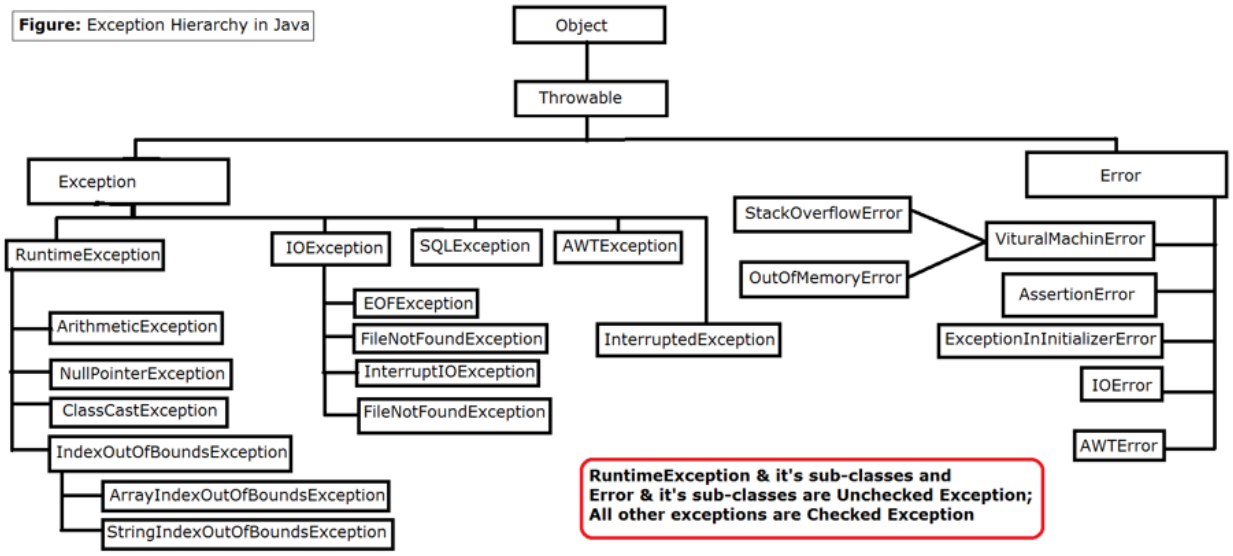
Exception Handling

The Exception Hierarchy

- All exception classes are derived from a class called **Throwable**.
- When an exception occurs in a program an object of some type of exception class is generated.
- There are 2 direct subclasses of **Throwable**: **exception** and **error**.
- Exceptions of type Error are related to errors that are beyond the control, which occur in JVM itself.
- Errors that result from program activity are represented by subclasses of Exception

Figure: Exception Hierarchy in Java



Exception-Handling Fundamentals

- Java exception handling is managed via five keywords: **try**, **catch**, **throw**, **throws**, and **finally**.
- Program statements that you want to monitor for exceptions are contained within a **try** block. If an exception occurs within the try block, it is thrown.
- Code can catch this exception (using **catch**) and handle it in some rational manner
- System-generated exceptions are automatically thrown by the Java run-time system.
- To manually throw an exception, use the keyword **throw**.
- Any exception that is thrown out of a method must be specified as such by a **throws** clause

Using try and catch

- This is the general form of an exception-handling block:

```
try {
   // block of code to monitor for errors
}
```

```
catch (ExceptionType1 exOb) {
   // exception handler for ExceptionType1
}

catch (ExceptionType2 exOb) {
   // exception handler for ExceptionType2
}
```

- *ExceptionType* is the type of exception that has occurred
- When an exception is thrown, it is caught by its corresponding **catch** clause
- There can be more than one catch clause associated with a **try** block
- The type of the exception determines which **catch** is executed
- If the exception type specified by a catch matches that of the exception, then that catch clause is executed. All other catch clauses are bypassed
- If no exception is thrown, then a try block ends normally
- If no exception is thrown by a try block, no catch clause will be executed and program control will resume after the catch.

```
class Example{
    public static void main(String[] args) {
        int d,a;
        try{
            d=0;
            a=25/d; //throws an exception object of type ArithmeticException
            System.out.println("What happens to this statement?");
        }
        catch(ArithmeticException e){
            //e is the reference variable which will hold the exception
            //object thrown by the catch clause
            System.out.println("Division by zero error!!");
        }
        System.out.println("Executes after the catch statement");
    }
}
```

OUTPUT:

```
Division by zero error!!
Executes after the catch statement
```

Key points on Exception Handling

- The code which may generate errors need to be contained within **try** block.
- When an exception occurs, the exception is thrown out of the **try** block making the **try** block to terminate. Then that exception will be caught by the **catch** block.
- Hence, the call to **println( )** inside the **try** block in the above code is never executed. Once an exception is thrown, program control transfers out of the **try** block into the **catch** block.
- **catch** is not "called," so execution never "returns" to the **try** block from a **catch**. Thus, the line "This will not be printed." is not displayed.
- Once the **catch** statement has executed, program control continues with the next line in the program following the entire **try**/**catch** mechanism.

Ex:2

```
class Example{
    public static void main(String[] args) {
        int d,a;
        try{
            d=2;
            a=25/d; //No exception is thrown
            System.out.println("What happens to this statement?");
        }
        catch(ArithmeticException e){ //control does not enter catch
                                      //as no exception is thrown
            System.out.println("Division by zero error!!");
        }
        System.out.println("Executes after the catch statement");
    }
}
```

OUTPUT:

```
What happens to this statement?
Executes after the catch statement
```

- In the above program, no exception is thrown, hence catch clause is not executed

Ex 3: Exception generated by a method called from within try block

```
class Method{
    static void division(){
        int c = 23/0; //exception is generated here
//causes an exception which will be thrown to the
//calling method(main()) as division() method is not
//handling the exception
        System.out.println("Division by zero error");//won't be executed
    }
}
public class MethodException {
    public static void main(String[] args) {
        try{
            Method.division();
        }
        catch(ArithmeticException e){ //exception is caught here
            System.out.println("Can't divide by zero");
        }
    }
}
```

OUTPUT:

```
Can't divide by zero
```

- **division**() is called from within try block, the exception that it generates is caught by the catch in main()
- if **division**() had caught the exception itself, it never would have been passed back to main().

For Example,

```
class Method{
    static void division(){
        try{
            int c = 23/0; //exception is generated here
        }
        catch(ArithmeticException e){ //exception is caught here
            System.out.println("Division by zero error");
        }
    }
}
public class MethodException {
    public static void main(String[] args) {
        try{
            Method.division();
        }
        catch(ArithmeticException e){ //exception is not propagated here
                                      //as division method is handling it
            System.out.println("Can't divide by zero"); //doesn't execute
        }
    }
}
```

OUTPUT:

```
Division by zero error
```

The Consequences of an Uncaught Exception

- If the program does not catch an exception, then it will be caught by the JVM
- But, JVM default exception handler terminates execution and displays an error message followed by list of method calls that cause the exception (referred as stack trace)→ "abnormal termination"
- For example,

```
class Demo{
    public static void main(String[] args) {
        int[] a = new int[4];
        System.out.println("Before exception is generated");
        a[5]=20; //generates an index out-of-bounds exception
    }
}
```

OUTPUT:

```
Before exception is generated
Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException: Index 5 out of bounds
        at Demo.main(Demo.java:5)
Command execution failed.
```

- As you can see in the output, program terminates as soon as exception occurs
- The type of the exception must match the type specified in a catch. If it does not, the exception would not be caught.
- For example,

```
class Demo{
    public static void main(String[] args) {
        int[] a = new int[4];
        try{
            System.out.println("Before exception is generated");
            a[5]=20; //throws an ArrayIndexOutOfBoundsException
            System.out.println("This won't be displayed");
        }
        catch(ArithmeticException e){ //can't catch an array boundary
                                      //error with an ArithmeticException
            System.out.println("Index out of bounds");
        }
        System.out.println("After the catch");
    }
}
```

OUTPUT:

```
Before exception is generated
Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException: Index 5 out of bounds
        at Demo.main(Demo.java:5)
Command execution failed.
```

- The above program tries to catch an array boundary error with a catch for ArithmeticException, whereas ArrayOutOfBoundsException is generated when the array boundary is overrun.

Exceptions Enable You to Handle Errors Gracefully

- One of the key benefits of exception handling is that it enables the program to respond to an error in a graceful way
- An exception handler can prevent abrupt program termination
- For example,

```
public class ExceptionDemo {
    public static void main(String[] args) {
        int[] numer = {10,20,30,40,50};
        int[] denom = {2,0,5,0,3};
        for(int i=0; i<numer.length; i++){
            try{
                System.out.println(numer[i]+"/"+denom[i]+" is "
                                   +numer[i]/denom[i]);
            }
            catch(ArithmeticException ex){
                System.out.println("Can't divide by zero");
            }

        }
        System.out.println("Program terminates normally");
    }
}
```

OUTPUT:

```
10/2 is 5
Can't divide by zero
30/5 is 6
Can't divide by zero
50/3 is 16
Program terminates normally
```

- In the above program, if a division by zero occurs, an ArithmeticException is generated. This exception is handled by reporting the error and then continue with execution
- Thus, attempting to divide by zero does not cause an abrupt termination of the program. Instead, it is handled and program execution is allowed to continue

Using Multiple catch Clauses

- In some cases, more than one exception could be raised by a single piece of code.
- To handle this type of situation, you can specify two or more **catch** clauses, each catching a different type of exception.
- When an exception is thrown, each **catch** statement is inspected in order, and the first one whose type matches that of the exception is executed.
- After one **catch** statement executes, the others are bypassed, and execution continues after the **try**/**catch** block.

```
public class ExceptionDemo {
    public static void main(String[] args) {
        int[] numer = {10,20,30,40,50,60,70};
        int[] denom = {2,0,5,0,3};
        for(int i=0; i<numer.length; i++){
            try{
                System.out.println(numer[i]+"/"+denom[i]+" is "
                                   +numer[i]/denom[i]);
            }
            catch(ArithmeticException e){
                System.out.println("Can't divide by zero");
            }
            catch(ArrayIndexOutOfBoundsException e){
                System.out.println("No matching element found");
            }
        }
        System.out.println("Program terminates normally");
    }
}
```

OUTPUT:

```
10/2 is 5
Can't divide by zero
30/5 is 6
Can't divide by zero
50/3 is 16
No matching element found
No matching element found
Program terminates normally
```

- Each catch responds only to its own type of exception
- **catch** clauses are checked in the order in which they occur in a program

Catching Subclass Exceptions

- When you use multiple **catch** statements, it is important to remember that exception subclasses must come before any of their superclasses.
- This is because a **catch** statement that uses a superclass will catch exceptions of that type plus any of its subclasses. Thus, a subclass would never be reached if it comes after its superclass.

```
/* This program contains an error.

   A subclass must come before its superclass in
   a series of catch statements. If not,
   unreachable code will be created and a
   compile-time error will result.
*/
class SuperSubCatch {
  public static void main(String args[]) {
    try {
      int a = 0;
      int b = 42 / a;
    } catch(Exception e) {
```

```
            System.out.println("Generic Exception catch.");
          }
          /* This catch is never reached because
             ArithmeticException is a subclass of Exception. */
          catch(ArithmeticException e) { // ERROR - unreachable
            System.out.println("This is never reached.");
          }
        }
      }
```

- **catch** statement will handle all **Exception**-based errors, including **ArithmeticException**. This means that the second **catch** statement will never execute
- To solve this problem, Superclass Exception class must be included as the last catch clause

Nested try blocks

- A **try** statement can be inside the block of another **try**.
- An exception generated within the inner try block that is not caught by a catch associated with that try is propagated to the outer try block

```
public class NestedTry {
    public static void main(String[] args) {
       int[] numer = {10,20,30,40,50,60,70};
       int[] denom = {2,0,5,0,3};
        try{
            for(int i=0; i<numer.length; i++){
                try{
                    System.out.println(numer[i]+"/"+denom[i]+" is "
                                       +numer[i]/denom[i]);
                }
                catch(ArithmeticException e){
                    System.out.println("Can't divide by zero");
                }
            }
        }
        catch(ArrayIndexOutOfBoundsException e){
            System.out.println("No matching element found");
        }
        System.out.println("Program terminates normally");
    }
}
```

OUTPUT:

```
10/2 is 5
Can't divide by zero
30/5 is 6
Can't divide by zero
50/3 is 16
No matching element found
Program terminates normally
```

- In this example, an exception that can be handled by the inner try, a divide by zero allows the program to continue.
- An array error boundary error is caught by the outer try which terminates the program

Throwing an Exception

- Preceding examples have only been catching exceptions that are thrown by the Java run-time system.
- However, it is possible for the program to throw an exception explicitly, using the **throw** statement.
- The general form of **throw** is as follows:

  throw exceptOb;
- exceptOb must be an object of an exception class derived from Throwable
- **throw** throws an object

```
class ExceptDemo{
    public static void main(String[] args) {
        try{
            System.out.println("Before throwing an exception");
            throw new ArithmeticException();
            //throws an exception explicitly
        }
        catch(ArithmeticException e){
            System.out.println("Exception caught");
        }
        System.out.println("After try/catch block");
    }
}
```

OUTPUT:

```
Before throwing an exception
Exception caught
After try/catch block
```

Rethrowing an Exception

- An exception caught by one catch can be rethrown so that it can be caught by an outer **catch**

For example,

```
class ReDemo{
    static void division(){
        try{
            int c = 20/0;
        }
        catch(ArithmeticException ex){
            System.out.println("Rethrows the exception");
            throw ex; //rethrowing the exception which is
                      //already caught by this catch
        }
    }
}
public class ReThrow {
    public static void main(String[] args) {
        try{
            ReDemo.division();
            System.out.println("This will be excecuted after "
                    + "returning from the division method");
        }
        catch(ArithmeticException e){//rethrown exception is caught here
            System.out.println("Division by zero");
        }
    }
}
```

- First, **main( )** sets up an exception context and then calls **division( )**.
- The **division()** method then sets up another exception handling context and immediately throws a new instance of ArithmeticException, which is caught on the next line. The exception is then rethrown**.**

Throwable

Method	Description
Throwable fillInStackTrace( )	Returns a **Throwable** object that contains a completed stack trace. This object can be rethrown.
String getLocalizedMessage( )	Returns a localized description of the exception.
String getMessage( )	Returns a description of the exception.
void printStackTrace( )	Displays the stack trace.
void printStackTrace(PrintStream *stream*)	Sends the stack trace to the specified stream.
void printStackTrace(PrintWriter *stream*)	Sends the stack trace to the specified stream.
String toString( )	Returns a **String** object containing a complete description of the exception. This method is called by **println( )** when outputting a **Throwable** object.

```
// Using two Throwable methods.

class ExcTest {
  static void genException() {
    int[] nums = new int[4];

    System.out.println("Before exception is generated.");

    // generate an index out-of-bounds exception
    nums[7] = 10;
    System.out.println("this won't be displayed");
  }
}

class UseThrowableMethods {
  public static void main(String[] args) {

    try {
      ExcTest.genException();
    }
    catch (ArrayIndexOutOfBoundsException exc) {
      // catch the exception
      System.out.println("Standard message is: ");
      System.out.println(exc);
      System.out.println("\nStack trace: ");
      exc.printStackTrace();
    }
    System.out.println("After catch.");
  }
}
```

The output from this program is shown here.

```
Before exception is generated.
Standard message is:
java.lang.ArrayIndexOutOfBoundsException: 7

Stack trace:
java.lang.ArrayIndexOutOfBoundsException: 7
    at ExcTest.genException(UseThrowableMethods.java:10)
    at UseThrowableMethods.main(UseThrowableMethods.java:19)
After catch.
```

Using finally

- A finally block will be executed whenever execution leaves a try/catch block, no matter what condition causes it
- Whether the try block ends normally, or because of an exception, the last code executed is that defined by **finally**
- The **finally** block is also executed if any code within the try block/ any of its **catch** clause return from a method
- The **finally** clause is optional. However, each **try** statement requires at least one **catch** or a **finally** clause
- The general form of **try/catch** that includes finally is

```
try
{
   // statements to try
}
catch(Exception e)
{
   // actions that occur if exception was thrown
}
finally
{
   // actions that occur whether catch block executed or not
}
```

Example,

```
class ReDemo{
    static void division(){
        try{
            int c = 20/0;
        }
        catch(ArithmeticException ex){
            System.out.println("Catches an exception");
            return; //even if the method returns finally block will execute
        }
        finally{
            System.out.println("This executes even when the method returns");
        }
    }
}
public class ReThrow {
    public static void main(String[] args) {
        try{
            ReDemo.division();
            System.out.println("This will be excecuted after "
                    + "returning from the division method");
        }
        catch(ArithmeticException e){//rethrown exception is caught here
            System.out.println("Division by zero");
        }
    }
}
```

OUTPUT:

```
Catches an exception
This executes even when the method returns
This will be excecuted after returning from the division method
```

- In the above example, finally block is executed even after the method returns

Using throws

- If a method generates an exception that it does not handle, it must declare that exception in a **throws** clause. This can be done by including a **throws** clause in the method's declaration.
- A throws clause lists the types of exceptions that a method might throw.
- The general form a method that includes a **throws** clause:

```
type method-name(parameter-list) throws exception-list
{
  // body of method
}
```

- Here, *exception-list* is a comma-separated list of the exceptions that a method can throw

```
class ThrowsDemo
{
    public static void main(String[] args) throws InterruptedException
    {
        Thread.sleep(10000);
        System.out.println("Excecuted successfully");
    }
}

/*In the above program, we are getting compile time error
because there is a chance of exception
if the main thread is going to sleep,
other threads get the chance to execute main() method
which will cause InterruptedException. */
```

- In the above example**, main( )** throws **InterruptedException** but does not handle it
- **main( )** must define a **try**/**catch** statement that catches this exception.

Important Points about throws:

- **throws** keyword is required only for checked exception and usage of **throws** keyword for unchecked exception is meaningless.
- **throws** keyword is required only to convince compiler and usage of **throws** keyword does not prevent abnormal termination of program.

Java's Built-in Exceptions

- java.lang is implicitly imported into all Java programs

Exception	Meaning
ArithmeticException	Arithmetic error, such as divide-by-zero.
ArrayIndexOutOfBoundsException	Array index is out-of-bounds.
ArrayStoreException	Assignment to an array element of an incompatible type.
ClassCastException	Invalid cast.
EnumConstantNotPresentException	An attempt is made to use an undefined enumeration value.
IllegalArgumentException	Illegal argument used to invoke a method.
IllegalMonitorStateException	Illegal monitor operation, such as waiting on an unlocked thread.
IllegalStateException	Environment or application is in incorrect state.
IllegalThreadStateException	Requested operation not compatible with current thread state.
IndexOutOfBoundsException	Some type of index is out-of-bounds.
NegativeArraySizeException	Array created with a negative size.
NullPointerException	Invalid use of a null reference.
NumberFormatException	Invalid conversion of a string to a numeric format.
SecurityException	Attempt to violate security.
StringIndexOutOfBounds	Attempt to index outside the bounds of a string.
TypeNotPresentException	Type not found.
UnsupportedOperationException	An unsupported operation was encountered.

TABLE 10-1 Java's Unchecked **RuntimeException** Subclasses Defined in **java.lang**

Exception	Meaning
ClassNotFoundException	Class not found.
CloneNotSupportedException	Attempt to clone an object that does not implement the **Cloneable** interface.
IllegalAccessException	Access to a class is denied.
InstantiationException	Attempt to create an object of an abstract class or interface.
InterruptedException	One thread has been interrupted by another thread.
NoSuchFieldException	A requested field does not exist.
NoSuchMethodException	A requested method does not exist.

TABLE 10-2 Java's Checked Exceptions Defined in **java.lang**

Exception Features Added by JDK 7 (FYI)

- Multi-catch feature
  - It allows 2 or more exceptions to be caught by the same catch clause
  - To create multi-catch, specify a list of exceptions within a single catch clause by separating each exception type in the list with the OR operator
  - Each multi catch parameter is implicitly **final**.

  catch(final ArithmeticException | ArrayIndexOutOfBoundsException e)

  Example

```
3  import java.io.IOException;
4  import java.sql.SQLException;
5
6  /** Copyright (c), AnkitMittal JavaMadeSoEasy.com */
7  public class ExceptionTest {
8      public static void main(String[] args) {
9
10         try{
11             int i=1;
12             if(i==1)
13                 throw new IOException();
14             else
15                 throw new SQLException();
16         }catch(IOException | SQLException ex){
17             System.out.println(ex + " handled ");
18         }
19
20     }
21 }
22
23 /*OUTPUT
24
25 java.io.IOException handled
26
27 */
```

- In the above program, single catch clause handles 2 types of Exceptions

Creating Exception Subclasses

- Two commonly used **Exception** constructors are:

  Exception( )

  Exception(String *msg*)

- The first form creates an exception that has no description.
- The second form lets you specify a description of the exception

The following example declares a new subclass of **Exception** and then uses that subclass to signal an error condition in a method. It overrides the **toString( )** method, allowing a carefully tailored description of the exception to be displayed.

```
// This program creates a custom exception type.
class MyException extends Exception {
  private int detail;

  MyException(int a) {
    detail = a;
  }

  public String toString() {
    return "MyException[" + detail + "]";
  }
}

class ExceptionDemo {
  static void compute(int a) throws MyException {
    System.out.println("Called compute(" + a + ")");
    if(a > 10)
      throw new MyException(a);
    System.out.println("Normal exit");
  }

  public static void main(String args[]) {
    try {
      compute(1);
      compute(20);
    } catch (MyException e) {
      System.out.println("Caught " + e);
    }
  }
}
```

- This example defines a subclass of **Exception** called **MyException**. This subclass is quite simple: it has only a constructor plus an overloaded **toString( )** method that displays the value of the exception.
- The **ExceptionDemo** class defines a method named **compute( )** that throws a **MyException** objec

PACKAGES

- It is helpful to group related pieces of a program together. This is accomplished by using a package.
- A package serves two purposes:
    - First, it provides a mechanism by which related pieces of a program can be organized as a unit. Classes defined within a package must be accessed through their package name.
    - Second, a package participates in Java's access control mechanism.
- Classes defined within a package can be made private to that package and not accessible by outside code.
- Hence, the package provides a means by which classes can be encapsulated.
- When you name a class, you are allocating a name from the **namespace**.
- No two classes can use the same name from the same **namespace**. This within a given namespace, each class name must be unique.
- In large programs, finding unique names for each class can be difficult. And also, you must avoid name collisions with code created by others
- The solution to these problems is the package, because it gives you a way to partition the namespace.
- When a class is defined within a package, the name of that package is attached to the class. Thus, avoiding name collisions with other classes that have the same name but are in other packages.

Defining a package

- All classes in Java belong to some package.
- When no package has been explicitly specified, the default or global package is used.
- The default package has no name.
- To create a package, use the package statement which is located at the top of a Java source file.
- A class declared within that file will belong to the specified package.
- The general form of the package statement is.

  package *pkg*;
- For example:

  package mypack;
- Hierarchy of packages can be created by separating each package name from the one above it by use of a period.
- The general form of a multi leveled package statement is

  package *pack1.pack2.pack3…….packN*;

Finding Packages and CLASSPATH

- The Java run-time system know where to look for packages that is created by doing following things:
    1. First, by default, the run-time system uses the current working directory as its starting point. If the package is in a subdirectory of the current directory, it will be found.

2. Second, a directory path or paths can be specified by setting the **CLASSPATH** environmental variable.
3. Third, the **-classpath** option can be used **java** and **javac** to specify the path to the classes

Example,

```
package BookDemo1;
class Book {
    private String title;
    private String author;
    private int year;

    Book(String t, String a, int y){
        title = t;
        author = a;
        year = y;
    }
    void show(){
        System.out.println(title);
        System.out.println(author);
        System.out.println(year);
    }
}
public class BookDemo1 {
   public static void main(String[] args) {
        Book[] b = new Book[5];
        b[0] = new Book("The Art pf Computer Programming", "Knuth", 1973);
        b[1] = new Book("Java Fundamentals", "Schildt", 2013);
        b[2] = new Book("Thirteen at Dinner", "Christie", 1933);
        b[3] = new Book("Red storm Rising", "Clancy", 1986);
        b[4] = new Book("On the Road", "Kerouac", 1955);
        for(int i=0; i<b.length; i++){
            b[i].show();
            System.out.println();
        }
    }
}
```

OUTPUT:

```
The Art pf Computer Programming
Knuth
1973

Java Fundamentals
Schildt
2013

Thirteen at Dinner
Christie
1933
```

```
Red storm Rising
Clancy
1986

On the Road
Kerouac
1955
```

Accessing a Package

- In the above example, if **Book** and **BookDemo1** were in different packages, then **Book** would not have been accessible to other package
- Following changes to be made to make **Book** available to other packages
    1. **Book** needs to be declared public
    2. Its constructor must be made public
    3. show( ) method needs to be public

Ex:

```
package bookpack;
public class Book {
    protected String title;
    protected String author;
    protected int date;

    public Book(String t, String a, int d){
        title = t;
        author = a;
        date = d;
    }
    public void show(){
        System.out.println(title);
        System.out.println(author);
        System.out.println(date);
    }
}
```

```
package mypack;
public class BookDemo {
    public static void main(String[] args) {
        bookpack.Book[] b = new bookpack.Book[5];
        b[0] = new bookpack.Book("The Art pf Computer Programming", "Knuth", 1973);
        b[1] = new bookpack.Book("Java Fundamentals", "Schildt", 2013);
        b[2] = new bookpack.Book("Thirteen at Dinner", "Christie", 1933);
        b[3] = new bookpack.Book("Red storm Rising", "Clancy", 1986);
        b[4] = new bookpack.Book("On the Road", "Kerouac", 1955);
        for(int i=0; i<b.length; i++){
            b[i].show();
            System.out.println();
        }

    }
}
```

- To access **Book**, we must fully qualify its name to include its full package specification
- Without this specification, **Book** would not be found
- Syntax is,

packageName.className;

Packages and Member Access

	default	private	protected	public
same class	yes	yes	yes	yes
same package subclass	yes	no	yes	yes
same package non-subclass	yes	no	yes	yes
different package subclass	no	no	yes	yes
different package non-subclass	no	no	no	yes

Protected Members

- protected modifier creates a member that is accessible within its package and to subclasses in other packages

```
package bookpack;
public class Book {
    protected String title;
    protected String author;
    protected int date;

    public Book(String t, String a, int d){
        title = t;
        author = a;
        date = d;
    }
    public void show(){
        System.out.println(title);
        System.out.println(author);
        System.out.println(date);
    }
}
```

```
package mypack;
public class BookDemo {
    public static void main(String[] args) {
        bookpack.Book[] b = new bookpack.Book[5];
        b[0] = new bookpack.Book("The Art pf Computer Programming", "Knuth", 1973);
        b[1] = new bookpack.Book("Java Fundamentals", "Schildt", 2013);
        b[2] = new bookpack.Book("Thirteen at Dinner", "Christie", 1933);
        b[3] = new bookpack.Book("Red storm Rising", "Clancy", 1986);
        b[4] = new bookpack.Book("On the Road", "Kerouac", 1955);
        for(int i=0; i<b.length; i++){
            b[i].show();
            System.out.println();
        }
        b[0].date=2014; //date has protected access in Book,
                        //so cannot be accessed in non subclass
    }
}
```

Importing Packages

- Qualifying the name of the class with name of its package is tedious and tiresome.
- import statement can be used to bring one or more members of a package into the scope
- The general form of the import statement is

  import pkg.className;
- pkg is the name of the package with its full path, className is the name of the class being imported. '*' is used to import the entire contents of a package

Ex:

import bookpack.Book; //Book class is imported from bookpack
import bookpack.*; //all of the classes in bookpack is imported

Ex:

```
package mypack;
import bookpack.Book;
public class BookDemo {
    public static void main(String[] args) {
        Book[] b = new Book[5]; //no need of qualify it with its package
                                //as import statement is used
        b[0] = new Book("The Art pf Computer Programming", "Knuth", 1973);
        b[1] = new Book("Java Fundamentals", "Schildt", 2013);
        b[2] = new Book("Thirteen at Dinner", "Christie", 1933);
        b[3] = new Book("Red storm Rising", "Clancy", 1986);
        b[4] = new Book("On the Road", "Kerouac", 1955);
        for(int i=0; i<b.length; i++){
            b[i].show();
            System.out.println();
        }
    }
}
```

- No longer need to qualify Book with its package name

Importing Java's Standard Packages

Package	*Provides classes for*
`java.applet`	programs (applets) that can be run from a web page
`java.awt`	Abstract Windowing Toolkit (AWT) – basic graphical user interface (GUI) components such as windows, fonts, colours, events, buttons and scroll bars
`java.io`	low-level input/output – for example, reading data from files or displaying on screen
`java.lang`	basic classes for the language – automatically imported and used by all Java programs
`java.net`	communication across a network, using clients, servers, sockets and URLs
`javax.swing`	creation of more sophisticated, platform-independent GUIs, building on the AWT capabilities
`java.util`	general utility classes, especially collection classes (data structures)

static Import

- **import** statement can be used to import static members of a class/interface by following **import** with the keyword **static**
- Two general forms are
    1. import static pkg.typeName.staticMemberName;
    2. import static pkg.typeName.*; //it imports all static members

Ex:

import static java.lang.Math.sqrt;
import static java.lang.Math.pow;
OR
import static java.lang.Math.*;

```
import static java.lang.Math.*;
public class StaticDemo {
    public static void main(String[] args) {
        //no need to use Math classname to import the following methods
        System.out.println("The squareroot of the number is"+sqrt(25));
        System.out.println("The exponent value is "+pow(2, 4));
        System.out.println("The absolute value is "+abs(2.6));
    }
}
```