other use of a local data store, such as the ones described in "Uses for local SQL databases" on page 714, where the data must be kept private from people who have access to the machine or the database files.

Understanding the reason why you want to use an encrypted database helps you decide how to architect your application. In particular, it can affect how your application creates, obtains, and stores the encryption key for the database. For more information about these considerations, see "Considerations for using encryption with a database" on page 762.

Other than an encrypted database, an alternative mechanism for keeping sensitive data private is the encrypted local store. With the encrypted local store, you store a single ByteArray value using a String key. Only the AIR application that stores the value can access it, and only on the computer on which it is stored. With the encrypted local store, it isn't necessary to create your own encryption key. For these reasons, the encrypted local store is most suitable for easily storing a single value or set of values that can easily be encoded in a ByteArray. An encrypted database is most suitable for larger data sets where structured data storage and querying are desirable. For more information about using the encrypted local store, see "Encrypted local storage" on page 710.

Creating an encrypted database

Adobe AIR 1.5 and later

To use an encrypted database, the database file must be encrypted when it is created. Once a database is created as unencrypted, it can't be encrypted later. Likewise, an encrypted database can't be unencrypted later. If needed you can change the encryption key of an encrypted database. For details, see "Changing the encryption key of a database" on page 761. If you have an existing database that's not encrypted and you want to use database encryption, you can create a new encrypted database and copy the existing table structure and data to the new database.

Creating an encrypted database is nearly identical to creating an unencrypted database, as described in "Creating a database" on page 719. You first create a SQLConnection instance that represents the connection to the database. You create the database by calling the SQLConnection object's `open()` method or `openAsync()` method, specifying for the database location a file that doesn't exist yet. The only difference when creating an encrypted database is that you provide a value for the `encryptionKey` parameter (the `open()` method's fifth parameter and the `openAsync()` method's sixth parameter).

A valid `encryptionKey` parameter value is a ByteArray object containing exactly 16 bytes.

The following examples demonstrate creating an encrypted database. For simplicity, in these examples the encryption key is hard-coded in the application code. However, this technique is strongly discouraged because it is not secure.

```
var conn:SQLConnection = new SQLConnection();

var encryptionKey:ByteArray = new ByteArray();
encryptionKey.writeUTFBytes("Some16ByteString"); // This technique is not secure!

// Create an encrypted database in asynchronous mode
conn.openAsync(dbFile, SQLMode.CREATE, null, false, 1024, encryptionKey);

// Create an encrypted database in synchronous mode
conn.open(dbFile, SQLMode.CREATE, false, 1024, encryptionKey);
```

For an example demonstrating a recommended way to generate an encryption key, see "Example: Generating and using an encryption key" on page 763.

Connecting to an encrypted database

Adobe AIR 1.5 and later

Like creating an encrypted database, the procedure for opening a connection to an encrypted database is like connecting to an unencrypted database. That procedure is described in greater detail in "Connecting to a database" on page 726. You use the `open()` method to open a connection in synchronous execution mode, or the `openAsync()` method to open a connection in asynchronous execution mode. The only difference is that to open an encrypted database, you specify the correct value for the `encryptionKey` parameter (the `open()` method's fifth parameter and the `openAsync()` method's sixth parameter).

If the encryption key that's provided is not correct, an error occurs. For the `open()` method, a SQLError exception is thrown. For the `openAsync()` method, the SQLConnection object dispatches a SQLErrorEvent, whose `error` property contains a SQLError object. In either case, the SQLError object generated by the exception has the `errorID` property value 3138. That error ID corresponds to the error message "File opened is not a database file."

The following example demonstrates opening an encrypted database in asynchronous execution mode. For simplicity, in this example the encryption key is hard-coded in the application code. However, this technique is strongly discouraged because it is not secure.

```
import flash.data.SQLConnection;
import flash.data.SQLMode;
import flash.events.SQLErrorEvent;
import flash.events.SQLEvent;
import flash.filesystem.File;

var conn:SQLConnection = new SQLConnection();
conn.addEventListener(SQLEvent.OPEN, openHandler);
conn.addEventListener(SQLErrorEvent.ERROR, errorHandler);
var dbFile:File = File.applicationStorageDirectory.resolvePath("DBSample.db");

var encryptionKey:ByteArray = new ByteArray();
encryptionKey.writeUTFBytes("Some16ByteString"); // This technique is not secure!

conn.openAsync(dbFile, SQLMode.UPDATE, null, false, 1024, encryptionKey);

function openHandler(event:SQLEvent):void
{
    trace("the database opened successfully");
}

function errorHandler(event:SQLErrorEvent):void
{
    if (event.error.errorID == 3138)
    {
        trace("Incorrect encryption key");
    }
    else
    {
        trace("Error message:", event.error.message);
        trace("Details:", event.error.details);
    }
}
```

The following example demonstrates opening an encrypted database in synchronous execution mode. For simplicity, in this example the encryption key is hard-coded in the application code. However, this technique is strongly discouraged because it is not secure.

```
import flash.data.SQLConnection;
import flash.data.SQLMode;
import flash.filesystem.File;

var conn:SQLConnection = new SQLConnection();
var dbFile:File = File.applicationStorageDirectory.resolvePath("DBSample.db");

var encryptionKey:ByteArray = new ByteArray();
encryptionKey.writeUTFBytes("Some16ByteString"); // This technique is not secure!

try
{
    conn.open(dbFile, SQLMode.UPDATE, false, 1024, encryptionKey);
    trace("the database was created successfully");
}
catch (error:SQLError)
{
    if (error.errorID == 3138)
    {
        trace("Incorrect encryption key");
    }
    else
    {
        trace("Error message:", error.message);
        trace("Details:", error.details);
    }
}
```

For an example demonstrating a recommended way to generate an encryption key, see "Example: Generating and using an encryption key" on page 763.

Changing the encryption key of a database

Adobe AIR 1.5 and later

When a database is encrypted, you can change the encryption key for the database at a later time. To change a database's encryption key, first open a connection to the database by creating a SQLConnection instance and calling its `open()` or `openAsync()` method. Once the database is connected, call the `reencrypt()` method, passing the new encryption key as an argument.

Like most database operations, the `reencrypt()` method's behavior varies depending on whether the database connection uses synchronous or asynchronous execution mode. If you use the `open()` method to connect to the database, the `reencrypt()` operation runs synchronously. When the operation finishes, execution continues with the next line of code:

```
var newKey:ByteArray = new ByteArray();
// ... generate the new key and store it in newKey
conn.reencrypt(newKey);
```

On the other hand, if the database connection is opened using the `openAsync()` method, the `reencrypt()` operation is asynchronous. Calling `reencrypt()` begins the reencryption process. When the operation completes, the SQLConnection object dispatches a `reencrypt` event. You use an event listener to determine when the reencryption finishes:

```
var newKey:ByteArray = new ByteArray();
// ... generate the new key and store it in newKey

conn.addEventListener(SQLEvent.REENCRYPT, reencryptHandler);

conn.reencrypt(newKey);

function reencryptHandler(event:SQLEvent):void
{
    // save the fact that the key changed
}
```

The `reencrypt()` operation runs in its own transaction. If the operation is interrupted or fails (for example, if the application is closed before the operation finishes) the transaction is rolled back. In that case, the original encryption key is still the encryption key for the database.

The `reencrypt()` method can't be used to remove encryption from a database. Passing a `null` value or encryption key that's not a 16-byte ByteArray to the `reencrypt()` method results in an error.

Considerations for using encryption with a database

Adobe AIR 1.5 and later

The section "Uses for an encrypted database" on page 758 presents several cases in which you would want to use an encrypted database. It's obvious that the usage scenarios of different applications (including these and other scenarios) have different privacy requirements. The way you architect the use of encryption in your application plays an important part in controlling how private a database's data is. For example, if you are using an encrypted database to keep personal data private, even from other users of the same machine, then each user's database needs its own encryption key. For the greatest security, your application can generate the key from a user-entered password. Basing the encryption key on a password ensures that even if another person is able to impersonate the user's account on the machine, the data still can't be accessed. On the other end of the privacy spectrum, suppose you want a database file to be readable by any user of your application but not to other applications. In that case every installed copy of the application needs access to a shared encryption key.

You can design your application, and in particular the technique used to generate the encryption key, according to the level of privacy that you want for your application data. The following list provides design suggestions for various levels of data privacy:

- To make a database accessible to any user who has access to the application on any machine, use a single key that's available to all instances of the application. For example, the first time an application runs it can download the shared encryption key from a server using a secure protocol such as SSL. It can then save the key in the encrypted local store for future use. As an alternative, encrypt the data per-user on the machine, and synchronize the data with a remote data store such as a server to make the data portable.
- To make a database accessible to a single user on any machine, generate the encryption key from a user secret (such as a password). In particular, do not use any value that's tied to a particular computer (such as a value stored in the encrypted local store) to generate the key. As an alternative, encrypt the data per-user on the machine, and synchronize the data with a remote data store such as a server to make the data portable.
- To make a database accessible only to a single individual on a single machine, generate the key from a password and a generated salt. For an example of this technique, see "Example: Generating and using an encryption key" on page 763.

The following are additional security considerations that are important to keep in mind when designing an application to use an encrypted database:

- A system is only as secure as its weakest link. If you are using a user-entered password to generate an encryption key, consider imposing minimum length and complexity restrictions on passwords. A short password that uses only basic characters can be guessed quickly.
- The source code of an AIR application is stored on a user's machine in plain text (for HTML content) or an easily decompilable binary format (for SWF content). Because the source code is accessible, two points to remember are:
  - Never hard-code an encryption key in your source code
  - Always assume that the technique used to generate an encryption key (such as random character generator or a particular hashing algorithm) can be easily worked out by an attacker
- AIR database encryption uses the Advanced Encryption Standard (AES) with Counter with CBC-MAC (CCM) mode. This encryption cipher requires a user-entered key to be combined with a salt value to be secure. For an example of this, see "Example: Generating and using an encryption key" on page 763.
- When you elect to encrypt a database, all disk files used by the database engine in conjunction with that database are encrypted. However, the database engine holds some data temporarily in an in-memory cache to improve read- and write-time performance in transactions. Any memory-resident data is unencrypted. If an attacker is able to access the memory used by an AIR application, for example by using a debugger, the data in a database that is currently open and unencrypted would be available.

Example: Generating and using an encryption key

Adobe AIR 1.5 and later

This example application demonstrates one technique for generating an encryption key. This application is designed to provide the highest level of privacy and security for users' data. One important aspect of securing private data is to require the user to enter a password each time the application connects to the database. Consequently, as shown in this example, an application that requires this level of privacy should never directly store the database encryption key.

The application consists of two parts: an ActionScript class that generates an encryption key (the EncryptionKeyGenerator class), and a basic user interface that demonstrates how to use that class. For the complete source code, see "Complete example code for generating and using an encryption key" on page 765.

Using the EncryptionKeyGenerator class to obtain a secure encryption key

Adobe AIR 1.5 and later

It isn't necessary to understand the details of how the EncryptionKeyGenerator class works to use it in your application. If you are interested in the details of how the class generates an encryption key for a database, see "Understanding the EncryptionKeyGenerator class" on page 770.

Follow these steps to use the EncryptionKeyGenerator class in your application:

1. Download the EncryptionKeyGenerator class as source code or a compiled SWC. The EncryptionKeyGenerator class is included in the open-source ActionScript 3.0 core library (as3corelib) project. You can download the as3corelib package including source code and documentation. You can also download the SWC or source code files from the project page.
2. Place the source code for the EncryptionKeyGenerator class (or the as3corelib SWC) in a location where your application source code can find it.
3. In your application source code, add an `import` statement for the EncryptionKeyGenerator class.

```
import com.adobe.air.crypto.EncryptionKeyGenerator;
```

4 Before the point where the code creates the database or opens a connection to it, add code to create an EncryptionKeyGenerator instance by calling the `EncryptionKeyGenerator()` constructor.

```
var keyGenerator:EncryptionKeyGenerator = new EncryptionKeyGenerator();
```

5 Obtain a password from the user:

```
var password:String = passwordInput.text;

if (!keyGenerator.validateStrongPassword(password))
{
    // display an error message
    return;
}
```

The EncryptionKeyGenerator instance uses this password as the basis for the encryption key (shown in the next step). The EncryptionKeyGenerator instance tests the password against certain strong password validation requirements. If the validation fails, an error occurs. As the example code shows, you can check the password ahead of time by calling the EncryptionKeyGenerator object's `validateStrongPassword()` method. That way you can determine whether the password meets the minimum requirements for a strong password and avoid an error.

6 Generate the encryption key from the password:

```
var encryptionKey:ByteArray = keyGenerator.getEncryptionKey(password);
```

The `getEncryptionKey()` method generates and returns the encryption key (a 16-byte ByteArray). You can then use the encryption key to create your new encrypted database or open your existing one.

The `getEncryptionKey()` method has one required parameter, which is the password obtained in step 5.

Note: *To maintain the highest level of security and privacy for data, an application must require the user to enter a password each time the application connects to the database. Do not store the user's password or the database encryption key directly. Doing so exposes security risks. Instead, as demonstrated in this example, an application should use the same technique to derive the encryption key from the password both when creating the encrypted database and when connecting to it later.*

The `getEncryptionKey()` method also accepts a second (optional) parameter, the `overrideSaltELSKey` parameter. The EncryptionKeyGenerator creates a random value (known as a *salt*) that is used as part of the encryption key. In order to be able to re-create the encryption key, the salt value is stored in the Encrypted Local Store (ELS) of your AIR application. By default, the EncryptionKeyGenerator class uses a particular String as the ELS key. Although unlikely, it's possible that the key can conflict with another key your application uses. Instead of using the default key, you might want to specify your own ELS key. In that case, specify a custom key by passing it as the second `getEncryptionKey()` parameter, as shown here:

```
var customKey:String = "My custom ELS salt key";
var encryptionKey:ByteArray = keyGenerator.getEncryptionKey(password, customKey);
```

7 Create or open the database

With an encryption key returned by the `getEncryptionKey()` method, your code can create a new encrypted database or attempt to open the existing encrypted database. In either case you use the SQLConnection class's `open()` or `openAsync()` method, as described in "Creating an encrypted database" on page 759 and "Connecting to an encrypted database" on page 759.

In this example, the application is designed to open the database in asynchronous execution mode. The code sets up the appropriate event listeners and calls the `openAsync()` method, passing the encryption key as the final argument:

```
conn.addEventListener(SQLEvent.OPEN, openHandler);
conn.addEventListener(SQLErrorEvent.ERROR, openError);

conn.openAsync(dbFile, SQLMode.CREATE, null, false, 1024, encryptionKey);
```

In the listener methods, the code removes the event listener registrations. It then displays a status message indicating whether the database was created, opened, or whether an error occurred. The most noteworthy part of these event handlers is in the `openError()` method. In that method an `if` statement checks if the database exists (meaning that the code is attempting to connect to an existing database) and if the error ID matches the constant `EncryptionKeyGenerator.ENCRYPTED_DB_PASSWORD_ERROR_ID`. If both of these conditions are true, it probably means that the password the user entered is incorrect. (It could also mean that the specified file isn't a database file at all.) The following is the code that checks the error ID:

```
if (!createNewDB && event.error.errorID ==
EncryptionKeyGenerator.ENCRYPTED_DB_PASSWORD_ERROR_ID)
{
    statusMsg.text = "Incorrect password!";
}
else
{
    statusMsg.text = "Error creating or opening database.";
}
```

For the complete code for the example event listeners, see "Complete example code for generating and using an encryption key" on page 765.

Complete example code for generating and using an encryption key

Adobe AIR 1.5 and later

The following is the complete code for the example application "Generating and using an encryption key." The code consists of two parts.

The example uses the EncryptionKeyGenerator class to create an encryption key from a password. The EncryptionKeyGenerator class is included in the open-source ActionScript 3.0 core library (as3corelib) project. You can download the as3corelib package including source code and documentation. You can also download the SWC or source code files from the project page.

Flex example

The application MXML file contains the source code for a simple application that creates or opens a connection to an encrypted database:

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" layout="vertical"
creationComplete="init();">
    <mx:Script>
        <![CDATA[
            import com.adobe.air.crypto.EncryptionKeyGenerator;

            private const dbFileName:String = "encryptedDatabase.db";

            private var dbFile:File;
            private var createNewDB:Boolean = true;
            private var conn:SQLConnection;

            // ------- Event handling -------

            private function init():void
            {
                conn = new SQLConnection();
                dbFile = File.applicationStorageDirectory.resolvePath(dbFileName);
                if (dbFile.exists)
                {
                    createNewDB = false;
                    instructions.text = "Enter your database password to open the encrypted
database.";
                    openButton.label = "Open Database";
                }
            }

            private function openConnection():void
            {
                var password:String = passwordInput.text;

                var keyGenerator:EncryptionKeyGenerator = new EncryptionKeyGenerator();

                if (password == null || password.length <= 0)
                {
                    statusMsg.text = "Please specify a password.";
                    return;
                }

                if (!keyGenerator.validateStrongPassword(password))
                {
                    statusMsg.text = "The password must be 8-32 characters long. It must
contain at least one lowercase letter, at least one uppercase letter, and at least one number
or symbol.";
                    return;
                }

                passwordInput.text = "";
                passwordInput.enabled = false;
                openButton.enabled = false;

                var encryptionKey:ByteArray = keyGenerator.getEncryptionKey(password);

                conn.addEventListener(SQLEvent.OPEN, openHandler);
                conn.addEventListener(SQLErrorEvent.ERROR, openError);
                conn.openAsync(dbFile, SQLMode.CREATE, null, false, 1024, encryptionKey);
            }
            
            private function openHandler(event:SQLEvent):void
            {
                conn.removeEventListener(SQLEvent.OPEN, openHandler);
                conn.removeEventListener(SQLErrorEvent.ERROR, openError);
                
                statusMsg.setStyle("color", 0x009900);
                if (createNewDB)
                {
                    statusMsg.text = "The encrypted database was created successfully.";
                }
                else
                {
                    statusMsg.text = "The encrypted database was opened successfully.";
                }
            }
            
            private function openError(event:SQLErrorEvent):void
            {
                conn.removeEventListener(SQLEvent.OPEN, openHandler);
                conn.removeEventListener(SQLErrorEvent.ERROR, openError);
                
                if (!createNewDB && event.error.errorID == 
EncryptionKeyGenerator.ENCRYPTED_DB_PASSWORD_ERROR_ID)
                {
                    statusMsg.text = "Incorrect password!";
                }
                else
                {
                    statusMsg.text = "Error creating or opening database.";
                }
            }
        ]]>
    </mx:Script>
    <mx:Text id="instructions" text="Enter a password to create an encrypted database. The next 
time you open the application, you will need to re-enter the password to open the database 
again." width="75%" height="65"/>
    <mx:HBox>
        <mx:TextInput id="passwordInput" displayAsPassword="true"/>
        <mx:Button id="openButton" label="Create Database" click="openConnection();"/>
    </mx:HBox>
    <mx:Text id="statusMsg" color="#990000" width="75%"/>
</mx:WindowedApplication>
```

Flash Professional example

The application FLA file contains the source code for a simple application that creates or opens a connection to an encrypted database. The FLA file has four components placed on the stage:

Instance name	Component type	Description
`instructions`	Label	Contains the instructions given to the user
`passwordInput`	TextInput	Input field where the user enters the password
`openButton`	Button	Button the user clicks after entering the password
`statusMsg`	Label	Displays status (success or failure) messages

The code for the application is defined on a keyframe on frame 1 of the main timeline. The following is the code for the application:

```
import com.adobe.air.crypto.EncryptionKeyGenerator;

const dbFileName:String = "encryptedDatabase.db";

var dbFile:File;
var createNewDB:Boolean = true;
var conn:SQLConnection;

init();

// ------- Event handling -------

function init():void
{
    passwordInput.displayAsPassword = true;
    openButton.addEventListener(MouseEvent.CLICK, openConnection);
    statusMsg.setStyle("textFormat", new TextFormat(null, null, 0x990000));

    conn = new SQLConnection();
    dbFile = File.applicationStorageDirectory.resolvePath(dbFileName);

    if (dbFile.exists)
    {
        createNewDB = false;
        instructions.text = "Enter your database password to open the encrypted database.";
        openButton.label = "Open Database";
    }
    else
    {
        instructions.text = "Enter a password to create an encrypted database. The next time 
you open the application, you will need to re-enter the password to open the database again.";
        openButton.label = "Create Database";
    }
}

function openConnection(event:MouseEvent):void
{
    var keyGenerator:EncryptionKeyGenerator = new EncryptionKeyGenerator();

    var password:String = passwordInput.text;

    if (password == null || password.length <= 0)
    {
        statusMsg.text = "Please specify a password.";
        return;
    }

    if (!keyGenerator.validateStrongPassword(password))
    {
        statusMsg.text = "The password must be 8-32 characters long. It must contain at least
one lowercase letter, at least one uppercase letter, and at least one number or symbol.";
        return;
    }

    passwordInput.text = "";
    passwordInput.enabled = false;
    openButton.enabled = false;

    var encryptionKey:ByteArray = keyGenerator.getEncryptionKey(password);

    conn.addEventListener(SQLEvent.OPEN, openHandler);
    conn.addEventListener(SQLErrorEvent.ERROR, openError);

    conn.openAsync(dbFile, SQLMode.CREATE, null, false, 1024, encryptionKey);
}

function openHandler(event:SQLEvent):void
{
    conn.removeEventListener(SQLEvent.OPEN, openHandler);
    conn.removeEventListener(SQLErrorEvent.ERROR, openError);

    statusMsg.setStyle("textFormat", new TextFormat(null, null, 0x009900));
    if (createNewDB)
    {
        statusMsg.text = "The encrypted database was created successfully.";
    }
    else
    {
        statusMsg.text = "The encrypted database was opened successfully.";
    }
}

function openError(event:SQLErrorEvent):void
{
    conn.removeEventListener(SQLEvent.OPEN, openHandler);
    conn.removeEventListener(SQLErrorEvent.ERROR, openError);

    if (!createNewDB && event.error.errorID ==
EncryptionKeyGenerator.ENCRYPTED_DB_PASSWORD_ERROR_ID)
    {
        statusMsg.text = "Incorrect password!";
    }
    else
    {
        statusMsg.text = "Error creating or opening database.";
    }
}
```

Understanding the EncryptionKeyGenerator class

Adobe AIR 1.5 and later

It isn't necessary to understand the inner workings of the EncryptionKeyGenerator class to use it to create a secure encryption key for your application database. The process for using the class is explained in "Using the EncryptionKeyGenerator class to obtain a secure encryption key" on page 763. However, you might find it valuable to understand the techniques that the class uses. For example, you might want to adapt the class or incorporate some of its techniques for situations where a different level of data privacy is desired.

The EncryptionKeyGenerator class is included in the open-source ActionScript 3.0 core library (as3corelib) project. You can download the as3corelib package including source code and documentation.You can also view the source code on the project site or download it to follow along with the explanations.

When code creates an EncryptionKeyGenerator instance and calls its `getEncryptionKey()` method, several steps are taken to ensure that only the rightful user can access the data. The process is the same to generate an encryption key from a user-entered password before the database is created as well as to re-create the encryption key to open the database.

Obtain and validate a strong password

Adobe AIR 1.5 and later

When code calls the `getEncryptionKey()` method, it passes in a password as a parameter. The password is used as the basis for the encryption key. By using a piece of information that only the user knows, this design ensures that only the user who knows the password can access the data in the database. Even if an attacker accesses the user's account on the computer, the attacker can't get into the database without knowing the password. For maximum security, the application never stores the password.

An application's code creates an EncryptionKeyGenerator instance and calls its `getEncryptionKey()` method, passing a user-entered password as an argument (the variable `password` in this example):

```
var keyGenerator:EncryptionKeyGenerator = new EncryptionKeyGenerator();
var encryptionKey:ByteArray = keyGenerator.getEncryptionKey(password);
```

The first step the EncryptionKeyGenerator class takes when the `getEncryptionKey()` method is called is to check the user-entered password to ensure that it meets the password strength requirements. The EncryptionKeyGenerator class requires a password to be 8 - 32 characters long. The password must contain a mix of uppercase and lowercase letters and at least one number or symbol character.

The regular expression that checks this pattern is defined as a constant named `STRONG_PASSWORD_PATTERN`:

```
private static const STRONG_PASSWORD_PATTERN:RegExp = 
/(?=^.{8,32}$)((?=.*\d)|(?=.*\W+))(?![.\n])(?=.*[A-Z])(?=.*[a-z]).*$/;
```

The code that checks the password is in the EncryptionKeyGenerator class's `validateStrongPassword()` method. The code is as follows:

```
public function vaidateStrongPassword(password:String):Boolean
{
    if (password == null || password.length <= 0)
    {
        return false;
    }
    
    return STRONG_PASSWORD_PATTERN.test(password))
}
```

Internally the `getEncryptionKey()` method calls the EncryptionKeyGenerator class's `validateStrongPassword()` method and, if the password isn't valid, throws an exception. The `validateStrongPassword()` method is a public method so that application code can check a password without calling the `getEncryptionKey()` method to avoid causing an error.

Expand the password to 256 bits

Adobe AIR 1.5 and later

Later in the process, the password is required to be 256 bits long. Rather than require each user to enter a password that's exactly 256 bits (32 characters) long, the code creates a longer password by repeating the password characters.

The `getEncryptionKey()` method calls the `concatenatePassword()` method to perform the task of creating the long password.

```
var concatenatedPassword:String = concatenatePassword(password);
```

The following is the code for the `concatenatePassword()` method:

```
private function concatenatePassword(pwd:String):String
{
    var len:int = pwd.length;
    var targetLength:int = 32;

    if (len == targetLength)
    {
        return pwd;
    }

    var repetitions:int = Math.floor(targetLength / len);
    var excess:int = targetLength % len;

    var result:String = "";

    for (var i:uint = 0; i < repetitions; i++)
    {
        result += pwd;
    }

    result += pwd.substr(0, excess);

    return result;
}
```

If the password is less than 256 bits, the code concatenates the password with itself to make it 256 bits. If the length doesn't work out exactly, the last repetition is shortened to get exactly 256 bits.

Generate or retrieve a 256-bit salt value

Adobe AIR 1.5 and later

The next step is to get a 256-bit salt value that in a later step is combined with the password. A *salt* is a random value that is added to or combined with a user-entered value to form a password. Using a salt with a password ensures that even if a user chooses a real word or common term as a password, the password-plus-salt combination that the system uses is a random value. This randomness helps guard against a dictionary attack, where an attacker uses a list of words to attempt to guess a password. In addition, by generating the salt value and storing it in the encrypted local store, it is tied to the user's account on the machine on which the database file is located.

If the application is calling the `getEncryptionKey()` method for the first time, the code creates a random 256-bit salt value. Otherwise, the code loads the salt value from the encrypted local store.

The salt is stored in a variable named `salt`. The code determines if it has already created a salt by attempting to load the salt from the encrypted local store:

```
var salt:ByteArray = EncryptedLocalStore.getItem(saltKey);
if (salt == null)
{
    salt = makeSalt();
    EncryptedLocalStore.setItem(saltKey, salt);
}
```

If the code is creating a new salt value, the `makeSalt()` method generates a 256-bit random value. Because the value is eventually stored in the encrypted local store, it is generated as a ByteArray object. The `makeSalt()` method uses the `Math.random()` method to randomly generate the value. The `Math.random()` method can't generate 256 bits at one time. Instead, the code uses a loop to call `Math.random()` eight times. Each time, a random uint value between 0 and 4294967295 (the maximum uint value) is generated. A uint value is used for convenience, because a uint uses exactly 32 bits. By writing eight uint values into the ByteArray, a 256-bit value is generated. The following is the code for the `makeSalt()` method:

```
private function makeSalt():ByteArray
{
    var result:ByteArray = new ByteArray;

    for (var i:uint = 0; i < 8; i++)
    {
        result.writeUnsignedInt(Math.round(Math.random() * uint.MAX_VALUE));
    }

    return result;
}
```

When the code is saving the salt to the Encrypted Local Store (ELS) or retrieving the salt from the ELS, it needs a String key under which the salt is saved. Without knowing the key, the salt value can't be retrieved. In that case, the encryption key can't be re-created each time to reopen the database. By default, the EncryptionKeyGenerator uses a predefined ELS key that is defined in the constant `SALT_ELS_KEY`. Instead of using the default key, application code can also specify an ELS key to use in the call to the `getEncryptionKey()` method. Either the default or the application-specified salt ELS key is stored in a variable named `saltKey`. That variable is used in the calls to `EncryptedLocalStore.setItem()` and `EncryptedLocalStore.getItem()`, as shown previously.

Combine the 256-bit password and salt using the XOR operator

Adobe AIR 1.5 and later

The code now has a 256-bit password and a 256-bit salt value. It next uses a bitwise XOR operation to combine the salt and the concatenated password into a single value. In effect, this technique creates a 256-bit password consisting of characters from the entire range of possible characters. This principle is true even though most likely the actual password input consists of primarily alphanumeric characters. This increased randomness provides the benefit of making the set of possible passwords large without requiring the user to enter a long complex password.

The result of the XOR operation is stored in the variable `unhashedKey`. The actual process of performing a bitwise XOR on the two values happens in the `xorBytes()` method:

```
var unhashedKey:ByteArray = xorBytes(concatenatedPassword, salt);
```

The bitwise XOR operator (`^`) takes two uint values and returns a uint value. (A uint value contains 32 bits.) The input values passed as arguments to the `xorBytes()` method are a String (the password) and a ByteArray (the salt). Consequently, the code uses a loop to extract 32 bits at a time from each input to combine using the XOR operator.

```
private function xorBytes(passwordString:String, salt:ByteArray):ByteArray
{
    var result:ByteArray = new ByteArray();

    for (var i:uint = 0; i < 32; i += 4)
    {
        // ...
    }

    return result;
}
```

Within the loop, first 32 bits (4 bytes) are extracted from the `passwordString` parameter. Those bits are extracted and converted into a uint (`o1`) in a two-part process. First, the `charCodeAt()` method gets each character's numeric value. Next, that value is shifted to the appropriate position in the uint using the bitwise left shift operator (`<<`) and the shifted value is added to `o1`. For example, the first character (`i`) becomes the first 8 bits by using the bitwise left shift operator (`<<`) to shift the bits left by 24 bits and assigning that value to `o1`. The second character `(i + 1)` becomes the second 8 bits by shifting its value left 16 bits and adding the result to `o1`. The third and fourth characters' values are added the same way.

```
        // ...

        // Extract 4 bytes from the password string and convert to a uint
        var o1:uint = passwordString.charCodeAt(i) << 24;
        o1 += passwordString.charCodeAt(i + 1) << 16;
        o1 += passwordString.charCodeAt(i + 2) << 8;
        o1 += passwordString.charCodeAt(i + 3);

        // ...
```

The variable `o1` now contains 32 bits from the `passwordString` parameter. Next, 32 bits are extracted from the `salt` parameter by calling its `readUnsignedInt()` method. The 32 bits are stored in the uint variable `o2`.

```
        // ...

        salt.position = i;
        var o2:uint = salt.readUnsignedInt();

        // ...
```

Finally, the two 32-bit (uint) values are combined using the XOR operator and the result is written into a ByteArray named `result`.

```
        // ...

        var xor:uint = o1 ^ o2;
        result.writeUnsignedInt(xor);
        // ...
```

Once the loop completes, the ByteArray containing the XOR result is returned.

```
        // ...
    }

    return result;
}
```

Hash the key

Adobe AIR 1.5 and later

Once the concatenated password and the salt have been combined, the next step is to further secure this value by hashing it using the SHA-256 hashing algorithm. Hashing the value makes it more difficult for an attacker to reverse-engineer it.

At this point the code has a ByteArray named `unhashedKey` containing the concatenated password combined with the salt. The ActionScript 3.0 core library (as3corelib) project includes a SHA256 class in the com.adobe.crypto package. The `SHA256.hashBytes()` method that performs a SHA-256 hash on a ByteArray and returns a String containing the 256-bit hash result as a hexadecimal number. The EncryptionKeyGenerator class uses the SHA256 class to hash the key:

```
var hashedKey:String = SHA256.hashBytes(unhashedKey);
```

Extract the encryption key from the hash

Adobe AIR 1.5 and later

The encryption key must be a ByteArray that is exactly 16 bytes (128 bits) long. The result of the SHA-256 hashing algorithm is always 256 bits long. Consequently, the final step is to select 128 bits from the hashed result to use as the actual encryption key.

In the EncryptionKeyGenerator class, the code reduces the key to 128 bits by calling the `generateEncryptionKey()` method. It then returns that method's result as the result of the `getEncryptionKey()` method:

```
var encryptionKey:ByteArray = generateEncryptionKey(hashedKey);
return encryptionKey;
```

It isn't necessary to use the first 128 bits as the encryption key. You could select a range of bits starting at some arbitrary point, you could select every other bit, or use some other way of selecting bits. The important thing is that the code selects 128 distinct bits, and that the same 128 bits are used each time.

In this case, the `generateEncryptionKey()` method uses the range of bits starting at the 18th byte as the encryption key. As mentioned previously, the SHA256 class returns a String containing a 256-bit hash as a hexadecimal number. A single block of 128 bits has too many bytes to add to a ByteArray at one time. Consequently, the code uses a `for` loop to extract characters from the hexadecimal String, convert them to actual numeric values, and add them to the ByteArray. The SHA-256 result String is 64 characters long. A range of 128 bits equals 32 characters in the String, and each character represents 4 bits. The smallest increment of data you can add to a ByteArray is one byte (8 bits), which is equivalent to two characters in the `hash` String. Consequently, the loop counts from 0 to 31 (32 characters) in increments of 2 characters.

Within the loop, the code first determines the starting position for the current pair of characters. Since the desired range starts at the character at index position 17 (the 18th byte), the `position` variable is assigned the current iterator value (`i`) plus 17. The code uses the String object's `substr()` method to extract the two characters at the current position. Those characters are stored in the variable `hex`. Next, the code uses the `parseInt()` method to convert the `hex` String to a decimal integer value. It stores that value in the int variable `byte`. Finally, the code adds the value in `byte` to the `result` ByteArray using its `writeByte()` method. When the loop finishes, the `result` ByteArray contains 16 bytes and is ready to use as a database encryption key.

```
private function generateEncryptionKey(hash:String):ByteArray
{
    var result:ByteArray = new ByteArray();

    for (var i:uint = 0; i < 32; i += 2)
    {
        var position:uint = i + 17;
        var hex:String = hash.substr(position, 2);
        var byte:int = parseInt(hex, 16);
        result.writeByte(byte);
    }

    return result;
}
```

Strategies for working with SQL databases

Adobe AIR 1.0 and later

There are various ways that an application can access and work with a local SQL database. The application design can vary in terms of how the application code is organized, the sequence and timing of how operations are performed, and so on. The techniques you choose can have an impact on how easy it is to develop your application. They can affect how easy it is to modify the application in future updates. They can also affect how well the application performs from the users' perspective.

Distributing a pre-populated database

Adobe AIR 1.0 and later

When you use an AIR local SQL database in your application, the application expects a database with a certain structure of tables, columns, and so forth. Some applications also expect certain data to be pre-populated in the database file. One way to ensure that the database has the proper structure is to create the database within the application code. When the application loads it checks for the existence of its database file in a particular location. If the file doesn't exist, the application executes a set of commands to create the database file, create the database structure, and populate the tables with the initial data.

The code that creates the database and its tables is frequently complex. It is often only used once in the installed lifetime of the application, but still adds to the size and complexity of the application. As an alternative to creating the database, structure, and data programmatically, you can distribute a pre-populated database with your application. To distribute a predefined database, include the database file in the application's AIR package.

Like all files that are included in an AIR package, a bundled database file is installed in the application directory (the directory represented by the `File.applicationDirectory` property). However, files in that directory are read only. Use the file from the AIR package as a "template" database. The first time a user runs the application, copy the original database file into the user's "Pointing to the application storage directory" on page 672 (or another location), and use that database within the application.

Best practices for working with local SQL databases

Adobe AIR 1.0 and later

The following list is a set of suggested techniques you can use to improve the performance, security, and ease of maintenance of your applications when working with local SQL databases.

Pre-create database connections

Adobe AIR 1.0 and later

Even if your application doesn't execute any statements when it first loads, instantiate a SQLConnection object and call its `open()` or `openAsync()` method ahead of time (such as after the initial application startup) to avoid delays when running statements. See "Connecting to a database" on page 726.

Reuse database connections

Adobe AIR 1.0 and later

If you access a certain database throughout the execution time of your application, keep a reference to the SQLConnection instance, and reuse it throughout the application, rather than closing and reopening the connection. See "Connecting to a database" on page 726.

Favor asynchronous execution mode

Adobe AIR 1.0 and later

When writing data-access code, it can be tempting to execute operations synchronously rather than asynchronously, because using synchronous operations frequently requires shorter and less complex code. However, as described in "Using synchronous and asynchronous database operations" on page 753, synchronous operations can have a performance impact that is obvious to users and detrimental to their experience with an application. The amount of time a single operation takes varies according to the operation and particularly the amount of data it involves. For instance, a SQL `INSERT` statement that only adds a single row to the database takes less time than a `SELECT` statement that retrieves thousands of rows of data. However, when you're using synchronous execution to perform multiple operations, the operations are usually strung together. Even if the time each single operation takes is very short, the application is frozen until all the synchronous operations finish. As a result, the cumulative time of multiple operations strung together may be enough to stall your application.

Use asynchronous operations as a standard approach, especially with operations that involve large numbers of rows. There is a technique for dividing up the processing of large sets of `SELECT` statement results, described in "Retrieving SELECT results in parts" on page 742. However, this technique can only be used in asynchronous execution mode. Only use synchronous operations when you can't achieve certain functionality using asynchronous programming, when you've considered the performance trade-off that your application's users will face, and when you've tested your application so that you know how your application's performance is affected. Using asynchronous execution can involve more complex coding. However, remember that you only have to write the code once, but the application's users have to use it repeatedly, fast or slow.

In many cases, by using a separate SQLStatement instance for each SQL statement to be executed, multiple SQL operations can be queued up at one time, which makes asynchronous code like synchronous code in terms of how the code is written. For more information, see "Understanding the asynchronous execution model" on page 757.

Use separate SQL statements and don't change the SQLStatement's text property

Adobe AIR 1.0 and later

For any SQL statement that is executed more than once in an application, create a separate SQLStatement instance for each SQL statement. Use that SQLStatement instance each time that SQL command executes. For example, suppose you are building an application that includes four different SQL operations that are performed multiple times. In that case, create four separate SQLStatement instances and call each statement's `execute()` method to run it. Avoid the alternative of using a single SQLStatement instance for all SQL statements, redefining its `text` property each time before executing the statement.

Use statement parameters

Adobe AIR 1.0 and later

Use SQLStatement parameters—never concatenate user input into statement text. Using parameters makes your application more secure because it prevents the possibility of SQL injection attacks. It makes it possible to use objects in queries (rather than only SQL literal values). It also makes statements run more efficiently because they can be reused without needing to be recompiled each time they're executed. See "Using parameters in statements" on page 730 for more information.

Chapter 41: Working with byte arrays

Flash Player 9 and later, Adobe AIR 1.0 and later

The ByteArray class allows you to read from and write to a binary stream of data, which is essentially an array of bytes. This class provides a way to access data at the most elemental level. Because computer data consists of bytes, or groups of 8 bits, the ability to read data in bytes means that you can access data for which classes and access methods do not exist. The ByteArray class allows you to parse any stream of data, from a bitmap to a stream of data traveling over the network, at the byte level.

The `writeObject()` method allows you to write an object in serialized Action Message Format (AMF) to a ByteArray, while the `readObject()` method allows you to read a serialized object from a ByteArray to a variable of the original data type. You can serialize any object except for display objects, which are those objects that can be placed on the display list. You can also assign serialized objects back to custom class instances if the custom class is available to the runtime. After converting an object to AMF, you can efficiently transfer it over a network connection or save it to a file.

The sample Adobe® AIR® application described here reads a .zip file as an example of processing a byte stream, extracting a list of the files that the .zip file contains and writing them to the desktop.

More Help topics

flash.utils.ByteArray

flash.utils.IExternalizable

Action Message Format specification

Reading and writing a ByteArray

Flash Player 9 and later, Adobe AIR 1.0 and later

The ByteArray class is part of the flash.utils package. To create a ByteArray object in ActionScript 3.0, import the ByteArray class and invoke the constructor, as shown in the following example:

```
 import flash.utils.ByteArray;
var stream:ByteArray = new ByteArray();
```

ByteArray methods

Flash Player 9 and later, Adobe AIR 1.0 and later

Any meaningful data stream is organized into a format that you can analyze to find the information that you want. A record in a simple employee file, for example, would probably include an ID number, a name, an address, a phone number, and so on. An MP3 audio file contains an ID3 tag that identifies the title, author, album, publishing date, and genre of the file that's being downloaded. The format allows you to know the order in which to expect the data on the data stream. It allows you to read the byte stream intelligently.

The ByteArray class includes several methods that make it easier to read from and write to a data stream. Some of these methods include `readBytes()` and `writeBytes()`, `readInt()` and `writeInt()`, `readFloat()` and `writeFloat()`, `readObject()` and `writeObject()`, and `readUTFBytes()` and `writeUTFBytes()`. These methods enable you to read data from the data stream into variables of specific data types and write from specific data types directly to the binary data stream.

For example, the following code reads a simple array of strings and floating-point numbers and writes each element to a ByteArray. The organization of the array allows the code to call the appropriate ByteArray methods (`writeUTFBytes()` and `writeFloat()`) to write the data. The repeating data pattern makes it possible to read the array with a loop.

```
 // The following example reads a simple Array (groceries), made up of strings
// and floating-point numbers, and writes it to a ByteArray.

import flash.utils.ByteArray;

// define the grocery list Array
var groceries:Array = ["milk", 4.50, "soup", 1.79, "eggs", 3.19, "bread" , 2.35]
// define the ByteArray
var bytes:ByteArray = new ByteArray();
// for each item in the array
for (var i:int = 0; i < groceries.length; i++) {
        bytes.writeUTFBytes(groceries[i++]); //write the string and position to the next item
        bytes.writeFloat(groceries[i]);// write the float
        trace("bytes.position is: " + bytes.position);//display the position in ByteArray
}
trace("bytes length is: " +  bytes.length);// display the length
```

The position property

Flash Player 9 and later, Adobe AIR 1.0 and later

The position property stores the current position of the pointer that indexes the ByteArray during reading or writing. The initial value of the position property is 0 (zero) as shown in the following code:

```
var bytes:ByteArray = new ByteArray();
trace("bytes.position is initially: " + bytes.position); // 0
```

When you read from or write to a ByteArray, the method that you use updates the position property to point to the location immediately following the last byte that was read or written. For example, the following code writes a string to a ByteArray and afterward the position property points to the byte immediately following the string in the ByteArray:

```
var bytes:ByteArray = new ByteArray();
trace("bytes.position is initially: " + bytes.position); // 0
bytes.writeUTFBytes("Hello World!");
trace("bytes.position is now: " + bytes.position);// 12
```

Likewise, a read operation increments the position property by the number of bytes read.

```
var bytes:ByteArray = new ByteArray();

trace("bytes.position is initially: " + bytes.position); // 0
bytes.writeUTFBytes("Hello World!");
trace("bytes.position is now: " + bytes.position);// 12
bytes.position = 0;
trace("The first 6 bytes are: " + (bytes.readUTFBytes(6)));//Hello
trace("And the next 6 bytes are: " + (bytes.readUTFBytes(6)));// World!
```

Notice that you can set the position property to a specific location in the ByteArray to read or write at that offset.

The bytesAvailable and length properties

Flash Player 9 and later, Adobe AIR 1.0 and later

The `length` and `bytesAvailable` properties tell you how long a ByteArray is and how many bytes remain in it from the current position to the end. The following example illustrates how you can use these properties. The example writes a String of text to the ByteArray and then reads the ByteArray one byte at a time until it encounters either the character "a" or the end (`bytesAvailable <= 0`).

```
var bytes:ByteArray = new ByteArray();
var text:String = "Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Vivamus etc.";

bytes.writeUTFBytes(text); // write the text to the ByteArray
trace("The length of the ByteArray is: " + bytes.length);// 70
bytes.position = 0; // reset position
while (bytes.bytesAvailable > 0 && (bytes.readUTFBytes(1) != 'a')) {
    //read to letter a or end of bytes
}
if (bytes.position < bytes.bytesAvailable) {
    trace("Found the letter a; position is: " + bytes.position); // 23
    trace("and the number of bytes available is: " + bytes.bytesAvailable);// 47
}
```

The endian property

Flash Player 9 and later, Adobe AIR 1.0 and later

Computers can differ in how they store multibyte numbers, that is, numbers that require more than 1 byte of memory to store them. An integer, for example, can take 4 bytes, or 32 bits, of memory. Some computers store the most significant byte of the number first, in the lowest memory address, and others store the least significant byte first. This attribute of a computer, or of byte ordering, is referred to as being either *big endian* (most significant byte first) or *little endian* (least significant byte first). For example, the number 0x31323334 would be stored as follows for big endian and little endian byte ordering, where a0 represents the lowest memory address of the 4 bytes and a3 represents the highest:

Big Endian	Big Endian	Big Endian	Big Endian
a0	a1	a2	a3
31	32	33	34

Little Endian	Little Endian	Little Endian	Little Endian
a0	a1	a2	a3
34	33	32	31

The `endian` property of the ByteArray class allows you to denote this byte order for multibyte numbers that you are processing. The acceptable values for this property are either `"bigEndian"` or `"littleEndian"` and the Endian class defines the constants `BIG_ENDIAN` and `LITTLE_ENDIAN` for setting the `endian` property with these strings.

The compress() and uncompress() methods

Flash Player 9 and later, Adobe AIR 1.0 and later

The `compress()` method allows you to compress a ByteArray in accordance with a compression algorithm that you specify as a parameter. The `uncompress()` method allows you to uncompress a compressed ByteArray in accordance with a compression algorithm. After calling `compress()` and `uncompress()`, the length of the byte array is set to the new length and the position property is set to the end.

The CompressionAlgorithm class defines constants that you can use to specify the compression algorithm. The ByteArray class supports the deflate (AIR-only), zlib, and lzma algorithms. The zlib compressed data format is described at http://www.ietf.org/rfc/rfc1950.txt. The lzma algorithm was added for Flash Player 11.4 and AIR 3.4. It is described at http://www.7-zip.org/7z.html.

The deflate compression algorithm is used in several compression formats, such as zlib, gzip, and some zip implementations. The deflate compression algorithm is described at http://www.ietf.org/rfc/rfc1951.txt.

The following example compresses a ByteArray called `bytes` using the lzma algorithm:

```
bytes.compress(CompressionAlgorithm.LZMA);
```

The following example uncompresses a compressed ByteArray using the deflate algorithm:

```
bytes.uncompress(CompressionAlgorithm.LZMA);
```

Reading and writing objects

Flash Player 9 and later, Adobe AIR 1.0 and later

The `readObject()` and `writeObject()` methods read an object from and write an object to a ByteArray, encoded in serialized Action Message Format (AMF). AMF is a proprietary message protocol created by Adobe and used by various ActionScript 3.0 classes, including Netstream, NetConnection, NetStream, LocalConnection, and Shared Objects.

A one-byte type marker describes the type of the encoded data that follows. AMF uses the following 13 data types:

```
value-type = undefined-marker | null-marker | false-marker | true-marker | integer-type |
    double-type | string-type | xml-doc-type | date-type | array-type | object-type |
    xml-type | byte-array-type
```

The encoded data follows the type marker unless the marker represents a single possible value, such as null or true or false, in which case nothing else is encoded.

There are two versions of AMF: AMF0 and AMF3. AMF 0 supports sending complex objects by reference and allows endpoints to restore object relationships. AMF 3 improves AMF 0 by sending object traits and strings by reference, in addition to object references, and by supporting new data types that were introduced in ActionScript 3.0. The `ByteArray.objectEcoding` property specifies the version of AMF that is used to encode the object data. The flash.net.ObjectEncoding class defines constants for specifying the AMF version: `ObjectEncoding.AMF0` and `ObjectEncoding.AMF3`.

The following example calls `writeObject()` to write an XML object to a ByteArray, which it then compresses using the Deflate algorithm and writes to the `order` file on the desktop. The example uses a label to display the message "Wrote order file to desktop!" in the AIR window when it is finished.

```
import flash.filesystem.*;
import flash.display.Sprite;
import flash.display.TextField;
import flash.utils.ByteArray;
public class WriteObjectExample extends Sprite
{
    public function WriteObjectExample()
    {
        var bytes:ByteArray = new ByteArray();
        var myLabel:TextField = new TextField();
        myLabel.x = 150;
        myLabel.y = 150;
        myLabel.width = 200;
        addChild(myLabel);

        var myXML:XML =
            <order>
                <item id='1'>
                    <menuName>burger</menuName>
                    <price>3.95</price>
                </item>
                <item id='2'>
                    <menuName>fries</menuName>
                    <price>1.45</price>
                </item>
            </order>;

        // Write XML object to ByteArray
        bytes.writeObject(myXML);
        bytes.position = 0;//reset position to beginning
        bytes.compress(CompressionAlgorithm.DEFLATE);// compress ByteArray
        writeBytesToFile("order.xml", bytes);
        myLabel.text = "Wrote order file to desktop!";
    }

    private function writeBytesToFile(fileName:String, data:ByteArray):void
    {
        var outFile:File = File.desktopDirectory; // dest folder is desktop
        outFile = outFile.resolvePath(fileName);  // name of file to write
        var outStream:FileStream = new FileStream();
        // open output file stream in WRITE mode
        outStream.open(outFile, FileMode.WRITE);
        // write out the file
        outStream.writeBytes(data, 0, data.length);
        // close it
        outStream.close();
    }
}
```

The `readObject()` method reads an object in serialized AMF from a ByteArray and stores it in an object of the specified type. The following example reads the `order` file from the desktop into a ByteArray (`inBytes`), uncompresses it, and calls `readObject()` to store it in the XML object `orderXML`. The example uses a `for each()` loop construct to add each node to a text area for display. The example also displays the value of the `objectEncoding` property along with a header for the contents of the `order` file.

```
import flash.filesystem.*;
import flash.display.Sprite;
import flash.display.TextField;
import flash.utils.ByteArray;

public class ReadObjectExample extends Sprite
{
    public function ReadObjectExample()
    {
        var inBytes:ByteArray = new ByteArray();
        // define text area for displaying XML content
        var myTxt:TextField = new TextField();
        myTxt.width = 550;
        myTxt.height = 400;
        addChild(myTxt);
        //display objectEncoding and file heading
        myTxt.text = "Object encoding is: " + inBytes.objectEncoding + "\n\n" + "order file: \n\n";
        readFileIntoByteArray("order", inBytes);

        inBytes.position = 0; // reset position to beginning
        inBytes.uncompress(CompressionAlgorithm.DEFLATE);
        inBytes.position = 0;//reset position to beginning
        // read XML Object
        var orderXML:XML = inBytes.readObject();
        // for each node in orderXML
        for each (var child:XML in orderXML)
        {
            // append child node to text area
            myTxt.text += child + "\n";
        }
    }

    // read specified file into byte array
    private function readFileIntoByteArray(fileName:String, data:ByteArray):void
    {
        var inFile:File = File.desktopDirectory; // source folder is desktop
        inFile = inFile.resolvePath(fileName);  // name of file to read
        var inStream:FileStream = new FileStream();
        inStream.open(inFile, FileMode.READ);
        inStream.readBytes(data);
        inStream.close();
    }
}
```

ByteArray example: Reading a .zip file

Adobe AIR 1.0 and later

This example demonstrates how to read a simple .zip file containing several files of different types. It does so by extracting relevant data from the metadata for each file, uncompressing each file into a ByteArray and writing the file to the desktop.

The general structure of a .zip file is based on the specification by PKWARE Inc., which is maintained at http://www.pkware.com/documents/casestudies/APPNOTE.TXT. First is a file header and file data for the first file in the .zip archive, followed by a file header and file data pair for each additional file. (The structure of the file header is described later.) Next, the .zip file optionally includes a data descriptor record (usually when the output zip file was created in memory rather than saved to a disk). Next are several additional optional elements: archive decryption header, archive extra data record, central directory structure, Zip64 end of central directory record, Zip64 end of central directory locator, and end of central directory record.

The code in this example is written to only parse zip files that do not contain folders and it does not expect data descriptor records. It ignores all information following the last file data.

The format of the file header for each file is as follows:

file header signature	4 bytes
required version	2 bytes
general-purpose bit flag	2 bytes
compression method	2 bytes (8=DEFLATE; 0=UNCOMPRESSED)
last modified file time	2 bytes
last modified file date	2 bytes
crc-32	4 bytes

compressed size	4 bytes
uncompressed size	4 bytes
file name length	2 bytes
extra field length	2 bytes
file name	variable
extra field	variable

Following the file header is the actual file data, which can be either compressed or uncompressed, depending on the compression method flag. The flag is 0 (zero) if the file data is uncompressed, 8 if the data is compressed using the DEFLATE algorithm, or another value for other compression algorithms.

The user interface for this example consists of a label and a text area (`taFiles`). The application writes the following information to the text area for each file it encounters in the .zip file: the file name, the compressed size, and the uncompressed size. The following MXML document defines the user interface for the Flex version of the application:

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" layout="vertical"
creationComplete="init();">
    <mx:Script>
        <![CDATA[
            // The application code goes here
        ]]>
    </mx:Script>
    <mx:Form>
        <mx:FormItem label="Output">
            <mx:TextArea id="taFiles" width="320" height="150"/>
        </mx:FormItem>
    </mx:Form>
</mx:WindowedApplication>
```

The beginning of the program performs the following tasks:

- Imports the required classes

```
import flash.filesystem.*;
import flash.utils.ByteArray;
import flash.events.Event;
```

- Defines the user interface for Flash

```
 import fl.controls.*;

//requires TextArea and Label components in the Library
var taFiles = new TextArea();
var output = new Label();
taFiles.setSize(320, 150);
taFiles.move(10, 30);
output.move(10, 10);
output.width = 150;
output.text = "Contents of HelloAir.zip";
addChild(taFiles);
addChild(output);
```

- Defines the `bytes` ByteArray

```
var bytes:ByteArray = new ByteArray();
```

- Defines variables to store metadata from the file header

```
 // variables for reading fixed portion of file header
var fileName:String = new String();
var flNameLength:uint;
var xfldLength:uint;
var offset:uint;
var compSize:uint;
var uncompSize:uint;
var compMethod:int;
var signature:int;
```

- Defines File (`zfile`) and FileStream (`zStream`) objects to represent the .zip file, and specifies the location of the .zip file from which the files are extracted—a file named "HelloAIR.zip" in the desktop directory.

```
 // File variables for accessing .zip file
var zfile:File = File.desktopDirectory.resolvePath("HelloAIR.zip");
var zStream:FileStream = new FileStream();
```

In Flex, the program code starts in the `init()` method, which is called as the `creationComplete` handler for the root `mx:WindowedApplication` tag.

```
// for Flex
private function init():void
{
```

The program begins by opening the .zip file in READ mode.

```
    zStream.open(zfile, FileMode.READ);
```

It then sets the `endian` property of `bytes` to `LITTLE_ENDIAN` to indicate that the byte order of numeric fields has the least significant byte first.

```
    bytes.endian = Endian.LITTLE_ENDIAN;
```

Next, a `while()` statement begins a loop that continues until the current position in the file stream is greater than or equal to the size of the file.

```
    while (zStream.position < zfile.size)
    {
```

The first statement inside the loop reads the first 30 bytes of the file stream into the ByteArray `bytes`. The first 30 bytes make up the fixed-size part of the first file header.

```
        // read fixed metadata portion of local file header
        zStream.readBytes(bytes, 0, 30);
```

Next, the code reads an integer (`signature`) from the first bytes of the 30-byte header. The ZIP format definition specifies that the signature for every file header is the hexadecimal value `0x04034b50`; if the signature is different it means that the code has moved beyond the file portion of the .zip file and there are no more files to extract. In that case the code exits the `while` loop immediately rather than waiting for the end of the byte array.

```
        bytes.position = 0;
        signature = bytes.readInt();
        // if no longer reading data files, quit
        if (signature != 0x04034b50)
        {
            break;
        }
```

The next part of the code reads the header byte at offset position 8 and stores the value in the variable `compMethod`. This byte contains a value indicating the compression method that was used to compress this file. Several compression methods are allowed, but in practice nearly all .zip files use the DEFLATE compression algorithm. If the current file is compressed with DEFLATE compression, `compMethod` is 8; if the file is uncompressed, `compMethod` is 0.

```
        bytes.position = 8;
        compMethod = bytes.readByte();  // store compression method (8 == Deflate)
```

Following the first 30 bytes is a variable-length portion of the header that contains the file name and, possibly, an extra field. The variable `offset` stores the size of this portion. The size is calculated by adding the file name length and extra field length, read from the header at offsets 26 and 28.

```
        offset = 0;// stores length of variable portion of metadata
        bytes.position = 26;  // offset to file name length
        flNameLength = bytes.readShort();// store file name
        offset += flNameLength; // add length of file name
        bytes.position = 28;// offset to extra field length
        xfldLength = bytes.readShort();
        offset += xfldLength;// add length of extra field
```

Next the program reads the variable-length portion of the file header for the number of bytes stored in the `offset` variable.

```
        // read variable length bytes between fixed-length header and compressed file data
        zStream.readBytes(bytes, 30, offset);
```

The program reads the file name from the variable length portion of the header and displays it in the text area along with the compressed (zipped) and uncompressed (original) sizes of the file.

```
// Flash version
        bytes.position = 30;
        fileName = bytes.readUTFBytes(flNameLength); // read file name
        taFiles.appendText(fileName + "\n"); // write file name to text area
        bytes.position = 18;
        compSize = bytes.readUnsignedInt();  // store size of compressed portion
        taFiles.appendText("\tCompressed size is: " + compSize + '\n');
        bytes.position = 22;  // offset to uncompressed size
        uncompSize = bytes.readUnsignedInt();  // store uncompressed size
        taFiles.appendText("\tUncompressed size is: " + uncompSize + '\n');


// Flex version
        bytes.position = 30;
        fileName = bytes.readUTFBytes(flNameLength); // read file name
        taFiles.text += fileName + "\n"; // write file name to text area
        bytes.position = 18;
        compSize = bytes.readUnsignedInt();  // store size of compressed portion
        taFiles.text += "\tCompressed size is: " + compSize + '\n';
        bytes.position = 22;  // offset to uncompressed size
        uncompSize = bytes.readUnsignedInt();  // store uncompressed size
        taFiles.text += "\tUncompressed size is: " + uncompSize + '\n';
```

The example reads the rest of the file from the file stream into `bytes` for the length specified by the compressed size, overwriting the file header in the first 30 bytes. The compressed size is accurate even if the file is not compressed because in that case the compressed size is equal to the uncompressed size of the file.

```
    // read compressed file to offset 0 of bytes; for uncompressed files
    // the compressed and uncompressed size is the same
    if (compSize == 0) continue;
    zStream.readBytes(bytes, 0, compSize);
```

Next, the example uncompresses the compressed file and calls the `outfile()` function to write it to the output file stream. It passes `outfile()` the file name and the byte array containing the file data.

```
        if (compMethod == 8) // if file is compressed, uncompress
        {
            bytes.uncompress(CompressionAlgorithm.DEFLATE);
        }
        outFile(fileName, bytes);   // call outFile() to write out the file
```

In the previously mentioned example, `bytes.uncompress(CompressionAlgorithm.DEFLATE)` will work only in AIR applications. To get deflated data uncompressed for both AIR and Flash Player, invoke ByteArray's `inflate()` function.

The closing braces indicate the end of the `while` loop, and of the `init()` method and the Flex application code, except for the `outFile()` method. Execution loops back to the beginning of the `while` loop and continues processing the next bytes in the .zip file—either extracting another file or ending processing of the .zip file if the last file has been processed.

```
    } // end of while loop
} // for Flex version, end of init() method and application
```

The `outfile()` function opens an output file in WRITE mode on the desktop, giving it the name supplied by the `filename` parameter. It then writes the file data from the `data` parameter to the output file stream (`outStream`) and closes the file.

```
// Flash version
function outFile(fileName:String, data:ByteArray):void
{
    var outFile:File = File.desktopDirectory; // destination folder is desktop
    outFile = outFile.resolvePath(fileName);  // name of file to write
    var outStream:FileStream = new FileStream();
    // open output file stream in WRITE mode
    outStream.open(outFile, FileMode.WRITE);
    // write out the file
    outStream.writeBytes(data, 0, data.length);
    // close it
    outStream.close();
}
```

```
private function outFile(fileName:String, data:ByteArray):void
{
    var outFile:File = File.desktopDirectory; // dest folder is desktop
    outFile = outFile.resolvePath(fileName);  // name of file to write
    var outStream:FileStream = new FileStream();
    // open output file stream in WRITE mode
    outStream.open(outFile, FileMode.WRITE);
    // write out the file
    outStream.writeBytes(data, 0, data.length);
    // close it
    outStream.close();
}
```

Chapter 42: Basics of networking and communication

Flash Player 9 and later, Adobe AIR 1.0 and later

When you build applications in Flash Player or AIR, you often need to access resources outside your application. For example, you might send a request for an image to an Internet web server and get the image data in return. Or, you might send serialized objects back and forth over a socket connection with an application server. The Flash Player and AIR APIs provide several classes that allow your applications to participate in this exchange. These APIs support IP-based networking for protocols like UDP, TCP, HTTP, RTMP, and RTMFP.

The following classes can be used to send and receive data across a network:

Class	Supported data formats	Protocols	Description
Loader	SWF, PNG, JPEG, GIF	HTTP, HTTPS	Loads supported data types and converts the data into a display object. See "Loading display content dynamically" on page 198.
URLLoader	Any (text, XML, binary, etc.)	HTTP, HTTPS	Loads arbitrary formats of data. Your application is responsible for interpreting the data. See "Using the URLLoader class" on page 815
FileReference	Any	HTTP	Upload and download files. See "Using the FileReference class" on page 653
NetConnection	Video, audio, ActionScript Message Format (AMF)	HTTP, HTTPS, RTMP, RTMFP	Connects to video, audio and remote object streams. See "Working with video" on page 474.
Sound	Audio	HTTP	Loads and plays supported audio formats. See "Loading external sound files" on page 443.
XMLSocket	XML	TCP	Exchanges XML messages with an XMLSocket server. See "XML sockets" on page 802.
Socket	Any	TCP	Connects to a TCP socket server. See "Binary client sockets" on page 798.
SecureSocket (AIR)	Any	TCP with SSLv3 or TLSv1	Connects to a TCP socket server that requires SSL or TLS security. See "Secure client sockets (AIR)" on page 798.
ServerSocket (AIR)	Any	TCP	Acts as a server for incoming TCP socket connections. See "Server sockets" on page 806.
DatagramSocket (AIR)	Any	UDP	Sends and receives UDP packets. See "UDP sockets (AIR)" on page 808

Often, when creating a web application it is helpful to store persistent information about the user's application state. HTML pages and applications typically use cookies for this purpose. In Flash Player, you can use the SharedObject class for the same purpose. See "Shared objects" on page 701. (The SharedObject class can be used in AIR applications, but there are fewer restrictions when just saving the data to a regular file.)

When your Flash Player or AIR application needs to communicate with another Flash Player or AIR application on the same computer, you can use the LocalConnection class. For example, two (or more) SWFs on the same web page can communicate with each other. Likewise, a SWF running on a web page can communicate with an AIR application. See "Communicating with other Flash Player and AIR instances" on page 830.

When you need to communicate with other, non-SWF processes on the local computer, you can use the NativeProcess class added in AIR 2. The NativeProcess class allows your AIR application to launch and communicate with other applications. See "Communicating with native processes in AIR" on page 837.

When you need information about the network environment of the computer on which an AIR application is running, you can use the following classes:

- NetworkInfo—Provides information about the available network interfaces, such as the computer's IP address. See "Network interfaces" on page 791.
- DNSResolver—Allows you to look up DNS records. See "Domain Name System (DNS) records" on page 794.
- ServiceMonitor—Allows you to monitor the availability of a server. See "Service monitoring" on page 792.
- URLMonitor—Allows you to monitor the availability of a resource at a particular URL. See "HTTP monitoring" on page 793.
- SocketMonitor and SecureSocketMonitor—Allows you to monitor the availability of a resource at a socket. See "Socket monitoring" on page 794.

Important concepts and terms

The following reference list contains important terms that you will encounter when programming networking and communications code:

External data Data that is stored in some form outside of the application, and loaded into the application when needed. This data could be stored in a file that's loaded directly, or stored in a database or other form that is retrieved by calling scripts or programs running on a server.

URL-encoded variables The URL-encoded format provides a way to represent several variables (pairs of variable names and values) in a single string of text. Individual variables are written in the format name=value. Each variable (that is, each name-value pair) is separated by ampersand characters, like this: variable1=value1&variable2=value2. In this way, an indefinite number of variables can be sent as a single message.

MIME type A standard code used to identify the type of a given file in Internet communication. Any given file type has a specific code that is used to identify it. When sending a file or message, a computer (such as a web server or a user's Flash Player or AIR instance) will specify the type of file being sent.

HTTP Hypertext Transfer Protocol—a standard format for delivering web pages and various other types of content that are sent over the Internet.

Request method When an application (such as an AIR application or a web browser) sends a message (called an HTTP request) to a web server, any data being sent can be embedded in the request in one of two ways; these are the two request methods GET and POST. On the server end, the program receiving the request will need to look in the appropriate portion of the request to find the data, so the request method used to send data from your application should match the request method used to read that data on the server.

Socket connection A persistent connection for communication between two computers.

Upload To send a file to another computer.

Download To retrieve a file from another computer.

Network interfaces

Adobe AIR 2 and later

You can use the NetworkInfo object to discover the hardware and software network interfaces available to your application. The NetworkInfo object is a *singleton* object, you do not need to create one. Instead, use the static class property, `networkInfo`, to access the single NetworkInfo object. The NetworkInfo object also dispatches a `networkChange` event when one of the available interfaces change.

Call the `findInterfaces()` method to get a list of NetworkInterface objects. Each NetworkInterface object in the list describes one of the available interfaces. The NetworkInterface object provides such information as the IP address, hardware address, maximum transmission unit, and whether the interface is active.

The following code example traces the NetworkInterface properties of each interface on the client computer:

```
package {
import flash.display.Sprite;
import flash.net.InterfaceAddress;
import flash.net.NetworkInfo;
import flash.net.NetworkInterface;

public class NetworkInformationExample extends Sprite
{
    public function NetworkInformationExample()
    {
        var networkInfo:NetworkInfo = NetworkInfo.networkInfo;
        var interfaces:Vector.<NetworkInterface> = networkInfo.findInterfaces();

        if( interfaces != null )
        {
            trace( "Interface count: " + interfaces.length );
            for each ( var interfaceObj:NetworkInterface in interfaces )
            {
                trace( "\nname: " + interfaceObj.name );
                trace( "display name: " + interfaceObj.displayName );
                trace( "mtu: "  + interfaceObj.mtu );
                trace( "active?: " + interfaceObj.active );
                trace( "parent interface: " + interfaceObj.parent );
                trace( "hardware address: " + interfaceObj.hardwareAddress );
                if( interfaceObj.subInterfaces != null )
                {
                    trace( "# subinterfaces: " + interfaceObj.subInterfaces.length );
                }
                trace("# addresses: " + interfaceObj.addresses.length );
                for each ( var address:InterfaceAddress in interfaceObj.addresses )
                {
                    trace( "  type: "           + address.ipVersion );
                    trace( "  address: " + address.address );
                    trace( "  broadcast: " + address.broadcast );
                    trace( "  prefix length: " + address.prefixLength );
                }
            }
        }
    }
}
}
```

For more information, see:

- NetworkInfo
- NetworkInterface
- InterfaceAddress
- Flexpert: Detecting the network connection type with Flex 4.5

Network connectivity changes

Adobe AIR 1.0 and later

Your AIR application can run in environments with uncertain and changing network connectivity. To help an application manage connections to online resources, Adobe AIR sends a network change event whenever a network connection becomes available or unavailable. Both the NetworkInfo object and the application's NativeApplication object dispatch the `networkChange` event. To react to this event, add a listener:

```
NetworkInfo.networkInfo.addEventListener(Event.NETWORK_CHANGE, onNetworkChange);
```

And define an event handler function:

```
function onNetworkChange(event:Event)
{
    //Check resource availability
}
```

The `networkChange` event does not indicate a change in all network activity, only that an individual network connection has changed. AIR does not attempt to interpret the meaning of the network change. A networked computer can have many real and virtual connections, so losing a connection does not necessarily mean losing a resource. On the other hand, new connections do not guarantee improved resource availability, either. Sometimes a new connection can even block access to resources previously available (for example, when connecting to a VPN).

In general, the only way for an application to determine whether it can connect to a remote resource is to try it. The service monitoring framework provides an event-based means of responding to changes in network connectivity to a specified host.

***Note:** The service monitoring framework detects whether a server responds acceptably to a request. A successful check does not guarantee full connectivity. Scalable web services often use caching and load-balancing appliances to redirect traffic to a cluster of web servers. In this situation, service providers only provide a partial diagnosis of network connectivity.*

Service monitoring

Adobe AIR 1.0 and later

The service monitor framework, separate from the AIR framework, resides in the file aircore.swc. To use the framework, the aircore.swc file must be included in your build process.

Adobe® Flash® Builder includes this library automatically.

The ServiceMonitor class implements the framework for monitoring network services and provides a base functionality for service monitors. By default, an instance of the ServiceMonitor class dispatches events regarding network connectivity. The ServiceMonitor object dispatches these events when the instance is created and whenever the runtime detects a network change. Additionally, you can set the `pollInterval` property of a ServiceMonitor instance to check connectivity at a specified interval in milliseconds, regardless of general network connectivity events. A ServiceMonitor object does not check network connectivity until the `start()` method is called.

The URLMonitor class, a subclass of the ServiceMonitor class, detects changes in HTTP connectivity for a specified URLRequest.

The SocketMonitor class, also a subclass of the ServiceMonitor class, detects changes in connectivity to a specified host at a specified port.

***Note:** Prior to AIR 2, the service monitor framework was published in the servicemonitor.swc library. This library is now deprecated. Use the aircore.swc library instead.*

Flash CS4 and CS5 Professional

To use these classes in Adobe® Flash® CS4 or CS5 Professional:

1 Select the File > Publish Settings command.

2 Click the Settings button for ActionScript 3.0. Select Library Path.

3 Click the Browse to SWC button and browse to the AIK folder in your Flash Professional installation folder.

4 Within this folder, find the /frameworks/libs/air/aircore.swc (for AIR 2) or /frameworks/libs/air/servicemonitor.swc (for AIR 1.5).

5 Click the OK button.

6 Add the following import statement to your ActionScript 3.0 code:

```
import air.net.*;
```

Flash CS3 Professional

To use these classes in Adobe® Flash® CS3 Professional, drag the ServiceMonitorShim component from the Components panel to the Library. Then, add the following `import`statement to your ActionScript 3.0 code:

```
 import air.net.*;
```

HTTP monitoring

Adobe AIR 1.0 and later

The URLMonitor class determines if HTTP requests can be made to a specified address at port 80 (the typical port for HTTP communication). The following code uses an instance of the URLMonitor class to detect connectivity changes to the Adobe website:

```
import air.net.URLMonitor;
import flash.net.URLRequest;
import flash.events.StatusEvent;
var monitor:URLMonitor;
monitor = new URLMonitor(new URLRequest('http://www.example.com'));
monitor.addEventListener(StatusEvent.STATUS, announceStatus);
monitor.start();
function announceStatus(e:StatusEvent):void {
    trace("Status change. Current status: " + monitor.available);
}
```

Socket monitoring

Adobe AIR 1.0 and later

AIR applications can also use socket connections for push-model connectivity. Firewalls and network routers typically restrict network communication on unauthorized ports for security reasons. For this reason, developers must consider that users do not always have the capability to make socket connections.

The following code uses an instance of the SocketMonitor class to detect connectivity changes to a socket connection. The port monitored is 6667, a common port for IRC:

```
import air.net.ServiceMonitor;
import flash.events.StatusEvent;

socketMonitor = new SocketMonitor('www.example.com',6667);
socketMonitor.addEventListener(StatusEvent.STATUS, socketStatusChange);
socketMonitor.start();

function announceStatus(e:StatusEvent):void {
    trace("Status change. Current status: " + socketMonitor.available);
}
```

If the socket server requires a secure connection, you can use the SecureSocketMonitor class instead of SocketMonitor.

Domain Name System (DNS) records

Adobe AIR 2.0 and later

You can look up DNS resource records using the DNSResolver class. DNS resource records provide information like the IP address of a domain name and the domain name of an IP address. You can look up the following types of DNS resource records:

- ARecord—IPv4 address for a host.
- AAAARecord—IPv6 address for a host.
- MXRecord—mail exchange record for a host.
- PTRRecord—host name for an IP address.
- SRVRecord—service record for a service.

To look up a record, you pass a query string and the class object representing the record type to the `lookup()` method of the DNSResolver object. The query string to use depends on the record type:

Record class	**Query string**	**Example query string**
ARecord	host name	"example.com"
AAAARecord	host name	"example.com"
MXRecord	host name	"example.com"
PTRRecord	IP address	"208.77.188.166"
SRVRecord	Service identifier: _service._protocol.host	"_sip._tcp.example.com"

The following code example looks up the IP address of the host "example.com".

```
package
{
    import flash.display.Sprite;
    import flash.events.DNSResolverEvent;
    import flash.events.ErrorEvent;
    import flash.net.dns.ARecord;
    import flash.net.dns.DNSResolver;

    public class DNSResolverExample extends Sprite
    {

        public function DNSResolverExample()
        {
            var resolver:DNSResolver = new DNSResolver();
            resolver.addEventListener( DNSResolverEvent.LOOKUP, lookupComplete );
            resolver.addEventListener( ErrorEvent.ERROR, lookupError );

            resolver.lookup( "example.com.", ARecord );
        }

        private function lookupComplete( event:DNSResolverEvent ):void
        {
            trace( "Query string: " + event.host );
            trace( "Record count: " + event.resourceRecords.length );
            for each( var record:* in event.resourceRecords )
            {
                if( record is ARecord ) trace( record.address );
            }

        }

        private function lookupError( error:ErrorEvent ):void
        {
            trace("Error: " + error.text );
        }
    }
}
```

For more information, see:

- DNSResolver
- DNSResolverEvent
- ARecord

- AAAARecord
- MXRecord
- PTRRecord
- SRVRecord

Chapter 43: Sockets

Flash Player 9 and later, Adobe AIR 1.0 and later

A socket is a type of network connection established between two computer processes. Typically, the processes are running on two different computers attached to the same Internet Protocol (IP) network. However, the connected processes can be running on the same computer using the special “local host” IP address.

Adobe Flash Player supports client-side Transport Control Protocol (TCP) sockets. A Flash Player application can connect to another process acting as a socket server, but cannot accept incoming connection requests from other processes. In other words, a Flash Player application can connect to a TCP server, but cannot serve as one.

The Flash Player API also includes the XMLSocket class. The XMLSocket class uses a Flash Player-specific protocol that allows you to exchange XML messages with a server that understands that protocol. The XMLSocket class was introduced in ActionScript 1 and is still supported to provide backward compatibility. In general, the Socket class should be used for new applications unless you are connecting to a server specifically created to communicate with Flash XMLSockets.

Adobe AIR adds several additional classes for socket-based network programming. AIR applications can act as TCP socket servers with the ServerSocket class and can connect to socket servers requiring SSL or TLS security with the SecureSocket class. AIR applications can also send and receive Universal Datagram Protocol (UDP) messages with the DatagramSocket class.

More Help topics

flash.net package

“Connecting to sockets” on page 1068

TCP sockets

Flash Player 9 and later, Adobe AIR 1.0 and later

The Transmission Control Protocol (TCP) provides a way to exchange messages over a persistent network connection. TCP guarantees that any messages sent arrive in the correct order (barring major network problems). TCP connections require a “client” and a “server.” Flash Player can create client sockets. Adobe AIR can, additionally, create server sockets.

The following ActionScript APIs provide TCP connections:

- Socket — allows a client application to connect to a server. The Socket class cannot listen for incoming connections.
- SecureSocket (AIR) — allows a client application to connect to a trusted server and engage in encrypted communications.
- ServerSocket (AIR) — allows an application to listen for incoming connections and act as a server.
- XMLSocket — allows a client application to connect to an XMLSocket server.

Binary client sockets

Flash Player 9 and later, Adobe AIR 1.0 and later

A binary socket connection is similar to an XML socket except that the client and server are not limited to exchanging XML messages. Instead, the connection can transfer data as binary information. Thus, you can connect to a wider range of services, including mail servers (POP3, SMTP, and IMAP), and news servers (NNTP).

Socket class

Flash Player 9 and later, Adobe AIR 1.0 and later

The Socket class enables you to make socket connections and to read and write raw binary data. The Socket class is useful for interoperating with servers that use binary protocols. By using binary socket connections, you can write code that interacts with several different Internet protocols, such as POP3, SMTP, IMAP, and NNTP. This interaction, in turn, enables your applications to connect to mail and news servers.

Flash Player can interface with a server by using the binary protocol of that server directly. Some servers use the big-endian byte order, and some use the little-endian byte order. Most servers on the Internet use the big-endian byte order because "network byte order" is big-endian. The little-endian byte order is popular because the Intel® x86 architecture uses it. You should use the endian byte order that matches the byte order of the server that is sending or receiving data. All operations that are performed by the IDataInput and IDataOutput interfaces, and the classes that implement those interfaces (ByteArray, Socket, and URLStream), are encoded by default in big-endian format; that is, with the most significant byte first. This default byte order was chosen to match Java and the official network byte order. To change whether big-endian or little-endian byte order is used, you can set the `endian` property to `Endian.BIG_ENDIAN` or `Endian.LITTLE_ENDIAN`.

The Socket class inherits all the methods defined by the IDataInput and IDataOutput interfaces (located in the flash.utils package). Those methods must be used to write to and read from the Socket.

For more information, see:

- Socket
- IDataInput
- IDataOutput
- socketData event

Secure client sockets (AIR)

Adobe AIR 2 and later

You can use the SecureSocket class to connect to socket servers that use Secure Sockets Layer version 4 (SSLv4) or Transport Layer Security version 1 (TLSv1). A secure socket provides three benefits: server authentication, data integrity, and message confidentiality. The runtime authenticates a server using the server certificate and its relationship to the root or intermediate certificate authority certificates in the user's trust store. The runtime relies on the cryptography algorithms used by the SSL and TLS protocol implementations to provide data integrity and message confidentiality.

When you connect to a server using the SecureSocket object, the runtime validates the server certificate using the certificate trust store. On Windows and Mac, the operating system provides the trust store. On Linux, the runtime provides its own trust store.

If the server certificate is not valid or not trusted, the runtime dispatches an `ioError` event. You can check the `serverCertificateStatus` property of the SecureSocket object to determine why validation failed. No provision is provided for communicating with a server that does not have a valid and trusted certificate.

The CertificateStatus class defines string constants that represent the possible validation results:

- Expired—the certificate expiration date has passed.
- Invalid—there are a number of reasons that a certificate can be invalid. For example, the certificate could have been altered, corrupted, or it could be the wrong type of certificate.
- Invalid chain—one or more of the certificates in the server's chain of certificates are invalid.
- Principal mismatch—the host name of the server and the certificate common name do not match. In other words, the server is using the wrong certificate.
- Revoked—the issuing certificate authority has revoked the certificate.
- Trusted—the certificate is valid and trusted. A SecureSocket object can only connect to a server that uses a valid, trusted certificate.
- Unknown—the SecureSocket object has not validated the certificate yet. The `serverCertificateStatus` property has this status value before you call `connect()` and before either a `connect` or an `ioError` event is dispatched.
- Untrusted signers—the certificate does not "chain" to a trusted root certificate in the trust store of the client computer.

Communicating with a SecureSocket object requires a server that uses a secure protocol and has a valid, trusted certificate. In other respects, using a SecureSocket object is the same as using a Socket object.

The SecureSocket object is not supported on all platforms. Use the SecureSocket class `isSupported` property to test whether the runtime supports use of the SecureSocket object on the current client computer.

For more information, see:

- SecureSocket
- CertificateStatus
- IDataInput
- IDataOutput
- socketData event

TCP socket example: Building a Telnet client

Flash Player 9 and later, Adobe AIR 1.0 and later

The Telnet example demonstrates techniques for connecting with a remote server and transmitting data using the Socket class. The example demonstrates the following techniques:

- Creating a custom telnet client using the Socket class
- Sending text to the remote server using a ByteArray object
- Handling received data from a remote server

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The Telnet application files can be found in the Samples/Telnet folder. The application consists of the following files:

File	Description
TelnetSocket.fla or TelnetSocket.mxml	The main application file consisting of the user interface for Flex (MXML) or Flash (FLA).
TelnetSocket.as	Document class providing the user interface logic (Flash only).
com/example/programmingas3/Telnet/Telnet.as	Provides the Telnet client functionality for the application, such as connecting to a remote server, and sending, receiving, and displaying data.

Telnet socket application overview

Flash Player 9 and later, Adobe AIR 1.0 and later

The main TelnetSocket.mxml file is responsible for creating the user interface (UI) for the entire application.

In addition to the UI, this file also defines two methods, `login()` and `sendCommand()`, to connect the user to the specified server.

The following code lists the ActionScript in the main application file:

```
import com.example.programmingas3.socket.Telnet;

private var telnetClient:Telnet;
private function connect():void
{
    telnetClient = new Telnet(serverName.text, int(portNumber.text), output);
    console.title = "Connecting to " + serverName.text + ":" + portNumber.text;
    console.enabled = true;
}
private function sendCommand():void
{
    var ba:ByteArray = new ByteArray();
    ba.writeMultiByte(command.text + "\n", "UTF-8");
    telnetClient.writeBytesToSocket(ba);
    command.text = "";
}
```

The first line of code imports the Telnet class from the custom com.example.programmingas.socket package. The second line of code declares an instance of the Telnet class, `telnetClient`, that is initialized later by the `connect()` method. Next, the `connect()` method is declared and initializes the `telnetClient` variable declared earlier. This method passes the user-specified telnet server name, telnet server port, and a reference to a TextArea component on the display list, which is used to display the text responses from the socket server. The final two lines of the `connect()` method set the `title` property for the Panel and enable the Panel component, which allows the user to send data to the remote server. The final method in the main application file, `sendCommand()`, is used to send the user's commands to the remote server as a ByteArray object.

Telnet class overview

Flash Player 9 and later, Adobe AIR 1.0 and later

The Telnet class is responsible for connecting to the remote Telnet server and sending/receiving data.

The Telnet class declares the following private variables:

```
private var serverURL:String;
private var portNumber:int;
private var socket:Socket;
private var ta:TextArea;
private var state:int = 0;
```

The first variable, `serverURL`, contains the user-specified server address to connect to.

The second variable, `portNumber`, is the port number that the Telnet server is currently running on. By default, the Telnet service runs on port 23.

The third variable, `socket`, is a Socket instance that attempts to connect to the server defined by the `serverURL` and `portNumber` variables.

The fourth variable, `ta`, is a reference to a TextArea component instance on the Stage. This component is used to display responses from the remote Telnet server, or any possible error messages.

The final variable, `state`, is a numeric value that is used to determine which options your Telnet client supports.

As you saw before, the Telnet class's constructor function is called by the `connect()` method in the main application file.

The Telnet constructor takes three parameters: `server`, `port`, and `output`. The `server` and `port` parameters specify the server name and port number where the Telnet server is running. The final parameter, `output`, is a reference to a TextArea component instance on the Stage where server output is displayed to users.

```
public function Telnet(server:String, port:int, output:TextArea)
{
    serverURL = server;
    portNumber = port;
    ta = output;
    socket = new Socket();
    socket.addEventListener(Event.CONNECT, connectHandler);
    socket.addEventListener(Event.CLOSE, closeHandler);
    socket.addEventListener(ErrorEvent.ERROR, errorHandler);
    socket.addEventListener(IOErrorEvent.IO_ERROR, ioErrorHandler);
    socket.addEventListener(ProgressEvent.SOCKET_DATA, dataHandler);
    Security.loadPolicyFile("http://" + serverURL + "/crossdomain.xml");
    try
    {
        msg("Trying to connect to " + serverURL + ":" + portNumber + "\n");
        socket.connect(serverURL, portNumber);
    }
    catch (error:Error)
    {
        msg(error.message + "\n");
        socket.close();
    }
}
```

Writing data to a socket

Flash Player 9 and later, Adobe AIR 1.0 and later

To write data to a socket connection, you call any of the write methods in the Socket class. These write methods include `writeBoolean()`, `writeByte()`, `writeBytes()`, `writeDouble()`, and others. Then, flush the data in the output buffer using the `flush()` method. In the Telnet server, data is written to the socket connection using the `writeBytes()` method which takes the byte array as a parameter and sends it to the output buffer. The `writeBytesToSocket()` method is as follows:

```
public function writeBytesToSocket(ba:ByteArray):void
{
    socket.writeBytes(ba);
    socket.flush();
}
```

This method gets called by the `sendCommand()` method of the main application file.

Displaying messages from the socket server

Flash Player 9 and later, Adobe AIR 1.0 and later

Whenever a message is received from the socket server, or an event occurs, the custom `msg()` method is called. This method appends a string to the TextArea on the Stage and calls a custom `setScroll()` method, which causes the TextArea component to scroll to the bottom. The `msg()` method is as follows:

```
private function msg(value:String):void
{
    ta.text += value;
    setScroll();
}
```

If you didn't automatically scroll the contents of the TextArea component, users would need to manually drag the scroll bars on the text area to see the latest response from the server.

Scrolling a TextArea component

Flash Player 9 and later, Adobe AIR 1.0 and later

The `setScroll()` method contains a single line of ActionScript that scrolls the TextArea component's contents vertically so the user can see the last line of the returned text. The following snippet shows the `setScroll()` method:

```
public function setScroll():void
{
    ta.verticalScrollPosition = ta.maxVerticalScrollPosition;
}
```

This method sets the `verticalScrollPosition` property, which is the line number of the top row of characters that is currently displayed, and sets it to the value of the `maxVerticalScrollPosition` property.

XML sockets

Flash Player 9 and later, Adobe AIR 1.0 and later

An XML socket lets you create a connection to a remote server that remains open until explicitly closed. You can exchange string data, such as XML, between the server and client. A benefit of using an XML socket server is that the client does not need to explicitly request data. The server can send data without waiting for a request and can send data to every connected client connected.

In Flash Player, and in Adobe AIR content outside the application sandbox, XML socket connections require the presence of a socket policy file on the target server. For more information, see "Website controls (policy files)" on page 1051 and "Connecting to sockets" on page 1068.

The XMLSocket class cannot tunnel through firewalls automatically because, unlike the Real-Time Messaging Protocol (RTMP), XMLSocket has no HTTP tunneling capability. If you need to use HTTP tunneling, consider using Flash Remoting or Flash Media Server (which supports RTMP) instead.

The following restrictions apply to how and where content in Flash Player or in an AIR application outside of the application security sandbox can use an XMLSocket object to connect to the server:

- For content outside of the application security sandbox, the `XMLSocket.connect()` method can connect only to TCP port numbers greater than or equal to 1024. One consequence of this restriction is that the server daemons that communicate with the `XMLSocket` object must also be assigned to port numbers greater than or equal to 1024. Port numbers below 1024 are often used by system services such as FTP (21), Telnet (23), SMTP (25), HTTP (80), and POP3 (110), so XMLSocket objects are barred from these ports for security reasons. The port number restriction limits the possibility that these resources will be inappropriately accessed and abused.
- For content outside of the application security sandbox, the `XMLSocket.connect()` method can connect only to computers in the same domain where the content resides. (This restriction is identical to the security rules for `URLLoader.load()`.) To connect to a server daemon running in a domain other than the one where the content resides, you can create a cross-domain policy file on the server that allows access from specific domains. For details on cross-domain policy files, see "AIR security" on page 1076.

Note: *Setting up a server to communicate with the XMLSocket object can be challenging. If your application does not require real-time interactivity, use the URLLoader class instead of the XMLSocket class.*

You can use the `XMLSocket.connect()` and `XMLSocket.send()` methods of the XMLSocket class to transfer XML to and from a server over a socket connection. The `XMLSocket.connect()` method establishes a socket connection with a web server port. The `XMLSocket.send()` method passes an XML object to the server specified in the socket connection.

When you invoke the `XMLSocket.connect()` method, the application opens a TCP/IP connection to the server and keeps that connection open until one of the following occurs:

- The `XMLSocket.close()` method of the XMLSocket class is called.
- No more references to the XMLSocket object exist.
- Flash Player exits.
- The connection is broken (for example, the modem disconnects).

Connecting to a server with the XMLSocket class

Flash Player 9 and later, Adobe AIR 1.0 and later

To create a socket connection, you must create a server-side application to wait for the socket connection request and send a response to the Flash Player or AIR application. This type of server-side application can be written in AIR or in another programming language such as Java, Python, or Perl. To use the XMLSocket class, the server computer must run a daemon that understands the simple protocol used by the XMLSocket class:

- XML messages are sent over a full-duplex TCP/IP stream socket connection.
- Each XML message is a complete XML document, terminated by a zero (0) byte.
- An unlimited number of XML messages can be sent and received over a single XMLSocket connection.

Creating and connecting to a Java XML socket server

Flash Player 9 and later, Adobe AIR 1.0 and later

The following code demonstrates a simple XMLSocket server written in Java that accepts incoming connections and displays the received messages in the command prompt window. By default, a new server is created on port 8080 of your local machine, although you can specify a different port number when starting your server from the command line.

Create a new text document and add the following code:

```
import java.io.*;
import java.net.*;

class SimpleServer
{
    private static SimpleServer server;
    ServerSocket socket;
    Socket incoming;
    BufferedReader readerIn;
    PrintStream printOut;

    public static void main(String[] args)
    {
        int port = 8080;

        try
        {
            port = Integer.parseInt(args[0]);
        }
        catch (ArrayIndexOutOfBoundsException e)
        {
            // Catch exception and keep going.
        }

        server = new SimpleServer(port);
    }

    private SimpleServer(int port)
    {
        System.out.println(">> Starting SimpleServer");
        try
        {
            socket = new ServerSocket(port);
            incoming = socket.accept();
            readerIn = new BufferedReader(new InputStreamReader(incoming.getInputStream()));
            printOut = new PrintStream(incoming.getOutputStream());
            printOut.println("Enter EXIT to exit.\r");
            out("Enter EXIT to exit.\r");
            boolean done = false;
            while (!done)
            {
                String str = readerIn.readLine();
                if (str == null)
                {
                    done = true;
                }
                else
                {
                    out("Echo: " + str + "\r");
                    if(str.trim().equals("EXIT"))
                    {
                        done = true;
                    }
                }
                incoming.close();
            }
        }
        catch (Exception e)
        {
            System.out.println(e);
        }
    }

    private void out(String str)
    {
        printOut.println(str);
        System.out.println(str);
    }
}
```

Save the document to your hard disk as SimpleServer.java and compile it using a Java compiler, which creates a Java class file named SimpleServer.class.

You can start the XMLSocket server by opening a command prompt and typing `java SimpleServer`. The SimpleServer.class file can be located anywhere on your local computer or network; it doesn't need to be placed in the root directory of your web server.

If you're unable to start the server because the files are not located within the Java classpath, try starting the server with `java -classpath . SimpleServer`.

To connect to the XMLSocket from your application, you need to create a new instance of the XMLSocket class, and call the `XMLSocket.connect()` method while passing a host name and port number, as follows:

```
var xmlsock:XMLSocket = new XMLSocket();
xmlsock.connect("127.0.0.1", 8080);
```

Whenever you receive data from the server, the `data` event (`flash.events.DataEvent.DATA`) is dispatched:

```
xmlsock.addEventListener(DataEvent.DATA, onData);
private function onData(event:DataEvent):void
{
    trace("[" + event.type + "] " + event.data);
}
```

To send data to the XMLSocket server, you use the `XMLSocket.send()` method and pass an XML object or string. Flash Player converts the supplied parameter to a String object and sends the content to the XMLSocket server followed by a zero (0) byte:

```
xmlsock.send(xmlFormattedData);
```

The `XMLSocket.send()` method does not return a value that indicates whether the data was successfully transmitted. If an error occurred while trying to send data, an IOError error is thrown.

Each message you send to the XML socket server must be terminated by a newline (`\n`) character.

For more information, see XMLSocket.

Server sockets

Adobe AIR 2 and later

Use the ServerSocket class to allow other processes to connect to your application using a Transport Control Protocol (TCP) socket. The connecting process can be running on the local computer or on another network-connected computer. When a ServerSocket object receives a connection request, it dispatches a `connect` event. The ServerSocketConnectEvent object dispatched with the event contains a Socket object. You can use this Socket object for subsequent communication with the other process.

To listen for incoming socket connections:

1. Create a ServerSocket object and bind it to a local port
2. Add event listeners for the `connect` event
3. Call the `listen()` method
4. Respond to the `connect` event, which provides a Socket object for each incoming connection

The ServerSocket object continues to listen for new connections until you call the `close()` method.

The following code example illustrates how to create a socket server application. The example listens for incoming connections on port 8087. When a connection is received, the example sends a message (the string "Connected.") to the client socket. Thereafter, the server echoes any messages received back to the client.

```
package
{
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.events.IOErrorEvent;
    import flash.events.ProgressEvent;
    import flash.events.ServerSocketConnectEvent;
    import flash.net.ServerSocket;
    import flash.net.Socket;

    public class ServerSocketExample extends Sprite
    {
        private var serverSocket:ServerSocket;
        private var clientSockets:Array = new Array();

        public function ServerSocketExample()
        {
            try
            {
                // Create the server socket
                serverSocket = new ServerSocket();

                // Add the event listener
                serverSocket.addEventListener( Event.CONNECT, connectHandler );
                serverSocket.addEventListener( Event.CLOSE, onClose );

                // Bind to local port 8087
                serverSocket.bind( 8087, "127.0.0.1" );

                // Listen for connections
                serverSocket.listen();
                trace( "Listening on " + serverSocket.localPort );
            }
            catch(e:SecurityError)
            {
                trace(e);
            }
        }

        public function connectHandler(event:ServerSocketConnectEvent):void
        {
            //The socket is provided by the event object
            var socket:Socket = event.socket as Socket;
            clientSockets.push( socket );

            socket.addEventListener( ProgressEvent.SOCKET_DATA, socketDataHandler);
            socket.addEventListener( Event.CLOSE, onClientClose );
            socket.addEventListener( IOErrorEvent.IO_ERROR, onIOError );

            //Send a connect message
            socket.writeUTFBytes("Connected.");
            socket.flush();

            trace( "Sending connect message" );
        }

        public function socketDataHandler(event:ProgressEvent):void
        {
            var socket:Socket = event.target as Socket

            //Read the message from the socket
            var message:String = socket.readUTFBytes( socket.bytesAvailable );
            trace( "Received: " + message);

            // Echo the received message back to the sender
            message = "Echo -- " + message;
            socket.writeUTFBytes( message );
            socket.flush();
            trace( "Sending: " + message );
        }

        private function onClientClose( event:Event ):void
        {
            trace( "Connection to client closed." );
            //Should also remove from clientSockets array...
        }

        private function onIOError( errorEvent:IOErrorEvent ):void
        {
            trace( "IOError: " + errorEvent.text );
        }

        private function onClose( event:Event ):void
        {
            trace( "Server socket closed by OS." );
        }
}}
```

For more information, see:

- ServerSocket
- ServerSocketConnectEvent
- Socket

UDP sockets (AIR)

Adobe AIR 2 and later

The Universal Datagram Protocol (UDP) provides a way to exchange messages over a stateless network connection. UDP provides no guarantees that messages are delivered in order or even that messages are delivered at all. With UDP, the operating system's network code usually spends less time marshaling, tracking, and acknowledging messages. Thus, UDP messages typically arrive at the destination application with a shorter delay than do TCP messages.

UDP socket communication is helpful when you must send real-time information such as position updates in a game, or sound packets in an audio chat application. In such applications, some data loss is acceptable, and low transmission latency is more important than guaranteed arrival. For almost all other purposes, TCP sockets are a better choice.

Your AIR application can send and receive UDP messages with the DatagramSocket and DatagramSocketDataEvent classes. To send or receive a UDP message:

1. Create a DatagramSocket object
2. Add an event listener for the `data` event
3. Bind the socket to a local IP address and port using the `bind()` method
4. Send messages by calling the `send()` method, passing in the IP address and port of the target computer
5. Receive messages by responding to the `data` event. The DatagramSocketDataEvent object dispatched for this event contains a ByteArray object containing the message data.

The following code example illustrates how an application can send and receive UDP messages. The example sends a single message containing the string, "Hello.", to the target computer. It also traces the contents of any messages received.

```
package
{
import flash.display.Sprite;
import flash.events.DatagramSocketDataEvent;
import flash.events.Event;
import flash.net.DatagramSocket;
import flash.utils.ByteArray;

public class DatagramSocketExample extends Sprite
{
    private var datagramSocket:DatagramSocket;

    //The IP and port for this computer
    private var localIP:String = "192.168.0.1";
    private var localPort:int = 55555;

    //The IP and port for the target computer
    private var targetIP:String = "192.168.0.2";
    private var targetPort:int = 55555;

    public function DatagramSocketExample()
    {
        //Create the socket
        datagramSocket = new DatagramSocket();
        datagramSocket.addEventListener( DatagramSocketDataEvent.DATA, dataReceived );

        //Bind the socket to the local network interface and port
        datagramSocket.bind( localPort, localIP );

        //Listen for incoming datagrams
        datagramSocket.receive();

        //Create a message in a ByteArray
        var data:ByteArray = new ByteArray();
        data.writeUTFBytes("Hello.");

        //Send the datagram message
        datagramSocket.send( data, 0, 0, targetIP, targetPort);
    }

    private function dataReceived( event:DatagramSocketDataEvent ):void
    {
        //Read the data from the datagram
        trace("Received from " + event.srcAddress + ":" + event.srcPort + "> " +
            event.data.readUTFBytes( event.data.bytesAvailable ) );
    }
}}
```

Keep in mind the following considerations when using UDP sockets:

- A single packet of data cannot be larger than the smallest maximum transmission unit (MTU) of the network interface or any network nodes between the sender and the recipient. All of the data in the ByteArray object passed to the send() method is sent as a single packet. (In TCP, large messages are broken up into separate packets.)
- There is no handshaking between the sender and the target. Messages are discarded without error if the target does not exist or does not have an active listener at the specified port.

- When you use the `connect()` method, messages sent from other sources are ignored. A UDP connection provides convenient packet filtering only. It does not mean that there is necessarily a valid, listening process at the target address and port.
- UDP traffic can swamp a network. Network administrators might need to implement quality-of-service controls if network congestion occurs. (TCP has built-in traffic control to reduce the impact of network congestion.)

For more information, see:

- DatagramSocket
- DatagramSocketDataEvent
- ByteArray

IPv6 addresses

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player 9.0.115.0 and later support IPv6 (Internet Protocol version 6). IPv6 is a version of Internet Protocol that supports 128-bit addresses (an improvement on the earlier IPv4 protocol that supports 32-bit addresses). You might need to activate IPv6 on your networking interfaces. For more information, see the Help for the operating system hosting the data.

If IPv6 is supported on the hosting system, you can specify numeric IPv6 literal addresses in URLs enclosed in brackets ([]), as in the following:

```
[2001:db8:ccc3:ffff:0:444d:555e:666f]
```

Flash Player returns literal IPv6 values, according to the following rules:

- Flash Player returns the long form of the string for IPv6 addresses.
- The IP value has no double-colon abbreviations.
- Hexadecimal digits are lowercase only.
- IPv6 addresses are enclosed in square brackets ([]).
- Each address quartet is output as 0 to 4 hexadecimal digits, with the leading zeros omitted.
- An address quartet of all zeros is output as a single zero (not a double colon) except as noted in the following list of exceptions.

The IPv6 values that Flash Player returns have the following exceptions:

- An unspecified IPv6 address (all zeros) is output as [::].
- The loopback or localhost IPv6 address is output as [::1].
- IPv4 mapped (converted to IPv6) addresses are output as [::ffff:a.b.c.d], where a.b.c.d is a typical IPv4 dotted-decimal value.
- IPv4 compatible addresses are output as [::a.b.c.d], where a.b.c.d is a typical IPv4 dotted-decimal value.

Chapter 44: HTTP communications

Flash Player 9 and later, Adobe AIR 1.0 and later

Adobe® AIR® and Adobe® Flash® Player applications can communicate with HTTP-based servers to load data, images, video and to exchange messages.

More Help topics

flash.net.URLLoader

flash.net.URLStream

flash.net.URLRequest

flash.net.URLRequestDefaults

flash.net.URLRequestHeader

flash.net.URLRequestMethod

flash.net.URLVariables

Loading external data

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 includes mechanisms for loading data from external sources. Those sources can provide static content such as text files, or dynamic content generated by a web script. The data can be formatted in various ways, and ActionScript provides functionality for decoding and accessing the data. You can also send data to the external server as part of the process of retrieving data.

Using the URLRequest class

Flash Player 9 and later, Adobe AIR 1.0 and later

Many APIs that load external data use the URLRequest class to define the properties of necessary network request.

URLRequest properties

Flash Player 9 and later, Adobe AIR 1.0 and later

You can set the following properties of a URLRequest object in any security sandbox:

Property	**Description**
contentType	The MIME content type of any data sent with the URL request. If no contentType is set, values are sent as `application/x-www-form-urlencoded`.
data	An object containing data to be transmitted with the URL request.
digest	A string that uniquely identifies the signed Adobe platform component to be stored to (or retrieved from) the Adobe® Flash® Player cache.
method	The HTTP request method, such as a GET or POST. (Content running in the AIR application security domain can specify strings other than `"GET"` or `"POST"` as the `method` property. Any HTTP verb is allowed and `"GET"` is the default method. See "AIR security" on page 1076.)
requestHeaders	The array of HTTP request headers to be appended to the HTTP request. Note that permission to set some headers is restricted in Flash Player as well as in AIR content running outside the application security sandbox.
url	Specifies the URL to be requested.

In AIR, you can set additional properties of the URLRequest class, which are only available to AIR content running in the application security sandbox. Content in the application sandbox can also define URLs using new URL schemes (in addition to standard schemes like `file` and `http`).

Property	**Description**
followRedirects	Specifies whether redirects are to be followed (`true`, the default value) or not (`false`). This is only supported in the AIR application sandbox.
manageCookies	Specifies whether the HTTP protocol stack should manage cookies (`true`, the default value) or not (`false`) for this request. Setting this property is only supported in the AIR application sandbox.
authenticate	Specifies whether authentication requests should be handled (`true`) for this request. Setting this property is only supported in the AIR application sandbox. The default is to authenticate requests—which may cause an authentication dialog box to be displayed if the server requires credentials. You can also set the user name and password using the URLRequestDefaults class—see "Setting URLRequest defaults (AIR only)" on page 812.
cacheResponse	Specifies whether response data should be cached for this request. Setting this property is only supported in the AIR application sandbox. The default is to cache the response (`true`).
useCache	Specifies whether the local cache should be consulted before this URLRequest fetches data. Setting this property is only supported in the AIR application sandbox. The default (`true`) is to use the local cached version, if available.
userAgent	Specifies the user-agent string to be used in the HTTP request.

***Note:** The HTMLLoader class has related properties for settings pertaining to content loaded by an HTMLLoader object. For details, see "About the HTMLLoader class" on page 981.*

Setting URLRequest defaults (AIR only)

Adobe AIR 1.0 and later

The URLRequestDefaults class lets you define application-specific default settings for URLRequest objects. For example, the following code sets the default values for the `manageCookies` and `useCache` properties. All new URLRequest objects will use the specified values for these properties instead of the normal defaults:

```
URLRequestDefaults.manageCookies = false;
URLRequestDefaults.useCache = false;
```

***Note:** The URLRequestDefaults class is defined for content running in Adobe AIR only. It is not supported in Flash Player.*

The URLRequestDefaults class includes a `setLoginCredentialsForHost()` method that lets you specify a default user name and password to use for a specific host. The host, which is defined in the hostname parameter of the method, can be a domain, such as `"www.example.com"`, or a domain and a port number, such as `"www.example.com:80"`. Note that `"example.com"`, `"www.example.com"`, and `"sales.example.com"` are each considered unique hosts.

These credentials are only used if the server requires them. If the user has already authenticated (for example, by using the authentication dialog box), then calling the `setLoginCredentialsForHost()` method does not change the authenticated user.

The following code sets the default user name and password to use for requests sent to www.example.com:

```
URLRequestDefaults.setLoginCredentialsForHost("www.example.com", "Ada", "love1816$X");
```

The URLRequestDefaults settings only apply to the current application domain, with one exception. The credentials passed to the `setLoginCredentialsForHost()` method are used for requests made in any application domain within the AIR application.

For more information, see the URLRequestDefaults class in the ActionScript 3.0 Reference for the Adobe Flash Platform.

URI schemes

Flash Player 9 and later, Adobe AIR 1.0 and later

The standard URI schemes, such as the following, can be used in requests made from any security sandbox:

http: and https:
Use these for standard Internet URLs (in the same way that they are used in a web browser).

file:
Use `file:` to specify the URL of a file located on the local file system. For example:

```
 file:///c:/AIR Test/test.txt
```

In AIR, you can also use the following schemes when defining a URL for content running in the application security sandbox:

app:
Use `app:` to specify a path relative to the root directory of the installed application. For example, the following path points to a resources subdirectory of the directory of the installed application:

```
 app:/resources
```

When an AIR application is launched using the AIR Debug Launcher (ADL), the application directory is the directory that contains the application descriptor file.

The URL (and `url` property) for a File object created with `File.applicationDirectory` uses the `app` URI scheme, as in the following:

```
var dir:File = File.applicationDirectory;
dir = dir.resolvePath("assets");
trace(dir.url); // app:/assets
```

app-storage:

Use `app-storage:` to specify a path relative to the data storage directory of the application. For each installed application (and user), AIR creates a unique application storage directory, which is a useful place to store data specific to that application. For example, the following path points to a prefs.xml file in a settings subdirectory of the application store directory:

```
 app-storage:/settings/prefs.xml
```

The URL (and `url` property) for a File object created with `File.applicationStorageDirectory` uses the `app-storage` URI scheme, as in the following:

```
var prefsFile:File = File.applicationStorageDirectory;
prefsFile = prefsFile.resolvePath("prefs.xml");
trace(dir.prefsFile); // app-storage:/prefs.xml
```

mailto:

You can use the mailto scheme in URLRequest objects passed to the `navigateToURL()` function. See "Opening a URL in another application" on page 827.

You can use a URLRequest object that uses any of these URI schemes to define the URL request for a number of different objects, such as a FileStream or a Sound object. You can also use these schemes in HTML content running in AIR; for example, you can use them in the `src` attribute of an `img` tag.

However, you can only use these AIR-specific URI schemes (`app:` and `app-storage:`) in content in the application security sandbox. For more information, see "AIR security" on page 1076.

Setting URL variables

While you can add variables to the URL string directly, it can be easier to use the URLVariables class to define any variables needed for a request.

There are three ways in which you can add parameters to a URLVariables object:

- Within the URLVariables constructor
- With the `URLVariables.decode()` method
- As dynamic properties of the URLVariables object itself

The following example illustrates all three methods and also how to assign the variables to a URLRequest object:

```
var urlVar:URLVariables = new URLVariables( "one=1&two=2" );
urlVar.decode("amp=" + encodeURIComponent( "&" ) );
urlVar.three = 3;
urlVar.amp2 = "&&";
trace(urlVar.toString()); //amp=%26&amp2=%26%26&one=1&two=2&three=3

var urlRequest:URLRequest = new URLRequest( "http://www.example.com/test.cfm" );
urlRequest.data = urlVar;
```

When you define variables within the URLVariables constructor or within the `URLVariables.decode()` method, make sure that you URL-encode the characters that have a special meaning in a URI string. For example, when you use an ampersand in a parameter name or value, you must encode the ampersand by changing it from `&` to `%26` because the ampersand acts as a delimiter for parameters. The top-level `encodeURIComponent()` function can be used for this purpose.

Using the URLLoader class

Flash Player 9 and later, Adobe AIR 1.0 and later

The URLLoader class let you send a request to a server and access the information returned. You can also use the URLLoader class to access files on the local file system in contexts where local file access is permitted (such as the Flash Player local-with-filesystem sandbox and the AIR application sandbox). The URLLoader class downloads data from a URL as text, binary data, or URL-encoded variables. The URLLoader class dispatches events such as `complete`, `httpStatus`, `ioError`, `open`, `progress`, and `securityError`.

The ActionScript 3.0 event-handling model is significantly different than the ActionScript 2.0 model, which used the `LoadVars.onData`, `LoadVars.onHTTPStatus`, and `LoadVars.onLoad` event handlers. For more information on handling events in ActionScript 3.0, see "Handling events" on page 125

Downloaded data is not available until the download has completed. You can monitor the progress of the download (bytes loaded and bytes total) by listening for the `progress` event to be dispatched. However, if a file loads quickly enough a `progress` event might not be dispatched. When a file has successfully downloaded, the `complete` event is dispatched. By setting the URLLoader `dataFormat` property, you can receive the data as text, raw binary data, or as a URLVariables object.

The `URLLoader.load()` method (and optionally the URLLoader class's constructor) takes a single parameter, `request`, which is a URLRequest object. A URLRequest object contains all of the information for a single HTTP request, such as the target URL, request method (`GET` or `POST`), additional header information, and the MIME type.

For example, to upload an XML packet to a server-side script, you could use the following code:

```
var secondsUTC:Number = new Date().time;
var dataXML:XML =
    <clock>
        <time>{secondsUTC}</time>
    </clock>;
var request:URLRequest = new URLRequest("http://www.yourdomain.com/time.cfm");
request.contentType = "text/xml";
request.data = dataXML.toXMLString();
request.method = URLRequestMethod.POST;
var loader:URLLoader = new URLLoader();
loader.load(request);
```

The previous snippet creates an XML document named `dataXML` that contains the XML packet to be sent to the server. The example sets the URLRequest `contentType` property to `"text/xml"` and assigns the XML document to the URLRequest `data` property. Finally, the example creates a URLLoader object and sends the request to the remote script by using the `load()` method.

Using the URLStream class

Flash Player 9 and later, Adobe AIR 1.0 and later

The URLStream class provides access to the downloading data as the data arrives. The URLStream class also lets you close a stream before it finishes downloading. The downloaded data is available as raw binary data.

When reading data from a URLStream object, use the `bytesAvailable` property to determine whether sufficient data is available before reading it. An EOFError exception is thrown if you attempt to read more data than is available.

The httpResponseStatus event (AIR)

In Adobe AIR, the URLStream class dispatches an `httpResponseStatus` event in addition to the `httpStatus` event. The `httpResponseStatus` event is delivered before any response data. The `httpResponseStatus` event (represented by the HTTPStatusEvent class) includes a `responseURL` property, which is the URL that the response was returned from, and a `responseHeaders` property, which is an array of URLRequestHeader objects representing the response headers that the response returned.

Loading data from external documents

Flash Player 9 and later, Adobe AIR 1.0 and later

When you build dynamic applications, it can be useful to load data from external files or from server-side scripts. This lets you build dynamic applications without having to edit or recompile your application. For example, if you build a "tip of the day" application, you can write a server-side script that retrieves a random tip from a database and saves it to a text file once a day. Then your application can load the contents of a static text file instead of querying the database each time.

The following snippet creates a URLRequest and URLLoader object, which loads the contents of an external text file, params.txt:

```
var request:URLRequest = new URLRequest("params.txt");
var loader:URLLoader = new URLLoader();
loader.load(request);
```

By default, if you do not define a request method, Flash Player and Adobe AIR load the content using the HTTP `GET` method. To send the request using the `POST` method, set the `request.method` property to `POST` using the static constant `URLRequestMethod.POST`, as the following code shows:

```
var request:URLRequest = new URLRequest("sendfeedback.cfm");
request.method = URLRequestMethod.POST;
```

The external document, params.txt, that is loaded at run time contains the following data:

```
monthNames=January,February,March,April,May,June,July,August,September,October,November,Dece
mber&dayNames=Sunday,Monday,Tuesday,Wednesday,Thursday,Friday,Saturday
```

The file contains two parameters, `monthNames` and `dayNames`. Each parameter contains a comma-separated list that is parsed as strings. You can split this list into an array using the `String.split()` method.

Avoid using reserved words or language constructs as variable names in external data files, because doing so makes reading and debugging your code more difficult.

Once the data has loaded, the `complete` event is dispatched, and the contents of the external document are available to use in the URLLoader's `data` property, as the following code shows:

```
function completeHandler(event)
{
    var loader2 = event.target;
    air.trace(loader2.data);
}
```

If the remote document contains name-value pairs, you can parse the data using the URLVariables class by passing in the contents of the loaded file, as follows:

```
private function completeHandler(event:Event):void
{
    var loader2:URLLoader = URLLoader(event.target);
    var variables:URLVariables = new URLVariables(loader2.data);
    trace(variables.dayNames);
}
```

Each name-value pair from the external file is created as a property in the URLVariables object. Each property within the variables object in the previous code sample is treated as a string. If the value of the name-value pair is a list of items, you can convert the string into an array by calling the `String.split()` method, as follows:

```
var dayNameArray:Array = variables.dayNames.split(",");
```

If you are loading numeric data from external text files, convert the values into numeric values by using a top-level function, such as `int()`, `uint()`, or `Number()`.

Instead of loading the contents of the remote file as a string and creating a new URLVariables object, you could instead set the `URLLoader.dataFormat` property to one of the static properties found in the URLLoaderDataFormat class. The three possible values for the `URLLoader.dataFormat` property are as follows:

- `URLLoaderDataFormat.BINARY`—The `URLLoader.data` property will contain binary data stored in a ByteArray object.
- `URLLoaderDataFormat.TEXT`—The `URLLoader.data` property will contain text in a String object.
- `URLLoaderDataFormat.VARIABLES`—The `URLLoader.data` property will contain URL-encoded variables stored in a URLVariables object.

The following code demonstrates how setting the `URLLoader.dataFormat` property to `URLLoaderDataFormat.VARIABLES` allows you to automatically parse loaded data into a URLVariables object:

```
package
{
    import flash.display.Sprite;
    import flash.events.*;
    import flash.net.URLLoader;
    import flash.net.URLLoaderDataFormat;
    import flash.net.URLRequest;

    public class URLLoaderDataFormatExample extends Sprite
    {
        public function URLLoaderDataFormatExample()
        {
            var request:URLRequest = new URLRequest("http://www.[yourdomain].com/params.txt");
            var variables:URLLoader = new URLLoader();
            variables.dataFormat = URLLoaderDataFormat.VARIABLES;
            variables.addEventListener(Event.COMPLETE, completeHandler);
            try
            {
                variables.load(request);
            }
            catch (error:Error)
            {
                trace("Unable to load URL: " + error);
            }
        }
        private function completeHandler(event:Event):void
        {
        var loader:URLLoader = URLLoader(event.target);
        trace(loader.data.dayNames);
        }
    }
}
```

***Note:** The default value for `URLLoader.dataFormat` is `URLLoaderDataFormat.TEXT`.*

As the following example shows, loading XML from an external file is the same as loading URLVariables. You can create a URLRequest instance and a URLLoader instance and use them to download a remote XML document. When the file has completely downloaded, the `Event.COMPLETE` event is dispatched and the contents of the external file are converted to an XML instance, which you can parse using XML methods and properties.

```
package
{
    import flash.display.Sprite;
    import flash.errors.*;
    import flash.events.*;
    import flash.net.URLLoader;
    import flash.net.URLRequest;

    public class ExternalDocs extends Sprite
    {
        public function ExternalDocs()
        {
            var request:URLRequest = new URLRequest("http://www.[yourdomain].com/data.xml");
            var loader:URLLoader = new URLLoader();
            loader.addEventListener(Event.COMPLETE, completeHandler);
            try
            {
                loader.load(request);
            }
            catch (error:ArgumentError)
            {
                trace("An ArgumentError has occurred.");
            }
            catch (error:SecurityError)
            {
                trace("A SecurityError has occurred.");
            }
        }
        private function completeHandler(event:Event):void
        {
            var dataXML:XML = XML(event.target.data);
            trace(dataXML.toXMLString());
        }
    }
}
```

Communicating with external scripts

Flash Player 9 and later, Adobe AIR 1.0 and later

In addition to loading external data files, you can also use the URLVariables class to send variables to a server-side script and process the server's response. This is useful, for example, if you are programming a game and want to send the user's score to a server to calculate whether it should be added to the high scores list, or even send a user's login information to a server for validation. A server-side script can process the user name and password, validate it against a database, and return confirmation of whether the user-supplied credentials are valid.

The following snippet creates a URLVariables object named `variables,` which creates a new variable called `name`. Next, a URLRequest object is created that specifies the URL of the server-side script to send the variables to. Then you set the `method` property of the URLRequest object to send the variables as an HTTP `POST` request. To add the URLVariables object to the URL request, you set the `data` property of the URLRequest object to the URLVariables object created earlier. Finally, the URLLoader instance is created and the `URLLoader.load()` method is invoked, which initiates the request.

```
var variables:URLVariables = new URLVariables("name=Franklin");
var request:URLRequest = new URLRequest();
request.url = "http://www.[yourdomain].com/greeting.cfm";
request.method = URLRequestMethod.POST;
request.data = variables;
var loader:URLLoader = new URLLoader();
loader.dataFormat = URLLoaderDataFormat.VARIABLES;
loader.addEventListener(Event.COMPLETE, completeHandler);
try
{
    loader.load(request);
}
catch (error:Error)
{
    trace("Unable to load URL");
}

function completeHandler(event:Event):void
{
    trace(event.target.data.welcomeMessage);
}
```

The following code contains the contents of the Adobe ColdFusion® greeting.cfm document used in the previous example:

```
<cfif NOT IsDefined("Form.name") OR Len(Trim(Form.Name)) EQ 0>
    <cfset Form.Name = "Stranger" />
</cfif>
<cfoutput>welcomeMessage=#UrlEncodedFormat("Welcome, " & Form.name)#
</cfoutput>
```

Web service requests

Flash Player 9 and later, Adobe AIR 1.0 and later

There are a variety of HTTP-based web services. The main types include:

- REST
- XML-RPC
- SOAP

To use a web service in ActionScript 3, you create a URLRequest object, construct the web service call using either URL variables or an XML document, and send the call to the service using a URLLoader object. The Flex framework contains several classes that make it easier to use web services—especially useful when accessing complex SOAP services. Starting with Flash Professional CS3, you can use the Flex classes in applications developed with Flash Professional as well as in applications developed in Flash Builder.

In HTML-based AIR applications, you can use either the URLRequest and URLLoader classes or the JavaScript XMLHttpRequest class. If desired, you can also create a SWF library that exposes the web service components of the Flex framework to your JavaScript code.

When your application runs in a browser, you can only use web services in the same Internet domain as the calling SWF unless the server hosting the web service also hosts a cross-domain policy file that permits access from other domains. A technique that is often used when a cross-domain policy file is not available is to proxy the requests through your own server. Adobe Blaze DS and Adobe LiveCycle support web service proxying.

In AIR applications, a cross-domain policy file is not required when the web service call originates from the application security sandbox. AIR application content is never served from a remote domain, so it cannot participate in the types of attacks that cross-domain policies prevent. In HTML-based AIR applications, content in the application security sandbox can make cross-domain XMLHttpRequests. You can allow content in other security sandboxes to make cross-domain XMLHttpRequests as long as that content is loaded into an iframe.

More Help topics

"Website controls (policy files)" on page 1051

Adobe BlazeDS

Adobe LiveCycle ES2

REST architecture

XML-RPC

SOAP protocol

REST-style web service requests

Flash Player 9 and later, Adobe AIR 1.0 and later

REST-style web services use HTTP method verbs to designate the basic action and URL variables to specify the action details. For example, a request to get data for an item could use the GET verb and URL variables to specify a method name and item ID. The resulting URL string might look like:

```
http://service.example.com/?method=getItem&id=d3452
```

To access a REST-style web service with ActionScript, you can use the URLRequest, URLVariables, and URLLoader classes. In JavaScript code within an AIR application, you can also use an XMLHttpRequest.

Programming a REST-style web service call in ActionScript, typically involves the following steps:

1. Create a URLRequest object.
2. Set the service URL and HTTP method verb on the request object.
3. Create a URLVariables object.
4. Set the service call parameters as dynamic properties of the variables object.
5. Assign the variables object to the data property of the request object.
6. Send the call to the service with a URLLoader object.
7. Handle the `complete` event dispatched by the URLLoader that indicates that the service call is complete. It is also wise to listen for the various error events that can be dispatched by a URLLoader object.

For example, consider a web service that exposes a test method that echoes the call parameters back to the requestor. The following ActionScript code could be used to call the service:

```
import flash.events.Event;
import flash.events.ErrorEvent;
import flash.events.IOErrorEvent;
import flash.events.SecurityErrorEvent;
import flash.net.URLLoader;
import flash.net.URLRequest;
import flash.net.URLRequestMethod;
import flash.net.URLVariables;

private var requestor:URLLoader = new URLLoader();
public function restServiceCall():void
{
    //Create the HTTP request object
    var request:URLRequest = new URLRequest( "http://service.example.com/" );
    request.method = URLRequestMethod.GET;

    //Add the URL variables
    var variables:URLVariables = new URLVariables();
    variables.method = "test.echo";
    variables.api_key = "123456ABC";
    variables.message = "Able was I, ere I saw Elba.";
    request.data = variables;

    //Initiate the transaction
    requestor = new URLLoader();
    requestor.addEventListener( Event.COMPLETE, httpRequestComplete );
    requestor.addEventListener( IOErrorEvent.IOERROR, httpRequestError );
    requestor.addEventListener( SecurityErrorEvent.SECURITY_ERROR, httpRequestError );
    requestor.load( request );
}
private function httpRequestComplete( event:Event ):void
{
    trace( event.target.data );
}

private function httpRequestError( error:ErrorEvent ):void{
    trace( "An error occured: " + error.message );
}
```

In JavaScript within an AIR application, you can make the same request using the XMLHttpRequest object:

```
<html>
<head><title>RESTful web service request</title>
<script type="text/javascript">

function makeRequest()
{
    var requestDisplay = document.getElementById( "request" );
    var resultDisplay  = document.getElementById( "result" );

    //Create a conveninece object to hold the call properties
    var request = {};
    request.URL = "http://service.example.com/";
    request.method = "test.echo";
    request.HTTPmethod = "GET";
    request.parameters = {};
    request.parameters.api_key = "ABCDEF123";
    request.parameters.message = "Able was I ere I saw Elba.";
    var requestURL = makeURL( request );
    xmlhttp = new XMLHttpRequest();
    xmlhttp.open( request.HTTPmethod, requestURL, true);
    xmlhttp.onreadystatechange = function() {
        if (xmlhttp.readyState == 4) {
            resultDisplay.innerHTML = xmlhttp.responseText;
        }
    }
    xmlhttp.send(null);

    requestDisplay.innerHTML = requestURL;
}
//Convert the request object into a properly formatted URL
function makeURL( request )
{
    var url = request.URL + "?method=" + escape( request.method );
    for( var property in request.parameters )
    {
        url += "&" + property + "=" + escape( request.parameters[property] );
    }

    return url;
}
</script>
</head>
<body onload="makeRequest()">
<h1>Request:</h1>
<div id="request"></div>
<h1>Result:</h1>
<div id="result"></div>
</body>
</html>
```

XML-RPC web service requests

Flash Player 9 and later, Adobe AIR 1.0 and later

An XML-RPC web service takes its call parameters as an XML document rather than as a set of URL variables. To conduct a transaction with an XML-RPC web service, create a properly formatted XML message and send it to the web service using the HTTP `POST` method. In addition, you should set the `Content-Type` header for the request so that the server treats the request data as XML.

The following example illustrates how to use the same web service call shown in the REST example, but this time as an XML-RPC service:

```
import flash.events.Event;
import flash.events.ErrorEvent;
import flash.events.IOErrorEvent;
import flash.events.SecurityErrorEvent;
import flash.net.URLLoader;
import flash.net.URLRequest;
import flash.net.URLRequestMethod;
import flash.net.URLVariables;
public function xmlRPCRequest():void
{
    //Create the XML-RPC document
    var xmlRPC:XML = <methodCall>
                                    <methodName></methodName>
                                    <params>
                                        <param>
                                            <value>
                                                <struct/>
                                            </value>
                                        </param>
                                    </params>
                                </methodCall>;

    xmlRPC.methodName = "test.echo";

    //Add the method parameters
    var parameters:Object = new Object();
    parameters.api_key = "123456ABC";
    parameters.message = "Able was I, ere I saw Elba.";

    for( var propertyName:String in parameters )
    {
        xmlRPC..struct.member[xmlRPC..struct.member.length + 1] =
            <member>
                <name>{propertyName}</name>
                <value>
                    <string>{parameters[propertyName]}</string>
                </value>
            </member>;
    }

    //Create the HTTP request object
    var request:URLRequest = new URLRequest( "http://service.example.com/xml-rpc/" );
    request.method = URLRequestMethod.POST;
    request.cacheResponse = false;
    request.requestHeaders.push(new URLRequestHeader("Content-Type", "application/xml"));
    request.data = xmlRPC;

    //Initiate the request
    requestor = new URLLoader();
    requestor.dataFormat = URLLoaderDataFormat.TEXT;
    requestor.addEventListener( Event.COMPLETE, xmlRPCRequestComplete );
    requestor.addEventListener( IOErrorEvent.IO_ERROR, xmlRPCRequestError );
    requestor.addEventListener( SecurityErrorEvent.SECURITY_ERROR, xmlRPCRequestError );
    requestor.load( request );
}

private function xmlRPCRequestComplete( event:Event ):void
{
    trace( XML(event.target.data).toXMLString() );
}

private function xmlRPCRequestError( error:ErrorEvent ):void
{
    trace( "An error occurred: " + error );
}
```

WebKit in AIR doesn't support E4X syntax, so the method used to create the XML document in the previous example does not work in JavaScript code. Instead, you must use the DOM methods to create the XML document or create the document as a string and use the JavaScript DOMParser class to convert the string to XML.

The following example uses DOM methods to create an XML-RPC message and an XMLHttpRequest to conduct the web service transaction:

```
<html>
<head>
<title>XML-RPC web service request</title>
<script type="text/javascript">

function makeRequest()
{
    var requestDisplay = document.getElementById( "request" );
    var resultDisplay  = document.getElementById( "result" );

    var request = {};
    request.URL = "http://services.example.com/xmlrpc/";
    request.method = "test.echo";
    request.HTTPmethod = "POST";
    request.parameters = {};
    request.parameters.api_key = "123456ABC";
    request.parameters.message = "Able was I ere I saw Elba.";
    var requestMessage = formatXMLRPC( request );

    xmlhttp = new XMLHttpRequest();
    xmlhttp.open( request.HTTPmethod, request.URL, true);
    xmlhttp.onreadystatechange = function() {
        if (xmlhttp.readyState == 4) {
            resultDisplay.innerText = xmlhttp.responseText;
        }
    }
    xmlhttp.send( requestMessage );

    requestDisplay.innerText = xmlToString( requestMessage.documentElement );
```

```
}

//Formats a request as XML-RPC document
function formatXMLRPC( request )
{
    var xmldoc = document.implementation.createDocument( "", "", null );
    var root = xmldoc.createElement( "methodCall" );
    xmldoc.appendChild( root );
    var methodName = xmldoc.createElement( "methodName" );
    var methodString = xmldoc.createTextNode( request.method );
    methodName.appendChild( methodString );

    root.appendChild( methodName );

        var params = xmldoc.createElement( "params" );
        root.appendChild( params );

        var param = xmldoc.createElement( "param" );
        params.appendChild( param );
        var value = xmldoc.createElement( "value" );
        param.appendChild( value );
        var struct = xmldoc.createElement( "struct" );
        value.appendChild( struct );

        for( var property in request.parameters )
        {
            var member = xmldoc.createElement( "member" );
            struct.appendChild( member );

            var name = xmldoc.createElement( "name" );
            var paramName = xmldoc.createTextNode( property );
            name.appendChild( paramName )
            member.appendChild( name );

            var value = xmldoc.createElement( "value" );
            var type = xmldoc.createElement( "string" );
            value.appendChild( type );
            var paramValue = xmldoc.createTextNode( request.parameters[property] );
            type.appendChild( paramValue )
            member.appendChild( value );
        }
    return xmldoc;
}

//Returns a string representation of an XML node
function xmlToString( rootNode, indent )
{
    if( indent == null ) indent = "";
    var result = indent + "<" + rootNode.tagName + ">\n";
    for( var i = 0; i < rootNode.childNodes.length; i++)
    {
        if(rootNode.childNodes.item( i ).nodeType == Node.TEXT_NODE )
        {
            result += indent + "    " + rootNode.childNodes.item( i ).textContent + "\n";
        }
    }
    if( rootNode.childElementCount > 0 )
    {
        result += xmlToString( rootNode.firstElementChild, indent + "    " );
    }
    if( rootNode.nextElementSibling )
    {
        result += indent + "</" + rootNode.tagName + ">\n";
        result += xmlToString( rootNode.nextElementSibling, indent );
    }
    else
    {
        result += indent +"</" + rootNode.tagName + ">\n";
    }
    return result;
}

</script>
</head>
<body onload="makeRequest()">
<h1>Request:</h1>
<pre id="request"></pre>
<h1>Result:</h1>
<pre id="result"></pre>
</body>
</html>
```

SOAP web service requests

Flash Player 9 and later, Adobe AIR 1.0 and later

SOAP builds on the general XML-RPC web service concept and provides a richer, albeit more complex, means for transferring typed data. SOAP web services typically provide a Web Service Description Language file (WSDL) that specifies the web service calls, data types, and service URL. While ActionScript 3 does not provide direct support for SOAP, you can construct a SOAP XML message "by hand," post it to the server, and then parse the results. However, for anything except the simplest SOAP web service, you can probably save a significant amount of development time using an existing SOAP library.

The Flex framework includes libraries for accessing SOAP web services. In Flash Builder the library, rpc.swc, is automatically included in Flex projects, since it is part of the Flex framework. In Flash Professional, you can add the Flex framework.swc and rpc.swc to the library path of a project and then access the Flex classes with ActionScript.

More Help topics

Using the Flex web service component in Flash Professional

Cristophe Coenraets: Real-time Trader Desktop for Android

Opening a URL in another application

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `navigateToURL()` function to open a URL in a web browser or other application. For content running in AIR, the `navigateToURL()` function opens the page in the default system web browser.

For the URLRequest object you pass as the `request` parameter of this function, only the `url` property is used.

The first parameter of the `navigateToURL()` function, the `navigate` parameter, is a URLRequest object (see "Using the URLRequest class" on page 811). The second is an optional `window` parameter, in which you can specify the window name. For example, the following code opens the www.adobe.com web page:

```
var url:String = "http://www.adobe.com";
var urlReq:URLRequest = new URLRequest(url);
navigateToURL(urlReq);
```

***Note:** When using the `navigateToURL()` function, the runtime treats a URLRequest object that uses the POST method (one that has its `method` property set to `URLRequestMethod.POST`) as using the GET method.*

When using the `navigateToURL()` function, URI schemes are permitted based on the security sandbox of the code calling the `navigateToURL()` function.

Some APIs allow you to launch content in a web browser. For security reasons, some URI schemes are prohibited when using these APIs in AIR. The list of prohibited schemes depends on the security sandbox of the code using the API. (For details on security sandboxes, see "AIR security" on page 1076.)

Application sandbox (AIR only)

Any URI scheme can be used in URL launched by content running in the AIR application sandbox. An application must be registered to handle the URI scheme or the request does nothing. The following schemes are supported on many computers and devices:

- `http:`
- `https:`
- `file:`
- `mailto:` — AIR directs these requests to the registered system mail application
- `sms:` — AIR directs `sms:` requests to the default text message app. The URL format must conform to the system conventions under which the app is running. For example, on Android, the URI scheme must be lowercase.

  ```
  navigateToURL( new URLRequest( "sms:+15555550101") );
  ```
- `tel:` — AIR directs `tel:` requests to the default telephone dialing app. The URL format must conform to the system conventions under which the app is running. For example, on Android, the URI scheme must be lowercase.

  ```
  navigateToURL( new URLRequest( "tel:5555555555") );
  ```
- `market:` — AIR directs `market:` requests to the Market app typically supported on Android devices.

  ```
  navigateToURL( new URLRequest( "market://search?q=Adobe Flash") );
  navigateToURL( new URLRequest( "market://search?q=pname:com.adobe.flashplayer") );
  ```

Where allowed by the operating system, applications can define and register custom URI schemes. You can create a URL using the scheme to launch the application from AIR.

Remote sandboxes

The following schemes are allowed. Use these schemes as you would use them in a web browser.

- `http:`
- `https:`
- `mailto:` — AIR directs these requests to the registered system mail application

All other URI schemes are prohibited.

Local-with-file sandbox

The following schemes are allowed. Use these schemes as you would use them in a web browser.

- `file:`
- `mailto:` — AIR directs these requests to the registered system mail application

All other URI schemes are prohibited.

Local-with-networking sandbox

The following schemes are allowed. Use these schemes as you would use them in a web browser.

- `http:`
- `https:`
- `mailto:` — AIR directs these requests to the registered system mail application

All other URI schemes are prohibited.

Local-trusted sandbox

The following schemes are allowed. Use these schemes as you would use them in a web browser.

- `file:`
- `http:`
- https:
- `mailto:` — AIR directs these requests to the registered system mail application

All other URI schemes are prohibited.

Chapter 45: Communicating with other Flash Player and AIR instances

Flash Player 9 and later, Adobe AIR 1.0 and later

The LocalConnection class enables communications between Adobe® AIR® applications, as well as between SWF content running in the browser. You can also use the LocalConnection class to communicate between an AIR application and SWF content running in the browser. The LocalConnection class allows you to build versatile applications that can share data between Flash Player and AIR instances.

About the LocalConnection class

Flash Player 9 and later, Adobe AIR 1.0 and later

The LocalConnection class lets you develop SWF files that can send instructions to other SWF files without the use of the fscommand() method or JavaScript. LocalConnection objects can communicate only among SWF files that are running on the same client computer, but they can run in different applications. For example, a SWF file running in a browser and a SWF file running in a projector can share information, with the projector maintaining local information and the browser-based SWF file connecting remotely. (A projector is a SWF file saved in a format that can run as a stand-alone application—that is, the projector doesn't require Flash Player to be installed because it is embedded inside the executable.)

LocalConnection objects can be used to communicate between SWFs using different ActionScript versions:

- ActionScript 3.0 LocalConnection objects can communicate with LocalConnection objects created in ActionScript 1.0 or 2.0.
- ActionScript 1.0 or 2.0 LocalConnection objects can communicate with LocalConnection objects created in ActionScript 3.0.

Flash Player handles this communication between LocalConnection objects of different versions automatically.

The simplest way to use a LocalConnection object is to allow communication only between LocalConnection objects located in the same domain or the same AIR application. That way, you do not have to worry about security issues. However, if you need to allow communication between domains, you have several ways to implement security measures. For more information, see the discussion of the `connectionName` parameter of the `send()` method and the `allowDomain()` and `domain` entries in the LocalConnection class listing in the ActionScript 3.0 Reference for the Adobe Flash Platform.

It is possible to use LocalConnection objects to send and receive data within a single SWF file, but Adobe does not recommended doing so. Instead, use shared objects.

There are three ways to add callback methods to your LocalConnection objects:

- Subclass the LocalConnection class and add methods.
- Set the `LocalConnection.client` property to an object that implements the methods.
- Create a dynamic class that extends LocalConnection and dynamically attach methods.

The first way to add callback methods is to extend the LocalConnection class. You define the methods within the custom class instead of dynamically adding them to the LocalConnection instance. This approach is demonstrated in the following code:

```
package
{
    import flash.net.LocalConnection;
    public class CustomLocalConnection extends LocalConnection
    {
        public function CustomLocalConnection(connectionName:String)
        {
            try
            {
                connect(connectionName);
            }
            catch (error:ArgumentError)
            {
                // server already created/connected
            }
        }
        public function onMethod(timeString:String):void
        {
            trace("onMethod called at: " + timeString);
        }
    }
}
```

In order to create a new instance of the CustomLocalConnection class, you can use the following code:

```
var serverLC:CustomLocalConnection;
serverLC = new CustomLocalConnection("serverName");
```

The second way to add callback methods is to use the `LocalConnection.client` property. This involves creating a custom class and assigning a new instance to the `client` property, as the following code shows:

```
var lc:LocalConnection = new LocalConnection();
lc.client = new CustomClient();
```

The `LocalConnection.client` property indicates the object callback methods that should be invoked. In the previous code, the `client` property was set to a new instance of a custom class, CustomClient. The default value for the `client` property is the current LocalConnection instance. You can use the `client` property if you have two data handlers that have the same set of methods but act differently—for example, in an application where a button in one window toggles the view in a second window.

To create the CustomClient class, you could use the following code:

```
package
{
    public class CustomClient extends Object
    {
        public function onMethod(timeString:String):void
        {
            trace("onMethod called at: " + timeString);
        }
    }
}
```

The third way to add callback methods, creating a dynamic class and dynamically attaching the methods, is very similar to using the LocalConnection class in earlier versions of ActionScript, as the following code shows:

```
import flash.net.LocalConnection;
dynamic class DynamicLocalConnection extends LocalConnection {}
```

Callback methods can be dynamically added to this class by using the following code:

```
var connection:DynamicLocalConnection = new DynamicLocalConnection();
connection.onMethod = this.onMethod;
// Add your code here.
public function onMethod(timeString:String):void
{
    trace("onMethod called at: " + timeString);
}
```

The previous way of adding callback methods is not recommended because the code is not very portable. In addition, using this method of creating local connections could create performance issues, because accessing dynamic properties is dramatically slower than accessing sealed properties.

isPerUser property

The `isPerUser` property was added to Flash Player (10.0.32) and AIR (1.5.2) to resolve a conflict that occurs when more than one user is logged into a Mac computer. On other operating systems, the property is ignored since the local connection has always been scoped to individual users. The `isPerUser` property should be set to `true` in new code. However, the default value is currently `false` for backward compatibility. The default may be changed in future versions of the runtimes.

Sending messages between two applications

Flash Player 9 and later, Adobe AIR 1.0 and later

You use the LocalConnection class to communicate between different AIR applications and between different Adobe® Flash® Player (SWF) applications running in a browser. You can also use the LocalConnection class to communicate between an AIR application and a SWF application running in a browser.

For example, you could have multiple Flash Player instances on a web page, or have a Flash Player instance retrieve data from a Flash Player instance in a pop-up window.

The following code defines a LocalConnection object that acts as a server and accepts incoming LocalConnection calls from other applications:

```
package
{
    import flash.net.LocalConnection;
    import flash.display.Sprite;
    public class ServerLC extends Sprite
    {
        public function ServerLC()
        {
            var lc:LocalConnection = new LocalConnection();
            lc.client = new CustomClient1();
            try
            {
                lc.connect("conn1");
            }
            catch (error:Error)
            {
                trace("error:: already connected");
            }
        }
    }
}
```

This code first creates a LocalConnection object named `lc` and sets the `client` property to an object, `clientObject`. When another application calls a method in this LocalConnection instance, the runtime looks for that method in the `clientObject` object.

If you already have a connection with the specified name, an Argument Error exception is thrown, indicating that the connection attempt failed because the object is already connected.

Whenever a Flash Player instance connects to this SWF file and tries to invoke any method for the specified local connection, the request is sent to the class specified by the `client` property, which is set to the CustomClient1 class:

```
package
{
    import flash.events.*;
    import flash.system.fscommand;
    import flash.utils.Timer;
    public class CustomClient1 extends Object
    {
        public function doMessage(value:String = ""):void
        {
            trace(value);
        }
        public function doQuit():void
        {
            trace("quitting in 5 seconds");
            this.close();
            var quitTimer:Timer = new Timer(5000, 1);
            quitTimer.addEventListener(TimerEvent.TIMER, closeHandler);
        }
        public function closeHandler(event:TimerEvent):void
        {
            fscommand("quit");
        }
    }
}
```

To create a LocalConnection server, call the `LocalConnection.connect()` method and provide a unique connection name. If you already have a connection with the specified name, an ArgumentError error is generated, indicating that the connection attempt failed because the object is already connected.

The following snippet demonstrates how to create a LocalConnection with the name `conn1`:

```
try
{
    connection.connect("conn1");
}
catch (error:ArgumentError)
{
    trace("Error! Server already exists\n");
}
```

Connecting to the primary application from a secondary application requires that you first create a LocalConnection object in the sending LocalConnection object; then call the `LocalConnection.send()` method with the name of the connection and the name of the method to execute. For example, to send the `doQuit` method to the LocalConnection object that you created earlier, use the following code:

```
sendingConnection.send("conn1", "doQuit");
```

This code connects to an existing LocalConnection object with the connection name `conn1` and invokes the `doMessage()` method in the remote application. If you want to send parameters to the remote application, you specify additional arguments after the method name in the `send()` method, as the following snippet shows:

```
sendingConnection.send("conn1", "doMessage", "Hello world");
```

Connecting to content in different domains and to AIR applications

Flash Player 9 and later, Adobe AIR 1.0 and later

To allow communications only from specific domains, you call the `allowDomain()` or `allowInsecureDomain()` method of the LocalConnection class and pass a list of one or more domains that are allowed to access this LocalConnection object, passing one or more names of domains to be allowed.

In earlier versions of ActionScript, `LocalConnection.allowDomain()` and `LocalConnection.allowInsecureDomain()` were callback methods that had to be implemented by developers and that had to return a Boolean value. In ActionScript 3.0, `LocalConnection.allowDomain()` and `LocalConnection.allowInsecureDomain()` are both built-in methods, which developers can call just like `Security.allowDomain()` and `Security.allowInsecureDomain()`, passing one or more names of domains to be allowed.

Flash Player 8 introduced security restrictions on local SWF files. A SWF file that is allowed to access the Internet cannot also have access to the local file system. If you specify `localhost`, any local SWF file can access the SWF file. If the `LocalConnection.send()` method attempts to communicate with a SWF file from a security sandbox to which the calling code does not have access, a `securityError` event(`SecurityErrorEvent.SECURITY_ERROR`) is dispatched. To work around this error, you can specify the caller's domain in the receiver's `LocalConnection.allowDomain()` method.

There are two special values that you can pass to the `LocalConnection.allowDomain()` and `LocalConnection.allowInsecureDomain()` methods: `*` and `localhost`. The asterisk value `(*)` allows access from all domains. The string `localhost` allows calls to the application from content locally installed, but outside of the application resource directory.

If the `LocalConnection.send()` method attempts to communicate with an application from a security sandbox to which the calling code does not have access, a `securityError` event(`SecurityErrorEvent.SECURITY_ERROR`) is dispatched. To work around this error, you can specify the caller's domain in the receiver's `LocalConnection.allowDomain()` method.

If you implement communication only between content in the same domain, you can specify a `connectionName` parameter that does not begin with an underscore (_) and does not specify a domain name (for example, `myDomain:connectionName`). Use the same string in the `LocalConnection.connect(connectionName)` command.

If you implement communication between content in different domains, you specify a `connectionName` parameter that begins with an underscore. Specifying the underscore makes the content with the receiving LocalConnection object more portable between domains. Here are the two possible cases:

- If the string for `connectionName` does not begin with an underscore, the runtime adds a prefix with the superdomain name and a colon (for example, `myDomain:connectionName`). Although this ensures that your connection does not conflict with connections of the same name from other domains, any sending LocalConnection objects must specify this superdomain (for example, `myDomain:connectionName`). If you move the HTML or SWF file with the receiving LocalConnection object to another domain, the runtime changes the prefix to reflect the new superdomain (for example, `anotherDomain:connectionName`). All sending LocalConnection objects have to be manually edited to point to the new superdomain.
- If the string for `connectionName` begins with an underscore (for example, `_connectionName`), the runtime does not add a prefix to the string. This means the receiving and sending LocalConnection objects use identical strings for `connectionName`. If the receiving object uses `LocalConnection.allowDomain()` to specify that connections from any domain will be accepted, you can move the HTML or SWF file with the receiving LocalConnection object to another domain without altering any sending LocalConnection objects.

  A downside to using underscore names in `connectionName` is the potential for collisions, such as when two applications both try to connect using the same `connectionName`. A second, related downside is security-related. Connection names that use underscore syntax do not identify the domain of the listening application. For these reasons, domain-qualified names are preferred.

Adobe AIR

To communicate with content running in the AIR application security sandbox (content installed with the AIR application), you must prefix the connection name with a superdomain identifying the AIR application. The superdomain string starts with `app#` followed by the application ID followed by a dot (.) character, followed by the publisher ID (if defined). For example, the proper superdomain to use in the `connectionName` parameter for an application with the application ID, `com.example.air.MyApp`, and no publisher ID is: `"app#com.example.air.MyApp"`. Thus, if the base connection name is "appConnection," then the entire string to use in the `connectionName` parameter is: `"app#com.example.air.MyApp:appConnection"`. If the application has the publisher ID, then the that ID must also be included in the superdomain string: `"app#com.example.air.MyApp.B146A943FBD637B68C334022D304CEA226D129B4.1"`.

When you allow another AIR application to communicate with your application through the local connection, you must call the `allowDomain()` of the LocalConnection object, passing in the local connection domain name. For an AIR application, this domain name is formed from the application and publisher IDs in the same fashion as the connection string. For example, if the sending AIR application has an application ID of `com.example.air.FriendlyApp` and a publisher ID of `214649436BD677B62C33D02233043EA236D13934.1`, then the domain string that you would use to allow this application to connect is: `app#com.example.air.FriendlyApp.214649436BD677B62C33D02233043EA236D13934.1`. (As of AIR 1.5.3, not all AIR applications have publisher IDs.)

Chapter 46: Communicating with native processes in AIR

Adobe AIR 2 and later

As of Adobe AIR 2, AIR applications can run and communicate with other native processes via the command line. For example, an AIR application can run a process and communicate with it via the standard input and output streams.

To communicate with native processes, package an AIR application to be installed via a native installer. The file type of native installer is specific to the operating system for which it is created:

- It is a DMG file on Mac OS.
- It is an EXE file on Windows.
- It is an RPM or DEB package on Linux.

These applications are known as extended desktop profile applications. You can create a native installer file by specifying the `-target native` option when calling the `-package` command using ADT.

More Help topics

flash.filesystem.File.openWithDefaultApplication()

flash.desktop.NativeProcess

Overview of native process communications

Adobe AIR 2 and later

An AIR application in the extended desktop profile can execute a file, as if it were invoked by the command line. It can communicate with the standard streams of the native process. Standard streams include the standard input stream (stdin), the output stream (stdout), the standard error stream (stderr).

Note: *Applications in the extended desktop profile can also launch files and applications using the* `File.openWithDefaultApplication()` *method. However, using this method does not provide the AIR application with access to the standard streams. For more information, see "Opening files with the default system application" on page 681*

The following code sample shows how to launch a test.exe application in the application directory. The application passes the argument `"hello"` as a command-line argument, and it adds an event listener to the process's standard output stream:

```
var nativeProcessStartupInfo:NativeProcessStartupInfo = new NativeProcessStartupInfo();
var file:File = File.applicationDirectory.resolvePath("test.exe");
nativeProcessStartupInfo.executable = file;
var processArgs:Vector.<String> = new Vector.<String>();
processArgs.push("hello");
nativeProcessStartupInfo.arguments = processArgs;
process = new NativeProcess();
process.addEventListener(ProgressEvent.STANDARD_OUTPUT_DATA, onOutputData);
process.start(nativeProcessStartupInfo);
public function onOutputData(event:ProgressEvent):void
{
    var stdOut:ByteArray = process.standardOutput;
    var data:String = stdOut.readUTFBytes(process.standardOutput.bytesAvailable);
    trace("Got: ", data);
}
```

Launching and closing a native process

Adobe AIR 2 and later

To launch a native process, set up a NativeProcessInfo object to do the following:

- Point to the file you want to launch
- Store command-line arguments to pass to the process when launched (optional)
- Set the working directory of the process (optional)

To start the native process, pass the NativeProcessInfo object as the parameter of the `start()` method of a NativeProcess object.

For example, the following code shows how to launch a test.exe application in the application directory. The application passes the argument `"hello"` and sets the user's documents directory as the working directory:

```
var nativeProcessStartupInfo:NativeProcessStartupInfo = new NativeProcessStartupInfo();
var file:File = File.applicationDirectory.resolvePath("test.exe");
nativeProcessStartupInfo.executable = file;
var processArgs:Vector.<String> = new Vector.<String>();
processArgs[0] = "hello";
nativeProcessStartupInfo.arguments = processArgs;
nativeProcessStartupInfo.workingDirectory = File.documentsDirectory;
process = new NativeProcess();
process.start(nativeProcessStartupInfo);
```

To terminate the process, call the `exit()` method of the NativeProcess object.

If you want a file to be executable in your installed application, make sure that it's executable on the file system when you package your application. (On Mac and Linux, you can use chmod to set the executable flag, if needed.)

Communicating with a native process

Adobe AIR 2 and later

Once an AIR application has started a native process, it can communicate with the standard input, standard output, and standard error streams of the process.

You read and write data to the streams using the following properties of the NativeProcess object:

- `standardInput`—Contains access to the standard input stream data.
- `standardOutput`—Contains access to the standard output stream data.
- `standardError`—Contains access to the standard error stream data.

Writing to the standard input stream

You can write data to the standard input stream using the write methods of the `standardInput` property of the NativeProcess object. As the AIR application writes data to the process, the NativeProcess object dispatches `standardInputProgress` events.

If an error occurs in writing to the standard input stream, the NativeProcess object dispatches an `ioErrorStandardInput` event.

You can close the input stream by calling the `closeInput()` method of the NativeProcess object. When the input stream closes, the NativeProcess object dispatches a `standardInputClose` event.

```
var nativeProcessStartupInfo:NativeProcessStartupInfo = new NativeProcessStartupInfo();
var file:File = File.applicationDirectory.resolvePath("test.exe");
nativeProcessStartupInfo.executable = file;
process = new NativeProcess();
process.start(nativeProcessStartupInfo);
process.standardInput.writeUTF("foo");
if(process.running)
{
    process.closeInput();
}
```

Reading from the standard output stream

You can read data from the standard output stream using the read methods of this property. As the AIR application gets output stream data from the process, the NativeProcess object dispatches `standardOutputData` events.

If an error occurs in writing to the standard output stream, the NativeProcess object dispatches a `standardOutputError` event.

When process closes the output stream, the NativeProcess object dispatches a `standardOutputClose` event.

When reading data from the standard input stream, be sure to read data as it is generated. In other words, add an event listener for the `standardOutputData` event. In the `standardOutputData` event listener, read the data from the `standardOutput` property of the NativeProcess object. Do not simply wait for the `standardOutputClose` event or the `exit` event to read all data. If you do not read data as the native process generates the data, the buffer can fill up, or data can be lost. A full buffer can cause the native process to stall when trying to write more data. However, if you do not register an event listener for the `standardOutputData` event, then the buffer will not fill and the process will not stall. In this case, you will not have access to the data.

```
var nativeProcessStartupInfo:NativeProcessStartupInfo = new NativeProcessStartupInfo();
var file:File = File.applicationDirectory.resolvePath("test.exe");
nativeProcessStartupInfo.executable = file;
process = new NativeProcess();
process.addEventListener(ProgressEvent.STANDARD_OUTPUT_DATA, dataHandler);
process.start(nativeProcessStartupInfo);
var bytes:ByteArray = new ByteArray();
function dataHandler(event:ProgressEvent):void
{
    bytes.writeBytes(process.standardOutput.readBytes(process.standardOutput.bytesAvailable);
}
```

Reading from the standard error stream

You can read data from the standard error stream using the read methods of this property. As the AIR application reads error stream data from the process, the NativeProcess object dispatches `standardErrorData` events.

If an error occurs in writing to the standard error stream, the NativeProcess object dispatches an `standardErrorIoError` event.

When process closes the error stream, the NativeProcess object dispatches a `standardErrorClose` event.

When reading data from the standard error stream, be sure to read data as it is generated. In other words, add an event listener for the `standardErrorData` event. In the `standardErrorData` event listener, read the data from the `standardError` property of the NativeProcess object. Do not simply wait for the `standardErrorClose` event or the `exit` event to read all data. If you do not read data as the native process generates the data, the buffer can fill up, or data can be lost. A full buffer can cause the native process to stall when trying to write more data. However, if you do not register an event listener for the `standardErrorData` event, then the buffer will not fill and the process will not stall. In this case, you will not have access to the data.

```
var nativeProcessStartupInfo:NativeProcessStartupInfo = new NativeProcessStartupInfo();
var file:File = File.applicationDirectory.resolvePath("test.exe");
nativeProcessStartupInfo.executable = file;
process = new NativeProcess();
process.addEventListener(ProgressEvent.STANDARD_ERROR_DATA, errorDataHandler);
process.start(nativeProcessStartupInfo);
var errorBytes:ByteArray = new ByteArray();
function errorDataHandler(event:ProgressEvent):void
{
    bytes.writeBytes(process.standardError.readBytes(process.standardError.bytesAvailable);
}
```

Security considerations for native process communication

Adobe AIR 2 and later

The native process API can run any executable on the user's system. Take extreme care when constructing and executing commands. If any part of a command to be executed originates from an external source, carefully validate that the command is safe to execute. Likewise, your AIR application should validate any data passed to a running process.

However, validating input can be difficult. To avoid such difficulties, it is best to write a native application (such as an EXE file on Windows) that has specific APIs. These APIs should process only those commands defined by the application. For example, the application may accept only a limited set of instructions via the standard input stream.

AIR on Windows does not allow you to run .bat files directly. The command interpreter application (cmd.exe) executes Windows .bat files. When you invoke a .bat file, this command application can interpret arguments passed to the command as additional applications to launch. A malicious injection of extra characters in the argument string could cause cmd.exe to execute a harmful or insecure application. For example, without proper data validation, your AIR application may call `myBat.bat myArguments c:/evil.exe`. The command application would launch the evil.exe application in addition to running your batch file.

Chapter 47: Using the external API

Flash Player 9 and later, Adobe AIR 1.0 and later

The ActionScript 3.0 external API (flash.external.ExternalInterface) enables straightforward communication between ActionScript and the container application within which Adobe Flash Player is running. Use the ExternalInterface API to create interaction between a SWF document and JavaScript in an HTML page.

You can use the external API to interact with a container application, pass data between ActionScript and JavaScript in an HTML page.

Some common external API tasks are:

- Getting information about the container application
- Using ActionScript to call code in a web page displayed in a browser or an AIR desktop application
- Calling ActionScript code from a web page
- Creating a proxy to simplify calling ActionScript code from a web page

Note: *This discussion of the external interface only covers communication between ActionScript in a SWF file and the container application that includes a reference to the Flash Player or instance in which the SWF file is loaded. Any other use of Flash Player within an application is outside the scope of this documentation. Flash Player is designed to be used as a browser plug-in or as a projector (standalone application). Other usage scenarios may have limited support.*

Using the external API in AIR

Since an AIR application does not have an external container, this external interface does not generally apply—nor is it generally needed. When your AIR application loads a SWF file directly, the application code can communicate directly with the ActionScript code in the SWF (subject to security sandbox restrictions).

However, when your AIR application loads a SWF file using an HTML page in an HTMLLoader object (or an HTML component in Flex), the HTMLLoader object serves as the external container. Thus, you can use the external interface to communicate between the ActionScript code in the loaded SWF and the JavaScript code in the HTML page loaded in the HTMLLoader.

Basics of using the external API

Flash Player 9 and later, Adobe AIR 1.0 and later

Although in some cases a SWF file can run on its own (for example, if you use Adobe® Flash® Professional to create a SWF projector), in the majority of cases a SWF application runs as an element inside of another application. Commonly, the container that includes the SWF is an HTML file; somewhat less frequently, a SWF file is used for all or part of the user interface of a desktop application.

As you work on more advanced applications, you may find a need to set up communication between the SWF file and the container application. For instance, it's common for a web page to display text or other information in HTML, and include a SWF file to display dynamic visual content such as a chart or video. In such a case, you might want to make it so that when users click a button on the web page, it changes something in the SWF file. ActionScript contains a mechanism, known as the external API, that facilitates this type of communication between ActionScript in a SWF file and other code in the container application.

Important concepts and terms

The following reference list contains important terms relevant to this feature:

Container application The application within which Flash Player is running a SWF file, such as a web browser and HTML page that includes Flash Player content or an AIR application that loads the SWF in a web page..

Projector An executable file that includes SWF content and an embedded version of Flash Player. You can create a projector file using Flash Professional or the standalone Flash Player. Projectors are commonly used to distribute SWF files by CD-ROM or in similar situations where download size is not an issue and the SWF author wants to be certain the user will be able to run the SWF file, regardless of whether Flash Player is installed on the user's computer.

Proxy A go-between application or code that calls code in one application (the "external application") on behalf of another application (the "calling application"), and returns values to the calling application. A proxy can be used for various reasons, including:

- To simplify the process of making external function calls by converting native function calls in the calling application into the format understood by the external application.
- To work around security or other restrictions that prevent the caller from communicating directly with the external application.

Serialize To convert objects or data values into a format that can be used to pass the values in messages between two programming systems, such as over the Internet or between two different applications running on a single computer.

Working through the examples

Many of the code examples provided are small listings of code for demonstration purposes rather than full working examples or code that checks values. Because using the external API requires (by definition) writing ActionScript code as well as code in a container application, testing the examples involves creating a container (for example, a web page containing the SWF file) and using the code listings to interact with the container.

To test an example of ActionScript-to-JavaScript communication:

1 Create a new document using Flash Professional and save it to your computer.

2 From the main menu, choose File > Publish Settings.

3 In the Publish Settings dialog box, on the Formats tab, confirm that the Flash and HTML check boxes are selected.

4 Click the Publish button. This generates a SWF file and HTML file in the same folder and with the same name that you used to save the document. Click OK to close the Publish Settings dialog box.

5 Deselect the HTML check box. Now that the HTML page is generated, you are going to modify it to add the appropriate JavaScript code. Deselecting the HTML check box ensures that after you modify the HTML page, Flash will not overwrite your changes with a new HTML page when it's publishing the SWF file.

6 Click OK to close the Publish Settings dialog box.

7 With an HTML or text editor application, open the HTML file that was created by Flash when you published the SWF file. In the HTML source code, add opening and closing `script` tags, and copy into them the JavaScript code from the example code listing:

```
<script>
// add the sample JavaScript code here
</script>
```

8 Save the HTML file and return to Flash.

9 Select the keyframe on Frame 1 of the Timeline, and open the Actions panel.

10 Copy the ActionScript code listing into the Script pane.

11 From the main menu, choose File > Publish to update the SWF file with the changes that you've made.

12 Using a web browser, open the HTML page you edited to view the page and test communication between ActionScript and the HTML page.

To test an example of ActionScript-to-ActiveX container communication:

1 Create a new document using Flash Professional and save it to your computer. You may want to save it in the folder where your container application will expect to find the SWF file.

2 From the main menu, choose File > Publish Settings.

3 In the Publish Settings dialog box, on the Formats tab, confirm that only the Flash check box is selected.

4 In the File field next to the Flash check box, click the folder icon to select the folder into which your SWF file will be published. By setting the location for your SWF file, you can (for example) keep the document in one folder, but put the published SWF file in another folder such as the folder containing the source code for the container application.

5 Select the keyframe on Frame 1 of the Timeline, and open the Actions panel.

6 Copy the ActionScript code for the example into the Script pane.

7 From the main menu, choose File > Publish to re-publish the SWF file.

8 Create and run your container application to test communication between ActionScript and the container application.

For full examples of using the external API to communicate with an HTML page, see the following topic:

- "External API example: Communicating between ActionScript and JavaScript in a web browser" on page 849

Those examples include the full code, including ActionScript and container error-checking code, which you should use when writing code using the external API. For another full example using the external API, see the class example for the ExternalInterface class in the ActionScript 3.0 Reference.

External API requirements and advantages

Flash Player 9 and later, Adobe AIR 1.0 and later

The external API is the portion of ActionScript that provides a mechanism for communication between ActionScript and code running in an "external application" that is acting as a container for Flash Player (commonly a web browser or stand-alone projector application). In ActionScript 3.0, the functionality of the external API is provided by the ExternalInterface class. In Flash Player versions prior to Flash Player 8, the `fscommand()` action was used to carry out communication with the container application. The ExternalInterface class is a replacement for `fscommand()`.

Note: *If you need to use the old `fscommand()` function—for example, to maintain compatibility with older applications or to interact with a third-party SWF container application or the stand-alone Flash Player—it is still available as a package-level function in the flash.system package.*

The ExternalInterface class is a subsystem that lets you easily communicate from ActionScript and Flash Player to JavaScript in an HTML page.

The ExternalInterface class is available only under the following conditions:

- In all supported versions of Internet Explorer for Windows (5.0 and later)
- In any browser that supports the NPRuntime interface, which currently includes Firefox 1.0 and later, Mozilla 1.7.5 and later, Netscape 8.0 and later, and Safari 1.3 and later.
- In an AIR application when the SWF is embedded in an HTML page displayed by the HTMLLoader control.

In all other situations (such as running in a stand-alone player), the `ExternalInterface.available` property returns `false`.

From ActionScript, you can call a JavaScript function on the HTML page. The external API offers the following improved functionality compared with `fscommand()`:

- You can use any JavaScript function, not only the functions that you can use with the `fscommand()` function.
- You can pass any number of arguments, with any names; you aren't limited to passing a command and a single string argument. This gives the external API much more flexibility than `fscommand()`.
- You can pass various data types (such as Boolean, Number, and String); you aren't limited to String parameters.
- You can receive the value of a call, and that value returns immediately to ActionScript (as the return value of the call you make).

Important: *If the name given to the Flash Player instance in an HTML page (the `object` tag's `id` attribute) includes a hyphen (`-`) or other characters that are defined as operators in JavaScript (such as `+`, `*`, `/`, `\`, `.`, and so on), ExternalInterface calls from ActionScript will not work when the container web page is viewed in Internet Explorer.In addition, if the HTML tags that define the Flash Player instance (the `object` and `embed` tags) are nested in an HTML `form` tag, ExternalInterface calls from ActionScript will not work.*

Using the ExternalInterface class

Flash Player 9 and later, Adobe AIR 1.0 and later

Communication between ActionScript and the container application can take one of two forms: either ActionScript can call code (such as a JavaScript function) defined in the container, or code in the container can call an ActionScript function that has been designated as being callable. In either case, information can be sent to the code being called, and results can be returned to the code making the call.

To facilitate this communication, the ExternalInterface class includes two static properties and two static methods. These properties and methods are used to obtain information about the external interface connection, to execute code in the container from ActionScript, and to make ActionScript functions available to be called by the container.

Getting information about the external container

Flash Player 9 and later, Adobe AIR 1.0 and later

The `ExternalInterface.available` property indicates whether the current Flash Player is in a container that offers an external interface. If the external interface is available, this property is `true`; otherwise, it is `false`. Before using any of the other functionality in the ExternalInterface class, you should always check to make sure that the current container supports external interface communication, as follows:

```
if (ExternalInterface.available)
{
    // Perform ExternalInterface method calls here.
}
```

***Note:** The `ExternalInterface.available` property reports whether the current container is a type that supports ExternalInterface connectivity. It doesn't tell you if JavaScript is enabled in the current browser.*

The `ExternalInterface.objectID` property allows you to determine the unique identifier of the Flash Player instance (specifically, the `id` attribute of the `object` tag in Internet Explorer or the `name` attribute of the `embed` tag in browsers using the NPRuntime interface). This unique ID represents the current SWF document in the browser, and can be used to make reference to the SWF document—for example, when calling a JavaScript function in a container HTML page. When the Flash Player container is not a web browser, this property is `null`.

Calling external code from ActionScript

Flash Player 9 and later, Adobe AIR 1.0 and later

The `ExternalInterface.call()` method executes code in the container application. It requires at least one parameter, a string containing the name of the function to be called in the container application. Any additional parameters passed to the `ExternalInterface.call()` method are passed along to the container as parameters of the function call.

```
// calls the external function "addNumbers"
// passing two parameters, and assigning that function's result
// to the variable "result"
var param1:uint = 3;
var param2:uint = 7;
var result:uint = ExternalInterface.call("addNumbers", param1, param2);
```

If the container is an HTML page, this method invokes the JavaScript function with the specified name, which must be defined in a `script` element in the containing HTML page. The return value of the JavaScript function is passed back to ActionScript.

```
<script language="JavaScript">
    // adds two numbers, and sends the result back to ActionScript
    function addNumbers(num1, num2)
    {
        return (num1 + num2);
    }
</script>
```

If the container is some other ActiveX container, this method causes the Flash Player ActiveX control to dispatch its `FlashCall` event. The specified function name and any parameters are serialized into an XML string by Flash Player. The container can access that information in the `request` property of the event object and use it to determine how to execute its own code. To return a value to ActionScript, the container code calls the ActiveX object's `SetReturnValue()` method, passing the result (serialized into an XML string) as a parameter of that method. For more information about the XML format used for this communication, see "The external API's XML format" on page 848.

Whether the container is a web browser or another ActiveX container, if the call fails or the container method does not specify a return value, `null` is returned. The `ExternalInterface.call()` method throws a SecurityError exception if the containing environment belongs to a security sandbox to which the calling code does not have access. You can work around this by setting an appropriate value for `allowScriptAccess` in the containing environment. For example, to change the value of `allowScriptAccess` in an HTML page, you would edit the appropriate attribute in the `object` and `embed` tags.

Calling ActionScript code from the container

Flash Player 9 and later, Adobe AIR 1.0 and later

A container can only call ActionScript code that's in a function—no other ActionScript code can be called by a container. To call an ActionScript function from the container application, you must do two things: register the function with the ExternalInterface class, and then call it from the container's code.

First, you must register your ActionScript function to indicate that it should be made available to the container. Use the `ExternalInterface.addCallback()` method, as follows:

```
function callMe(name:String):String
{
    return "busy signal";
}
ExternalInterface.addCallback("myFunction", callMe);
```

The `addCallback()` method takes two parameters. The first, a function name as a String, is the name by which the function will be known to the container. The second parameter is the actual ActionScript function that will be executed when the container calls the defined function name. Because these names are distinct, you can specify a function name that will be used by the container, even if the actual ActionScript function has a different name. This is especially useful if the function name is not known—for example, if an anonymous function is specified, or if the function to be called is determined at run time.

Once an ActionScript function has been registered with the ExternalInterface class, the container can actually call the function. How this is done varies according to the type of container. For example, in JavaScript code in a web browser, the ActionScript function is called using the registered function name as though it's a method of the Flash Player browser object (that is, a method of the JavaScript object representing the `object` or `embed` tag). In other words, parameters are passed and a result is returned as though a local function is being called.

```
<script language="JavaScript">
    // callResult gets the value "busy signal"
    var callResult = flashObject.myFunction("my name");
</script>
...
<object id="flashObject"...>
    ...
    <embed name="flashObject".../>
</object>
```

Alternatively, when calling an ActionScript function in a SWF file running in a desktop application, the registered function name and any parameters must be serialized into an XML-formatted string. Then the call is actually performed by calling the `CallFunction()` method of the ActiveX control with the XML string as a parameter. For more information about the XML format used for this communication, see "The external API's XML format" on page 848.

In either case, the return value of the ActionScript function is passed back to the container code, either directly as a value when the caller is JavaScript code in a browser, or serialized as an XML-formatted string when the caller is an ActiveX container.

The external API's XML format

Flash Player 9 and later, Adobe AIR 1.0 and later

Communication between ActionScript and an application hosting the Shockwave Flash ActiveX control uses a specific XML format to encode function calls and values. There are two parts to the XML format used by the external API. One format is used to represent function calls. Another format is used to represent individual values; this format is used for parameters in functions as well as function return values. The XML format for function calls is used for calls to and from ActionScript. For a function call from ActionScript, Flash Player passes the XML to the container; for a call from the container, Flash Player expects the container application to pass it an XML string in this format. The following XML fragment shows an example XML-formatted function call:

```
<invoke name="functionName" returntype="xml">
    <arguments>
        ... (individual argument values)
    </arguments>
</invoke>
```

The root node is the `invoke` node. It has two attributes: `name` indicates the name of the function to call, and `returntype` is always `xml`. If the function call includes parameters, the `invoke` node has a child `arguments` node, whose child nodes will be the parameter values formatted using the individual value format explained next.

Individual values, including function parameters and function return values, use a formatting scheme that includes data type information in addition to the actual values. The following table lists ActionScript classes and the XML format used to encode values of that data type:

ActionScript class/value	C# class/value	Format	Comments
null	null	<null/>	
Boolean `true`	bool true	<true/>	
Boolean `false`	bool false	<false/>	
String	string	<string>string value</string>	

Number, int, uint	single, double, int, uint	`<number>27.5</number>`
		`<number>-12</number>`	

ActionScript class/value	C# class/value	Format	Comments

Array (elements can be mixed types)	A collection that allows mixed-type elements, such as ArrayList or object[]	`<array>`
		`<property id="0">`
		`<number>27.5</number>`
		`</property>`
		`<property id="1">`
		`<string>Hello there!</string>`
		`</property>`
		`...`
		`</array>`
			The `property` node defines individual elements, and the `id` attribute is the numeric, zero-based index.

Object	A dictionary with string keys and object values, such as a HashTable with string keys	`<object>`
		`<property id="name">`
		`<string>John Doe</string>`
		`</property>`
		`<property id="age">`
		`<string>33</string>`
		`</property>`
		`...`
		`</object>`
			The `property` node defines individual properties, and the `id` attribute is the property name (a string).

Other built-in or custom classes		`<null/> or`
		`<object></object>`
			ActionScript encodes other objects as null or as an empty object. In either case any property values are lost.

***Note:** By way of example, this table shows equivalent C# classes in addition to ActionScript classes; however, the external API can be used to communicate with any programming language or run time that supports ActiveX controls, and is not limited to C# applications.*

When you are building your own applications using the external API with an ActiveX container application, you'll probably find it convenient to write a proxy that will perform the task of converting native function calls to the serialized XML format. For an example of a proxy class written in C#, see Inside the ExternalInterfaceProxy class.

External API example: Communicating between ActionScript and JavaScript in a web browser

Flash Player 9 and later, Adobe AIR 1.0 and later

This sample application demonstrates appropriate techniques for communicating between ActionScript and JavaScript in a web browser, in the context of an Instant Messaging application that allows a person to chat with him or herself (hence the name of the application: Introvert IM). Messages are sent between an HTML form in the web page and a SWF interface using the external API. The techniques demonstrated by this example include the following:

- Properly initiating communication by verifying that the browser is ready to communicate before setting up communication
- Checking whether the container supports the external API
- Calling JavaScript functions from ActionScript, passing parameters, and receiving values in response
- Making ActionScript methods available to be called by JavaScript, and performing those calls

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The Introvert IM application files can be found in the Samples/IntrovertIM_HTML folder. The application consists of the following files:

File	Description
IntrovertIMApp.fla or IntrovertIMApp.mxml	The main application file for Flash (FLA) or Flex (MXML).
com/example/programmingas3/introvertIM/IMManager.as	The class that establishes and manages communication between ActionScript and the container.
com/example/programmingas3/introvertIM/IMMessageEvent.as	Custom event type, dispatched by the IMManager class when a message is received from the container.
com/example/programmingas3/introvertIM/IMStatus.as	Enumeration whose values represent the different "availability" status values that can be selected in the application.
html-flash/IntrovertIMApp.html or html-template/index.template.html	The HTML page for the application for Flash (html-flash/IntrovertIMApp.html) or the template that is used to create the container HTML page for the application for Adobe Flex (html-template/index.template.html). This file contains all the JavaScript functions that make up the container part of the application.

Preparing for ActionScript-browser communication

Flash Player 9 and later, Adobe AIR 1.0 and later

One of the most common uses for the external API is to allow ActionScript applications to communicate with a web browser. Using the external API, ActionScript methods can call code written in JavaScript and vice versa. Because of the complexity of browsers and how they render pages internally, there is no way to guarantee that a SWF document will register its callbacks before the first JavaScript on the HTML page runs. For that reason, before calling functions in the SWF document from JavaScript, your SWF document should always call the HTML page to notify it that the SWF document is ready to accept connections.

For example, through a series of steps performed by the IMManager class, the Introvert IM determines whether the browser is ready for communication and prepares the SWF file for communication. The first step, determining when the browser is ready for communication, happens in the IMManager constructor, as follows:

```
public function IMManager(initialStatus:IMStatus)
{
    _status = initialStatus;

    // Check if the container is able to use the external API.
    if (ExternalInterface.available)
    {
        try
        {
            // This calls the isContainerReady() method, which in turn calls
            // the container to see if Flash Player has loaded and the container
            // is ready to receive calls from the SWF.
            var containerReady:Boolean = isContainerReady();
            if (containerReady)
            {
                // If the container is ready, register the SWF's functions.
                setupCallbacks();
            }
            else
            {
                // If the container is not ready, set up a Timer to call the
                // container at 100ms intervals. Once the container responds that
                // it's ready, the timer will be stopped.
                var readyTimer:Timer = new Timer(100);
                readyTimer.addEventListener(TimerEvent.TIMER, timerHandler);
                readyTimer.start();
            }
        }
        ...
    }
    else
    {
        trace("External interface is not available for this container.");
    }
}
```

First of all, the code checks whether the external API is even available in the current container using the `ExternalInterface.available` property. If so, it begins the process of setting up communication. Because security exceptions and other errors can occur when you attempt communication with an external application, the code is wrapped in a `try` block (the corresponding `catch` blocks were omitted from the listing for brevity).

The code next calls the `isContainerReady()` method, listed here:

```
private function isContainerReady():Boolean
{
    var result:Boolean = ExternalInterface.call("isReady");
    return result;
}
```

The `isContainerReady()` method in turn uses `ExternalInterface.call()` method to call the JavaScript function `isReady()`, as follows:

```
<script language="JavaScript">
<!--
// ------- Private vars -------
var jsReady = false;
...
// ------- functions called by ActionScript -------
// called to check if the page has initialized and JavaScript is available
function isReady()
{
    return jsReady;
}
...
// called by the onload event of the <body> tag
function pageInit()
{
    // Record that JavaScript is ready to go.
    jsReady = true;
}
...
//-->
</script>
```

The `isReady()` function simply returns the value of the `jsReady` variable. That variable is initially `false`; once the `onload` event of the web page has been triggered, the variable's value is changed to `true`. In other words, if ActionScript calls the `isReady()` function before the page is loaded, JavaScript returns `false` to `ExternalInterface.call("isReady")`, and consequently the ActionScript `isContainerReady()` method returns `false`. Once the page has loaded, the JavaScript `isReady()` function returns `true`, so the ActionScript `isContainerReady()` method also returns `true`.

Back in the IMManager constructor, one of two things happens depending on the readiness of the container. If `isContainerReady()` returns `true`, the code simply calls the `setupCallbacks()` method, which completes the process of setting up communication with JavaScript. On the other hand, if `isContainerReady()` returns `false`, the process is essentially put on hold. A Timer object is created and is told to call the `timerHandler()` method every 100 milliseconds, as follows:

```
private function timerHandler(event:TimerEvent):void
{
    // Check if the container is now ready.
    var isReady:Boolean = isContainerReady();
    if (isReady)
    {
        // If the container has become ready, we don't need to check anymore,
        // so stop the timer.
        Timer(event.target).stop();
        // Set up the ActionScript methods that will be available to be
        // called by the container.
        setupCallbacks();
    }
}
```

Each time the `timerHandler()` method gets called, it once again checks the result of the `isContainerReady()` method. Once the container is initialized, that method returns `true`. The code then stops the Timer and calls the `setupCallbacks()` method to finish the process of setting up communication with the browser.

Exposing ActionScript methods to JavaScript

Flash Player 9 and later, Adobe AIR 1.0 and later

As the previous example showed, once the code determines that the browser is ready, the `setupCallbacks()` method is called. This method prepares ActionScript to receive calls from JavaScript, as shown here:

```
private function setupCallbacks():void
{
    // Register the SWF client functions with the container
    ExternalInterface.addCallback("newMessage", newMessage);
    ExternalInterface.addCallback("getStatus", getStatus);
    // Notify the container that the SWF is ready to be called.
    ExternalInterface.call("setSWFIsReady");
}
```

The `setCallBacks()` method finishes the task of preparing for communication with the container by calling `ExternalInterface.addCallback()` to register the two methods that will be available to be called from JavaScript. In this code, the first parameter—the name by which the method is known to JavaScript (`"newMessage"` and `"getStatus"`)—is the same as the method's name in ActionScript. (In this case, there was no benefit to using different names, so the same name was reused for simplicity.) Finally, the `ExternalInterface.call()` method is used to call the JavaScript function `setSWFIsReady()`, which notifies the container that the ActionScript functions have been registered.

Communication from ActionScript to the browser

Flash Player 9 and later, Adobe AIR 1.0 and later

The Introvert IM application demonstrates a range of examples of calling JavaScript functions in the container page. In the simplest case (an example from the `setupCallbacks()` method), the JavaScript function `setSWFIsReady()` is called without passing any parameters or receiving a value in return:

```
ExternalInterface.call("setSWFIsReady");
```

In another example from the `isContainerReady()` method, ActionScript calls the `isReady()` function and receives a Boolean value in response:

```
var result:Boolean = ExternalInterface.call("isReady");
```

You can also pass parameters to JavaScript functions using the external API. For instance, consider the IMManager class's `sendMessage()` method, which is called when the user is sending a new message to his or her "conversation partner":

```
public function sendMessage(message:String):void
{
    ExternalInterface.call("newMessage", message);
}
```

Once again, `ExternalInterface.call()` is used to call the designated JavaScript function, notifying the browser of the new message. In addition, the message itself is passed as an additional parameter to `ExternalInterface.call()`, and consequently it is passed as a parameter to the JavaScript function `newMessage()`.

Calling ActionScript code from JavaScript

Flash Player 9 and later, Adobe AIR 1.0 and later

Communication is supposed to be a two-way street, and the Introvert IM application is no exception. Not only does the Flash Player IM client call JavaScript to send messages, but the HTML form calls JavaScript code to send messages to and ask for information from the SWF file as well. For example, when the SWF file notifies the container that it has finished establishing contact and it's ready to communicate, the first thing the browser does is call the IMManager class's `getStatus()` method to retrieve the initial user availability status from the SWF IM client. This is done in the web page, in the `updateStatus()` function, as follows:

```
<script language="JavaScript">
...
function updateStatus()
{
    if (swfReady)
    {
        var currentStatus = getSWF("IntrovertIMApp").getStatus();
        document.forms["imForm"].status.value = currentStatus;
    }
}
...
</script>
```

The code checks the value of the `swfReady` variable, which tracks whether the SWF file has notified the browser that it has registered its methods with the ExternalInterface class. If the SWF file is ready to receive communication, the next line (`var currentStatus =` ...) actually calls the `getStatus()` method in the IMManager class. Three things happen in this line of code:

- The `getSWF()` JavaScript function is called, returning a reference to the JavaScript object representing the SWF file. The parameter passed to `getSWF()` determines which browser object is returned in case there is more than one SWF file in an HTML page. The value passed to that parameter must match the `id` attribute of the `object` tag and `name` attribute of the `embed` tag used to include the SWF file.
- Using the reference to the SWF file, the `getStatus()` method is called as though it's a method of the SWF object. In this case the function name "`getStatus`" is used because that's the name under which the ActionScript function is registered using `ExternalInterface.addCallback()`.
- The `getStatus()` ActionScript method returns a value, and that value is assigned to the `currentStatus` variable, which is then assigned as the content (the `value` property) of the `status` text field.

Note: *If you're following along in the code, you've probably noticed that in the source code for the* `updateStatus()` *function, the line of code that calls the* `getSWF()` *function, is actually written as follows: var currentStatus = getSWF("${application}").getStatus(); The* `${application}` *text is a placeholder in the HTML page template; when Adobe Flash Builder generates the actual HTML page for the application, this placeholder text is replaced by the same text that is used as the* `object` *tag's* `id` *attribute and the* `embed` *tag's* `name` *attribute (*`IntrovertIMApp` *in the example). That is the value that is expected by the* `getSWF()` *function.*

The `sendMessage()` JavaScript function demonstrates passing a parameter to an ActionScript function. (`sendMessage()` is thefunction that is called when the user presses the Send button on the HTML page.)

```
<script language="JavaScript">
...
function sendMessage(message)
{
    if (swfReady)
    {
        ...
        getSWF("IntrovertIMApp").newMessage(message);
    }
}
...
</script>
```

The `newMessage()` ActionScript method expects one parameter, so the JavaScript `message` variable gets passed to ActionScript by using it as a parameter in the `newMessage()` method call in the JavaScript code.

Detecting the browser type

Flash Player 9 and later, Adobe AIR 1.0 and later

Because of differences in how browsers access content, it's important to always use JavaScript to detect which browser the user is running and to access the movie according to the browser-specific syntax, using the window or document object, as shown in the `getSWF()` JavaScript function in this example:

```
<script language="JavaScript">
...
function getSWF(movieName)
{
    if (navigator.appName.indexOf("Microsoft") != -1)
    {
        return window[movieName];
    }
    else
    {
        return document[movieName];
    }
}
...
</script>
```

If your script does not detect the user's browser type, the user might see unexpected behavior when playing SWF files in an HTML container.

Chapter 48: XML signature validation in AIR

Adobe AIR 1.5 and later

Use the classes in the Adobe® AIR® XMLSignatureValidator API to validate digital signatures conforming to a subset of the W3C recommendation for XML-Signature Syntax and Processing (http://http://www.w3.org/TR/xmldsig-core/). XML signatures can be used to help verify the integrity and signer identity of data or information.

XML signatures can be used to validate messages or resources downloaded by your application. For example, if your application provides services on a subscription basis, you could encapsulate the subscription terms in a signed XML document. If someone attempted to alter the subscription document, validation would fail.

You could also use an XML signature to help validate downloaded resources used by your application by including a signed manifest containing digests of those resources. Your application could verify that the resources have not been altered by comparing the digest in the signed file with a digest computed from the loaded bytes. This is particularly valuable when the downloaded resource is a SWF file or other active content that you want to run in the application security sandbox.

Basics of XML signature validation

Adobe AIR 1.5 and later

For a quick explanation and code examples of validating XML signatures, see the following quick start articles on the Adobe Developer Connection:

- Creating and validating XML signatures (Flex)
- Creating and validating XML signatures (Flash)

Adobe® AIR® provides the XMLSignatureValidator class and IURIDereferencer interface for validating XML signatures. The XML syntax accepted by the XMLSignatureValidator class is a subset of the W3C recommendation for XML Signature Syntax and Processing. (Because only a subset of the recommendation is supported, not all legal signatures can be validated.) AIR does not provide an API for creating XML signatures.

XML signature validation classes

Adobe AIR 1.5 and later

The XML signature validation API includes the following classes:

Package	Classes
flash.security	• XMLSignatureValidator • IURIDereferencer (interface) XMLSignatureValidator string constants are defined in the following classes: • ReferencesValidationSetting • RevocationCheckSettings • SignatureStatus • SignerTrustSettings
flash.events	• Event • ErrorEvent

Using the XML signature validation classes

Adobe AIR 1.5 and later

To use the XMLSignatureValidator class to validate an XML signature, you must:

- Create an XMLSignatureValidator object
- Provide an implementation of the IURIDereferencer interface. The XMLSignatureValidator object calls the IURIDereferencer `dereference()` method, passing in the URI for each reference in a signature. The `dereference()` method must resolve the URI and return the referenced data (which could be in the same document as the signature, or could be in an external resource).
- Set the certificate trust, revocation checking, and reference validation settings of the XMLSignatureValidator object as appropriate for your application.
- Add event listeners for the `complete` and `error` events.
- Call the `verify()` method, passing in the signature to validate.
- Handle the `complete` and `error` events and interpret the results.

The following example implements a `validate()` function that verifies the validity of an XML signature. The XMLSignatureValidator properties are set such that the signing certificate must be in the system trust store, or chain to a certificate in the trust store. The example also assumes that a suitable IURIDereferencer class named *XMLDereferencer* exists.

```
private function validate( xmlSignature:XML ):void
{
    var verifier:XMLSignatureValidator = new XMLSignatureValidator();
    verifier.addEventListener(Event.COMPLETE, verificationComplete);
    verifier.addEventListener(ErrorEvent.ERROR, verificationError);
    try
    {
        verifier.uriDereferencer = new XMLDereferencer();

        verifier.referencesValidationSetting =
            ReferencesValidationSetting.VALID_IDENTITY;
        verifier.revocationCheckSetting = RevocationCheckSettings.BEST_EFFORT;
        verifier.useSystemTrustStore = true;

        //Verify the signature
        verifier.verify( xmlSignature );
    }
    catch (e:Error)
        {
            trace("Verification error.\n" + e);
        }
}

//Trace verification results
private function verificationComplete(event:Event):void

    var signature:XMLSignatureValidator = event.target as XMLSignatureValidator;
    trace("Signature status: " + signature.validityStatus + "\n");
    trace("  Digest status: " + signature.digestStatus + "\n");
    trace("  Identity status: " + signature.identityStatus + "\n");
    trace("  Reference status: " + signature.referencesStatus + "\n");
}

private function verificationError(event:ErrorEvent):void
{
    trace("Verification error.\n" + event.text);
}
```

The XML signature validation process

Adobe AIR 1.5 and later

When you call the XMLSignatureValidator `verify()` method, AIR performs the following steps:

- The runtime verifies the cryptographic integrity of the signature using the public key of the signing certificate.
- The runtime establishes the cryptographic integrity, identity, and trustworthiness of the certificate based on the current settings of the XMLSignatureValidator object.

  The trust placed in the signing certificate is key to the integrity of the validation process. Signature validation is conducted using a well-defined cryptographic process, but the trustworthiness of the signing certificate is a judgment that cannot be made algorithmically.

  In general, you have three ways to decide whether a certificate is trustworthy:

  - By relying on certification authorities and the operating system trust store.

- By obtaining, directly from the signer, a copy of the certificate, another certificate that serves as a trust anchor for the certificate, or sufficient information to reliably identify the certificate, such as the public key.
- Asking the end user of your application if they trust the certificate. Such a query is invalid with self-signed certificates since the identifying information in the certificate is inherently unreliable.

- The runtime verifies the cryptographic integrity of the signed data.

  The signed data is verified with the help of your IURIDereferencer implementation. For each reference in the signature document, the IURIDereferencer implementation `dereference()` method is called. The data returned by the `dereference()` method is used to compute the reference digest. This digest value is compared to the digest recorded in the signature document. If the digests match, then the data has not been altered since it was signed.

  One important consideration when relying on the results of validating an XML signature is that only what is signed is secure. For example, consider a signed manifest listing the files in a package. When the XMLSignatureValidator verifies the signature, it only checks whether the manifest itself is unaltered. The data in the files is not signed, so the signature will still validate when files referenced in the manifest are changed or deleted.

  Note: *To verify files in such a manifest, you can compute the digest of the file data (using the same hashing algorithm used in the manifest) and compare the result to the digest stored in the signed manifest. In some cases, you should also check for the presence of additional files.*

Interpreting validation results

Adobe AIR 1.5 and later

The validation results are reported by the status properties of the XMLSignatureValidator object. These properties can be read after the validator object dispatches the *complete* event. The four status properties include: `validityStatus`, `digestStatus`, `identityStatus`, and `referencesStatus`.

The validityStatus property

Adobe AIR 1.5 and later

The `validityStatus` property reports the overall validity of the signature. The `validityStatus` depends on the state of the other three status properties and can have one of the following values:

- `valid` — If `digestStatus`, `identityStatus`, and `referencesStatus` are all `valid`.
- `invalid` — If one or more of the individual status properties is `invalid`.
- `unknown` — If one or more of the individual status properties is `unknown` and no individual status is `invalid`.

The digestStatus property

Adobe AIR 1.5 and later

The `digestStatus` property reports the results of the cryptographic verification of the message digest. The `digestStatus` property can have one of the following values:

- `valid` — If the signature document itself is unaltered since signing.
- `invalid` — If the signature document has been altered or is malformed.
- `unknown` — If the `verify()` method has not completed without error.

The identityStatus property
Adobe AIR 1.5 and later

The `identityStatus` property reports the status of the signing certificate. The value of this property depends on several factors including:

- the cryptographic integrity of the certificate
- whether the certificate is expired or revoked
- whether the certificate is trusted on the current machine
- the state of the XMLSignatureValidator object (such as whether additional certificates have been added for building the trust chain, whether those certificates are trusted, and the values of the `useSystemTrustStore` and `revocationCheckSettings` properties)

The `identityStatus` property can have the following values:

- `valid` — To be considered valid, the signing certificate must meet the following conditions:
    - The signing certificate must be unaltered.
    - The signing certificate must not be expired or revoked—except when a valid timestamp is present in the signature. If the signature is timestamped, the certificate will be considered valid as long as it was valid at the time the document was signed. (The certificate used by the timestamp service to sign the timestamp must chain to a trusted root certificate on the user's computer.)
    - The signing certificate is trusted. A certificate is trusted if the certificate is in the system trust store or chains to another certificate in the system trust store and you set the `useSystemTrustStore` property to true. You can also designate a certificate as trusted using the `addCertificate()` method of the XMLSignatureValidator object.
    - The certificate is, in fact, the signing certificate.
- `invalid` — The certificate is expired or revoked—and no timestamp proving validity at the time of signing is present—or the certificate has been altered.
- `unknown` — If the certificate is not invalid, but is not trusted either. Self-signed certificates, for example, will be reported as `unknown` (unless explicitly trusted). The `identityStatus` is also reported as `unknown` if the `verify()` method has not completed without error or if the identity has not been checked because the signature digest is invalid.

The referencesStatus property
Adobe AIR 1.5 and later

The `referencesStatus` property reports the cryptographic integrity of the references in the SignedData element of the signature.

- `valid` — If the computed digest of every reference in the signature matches the corresponding digest recorded in the XML signature. A `valid` status indicates that the signed data has not been altered.
- `invalid` — If any computed digest does not match the corresponding digest in the signature.
- `unknown` — If the reference digests have not been checked. The references are not checked if the overall signature digest is `invalid` or the signing certificate is invalid. If the `identityStatus` is `unknown`, then the references are only checked when the `referencesValidationSetting` is `validOrUnknown`.

About XML signatures

Adobe AIR 1.5 and later

An XML signature is a digital signature represented in XML syntax. The data in an XML signature can be used to validate that the signed information has not been altered since signing. In addition, when a signing certificate has been issued by a trusted certification authority, the identity of the signer can be verified through the public key infrastructure.

An XML signature can be applied to any type of digital data (in binary or XML format). XML signatures are typically used for such purposes as:

- checking whether external or downloaded resources have been modified
- verifying that messages come from a known source
- validating application license or subscription privileges

Supported XML signature syntax

Adobe AIR 1.5 and later

AIR supports the following elements from the W3C recommendation for XML Signature Syntax and Processing:

- All core signature syntax elements (section 4 of the W3C recommendation document)—except the KeyInfo element is not fully supported
- The KeyInfo element must only contain an X509Data element
- An X509Data element must only contain an X509Certificate element
- The SHA256 digest method
- The RSA-SHA1 (PKCS1) signing algorithm
- The "Canonical XML without comments" canonicalization method and transform
- The enveloped signature transform
- timestamps

The following document illustrates a typical XML signature (most of the cryptographic data has been removed to simplify the example):

```
<Signature xmlns="http://www.w3.org/2000/09/xmldsig#">
    <SignedInfo>
        <CanonicalizationMethod Algorithm="http://www.w3.org/TR/2001/REC-xml-c14n-
20010315"/>
        <SignatureMethod Algorithm="http://www.w3.org/2000/09/xmldsig#rsa-sha1"/>
        <Reference URI="URI_to_signed_data">
            <Transforms>
                <Transform Algorithm="http://www.w3.org/2000/09/xmldsig#enveloped-
signature"/></Transforms>
            <DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256"/>
            <DigestValue>uoo...vY=</DigestValue>
        </Reference>
    </SignedInfo>
    <SignatureValue>Ked...w==</SignatureValue>
    <KeyInfo>
        <X509Data>
            <X509Certificate>i7d...w==</X509Certificate>
        </X509Data>
    </KeyInfo>
</Signature>
```

The key elements of a signature are:

- SignedInfo — Contains references to the signed data and the computed digest values at the time of signing. The signed data itself may be included in the same document as the XML signature or may be external.
- SignatureValue — Contains a digest of the SignedInfo element encrypted with the signer's private key.
- KeyInfo — Contains the signing certificate, as well as any additional certificates needed to establish the chain of trust. Note that although the KeyInfo element is technically optional, AIR cannot validate the signature if it is not included.

There are three general types of XML signatures:

- Enveloped — the signature is inserted inside the XML data that it is signing.
- Enveloping — the signed XML data is contained within an Object element within the Signature element.
- Detached — the signed data is external to the XML signature. The signed data might be in an external file. Alternately, it might be in the same XML document as the signature, just not a parent or child element of the Signature element.

XML signatures use URIs to reference the signed data. The signing and the validating applications must use the same conventions for resolving these URIs. When using the XMLSignatureValidator class, you must provide an implementation of the IURIDereferencer interface. This implementation is responsible for resolving the URI and returning the signed data as a ByteArray object. The returned ByteArray object is digested using the same algorithm that produced the digest in the signature.

Certificates and trust

Adobe AIR 1.5 and later

A certificate consists of a public key, identifying information, and possibly one or more certificates belonging to the issuing certification authority.

There are two ways to establish trust in a certificate. You can establish trust by obtaining a copy of the certificate directly from the signer, for example on physical media, or through a secure digital transmission such as an SSL transaction. You can also rely on a certification authority to determine whether the signing certificate is trustworthy.

To rely on a certification authority, the signing certificate must be issued by an authority that is trusted on the computer upon which the signature is validated. Most operating system manufacturers place the root certificates of a number of certification authorities into the operating system trust store. Users can also add and remove certificates from the store.

Even if a certificate is issued by a trusted certification authority, you must still decide whether the certificate belongs to someone you trust. In many use cases, this decision is passed along to the end-user. For example, when an AIR application is installed, the AIR installer displays the identifying information from the publisher's certificate when asking the user to verify whether they want to install the application. In other cases, you might have to compare the public key or other certificate information to a list of acceptable keys. (This list must be secured, perhaps by its own signature, or by storing in the AIR encrypted local store, so that the list itself cannot be tampered with.)

***Note:** While you can elect to trust the signing certificate without independent verification—such as when a signature is "self-signed"—you do not thereby gain much assurance of anything by verifying the signature. Without knowing who created a signature, the assurance that the signature has not been tampered with, is of little, if any, value. The signature could be a validly signed forgery.*

Certificate expiration and revocation

Adobe AIR 1.5 and later

All certificates expire. Certificates can also be revoked by the issuing certification authority if, for example, the private key related to the certificate is compromised or stolen. If a signature is signed with an expired or revoked certificate, then the signature will be reported as invalid unless a timestamp has been included as part of the signature. If a timestamp is present, then the XMLSignatureValidator class will validate the signature as long as the certificate was valid at the time of signing.

A timestamp is a signed digital message from a timestamp service that certifies that the data was signed at a particular time and date. Timestamps are issued by timestamp authorities and signed by the timestamp authority's own certificate. The timestamp authority certificate embedded in the timestamp must be trusted on the current machine for the timestamp to be considered valid. The XMLSignatureValidator does not provide an API for designating a different certificate to use in validating the timestamp.

Implementing the IURIDereferencer interface

Adobe AIR 1.5 and later

To validate an XML signature, you must provide an implementation of the IURIDereferencer interface. The implementation is responsible for resolving the URIs within the Reference elements of an XML signature document and returning the data so that the digest can be computed. The computed digest is compared with the digest in the signature to determine if the referenced data has been altered since the signature was created.

***Note:** HTML-based AIR applications must import a SWF library containing an ActionScript implementation in order to validate XML signatures. The IURIDereferencer interface cannot be implemented in JavaScript.*

The IURIDerefencer interface has a single method, `dereference(uri:String)`, that must be implemented. The XMLSignatureValidator object calls this method for each reference in the signature. The method must return the data in a ByteArray object.

In most cases, you will also need to add properties or methods that allow your dereferencer object to locate the referenced data. For example, if the signed data is located in the same document as the signature, you could add a member variable that provides a reference to the XML document. The `dereference()` method can then use this variable, along with the URI, to locate the referenced data. Likewise, if the signed data is located in a directory of the local file system, the `dereference()` method might need a property providing the path to that directory in order to resolve the referenced files.

The XMLSignatureValidator relies entirely on the dereferencer for interpreting URI strings. The standard rules for dereferencing URIs are given in the section 4.3.3 of the W3C Recommendation for XML Signature Syntax and Processing.

Dereferencing URIs in enveloped signatures

Adobe AIR 1.5 and later

When an enveloped XML signature is generated, the signature elements are inserted into the signed data. For example, if you signed the following message using an enveloped signature structure:

```
<message>
    <data>...</data>
</message>
```

The resulting signed document will look like this:

```
<message>
    <data>...</data>
     <Signature xmlns="http://www.w3.org/2000/09/xmldsig#">
        <SignedInfo>
            <CanonicalizationMethod Algorithm="http://www.w3.org/TR/2001/REC-xml-c14n-
20010315"/>
            <SignatureMethod Algorithm="http://www.w3.org/2000/09/xmldsig#rsa-sha1"/>
            <Reference URI="">
                <Transforms>
                    <Transform Algorithm="http://www.w3.org/2000/09/xmldsig#enveloped-
signature"/>
                </Transforms>
                <DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256"/>
                <DigestValue>yv6...Z0Y=</DigestValue>
            </Reference>
        </SignedInfo>
        <SignatureValue>cCY...LQ==</SignatureValue>
        <KeyInfo>
            <X509Data>
                <X509Certificate>MII...4e</X509Certificate>
            </X509Data>
        </KeyInfo>
    </Signature>
</message>
```

Notice that the signature contains a single Reference element with an empty string as its URI. An empty string in this context refers to the root of the document.

Also notice that the transform algorithm specifies that an enveloped signature transform has been applied. When an enveloped signature transform has been applied, the XMLSignatureValidator automatically removes the signature from the document before computing the digest. This means that the dereferencer does not need to remove the Signature element when returning the data.

The following example illustrates a dereferencer for enveloped signatures:

```
package
{
    import flash.events.ErrorEvent;
    import flash.events.EventDispatcher;
    import flash.security.IURIDereferencer;
    import flash.utils.ByteArray;
    import flash.utils.IDataInput;

    public class EnvelopedDereferencer
        extends EventDispatcher implements IURIDereferencer
    {
        private var signedMessage:XML;

        public function EnvelopedDereferencer( signedMessage:XML )
        {
            this.signedMessage = signedMessage;
        }

        public function dereference( uri:String ):IDataInput
        {
            try
            {
                if( uri.length != 0 )
                {
                    throw( new Error("Unsupported signature type.") );
                }
                var data:ByteArray = new ByteArray();
                data.writeUTFBytes( signedMessage.toXMLString() );
                data.position = 0;
            }
            catch (e:Error)
                {
                var error:ErrorEvent =
                    new ErrorEvent("Ref error " + uri + " ", false, false, e.message);
                this.dispatchEvent(error);
                data = null;
                throw new Error("Reference not resolvable: " + uri + ", " + e.message);
            }
            finally
            {
                return data;
            }
        }
    }
}
```

This dereferencer class uses a constructor function with a parameter, `signedMessage`, to make the enveloped signature document available to the `dereference()` method. Since the reference in an enveloped signature always refers to the root of the signed data, the `dereferencer()` method writes the document into a byte array and returns it.

Dereferencing URIs in enveloping and detached signatures

Adobe AIR 1.5 and later

When the signed data is located in the same document as the signature itself, the URIs in the references typically use XPath or XPointer syntax to address the elements that are signed. The W3C Recommendation for XML Signature Syntax and Processing only recommends this syntax, so you should base your implementation on the signatures you expect to encounter (and add sufficient error checking to gracefully handle unsupported syntax).

The signature of an AIR application is an example of an enveloping signature. The files in the application are listed in a Manifest element. The Manifest element is addressed in the Reference URI attribute using the string, "#PackageContents", which refers to the Id of the Manifest element:

```
<Signature xmlns="http://www.w3.org/2000/09/xmldsig#" Id="PackageSignature">
    <SignedInfo>
        <CanonicalizationMethod Algorithm="http://www.w3.org/TR/2001/REC-xml-c14n-
20010315"/>
        <SignatureMethod Algorithm="http://www.w3.org/TR/xmldsig-core#rsa-sha1"/>
        <Reference URI="#PackageContents">
            <Transforms>
                <Transform Algorithm="http://www.w3.org/TR/2001/REC-xml-c14n-20010315"/>
            </Transforms>
            <DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256"/>
            <DigestValue>ZMGqQdaRKQc1HirIRsDpeBDlaElS+pPotdziIAyAYDk=</DigestValue>
        </Reference>
    </SignedInfo>
    <SignatureValue Id="PackageSignatureValue">cQK...7Zg==</SignatureValue>
    <KeyInfo>
        <X509Data>
            <X509Certificate>MII...T4e</X509Certificate>
        </X509Data>
    </KeyInfo>
    <Object>
    <Manifest Id="PackageContents">
        <Reference URI="mimetype">
            <DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256">
            </DigestMethod>
            <DigestValue>0/oCb84THKMagtI0Dy0KogEu92TegdesqRr/clXct1c=</DigestValue>
        </Reference>
        <Reference URI="META-INF/AIR/application.xml">
            <DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256">
            </DigestMethod>
            <DigestValue>P9MqtqSdqcqnFgeoHCJysLQu4PmbUW2JdAnc1WLq8h4=</DigestValue>
        </Reference>
        <Reference URI="XMLSignatureValidation.swf">
            <DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256">
            </DigestMethod>
            <DigestValue>OliRHRAgc9qt3Dk0m0Bi53Ur5ur3fAweIFwju74rFgE=</DigestValue>
        </Reference>
    </Manifest>
</Object>
</Signature>
```

A dereferencer for validating this signature must take the URI string containing, `"#PackageContents"` from the Reference element, and return the Manifest element in a ByteArray object. The "#" symbol refers to the value of an element Id attribute.

The following example implements a dereferencer for validating AIR application signatures. The implementation is kept simple by relying on the known structure of an AIR signature. A general-purpose dereferencer could be significantly more complex.

```
package
{
    import flash.events.ErrorEvent;
    import flash.security.IURIDereferencer;
    import flash.utils.ByteArray;
    import flash.utils.IDataInput;

    public class AIRSignatureDereferencer implements IURIDereferencer {
        private const XML_SIG_NS:Namespace =
            new Namespace( "http://www.w3.org/2000/09/xmldsig#" );
        private var airSignature:XML;

        public function AIRSignatureDereferencer( airSignature:XML ) {
            this.airSignature = airSignature;
        }

        public function dereference( uri:String ):IDataInput {
            var data:ByteArray = null;
            try
            {
                if( uri != "#PackageContents" )
                {
                    throw( new Error("Unsupported signature type.") );
                }
                var manifest:XMLList =
                    airSignature.XML_SIG_NS::Object.XML_SIG_NS::Manifest;
                data = new ByteArray();
                data.writeUTFBytes( manifest.toXMLString());
                data.position = 0;
            }
            catch (e:Error)
            {
                data = null;
                throw new Error("Reference not resolvable: " + uri + ", " + e.message);
            }
            finally
            {
                return data;
            }

        }
    }
}
```

When you verify this type of signature, only the data in the Manifest element is validated. The actual files in the package are not checked at all. To check the package files for tampering, you must read the files, compute the SHA256 digest and compare the result to digest recorded in the manifest. The XMLSignatureValidator does not automatically check such secondary references.

***Note:** This example is provided only to illustrate the signature validation process. There is little use in an AIR application validating its own signature. If the application has already been tampered with, the tampering agent could simply remove the validation check.*

Computing digest values for external resources

Adobe AIR 1.5 and later

AIR does not include built-in functions for computing SHA256 digests, but the Flex SDK does include a SHA256 utility class. The SDK also includes the Base64 encoder utility class that is helpful for comparing the computed digest to the digest stored in a signature.

The following example function reads and validates the files in an AIR package manifest:

```
import mx.utils.Base64Encoder;
import mx.utils.SHA256;

private function verifyManifest( sigFile:File, manifest:XML ):Boolean
{
    var result:Boolean = true;
    var message:String = '';
    var nameSpace:Namespace = manifest.namespace();

    if( manifest.nameSpace::Reference.length() <= 0 )
    {
        result = false;
        message = "Nothing to validate.";
    }
    for each (var reference:XML in manifest.nameSpace::Reference)
    {
        var file:File = sigFile.parent.parent.resolvePath( reference.@URI );
        var stream:FileStream = new FileStream();
        stream.open(file, FileMode.READ);
        var fileData:ByteArray = new ByteArray();
        stream.readBytes( fileData, 0, stream.bytesAvailable );

        var digestHex:String = SHA256.computeDigest( fileData );
        //Convert hexidecimal string to byte array
        var digest:ByteArray = new ByteArray();
        for( var c:int = 0; c < digestHex.length; c += 2 ){
            var byteChar:String = digestHex.charAt(c) + digestHex.charAt(c+1);
            digest.writeByte( parseInt( byteChar, 16 ));
        }
        digest.position = 0;
        var base64Encoder:Base64Encoder = new Base64Encoder();
        base64Encoder.insertNewLines = false;
        base64Encoder.encodeBytes( digest, 0, digest.bytesAvailable );
        var digestBase64:String = base64Encoder.toString();
        if( digestBase64 == reference.nameSpace::DigestValue )
        {
            result = result && true;
            message += "    " + reference.@URI + " verified.\n";
        }
        else
        {
            result = false;
            message += " ---- " + reference.@URI + " has been modified!\n";
        }
        base64Encoder.reset();
    }
    trace( message );
    return result;
}
```

The function loops through all the references in the Manifest element. For each reference, the SHA256 digest is computed, encoded in base64 format, and compared to the digest in the manifest. The URIs in an AIR package refer to paths relative to the application directory. The paths are resolved based on the location of the signature file, which is always in the META-INF subdirectory within the application directory. Note that the Flex SHA256 class returns the digest as a string of hexadecimal characters. This string must be converted into a ByteArray containing the bytes represented by the hexadecimal string.

To use the mx.utils.SHA256 and Base64Encoder classes in Flash CS4, you can either locate and copy these classes into your application development directory or compile a library SWF containing the classes using the Flex SDK.

Dereferencing URIs in detached signatures referencing external data

Adobe AIR 1.5 and later

When a URI refers to an external resource, the data must be accessed and loaded into a ByteArray object. If the URI contains an absolute URL, then it is simply a matter of reading a file or requesting a URL. If, as is probably the more common case, the URI contains to a relative path, then your IURIDereferencer implementation must include a way to resolve the paths to the signed files.

The following example uses a File object initialized when the dereferencer instance is constructed as the base for resolving signed files.

```
package
{
    import flash.events.ErrorEvent;
    import flash.events.EventDispatcher;
    import flash.filesystem.File;
    import flash.filesystem.FileMode;
    import flash.filesystem.FileStream;
    import flash.security.IURIDereferencer;
    import flash.utils.ByteArray;
    import flash.utils.IDataInput;
    public class RelativeFileDereferencer
        extends EventDispatcher implements IURIDereferencer
    {
        private var base:File;

        public function RelativeFileDereferencer( base:File )
        {
            this.base = base;
        }

        public function dereference( uri:String ):IDataInput
        {
            var data:ByteArray = null;
            try{
                var referent:File = this.base.resolvePath( uri );
                var refStream:FileStream = new FileStream();
                data = new ByteArray();
                refStream.open( referent, FileMode.READ );

                refStream.readBytes( data, 0, data.bytesAvailable );

            } catch ( e:Error ) {
                data = null;
                throw new Error("Reference not resolvable: " + referent.nativePath + ", " +
e.message );
            } finally {
                return data;
            }
        }
    }
}
```

The `dereference()` function simply locates the file addressed by the reference URI, loads the file contents into a byte array, and returns the ByteArray object.

Note: *Before validating remote external references, consider whether your application could be vulnerable to a "phone home" or similar type of attack by a maliciously constructed signature document.*

Chapter 49: Client system environment

Flash Player 9 and later, Adobe AIR 1.0 and later

This discussion explains how to interact with the user's system. It shows you how to determine what features are supported and how to build multilingual applications using the user's installed input method editor (IME) if available. It also shows typical uses for application domains.

More Help topics

flash.system.System

flash.system.Capabilities

Basics of the client system environment

Flash Player 9 and later, Adobe AIR 1.0 and later

As you build more advanced applications, you may find a need to know details about—and access functions of—your users' operating systems. The flash.system package contains a collection of classes that allow you to access system-level functionality such as the following:

- Determining which application and security domain code is executing in
- Determining the capabilities of the user's Flash runtime (such as Flash® Player or Adobe® AIR™) instance, such as the screen size (resolution) and whether certain functionality is available, such as mp3 audio
- Building multilingual sites using the IME
- Interacting with the Flash runtime's container (which could be an HTML page or a container application).
- Saving information to the user's clipboard

The flash.system package also includes the IMEConversionMode and SecurityPanel classes. These classes contain static constants that you use with the IME and Security classes, respectively.

Important concepts and terms

The following reference list contains important terms:

Operating system The main program that runs on a computer, within which all other applications run—such as Microsoft Windows, Mac OS X, or Linux®.

Clipboard The operating system's container for holding text or items that are copied or cut, and from which items are pasted into applications.

Application domain A mechanism for separating classes used in different SWF files, so that if the SWF files include different classes with the same name, the classes don't overwrite each other.

IME (input method editor) A program (or operating system tool) that is used to enter complex characters or symbols using a standard keyboard.

Client system In programming terms, a client is the part of an application (or whole application) that runs on an individual's computer and is used by a single user. The client system is the underlying operating system on the user's computer.

Using the System class

Flash Player 9 and later, Adobe AIR 1.0 and later

The System class contains methods and properties that allow you to interact with the user's operating system and retrieve the current memory usage of the runtime. The methods and properties of the System class also allow you to listen for `imeComposition` events, instruct the runtime to load external text files using the user's current code page or to load them as Unicode, or set the contents of the user's clipboard.

Getting data about the user's system at run time

Flash Player 9 and later, Adobe AIR 1.0 and later

By checking the `System.totalMemory` property, you can determine the amount of memory (in bytes) that the runtime is currently using. This property allows you to monitor memory usage and optimize your applications based on how the memory level changes. For example, if a particular visual effect causes a large increase in memory usage, you may want to consider modifying the effect or eliminating it altogether.

The `System.ime` property is a reference to the currently installed Input Method Editor (IME). This property allows you to listen for `imeComposition` events (`flash.events.IMEEvent.IME_COMPOSITION`) by using the `addEventListener()` method.

The third property in the System class is `useCodePage`. When `useCodePage` is set to `true`, the runtime uses the traditional code page of the operating system to load external text files. If you set this property to `false`, you tell the runtime to interpret the external file as Unicode.

If you set `System.useCodePage` to `true`, remember that the traditional code page of the operating system must include the characters used in your external text file in order for the text to display. For example, if you load an external text file that contains Chinese characters, those characters cannot display on a system that uses the English Windows code page because that code page does not include Chinese characters.

To ensure that users on all platforms can view the external text files that are used in your application, you should encode all external text files as Unicode and leave `System.useCodePage` set to `false` by default. This way, the runtime interprets the text as Unicode.

Saving text to the clipboard

Flash Player 9 and later, Adobe AIR 1.0 and later

The System class includes a method called `setClipboard()` that allows the Flash runtime to set the contents of the user's clipboard with a specified string. For security reasons, there is no `Security.getClipboard()` method, since such a method could potentially allow malicious sites to access the data last copied to the user's clipboard.

The following code illustrates how an error message can be copied to the user's clipboard when a security error occurs. The error message can be useful if the user wants to report a potential bug with an application.

```
private function securityErrorHandler(event:SecurityErrorEvent):void
{
    var errorString:String = "[" + event.type + "] " + event.text;
    trace(errorString);
    System.setClipboard(errorString);
}
```

Flash Player 10 and AIR 1.0

You can use the Clipboard class to read and write clipboard data in response to a user event. In AIR, a user event is not required for code running in the application sandbox to access the clipboard.

Using the Capabilities class

Flash Player 9 and later, Adobe AIR 1.0 and later

The Capabilities class allows developers to determine the environment in which an application is being run. Using various properties of the Capabilities class, you can find out the resolution of the user's system, whether the user's system supports accessibility software, and the language of the user's operating system, as well as the currently installed version of the Flash runtime.

By checking the properties in the Capabilities class, you can customize your application to work best with the specific user's environment. For example, by checking the `Capabilities.screenResolutionX` and `Capabilities.screenResolutionY` properties, you can determine the display resolution the user's system is using and decide which video size may be most appropriate. Or you can check the `Capabilities.hasMP3` property to see if the user's system supports mp3 playback before attempting to load an external mp3 file.

The following code uses a regular expression to parse the Flash runtime version that the client is using:

```
var versionString:String = Capabilities.version;
var pattern:RegExp = /^(\w*) (\d*),(\d*),(\d*),(\d*)$/;
var result:Object = pattern.exec(versionString);
if (result != null)
{
    trace("input: " + result.input);
    trace("platform: " + result[1]);
    trace("majorVersion: " + result[2]);
    trace("minorVersion: " + result[3]);
    trace("buildNumber: " + result[4]);
    trace("internalBuildNumber: " + result[5]);
}
else
{
    trace("Unable to match RegExp.");
}
```

If you want to send the user's system capabilities to a server-side script so that the information can be stored in a database, you can use the following ActionScript code:

```
var url:String = "log_visitor.cfm";
var request:URLRequest = new URLRequest(url);
request.method = URLRequestMethod.POST;
request.data = new URLVariables(Capabilities.serverString);
var loader:URLLoader = new URLLoader(request);
```

Capabilities example: Detecting system capabilities

Flash Player 9 and later

The CapabilitiesExplorer example demonstrates how you can use the flash.system.Capabilities class to determine which features the user's version of the Flash runtime supports. This example teaches the following techniques:

- Detecting which capabilities the user's version of the Flash runtime supports using the Capabilities class
- Using the ExternalInterface class to detect which browser settings the user's browser supports

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The CapabilitiesExplorer application files can be found in the folder Samples/CapabilitiesExplorer. This application consists of the following files:

File	Description
CapabilitiesExplorer.fla or CapabilitiesExplorer.mxml	The main application file in Flash (FLA) or Flex (MXML).
com/example/programmingas3/capabilities/CapabilitiesGrabber.as	The class that provides the main functionality of the application, including adding the system Capabilities to an array, sorting the items, and using the ExternalInterface class to retrieve browser capabilities.
capabilities.html	An HTML container that contains the necessary JavaScript to communicate with the external API.

CapabilitiesExplorer overview

Flash Player 9 and later

The CapabilitiesExplorer.mxml file is responsible for setting up the user interface for the CapabilitiesExplorer application. The capabilities of the user's version of the Flash runtime will be displayed within a DataGrid component instance on the Stage. Their browser capabilities will also be displayed if they are running the application from an HTML container and if the external API is available.

When the main application file's `creationComplete` event is dispatched, the `initApp()` method is invoked. The `initApp()` method calls the `getCapabilities()` method from within the com.example.programmingas3.capabilities.CapabilitiesGrabber class. The code for the `initApp()` method is as follows:

```
private function initApp():void
{
    var dp:Array = CapabilitiesGrabber.getCapabilities();
    capabilitiesGrid.dataProvider = dp;
}
```

The CapabilitiesGrabber.getCapabilities() method returns a sorted array of the Flash runtime and browser capabilities, which then gets set to the dataProvider property of the capabilitiesGrid DataGrid component instance on the Stage.

CapabilitiesGrabber class overview

Flash Player 9 and later

The static getCapabilities() method of the CapabilitiesGrabber class adds each property from the flash.system.Capabilities class to an array (capDP). It then calls the static getBrowserObjects() method in the CapabilitiesGrabber class. The getBrowserObjects() method uses the external API to loop over the browser's navigator object, which contains the browser's capabilities. The getCapabilities() method is as follows:

```
public static function getCapabilities():Array
{
    var capDP:Array = new Array();
    capDP.push({name:"Capabilities.avHardwareDisable", value:Capabilities.avHardwareDisable});
    capDP.push({name:"Capabilities.hasAccessibility", value:Capabilities.hasAccessibility});
    capDP.push({name:"Capabilities.hasAudio", value:Capabilities.hasAudio});
    ...
    capDP.push({name:"Capabilities.version", value:Capabilities.version});
    var navArr:Array = CapabilitiesGrabber.getBrowserObjects();
    if (navArr.length > 0)
    {
        capDP = capDP.concat(navArr);
    }
    capDP.sortOn("name", Array.CASEINSENSITIVE);
    return capDP;
}
```

The getBrowserObjects() method returns an array of each of the properties in the browser's navigator object. If this array has a length of one or more items, the array of browser capabilities (navArr) is appended to the array of Flash Player capabilities (capDP), and the entire array is sorted alphabetically. Finally, the sorted array is returned to the main application file, which then populates the data grid. The code for the getBrowserObjects() method is as follows:

```
private static function getBrowserObjects():Array
{
    var itemArr:Array = new Array();
    var itemVars:URLVariables;
    if (ExternalInterface.available)
    {
        try
        {
            var tempStr:String = ExternalInterface.call("JS_getBrowserObjects");
            itemVars = new URLVariables(tempStr);
            for (var i:String in itemVars)
            {
                itemArr.push({name:i, value:itemVars[i]});
            }
        }
        catch (error:SecurityError)
        {
            // ignore
        }
    }
    return itemArr;
}
```

If the external API is available in the current user environment, the Flash runtime calls the JavaScript `JS_getBrowserObjects()` method, which loops over the browser's navigator object and returns a string of URL-encoded values to ActionScript. This string is then converted into a URLVariables object (`itemVars`) and added to the `itemArr` array, which is returned to the calling script.

Communicating with JavaScript

Flash Player 9 and later

The final piece in building the CapabilitiesExplorer application is writing the necessary JavaScript to loop over each of the items in the browser's navigator object and append a name-value pair to a temporary array. The code for the JavaScript `JS_getBrowserObjects()` method in the container.html file is as follows:

```
<script language="JavaScript">
    function JS_getBrowserObjects()
    {
        // Create an array to hold each of the browser's items.
        var tempArr = new Array();

        // Loop over each item in the browser's navigator object.
        for (var name in navigator)
        {
            var value = navigator[name];

            // If the current value is a string or Boolean object, add it to the
            // array, otherwise ignore the item.
            switch (typeof(value))
            {
                case "string":
                case "boolean":

                    // Create a temporary string which will be added to the array.
                    // Make sure that we URL-encode the values using JavaScript's
                    // escape() function.
                    var tempStr = "navigator." + name + "=" + escape(value);
                    // Push the URL-encoded name/value pair onto the array.
                    tempArr.push(tempStr);
                    break;
            }
        }
        // Loop over each item in the browser's screen object.
        for (var name in screen)
        {
            var value = screen[name];

            // If the current value is a number, add it to the array, otherwise
            // ignore the item.
            switch (typeof(value))
            {
                case "number":
                    var tempStr = "screen." + name + "=" + escape(value);
                    tempArr.push(tempStr);
                    break;
            }
        }
        // Return the array as a URL-encoded string of name-value pairs.
        return tempArr.join("&");
    }
</script>
```

The code begins by creating a temporary array that will hold all the name-value pairs in the navigator object. Next, the navigator object is looped over using a `for..in` loop, and the data type of the current value is evaluated to filter out unwanted values. In this application, we are interested only in String or Boolean values, and other data types (such as functions or arrays) are ignored. Each String or Boolean value in the navigator object is appended to the `tempArr` array. Next, the browser's screen object is looped over using a `for..in` loop, and each numeric value is added to the `tempArr` array. Finally, the temporary array is converted into a string using the `Array.join()` method. The array uses an ampersand (&) as a delimiter, which allows ActionScript to easily parse the data using the URLVariables class.

Chapter 50: AIR application invocation and termination

Adobe AIR 1.0 and later

This section discusses the ways in which an installed Adobe® AIR® application can be invoked, as well as options and considerations for closing a running application.

***Note:** The NativeApplication, InvokeEvent, and BrowserInvokeEvent objects are only available to SWF content running in the AIR application sandbox. SWF content running in the Flash Player runtime, within the browser or the standalone player (projector), or in an AIR application outside the application sandbox, cannot access these classes.*

For a quick explanation and code examples of invoking and terminating AIR applications, see the following quick start articles on the Adobe Developer Connection:

- Startup Options

More Help topics

flash.desktop.NativeApplication

flash.events.InvokeEvent

flash.events.BrowserInvokeEvent

Application invocation

Adobe AIR 1.0 and later

An AIR application is invoked when the user (or the operating system):

- Launches the application from the desktop shell.
- Uses the application as a command on a command line shell.
- Opens a type of file for which the application is the default opening application.
- (Mac OS X) clicks the application icon in the dock taskbar (whether or not the application is currently running).
- Chooses to launch the application from the installer (either at the end of a new installation process, or after double-clicking the AIR file for an already installed application).
- Begins an update of an AIR application when the installed version has signaled that it is handling application updates itself (by including a `<customUpdateUI>true</customUpdateUI>` declaration in the application descriptor file).
- (iOS) Receives a notification from the Apple Push Notification service (APNs).
- Invokes the application via a URL.

- Visits a web page hosting a Flash badge or application that calls `com.adobe.air.AIR launchApplication()` method specifying the identifying information for the AIR application. (The application descriptor must also include a `<allowBrowserInvocation>true</allowBrowserInvocation>` declaration for browser invocation to succeed.)

Whenever an AIR application is invoked, AIR dispatches an InvokeEvent object of type `invoke` through the singleton NativeApplication object. To allow an application time to initialize itself and register an event listener, `invoke` events are queued instead of discarded. As soon as a listener is registered, all the queued events are delivered.

***Note:** When an application is invoked using the browser invocation feature, the NativeApplication object only dispatches an `invoke` event if the application is not already running.*

To receive `invoke` events, call the `addEventListener()` method of the NativeApplication object (`NativeApplication.nativeApplication)`. When an event listener registers for an `invoke` event, it also receives all `invoke` events that occurred before the registration. Queued `invoke` events are dispatched one at a time on a short interval after the call to `addEventListener()` returns. If a new `invoke` event occurs during this process, it may be dispatched before one or more of the queued events. This event queuing allows you to handle any `invoke` events that have occurred before your initialization code executes. Keep in mind that if you add an event listener later in execution (after application initialization), it will still receive all `invoke` events that have occurred since the application started.

Only one instance of an AIR application is started. When an already running application is invoked again, AIR dispatches a new `invoke` event to the running instance. It is the responsibility of an AIR application to respond to an `invoke` event and take the appropriate action (such as opening a new document window).

An `InvokeEvent` object contains any arguments passed to the application, as well as the directory from which the application has been invoked. If the application was invoked because of a file-type association, then the full path to the file is included in the command line arguments. Likewise, if the application was invoked because of an application update, the full path to the update AIR file is provided.

When multiple files are opened in one operation a single InvokeEvent object is dispatched on Mac OS X. Each file is included in the `arguments` array. On Windows and Linux, a separate InvokeEvent object is dispatched for each file.

Your application can handle `invoke` events by registering a listener with its NativeApplication object:

```
NativeApplication.nativeApplication.addEventListener(InvokeEvent.INVOKE, onInvokeEvent);
```

And defining an event listener:

```
 var arguments:Array;
var currentDir:File;
public function onInvokeEvent(invocation:InvokeEvent):void {
    arguments = invocation.arguments;
    currentDir = invocation.currentDirectory;
}
```

Capturing command line arguments

Adobe AIR 1.0 and later

The command line arguments associated with the invocation of an AIR application are delivered in the InvokeEvent object dispatched by the NativeApplication object. The InvokeEvent `arguments` property contains an array of the arguments passed by the operating system when an AIR application is invoked. If the arguments contain relative file paths, you can typically resolve the paths using the `currentDirectory` property.

The arguments passed to an AIR program are treated as white-space delimited strings, unless enclosed in double quotes:

Arguments	Array
tick tock	{tick,tock}
tick "tick tock"	{tick,tick tock}
"tick" “tock”	{tick,tock}
\"tick\" \"tock\"	{"tick","tock"}

The `currentDirectory` property of an InvokeEvent object contains a File object representing the directory from which the application was launched.

When an application is invoked because a file of a type registered by the application is opened, the native path to the file is included in the command line arguments as a string. (Your application is responsible for opening or performing the intended operation on the file.) Likewise, when an application is programmed to update itself (rather than relying on the standard AIR update user interface), the native path to the AIR file is included when a user double-clicks an AIR file containing an application with a matching application ID.

You can access the file using the `resolve()` method of the `currentDirectory` File object:

```
if((invokeEvent.currentDirectory != null)&&(invokeEvent.arguments.length > 0)){
    dir = invokeEvent.currentDirectory;
    fileToOpen = dir.resolvePath(invokeEvent.arguments[0]);
}
```

You should also validate that an argument is indeed a path to a file.

Example: Invocation event log

Adobe AIR 1.0 and later

The following example demonstrates how to register listeners for and handle the `invoke` event. The example logs all the invocation events received and displays the current directory and command line arguments.

ActionScript example

```
package
{
    import flash.display.Sprite;
    import flash.events.InvokeEvent;
    import flash.desktop.NativeApplication;
    import flash.text.TextField;

    public class InvokeEventLogExample extends Sprite
    {
        public var log:TextField;

        public function InvokeEventLogExample()
        {
            log = new TextField();
            log.x = 15;
            log.y = 15;
            log.width = 520;
            log.height = 370;
            log.background = true;

            addChild(log);

            NativeApplication.nativeApplication.addEventListener(InvokeEvent.INVOKE, onInvoke);
        }

        public function onInvoke(invokeEvent:InvokeEvent):void
        {
            var now:String = new Date().toTimeString();
            logEvent("Invoke event received: " + now);

            if (invokeEvent.currentDirectory != null)
            {
                logEvent("Current directory=" + invokeEvent.currentDirectory.nativePath);
            }
            else
            {
                logEvent("--no directory information available--");
            }

            if (invokeEvent.arguments.length > 0)
            {
                logEvent("Arguments: " + invokeEvent.arguments.toString());
            }
            else
            {
                logEvent("--no arguments--");
            }
        }

        public function logEvent(entry:String):void
        {
            log.appendText(entry + "\n");
            trace(entry);
        }
    }
}
```

Flex example

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" layout="vertical"
    invoke="onInvoke(event)" title="Invocation Event Log">
    <mx:Script>
    <![CDATA[
    import flash.events.InvokeEvent;
    import flash.desktop.NativeApplication;

    public function onInvoke(invokeEvent:InvokeEvent):void {
        var now:String = new Date().toTimeString();
        logEvent("Invoke event received: " + now);

        if (invokeEvent.currentDirectory != null){
            logEvent("Current directory=" + invokeEvent.currentDirectory.nativePath);
        } else {
            logEvent("--no directory information available--");
        }

        if (invokeEvent.arguments.length > 0){
            logEvent("Arguments: " + invokeEvent.arguments.toString());
        } else {
            logEvent("--no arguments--");
        }
    }

    public function logEvent(entry:String):void {
        log.text += entry + "\n";
        trace(entry);
    }
    ]]>
    </mx:Script>
    <mx:TextArea id="log" width="100%" height="100%" editable="false"
        valueCommit="log.verticalScrollPosition=log.textHeight;"/>
</mx:WindowedApplication>
```

Invoking an AIR application on user login

Adobe AIR 1.0 and later

An AIR application can be set to launch automatically when the current user logs in by setting the NativeApplication `startAtLogin` property to `true`. Once set, the application automatically starts whenever the user logs in. It continues to launch at login until the setting is changed to `false`, the user manually changes the setting through the operating system, or the application is uninstalled. Launching at login is a run-time setting. The setting only applies to the current user. The application must be installed to successfully set the `startAtLogin` property to `true`. An error is thrown if the property is set when an application is not installed (such as when it is launched with ADL).

Note: *The application does not launch when the computer system starts. It launches when the user logs in.*

To determine whether an application has launched automatically or as a result of a user action, you can examine the `reason` property of the InvokeEvent object. If the property is equal to `InvokeEventReason.LOGIN`, then the application started automatically. For other invocation paths, the `reason` property is set as follows:

- `InvokeEventReason.NOTIFICATION` (iOS only) - The application was invoked through APNs. For more information on APNs, see Use push notifications.
- `InvokeEventReason.OPEN_URL` - The application was invoked by another application or by the system.
- `InvokeEventReason.Standard` - All other cases.

To access the `reason` property, your application must target AIR 1.5.1 or higher (by setting the correct namespace value in the application descriptor file).

The following, simplified application uses the InvokeEvent reason property to decide how to behave when an invoke event occurs. If the reason property is "login", then the application remains in the background. Otherwise, it makes the main application visible. An application using this pattern typically starts at login so that it can carry out background processing or event monitoring and opens a window in response to a user-triggered invoke event.

```
package {
    import flash.desktop.InvokeEventReason;
    import flash.desktop.NativeApplication;
    import flash.display.Sprite;
    import flash.events.InvokeEvent;

    public class StartAtLogin extends Sprite
    {
        public function StartAtLogin()
        {
            try
            {
                NativeApplication.nativeApplication.startAtLogin = true;
            }
            catch ( e:Error )
            {
                trace( "Cannot set startAtLogin:" + e.message );
            }

            NativeApplication.nativeApplication.addEventListener( InvokeEvent.INVOKE, onInvoke );
        }

        private function onInvoke( event:InvokeEvent ):void
        {
            if( event.reason == InvokeEventReason.LOGIN )
            {
                //do background processing...
                trace( "Running in background..." );
            }
            else
            {
                this.stage.nativeWindow.activate();
            }
        }
    }
}
```

***Note:** To see the difference in behavior, package and install the application. The `startAtLogin` property can only be set for installed applications.*

Invoking an AIR application from the browser

Adobe AIR 1.0 and later

Using the browser invocation feature, a web site can launch an installed AIR application to be launched from the browser. Browser invocation is only permitted if the application descriptor file sets `allowBrowserInvocation` to `true`:

```
<allowBrowserInvocation>true</allowBrowserInvocation>
```

When the application is invoked via the browser, the application's NativeApplication object dispatches a BrowserInvokeEvent object.

To receive BrowserInvokeEvent events, call the `addEventListener()` method of the NativeApplication object (`NativeApplication.nativeApplication`) in the AIR application. When an event listener registers for a BrowserInvokeEvent event, it also receives all BrowserInvokeEvent events that occurred before the registration. These events are dispatched after the call to `addEventListener()` returns, but not necessarily before other BrowserInvokeEvent events that might be received after registration. This allows you to handle BrowserInvokeEvent events that have occurred before your initialization code executes (such as when the application was initially invoked from the browser). Keep in mind that if you add an event listener later in execution (after application initialization) it still receives all BrowserInvokeEvent events that have occurred since the application started.

The BrowserInvokeEvent object includes the following properties:

Property	**Description**
arguments	An array of arguments (strings) to pass to the application.
isHTTPS	Whether the content in the browser uses the https URL scheme (`true`) or not (`false`).
isUserEvent	Whether the browser invocation resulted in a user event (such as a mouse click). In AIR 1.0, this is always set to `true`; AIR requires a user event to the browser invocation feature.
sandboxType	The sandbox type for the content in the browser. Valid values are defined the same as those that can be used in the `Security.sandboxType` property, and can be one of the following: • `Security.APPLICATION` — The content is in the application security sandbox. • `Security.LOCAL_TRUSTED` — The content is in the local-with-filesystem security sandbox. • `Security.LOCAL_WITH_FILE` — The content is in the local-with-filesystem security sandbox. • `Security.LOCAL_WITH_NETWORK` — The content is in the local-with-networking security sandbox. • `Security.REMOTE` — The content is in a remote (network) domain.
securityDomain	The security domain for the content in the browser, such as `"www.adobe.com"` or `"www.example.org"`. This property is only set for content in the remote security sandbox (for content from a network domain). It is not set for content in a local or application security sandbox.

If you use the browser invocation feature, be sure to consider security implications. When a web site launches an AIR application, it can send data via the `arguments` property of the BrowserInvokeEvent object. Be careful using this data in any sensitive operations, such as file or code loading APIs. The level of risk depends on what the application is doing with the data. If you expect only a specific web site to invoke the application, the application should check the `securityDomain` property of the BrowserInvokeEvent object. You can also require the web site invoking the application to use HTTPs, which you can verify by checking the `isHTTPS` property of the BrowserInvokeEvent object.

The application should validate the data passed in. For example, if an application expects to be passed URLs to a specific domain, it should validate that the URLs really do point to that domain. This can prevent an attacker from tricking the application into sending it sensitive data.

No application should use BrowserInvokeEvent arguments that might point to local resources. For example, an application should not create File objects based on a path passed from the browser. If remote paths are expected to be passed from the browser, the application should ensure that the paths do not use the `file://` protocol instead of a remote protocol.

Application termination

Adobe AIR 1.0 and later

The quickest way to terminate an application is to call the NativeApplication exit() method. This works fine when your application has no data to save or external resources to clean up. Calling `exit()` closes all windows and then terminates the application. However, to allow windows or other components of your application to interrupt the termination process, perhaps to save vital data, dispatch the proper warning events before calling `exit()`.

Another consideration in gracefully shutting down an application is providing a single execution path, no matter how the shut-down process starts. The user (or operating system) can trigger application termination in the following ways:

- By closing the last application window when `NativeApplication.nativeApplication.autoExit` is `true`.
- By selecting the application exit command from the operating system; for example, when the user chooses the exit application command from the default menu. (This only happens on Mac OS; Windows and Linux do not provide an application exit command through system chrome.)
- By shutting down the computer.

When an exit command is mediated through the operating system by one of these routes, the NativeApplication dispatches an `exiting` event. If no listeners cancel the `exiting` event, any open windows are closed. Each window dispatches a `closing` and then a `close` event. If any of the windows cancel the `closing` event, the shut-down process stops.

If the order of window closure is an issue for your application, listen for the `exiting` event from the NativeApplication and close the windows in the proper order yourself. You might need to do this, for example, if you have a document window with tool palettes. It could be inconvenient, or worse, if the system closed the palettes, but the user decided to cancel the exit command to save some data. On Windows, the only time you will get the `exiting` event is after closing the last window (when the `autoExit` property of the NativeApplication object is set to `true`).

To provide consistent behavior on all platforms, whether the exit sequence is initiated via operating system chrome, menu commands, or application logic, observe the following good practices for exiting the application:

1 Always dispatch an `exiting` event through the NativeApplication object before calling `exit()` in application code and check that another component of your application doesn't cancel the event.

```
 public function applicationExit():void {
     var exitingEvent:Event = new Event(Event.EXITING, false, true);
     NativeApplication.nativeApplication.dispatchEvent(exitingEvent);
     if (!exitingEvent.isDefaultPrevented()) {
         NativeApplication.nativeApplication.exit();
     }
}
```

2 Listen for the application `exiting` event from the `NativeApplication.nativeApplication` object and, in the handler, close any windows (dispatching a `closing` event first). Perform any needed clean-up tasks, such as saving application data or deleting temporary files, after all windows have been closed. Only use synchronous methods during cleanup to ensure that they finish before the application quits.

If the order in which your windows are closed doesn't matter, then you can loop through the `NativeApplication.nativeApplication.openedWindows` array and close each window in turn. If order *does* matter, provide a means of closing the windows in the correct sequence.

```
private function onExiting(exitingEvent:Event):void {
    var winClosingEvent:Event;
    for each (var win:NativeWindow in NativeApplication.nativeApplication.openedWindows) {
        winClosingEvent = new Event(Event.CLOSING,false,true);
        win.dispatchEvent(winClosingEvent);
        if (!winClosingEvent.isDefaultPrevented()) {
            win.close();
        } else {
            exitingEvent.preventDefault();
        }
    }

    if (!exitingEvent.isDefaultPrevented()) {
        //perform cleanup
    }
}
```

3 Windows should always handle their own clean up by listening for their own `closing` events.

4 Only use one `exiting` listener in your application since handlers called earlier cannot know whether subsequent handlers will cancel the `exiting` event (and it would be unwise to rely on the order of execution).

Chapter 51: Working with AIR runtime and operating system information

Adobe AIR 1.0 and later

This section discusses ways that an AIR application can manage operating system file associations, detect user activity, and get information about the Adobe® AIR® runtime.

More Help topics

flash.desktop.NativeApplication

Managing file associations

Adobe AIR 1.0 and later

Associations between your application and a file type must be declared in the application descriptor. During the installation process, the AIR application installer associates the AIR application as the default opening application for each of the declared file types, unless another application is already the default. The AIR application install process does not override an existing file type association. To take over the association from another application, call the `NativeApplication.setAsDefaultApplication()` method at run time.

It is a good practice to verify that the expected file associations are in place when your application starts up. This is because the AIR application installer does not override existing file associations, and because file associations on a user's system can change at any time. When another application has the current file association, it is also a polite practice to ask the user before taking over an existing association.

The following methods of the NativeApplication class let an application manage file associations. Each of the methods takes the file type extension as a parameter:

Method	Description
isSetAsDefaultApplication()	Returns true if the AIR application is currently associated with the specified file type.
setAsDefaultApplication()	Creates the association between the AIR application and the open action of the file type.
removeAsDefaultApplication()	Removes the association between the AIR application and the file type.
getDefaultApplication()	Reports the path of the application that is currently associated with the file type.

AIR can only manage associations for the file types originally declared in the application descriptor. You cannot get information about the associations of a non-declared file type, even if a user has manually created the association between that file type and your application. Calling any of the file association management methods with the extension for a file type not declared in the application descriptor causes the application to throw a runtime exception.

Getting the runtime version and patch level

Adobe AIR 1.0 and later

The NativeApplication object has a `runtimeVersion` property, which is the version of the runtime in which the application is running (a string, such as `"1.0.5"`). The NativeApplication object also has a `runtimePatchLevel` property, which is the patch level of the runtime (a number, such as 2960). The following code uses these properties:

```
trace(NativeApplication.nativeApplication.runtimeVersion);
trace(NativeApplication.nativeApplication.runtimePatchLevel);
```

Detecting AIR capabilities

Adobe AIR 1.0 and later

For a file that is bundled with the Adobe AIR application, the `Security.sandboxType` property is set to the value defined by the `Security.APPLICATION` constant. You can load content (which may or may not contain APIs specific to AIR) based on whether a file is in the Adobe AIR security sandbox, as illustrated in the following code:

```
if (Security.sandboxType == Security.APPLICATION)
{
    // Load SWF that contains AIR APIs
}
else
{
    // Load SWF that does not contain AIR APIs
}
```

All resources that are not installed with the AIR application are assigned to the same security sandboxes as would be assigned by Adobe® Flash® Player in a web browser. Remote resources are put in sandboxes according to their source domains, and local resources are put in the local-with-networking, local-with-filesystem, or local-trusted sandbox.

You can check if the `Capabilities.playerType` static property is set to `"Desktop"` to see if content is executing in the runtime (and not running in Flash Player running in a browser).

For more information, see "AIR security" on page 1076.

Tracking user presence

Adobe AIR 1.0 and later

The NativeApplication object dispatches two events that help you detect when a user is actively using a computer. If no mouse or keyboard activity is detected in the interval determined by the `NativeApplication.idleThreshold` property, the NativeApplication dispatches a `userIdle` event. When the next keyboard or mouse input occurs, the NativeApplication object dispatches a `userPresent` event. The `idleThreshold` interval is measured in seconds and has a default value of 300 (5 minutes). You can also get the number of seconds since the last user input from the `NativeApplication.nativeApplication.lastUserInput` property.

The following lines of code set the idle threshold to 2 minutes and listen for both the `userIdle` and `userPresent` events:

```
NativeApplication.nativeApplication.idleThreshold = 120;
NativeApplication.nativeApplication.addEventListener(Event.USER_IDLE, function(event:Event) {
    trace("Idle");
});
NativeApplication.nativeApplication.addEventListener(Event.USER_PRESENT,
function(event:Event) {
    trace("Present");
});
```

Note: *Only a single* `userIdle` *event is dispatched between any two* `userPresent` *events.*

Chapter 52: Working with AIR native windows

Adobe AIR 1.0 and later

You use the classes provided by the Adobe® AIR® native window API to create and manage desktop windows.

Basics of native windows in AIR

Adobe AIR 1.0 and later

For quick explanations and code examples of working with native windows in AIR, see the following quick start articles on the Adobe Developer Connection:

- Creating a transparent window application (Flex)
- Interacting with a window (Flex)
- Customizing the look and feel of a native window (Flex)
- Launching windows (Flex)
- Creating toast-style windows (Flex)
- Controlling the display order of windows (Flex)
- Creating resizable, non-rectangular windows (Flex)
- Interacting with a window (Flash)
- Customizing the look and feel of a native window (Flash)
- Creating toast-style windows (Flash)
- Controlling the display order of windows (Flash)
- Creating resizable, non-rectangular windows (Flash)

AIR provides an easy-to-use, cross-platform window API for creating native operating system windows using Flash®, Flex™, and HTML programming techniques.

With AIR, you have a wide latitude in developing the appearance of your application. The windows you create can look like a standard desktop application, matching Apple style when run on the Mac, conforming to Microsoft conventions when run on Windows, and harmonizing with the window manager on Linux—all without including a line of platform-specific code. Or you can use the skinnable, extensible chrome provided by the Flex framework to establish your own style no matter where your application is run. You can even draw your own window chrome with vector and bitmap artwork with full support for transparency and alpha blending against the desktop. Tired of rectangular windows? Draw a round one.

Windows in AIR

Adobe AIR 1.0 and later

AIR supports three distinct APIs for working with windows:

- The ActionScript-oriented NativeWindow class provides the lowest level window API. Use NativeWindows in ActionScript and Flash Professional-authored applications. Consider extending the NativeWindow class to specialize the windows used in your application.
- In the HTML environment, you can use the JavaScript Window class, just as you would in a browser-based web application. Calls to JavaScript Window methods are forwarded to the underlying native window object.
- The Flex framework mx:WindowedApplication and mx:Window classes provide a Flex "wrapper" for the NativeWindow class. The WindowedApplication component replaces the Application component when you create an AIR application with Flex and must always be used as the initial window in your Flex application.

ActionScript windows

When you create windows with the NativeWindow class, use the Flash Player stage and display list directly. To add a visual object to a NativeWindow, add the object to the display list of the window stage or to another display object container on the stage.

HTML windows

When you create HTML windows, you use HTML, CSS, and JavaScript to display content. To add a visual object to an HTML window, you add that content to the HTML DOM. HTML windows are a special category of NativeWindow. The AIR host defines a `nativeWindow` property in HTML windows that provides access to the underlying NativeWindow instance. You can use this property to access the NativeWindow properties, methods, and events described here.

Note: *The JavaScript Window object also has methods for scripting the containing window, such as* `moveTo()` *and* `close()`*. Where overlapping methods are available, you can use whichever method that is convenient.*

Flex Framework windows

When you create windows with the Flex framework, you typically use MXML components to populate the window. To add a Flex component to a window, you add the component element to the window MXML definition. You can also use ActionScript to add content dynamically. The mx:WindowedApplication and mx:Window components are designed as Flex containers and so can accept Flex components directly, whereas NativeWindow objects cannot. When necessary, the NativeWindow properties and methods can be accessed through the WindowedApplication and Window objects using the `nativeWindow` property.

The initial application window

The first window of your application is automatically created for you by AIR. AIR sets the properties and content of the window using the parameters specified in the `initialWindow` element of the application descriptor file.

If the root content is a SWF file, AIR creates a NativeWindow instance, loads the SWF file, and adds it to the window stage. If the root content is an HTML file, AIR creates an HTML window and loads the HTML.

Native window classes

Adobe AIR 1.0 and later

The native window API contains the following classes:

Package	Classes
flash.display	• NativeWindow • NativeWindowInitOptions • NativeWindowDisplayState • NativeWindowResize • NativeWindowSystemChrome • NativeWindowType
flash.events	• NativeWindowBoundsEvent • NativeWindowDisplayStateEvent

Native window event flow

Adobe AIR 1.0 and later

Native windows dispatch events to notify interested components that an important change is about to occur or has already occurred. Many window-related events are dispatched in pairs. The first event warns that a change is about to happen. The second event announces that the change has been made. You can cancel a warning event, but not a notification event. The following sequence illustrates the flow of events that occurs when a user clicks the maximize button of a window:

1 The NativeWindow object dispatches a `displayStateChanging` event.

2 If no registered listeners cancel the event, the window maximizes.

3 The NativeWindow object dispatches a `displayStateChange` event.

   In addition, the NativeWindow object also dispatches events for related changes to the window size and position. The window does not dispatch warning events for these related changes. The related events are:

   a A `move` event is dispatched if the top, left corner of the window moved because of the maximize operation.

   b A `resize` event is dispatched if the window size changed because of the maximize operation.

   A NativeWindow object dispatches a similar sequence of events when minimizing, restoring, closing, moving, and resizing a window.

   The warning events are only dispatched when a change is initiated through window chrome or other operating-system controlled mechanism. When you call a window method to change the window size, position, or display state, the window only dispatches an event to announce the change. You can dispatch a warning event, if desired, using the window `dispatchEvent()` method, then check to see if your warning event has been canceled before proceeding with the change.

   For detailed information about the window API classes, methods, properties, and events, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

Properties controlling native window style and behavior

Flash Player 9 and later, Adobe AIR 1.0 and later

The following properties control the basic appearance and behavior of a window:

- `type`
- `systemChrome`
- `transparent`
- `owner`

When you create a window, you set these properties on the NativeWindowInitOptions object passed to the window constructor. AIR reads the properties for the initial application window from the application descriptor. (Except the `type` property, which cannot be set in the application descriptor and is always set to `normal`.) The properties cannot be changed after window creation.

Some settings of these properties are mutually incompatible: `systemChrome` cannot be set to `standard` when either `transparent` is `true` or `type` is `lightweight`.

Window types

Adobe AIR 1.0 and later

The AIR window types combine chrome and visibility attributes of the native operating system to create three functional types of window. Use the constants defined in the NativeWindowType class to reference the type names in code. AIR provides the following window types:

Type	Description
Normal	A typical window. Normal windows use the full-size style of chrome and appear on the Windows taskbar and the Mac OS X window menu.
Utility	A tool palette. Utility windows use a slimmer version of the system chrome and do not appear on the Windows taskbar and the Mac OS X window menu.
Lightweight	Lightweight windows have no chrome and do not appear on the Windows taskbar or the Mac OS X window menu. In addition, lightweight windows do not have the System (Alt+Space) menu on Windows. Lightweight windows are suitable for notification bubbles and controls such as combo-boxes that open a short-lived display area. When the lightweight `type` is used, `systemChrome` must be set to `none`.

Window chrome

Adobe AIR 1.0 and later

Window chrome is the set of controls that allow users to manipulate a window in the desktop environment. Chrome elements include the title bar, title bar buttons, border, and resize grippers.

System chrome

You can set the `systemChrome` property to `standard` or `none`. Choose `standard` system chrome to give your window the set of standard controls created and styled by the user's operating system. Choose `none` to provide your own chrome for the window. Use the constants defined in the NativeWindowSystemChrome class to reference the system chrome settings in code.

System chrome is managed by the system. Your application has no direct access to the controls themselves, but can react to the events dispatched when the controls are used. When you use standard chrome for a window, the `transparent` property must be set to `false` and the `type` property must be `normal` or `utility`.

Flex chrome

When you use the Flex WindowedApplication or Window components, the window can be use either system chrome or chrome provided by the Flex framework. To use the Flex chrome, set the `systemChrome` property used to create the window to `none`. When using the Flex 4 spark components rather than the mx components, you must specify the skin class in order to use Flex chrome. You can use the built-in skins or provide your own. The following example demonstrates how to use the built-in spark WindowedApplication skin class to provide the window chrome:

```
<?xml version="1.0" encoding="utf-8"?>
<s:WindowedApplication xmlns:fx="http://ns.adobe.com/mxml/2009"
xmlns:s="library://ns.adobe.com/flex/spark"
xmlns:mx="library://ns.adobe.com/flex/mx">
<fx:Style>
@namespace "library://ns.adobe.com/flex/spark";
WindowedApplication
{
    skinClass:ClassReference("spark.skins.spark.SparkChromeWindowedApplicationSkin");
}
</fx:Style>
</s:WindowedApplication>
```

For more information, see Using Flex 4: About the AIR window containers: Controlling window chrome

Custom chrome

When you create a window with no system chrome, then you must add your own chrome controls to handle the interactions between a user and the window. You are also free to make transparent, non-rectangular windows.

To use custom chrome with the mx:WindowedApplication or mx:Window components, you must set the `showFlexChrome` style to `false`. Otherwise, Flex will add its own chrome to your windows.

Window transparency

Adobe AIR 1.0 and later

To allow alpha blending of a window with the desktop or other windows, set the window `transparent` property to `true`. The `transparent` property must be set before the window is created and cannot be changed.

A transparent window has no default background. Any window area not containing an object drawn by the application is invisible. If a displayed object has an alpha setting of less than one, then anything below the object shows through, including other display objects in the same window, other windows, and the desktop.

Transparent windows are useful when you want to create applications with borders that are irregular in shape or that "fade out" or appear to be invisible. However, rendering large alpha-blended areas can be slow, so the effect should be used conservatively.

***Important:** On Linux, mouse events do not pass through fully transparent pixels. You should avoid creating windows with large, fully transparent areas since you may invisibly block the user's access to other windows or items on their desktop. On Mac OS X and Windows, mouse events do pass through fully transparent pixels.*

Transparency cannot be used with windows that have system chrome. In addition, SWF and PDF content in HTML may not display in transparent windows. For more information, see "Considerations when loading SWF or PDF content in an HTML page" on page 1004.

The static `NativeWindow.supportsTransparency` property reports whether window transparency is available. When transparency is not supported, the application is composited against a black background. In these cases, any transparent areas of the application display as an opaque black. It is a good practice to provide a fallback in case this property tests `false`. For example, you could display a warning dialog to the user, or display a rectangular, non-transparent user interface.

Note that transparency is always supported by the Mac and Windows operating systems. Support on Linux operating systems requires a compositing window manager, but even when a compositing window manager is active, transparency can be unavailable because of user display options or hardware configuration.

Transparency in an MXML application window

Adobe AIR 1.0 and later

By default, the background of an MXML window is opaque, even if you create the window as *transparent*. (Notice the transparency effect at the corners of the window.) To present a transparent background for the window, set a background color and alpha value in the style sheet or <mx:Style> element contained in your application MXML file. For example, the following style declaration gives the background a slightly transparent green shade:

```
WindowedApplication
{
    background-alpha:".8";
    background-color:"0x448234";
}
```

Transparency in an HTML application window

Adobe AIR 1.0 and later

By default the background of HTML content displayed in HTML windows and HTMLLoader objects is opaque, event if the containing window is transparent. To turn off the default background displayed for HTML content, set the `paintsDefaultBackground` property to `false`. The following example creates an HTMLLoader and turns off the default background:

```
var htmlView:HTMLLoader = new HTMLLoader();
htmlView.paintsDefaultBackground = false;
```

This example uses JavaScript to turn off the default background of an HTML window:

```
window.htmlLoader.paintsDefaultBackground = false;
```

If an element in the HTML document sets a background color, the background of that element is not transparent. Setting a partial transparency (or opacity) value is not supported. However, you can use a transparent PNG-format graphic as the background for a page or a page element to achieve a similar visual effect.

Window ownership

One window can *own* one or more other windows. These owned windows always appear in front of the master window, are minimized and restored along with the master window, and are closed when the master window is closed. Window ownership cannot be transfered to another window or removed. A window can only be owned by one master window, but can own any number of other windows.

You can use window ownership to make it easier to manage windows used for tool palettes and dialogs. For example, if you displayed a Save dialog in association with a document window, making the document window own the dialog will keep the dialog in front of the document window automatically.

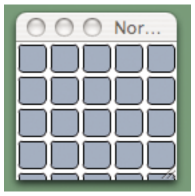
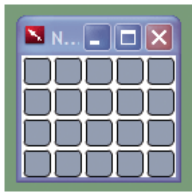
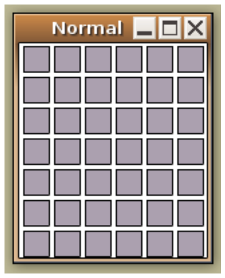
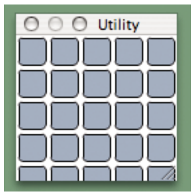
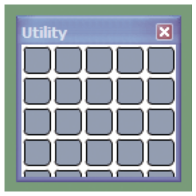
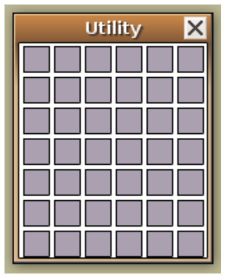
- NativeWindow.owner

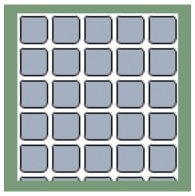
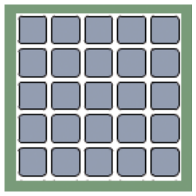
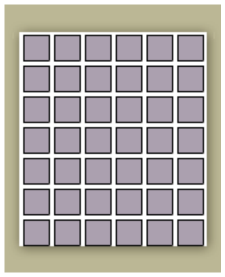
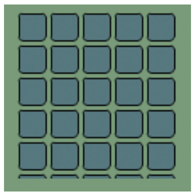
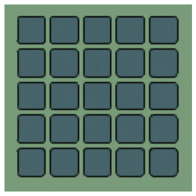
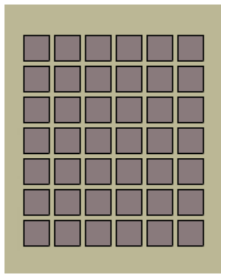
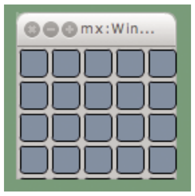
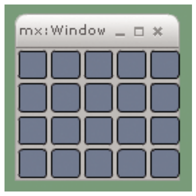
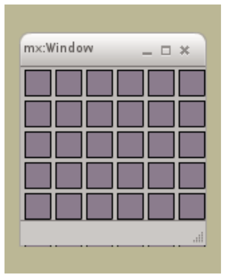
- Christian Cantrell: Owned windows in AIR 2.6

A visual window catalog

Adobe AIR 1.0 and later

The following table illustrates the visual effects of different combinations of window property settings on the Mac OS X, Windows, and Linux operating systems:

Window settings	**Mac OS X**	**Microsoft Windows**	**Linux***
Type: normal SystemChrome: standard Transparent: false			
Type: utility SystemChrome: standard Transparent: false			

Window settings	**Mac OS X**	**Microsoft Windows**	**Linux**[*]
Type: Any SystemChrome: none Transparent: false			
Type: Any SystemChrome: none Transparent: true			
mxWindowedApplication or mx:Window Type: Any SystemChrome: none Transparent: true			

[*]*Ubuntu with Compiz window manager*

***Note:** The following system chrome elements are not supported by AIR: the Mac OS X Toolbar, the Mac OS X Proxy Icon, Windows title bar icons, and alternate system chrome.*

Creating windows

Adobe AIR 1.0 and later

AIR automatically creates the first window for an application, but you can create any additional windows you need. To create a native window, use the NativeWindow constructor method.

To create an HTML window, either use the HTMLLoader `createRootWindow()` method or, from an HTML document, call the JavaScript `window.open()` method. The window created is a NativeWindow object whose display list contains an HTMLLoader object. The HTMLLoader object interprets and displays the HTML and JavaScript content for the window. You can access the properties of the underlying NativeWindow object from JavaScript using the `window.nativeWindow` property. (This property is only accessible to code running in the AIR application sandbox.)

When you initialize a window—including the initial application window—you should consider creating the window in the invisible state, loading content or executing any graphical updates, and then making the window visible. This sequence prevents any jarring visual changes from being visible to your users. You can specify that the initial window of your application should be created in the invisible state by specifying the `<visible>false</visible>` tag in the application descriptor (or by leaving the tag out altogether since `false` is the default value). New NativeWindows are invisible by default. When you create an HTML window with the HTMLLoader `createRootWindow()` method, you can set the `visible` argument to `false`. Call the NativeWindow `activate()` method or set the `visible` property to `true` to make a window visible.

Specifying window initialization properties

Adobe AIR 1.0 and later

The initialization properties of a native window cannot be changed after the desktop window is created. These immutable properties and their default values include:

Property	Default value
systemChrome	standard
type	normal
transparent	false
owner	null
maximizable	true
minimizable	true
resizable	true

Set the properties for the initial window created by AIR in the application descriptor file. The main window of an AIR application is always type, *normal*. (Additional window properties can be specified in the descriptor file, such as `visible`, `width`, and `height`, but these properties can be changed at any time.)

Set the properties for other native and HTML windows created by your application using the NativeWindowInitOptions class. When you create a window, you must pass a NativeWindowInitOptions object specifying the window properties to either the NativeWindow constructor function or the HTMLLoader `createRootWindow()` method.

The following code creates a NativeWindowInitOptions object for a utility window:

```
var options:NativeWindowInitOptions = new NativeWindowInitOptions();
options.systemChrome = NativeWindowSystemChrome.STANDARD;
options.type = NativeWindowType.UTILITY
options.transparent = false;
options.resizable = false;
options.maximizable = false;
```

Setting *systemChrome* to *standard* when *transparent* is `true` or `type` is `lightweight` *is not supported.*

***Note:** You cannot set the initialization properties for a window created with the JavaScript `window.open()` function. You can, however, override how these windows are created by implementing your own HTMLHost class. See "Handling JavaScript calls to window.open()" on page 1016 for more information.*

When you create a window with the Flex mx:Window class, specify the initialization properties on the window object itself, either in the MXML declaration for the window, or in the code that creates the window. The underlying NativeWindow object is not created until you call the `open()` method. Once a window is opened, these initialization properties cannot be changed.

Creating the initial application window

Adobe AIR 1.0 and later

AIR creates the initial application window based on the properties specified in the application descriptor and loads the file referenced in the content element. The content element must reference a SWF file or an HTML file.

The initial window can be the main window of your application or it can merely serve to launch one or more other windows. You do not have to make it visible at all.

Creating the initial window with ActionScript

Adobe AIR 1.0 and later

When you create an AIR application using ActionScript, the main class of your application must extend the Sprite class (or a subclass of Sprite). This class serves as the main entry point for the application.

When your application launches, AIR creates a window, creates an instance of the main class, and adds the instance to the window stage. To access the window, you can listen for the `addedToStage` event and then use the `nativeWindow` property of the Stage object to get a reference to the NativeWindow object.

The following example illustrates the basic skeleton for the main class of an AIR application built with ActionScript:

```
package {
    import flash.display.NativeWindow;
    import flash.display.Sprite;
    import flash.events.Event;

    public class MainClass extends Sprite
    {
        private var mainWindow:NativeWindow;
        public function MainClass(){
            this.addEventListener(Event.ADDED_TO_STAGE, initialize);
        }

        private function initialize(event:Event):void{
            mainWindow = this.stage.nativeWindow;
            //perform initialization...
            mainWindow.activate(); //show the window
        }
    }
}
```

Note: *Technically, you CAN access the `nativeWindow` property in the constructor function of the main class. However, this is a special case applying only to the initial application window.*

When creating an application in Flash Professional, the main document class is created automatically if you do not create your own in a separate ActionScript file. You can access the NativeWindow object for the initial window using the stage `nativeWindow` property. For example, the following code activates the main window in the maximized state (from the timeline):

```
import flash.display.NativeWindow;

var mainWindow:NativeWindow = this.stage.nativeWindow;
mainWindow.maximize();
mainWindow.activate();
```

Creating the initial window with Flex

Adobe AIR 1.0 and later

When creating an AIR application with the Flex framework, use the mx:WindowedApplication as the root element of your main MXML file. (You can use the mx:Application component, but it does not support all the features available in AIR.) The WindowedApplication component serves as the initial entry point for the application.

When you launch the application, AIR creates a native window, initializes the Flex framework, and adds the WindowedApplication object to the window stage. When the launch sequence finishes, the WindowedApplication dispatches an `applicationComplete` event. Access the desktop window object with the `nativeWindow` property of the WindowedApplication instance.

The following example creates a simple WindowedApplication component that sets its x and y coordinates:

```
 <?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml"
    applicationComplete="placeWindow()">
    <mx:Script>
        <![CDATA[
            private function placeWindow():void{
                this.nativeWindow.x = 300;
                this.nativeWindow.y = 300;
            }
        ]]>
    </mx:Script>
    <mx:Label text="Hello World" horizontalCenter="0" verticalCenter="0"/>
</mx:WindowedApplication>
```

Creating a NativeWindow

Adobe AIR 1.0 and later

To create a NativeWindow, pass a NativeWindowInitOptions object to the NativeWindow constructor:

```
 var options:NativeWindowInitOptions = new NativeWindowInitOptions();
options.systemChrome = NativeWindowSystemChrome.STANDARD;
options.transparent = false;
var newWindow:NativeWindow = new NativeWindow(options);
```

The window is not shown until you set the `visible` property to `true` or call the `activate()` method.

Once the window is created, you can initialize its properties and load content into the window using the stage property and Flash display list techniques.

In almost all cases, you should set the stage `scaleMode` property of a new native window to `noScale` (use the `StageScaleMode.NO_SCALE` constant). The Flash scale modes are designed for situations in which the application author does not know the aspect ratio of the application display space in advance. The scale modes let the author choose the least-bad compromise: clip the content, stretch or squash it, or pad it with empty space. Since you control the display space in AIR (the window frame), you can size the window to the content or the content to the window without compromise.

The scale mode for Flex and HTML windows is set to `noScale` automatically.

***Note:** To determine the maximum and minimum window sizes allowed on the current operating system, use the following static NativeWindow properties:*

```
 var maxOSSize:Point = NativeWindow.systemMaxSize;
var minOSSize:Point = NativeWindow.systemMinSize;
```

Creating an HTML window

Adobe AIR 1.0 and later

To create an HTML window, you can either call the JavaScript `Window.open()` method, or you can call the AIR HTMLLoader class `createRootWindow()` method.

HTML content in any security sandbox can use the standard JavaScript `Window.open()` method. If the content is running outside the application sandbox, the `open()` method can only be called in response to user interaction, such as a mouse click or keypress. When `open()` is called, a window with system chrome is created to display the content at the specified URL. For example:

```
newWindow = window.open("xmpl.html", "logWindow", "height=600, width=400, top=10, left=10");
```

***Note:** You can extend the HTMLHost class in ActionScript to customize the window created with the JavaScript `window.open()` function. See "About extending the HTMLHost class" on page 1009.*

Content in the application security sandbox has access to the more powerful method of creating windows, `HTMLLoader.createRootWindow()`. With this method, you can specify all the creation options for a new window. For example, the following JavaScript code creates a lightweight type window without system chrome that is 300x400 pixels in size:

```
 var options = new air.NativeWindowInitOptions();
options.systemChrome = "none";
options.type = "lightweight";

var windowBounds = new air.Rectangle(200,250,300,400);
newHTMLLoader = air.HTMLLoader.createRootWindow(true, options, true, windowBounds);
newHTMLLoader.load(new air.URLRequest("xmpl.html"));
```

***Note:** If the content loaded by a new window is outside the application security sandbox, the window object does not have the AIR properties: `runtime`, `nativeWindow`, or `htmlLoader`.*

If you create a transparent window, then SWF content embedded in the HTML loaded into that window is not always displayed. You must set the `wmode` parameter of the object or embed tag used to reference the SWF file to either `opaque` or `transparent`. The default value of `wmode` is `window`, so, by default, SWF content is not displayed in transparent windows. PDF content cannot be displayed in transparent windows, no matter which `wmode` value is set. (Prior to AIR 1.5.2, SWF content could not be displayed in transparent windows, either.)

Windows created with the `createRootWindow()` method remain independent from the opening window. The `parent` and `opener` properties of the JavaScript Window object are `null`. The opening window can access the Window object of the new window using the HTMLLoader reference returned by the `createRootWindow()` function. In the context of the previous example, the statement `newHTMLLoader.window` would reference the JavaScript Window object of the created window.

***Note:** The `createRootWindow()` function can be called from both JavaScript and ActionScript.*

Creating a mx:Window

Adobe AIR 1.0 and later

To create a mx:Window, you can create an MXML file using mx:Window as the root tag, or you can call the Window class constructor directly.

The following example creates and shows a mx:Window by calling the Window constructor:

```
 var newWindow:Window = new Window();
newWindow.systemChrome = NativeWindowSystemChrome.NONE;
newWindow.transparent = true;
newWindow.title = "New Window";
newWindow.width = 200;
newWindow.height = 200;
newWindow.open(true);
```

Adding content to a window

Adobe AIR 1.0 and later

How you add content to an AIR window depends on the type of window. For example, MXML and HTML let you declaratively define the basic content of the window. You can embed resources in the application SWF files or you can load them from separate application files. Flex, Flash, and HTML content can all be created on the fly and added to a window dynamically.

When you load SWF content, or HTML content containing JavaScript, you must take the AIR security model into consideration. Any content in the application security sandbox, that is, content installed with your application and loadable with the app: URL scheme, has full privileges to access all the AIR APIs. Any content loaded from outside this sandbox cannot access the AIR APIs. JavaScript content outside the application sandbox is not able to use the `runtime`, `nativeWindow`, or `htmlLoader` properties of the JavaScript Window object.

To allow safe cross-scripting, you can use a sandbox bridge to provide a limited interface between application content and non-application content. In HTML content, you can also map pages of your application into a non-application sandbox to allow the code on that page to cross-script external content. See "AIR security" on page 1076.

Loading a SWF file or image

You can load Flash SWF files or images into the display list of a native window using the `flash.display.Loader` class:

```
package {
    import flash.display.Sprite;
    import flash.events.Event;
    import flash.net.URLRequest;
    import flash.display.Loader;

    public class LoadedSWF extends Sprite
    {
        public function LoadedSWF(){
            var loader:Loader = new Loader();
            loader.load(new URLRequest("visual.swf"));
            loader.contentLoaderInfo.addEventListener(Event.COMPLETE,loadFlash);
        }

        private function loadFlash(event:Event):void{
            addChild(event.target.loader);
        }
    }
}
```

Note: *Older SWF files created using ActionScript 1 or 2 share global states such as class definitions, singletons, and global variables if they are loaded into the same window. If such a SWF file relies on untouched global states to work correctly, it cannot be loaded more than once into the same window, or loaded into the same window as another SWF file using overlapping class definitions and variables. This content can be loaded into separate windows.*

Loading HTML content into a NativeWindow

To load HTML content into a NativeWindow, you can either add an HTMLLoader object to the window stage and load the HTML content into the HTMLLoader, or create a window that already contains an HTMLLoader object by using the `HTMLLoader.createRootWindow()` method. The following example displays HTML content within a 300 by 500 pixel display area on the stage of a native window:

```
//newWindow is a NativeWindow instance
var htmlView:HTMLLoader = new HTMLLoader();
htmlView.width = 300;
htmlView.height = 500;

//set the stage so display objects are added to the top-left and not scaled
newWindow.stage.align = "TL";
newWindow.stage.scaleMode = "noScale";
newWindow.stage.addChild( htmlView );

//urlString is the URL of the HTML page to load
htmlView.load( new URLRequest(urlString) );
```

To load an HTML page into a Flex application, you can use the Flex HTML component.

SWF content in an HTML file is not displayed if the window uses transparency (that is the `transparent` property of the window is `true`) unless the `wmode` parameter of the object or embed tag used to reference the SWF file is set to either `opaque` or `transparent`. Since the default `wmode` value is `window`, by default, SWF content is not displayed in a transparent window. PDF content is not displayed in a transparent window no matter what `wmode` value is used.

Also, neither SWF nor PDF content is displayed if the HTMLLoader control is scaled, rotated, or if the HTMLLoader `alpha` property is set to a value other than 1.0.

Adding SWF content as an overlay on an HTML window

Because HTML windows are contained within a NativeWindow instance, you can add Flash display objects both above and below the HTML layer in the display list.

To add a display object above the HTML layer, use the `addChild()` method of the `window.nativeWindow.stage` property. The `addChild()` method adds content layered above any existing content in the window.

To add a display object below the HTML layer, use the `addChildAt()` method of the `window.nativeWindow.stage` property, passing in a value of zero for the `index` parameter. Placing an object at the zero index moves existing content, including the HTML display, up one layer and insert the new content at the bottom. For content layered underneath the HTML page to be visible, you must set the `paintsDefaultBackground` property of the `HTMLlLoader` object to `false`. In addition, any elements of the page that set a background color, will not be transparent. If, for example, you set a background color for the body element of the page, none of the page will be transparent.

The following example illustrates how to add a Flash display objects as overlays and underlays to an HTML page. The example creates two simple shape objects, adds one below the HTML content and one above. The example also updates the shape position based on the `enterFrame` event.

```
 <html>
<head>
<title>Bouncers</title>
<script src="AIRAliases.js" type="text/javascript"></script>
<script language="JavaScript" type="text/javascript">
air.Shape = window.runtime.flash.display.Shape;

function Bouncer(radius, color){
    this.radius = radius;
    this.color = color;

    //velocity
    this.vX = -1.3;
    this.vY = -1;

    //Create a Shape object and draw a circle with its graphics property
    this.shape = new air.Shape();
    this.shape.graphics.lineStyle(1,0);
    this.shape.graphics.beginFill(this.color,.9);
    this.shape.graphics.drawCircle(0,0,this.radius);
    this.shape.graphics.endFill();

    //Set the starting position
    this.shape.x = 100;
    this.shape.y = 100;


    //Moves the sprite by adding (vX,vY) to the current position
    this.update = function(){
        this.shape.x += this.vX;
        this.shape.y += this.vY;

        //Keep the sprite within the window
        if( this.shape.x - this.radius < 0){
            this.vX = -this.vX;
        }
        if( this.shape.y - this.radius < 0){
            this.vY = -this.vY;
        }
        if( this.shape.x  + this.radius > window.nativeWindow.stage.stageWidth){
            this.vX = -this.vX;
        }
        if( this.shape.y  + this.radius > window.nativeWindow.stage.stageHeight){
            this.vY = -this.vY;
        }

    };
}

function init(){
    //turn off the default HTML background
    window.htmlLoader.paintsDefaultBackground = false;
    var bottom = new Bouncer(60,0xff2233);
    var top = new Bouncer(30,0x2441ff);

    //listen for the enterFrame event
    window.htmlLoader.addEventListener("enterFrame",function(evt){
        bottom.update();
        top.update();
    });

    //add the bouncing shapes to the window stage
    window.nativeWindow.stage.addChildAt(bottom.shape,0);
    window.nativeWindow.stage.addChild(top.shape);
}
</script>
<body onload="init();">
<h1>de Finibus Bonorum et Malorum</h1>
<p>Sed ut perspiciatis unde omnis iste natus error sit voluptatem accusantium
doloremque laudantium, totam rem aperiam, eaque ipsa quae ab illo inventore veritatis
et quasi architecto beatae vitae dicta sunt explicabo.</p>
<p style="background-color:#FFFF00; color:#660000;">This paragraph has a background color.</p>
<p>At vero eos et accusamus et iusto odio dignissimos ducimus qui blanditiis
praesentium voluptatum deleniti atque corrupti quos dolores et quas molestias
excepturi sint occaecati cupiditate non provident, similique sunt in culpa qui
officia deserunt mollitia animi, id est laborum et dolorum fuga.</p>
</body>
</html>
```

This example provides a rudimentary introduction to some advanced techniques that cross over the boundaries between JavaScript and ActionScript in AIR. If your are unfamiliar with using ActionScript display objects, refer to "Display programming" on page 151 in the *ActionScript 3.0 Developer's Guide*.

Example: Creating a native window

Adobe AIR 1.0 and later

The following example illustrates how to create a native window:

```
public function createNativeWindow():void {
    //create the init options
    var options:NativeWindowInitOptions = new NativeWindowInitOptions();
    options.transparent = false;
    options.systemChrome = NativeWindowSystemChrome.STANDARD;
    options.type = NativeWindowType.NORMAL;

    //create the window
    var newWindow:NativeWindow = new NativeWindow(options);
    newWindow.title = "A title";
    newWindow.width = 600;
    newWindow.height = 400;

    newWindow.stage.align = StageAlign.TOP_LEFT;
    newWindow.stage.scaleMode = StageScaleMode.NO_SCALE;

    //activate and show the new window
    newWindow.activate();
}
```

Managing windows

Adobe AIR 1.0 and later

You use the properties and methods of the NativeWindow class to manage the appearance, behavior, and life cycle of desktop windows.

Note: *When using the Flex framework, it is generally better to manage window behavior using the framework classes. Most of the NativeWindow properties and methods can be accessed through the mx:WindowedApplication and mx:Window classes.*

Getting a NativeWindow instance

Adobe AIR 1.0 and later

To manipulate a window, you must first get the window instance. You can get a window instance from one of the following places:

- The native window constructor used to create the window:

  ```
  var win:NativeWindow = new NativeWindow(initOptions);
  ```

- The `nativeWindow` property of the window stage:

  ```
  var win:NativeWindow = stage.nativeWindow;
  ```

- The `stage` property of a display object in the window:

  ```
  var win:NativeWindow = displayObject.stage.nativeWindow;
  ```

- The `target` property of a native window event dispatched by the window:

  ```
  private function onNativeWindowEvent(event:NativeWindowBoundsEvent):void
  {
      var win:NativeWindow = event.target as NativeWindow;
  }
  ```

- The `nativeWindow` property of an HTML page displayed in the window:

  ```
  var win:NativeWindow = htmlLoader.window.nativeWindow;
  ```

- The `activeWindow` and `openedWindows` properties of the NativeApplication object:

  ```
  var nativeWin:NativeWindow = NativeApplication.nativeApplication.activeWindow;
  var firstWindow:NativeWindow = NativeApplication.nativeApplication.openedWindows[0];
  ```

  `NativeApplication.nativeApplication.activeWindow` references the active window of an application (but returns `null` if the active window is not a window of this AIR application). The `NativeApplication.nativeApplication.openedWindows` array contains all of the windows in an AIR application that have not been closed.

Because the Flex mx:WindowedApplication, and mx:Window objects are display objects, you can easily reference the application window in an MXML file using the `stage` property, as follows:

```
 <?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml"
applicationComplete="init();">
    <mx:Script>
        <![CDATA[
            import flash.display.NativeWindow;

            public function init():void{
                var appWindow:NativeWindow = this.stage.nativeWindow;
                //set window properties
                appWindow.visible = true;
            }
        ]]>
    </mx:Script>
</WindowedApplication
```

***Note:** Until the WindowedApplication or Window component is added to the window stage by the Flex framework, the component's `stage` property is `null`. This behavior is consistent with that of the Flex Application component, but does mean that it is not possible to access the stage or the NativeWindow instance in listeners for events that occur earlier in the initialization cycle of the WindowedApplication and Window components, such as `creationComplete`. It is safe to access the stage and NativeWindow instance when the `applicationComplete` event is dispatched.*

Activating, showing, and hiding windows

Adobe AIR 1.0 and later

To activate a window, call the NativeWindow `activate()` method. Activating a window brings the window to the front, gives it keyboard and mouse focus, and, if necessary, makes it visible by restoring the window or setting the `visible` property to `true`. Activating a window does not change the ordering of other windows in the application. Calling the `activate()` method causes the window to dispatch an `activate` event.

To show a hidden window without activating it, set the `visible` property to `true`. This brings the window to the front, but will not assign the focus to the window.

To hide a window from view, set its `visible` property to `false`. Hiding a window suppresses the display of both the window, any related taskbar icons, and, on Mac OS X, the entry in the Windows menu.

When you change the visibility of a window, the visibility of any windows that window owns is also changed. For example, if you hide a window, all of its owned windows are also hidden.

Note: *On Mac OS X, it is not possible to completely hide a minimized window that has an icon in the window portion of the dock. If the* `visible` *property is set to* `false` *on a minimized window, the dock icon for the window is still displayed. If the user clicks the icon, the window is restored to a visible state and displayed.*

Changing the window display order

Adobe AIR 1.0 and later

AIR provides several methods for directly changing the display order of windows. You can move a window to the front of the display order or to the back; you can move a window above another window or behind it. At the same time, the user can reorder windows by activating them.

You can keep a window in front of other windows by setting its `alwaysInFront` property to `true`. If more than one window has this setting, then the display order of these windows is sorted among each other, but they are always sorted above windows which have `alwaysInFront` set to false.

Windows in the top-most group are also displayed above windows in other applications, even when the AIR application is not active. Because this behavior can be disruptive to a user, setting `alwaysInFront` to `true` should only be done when necessary and appropriate. Examples of justified uses include:

- Temporary pop-up windows for controls such as tool tips, pop-up lists, custom menus, or combo boxes. Because these windows should close when they lose focus, the annoyance of blocking a user from viewing another window can be avoided.
- Extremely urgent error messages and alerts. When an irrevocable change may occur if the user does not respond in a timely manner, it may be justified to push an alert window to the forefront. However, most errors and alerts can be handled in the normal window display order.
- Short-lived toast-style windows.

Note: *AIR does not enforce proper use of the* `alwaysInFront` *property. However, if your application disrupts a user's workflow, it is likely to be consigned to that same user's trash can.*

If a window owns other windows, those windows are always ordered in front of it. If you call `orderToFront()` or set `alwaysInFront` to `true` on a window that owns other windows, then the owned windows are re-ordered along with the owner window in front of other windows, but the owned windows still display in front of the owner.

Calling the window ordering methods on owned windows works normally among windows owned by the same window, but can also change the ordering of the entire group of owned windows compared to windows outside that group. For example, if you call `orderToFront()` on an owned window, then both that window, its owner, and any other windows owned by the same owner are moved to the front of the window display order.

The NativeWindow class provides the following properties and methods for setting the display order of a window relative to other windows:

Member	Description
alwaysInFront property	Specifies whether the window is displayed in the top-most group of windows. In almost all cases, `false` is the best setting. Changing the value from `false` to `true` brings the window to the front of all windows (but does not activate it). Changing the value from `true` to `false` orders the window behind windows remaining in the top-most group, but still in front of other windows. Setting the property to its current value for a window does not change the window display order. The `alwaysInFront` setting has no affect on windows owned by another window.
orderToFront()	Brings the window to the front.
orderInFrontOf()	Brings the window directly in front of a particular window.

Member	Description
orderToBack()	Sends the window behind other windows.
orderBehind()	Sends the window directly behind a particular window.
activate()	Brings the window to the front (along with making the window visible and assigning focus).

***Note:** If a window is hidden (`visible` is `false`) or minimized, then calling the display order methods has no effect.*

On the Linux operating system, different window managers enforce different rules regarding the window display order:

- On some window managers, utility windows are always displayed in front of normal windows.
- On some window managers, a full screen window with `alwaysInFront` set to `true` is always displayed in front of other windows that also have `alwaysInFront` set to `true`.

Closing a window

Adobe AIR 1.0 and later

To close a window, use the `NativeWindow.close()` method.

Closing a window unloads the contents of the window, but if other objects have references to this content, the content objects will not be destroyed. The `NativeWindow.close()` method executes asynchronously, the application that is contained in the window continues to run during the closing process. The close method dispatches a close event when the close operation is complete. The NativeWindow object is still technically valid, but accessing most properties and methods on a closed window generates an IllegalOperationError. You cannot reopen a closed window. Check the `closed` property of a window to test whether a window has been closed. To simply hide a window from view, set the `NativeWindow.visible` property to `false`.

If the `Nativeapplication.autoExit` property is `true`, which is the default, then the application exits when its last window closes.

Any windows that have an owner are closed when the owner is closed. The owned windows do not dispatch a closing event and hence cannot prevent closure. A close event is dispatched.

Allowing cancellation of window operations

Adobe AIR 1.0 and later

When a window uses system chrome, user interaction with the window can be canceled by listening for, and canceling the default behavior of the appropriate events. For example, when a user clicks the system chrome close button, the `closing` event is dispatched. If any registered listener calls the `preventDefault()` method of the event, then the window does not close.

When a window does not use system chrome, notification events for intended changes are not automatically dispatched before the change is made. Hence, if you call the methods for closing a window, changing the window state, or set any of the window bounds properties, the change cannot be canceled. To notify components in your application before a window change is made, your application logic can dispatch the relevant notification event using the `dispatchEvent()` method of the window.

For example, the following logic implements a cancelable event handler for a window close button:

```
public function onCloseCommand(event:MouseEvent):void{
    var closingEvent:Event = new Event(Event.CLOSING,true,true);
    dispatchEvent(closing);
    if(!closingEvent.isDefaultPrevented()){
        win.close();
    }
}
```

The `dispatchEvent()` method returns `false` if the event `preventDefault()` method is called by a listener. However, it can also return `false` for other reasons, so it is better to explicitly use the `isDefaultPrevented()` method to test whether the change should be canceled.

Maximizing, minimizing, and restoring a window

Adobe AIR 1.0 and later

To maximize the window, use the NativeWindow `maximize()` method.

```
myWindow.maximize();
```

To minimize the window, use the NativeWindow `minimize()` method.

```
myWindow.minimize();
```

To restore the window (that is, return it to the size that it was before it was either minimized or maximized), use the NativeWindow `restore()` method.

```
myWindow.restore();
```

A window that has an owner is minimized and restored when the owning window is minimized or restored. No events are dispatched by the owned window when it is minimized because its owner is minimized.

Note: *The behavior that results from maximizing an AIR window is different from the Mac OS X standard behavior. Rather than toggling between an application-defined "standard" size and the last size set by the user, AIR windows toggle between the size last set by the application or user and the full usable area of the screen.*

On the Linux operating system, different window managers enforce different rules regarding setting the window display state:

- On some window managers, utility windows cannot be maximized.
- If a maximum size is set for the window, then some windows do not allow a window to be maximized. Some other window managers set the display state to maximized, but do not resize the window. In either of these cases, no display state change event is dispatched.
- Some window managers do not honor the window `maximizable` or `minimizable` settings.

Note: *On Linux, window properties are changed asynchronously. If you change the display state in one line of your program, and read the value in the next, the value read will still reflect the old setting. On all platforms, the NativeWindow object dispatches the `displayStateChange` event when the display state changes. If you need to take some action based on the new state of the window, always do so in a `displayStateChange` event handler. See "Listening for window events" on page 916.*

Example: Minimizing, maximizing, restoring and closing a window

Adobe AIR 1.0 and later

The following short MXML application demonstrates the Window `maximize()`, `minimize()`, `restore()`, and `close()` methods:

```
 <?xml version="1.0" encoding="utf-8"?>

<mx:WindowedApplication
    xmlns:mx="http://www.adobe.com/2006/mxml"
    layout="vertical">


    <mx:Script>
    <![CDATA[
    public function minimizeWindow():void
    {
        this.stage.nativeWindow.minimize();
    }

    public function maximizeWindow():void
    {
        this.stage.nativeWindow.maximize();
    }

    public function restoreWindow():void
    {
        this.stage.nativeWindow.restore();
    }

    public function closeWindow():void
    {
        this.stage.nativeWindow.close();
    }
    ]]>
    </mx:Script>

    <mx:VBox>
        <mx:Button label="Minimize" click="minimizeWindow()"/>
        <mx:Button label="Restore" click="restoreWindow()"/>
        <mx:Button label="Maximize" click="maximizeWindow()"/>
        <mx:Button label="Close" click="closeWindow()"/>
    </mx:VBox>

</mx:WindowedApplication>
```

The following ActionScript example for Flash creates four clickable text fields that trigger the NativeWindow `minimize()`, `maximize()`, `restore()`, and `close()` methods:

```
package
{
    import flash.display.Sprite;
    import flash.events.MouseEvent;
    import flash.text.TextField;

    public class MinimizeExample extends Sprite
    {
        public function MinimizeExample():void
        {
            var minTextBtn:TextField = new TextField();
            minTextBtn.x = 10;
            minTextBtn.y = 10;
            minTextBtn.text = "Minimize";
            minTextBtn.background = true;
            minTextBtn.border = true;
            minTextBtn.selectable = false;
            addChild(minTextBtn);
            minTextBtn.addEventListener(MouseEvent.CLICK, onMinimize);

            var maxTextBtn:TextField = new TextField();
            maxTextBtn.x = 120;
            maxTextBtn.y = 10;
            maxTextBtn.text = "Maximize";
            maxTextBtn.background = true;
            maxTextBtn.border = true;
            maxTextBtn.selectable = false;
            addChild(maxTextBtn);
            maxTextBtn.addEventListener(MouseEvent.CLICK, onMaximize);

            var restoreTextBtn:TextField = new TextField();
            restoreTextBtn.x = 230;
            restoreTextBtn.y = 10;
            restoreTextBtn.text = "Restore";
            restoreTextBtn.background = true;
            restoreTextBtn.border = true;
            restoreTextBtn.selectable = false;
            addChild(restoreTextBtn);
            restoreTextBtn.addEventListener(MouseEvent.CLICK, onRestore);

            var closeTextBtn:TextField = new TextField();
            closeTextBtn.x = 340;
            closeTextBtn.y = 10;
            closeTextBtn.text = "Close Window";
            closeTextBtn.background = true;
            closeTextBtn.border = true;
            closeTextBtn.selectable = false;
            addChild(closeTextBtn);
            closeTextBtn.addEventListener(MouseEvent.CLICK, onCloseWindow);
        }
        function onMinimize(event:MouseEvent):void
        {
            this.stage.nativeWindow.minimize();
        }
        function onMaximize(event:MouseEvent):void
        {
            this.stage.nativeWindow.maximize();
        }
        function onRestore(event:MouseEvent):void
        {
            this.stage.nativeWindow.restore();
        }
        function onCloseWindow(event:MouseEvent):void
        {
            this.stage.nativeWindow.close();
        }
    }
}
```

Resizing and moving a window

Adobe AIR 1.0 and later

When a window uses system chrome, the chrome provides drag controls for resizing the window and moving around the desktop. If a window does not use system chrome you must add your own controls to allow the user to resize and move the window.

***Note:** To resize or move a window, you must first obtain a reference to the NativeWindow instance. For information about how to obtain a window reference, see "Getting a NativeWindow instance" on page 907.*

Resizing a window

To allow a user to resize a window interactively, use the NativeWindow `startResize()` method. When this method is called from a `mouseDown` event, the resizing operation is driven by the mouse and completes when the operating system receives a `mouseUp` event. When calling `startResize()`, you pass in an argument that specifies the edge or corner from which to resize the window.

To set the window size programmatically, set the `width`, `height`, or `bounds` properties of the window to the desired dimensions. When you set the bounds, the window size and position can all be changed at the same time. However, the order that the changes occur is not guaranteed. Some Linux window managers do not allow windows to extend outside the bounds of the desktop screen. In these cases, the final window size may be limited because of the order in which the properties are set, even though the net affect of the changes would otherwise have resulted in a legal window. For example, if you change both the height and y position of a window near the bottom of the screen, then the full height change might not occur when the height change is applied before the y position change.

***Note:** On Linux, window properties are changed asynchronously. If you resize a window in one line of your program, and read the dimensions in the next, they will still reflect the old settings. On all platforms, the NativeWindow object dispatches the `resize` event when the window resizes. If you need to take some action, such as laying out controls in the window, based on the new size or state of the window, always do so in a `resize` event handler. See "Listening for window events" on page 916.*

The scale mode of the stage determines how the window stage and its contents behaves when a window is resized. Keep in mind that the stage scale modes are designed for situations, such as a web browser, where the application is not in control of the size or aspect ratio of its display space. In general, you get the best results by setting the stage `scaleMode` property to `StageScaleMode.NO_SCALE`. If you want the contents of the window to scale, you can still set the `scaleX` and `scaleY` parameters of the content in response to the window bounds changes.

Moving a window

To move a window without resizing it, use the NativeWindow `startMove()` method. Like the `startResize()` method, when the `startMove()` method is called from a `mouseDown` event, the move process is mouse-driven and completes when the operating system receives a `mouseUp` event.

For more information about the `startResize()` and `startMove()` methods, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

To move a window programmatically, set the `x`, `y`, or `bounds` properties of the window to the desired position. When you set the bounds, the window size and position can both be changed at the same time.

Note: *On Linux, window properties are changed asynchronously. If you move a window in one line of your program, and read the position in the next, the value read will still reflect the old setting. On all platforms, the NativeWindow object dispatches the* `move` *event when the position changes. If you need to take some action based on the new position of the window, always do so in a* `move` *event handler. See "Listening for window events" on page 916.*

Example: Resizing and moving windows

Adobe AIR 1.0 and later

The following example shows how to initiate resizing and moving operations on a window:

```
package
{
    import flash.display.Sprite;
    import flash.events.MouseEvent;
    import flash.display.NativeWindowResize;

    public class NativeWindowResizeExample extends Sprite
    {
        public function NativeWindowResizeExample():void
        {
            // Fills a background area.
            this.graphics.beginFill(0xFFFFFF);
            this.graphics.drawRect(0, 0, 400, 300);
            this.graphics.endFill();

            // Creates a square area where a mouse down will start the resize.
            var resizeHandle:Sprite =
                createSprite(0xCCCCCC, 20, this.width - 20, this.height - 20);
            resizeHandle.addEventListener(MouseEvent.MOUSE_DOWN, onStartResize);

            // Creates a square area where a mouse down will start the move.
            var moveHandle:Sprite = createSprite(0xCCCCCC, 20, this.width - 20, 0);
            moveHandle.addEventListener(MouseEvent.MOUSE_DOWN, onStartMove);
        }

        public function createSprite(color:int, size:int, x:int, y:int):Sprite
        {
            var s:Sprite = new Sprite();
            s.graphics.beginFill(color);
            s.graphics.drawRect(0, 0, size, size);
            s.graphics.endFill();
            s.x = x;
            s.y = y;
            this.addChild(s);
            return s;
        }

        public function onStartResize(event:MouseEvent):void
        {
            this.stage.nativeWindow.startResize(NativeWindowResize.BOTTOM_RIGHT);
        }

        public function onStartMove(event:MouseEvent):void
        {
            this.stage.nativeWindow.startMove();
        }
    }
}
```

Listening for window events

Adobe AIR 1.0 and later

To listen for the events dispatched by a window, register a listener with the window instance. For example, to listen for the closing event, register a listener with the window as follows:

```
myWindow.addEventListener(Event.CLOSING, onClosingEvent);
```

When an event is dispatched, the `target` property references the window sending the event.

Most window events have two related messages. The first message signals that a window change is imminent (and can be canceled), while the second message signals that the change has occurred. For example, when a user clicks the close button of a window, the closing event message is dispatched. If no listeners cancel the event, the window closes and the close event is dispatched to any listeners.

Typically, the warning events, such as `closing`, are only dispatched when system chrome has been used to trigger an event. Calling the window `close()` method, for example, does not automatically dispatch the `closing` event—only the `close` event is dispatched. You can, however, construct a closing event object and dispatch it using the window `dispatchEvent()` method.

The window events that dispatch an Event object are:

Event	Description
activate	Dispatched when the window receives focus.
deactivate	Dispatched when the window loses focus
closing	Dispatched when the window is about to close. This only occurs automatically when the system chrome close button is pressed or, on Mac OS X, when the Quit command is invoked.
close	Dispatched when the window has closed.

The window events that dispatch an NativeWindowBoundsEvent object are:

Event	Description
moving	Dispatched immediately before the top-left corner of the window changes position, either as a result of moving, resizing or changing the window display state.
move	Dispatched after the top-left corner has changed position.
resizing	Dispatched immediately before the window width or height changes either as a result of resizing or a display state change.
resize	Dispatched after the window has changed size.

For NativeWindowBoundsEvent events, you can use the `beforeBounds` and `afterBounds` properties to determine the window bounds before and after the impending or completed change.

The window events that dispatch an NativeWindowDisplayStateEvent object are:

Event	Description
displayStateChanging	Dispatched immediately before the window display state changes.
displayStateChange	Dispatched after the window display state has changed.

For NativeWindowDisplayStateEvent events, you can use the `beforeDisplayState` and `afterDisplayState` properties to determine the window display state before and after the impending or completed change.

On some Linux window managers, a display state change event is not dispatched when a window with a maximum size setting is maximized. (The window is set to the maximized display state, but is not resized.)

Displaying full-screen windows

Adobe AIR 1.0 and later

Setting the `displayState` property of the Stage to `StageDisplayState.FULL_SCREEN_INTERACTIVE` places the window in full-screen mode, and keyboard input *is* permitted in this mode. (In SWF content running in a browser, keyboard input is not permitted). To exit full-screen mode, the user presses the Escape key.

***Note:** Some Linux window managers will not change the window dimensions to fill the screen if a maximum size is set for the window (but do remove the window system chrome).*

For example, the following Flex code defines a simple AIR application that sets up a simple full-screen terminal:

```
 <?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml"
    layout="vertical"
    applicationComplete="init()" backgroundColor="0x003030" focusRect="false">
    <mx:Script>
        <![CDATA[
            private function init():void
            {
                stage.displayState = StageDisplayState.FULL_SCREEN_INTERACTIVE;
                focusManager.setFocus(terminal);
                terminal.text = "Welcome to the dumb terminal app. Press the ESC key to
exit..\n";
                terminal.selectionBeginIndex = terminal.text.length;
                terminal.selectionEndIndex = terminal.text.length;
            }
        ]]>
    </mx:Script>
    <mx:TextArea
        id="terminal"
        height="100%" width="100%"
        scroll="false"
        backgroundColor="0x003030"
        color="0xCCFF00"
        fontFamily="Lucida Console"
        fontSize="44"/>
</mx:WindowedApplication>
```

The following ActionScript example for Flash simulates a simple full-screen text terminal:

```
    import flash.display.Sprite;
    import flash.display.StageDisplayState;
    import flash.text.TextField;
    import flash.text.TextFormat;

    public class FullScreenTerminalExample extends Sprite
    {
        public function FullScreenTerminalExample():void
        {
            var terminal:TextField = new TextField();
            terminal.multiline = true;
            terminal.wordWrap = true;
            terminal.selectable = true;
            terminal.background = true;
            terminal.backgroundColor = 0x00333333;

            this.stage.displayState = StageDisplayState.FULL_SCREEN_INTERACTIVE;

            addChild(terminal);
            terminal.width = 550;
            terminal.height = 400;

            terminal.text = "Welcome to the dumb terminal application. Press the ESC key to 
exit.\n_";

            var tf:TextFormat = new TextFormat();
            tf.font = "Courier New";
            tf.color = 0x00CCFF00;
            tf.size = 12;
            terminal.setTextFormat(tf);

            terminal.setSelection(terminal.text.length - 1, terminal.text.length);
        }
    }
```

Chapter 53: Display screens in AIR

Adobe AIR 1.0 and later

Use the Adobe® AIR® Screen class to access information about the display screens attached to a computer or device.

More Help topics

flash.display.Screen

Basics of display screens in AIR

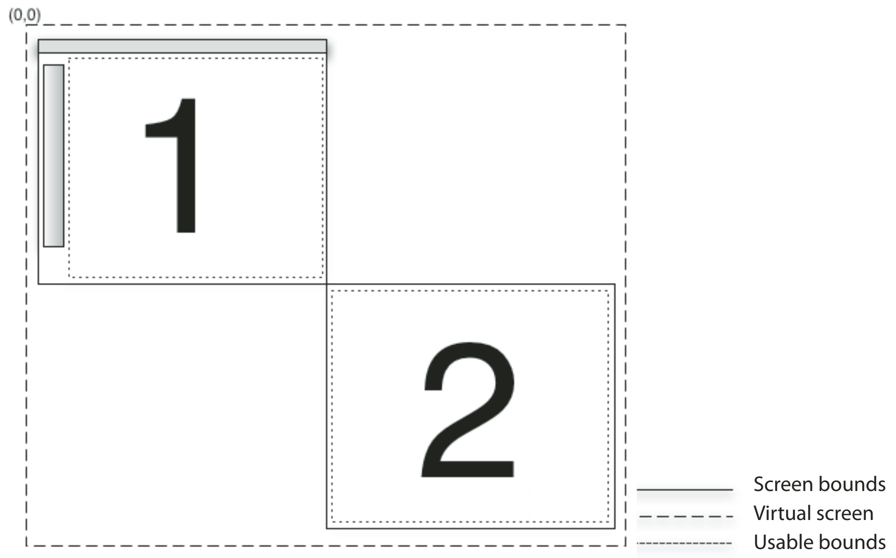
Adobe AIR 1.0 and later

- Measuring the virtual desktop (Flex)
- Measuring the virtual desktop (Flash)

The screen API contains a single class, Screen, which provides static members for getting system screen information, and instance members for describing a particular screen.

A computer system can have several monitors or displays attached, which can correspond to several desktop screens arranged in a virtual space. The AIR Screen class provides information about the screens, their relative arrangement, and their usable space. If more than one monitor maps to the same screen, only one screen exists. If the size of a screen is larger than the display area of the monitor, there is no way to determine which portion of the screen is currently visible.

A screen represents an independent desktop display area. Screens are described as rectangles within the virtual desktop. The upper-left corner of screen designated as the primary display is the origin of the virtual desktop coordinate system. All values used to describe a screen are provided in pixels.



In this screen arrangement, two screens exist on the virtual desktop. The coordinates of the upper-left corner of the main screen (#1) are always (0,0). If the screen arrangement is changed to designate screen #2 as the main screen, then the coordinates of screen #1 become negative. Menubars, taskbars, and docks are excluded when reporting the usable bounds for a screen.

For detailed information about the screen API class, methods, properties, and events, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

Enumerating the screens

Adobe AIR 1.0 and later

You can enumerate the screens of the virtual desktop with the following screen methods and properties:

Method or Property	Description
Screen.screens	Provides an array of Screen objects describing the available screens. The order of the array is not significant.
Screen.mainScreen	Provides a Screen object for the main screen. On Mac OS X, the main screen is the screen displaying the menu bar. On Windows, the main screen is the system-designated primary screen.
Screen.getScreensForRectangle()	Provides an array of Screen objects describing the screens intersected by the given rectangle. The rectangle passed to this method is in pixel coordinates on the virtual desktop. If no screens intersect the rectangle, then the array is empty. You can use this method to find out on which screens a window is displayed.

Do not save the values returned by the Screen class methods and properties. The user or operating system can change the available screens and their arrangement at any time.

The following example uses the screen API to move a window between multiple screens in response to pressing the arrow keys. To move the window to the next screen, the example gets the `screens` array and sorts it either vertically or horizontally (depending on the arrow key pressed). The code then walks through the sorted array, comparing each screen to the coordinates of the current screen. To identify the current screen of the window, the example calls `Screen.getScreensForRectangle()`, passing in the window bounds.

```
package {
    import flash.display.Sprite;
    import flash.display.Screen;
    import flash.events.KeyboardEvent;
    import flash.ui.Keyboard;
    import flash.display.StageAlign;
    import flash.display.StageScaleMode;

    public class ScreenExample extends Sprite
    {
        public function ScreenExample()
        {
                stage.align = StageAlign.TOP_LEFT;
                stage.scaleMode = StageScaleMode.NO_SCALE;

                stage.addEventListener(KeyboardEvent.KEY_DOWN,onKey);
        }

        private function onKey(event:KeyboardEvent):void{
            if(Screen.screens.length > 1){
                switch(event.keyCode){
                    case Keyboard.LEFT :
                        moveLeft();
                        break;
                    case Keyboard.RIGHT :
                        moveRight();
                        break;
                    case Keyboard.UP :
                        moveUp();
                        break;
                    case Keyboard.DOWN :
                        moveDown();
                        break;
                }
            }
        }

        private function moveLeft():void{
            var currentScreen = getCurrentScreen();
            var left:Array = Screen.screens;
            left.sort(sortHorizontal);
            for(var i:int = 0; i < left.length - 1; i++){
                if(left[i].bounds.left < stage.nativeWindow.bounds.left){
                    stage.nativeWindow.x +=
                        left[i].bounds.left - currentScreen.bounds.left;
                    stage.nativeWindow.y += left[i].bounds.top - currentScreen.bounds.top;
                }
            }
        }

        private function moveRight():void{
            var currentScreen:Screen = getCurrentScreen();
            var left:Array = Screen.screens;
            left.sort(sortHorizontal);
            for(var i:int = left.length - 1; i > 0; i--){
                if(left[i].bounds.left > stage.nativeWindow.bounds.left){
                    stage.nativeWindow.x +=
                        left[i].bounds.left - currentScreen.bounds.left;
                    stage.nativeWindow.y += left[i].bounds.top - currentScreen.bounds.top;
                }
            }
        }

        private function moveUp():void{
            var currentScreen:Screen = getCurrentScreen();
            var top:Array = Screen.screens;
            top.sort(sortVertical);
            for(var i:int = 0; i < top.length - 1; i++){
                if(top[i].bounds.top < stage.nativeWindow.bounds.top){
                    stage.nativeWindow.x += top[i].bounds.left - currentScreen.bounds.left;
                    stage.nativeWindow.y += top[i].bounds.top - currentScreen.bounds.top;
                    break;
                }
            }
        }

        private function moveDown():void{
            var currentScreen:Screen = getCurrentScreen();

            var top:Array = Screen.screens;
            top.sort(sortVertical);
            for(var i:int = top.length - 1; i > 0; i--){
                if(top[i].bounds.top > stage.nativeWindow.bounds.top){
                    stage.nativeWindow.x += top[i].bounds.left - currentScreen.bounds.left;
                    stage.nativeWindow.y += top[i].bounds.top - currentScreen.bounds.top;
                    break;
                }
            }
        }

        private function sortHorizontal(a:Screen,b:Screen):int{
            if (a.bounds.left > b.bounds.left){
                return 1;
            } else if (a.bounds.left < b.bounds.left){
                return -1;
            } else {return 0;}
        }

        private function sortVertical(a:Screen,b:Screen):int{
            if (a.bounds.top > b.bounds.top){
                return 1;
            } else if (a.bounds.top < b.bounds.top){
                return -1;
            } else {return 0;}
        }

        private function getCurrentScreen():Screen{
            var current:Screen;
            var screens:Array = Screen.getScreensForRectangle(stage.nativeWindow.bounds);
            (screens.length > 0) ? current = screens[0] : current = Screen.mainScreen;
            return current;
        }
    }
}
```

Chapter 54: Printing

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash runtimes (such as Adobe® Flash® Player and Adobe® AIR™) can communicate with an operating system's printing interface so that you can pass pages to the print spooler. Each page sent to the spooler can contain content that is visible, dynamic, or off screen to the user, including database values and dynamic text. Additionally, the properties of the flash.printing.PrintJob class contain values based on a user's printer settings, so that you can format pages appropriately.

The following content provides strategies for using the flash.printing.PrintJob class methods and properties to create a print job, read a user's print settings, and adjust a print job based on feedback from a Flash runtime and the user's operating system.

Basics of printing

Flash Player 9 and later, Adobe AIR 1.0 and later

In ActionScript 3.0, you use the PrintJob class to create snapshots of display content to convert to the ink-and-paper representation in a printout. In some ways, setting up content for printing is the same as setting it up for on-screen display—you position and size elements to create the desired layout. However printing has some idiosyncrasies that make it different from screen layout. For example, printers use different resolution than computer monitors; the contents of a computer screen are dynamic and can change, while printed content is inherently static; and in planning printing, consider the constraints of fixed page size and the possibility of multipage printing.

Even though these differences seem obvious, it's important to keep them in mind when setting up printing with ActionScript. Accurate printing depends on a combination of the values specified by you and the characteristics of the user's printer. The PrintJob class includes properties that allow you to determine the important characteristics of the user's printer.

Important concepts and terms

The following reference list contains important terms related to printing:

Spooler A portion of the operating system or printer driver software that tracks the pages as they are waiting to be printed and sends them to the printer when it is available.

Page orientation The rotation of the printed content in relation to the paper—either horizontal (landscape) or vertical (portrait).

Print job The page or set of pages that make up a single printout.

Printing a page

Flash Player 9 and later, Adobe AIR 1.0 and later

You use an instance of the PrintJob class to handle printing. To print a basic page through Flash Player or AIR, you use these four statements in sequence:

- `new PrintJob()`: Creates a new print job instance of the name you specify.
- `PrintJob.start()`: Initiates the printing process for the operating system, calling the print dialog box for the user, and populates the read-only properties of the print job.
- `PrintJob.addPage()`: Contains the details about the print job contents, including the Sprite object (and any children it contains), the size of the print area, and whether the printer prints the image as a vector or bitmap. You can use successive calls to `addPage()` to print multiple sprites over several pages.
- `PrintJob.send()`: Sends the pages to the operating system's printer.

So, for example, a simple print job script is (including `package`, `import` and `class` statements for compiling):

```
package
{
    import flash.printing.PrintJob;
    import flash.display.Sprite;

    public class BasicPrintExample extends Sprite
    {
        var myPrintJob:PrintJob = new PrintJob();
        var mySprite:Sprite = new Sprite();

        public function BasicPrintExample()
        {
            myPrintJob.start();
            myPrintJob.addPage(mySprite);
            myPrintJob.send();
        }
    }
}
```

Note: *This example is intended to show the basic elements of a print job script, and does not contain any error handling. To build a script that responds properly to a user canceling a print job, see "Working with exceptions and returns" on page 926.*

To clear a PrintJob object's properties for any reason, set the PrintJob variable to `null` (as in `myPrintJob = null`).

Flash runtime tasks and system printing

Flash Player 9 and later, Adobe AIR 1.0 and later

Because Flash runtimes dispatch pages to the operating system's printing interface, be aware of the tasks managed by Flash runtimes and the tasks managed by an operating system's own printing interface. Flash runtimes can initiate a print job, read some of a printer's page settings, pass the content for a print job to the operating system, and verify if the user or system has canceled a print job. Other processes, such as displaying printer specific dialog boxes, canceling a spooled print job, or reporting on the printer's status, are all handled by the operating system. Flash runtimes are able to respond if there is a problem initiating or formatting a print job, but can report back only on certain properties or conditions from the operating system's printing interface. As a developer, your code needs to respond to these properties or conditions.

Working with exceptions and returns

Flash Player 9 and later, Adobe AIR 1.0 and later

Check to see if the `PrintJob.start()` method returns `true` before executing `addPage()` and `send()` calls, in case the user has canceled the print job. A simple way to check whether these methods have been canceled before continuing is to wrap them in an `if` statement, as follows:

```
if (myPrintJob.start())
{
    // addPage() and send() statements here
}
```

If `PrintJob.start()` is `true`, the user selected Print (or a Flash runtime, such as Flash Player or AIR, has initiated a Print command). So, the `addPage()` and `send()` methods can be called.

Also, to help manage the printing process, Flash runtimes throw exceptions for the `PrintJob.addPage()` method, so that you can catch errors and provide information and options to the user. If a `PrintJob.addPage()` method fails, you can also call another function or stop the current print job. You catch these exceptions by embedding `addPage()` calls within a `try..catch` statement, as in the following example. In the example, `[params]` is a placeholder for the parameters specifying the actual content you want to print:

```
if (myPrintJob.start())
{
    try
    {
        myPrintJob.addPage([params]);
    }
    catch (error:Error)
    {
        // Handle error,
    }
    myPrintJob.send();
}
```

After the print job starts, you can add the content using `PrintJob.addPage()` and see if that generates an exception (for example, if the user has canceled the print job). If it does, you can add logic to the `catch` statement to provide the user (or the Flash runtime) with information and options, or you can stop the current print job. If you add the page successfully, you can proceed to send the pages to the printer using `PrintJob.send()`.

If the Flash runtime encounters a problem sending the print job to the printer (for example, if the printer is offline), you can catch that exception, too, and provide more information or more options (such as displaying message text or providing an alert within an animation). For example, you can assign new text to a text field in an `if..else` statement, as the following code shows:

```
if (myPrintJob.start())
{
    try
    {
        myPrintJob.addPage([params]);
    }
    catch (error:Error)
    {
        // Handle error.
    }
    myPrintJob.send();
}
else
{
    myAlert.text = "Print job canceled";
}
```

For a working example, see "Printing example: Scaling, cropping, and responding" on page 934.

Working with page properties

Flash Player 9 and later, Adobe AIR 1.0 and later

Once the user clicks OK in the Print dialog box and `PrintJob.start()` returns `true`, you can access the properties defined by the printer's settings. These settings include the paper width, paper height (`pageHeight` and `pageWidth`), and content orientation on the paper. Because these are printer settings, not controlled by the Flash runtime, you cannot alter these settings; however, you can use them to align the content you send to the printer to match the current settings. For more information, see "Setting size, scale, and orientation" on page 928.

Setting vector or bitmap rendering

Flash Player 9 and later, Adobe AIR 1.0 and later

You can manually set the print job to spool each page as vector graphics or a bitmap image. In some cases, vector printing produces a smaller spool file, and a better image than bitmap printing. However, if your content includes a bitmap image, and you want to preserve any alpha transparency or color effects, print the page as a bitmap image. Also, a non-PostScript printer automatically converts any vector graphics to bitmap images.

You specify bitmap printing by passing a PrintJobOptions object as the third parameter of `PrintJob.addPage()`.

For Flash Player and AIR prior to AIR 2, set the PrintJobOptions object's `printAsBitmap` parameter set to `true`, as follows:

```
var options:PrintJobOptions = new PrintJobOptions();
options.printAsBitmap = true;
myPrintJob.addPage(mySprite, null, options);
```

If you don't specify a value for the third parameter, the print job uses the default, which is vector printing.

For AIR 2 and later, use the PrintJobOptions object's `printMethod` property to specify the print method. This property accepts three values, which are defined as constants in the PrintMethod class:

- `PrintMethod.AUTO`: Automatically chooses the best print method based on the content being printed. For example, if a page consists of text, the vector print method is chosen. However, if a watermark image with alpha transparency is overlaid on the text, bitmap printing is chosen to preserve the transparency.
- `PrintMethod.BITMAP`: Forces bitmap printing regardless of the content
- `PrintMethod.VECTOR`: Forces vector printing regardless of the content

Timing print job statements

Flash Player 9 and later, Adobe AIR 1.0 and later

ActionScript 3.0 does not restrict a PrintJob object to a single frame (as did previous versions of ActionScript). However, because the operating system displays print status information to the user once the user has clicked the OK button in the Print dialog box, call `PrintJob.addPage()` and `PrintJob.send()` as soon as possible to send pages to the spooler. A delay reaching the frame containing the `PrintJob.send()` call delays the printing process.

In ActionScript 3.0, there is a script time-out limit of 15 seconds. Therefore, the time between each major statement in a print job sequence cannot exceed 15 seconds. In other words, the 15-second script time-out limit applies to the following intervals:

- Between `PrintJob.start()` and the first `PrintJob.addPage()`
- Between `PrintJob.addPage()` and the next `PrintJob.addPage()`
- Between the last `PrintJob.addPage()` and `PrintJob.send()`

If any of these intervals spans more than 15 seconds, the next call to `PrintJob.start()` on the PrintJob instance returns `false`, and the next `PrintJob.addPage()` on the PrintJob instance causes Flash Player or AIR to throw a runtime exception.

Setting size, scale, and orientation

Flash Player 9 and later, Adobe AIR 1.0 and later

The section "Printing a page" on page 925 details the steps for a basic print job, where the output directly reflects the printed equivalent of the screen size and position of the specified sprite. However, printers use different resolutions for printing, and can have settings that adversely affect the appearance of the printed sprite.

Flash runtimes can read an operating system's printing settings, but note that these properties are read-only: although you can respond to their values, you can't set them. So, for example, you can find out the printer's page size setting and adjust your content to fit the size. You can also determine a printer's margin settings and page orientation. To respond to the printer settings, specify a print area, adjust for the difference between a screen's resolution and a printer's point measurements, or transform your content to meet the size or orientation settings of the user's printer.

Using rectangles for the print area

Flash Player 9 and later, Adobe AIR 1.0 and later

The `PrintJob.addPage()` method allows you to specify the region of a sprite that you want printed. The second parameter, `printArea`, is in the form of a Rectangle object. You have three options for providing a value for this parameter:

- Create a Rectangle object with specific properties and then use that rectangle in the `addPage()` call, as in the following example:

```
private var rect1:Rectangle = new Rectangle(0, 0, 400, 200);
myPrintJob.addPage(sheet, rect1);
```

- If you haven't already specified a Rectangle object, you can do it within the call itself, as in the following example:

```
myPrintJob.addPage(sheet, new Rectangle(0, 0, 100, 100));
```

- If you plan to provide values for the third parameter in the `addPage()` call, but don't want to specify a rectangle, you can use `null` for the second parameter, as in the following;

```
myPrintJob.addPage(sheet, null, options);
```

Comparing points and pixels

Flash Player 9 and later, Adobe AIR 1.0 and later

A rectangle's width and height are pixel values. A printer uses points as print units of measurement. Points are a fixed physical size (1/72 inch), but the size of a pixel on the screen depends on the resolution of the particular screen. The conversion rate between pixels and points depends on the printer settings and whether the sprite is scaled. An unscaled sprite that is 72 pixels wide prints out one inch wide, with one point equal to one pixel, independent of screen resolution.

You can use the following equivalencies to convert inches or centimeters to twips or points (a twip is 1/20 of a point):

- 1 point = 1/72 inch = 20 twips
- 1 inch = 72 points = 1440 twips
- 1 centimeter = 567 twips

If you omit the `printArea` parameter, or if it is passed incorrectly, the full area of the sprite is printed.

Scaling

Flash Player 9 and later, Adobe AIR 1.0 and later

If you want to scale a Sprite object before you print it, set the scale properties (see "Manipulating size and scaling objects" on page 179) before calling the `PrintJob.addPage()` method, and set them back to their original values after printing. The scale of a Sprite object has no relation to the `printArea` property. In other words, if you specify a print area that is 50 pixels by 50 pixels, 2500 pixels are printed. If you scale the Sprite object, the same 2500 pixels are printed, but the Sprite object is printed at the scaled size.

For an example, see "Printing example: Scaling, cropping, and responding" on page 934.

Printing for landscape or portrait orientation

Flash Player 9 and later, Adobe AIR 1.0 and later

Because Flash Player and AIR can detect the settings for orientation, you can build logic into your ActionScript to adjust the content size or rotation in response to the printer settings, as the following example illustrates:

```
if (myPrintJob.orientation == PrintJobOrientation.LANDSCAPE)
{
    mySprite.rotation = 90;
}
```

***Note:** If you plan to read the system setting for content orientation on the paper, remember to import the PrintJobOrientation class. The PrintJobOrientation class provides constant values that define the content orientation on the page. You import the class using the following statement:*

```
import flash.printing.PrintJobOrientation;
```

Responding to page height and width

Flash Player 9 and later, Adobe AIR 1.0 and later

Using a strategy that is similar to handling printer orientation settings, you can read the page height and width settings and respond to them by embedding some logic into an `if` statement. The following code shows an example:

```
if (mySprite.height > myPrintJob.pageHeight)
{
    mySprite.scaleY = .75;
}
```

In addition, a page's margin settings can be determined by comparing the page and paper dimensions, as the following example illustrates:

```
margin_height = (myPrintJob.paperHeight - myPrintJob.pageHeight) / 2;
margin_width = (myPrintJob.paperWidth - myPrintJob.pageWidth) / 2;
```

Advanced printing techniques

Adobe AIR 2 and later

Starting with Adobe AIR 2, the PrintJob class has additional properties and methods, and three additional classes are supported: PrintUIOptions, PaperSize, and PrintMethod. These changes allow additional printer workflows and give authors greater control over the printing process. Changes include:

- Page setup dialogs: Both standard and custom page setup dialogs can be displayed. The user can set page ranges, paper size, orientation, and scaling before printing.
- Print view: A viewing mode can be created which accurately shows paper size, margins, and the position of content on the page.
- Restricted printing: Authors can restrict printing options, such as the range of printable pages.
- Quality options: Authors can adjust the print quality for a document and allow the user to select resolution and color options.

- Multiple print sessions: A single PrintJob instance can now be used for multiple printing sessions. Applications can provide consistent settings each time the page setup and print dialogs are displayed.

Print workflow changes

The new print workflow consists of the following steps:

- `new PrintJob()`: Creates a PrintJob instance (or reuse an existing instance). Many new PrintJob properties and methods, such as `selectPaperSize()`, are available before the print job starts or during printing.
- `PrintJob.showPageSetupDialog()`: (optional) Display the page setup dialog without starting a print job.
- `PrintJob.start()` or `PrintJob.start2()`: In addition to the `start()` method, the `start2()` method is used to initiate the print spooling process. The `start2()` method allows you to choose whether to display the Print dialog and customize the dialog if it is shown.
- `PrintJob.addPage()`: Add content to the print job. Unchanged from existing process.
- `PrintJob.send()` or `PrintJob.terminate()`: Send the pages to the selected printer or terminate the print job without sending. Print jobs are terminated in response to an error. If a PrintJob instance is terminated, it can still be reused. Regardless of whether the print job is sent to the printer or terminated, the current print settings are retained when you reuse the PrintJob instance.

Page setup dialog

The `showPageSetupDialog()` method displays the operating system's Page Setup dialog, if the current environment supports it. Always check the `supportsPageSetupDialog` property before calling this method. Here is a simple example:

```
import flash.printing.PrintJob;

var myPrintJob:PrintJob = new PrintJob();
//check for static property supportsPageSetupDialog of PrintJob class
if (PrintJob.supportsPageSetupDialog) {
    myPrintJob.showPageSetupDialog();
}
```

The method can optionally be called with a PrintUIOptions class property to control which options are displayed in the Page Setup dialog. The min and max page numbers can be set. The following example limits printing to the first three pages:

```
import flash.printing.PrintJob;

var myPrintJob:PrintJob = new PrintJob();
if (PrintJob.supportsPageSetupDialog) {
    var uiOpt:PrintUIOptions = new PrintUIOptions();
    uiOpt.minPage = 1;
    uiOpt.maxPage = 3;
    myPrintJob.showPageSetupDialog(uiOpt);
}
```

Changing print settings

The settings for a PrintJob instance can be changed at any time after it is constructed. This includes changing settings between `addPage()` calls and after a print job has been sent or terminated. Some settings, such as the `printer` property, apply to the entire print job, not individual pages. Those settings must be set before a call to `start()` or `start2()`.

The `selectPaperSize()` method can be called to set the default paper size in the Page Setup and Print dialogs. It can also be called during a print job to set the paper size for a range of pages. It is called using constants defined in the `PaperSize` class, as in this example, which selects a number 10 envelope size:

```
import flash.printing.PrintJob;
import flash.printing.PaperSize;

var myPrintJob:PrintJob = new PrintJob();
myPrintJob.selectPaperSize(PaperSize.ENV_10);
```

Use the `printer` property to get or set the name of the printer for the current print job. By default it is set to the name of the default printer. The `printer` property is `null` if no printers are available or the system does not support printing. To change the printer, first get the list of available printers using the `printers` property. That property is a Vector whose String elements are available printer names. Set the `printer` property to one of those String values to make that printer the active one. The `printer` property of an active print job cannot be changed. Attempts to change it after a successful call to `start()` or `start2()` and before the job is sent or terminated fail. Here is an example of setting this property:

```
import flash.printing.PrintJob;

var myPrintJob:PrintJob = new PrintJob();
myPrintJob.printer = "HP_LaserJet_1";
myPrintJob.start();
```

The `copies` property gets the value for the number of copies set in the operating system's Print dialog. The `firstPage` and `lastPage` properties get the page range. The `orientation` property gets the paper orientation setting. These properties can be set to override the values from the Print dialog. The following example sets these properties:

```
import flash.printing.PrintJob;
import flash.printing.PrintJobOrientation;

var myPrintJob:PrintJob = new PrintJob();
myPrintJob.copies = 3;
myPrintJob.firstPage = 1;
myPrintJob.lastPage = 3;
myPrintJob.orientation = PrintJobOrientation.LANDSCAPE;
```

The following read-only settings associated with `PrintJob` provide helpful information on the current printer setup:

- `paperArea`: The rectangular bounds of the printer medium, in points.
- `printableArea`: The rectangular bounds of the printable area, in points.
- `maxPixelsPerInch`: The physical resolution of the current printer, in pixels per inch.
- `isColor`: The ability of the current printer to print color (returns `true` if the current printer can print color).

See "Printing example: Page setup and print options" on page 936.

Printing example: Multiple-page printing

Flash Player 9 and later, Adobe AIR 1.0 and later

When printing more than one page of content, you can associate each page of content with a different sprite (in this case, `sheet1` and `sheet2`), and then use `PrintJob.addPage()` for each sprite. The following code illustrates this technique:

```
package
{
    import flash.display.MovieClip;
    import flash.printing.PrintJob;
    import flash.printing.PrintJobOrientation;
    import flash.display.Stage;
    import flash.display.Sprite;
    import flash.text.TextField;
    import flash.geom.Rectangle;

    public class PrintMultiplePages extends MovieClip
    {
        private var sheet1:Sprite;
        private var sheet2:Sprite;

        public function PrintMultiplePages():void
        {
            init();
            printPages();
        }

        private function init():void
        {
            sheet1 = new Sprite();
            createSheet(sheet1, "Once upon a time...", {x:10, y:50, width:80, height:130});
            sheet2 = new Sprite();
            createSheet(sheet2, "There was a great story to tell, and it ended quickly.\n\nThe
end.", null);
        }

        private function createSheet(sheet:Sprite, str:String, imgValue:Object):void
        {
            sheet.graphics.beginFill(0xEEEEEE);
            sheet.graphics.lineStyle(1, 0x000000);
            sheet.graphics.drawRect(0, 0, 100, 200);
            sheet.graphics.endFill();

            var txt:TextField = new TextField();
            txt.height = 200;
            txt.width = 100;
            txt.wordWrap = true;
            txt.text = str;

            if (imgValue != null)
            {
                var img:Sprite = new Sprite();
                img.graphics.beginFill(0xFFFFFF);
                img.graphics.drawRect(imgValue.x, imgValue.y, imgValue.width, imgValue.height);
                img.graphics.endFill();
                sheet.addChild(img);
            }
            sheet.addChild(txt);
        }

        private function printPages():void
        {
            var pj:PrintJob = new PrintJob();
            var pagesToPrint:uint = 0;
            if (pj.start())
            {
                if (pj.orientation == PrintJobOrientation.LANDSCAPE)
                {
                    throw new Error("Page is not set to an orientation of portrait.");
                }

                sheet1.height = pj.pageHeight;
                sheet1.width = pj.pageWidth;
                sheet2.height = pj.pageHeight;
                sheet2.width = pj.pageWidth;

                try
                {
                    pj.addPage(sheet1);
                    pagesToPrint++;
                }
                catch (error:Error)
                {
                // Respond to error.
                }

                try
                {
                    pj.addPage(sheet2);
                    pagesToPrint++;
                }
                catch (error:Error)
                {
                    // Respond to error.
                }

                if (pagesToPrint > 0)
                {
                    pj.send();
                }
            }
        }
    }
}
```

Printing example: Scaling, cropping, and responding

Flash Player 9 and later, Adobe AIR 1.0 and later

In some cases, you want to adjust the size (or other properties) of a display object when printing it to accommodate differences between the way it appears on screen and the way it appears printed on paper. When you adjust the properties of a display object before printing (for example, by using the `scaleX` and `scaleY` properties), be aware that if the object scales larger than the defined rectangle for the print area, the object is cropped. You will also probably want to reset the properties after the pages have been printed.

The following code scales the dimensions of the `txt` display object (but not the green box background), and the text field ends up cropped by the dimensions of the specified rectangle. After printing, the text field is returned to its original size for display on screen. If the user cancels the print job from the operating system's Print dialog box, the content in the Flash runtime changes to alert the user that the job has been canceled.

```
package
{
    import flash.printing.PrintJob;
    import flash.display.Sprite;
    import flash.text.TextField;
    import flash.display.Stage;
    import flash.geom.Rectangle;

    public class PrintScaleExample extends Sprite
    {
        private var bg:Sprite;
        private var txt:TextField;

        public function PrintScaleExample():void
        {
            init();
            draw();
            printPage();
        }

        private function printPage():void
        {
            var pj:PrintJob = new PrintJob();
            txt.scaleX = 3;
            txt.scaleY = 2;
            if (pj.start())
            {
                trace(">> pj.orientation: " + pj.orientation);
                trace(">> pj.pageWidth: " + pj.pageWidth);
                trace(">> pj.pageHeight: " + pj.pageHeight);
                trace(">> pj.paperWidth: " + pj.paperWidth);
                trace(">> pj.paperHeight: " + pj.paperHeight);

                try
                {
                    pj.addPage(this, new Rectangle(0, 0, 100, 100));
                }
                catch (error:Error)
                {
                    // Do nothing.
                }
                pj.send();
            }
            else
            {
                txt.text = "Print job canceled";
            }
            // Reset the txt scale properties.
            txt.scaleX = 1;
            txt.scaleY = 1;
        }
        private function init():void
        {
            bg = new Sprite();
            bg.graphics.beginFill(0x00FF00);
            bg.graphics.drawRect(0, 0, 100, 200);
            bg.graphics.endFill();

            txt = new TextField();
            txt.border = true;
            txt.text = "Hello World";
        }

        private function draw():void
        {
            addChild(bg);
            addChild(txt);
            txt.x = 50;
            txt.y = 50;
        }
    }
}
```

Printing example: Page setup and print options

Adobe AIR 2 and later

The following example initializes the PrintJob settings for number of copies, paper size (legal), and page orientation (landscape). It forces the Page Setup dialog to be displayed first, then starts the print job by displaying the Print dialog.

```
package
{
    import flash.printing.PrintJob;
    import flash.printing.PrintJobOrientation;
    import flash.printing.PaperSize;
    import flash.printing.PrintUIOptions;
    import flash.display.Sprite;
    import flash.text.TextField;
    import flash.display.Stage;
    import flash.geom.Rectangle;

    public class PrintAdvancedExample extends Sprite
    {
        private var bg:Sprite = new Sprite();
        private var txt:TextField = new TextField();
        private var pj:PrintJob = new PrintJob();
        private var uiOpt:PrintUIOptions = new PrintUIOptions();

        public function PrintAdvancedExample():void
        {
            initPrintJob();
            initContent();
            draw();
            printPage();
        }

        private function printPage():void
        {
            //test for dialog support as a static property of PrintJob class
            if (PrintJob.supportsPageSetupDialog)
            {
                pj.showPageSetupDialog();
            }
            if (pj.start2(uiOpt, true))
            {
                try
                {
                    pj.addPage(this, new Rectangle(0, 0, 100, 100));
                }
                catch (error:Error)
                {
                    // Do nothing.
                }
                pj.send();
            }
            else
            {
                txt.text = "Print job terminated";
                pj.terminate();
            }
        }

        private function initContent():void
        {
            bg.graphics.beginFill(0x00FF00);
            bg.graphics.drawRect(0, 0, 100, 200);
            bg.graphics.endFill();

            txt.border = true;
            txt.text = "Hello World";
        }

        private function initPrintJob():void
        {
            pj.selectPaperSize(PaperSize.LEGAL);
            pj.orientation = PrintJobOrientation.LANDSCAPE;
            pj.copies = 2;
            pj.jobName = "Flash test print";
        }

        private function draw():void
        {
            addChild(bg);
            addChild(txt);
            txt.x = 50;
            txt.y = 50;
        }
    }
}
```

Chapter 55: Geolocation

If a device supports geolocation, you can use the geolocation API to obtain the current geographical location of the device. If the device supports this feature, you can obtain geolocation information. This information includes the altitude, accuracy, heading, speed, and timestamp of the latest change in the location.

The Geolocation class dispatches `update` events in response to the device's location sensor. The `update` event is a GeolocationEvent object.

More Help topics

flash.sensors.Geolocation

flash.events.GeolocationEvent

Detecting geolocation changes

To use the geolocation sensor, instantiate a Geolocation object and register for `update` events it dispatches. The `update` event is a Geolocation event object. The event has eight properties:

- `altitude`—The altitude in meters.
- `heading`—The direction of movement (with respect to true north) in degrees.
- `horizontalAccuracy`—The horizontal accuracy in meters.
- `latitude`—The latitude in degrees.
- `longitude`—The longitude in degrees.
- `speed`—The speed in meters per second.
- `timestamp`—The number of milliseconds at the time of the event since the runtime was initialized.
- `verticalAccuracy`—The vertical accuracy in meters.

The `timestamp` property is an int object. The others are Number objects.

Here is a basic example that displays geolocation data in a text field:

```
var geo:Geolocation;
if (Geolocation.isSupported)
{
    geo = new Geolocation();
    geo.addEventListener(GeolocationEvent.UPDATE, updateHandler);
}
else
{
    geoTextField.text = "Geolocation feature not supported";
}
function updateHandler(event:GeolocationEvent):void
{
    geoTextField.text = "latitude: " + event.latitude.toString() + "\n"
            + "longitude: " + event.longitude.toString() + "\n"
            + "altitude: " + event.altitude.toString()
            + "speed: " + event.speed.toString()
            + "heading: " + event.heading.toString()
            + "horizontal accuracy: " + event.horizontalAccuracy.toString()
            + "vertical accuracy: " + event.verticalAccuracy.toString()
}
```

To use this example, be sure to create the `geoTextField` text field and add it to the display list before using this code.

You can adjust the desired time interval for geolocation events by calling the `setRequestedUpdateInterval()` method of the Geolocation object. This method takes one parameter, `interval`, which is the requested update interval in milliseconds:

```
var geo:Geolocation = new Geolocation();
geo.setRequestedUpdateInterval(10000);
```

The actual time between geolocation updates may be greater or lesser than this value. Any change in the update interval affects all registered listeners. If you don't call the `setRequestedUpdateInterval()` method, the application receives updates based on the device's default interval.

The user can prevent an application from accessing geolocation data. For example, the iPhone prompts the user when an application attempts to obtain geolocation data. In response to the prompt, the user can deny the application access to geolocation data. The Geolocation object dispatches a `status` event when the user makes access to geolocation data unavailable. Also, the Geolocation object has a `muted` property, which is set to `true` when the geolocation sensor is unavailable. The Geolocation object dispatches a `status` event when the `muted` property changes. The following code shows how to detect when geolocation data is unavailable:

```
package
{
    import flash.display.Sprite;
    import flash.display.StageAlign;
    import flash.display.StageScaleMode;
    import flash.events.GeolocationEvent;
    import flash.events.MouseEvent;
    import flash.events.StatusEvent;
    import flash.sensors.Geolocation;
    import flash.text.TextField;
    import flash.text.TextFormat;

    public class GeolocationTest extends Sprite
    {

        private var geo:Geolocation;
        private var log:TextField;

        public function GeolocationTest()
        {
            super();
            stage.align = StageAlign.TOP_LEFT;
            stage.scaleMode = StageScaleMode.NO_SCALE;
            setUpTextField();

            if (Geolocation.isSupported)
            {
                geo = new Geolocation();
                if (!geo.muted)
                {
                    geo.addEventListener(GeolocationEvent.UPDATE, geoUpdateHandler);
                }
                geo.addEventListener(StatusEvent.STATUS, geoStatusHandler);
            }
            else
            {
                log.text = "Geolocation not supported";
            }
        }

        public function geoUpdateHandler(event:GeolocationEvent):void
        {
            log.text = "latitude : " + event.latitude.toString() + "\n";
            log.appendText("longitude : " + event.longitude.toString() + "\n");
        }

        public function geoStatusHandler(event:StatusEvent):void
        {
            if (geo.muted)
                geo.removeEventListener(GeolocationEvent.UPDATE, geoUpdateHandler);
            else
                geo.addEventListener(GeolocationEvent.UPDATE, geoStatusHandler);
        }

        private function setUpTextField():void
        {
            log = new TextField();
            var format:TextFormat = new TextFormat("_sans", 24);
            log.defaultTextFormat = format;
            log.border = true;
            log.wordWrap = true;
            log.multiline = true;
            log.x = 10;
            log.y = 10;
            log.height = stage.stageHeight - 20;
            log.width = stage.stageWidth - 20;
            log.addEventListener(MouseEvent.CLICK, clearLog);
            addChild(log);
        }
        private function clearLog(event:MouseEvent):void
        {
            log.text = "";
        }
    }
}
```

***Note:** First-generation iPhones, which do not include a GPS unit, dispatch `update` events only occasionally. On these devices, a Geolocation object initially dispatches one or two `update` events. It then dispatches `update` events when information changes noticeably.*

Checking geolocation support

Use the `Geolocation.isSupported` property to test the runtime environment for the ability to use this feature:

```
if (Geolocation.isSupported)
{
    // Set up geolocation event listeners and code.
}
```

Currently, geolocation is only supported on ActionScript-based applications for the iPhone and in Flash Lite 4. If `Geolocation.isSupported` is `true` at run time, then geolocation support exists.

Some iPhone models do not have a GPS unit. These models use other means (such as mobile phone triangulation) to obtain geolocation data. For these models, or on any iPhone that has the GPS disabled, a Geolocation object may only dispatch one or two initial `update` events.

Chapter 56: Internationalizing applications

Flash Player 10.1 and later, Adobe AIR 2.0 and later

The flash.globalization package makes it easier to create international software that adapts to the conventions of different languages and regions.

More Help topics

flash.globalization package

"Localizing applications" on page 959

Charles Bihis: Want to Localize your Flex/AIR Apps?

Basics of internationalizing applications

The terms globalization and internationalization are sometimes used interchangeably. But most definitions of these terms say that globalization refers to a combination of business and engineering processes while internationalization refers to engineering alone.

Here are some definitions for important terms:

Globalization A broad range of engineering and business processes needed for preparing and launching products and company activities globally. Globalization consists of engineering activities like internationalization, localization and culturization and business activities like product management, financial planning, marketing, and legal work. Globalization is sometimes abbreviated as *G11n* (which stands for the letter G, then 11 more letters, and then the letter n). *"Globalization is what businesses do."*

Internationalization An engineering process for generalizing a product so that it can handle multiple languages, scripts and cultural conventions (including currencies, sorting rules, number and date formats, and more) without the need for redesign or recompilation. This process can be divided into two sets of activities: enablement and localization. Internationalization is sometimes known as *world-readiness*, and sometimes abbreviated as *I18n*. *"Internationalization is what engineers do."*

Localization A process of adapting a product or service to a particular language, culture, and desired local appearance. Localization is sometimes abbreviated as *L10n*. *"Localization is what translators do."*

Culturization An engineering process for developing or adapting specific features for the unique needs of a culture. Examples include the Japanese publishing features available in Adobe InDesign, and the Hanko support feature in Adobe Acrobat.

Some other important internationalization terms can be defined as follows:

Character Set The characters used by a language or by a group of languages. A character set includes national characters, special characters (such as punctuation marks and mathematical symbols), numeric digits, and computer control characters.

Collation The sorting of text into a proper order for a given locale.

Locale A value that represents the language and cultural conventions used in a geographical, political, or cultural region (which in many cases indicates a single country). A unique locale identifier (locale ID) represents this value. The locale ID is used to look up a set of locale data that provides locale-specific support. This support applies to measurement units, the parsing and formatting of numbers and dates, and so on.

Resource Bundle A stored set of locale-specific elements that are created for a locale in which an application is used. A resource bundle typically contains all text elements in the application's user interface. Within the bundle, these elements are translated into the appropriate language for the given locale. It can also contain other settings that alter the layout or behavior of the user interface for a specific locale. A resource bundle can contain other media types, or references to other media types, that are locale-specific.

Overview of the flash.globalization package

Flash Player 10.1 and later, Adobe AIR 2.0 and later

The flash.globalization package harnesses the cultural support capabilities of the underlying operating system. It makes it easier to write applications that follow the cultural conventions of individual users.

The main classes in the package include:

- The Collator class which governs the sorting and matching of strings
- The CurrencyFormatter class which formats numbers into currency amount strings, and parses currency amounts and symbols from input strings
- The DateTimeFormatter class which formats date values
- The LocaleID class for retrieving information about a specific locale
- The NumberFormatter class which formats and parses numeric values
- The StringTools class which handles locale-sensitive case conversion of strings

The flash.globalization package and resource localization

The flash.globalization package doesn't handle resource localization. However you can use the flash.globalization locale ID as the key value for retrieving localized resources using other techniques. For example, you can localize application resources built with Flex using the ResourceManager and ResourceBundle classes. For more information, see Localizing Flex Applications.

Adobe AIR 1.1 also contains some features to help localize AIR applications, as discussed in "Localizing AIR applications" on page 960.

A general approach to internationalizing an application

The following steps describe a high-level common approach for internationalizing an application using the flash.globalization package:

1. Determine or set the locale.
2. Create an instance of a service class (Collator, CurrencyFormatter, DateTimeFormatter, NumberFormatter, or StringTools).
3. Check for errors and fallbacks using lastOperationStatus properties.
4. Format and display information using locale-specific settings.

The next step is to load and display strings and user interface resources that are specific to the locale. This step can include tasks such as:

- Using the autolayout features to resize the UI to accommodate the string lengths
- Choosing the right fonts and supporting font fallbacks
- Using the FTE text engine to support other writing systems
- Ensuring that input method editors are correctly handled

Checking for errors and fallbacks

The flash.globalization service classes all follow a similar pattern for identifying errors. They also share a pattern for falling back from an unavailable requested locale to one that the user's operating system supports.

The following example shows how to check for errors and fallbacks when instantiating service classes. Each service class has a lastOperationStatus property that indicates whether the most recent method call triggered their errors or warnings.

```
var nf:NumberFormatter = new NumberFormatter("de-DE");
if(nf.lastOperationStatus != LastOperationStatus.NO_ERROR)
{
    if(nf.lastOperationStatus == LastOperationStatus.USING_FALLBACK_WARNING)
    {
        // perform fallback logic here, if needed
        trace("Warning - Fallback locale ID: " + nf.actualLocaleIDName);
    }
    else
    {
        // perform error handling logic here, if needed
        trace("Error: " + nf.lastOperationStatus);
    }
}
```

This example simply traces a message if a fallback locale ID is used, or if there is an error. Your application can perform additional error handling logic, if needed. For example, you could display a message to the user or force the application to use a specific, supported locale.

Determining the locale

Flash Player 10.1 and later, Adobe AIR 2.0 and later

A locale identifies a specific combination of language and cultural conventions for a country or region.

A locale identifier can be safely managed as a string. But you can use the LocaleID class to obtain additional information related to a locale.

You create a LocaleID object as follows:

```
var locale:LocaleID = new LocaleID("es-MX");
```

After the LocaleID object is created, you can retrieve data about the locale ID. Use the `getKeysAndValues()`, `getLanguage()`, `getRegion()`, `getScript()`, `getVariant()`, and `isRightToLeft()` methods, and the `name` property.

The values retrieved from these methods and properties can reflect additional information that cannot be extracted directly from the locale identifier about the locale.

When an application creates a locale-aware service, such as a date formatter, it must specify the intended locale. The list of supported locales varies from one operating system to another; hence, the requested locale can be unavailable.

Flash Player first tries to match the language code of the locale that you requested. Then it tries to refine the locale by finding a matching writing system (script) and region. For example:

```
var loc:LocaleID = new LocaleID("es");
trace(loc.getLanguage()); // es
trace(loc.getScript()); // Latn
trace(loc.getRegion()); // ES
```

In this example, the `LocaleID()` constructor retrieved data about the locale that best matches the language code "es" for that user.

Setting the locale ID

There are a number of ways to set the current locale for an application, including:

- Hard-code a single locale ID into the application. This approach is common, but it does not support internationalization of the application.
- Use the locale ID preferences from the user's operating system, or browser, or other user preferences. This technique usually results in the best locale settings for the user, but it is not always accurate. There is a risk that the operating system settings do not reflect the user's actual preferences. For example, the user could be using a shared computer and be unable to change the operating system's preferred locales.
- After setting the locale ID based on the user's preferences, let the user select from a list of supported locales. This strategy is normally the best option if your application can support more than one locale.

You can implement this third option as follows:

1. Retrieve a list of the user's preferred locales or languages from a user profile, browser settings, operating system settings, or a cookie. (Your application would need to implement this logic itself. The flash.globalization library does not support reading such preferences directly.)
2. Determine which of those locales your application supports and select the best one by default. Use the method LocaleID.determinePreferredLocales() to find the best locales for a user based on their preferred locales and the locales supported by the operating system.
3. Give the user a way to change the default locale setting in case the default locale is not satisfactory.

Limitations of other locale and language classes

The `fl.lang.Locale` class lets you replace text strings based on a locale, using resource bundles containing string values. However this class does not support other internationalization features such as number, currency, or date formatting, sorting and matching, and so on. In addition, this class is only available with Flash Professional.

You can also retrieve the current language code setting for the operating system using the `flash.system.Capabilities.language` property. However, this property retrieves only the two-character ISO 639-1 language code—not the full locale ID—and it only supports a specific set of locales.

With AIR 1.5, you can use the `flash.system.Capabilities.languages` property. This property provides an array of the user's preferred user interface languages. Thus, it does not have the limitations of `Capabilities.language`.

Formatting numbers

Flash Player 10.1 and later, Adobe AIR 2.0 and later

The display format of numeric values varies widely from region to region. For example, here is how the number 123456.78 is formatted for certain locales:

Locale	Number Format
en-US (English, USA)	-123,456.78
de-DE (German, Germany)	-123.456,78
fr-FR (France, French)	-123 456,78
de-CH (German, Switzerland)	-123'456.78
en-IN (English, India)	-1,23,456.78
Many Arabic locales	123,456.78-

There are many factors that influence number formats, including:

- Separators. The decimal separator is placed between the integer and fractional portions of a number. It can be a period, comma, or another character. The grouping separator or thousands separator can be a period, a comma, a non-breaking space, or another character.
- Grouping patterns. The number of digits between each grouping separator to the left of the decimal point can be two or three or another value.
- Negative number indicators. Negative numbers can be shown with a minus sign to the left or the right of the number, or within parentheses for financial applications. For example, negative 19 can be shown as -19, 19-, or (19).
- Leading and trailing zeroes. Some cultural conventions add leading or trailing zeroes to displayed numbers. For example the value 0.17 can be displayed as .17, 0.17, or 0.170, among other options.
- Sets of digit characters. Many languages, including Hindi, Arabic, and Japanese, use different sets of digit characters. The flash.globalization package supports any digit character sets that map to the digits 0-9.

The NumberFormatter class considers all of these factors when formatting numeric values.

Using the NumberFormatter class

The NumberFormatter class formats numeric values (of type int, uint, or Number) according to the conventions of a specific locale.

The following example shows the simplest way to format a number using the default formatting properties provided by the user's operating system:

```
var nf:NumberFormatter = new NumberFormatter(LocaleID.DEFAULT);
trace(nf.formatNumber(-123456.789))
```

The result vary based on the user's locale settings and user preferences. For example, if the user's locale is fr-FR then the formatted value would be:

-123.456,789

If you only want to format a number for a specific locale, regardless of the user's settings, set the locale name specifically. For example:

```
var nf:NumberFormatter = new NumberFormatter("de-CH");
trace(nf.formatNumber(-123456.789));
```

The result in this case are:

-123'456.789

The formatNumber() method takes a Number as a parameter. The NumberFormatter class also has a formatInt() method that takes an int as input, and a formatUint() method that takes a uint.

You can explicitly control the formatting logic by setting properties of the NumberFormatter class, as shown in this example:

```
var nf:NumberFormatter = new NumberFormatter("de-CH");
nf.negativeNumberFormat = 0;
nf.fractionalDigits = 5;
nf.trailingZeros = true;
nf.decimalSeparator = ",";
nf.useGrouping = false;
trace(nf.formatNumber(-123456.789)); //(123456.78900)
```

This example first creates a NumberFormatter object and then:

- sets the negative number format to use parentheses (as in financial applications);
- sets the number of digits after the decimal separator to 5;
- specifies that trailing zeroes be used to ensure five decimal places;
- sets the decimal separator to a comma;
- tells the formatter not to use any grouping separators.

***Note:** When some of these properties change, the resulting number format no longer corresponds to the preferred format for the specified locale. Use some of these properties only when locale-awareness is not important; when you need detailed control over a single aspect of the format, such as the number of trailing zeroes; or when the user requests the change directly, for example, through the Windows Control Panel.*

Parsing strings that contain numeric values

The NumberFormatter class can also extract numeric values from strings that conform to locale-specific formatting requirements. The NumberFormatter.parseNumber() method extracts a single numeric value from a string. For example:

```
var nf:NumberFormatter = new NumberFormatter( "en-US" );
var inputNumberString:String =  "-1,234,567.890"
var parsedNumber:Number = nf.parseNumber(inputNumberString);
trace("Value:" + parsedNumber); // -1234567.89
trace("Status:" + nf.lastOperationStatus); // noError
```

The parseNumber() method handles strings that contain only digits and number formatting characters such as negative signs and separators. If the string contains other characters, an error code is set:

```
var nf:NumberFormatter = new NumberFormatter( "en-US" );
var inputNumberString:String =  "The value is 1,234,567.890"
var parsedNumber:Number = nf.parseNumber(inputNumberString);
trace("Value:" + parsedNumber); // NaN
trace("Status:" + nf.lastOperationStatus); // parseError
```

To extract numbers from strings that contain additional alphabetic characters, use the NumberFormatter.parse() method:

```
var nf:NumberFormatter = new NumberFormatter( "en-US" );
var inputNumberString:String = "The value is 123,456,7.890";
var parseResult:NumberParseResult = nf.parse(inputNumberString);
trace("Value:" + parseResult.value); // 1234567.89
trace("startIndex: " + parseResult.startIndex); // 14
trace("Status:" + nf.lastOperationStatus); // noError
```

The parse() method returns a NumberParseResult object that contains the parsed numeric value in its value property. The startIndex property indicates the index of the first numeric character that was found. You can use the startIndex and endIndex properties to extract the portions of the string that come before and after the digits.

Formatting currency values

Flash Player 10.1 and later, Adobe AIR 2.0 and later

The display formats of currency values vary as much as number formats do. For example, here is how the US dollar value $123456.78 is formatted for certain locales:

Locale	**Number Format**
en-US (English, USA)	$123,456.78
de-DE (German, Germany)	123.456,78 $
en-IN (English, India)	$ 1,23,456.78

Currency formatting involves all the same factors as number formatting, plus these additional factors:

- Currency ISO code. The three letter ISO 4217 currency code for the actual locale being used, such as USD or EUR.
- Currency symbol. The currency symbol or string for the actual locale being used, such as $ or €.
- Negative currency format. Defines the location of the currency symbol and the negative symbol or parentheses in relation to the numeric portion of the currency amount.
- Positive currency format. Defines the location of currency symbol relative to the numeric portion of the currency amount.

Using the CurrencyFormatter class

The CurrencyFormatter class formats numeric values into strings that contain currency strings and formatted numbers, according to the conventions of a specific locale.

When you instantiate a new CurrencyFormatter object, it sets its currency to the default currency for the given locale.

The following example shows that a CurrencyFormatter object created using a German locale assumes that currency amounts are in Euros:

```
var cf:CurrencyFormatter = new CurrencyFormatter( "de-DE" );
trace(cf.format(1234567.89)); // 1.234.567,89 EUR
```

In most cases, do not rely on the default currency for a locale. If the user's default locale is not supported, then the CurrencyFormatter class assigns a fallback locale. The fallback locale can have a different default currency. In addition, you normally want the currency formats to look correct to your user, even if the amounts are not in the user's local currency. For example, a Canadian user can want to see a German company's prices in Euros, but formatted in the Canadian style.

The CurrencyFormatter.setCurrency() method specifies the exact currency string and currency symbol to use.

The following example shows currency amounts in Euros to users in the French part of Canada:

```
var cf:CurrencyFormatter = new CurrencyFormatter( "fr-CA" );
cf.setCurrency("EUR", "€");
trace(cf.format(1234567.89)); // 1.234.567,89 EUR
```

The setCurrency() method can also be used to reduce confusion by setting unambiguous currency symbols. For example:

```
cf.setCurrency("USD","US$");
```

By default the format() method displays a three character ISO 4217 currency code instead of the currency symbol. ISO 4217 codes are unambiguous and do not require localization. However many users prefer to see currency symbols rather than ISO codes.

The CurrencyFormatter class can help you decide which symbol a formatted currency string uses: a currency symbol, like a dollar sign or Euro sign, or a three character ISO currency string, such as USD or EUR. For example, an amount in Canadian dollars could be displayed as $200 for a user in Canada. For a user in the United States, however, it could be displayed as CAD 200. Use the method formattingWithCurrencySymbolIsSafe() to determine whether the amount's currency symbol would be ambiguous or incorrect given the user's locale settings.

The following example formats a value in Euros into a format for the en-US locale. Depending on the user's locale, the output string uses either the ISO currency code or the currency symbol.

```
var cf:CurrencyFormatter = new CurrencyFormatter( "en-CA");

if (cf.formattingWithCurrencySymbolIsSafe("USD"))
{
    trace(cf.format(1234567.89, true)); // $1,234,567.89
}
else
{
    cf.setCurrency("USD", "$");
    trace(cf.format(1234567.89)); // USD1,234,567.89
}
```

Parsing strings that contain currency values

The CurrencyFormatter class can also extract a currency amount and a currency string from an input string that conforms to locale-specific formatting requirements. The CurrencyFormatter.parse() method stores the parsed amount and currency string in a CurrencyParseResult object, as shown here:

```
var cf:CurrencyFormatter = new CurrencyFormatter( "en-US" );
var inputCurrencyString:String = "(GBP 123,56,7.890)";
var parseResult:CurrencyParseResult = cf.parse(inputCurrencyString);
trace("parsed amount: " + parseResult.value); // -1234567.89
trace("currencyString: " + parseResult.currencyString ); // GBP
```

The currency string portion of the input string can contain a currency symbol, a currency ISO code, and additional text characters. The positions of the currency string, the negative number indicator, and the numeric value, match the formats specified by the negativeCurrencyFormat and positiveCurrencyFormat properties. For example:

```
var cf:CurrencyFormatter = new CurrencyFormatter( "en-US" );
var inputCurrencyString:String = "Total $-123,56,7.890";
var parseResult:CurrencyParseResult = cf.parse(inputCurrencyString);
trace("status: " + cf.lastOperationStatus ); // parseError
trace("parsed amount: " + parseResult.value); // NaN
trace("currencyString: " + parseResult.currencyString ); //
cf.negativeCurrencyFormat = 2;
parseResult = cf.parse(inputCurrencyString);
trace("status: " + cf.lastOperationStatus ); // noError
trace("parsed amount: " + parseResult.value); // -123567.89
trace("currencyString: " + parseResult.currencyString ); // Total $
```

In this example, the input string has a currency string followed by a minus sign and a number. However the default negativeCurrencyFormat value for the en-US locale specifies that the negative indicator comes first. As a result, the parse() method generates an error and the parsed value is NaN.

After it sets the negativeCurrencyFormat to 2, which specifies that the currency string comes first, the parse() method succeeds.

Formatting dates and times

Flash Player 10.1 and later, Adobe AIR 2.0 and later

The display format of date and time values also varies widely from region to region. For example, here is how the second day of January, 1962 at 1:01 PM is displayed in a short format for certain locales:

Locale	Date and Time Format
en-US (English, USA)	1/2/62 1:01pm
fr-FR (France, French)	2/1/62 13:01
ja-JP (Japan, Japanese)	1962/2/1 13:01

Using the DateTimeFormatter class

The DateTimeFormatter class formats Date values into date and time strings according to the conventions of a specific locale.

Formatting follows a pattern string which contains sequences of letters that are replaced with date or time values. For example, in the pattern "yyyy/MM" the characters "yyyy" are replaced with a four-digit year, followed by a "/" character, and a two-digit month.

The pattern string can be set explicitly using the setDateTimePattern() method. However it is best to let the pattern be set automatically according to the user's locale and operating system preferences. This practice helps assure that the result is culturally appropriate.

The DateTimeFormatter can represent dates and times in three standard styles (LONG, MEDIUM, and SHORT) and it can also use a CUSTOM pattern. One style can be used for the date, and a second style for the time. The actual patterns used for each style vary somewhat by operating system.

You can specify the styles when you create a DateTimeFormatter object. If the style parameters are not specified, then they are set to DateTimeStyle.LONG by default. You can change the styles later by using the setDateTimeStyles() method, as shown in the following example:

```
var date:Date = new Date(2009, 2, 27, 13, 1);
var dtf:DateTimeFormatter = new DateTimeFormatter("en-US",
    DateTimeStyle.LONG, DateTimeStyle.LONG);

var longDate:String = dtf.format(date);
trace(longDate); // March 27, 2009 1:01:00 PM

dtf.setDateTimeStyles(DateTimeStyle.SHORT, DateTimeStyle.SHORT);
var shortDate:String = dtf.format(date);
trace(shortDate); // 3/27/09 1:01 PM
```

Localizing month names and day names

Many applications use lists of month names and the names of the days of the week in calendar displays or pull-down lists.

You can retrieve a localized list of the month names using the method DateTimeFormatter.getMonthNames(). Depending on the operating system, full and abbreviated forms might be available. Pass the value DateTimeNameStyle.FULL to get full length month names. Pass the values DateTimeNameStyle.LONG_ABBREVIATION or DateTimeNameStyle.SHORT_ABBREVIATION to get shorter versions.

In some languages, a month name changes (into its genitive form) when it is placed next to the day value in a date format. If you plan to use the month names alone, pass the value DateTimeNameContext.STANDALONE to the getMonthNames() method. To use the month names in formatted dates, however, pass the value DateTimeNameContext.FORMAT.

```
var dtf:DateTimeFormatter = new DateTimeFormatter("fr-FR");
var months:Vector.<String> = dtf.getMonthNames(DateTimeNameStyle.FULL,
        DateTimeNameContext.STANDALONE);
trace(months[0]); // janvier
months = dtf.getMonthNames(DateTimeNameStyle.SHORT_ABBREVIATION,
         DateTimeNameContext.STANDALONE);
trace(months[0]); // janv.
```

The DateTimeFormatter.getWeekdayNames() method provides a localized list of the names of the days of the week. The getWeekdayNames() method accepts the same nameStyle and context parameters that the getMonthNames() method does.

```
var dtf:DateTimeFormatter = new DateTimeFormatter("fr-FR");
var weekdays:Vector.<String> = dtf.getWeekdayNames(DateTimeNameStyle.FULL,
           DateTimeNameContext.STANDALONE);
trace(weekdays[0]); // dimanche
weekdays = dtf.getWeekdayNames(DateTimeNameStyle.LONG_ABBREVIATION,
           DateTimeNameContext.STANDALONE);
trace(weekdays[0]); // dim.
```

In addition, the getFirstWeekday() method returns the index value of the day that traditionally marks the beginning of the week in the selected locale.

Sorting and comparing strings

Flash Player 10.1 and later, Adobe AIR 2.0 and later

Collation is the process of arranging things in their proper order. Collation rules vary significantly by locale. The rules also differ if you are sorting a list or matching similar items, such as in a text search algorithm.

When sorting, small differences such as upper and lowercase letters or diacritic marks such as accents, are often significant. For example, the letter ö (o with a diaeresis) is considered mostly equivalent to the plain letter o in French or English. The same letter, however, follows the letter z in Swedish. Also, in French and some other languages, the last accent difference in a word determines its order in a sorted list.

When searching, you often want to ignore differences in case or diacritics, to increase the chance of finding relevant matches. For example, a search for the characters "cote" in a French document conceivably returns matches for "cote", "côte", and "coté".

Using the Collator class

The main methods of the Collator class are the compare() method, used primarily for sorting, and the equals() method, used for matching values.

The following example shows the different behavior of the compare() and equals() methods.

```
var words:Array = new  Array("coté", "côte");

var sorter:Collator = new Collator("fr-FR", CollatorMode.SORTING);
words.sort(sorter.compare);
trace(words); // côte,coté

var matcher:Collator = new Collator("fr-FR", CollatorMode.MATCHING);
if (matcher.equals(words[0], words[1]))
{
    trace(words[0] + " = " + words[1]); // côte = coté
}
```

The example first creates a Collator object in SORTING mode for the French-France locale. Then it sorts two words that differ only by diacritical marks. This shows that the SORTING comparison distinguishes between accented and non-accented characters.

The sorting is performed by passing a reference to the Collator object's sort() method as a parameter to the Array.sort() method. This technique is one of the most efficient ways of using a Collator object to control sort order.

The example then creates a Collator object in MATCHING mode. When that Collator object compares the two words, it treats them as equal. That shows that the MATCHING comparison values accented and non-accented characters the same.

Customizing the behavior of the Collator class

By default, the Collator class uses string comparison rules obtained from the operating system based on the locale and the user's system preferences. You can customize the behavior of the compare() and equals() methods by explicitly setting various properties. The following table lists the properties and the effect they have upon comparisons:

Collator Property	**Effect**
numericComparison	Controls whether digit characters are treated as numbers or as text.
ignoreCase	Controls whether uppercase and lowercase differences are ignored.
ignoreCharacterWidth	Controls whether full-width and half-width forms of some Chinese and Japanese characters are evaluated as equal.
ignoreDiacritics	Controls whether strings that use the same base characters but different accents or other diacritic marks are evaluated as equal.
ignoreKanaType	Controls whether strings that differ only by the type of kana character being used are treated as equal.
ignoreSymbols	Controls whether symbol characters such as spaces, currency symbols, math symbols, and others are ignored.

The following code shows that setting the ignoreDiacritics property to true changes the sort order of a list of French words:

```
var words:Array = new  Array("COTE", "coté", "côte", "Coté","cote");
var sorter:Collator = new Collator("fr-CA", CollatorMode.SORTING);
words.sort(sorter.compare);
trace(words); // cote,COTE,côte,coté,Coté

sorter.ignoreDiacritics = true;
words.sort(sorter.compare);
trace(words); // côte,coté,cote,Coté,COTE
```

Case conversion

Flash Player 10.1 and later, Adobe AIR 2.0 and later

Languages also differ in their rules for converting letters between uppercase forms (majiscules) and lowercase forms (miniscules).

For example, in most languages that use the Latin alphabet the lowercase form of the capital letter "I" is "i". However in some languages (such as Turkish and Azeri) there is an additional dotless letter "ı". As a result in those languages a lowercase dotless "ı" transforms into an uppercase "I". A lowercase "i" transforms into an uppercase "İ" with a dot.

The StringTools class provides methods that use language-specific rules to perform such transformations.

Using the StringTools class

The StringTools class provides two methods to perform case transformations: toLowerCase() and toUpperCase(). You create a StringTools object by calling the constructor with a locale ID. The StringTools class retrieves the case conversion rules for that locale (or a fallback locale) from the operating system. It is not possible to further customize the case conversion algorithm.

The following example uses the toUpperCase() and toLowerCase() methods to transform a German phrase that includes the letter "ß" (sharp S).

```
var phrase:String = "Schloß Neuschwanstein";
var converter:StringTools = new StringTools("de-DE");

var upperPhrase:String = converter.toUpperCase(phrase);
trace(upperPhrase); // SCHLOSS NEUSCHWANSTEIN

var lowerPhrase:String = converter.toLowerCase(upperPhrase);
trace(lowerPhrase);// schloss neuschwanstein
```

The toUpperCase() method transforms the lowercase letter "ß" into the uppercase letters "SS". This transformation works only in one direction. When the letters "SS" are transformed back to lowercase, the result is "ss" not "ß".

Example: Internationalizing a stock ticker application

Flash Player 10.1 and later, Adobe AIR 2.0 and later

The Global Stock Ticker application retrieves and displays fictitious data about stocks in three different stock markets: the United States, Japan, and Europe. It formats the data according to the conventions of various locales.

This example illustrates the following features of the flash.globalization package:

- Locale-aware number formatting
- Locale-aware currency formatting
- Setting currency ISO code and currency symbols
- Locale-aware date formatting
- Retrieving and displaying appropriate month name abbreviations

To get the application files for this sample, see www.adobe.com/go/learn_programmingAS3samples_flash. The Global Stock Ticker application files can be found in the folder Samples/GlobalStockTicker. The application consists of the following files:

File	Description
GlobalStockTicker.mxml or GlobalStockTicker.fla	The user interface for the application for Flex (MXML) or Flash (FLA).
styles.css	Styles for the application user interface (Flex only).
com/example/programmingas3/stockticker/flex/FinGraph.mxml	An MXML component that displays a chart of simulated stock data, for Flex only.
com/example/programmingas3/stockticker/flash/GlobalStockTicker.as	Document class containing the user interface logic for the application (Flash only).
comp/example/programmingas3/stockticker/flash/RightAlignedColumn.as	A custom cell renderer for the Flash DataGrid component (Flash only).

File	Description
com/example/programmingas3/stockticker/FinancialGraph.as	An ActionScript class that draws a chart of simulated stock data.
com/example/programmingas3/stockticker/Localizer.as	An ActionScript class that manages the locale and currency and handles the localized formatting of numbers, currency amounts, and dates.
com/example/programmingas3/stockticker/StockDataModel.as	An ActionScript class that holds all the sample data for the Global Stock Ticker example.

Understanding the user interface and sample data

The application's main user interface elements are:

- a combo box for selecting a Locale
- a combo box for selecting a Market
- a DataGrid that displays data for six companies in each market
- a chart that shows simulated historical data for the selected company's stock

The application stores all of its sample data about locales, markets, and company stocks in the StockDataModel class. A real application would retrieve data from a server and then store it in a class like StockDataModel. In this example, all the data is hard coded in the StockDataModel class.

***Note:** The data displayed in the financial chart doesn't necessarily match the data shown in the DataGrid control. The chart is randomly redrawn each time a different company is selected. It is for illustration purposes only.*

Setting the locale

After some initial setup work, the application calls the method Localizer.setLocale() to create formatter objects for the default locale. The setLocale() method is also called each time the user selects a new value from the Locale combo box.

```
public function setLocale(newLocale:String):void
{
    locale  = new LocaleID(newLocale);

    nf = new NumberFormatter(locale.name);
    traceError(nf.lastOperationStatus, "NumberFormatter", nf.actualLocaleIDName);

    cf = new CurrencyFormatter(locale.name);
    traceError(cf.lastOperationStatus, "CurrencyFormatter", cf.actualLocaleIDName);
    symbolIsSafe = cf.formattingWithCurrencySymbolIsSafe(currentCurrency);
    cf.setCurrency(currentCurrency, currentSymbol);
    cf.fractionalDigits = currentFraction;

    df = new DateTimeFormatter(locale.name, DateTimeStyle.LONG, DateTimeStyle.SHORT);
    traceError(df.lastOperationStatus, "DateTimeFormatter", df.actualLocaleIDName);
    monthNames = df.getMonthNames(DateTimeNameStyle.LONG_ABBREVIATION);
}

public function traceError(status:String, serviceName:String, localeID:String) :void
{
    if(status != LastOperationStatus.NO_ERROR)
    {
        if(status == LastOperationStatus.USING_FALLBACK_WARNING)
        {
            trace("Warning - Fallback locale ID used by "
                    + serviceName + ": " + localeID);
        }
        else if (status == LastOperationStatus.UNSUPPORTED_ERROR)
        {
            trace("Error in " + serviceName + ": " + status);
            //abort application
            throw(new Error("Fatal error", 0));
        }
        else
        {
            trace("Error in " + serviceName + ": " + status);
        }
    }
    else
    {
        trace(serviceName + " created for locale ID: " + localeID);
    }
}
```

First the setLocale() method creates a LocaleID object. This object makes it easier to get details about the actual locale later, if needed.

Next it creates new NumberFormatter, CurrencyFormatter, and DateTimeFormatter objects for the locale. After creating each formatter object it calls the traceError() method. This method displays error and warning messages in the console if there is a problem with the requested locale. (A real application should react based on such errors rather than just tracing them).

After creating the CurrencyFormatter object, the setLocale() method sets the formatter's currency ISO code, currency symbol, and fractionalDigits properties to previously determined values. (Those values are set each time the user selects a new market from the Markets combo box).

After creating the DateTimeFormatter object, the setLocale() method also retrieves an array of localized month name abbreviations.

Formatting the data

The formatted stock data is presented in a DataGrid control. The DataGrid columns each call a label function that formats the column value using the appropriate formatter object.

In the Flash version, for example, the following code sets up the DataGrid columns:

```
var col1:DataGridColumn = new DataGridColumn("ticker");
col1.headerText = "Company";
col1.sortOptions = Array.NUMERIC;
col1.width = 200;

var col2:DataGridColumn = new DataGridColumn("volume");
col2.headerText = "Volume";
col2.width = 120;
col2.cellRenderer = RightAlignedCell;
col2.labelFunction = displayVolume;

var col3:DataGridColumn = new DataGridColumn("price");
col3.headerText = "Price";
col3.width = 70;
col3.cellRenderer = RightAlignedCell;
col3.labelFunction = displayPrice;

var col4:DataGridColumn = new DataGridColumn("change");
col4.headerText = "Change";
col4.width = 120;
col4.cellRenderer = RightAlignedCell;
col4.labelFunction = displayPercent;
```

The Flex version of the example declares its DataGrid in MXML. It also defines similar label functions for each column.

The labelFunction properties refer to the following functions, which call formatting methods of the Localizer class:

```
private function displayVolume(item:Object):String
{
    return localizer.formatNumber(item.volume, 0);
}

private function displayPercent(item:Object):String
{
    return localizer.formatPercent(item.change )   ;
}

  private function displayPrice(item:Object):String
{
    return localizer.formatCurrency(item.price);
}
```

The Localizer methods then set up and call the appropriate formatters:

```
public function formatNumber(value:Number, fractionalDigits:int = 2):String
{
    nf.fractionalDigits = fractionalDigits;
    return nf.formatNumber(value);
}

public function formatPercent(value:Number, fractionalDigits:int = 2):String
{
    // HACK WARNING: The position of the percent sign, and whether a space belongs
    // between it and the number, are locale-sensitive decisions. For example,
    // in Turkish the positive format is %12 and the negative format is -%12.
    // Like most operating systems, flash.globalization classes do not currently
    // provide an API for percentage formatting.
    nf.fractionalDigits = fractionalDigits;
    return nf.formatNumber(value) + "%";
}

public function formatCurrency(value:Number):String
{
    return cf.format(value, symbolIsSafe);
}

public function formatDate(dateValue:Date):String
{
    return df.format(dateValue);
}
|
```

Chapter 57: Localizing applications

Flash Player 9 and later, Adobe AIR 1.0 and later

Localization is the process of including assets to support multiple locales. A locale is the combination of a language and a country code. For example, en_US refers to the English language as spoken in the United States, and fr_FR refers to the French language as spoken in France. To localize an application for these locales, you would provide two sets of assets: one for the en_US locale and one for the fr_FR locale.

Locales can share languages. For example, en_US and en_GB (Great Britain) are different locales. In this case, both locales use the English language, but the country code indicates that they are different locales, and might therefore use different assets. For example, an application in the en_US locale might spell the word "color", whereas the word would be "colour" in the en_GB locale. Also, units of currency would be represented in dollars or pounds, depending on the locale, and the format of dates and times might also be different.

You can also provide a set of assets for a language without specifying a country code. For example, you can provide en assets for the English language and provide additional assets for the en_US locale, specific to U.S. English.

Localization goes beyond just translating strings used in your application. It can also include any type of asset such as audio files, images, and videos.

Choosing a locale

Flash Player 9 and later, Adobe AIR 1.0 and later

To determine which locale your content or application uses, you can use one of the following methods:

- flash.globalization package — Use the locale-aware classes in the flash.globalization package to retrieve the default locale for the user based on the operating system and user preferences. This is the preferred approach for applications that will run on the Flash Player 10.1 or later or AIR 2.0 or later runtimes. See "Determining the locale" on page 944 for more information.
- User prompt — You can start the application in some default locale, and then ask the user to choose their preferred locale.
- `(AIR only) Capabilities.languages` — The `Capabilities.languages` property lists an array of languages available on the user's preferred languages, as set through the operating system. The strings contain language tags (and script and region information, where applicable) defined by RFC4646 (http://www.ietf.org/rfc/rfc4646.txt). The strings use hyphens as a delimiter (for example, `"en-US"` or `"ja-JP"`). The first entry in the returned array has the same primary language ID as the language property. For example, if `languages[0]` is set to `"en-US"`, then the `language` property is set to `"en"`. However, if the language property is set to `"xu"` (specifying an unknown language), the first element in the `languages` array is different.
- `Capabilities.language` — The `Capabilities.language` property provides the user interface language code of the operating system. However, this property is limited to 20 known languages. And on English systems, this property returns only the language code, not the country code. For these reasons, it is better to use the first element in the `Capabilities.languages` array.

Localizing Flex content

Flash Player 9 and later, Adobe AIR 1.0 and later

Adobe Flex includes a framework for localizing Flex content. This framework includes the Locale, ResourceBundle, and ResourceManagerImpl classes, as well as the IResourceBundle, IResourceManagerImpl interfaces.

A Flex localization library containing utility classes for sorting application locales is available on Google Code (http://code.google.com/p/as3localelib/).

More Help topics

http://code.google.com/p/as3localelib/

Localizing Flash content

Flash Player 9 and later, Adobe AIR 1.0 and later

Adobe Flash Professional includes a Locale class in the ActionScript 3.0 components. The Locale class allows you to control how a SWF file displays multilanguage text. The Flash Strings panel allows you to use string IDs instead of string literals in dynamic text fields. This facility allows you to create a SWF file that displays text loaded from a language-specific XML file. For information on using the Locale class, see the ActionScript 3.0 Reference for the Adobe Flash Platform.

Localizing AIR applications

Adobe AIR 1.0 and later

The AIR SDK provides an HTML Localization Framework (contained in an AIRLocalizer.js file). This framework includes APIs that assist in working with multiple locales in an HTML-based application. An ActionScript library for sorting locales is provided at http://code.google.com/p/as3localelib/.

More Help topics

http://code.google.com/p/as3localelib/

Localizing dates, times, and currencies

Flash Player 9 and later, Adobe AIR 1.0 and later

The way applications present dates, times, and currencies varies greatly for each locale. For example, the U.S. standard for representing dates is month/day/year, whereas the European standard for representing dates is day/month/year.

You can write code to format dates, times, and currencies. For example, the following code converts a Date object into month/day/year format or day/month/year format. if the `locale` variable (representing the locale) is set to `"en_US"`, the function returns month/day/year format. The example converts a Date object into day/month/year format for all other locales:

```
function convertDate(date)
{
    if (locale == "en_US")
    {
        return (date.getMonth() + 1) + "/" + date.getDate() + "/" + date.getFullYear();
    }
    else
    {
        return date.getDate() + "/" + (date.getMonth() + 1) + "/" + date.getFullYear();
    }
}
```

ADOBE FLEX

The Flex framework includes controls for formatting dates, times, and currencies. These controls include the DateFormatter and CurrencyFormatter controls.

- mx:DateFormatter
- mx:CurrencyFormatter

Chapter 58: About the HTML environment

Adobe AIR 1.0 and later

Adobe® AIR® uses WebKit (*www.webkit.org*), also used by the Safari web browser, to parse, layout, and render HTML and JavaScript content. Using the AIR APIs in HTML content is optional. You can program in the content of an HTMLLoader object or HTML window entirely with HTML and JavaScript. Most existing HTML pages and applications should run with few changes (assuming they use HTML, CSS, DOM, and JavaScript features compatible with WebKit).

Important: New versions of the Adobe AIR runtime may include updated versions of WebKit. A WebKit update in a new version of AIR *may* result in unexpected changes in a deployed AIR application. These changes may affect the behavior or appearance of HTML content in an application. For example, improvements or corrections in WebKit rendering may change the layout of elements in an application's user interface. For this reason, it is highly recommended that you provide an update mechanism in your application. Should you need to update your application due to a change in the WebKit version included in AIR, the AIR update mechanism can prompt the user to install the new version of your application.

The following table lists the version of the Safari web browser that uses the version of WebKit equivalent to that used in AIR:

AIR version	Safari version
1.0	2.04
1.1	3.04
1.5	4.0 Beta
2.0	4.03
2.5	4.03
2.6	4.03
2.7	4.03
3	5.0.3

You can always determine the installed version of WebKit by examining the default user agent string returned by a HTMLLoader object:

```
var htmlLoader:HTMLLoader = new HTMLLoader();
trace( htmlLoader.userAgent );
```

Keep in mind that the version of WebKit used in AIR is not identical to the open source version. Some features are not supported in AIR and the AIR version can include security and bug fixes not yet available in the corresponding WebKit version. See "WebKit features not supported in AIR" on page 977.

Because AIR applications run directly on the desktop, with full access to the file system, the security model for HTML content is more stringent than the security model of a typical web browser. In AIR, only content loaded from the application installation directory is placed in the *application sandbox*. The application sandbox has the highest level of privilege and allows access to the AIR APIs. AIR places other content into isolated sandboxes based on where that content came from. Files loaded from the file system go into a local sandbox. Files loaded from the network using the http: or https: protocols go into a sandbox based on the domain of the remote server. Content in these non-application sandboxes is prohibited from accessing any AIR API and runs much as it would in a typical web browser.

HTML content in AIR does not display SWF or PDF content if alpha, scaling, or transparency settings are applied. For more information, see "Considerations when loading SWF or PDF content in an HTML page" on page 1004 and "Window transparency" on page 895.

More Help topics

Webkit DOM Reference

Safari HTML Reference

Safari CSS Reference

www.webkit.org

Overview of the HTML environment

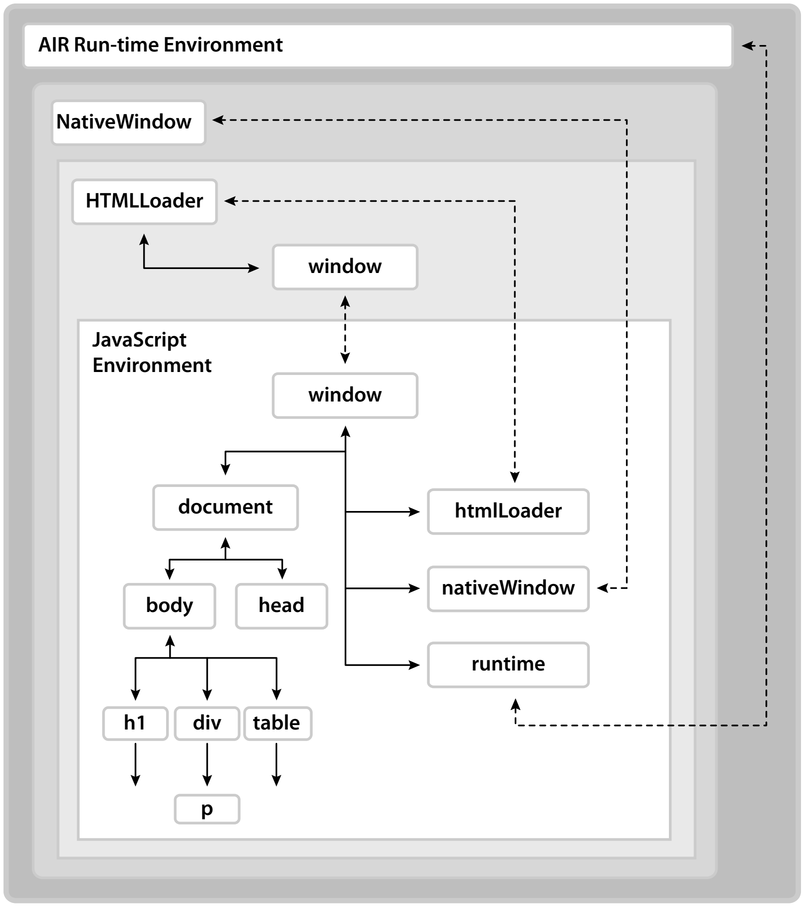
Adobe AIR 1.0 and later

Adobe AIR provides a complete browser-like JavaScript environment with an HTML renderer, document object model, and JavaScript interpreter. The JavaScript environment is represented by the AIR HTMLLoader class. In HTML windows, an HTMLLoader object contains all HTML content, and is, in turn, contained within a NativeWindow object. In SWF content, the HTMLLoader class, which extends the Sprite class, can be added to the display list of a stage like any other display object. The Adobe® ActionScript® 3.0 properties of the class are described in "Scripting the AIR HTML Container" on page 1003 and also in the *ActionScript 3.0 Reference for the Adobe Flash Platform*. In the Flex framework, the AIR HTMLLoader class is wrapped in a mx:HTML component. The mx:HTML component extends the UIComponent class, so it can be used directly with other Flex containers. The JavaScript environment within the mx:HTML component is otherwise identical.

About the JavaScript environment and its relationship to the AIR host

Adobe AIR 1.0 and later

The following diagram illustrates the relationship between the JavaScript environment and the AIR run-time environment. Although only a single native window is shown, an AIR application can contain multiple windows. (And a single window can contain multiple HTMLLoader objects.)



The JavaScript environment has its own Document and Window objects. JavaScript code can interact with the AIR run-time environment through the runtime, nativeWindow, and htmlLoader properties. ActionScript code can interact with the JavaScript environment through the window property of an HTMLLoader object, which is a reference to the JavaScript Window object. In addition, both ActionScript and JavaScript objects can listen for events dispatched by both AIR and JavaScript objects.

The `runtime` property provides access to AIR API classes, allowing you to create new AIR objects as well as access class (also called static) members. To access an AIR API, you add the name of the class, with package, to the `runtime` property. For example, to create a File object, you would use the statement:

```
var file = new window.runtime.filesystem.File();
```

Note: *The AIR SDK provides a JavaScript file,* `AIRAliases.js`*, that defines more convenient aliases for the most commonly used AIR classes. When you import this file, you can use the shorter form air.Class instead of window.runtime.package.Class. For example, you could create the File object with* `new air.File()`.

The NativeWindow object provides properties for controlling the desktop window. From within an HTML page, you can access the containing NativeWindow object with the `window.nativeWindow` property.

The HTMLLoader object provides properties, methods, and events for controlling how content is loaded and rendered. From within an HTML page, you can access the parent HTMLLoader object with the `window.htmlLoader` property.

Important: *Only pages installed as part of an application have the* `htmlLoader`*,* `nativeWindow`*, or* `runtime` *properties and only when loaded as the top-level document. These properties are not added when a document is loaded into a frame or iframe. (A child document can access these properties on the parent document as long as it is in the same security sandbox. For example, a document loaded in a frame could access the* `runtime` *property of its parent with* `parent.runtime`*.)*

About security

Adobe AIR 1.0 and later

AIR executes all code within a security sandbox based on the domain of origin. Application content, which is limited to content loaded from the application installation directory, is placed into the *application* sandbox. Access to the run-time environment and the AIR APIs are only available to HTML and JavaScript running within this sandbox. At the same time, most dynamic evaluation and execution of JavaScript is blocked in the application sandbox after all handlers for the page `load` event have returned.

You can map an application page into a non-application sandbox by loading the page into a frame or iframe and setting the AIR-specific `sandboxRoot` and `documentRoot` attributes of the frame. By setting the `sandboxRoot` value to an actual remote domain, you can enable the sandboxed content to cross-script content in that domain. Mapping pages in this way can be useful when loading and scripting remote content, such as in a *mash-up* application.

Another way to allow application and non-application content to cross-script each other, and the only way to give non-application content access to AIR APIs, is to create a *sandbox bridge*. A *parent-to-child* bridge allows content in a child frame, iframe, or window to access designated methods and properties defined in the application sandbox. Conversely, a *child-to-parent* bridge allows application content to access designated methods and properties defined in the sandbox of the child. Sandbox bridges are established by setting the `parentSandboxBridge` and `childSandboxBridge` properties of the window object. For more information, see "HTML security in Adobe AIR" on page 1080 and "HTML frame and iframe elements" on page 973.

About plug-ins and embedded objects

Adobe AIR 1.0 and later

AIR supports the Adobe® Acrobat® plug-in. Users must have Acrobat or Adobe® Reader® 8.1 (or better) to display PDF content. The HTMLLoader object provides a property for checking whether a user's system can display PDF. SWF file content can also be displayed within the HTML environment, but this capability is built in to AIR and does not use an external plug-in.

No other WebKit plug-ins are supported in AIR.

More Help topics

"HTML security in Adobe AIR" on page 1080

"HTML Sandboxes" on page 966

"HTML frame and iframe elements" on page 973

"JavaScript Window object" on page 971

"The XMLHttpRequest object" on page 967

"Adding PDF content in AIR" on page 551

AIR and WebKit

Adobe AIR 1.0 and later

Adobe AIR uses the open source WebKit engine, also used in the Safari web browser. AIR adds several extensions to allow access to the runtime classes and objects as well as for security. In addition, WebKit itself adds features not included in the W3C standards for HTML, CSS, and JavaScript.

Only the AIR additions and the most noteworthy WebKit extensions are covered here; for additional documentation on non-standard HTML, CSS, and JavaScript, see www.webkit.org and developer.apple.com. For standards information, see the W3C web site. Mozilla also provides a valuable general referenceon HTML, CSS, and DOM topics (of course, the WebKit and Mozilla engines are not identical).

JavaScript in AIR

Flash Player 9 and later, Adobe AIR 1.0 and later

AIR makes several changes to the typical behavior of common JavaScript objects. Many of these changes are made to make it easier to write secure applications in AIR. At the same time, these differences in behavior mean that some common JavaScript coding patterns, and existing web applications using those patterns, might not always execute as expected in AIR. For information on correcting these types of issues, see "Avoiding security-related JavaScript errors" on page 983.

HTML Sandboxes

Adobe AIR 1.0 and later

AIR places content into isolated sandboxes according to the origin of the content. The sandbox rules are consistent with the same-origin policy implemented by most web browsers, as well as the rules for sandboxes implemented by the Adobe Flash Player. In addition, AIR provides a new *application* sandbox type to contain and protect application content. See "Security sandboxes" on page 1044 for more information on the types of sandboxes you may encounter when developing AIR applications.

Access to the run-time environment and AIR APIs are only available to HTML and JavaScript running within the application sandbox. At the same time, however, dynamic evaluation and execution of JavaScript, in its various forms, is largely restricted within the application sandbox for security reasons. These restrictions are in place whether or not your application actually loads information directly from a server. (Even file content, pasted strings, and direct user input may be untrustworthy.)

The origin of the content in a page determines the sandbox to which it is consigned. Only content loaded from the application directory (the installation directory referenced by the `app:` URL scheme) is placed in the application sandbox. Content loaded from the file system is placed in the *local-with-file system* or the *local-trusted* sandbox, which allows access and interaction with content on the local file system, but not remote content. Content loaded from the network is placed in a remote sandbox corresponding to its domain of origin.

To allow an application page to interact freely with content in a remote sandbox, the page can be mapped to the same domain as the remote content. For example, if you write an application that displays map data from an Internet service, the page of your application that loads and displays content from the service could be mapped to the service domain. The attributes for mapping pages into a remote sandbox and domain are new attributes added to the frame and iframe HTML elements.

To allow content in a non-application sandbox to safely use AIR features, you can set up a parent sandbox bridge. To allow application content to safely call methods and access properties of content in other sandboxes, you can set up a child sandbox bridge. Safety here means that remote content cannot accidentally get references to objects, properties, or methods that are not explicitly exposed. Only simple data types, functions, and anonymous objects can be passed across the bridge. However, you must still avoid explicitly exposing potentially dangerous functions. If, for example, you exposed an interface that allowed remote content to read and write files anywhere on a user's system, then you might be giving remote content the means to do considerable harm to your users.

JavaScript eval() function

Adobe AIR 1.0 and later

Use of the `eval()` function is restricted within the application sandbox once a page has finished loading. Some uses are permitted so that JSON-formatted data can be safely parsed, but any evaluation that results in executable statements results in an error. "Code restrictions for content in different sandboxes" on page 1082 describes the allowed uses of the `eval()` function.

Function constructors

Adobe AIR 1.0 and later

In the application sandbox, function constructors can be used before a page has finished loading. After all page `load` event handlers have finished, new functions cannot be created.

Loading external scripts

Adobe AIR 1.0 and later

HTML pages in the application sandbox cannot use the `script` tag to load JavaScript files from outside of the application directory. For a page in your application to load a script from outside the application directory, the page must be mapped to a non-application sandbox.

The XMLHttpRequest object

Adobe AIR 1.0 and later

AIR provides an XMLHttpRequest (XHR) object that applications can use to make data requests. The following example illustrates a simple data request:

```
xmlhttp = new XMLHttpRequest();
xmlhttp.open("GET", "http:/www.example.com/file.data", true);
xmlhttp.onreadystatechange = function() {
    if (xmlhttp.readyState == 4) {
        //do something with data...
    }
}
xmlhttp.send(null);
```

In contrast to a browser, AIR allows content running in the application sandbox to request data from any domain. The result of an XHR that contains a JSON string can be evaluated into data objects unless the result also contains executable code. If executable statements are present in the XHR result, an error is thrown and the evaluation attempt fails.

To prevent accidental injection of code from remote sources, synchronous XHRs return an empty result if made before a page has finished loading. Asynchronous XHRs will always return after a page has loaded.

By default, AIR blocks cross-domain XMLHttpRequests in non-application sandboxes. A parent window in the application sandbox can choose to allow cross-domain requests in a child frame containing content in a non-application sandbox by setting `allowCrossDomainXHR`, an attribute added by AIR, to `true` in the containing frame or iframe element:

```
<iframe id="mashup"
    src="http://www.example.com/map.html"
    allowCrossDomainXHR="true"
</iframe>
```

***Note:** When convenient, the AIR URLStream class can also be used to download data.*

If you dispatch an XMLHttpRequest to a remote server from a frame or iframe containing application content that has been mapped to a remote sandbox, make sure that the mapping URL does not mask the server address used in the XHR. For example, consider the following iframe definition, which maps application content into a remote sandbox for the example.com domain:

```
<iframe id="mashup"
    src="http://www.example.com/map.html"
    documentRoot="app:/sandbox/"
    sandboxRoot="http://www.example.com/"
    allowCrossDomainXHR="true"
</iframe>
```

Because the `sandboxRoot` attribute remaps the root URL of the www.example.com address, all requests are loaded from the application directory and not the remote server. Requests are remapped whether they derive from page navigation or from an XMLHttpRequest.

To avoid accidentally blocking data requests to your remote server, map the `sandboxRoot` to a subdirectory of the remote URL rather than the root. The directory does not have to exist. For example, to allow requests to the www.example.com to load from the remote server rather than the application directory, change the previous iframe to the following:

```
<iframe id="mashup"
    src="http://www.example.com/map.html"
    documentRoot="app:/sandbox/"
    sandboxRoot="http://www.example.com/air/"
    allowCrossDomainXHR="true"
</iframe>
```

In this case, only content in the `air` subdirectory is loaded locally.

For more information on sandbox mapping see "HTML frame and iframe elements" on page 973 and "HTML security in Adobe AIR" on page 1080.

Cookies

Adobe AIR 1.0 and later

In AIR applications, only content in remote sandboxes (content loaded from http: and https: sources) can use cookies (the `document.cookie` property). In the application sandbox, other means for storing persistent data are available, including the EncryptedLocalStore, SharedObject, and FileStream classes.

The Clipboard object

Adobe AIR 1.0 and later

The WebKit Clipboard API is driven with the following events: `copy`, `cut`, and `paste`. The event object passed in these events provides access to the clipboard through the `clipboardData` property. Use the following methods of the `clipboardData` object to read or write clipboard data:

Method	Description
clearData(mimeType)	Clears the clipboard data. Set the `mimeType` parameter to the MIME type of the data to clear.
getData(mimeType)	Get the clipboard data. This method can only be called in a handler for the `paste` event. Set the `mimeType` parameter to the MIME type of the data to return.
setData(mimeType, data)	Copy data to the clipboard. Set the `mimeType` parameter to the MIME type of the data.

JavaScript code outside the application sandbox can only access the clipboard through theses events. However, content in the application sandbox can access the system clipboard directly using the AIR Clipboard class. For example, you could use the following statement to get text format data on the clipboard:

```
var clipping = air.Clipboard.generalClipboard.getData("text/plain",
                                air.ClipboardTransferMode.ORIGINAL_ONLY);
```

The valid data MIME types are:

MIME type	Value
Text	"text/plain"
HTML	"text/html"
URL	"text/uri-list"
Bitmap	"image/x-vnd.adobe.air.bitmap"
File list	"application/x-vnd.adobe.air.file-list"

Important: *Only content in the application sandbox can access file data present on the clipboard. If non-application content attempts to access a file object from the clipboard, a security error is thrown.*

For more information on using the clipboard, see "Copy and paste" on page 596 and Using the Pasteboard from JavaScript (Apple Developer Center).

Drag and Drop

Adobe AIR 1.0 and later

Drag-and-drop gestures into and out of HTML produce the following DOM events: `dragstart`, `drag`, `dragend`, `dragenter`, `dragover`, `dragleave`, and `drop`. The event object passed in these events provides access to the dragged data through the `dataTransfer` property. The `dataTransfer` property references an object that provides the same methods as the `clipboardData` object associated with a clipboard event. For example, you could use the following function to get text format data from a `drop` event:

```
function onDrop(dragEvent){
    return dragEvent.dataTransfer.getData("text/plain",
            air.ClipboardTransferMode.ORIGINAL_ONLY);
}
```

The `dataTransfer` object has the following important members:

Member	Description
clearData(mimeType)	Clears the data. Set the `mimeType` parameter to the MIME type of the data representation to clear.
getData(mimeType)	Get the dragged data. This method can only be called in a handler for the `drop` event. Set the `mimeType` parameter to the MIME type of the data to get.
setData(mimeType, data)	Set the data to be dragged. Set the `mimeType` parameter to the MIME type of the data.
types	An array of strings containing the MIME types of all data representations currently available in the `dataTransfer` object.
effectsAllowed	Specifies whether the data being dragged can be copied, moved, linked, or some combination thereof. Set the `effectsAllowed` property in the handler for the `dragstart` event.
dropEffect	Specifies which of the allowed drop effects are supported by a drag target. Set the `dropEffect` property in the handler for the `dragEnter` event. During the drag, the cursor changes to indicate which effect would occur if the user released the mouse. If no `dropEffect` is specified, an `effectsAllowed` property effect is chosen. The copy effect has priority over the move effect, which itself has priority over the link effect. The user can modify the default priority using the keyboard.

For more information on adding support for drag-and-drop to an AIR application see "Drag and drop in AIR" on page 608 and Using the Drag-and-Drop from JavaScript (Apple Developer Center).

innerHTML and outerHTML properties

Adobe AIR 1.0 and later

AIR places security restrictions on the use of the `innerHTML` and `outerHTML` properties for content running in the application sandbox. Before the page load event, as well as during the execution of any load event handlers, use of the `innerHTML` and `outerHTML` properties is unrestricted. However, once the page has loaded, you can only use `innerHTML` or `outerHTML` properties to add static content to the document. Any statement in the string assigned to `innerHTML` or `outerHTML` that evaluates to executable code is ignored. For example, if you include an event callback attribute in an element definition, the event listener is not added. Likewise, embedded `<script>` tags are not evaluated. For more information, see the "HTML security in Adobe AIR" on page 1080.

Document.write() and Document.writeln() methods

Adobe AIR 1.0 and later

Use of the `write()` and `writeln()` methods is not restricted in the application sandbox before the `load` event of the page. However, once the page has loaded, calling either of these methods does not clear the page or create a new one. In a non-application sandbox, as in most web browsers, calling `document.write()` or `writeln()` after a page has finished loading clears the current page and opens a new, blank one.

Document.designMode property

Adobe AIR 1.0 and later

Set the `document.designMode` property to a value of `on` to make all elements in the document editable. Built-in editor support includes text editing, copy, paste, and drag-and-drop. Setting `designMode` to `on` is equivalent to setting the `contentEditable` property of the `body` element to `true`. You can use the `contentEditable` property on most HTML elements to define which sections of a document are editable. See "HTML contentEditable attribute" on page 975 for additional information.

unload events (for body and frameset objects)

Adobe AIR 1.0 and later

In the top-level `frameset` or `body` tag of a window (including the main window of the application), do not use the `unload` event to respond to the window (or application) being closed. Instead, use `exiting` event of the NativeApplication object (to detect when an application is closing). Or use the `closing` event of the NativeWindow object (to detect when a window is closing). For example, the following JavaScript code displays a message (`"Goodbye."`) when the user closes the application:

```
var app = air.NativeApplication.nativeApplication;
app.addEventListener(air.Event.EXITING, closeHandler);
function closeHandler(event)
{
    alert("Goodbye.");
}
```

However, scripts *can* successfully respond to the `unload` event caused by navigation of a frame, iframe, or top-level window content.

***Note:** These limitations may be removed in a future version of Adobe AIR.*

JavaScript Window object

Adobe AIR 1.0 and later

The Window object remains the global object in the JavaScript execution context. In the application sandbox, AIR adds new properties to the JavaScript Window object to provide access to the built-in classes of AIR, as well as important host objects. In addition, some methods and properties behave differently depending on whether they are within the application sandbox or not.

Window.runtime property The `runtime` property allows you to instantiate and use the built-in runtime classes from within the application sandbox. These classes include the AIR and Flash Player APIs (but not, for example, the Flex framework). For example, the following statement creates an AIR file object:

```
 var preferencesFile = new window.runtime.flash.filesystem.File();
```

The `AIRAliases.js` file, provided in the AIR SDK, contains alias definitions that allow you to shorten such references. For example, when `AIRAliases.js` is imported into a page, a File object can be created with the following statement:

```
var preferencesFile = new air.File();
```

The `window.runtime` property is only defined for content within the application sandbox and only for the parent document of a page with frames or iframes.

See "Using the AIRAliases.js file" on page 988.

Window.nativeWindow property The `nativeWindow` property provides a reference to the underlying native window object. With this property, you can script window functions and properties such as screen position, size, and visibility, and handle window events such as closing, resizing, and moving. For example, the following statement closes the window:

```
 window.nativeWindow.close();
```

***Note:** The window control features provided by the NativeWindow object overlap the features provided by the JavaScript Window object. In such cases, you can use whichever method you find most convenient.*

The `window.nativeWindow` property is only defined for content within the application sandbox and only for the parent document of a page with frames or iframes.

Window.htmlLoader property The `htmlLoader` property provides a reference to the AIR HTMLLoader object that contains the HTML content. With this property, you can script the appearance and behavior of the HTML environment. For example, you can use the `htmlLoader.paintsDefaultBackground` property to determine whether the control paints a default, white background:

```
window.htmlLoader.paintsDefaultBackground = false;
```

***Note:** The HTMLLoader object itself has a `window` property, which references the JavaScript Window object of the HTML content it contains. You can use this property to access the JavaScript environment through a reference to the containing HTMLLoader.*

The `window.htmlLoader` property is only defined for content within the application sandbox and only for the parent document of a page with frames or iframes.

Window.parentSandboxBridge and Window.childSandboxBridge properties The `parentSandboxBridge` and `childSandboxBridge` properties allow you to define an interface between a parent and a child frame. For more information, see "Cross-scripting content in different security sandboxes" on page 999.

Window.setTimeout() and Window.setInterval() functions AIR places security restrictions on use of the `setTimeout()` and `setInterval()` functions within the application sandbox. You cannot define the code to be executed as a string when calling `setTimeout()` or `setInterval()`. You must use a function reference. For more information, see "setTimeout() and setInterval()" on page 985.

Window.open() function When called by code running in a non-application sandbox, the `open()` method only opens a window when called as a result of user interaction (such as a mouse click or keypress). In addition, the window title is prefixed with the application title (to prevent windows opened by remote content from impersonating windows opened by the application). For more information, see the "Restrictions on calling the JavaScript window.open() method" on page 1085.

air.NativeApplication object

Adobe AIR 1.0 and later

The NativeApplication object provides information about the application state, dispatches several important application-level events, and provides useful functions for controlling application behavior. A single instance of the NativeApplication object is created automatically and can be accessed through the class-defined `NativeApplication.nativeApplication` property.

To access the object from JavaScript code you could use:

```
var app = window.runtime.flash.desktop.NativeApplication.nativeApplication;
```

Or, if the `AIRAliases.js` script has been imported, you could use the shorter form:

```
var app = air.NativeApplication.nativeApplication;
```

The NativeApplication object can only be accessed from within the application sandbox. For more information about the NativeApplication object, see "Working with AIR runtime and operating system information" on page 888.

The JavaScript URL scheme

Adobe AIR 1.0 and later

Execution of code defined in a JavaScript URL scheme (as in `href="javascript:alert('Test')"`) is blocked within the application sandbox. No error is thrown.

HTML in AIR

Adobe AIR 1.0 and later

AIR and WebKit define a couple of non-standard HTML elements and attributes, including:

"HTML frame and iframe elements" on page 973

"HTML element event handlers" on page 975

HTML frame and iframe elements

Adobe AIR 1.0 and later

AIR adds new attributes to the frame and iframe elements of content in the application sandbox:

sandboxRoot attribute The `sandboxRoot` attribute specifies an alternate, non-application domain of origin for the file specified by the frame `src` attribute. The file is loaded into the non-application sandbox corresponding to the specified domain. Content in the file and content loaded from the specified domain can cross-script each other.

***Important:** If you set the value of `sandboxRoot` to the base URL of the domain, all requests for content from that domain are loaded from the application directory instead of the remote server (whether that request results from page navigation, from an XMLHttpRequest, or from any other means of loading content).*

documentRoot attribute The `documentRoot` attribute specifies the local directory from which to load URLs that resolve to files within the location specified by `sandboxRoot`.

When resolving URLs, either in the frame `src` attribute, or in content loaded into the frame, the part of the URL matching the value specified in `sandboxRoot` is replaced with the value specified in `documentRoot`. Thus, in the following frame tag:

```
<iframe src="http://www.example.com/air/child.html"
            documentRoot="app:/sandbox/"
            sandboxRoot="http://www.example.com/air/"/>
```

`child.html` is loaded from the `sandbox` subdirectory of the application installation folder. Relative URLs in `child.html` are resolved based on `sandbox` directory. Note that any files on the remote server at `www.example.com/air` are not accessible in the frame, since AIR would attempt to load them from the app:/sandbox/ directory.

allowCrossDomainXHR attribute Include `allowCrossDomainXHR="allowCrossDomainXHR"` in the opening frame tag to allow content in the frame to make XMLHttpRequests to any remote domain. By default, non-application content can only make such requests to its own domain of origin. There are serious security implications involved in allowing cross-domain XHRs. Code in the page is able to exchange data with any domain. If malicious content is somehow injected into the page, any data accessible to code in the current sandbox can be compromised. Only enable cross-domain XHRs for pages that you create and control and only when cross-domain data loading is truly necessary. Also, carefully validate all external data loaded by the page to prevent code injection or other forms of attack.

***Important:** If the `allowCrossDomainXHR` attribute is included in a frame or iframe element, cross-domain XHRs are enabled (unless the value assigned is "0" or starts with the letters "f" or "n"). For example, setting `allowCrossDomainXHR` to `"deny"` would still enable cross-domain XHRs. Leave the attribute out of the element declaration altogether if you do not want to enable cross-domain requests.*

ondominitialize attribute Specifies an event handler for the `dominitialize` event of a frame. This event is an AIR-specific event that fires when the window and document objects of the frame have been created, but before any scripts have been parsed or document elements created.

The frame dispatches the `dominitialize` event early enough in the loading sequence that any script in the child page can reference objects, variables, and functions added to the child document by the `dominitialize` handler. The parent page must be in the same sandbox as the child to directly add or access any objects in a child document. However, a parent in the application sandbox can establish a sandbox bridge to communicate with content in a non-application sandbox.

The following examples illustrate use of the iframe tag in AIR:

Place `child.html` in a remote sandbox, without mapping to an actual domain on a remote server:

```
<iframe src="http://localhost/air/child.html"
            documentRoot="app:/sandbox/"
            sandboxRoot="http://localhost/air/"/>
```

Place `child.html` in a remote sandbox, allowing XMLHttpRequests only to `www.example.com`:

```
<iframe src="http://www.example.com/air/child.html"
            documentRoot="app:/sandbox/"
            sandboxRoot="http://www.example.com/air/"/>
```

Place `child.html` in a remote sandbox, allowing XMLHttpRequests to any remote domain:

```
<iframe src="http://www.example.com/air/child.html"
            documentRoot="app:/sandbox/"
            sandboxRoot="http://www.example.com/air/"
            allowCrossDomainXHR="allowCrossDomainXHR"/>
```

Place `child.html` in a local-with-file-system sandbox:

```
<iframe     src="file:///templates/child.html"
            documentRoot="app:/sandbox/"
            sandboxRoot="app-storage:/templates/"/>
```

Place `child.html` in a remote sandbox, using the `dominitialize` event to establish a sandbox bridge:

```
<html>
<head>
<script>
var bridgeInterface = {};
bridgeInterface.testProperty = "Bridge engaged";
function engageBridge(){
    document.getElementById("sandbox").parentSandboxBridge = bridgeInterface;
}
</script>
</head>
<body>
<iframe id="sandbox"
            src="http://www.example.com/air/child.html"
            documentRoot="app:/"
            sandboxRoot="http://www.example.com/air/"
            ondominitialize="engageBridge()"/>
</body>
</html>
```

The following `child.html` document illustrates how child content can access the parent sandbox bridge:

```
<html>
    <head>
        <script>
            document.write(window.parentSandboxBridge.testProperty);
        </script>
    </head>
    <body></body>
</html>
```

For more information, see "Cross-scripting content in different security sandboxes" on page 999 and "HTML security in Adobe AIR" on page 1080.

HTML element event handlers

Adobe AIR 1.0 and later

DOM objects in AIR and WebKit dispatch some events not found in the standard DOM event model. The following table lists the related event attributes you can use to specify handlers for these events:

Callback attribute name	Description
oncontextmenu	Called when a context menu is invoked, such as through a right-click or command-click on selected text.
oncopy	Called when a selection in an element is copied.
oncut	Called when a selection in an element is cut.
ondominitialize	Called when the DOM of a document loaded in a frame or iframe is created, but before any DOM elements are created or scripts parsed.
ondrag	Called when an element is dragged.
ondragend	Called when a drag is released.
ondragenter	Called when a drag gesture enters the bounds of an element.
ondragleave	Called when a drag gesture leaves the bounds of an element.
ondragover	Called continuously while a drag gesture is within the bounds of an element.
ondragstart	Called when a drag gesture begins.
ondrop	Called when a drag gesture is released while over an element.
onerror	Called when an error occurs while loading an element.
oninput	Called when text is entered into a form element.
onpaste	Called when an item is pasted into an element.
onscroll	Called when the content of a scrollable element is scrolled.
onselectstart	Called when a selection begins.

HTML contentEditable attribute

Adobe AIR 1.0 and later

You can add the `contentEditable` attribute to any HTML element to allow users to edit the content of the element. For example, the following example HTML code sets the entire document as editable, except for first `p` element:

```
<html>
<head/>
<body contentEditable="true">
    <h1>de Finibus Bonorum et Malorum</h1>
    <p contentEditable="false">Sed ut perspiciatis unde omnis iste natus error.</p>
    <p>At vero eos et accusamus et iusto odio dignissimos ducimus qui blanditiis.</p>
</body>
</html>
```

***Note:** If you set the `document.designMode` property to `on`, then all elements in the document are editable, regardless of the setting of `contentEditable` for an individual element. However, setting `designMode` to `off`, does not disable editing of elements for which `contentEditable` is `true`. See "Document.designMode property" on page 970 for additional information.*

Data: URLs

Adobe AIR 2 and later

AIR supports `data:` URLs for the following elements:

- img
- input type="image"
- CSS rules allowing images (such as background-image)

Data URLs allow you to insert binary image data directly into a CSS or HTML document as a base64-encoded string. The following example uses a data: URL as a repeating background:

```
<html>
<head>
<style>
body {
background-
image:url('data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAGQAAABkCAMAAABHPGVmAAAAGXRFWHRTb2Z
0d2FyZQBBZG9iZSBJbWFnZVJlYWR5ccllPAAAAAZQTFRF%2F6cA%2F%2F%2F%2Fgxp3lwAAAAJ0Uk5T%2FwDltzBKAAA
BF0lEQVR42uzZQQ7CMAxE0e%2F7X5oNCyRocWzPiJbMBZ6qpIljE%2BnwklgKG7kwUjc2IkIaxkY0CPdEsCCasws6ShX
BgmBBmEagpXQQLAgWBAuSY2gaKaWPYEGwIEwg0FRmECwIFoQeQjJlhJWUEFazjFDJCkI5WYRWMgjtfEGYyQnCXD4jTCd
m1zmngFpBFznwVNi5RPSbwbWnpYr%2BBHi%2FtCTfgPLEPL7jBctAKBRptXJ8M%2BprIuZKu%2BUKcg4YK1PLz7kx4bS
qHyPaT4d%2B28OCJJiRBo4FCQsSA0bziT3XubMgYUG6fc5fatmGBQkL0hoJ1IaZMiQsSFiQ8vRscTjlQOI2iHZwtpHuf
%2BJAYiOiJSkj8Z%2FIQ4ABANvXGLd3%2BZMrAAAAAElFTkSuQmCC');
background-repeat:repeat;
}
</style>
</head>
<body>
</body>
</html>
```

When using data: URLS, be aware that extra whitespace is significant. For example, the data string must be entered as a single, unbroken line. Otherwise, the line breaks are treated as part of the data and the image cannot be decoded.

CSS in AIR

Adobe AIR 1.0 and later

WebKit supports several extended CSS properties. Many of these extensions use the prefix: `-webkit`. Note that some of these extensions are experimental in nature and may be removed from a future version of WebKit. For more information about the Webkit support for CSS and its extensions to CSS, see Safari CSS Reference.

WebKit features not supported in AIR

Adobe AIR 1.0 and later

AIR does not support the following features available in WebKit or Safari 4:

- Cross-domain messaging via window.postMessage (AIR provides its own cross-domain communication APIs)
- CSS variables
- Web Open Font Format (WOFF) and SVG fonts.
- HTML video and audio tags
- Media device queries
- Offline application cache
- Printing (AIR provides its own PrintJob API)
- Spelling and grammar checkers
- SVG
- WAI-ARIA
- WebSockets (AIR provides its own socket APIs)
- Web workers
- WebKit SQL API (AIR provides its own API)
- WebKit geolocation API (AIR provides its own geolocation API on supported devices)
- WebKit multi-file upload API
- WebKit touch events (AIR provides its own touch events)
- Wireless Markup Language (WML)

The following lists contain specific JavaScript APIs, HTML elements, and CSS properties and values that AIR does not support:

Unsupported JavaScript Window object members:

- applicationCache()
- console
- openDatabase()
- postMessage()
- document.print()

Unsupported HTML tags:

- audio

- video

Unsupported HTML attributes:

- aria-*
- draggable
- formnovalidate
- list
- novalidate
- onbeforeload
- onhashchange
- onorientationchange
- onpagehide
- onpageshow
- onpopstate
- ontouchstart
- ontouchmove
- ontouchend
- ontouchcancel
- onwebkitbeginfullscreen
- onwebkitendfullscreen
- pattern
- required
- sandbox

Unsupported JavaScript events:

- beforeload
- hashchange
- orientationchange
- pagehide
- pageshow
- popstate
- touchstart
- touchmove
- touchend
- touchcancel
- webkitbeginfullscreen
- webkitendfullscreen

Unsupported CSS properties:

- background-clip
- background-origin (use -webkit-background-origin)
- background-repeat-x
- background-repeat-y
- background-size (use -webkit-background-size)
- border-bottom-left-radius
- border-bottom-right-radius
- border-radius
- border-top-left-radius
- border-top-right-radius
- text-rendering
- -webkit-animation-play-state
- -webkit-background-clip
- -webkit-color-correction
- -webkit-font-smoothing

Unsupported CSS values:

- appearance property values:
  - media-volume-slider-container
  - media-volume-slider
  - media-volume-sliderthumb
  - outer-spin-button
- border-box (background-clip and background-origin)
- contain (background-size)
- content-box (background-clip and background-origin)
- cover (background-size)
- list property values:
  - afar
  - amharic
  - amharic-abegede
  - cjk-earthly-branch
  - cjk-heavenly-stem
  - ethiopic
  - ethiopic-abegede
  - ethiopic-abegede-am-et
  - ethiopic-abegede-gez
  - ethiopic-abegede-ti-er

- ethiopic-abegede-ti-et
    - ethiopic-halehame-aa-er
    - ethiopic-halehame-aa-et
    - ethiopic-halehame-am-et
    - ethiopic-halehame-gez
    - ethiopic-halehame-om-et
    - ethiopic-halehame-sid-et
    - ethiopic-halehame-so-et
    - ethiopic-halehame-ti-er
    - ethiopic-halehame-ti-et
    - ethiopic-halehame-tig
    - hangul
    - hangul-consonant
    - lower-norwegian
    - oromo
    - sidama
    - somali
    - tigre
    - tigrinya-er
    - tigrinya-er-abegede
    - tigrinya-et
    - tigrinya-et-abegede
    - upper-greek
    - upper-norwegian
- -wap-marquee (display property)

Chapter 59: Programming HTML and JavaScript in AIR

Adobe AIR 1.0 and later

A number of programming topics are unique to developing Adobe® AIR® applications with HTML and JavaScript. The following information is important whether you are programming an HTML-based AIR application or programming a SWF-based AIR application that runs HTML and JavaScript using the HTMLLoader class (or mx:HTML Flex™ component).

About the HTMLLoader class

Adobe AIR 1.0 and later

The HTMLLoader class of Adobe AIR defines the display object that can display HTML content in an AIR application. SWF-based applications can add an HTMLLoader control to an existing window or create an HTML window that automatically contains a HTMLLoader object with `HTMLLoader.createRootWindow()`. The HTMLLoader object can be accessed through the JavaScript `window.htmlLoader` property from within the loaded HTML page.

Loading HTML content from a URL

Adobe AIR 1.0 and later

The following code loads a URL into an HTMLLoader object (add the HTMLLoader as a child of the stage or other display object container to display the HTML content in your application):

```
import flash.html.HTMLLoader;

var html:HTMLLoader = new HTMLLoader;
html.width = 400;
html.height = 600;
var urlReq:URLRequest = new URLRequest("http://www.adobe.com/");
html.load(urlReq);
```

An HTMLLoader object's `width` and `height` properties are both set to 0 by default. You will want to set these dimensions when adding an HTMLLoader object to the stage. The HTMLLoader dispatches several events as a page loads. You can use these events to determine when it is safe to interact with the loaded page. These events are described in "Handling HTML-related events in AIR" on page 1020.

Note: *In the Flex framework, only classes that extend the UIComponent class can be added as children of a Flex Container components. For this reason, you cannot directly add an HTMLLoader as a child of a Flex Container component; however you can use the Flex mx:HTML control, you can build a custom class that extends UIComponent and contains an HTMLLoader as a child of the UIComponent, or you can add the HTMLLoader as a child of a UIComponent and add the UIComponent to the Flex container.*

You can also render HTML text by using the TextField class, but its capabilities are limited. The Adobe® Flash® Player's TextField class supports a subset of HTML markup, but because of size limitations, its capabilities are limited. (The HTMLLoader class included in Adobe AIR is not available in Flash Player.)

Loading HTML content from a string

Adobe AIR 1.0 and later

The `loadString()` method of an HTMLLoader object loads a string of HTML content into the HTMLLoader object:

```
var html:HTMLLoader = new HTMLLoader();
var htmlStr:String = "<html><body>Hello <b>world</b>.</body></html>";
html.loadString(htmlStr);
```

By default, content loaded via the `loadString()` method is placed in a non-application sandbox with the following characteristics:

- It has access to load content from the network (but not from the file system).
- It cannot load data using XMLHttpRequest.
- The `window.location` property is set to `"about:blank"`.
- The content cannot access the `window.runtime` property (like content in any non-application sandbox can).

In AIR 1.5, the HTMLLoader class includes a `placeLoadStringContentInApplicationSandbox` property. When this property is set to `true` for an HTMLLoader object, content loaded via the `loadString()` method is placed in the application sandbox. (The default value is `false`.) This gives content loaded via the `loadString()` method access to the `window.runtime` property and to all AIR APIs. If you set this property to `true`, ensure that the data source for a string used in a call to the `loadString()` method is trusted. Code statements in the HTML string are executed with full application privileges when this property is set to `true`. Only set this property to `true` when you are certain that the string cannot contain harmful code.

In applications compiled with the AIR 1.0 or AIR 1.1 SDKs, content loaded via the `loadString()` method is placed in the application sandbox.

Important security rules when using HTML in AIR applications

Adobe AIR 1.0 and later

The files you install with the AIR application have access to the AIR APIs. For security reasons, content from other sources do not. For example, this restriction prevents content from a remote domain (such as http://example.com) from reading the contents the user's desktop directory (or worse).

Because there are security loopholes that can be exploited through calling the `eval()` function (and related APIs), content installed with the application, by default, is restricted from using these methods. However, some Ajax frameworks use the calling the `eval()` function and related APIs.

To properly structure content to work in an AIR application, you must take into account the rules for the security restrictions on content from different sources. Content from different sources is placed in separate security classifications, called sandboxes (see "Security sandboxes" on page 1044). By default, content installed with the application is installed in a sandbox known as the *application* sandbox, and this grants it access to the AIR APIs. The application sandbox is generally the most secure sandbox, with restrictions designed to prevent the execution of untrusted code.

The runtime allows you to load content installed with your application into a sandbox other than the application sandbox. Content in non-application sandboxes operates in a security environment similar to that of a typical web browser. For example, code in non-application sandboxes can use `eval()` and related methods (but at the same time is not allowed to access the AIR APIs). The runtime includes ways to have content in different sandboxes communicate securely (without exposing AIR APIs to non-application content, for example). For details, see "Cross-scripting content in different security sandboxes" on page 999.

If you call code that is restricted from use in a sandbox for security reasons, the runtime dispatches a JavaScript error: "Adobe AIR runtime security violation for JavaScript code in the application security sandbox."

To avoid this error, follow the coding practices described in the next section, "Avoiding security-related JavaScript errors" on page 983.

For more information, see "HTML security in Adobe AIR" on page 1080.

Avoiding security-related JavaScript errors

Adobe AIR 1.0 and later

If you call code that is restricted from use in a sandbox due to these security restrictions, the runtime dispatches a JavaScript error: "Adobe AIR runtime security violation for JavaScript code in the application security sandbox." To avoid this error, follow these coding practices.

Causes of security-related JavaScript errors

Adobe AIR 1.0 and later

Code executing in the application sandbox is restricted from most operations that involve evaluating and executing strings once the document `load` event has fired and any `load` event handlers have exited. Attempting to use the following types of JavaScript statements that evaluate and execute potentially insecure strings generates JavaScript errors:

- eval() function
- setTimeout() and setInterval()
- Function constructor

  In addition, the following types of JavaScript statements fail without generating an unsafe JavaScript error:

- javascript: URLs
- Event callbacks assigned through onevent attributes in innerHTML and outerHTML statements
- Loading JavaScript files from outside the application installation directory
- document.write() and document.writeln()
- Synchronous XMLHttpRequests before the load event or during a load event handler
- Dynamically created script elements

  Note: *In some restricted cases, evaluation of strings is permitted. See "Code restrictions for content in different sandboxes" on page 1082for more information.*

  Adobe maintains a list of Ajax frameworks known to support the application security sandbox, at http://www.adobe.com/go/airappsandboxframeworks.

The following sections describe how to rewrite scripts to avoid these unsafe JavaScript errors and silent failures for code running in the application sandbox.

Mapping application content to a different sandbox

Adobe AIR 1.0 and later

In most cases, you can rewrite or restructure an application to avoid security-related JavaScript errors. However, when rewriting or restructuring is not possible, you can load the application content into a different sandbox using the technique described in "Loading application content into a non-application sandbox" on page 999. If that content also must access AIR APIs, you can create a sandbox bridge, as described in "Setting up a sandbox bridge interface" on page 1000.

eval() function

Flash Player 9 and later, Adobe AIR 1.0 and later

In the application sandbox, the `eval()` function can only be used before the page `load` event or during a `load` event handler. After the page has loaded, calls to `eval()` will not execute code. However, in the following cases, you can rewrite your code to avoid the use of `eval()`.

Assigning properties to an object

Adobe AIR 1.0 and later

Instead of parsing a string to build the property accessor:

```
eval("obj." + propName + " = " + val);
```

access properties with bracket notation:

```
obj[propName] = val;
```

Creating a function with variables available in context

Adobe AIR 1.0 and later

Replace statements such as the following:

```
function compile(var1, var2){
    eval("var fn = function(){ this."+var1+"(var2) }");
    return fn;
}
```

with:

```
function compile(var1, var2){
    var self = this;
    return function(){ self[var1](var2) };
}
```

Creating an object using the name of the class as a string parameter

Adobe AIR 1.0 and later

Consider a hypothetical JavaScript class defined with the following code:

```
var CustomClass =
    {
        Utils:
        {
            Parser: function(){ alert('constructor') }
        },
        Data:
        {

        }
    };
var constructorClassName = "CustomClass.Utils.Parser";
```

The simplest way to create a instance would be to use `eval()`:

```
var myObj;
eval('myObj=new ' + constructorClassName +'()')
```

However, you could avoid the call to `eval()` by parsing each component of the class name and building the new object using bracket notation:

```
function getter(str)
{
    var obj = window;
    var names = str.split('.');
    for(var i=0;i<names.length;i++){
        if(typeof obj[names[i]]=='undefined'){
            var undefstring = names[0];
            for(var j=1;j<=i;j++)
                undefstring+="."+names[j];
            throw new Error(undefstring+" is undefined");
        }
        obj = obj[names[i]];
    }
    return obj;
}
```

To create the instance, use:

```
try{
    var Parser = getter(constructorClassName);
    var a = new Parser();
    }catch(e){
        alert(e);
}
```

setTimeout() and setInterval()

Adobe AIR 1.0 and later

Replace the string passed as the handler function with a function reference or object. For example, replace a statement such as:

```
setTimeout("alert('Timeout')", 100);
```

with:

```
setTimeout(function(){alert('Timeout')}, 100);
```

Or, when the function requires the `this` object to be set by the caller, replace a statement such as:

```
this.appTimer = setInterval("obj.customFunction();", 100);
```

with the following:

```
var _self = this;
this.appTimer = setInterval(function(){obj.customFunction.apply(_self);}, 100);
```

Function constructor

Adobe AIR 1.0 and later

Calls to `new Function(param, body)` can be replaced with an inline function declaration or used only before the page `load` event has been handled.

javascript: URLs

Adobe AIR 1.0 and later

The code defined in a link using the javascript: URL scheme is ignored in the application sandbox. No unsafe JavaScript error is generated. You can replace links using javascript: URLs, such as:

```
<a href="javascript:code()">Click Me</a>
```

with:

```
<a href="#" onclick="code()">Click Me</a>
```

Event callbacks assigned through onevent attributes in innerHTML and outerHTML statements

Adobe AIR 1.0 and later

When you use innerHTML or outerHTML to add elements to the DOM of a document, any event callbacks assigned within the statement, such as `onclick` or `onmouseover`, are ignored. No security error is generated. Instead, you can assign an `id` attribute to the new elements and set the event handler callback functions using the `addEventListener()` method.

For example, given a target element in a document, such as:

```
<div id="container"></div>
```

Replace statements such as:

```
document.getElementById('container').innerHTML =
    '<a href="#" onclick="code()">Click Me.</a>';
```

with:

```
document.getElementById('container').innerHTML = '<a href="#" id="smith">Click Me.</a>';
document.getElementById('smith').addEventListener("click", function() { code(); });
```

Loading JavaScript files from outside the application installation directory

Adobe AIR 1.0 and later

Loading script files from outside the application sandbox is not permitted. No security error is generated. All script files that run in the application sandbox must be installed in the application directory. To use external scripts in a page, you must map the page to a different sandbox. See "Loading application content into a non-application sandbox" on page 999.

document.write() and document.writeln()

Adobe AIR 1.0 and later

Calls to `document.write()` or `document.writeln()` are ignored after the page `load` event has been handled. No security error is generated. As an alternative, you can load a new file, or replace the body of the document using DOM manipulation techniques.

Synchronous XMLHttpRequests before the load event or during a load event handler

Adobe AIR 1.0 and later

Synchronous XMLHttpRequests initiated before the page `load` event or during a `load` event handler do not return any content. Asynchronous XMLHttpRequests can be initiated, but do not return until after the `load` event. After the `load` event has been handled, synchronous XMLHttpRequests behave normally.

Dynamically created script elements

Adobe AIR 1.0 and later

Dynamically created script elements, such as when created with innerHTML or `document.createElement()` method are ignored.

Accessing AIR API classes from JavaScript

Adobe AIR 1.0 and later

In addition to the standard and extended elements of Webkit, HTML and JavaScript code can access the host classes provided by the runtime. These classes let you access the advanced features that AIR provides, including:

- Access to the file system
- Use of local SQL databases
- Control of application and window menus
- Access to sockets for networking
- Use of user-defined classes and objects
- Sound capabilities

For example, the AIR file API includes a File class, contained in the flash.filesystem package. You can create a File object in JavaScript as follows:

```
var myFile = new window.runtime.flash.filesystem.File();
```

The `runtime` object is a special JavaScript object, available to HTML content running in AIR in the application sandbox. It lets you access runtime classes from JavaScript. The `flash` property of the `runtime` object provides access to the flash package. In turn, the `flash.filesystem` property of the `runtime` object provides access to the flash.filesystem package (and this package includes the File class). Packages are a way of organizing classes used in ActionScript.

***Note:** The `runtime` property is not automatically added to the window objects of pages loaded in a frame or iframe. However, as long as the child document is in the application sandbox, the child can access the `runtime` property of the parent.*

Because the package structure of the runtime classes would require developers to type long strings of JavaScript code strings to access each class (as in `window.runtime.flash.desktop.NativeApplication`), the AIR SDK includes an AIRAliases.js file that lets you access runtime classes much more easily (for instance, by simply typing `air.NativeApplication`).

The AIR API classes are discussed throughout this guide. Other classes from the Flash Player API, which may be of interest to HTML developers, are described in the *Adobe AIR API Reference for HTML Developers*. ActionScript is the language used in SWF (Flash Player) content. However, JavaScript and ActionScript syntax are similar. (They are both based on versions of the ECMAScript language.) All built-in classes are available in both JavaScript (in HTML content) and ActionScript (in SWF content).

***Note:** JavaScript code cannot use the Dictionary, XML, and XMLList classes, which are available in ActionScript.*

Using the AIRAliases.js file

Adobe AIR 1.0 and later

The runtime classes are organized in a package structure, as in the following:

- `window.runtime.flash.desktop.NativeApplication`
- `window.runtime.flash.desktop.ClipboardManager`
- `window.runtime.flash.filesystem.FileStream`
- `window.runtime.flash.data.SQLDatabase`

Included in the AIR SDK is an AIRAliases.js file that provide "alias" definitions that let you access the runtime classes with less typing. For example, you can access the classes listed above by simply typing the following:

- `air.NativeApplication`
- `air.Clipboard`
- `air.FileStream`
- `air.SQLDatabase`

This list is just a short subset of the classes in the AIRAliases.js file. The complete list of classes and package-level functions is provided in the *Adobe AIR API Reference for HTML Developers*.

In addition to commonly used runtime classes, the AIRAliases.js file includes aliases for commonly used package-level functions: `window.runtime.trace()`, `window.runtime.flash.net.navigateToURL()`, and `window.runtime.flash.net.sendToURL()`, which are aliased as `air.trace()`, `air.navigateToURL()`, and `air.sendToURL()`.

To use the AIRAliases.js file, include the following `script` reference in your HTML page:

```
<script src="AIRAliases.js"></script>
```

Adjust the path in the `src` reference, as needed.

***Important:** Except where noted, the JavaScript example code in this documentation assumes that you have included the AIRAliases.js file in your HTML page.*

About URLs in AIR

Adobe AIR 1.0 and later

In HTML content running in AIR, you can use any of the following URL schemes in defining `src` attributes for `img`, `frame`, `iframe`, and `script` tags, in the `href` attribute of a `link` tag, or anywhere else you can provide a URL.

URL scheme	Description	Example
file	A path relative to the root of the file system.	`file:///c:/AIR Test/test.txt`
app	A path relative to the root directory of the installed application.	`app:/images`
app-storage	A path relative to the application store directory. For each installed application, AIR defines a unique application store directory, which is a useful place to store data specific to that application.	`app-storage:/settings/prefs.xml`
http	A standard HTTP request.	`http://www.adobe.com`
https	A standard HTTPS request.	`https://secure.example.com`

For more information about using URL schemes in AIR, see "URI schemes" on page 813.

Many of AIR APIs, including the File, Loader, URLStream, and Sound classes, use a URLRequest object rather than a string containing the URL. The URLRequest object itself is initialized with a string, which can use any of the same url schemes. For example, the following statement creates a URLRequest object that can be used to request the Adobe home page:

```
var urlReq = new air.URLRequest("http://www.adobe.com/");
```

For information about URLRequest objects see "HTTP communications" on page 811.

Making ActionScript objects available to JavaScript

Adobe AIR 1.0 and later

JavaScript in the HTML page loaded by an HTMLLoader object can call the classes, objects, and functions defined in the ActionScript execution context using the `window.runtime`, `window.htmlLoader`, and `window.nativeWindow` properties of the HTML page. You can also make ActionScript objects and functions available to JavaScript code by creating references to them within the JavaScript execution context.

A basic example of accessing JavaScript objects from ActionScript

Adobe AIR 1.0 and later

The following example illustrates how to add properties referencing ActionScript objects to the global window object of an HTML page:

```
var html:HTMLLoader = new HTMLLoader();
var foo:String = "Hello from container SWF."
function helloFromJS(message:String):void {
    trace("JavaScript says:", message);
}
var urlReq:URLRequest = new URLRequest("test.html");
html.addEventListener(Event.COMPLETE, loaded);
html.load(urlReq);

function loaded(e:Event):void{
    html.window.foo = foo;
    html.window.helloFromJS = helloFromJS;
}
```

The HTML content (in a file named test.html) loaded into the HTMLLoader object in the previous example can access the `foo` property and the `helloFromJS()` method defined in the parent SWF file:

```
<html>
    <script>
        function alertFoo() {
            alert(foo);
        }
    </script>
    <body>
        <button onClick="alertFoo()">
            What is foo?
        </button>
        <p><button onClick="helloFromJS('Hi.')">
            Call helloFromJS() function.
        </button></p>
    </body>
</html>
```

When accessing the JavaScript context of a loading document, you can use the `htmlDOMInitialize` event to create objects early enough in the page construction sequence that any scripts defined in the page can access them. If you wait for the `complete` event, only scripts in the page that run after the page `load` event can access the added objects.

Making class definitions available to JavaScript

Adobe AIR 1.0 and later

To make the ActionScript classes of your application available in JavaScript, you can assign the loaded HTML content to the application domain containing the class definitions. The application domain of the JavaScript execution context can be set with the `runtimeApplicationDomain` property of the HTMLLoader object. To set the application domain to the primary application domain, for example, set `runtimeApplicationDomain` to `ApplicationDomain.currentDomain`, as shown in the following code:

```
html.runtimeApplicationDomain = ApplicationDomain.currentDomain;
```

Once the `runtimeApplicationDomain` property is set, the JavaScript context shares class definitions with the assigned domain. To create an instance of a custom class in JavaScript, reference the class definition through the `window.runtime` property and use the `new` operator:

```
var customClassObject = new window.runtime.CustomClass();
```

The HTML content must be from a compatible security domain. If the HTML content is from a different security domain than that of the application domain you assign, the page uses a default application domain instead. For example, if you load a remote page from the Internet, you could not assign ApplicationDomain.currentDomain as the application domain of the page.

Removing event listeners

Adobe AIR 1.0 and later

When you add JavaScript event listeners to objects outside the current page, including runtime objects, objects in loaded SWF content, and even JavaScript objects running in other pages, you should always remove those event listeners when the page unloads. Otherwise, the event listener dispatches the event to a handler function that no longer exists. If this happens, you will see the following error message: "The application attempted to reference a JavaScript object in an HTML page that is no longer loaded." Removing unneeded event listeners also lets AIR reclaim the associated memory. For more information, see "Removing event listeners in HTML pages that navigate" on page 1025.

Accessing HTML DOM and JavaScript objects from ActionScript

Adobe AIR 1.0 and later

Once the HTMLLoader object dispatches the `complete` event, you can access all the objects in the HTML DOM (document object model) for the page. Accessible objects include display elements (such as `div` and `p` objects in the page) as well as JavaScript variables and functions. The `complete` event corresponds to the JavaScript page `load` event. Before `complete` is dispatched, DOM elements, variables, and functions may not have been parsed or created. If possible, wait for the `complete` event before accessing the HTML DOM.

For example, consider the following HTML page:

```
<html>
    <script>
        foo = 333;
        function test() {
            return "OK.";
        }
    </script>
    <body>
        <p id="p1">Hi.</p>
    </body>
</html>
```

This simple HTML page defines a JavaScript variable named *foo* and a JavaScript function named *test()*. Both of these are properties of the global `window` object of the page. Also, the `window.document` object includes a named P element (with the ID *p1*), which you can access using the `getElementById()` method. Once the page is loaded (when the HTMLLoader object dispatches the `complete` event), you can access each of these objects from ActionScript, as shown in the following ActionScript code:

```
 var html:HTMLLoader = new HTMLLoader();
html.width = 300;
html.height = 300;
html.addEventListener(Event.COMPLETE, completeHandler);
var xhtml:XML =
    <html>
        <script>
            foo = 333;
            function test() {
                return "OK.";
            }
        </script>
        <body>
            <p id="p1">Hi.</p>
        </body>
    </html>;
html.loadString(xhtml.toString());

function completeHandler(e:Event):void {
    trace(html.window.foo); // 333
    trace(html.window.document.getElementById("p1").innerHTML); // Hi.
    trace(html.window.test()); // OK.
}
```

To access the content of an HTML element, use the `innerHTML` property. For example, the previous code uses `html.window.document.getElementById("p1").innerHTML` to get the contents of the HTML element named *p1*.

You can also set properties of the HTML page from ActionScript. For example, the following example sets the contents of the `p1` element and the value of the `foo` JavaScript variable on the page using a reference to the containing HTMLLoader object:

```
 html.window.document.getElementById("p1").innerHTML = "Goodbye";
html.window.foo = 66;
```

Embedding SWF content in HTML

Adobe AIR 1.0 and later

You can embed SWF content in HTML content within an AIR application just as you would in a browser. Embed the SWF content using an `object` tag, an `embed` tag, or both.

Note: *A common web development practice is to use both an `object` tag and an `embed` tag to display SWF content in an HTML page. This practice has no benefit in AIR. You can use the W3C-standard `object` tag by itself in content to be displayed in AIR. At the same time, you can continue to use the `object` and `embed` tags together, if necessary, for HTML content that is also displayed in a browser.*

If you have enabled transparency in the NativeWindow object displaying the HTML and SWF content, then AIR does not display the SWF content when window mode (`wmode`) used to embed the content is set to the value: `window`. To display SWF content in an HTML page of a transparent window, set the `wmode` parameter to `opaque` or `transparent`. The `window` is the default value for `wmode`, so if you do not specify a value, your content may not be displayed.

The following example illustrates the use of the HTML `object` tag to display a SWF file within HTML content. The `wmode` parameter is set to `opaque` so that the content is displayed, even if the underlying NativeWindow object is transparent. The SWF file is loaded from the application directory, but you can use any of the URL schemes supported by AIR. (The location from which the SWF file is loaded determines the security sandbox in which AIR places the content.)

```
<object type="application/x-shockwave-flash" width="100%" height="100%">
    <param name="movie" value="app:/SWFFile.swf"></param>
    <param name="wmode" value="opaque"></param>
</object>
```

You can also use a script to load content dynamically. The following example creates an `object` node to display the SWF file specified in the `urlString` parameter. The example adds the node as a child of the page element with the ID specified by the `elementID` parameter:

```
<script>
function showSWF(urlString, elementID){
    var displayContainer = document.getElementById(elementID);
    var flash = createSWFObject(urlString, 'opaque', 650, 650);
    displayContainer.appendChild(flash);
}
function createSWFObject(urlString, wmodeString, width, height){
    var SWFObject = document.createElement("object");
    SWFObject.setAttribute("type","application/x-shockwave-flash");
    SWFObject.setAttribute("width","100%");
    SWFObject.setAttribute("height","100%");
    var movieParam = document.createElement("param");
    movieParam.setAttribute("name","movie");
    movieParam.setAttribute("value",urlString);
    SWFObject.appendChild(movieParam);
    var wmodeParam = document.createElement("param");
    wmodeParam.setAttribute("name","wmode");
    wmodeParam.setAttribute("value",wmodeString);
    SWFObject.appendChild(wmodeParam);
    return SWFObject;
}
</script>
```

SWF content is not displayed if the HTMLLoader object is scaled or rotated, or if the `alpha` property is set to a value other than 1.0. Prior to AIR 1.5.2, SWF content was not displayed in a transparent window no matter which `wmode` value was set.

***Note:** When an embedded SWF object attempts to load an external asset like a video file, the SWF content may not be rendered properly if an absolute path to the video file is not provided in the HTML file. However, an embedded SWF object can load an external image file using a relative path.*

The following example depicts how external assets can be loaded through a SWF object embedded in an HTML content:

```
    var imageLoader;

    function showSWF(urlString, elementID){
        var displayContainer = document.getElementById(elementID);
        imageLoader = createSWFObject(urlString,650,650);
        displayContainer.appendChild(imageLoader);
    }

    function createSWFObject(urlString, width, height){

        var SWFObject = document.createElement("object");
        SWFObject.setAttribute("type","application/x-shockwave-flash");
        SWFObject.setAttribute("width","100%");
        SWFObject.setAttribute("height","100%");

        var movieParam = document.createElement("param");
        movieParam.setAttribute("name","movie");
        movieParam.setAttribute("value",urlString);
        SWFObject.appendChild(movieParam);

        var flashVars = document.createElement("param");
        flashVars.setAttribute("name","FlashVars");

        //Load the asset inside the SWF content.
        flashVars.setAttribute("value","imgPath=air.jpg");
        SWFObject.appendChild(flashVars);

        return SWFObject;
    }
    function loadImage()
    {
      showSWF("ImageLoader.swf", "imageSpot");

    }
```

In the following ActionScript example, the image path passed by the HTML file is read and the image is loaded on stage:

```
package
{
      import flash.display.Sprite;
      import flash.display.LoaderInfo;
      import flash.display.StageScaleMode;
      import flash.display.StageAlign;
      import flash.display.Loader;
      import flash.net.URLRequest;

      public class ImageLoader extends Sprite
      {
            public function ImageLoader()
            {

                  var flashvars = LoaderInfo(this.loaderInfo).parameters;

                  if(flashvars.imgPath){
                        var imageLoader = new Loader();
                        var image = new URLRequest(flashvars.imgPath);
                        imageLoader.load(image);
                        addChild(imageLoader);
                        imageLoader.x = 0;
                        imageLoader.y = 0;
                        stage.scaleMode=StageScaleMode.NO_SCALE;
                        stage.align=StageAlign.TOP_LEFT;
                  }
            }
      }
}
```

Using ActionScript libraries within an HTML page

Adobe AIR 1.0 and later

AIR extends the HTML script element so that a page can import ActionScript classes in a compiled SWF file. For example, to import a library named, *myClasses.swf*, located in the `lib` subdirectory of the root application folder, include the following script tag within an HTML file:

```
<script src="lib/myClasses.swf" type="application/x-shockwave-flash"></script>
```

***Important:** The type attribute must be `type="application/x-shockwave-flash"` for the library to be properly loaded.*

If the SWF content is compiled as a Flash Player 10 or AIR 1.5 SWF, you must set the XML namespace of the application descriptor file to the AIR 1.5 namespace.

The `lib` directory and `myClasses.swf` file must also be included when the AIR file is packaged.

Access the imported classes through the `runtime` property of the JavaScript Window object:

```
var libraryObject = new window.runtime.LibraryClass();
```

If the classes in the SWF file are organized in packages, you must include the package name as well. For example, if the LibraryClass definition was in a package named *utilities*, you would create an instance of the class with the following statement:

```
var libraryObject = new window.runtime.utilities.LibraryClass();
```

***Note:** To compile an ActionScript SWF library for use as part of an HTML page in AIR, use the `acompc` compiler. The acompc utility is part of the Flex SDK and is described in the Flex SDK documentation.*

Accessing the HTML DOM and JavaScript objects from an imported ActionScript file

Adobe AIR 1.0 and later

To access objects in an HTML page from ActionScript in a SWF file imported into the page using the `<script>` tag, pass a reference to a JavaScript object, such as `window` or `document`, to a function defined in the ActionScript code. Use the reference within the function to access the JavaScript object (or other objects accessible through the passed-in reference).

For example, consider the following HTML page:

```
<html>
    <script src="ASLibrary.swf" type="application/x-shockwave-flash"></script>
    <script>
        num = 254;
        function getStatus() {
            return "OK.";
        }
        function runASFunction(window){
            var obj = new runtime.ASClass();
            obj.accessDOM(window);
        }
    </script>
    <body onload="runASFunction">
        <p id="p1">Body text.</p>
    </body>
</html>
```

This simple HTML page has a JavaScript variable named *num* and a JavaScript function named *getStatus()*. Both of these are properties of the `window` object of the page. Also, the `window.document` object includes a named P element (with the ID *p1*).

The page loads an ActionScript file, "ASLibrary.swf," that contains a class, ASClass. ASClass defines a function named `accessDOM()` that simply traces the values of these JavaScript objects. The `accessDOM()` method takes the JavaScript Window object as an argument. Using this Window reference, it can access other objects in the page including variables, functions, and DOM elements as illustrated in the following definition:

```
public class ASClass{
    public function accessDOM(window:*):void {
        trace(window.num); // 254
        trace(window.document.getElementById("p1").innerHTML); // Body text..
        trace(window.getStatus()); // OK.
    }
}
```

You can both get and set properties of the HTML page from an imported ActionScript class. For example, the following function sets the contents of the `p1` element on the page and it sets the value of the `foo` JavaScript variable on the page:

```
public function modifyDOM(window:*):void {
    window.document.getElementById("p1").innerHTML = "Bye";
    window.foo = 66;
```

Converting Date and RegExp objects

Adobe AIR 1.0 and later

The JavaScript and ActionScript languages both define Date and RegExp classes, but objects of these types are not automatically converted between the two execution contexts. You must convert Date and RegExp objects to the equivalent type before using them to set properties or function parameters in the alternate execution context.

For example, the following ActionScript code converts a JavaScript Date object named `jsDate` to an ActionScript Date object:

```
var asDate:Date = new Date(jsDate.getMilliseconds());
```

The following ActionScript code converts a JavaScript RegExp object named `jsRegExp` to an ActionScript RegExp object:

```
var flags:String = "";
if (jsRegExp.dotAll) flags += "s";
if (jsRegExp.extended) flags += "x";
if (jsRegExp.global) flags += "g";
if (jsRegExp.ignoreCase) flags += "i";
if (jsRegExp.multiline) flags += "m";
var asRegExp:RegExp = new RegExp(jsRegExp.source, flags);
```

Manipulating an HTML stylesheet from ActionScript

Adobe AIR 1.0 and later

Once the HTMLLoader object has dispatched the `complete` event, you can examine and manipulate CSS styles in a page.

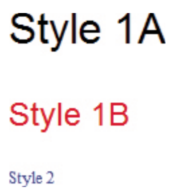
For example, consider the following simple HTML document:

```
<html>
<style>
    .style1A { font-family:Arial; font-size:12px }
    .style1B { font-family:Arial; font-size:24px }
</style>
<style>
    .style2 { font-family:Arial; font-size:12px }
</style>
<body>
    <p class="style1A">
        Style 1A
    </p>
    <p class="style1B">
        Style 1B
    </p>
    <p class="style2">
        Style 2
    </p>
</body>
</html>
```

After an HTMLLoader object loads this content, you can manipulate the CSS styles in the page via the `cssRules` array of the `window.document.styleSheets` array, as shown here:

```
var html:HTMLLoader = new HTMLLoader( );
var urlReq:URLRequest = new URLRequest("test.html");
html.load(urlReq);
html.addEventListener(Event.COMPLETE, completeHandler);
function completeHandler(event:Event):void {
    var styleSheet0:Object = html.window.document.styleSheets[0];
    styleSheet0.cssRules[0].style.fontSize = "32px";
    styleSheet0.cssRules[1].style.color = "#FF0000";
    var styleSheet1:Object = html.window.document.styleSheets[1];
    styleSheet1.cssRules[0].style.color = "blue";
    styleSheet1.cssRules[0].style.font-family = "Monaco";
}
```

This code adjusts the CSS styles so that the resulting HTML document appears like the following:



Style 1A

Style 1B

Style 2

Keep in mind that code can add styles to the page after the HTMLLoader object dispatches the `complete` event.

Cross-scripting content in different security sandboxes

Adobe AIR 1.0 and later

The runtime security model isolates code from different origins. By cross-scripting content in different security sandboxes, you can allow content in one security sandbox to access selected properties and methods in another sandbox.

AIR security sandboxes and JavaScript code

Adobe AIR 1.0 and later

AIR enforces a same-origin policy that prevents code in one domain from interacting with content in another. All files are placed in a sandbox based on their origin. Ordinarily, content in the application sandbox cannot violate the same-origin principle and cross-script content loaded from outside the application install directory. However, AIR provides a few techniques that let you cross-script non-application content.

One technique uses frames or iframes to map application content into a different security sandbox. Any pages loaded from the sandboxed area of the application behave as if they were loaded from the remote domain. For example, by mapping application content to the *example.com* domain, that content could cross-script pages loaded from example.com.

Since this technique places the application content into a different sandbox, code within that content is also no longer subject to the restrictions on the execution of code in evaluated strings. You can use this sandbox mapping technique to ease these restrictions even when you don't need to cross-script remote content. Mapping content in this way can be especially useful when working with one of the many JavaScript frameworks or with existing code that relies on evaluating strings. However, you should consider and guard against the additional risk that untrusted content could be injected and executed when content is run outside the application sandbox.

At the same time, application content mapped to another sandbox loses its access to the AIR APIs, so the sandbox mapping technique cannot be used to expose AIR functionality to code executed outside the application sandbox.

Another cross-scripting technique lets you create an interface called a *sandbox bridge* between content in a non-application sandbox and its parent document in the application sandbox. The bridge allows the child content to access properties and methods defined by the parent, the parent to access properties and methods defined by the child, or both.

Finally, you can also perform cross-domain XMLHttpRequests from the application sandbox and, optionally, from other sandboxes.

For more information, see "HTML frame and iframe elements" on page 973, "HTML security in Adobe AIR" on page 1080, and "The XMLHttpRequest object" on page 967.

Loading application content into a non-application sandbox

Adobe AIR 1.0 and later

To allow application content to safely cross-script content loaded from outside the application install directory, you can use `frame` or `iframe` elements to load application content into the same security sandbox as the external content. If you do not need to cross-script remote content, but still wish to load a page of your application outside the application sandbox, you can use the same technique, specifying `http://localhost/` or some other innocuous value, as the domain of origin.

AIR adds the new attributes, `sandboxRoot` and `documentRoot`, to the frame element that allow you to specify whether an application file loaded into the frame should be mapped to a non-application sandbox. Files resolving to a path underneath the `sandboxRoot` URL are loaded instead from the `documentRoot` directory. For security purposes, the application content loaded in this way is treated as if it was actually loaded from the `sandboxRoot` URL.

The `sandboxRoot` property specifies the URL to use for determining the sandbox and domain in which to place the frame content. The `file:`, `http:`, or `https:` URL schemes must be used. If you specify a relative URL, the content remains in the application sandbox.

The `documentRoot` property specifies the directory from which to load the frame content. The `file:`, `app:`, or `app-storage:` URL schemes must be used.

The following example maps content installed in the `sandbox` subdirectory of the application to run in the remote sandbox and the `www.example.com` domain:

```
 <iframe
    src="http://www.example.com/local/ui.html"
    sandboxRoot="http://www.example.com/local/"
    documentRoot="app:/sandbox/">
</iframe>
```

The `ui.html` page could load a javascript file from the local, `sandbox` folder using the following script tag:

```
<script src="http://www.example.com/local/ui.js"></script>
```

It could also load content from a directory on the remote server using a script tag such as the following:

```
<script src="http://www.example.com/remote/remote.js"></script>
```

The `sandboxRoot` URL will mask any content at the same URL on the remote server. In the above example, you would not be able to access any remote content at `www.example.com/local/` (or any of its subdirectories) because AIR remaps the request to the local application directory. Requests are remapped whether they derive from page navigation, from an XMLHttpRequest, or from any other means of loading content.

Setting up a sandbox bridge interface

Adobe AIR 1.0 and later

You can use a sandbox bridge when content in the application sandbox must access properties or methods defined by content in a non-application sandbox, or when non-application content must access properties and methods defined by content in the application sandbox. Create a bridge with the `childSandboxBridge` and `parentSandboxBridge` properties of the `window` object of any child document.

Establishing a child sandbox bridge

Adobe AIR 1.0 and later

The `childSandboxBridge` property allows the child document to expose an interface to content in the parent document. To expose an interface, you set the `childSandbox` property to a function or object in the child document. You can then access the object or function from content in the parent document. The following example shows how a script running in a child document can expose an object containing a function and a property to its parent:

```
 var interface = {};
interface.calculatePrice = function(){
    return ".45 cents";
}
interface.storeID = "abc"
window.childSandboxBridge = interface;
```

If this child content was loaded into an iframe assigned an id of "child", you could access the interface from parent content by reading the `childSandboxBridge` property of the frame:

```
 var childInterface = document.getElementById("child").contentWindow.childSandboxBridge;
air.trace(childInterface.calculatePrice()); //traces ".45 cents"
air.trace(childInterface.storeID)); //traces "abc"
```

Establishing a parent sandbox bridge

Adobe AIR 1.0 and later

The `parentSandboxBridge` property allows the parent document to expose an interface to content in a child document. To expose an interface, the parent document sets the `parentSandbox` property of the child document to a function or object defined in the parent document. You can then access the object or function from content in the child. The following example shows how a script running in a parent frame can expose an object containing a function to a child document:

```
 var interface = {};
interface.save = function(text){
    var saveFile = air.File("app-storage:/save.txt");
    //write text to file
}
document.getElementById("child").contentWindow.parentSandboxBridge = interface;
```

Using this interface, content in the child frame could save text to a file named `save.txt`, but would not have any other access to the file system. The child content could call the save function as follows:

```
 var textToSave = "A string.";
window.parentSandboxBridge.save(textToSave);
```

Application content should expose the narrowest interface possible to other sandboxes. Non-application content should be considered inherently untrustworthy since it may be subject to accidental or malicious code injection. You must put appropriate safeguards in place to prevent misuse of the interface you expose through the parent sandbox bridge.

Accessing a parent sandbox bridge during page loading

Adobe AIR 1.0 and later

In order for a script in a child document to access a parent sandbox bridge, the bridge must be set up before the script is run. Window, frame and iframe objects dispatch a `dominitialize` event when a new page DOM has been created, but before any scripts have been parsed, or DOM elements added. You can use the `dominitialize` event to establish the bridge early enough in the page construction sequence that all scripts in the child document can access it.

The following example illustrates how to create a parent sandbox bridge in response to the `dominitialize` event dispatched from the child frame:

```
<html>
<head>
<script>
var bridgeInterface = {};
bridgeInterface.testProperty = "Bridge engaged";
function engageBridge(){
    document.getElementById("sandbox").contentWindow.parentSandboxBridge = bridgeInterface;
}
</script>
</head>
<body>
<iframe id="sandbox"
            src="http://www.example.com/air/child.html"
            documentRoot="app:/"
            sandboxRoot="http://www.example.com/air/"
            ondominitialize="engageBridge()"/>
</body>
</html>
```

The following `child.html` document illustrates how child content can access the parent sandbox bridge:

```
<html>
    <head>
        <script>
            document.write(window.parentSandboxBridge.testProperty);
        </script>
    </head>
    <body></body>
</html>
```

To listen for the `dominitialize` event on a child window, rather than a frame, you must add the listener to the new child window object created by the `window.open()` function:

```
var childWindow = window.open();
childWindow.addEventListener("dominitialize", engageBridge());
childWindow.document.location = "http://www.example.com/air/child.html";
```

In this case, there is no way to map application content into a non-application sandbox. This technique is only useful when `child.html` is loaded from outside the application directory. You can still map application content in the window to a non-application sandbox, but you must first load an intermediate page that itself uses frames to load the child document and map it to the desired sandbox.

If you use the HTMLLoader class `createRootWindow()` function to create a window, the new window is not a child of the document from which `createRootWindow()` is called. Thus, you cannot create a sandbox bridge from the calling window to non-application content loaded into the new window. Instead, you must use load an intermediate page in the new window that itself uses frames to load the child document. You can then establish the bridge from the parent document of the new window to the child document loaded into the frame.

Chapter 60: Scripting the AIR HTML Container

Adobe AIR 1.0 and later

The HTMLLoader class serves as the container for HTML content in Adobe® AIR®. The class provides many properties and methods, inherited from the Sprite class, for controlling the behavior and appearance of the object on the ActionScript® 3.0 display list. In addition, the class defines properties and methods for such tasks as loading and interacting with HTML content and managing history.

The HTMLHost class defines a set of default behaviors for an HTMLLoader. When you create an HTMLLoader object, no HTMLHost implementation is provided. Thus when HTML content triggers one of the default behaviors, such as changing the window location, or the window title, nothing happens. You can extend the HTMLHost class to define the behaviors desired for your application.

A default implementation of the HTMLHost is provided for HTML windows created by AIR. You can assign the default HTMLHost implementation to another HTMLLoader object by setting the `htmlHost` property of the object using a new HTMLHost object created with the `defaultBehavior` parameter set to `true`.

***Note:** In the Adobe® Flex™ Framework, the HTMLLoader object is wrapped by the mx:HTML component. When using Flex, use the HTML component.*

Display properties of HTMLLoader objects

Adobe AIR 1.0 and later

An HTMLLoader object inherits the display properties of the Adobe® Flash® Player Sprite class. You can resize, move, hide, and change the background color, for example. Or you can apply advanced effects like filters, masks, scaling, and rotation. When applying effects, consider the impact on legibility. SWF and PDF content loaded into an HTML page cannot be displayed when some effects are applied.

HTML windows contain an HTMLLoader object that renders the HTML content. This object is constrained within the area of the window, so changing the dimensions, position, rotation, or scale factor does not always produce desirable results.

Basic display properties

Adobe AIR 1.0 and later

The basic display properties of the HTMLLoader allow you to position the control within its parent display object, to set the size, and to show or hide the control. You should not change these properties for the HTMLLoader object of an HTML window.

The basic properties include:

Property	Notes
`x`, `y`	Positions the object within its parent container.
`width`, `height`	Changes the dimensions of the display area.
`visible`	Controls the visibility of the object and any content it contains.

Outside an HTML window, the `width` and `height` properties of an HTMLLoader object default to 0. You must set the width and height before the loaded HTML content can be seen. HTML content is drawn to the HTMLLoader size, laid out according to the HTML and CSS properties in the content. Changing the HTMLLoader size reflows the content.

When loading content into a new HTMLLoader object (with `width` still set to 0), it can be tempting to set the display `width` and `height` of the HTMLLoader using the `contentWidth` and `contentHeight` properties. This technique works for pages that have a reasonable minimum width when laid out according the HTML and CSS flow rules. However, some pages flow into a long and narrow layout in the absence of a reasonable width provided by the HTMLLoader.

***Note:** When you change the width and height of an HTMLLoader object, the scaleX and scaleY values do not change, as would happen with most other types of display objects.*

Transparency of HTMLLoader content

Adobe AIR 1.0 and later

The `paintsDefaultBackground` property of an HTMLLoader object, which is `true` by default, determines whether the HTMLLoader object draws an opaque background. When `paintsDefaultBackground` is `false`, the background is clear. The display object container or other display objects below the HTMLLoader object are visible behind the foreground elements of the HTML content.

If the body element or any other element of the HTML document specifies a background color (using `style="background-color:gray"`, for example), then the background of that portion of the HTML is opaque and rendered with the specified background color. If you set the `opaqueBackground` property of the HTMLLoader object, and `paintsDefaultBackground` is `false`, then the color set for the `opaqueBackground` is visible.

***Note:** You can use a transparent, PNG-format graphic to provide an alpha-blended background for an element in an HTML document. Setting the opacity style of an HTML element is not supported.*

Scaling HTMLLoader content

Adobe AIR 1.0 and later

Avoid scaling an HTMLLoader object beyond a scale factor of 1.0. Text in HTMLLoader content is rendered at a specific resolution and appears pixelated if the HTMLLoader object is scaled up. To prevent the HTMLLoader, as well as its contents, from scaling when a window is resized, set the `scaleMode` property of the Stage to `StageScaleMode.NO_SCALE`.

Considerations when loading SWF or PDF content in an HTML page

Adobe AIR 1.0 and later

SWF and PDF content loaded into in an HTMLLoader object disappears in the following conditions:

- If you scale the HTMLLoader object to a factor other that 1.0.

- If you set the alpha property of the HTMLLoader object to a value other than 1.0.
- If you rotate the HTMLLoader content.

The content reappears if you remove the offending property setting and remove the active filters.

In addition, the runtime cannot display PDF content in transparent windows. The runtime only displays SWF content embedded in an HTML page when the `wmode` parameter of the object or embed tag is set to `opaque` or `transparent`. Since the default value of `wmode` is `window`, SWF content is not displayed in transparent windows unless you explicitly set the wmode parameter.

***Note:** Prior to AIR 1.5.2, SWF embedded in HTML could not be displayed no matter which wmode value was used.*

For more information on loading these types of media in an HTMLLoader, see "Embedding SWF content in HTML" on page 992and "Adding PDF content in AIR" on page 551.

Advanced display properties

Adobe AIR 1.0 and later

The HTMLLoader class inherits several methods that can be used for special effects. In general, these effects have limitations when used with the HTMLLoader display, but they can be useful for transitions or other temporary effects. For example, if you display a dialog window to gather user input, you could blur the display of the main window until the user closes the dialog. Likewise, you could fade the display out when closing a window.

The advanced display properties include:

Property	Limitations
`alpha`	Can reduce the legibility of HTML content
`filters`	In an HTML Window, exterior effects are clipped by the window edge
`graphics`	Shapes drawn with graphics commands appear below HTML content, including the default background. The paintsDefaultBackground property must be false for the drawn shapes to be visible.
`opaqueBackground`	Does not change the color of the default background. The paintsDefaultBackground property must be false for this color layer to be visible.
`rotation`	The corners of the rectangular HTMLLoader area can be clipped by the window edge. SWF and PDF content loaded in the HTML content is not displayed.
`scaleX`, `scaleY`	The rendered display can appear pixelated at scale factors greater than 1. SWF and PDF content loaded in the HTML content is not displayed.
`transform`	Can reduce legibility of HTML content. The HTML display can be clipped by the window edge. SWF and PDF content loaded in the HTML content is not displayed if the transform involves rotation, scaling, or skewing.

The following example illustrates how to set the `filters` array to blur the entire HTML display:

```
 var html:HTMLLoader = new HTMLLoader();
var urlReq:URLRequest = new URLRequest("http://www.adobe.com/");
html.load(urlReq);
html.width = 800;
html.height = 600;

var blur:BlurFilter = new BlurFilter(8);
var filters:Array = [blur];
html.filters = filters;
```

Scrolling HTML content

Adobe AIR 1.0 and later

The HTMLLoader class includes the following properties that let you control the scrolling of HTML content:

Property	Description
`contentHeight`	The height, in pixels, of the HTML content.
contentWidth	The width, in pixels, of the HTML content.
scrollH	The horizontal scroll position of the HTML content within the HTMLLoader object.
scrollV	The vertical scroll position of the HTML content within the HTMLLoader object.

The following code sets the `scrollV` property so that HTML content is scrolled to the bottom of the page:

```
 var html:HTMLLoader = new HTMLLoader();
html.addEventListener(Event.HTML_BOUNDS_CHANGE, scrollHTML);

const SIZE:Number = 600;
html.width = SIZE;
html.height = SIZE;

var urlReq:URLRequest = new URLRequest("http://www.adobe.com");
html.load(urlReq);
this.addChild(html);

function scrollHTML(event:Event):void
{
    html.scrollV = html.contentHeight - SIZE;
}
```

The HTMLLoader does not include horizontal and vertical scroll bars. You can implement scroll bars in ActionScript or by using a Flex component. The Flex HTML component automatically includes scroll bars for HTML content. You can also use the `HTMLLoader.createRootWindow()` method to create a window that contains an HTMLLoader object with scroll bars (see "Creating windows with scrolling HTML content" on page 1018).

Accessing the HTML history list

Adobe AIR 1.0 and later

As new pages are loaded in an HTMLLoader object, the runtime maintains a history list for the object. The history list corresponds to the `window.history` object in the HTML page. The HTMLLoader class includes the following properties and methods that let you work with the HTML history list:

Class member	Description
`historyLength`	The overall length of the history list, including back and forward entries.
`historyPosition`	The current position in the history list. History items before this position represent "back" navigation, and items after this position represent "forward" navigation.
`getHistoryAt()`	Returns the URLRequest object corresponding to the history entry at the specified position in the history list.
`historyBack()`	Navigates back in the history list, if possible.
`historyForward()`	Navigates forward in the history list, if possible.
`historyGo()`	Navigates the indicated number of steps in the browser history. Navigates forward if positive, backward if negative. Navigating to zero reloads the page. Specifying a position beyond the end navigates to the end of the list.

Items in the history list are stored as objects of type HTMLHistoryItem. The HTMLHistoryItem class has the following properties:

Property	Description
`isPost`	Set to `true` if the HTML page includes POST data.
`originalUrl`	The original URL of the HTML page, before any redirects.
`title`	The title of the HTML page.
`url`	The URL of the HTML page.

Setting the user agent used when loading HTML content

Adobe AIR 1.0 and later

The HTMLLoader class has a `userAgent` property, which lets you set the user agent string used by the HTMLLoader. Set the `userAgent` property of the HTMLLoader object before calling the `load()` method. If you set this property on the HTMLLoader instance, then the `userAgent` property of the URLRequest passed to the `load()` method is *not* used.

You can set the default user agent string used by all HTMLLoader objects in an application domain by setting the `URLRequestDefaults.userAgent` property. The static URLRequestDefaults properties apply as defaults for all URLRequest objects, not only URLRequests used with the `load()` method of HTMLLoader objects. Setting the `userAgent` property of an HTMLLoader overrides the default `URLRequestDefaults.userAgent` setting.

If you do not set a user agent value for either the `userAgent` property of the HTMLLoader object or for `URLRequestDefaults.userAgent`, then the default AIR user agent value is used. This default value varies depending on the runtime operating system (such as Mac OS or Windows), the runtime language, and the runtime version, as in the following two examples:

- `"Mozilla/5.0 (Macintosh; U; PPC Mac OS X; en) AppleWebKit/420+ (KHTML, like Gecko) AdobeAIR/1.0"`
- `"Mozilla/5.0 (Windows; U; en) AppleWebKit/420+ (KHTML, like Gecko) AdobeAIR/1.0"`

Setting the character encoding to use for HTML content

Adobe AIR 1.0 and later

An HTML page can specify the character encoding it uses by including `meta` tag, such as the following:

```
 meta http-equiv="content-type" content="text/html" charset="ISO-8859-1";
```

Override the page setting to ensure that a specific character encoding is used by setting the `textEncodingOverride` property of the HTMLLoader object:

```
 var html:HTMLLoader = new HTMLLoader();
html.textEncodingOverride = "ISO-8859-1";
```

Specify the character encoding for the HTMLLoader content to use when an HTML page does not specify a setting with the `textEncodingFallback` property of the HTMLLoader object:

```
 var html:HTMLLoader = new HTMLLoader();
html.textEncodingFallback = "ISO-8859-1";
```

The `textEncodingOverride` property overrides the setting in the HTML page. And the `textEncodingOverride` property and the setting in the HTML page override the `textEncodingFallback` property.

Set the `textEncodingOverride` property or the `textEncodingFallback` property before loading the HTML content.

Defining browser-like user interfaces for HTML content

Adobe AIR 1.0 and later

JavaScript provides several APIs for controlling the window displaying the HTML content. In AIR, these APIs can be overridden by implementing a custom HTMLHost class.

About extending the HTMLHost class

Adobe AIR 1.0 and later

If, for example, your application presents multiple HTMLLoader objects in a tabbed interface, you may want title changes made by the loaded HTML pages to change the label of the tab, not the title of the main window. Similarly, your code could respond to a `window.moveTo()` call by repositioning the HTMLLoader object in its parent display object container, by moving the window that contains the HTMLLoader object, by doing nothing at all, or by doing something else entirely.

The AIR HTMLHost class controls the following JavaScript properties and methods:

- `window.status`
- `window.document.title`
- `window.location`
- `window.blur()`
- `window.close()`
- `window.focus()`
- `window.moveBy()`
- `window.moveTo()`
- `window.open()`
- `window.resizeBy()`
- `window.resizeTo()`

When you create an HTMLLoader object using `new HTMLLoader()`, the listed JavaScript properties or methods are not enabled. The HTMLHost class provides a default, browser-like implementation of these JavaScript APIs. You can also extend the HTMLHost class to customize the behavior. To create an HTMLHost object supporting the default behavior, set the `defaultBehaviors` parameter to true in the HTMLHost constructor:

```
var defaultHost:HTMLHost = new HTMLHost(true);
```

When you create an HTML window in AIR with the HTMLLoader class `createRootWindow()` method, an HTMLHost instance supporting the default behaviors is assigned automatically. You can change the host object behavior by assigning a different HTMLHost implementation to the `htmlHost` property of the HTMLLoader, or you can assign `null` to disable the features entirely.

Note: *AIR assigns a default HTMLHost object to the initial window created for an HTML-based AIR application and any windows created by the default implementation of the JavaScript `window.open()` method.*

Example: Extending the HTMLHost class

Adobe AIR 1.0 and later

The following example shows how to customize the way that an HTMLLoader object affects the user interface, by extending the HTMLHost class:

Flex example:

1 Create a class that extends the HTMLHost class (a subclass).

2 Override methods of the new class to handle changes in the user interface-related settings. For example, the following class, CustomHost, defines behaviors for calls to `window.open()` and changes to `window.document.title`. Calls to `window.open()` open the HTML page in a new window, and changes to `window.document.title` (including the setting of the `<title>` element of an HTML page) set the title of that window.

```
 package
{
    import flash.html.*;
    import flash.display.StageScaleMode;
    import flash.display.NativeWindow;
    import flash.display.NativeWindowInitOptions;

    public class CustomHost extends HTMLHost
    {
        import flash.html.*;
        override public function
            createWindow(windowCreateOptions:HTMLWindowCreateOptions):HTMLLoader
        {
            var initOptions:NativeWindowInitOptions = new NativeWindowInitOptions();
            var bounds:Rectangle = new Rectangle(windowCreateOptions.x,
                                                windowCreateOptions.y,
                                                windowCreateOptions.width,
                                                windowCreateOptions.height);
            var htmlControl:HTMLLoader = HTMLLoader.createRootWindow(true, initOptions,
                                            windowCreateOptions.scrollBarsVisible, bounds);
            htmlControl.htmlHost = new HTMLHostImplementation();
            if(windowCreateOptions.fullscreen){
                htmlControl.stage.displayState =
                    StageDisplayState.FULL_SCREEN_INTERACTIVE;
            }
            return htmlControl;
        }
        override public function updateTitle(title:String):void
        {
            htmlLoader.stage.nativeWindow.title = title;
        }
    }
}
```

3 In the code that contains the HTMLLoader (not the code of the new subclass of HTMLHost), create an object of the new class. Assign the new object to the `htmlHost` property of the HTMLLoader. The following Flex code uses the CustomHost class defined in the previous step:

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication
    xmlns:mx="http://www.adobe.com/2006/mxml"
    layout="vertical"
    applicationComplete="init()">
    <mx:Script>
        <![CDATA[
            import flash.html.HTMLLoader;
            import CustomHost;
            private function init():void
            {
                var html:HTMLLoader = new HTMLLoader();
                html.width = container.width;
                html.height = container.height;
                var urlReq:URLRequest = new URLRequest("Test.html");
                html.htmlHost = new CustomHost();
                html.load(urlReq);
                container.addChild(html);
            }
        ]]>
    </mx:Script>
    <mx:UIComponent id="container" width="100%" height="100%"/>
</mx:WindowedApplication>
```

To test the code described here, include an HTML file with the following content in the application directory:

```
<html>
    <head>
        <title>Test</title>
    </head>
    <script>
        function openWindow()
        {
            window.runtime.trace("in");
            document.title = "foo"
            window.open('Test.html');
            window.runtime.trace("out");
        }
    </script>
    <body>
        <a href="#" onclick="openWindow()">window.open('Test.html')</a>
    </body>
</html>
```

Flash Professional example:

1 Create a Flash file for AIR. Set its document class to CustomHostExample and then save the file as CustomHostExample.fla.

2 Create an ActionScript file called CustomHost.as containing a class that extends the HTMLHost class (a subclass). This class overrides certain methods of the new class to handle changes in the user interface-related settings. For example, the following class, CustomHost, defines behaviors for calls to `window.open()` and changes to `window.document.title`. Calls to the `window.open()` method open the HTML page in a new window, and changes to the `window.document.title` property (including the setting of the `<title>` element of an HTML page) set the title of that window.

```
package
{
    import flash.display.StageScaleMode;
    import flash.display.NativeWindow;
    import flash.display.NativeWindowInitOptions;
    import flash.events.Event;
    import flash.events.NativeWindowBoundsEvent;
    import flash.geom.Rectangle;
    import flash.html.HTMLLoader;
    import flash.html.HTMLHost;
    import flash.html.HTMLWindowCreateOptions;
    import flash.text.TextField;

    public class CustomHost extends HTMLHost
    {
        public var statusField:TextField;

        public function CustomHost(defaultBehaviors:Boolean=true)
        {
            super(defaultBehaviors);
        }
        override public function windowClose():void
        {
            htmlLoader.stage.nativeWindow.close();
        }
        override public function createWindow(
                                windowCreateOptions:HTMLWindowCreateOptions ):HTMLLoader
        {
            var initOptions:NativeWindowInitOptions = new NativeWindowInitOptions();
            var bounds:Rectangle = new Rectangle(windowCreateOptions.x,
                                            windowCreateOptions.y,
                                            windowCreateOptions.width,
                                            windowCreateOptions.height);
            var htmlControl:HTMLLoader = HTMLLoader.createRootWindow(true, initOptions,
                                        windowCreateOptions.scrollBarsVisible, bounds);
            htmlControl.htmlHost = new HTMLHostImplementation();
            if(windowCreateOptions.fullscreen){
                htmlControl.stage.displayState =
                    StageDisplayState.FULL_SCREEN_INTERACTIVE;
            }
            return htmlControl;
        }
        override public function updateLocation(locationURL:String):void
        {
            trace(locationURL);
        }
        override public function set windowRect(value:Rectangle):void
        {
            htmlLoader.stage.nativeWindow.bounds = value;
        }
        override public function updateStatus(status:String):void
        {
            statusField.text = status;
            trace(status);
        }
        override public function updateTitle(title:String):void
        {
            htmlLoader.stage.nativeWindow.title = title + "- Example Application";
        }
        override public function windowBlur():void
        {
            htmlLoader.alpha = 0.5;
        }
        override public function windowFocus():void
        {
            htmlLoader.alpha = 1;
        }
    }
}
```

3 Create another ActionScript file named CustomHostExample.as to contain the document class for the application. This class creates an HTMLLoader object and sets its host property to an instance of the CustomHost class defined in the previous step:

```
package
{
    import flash.display.Sprite;
    import flash.html.HTMLLoader;
    import flash.net.URLRequest;
    import flash.text.TextField;

    public class CustomHostExample extends Sprite
    {
        function CustomHostExample():void
        {
            var html:HTMLLoader = new HTMLLoader();
            html.width = 550;
            html.height = 380;
            var host:CustomHost = new CustomHost();
            html.htmlHost = host;

            var urlReq:URLRequest = new URLRequest("Test.html");
            html.load(urlReq);

            addChild(html);

            var statusTxt:TextField = new TextField();
            statusTxt.y = 380;
            statusTxt.height = 20;
            statusTxt.width = 550;
            statusTxt.background = true;
            statusTxt.backgroundColor = 0xEEEEEEEE;
            addChild(statusTxt);

            host.statusField = statusTxt;
        }
    }
}
```

To test the code described here, include an HTML file with the following content in the application directory:

```
<html>
     <head>
     <title>Test</title>
     <script>
     function openWindow()
     {
     document.title = "Test"
     window.open('Test.html');
     }
     </script>
     </head>
     <body bgColor="#EEEEEE">
     <a href="#" onclick="window.open('Test.html')">window.open('Test.html')</a>
     <br/><a href="#" onclick="window.document.location='http://www.adobe.com'">
     window.document.location = 'http://www.adobe.com'</a>
     <br/><a href="#" onclick="window.moveBy(6, 12)">moveBy(6, 12)</a>
     <br/><a href="#" onclick="window.close()">window.close()</a>
     <br/><a href="#" onclick="window.blur()">window.blur()</a>
     <br/><a href="#" onclick="window.focus()">window.focus()</a>
     <br/><a href="#" onclick="window.status = new Date().toString()">window.status=new
Date().toString()</a>
     </body>
</html>
```

Handling changes to the window.location property

Adobe AIR 1.0 and later

Override the `locationChange()` method to handle changes of the URL of the HTML page. The `locationChange()` method is called when JavaScript in a page changes the value of `window.location`. The following example simply loads the requested URL:

```
override public function updateLocation(locationURL:String):void
{
    htmlLoader.load(new URLRequest(locationURL));
}
```

Note: *You can use the htmlLoader property of the HTMLHost object to reference the current HTMLLoader object.*

Handling JavaScript calls to window.moveBy(), window.moveTo(), window.resizeTo(), window.resizeBy()

Adobe AIR 1.0 and later

Override the `set windowRect()` method to handle changes in the bounds of the HTML content. The `set windowRect()` method is called when JavaScript in a page calls `window.moveBy()`, `window.moveTo()`, `window.resizeTo()`, or `window.resizeBy()`. The following example simply updates the bounds of the desktop window:

```
override public function set windowRect(value:Rectangle):void
{
    htmlLoader.stage.nativeWindow.bounds = value;
}
```

Handling JavaScript calls to window.open()

Adobe AIR 1.0 and later

Override the `createWindow()` method to handle JavaScript calls to `window.open()`. Implementations of the `createWindow()` method are responsible for creating and returning a new HTMLLoader object. Typically, you would display the HTMLLoader in a new window, but creating a window is not required.

The following example illustrates how to implement the `createWindow()` function using the `HTMLLoader.createRootWindow()` to create both the window and the HTMLLoader object. You can also create a NativeWindow object separately and add the HTMLLoader to the window stage.

```
override public function createWindow(windowCreateOptions:HTMLWindowCreateOptions):HTMLLoader{
    var initOptions:NativeWindowInitOptions = new NativeWindowInitOptions();
    var bounds:Rectangle = new Rectangle(windowCreateOptions.x, windowCreateOptions.y,
                                windowCreateOptions.width, windowCreateOptions.height);
    var htmlControl:HTMLLoader = HTMLLoader.createRootWindow(true, initOptions,
                                    windowCreateOptions.scrollBarsVisible, bounds);
    htmlControl.htmlHost = new HTMLHostImplementation();
    if(windowCreateOptions.fullscreen){
        htmlControl.stage.displayState = StageDisplayState.FULL_SCREEN_INTERACTIVE;
    }
    return htmlControl;
}
```

***Note:** This example assigns the custom HTMLHost implementation to any new windows created with `window.open()`. You can also use a different implementation or set the `htmlHost` property to null for new windows, if desired.*

The object passed as a parameter to the `createWindow()` method is an HTMLWindowCreateOptions object. The HTMLWindowCreateOptions class includes properties that report the values set in the `features` parameter string in the call to `window.open()`:

HTMLWindowCreateOptions property	Corresponding setting in the features string in the JavaScript call to window.open()
`fullscreen`	`fullscreen`
`height`	`height`
`locationBarVisible`	`location`
`menuBarVisible`	`menubar`
`resizeable`	`resizable`
`scrollBarsVisible`	`scrollbars`
`statusBarVisible`	`status`
`toolBarVisible`	`toolbar`
`width`	`width`
`x`	`left` or `screenX`
`y`	`top` or `screenY`

The HTMLLoader class does not implement all the features that can be specified in the feature string. Your application must provide scroll bars, location bars, menu bars, status bars, and toolbars when appropriate.

The other arguments to the JavaScript `window.open()` method are handled by the system. A `createWindow()` implementation should not load content in the HTMLLoader object, or set the window title.

Handling JavaScript calls to window.close()

Adobe AIR 1.0 and later

Override the `windowClose()` to handle JavaScript calls to `window.close()` method. The following example closes the desktop window when the `window.close()` method is called:

```
override public function windowClose():void
{
    htmlLoader.stage.nativeWindow.close();
}
```

JavaScript calls to `window.close()` do not have to close the containing window. You could, for example, remove the HTMLLoader from the display list, leaving the window (which may have other content) open, as in the following code:

```
override public function windowClose():void
{
    htmlLoader.parent.removeChild(htmlLoader);
}
```

Handling changes of the window.status property

Adobe AIR 1.0 and later

Override the `updateStatus()` method to handle JavaScript changes to the value of `window.status`. The following example traces the status value:

```
 override public function updateStatus(status:String):void
{
    trace(status);
}
```

The requested status is passed as a string to the `updateStatus()` method.

The HTMLLoader object does not provide a status bar.

Handling changes of the window.document.title property

Adobe AIR 1.0 and later

override the `updateTitle()` method to handle JavaScript changes to the value of `window.document.title`. The following example changes the window title and appends the string, "Sample," to the title:

```
 override public function updateTitle(title:String):void
{
    htmlLoader.stage.nativeWindow.title = title + " - Sample";
}
```

When `document.title` is set on an HTML page, the requested title is passed as a string to the `updateTitle()` method.

Changes to `document.title` do not have to change the title of the window containing the HTMLLoader object. You could, for example, change another interface element, such as a text field.

Handling JavaScript calls to window.blur() and window.focus()

Adobe AIR 1.0 and later

Override the `windowBlur()` and `windowFocus()` methods to handle JavaScript calls to `window.blur()` and `window.focus()`, as shown in the following example:

```
 override public function windowBlur():void
{
    htmlLoader.alpha = 0.5;
}
override public function windowFocus():void
{
    htmlLoader.alpha = 1.0;
    NativeApplication.nativeApplication.activate(htmlLoader.stage.nativeWindow);
}
```

Note: *AIR does not provide an API for deactivating a window or application.*

Creating windows with scrolling HTML content

Adobe AIR 1.0 and later

The HTMLLoader class includes a static method, `HTMLLoader.createRootWindow()`, which lets you open a new window (represented by a NativeWindow object) that contains an HTMLLoader object and define some user interface settings for that window. The method takes four parameters, which let you define the user interface:

Parameter	Description
`visible`	A Boolean value that specifies whether the window is initially visible (`true`) or not (`false`).
`windowInitOptions`	A NativeWindowInitOptions object. The NativeWindowInitOptions class defines initialization options for a NativeWindow object, including the following: whether the window is minimizable, maximizable, or resizable, whether the window has system chrome or custom chrome, whether the window is transparent or not (for windows that do not use system chrome), and the type of window.
`scrollBarsVisible`	Whether there are scroll bars (`true`) or not (`false`).
`bounds`	A Rectangle object defining the position and size of the new window.

For example, the following code uses the `HTMLLoader.createRootWindow()` method to create a window with HTMLLoader content that uses scroll bars:

```
 var initOptions:NativeWindowInitOptions = new NativeWindowInitOptions();
var bounds:Rectangle = new Rectangle(10, 10, 600, 400);
var html2:HTMLLoader = HTMLLoader.createRootWindow(true, initOptions, true, bounds);
var urlReq2:URLRequest = new URLRequest("http://www.example.com");
html2.load(urlReq2);
html2.stage.nativeWindow.activate();
```

Note: *Windows created by calling `createRootWindow()` directly in JavaScript remain independent from the opening HTML window. The JavaScript Window `opener` and `parent` properties, for example, are `null`. However, if you call `createRootWindow()` indirectly by overriding the HTMLHost `createWindow()` method to call `createRootWindow()`, then `opener` and `parent` do reference the opening HTML window.*

Creating subclasses of the HTMLLoader class

Adobe AIR 1.0 and later

You can create a subclass of the HTMLLoader class, to create new behaviors. For example, you can create a subclass that defines default event listeners for HTMLLoader events (such as those events dispatched when HTML is rendered or when the user clicks a link).

The following example extends the HTMLHost class to provide *normal* behavior when the JavaScript `window.open()` method is called. The example then defines a subclass of HTMLLoader that uses the custom HTMLHost implementation class:

```
 package
{
        import flash.html.HTMLLoader;
    public class MyHTMLHost extends HTMLHost
        {
             public function MyHTMLHost()
             {
                  super(false);
         }
         override public function createWindow(opts:HTMLWindowCreateOptions):void
         {
              var initOptions:NativeWindowInitOptions = new NativeWindowInitOptions();
              var bounds:Rectangle = new Rectangle(opts.x, opts.y, opts.width, opts.height);
              var html:HTMLLoader = HTMLLoader.createRootWindow(true,
                                                  initOptions,
                                                  opts.scrollBarsVisible,
                                                  bounds);
              html.stage.nativeWindow.orderToFront();
              return html
        }
}
```

The following defines a subclass of the HTMLLoader class that assigns a MyHTMLHost object to its `htmlHost` property:

```
 package
{
        import flash.html.HTMLLoader;
    import MyHTMLHost;
    import HTMLLoader;
        public class MyHTML extends HTMLLoader
        {
             public function MyHTML()
             {
                  super();
                  htmlHost = new MyHTMLHost();
             }
        }
}
```

For details on the HTMLHost class and the `HTMLLoader.createRootWindow()` method used in this example, see "Defining browser-like user interfaces for HTML content" on page 1008.

Chapter 61: Handling HTML-related events in AIR

Adobe AIR 1.0 and later

An event-handling system allows programmers to respond to user input and system events in a convenient way. The Adobe® AIR® event model is not only convenient, but also standards-compliant. Based on the Document Object Model (DOM) Level 3 Events Specification, an industry-standard event-handling architecture, the event model provides a powerful, yet intuitive, event-handling tool for programmers.

HTMLLoader events

Adobe AIR 1.0 and later

An HTMLLoader object dispatches the following Adobe® ActionScript® 3.0 events:

Event	Description
`htmlDOMInitialize`	Dispatched when the HTML document is created, but before any scripts are parsed or DOM nodes are added to the page.
`complete`	Dispatched when the HTML DOM has been created in response to a load operation, immediately after the `onload` event in the HTML page.
`htmlBoundsChanged`	Dispatched when one or both of the `contentWidth` and `contentHeight` properties have changed.
`locationChange`	Dispatched when the location property of the HTMLLoader has changed.
`locationChanging`	Dispatched before the location of the HTMLLoader changes because of user navigation, a JavaScript call, or a redirect. The `locationChanging` event is not dispatched when you call the `load()`, `loadString()`, `reload()`, `historyGo()`, `historyForward()`, or `historyBack()` methods. Calling the `preventDefault()` method of the dispatched event object cancels navigation. If a link is opened in the system browser, a locationChanging event is not dispatched since the HTMLLoader does not change location.
`scroll`	Dispatched anytime the HTML engine changes the scroll position. Scroll events can be because of navigation to anchor links (`#` links) in the page or because of calls to the `window.scrollTo()` method. Entering text in a text input or text area can also cause a scroll event.
`uncaughtScriptException`	Dispatched when a JavaScript exception occurs in the HTMLLoader and the exception is not caught in JavaScript code.

You can also register an ActionScript function for a JavaScript event (such as `onClick`). For details, see “Handling DOM events with ActionScript” on page 1021.

Handling DOM events with ActionScript

Adobe AIR 1.0 and later

You can register ActionScript functions to respond to JavaScript events. For example, consider the following HTML content:

```
<html>
<body>
    <a href="#" id="testLink">Click me.</a>
</html>
```

You can register an ActionScript function as a handler for any event in the page. For example, the following code adds the `clickHandler()` function as the listener for the `onclick` event of the `testLink` element in the HTML page:

```
var html:HTMLLoader = new HTMLLoader( );
var urlReq:URLRequest = new URLRequest("test.html");
html.load(urlReq);
html.addEventListener(Event.COMPLETE, completeHandler);

function completeHandler(event:Event):void {
    html.window.document.getElementById("testLink").onclick = clickHandler;
}

function clickHandler( event:Object ):void {
    trace("Event of type: " + event.type );
}
```

The event object dispatched is not of type flash.events.Event or one of the Event subclasses. Use the Object class to declare a type for the event handler function argument.

You can also use the `addEventListener()` method to register for these events. For example, you could replace the `completeHandler()` method in the previous example with the following code:

```
function completeHandler(event:Event):void {
    var testLink:Object = html.window.document.getElementById("testLink");
    testLink.addEventListener("click", clickHandler);
}
```

When a listener refers to a specific DOM element, it is good practice to wait for the parent HTMLLoader to dispatch the `complete` event before adding the event listeners. HTML pages often load multiple files and the HTML DOM is not fully built until all the files are loaded and parsed. The HTMLLoader dispatches the `complete` event when all elements have been created.

Responding to uncaught JavaScript exceptions

Adobe AIR 1.0 and later

Consider the following HTML:

```
<html>
<head>
    <script>
        function throwError() {
            var x = 400 * melbaToast;
        }
    </script>
</head>
<body>
    <a href="#" onclick="throwError()">Click me.</a>
</html>
```

It contains a JavaScript function, `throwError()`, that references an unknown variable, `melbaToast`:

```
var x = 400 * melbaToast;
```

When a JavaScript operation encounters an illegal operation that is not caught in the JavaScript code with a `try`/`catch` structure, the HTMLLoader object containing the page dispatches an HTMLUncaughtScriptExceptionEvent event. You can register a handler for this event, as in the following code:

```
var html:HTMLLoader = new HTMLLoader();
var urlReq:URLRequest = new URLRequest("test.html");
html.load(urlReq);
html.width = container.width;
html.height = container.height;
container.addChild(html);
html.addEventListener(HTMLUncaughtScriptExceptionEvent.UNCAUGHT_SCRIPT_EXCEPTION,
                           htmlErrorHandler);
function htmlErrorHandler(event:HTMLUncaughtJavaScriptExceptionEvent):void
{
    event.preventDefault();
    trace("exceptionValue:", event.exceptionValue)
    for (var i:int = 0; i < event.stackTrace.length; i++)
    {
        trace("sourceURL:", event.stackTrace[i].sourceURL);
        trace("line:", event.stackTrace[i].line);
        trace("function:", event.stackTrace[i].functionName);
    }
}
```

Within JavaScript, you can handle the same event using the window.htmlLoader property:

```
 <html>
<head>
<script language="javascript" type="text/javascript" src="AIRAliases.js"></script>

    <script>
        function throwError() {
            var x = 400 * melbaToast;
        }

        function htmlErrorHandler(event) {
            event.preventDefault();
            var message = "exceptionValue:" + event.exceptionValue + "\n";
            for (var i = 0; i < event.stackTrace.length; i++){
                message += "sourceURL:" + event.stackTrace[i].sourceURL +"\n";
                message += "line:" + event.stackTrace[i].line +"\n";
                message += "function:" + event.stackTrace[i].functionName + "\n";
            }
            alert(message);
        }

        window.htmlLoader.addEventListener("uncaughtScriptException", htmlErrorHandler);
    </script>
</head>
<body>
    <a href="#" onclick="throwError()">Click me.</a>
</html>
```

The `htmlErrorHandler()` event handler cancels the default behavior of the event (which is to send the JavaScript error message to the AIR trace output), and generates its own output message. It outputs the value of the `exceptionValue` of the HTMLUncaughtScriptExceptionEvent object. It outputs the properties of each object in the `stackTrace` array:

```
 exceptionValue: ReferenceError: Can't find variable: melbaToast
sourceURL: app:/test.html
line: 5
function: throwError
sourceURL: app:/test.html
line: 10
function: onclick
```

Handling runtime events with JavaScript

Adobe AIR 1.0 and later

The runtime classes support adding event handlers with the `addEventListener()` method. To add a handler function for an event, call the `addEventListener()` method of the object that dispatches the event, providing the event type and the handling function. For example, to listen for the `closing` event dispatched when a user clicks the window close button on the title bar, use the following statement:

```
 window.nativeWindow.addEventListener(air.NativeWindow.CLOSING, handleWindowClosing);
```

Creating an event handler function

Adobe AIR 1.0 and later

The following code creates a simple HTML file that displays information about the position of the main window. A handler function named `moveHandler()`, listens for a move event (defined by the NativeWindowBoundsEvent class) of the main window.

```
<html>
    <script src="AIRAliases.js" />
    <script>
        function init() {
            writeValues();
            window.nativeWindow.addEventListener(air.NativeWindowBoundsEvent.MOVE,
                                                    moveHandler);
        }
        function writeValues() {
            document.getElementById("xText").value = window.nativeWindow.x;
            document.getElementById("yText").value = window.nativeWindow.y;
        }
        function moveHandler(event) {
            air.trace(event.type); // move
            writeValues();
        }
    </script>
    <body onload="init()" />
        <table>
            <tr>
                <td>Window X:</td>
                <td><textarea id="xText"></textarea></td>
            </tr>
            <tr>
                <td>Window Y:</td>
                <td><textarea id="yText"></textarea></td>
            </tr>
        </table>
    </body>
</html>
```

When a user moves the window, the textarea elements display the updated X and Y positions of the window:

Notice that the event object is passed as an argument to the `moveHandler()` method. The event parameter allows your handler function to examine the event object. In this example, you use the event object's `type` property to report that the event is a `move` event.

Removing event listeners

Adobe AIR 1.0 and later

You can use the `removeEventListener()` method to remove an event listener that you no longer need. It is a good idea to remove any listeners that will no longer be used. Required parameters include the `eventName` and `listener` parameters, which are the same as the required parameters for the `addEventListener()` method.

Removing event listeners in HTML pages that navigate

Adobe AIR 1.0 and later

When HTML content navigates, or when HTML content is discarded because a window that contains it is closed, the event listeners that reference objects on the unloaded page are not automatically removed. When an object dispatches an event to a handler that has already been unloaded, you see the following error message: "The application attempted to reference a JavaScript object in an HTML page that is no longer loaded."

To avoid this error, remove JavaScript event listeners in an HTML page before it goes away. In the case of page navigation (within an HTMLLoader object), remove the event listener during the `unload` event of the `window` object.

For example, the following JavaScript code removes an event listener for an `uncaughtScriptException` event:

```
window.onunload = cleanup;
window.htmlLoader.addEventListener('uncaughtScriptException', uncaughtScriptException);
function cleanup()
{
    window.htmlLoader.removeEventListener('uncaughtScriptException',
                            uncaughtScriptExceptionHandler);
}
```

To prevent the error from occurring when closing windows that contain HTML content, call a cleanup function in response to the `closing` event of the NativeWindow object (`window.nativeWindow`). For example, the following JavaScript code removes an event listener for an `uncaughtScriptException` event:

```
 window.nativeWindow.addEventListener(air.Event.CLOSING, cleanup);
function cleanup()
{
    window.htmlLoader.removeEventListener('uncaughtScriptException',
                            uncaughtScriptExceptionHandler);
}
```

You can also prevent this error from occurring by removing an event listener as soon as it runs (if the event only needs to be handled once). For example, the following JavaScript code creates an html window by calling the `createRootWindow()` method of the HTMLLoader class and adds an event listener for the `complete` event. When the `complete` event handler is called, it removes its own event listener using the `removeEventListener()` function:

```
 var html = runtime.flash.html.HTMLLoader.createRootWindow(true);
html.addEventListener('complete', htmlCompleteListener);
function htmlCompleteListener()
{
    html.removeEventListener(complete, arguments.callee)
    // handler code..
}
html.load(new runtime.flash.net.URLRequest("second.html"));
```

Removing unneeded event listeners also allows the system garbage collector to reclaim any memory associated with those listeners.

Checking for existing event listeners

Adobe AIR 1.0 and later

The `hasEventListener()` method lets you check for the existence of an event listener on an object.

Chapter 62: Displaying HTML content in mobile apps

Adobe AIR 2.5 and later

The StageWebView class displays HTML content using the system browser control on mobile devices and using the standard Adobe® AIR® HTMLLoader control on desktop computers. Check the `StageWebView.isSupported` property to determine whether the class is supported on the current device. Support is not guaranteed for all devices in the mobile profile.

In all profiles, the StageWebView class supports only limited interaction between the HTML content and the rest of the application. You can control navigation, but no cross-scripting or direct exchange of data is allowed. You can load content from a local or remote URL or pass in a string of HTML.

StageWebView objects

A StageWebView object is not a display object and cannot be added to the display list. Instead, it operates as a viewport attached directly to the stage. StageWebView content draws over the top of any display list content. There is no way to control the drawing order of multiple StageWebView objects.

To display a StageWebView object, you assign the stage on which the object is to appear to the `stage` property of the StageWebView. Set the size of the display using the `viewPort` property.

Set the x and y coordinates of the `viewPort` property between -8192 and 8191. The maximum value of stage width and height is 8191. If the size exceeds the maximum values, an exception is thrown.

The following example creates a StageWebView object, sets the `stage` and `viewPort` properties, and displays a string of HTML:

```
var webView:StageWebView = new StageWebView();
webView.viewPort = new Rectangle( 0, 0, this.stage.stageWidth, this .stage.stageHeight);
webView.stage = this.stage;
var htmlString:String = "<!DOCTYPE HTML>" +
                        "<html><body>" +
                        "<p>King Philip could order five good steaks.</p>" +
                        "</body></html>";
webView.loadString( htmlString );
```

To hide a StageWebView object, set its `stage` property to `null`. To destroy the object entirely, call the `dispose()` method. Calling `dispose()` is optional, but does help the garbage collector reclaim the memory used by the object sooner.

Content

You can load content into a StageWebView object using two methods: `loadURL()` and `loadString()`.

The `loadURL()` method loads a resource at the specified URL. You can use any URI scheme supported by the system web browser control, including: data:, file:, http:, https:, and javascript:. The app: and app-storage: schemes are not supported. AIR does not validate the URL string.

The `loadString()` method loads a literal string containing HTML content. The location of a page loaded with this method is expressed as:

- On Desktop: about:blank
- On iOS: *htmlString*
- On Android: the data URI format of the encoded *htmlString*

The URI scheme determines the rules for loading embedded content or data.

URI scheme	Load local resource	Load remote resource	Local XMLHttpRequest	Remote XMLHttpRequest
data:	No	Yes	No	No
file:	Yes	Yes	Yes	Yes
http:, https:	No	Yes	No	Same domain
about: (loadString() method)	No	Yes	No	No

***Note:** If the stage's `displayState` property is set to `FULL_SCREEN`, in Desktop, you cannot type in a text field displayed in the StageWebView. However, in iOS and Android, you can type in a text field on StageWebView even if the stage's `displayState` is `FULL_SCREEN`.*

The following example uses a StageWebView object to display Adobe's website:

```
package  {
    import flash.display.MovieClip;
    import flash.media.StageWebView;
    import flash.geom.Rectangle;

    public class StageWebViewExample extends MovieClip{

        var webView:StageWebView = new StageWebView();

        public function StageWebViewExample() {
            webView.stage = this.stage;
            webView.viewPort = new Rectangle( 0, 0, stage.stageWidth, stage.stageHeight );
            webView.loadURL( "http://www.adobe.com" );
        }
    }
}
```

On Android devices, you must specify the Android INTERNET permission in order for the app to successfully load remote resources.

In Android 3.0+, an application must enable hardware acceleration in the Android manifestAdditions element of the AIR application descriptor to display plug-in content in a StageWebView object. See Enabling Flash Player and other plug-ins in a StageWebView object.

JavaScript URI

You can use a JavaScript URI to call a function defined in the HTML page that is loaded by a StageWebView object. The function you call using the JavaScript URI runs in the context of the loaded web page. The following example uses a StageWebView object to call a JavaScript function:

```
package {
    import flash.display.*;
    import flash.geom.Rectangle;
    import flash.media.StageWebView;
    public class WebView extends Sprite
    {
        public var webView:StageWebView = new StageWebView();
        public function WebView()
        {
            var htmlString:String = "<!DOCTYPE HTML>" +
            "<html><script type=text/javascript>" +
            "function callURI(){" +
            "alert(\"You clicked me!!\");"+
            "}</script><body>" +
            "<p><a href=javascript:callURI()>Click Me</a></p>" +
            "</body></html>";
            webView.stage = this.stage;
            webView.viewPort = new Rectangle( 0, 0, stage.stageWidth, stage.stageHeight );
            webView.loadString( htmlString );
        }
    }
}
```

More Help topics

Sean Voisen: Making the Most of StageWebView

Navigation events

When a user clicks a link in the HTML, the StageWebView object dispatches a `locationChanging` event. You can call the `preventDefault()` method of the event object to stop the navigation. Otherwise, the StageWebView object navigates to the new page and dispatches a `locationChange` event. When the page load has finished, the StageWebView dispatches a `complete` event.

A `locationChanging` event is dispatched on every HTML redirect. The `locationChange` and `complete` events are dispatched at the appropriate time.

On iOS, a `locationChanging` event is dispatched before a `locationChange` event, except for the first `loadURL()` or `loadString()` methods. A `locationChange` event is also dispatched for navigational changes through iFrames and Frames.

The following example illustrates how you can prevent a location change and open the new page in the system browser instead.

```
package  {
    import flash.display.MovieClip;
    import flash.media.StageWebView;
    import flash.events.LocationChangeEvent;
    import flash.geom.Rectangle;
    import flash.net.navigateToURL;
    import flash.net.URLRequest;

    public class StageWebViewNavEvents extends MovieClip{
        var webView:StageWebView = new StageWebView();

        public function StageWebViewNavEvents() {
            webView.stage = this.stage;
            webView.viewPort = new Rectangle( 0, 0, stage.stageWidth, stage.stageHeight );
        webView.addEventListener( LocationChangeEvent.LOCATION_CHANGING, onLocationChanging );
            webView.loadURL( "http://www.adobe.com" );
        }
        private function onLocationChanging( event:LocationChangeEvent ):void
        {
            event.preventDefault();
            navigateToURL( new URLRequest( event.location ) );
        }
    }
}
```

History

As a user clicks links in the content displayed in a StageWebView object, the control saves the backwards and forwards history stacks. The following example illustrates how to navigate through the two history stacks. The example uses the Back and Search soft keys.

```
package  {
    import flash.display.MovieClip;
    import flash.media.StageWebView;
    import flash.geom.Rectangle;
    import flash.events.KeyboardEvent;
    import flash.ui.Keyboard;

    public class StageWebViewExample extends MovieClip{

        var webView:StageWebView = new StageWebView();

        public function StageWebViewExample()
        {
            webView.stage = this.stage;
            webView.viewPort = new Rectangle( 0, 0, stage.stageWidth, stage.stageHeight );
            webView.loadURL( "http://www.adobe.com" );

            stage.addEventListener( KeyboardEvent.KEY_DOWN, onKey );
        }

        private function onKey( event:KeyboardEvent ):void
        {
            if( event.keyCode == Keyboard.BACK && webView.isHistoryBackEnabled )
            {
                trace("back");
                webView.historyBack();
                event.preventDefault();
            }
            if( event.keyCode == Keyboard.SEARCH && webView.isHistoryForwardEnabled )
            {
                trace("forward");
                webView.historyForward();
            }
        }
    }
}
```

Focus

Even though it is not a display object, the StageWebView class contains members that allow you to manage the focus transitions into and out of the control.

When the StageWebView object gains focus, it dispatches a `focusIn` event. You use this event to manage the focus elements in your application, if necessary.

When the StageWebView relinquishes the focus, it dispatches a `focusOut` event. A StageWebView instance can relinquish focus when a user "tabs" past the first or last control on the web page using a device trackball or directional arrows. The `direction` property of the event object lets you know whether the focus flow is rising up past the top of the page or down through the bottom of the page. Use this information to assign focus to the appropriate display object above or below the StageWebView.

On iOS, focus cannot be set programmatically. StageWebView dispatches `focusIn` and `focusOut` events with the direction property of `FocusEvent` set to `none`. If the user touches inside the StageWebView, the `focusIn` event is dispatched. If the user touches outside the StageWebView, the `focusOut` event is dispatched.

The following example illustrates how focus passes from the StageWebView object to Flash display objects:

```
package  {
    import flash.display.MovieClip;
    import flash.media.StageWebView;
    import flash.geom.Rectangle;
    import flash.events.KeyboardEvent;
    import flash.ui.Keyboard;
    import flash.text.TextField;
    import flash.text.TextFieldType;
    import flash.events.FocusEvent;
    import flash.display.FocusDirection;
    import flash.events.LocationChangeEvent;

    public class StageWebViewFocusEvents extends MovieClip{
        var webView:StageWebView = new StageWebView();
        var topControl:TextField = new TextField();
        var bottomControl:TextField = new TextField();

        public function StageWebViewFocusEvents()
        {
            trace("Starting");
            topControl.type = TextFieldType.INPUT;
            addChild( topControl );
            topControl.height = 60;
            topControl.width = stage.stageWidth;
            topControl.background = true;
            topControl.text = "One control on top.";
            topControl.addEventListener( FocusEvent.FOCUS_IN, flashFocusIn );
            topControl.addEventListener( FocusEvent.FOCUS_OUT, flashFocusOut );

            webView.stage = this.stage;
            webView.viewPort = new Rectangle( 0, 60, stage.stageWidth, stage.stageHeight 
- 120 );
            webView.addEventListener( FocusEvent.FOCUS_IN, webFocusIn );
            webView.addEventListener(FocusEvent.FOCUS_OUT, webFocusOut );
            webView.addEventListener(LocationChangeEvent.LOCATION_CHANGING,
                                     function( event:LocationChangeEvent ):void
                                     {
                                        event.preventDefault();
                                     } );
            webView.loadString("<form action='#'><input/><input/><input/></form>");
            webView.assignFocus();

            bottomControl.type = TextFieldType.INPUT;
            addChild( bottomControl );
            bottomControl.y = stage.stageHeight - 60;
            bottomControl.height = 60;
            bottomControl.width = stage.stageWidth;
            bottomControl.background = true;
            bottomControl.text = "One control on the bottom.";
            bottomControl.addEventListener( FocusEvent.FOCUS_IN, flashFocusIn );
            bottomControl.addEventListener( FocusEvent.FOCUS_OUT, flashFocusOut );}

        private function webFocusIn( event:FocusEvent ):void
        {
            trace("Web focus in");
        }

        private function webFocusOut( event:FocusEvent ):void
        {
            trace("Web focus out: " + event.direction);
            if( event.direction == FocusDirection.TOP )
            {
                stage.focus = topControl;
            }
            else
            {
                stage.focus = bottomControl;
            }
        }

        private function flashFocusIn( event:FocusEvent ):void
        {
            trace("Flash focus in");
            var textfield:TextField = event.target as TextField;
            textfield.backgroundColor = 0xff5566;
        }

        private function flashFocusOut( event:FocusEvent ):void
        {
            trace("Flash focus out");
            var textfield:TextField = event.target as TextField;
            textfield.backgroundColor = 0xffffff;
        }

    }
}
```

Bitmap capture

A StageWebView object is rendered above all display list content. You cannot add a content above a StageWebView object. For example, you cannot expand a drop-down over the StageWebView content. To solve this issue, capture a snapshot of the StageWebView. Then, hide the StageWebView and add the bitmap snapshot instead.

The following example illustrates how to capture the snapshot of a StageWebView object using the `drawViewPortToBitmapData` method. It hides the StageWebView object by setting the stage to null. After the web page is fully loaded, it calls a function that captures the bitmap and displays it. When you run, the code displays two labels, Google and Facebook. Clicking the label captures the corresponding web page and displays it as a snapshot on the stage.

```
package
{
    import flash.display.Bitmap;
    import flash.display.BitmapData;
    import flash.display.Sprite;
    import flash.events.*;
    import flash.geom.Rectangle;
    import flash.media.StageWebView;
    import flash.net.*;
    import flash.text.TextField;
    public class stagewebview extends Sprite
    {
        public var webView:StageWebView=new StageWebView();
        public var textGoogle:TextField=new TextField();
        public var textFacebook:TextField=new TextField();
        public function stagewebview()
        {
            textGoogle.htmlText="<b>Google</b>";
            textGoogle.x=300;
            textGoogle.y=-80;
            addChild(textGoogle);
            textFacebook.htmlText="<b>Facebook</b>";
            textFacebook.x=0;
            textFacebook.y=-80;
            addChild(textFacebook);
            textGoogle.addEventListener(MouseEvent.CLICK,goGoogle);
            textFacebook.addEventListener(MouseEvent.CLICK,goFaceBook);
            webView.stage = this.stage;
            webView.viewPort = new Rectangle(0, 0, stage.stageWidth, stage.stageHeight);
        }
    public function goGoogle(e:Event):void
        {
            webView.loadURL("http://www.google.com");
            webView.stage = null;
            webView.addEventListener(Event.COMPLETE,handleLoad);
        }

    public function goFaceBook(e:Event):void
        {
            webView.loadURL("http://www.facebook.com");
            webView.stage = null;
            webView.addEventListener(Event.COMPLETE,handleLoad);
        }
    public function handleLoad(e:Event):void
        {
            var bitmapData:BitmapData = new BitmapData(webView.viewPort.width, 
webView.viewPort.height);
            webView.drawViewPortToBitmapData(bitmapData);
            var webViewBitmap:Bitmap=new Bitmap(bitmapData);
            addChild(webViewBitmap);
        }
    }
}
```

Chapter 63: Using workers for concurrency

Flash Player 11.4 and later, Adobe AIR 13.4 and later for desktop platforms

ActionScript workers make it possible to execute code concurrently, or in other words, to execute code in the background without interrupting the main code's execution.

The ActionScript concurrency apis are available on desktop platforms only in Flash Player 11.4 and later, and AIR 3.4 and later. Concurrency is not supported in AIR for mobile platforms.

Understanding workers and concurrency

Flash Player 11.4 and later, Adobe AIR 13.4 and later for desktop platforms

When an application doesn't use workers, the application's code executes in a single linear block of executing steps known as an execution *thread*. The thread executes the code that a developer writes. It also executes much of the code that's part of the runtime, most notably the code that updates the screen when display objects' properties change. Although code is written in chunks as methods and classes, at run time the code executes one line at a time as though it were written in a single long series of steps. Consider this hypothetical example of the steps that an application executes:

1. Enter frame: The runtime calls any `enterFrame` event handlers and runs their code one at a time
2. Mouse event: The user moves the mouse, and the runtime calls any mouse event handlers as the various rollover and rollout events happen
3. Load complete event: A request to load an xml file from a url returns with the loaded file data. The event handler is called and runs its steps, reading the xml content and creating a set of objects from the xml data.
4. Mouse event: The mouse has moved again, so the runtime calls the relevant mouse event handlers
5. Rendering: No more events are waiting, so the runtime updates the screen based on any changes made to display objects
6. Enter frame: The cycle begins again

As described in the example, the hypothetical steps 1-5 run in sequence within a single block of time called a frame. Because they run in sequence in a single thread, the runtime can't interrupt one step of the process to run another one. At a frame rate of 30 frames-per-second, the runtime has less than one thirtieth of a second to execute all those operations. In many cases that is enough time for the code to run, and the runtime simply waits during the remaining time. However, suppose the xml data that loads in step 3 is a very large, deeply nested xml structure. As the code loops over the xml and creates objects, it might conceivably take longer than one thirtieth of a second to do that work. In that case, the later steps (responding to the mouse and redrawing the screen) do not happen as soon as they should. This causes the screen to freeze and stutter as the screen isn't redrawn fast enough in response to the user moving the mouse.

If all the code executes in the same thread, there is only one way to avoid occasional stutters and freezes. This is to not do long-running operations such as looping over a large set of data. ActionScript workers provide another solution. Using a worker, you can execute long-running code in a separate worker. Each worker runs in a separate thread, so the background worker performs the long-running operation in its own thread. That frees up the main worker's execution thread to redraw the screen each frame without being blocked by other work.

The ability to run multiple code operations at the same time in this way is known as *concurrency*. When the background worker finishes its work, or at "progress" points along the way, you can send the main worker notifications and data. In this way, you can write code that performs complex or time consuming operations but avoid the bad user experience of having the screen freeze.

Workers are useful because they decrease the chances of the frame rate dropping due to the main rendering thread being blocked by other code. However, workers require additional system memory and CPU use, which can be costly to overall application performance. Because each worker uses its own instance of the runtime virtual machine, even the overhead of a trivial worker can be large. When using workers, test your code across all your target platforms to ensure that the demands on the system are not too large. Adobe recommends that you do not use more than one or two background workers in a typical scenario.

Creating and managing workers

Flash Player 11.4 and later, Adobe AIR 13.4 and later for desktop platforms

The first step in using a worker for concurrency is to create a background worker. You use two types of objects to create a worker. First is a Worker instance, which is what you create. The other is a WorkerDomain object, which creates the Worker and manages the running Worker objects in an application.

When the runtime loads, it automatically creates the WorkerDomain object. The runtime also automatically creates a worker for the main swf of the application. This first worker is known as the *primordial worker*.

Because there is only one WorkerDomain object for an application, you access the WorkerDomain instance using the static `WorkerDomain.current` property.

At any time, you can access the current Worker instance (the worker in which the current code is running) using the static `Worker.current` property.

Creating a Worker object from a swf

Just as the main swf runs within the primordial worker, a background worker executes the code of a single swf file. To use a background worker, you must author and compile the worker's code as a swf file. To create the background worker, the parent worker needs access to that swf file's bytes as a ByteArray object. You pass that ByteArray to the WorkerDomain object's `createWorker()` method to actually create the worker.

There are three main ways to get the background worker swf as a ByteArray object:

Embedding the worker swf

Use the [Embed] metatag to embed the worker swf into the main swf as a ByteArray:

```
[Embed(source="../swfs/BgWorker.swf", mimeType="application/octet-stream")]
private static var BgWorker_ByteClass:Class;
private function createWorker():void
{
    var workerBytes:ByteArray = new BgWorker_ByteClass();
    var bgWorker:Worker = WorkerDomain.current.createWorker(workerBytes);

    // ... set up worker communication and start the worker
}
```

The worker swf is compiled into the main swf as a ByteArray subclass named BgWorker_ByteClass. Creating an instance of that class gives you a ByteArray pre-populated with the worker swf's bytes.

Loading an external worker swf

Use a URLLoader object to load an external swf file. The swf file must come from the same security domain, such as a swf file loaded from the same internet domain as the main swf or included in an AIR application package.

```
var workerLoader:URLLoader = new URLLoader();
workerLoader.dataFormat = URLLoaderDataFormat.BINARY;
workerLoader.addEventListener(Event.COMPLETE, loadComplete);
workerLoader.load(new URLRequest("BgWorker.swf"));

private function loadComplete(event:Event):void
{
    // create the background worker
    var workerBytes:ByteArray = event.target.data as ByteArray;
    var bgWorker:Worker = WorkerDomain.current.createWorker(workerBytes);

    // ... set up worker communication and start the worker
}
```

When the URLLoader finishes loading the swf file, the swf's bytes are available in the URLLoader object's `data` property (`event.target.data` in the example).

Using the main swf as the worker swf

You can use a single swf as both the main swf and the worker swf. Use the main display class's `loaderInfo.bytes` property to access the swf's bytes.

```
// The primordial worker's main class constructor
public function PrimordialWorkerClass()
{
    init();
}

private function init():void
{
    var swfBytes:ByteArray = this.loaderInfo.bytes;

    // Check to see if this is the primordial worker or the background worker
    if (Worker.current.isPrimordial)
    {
        // create a background worker
        var bgWorker:Worker = WorkerDomain.current.createWorker(swfBytes);

        // ... set up worker communication and start the worker
    }
    else // entry point for the background worker
    {
        // set up communication between workers using getSharedProperty()
        // ... (not shown)

        // start the background work
    }
}
```

If you use this technique, use an `if` statement to branch the swf file code within the main class's constructor or a method it calls. To determine whether the code is running in the main worker or the background worker, check the current Worker object's `isPrimordial` property, as shown in the example.

Starting a worker's execution

Once you have created a worker, you start its code executing by calling the Worker object's `start()` method. The `start()` operation doesn't happen immediately. To know when the worker is running, register a listener for the Worker object's `workerState` event. That event is dispatched when the Worker object switches states in its lifecycle, such as when it starts executing code. In your `workerState` event handler, check that the Worker object's `state` property is `WorkerState.RUNNING`. At that point the worker is running and its main class's constructor has run. The following code listing shows an example of registering for the `workerState` event and calling the `start()` method:

```
// listen for worker state changes to know when the worker is running
bgWorker.addEventListener(Event.WORKER_STATE, workerStateHandler);
// set up communication between workers using
// setSharedProperty(), createMessageChannel(), etc.
// ... (not shown)
bgWorker.start();
private function workerStateHandler(event:Event):void
{
    if (bgWorker.state == WorkerState.RUNNING)
    {
        // The worker is running.
        // Send it a message or wait for a response.
    }
}
```

Managing worker execution

At any time you can access the set of running workers in your application using the WorkerDomain class's `listWorkers()` method. This method returns the set of workers whose `state` property is `WorkerState.RUNNING`, including the primordial worker. If a worker hasn't been started or if its execution has already been stopped, it is not included.

If you no longer need a worker, you can call the Worker object's `terminate()` method to shut down the worker and release its memory and other system resources.

Communicating between workers

Flash Player 11.4 and later, Adobe AIR 13.4 and later for desktop platforms

Although workers run their code in separate execution threads, they wouldn't offer any benefit if they were completely isolated from each other. Communication between workers ultimately means passing data between workers. There are three main mechanisms for getting data from one worker to another.

When deciding which of these data-sharing techniques is appropriate for a particular data-passing need, consider the two main ways they differ. One difference between them is with whether there is an event to notify the receiver that new data is available or whether the receiving worker must check for updates. Another difference between these data-sharing techniques has to do with how the data is actually passed. In some cases the receiving worker gets is a copy of the shared data, which means that more objects are created taking more memory and cpu cycles. In other cases the workers access objects that reference the same underlying system memory, which means fewer objects are created and less memory is used overall. These differences are outlined here:

Communication technique	Dispatches event when receiving data	Shares memory between workers
Worker shared properties	No	No, objects are copies not references
MessageChannel	Yes	No, objects are copies not references
Shareable ByteArray	No	Yes, memory is shared

Passing data with a shared property

The most basic way to share data between workers is to use a shared property. Each worker maintains an internal dictionary of shared property values. The properties are stored with String key names to distinguish between the properties. To store an object on a worker as a shared property, call the Worker object's `setSharedProperty()` method with two arguments, the key name and the value to store:

```
// code running in the parent worker
bgWorker.setSharedProperty("sharedPropertyName", someObject);
```

Once the shared property has been set, the value can be read by calling the Worker object's `getSharedProperty()` method, passing in the key name:

```
// code running in the background worker
receivedProperty = Worker.current.getSharedProperty("sharedPropertyName");
```

There is no restriction on which worker reads or sets the property value. For example, code in a background worker can call its `setSharedProperty()` method to store a value. Code running in the parent worker can then use `getSharedProperty()` to receive the data.

The value that's passed to the `setSharedProperty()` method can be almost any type of object. When you call the `getSharedProperty()` method, the object that's returned is a copy of the object passed in to `setSharedProperty()` and not a reference to the same object, except in a few special cases. The specifics of how data is shared are explained in "Shared references and copied values" on page 1040.

The biggest advantage of using a shared property to pass data between workers is that it's available even before the worker is running. You can call a background Worker object's `setSharedProperty()` method to set a shared property even before the worker is running. When the parent worker calls the Worker's `start()` method, the runtime calls the child worker's main class's constructor. Any shared properties that were set before `start()` was called are available for code in the child worker to read.

Passing data with a MessageChannel

A message channel provides a one-way data-passing link between two workers. Using a MessageChannel object to pass data between workers has one key advantage. When you send a message (an object) using a message channel, the MessageChannel object dispatches a `channelMessage` event. Code in the receiving worker can listen for that event to know when data is available. That way the receiving worker doesn't need to continuously check for data updates.

A message channel is associated with only two workers, a sender and a receiver. To create a MessageChannel object, call the sending Worker object's `createMessageChannel()` method, passing the receiving worker as an argument:

```
// In the sending worker swf
var sendChannel:MessageChannel;
sendChannel = Worker.current.createMessageChannel(receivingWorker);
```

Both workers need to have access to the MessageChannel object. The simplest way to do this is to pass the MessageChannel object using the `setSharedProperty()` method:

```
receivingWorker.setSharedProperty("incomingChannel", sendChannel);
```

In the receiving worker, register a listener for the MessageChannel object's `channelMessage` event. This event is dispatched when the sending worker sends data through the message channel.

```
// In the receiving worker swf
var incomingChannel:MessageChannel;
incomingChannel = Worker.current.getSharedProperty("incomingChannel");
incomingChannel.addEventListener(Event.CHANNEL_MESSAGE, handleIncomingMessage);
```

To actually send data, in the sending worker call the MessageChannel object's `send()` method:

```
// In the sending worker swf
sendChannel.send("This is a message");
```

In the receiving worker, the MessageChannel calls the `channelMessage` event handler. The receiving worker can then get the data by calling the MessageChannel object's `receive()` method.

```
private function handleIncomingMessage(event:Event):void
{
    var message:String = incomingChannel.receive() as String;
}
```

The object returned by the receive method has the same data type as the object that was passed in to the `send()` method. The received object is a copy of the object passed in by the sender and not a reference to the object in the sending worker, unless it is one of a few data types, as described in "Shared references and copied values" on page 1040.

Sharing data using a shareable ByteArray

When an object is passed between two workers, the receiving worker gets a new object that's a copy of the original one. The two objects are stored in different locations in the system's memory. Consequently, each copy of the object that's received increases the total memory used by the runtime. In addition, any changes that you make to an object in one worker do not affect the copy in the other worker. For more details about how data is copied, see "Shared references and copied values" on page 1040.

By default, a ByteArray object uses the same behavior. If you pass a ByteArray instance to a Worker object's `setSharedProperty()` method or a MessageChannel object's `send()` method, the runtime creates a new ByteArray in the computer's memory and the receiving worker gets a ByteArray instance that's a reference to that new ByteArray. However, you can change this behavior for a ByteArray object by setting its `shareable` property to `true`.

When a shareable ByteArray object is passed from one worker to another, the ByteArray instance in the receiving worker is a reference to the same underlying operating system memory that's used by the ByteArray instance in the sending worker. When code in one worker changes the contents of the byte array, those changes are immediately available in other workers that have access to that shared byte array.

Because workers execute their code simultaneously, it's possible for two workers to attempt to access the same bytes in a byte array at the same time. This could lead to data loss or corruption. There are several apis that you can use to manage access to shared resources and avoid those issues.

The ByteArray class has methods that allow you to validate and change the byte array's contents in a single operation:

- atomicCompareAndSwapIntAt() method
- atomicCompareAndSwapLength() method

In addition, the flash.concurrent package includes classes that provide access control for working with shared resources:

- Mutex class
- Condition class

Shared references and copied values

In the normal case, when you call `Worker.setSharedProperty()` or `MessageChannel.send()`, the object that's passed to the receiving worker is passed by serializing it in AMF format. This has a few consequences:

- The object that's created in the receiving worker when it's `getSharedProperty()` method is called is deserialized from the AMF bytes. It is a copy of the original object, not a reference to the object. Any changes that are made to the object in either worker are not changed in the copy in the other worker.
- Objects that can't be serialized in AMF format such as display objects can't be passed to a worker using `Worker.setSharedProperty()` or `MessageChannel.send()`.
- In order for a custom class to be deserialized properly, the class definition must be registered using the `flash.net.registerClassAlias()` function or `[RemoteClass]` metadata. The same alias must be used for both worker's versions of the class.

There are five special cases of objects that are truly shared rather than copied between workers:

- Worker objects
- MessageChannel objects
- shareable byte array (a ByteArray object whose `shareable` property is `true`)
- Mutex objects
- Condition objects

When you pass an instance of one of these objects using the `Worker.setSharedProperty()` method or `MessageChannel.send()` method, each worker has a reference to the same underlying object. Changes made to an instance in one worker are immediately available in other workers. In addition, if you pass the same instance of one of these objects to a worker more than once, the runtime doesn't create a new copy of the object in the receiving worker. Instead, the same reference is re-used.

Additional data-sharing techniques

In addition to the worker-specific mechanisms for passing data, workers can also exchange data using any of the existing apis that support sharing data between two swf applications, such as the following:

- local shared objects
- writing data to a file in one worker and reading from the file in another worker
- storing data to and reading data from a SQLite database

When you share a resource between two or more workers, you generally need to avoid having multiple workers accessing the resource at the same time. For example, having multiple workers access a file on the local file system could cause data loss or corruption and may not be supported by the operating system.

To guard against concurrent access problems, use the Mutex and Condition classes in the flash.concurrent package to provide access control for working with shared resources.

Unlike other data-sharing mechanisms, the SQLite database engine is designed for concurrent access and has its own transaction support built in. Multiple workers can access a SQLite database without risk of corrupting the data. Because the workers use different SQLConnection instances, each worker accesses the database in a separate transaction. Simultaneous data manipulation operations do not affect the integrity of the data.

See also

"Working with local SQL databases in AIR" on page 714
flash.concurrent package

Chapter 64: Security

Flash Player 9 and later, Adobe AIR 1.0 and later

Security is a key concern of Adobe, users, website owners, and content developers. For this reason, Adobe® Flash® Player and Adobe® AIR™ include a set of security rules and controls to safeguard the user, website owner, and content developer. This discussion covers the security model for SWF files published with ActionScript 3.0 and running in Flash Player 9.0.124.0 or later, and SWF, HTML, and JavaScript files running in AIR 1.0 or later, unless otherwise noted.

This discussion provides an overview of security; it does not try to comprehensively explain all implementation details, usage scenarios, or ramifications for using certain APIs. For a more detailed discussion of Flash Player security concepts, see the Flash Player Developer Center topic "Security" at www.adobe.com/go/devnet_security_en.

Flash Platform security overview

Flash Player 9 and later, Adobe AIR 1.0 and later

Much of security model used by the Flash Player and AIR runtimes is based on the domain of origin for loaded SWF files, HTML, media, and other assets. Executable code in a file from a specific Internet domain, such as www.example.com, can always access all data from that domain. These assets are put in the same security grouping, known as a *security sandbox*. (For more information, see "Security sandboxes" on page 1044.)

For example, ActionScript code in a SWF file can load SWF files, bitmaps, audio, text files, and any other asset from its own domain. Also, cross-scripting between two SWF files from the same domain is always permitted, as long as both files are written using ActionScript 3.0. *Cross-scripting* is the ability of code in one file to access the properties, methods, and objects defined by the code in another file.

Cross-scripting is not supported between SWF files written using ActionScript 3.0 and those using previous versions of ActionScript; however, these files can communicate by using the LocalConnection class. Also, the ability of a SWF file to cross-script ActionScript 3.0 SWF files from other domains and to load data from other domains is prohibited by default; however, such access can be granted with a call to the `Security.allowDomain()` method in the loaded SWF file. For more information, see "Cross-scripting" on page 1063.

The following basic security rules always apply by default:

- Resources in the same security sandbox can always access each other.
- Executable code in files in a remote sandbox can never access local files and data.

The Flash Player and AIR runtimes consider the following to be individual domains, and set up individual security sandboxes for each:

- `http://example.com`
- `http://www.example.com`
- `http://store.example.com`
- `https://www.example.com`
- `http://192.0.34.166`

Even if a named domain, such as http://example.com, maps to a specific IP address, such as http://192.0.34.166, the runtimes set up separate security sandboxes for each.

There are two basic methods that a developer can use to grant a SWF file access to assets from sandboxes other than that of the SWF file:

- The `Security.allowDomain()` method (see "Author (developer) controls" on page 1055)
- The URL policy file (see "Website controls (policy files)" on page 1051)

In the Flash Player and AIR runtime security models, there is a distinction between loading content and extracting or accessing data. *Content* is defined as media, including visual media the runtimes can display, audio, video, or a SWF file or HTML that includes displayed media. *Data* is defined as something that is accessible only to code. Content and data are loaded in different ways.

- Loading content—You can load content using classes such as the Loader, Sound, and NetStream classes; through MXML tags when using Flex; or through HTML tags in an AIR application.
- Extracting data—You can extract data from loaded media content by using Bitmap objects, the `BitmapData.draw()` and `BitmapData.drawWithQuality()` methods, the `Sound.id3` property, or the `SoundMixer.computeSpectrum()` method. The `drawWithQuality` method is available in Flash Player 11.3 and higher; AIR 3.3 and higher.
- Accessing data—You can access data directly by loading it from an external file (such as an XML file) using classes such as the URLStream, URLLoader, FileReference, Socket, and XMLSocket classes. AIR provides additional classes for loading data, such as FileStream, and XMLHttpRequest.

The Flash Player security model defines different rules for loading content and accessing data. In general, there are fewer restrictions on loading content than on accessing data.

In general, content (SWF files, bitmaps, mp3 files, and videos) can be loaded from anywhere, but if the content is from a domain other than that of the loading code or content, it will be partitioned in a separate security sandbox.

There are a few barriers to loading content:

- By default, local SWF files (those loaded from a non-network address, such as a user's hard drive) are classified in the local-with-filesystem sandbox. These files cannot load content from the network. For more information, see "Local sandboxes" on page 1044.
- Real-Time Messaging Protocol (RTMP) servers can limit access to content. For more information, see "Content delivered using RTMP servers" on page 1062.

If the loaded media is an image, audio, or video, its data, such as pixel data and sound data, can be accessed by a SWF file outside its security sandbox only if the domain of that SWF file has been included in a URL policy file at the origin domain of the media. For details, see "Accessing loaded media as data" on page 1066.

Other forms of loaded data include text or XML files, which are loaded with a URLLoader object. Again in this case, to access any data from another security sandbox, permission must be granted by means of a URL policy file at the origin domain. For details, see "Using URLLoader and URLStream" on page 1068.

***Note:** Policy files are never required in order for code executing in the AIR application sandbox to load remote content or data.*

Security sandboxes

Flash Player 9 and later, Adobe AIR 1.0 and later

Client computers can obtain individual files containing code, content, and data from a number of sources, such as from external websites, from a local file system, or from an installed AIR application. The Flash Player and AIR runtimes individually assign code files and other resources, such as shared objects, bitmaps, sounds, videos, and data files, to security sandboxes based on their origin when they are loaded. The following sections describe the rules, enforced by the runtimes, that govern what a code or content executing within a given sandbox can access.

For more information on Flash Player security, see the Flash Player Developer Center topic "Security" at www.adobe.com/go/devnet_security_en.

Remote sandboxes

Flash Player 9 and later, Adobe AIR 1.0 and later

The Flash Player and AIR runtimes classify assets (including SWF files) from the Internet in separate sandboxes that correspond to their domain of origin. For example, assets loaded from *example.com* will be placed into a different security sandbox than assets loaded from *foo.org*. By default, these files are authorized to access any resources from their own server. Remote SWF files can be allowed to access additional data from other domains by explicit website and author permissions, such as URL policy files and the `Security.allowDomain()` method. For details, see "Website controls (policy files)" on page 1051 and "Author (developer) controls" on page 1055.

Remote SWF files cannot load any local files or resources.

For more information on Flash Player security, see the Flash Player Developer Center topic "Security" at www.adobe.com/go/devnet_security_en.

Local sandboxes

Flash Player 9 and later, Adobe AIR 1.0 and later

Local file describes any file that is referenced by using the `file:` protocol or a Universal Naming Convention (UNC) path. Local SWF files are placed into one of four local sandboxes:

- The local-with-filesystem sandbox—For security purposes, the Flash Player and AIR runtimes place all local files in the local-with-file-system sandbox, by default. From this sandbox, executable code can read local files (by using the URLLoader class, for example), but cannot communicate with the network in any way. This assures the user that local data cannot be leaked out to the network or otherwise inappropriately shared.
- The local-with-networking sandbox—When compiling a SWF file, you can specify that it has network access when run as a local file (see "Setting the sandbox type of local SWF files" on page 1047).These files are placed in the local-with-networking sandbox. SWF files that are assigned to the local-with-networking sandbox forfeit their local file access. In return, the SWF files are allowed to access data from the network. However, a local-with-networking SWF file is still not allowed to read any network-derived data unless permissions are present for that action, through a URL policy file or a call to the `Security.allowDomain()` method. In order to grant such permission, a URL policy file must grant permission to *all* domains by using `<allow-access-from domain="*"/>` or by using `Security.allowDomain("*")`. For more information, see "Website controls (policy files)" on page 1051 and "Author (developer) controls" on page 1055.

- The local-trusted sandbox—Local SWF files that are registered as trusted (by users or by installer programs) are placed in the local-trusted sandbox. System administrators and users also have the ability to reassign (move) a local SWF file to or from the local-trusted sandbox based on security considerations (see "Administrator controls" on page 1048 and "User controls" on page 1050). SWF files that are assigned to the local-trusted sandbox can interact with any other SWF files and can load data from anywhere (remote or local).
- The AIR application sandbox—This sandbox contains content that was installed with the running AIR application. By default, code executing in the AIR application sandbox can cross-script code from any domain. However, files outside the AIR application sandbox are not permitted to cross-script code in the application sandbox. By default, code and content in the AIR application sandbox can load content and data from any domain.

Communication between the local-with-networking and local-with-filesystem sandboxes, as well as communication between the local-with-filesystem and remote sandboxes, is strictly forbidden. Permission to allow such communication cannot be granted by an application running in Flash Player or by a user or administrator.

Scripting in either direction between local HTML files and local SWF files—for example, using the ExternalInterface class—requires that both the HTML file and SWF file involved be in the local-trusted sandbox. This is because the local security models for browsers differ from the Flash Player local security model.

SWF files in the local-with-networking sandbox cannot load SWF files in the local-with-filesystem sandbox. SWF files in the local-with-filesystem sandbox cannot load SWF files in the local-with-networking sandbox.

The AIR application sandbox

Adobe AIR 1.0 and later

The Adobe AIR runtime adds an additional sandbox, called the *application* sandbox, to the Flash Player security sandbox model. Files installed as part of an AIR application load into the application sandbox. Any other files loaded by the application have security restrictions corresponding to those specified by the regular Flash Player security model.

When an application is installed, all files included within an AIR package are installed onto the user's computer into an application directory. Developers can reference this directory in code through the `app:/` URL scheme (see "URI schemes" on page 813). All files within the application directory tree are assigned to the application sandbox when the application is run. Content in the application sandbox is blessed with the full privileges available to an AIR application, including interaction with the local file system.

Many AIR applications use only these locally installed files to run the application. However, AIR applications are not restricted to just the files within the application directory — they can load any type of file from any source. This includes files local to the user's computer as well as files from available external sources, such as those on a local network or on the Internet. File type has no impact on security restrictions; loaded HTML files have the same security privileges as loaded SWF files from the same source.

Content in the application security sandbox has access to AIR APIs that content in other sandboxes are prevented from using. For example, the `air.NativeApplication.nativeApplication.applicationDescriptor` property, which returns the contents of the application descriptor file for the application, is restricted to content in the application security sandbox. Another example of a restricted API is the FileStream class, which contains methods for reading and writing to the local file system.

ActionScript APIs that are only available to content in the application security sandbox are indicated with the AIR logo in the *ActionScript 3.0 Reference for Adobe Flash Platform*. Using these APIs in other sandboxes causes the runtime to throw a SecurityError exception.

For HTML content (in an HTMLLoader object), all AIR JavaScript APIs (those that are available via the `window.runtime` property, or via the `air` object when using the AIRAliases.js file) are available to content in the application security sandbox. HTML content in another sandbox does not have access to the `window.runtime` property, so this content cannot access the AIR or Flash Player APIs.

Content executing within the AIR application sandbox has the following additional restrictions:

- For HTML content in the application security sandbox, there are limitations on using APIs that can dynamically transform strings into executable code after the code is loaded. This is to prevent the application from inadvertently injecting (and executing) code from non-application sources (such as potentially insecure network domains). An example is the use of the `eval()` function. For details, see "Code restrictions for content in different sandboxes" on page 1082.
- To prevent possible phishing attacks, `img` tags in HTML content in ActionScript TextField objects are ignored in SWF content in the application security sandbox.
- Content in the application sandbox cannot use the `asfunction` protocol in HTML content in ActionScript 2.0 text fields.
- SWF content in the application sandbox cannot use the cross-domain cache, a feature that was added to Flash Player 9 Update 3. This feature lets Flash Player persistently cache Adobe platform component content and reuse it in loaded SWF content on demand (eliminating the need to reload the content multiple times).

Restrictions for JavaScript inside AIR

Adobe AIR 1.0 and later

Unlike content in the application security sandbox, JavaScript content in a non-application security sandbox *can* call the `eval()` function to execute dynamically generated code at any time. However, there are restrictions on JavaScript running in a non-application security sandbox within AIR. These include:

- JavaScript code in a non-application sandbox does not have access to the `window.runtime` object, and as such this code cannot execute AIR APIs.
- By default, content in a non-application security sandbox cannot use XMLHttpRequest calls to load data from other domains other than the domain calling the request. However, application code can grant non-application content permission to do so by setting an `allowCrossdomainXHR` attribute in the containing frame or iframe. For more information, see "Code restrictions for content in different sandboxes" on page 1082.
- There are restrictions on calling the JavaScript `window.open()` method. For details, see "Restrictions on calling the JavaScript window.open() method" on page 1085.
- HTML content in remote (network) security sandboxes can only load CSS, `frame`, `iframe`, and `img` content from remote domains (from network URLs).
- HTML content in local-with-filesystem, local-with-networking, or local-trusted sandboxes can only load CSS, `frame`, `iframe`, and `img` content from local sandboxes (not from application or network URLs).

For details, see "Code restrictions for content in different sandboxes" on page 1082.

Setting the sandbox type of local SWF files

Flash Player 9 and later, Adobe AIR 1.0 and later

An end user or the administrator of a computer can specify that a local SWF file is trusted, allowing it to load data from all domains, both local and network. This is specified in the Global Flash Player Trust and User Flash Player Trust directories. For more information, see "Administrator controls" on page 1048 and "User controls" on page 1050.

For more information on local sandboxes, see "Local sandboxes" on page 1044.

Adobe Flash Professional

You can configure a SWF file for the local-with-filesystem sandbox or the local-with-networking sandbox by setting the document's publish settings in the authoring tool.

Adobe Flex

You can configure a SWF file for the local-with-filesystem sandbox or the local-with-networking sandbox by setting the `use-network` flag in the Adobe Flex compiler. For more information, see "About the application compiler options" in *Building and Deploying Adobe Flex 3 Applications*.

The Security.sandboxType property

Flash Player 9 and later, Adobe AIR 1.0 and later

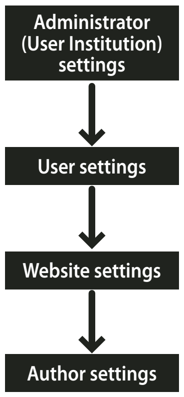
An author of a SWF file can use the read-only static `Security.sandboxType` property to determine the type of sandbox to which the Flash Player or AIR runtime has assigned the SWF file. The Security class includes constants that represent possible values of the `Security.sandboxType` property, as follows:

- `Security.REMOTE`—The SWF file is from an Internet URL, and operates under domain-based sandbox rules.
- `Security.LOCAL_WITH_FILE`—The SWF file is a local file, but it has not been trusted by the user and was not published with a networking designation. The SWF file can read from local data sources but cannot communicate with the Internet.
- `Security.LOCAL_WITH_NETWORK`—The SWF file is a local file and has not been trusted by the user, but it was published with a networking designation. The SWF file can communicate with the Internet but cannot read from local data sources.
- `Security.LOCAL_TRUSTED`—The SWF file is a local file and has been trusted by the user, using either the Settings Manager or a Flash Player trust configuration file. The SWF file can both read from local data sources and communicate with the Internet.
- `Security.APPLICATION`—The SWF file is running in an AIR application, and it was installed with the package (AIR file) for that application. By default, files in the AIR application sandbox can cross-script any file from any domain. However, files outside the AIR application sandbox are not permitted to cross-script the AIR file. By default, files in the AIR application sandbox can load content and data from any domain.

Permission controls

Flash Player 9 and later, Adobe AIR 1.0 and later

The Flash Player client run-time security model has been designed around resources, which are objects such as SWF files, local data, and Internet URLs. *Stakeholders* are the parties who own or use those resources. Stakeholders can exercise controls (security settings) over their own resources, and each resource has four stakeholders. Flash Player strictly enforces a hierarchy of authority for these controls, as the following illustration shows:



Hierarchy of security controls

This means, for instance, that if an administrator restricts access to a resource, no other stakeholders can override that restriction.

For AIR applications, these permission controls only apply to content running outside the AIR application sandbox.

Administrator controls

Flash Player 9 and later, Adobe AIR 1.0 and later

An administrative user of a computer (a user who has logged in with administrative rights) can apply Flash Player security settings that affect all users of the computer. In a non-enterprise environment, such as on a home computer, there is usually one user who also has administrative access. Even in an enterprise environment, individual users may have administrative rights to the computer.

There are two types of administrative user controls:

- The mms.cfg file
- The Global Flash Player Trust directory

The mms.cfg file

Flash Player 9 and later, Adobe AIR 1.0 and later

The mms.cfg file is a text file that lets administrators enable or restrict access to a variety of capabilities. When Flash Player starts, it reads its security settings from this file, and uses them to limit functionality. The mms.cfg file includes settings that the administrator uses to manage capabilities such as privacy controls, local file security, socket connections, and so on.

A SWF file can access some information on capabilities that have been disabled by calling the `Capabilities.avHardwareDisable` and `Capabilities.localFileReadDisable` properties. However, most of the settings in the mms.cfg file cannot be queried from ActionScript.

To enforce application-independent security and privacy policies for a computer, the mms.cfg file should be modified only by system administrators. The mms.cfg file is not for use by application installers. While an installer running with administrative privileges could modify the contents of the mms.cfg file, Adobe considers such usage a violation of the user's trust and urges creators of installers never to modify the mms.cfg file.

The mms.cfg file is stored in the following location:

- Windows 32-bit: *system*%WINDIR%\System32\Macromed\Flash\mms.cfg

  (for example, C:\WINDOWS\system32\Macromed\Flash\mms.cfg)
- Windows 64-bit: *system*%WINDIR%\SysWOW64\Macromed\Flash\mms.cfg

  (for example, C:\WINDOWS\sysWOW64\Macromed\Flash\mms.cfg)
- Mac: *app support*/Macromedia/mms.cfg

  (for example, /Library/Application Support/Macromedia/mms.cfg)
- Linux: /etc/adobe/mms.cfg

Google Chrome: Google Chrome uses its own version of the mms.cfg file, saved at:

- Mac: */Users/(username)*/Library/Application Support/Google/Chrome/Default/Pepper Data/Shockwave Flash/System
- Win: *%USERNAME%*/AppData/Local/Google/Chrome/User Data/Default/Pepper Data/Shockwave Flash/System

  The System directory may not exist. If not, create it manually.

  You might use third-party administration tools, such as Microsoft System Management Server, to replicate the configuration file to the user's computer.

  Use the standard techniques provided by your operating system to hide or otherwise prevent end users from seeing or modifying the mms.cfg file on their systems.

For more information about the mms.cfg file, see the Flash Player Administration Guide at www.adobe.com/go/flash_player_admin.

The Global Flash Player Trust directory

Flash Player 9 and later, Adobe AIR 1.0 and later

Administrative users and installer applications can register specified local SWF files as trusted for all users. These SWF files are assigned to the local-trusted sandbox. They can interact with any other SWF files, and they can load data from anywhere, remote or local. Files are designated as trusted in the Global Flash Player Trust directory, in the following location:

- Windows: *system*\Macromed\Flash\FlashPlayerTrust

  (for example, C:\WINDOWS\system32\Macromed\Flash\FlashPlayerTrust)
- Mac: *app support*/Macromedia/FlashPlayerTrust

  (for example, /Library/Application Support/Macromedia/FlashPlayerTrust)

The Flash Player Trust directory can contain any number of text files, each of which lists trusted paths, with one path per line. Each path can be an individual SWF file, HTML file, or directory. Comment lines begin with the # symbol. For example, a Flash Player trust configuration file containing the following text grants trusted status to all files in the specified directory and all subdirectories:

```
# Trust files in the following directories:
C:\Documents and Settings\All Users\Documents\SampleApp
```

The paths listed in a trust configuration file should always be local paths or SMB network paths. Any HTTP path in a trust configuration file is ignored; only local files can be trusted.

To avoid conflicts, give each trust configuration file a filename corresponding to the installing application, and use a .cfg file extension.

As a developer distributing a locally run SWF file through an installer application, you can have the installer application add a configuration file to the Global Flash Player Trust directory, granting full privileges to the file that you are distributing. The installer application must be run by a user with administrative rights. Unlike the mms.cfg file, the Global Flash Player Trust directory is included for the purpose of installer applications granting trust permissions. Both administrative users and installer applications can designate trusted local applications using the Global Flash Player Trust directory.

There are also Flash Player Trust directories for individual users (see "User controls" on page 1050).

User controls

Flash Player 9 and later

Flash Player provides three different user-level mechanisms for setting permissions: the Settings UI and Settings Manager, and the User Flash Player Trust directory.

The Settings UI and Settings Manager

Flash Player 9 and later

The Settings UI is a quick, interactive mechanism for configuring the settings for a specific domain. The Settings Manager presents a more detailed interface and provides the ability to make global changes that affect permissions for many or all domains. Additionally, when a new permission is requested by a SWF file, requiring run-time decisions concerning security or privacy, dialog boxes are displayed in which users can adjust some Flash Player settings.

The Settings Manager and Settings UI provide security-related options such as camera and microphone settings, shared object storage settings, settings related to legacy content, and so on. Neither the Settings Manager nor the Settings UI are available to AIR applications.

Note: *Any settings made in the mms.cfg file (see "Administrator controls" on page 1048) are not reflected in the Settings Manager.*

For details on the Settings Manager, see www.adobe.com/go/settingsmanager.

The User Flash Player Trust directory

Flash Player 9 and later, Adobe AIR 1.0 and later

Users and installer applications can register specified local SWF files as trusted. These SWF files are assigned to the local-trusted sandbox. They can interact with any other SWF files, and they can load data from anywhere, remote or local. A user designates a file as trusted in the User Flash Player Trust directory, which is in same directory as the shared object storage area, in the following locations (locations are specific to the current user):

- Windows: app data\Macromedia\Flash Player\#Security\FlashPlayerTrust

  (for example, C:\Documents and Settings\JohnD\Application Data\Macromedia\Flash Player\#Security\FlashPlayerTrust on Windows XP or C:\Users\JohnD\AppData\Roaming\Macromedia\Flash Player\#Security\FlashPlayerTrust on Windows Vista)

  In Windows, the Application Data folder is hidden by default. To show hidden folders and files, select My Computer to open Windows Explorer, select Tools > Folder Options and then select the View tab. Under the View tab, select the Show hidden files and folders radio button.

- Mac: app data/Macromedia/Flash Player/#Security/FlashPlayerTrust

  (for example, /Users/JohnD/Library/Preferences/Macromedia/Flash Player/#Security/FlashPlayerTrust)

  These settings affect only the current user, not other users who log in to the computer. If a user without administrative rights installs an application in their own portion of the system, the User Flash Player Trust directory lets the installer register the application as trusted for that user.

  As a developer distributing a locally run SWF file by way of an installer application, you can have the installer application add a configuration file to the User Flash Player Trust directory, granting full privileges to the file that you are distributing. Even in this situation, the User Flash Player Trust directory file is considered a user control, because a user action (installation) initiates it.

  There is also a Global Flash Player Trust directory, used by the administrative user or installers to register an application for all users of a computer (see "Administrator controls" on page 1048).

Website controls (policy files)

Flash Player 9 and later, Adobe AIR 1.0 and later

To make data from your web server available to SWF files from other domains, you can create a policy file on your server. A *policy file* is an XML file placed in a specific location on your server.

Policy files affect access to a number of assets, including the following:

- Data in bitmaps, sounds, and videos
- Loading XML and text files
- Importing SWF files from other security domains into the security domain of the loading SWF file
- Access to socket and XML socket connections

ActionScript objects instantiate two different kinds of server connections: document-based server connections and socket connections. ActionScript objects like Loader, Sound, URLLoader, and URLStream instantiate document-based server connections, and these objects load a file from a URL. ActionScript Socket and XMLSocket objects make socket connections, which operate with streaming data, not loaded documents.

Because Flash Player supports two kinds of server connections, there are two types of policy files—URL policy files and socket policy files.

- Document-based connections require *URL policy files*. These files let the server indicate that its data and documents are available to SWF files served from certain domains or from all domains.
- Socket connections require *socket policy files,* which enable networking directly at the lower TCP socket level, using the Socket and XMLSocket classes.

Flash Player requires policy files to be transmitted using the same protocol that the attempted connection wants to use. For example, when you place a policy file on your HTTP server, SWF files from other domains are allowed to load data from it as an HTTP server. However, if you don't provide a socket policy file at the same server, you are forbidding SWF files from other domains to connect to the server at the socket level. In other words, the means by which a policy file is retrieved must match the means of connecting.

Policy file usage and syntax are discussed briefly in the rest of this section, as they apply to SWF files published for Flash Player 10. (Policy file implementation is slightly different in earlier versions of Flash Player, as successive releases have strengthened Flash Player security.) For more detailed information on policy files, see the Flash Player Developer Center topic "Policy File Changes in Flash Player 9" at www.adobe.com/go/devnet_security_en.

Code executing in the AIR application sandbox does not require a policy file to access data from a URL or socket. Code in an AIR application executing in a non-application sandbox does require a policy file.

Master policy files

Flash Player 9 and later, Adobe AIR 1.0 and later

By default, Flash Player (and AIR content that is not in the AIR application sandbox) first looks for a URL policy file named `crossdomain.xml` in the root directory of the server, and looks for a socket policy file on port 843. A file in either of these locations is called the *master policy file*. (In the case of socket connections, Flash Player also looks for a socket policy file on the same port as the main connection. However, a policy file found on that port is not considered a master policy file.)

In addition to specifying access permissions, the master policy file can also contain a *meta-policy* statement. A meta-policy specifies which locations can contain policy files. The default meta-policy for URL policy files is "master-only," which means that /crossdomain.xml is the only policy file allowed on the server. The default meta-policy for socket policy files is "all," which means that any socket on the host can serve a socket policy file.

***Note:** In Flash Player 9 and earlier, the default meta-policy for URL policy files was "all," which means that any directory can contain a policy file. If you have deployed applications that load policy files from locations other than the default /crossdomain.xml file, and those applications might now be running in Flash Player 10, make sure you (or the server administrator) modify the master policy file to allow additional policy files. For information on how to specify different a different meta-policy, see the Flash Player Developer Center topic "Policy File Changes in Flash Player 9" at www.adobe.com/go/devnet_security_en.*

A SWF file can check for a different policy filename or a different directory location by calling the `Security.loadPolicyFile()` method. However, if the master policy file doesn't specify that the target location can serve policy files, the call to `loadPolicyFile()` has no effect, even if there is a policy file at that location. Call `loadPolicyFile()` before attempting any network operations that require the policy file. Flash Player automatically queues networking requests behind their corresponding policy file attempts. So, for example, it is acceptable to call `Security.loadPolicyFile()` immediately before initiating a networking operation.

When checking for a master policy file, Flash Player waits three seconds for a server response. If a response isn't received, Flash Player assumes that no master policy file exists. However, there is no default timeout value for calls to `loadPolicyFile()`; Flash Player assumes that the file being called exists, and waits as long as necessary to load it. Therefore, if you want to make sure that a master policy file is loaded, use `loadPolicyFile()` to call it explicitly.

Even though the method is named `Security.loadPolicyFile()`, a policy file isn't loaded until a network call that requires a policy file is issued. Calls to `loadPolicyFile()` simply tell Flash Player where to look for policy files when they are needed.

You can't receive notification of when a policy file request is initiated or completed, and there is no reason to do so. Flash Player performs policy checks asynchronously, and automatically waits to initiate connections until after the policy file checks have succeeded.

The following sections contain information that applies only to URL policy files. For more information on socket policy files, see "Connecting to sockets" on page 1068.

URL policy file scope

Flash Player 9 and later, Adobe AIR 1.0 and later

A URL policy file applies only to the directory from which it is loaded and to its child directories. A policy file in the root directory applies to the whole server; a policy file loaded from an arbitrary subdirectory applies only to that directory and its subdirectories.

A policy file affects access only to the particular server on which it resides. For example, a policy file located at https://www.adobe.com:8080/crossdomain.xml applies only to data- loading calls made to www.adobe.com over HTTPS at port 8080.

Specifying access permissions in a URL policy file

Flash Player 9 and later, Adobe AIR 1.0 and later

A policy file contains a single `<cross-domain-policy>` tag, which in turn contains zero or more `<allow-access-from>` tags. Each `<allow-access-from>` tag contains an attribute, `domain`, which specifies either an exact IP address, an exact domain, or a wildcard domain (any domain). Wildcard domains are indicated in one of two ways:

- By a single asterisk (*), which matches all domains and all IP addresses
- By an asterisk followed by a suffix, which matches only those domains that end with the specified suffix

Suffixes must begin with a dot. However, wildcard domains with suffixes can match domains that consist of only the suffix without the leading dot. For example, xyz.com is considered to be part of *.xyz.com. Wildcards are not allowed in IP domain specifications.

The following example shows a URL policy file that permits access to SWF files that originate from *.example.com, www.friendOfExample.com and 192.0.34.166:

```
<?xml version="1.0"?>
<cross-domain-policy>
    <allow-access-from domain="*.example.com" />
    <allow-access-from domain="www.friendOfExample.com" />
    <allow-access-from domain="192.0.34.166" />
</cross-domain-policy>
```

If you specify an IP address, access is granted only to SWF files loaded from that IP address using IP syntax (for example, http://65.57.83.12/flashmovie.swf). Access isn't granted to SWF files using domain-name syntax. Flash Player does not perform DNS resolution.

You can permit access to documents originating from any domain, as shown in the following example:

```
<?xml version="1.0"?>
<!-- http://www.foo.com/crossdomain.xml -->
<cross-domain-policy>
<allow-access-from domain="*" />
</cross-domain-policy>
```

Each `<allow-access-from>` tag also has the optional `secure` attribute, which defaults to `true`. If your policy file is on an HTTPS server and you want to allow SWF files on a non-HTTPS server to load data from the HTTPS server, you can set the attribute to `false`.

Setting the `secure` attribute to `false` could compromise the security offered by HTTPS. In particular, setting this attribute to `false` opens secure content to snooping and spoofing attacks. Adobe strongly recommends that you not set the `secure` attribute to `false`.

If data to be loaded is on an HTTPS server, but the SWF file loading it is on an HTTP server, Adobe recommends that you move the loading SWF file to an HTTPS server. Doing so lets you keep all copies of your secure data under the protection of HTTPS. However, if you decide that you must keep the loading SWF file on an HTTP server, add the `secure="false"` attribute to the `<allow-access-from>` tag, as shown in the following code:

```
<allow-access-from domain="www.example.com" secure="false" />
```

Another element you can use to permit access is the `allow-http-request-headers-from` tag. This element grants a client hosting content from another permission domain to send user-defined headers to your domain. While the `<allow-access-from>` tag grants other domains permission to pull data from your domain, the `allow-http-request-headers-from` tag grants other domains permission to push data to your domain, in the form of headers. In the following example, any domain is permitted to send the SOAPAction header to the current domain:

```
<cross-domain-policy>
    <allow-http-request-headers-from domain="*" headers="SOAPAction"/>
</cross-domain-policy>
```

If the `allow-http-request-headers-from` statement is in the master policy file, it applies to all directories on the host. Otherwise, it applies only to the directory and subdirectories of the policy file that contains the statement.

Preloading policy files

Flash Player 9 and later, Adobe AIR 1.0 and later

Loading data from a server or connecting to a socket is an asynchronous operation. Flash Player simply waits for the policy file to finish downloading before it begins the main operation. However, extracting pixel data from images or extracting sample data from sounds is a synchronous operation. The policy file must load before you can extract data. When you load the media, specify that it check for a policy file:

- When using the `Loader.load()` method, set the `checkPolicyFile` property of the `context` parameter, which is a LoaderContext object.
- When embedding an image in a text field using the `<img>` tag, set the `checkPolicyFile` attribute of the `<img>` tag to `"true"`, as in the following:

  ```
  <img checkPolicyFile = "true" src = "example.jpg">
  ```

- When using the `Sound.load()` method, set the `checkPolicyFile` property of the `context` parameter, which is a SoundLoaderContext object.
- When using the NetStream class, set the `checkPolicyFile` property of the NetStream object.

When you set one of these parameters, Flash Player first checks for any policy files that it already has downloaded for that domain. Then it looks for the policy file in the default location on the server, checking both for `<allow-access-from>` statements and for the presence of a meta-policy. Finally, it considers any pending calls to the `Security.loadPolicyFile()` method to see if they are in scope.

Author (developer) controls

Flash Player 9 and later, Adobe AIR 1.0 and later

The main ActionScript API used to grant security privileges is the `Security.allowDomain()` method, which grant privileges to SWF files in the domains that you specify. In the following example, a SWF file grants access to SWF files served from the www.example.com domain:

```
Security.allowDomain("www.example.com")
```

This method grants permissions for the following:

- Cross-scripting between SWF files (see "Cross-scripting" on page 1063)
- Display list access (see "Traversing the display list" on page 1065)
- Event detection (see "Event security" on page 1065)
- Full access to properties and methods of the Stage object (see "Stage security" on page 1064)

The primary purpose of calling the `Security.allowDomain()` method is to grant permission for SWF files in an outside domain to script the SWF file calling the `Security.allowDomain()` method. For more information, see "Cross-scripting" on page 1063.

Specifying an IP address as a parameter to the `Security.allowDomain()` method does not permit access by all parties that originate at the specified IP address. Instead, it permits access only by a party that contains the specified IP address as its URL, rather than a domain name that maps to that IP address. For example, if the domain name www.example.com maps to the IP address 192.0.34.166, a call to `Security.allowDomain("192.0.34.166")` does not grant access to www.example.com.

You can pass the `"*"` wildcard to the `Security.allowDomain()` method to allow access from all domains. Because it grants permission for SWF files from *all* domains to script the calling SWF file, use the `"*"` wildcard with care.

ActionScript includes a second permission API, called `Security.allowInsecureDomain()`. This method does the same thing as the `Security.allowDomain()` method, except that, when called from a SWF file served by a secure HTTPS connection, it additionally permits access to the calling SWF file by other SWF files that are served from an insecure protocol, such as HTTP. However, it is not a good security practice to allow scripting between files from a secure protocol (HTTPS) and those from insecure protocols (such as HTTP); doing so can open secure content to snooping and spoofing attacks. Here is how such attacks can work: since the `Security.allowInsecureDomain()` method allows access to your secure HTTPS data by SWF files served over HTTP connections, an attacker interposed between your HTTP server and your users could replace your HTTP SWF file with one of their own, which can then access your HTTPS data.

Important: *Code executing in the AIR application sandbox is not permitted to call either the* `allowDomain()` *or* `allowInsecureDomain()` *methods of the Security class.*

Another important security-related method is the `Security.loadPolicyFile()` method, which causes Flash Player to check for a policy file at a nonstandard location. For more information, see "Website controls (policy files)" on page 1051.

Restricting networking APIs

Flash Player 9 and later, Adobe AIR 1.0 and later

Networking APIs can be restricted in two ways. To prevent malicious activity, access to commonly reserved ports is blocked; you can't override these blocks in your code. To control a SWF file's access to network functionality with regard to other ports, you can use the `allowNetworking` setting.

Blocked ports

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player and Adobe AIR have restrictions on HTTP access to certain ports, as do browsers. HTTP requests are not permitted to certain standard ports that are conventionally used for non-HTTP types of servers.

Any API that accesses a network URL is subject to these port blocking restrictions. The only exception is APIs that call sockets directly, such as `Socket.connect()` and `XMLSocket.connect()`, or calls to `Security.loadPolicyFile()` in which a socket policy file is being loaded. Socket connections are permitted or denied through the use of socket policy files on the target server.

The following list shows the ActionScript 3.0 APIs to which port blocking applies:

`FileReference.download()`,`FileReference.upload()`, `Loader.load()`, `Loader.loadBytes()`, `navigateToURL()`, `NetConnection.call()`, `NetConnection.connect()`, `NetStream.play()`, `Security.loadPolicyFile()`, `sendToURL()`, `Sound.load()`, `URLLoader.load()`, `URLStream.load()`

Port blocking also applies to Shared Library importing, the use of the `<img>` tag in text fields, and the loading of SWF files in an HTML page using the `<object>` and `<embed>` tags.

Port blocking also applies to the use of the `<img>` tag in text fields and the loading of SWF files in an HTML page using the `<object>` and `<embed>` tags.

The following lists show which ports are blocked:

HTTP: 20 (ftp data), 21 (ftp control)

HTTP and FTP: 1 (tcpmux), 7 (echo), 9 (discard), 11 (systat), 13 (daytime), 15 (netstat), 17 (qotd), 19 (chargen), 22 (ssh), 23 (telnet), 25 (smtp), 37 (time), 42 (name), 43 (nicname), 53 (domain), 77 (priv-rjs), 79 (finger), 87 (ttylink), 95 (supdup), 101 (hostriame), 102 (iso-tsap), 103 (gppitnp), 104 (acr-nema), 109 (pop2), 110 (pop3), 111 (sunrpc), 113 (auth), 115 (sftp), 117 (uucp-path), 119 (nntp), 123 (ntp), 135 (loc-srv / epmap), 139 (netbios), 143 (imap2), 179 (bgp), 389 (ldap), 465 (smtp+ssl), 512 (print / exec), 513 (login), 514 (shell), 515 (printer), 526 (tempo), 530 (courier), 531 (chat), 532 (netnews), 540 (uucp), 556 (remotefs), 563 (nntp+ssl), 587 (smtp), 601 (syslog), 636 (ldap+ssl), 993 (ldap+ssl), 995 (pop3+ssl), 2049 (nfs), 4045 (lockd), 6000 (x11)

Using the allowNetworking parameter

Flash Player 9 and later, Adobe AIR 1.0 and later

You can control a SWF file's access to network functionality by setting the `allowNetworking` parameter in the `<object>` and `<embed>` tags in the HTML page that contains the SWF content.

Possible values of `allowNetworking` are:

- `"all"` (the default)—All networking APIs are permitted in the SWF file.

- `"internal"`—The SWF file may not call browser navigation or browser interaction APIs, listed later in this section, but it may call any other networking APIs.
- `"none"`—The SWF file may not call browser navigation or browser interaction APIs, listed later in this section, and it cannot use any SWF-to-SWF communication APIs, also listed later.

The `allowNetworking` parameter is designed to be used primarily when the SWF file and the enclosing HTML page are from different domains. Using the value of `"internal"` or `"none"` is not recommended when the SWF file being loaded is from the same domain as its enclosing HTML pages, because you can't ensure that a SWF file is always loaded with the HTML page you intend. Untrusted parties could load a SWF file from your domain with no enclosing HTML, in which case the `allowNetworking` restriction will not work as you intended.

Calling a prevented API throws a SecurityError exception.

Add the `allowNetworking` parameter and set its value in the `<object>` and `<embed>` tags in the HTML page that contains a reference to the SWF file, as shown in the following example:

```
<object classic="clsid:d27cdb6e-ae6d-11cf-96b8-444553540000"
    Code
base="http://fpdownload.macromedia.com/pub/shockwave/cabs/flash/swflash.cab#version=9,0,124,
0"
    width="600" height="400" ID="test" align="middle">
<param name="allowNetworking" value="none" />
<param name="movie" value="test.swf" />
<param name="bgcolor" value="#333333" />
<embed src="test.swf" allowNetworking="none" bgcolor="#333333"
    width="600" height="400"
    name="test" align="middle" type="application/x-shockwave-flash"
    pluginspage="http://www.macromedia.com/go/getflashplayer" />
</object>
```

An HTML page may also use a script to generate SWF-embedding tags. You need to alter the script so that it inserts the proper `allowNetworking` settings. HTML pages generated by Adobe Flash Professional and Adobe Flash Builder use the `AC_FL_RunContent()` function to embed references to SWF files. Add the `allowNetworking` parameter settings to the script, as in the following:

```
AC_FL_RunContent( ... "allowNetworking", "none", ...)
```

The following APIs are prevented when `allowNetworking` is set to `"internal"`:

`navigateToURL()`, `fscommand()`, `ExternalInterface.call()`

In addition to the APIs on the previous list, the following APIs are also prevented when `allowNetworking` is set to `"none"`:

`sendToURL()`, `FileReference.download()`, `FileReference.upload()`, `Loader.load()`, `LocalConnection.connect()`, `LocalConnection.send()`, `NetConnection.connect()`, `NetStream.play()`, `Security.loadPolicyFile()`, `SharedObject.getLocal()`, `SharedObject.getRemote()`, `Socket.connect()`, `Sound.load()`, `URLLoader.load()`, `URLStream.load()`, `XMLSocket.connect()`

Even if the selected `allowNetworking` setting permits a SWF file to use a networking API, there may be other restrictions based on security sandbox limitations (see "Security sandboxes" on page 1044).

When `allowNetworking` is set to `"none"`, you cannot reference external media in an `<img>` tag in the `htmlText` property of a TextField object (a SecurityError exception is thrown).

When `allowNetworking` is set to `"none"`, a symbol from an imported shared library added in the Flash Professional (not ActionScript) is blocked at run time.

Full-screen mode security

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player 9.0.27.0 and later support full-screen mode, in which content running in Flash Player can fill the entire screen. To enter full-screen mode, the `displayState` property of the Stage is set to the `StageDisplayState.FULL_SCREEN` constant. For more information, see "Working with full-screen mode" on page 167.

For SWF files running in a remote sandbox, there are some security considerations.

To enable full-screen mode, in the `<object>` and `<embed>` tags in the HTML page that contains a reference to the SWF file, add the `allowFullScreen` parameter, with its value set to `"true"` (the default value is `"false"`), as shown in the following example:

```
<object classid="clsid:d27cdb6e-ae6d-11cf-96b8-444553540000"

codebase="http://fpdownload.macromedia.com/pub/shockwave/cabs/flash/swflash.cab#version=9,0,
18,0"
    width="600" height="400" id="test" align="middle">
<param name="allowFullScreen" value="true" />
<param name="movie" value="test.swf" />
<param name="bgcolor" value="#333333" />
<embed src="test.swf" allowFullScreen="true" bgcolor="#333333"
    width="600" height="400"
    name="test" align="middle" type="application/x-shockwave-flash"
    pluginspage="http://www.macromedia.com/go/getflashplayer" />
</object>
```

An HTML page may also use a script to generate SWF-embedding tags. You must alter the script so that it inserts the proper `allowFullScreen` settings. HTML pages generated by Flash Professional and Flash Builder use the `AC_FL_RunContent()` function to embed references to SWF files, and you need to add the `allowFullScreen` parameter settings, as in the following:

```
AC_FL_RunContent( ... "allowFullScreen", "true", ...)
```

The ActionScript that initiates full-screen mode can be called only in response to a mouse event or keyboard event. If it is called in other situations, Flash Player throws an exception.

A message appears when the content enters full-screen mode, instructing the user how to exit and return to normal mode. The message appears for a few seconds and then fades out.

For content that is running in a browser, keyboard usage is restricted in full-screen mode. In Flash Player 9, only keyboard shortcuts that return the application to normal mode, such as pressing the Escape key, are supported. Users can't enter text in text fields or navigate around the screen. In Flash Player 10 and later, certain non-printing keys (specifically the arrow keys, space, and Tab key) are supported. However, text input is still prohibited.

Full-screen mode is always permitted in the stand-alone player or in a projector file. Also, keyboard usage (including text input) is fully supported in those environments.

Calling the `displayState` property of a Stage object throws an exception for any caller that is not in the same security sandbox as the Stage owner (the main SWF file). For more information, see "Stage security" on page 1064.

Administrators can disable full-screen mode for SWF files running in browsers by setting `FullScreenDisable = 1` in the mms.cfg file. For details, see "Administrator controls" on page 1048.

In a browser, a SWF file must be contained in an HTML page to allow full-screen mode.

Full-screen interactive mode security

Flash Player 11.3 and later, Adobe AIR 1.0 and later

Flash Player 11.3 and later support full-screen interactive mode, in which content running in Flash Player can fill the entire screen *and accept text input.* To enter full-screen interactive mode, the `displayState` property of the Stage is set to the `StageDisplayState.FULL_SCREEN_INTERACTIVE` constant. For more information, see "Working with full-screen mode" on page 167.

For SWF files running in a remote sandbox, there are some security considerations.

To enable full-screen mode, in the `<object>` and `<embed>` tags in the HTML page that contains a reference to the SWF file, add the `allowFullScreenInteractive` parameter, with its value set to `"true"` (the default value is `"false"`), as shown in the following example:

```
<object classid="clsid:d27cdb6e-ae6d-11cf-96b8-444553540000"

codebase="http://fpdownload.macromedia.com/pub/shockwave/cabs/flash/swflash.cab#version=9,0,
18,0"
    width="600" height="400" id="test" align="middle">
<param name="allowFullScreenInteractive" value="true" />
<param name="movie" value="test.swf" />
<param name="bgcolor" value="#333333" />
<embed src="test.swf" allowFullScreen="true" bgcolor="#333333"
    width="600" height="400"
    name="test" align="middle" type="application/x-shockwave-flash"
    pluginspage="http://www.macromedia.com/go/getflashplayer" />
</object>
```

An HTML page may also use a script to generate SWF-embedding tags. You must alter the script so that it inserts the proper `allowFullScreenInteractive` settings. HTML pages generated by Flash Professional and Flash Builder use the `AC_FL_RunContent()` function to embed references to SWF files, and you need to add the `allowFullScreenInteractive` parameter settings, as in the following:

```
AC_FL_RunContent( ... "allowFullScreenInteractive", "true", ...)
```

The ActionScript that initiates full-screen interactive mode can be called only in response to a mouse event or keyboard event. If it is called in other situations, Flash Player throws an exception.

An overlay message appears when the content enters full-screen interactive mode. The message displays the domain of the full-screen page, instructions on how to exit full-screen mode, and an **Allow** button. The overlay persists until the user clicks **Allow**, acknowledging they are in full-screen interactive mode.

Administrators can disable full-screen interactive mode for SWF files running in browsers by setting `FullScreenInteractiveDisable = 1` in the mms.cfg file. For details, see "Administrator controls" on page 1048.

In a browser, a SWF file must be contained in an HTML page to allow full-screen interactive mode.

Loading content

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player and AIR content can load many types of other content, including the following:

- SWF files
- Images
- Sound
- Video
- HTML files (AIR only)
- JavaScript (AIR only)

Loading SWF files and images with the Loader class

Flash Player 9 and later, Adobe AIR 1.0 and later

You use the Loader class to load SWF files and images (JPG, GIF, or PNG files). Any SWF file, other than one in the local-with-filesystem sandbox, can load SWF files and images from any network domain. Only SWF files in local sandboxes can load SWF files and images from the local file system. However, files in the local-with-networking sandbox can only load local SWF files that are in the local-trusted or local-with-networking sandbox. SWF files in the local-with-networking sandbox load local content other than SWF files (such as images), however they cannot access data in the loaded content.

When loading a SWF file from a non-trusted source (such as a domain other than that of the Loader object's root SWF file), you may want to define a mask for the Loader object, to prevent the loaded content (which is a child of the Loader object) from drawing to portions of the Stage outside of that mask, as in the following code:

```
import flash.display.*;
import flash.net.URLRequest;
var rect:Shape = new Shape();
rect.graphics.beginFill(0xFFFFFF);
rect.graphics.drawRect(0, 0, 100, 100);
addChild(rect);
var ldr:Loader = new Loader();
ldr.mask = rect;
var url:String = "http://www.unknown.example.com/content.swf";
var urlReq:URLRequest = new URLRequest(url);
ldr.load(urlReq);
addChild(ldr);
```

When you call the `load()` method of the Loader object, you can specify a `context` parameter, which is a LoaderContext object. The LoaderContext class includes three properties that let you define the context of how the loaded content can be used:

- `checkPolicyFile`: Use this property only when loading an image file (not a SWF file). Specify this for an image file from a domain other than that of the file containing the Loader object. If you set this property to `true`, the Loader checks the origin server for a URL policy file (see "Website controls (policy files)" on page 1051). If the server grants permission to the Loader domain, ActionScript from SWF files in the Loader domain can access data in the loaded image. In other words, you can use the `Loader.content` property to obtain a reference to the Bitmap object that represents the loaded image, or the `BitmapData.draw()` or `BitmapData.drawWithQuality()` methods to access pixels from the loaded image. The `drawWithQuality` method is available in Flash Player 11.3 and higher; AIR 3.3 and higher.
- `securityDomain`: Use this property only when loading a SWF file (not an image). Specify this for a SWF file from a domain other than that of the file containing the Loader object. Only two values are currently supported for the `securityDomain` property: `null` (the default) and `SecurityDomain.currentDomain`. If you specify `SecurityDomain.currentDomain`, this requests that the loaded SWF file be *imported* to the sandbox of the loading SWF file, meaning that it operates as though it had been loaded from the loading SWF file's own server. This is only permitted if a URL policy file is found on the loaded SWF file's server, allowing access by the loading SWF file's domain. If the required policy file is found, the loader and loadee can freely script each other once the load begins, since they are in the same sandbox. Note that sandbox importing can mostly be replaced by performing an ordinary load and then having the loaded SWF file call the `Security.allowDomain()` method. This latter method may be easier to use, since the loaded SWF file will then be in its own natural sandbox, and thus able to access resources on its own actual server.
- `applicationDomain`: Use this property only when loading a SWF file written in ActionScript 3.0 (not an image or a SWF file written in ActionScript 1.0 or 2.0). When loading the file, you can specify that the file be placed into a particular application domain, rather than the default of being placed in a new application domain that is a child of the loading SWF file's application domain. Note that application domains are subunits of security domains, and thus you can specify a target application domain only if the SWF file that you are loading is from your own security domain, either because it is from your own server, or because you have successfully imported it into your security domain using the `securityDomain` property. If you specify an application domain but the loaded SWF file is part of a different security domain, the domain you specify in `applicationDomain` is ignored. For more information, see "Working with application domains" on page 147.

For details, see "Specifying loading context" on page 200.

An important property of a Loader object is the `contentLoaderInfo` property, which is a LoaderInfo object. Unlike most other objects, a LoaderInfo object is shared between the loading SWF file and the loaded content, and it is always accessible to both parties. When the loaded content is a SWF file, it can access the LoaderInfo object through the `DisplayObject.loaderInfo` property. LoaderInfo objects include information such as load progress, the URLs of loader and loadee, the trust relationship between loader and loadee, and other information. For more information, see "Monitoring loading progress" on page 199.

Loading sound and videos

Flash Player 9 and later, Adobe AIR 1.0 and later

Any content, except content in the local-with-filesystem sandbox, is allowed to load sound and video from network origins, using the `Sound.load()`, `NetConnection.connect()`, and `NetStream.play()` methods.

Only content in the local-with-filesystem and AIR application sandboxes can load media from the local file system. Only content in the local-with-filesystem sandbox, the AIR application sandbox, or the local-trusted sandbox can access data in these loaded files.

There are other restrictions on accessing data from loaded media. For details, see "Accessing loaded media as data" on page 1066.

Loading SWF files and images using the <img> tag in a text field

Flash Player 9 and later, Adobe AIR 1.0 and later

You can load SWF files and bitmaps into a text field by using the `<img>` tag, as in the following code:

```
<img src = 'filename.jpg' id = 'instanceName' >
```

You can access content loaded this way by using the `getImageReference()` method of the TextField instance, as in the following code:

```
var loadedObject:DisplayObject = myTextField.getImageReference('instanceName');
```

Note, however, that SWF files and images loaded in this way are put in the sandbox that corresponds to their origin.

When you load an image file using an `<img>` tag in a text field, access to the data in the image may be permitted by a URL policy file. You can check for a policy file by adding a `checkPolicyFile` attribute to the `<img>` tag, as in the following code:

```
<img src = 'filename.jpg' checkPolicyFile = 'true' id = 'instanceName' >
```

When you load a SWF using an `<img>` tag in a text field, you can permit access to that SWF file's data through a call to the `Security.allowDomain()` method.

When you use an `<img>` tag in a text field to load an external file (as opposed to using a Bitmap class embedded within your SWF), a Loader object is automatically created as a child of the TextField object, and the external file is loaded into that Loader just as if you had used a Loader object in ActionScript to load the file. In this case, the `getImageReference()` method returns the Loader that was automatically created. No security check is needed to access this Loader object because it is in the same security sandbox as the calling code.

However, when you refer to the `content` property of the Loader object to access the loaded media, security rules apply. If the content is an image, you need to implement a URL policy file, and if the content is a SWF file, you need to have the code in the SWF file call the `allowDomain()` method.

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In the application sandbox, <img> tags in a text field are ignored to prevent phishing attacks. In addition, code running in the application sandbox is not permitted to call the Security `allowDomain()` method.

Content delivered using RTMP servers

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Media Server uses the Real-Time Media Protocol (RTMP) to serve data, audio, and video. You can load this media by using the `connect()` method of the NetConnection class, passing an RTMP URL as the parameter. Flash Media Server can restrict connections and prevent content from downloading, based on the domain of the requesting file. For details, see the Flash Media Server documentation online at www.adobe.com/go/learn_fms_docs_en.

To use the `BitmapData.draw()`, `BitmapData.drawWithQuality()`, and `SoundMixer.computeSpectrum()` methods to extract run-time graphics and sound data from RTMP streams, you must allow access on the server. Use the Server-Side ActionScript `Client.videoSampleAccess` and `Client.audioSampleAccess` properties to allow access to specific directories on Flash Media Server. For more information, see the Server-Side ActionScript Language Reference. (The `drawWithQuality` method is available in Flash Player 11.3 and higher; AIR 3.3 and higher.)

Cross-scripting

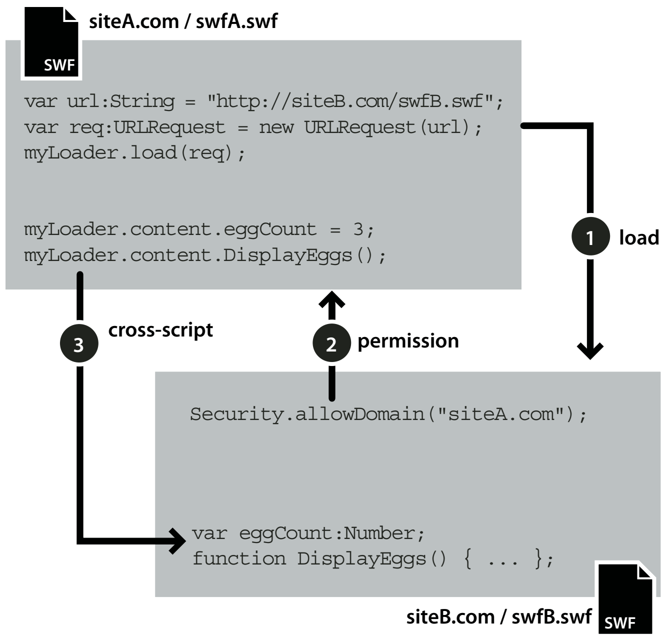
Flash Player 9 and later, Adobe AIR 1.0 and later

If two SWF files written with ActionScript 3.0, or two HTML files running in AIR are served from the same domain—for example, the URL for one SWF file is http://www.example.com/swfA.swf and the URL for the other is http://www.example.com/swfB.swf—then code defined in one file can examine and modify variables, objects, properties, methods, and so on in the other, and vice versa. This is called *cross-scripting*.

If the two files are served from different domains—for example, http://siteA.com/swfA.swf and http://siteB.com/swfB.swf—then, by default, Flash Player and AIR do not allow swfA.swf to script swfB.swf, nor swfB.swf to script swfA.swf. A SWF file gives permission to SWF files from other domains by calling `Security.allowDomain()`. By calling `Security.allowDomain("siteA.com")`, swfB.swf gives SWF files from siteA.com permission to script it.

Cross-scripting is not supported between AVM1 SWF files and AVM2 SWF files. An AVM1 SWF file is one created by using ActionScript 1.0 or ActionScript 2.0. (AVM1 and AVM2 refer to the ActionScript Virtual Machine.) You can, however, use the LocalConnection class to send data between AVM1 and AVM2.

In any cross-domain situation, it is important to be clear about the two parties involved. For the purposes of this discussion, the side that is performing the cross-scripting is called the *accessing party* (usually the accessing SWF), and the other side is called the *party being accessed* (usually the SWF being accessed). When siteA.swf scripts siteB.swf, siteA.swf is the accessing party, and siteB.swf is the party being accessed, as the following illustration shows:



```
var url:String = "http://siteB.com/swfB.swf";
var req:URLRequest = new URLRequest(url);
myLoader.load(req);

myLoader.content.eggCount = 3;
myLoader.content.DisplayEggs();
```

```
Security.allowDomain("siteA.com");

var eggCount:Number;
function DisplayEggs() { ... };
```

Cross-domain permissions that are established with the `Security.allowDomain()` method are asymmetrical. In the previous example, siteA.swf can script siteB.swf, but siteB.swf cannot script siteA.swf, because siteA.swf has not called the `Security.allowDomain()` method to give SWF files at siteB.com permission to script it. You can set up symmetrical permissions by having both SWF files call the `Security.allowDomain()` method.

In addition to protecting SWF files from cross-domain scripting originated by other SWF files, Flash Player protects SWF files from cross-domain scripting originated by HTML files. HTML-to-SWF scripting can occur with callbacks established through the `ExternalInterface.addCallback()` method. When HTML-to-SWF scripting crosses domains, the SWF file being accessed must call the `Security.allowDomain()` method, just as when the accessing party is a SWF file, or the operation will fail. For more information, see "Author (developer) controls" on page 1055.

Also, Flash Player provides security controls for SWF-to-HTML scripting. For more information, see "Controlling outbound URL access" on page 1072.

Stage security

Flash Player 9 and later, Adobe AIR 1.0 and later

Some properties and methods of the Stage object are available to any sprite or movie clip on the display list.

However, the Stage object is said to have an owner: the first SWF file loaded. By default, the following properties and methods of the Stage object are available only to SWF files in the same security sandbox as the Stage owner:

Properties	Methods
`align`	`addChild()`
displayState	`addChildAt()`
frameRate	`addEventListener()`
`height`	`dispatchEvent()`
`mouseChildren`	`hasEventListener()`
`numChildren`	`setChildIndex()`
`quality`	`willTrigger()`
`scaleMode`	
`showDefaultContextMenu`	
`stageFocusRect`	
`stageHeight`	
`stageWidth`	
`tabChildren`	
`textSnapshot`	
`width`	

In order for a SWF file in a sandbox other than that of the Stage owner to access these properties and methods, the Stage owner SWF file must call the `Security.allowDomain()` method to permit the domain of the external sandbox. For more information, see "Author (developer) controls" on page 1055.

The `frameRate` property is a special case—any SWF file can read the `frameRate` property. However, only those in the Stage owner's security sandbox (or those granted permission by a call to the `Security.allowDomain()` method) can change the property.

There are also restrictions on the `removeChildAt()` and `swapChildrenAt()` methods of the Stage object, but these are different from the other restrictions. Rather than needing to be in the same domain as the Stage owner, to call these methods code must be in the same domain as the owner of the affected child object(s), or the child object(s) can call the `Security.allowDomain()` method.

Traversing the display list

Flash Player 9 and later, Adobe AIR 1.0 and later

The ability of one SWF file to access display objects loaded from other sandboxes is restricted. In order for a SWF file to access a display object created by another SWF file in a different sandbox, the SWF file being accessed must call the `Security.allowDomain()` method to permit access by the domain of the accessing SWF file. For more information, see "Author (developer) controls" on page 1055.

To access a Bitmap object that was loaded by a Loader object, a URL policy file must exist on the origin server of the image file, and that policy file must grant permission to the domain of the SWF file trying to access the Bitmap object (see "Website controls (policy files)" on page 1051).

The LoaderInfo object that corresponds to a loaded file (and to the Loader object) includes the following three properties, which define the relationship between the loaded object and the Loader object: `childAllowsParent`, `parentAllowsChild`, and `sameDomain`.

Event security

Flash Player 9 and later, Adobe AIR 1.0 and later

Events related to the display list have security access limitations, based on the sandbox of the display object that is dispatching the event. An event in the display list has bubbling and capture phases (described in "Handling events" on page 125). During the bubbling and capture phases, an event migrates from the source display object through parent display objects in the display list. If a parent object is in a different security sandbox than the source display object, the capture and bubble phase stops below that parent object, unless there is mutual trust between the owner of the parent object and the owner of the source object. This mutual trust can be achieved by the following:

1. The SWF file that owns the parent object must call the `Security.allowDomain()` method to trust the domain of the SWF file that owns the source object.
2. The SWF file that owns the source object must call the `Security.allowDomain()` method to trust the domain of the SWF file that owns the parent object.

The LoaderInfo object that corresponds to a loaded file (and to the Loader object) includes the following two properties, which define the relationship between the loaded object and the Loader object: `childAllowsParent` and `parentAllowsChild`.

For events that are dispatched from objects other than display objects, there are no security checks or security-related implications.

Accessing loaded media as data

Flash Player 9 and later, Adobe AIR 1.0 and later

To access load data use the `BitmapData.draw()`, `BitmapData.drawWithQuality()`, and `SoundMixer.computeSpectrum()` methods. By default, you cannot obtain pixel data or audio data from graphic or audio objects rendered or played by media loaded in a different sandbox. However, you can use the following methods to grant permission to access such data across sandbox boundaries:

- In the content rendering or playing the data to be accessed, call the `Security.allowDomain()` method to grant data access to content in other domains.
- For a loaded image, sound, or video, add a URL policy file on the server of the loaded file. This policy file must grant access to the domain of the SWF file that is attempting to call the `BitmapData.draw()`, `BitmapData.drawWithQuality()`, or `SoundMixer.computeSpectrum()` methods to extract data from the file. The `drawWithQuality` method is available in Flash Player 11.3 and higher; AIR 3.3 and higher.

The following sections provide details on accessing bitmap, sound, and video data.

Accessing bitmap data

Flash Player 9 and later, Adobe AIR 1.0 and later

The `draw()` and `drawWithQuality()` (Flash Player 11.3; AIR 3.3) methods of a BitmapData object lets you draw the currently displayed pixels of any display object to the BitmapData object. This could include the pixels of a MovieClip object, a Bitmap object, or any display object. The following conditions must be met for these methods to draw pixels to the BitmapData object:

- In the case of a source object other than a loaded bitmap, the source object and (in the case of a Sprite or MovieClip object) all of its child objects must come from the same domain as the object calling the draw method, or they must be in a SWF file that is accessible to the caller by having called the `Security.allowDomain()` method.
- In the case of a Loaded bitmap source object, the source object must come from the same domain as the object calling the draw method, or its source server must include a URL policy file that grants permission to the calling domain.

If these conditions are not met, a SecurityError exception is thrown.

When you load the image using the `load()` method of the Loader class, you can specify a `context` parameter, which is a LoaderContext object. If you set the `checkPolicyFile` property of the LoaderContext object to `true`, Flash Player checks for a URL policy file on the server from which the image is loaded. If there is a policy file, and the file permits the domain of the loading SWF file, the file is allowed to access data in the Bitmap object; otherwise, access is denied.

You can also specify a `checkPolicyFile` property in an image loaded via an `<img>` tag in a text field. For details, see "Loading SWF files and images using the <img> tag in a text field" on page 1062.

Accessing sound data

Flash Player 9 and later, Adobe AIR 1.0 and later

The following sound-related ActionScript 3.0 APIs have security restrictions:

- The `SoundMixer.computeSpectrum()` method—Always permitted for code running in the same security sandbox as the sound file. For code running in other sandboxes, there are security checks.

- The `SoundMixer.stopAll()` method—Always permitted for code running in the same security sandbox as the sound file. For files in other sandboxes, there are security checks.
- The `id3` property of the Sound class—Always permitted for SWF files that are in the same security sandbox as the sound file. For code running in other sandboxes, there are security checks.

Every sound has two kinds of sandboxes associated with it—a content sandbox and an owner sandbox:

- The origin domain for the sound determines the content sandbox, and this determines whether data can be extracted from the sound via the `id3` property of the sound and the `SoundMixer.computeSpectrum()` method.
- The object that started the sound playing determines the owner sandbox, and this determines whether the sound can be stopped using the `SoundMixer.stopAll()` method.

When you load the sound using the `load()` method of the Sound class, you can specify a `context` parameter, which is a SoundLoaderContext object. If you set the `checkPolicyFile` property of the SoundLoaderContext object to `true`, the runtime checks for a URL policy file on the server from which the sound is loaded. If there is a policy file, and the file permits the domain of the loading code, the code is allowed to access the `id` property of the Sound object; otherwise, it will not. Also, setting the `checkPolicyFile` property can enable the `SoundMixer.computeSpectrum()` method for loaded sounds.

You can use the `SoundMixer.areSoundsInaccessible()` method to find out whether a call to the `SoundMixer.stopAll()` method would not stop all sounds because the sandbox of one or more sound owners is inaccessible to the caller.

Calling the `SoundMixer.stopAll()` method stops those sounds whose owner sandbox is the same as that of the caller of `stopAll()`. It also stops those sounds whose playback was started by SWF files that have called the `Security.allowDomain()` method to permit access by the domain of the SWF file calling the `stopAll()` method. Any other sounds are not stopped, and the presence of such sounds can be revealed by calling the `SoundMixer.areSoundsInaccessible()` method.

Calling the `computeSpectrum()` method requires that every sound that is playing be either from the same sandbox as the object calling the method or from a source that has granted permission to the caller's sandbox; otherwise, a SecurityError exception is thrown. For sounds that were loaded from embedded sounds in a library in a SWF file, permission is granted with a call to the `Security.allowDomain()` method in the loaded SWF file. For sounds loaded from sources other than SWF files (originating from loaded mp3 files or from video files), a URL policy file on the source server grants access to data in loaded media.

For more information, see "Author (developer) controls" on page 1055 and "Website controls (policy files)" on page 1051.

To access sound data from RTMP streams, you must allow access on the server. Use the Server-Side ActionScript `Client.audioSampleAccess` property to allow access to specific directories on Flash Media Server. For more information, see the Server-Side ActionScript Language Reference.

Accessing video data

Flash Player 9 and later, Adobe AIR 1.0 and later

You can use the `BitmapData.draw()` or `BitmapData.drawWithQuality()` method to capture the pixel data of the current frame of a video. (The `drawWithQuality` method is available in Flash Player 11.3 and higher; AIR 3.3 and higher.)

There are two different kinds of video:

- Video streamed over RTMP from Flash Media Server

- Progressive video, which is loaded from an FLV or F4V file

To use the draw methods to extract run-time graphics from RTMP streams, you must allow access on the server. Use the Server-Side ActionScript `Client.videoSampleAccess` property to allow access to specific directories on Flash Media Server. For more information, see the Server-Side ActionScript Language Reference.

When you call a draw method with progressive video as the `source` parameter, the caller of the method must either be from the same sandbox as the FLV file, or the server of the FLV file must have a policy file that grants permission to the domain of the calling SWF file. You can request that the policy file be downloaded by setting the `checkPolicyFile` property of the NetStream object to `true`.

Loading data

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player and AIR content can exchange data with servers. Loading data is a different kind of operation from loading media, because the loaded information appears as program objects, rather than being displayed as media. Generally, content may load data from the same domain that the content originated from. However, content usually requires policy files in order to load data from other domains (see "Website controls (policy files)" on page 1051).

***Note:** Content running in the AIR application sandbox is never served from a remote domain (unless the developer intentionally imports remote content into the application sandbox), so it cannot participate in the types of attacks that policy files protect against. AIR content in the application sandbox is not restricted from loading data by policy files. However, AIR content in other sandboxes is subject to the restrictions described here.*

Using URLLoader and URLStream

Flash Player 9 and later, Adobe AIR 1.0 and later

You can load data, such as an XML file or a text file. The `load()` methods of the URLLoader and URLStream classes are governed by URL policy file permissions.

If you use the `load()` method to load content from a domain other than that of the code that is calling the method, the runtime checks for a URL policy file on the server of the loaded assets. If there is a policy file, and it grants access to the domain of the loading content, you can load the data.

Connecting to sockets

Flash Player 9 and later, Adobe AIR 1.0 and later

By default, the runtime looks for a socket policy file served from port 843. As with URL policy files, this file is called the *master policy file*.

When policy files were first introduced in Flash Player 6, there was no support for socket policy files. Connections to socket servers were authorized by a policy file in the default location on an HTTP server on port 80 of the same host as the socket server. Flash Player 9 still supports this capability, but Flash Player 10 does not. In Flash Player 10, only socket policy files can authorize socket connections.

Like URL policy files, socket policy files support a meta-policy statement that specifies which ports can serve policy files. However, instead of "master-only," the default meta-policy for socket policy files is "all." That is, unless the master policy file specifies a more restrictive setting, Flash Player assumes that any socket on the host can serve a socket policy file.

Access to socket and XML socket connections is disabled by default, even if the socket you are connecting to is in the same domain as the SWF file. You can permit socket-level access by serving a socket policy file from any of the following locations:

- Port 843 (the location of the master policy file)
- The same port as the main socket connection
- A different port than the main socket connection

By default, Flash Player looks for a socket policy file on port 843 and on the same port as the main socket connection. If you want to serve a socket policy file from a different port, the SWF file must call `Security.loadPolicyFile()`.

A socket policy file has the same syntax as a URL policy file, except that it must also specify the ports to which it grants access. When a socket policy file is served from a port number below 1024, it may grant access to any ports; when a policy file comes from port 1024 or higher, it may grant access only to ports 1024 and higher. The allowed ports are specified in a `to-ports` attribute in the `<allow-access-from>` tag. Single port numbers, port ranges, and wildcards are accepted values.

Here is an example socket policy file:

```
<?xml version="1.0"?>
<!DOCTYPE cross-domain-policy SYSTEM "http://www.adobe.com/xml/dtds/cross-domain-policy.dtd">
<!-- Policy file for xmlsocket://socks.mysite.com -->
<cross-domain-policy>
    <allow-access-from domain="*" to-ports="507" />
    <allow-access-from domain="*.example.com" to-ports="507,516" />
    <allow-access-from domain="*.example.org" to-ports="516-523" />
    <allow-access-from domain="adobe.com" to-ports="507,516-523" />
    <allow-access-from domain="192.0.34.166" to-ports="*" />
</cross-domain-policy>
```

To retrieve a socket policy file from port 843 or from the same port as a main socket connection, call the `Socket.connect()` or `XMLSocket.connect()` method. Flash Player first checks for a master policy file on port 843. If it finds one, it checks to see if the file contains a meta-policy statement that prohibits socket policy files on the target port. If access isn't prohibited, Flash Player first looks for the appropriate `allow-access-from` statement in the master policy file. If it doesn't find one, it then looks for a socket policy file on the same port as the main socket connection.

To retrieve a socket policy file a different location, first call the `Security.loadPolicyFile()` method with the special `"xmlsocket"` syntax, as in the following:

```
Security.loadPolicyFile("xmlsocket://server.com:2525");
```

Call the `Security.loadPolicyFile()` method before calling the `Socket.connect()` or `XMLSocket.connect()` method. Flash Player then waits until it has fulfilled your policy file request before deciding whether to allow your main connection. However, if the master policy file specifies that the target location can't serve policy files, the call to `loadPolicyFile()` has no effect, even if there is a policy file at that location.

If you are implementing a socket server and you need to provide a socket policy file, decide whether to provide the policy file using the same port that accepts main connections, or using a different port. In either case, your server must wait for the first transmission from your client before sending a response.

When Flash Player requests a policy file, it always transmits the following string as soon as a connection is established:

```
<policy-file-request/>
```

Once the server receives this string, it can transmit the policy file. The request from Flash Player is always terminated by a null byte, and the response from the server must also be terminated by a null byte.

Do not expect to reuse the same connection for both a policy file request and a main connection; close the connection after transmitting the policy file. If you do not, Flash Player closes the policy file connection before reconnecting to set up the main connection.

Protecting data

Flash Player 9 and later, Adobe AIR 1.0 and later

To protect data from eavesdropping and alteration as it travels over the Internet, you can use the Transport Layer Security (TLS) or Socket Layer Security (SSL) on the server where the data originates. You can then connect to the server using the HTTPS protocol.

In applications created for AIR 2 or above, you can also protect TCP socket communications. The SecureSocket class allows you to initiate a socket connection to a socket server that uses TLS version 1or SSL version 4.

Sending data

Flash Player 9 and later, Adobe AIR 1.0 and later

Data sending occurs when code sends data to a server or resource. Sending data is always permitted for content from a network domain. A local SWF file can send data to network addresses only if it is in the local-trusted, local-with-networking, or AIR application sandbox. For more information, see "Local sandboxes" on page 1044.

You can use the `flash.net.sendToURL()` function to send data to a URL. Other methods also send requests to URLs. These include loading methods, such as `Loader.load()` and `Sound.load()`, and data-loading methods, such as `URLLoader.load()` and `URLStream.load()`.

Uploading and downloading files

Flash Player 9 and later, Adobe AIR 1.0 and later

The `FileReference.upload()` method starts the upload of a file selected by a user to a remote server. You must call the `FileReference.browse()` or `FileReferenceList.browse()` method before calling the `FileReference.upload()` method.

The code that initiates the `FileReference.browse()` or `FileReferenceList.browse()` method can be called only in response to a mouse event or keyboard event. If it is called in other situations, Flash Player 10 and later throws an exception. However, a user-initiated event is not required to call these methods from the AIR application sandbox.

Calling the `FileReference.download()` method opens a dialog box in which the user can download a file from a remote server.

***Note:** If your server requires user authentication, only SWF files running in a browser—that is, using the browser plug-in or ActiveX control—can provide a dialog box to prompt the user for a user name and password for authentication, and only for downloads. Flash Player does not allow uploads to a server that requires user authentication.*

Uploads and downloads are not allowed if the calling SWF file is in the local-with-filesystem sandbox.

By default, a SWF file may not initiate an upload to, or a download from, a server other than its own. A SWF file may upload to, or download from, a different server if that server provides a policy file that grants permission to the domain of the invoking SWF file.

Loading embedded content from SWF files imported into a security domain

Flash Player 9 and later, Adobe AIR 1.0 and later

When you load a SWF file, you can set the `context` parameter of the `load()` method of the Loader object that is used to load the file. This parameter takes a LoaderContext object. When you set the `securityDomain` property of this LoaderContext object to `Security.currentDomain`, Flash Player checks for a URL policy file on the server of the loaded SWF file. If there is a policy file, and it grants access to the domain of the loading SWF file, you can load the SWF file as imported media. In this way, the loading file can get access to objects in the library of the SWF file.

An alternative way for a SWF file to access classes in loaded SWF files from a different security sandbox is to have the loaded SWF file call the `Security.allowDomain()` method to grant access to the domain of the calling SWF file. You can add the call to the `Security.allowDomain()` method to the constructor method of the main class of the loaded SWF file, and then have the loading SWF file add an event listener to respond to the `init` event dispatched by the `contentLoaderInfo` property of the Loader object. When this event is dispatched, the loaded SWF file has called the `Security.allowDomain()` method in the constructor method, and classes in the loaded SWF file are available to the loading SWF file. The loading SWF file can retrieve classes from the loaded SWF file by calling `Loader.contentLoaderInfo.applicationDomain.getDefinition()` or Loader.contentLoaderInfo.applicationDomain.getQualifiedDefinitionNames()(Flash Player 11.3 and higher; AIR 3.3 and higher).

Working with legacy content

Flash Player 9 and later, Adobe AIR 1.0 and later

In Flash Player 6, the domain that is used for certain Flash Player settings is based on the trailing portion of the domain of the SWF file. These settings include settings for camera and microphone permissions, storage quotas, and storage of persistent shared objects.

If the domain of a SWF file includes more than two segments, such as www.example.com, the first segment of the domain (www) is removed, and the remaining portion of the domain is used. So, in Flash Player 6, www.example.com and store.example.com both use example.com as the domain for these settings. Similarly, www.example.co.uk and store.example.co.uk both use example.co.uk as the domain for these settings. This can lead to problems in which SWF files from unrelated domains, such as example1.co.uk and example2.co.uk, have access to the same shared objects.

In Flash Player 7 and later, player settings are chosen by default according to a SWF file's exact domain. For example, a SWF file from www.example.com would use the player settings for www.example.com. A SWF file from store.example.com would use the separate player settings for store.example.com.

In a SWF file written using ActionScript 3.0, when `Security.exactSettings` is set to `true` (the default), Flash Player uses exact domains for player settings. When it is set to `false`, Flash Player uses the domain settings used in Flash Player 6. If you change `exactSettings` from its default value, you must do so before any events occur that require Flash Player to choose player settings—for example, using a camera or microphone, or retrieving a persistent shared object.

If you published a version 6 SWF file and created persistent shared objects from it, to retrieve those persistent shared objects from a SWF that uses ActionScript 3.0, you must set `Security.exactSettings` to `false` before calling `SharedObject.getLocal()`.

Setting LocalConnection permissions

Flash Player 9 and later, Adobe AIR 1.0 and later

The LocalConnection class lets you send messages between one Flash Player or AIR application and another. LocalConnection objects can communicate only among Flash Player or AIR content running on the same client computer, but they can be running in different applications—for example, a SWF file running in a browser, a SWF file running in a projector, and an AIR application can all communicate use the LocalConnection class.

For every LocalConnection communication, there is a sender and a listener. By default, Flash Player allows LocalConnection communication between code running in the same domain. For code running in different sandboxes, the listener must allow the sender permission by using the `LocalConnection.allowDomain()` method. The string you pass as an argument to the `LocalConnection.allowDomain()` method can contain any of the following: exact domain names, IP addresses, and the `*` wildcard.

The `allowDomain()` method has changed from the form it had in ActionScript 1.0 and 2.0. In those earlier versions, `allowDomain()` was a callback method that you implemented. In ActionScript 3.0, `allowDomain()` is a built-in method of the LocalConnection class that you call. With this change, `allowDomain()` works in much the same way as `Security.allowDomain()`.

A SWF file can use the `domain` property of the LocalConnection class to determine its domain.

Controlling outbound URL access

Flash Player 9 and later, Adobe AIR 1.0 and later

Outbound scripting and URL access (through the use of HTTP URLs, mailto: and so on) are achieved through use of the following APIs:

- The `flash.system.fscommand()` function
- The `ExternalInterface.call()` method
- The `flash.net.navigateToURL()` function

For content loaded from the local file system, calls to these methods are successful only if the code and the containing web page (if there is one) are in the local-trusted or AIR application security sandboxes. Calls to these methods fail if the content is in the local-with-networking or local-with-filesystem sandbox.

For content that is not loaded locally, all of these APIs can communicate with the web page in which they are embedded, depending on the value of the AllowScriptAccess parameter described below. The `flash.net.navigateToURL()` function has the additional ability to communicate with any open browser window or frame, not just the page in which the SWF file is embedded. For more information on this functionality, see "Using the navigateToURL() function" on page 1073.

The `AllowScriptAccess` parameter in the HTML code that loads a SWF file controls the ability to perform outbound URL access from within the SWF file. Set this parameter inside the PARAM or EMBED tag. If no value is set for `AllowScriptAccess`, the SWF file and the HTML page can communicate only if both are from the same domain.

The `AllowScriptAccess` parameter can have one of three possible values: `"always"`, `"sameDomain"`, or `"never"`.

- When `AllowScriptAccess` is `"always"`, the SWF file can communicate with the HTML page in which it is embedded even when the SWF file is from a different domain than the HTML page.
- When `AllowScriptAccess` is `"sameDomain"`, the SWF file can communicate with the HTML page in which it is embedded only when the SWF file is from the same domain as the HTML page. This value is the default value for `AllowScriptAccess`. Use this setting, or do not set a value for `AllowScriptAccess`, to prevent a SWF file hosted from one domain from accessing a script in an HTML page that comes from another domain.
- When `AllowScriptAccess` is `"never"`, the SWF file cannot communicate with any HTML page. Using this value has been deprecated since the release of Adobe Flash CS4 Professional. It is not recommended and shouldn't be necessary if you don't serve untrusted SWF files from your own domain. If you do need to serve untrusted SWF files, Adobe recommends that you create a distinct subdomain and place all untrusted content there.

Here is an example of setting the `AllowScriptAccess` tag in an HTML page to allow outbound URL access to a different domain:

```
<object id='MyMovie.swf' classid='clsid:D27CDB6E-AE6D-11cf-96B8-444553540000'
codebase='http://download.adobe.com/pub/shockwave/cabs/flash/swflash.cab#version=9,0,0,0'
height='100%' width='100%'>
<param name='AllowScriptAccess' value='always'/>
<param name='src' value=''MyMovie.swf'/>
<embed name='MyMovie.swf' pluginspage='http://www.adobe.com/go/getflashplayer'
src='MyMovie.swf' height='100%' width='100%' AllowScriptAccess='never'/>
</object>
```

Using the navigateToURL() function

Flash Player 9 and later, Adobe AIR 1.0 and later

In addition to the security setting specified by the `allowScriptAccess` parameter discussed above, the `navigateToURL()` function has an optional second parameter - `target`. The `target` parameter can be used to specify the name of an HTML window or frame to send the URL request to. Additional security restrictions apply to such requests, and the restrictions vary depending on whether `navigateToURL()` is being used as a scripting or non-scripting statement.

For scripting statements, such as `navigateToURL("javascript: alert('Hello from Flash Player.')")`, the following rules apply.

- If the SWF file is a locally trusted file, the request succeeds.
- If the target is the HTML page in which the SWF file is embedded, the `allowScriptAccess` rules described above apply.
- If the target holds content loaded from the same domain as the SWF file, the request succeeds.

- If the target holds content loaded from a different domain than the SWF file, and neither of the previous two conditions is met, the request fails.

For non-scripting statements (such as HTTP, HTTPS, and `mailto:`, the request fails if all of the following conditions apply:

- The target is one of the special keywords `"_top"` or `"_parent"`, and
- the SWF file is in a web page hosted from a different domain, and
- the SWF file is embedded with a value for `allowScriptAccess` that is not `"always"`.

For more information

Flash Player 9 and later, Adobe AIR 1.0 and later

For more information on outbound URL access, see the following entries in the *ActionScript 3.0 Reference for the Adobe Flash Platform:*

- The flash.system.fscommand() function
- The call() method of the ExternalInterface class
- The `flash.net.navigateToURL()` function

Shared objects

Flash Player 9 and later, Adobe AIR 1.0 and later

Flash Player provides the ability to use *shared objects*, which are ActionScript objects that persist outside of a SWF file, either locally on a user's file system or remotely on an RTMP server. Shared objects, like other media in Flash Player, are partitioned into security sandboxes. However, the sandbox model for shared objects is somewhat different, because shared objects are not resources that can ever be accessed across domain boundaries. Instead, shared objects are always retrieved from a shared object store that is particular to the domain of each SWF file that calls methods of the SharedObject class. Usually a shared object store is even more particular than a SWF file's domain: by default, each SWF file uses a shared object store particular to its entire origin URL. For more information on shared objects, see "Shared objects" on page 701.

A SWF file can use the `localPath` parameter of the `SharedObject.getLocal()` and `SharedObject.getRemote()` methods to use a shared object store associated with only a part of its URL. In this way, the SWF file can permit sharing with other SWF files from other URLs. Even if you pass `'/'` as the `localPath` parameter, this still specifies a shared object store particular to its own domain.

Users can restrict shared object access by using the Flash Player Settings dialog box or the Settings Manager. By default, shared objects can be created up to a maximum of 100 KB of data per domain. Administrative users and users can also place restrictions on the ability to write to the file system. For more information, see "Administrator controls" on page 1048 and "User controls" on page 1050.

You can specify that a shared object is secure, by specifying `true` for the `secure` parameter of the `SharedObject.getLocal()` method or the `SharedObject.getRemote()` method. Note the following about the `secure` parameter:

- If this parameter is set to `true`, Flash Player creates a new secure shared object or gets a reference to an existing secure shared object. This secure shared object can be read from or written to only by SWF files delivered over HTTPS that call `SharedObject.getLocal()` with the `secure` parameter set to `true`.
- If this parameter is set to `false`, Flash Player creates a new shared object or gets a reference to an existing shared object that can be read from or written to by SWF files delivered over non-HTTPS connections.

If the calling SWF file is not from an HTTPS URL, specifying `true` for the `secure` parameter of the `SharedObject.getLocal()` method or the `SharedObject.getRemote()` method results in a SecurityError exception.

The choice of a shared object store is based on a SWF file's origin URL. This is true even in the two situations where a SWF file does not originate from a simple URL: import loading and dynamic loading. Import loading refers to the situation where you load a SWF file with the `LoaderContext.securityDomain` property set to `SecurityDomain.currentDomain`. In this situation, the loaded SWF file will have a pseudo-URL that begins with its loading SWF file's domain and then specifies its actual origin URL. Dynamic loading refers to the loading of a SWF file using the `Loader.loadBytes()` method. In this situation, the loaded SWF file will have a pseudo-URL that begins with its loading SWF file's full URL followed by an integer ID. In both the import loading and dynamic loading cases, a SWF file's pseudo-URL can be examined using the `LoaderInfo.url` property. The pseudo-URL is treated exactly like a real URL for the purposes of choosing a shared object store. You can specify a shared object `localPath` parameter that uses part or all of the pseudo-URL.

Users and administrators can elect to disable the use of *third-party shared objects*. This is the usage of shared objects by any SWF file that is executing in a web browser, when that SWF file's origin URL is from a different domain than the URL shown in the browser's address bar. Users and administrators may choose to disable third-party shared object usage for reasons of privacy, wishing to avoid cross-domain tracking. In order to avoid this restriction, you may wish to ensure that any SWF file using shared objects is loaded only within HTML page structures that ensure that the SWF file comes from the same domain as is shown in the browser's address bar. When you attempt to use shared objects from a third-party SWF file, and third-party shared object use is disabled, the`SharedObject.getLocal()` and `SharedObject.getRemote()` methods return `null`. For more information, see www.adobe.com/products/flashplayer/articles/thirdpartylso.

Camera, microphone, clipboard, mouse, and keyboard access

Flash Player 9 and later, Adobe AIR 1.0 and later

When a SWF file attempts to access a user's camera or microphone using the `Camera.get()` or `Microphone.get()` methods, Flash Player displays a Privacy dialog box, in which the user can allow or deny access to their camera and microphone. The user and the administrative user can also disable camera access on a per-site or global basis, through controls in the mms.cfg file, the Settings UI, and the Settings Manager (see "Administrator controls" on page 1048 and "User controls" on page 1050). With user restrictions, the `Camera.get()` and `Microphone.get()` methods each return a `null` value. You can use the `Capabilities.avHardwareDisable` property to determine whether the camera and microphone have been administratively prohibited (`true`) or allowed (`false`).

The `System.setClipboard()` method allows a SWF file to replace the contents of the clipboard with a plain-text string of characters. This poses no security risk. To protect against the risk posed by passwords and other sensitive data being cut or copied to clipboards, there is no corresponding `getClipboard()` method.

An application running in Flash Player can monitor only keyboard and mouse events that occur within its focus. Content running in Flash Player cannot detect keyboard or mouse events in another application.

AIR security

Adobe AIR 1.0 and later

AIR security basics

Adobe AIR 1.0 and later

AIR applications run with the same security restrictions as native applications. In general, AIR applications, like native applications, have broad access to operating system capabilities such as reading and writing files, starting applications, drawing to the screen, and communicating with the network. Operating system restrictions that apply to native applications, such as user-specific privileges, equally apply to AIR applications.

Although the Adobe® AIR® security model is an evolution of the Adobe® Flash® Player security model, the security contract is different from the security contract applied to content in a browser. This contract offers developers a secure means of broader functionality for rich experiences with freedoms that would be inappropriate for a browser-based application.

AIR applications are written using either compiled bytecode (SWF content) or interpreted script (JavaScript, HTML) so that the runtime provides memory management. This minimizes the chances of AIR applications being affected by vulnerabilities related to memory management, such as buffer overflows and memory corruption. These are some of the most common vulnerabilities affecting desktop applications written in native code.

Installation and updates

Adobe AIR 1.0 and later

AIR applications are distributed via AIR installer files which use the `air` extension or via native installers, which use the file format and extension of the native platform. For example, the native installer format of Windows is an EXE file, and for Android the native format is an APK file.

When Adobe AIR is installed and an AIR installer file is opened, the AIR runtime administers the installation process. When a native installer is used, the operating system administers the installation process.

***Note:** Developers can specify a version, and application name, and a publisher source when using the AIR file format, but the initial application installation workflow itself cannot be modified. This restriction is advantageous for users because all AIR applications share a secure, streamlined, and consistent installation procedure administered by the runtime. If application customization is necessary, it can be provided when the application is first executed.*

Runtime installation location

Adobe AIR 1.0 and later

AIR applications using the AIR file format first require the runtime to be installed on a user's computer, just as SWF files first require the Flash Player browser plug-in to be installed.

The runtime is installed to the following location on desktop computers:

- Mac OS: `/Library/Frameworks/`
- Windows: `C:\Program Files\Common Files\Adobe AIR`
- Linux: `/opt/Adobe AIR/`

On Mac OS, to install an updated version of an application, the user must have adequate system privileges to install to the application directory. On Windows and Linux, a user must have administrative privileges.

Note: *On iOS, the AIR runtime is not installed separately; every AIR app is a self-contained application.*

The runtime can be installed in two ways: using the seamless install feature (installing directly from a web browser) or via a manual install. AIR applications packaged as native installers can also install the AIR runtime as part of their normal application install process. (Distributing the AIR runtime in this way requires a redistribution agreement with Adobe.)

Seamless install (runtime and application)

Adobe AIR 1.0 and later

The seamless install feature provides developers with a streamlined installation experience for users who do not have Adobe AIR installed yet. In the seamless install method, the developer creates a SWF file that presents the application for installation. When a user clicks in the SWF file to install the application, the SWF file attempts to detect the runtime. If the runtime cannot be detected it is installed, and the runtime is activated immediately with the installation process for the developer's application.

Manual install

Adobe AIR 1.0 and later

Alternatively, the user can manually download and install the runtime before opening an AIR file. The developer can then distribute an AIR file by different means (for instance, via e-mail or an HTML link on a website). When the AIR file is opened, the runtime begins to process the application installation.

Application installation flow

Adobe AIR 1.0 and later

The AIR security model allows users to decide whether to install an AIR application. The AIR install experience provides several improvements over native application install technologies that make this trust decision easier for users:

- The runtime provides a consistent installation experience on all operating systems, even when an AIR application is installed from a link in a web browser. Most native application install experiences depend upon the browser or other application to provide security information, if it is provided at all.
- The AIR application install experience identifies the source of the application and information about what privileges are available to the application (if the user allows the installation to proceed).

- The runtime administers the installation process of an AIR application. An AIR application cannot manipulate the installation process the runtime uses.

In general, users should not install any desktop application that comes from a source that they do not trust, or that cannot be verified. The burden of proof on security for native applications is equally true for AIR applications as it is for other installable applications.

Application destination

Adobe AIR 1.0 and later

The installation directory can be set using one of the following two options:

1. The user customizes the destination during installation. The application installs to wherever the user specifies.
2. If the user does not change the install destination, the application installs to the default path as determined by the runtime:
   - Mac OS: `~/Applications/`
   - Windows XP and earlier: `C:\Program Files\`
   - Windows Vista: `~/Apps/`
   - Linux: /opt/

   If the developer specifies an `installFolder` setting in the application descriptor file, the application is installed to a subpath of this directory.

The AIR file system

Adobe AIR 1.0 and later

The install process for AIR applications copies all files that the developer has included within the AIR installer file onto the user's local computer. The installed application is composed of:

- Windows: A directory containing all files included in the AIR installer file. The runtime also creates an exe file during the installation of the AIR application.
- Linux: A directory containing all files included in the AIR installer file. The runtime also creates a bin file during the installation of the AIR application.
- Mac OS: An `app` file that contains all of the contents of the AIR installer file. It can be inspected using the "Show Package Contents" option in Finder. The runtime creates this app file as part of the installation of the AIR application.

An AIR application is run by:

- Windows: Running the .exe file in the install folder, or a shortcut that corresponds to this file (such as a shortcut on the Start Menu or desktop).
- Linux: Launching the .bin file in the install folder, choosing the application from the Applications menu, or running from an alias or desktop shortcut.
- Mac OS: Running the .app file or an alias that points to it.

The application file system also includes subdirectories related to the function of the application. For example, information written to encrypted local storage is saved to a subdirectory in a directory named after the application identifier of the application.

AIR application storage

Adobe AIR 1.0 and later

AIR applications have privileges to write to any location on the user's hard drive; however, developers are encouraged to use the `app-storage:/` path for local storage related to their application. Files written to `app-storage:/` from an application are located in a standard location depending on the user's operating system:

- On Mac OS: the storage directory of an application varies by AIR version:
  - **AIR 3.2 and earlier** - `<appData>/<appId>/Local Store/` where `<appData>` is the user's "preferences folder," typically: `/Users/<user>/Library/Preferences`
  - **AIR 3.3 and higher** - `<path>/Library/Application Support/<appID>/Local Store`, where `<path>` is either `/Users/<user>/Library/Containers/<bundle-id>/Data` (sandboxed environment) or `/Users/<user>` (when running outside a sandboxed environment)
- On Windows: the storage directory of an application is `<appData>\<appId>\Local Store\` where `<appData>` is the user's CSIDL_APPDATA "Special Folder," typically: `C:\Documents and Settings\<user>\Application Data`
- On Linux: `<appData>/<appID>/Local Store/`where `<appData>` is `/home/<user>/.appdata`

You can access the application storage directory via the `air.File.applicationStorageDirectory` property. You can access its contents using the `resolvePath()` method of the File class. For details, see "Working with the file system" on page 653.

Updating Adobe AIR

Adobe AIR 1.0 and later

When the user installs an AIR application that requires an updated version of the runtime, the runtime automatically installs the required runtime update.

To update the runtime, a user must have administrative privileges for the computer.

Updating AIR applications

Adobe AIR 1.0 and later

Development and deployment of software updates are one of the biggest security challenges facing native code applications. The AIR API provides a mechanism to improve this: the `Updater.update()` method can be invoked upon launch to check a remote location for an AIR file. If an update is appropriate, the AIR file is downloaded, installed, and the application restarts. Developers can use this class not only to provide new functionality but also respond to potential security vulnerabilities.

The Updater class can only be used to update applications distributed as AIR files. Applications distributed as native applications must use the update facilities, if any, of the native operating system.

***Note:** Developers can specify the version of an application by setting the versionNumber property of the application descriptor file.*

Uninstalling an AIR application

Adobe AIR 1.0 and later

Removing an AIR application removes all files in the application directory. However, it does not remove all files that the application may have written to outside of the application directory. Removing AIR applications does not revert changes the AIR application has made to files outside of the application directory.

Windows registry settings for administrators

Adobe AIR 1.0 and later

On Windows, administrators can configure a machine to prevent (or allow) AIR application installation and runtime updates. These settings are contained in the Windows registry under the following key: HKLM\Software\Policies\Adobe\AIR. They include the following:

Registry setting	Description
AppInstallDisabled	Specifies that AIR application installation and uninstallation are allowed. Set to 0 for "allowed," set to 1 for "disallowed."
UntrustedAppInstallDisabled	Specifies that installation of untrusted AIR applications (applications that do not includes a trusted certificate) is allowed. Set to 0 for "allowed," set to 1 for "disallowed."
UpdateDisabled	Specifies that updating the runtime is allowed, either as a background task or as part of an explicit installation. Set to 0 for "allowed," set to 1 for "disallowed."

HTML security in Adobe AIR

Adobe AIR 1.0 and later

This topic describes the AIR HTML security architecture and how to use iframes, frames, and the sandbox bridge to set up HTML-based applications and safely integrate HTML content into SWF-based applications.

The runtime enforces rules and provides mechanisms for overcoming possible security vulnerabilities in HTML and JavaScript. The same rules are enforced whether your application is primarily written in JavaScript or whether you load the HTML and JavaScript content into a SWF-based application. Content in the application sandbox and the non-application security sandbox have different privileges. When loading content into an iframe or frame, the runtime provides a secure *sandbox bridge* mechanism that allows content in the frame or iframe to communicate securely with content in the application security sandbox.

The AIR SDK provides three classes for rendering HTML content.

The HTMLLoader class provides close integration between JavaScript code and the AIR APIs.

The StageWebView class is an HTML rendering class and has very limited integration with the host AIR application. Content loaded by the StageWebView class is never placed in the application security sandbox and cannot access data or call functions in the host AIR application. On desktop platforms, the StageWebView class uses the built-in AIR HTML engine, based on Webkit, which is also used by the HTMLLoader class. On mobile platforms, the StageWebView class uses the HTML control provided by the operating system. Thus, on mobile platforms the StageWebView class has the same security considerations and vulnerabilities as the system web browser.

The TextField class can display strings of HTML text. No JavaScript can be executed, but the text can include links and externally loaded images.

For more information, see "Avoiding security-related JavaScript errors" on page 983.

Overview on configuring your HTML-based application

Adobe AIR 1.0 and later

Frames and iframes provide a convenient structure for organizing HTML content in AIR. Frames provide a means both for maintaining data persistence and for working securely with remote content.

Because HTML in AIR retains its normal, page-based organization, the HTML environment completely refreshes if the top frame of your HTML content "navigates" to a different page. You can use frames and iframes to maintain data persistence in AIR, much the same as you would for a web application running in a browser. Define your main application objects in the top frame and they persist as long as you don't allow the frame to navigate to a new page. Use child frames or iframes to load and display the transient parts of the application. (There are a variety of ways to maintain data persistence that can be used in addition to, or instead of, frames. These include cookies, local shared objects, local file storage, the encrypted file store, and local database storage.)

Because HTML in AIR retains its normal, blurred line between executable code and data, AIR puts content in the top frame of the HTML environment into the application sandbox. After the page `load` event, AIR restricts any operations, such as `eval()`, that can convert a string of text into an executable object. This restriction is enforced even when an application does not load remote content. To allow HTML content to execute these restricted operations, you must use frames or iframes to place the content into a non-application sandbox. (Running content in a sandboxed child frame may be necessary when using some JavaScript application frameworks that rely on the `eval()` function.) For a complete list of the restrictions on JavaScript in the application sandbox, see "Code restrictions for content in different sandboxes" on page 1082.

Because HTML in AIR retains its ability to load remote, possibly insecure content, AIR enforces a same-origin policy that prevents content in one domain from interacting with content in another. To allow interaction between application content and content in another domain, you can set up a bridge to serve as the interface between a parent and a child frame.

Setting up a parent-child sandbox relationship

Adobe AIR 1.0 and later

AIR adds the `sandboxRoot` and `documentRoot` attributes to the HTML frame and iframe elements. These attributes let you treat application content as if it came from another domain:

Attribute	Description
sandboxRoot	The URL to use for determining the sandbox and domain in which to place the frame content. The `file:`, `http:`, or `https:` URL schemes must be used.
documentRoot	The URL from which to load the frame content. The `file:`, `app:`, or `app-storage:` URL schemes must be used.

The following example maps content installed in the sandbox subdirectory of the application to run in the remote sandbox and the www.example.com domain:

```
<iframe
    src="ui.html"
    sandboxRoot="http://www.example.com/local/"
    documentRoot="app:/sandbox/">
</iframe>
```

Setting up a bridge between parent and child frames in different sandboxes or domains

Adobe AIR 1.0 and later

AIR adds the `childSandboxBridge` and `parentSandboxBridge` properties to the `window` object of any child frame. These properties let you define bridges to serve as interfaces between a parent and a child frame. Each bridge goes in one direction:

`childSandboxBridge` — The `childSandboxBridge` property allows the child frame to expose an interface to content in the parent frame. To expose an interface, you set the `childSandbox` property to a function or object in the child frame. You can then access the object or function from content in the parent frame. The following example shows how a script running in a child frame can expose an object containing a function and a property to its parent:

```
var interface = {};
interface.calculatePrice = function(){
    return .45 + 1.20;
}
interface.storeID = "abc"
window.childSandboxBridge = interface;
```

If this child content is in an iframe assigned an `id` of `"child"`, you can access the interface from parent content by reading the `childSandboxBridge` property of the frame:

```
var childInterface = document.getElementById("child").childSandboxBridge;
air.trace(childInterface.calculatePrice()); //traces "1.65"
air.trace(childInterface.storeID)); //traces "abc"
```

`parentSandboxBridge` — The `parentSandboxBridge` property allows the parent frame to expose an interface to content in the child frame. To expose an interface, you set the `parentSandbox` property of the child frame to a function or object in the parent frame. You can then access the object or function from content in the child frame. The following example shows how a script running in the parent frame can expose an object containing a save function to a child:

```
var interface = {};
interface.save = function(text){
    var saveFile = air.File("app-storage:/save.txt");
    //write text to file
}
document.getElementById("child").parentSandboxBridge = interface;
```

Using this interface, content in the child frame could save text to a file named save.txt. However, it would not have any other access to the file system. In general, application content should expose the narrowest possible interface to other sandboxes. The child content could call the save function as follows:

```
var textToSave = "A string.";
window.parentSandboxBridge.save(textToSave);
```

If child content attempts to set a property of the `parentSandboxBridge` object, the runtime throws a SecurityError exception. If parent content attempts to set a property of the `childSandboxBridge` object, the runtime throws a SecurityError exception.

Code restrictions for content in different sandboxes

Adobe AIR 1.0 and later

As discussed in the introduction to this topic, "HTML security in Adobe AIR" on page 1080, the runtime enforces rules and provides mechanisms for overcoming possible security vulnerabilities in HTML and JavaScript. This topic lists those restrictions. If code attempts to call these restricted APIs, the runtime throws an error with the message "Adobe AIR runtime security violation for JavaScript code in the application security sandbox."

For more information, see "Avoiding security-related JavaScript errors" on page 983.

Restrictions on using the JavaScript eval() function and similar techniques

Adobe AIR 1.0 and later

For HTML content in the application security sandbox, there are limitations on using APIs that can dynamically transform strings into executable code after the code is loaded (after the `onload` event of the `body` element has been dispatched and the `onload` handler function has finished executing). This is to prevent the application from inadvertently injecting (and executing) code from non-application sources (such as potentially insecure network domains).

For example, if your application uses string data from a remote source to write to the innerHTML property of a DOM element, the string could include executable (JavaScript) code that could perform insecure operations. However, while the content is loading, there is no risk of inserting remote strings into the DOM.

One restriction is in the use of the JavaScript `eval()` function. Once code in the application sandbox is loaded and after processing of the onload event handler, you can only use the `eval()` function in limited ways. The following rules apply to the use of the `eval()` function *after* code is loaded from the application security sandbox:

- Expressions involving literals are allowed. For example:

  ```
  eval("null");
  eval("3 + .14");
  eval("'foo'");
  ```

- Object literals are allowed, as in the following:

  ```
  { prop1: val1, prop2: val2 }
  ```

- Object literal setter/getters are *prohibited*, as in the following:

  ```
  { get prop1() { ... }, set prop1(v) { ... } }
  ```

- Array literals are allowed, as in the following:

  ```
  [ val1, val2, val3 ]
  ```

- Expressions involving property reads are *prohibited*, as in the following:

  ```
  a.b.c
  ```

- Function invocation is *prohibited.*
- Function definitions are *prohibited.*
- Setting any property is *prohibited.*
- Function literals are *prohibited.*

However, while the code is loading, before the `onload` event, and during execution the `onload` event handler function, these restrictions do not apply to content in the application security sandbox.

For example, after code is loaded, the following code results in the runtime throwing an exception:

```
eval("alert(44)");
eval("myFunction(44)");
eval("NativeApplication.applicationID");
```

Dynamically generated code, such as that which is made when calling the `eval()` function, would pose a security risk if allowed within the application sandbox. For example, an application may inadvertently execute a string loaded from a network domain, and that string may contain malicious code. For example, this could be code to delete or alter files on the user's computer. Or it could be code that reports back the contents of a local file to an untrusted network domain.

Ways to generate dynamic code are the following:

- Calling the `eval()` function.
- Using `innerHTML` properties or DOM functions to insert script tags that load a script outside of the application directory.
- Using `innerHTML` properties or DOM functions to insert script tags that have inline code (rather than loading a script via the `src` attribute).
- Setting the `src` attribute for a `script` tags to load a JavaScript file that is outside of the application directory.
- Using the `javascript` URL scheme (as in `href="javascript:alert('Test')"`).
- Using the `setInterval()` or `setTimout()` function where the first parameter (defining the function to run asynchronously) is a string (to be evaluated) rather than a function name (as in `setTimeout('x = 4', 1000)`).
- Calling `document.write()` or `document.writeln()`.

Code in the application security sandbox can only use these methods while content is loading.

These restrictions do *not* prevent using `eval()` with JSON object literals. This lets your application content work with the JSON JavaScript library. However, you are restricted from using overloaded JSON code (with event handlers).

For other Ajax frameworks and JavaScript code libraries, check to see if the code in the framework or library works within these restrictions on dynamically generated code. If they do not, include any content that uses the framework or library in a non-application security sandbox. For details, see "Restrictions for JavaScript inside AIR" on page 1046 and "Scripting between application and non-application content" on page 1090. Adobe maintains a list of Ajax frameworks known to support the application security sandbox, at http://www.adobe.com/products/air/develop/ajax/features/.

Unlike content in the application security sandbox, JavaScript content in a non-application security sandbox *can* call the `eval()` function to execute dynamically generated code at any time.

Restrictions on access to AIR APIs (for non-application sandboxes)

Adobe AIR 1.0 and later

JavaScript code in a non-application sandbox does not have access to the `window.runtime` object, and as such this code cannot execute AIR APIs. If content in a non-application security sandbox calls the following code, the application throws a TypeError exception:

```
try {
    window.runtime.flash.system.NativeApplication.nativeApplication.exit();
}
catch (e)
{
    alert(e);
}
```

The exception type is TypeError (undefined value), because content in the non-application sandbox does not recognize the `window.runtime` object, so it is seen as an undefined value.

You can expose runtime functionality to content in a non-application sandbox by using a script bridge. For details, see and "Scripting between application and non-application content" on page 1090.

Restrictions on using XMLHttpRequest calls

Adobe AIR 1.0 and later

HTML content in the application security sandbox cannot use synchronous XMLHttpRequest methods to load data from outside of the application sandbox while the HTML content is loading and during `onLoad` event.

By default, HTML content in non-application security sandboxes are not allowed to use the JavaScript XMLHttpRequest object to load data from domains other than the domain calling the request. A `frame` or `iframe` tag can include an `allowcrosscomainxhr` attribute. Setting this attribute to any non-null value allows the content in the frame or iframe to use the JavaScript XMLHttpRequest object to load data from domains other than the domain of the code calling the request:

```
<iframe id="UI"
    src="http://example.com/ui.html"
    sandboxRoot="http://example.com/"
    allowcrossDomainxhr="true"
    documentRoot="app:/">
</iframe>
```

For more information, see "Scripting between content in different domains" on page 1086.

Restrictions on loading CSS, frame, iframe, and img elements (for content in non-application sandboxes)

Adobe AIR 1.0 and later

HTML content in remote (network) security sandboxes can only load CSS, `frame`, `iframe`, and `img` content from remote sandboxes (from network URLs).

HTML content in local-with-filesystem, local-with-networking, or local-trusted sandboxes can only load CSS, frame, iframe, and `img` content from local sandboxes (not from application or remote sandboxes).

Restrictions on calling the JavaScript window.open() method

Adobe AIR 1.0 and later

If a window that is created via a call to the JavaScript `window.open()` method displays content from a non-application security sandbox, the window's title begins with the title of the main (launching) window, followed by a colon character. You cannot use code to move that portion of the title of the window off screen.

Content in non-application security sandboxes can only successfully call the JavaScript `window.open()` method in response to an event triggered by a user mouse or keyboard interaction. This prevents non-application content from creating windows that might be used deceptively (for example, for phishing attacks). Also, the event handler for the mouse or keyboard event cannot set the `window.open()` method to execute after a delay (for example by calling the `setTimeout()` function).

Content in remote (network) sandboxes can only use the `window.open()` method to open content in remote network sandboxes. It cannot use the `window.open()` method to open content from the application or local sandboxes.

Content in the local-with-filesystem, local-with-networking, or local-trusted sandboxes (see "Security sandboxes" on page 1044) can only use the `window.open()` method to open content in local sandboxes. It cannot use `window.open()` to open content from the application or remote sandboxes.

Errors when calling restricted code

Adobe AIR 1.0 and later

If you call code that is restricted from use in a sandbox due to these security restrictions, the runtime dispatches a JavaScript error: "Adobe AIR runtime security violation for JavaScript code in the application security sandbox."

For more information, see "Avoiding security-related JavaScript errors" on page 983.

Sandbox protection when loading HTML content from a string

Adobe AIR 1.0 and later

The `loadString()` method of the HTMLLoader class lets you create HTML content at run time. However, data that you use as the HTML content can be corrupted if the data is loaded from an insecure Internet source. For this reason, by default, HTML created using the `loadString()` method is not placed in the application sandbox and it has no access to AIR APIs. However, you can set the `placeLoadStringContentInApplicationSandbox` property of an HTMLLoader object to true to place HTML created using the `loadString()` method into the application sandbox. For more information, see "Loading HTML content from a string" on page 982.

Scripting between content in different domains

Adobe AIR 1.0 and later

AIR applications are granted special privileges when they are installed. It is crucial that the same privileges not be leaked to other content, including remote files and local files that are not part of the application.

About the AIR sandbox bridge

Adobe AIR 1.0 and later

Normally, content from other domains cannot call scripts in other domains. To protect AIR applications from accidental leakage of privileged information or control, the following restrictions are placed on content in the `application` security sandbox (content installed with the application):

- Code in the application security sandbox cannot allow to other sandboxes by calling the `Security.allowDomain()` method. Calling this method from the application security sandbox will throw an error.
- Importing non-application content into the application sandbox by setting the `LoaderContext.securityDomain` or the `LoaderContext.applicationDomain` property is prevented.

There are still cases where the main AIR application requires content from a remote domain to have controlled access to scripts in the main AIR application, or vice versa. To accomplish this, the runtime provides a *sandbox bridge* mechanism, which serves as a gateway between the two sandboxes. A sandbox bridge can provide explicit interaction between remote and application security sandboxes.

The sandbox bridge exposes two objects that both loaded and loading scripts can access:

- The `parentSandboxBridge` object lets loading content expose properties and functions to scripts in the loaded content.
- The `childSandboxBridge` object lets loaded content expose properties and function to scripts in the loading content.

Objects exposed via the sandbox bridge are passed by value, not by reference. All data is serialized. This means that the objects exposed by one side of the bridge cannot be set by the other side, and that objects exposed are all untyped. Also, you can only expose simple objects and functions; you cannot expose complex objects.

If child content attempts to set an object to the parentSandboxBridge object, the runtime throws a SecurityError exception. Similarly, if parent content attempts to set an object to the childSandboxBridge object, the runtime throws a SecurityError exception.

Sandbox bridge example (SWF)

Adobe AIR 1.0 and later

Suppose an AIR music store application wants to allow remote SWF files to broadcast the price of albums, but does not want the remote SWF file to disclose whether the price is a sale price. To do this, a StoreAPI class provides a method to acquire the price, but obscures the sale price. An instance of this StoreAPI class is then assigned to the `parentSandboxBridge` property of the LoaderInfo object of the Loader object that loads the remote SWF.

The following is the code for the AIR music store:

```
<?xml version="1.0" encoding="utf-8"?>
<mx:WindowedApplication xmlns:mx="http://www.adobe.com/2006/mxml" layout="absolute"
title="Music Store" creationComplete="initApp()">
    <mx:Script>
        import flash.display.Loader;
        import flash.net.URLRequest;

        private var child:Loader;
        private var isSale:Boolean = false;

        private function initApp():void {
            var request:URLRequest =
                    new URLRequest("http://[www.yourdomain.com]/PriceQuoter.swf")

            child = new Loader();
            child.contentLoaderInfo.parentSandboxBridge = new StoreAPI(this);
            child.load(request);
            container.addChild(child);
        }
        public function getRegularAlbumPrice():String {
            return "$11.99";
        }
        public function getSaleAlbumPrice():String {
            return "$9.99";
        }
        public function getAlbumPrice():String {
            if(isSale) {
                return getSaleAlbumPrice();
            }
            else {
                return getRegularAlbumPrice();
            }
        }
    </mx:Script>
    <mx:UIComponent id="container" />
</mx:WindowedApplication>
```

The StoreAPI object calls the main application to retrieve the regular album price, but returns “Not available” when the `getSaleAlbumPrice()` method is called. The following code defines the StoreAPI class:

```
public class StoreAPI
{
    private static var musicStore:Object;

    public function StoreAPI(musicStore:Object)
    {
        this.musicStore = musicStore;
    }

    public function getRegularAlbumPrice():String {
        return musicStore.getRegularAlbumPrice();
    }

    public function getSaleAlbumPrice():String {
        return "Not available";
    }

    public function getAlbumPrice():String {
        return musicStore.getRegularAlbumPrice();
    }
}
```

The following code represents an example of a PriceQuoter SWF file that reports the store's price, but cannot report the sale price:

```
package
{
    import flash.display.Sprite;
    import flash.system.Security;
    import flash.text.*;

    public class PriceQuoter extends Sprite
    {
        private var storeRequester:Object;

        public function PriceQuoter() {
            trace("Initializing child SWF");
            trace("Child sandbox: " + Security.sandboxType);
            storeRequester = loaderInfo.parentSandboxBridge;

            var tf:TextField = new TextField();
            tf.autoSize = TextFieldAutoSize.LEFT;
            addChild(tf);

            tf.appendText("Store price of album is: " + storeRequester.getAlbumPrice());
            tf.appendText("\n");
            tf.appendText("Sale price of album is: " + storeRequester.getSaleAlbumPrice());
        }
    }
}
```

Sandbox bridge example (HTML)

Adobe AIR 1.0 and later

In HTML content, the `parentSandboxBridge` and `childSandboxBridge` properties are added to the JavaScript window object of a child document. For an example of how to set up bridge functions in HTML content, see "Setting up a sandbox bridge interface" on page 1000.

Limiting API exposure

Adobe AIR 1.0 and later

When exposing sandbox bridges, it's important to expose high-level APIs that limit the degree to which they can be abused. Keep in mind that the content calling your bridge implementation may be compromised (for example, via a code injection). So, for example, exposing a `readFile(path:String)` method (that reads the contents of an arbitrary file) via a bridge is vulnerable to abuse. It would be better to expose a `readApplicationSetting()` API that doesn't take a path and reads a specific file. The more semantic approach limits the damage that an application can do once part of it is compromised.

More Help topics

"Cross-scripting content in different security sandboxes" on page 999

"The AIR application sandbox" on page 1045

Writing to disk

Adobe AIR 1.0 and later

Applications running in a web browser have only limited interaction with the user's local file system. Web browsers implement security policies that ensure that a user's computer cannot be compromised as a result of loading web content. For example, SWF files running through Flash Player in a browser cannot directly interact with files already on a user's computer. Shared objects and cookies can be written to a user's computer for the purpose of maintaining user preferences and other data, but this is the limit of file system interaction. Because AIR applications are natively installed, they have a different security contract, one which includes the capability to read and write across the local file system.

This freedom comes with high responsibility for developers. Accidental application insecurities jeopardize not only the functionality of the application, but also the integrity of the user's computer. For this reason, developers should read "Best security practices for developers" on page 1091.

AIR developers can access and write files to the local file system using several URL scheme conventions:

URL scheme	Description
app:/	An alias to the application directory. Files accessed from this path are assigned the application sandbox and have the full privileges granted by the runtime.
app-storage:/	An alias to the local storage directory, standardized by the runtime. Files accessed from this path are assigned a non-application sandbox.
file:///	An alias that represents the root of the user's hard disk. A file accessed from this path is assigned an application sandbox if the file exists in the application directory, and a non-application sandbox otherwise.

***Note:** AIR applications cannot modify content using the app: URL scheme. Also, the application directory may be read only because of administrator settings.*

Unless there are administrator restrictions to the user's computer, AIR applications are privileged to write to any location on the user's hard drive. Developers are advised to use the `app-storage:/` path for local storage related to their application. Files written to `app-storage:/` from an application are put in a standard location:

- On Mac OS: the storage directory of an application is `<appData>/<appId>/Local Store/` where `<appData>` is the user's preferences folder. This is typically `/Users/<user>/Library/Preferences`
- On Windows: the storage directory of an application is `<appData>\<appId>\Local Store\` where `<appData>` is the user's CSIDL_APPDATA Special Folder. This is typically `C:\Documents and Settings\<userName>\Application Data`
- On Linux: `<appData>/<appID>/Local Store/`where `<appData>` is `/home/<user>/.appdata`

If an application is designed to interact with existing files in the user's file system, be sure to read "Best security practices for developers" on page 1091.

Working securely with untrusted content

Adobe AIR 1.0 and later

Content not assigned to the application sandbox can provide additional scripting functionality to your application, but only if it meets the security criteria of the runtime. This topic explains the AIR security contract with non-application content.

Security.allowDomain()

Adobe AIR 1.0 and later

AIR applications restrict scripting access for non-application content more stringently than the Flash Player browser plug-in restricts scripting access for untrusted content. For example, in Flash Player in the browser, when a SWF file that is assigned to the `local-trusted` sandbox calls the `System.allowDomain()` method, scripting access is granted to any SWF loaded from the specified domain. The analogous approach is not permitted from `application` content in AIR applications, since it would grant unreasonable access unto the non-application file into the user's file system. Remote files cannot directly access the application sandbox, regardless of calls to the `Security.allowDomain()` method.

Scripting between application and non-application content

Adobe AIR 1.0 and later

AIR applications that script between application and non-application content have more complex security arrangements. Files that are not in the application sandbox are only allowed to access the properties and methods of files in the application sandbox through the use of a sandbox bridge. A sandbox bridge acts as a gateway between application content and non-application content, providing explicit interaction between the two files. When used correctly, sandbox bridges provide an extra layer of security, restricting non-application content from accessing object references that are part of application content.

The benefit of sandbox bridges is best illustrated through example. Suppose an AIR music store application wants to provide an API to advertisers who want to create their own SWF files, with which the store application can then communicate. The store wants to provide advertisers with methods to look up artists and CDs from the store, but also wants to isolate some methods and properties from the third-party SWF file for security reasons.

A sandbox bridge can provide this functionality. By default, content loaded externally into an AIR application at runtime does not have access to any methods or properties in the main application. With a custom sandbox bridge implementation, a developer can provide services to the remote content without exposing these methods or properties. Consider the sandbox bridge as a pathway between trusted and untrusted content, providing communication between loader and loadee content without exposing object references.

For more information on how to securely use sandbox bridges, see "Scripting between content in different domains" on page 1086.

Protection against dynamically generating unsafe SWF content

Adobe AIR 1.0 and later

The `Loader.loadBytes()` method provides a way for an application to generate SWF content from a byte array. However, injection attacks on data loaded from remote sources could do severe damage when loading content. This is especially true when loading data into the application sandbox, where the generated SWF content can access the full set of AIR APIs.

There are legitimate uses for using the `loadBytes()` method without generating executable SWF code. You can use the `loadBytes()` method to generate an image data to control the timing of image display, for example. There are also legitimate uses that *do* rely on executing code, such as dynamic creation of SWF content for audio playback. In AIR, by default the `loadBytes()` method does *not* let you load SWF content; it only allows you to load image content. In AIR, the `loaderContext` property of the `loadBytes()` method has an `allowLoadBytesCodeExecution` property, which you can set to `true` to explicitly allow the application to use `loadBytes()` to load executable SWF content. The following code shows how to use this feature:

```
var loader:Loader = new Loader();
var loaderContext:LoaderContext = new LoaderContext();
loaderContext.allowLoadBytesCodeExecution = true;
loader.loadBytes(bytes, loaderContext);
```

If you call `loadBytes()` to load SWF content and the `allowLoadBytesCodeExecution` property of the LoaderContext object is set to `false` (the default), the Loader object throws a SecurityError exception.

Note: *In a future release of Adobe AIR, this API may change. When that occurs, you may need to recompile content that uses the* `allowLoadBytesCodeExecution` *property of the LoaderContext class.*

Best security practices for developers

Adobe AIR 1.0 and later

Although AIR applications are built using web technologies, it is important for developers to note that they are not working within the browser security sandbox. This means that it is possible to build AIR applications that can do harm to the local system, either intentionally or unintentionally. AIR attempts to minimize this risk, but there are still ways where vulnerabilities can be introduced. This topic covers important potential insecurities.

Risk from importing files into the application security sandbox

Adobe AIR 1.0 and later

Files that exist in the application directory are assigned to the application sandbox and have the full privileges of the runtime. Applications that write to the local file system are advised to write to `app-storage:/`. This directory exists separately from the application files on the user's computer, hence the files are not assigned to the application sandbox and present a reduced security risk. Developers are advised to consider the following:

- Include a file in an AIR file (in the installed application) only if it is necessary.
- Include a scripting file in an AIR file (in the installed application) only if its behavior is fully understood and trusted.
- Do not write to or modify content in the application directory. The runtime prevents applications from writing or modifying files and directories using the `app:/` URL scheme by throwing a SecurityError exception.
- Do not use data from a network source as parameters to methods of the AIR API that may lead to code execution. This includes use of the `Loader.loadBytes()` method and the JavaScript `eval()` function.

Risk from using an external source to determine paths

Adobe AIR 1.0 and later

An AIR application can be compromised when using external data or content. For this reason, take special care when using data from the network or file system. The onus of trust is ultimately on the developer and the network connections they make, but loading foreign data is inherently risky, and should not be used for input into sensitive operations. Developers are advised against the following:

- Using data from a network source to determine a file name
- Using data from a network source to construct a URL that the application uses to send private information

Risk from using, storing, or transmitting insecure credentials

Adobe AIR 1.0 and later

Storing user credentials on the user's local file system inherently introduces the risk that these credentials may be compromised. Developers are advised to consider the following:

- If credentials must be stored locally, encrypt the credentials when writing to the local file system. The runtime provides an encrypted storage unique to each installed application, via the EncryptedLocalStore class. For details, see "Encrypted local storage" on page 710.
- Do not transmit unencrypted user credentials to a network source unless that source is trusted and the transmission uses the HTTPS: or Transport Layer Security (TLS) protocols.
- Never specify a default password in credential creation — let users create their own. Users who leave the default unchanged expose their credentials to an attacker who already knows the default password.

Risk from a downgrade attack

Adobe AIR 1.0 and later

During application install, the runtime checks to ensure that a version of the application is not currently installed. If an application is already installed, the runtime compares the version string against the version that is being installed. If this string is different, the user can choose to upgrade their installation. The runtime does not guarantee that the newly installed version is newer than the older version, only that it is different. An attacker can distribute an older version to the user to circumvent a security weakness. For this reason, the developer is advised to make version checks when the application is run. It is a good idea to have applications check the network for required updates. That way, even if an attacker gets the user to run an old version, that old version will recognize that it needs to be updated. Also, using a clear versioning scheme for your application makes it more difficult to trick users into installing a downgraded version.

Code signing

Adobe AIR 1.0 and later

All AIR installer files are required to be code signed. Code signing is a cryptographic process of confirming that the specified origin of software is accurate. AIR applications can be signed using either by a certificate issued by an external certificate authority (CA) or by a self-signed certificate you create yourself. A commercial certificate from a well-known CA is strongly recommended and provides assurance to your users that they are installing your application, not a forgery. However, self-signed certificates can be created using `adt` from the SDK or using either Flash, Flash Builder, or another application that uses `adt` for certificate generation. Self-signed certificates do not provide any assurance that the application being installed is genuine and should only be used for testing an application prior to public release.

Security on Android devices

Adobe AIR 2.5 and later

On Android, as on all computing devices, AIR conforms to the native security model. At the same time, AIR maintains its own security rules, which are intended to make it easy for developers to write secure, Internet-connected applications.

Since AIR applications on Android use the Android package format, installation falls under the Android security model. The AIR application installer is not used.

The Android security model has three primary aspects:

- Permissions
- Application signatures
- Application user IDs

Android permissions

Many features of Android are protected by the operating system permission mechanism. In order to use a protected feature, the AIR application descriptor must declare that the application requires the necessary permission. When a user attempts to install the app, the Android operating system displays all requested permissions to the user before the installation proceeds.

Most AIR applications will need to specify Android permissions in the application descriptor. By default, no permissions are included. The following permissions are required for protected Android features exposed through the AIR runtime:

ACCESS_COARSE_LOCATION Allows the application to access WIFI and cellular network location data through the Geolocation class.

ACCESS_FINE_LOCATION Allows the application to access GPS data through the Geolocation class.

ACCESS_NETWORK_STATE and ACCESS_WIFI_STATE Allows the application to access network information the NetworkInfo class.

CAMERA Allows the application to access the camera.

INTERNET Allows the application to make network requests. Also allows remote debugging.

READ_PHONE_STATE Allows the AIR runtime to mute audio when an incoming call occurs.

RECORD_AUDIO Allows the application to access the microphone.

WAKE_LOCK and DISABLE_KEYGUARD Allows the application to prevent the device from going to sleep using the SystemIdleMode class settings.

WRITE_EXTERNAL_STORAGE Allows the application to write to the external memory card on the device.

Application signatures

All application packages created for the Android platform must be signed. Since AIR applications on Android are packaged in the native Android APK format, they are signed in accordance to Android conventions rather than AIR conventions. While Android and AIR use code signing in a similar fashion, there are significant differences:

- On Android, the signature verifies that the private key is in possession of the developer, but is not used to verify the identity of the developer.
- For apps submitted to the Android market, the certificate must be valid for at least 25 years.
- Android does not support migrating the package signature to another certificate. If an update is signed by a different certificate, then users must uninstall the original app before they can install the updated app.
- Two apps signed with the same certificate can specify a shared ID that permits them to access each others cache and data files. (Such sharing is not facilitated by AIR.)

Application user IDs

Android uses a Linux kernel. Every installed app is assigned a Linux-type user ID that determines its permissions for such operations as file access. Files in the application, application storage, and temporary directories are protected from access by file system permissions. Files written to external storage (in other words, the SD card) can be read, modified, and deleted by other applications, or by the user, when the SD card is mounted as a mass storage device on a computer.

Cookies received with internet requests are not shared between AIR applications.

Background image privacy

When a user switches an application to the background, some Android versions capture a screenshot that it uses a thumbnail in the recent applications list. This screenshot is stored in device memory and can be accessed by an attacker in physical control of the device.

If your application displays sensitive information, you should guard against such information being captured by the background screenshot. The `deactivate` event dispatched by the NativeApplication object signals that an application is about to switch to the background. Use this event to clear or hide any sensitive information.

More Help topics

Android: Security and Permissions

Encrypted data on Android

AIR applications on Android can use the encryption options available in the built-in SQL database to save encrypted data. For optimum security, base the encryption key on a user-entered password that is entered whenever the application is run. A locally stored encryption key or password is difficult or impossible to "hide" from an attacker who has access to the application files. If the attacker can retrieve the key, then encrypting the data does not afford any additional protection beyond the user ID-based filesystem security provided by the Android system.

The EncryptedLocalStore class can be used to save data, but that data is not encrypted on Android devices. Instead, the Android security model relies on the application user ID to protect the data from other applications. Applications that use a shared user ID and which are signed with the same code signing certificate use the same encrypted local store.

Important: *On a rooted phone, any application running with root privileges can access the files of any other application. Thus, data stored using the encrypted local store is not secure on a rooted device.*

Security on iOS devices

On iOS AIR conforms to the native security model. At the same time, AIR maintains its own security rules, which are intended to make it easy for developers to write secure, Internet-connected applications.

Since AIR applications on iOS use the iOS package format, installation falls under the iOS security model. The AIR application installer is not used. Furthermore, a separate AIR runtime is not used on iOS devices. Every AIR application contains all the code needed to function.

Application signatures

All application packages created for the iOS platform must be signed. Since AIR applications on iOS are packaged in the native iOS IPA format, they are signed in accordance with iOS requirements rather than AIR requirements. While iOS and AIR use code signing in a similar fashion, there are significant differences:

- On iOS, the certificate used to sign an application must be issued by Apple; Certificates from other certificate authorities cannot be used.
- On iOS, Apple-issued distribution certificates are typically valid for one year.

Background image privacy

When a user switches an application to the background on iOS, the operating system captures a screenshot that it uses to animate the transition. This screenshot is stored in device memory and can be accessed by an attacker in physical control of the device.

If your application displays sensitive information, you should guard against such information being captured by the background screenshot. The `deactivate` event dispatched by the NativeApplication object signals that an application is about to switch to the background. Use this event to clear or hide any sensitive information.

Chapter 65: How to Use ActionScript Examples

Running an ActionScript 3.0 code example is one of the best ways to learn how particular classes and methods work. You can use examples in different ways, depending on the devices you are using or targeting.

Computers running Flash Professional or Flash Builder See "Running ActionScript 3.0 examples in Flash Professional" on page 1098 or "Running ActionScript 3.0 examples in Flash Builder" on page 1099 for information about how to use these development environments to run ActionScript 3.0 examples. Use trace statements and other debugging tools to increase your understanding of how a code example works.

Mobile devices You can run the ActionScript 3.0 code examples on mobile devices that support Flash Player 10.1 and later releases. See "Running ActionScript 3.0 examples on mobile devices" on page 1100. You can also run these examples on your computer using Flash Professional or Flash Builder.

TV devices Though you cannot run these examples on TV devices, you can still learn from the examples by running them on your computer. See Flash Platform for TV on the Adobe Developer Connection website for information about developing applications for TV devices.

Types of examples

The types of ActionScript 3.0 code examples are:

- Code snippet examples (found throughout the ActionScript 3.0 documentation set)
- Class-based examples (found primarily in the ActionScript 3.0 Language Reference)
- Practical examples containing multiple source files (download source ZIP files from www.adobe.com/go/learn_programmingAS3samples_flash)

Code snippet examples

A code snippet example looks like this:

```
var x:int = 5;
trace(x); // 5
```

Code snippets only contain enough code to demonstrate a single idea. They do not normally contain package or class statements.

Class-based examples

Many examples show the source code for a complete ActionScript class. A class-based example looks like this:

```
package {
    public class Example1 {
        public function Example1():void {
            var x:int = 5;
            trace(x); //5
        }
    }
}
```

The code for a class-based example includes a package statement, a class declaration, and a constructor function.

Practical examples containing multiple source files

Many of the topics in the ActionScript 3.0 Developer's Guide conclude with practical examples that show how to use certain ActionScript features in a practical, real-world context. These examples usually contain multiple files including:

- One or more ActionScript source files
- A .FLA file for use with Flash Professional
- One or more MXML files for use with Flash Builder
- Data files, image files, sound files, or other assets used by the example application (optional).

Practical examples are normally delivered as ZIP archive files.

List of Developer Guide examples in the ZIP file

The ZIP file for Flash Professional CS5 and Flex 4 (download from www.adobe.com/go/learn_programmingAS3samples_flash) contains the following examples:

- AlarmClock ("Event handling example: Alarm Clock" on page 140)
- AlgorithmicVisualGenerator ("Drawing API example: Algorithmic Visual Generator" on page 233)
- ASCIIArt ("Strings example: ASCII art" on page 19)
- CapabilitiesExplorer ("Capabilities example: Detecting system capabilities" on page 874)
- CustomErrors ("Handling errors example: CustomErrors application" on page 70)
- DisplayObjectTransformer ("Geometry example: Applying a matrix transformation to a display object" on page 217)
- FilterWorkbench ("Filtering display objects example: Filter Workbench" on page 292)
- GlobalStockTicker ("Example: Internationalizing a stock ticker application" on page 954)
- IntrovertIM_HTML ("External API example: Communicating between ActionScript and JavaScript in a web browser" on page 849)
- NewsLayout ("TextField Example: Newspaper-style text formatting" on page 387)
- PlayList ("Arrays example: PlayList" on page 48)
- PodcastPlayer ("Sound example: Podcast Player" on page 467)
- ProjectionDragger ("Example: Perspective projection" on page 357)
- ReorderByZ ("Using Matrix3D objects for reordering display" on page 362)
- RSSViewer ("XML in ActionScript example: Loading RSS data from the Internet" on page 113)
- RuntimeAssetsExplorer ("Movie clip example: RuntimeAssetsExplorer" on page 331)
- SimpleClock ("Date and time example: Simple analog clock" on page 6)
- SpinningMoon ("Bitmap example: Animated spinning moon" on page 254)
- SpriteArranger ("Display object example: SpriteArranger" on page 203)
- TelnetSocket ("TCP socket example: Building a Telnet client" on page 799)
- VideoJukebox ("Video example: Video Jukebox" on page 507)
- WikiEditor ("Regular expressions example: A Wiki parser" on page 91)

- WordSearch ("Mouse input example: WordSearch" on page 577)

Practical examples are also found with many of the Quick Start articles in the Flash Developer Center and Flex Developer Center.

Running ActionScript 3.0 examples in Flash Professional

Use one of the following procedures (depending on example type) to run an example using Flash Professional.

Running a code snippet example in Flash Professional

To run a code snippet example in Flash Professional:

1 Select File > New.

2 In the New Document dialog box, select Flash Document, and click OK.

  A new Flash window is displayed.

3 Click on the first frame of the first layer in the Timeline panel.

4 In the Actions panel, type or paste the code snippet example.

5 Select File > Save. Give the file a name and click OK.

6 To test the example, select Control > Test Movie.

Running a class-based example in Flash Professional

To run a class-based example in Flash Professional:

1 Select File > New.

2 In the New Document dialog box, select ActionScript File, and click OK. A new editor window is displayed.

3 Copy the class-based example code and paste it into the editor window.

  If the class is the main document class for the program, it must extend the MovieClip class:

```
import flash.display.MovieClip;
public class Example1 extends MovieClip{
//...
}
```

  Also make sure that all the classes referenced in the example are declared using `import` statements.

4 Select File > Save. Give the file the same name as the class in the example (e.g. ContextMenuExample.as).

  ***Note:** Some of the class-based examples, such as the flashx.textLayout.container.ContainerController class example, include multiple levels in the package declaration (`package flashx.textLayout.container.examples {`). For these examples, save the file in a sub folder that matches the package declaration (flashx/textLayout/container/examples), or remove the package name (so the ActionScript starts with `package {` only) and you can test the file from any location.*

5 Select File > New.

6 In the New Document dialog box, select Flash Document (ActionScript 3.0), and click OK. A new Flash window is displayed.

7 In the Properties panel, in the Document Class field, enter the name of the example class, which should match the name of the ActionScript source file you just saved (e.g. ContextMenuExample).

8 Select File > Save. Give the FLA file the same name as the class in the example (e.g. ContextMenuExample.fla).

9 To test the example, select Control > Test Movie.

Running a practical example in Flash Professional

Practical examples are normally delivered as ZIP archive files. To run a practical example using Flash Professional:

1 Unzip the archive file into a folder of your choice.

2 In Flash Professional select File > Open.

3 Browse to the folder where you unzipped the archive file. Select the FLA file in that folder and click Open.

4 To test the example, select Control > Test Movie.

Running ActionScript 3.0 examples in Flash Builder

Use one of the following procedures (depending on example type) to run an example using Flash Builder.

Running a code snippet example in Flash Builder

To run a code snippet example in Flash Builder:

1 Either create a new Flex Project (select File > New > Flex Project), or within an existing Flex project create a new MXML Application (select File > New > MXML Application). Give the project or application a descriptive name (such as ContextMenuExample).

2 Inside the generated MXML file, add a `<mx:Script>` tag.

3 Paste the contents of the code snippet example between the `<mx:Script>` and `</mx:Script>` tags. Save the MXML file.

4 To run the example, select the Run > Run menu option for the main MXML file (such as Run > Run ContextMenuExample).

Running a class-based example in Flash Builder

To run a class-based example in Flash Builder:

1 Select File > New > ActionScript Project.

2 Enter the name of the primary class (such as ContextMenuExample) into the Project Name field. Use the default values for other fields (or change them according to your specific environment). Click Finish to create the project and the main ActionScript file.

3 Erase any generated content from the ActionScript file. Paste the example code, including package and import statements, into the ActionScript file and save the file.

***Note:** Some of the class-based examples, such as the flashx.textLayout.container.ContainerController class example, include multiple levels in the package declaration (`package flashx.textLayout.container.examples {`). For these examples, save the file in a sub folder that matches the package declaration (flashx/textLayout/container/examples), or remove the package name (so the ActionScript starts with `package {` only) and you can test the file from any location.*

4 To run the example, select the Run > Run menu option for the main ActionScript class name (such as Run > Run ContextMenuExample).

Running a practical example inFlash Builder

Practical examples are normally delivered as ZIP archive files. To run a practical example using Flash Builder:

1 Unzip the archive file into a folder of your choice. Give the folder a descriptive name (such as ContextMenuExample).

2 In Flash Builder select File > New Flex Project. In the Project Location section, click Browse and select the folder containing the example files. In the Project Name field enter the folder name (such as ContextMenuExample). Use the default values for other fields (or change them according to your specific environment). Click Next to continue.

3 In the Output panel click Next to accept the default value.

4 In the Source Paths panel click the Browse button next to the Main Application File field. Select the main MXML example file from the example folder. Click Finish to create the project files.

5 To run the example, select the Run > Run menu option for the main MXML file (such as Run > Run ContextMenuExample).

Running ActionScript 3.0 examples on mobile devices

You can run the ActionScript 3.0 code examples on mobile devices that support Flash Player 10.1. However, typically you run a code example to learn how particular classes and methods work. In that case, run the example on a non-mobile device such as a desktop computer. On the desktop computer, you can use trace statements and other debugging tools in Flash Professional or Flash Builder to increase your understanding of a code example.

If you want to run the example on a mobile device, you can either copy the files to the device or to a web server. To copy files to the device and run the example in the browser, do the following:

1 Create the SWF file by following the instructions in "Running ActionScript 3.0 examples in Flash Professional" on page 1098 or in "Running ActionScript 3.0 examples in Flash Builder" on page 1099. In Flash Professional, you create the SWF file when you select Control > Test Movie. In Flash Builder, you create the SWF file when you run, debug, or build your Flash Builder project.

2 Copy the SWF file to a directory on the mobile device. Use software provided with the device to copy the file.

3 In the address bar of browser on the mobile device, enter the file:// URL for the SWF file. For example, enter `file::/applications/myExample.swf`.

To copy files to a web server and run the example in the device's browser, do the following:

1 Create a SWF file and an HTML file. First, follow the instructions in "Running ActionScript 3.0 examples in Flash Professional" on page 1098 or in "Running ActionScript 3.0 examples in Flash Builder" on page 1099. In Flash Professional, selecting Control > Test Movie creates only the SWF file. To create both files, first select both Flash and HTML on the Formats tab in the Publish Settings dialog. Then select File > Publish to create both the HTML and SWF files. In Flash Builder, you create both the SWF file and HTML file when you run, debug, or build your Flash Builder project.

2 Copy the SWF file and HTML file to a directory on the web server.

3 In the address bar of browser on the mobile device, enter the HTTP address for the HTML file. For example, enter `http://www.myWebServer/examples/myExample.html`.

Before running an example on a mobile device, consider each of the following issues.

Stage size

The stage size you use when running an example on a mobile device is much smaller than when you use a non-mobile device. Many examples do not require a particular Stage size. When creating the SWF file, specify a Stage size appropriate to your device. For example, specify 176 x 208 pixels.

The purpose of the practical examples in the ActionScript 3.0 Development Guide is to illustrate different ActionScript 3.0 concepts and classes. Their user interfaces are designed to look good and work well on a desktop or laptop computer. Although the examples work on mobile devices, the Stage size and user interface design is not suitable to the small screen. Adobe recommends that you run the practical examples on a computer to learn the ActionScript, and then use pertinent code snippets in your mobile applications.

Text fields instead of trace statements

When running an example on a mobile device, you cannot see the output from the example's trace statements. To see the output, create an instance of the TextField class. Then, append the text from the trace statements to the `text` property of the text field.

You can use the following function to set up a text field to use for tracing:

```
function createTracingTextField(x:Number, y:Number,
                                width:Number, height:Number):TextField {

    var tracingTF:TextField = new TextField();
    tracingTF.x = x;
    tracingTF.y = y;
    tracingTF.width = width;
    tracingTF.height = height;

    // A border lets you more easily see the area the text field covers.
    tracingTF.border = true;
    // Left justifying means that the right side of the text field is automatically
    // resized if a line of text is wider than the width of the text field.
    // The bottom is also automatically resized if the number of lines of text
    // exceed the length of the text field.
    tracingTF.autoSize = TextFieldAutoSize.LEFT;

    // Use a text size that works well on the device.
    var myFormat:TextFormat = new TextFormat();
    myFormat.size = 18;
    tracingTF.defaultTextFormat = myFormat;

    addChild(tracingTF);
    return tracingTF;
}
```

For example, add this function to the document class as a private function. Then, in other methods of the document class, trace data with code like the following:

```
var traceField:TextField = createTracingTextField(10, 10, 150, 150);
// Use the newline character "\n" to force the text to the next line.
traceField.appendText("data to trace\n");
traceField.appendText("more data to trace\n");
// Use the following line to clear the text field.
traceField.appendText("");
```

The `appendText()` method accepts only one value as a parameter. That value is a string (either a String instance or a string literal). To print the value of a non-string variable, first convert the value to a String. The easiest way to do that is to call the object's `toString()` method:

```
var albumYear:int = 1999;
traceField.appendText("albumYear = ");
traceField.appendText(albumYear.toString());
```

Text size

Many examples use text fields to help illustrate a concept. Sometimes adjusting the size of the text in the text field provides better readability on a mobile device. For example, if an example uses a text field instance named `myTextField`, change the size of its text with the following code:

```
// Use a text size that works well on the device.
var myFormat:TextFormat = new TextFormat();
myFormat.size = 18;
myTextField.defaultTextFormat = myFormat
```

Capturing user input

The mobile operating system and browser capture some user input events that the SWF content does not receive. Specific behavior depends on the operating system and browser, but could result in unexpected behavior when you run the examples on a mobile device. For more information, see "KeyboardEvent precedence" on page 562.

Also, the user interfaces of many examples are designed for a desktop or laptop computer. For example, most of the practical examples in the ActionScript 3.0 Developer's Guide are well-suited for desktop viewing. Therefore, the entire Stage is sometimes not visible on the mobile device's screen. The ability to pan through the browser's contents depends on the browser. Furthermore, the examples are not designed to catch and handle scrolling or panning events. Therefore, some examples' user interfaces are not suitable for running on the small screen. Adobe recommends that you run the examples on a computer to learn the ActionScript, and then use pertinent code snippets in your mobile applications.

For more information, see "Panning and scrolling display objects" on page 178.

Handling focus

Some examples require you to give a field the focus. By giving a field the focus, you can, for example, enter text or select a button. To give a field focus, use the mobile device's pointer device, such as a stylus or your finger. Or, use the mobile device's navigation keys to give a field focus. To select a button that has the focus, use the mobile device's Select key as you would use Enter on a computer. On some devices, tapping twice on a button selects it.

For more information about focus, see "Managing focus" on page 557.

Handling mouse events

Many examples listen for mouse events. On a computer, these mouse events can occur, for example, when a user rolls over a display object with the mouse, or clicks the mouse button on a display object. On mobile devices, events from using pointer devices such as a stylus or finger, are called touch events. Flash Player 10.1 maps touch events to mouse events. This mapping ensures that SWF content that was developed before Flash Player 10.1 continues to work. Therefore, examples work when using a pointer device to select or drag a display object.

Performance

Mobile devices have less processing power than desktop devices. Some CPU-intensive examples possibly perform slowly on mobile devices. For example, the example in "Drawing API example: Algorithmic Visual Generator" on page 233 does extensive computations and drawing upon entering every frame. Running this example on a computer illustrates various drawing APIs. However, the example is not suitable on some mobile devices due to their performance limitations.

For more information about performance on mobile devices, see *Optimizing Performance for the Flash Platform*.

Best practices

The examples do not consider best practices in developing applications for mobile devices. Limitations in memory and processing power in mobile devices require special consideration. Similarly, the user interface for the small screen has different needs than a desktop display. For more information about developing applications for mobile devices, *see Optimizing Performance for the Flash Platform*.

Chapter 66: SQL support in local databases

Adobe AIR includes a SQL database engine with support for local SQL databases with many standard SQL features, using the open source SQLite database system. The runtime does not specify how or where database data is stored on the file system. Each database is stored completely within a single file. A developer can specify the location in the file system where the database file is stored, and a single AIR application can access one or many separate databases (i.e. separate database files).This document outlines the SQL syntax and data type support for Adobe AIR local SQL databases. This document is not intended to serve as a comprehensive SQL reference. Rather, it describes specific details of the SQL dialect that Adobe AIR supports. The runtime supports most of the SQL-92 standard SQL dialect. Because there are numerous references, web sites, books, and training materials for learning SQL, this document is not intended to be a comprehensive SQL reference or tutorial. Instead, this document particularly focuses on the AIR-supported SQL syntax, and the differences between SQL-92 and the supported SQL dialect.

SQL statement definition conventions

Within statement definitions in this document, the following conventions are used:

- Text case
  - UPPER CASE - literal SQL keywords are written in all upper case.
  - lower case - placeholder terms or clause names are written in all lower case.
- Definition characters
  - ::= Indicates a clause or statement definition.
- Grouping and alternating characters
  - | The pipe character is used between alternative options, and can be read as "or".
  - [] Items in square brackets are optional items; the brackets can contain a single item or a set of alternative items.
  - () Parentheses surrounding a set of alternatives (a set of items separated by pipe characters), designates a required group of items, that is, a set of items that are the possible values for a single required item.
- Quantifiers
  - + A plus character following an item in parentheses indicates that the preceding item can occur 1 or more times.
  - * An asterisk character following an item in square brackets indicates that the preceding (bracketed) item can occur 0 or more times
- Literal characters
  - * An asterisk character used in a column name or between the parentheses following a function name signifies a literal asterisk character rather than the "0 or more" quantifier.
  - . A period character represents a literal period.
  - , A comma character represents a literal comma.
  - () A pair of parentheses surrounding a single clause or item indicates that the parentheses are required, literal parentheses characters.
  - Other characters, unless otherwise indicated, represent those literal characters.

Supported SQL syntax

The following SQL syntax listings are supported by the Adobe AIR SQL database engine. The listings are divided into explanations of different statement and clause types, expressions, built-in functions, and operators. The following topics are covered:

- General SQL syntax
- Data manipulation statements (SELECT, INSERT, UPDATE, and DELETE)
- Data definition statements (CREATE, ALTER, and DROP statements for tables, indices, views, and triggers)
- Special statements and clauses
- Built-in functions (Aggregate, scalar, and date/time formatting functions)
- Operators
- Parameters
- Unsupported SQL features
- Additional SQL features

General SQL syntax

In addition to the specific syntax for various statements and expressions, the following are general rules of SQL syntax:

Case sensitivity SQL statements, including object names, are not case sensitive. Nevertheless, SQL statements are frequently written with SQL keywords written in uppercase, and this document uses that convention. While SQL syntax is not case sensitive, literal text values in SQL are case sensitive, and comparison and sorting operations can be case sensitive, as specified by the collation sequence defined for a column or operation. For more information see COLLATE.

White space A white-space character (such as space, tab, new line, and so forth) must be used to separate individual words in an SQL statement. However, white space is optional between words and symbols. The type and quantity of white-space characters in a SQL statement is not significant. You can use white space, such as indenting and line breaks, to format your SQL statements for easy readability, without affecting the meaning of the statement.

Data manipulation statements

Data manipulation statements are the most commonly used SQL statements. These statements are used to retrieve, add, modify, and remove data from database tables. The following data manipulation statements are supported: SELECT, INSERT, UPDATE, and DELETE.

SELECT

The SELECT statement is used to query the database. The result of a SELECT is zero or more rows of data where each row has a fixed number of columns. The number of columns in the result is specified by the result column name or expression list between the SELECT and optional FROM keywords.

```
sql-statement   ::=  SELECT [ALL | DISTINCT] result
                     [FROM table-list]
                     [WHERE expr]
                     [GROUP BY expr-list]
                     [HAVING expr]
                     [compound-op select-statement]*
                     [ORDER BY sort-expr-list]
                     [LIMIT integer [( OFFSET | , ) integer]]
result          ::=  result-column [, result-column]*
result-column   ::=  * | table-name . * | expr [[AS] string]
table-list      ::=  table [ join-op table join-args ]*
table           ::=  table-name [AS alias] |
                     ( select ) [AS alias]
join-op         ::=  , | [NATURAL] [LEFT | RIGHT | FULL] [OUTER | INNER | CROSS] JOIN
join-args       ::=  [ON expr] [USING ( id-list )]
compound-op     ::=  UNION | UNION ALL | INTERSECT | EXCEPT
sort-expr-list  ::=  expr [sort-order] [, expr [sort-order]]*
sort-order      ::=  [COLLATE collation-name] [ASC | DESC]
collation-name  ::=  BINARY | NOCASE
```

Any arbitrary expression can be used as a result. If a result expression is * then all columns of all tables are substituted for that one expression. If the expression is the name of a table followed by .* then the result is all columns in that one table.

The DISTINCT keyword causes a subset of result rows to be returned, in which each result row is different. NULL values are not treated as distinct from each other. The default behavior is that all result rows are returned, which can be made explicit with the keyword ALL.

The query is executed against one or more tables specified after the FROM keyword. If multiple table names are separated by commas, then the query uses the cross join of the various tables. The JOIN syntax can also be used to specify how tables are joined. The only type of outer join that is supported is LEFT OUTER JOIN. The ON clause expression in join-args must resolve to a boolean value. A subquery in parentheses may be used as a table in the FROM clause. The entire FROM clause may be omitted, in which case the result is a single row consisting of the values of the result expression list.

The WHERE clause is used to limit the number of rows the query retrieves. WHERE clause expressions must resolve to a boolean value. WHERE clause filtering is performed before any grouping, so WHERE clause expressions may not include aggregate functions.

The GROUP BY clause causes one or more rows of the result to be combined into a single row of output. A GROUP BY clause is especially useful when the result contains aggregate functions. The expressions in the GROUP BY clause do not have to be expressions that appear in the SELECT expression list.

The HAVING clause is like WHERE in that it limits the rows returned by the statement. However, the HAVING clause applies after any grouping specified by a GROUP BY clause has occurred. Consequently, the HAVING expression may refer to values that include aggregate functions. A HAVING clause expression is not required to appear in the SELECT list. Like a WHERE expression, a HAVING expression must resolve to a boolean value.

The ORDER BY clause causes the output rows to be sorted. The sort-expr-list argument to the ORDER BY clause is a list of expressions that are used as the key for the sort. The expressions do not have to be part of the result for a simple SELECT, but in a compound SELECT (a SELECT using one of the compound-op operators) each sort expression must exactly match one of the result columns. Each sort expression may be optionally followed by a sort-order clause consisting of the COLLATE keyword and the name of a collation function used for ordering text and/or the keyword ASC or DESC to specify the sort order (ascending or descending). The sort-order can be omitted and the default (ascending order) is used. For a definition of the COLLATE clause and collation functions, see COLLATE.

The LIMIT clause places an upper bound on the number of rows returned in the result. A negative LIMIT indicates no upper bound. The optional OFFSET following LIMIT specifies how many rows to skip at the beginning of the result set. In a compound SELECT query, the LIMIT clause may only appear after the final SELECT statement, and the limit is applied to the entire query. Note that if the OFFSET keyword is used in the LIMIT clause, then the limit is the first integer and the offset is the second integer. If a comma is used instead of the OFFSET keyword, then the offset is the first number and the limit is the second number. This seeming contradiction is intentional — it maximizes compatibility with legacy SQL database systems.

A compound SELECT is formed from two or more simple SELECT statements connected by one of the operators UNION, UNION ALL, INTERSECT, or EXCEPT. In a compound SELECT, all the constituent SELECT statements must specify the same number of result columns. There can only be a single ORDER BY clause after the final SELECT statement (and before the single LIMIT clause, if one is specified). The UNION and UNION ALL operators combine the results of the preceding and following SELECT statements into a single table. The difference is that in UNION, all result rows are distinct, but in UNION ALL, there may be duplicates. The INTERSECT operator takes the intersection of the results of the preceding and following SELECT statements. EXCEPT takes the result of preceding SELECT after removing the results of the following SELECT. When three or more SELECT statements are connected into a compound, they group from first to last.

For a definition of permitted expressions, see Expressions.

Starting with AIR 2.5, the SQL CAST operator is supported when reading to convert BLOB data to ActionScript ByteArray objects. For example, the following code reads raw data that is not stored in the AMF format and stores it in a ByteArray object:

```
stmt.text = "SELECT CAST(data AS ByteArray) AS data FROM pictures;";
stmt.execute();
var result:SQLResult = stmt.getResult();
var bytes:ByteArray = result.data[0].data;
```

INSERT

The INSERT statement comes in two basic forms and is used to populate tables with data.

```
sql-statement  ::=  INSERT [OR conflict-algorithm] INTO [database-name.] table-name [(column-
list)] VALUES (value-list) |
                    INSERT [OR conflict-algorithm] INTO [database-name.] table-name [(column-
list)] select-statement
               REPLACE INTO [database-name.] table-name [(column-list)] VALUES (value-list) |
                    REPLACE INTO [database-name.] table-name [(column-list)] select-statement
```

The first form (with the VALUES keyword) creates a single new row in an existing table. If no column-list is specified then the number of values must be the same as the number of columns in the table. If a column-list is specified, then the number of values must match the number of specified columns. Columns of the table that do not appear in the column list are filled with the default value defined when the table is created, or with NULL if no default value is defined.

The second form of the INSERT statement takes its data from a SELECT statement. The number of columns in the result of the SELECT must exactly match the number of columns in the table if column-list is not specified, or it must match the number of columns named in the column-list. A new entry is made in the table for every row of the SELECT result. The SELECT may be simple or compound. For a definition of allowable SELECT statements, see SELECT.

The optional conflict-algorithm allows the specification of an alternative constraint conflict resolution algorithm to use during this one command. For an explanation and definition of conflict algorithms, see "Special statements and clauses" on page 1114.

The two REPLACE INTO forms of the statement are equivalent to using the standard INSERT [OR conflict-algorithm] form with the REPLACE conflict algorithm (i.e. the INSERT OR REPLACE... form).

The two REPLACE INTO forms of the statement are equivalent to using the standard INSERT [OR conflict-algorithm] form with the REPLACE conflict algorithm (i.e. the INSERT OR REPLACE... form).

UPDATE

The update command changes the existing records in a table.

```
sql-statement  ::=  UPDATE [database-name.] table-name SET column1=value1, column2=value2,...
[WHERE expr]
```

The command consists of the UPDATE keyword followed by the name of the table in which you want to update the records. After the SET keyword, provide the name of the column and the value to which the column to be changed as a comma-separated list. The WHERE clause expression provides the row or rows in which the records are updated.

DELETE

The delete command is used to remove records from a table.

```
sql-statement  ::=  DELETE FROM [database-name.] table-name [WHERE expr]
```

The command consists of the DELETE FROM keywords followed by the name of the table from which records are to be removed.

Without a WHERE clause, all rows of the table are removed. If a WHERE clause is supplied, then only those rows that match the expression are removed. The WHERE clause expression must resolve to a boolean value. For a definition of permitted expressions, see Expressions.

Data definition statements

Data definition statements are used to create, modify, and remove database objects such as tables, views, indices, and triggers. The following data definition statements are supported:

- Tables:
  - CREATE TABLE
  - ALTER TABLE
  - DROP TABLE
- Indices:
  - CREATE INDEX
  - DROP INDEX
- Views:
  - CREATE VIEWS
  - DROP VIEWS
- Triggers:
  - CREATE TRIGGERS
  - DROP TRIGGERS

CREATE TABLE

A CREATE TABLE statement consists of the keywords CREATE TABLE followed by the name of the new table, then (in parentheses) a list of column definitions and constraints. The table name can be either an identifier or a string.

```
sql-statement      ::=  CREATE [TEMP | TEMPORARY] TABLE [IF NOT EXISTS] [database-name.] table-
name
                         ( column-def [, column-def]* [, constraint]* )
sql-statement      ::=  CREATE [TEMP | TEMPORARY] TABLE [database-name.] table-name AS select-
statement
column-def          ::=  name [type] [[CONSTRAINT name] column-constraint]*
type                ::=  typename | typename ( number ) | typename ( number , number )
column-constraint   ::=  NOT NULL [ conflict-clause ] |
                         PRIMARY KEY [sort-order] [ conflict-clause ] [AUTOINCREMENT] |
                         UNIQUE [conflict-clause] |
                         CHECK ( expr ) |
                         DEFAULT default-value |
                         COLLATE collation-name
constraint          ::=  PRIMARY KEY ( column-list ) [conflict-clause] |
                         UNIQUE ( column-list ) [conflict-clause] |
                         CHECK ( expr )
conflict-clause     ::=  ON CONFLICT conflict-algorithm
conflict-algorithm  ::=  ROLLBACK | ABORT | FAIL | IGNORE | REPLACE
default-value      ::=  NULL | string | number | CURRENT_TIME | CURRENT_DATE | CURRENT_TIMESTAMP
sort-order          ::=  ASC | DESC
collation-name      ::=  BINARY | NOCASE
column-list         ::=  column-name [, column-name]*
```

Each column definition is the name of the column followed by the data type for that column, then one or more optional column constraints. The data type for the column restricts what data may be stored in that column. If an attempt is made to store a value in a column with a different data type, the runtime converts the value to the appropriate type if possible, or raises an error. See the Data type support section for additional information.

The NOT NULL column constraint indicates that the column cannot contain NULL values.

A UNIQUE constraint causes an index to be created on the specified column or columns. This index must contain unique keys—no two rows may contain duplicate values or combinations of values for the specified column or columns. A CREATE TABLE statement can have multiple UNIQUE constraints, including multiple columns with a UNIQUE constraint in the column's definition and/or multiple table-level UNIQUE constraints.

A CHECK constraint defines an expression that is evaluated and must be true in order for a row's data to be inserted or updated. The CHECK expression must resolve to a boolean value.

A COLLATE clause in a column definition specifies what text collation function to use when comparing text entries for the column. The BINARY collating function is used by default. For details on the COLLATE clause and collation functions, see COLLATE.

The DEFAULT constraint specifies a default value to use when doing an INSERT. The value may be NULL, a string constant, or a number. The default value may also be one of the special case-independent keywords CURRENT_TIME, CURRENT_DATE or CURRENT_TIMESTAMP. If the value is NULL, a string constant, or a number, it is literally inserted into the column whenever an INSERT statement does not specify a value for the column. If the value is CURRENT_TIME, CURRENT_DATE or CURRENT_TIMESTAMP, then the current UTC date and/or time is inserted into the column. For CURRENT_TIME, the format is HH:MM:SS. For CURRENT_DATE, the format is YYYY-MM-DD. The format for CURRENT_TIMESTAMP is YYYY-MM-DD HH:MM:SS.

Specifying a PRIMARY KEY normally just creates a UNIQUE index on the corresponding column or columns. However, if the PRIMARY KEY constraint is on a single column that has the data type INTEGER (or one of its synonyms such as int) then that column is used by the database as the actual primary key for the table. This means that the column may only hold unique integer values. (Note that in many SQLite implementations, only the column type INTEGER causes the column to serve as the internal primary key, but in Adobe AIR synonyms for INTEGER such as int also specify that behavior.)

If a table does not have an INTEGER PRIMARY KEY column, an integer key is automatically generated when a row is inserted. The primary key for a row can always be accessed using one of the special names ROWID, OID, or _ROWID_. These names can be used regardless of whether it is an explicitly declared INTEGER PRIMARY KEY or an internal generated value. However, if the table has an explicit INTEGER PRIMARY KEY, the name of the column in the result data is the actual column name rather than the special name.

An INTEGER PRIMARY KEY column can also include the keyword AUTOINCREMENT. When the AUTOINCREMENT keyword is used, the database automatically generates and inserts a sequentially incremented integer key in the INTEGER PRIMARY KEY column when it executes an INSERT statement that doesn't specify an explicit value for the column.

There can only be one PRIMARY KEY constraint in a CREATE TABLE statement. It can either be part of one column's definition or one single table-level PRIMARY KEY constraint. A primary key column is implicitly NOT NULL.

The optional conflict-clause following many constraints allows the specification of an alternative default constraint conflict resolution algorithm for that constraint. The default is ABORT. Different constraints within the same table may have different default conflict resolution algorithms. If an INSERT or UPDATE statement specifies a different conflict resolution algorithm, that algorithm is used in place of the algorithm specified in the CREATE TABLE statement. See the ON CONFLICT section of "Special statements and clauses" on page 1114 for additional information.

Additional constraints, such as FOREIGN KEY constraints, do not result in an error but the runtime ignores them.

If the TEMP or TEMPORARY keyword occurs between CREATE and TABLE then the table that is created is only visible within the same database connection (SQLConnection instance). It is automatically deleted when the database connection is closed. Any indices created on a temporary table are also temporary. Temporary tables and indices are stored in a separate file distinct from the main database file.

If the optional database-name prefix is specified, then the table is created in a named database (a database that was connected to the SQLConnection instance by calling the attach() method with the specified database name). It is an error to specify both a database-name prefix and the TEMP keyword, unless the database-name prefix is temp. If no database name is specified, and the TEMP keyword is not present, the table is created in the main database (the database that was connected to the SQLConnection instance using the open() or openAsync()method).

There are no arbitrary limits on the number of columns or on the number of constraints in a table. There is also no arbitrary limit on the amount of data in a row.

The CREATE TABLE AS form defines the table as the result set of a query. The names of the table columns are the names of the columns in the result.

If the optional IF NOT EXISTS clause is present and another table with the same name already exists, then the database ignores the CREATE TABLE command.

A table can be removed using the DROP TABLE statement, and limited changes can be made using the ALTER TABLE statement.

ALTER TABLE

The ALTER TABLE command allows the user to rename or add a new column to an existing table. It is not possible to remove a column from a table.

```
sql-statement ::= ALTER TABLE [database-name.] table-name alteration
alteration    ::= RENAME TO new-table-name
alteration    ::= ADD [COLUMN] column-def
```

The RENAME TO syntax is used to rename the table identified by [database-name.] table-name to new-table-name. This command cannot be used to move a table between attached databases, only to rename a table within the same database.

If the table being renamed has triggers or indices, then they remain attached to the table after it has been renamed. However, if there are any view definitions or statements executed by triggers that refer to the table being renamed, they are not automatically modified to use the new table name. If a renamed table has associated views or triggers, you must manually drop and recreate the triggers or view definitions using the new table name.

The ADD [COLUMN] syntax is used to add a new column to an existing table. The new column is always appended to the end of the list of existing columns. The column-def clause may take any of the forms permissible in a CREATE TABLE statement, with the following restrictions:

- The column may not have a PRIMARY KEY or UNIQUE constraint.
- The column may not have a default value of CURRENT_TIME, CURRENT_DATE or CURRENT_TIMESTAMP.
- If a NOT NULL constraint is specified, the column must have a default value other than NULL.

The execution time of the ALTER TABLE statement is not affected by the amount of data in the table.

DROP TABLE

The DROP TABLE statement removes a table added with a CREATE TABLE statement. The table with the specified table-name is the table that's dropped. It is completely removed from the database and the disk file. The table cannot be recovered. All indices associated with the table are also deleted.

```
sql-statement  ::=  DROP TABLE [IF EXISTS] [database-name.] table-name
```

By default the DROP TABLE statement does not reduce the size of the database file. Empty space in the database is retained and used in subsequent INSERT operations. To remove free space in the database use the SQLConnection.clean() method. If the autoClean parameter is set to true when the database is initially created, the space is freed automatically.

The optional IF EXISTS clause suppresses the error that would normally result if the table does not exist.

CREATE INDEX

The CREATE INDEX command consists of the keywords CREATE INDEX followed by the name of the new index, the keyword ON, the name of a previously created table that is to be indexed, and a parenthesized list of names of columns in the table whose values are used for the index key.

```
sql-statement  ::=  CREATE [UNIQUE] INDEX [IF NOT EXISTS] [database-name.] index-name
                    ON table-name ( column-name [, column-name]* )
column-name    ::=  name [COLLATE collation-name] [ASC | DESC]
```

Each column name can be followed by ASC or DESC keywords to indicate sort order, but the sort order designation is ignored by the runtime. Sorting is always done in ascending order.

The COLLATE clause following each column name defines a collating sequence used for text values in that column. The default collation sequence is the collation sequence defined for that column in the CREATE TABLE statement. If no collation sequence is specified, the BINARY collation sequence is used. For a definition of the COLLATE clause and collation functions see COLLATE.

There are no arbitrary limits on the number of indices that can be attached to a single table. There are also no limits on the number of columns in an index.

DROP INDEX

The drop index statement removes an index added with the CREATE INDEX statement. The specified index is completely removed from the database file. The only way to recover the index is to reenter the appropriate CREATE INDEX command.

```
sql-statement ::= DROP INDEX [IF EXISTS] [database-name.] index-name
```

By default the DROP INDEX statement does not reduce the size of the database file. Empty space in the database is retained and used in subsequent INSERT operations. To remove free space in the database use the SQLConnection.clean() method. If the autoClean parameter is set to true when the database is initially created, the space is freed automatically.

CREATE VIEW

The CREATE VIEW command assigns a name to a pre-defined SELECT statement. This new name can then be used in a FROM clause of another SELECT statement in place of a table name. Views are commonly used to simplify queries by combining a complex (and frequently used) set of data into a structure that can be used in other operations.

```
sql-statement ::= CREATE [TEMP | TEMPORARY] VIEW [IF NOT EXISTS] [database-name.] view-name AS
select-statement
```

If the TEMP or TEMPORARY keyword occurs in between CREATE and VIEW then the view that is created is only visible to the SQLConnection instance that opened the database and is automatically deleted when the database is closed.

If a [database-name] is specified the view is created in the named database (a database that was connected to the SQLConnection instance using the attach() method, with the specified name argument. It is an error to specify both a [database-name] and the TEMP keyword unless the [database-name] is temp. If no database name is specified, and the TEMP keyword is not present, the view is created in the main database (the database that was connected to the SQLConnection instance using the open() or openAsync() method).

Views are read only. A DELETE, INSERT, or UPDATE statement cannot be used on a view, unless at least one trigger of the associated type (INSTEAD OF DELETE, INSTEAD OF INSERT, INSTEAD OF UPDATE) is defined. For information on creating a trigger for a view, see CREATE TRIGGER.

A view is removed from a database using the DROP VIEW statement.

DROP VIEW

The DROP VIEW statement removes a view created by a CREATE VIEW statement.

```
sql-statement ::= DROP VIEW [IF EXISTS] view-name
```

The specified view-name is the name of the view to drop. It is removed from the database, but no data in the underlying tables is modified.

CREATE TRIGGER

The create trigger statement is used to add triggers to the database schema. A trigger is a database operation (the trigger-action) that is automatically performed when a specified database event (the database-event) occurs.

```
sql-statement  ::=  CREATE [TEMP | TEMPORARY] TRIGGER [IF NOT EXISTS] [database-name.] trigger-
name
                     [BEFORE | AFTER] database-event
                     ON table-name
                     trigger-action
sql-statement  ::=  CREATE [TEMP | TEMPORARY] TRIGGER [IF NOT EXISTS] [database-name.] trigger-
name
                     INSTEAD OF database-event
                     ON view-name
                     trigger-action
database-event  ::=  DELETE |
                     INSERT |
                     UPDATE |
                     UPDATE OF column-list
trigger-action  ::=  [FOR EACH ROW] [WHEN expr]
                     BEGIN
                       trigger-step ;
                       [ trigger-step ; ]*
                     END
trigger-step    ::=  update-statement |
                     insert-statement |
                     delete-statement |
                     select-statement
column-list     ::=  column-name [, column-name]*
```

A trigger is specified to fire whenever a DELETE, INSERT, or UPDATE of a particular database table occurs, or whenever an UPDATE of one or more specified columns of a table are updated. Triggers are permanent unless the TEMP or TEMPORARY keyword is used. In that case the trigger is removed when the SQLConnection instance's main database connection is closed. If no timing is specified (BEFORE or AFTER) the trigger defaults to BEFORE.

Only FOR EACH ROW triggers are supported, so the FOR EACH ROW text is optional. With a FOR EACH ROW trigger, the trigger-step statements are executed for each database row being inserted, updated or deleted by the statement causing the trigger to fire, if the WHEN clause expression evaluates to true.

If a WHEN clause is supplied, the SQL statements specified as trigger-steps are only executed for rows for which the WHEN clause is true. If no WHEN clause is supplied, the SQL statements are executed for all rows.

Within the body of a trigger, (the trigger-action clause) the pre-change and post-change values of the affected table are available using the special table names OLD and NEW. The structure of the OLD and NEW tables matches the structure of the table on which the trigger is created. The OLD table contains any rows that are modified or deleted by the triggering statement, in their state before the triggering statement's operations. The NEW table contains any rows that are modified or created by the triggering statement, in their state after the triggering statement's operations. Both the WHEN clause and the trigger-step statements can access values from the row being inserted, deleted or updated using references of the form NEW.column-name and OLD.column-name, where column-name is the name of a column from the table with which the trigger is associated. The availability of the OLD and NEW table references depends on the type of database-event the trigger handles:

- INSERT – NEW references are valid
- UPDATE – NEW and OLD references are valid
- DELETE – OLD references are valid

The specified timing (BEFORE, AFTER, or INSTEAD OF) determines when the trigger-step statements are executed relative to the insertion, modification or removal of the associated row. An ON CONFLICT clause may be specified as part of an UPDATE or INSERT statement in a trigger-step. However, if an ON CONFLICT clause is specified as part of the statement causing the trigger to fire, then that conflict handling policy is used instead.

In addition to table triggers, an INSTEAD OF trigger can be created on a view. If one or more INSTEAD OF INSERT, INSTEAD OF DELETE, or INSTEAD OF UPDATE triggers are defined on a view, it is not considered an error to execute the associated type of statement (INSERT, DELETE, or UPDATE) on the view. In that case, executing an INSERT, DELETE or UPDATE on the view causes the associated triggers to fire. Because the trigger is an INSTEAD OF trigger, the tables underlying the view are not modified by the statement that causes the trigger to fire. However, the triggers can be used to perform modifying operations on the underlying tables.

There is an important issue to keep in mind when creating a trigger on a table with an INTEGER PRIMARY KEY column. If a BEFORE trigger modifies the INTEGER PRIMARY KEY column of a row that is to be updated by the statement that causes the trigger to fire, the update doesn't occur. A workaround is to create the table with a PRIMARY KEY column instead of an INTEGER PRIMARY KEY column.

A trigger can be removed using the DROP TRIGGER statement. When a table or view is dropped, all triggers associated with that table or view are automatically dropped as well.

RAISE () function

A special SQL function RAISE() can be used in a trigger-step statement of a trigger. This function has the following syntax:

```
raise-function  ::=  RAISE ( ABORT, error-message ) |
                     RAISE ( FAIL, error-message ) |
                     RAISE ( ROLLBACK, error-message ) |
                     RAISE ( IGNORE )
```

When one of the first three forms is called during trigger execution, the specified ON CONFLICT processing action (ABORT, FAIL, or ROLLBACK) is performed and the current statement's execution ends. The ROLLBACK is considered a statement execution failure, so the SQLStatement instance whose execute() method was being carried out dispatches an error (SQLErrorEvent.ERROR) event. The SQLError object in the dispatched event object's error property has its details property set to the error-message specified in the RAISE() function.

When RAISE(IGNORE) is called, the remainder of the current trigger, the statement that caused the trigger to execute, and any subsequent triggers that would have been executed are abandoned. No database changes are rolled back. If the statement that caused the trigger to execute is itself part of a trigger, that trigger program resumes execution at the beginning of the next step. For more information about the conflict resolution algorithms, see the section ON CONFLICT (conflict algorithms).

DROP TRIGGER

The DROP TRIGGER statement removes a trigger created by the CREATE TRIGGER statement.

```
sql-statement  ::=  DROP TRIGGER [IF EXISTS] [database-name.] trigger-name
```

The trigger is deleted from the database. Note that triggers are automatically dropped when their associated table is dropped.

Special statements and clauses

This section describes several clauses that are extensions to SQL provided by the runtime, as well as two language elements that can be used in many statements, comments and expressions.

COLLATE

The COLLATE clause is used in SELECT, CREATE TABLE, and CREATE INDEX statements to specify the comparison algorithm that is used when comparing or sorting values.

```
sql-statement   ::=  COLLATE collation-name
collation-name  ::=  BINARY | NOCASE
```

The default collation type for columns is BINARY. When BINARY collation is used with values of the TEXT storage class, binary collation is performed by comparing the bytes in memory that represent the value regardless of the text encoding.

The NOCASE collation sequence is only applied for values of the TEXT storage class. When used, the NOCASE collation performs a case-insensitive comparison.

No collation sequence is used for storage classes of type NULL, BLOB, INTEGER, or REAL.

To use a collation type other than BINARY with a column, a COLLATE clause must be specified as part of the column definition in the CREATE TABLE statement. Whenever two TEXT values are compared, a collation sequence is used to determine the results of the comparison according to the following rules:

- For binary comparison operators, if either operand is a column, then the default collation type of the column determines the collation sequence that is used for the comparison. If both operands are columns, then the collation type for the left operand determines the collation sequence used. If neither operand is a column, then the BINARY collation sequence is used.
- The BETWEEN...AND operator is equivalent to using two expressions with the >= and <= operators. For example, the expression x BETWEEN y AND z is equivalent to x >= y AND x <= z. Consequently, the BETWEEN...AND operator follows the preceding rule to determine the collation sequence.
- The IN operator behaves like the =operator for the purposes of determining the collation sequence to use. For example, the collation sequence used for the expressionx IN (y, z) is the default collation type of x if x is a column. Otherwise, BINARY collation is used.
- An ORDER BY clause that is part of a SELECT statement may be explicitly assigned a collation sequence to be used for the sort operation. In that case the explicit collation sequence is always used. Otherwise, if the expression sorted by an ORDER BYclause is a column, the default collation type of the column is used to determine sort order. If the expression is not a column, the BINARY collation sequence is used.

EXPLAIN

The EXPLAIN command modifier is a non-standard extension to SQL.

```
sql-statement  ::=  EXPLAIN sql-statement
```

If the EXPLAIN keyword appears before any other SQL statement, then instead of actually executing the command, the result reports the sequence of virtual machine instructions it would have used to execute the command, had the EXPLAIN keyword not been present. The EXPLAIN feature is an advanced feature and allows developers to change SQL statement text in an attempt to optimize performance or debug a statement that doesn't appear to be working properly.

ON CONFLICT (conflict algorithms)

The ON CONFLICT clause is not a separate SQL command. It is a non-standard clause that can appear in many other SQL commands.

```
conflict-clause     ::=  ON CONFLICT conflict-algorithm
conflict-clause     ::=  OR conflict-algorithm
conflict-algorithm  ::=  ROLLBACK |
                         ABORT |
                         FAIL |
                         IGNORE |
                         REPLACE
```

The first form of the ON CONFLICT clause, using the keywords ON CONFLICT, is used in a CREATE TABLE statement. For an INSERT or UPDATE statement, the second form is used, with ON CONFLICT replaced by OR to make the syntax seem more natural. For example, instead of INSERT ON CONFLICT IGNORE, the statement becomes INSERT OR IGNORE. Although the keywords are different, the meaning of the clause is the same in either form.

The ON CONFLICT clause specifies the algorithm that is used to resolve constraint conflicts. The five algorithms are ROLLBACK, ABORT, FAIL, IGNORE, and REPLACE. The default algorithm is ABORT. The following is an explanation of the five conflict algorithms:

ROLLBACK When a constraint violation occurs, an immediate ROLLBACK occurs, ending the current transaction. The command aborts and the SQLStatement instance dispatches an error event. If no transaction is active (other than the implied transaction that is created on every command) then this algorithm works the same as ABORT.

ABORT When a constraint violation occurs, the command backs out any prior changes it might have made and the SQLStatement instance dispatches an error event. No ROLLBACK is executed, so changes from prior commands within a transaction are preserved. ABORT is the default behavior.

FAIL When a constraint violation occurs, the command aborts and the SQLStatement dispatches an error event. However, any changes to the database that the statement made before encountering the constraint violation are preserved and are not backed out. For example, if an UPDATE statement encounters a constraint violation on the 100th row that it attempts to update, then the first 99 row changes are preserved but changes to rows 100 and beyond don't occur.

IGNORE When a constraint violation occurs, the one row that contains the constraint violation is not inserted or changed. Aside from this row being ignored, the command continues executing normally. Other rows before and after the row that contained the constraint violation continue to be inserted or updated normally. No error is returned.

REPLACE When a UNIQUE constraint violation occurs, the pre-existing rows that are causing the constraint violation are removed before inserting or updating the current row. Consequently, the insert or update always occurs, and the command continues executing normally. No error is returned. If a NOT NULL constraint violation occurs, the NULL value is replaced by the default value for that column. If the column has no default value, then the ABORT algorithm is used. If a CHECK constraint violation occurs then the IGNORE algorithm is used. When this conflict resolution strategy deletes rows in order to satisfy a constraint, it does not invoke delete triggers on those rows.

The algorithm specified in the OR clause of an INSERT or UPDATE statement overrides any algorithm specified in a CREATE TABLE statement. If no algorithm is specified in the CREATE TABLE statement or the executing INSERT or UPDATE statement, the ABORT algorithm is used.

REINDEX

The REINDEX command is used to delete and re-create one or more indices. This command is useful when the definition of a collation sequence has changed.

```
sql-statement  ::=  REINDEX collation-name
sql-statement  ::=  REINDEX [database-name .] ( table-name | index-name )
```

In the first form, all indices in all attached databases that use the named collation sequence are recreated. In the second form, when a table-name is specified, all indices associated with the table are rebuilt. If an index-name is given, only the specified index is deleted and recreated.

COMMENTS

Comments aren't SQL commands, but they can occur in SQL queries. They are treated as white space by the runtime. They can begin anywhere white space can be found, including inside expressions that span multiple lines.

```
comment             ::=  single-line-comment |
                         block-comment
single-line-comment ::=  -- single-line
block-comment       ::=  /* multiple-lines or block [*/]
```

A single-line comment is indicated by two dashes. A single line comment only extends to the end of the current line.

Block comments can span any number of lines, or be embedded within a single line. If there is no terminating delimiter, a block comment extends to the end of the input. This situation is not treated as an error. A new SQL statement can begin on a line after a block comment ends. Block comments can be embedded anywhere white space can occur, including inside expressions, and in the middle of other SQL statements. Block comments do not nest. Single-line comments inside a block comment are ignored.

EXPRESSIONS

Expressions are subcommands within other SQL blocks. The following describes the valid syntax for an expression within a SQL statement:

```
expr            ::=  expr binary-op expr |
                     expr [NOT] like-op expr [ESCAPE expr] |
                     unary-op expr |
                     ( expr ) |
                     column-name |
                     table-name.column-name |
                     database-name.table-name.column-name |
                     literal-value |
                     parameter |
                     function-name( expr-list | * ) |
                     expr ISNULL |
                     expr NOTNULL |
                     expr [NOT] BETWEEN expr AND expr |
                     expr [NOT] IN ( value-list ) |
                     expr [NOT] IN ( select-statement ) |
                     expr [NOT] IN [database-name.] table-name |
                     [EXISTS] ( select-statement ) |
                     CASE [expr] ( WHEN expr THEN expr )+ [ELSE expr] END |
                     CAST ( expr AS type ) |
                     expr COLLATE collation-name
like-op         ::=  LIKE | GLOB
binary-op       ::=  see Operators
unary-op        ::=  see Operators
parameter       ::=  :param-name | @param-name | ?
value-list      ::=  literal-value [, literal-value]*
literal-value   ::=  literal-string | literal-number | literal-boolean | literal-blob |
literal-null
literal-string  ::=  'string value'
literal-number  ::=  integer | number
literal-boolean  ::=  true | false
literal-blob  ::=  X'string of hexadecimal data'
literal-null  ::=  NULL
```

An expression is any combination of values and operators that can be resolved to a single value. Expressions can be divided into two general types, according to whether they resolve to a boolean (true or false) value or whether they resolve to a non-boolean value.

In several common situations, including in a WHERE clause, a HAVING clause, the ON expression in a JOIN clause, and a CHECK expression, the expression must resolve to a boolean value. The following types of expressions meet this condition:

- ISNULL
- NOTNULL
- IN ()
- EXISTS ()
- LIKE
- GLOB
- Certain functions
- Certain operators (specifically comparison operators)

Literal values
A literal numeric value is written as an integer number or a floating point number. Scientific notation is supported. The . (period) character is always used as the decimal point.

A string literal is indicated by enclosing the string in single quotes '. To include a single quote within a string, put two single quotes in a row like this example: ''.

A boolean literal is indicated by the value true or false. Literal boolean values are used with the Boolean column data type.

A BLOB literal is a string literal containing hexadecimal data and proceeded by a single x or X character, such as X'53514697465'.

A literal value can also be the token NULL.

Column name
A column name can be any of the names defined in the CREATE TABLE statement or one of the following special identifiers: ROWID, OID, or _ROWID_. These special identifiers all describe the unique random integer key (the "row key") associated with every row of every table. The special identifiers only refer to the row key if the CREATE TABLE statement does not define a real column with the same name. Row keys behave as read-only columns. A row key can be used anywhere a regular column can be used, except that you cannot change the value of a row key in an UPDATE or INSERT statement. The SELECT * FROM table statement does not include the row key in its result set.

SELECT statement
A SELECT statement can appear in an expression as either the right-hand operand of the IN operator, as a scalar quantity (a single result value), or as the operand of an EXISTS operator. When used as a scalar quantity or the operand of an IN operator, the SELECT can only have a single column in its result. A compound SELECT statement (connected with keywords like UNION or EXCEPT) is allowed. With the EXISTS operator, the columns in the result set of the SELECT are ignored and the expression returns TRUE if one or more rows exist and FALSE if the result set is empty. If no terms in the SELECT expression refer to the value in the containing query, then the expression is evaluated once before any other processing and the result is reused as necessary. If the SELECT expression does contain variables from the outer query, known as a correlated subquery, then the SELECT is re-evaluated every time it is needed.

When a SELECT is the right operand of the IN operator, the IN operator returns TRUE if the result of the left operand is equal to any of the values in the SELECT statement's result set. The IN operator may be preceded by the NOT keyword to invert the sense of the test.

When a SELECT appears within an expression but is not the right operand of an IN operator, then the first row of the result of the SELECT becomes the value used in the expression. If the SELECT yields more than one result row, all rows after the first are ignored. If the SELECT yields no rows, then the value of the SELECT is NULL.

CAST expression

A CAST expression changes the data type of the value specified to the one given. The type specified can be any non-empty type name that is valid for the type in a column definition of a CREATE TABLE statement. See Data type support for details.

Additional expression elements

The following SQL elements can also be used in expressions:

- Built-in functions: Aggregate functions, Scalar functions, and Date and time formatting functions
- Operators
- Parameters

Built-in functions

The built-in functions fall into three main categories:

- Aggregate functions
- Scalar functions
- Date and time functions

In addition to these functions, there is a special function RAISE() that is used to provide notification of an error in the execution of a trigger. This function can only be used within the body of a CREATE TRIGGER statement. For information on the RAISE() function, see CREATE TRIGGER > RAISE().

Like all keywords in SQL, function names are not case sensitive.

Aggregate functions

Aggregate functions perform operations on values from multiple rows. These functions are primarily used in SELECT statements in conjunction with the GROUP BY clause.

AVG(X)	Returns the average value of all non-NULL X within a group. String and BLOB values that do not look like numbers are interpreted as 0. The result of AVG() is always a floating point value even if all inputs are integers.

COUNT(X)
COUNT(*)
	The first form returns a count of the number of times that X is not NULL in a group. The second form (with the * argument) returns the total number of rows in the group.

MAX(X)	Returns the maximum value of all values in the group. The usual sort order is used to determine the maximum.
MIN(X)	Returns the minimum non-NULL value of all values in the group. The usual sort order is used to determine the minimum. If all values in the group are NULL, NULL is returned.

SUM(X)
TOTAL(X)
	Returns the numeric sum of all non-NULL values in the group. If all of the values are NULL then SUM() returns NULL, and TOTAL() returns 0.0. The result of TOTAL() is always a floating point value. The result of SUM() is an integer value if all non-NULL inputs are integers. If any input to SUM() is not an integer and not NULL then SUM() returns a floating point value. This value might be an approximation to the true sum.

In any of the preceding aggregate functions that take a single argument, that argument can be preceded by the keyword DISTINCT. In that case, duplicate elements are filtered before being passed into the aggregate function. For example, the function call COUNT(DISTINCT x) returns the number of distinct values of column X instead of the total number of non-NULL values in column x.

Scalar functions

Scalar functions operate on values one row at a time.

ABS(X)	Returns the absolute value of argument X.
COALESCE(X, Y, ...)	Returns a copy of the first non-NULL argument. If all arguments are NULL then NULL is returned. There must be at least two arguments.
GLOB(X, Y)	This function is used to implement the X GLOB Y syntax.
IFNULL(X, Y)	Returns a copy of the first non-NULL argument. If both arguments are NULL then NULL is returned. This function behaves the same as COALESCE().
HEX(X)	The argument is interpreted as a value of the BLOB storage type. The result is a hexadecimal rendering of the content of that value.
LAST_INSERT_ROWID( )	Returns the row identifier (generated primary key) of the last row inserted to the database through the current SQLConnection. This value is the same as the value returned by the SQLConnection.lastInsertRowID property.
LENGTH(X)	Returns the string length of X in characters.
LIKE(X, Y [, Z])	This function is used to implement the X LIKE Y [ESCAPE Z] syntax of SQL. If the optional ESCAPE clause is present, then the function is invoked with three arguments. Otherwise, it is invoked with two arguments only.
LOWER(X)	Returns a copy of string X with all characters converted to lower case.
LTRIM(X) LTRIM(X, Y)	Returns a string formed by removing spaces from the left side of X. If a Y argument is specified, the function removes any of the characters in Y from the left side of X.
MAX(X, Y, ...)	Returns the argument with the maximum value. Arguments may be strings in addition to numbers. The maximum value is determined by the defined sort order. Note that MAX() is a simple function when it has 2 or more arguments but is an aggregate function when it has a single argument.
MIN(X, Y, ...)	Returns the argument with the minimum value. Arguments may be strings in addition to numbers. The minimum value is determined by the defined sort order. Note that MIN() is a simple function when it has 2 or more arguments but is an aggregate function when it has a single argument.
NULLIF(X, Y)	Returns the first argument if the arguments are different, otherwise returns NULL.
QUOTE(X)	This routine returns a string which is the value of its argument suitable for inclusion into another SQL statement. Strings are surrounded by single-quotes with escapes on interior quotes as needed. BLOB storage classes are encoded as hexadecimal literals. The function is useful when writing triggers to implement undo/redo functionality.
RANDOM(*)	Returns a pseudo-random integer between -9223372036854775808 and 9223372036854775807. This random value is not crypto-strong.
RANDOMBLOB(N)	Returns an N-byte BLOB containing pseudo-random bytes. N should be a positive integer. This random value is not crypto-strong. If the value of N is negative a single byte is returned.
ROUND(X) ROUND(X, Y)	Rounds off the number X to Y digits to the right of the decimal point. If the Y argument is omitted, 0 is used.
RTRIM(X) RTRIM(X, Y)	Returns a string formed by removing spaces from the right side of X. If a Y argument is specified, the function removes any of the characters in Y from the right side of X.
SUBSTR(X, Y, Z)	Returns a substring of input string X that begins with the Y-th character and which is Z characters long. The left-most character of X is index position 1. If Y is negative the first character of the substring is found by counting from the right rather than the left.
TRIM(X) TRIM(X, Y)	Returns a string formed by removing spaces from the right side of X. If a Y argument is specified, the function removes any of the characters in Y from the right side of X.
TYPEOF(X)	Returns the type of the expression X. The possible return values are 'null', 'integer', 'real', 'text', and 'blob'. For more information on data types see Data type support.
UPPER(X)	Returns a copy of input string X converted to all upper-case letters.
ZEROBLOB(N)	Returns a BLOB containing N bytes of 0x00.

Date and time formatting functions

The date and time formatting functions are a group of scalar functions that are used to create formatted date and time data. Note that these functions operate on and return string and number values. These functions are not intended to be used with the DATE data type. If you use these functions on data in a column whose declared data type is DATE, they do not behave as expected.

DATE(T, ...)	The DATE() function returns a string containing the date in this format: YYYY-MM-DD. The first parameter (T) specifies a time string of the format found under Time formats. Any number of modifiers can be specified after the time string. The modifiers can be found under Modifiers.
TIME(T, ...)	The TIME() function returns a string containing the time as HH:MM:SS. The first parameter (T) specifies a time string of the format found under Time formats. Any number of modifiers can be specified after the time string. The modifiers can be found under Modifiers.
DATETIME(T, ...)	The DATETIME() function returns a string containing the date and time in YYYY-MM-DD HH:MM:SS format. The first parameter (T) specifies a time string of the format found under Time formats. Any number of modifiers can be specified after the time string. The modifiers can be found under Modifiers.
JULIANDAY(T, ...)	The JULIANDAY() function returns a number indicating the number of days since noon in Greenwich on November 24, 4714 B.C. and the provided date. The first parameter (T) specifies a time string of the format found under Time formats. Any number of modifiers can be specified after the time string. The modifiers can be found under Modifiers.
STRFTIME(F, T, ...)	The STRFTIME() routine returns the date formatted according to the format string specified as the first argument F. The format string supports the following substitutions: %d - day of month %f - fractional seconds SS.SSS %H - hour 00-24 %j - day of year 001-366 %J - Julian day number %m -month 01-12 %M - minute 00-59 %s - seconds since 1970-01-01 %S - seconds 00-59 %w - day of week 0-6 (sunday = 0) %W - week of year 00-53 %Y - year 0000-9999 %% - % The second parameter (T) specifies a time string of the format found under Time formats. Any number of modifiers can be specified after the time string. The modifiers can be found under Modifiers.

Time formats

A time string can be in any of the following formats:

YYYY-MM-DD	2007-06-15
YYYY-MM-DD HH:MM	2007-06-15 07:30
YYYY-MM-DD HH:MM:SS	2007-06-15 07:30:59
YYYY-MM-DD HH:MM:SS.SSS	2007-06-15 07:30:59.152
YYYY-MM-DDTHH:MM	2007-06-15T07:30
YYYY-MM-DDTHH:MM:SS	2007-06-15T07:30:59
YYYY-MM-DDTHH:MM:SS.SSS	2007-06-15T07:30:59.152
HH:MM	07:30 (date is 2000-01-01)
HH:MM:SS	07:30:59 (date is 2000-01-01)
HH:MM:SS.SSS	07:30:59:152 (date is 2000-01-01)
now	Current date and time in Universal Coordinated Time.
DDDD.DDDD	Julian day number as a floating-point number.

The character T in these formats is a literal character "T" separating the date and the time. Formats that only include a time assume the date 2001-01-01.

Modifiers

The time string can be followed by zero or more modifiers that alter the date or alter the interpretation of the date. The available modifiers are as follows:

NNN days	Number of days to add to the time.
NNN hours	Number of hours to add to the time.
NNN minutes	Number of minutes to add to the time.
NNN.NNNN seconds	Number of seconds and milliseconds to add to the time.
NNN months	Number of months to add to the time.
NNN years	Number of years to add to the time.
start of month	Shift time backwards to the start of the month.
start of year	Shift time backwards to the start of the year.
start of day	Shift time backwards to the start of the day.
weekday N	Forwards the time to the specified weekday. (0 = Sunday, 1 = Monday, and so forth).
localtime	Converts the date to local time.
utc	Converts the date to Universal Coordinated Time.

Operators

SQL supports a large selection of operators, including common operators that exist in most programming languages, as well as several operators that are unique to SQL.

Common operators

The following binary operators are allowed in a SQL block and are listed in order from highest to lowest precedence:

```
*     /     %
+     -
<<  >>  &  |
<  >=    >  >=
=     ==    !=    <> IN
AND
OR
```

Supported unary prefix operators are:

```
 !     ~     NOT
```

The COLLATE operator can be thought of as a unary postfix operator. The COLLATE operator has the highest precedence. It always binds more tightly than any prefix unary operator or any binary operator.

Note that there are two variations of the equals and not equals operators. Equals can be either = or ==. The not-equals operator can be either != or <>.

The || operator is the string concatenation operator—it joins together the two strings of its operands.

The operator % outputs the remainder of its left operand modulo its right operand.

The result of any binary operator is a numeric value, except for the || concatenation operator which gives a string result.

SQL operators

LIKE

The LIKE operator does a pattern matching comparison.

```
expr     ::=  (column-name | expr) LIKE pattern
pattern  ::=  '[ string | % | _ ]'
```

The operand to the right of the LIKE operator contains the pattern, and the left-hand operand contains the string to match against the pattern. A percent symbol (%) in the pattern is a wildcard character—it matches any sequence of zero or more characters in the string. An underscore (_) in the pattern matches any single character in the string. Any other character matches itself or its lower/upper case equivalent, that is, matches are performed in a case-insensitive manner. (Note: the database engine only understands upper/lower case for 7-bit Latin characters. Consequently, the LIKE operator is case sensitive for 8-bit iso8859 characters or UTF-8 characters. For example, the expression 'a' LIKE 'A' is TRUE but 'æ' LIKE 'Æ' is FALSE). Case sensitivity for Latin characters can be changed using the SQLConnection.caseSensitiveLike property.

If the optional ESCAPE clause is present, then the expression following the ESCAPE keyword must evaluate to a string consisting of a single character. This character may be used in the LIKE pattern to match literal percent or underscore characters. The escape character followed by a percent symbol, underscore or itself matches a literal percent symbol, underscore or escape character in the string, respectively.

GLOB

The GLOB operator is similar to LIKE but uses the Unix file globbing syntax for its wildcards. Unlike LIKE, GLOB is case sensitive.

IN

The IN operator calculates whether its left operand is equal to one of the values in its right operand (a set of values in parentheses).

```
in-expr         ::=  expr [NOT] IN ( value-list ) |
                     expr [NOT] IN ( select-statement ) |
                     expr [NOT] IN [database-name.] table-name
value-list      ::=  literal-value [, literal-value]*
```

The right operand can be a set of comma-separated literal values, or it can be the result of a SELECT statement. See SELECT statements in expressions for an explanation and limitations on using a SELECT statement as the right-hand operand of the IN operator.

BETWEEN...AND

The BETWEEN...AND operator is equivalent to using two expressions with the >= and <= operators. For example, the expression x BETWEEN y AND z is equivalent to x >= y AND x <= z.

NOT

The NOT operator is a negation operator. The GLOB, LIKE, and IN operators may be preceded by the NOT keyword to invert the sense of the test (in other words, to check that a value does not match the indicated pattern).

Parameters

A parameter specifies a placeholder in the expression for a literal value that is filled in at runtime by assigning a value to the SQLStatement.parameters associative array. Parameters can take three forms:

?	A question mark indicates an indexed parameter. Parameters are assigned numerical (zero-based) index values according to their order in the statement.
:AAAA	A colon followed by an identifier name holds a spot for a named parameter with the name AAAA. Named parameters are also numbered according to their order in the SQL statement. To avoid confusion, it is best to avoid mixing named and numbered parameters.
@AAAA	An "at sign" is equivalent to a colon.

Unsupported SQL features

The following is a list of the standard SQL elements that are not supported in Adobe AIR:

FOREIGN KEY constraints FOREIGN KEY constraints are parsed but are not enforced.

Triggers FOR EACH STATEMENT triggers are not supported (all triggers must be FOR EACH ROW). INSTEAD OF triggers are not supported on tables (INSTEAD OF triggers are only allowed on views). Recursive triggers—triggers that trigger themselves—are not supported.

ALTER TABLE Only the RENAME TABLE and ADD COLUMN variants of the ALTER TABLE command are supported. Other kinds of ALTER TABLE operations such as DROP COLUMN, ALTER COLUMN, ADD CONSTRAINT, and so forth are ignored.

Nested transactions Only a single active transaction is allowed.

RIGHT and FULL OUTER JOIN RIGHT OUTER JOIN or FULL OUTER JOIN are not supported.

Updateable VIEW A view is read only. You may not execute a DELETE, INSERT, or UPDATE statement on a view. An INSTEAD OF trigger that fires on an attempt to DELETE, INSERT, or UPDATE a view is supported and can be used to update supporting tables in the body of the trigger.

GRANT and REVOKE A database is an ordinary disk file; the only access permissions that can be applied are the normal file access permissions of the underlying operating system. The GRANT and REVOKE commands commonly found on client/server RDBMSes are not implemented.

The following SQL elements and SQLite features are supported in some SQLite implementations, but are not supported in Adobe AIR. Most of this functionality is available through methods of the SQLConnection class:

Transaction-related SQL elements (BEGIN, END, COMMIT, ROLLBACK) This functionality is available through the transaction-related methods of the SQLConnection class: SQLConnection.begin(), SQLConnection.commit(), and SQLConnection.rollback().

ANALYZE This functionality is available through the SQLConnection.analyze() method.

ATTACH This functionality is available through the SQLConnection.attach() method.

COPY This statement is not supported.

CREATE VIRTUAL TABLE This statement is not supported.

DETACH This functionality is available through the SQLConnection.detach() method.

PRAGMA This statement is not supported.

VACUUM This functionality is available through the SQLConnection.compact() method.

System table access is not available The system tables including sqlite_master and other tables with the "sqlite_" prefix are not available in SQL statements. The runtime includes a schema API that provides an object-oriented way to access schema data. For more information see the SQLConnection.loadSchema() method.

Regular-expression functions (MATCH() and REGEX()) These functions are not available in SQL statements.

The following functionality differs between many SQLite implementations and Adobe AIR:

Indexed statement parameters In many implementations indexed statement parameters are one-based. However, in Adobe AIR indexed statement parameters are zero-based (that is, the first parameter is given the index 0, the second parameter is given the index 1, and so forth.

INTEGER PRIMARY KEY column definitions In many implementations, only columns that are defined exactly as INTEGER PRIMARY KEY are used as the actual primary key column for a table. In those implementations, using another data type that is usually a synonym for INTEGER (such as int) does not cause the column to be used as the internal primary key. However, in Adobe AIR, the int data type (and other INTEGER synonyms) are considered exactly equivalent to INTEGER. Consequently, a column defined as int PRIMARY KEY is used as the internal primary key for a table. For more information, see the sections CREATE TABLE and Column affinity.

Additional SQL features

The following column affinity types are not supported by default in SQLite, but are supported in Adobe AIR (Note that, like all keywords in SQL, these data type names are not case-sensitive):

Boolean corresponding to the Boolean class.

Date corresponding to the Date class.

int corresponding to the int class (equivalent to the INTEGER column affinity).

Number corresponding to the Number class (equivalent to the REAL column affinity).

Object corresponding to the Object class or any subclass that can be serialized and deserialized using AMF3. (This includes most classes including custom classes, but excludes some classes including display objects and objects that include display objects as properties.)

String corresponding to the String class (equivalent to the TEXT column affinity).

XML corresponding to the ActionScript (E4X) XML class.

XMLList corresponding to the ActionScript (E4X) XMLList class.

The following literal values are not supported by default in SQLite, but are supported in Adobe AIR:

true used to represent the literal boolean value true, for working with BOOLEAN columns.

false used to represent the literal boolean value false, for working with BOOLEAN columns.

Data type support

Unlike most SQL databases, the Adobe AIR SQL database engine does not require or enforce that table columns contain values of a certain type. Instead, the runtime uses two concepts, storage classes and column affinity, to control data types. This section describes storage classes and column affinity, as well as how data type differences are resolved under various conditions:

- "Storage classes" on page 1126
- "Column affinity" on page 1126
- "Data types and comparison operators" on page 1129
- "Data types and mathematical operators" on page 1129
- "Data types and sorting" on page 1129
- "Data types and grouping" on page 1129
- "Data types and compound SELECT statements" on page 1130

Storage classes

Storage classes represent the actual data types that are used to store values in a database. The following storage classes are used by the database:

NULL The value is a NULL value.

INTEGER The value is a signed integer.

REAL The value is a floating-point number value.

TEXT The value is a text string (limited to 256 MB).

BLOB The value is a Binary Large Object (BLOB); in other words, raw binary data (limited to 256 MB).

All values supplied to the database as literals embedded in a SQL statement or values bound using parameters to a prepared SQL statement are assigned a storage class before the SQL statement is executed.

Literals that are part of a SQL statement are assigned storage class TEXT if they are enclosed by single or double quotes, INTEGER if the literal is specified as an unquoted number with no decimal point or exponent, REAL if the literal is an unquoted number with a decimal point or exponent and NULL if the value is a NULL. Literals with storage class BLOB are specified using the X'ABCD' notation. For more information, see Literal values in expressions.

Values supplied as parameters using the SQLStatement.parameters associative array are assigned the storage class that most closely matches the native data type bound. For example, int values are bound as INTEGER storage class, Number values are given the REAL storage class, String values are given the TEXT storage class, and ByteArray objects are given the BLOB storage class.

Column affinity

The *affinity* of a column is the recommended type for data stored in that column. When a value is stored in a column (through an INSERT or UPDATE statement), the runtime attempts to convert that value from its data type to the specified affinity. For example, if a Date value (an ActionScript or JavaScript Date instance) is inserted into a column whose affinity is TEXT, the Date value is converted to the String representation (equivalent to calling the object's toString() method) before being stored in the database. If the value cannot be converted to the specified affinity an error occurs and the operation is not performed. When a value is retrieved from the database using a SELECT statement, it is returned as an instance of the class corresponding to the affinity, regardless of whether it was converted from a different data type when it was stored.

If a column accepts NULL values, the ActionScript or JavaScript value null can be used as a parameter value to store NULL in the column. When a NULL storage class value is retrieved in a SELECT statement, it is always returned as the ActionScript or JavaScript value null, regardless of the column's affinity. If a column accepts NULL values, always check values retrieved from that column to determine if they're null before attempting to cast the values to a non-nullable type (such as Number or Boolean).

Each column in the database is assigned one of the following type affinities:

- TEXT (or String)
- NUMERIC
- INTEGER (or int)
- REAL (or Number)
- Boolean
- Date
- XML

- XMLLIST
- Object
- NONE

TEXT (or String)

A column with TEXT or String affinity stores all data using storage classes NULL, TEXT, or BLOB. If numerical data is inserted into a column with TEXT affinity it is converted to text form before being stored.

NUMERIC

A column with NUMERIC affinity contains values using storage classes NULL, REAL, or INTEGER. When text data is inserted into a NUMERIC column, an attempt is made to convert it to an integer or real number before it is stored. If the conversion is successful, then the value is stored using the INTEGER or REAL storage class (for example, a value of '10.05' is converted to REAL storage class before being stored). If the conversion cannot be performed an error occurs. No attempt is made to convert a NULL value. A value that's retrieved from a NUMERIC column is returned as an instance of the most specific numeric type into which the value fits. In other words, if the value is a positive integer or 0, it's returned as a uint instance. If it's a negative integer, it's returned as an int instance. Finally, if it has a floating-point component (it's not an integer) it's returned as a Number instance.

INTEGER (or int)

A column that uses INTEGER affinity behaves in the same way as a column with NUMERIC affinity, with one exception. If the value to be stored is a real value (such as a Number instance) with no floating point component or if the value is a text value that can be converted to a real value with no floating point component, it is converted to an integer and stored using the INTEGER storage class. If an attempt is made to store a real value with a floating point component an error occurs.

REAL (or Number)

A column with REAL or NUMBER affinity behaves like a column with NUMERIC affinity except that it forces integer values into floating point representation. A value in a REAL column is always returned from the database as a Number instance.

Boolean

A column with Boolean affinity stores true or false values. A Boolean column accepts a value that is an ActionScript or JavaScript Boolean instance. If code attempts to store a String value, a String with a length greater than zero is considered true, and an empty String is false. If code attempts to store numeric data, any non-zero value is stored as true and 0 is stored as false. When a Boolean value is retrieved using a SELECT statement, it is returned as a Boolean instance. Non-NULL values are stored using the INTEGER storage class (0 for false and 1 for true) and are converted to Boolean objects when data is retrieved.

Date

A column with Date affinity stores date and time values. A Date column is designed to accept values that are ActionScript or JavaScript Date instances. If an attempt is made to store a String value in a Date column, the runtime attempts to convert it to a Julian date. If the conversion fails an error occurs. If code attempts to store a Number, int, or uint value, no attempt is made to validate the data and it is assumed to be a valid Julian date value. A Date value that's retrieved using a SELECT statement is automatically converted to a Date instance. Date values are stored as Julian date values using the REAL storage class, so sorting and comparing operations work as you would expect them to.

XML or XMLList

A column that uses XML or XMLList affinity stores XML structures. When code attempts to store data in an XML column using a SQLStatement parameter the runtime attempts to convert and validate the value using the ActionScript XML() or XMLList() function. If the value cannot be converted to valid XML an error occurs. If the attempt to store the data uses a literal SQL text value (for example INSERT INTO (col1) VALUES ('Invalid XML (no closing tag)'), the value is not parsed or validated — it is assumed to be well-formed. If an invalid value is stored, when it is retrieved it is returned as an empty XML object. XML and XMLList Data is stored using the TEXT storage class or the NULL storage class.

Object

A column with Object affinity stores ActionScript or JavaScript complex objects, including Object class instances as well as instances of Object subclasses such as Array instances and even custom class instances. Object column data is serialized in AMF3 format and stored using the BLOB storage class. When a value is retrieved, it is deserialized from AMF3 and returned as an instance of the class as it was stored. Note that some ActionScript classes, notably display objects, cannot be deserialized as instances of their original data type. Before storing a custom class instance, you must register an alias for the class using the flash.net.registerClassAlias() method (or in Flex by adding [RemoteObject] metadata to the class declaration). Also, before retrieving that data you must register the same alias for the class. Any data that can't be deserialized properly, either because the class inherently can't be deserialized or because of a missing or mismatched class alias, is returned as an anonymous object (an Object class instance) with properties and values corresponding to the original instance as stored.

NONE

A column with affinity NONE does not prefer one storage class over another. It makes no attempt to convert data before it is inserted.

Determining affinity

The type affinity of a column is determined by the declared type of the column in the CREATE TABLE statement. When determining the type the following rules (not case-sensitive) are applied:

- If the data type of the column contains any of the strings "CHAR", "CLOB", "STRI", or "TEXT" then that column has TEXT/String affinity. Notice that the type VARCHAR contains the string "CHAR" and is thus assigned TEXT affinity.
- If the data type for the column contains the string "BLOB" or if no data type is specified then the column has affinity NONE.
- If the data type for column contains the string "XMLL" then the column has XMLList affinity.
- If the data type is the string "XML" then the column has XML affinity.
- If the data type contains the string "OBJE" then the column has Object affinity.
- If the data type contains the string "BOOL" then the column has Boolean affinity.
- If the data type contains the string "DATE" then the column has Date affinity.
- If the data type contains the string "INT" (including "UINT") then it is assigned INTEGER/int affinity.
- If the data type for a column contains any of the strings "REAL", "NUMB", "FLOA", or "DOUB" then the column has REAL/Number affinity.
- Otherwise, the affinity is NUMERIC.
- If a table is created using a CREATE TABLE t AS SELECT... statement then all columns have no data type specified and they are given the affinity NONE.

Data types and comparison operators

The following binary comparison operators =, <, <=, >= and != are supported, along with an operation to test for set membership, IN, and the ternary comparison operator BETWEEN. For details about these operators see Operators.

The results of a comparison depend on the storage classes of the two values being compared. When comparing two values the following rules are applied:

- A value with storage class NULL is considered less than any other value (including another value with storage class NULL).
- An INTEGER or REAL value is less than any TEXT or BLOB value. When an INTEGER or REAL is compared to another INTEGER or REAL, a numerical comparison is performed.
- A TEXT value is less than a BLOB value. When two TEXT values are compared, a binary comparison is performed.
- When two BLOB values are compared, the result is always determined using a binary comparison.

The ternary operator BETWEEN is always recast as the equivalent binary expression. For example, a BETWEEN b AND c is recast to a >= b AND a <= c, even if this means that different affinities are applied to a in each of the comparisons required to evaluate the expression.

Expressions of the type a IN (SELECT b ....) are handled by the three rules enumerated previously for binary comparisons, that is, in a similar manner to a = b. For example, if b is a column value and a is an expression, then the affinity of b is applied to a before any comparisons take place. The expression a IN (x, y, z) is recast as a = +x OR a = +y OR a = +z. The values to the right of the IN operator (the x, y, and z values in this example) are considered to be expressions, even if they happen to be column values. If the value of the left of the IN operator is a column, then the affinity of that column is used. If the value is an expression then no conversions occur.

How comparisons are performed can also be affected by the use of a COLLATE clause. For more information, see COLLATE.

Data types and mathematical operators

For each of the supported mathematical operators, *, /, %, +, and -, numeric affinity is applied to each operand before evaluating the expression. If any operand cannot be converted to the NUMERIC storage class successfully the expression evaluates to NULL.

When the concatenation operator || is used each operand is converted to the TEXT storage class before the expression is evaluated. If any operand cannot be converted to the TEXT storage class then the result of the expression is NULL. This inability to convert the value can happen in two situations, if the value of the operand is NULL, or if it's a BLOB containing a non-TEXT storage class.

Data types and sorting

When values are sorted by an ORDER BY clause, values with storage class NULL come first. These are followed by INTEGER and REAL values interspersed in numeric order, followed by TEXT values in binary order or based on the specified collation (BINARY or NOCASE). Finally come BLOB values in binary order. No storage class conversions occur before the sort.

Data types and grouping

When grouping values with the GROUP BY clause, values with different storage classes are considered distinct. An exception is INTEGER and REAL values which are considered equal if they are numerically equivalent. No affinities are applied to any values as the result of a GROUP BY clause.

Data types and compound SELECT statements

The compound SELECT operators UNION, INTERSECT, and EXCEPT perform implicit comparisons between values. Before these comparisons are performed an affinity may be applied to each value. The same affinity, if any, is applied to all values that may be returned in a single column of the compound SELECT result set. The affinity that is applied is the affinity of the column returned by the first component SELECT statement that has a column value (and not some other kind of expression) in that position. If for a given compound SELECT column none of the component SELECT statements return a column value, no affinity is applied to the values from that column before they are compared.

Chapter 67: SQL error detail messages, ids, and arguments

The SQLError class represents various errors that can occur while working with an Adobe AIR local SQL database. For any given exception, the SQLError instance has a `details` property containing an English error message. In addition, each error message has an associated unique identifier that is available in the SQLError object's `detailID` property. Using the `detailID` property, an application can identify the specific details error message. The application can provide alternate text for the end user in the language of his or her locale. The argument values in the `detailArguments` array can be substituted in the appropriate position in the error message string. This is useful for applications that display the `details` property error message for an error directly to end users in a specific locale.

The following table contains a list of the `detailID` values and the associated English error message text. Placeholder text in the messages indicates where `detailArguments` values are substituted in by the runtime. This list can be used as a source for localizing the error messages that can occur in SQL database operations.

SQLError detailID	English error detail message and parameters
1001	Connection closed.
1102	Database must be open to perform this operation.
1003	%s [,|and %s] parameter name(s) found in parameters property but not in the SQL specified.
1004	Mismatch in parameter count. Found %d in SQL specified and %d value(s) set in parameters property. Expecting values for %s [,|and %s].
1005	Auto compact could not be turned on.
1006	The pageSize value could not be set.
1007	The schema object with name '%s' of type '%s' in database '%s' was not found.
1008	The schema object with name '%s' in database '%s' was not found.
1009	No schema objects with type '%s' in database '%s' were found.
1010	No schema objects in database '%s' were found.
2001	Parser stack overflow.
2002	Too many arguments on function '%s'
2003	near '%s': syntax error
2004	there is already another table or index with this name: '%s'
2005	PRAGMA is not allowed in SQL.
2006	Not a writable directory.
2007	Unknown or unsupported join type: '%s %s %s'
2008	RIGHT and FULL OUTER JOINs are not currently supported.
2009	A NATURAL join may not have an ON or USING clause.
2010	Cannot have both ON and USING clauses in the same join.
2011	Cannot join using column '%s' - column not present in both tables.
2012	Only a single result allowed for a SELECT that is part of an expression.
2013	No such table: '[%s.]%s'
2014	No tables specified.
2015	Too many columns in result set|too many columns on '%s'.
2016	%s ORDER|GROUP BY term out of range - should be between 1 and %d
2017	Too many terms in ORDER BY clause.
2018	%s ORDER BY term out of range - should be between 1 and %d.
2019	%r ORDER BY term does not match any column in the result set.
2020	ORDER BY clause should come after '%s' not before.
2021	LIMIT clause should come after '%s' not before.
2022	SELECTs to the left and right of '%s' do not have the same number of result columns.
2023	A GROUP BY clause is required before HAVING.
2024	Aggregate functions are not allowed in the GROUP BY clause.
2025	DISTINCT in aggregate must be followed by an expression.

2026	Too many terms in compound SELECT.
2027	Too many terms in ORDER|GROUP BY clause
2028	Temporary trigger may not have qualified name
2030	Trigger '%s' already exists
2032	Cannot create BEFORE|AFTER trigger on view: '%s'.
2033	Cannot create INSTEAD OF trigger on table: '%s'.
2034	No such trigger: '%s'
2035	Recursive triggers not supported ('%s').
2036	No such column: %s[.%s[.%s]]
2037	VACUUM is not allowed from SQL.
2043	Table '%s': indexing function returned an invalid plan.
2044	At most %d tables in a join.
2046	Cannot add a PRIMARY KEY column.
2047	Cannot add a UNIQUE column.
2048	Cannot add a NOT NULL column with default value NULL.
2049	Cannot add a column with non-constant default.
2050	Cannot add a column to a view.
2051	ANALYZE is not allowed in SQL.
2052	Invalid name: '%s'
2053	ATTACH is not allowed from SQL.
2054	%s '%s' cannot reference objects in database '%s'
2055	Access to '[%s.]%s.%s' is prohibited.
2056	Not authorized.
2058	No such view: '[%s.]%s'
2060	Temporary table name must be unqualified.
2061	Table '%s' already exists.
2062	There is already an index named: '%s'
2064	Duplicate column name: '%s'
2065	Table '%s' has more than one primary key.
2066	AUTOINCREMENT is only allowed on an INTEGER PRIMARY KEY
2067	No such collation sequence: '%s'
2068	Parameters are not allowed in views.
2069	View '%s' is circularly defined.
2070	Table '%s' may not be dropped.
2071	Use DROP VIEW to delete view '%s'
2072	Use DROP TABLE to delete table '%s'
2073	Foreign key on '%s' should reference only one column of table '%s'
2074	Number of columns in foreign key does not match the number of columns in the referenced table.
2075	Unknown column '%s' in foreign key definition.
2076	Table '%s' may not be indexed.
2077	Views may not be indexed.
2080	Conflicting ON CONFLICT clauses specified.
2081	No such index: '%s'
2082	Index associated with UNIQUE or PRIMARY KEY constraint cannot be dropped.
2083	BEGIN is not allowed in SQL.
2084	COMMIT is not allowed in SQL.
2085	ROLLBACK is not allowed in SQL.
2086	Unable to open a temporary database file for storing temporary tables.
2087	Unable to identify the object to be reindexed.
2088	Table '%s' may not be modified.
2089	Cannot modify '%s' because it is a view.
2090	Variable number must be between ?0 and ?%d<
2092	Misuse of aliased aggregate '%s'
2093	Ambiguous column name: '[%s.[%s.]]%s'
2094	No such function: '%s'
2095	Wrong number of arguments to function '%s'
2096	Subqueries prohibited in CHECK constraints.
2097	Parameters prohibited in CHECK constraints.

2098	Expression tree is too large (maximum depth %d)
2099	RAISE() may only be used within a trigger-program
2100	Table '%s' has %d columns but %d values were supplied
2101	Database schema is locked: '%s'
2102	Statement too long.
2103	Unable to delete/modify collation sequence due to active statements
2104	Too many attached databases - max %d
2105	Cannot ATTACH database within transaction.
2106	Database '%s' is already in use.
2108	Attached databases must use the same text encoding as main database.
2200	Out of memory.
2201	Unable to open database.
2202	Cannot DETACH database within transaction.
2203	Cannot detach database: '%s'
2204	Database '%s' is locked.
2205	Unable to acquire a read lock on the database.
2206	[column|columns] '%s'[,'%s'] are not [unique|is] not unique.
2207	Malformed database schema.
2208	Unsupported file format.
2209	Unrecognized token: '%s'
2300	Could not convert text value to numeric value.
2301	Could not convert string value to date.
2302	Could not convert floating point value to integer without loss of data.
2303	Cannot rollback transaction - SQL statements in progress.
2304	Cannot commit transaction - SQL statements in progress.
2305	Database table is locked: '%s'
2306	Read-only table.
2307	String or blob too big.
2309	Cannot open indexed column for writing.
2400	Cannot open value of type %s.
2401	No such rowid: %s<
2402	Object name reserved for internal use: '%s'
2403	View '%s' may not be altered.
2404	Default value of column '%s' is not constant.
2405	Not authorized to use function '%s'
2406	Misuse of aggregate function '%s'
2407	Misuse of aggregate: '%s'
2408	No such database: '%s'
2409	Table '%s' has no column named '%s'
2501	No such module: '%s'
2508	No such savepoint: '%s'
2510	Cannot rollback - no transaction is active.
2511	Cannot commit - no transaction is active.

Chapter 68: Adobe Graphics Assembly Language (AGAL)

The Adobe Graphics Assembly Language (AGAL) is a shader language for defining vertex and fragment rendering programs. The AGAL programs must be uploaded to the rendering context in the binary bytecode format described in this document.

AGAL bytecode format

AGAL bytecode must use Endian.LITTLE_ENDIAN format.

Bytecode Header

AGAL bytecode must begin with a 7-byte header:

```
A0 01000000 A1 00 -- for a vertex program
A0 01000000 A1 01 -- for a fragment program
```

Offset (bytes)	Size (bytes)	Name	Description
0	1	magic	must be 0xa0
1	4	version	must be 1
5	1	shader type ID	must be 0xa1
6	1	shader type	0 for a vertex program; 1 for a fragment program

Tokens

The header is immediately followed by any number of tokens. Every token is 192 bits (24 bytes) in size and always has the format:

```
[opcode][destination][source1][source2 or sampler]
```

Not every opcode uses all of these fields. Unused fields must be set to 0.

Operation codes

The [opcode] field is 32 bits in size and can take one of these values:

Name	Opcode	Operation	Description
mov	0x00	move	move data from source1 to destination, component-wise
add	0x01	add	destination = source1 + source2, component-wise
sub	0x02	subtract	destination = source1 - source2, component-wise
mul	0x03	multiply	destination = source1 * source2, component-wise
div	0x04	divide	destination = source1 / source2, component-wise
rcp	0x05	reciprocal	destination = 1/source1, component-wise

Name	Opcode	Operation	Description
min	0x06	minimum	destination = minimum(source1,source2), component-wise
max	0x07	maximum	destination = maximum(source1,source2), component-wise
frc	0x08	fractional	destination = source1 - (float)floor(source1), component-wise
sqt	0x09	square root	destination = sqrt(source1), component-wise
rsq	0x0a	reciprocal root	destination = 1/sqrt(source1), component-wise
pow	0x0b	power	destination = pow(source1,source2), component-wise
log	0x0c	logarithm	destination = log_2(source1), component-wise
exp	0x0d	exponential	destination = 2^source1, component-wise
nrm	0x0e	normalize	destination = normalize(source1), component-wise (produces only a 3 component result, destination must be masked to .xyz or less)
sin	0x0f	sine	destination = sin(source1), component-wise
cos	0x10	cosine	destination = cos(source1), component-wise

crs	0x11	cross product	destination.x = source1.y * source2.z - source1.z * source2.y
			
			destination.y = source1.z * source2.x - source1.x * source2.z
			
			destination.z = source1.x * source2.y - source1.y * source2.x
			
			(produces only a 3 component result, destination must be masked to .xyz or less)

dp3	0x12	dot product	destination = source1.x*source2.x + source1.y*source2.y + source1.z*source2.z
dp4	0x13	dot product	destination = source1.x*source2.x + source1.y*source2.y + source1.z*source2.z + source1.w*source2.w
abs	0x14	absolute	destination = abs(source1), component-wise
neg	0x15	negate	destination = -source1, component-wise
sat	0x16	saturate	destination = maximum(minimum(source1,1),0), component-wise

m33	0x17	multiply matrix 3x3	destination.x = (source1.x * source2[0].x) + (source1.y * source2[0].y) + (source1.z * source2[0].z)
			
			destination.y = (source1.x * source2[1].x) + (source1.y * source2[1].y) + (source1.z * source2[1].z)
			
			destination.z = (source1.x * source2[2].x) + (source1.y * source2[2].y) + (source1.z * source2[2].z)
			
			(produces only a 3 component result, destination must be masked to .xyz or less)

m44	0x18	multiply matrix 4x4	destination.x = (source1.x * source2[0].x) + (source1.y * source2[0].y) + (source1.z * source2[0].z) + (source1.w * source2[0].w)
			
			destination.y = (source1.x * source2[1].x) + (source1.y * source2[1].y) + (source1.z * source2[1].z) + (source1.w * source2[1].w)
			
			destination.z = (source1.x * source2[2].x) + (source1.y * source2[2].y) + (source1.z * source2[2].z) + (source1.w * source2[2].w)
			
			destination.w = (source1.x * source2[3].x) + (source1.y * source2[3].y) + (source1.z * source2[3].z) + (source1.w * source2[3].w)

Name	**Opcode**	**Operation**	**Description**

m34	0x19	multiply matrix 3x4	destination.x = (source1.x * source2[0].x) + (source1.y * source2[0].y) + (source1.z * source2[0].z) + (source1.w * source2[0].w)
			destination.y = (source1.x * source2[1].x) + (source1.y * source2[1].y) + (source1.z * source2[1].z) + (source1.w * source2[1].w)
			destination.z = (source1.x * source2[2].x) + (source1.y * source2[2].y) + (source1.z * source2[2].z) + (source1.w * source2[2].w)
			(produces only a 3 component result, destination must be masked to .xyz or less)

kil	0x27	kill/discard (fragment shader only)	If single scalar source component is less than zero, fragment is discarded and not drawn to the frame buffer. (Destination register must be set to all 0)
tex	0x28	texture sample (fragment shader only)	destination equals load from texture source2 at coordinates source1. In this case, source2 must be in sampler format.
sge	0x29	set-if-greater-equal	destination = source1 >= source2 ? 1 : 0, component-wise
slt	0x2a	set-if-less-than	destination = source1 < source2 ? 1 : 0, component-wise
seq	0x2c	set-if-equal	destination = source1 == source2 ? 1 : 0, component-wise
sne	0x2d	set-if-not-equal	destination = source1 != source2 ? 1 : 0, component-wise

In AGAL2, the following opcodes have been introduced:

Name	**Opcode**	**Operation**	**Description**
ddx	0x1a	partial derivative in X	Load partial derivative in X of source1 into destination.
ddy	0x1b	partial derivative in Y	Load partial derivative in Y of source1 into destination.
ife	0x1c	if equal to	Jump if source1 is equal to source2.
ine	0x1d	if not equal to	Jump if source1 is not equal to source2.
ifg	0x1e	if greater than	Jump if source1 is greater than or equal to source2.
ifl	0x1f	if less than	Jump if source1 is less than source2.
els	0x20	else	Else block
eif	0x21	Endif	Close if or else block.

Destination field format

The [destination] field is 32 bits in size:

```
31.............................0
----TTTT----MMMMNNNNNNNNNNNNNNNN
```

T = Register type (4 bits)

M = Write mask (4 bits)

N = Register number (16 bits)

- = undefined, must be 0

Source field format

The [source] field is 64 bits in size:

```
63.............................................................0
D-------------QQ----IIII----TTTTSSSSSSSSOOOOOOOONNNNNNNNNNNNNNNN
```

D = Direct=0/Indirect=1 for direct Q and I are ignored, 1bit

Q = Index register component select (2 bits)

I = Index register type (4 bits)

T = Register type (4 bits)

S = Swizzle (8 bits, 2 bits per component)

O = Indirect offset (8 bits)

N = Register number (16 bits)

- = undefined, must be 0

Sampler field format

The second source field for the tex opcode must be in [sampler] format, which is 64 bits in size:

```
63.............................................................0
FFFFMMMMWWWWSSSSDDDD--------TTTT--------BBBBBBBBNNNNNNNNNNNNNNNN
```

N = Sampler register number (16 bits)

B = Texture level-of-detail (LOD) bias, signed integer, scale by 8. The floating point value used is b/8.0 (8 bits)

T = Register type, must be 5, Sampler (4 bits)

F = Filter (0=nearest,1=linear) (4 bits)

M = Mipmap (0=disable,1=nearest, 2=linear)

W = Wrapping (0=clamp,1=repeat)

S = Special flag bits (must be 0)

D = Dimension (0=2D, 1=Cube)

Program Registers

The number of registers used depend upon the Context3D profile used. The number of registers along with their usage are defined in the following table:

Name **AGAL2** **AGAL3** **Usage**	**Value**	**AGAL**	
Number per fragment program Number per vertex program Number per fragment program Number per vertex program		Number per fragment program	Number per vertex program
Context 3D Profiles Support Standard Standard Extended		Below Standard	
SWF version 25 28 and above		Below 25	
Attribute NA 8 NA 16 Vertex shader input; read from a vertex buffer specified using Context3D .setVertex BufferAt().	0	NA	8

Name **AGAL2** **AGAL3** **Usage**	**Value**	**AGAL**	
Constant 64 250 200 250 Shader input; set using the Context3D.setProgramConstants() family of functions.	1	28	128
Temporary 26 26 26 26 Temporary register for computation; not accessible outside program.	2	8	8
Output 1 1 1 1 Shader output: in a vertex program, the output is the clip space position; in a fragment program, the output is a color.	3	1	1

Name **AGAL2** **AGAL3** **Usage**	**Value**	**AGAL**	
Varying 10 10 10 10 Transfer interpolated data between vertex and fragment shaders. The varying registers from the vertex program are applied as input to the fragment program. Values are interpolated according to the distance from the triangle vertices.	4	8	8

Name **AGAL2** **AGAL3** **Usage**	**Value**	**AGAL**	
Sampler 16 NA 16 NA Fragment shader input; read from a texture specified using Context3D.setTextureAt().	5	8	NA
Fragment register 1 NA 1 NA It is write-only and used to re-write z-value (or depth value) written in vertex shader.	6	NA	NA
Tokens 1024 2048		200	

The latest AGAL Mini Assembler can be found here.