Objects and Classes

Control Flow in Java

Object Interaction


Objects and Classes

The foundation of Object Oriented Programming


Fundamental Concepts

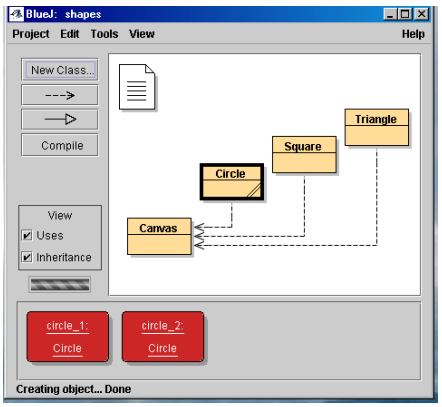
- object
- class
- method
- parameter
- data type

Objects and Classes

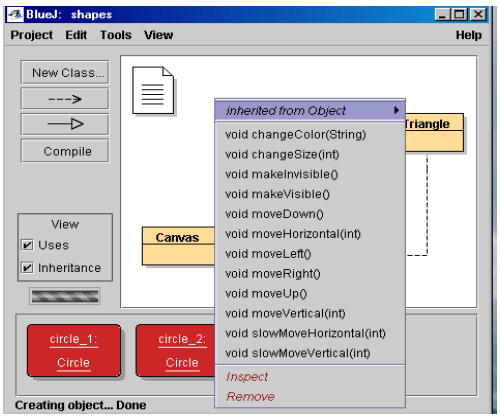
- Objects
  - represent ‘things’ from the real world, or from some problem domain (example: “the red car down there in the car park”)
- Classes
  - represent all objects of a kind (example: “car”)

Objects represent individual instantiations of the class. Object are **instantiated**.

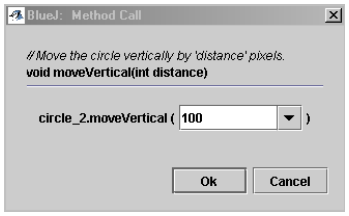
Objects and Classes in BlueJ



Things we can do with Objects



Things we can do with Objects



Methods and Parameters

- Objects/classes have operations which can be invoked. They are called **methods**
- void moveHorizontal(int distance) is called the **signature** of the methods
- The collection of methods of a class is referred to as the **interface** of that class
- methods may have **parameters** to pass additional information needed to execute
- Methods are **called** or **invoked**

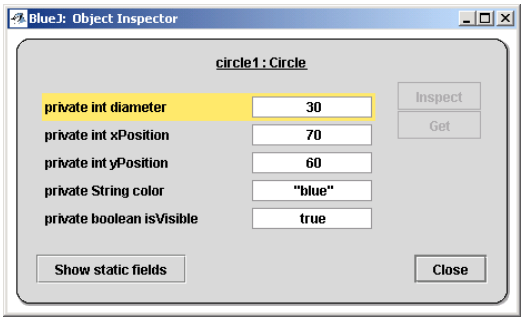
Data Types

- Parameters have **types**. A type defines what kinds of values a parameter can take.
- Defining a class defines a type
- In Java, everything has a type.
- Java is strongly typed language
- Examples of types: int, String, Circle, …

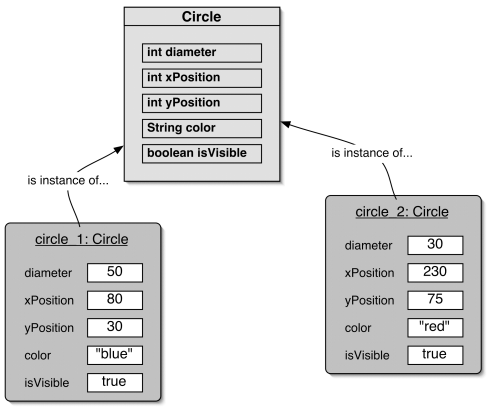
Other Observations

- many *instances* can be created from a single class
- an object has *attributes*: values stored in *fields*.
- the class defines what fields an object has, but each object stores its own set of values.
- These set of values is called the ***state*** of the object.

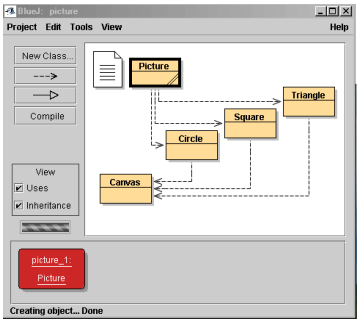
State

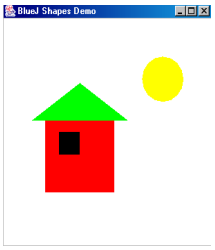


Two Circle Objects



Object Interaction





Source Code

- Each class has source code (Java code) associated with it that defines its details (fields and methods).
- In other words, it determines the structure and the behaviour of each of its instance.
- This source code is compiled and interpreted by Java.

Return Values

- Methods may return a result via a return value.
- Example: String getName()
  - This method returns a String.
- Example: void changeName()
  - Void indicates that this method does not return anything

Developing Java Programs

- To learn to develop Java programs, one needs to learn how to write class definitions, including fields and methods, and how to put these classes together as well
- During the rest of this unit we will deal with these issues in more detail

Coding Conventions

- Classes: Uppercase to start, merge words, consecutive words uppercase, nouns
  - E.g. Car, Number, BankAccount
- Objects: Lowercase to start, merge words, consecutive words uppercase, nouns
  - E.g. myBlueCar, Rational
- Methods: Lowercase to start, merge words, consecutive words uppercase, verbs
  - E.g. moveLocation, deposit

Terms

- Object
- Instance
- State
- Compiler
- Virtual Machine
- Method Calling
- Class
- Method
- Return Value
- Signature
- Parameter
- Type
- Source Code

Understanding class definitions

Looking inside classes

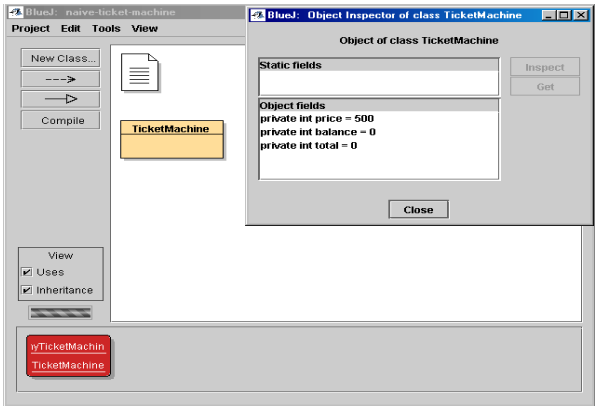

Main concepts to be covered

- fields
- constructors
- methods
- parameters
- assignment statements
- conditional statements

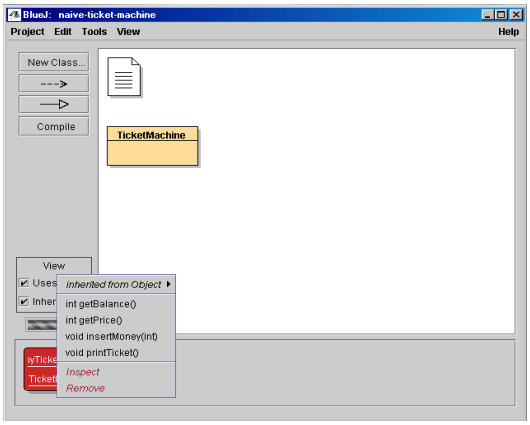
Ticket machines – an external view

- Exploring the behavior of a typical ticket machine.
  - Use the *naive-ticket-machine* project.
  - Machines supply tickets of a fixed price.
    - How is that price determined?
  - How is 'money' entered into a machine?
  - How does a machine keep track of the money that is entered?
  - How is a ticket provided?

Resulting Fields



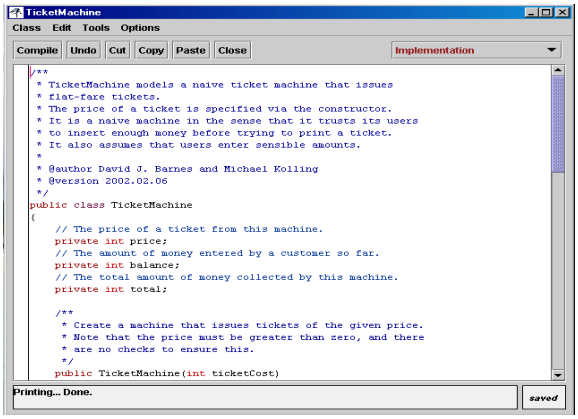
Resulting Methods



Ticket machines – an internal view

- Interacting with an object gives us clues about its behavior.
- Looking inside allows us to determine how that behavior is provided or implemented.
  - Looking at the source code
- All Java classes have a similar-looking internal view.

The Source Code



Basic class structure

```
public class TicketMachine
{
    Inner part of the class omitted.
}
```

The outer wrapper of TicketMachine

```
public class ClassName
{
    Fields
    Constructors
    Methods
}
```

The contents of a class

Comments/Documentation

- Comments make source code easier to read for humans. No effect on the functionality.
- Three sorts:
  - // comment: single-line comments
  - /* comments */: multiple-lines – more detail
  - /** */: similar to previous, but used when documentation software is used.

Fields

- Fields store values for an object.
- They are also known as **instance variables**.
- Use the *Inspect* option to view an object's fields.
- Fields define the state of an object.

```
public class TicketMachine
{
    private int price;
    private int balance;
    private int total;

    Constructor and methods omitted.
}
```

visibility modifier type variable name

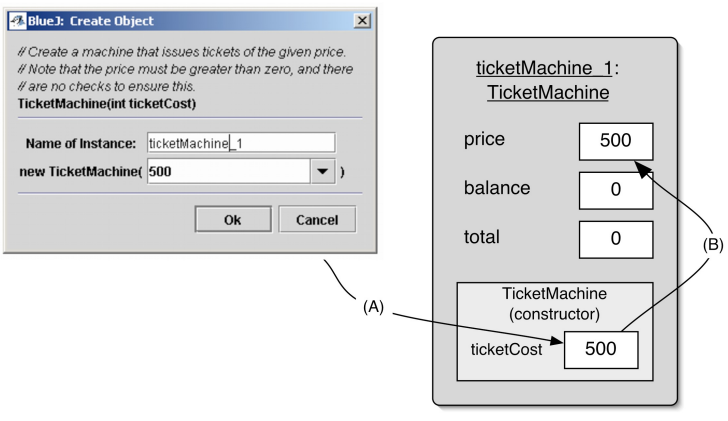
```
private int price;
```

Constructors

- Constructors initialize an object.
- Then assign the necessary memory to the created object
- They have the same name as their class.
- They store initial values into the fields.
- They often receive external parameter values for this.

```
public TicketMachine(int ticketCost)
{
    price = ticketCost;
    balance = 0;
    total = 0;
}
```

Passing data via parameters



Parameters

- Parameter names inside a constructor or method are referred to as **Formal Parameters.**
- Parameter values provided from the outside are referred to as **Actual Parameters.**
- In the example: ticketCost is a formal parameter and 500 is an actual parameter.

Space

- The ticketCost box in the object representation is only created when the constructor is executed.
- Extra temporarily storage is provided to store a value for ticketCost. This is called the **constructor space** or **method space.**
- Values can only be used during the execution.

Scope and Lifetime

- The scope of a variable/parameter defines the section of the code from where it can be accessed.
- For instance variables this is the entire class.
- For parameters, this is the constructor or method that declares it.
- Trick: find the enclosing {}, this is the scope
- The lifetime of a variable/parameter describes how long the variable continues to exist before it is destroyed.

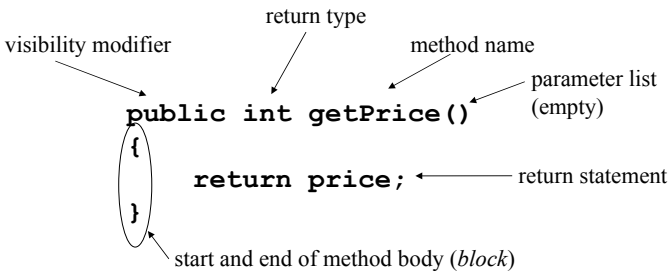
Assignment

- Values are stored into fields (and other variables) via assignment statements:
  - *variable* = *expression;*
  - `price = ticketCost;`
- Both sides of the assignment should have the same type, e.g. int, double, String, …
- A variable stores a single value, so any previous value is lost.

Accessor methods

- Methods implement the behavior of objects.
- Accessors provide information about an object.
- Methods have a structure consisting of a header and a body.
- The header defines the method's *signature*.
  `public int getPrice()`
- The body encloses the method's statements.

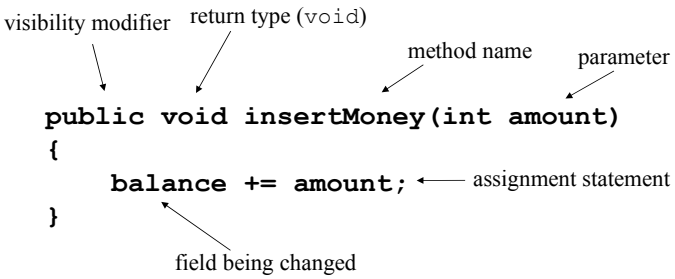
Accessor methods



Mutator methods

- Have a similar method structure: header and body.
- Used to *mutate* (i.e., change) an object's state.
- Achieved through changing the value of one or more fields.
  - Typically contain assignment statements.
  - Typically receive parameters.

Mutator methods



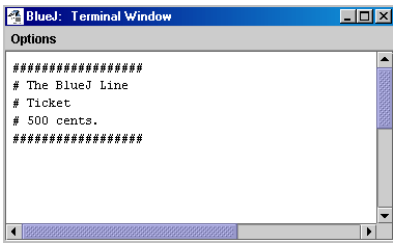
Abstract Data Types

- Classes define types
  - Can be used as parameter, field and return types
- The internal is hidden from the user
  - No direct access to fields (unless special reason)
  - Access to state via accessor and mutator methods
- User does not need to know how the class is implemented to use/instantiate it
- The usage of a class is defined by its methods

Printing from methods

```
public void printTicket()
{
    // Simulate the printing of a ticket.
    System.out.println("###################");
    System.out.println("# The BlueJ Line");
    System.out.println("# Ticket");
    System.out.println("# " + price + " cents.");
    System.out.println("###################");
    System.out.println();

    // Update the total collected with the balance.
    total += balance;
    // Clear the balance.
    balance = 0;
}
```

Output



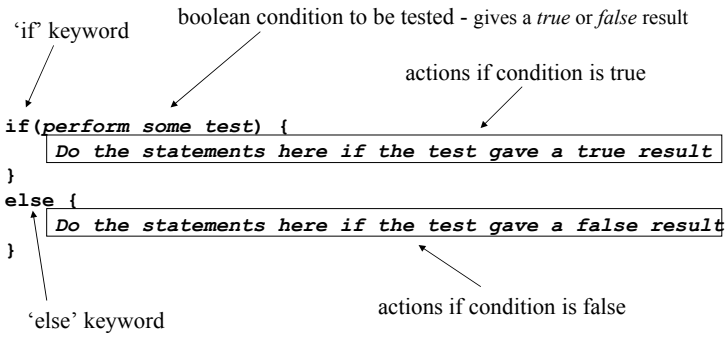
Reflecting on the ticket machines

- Their behavior is inadequate in several ways:
  - No checks on the amounts entered.
  - No refunds.
  - No checks for a sensible initialization.
- How can we do better?
  - We need more sophisticated behavior.

Making choices

```
public void insertMoney(int amount)
{
    if(amount > 0) {
        balance += amount;
    }
    else {
        System.out.println("Use a positive amount: " +
                           amount);
    }
}
```

Making choices



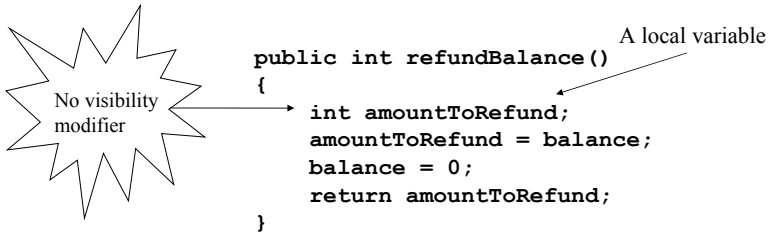
Boolean Tests

- == : equality
- > : greater than
- < : less than
- <= : less or equal than
- >= : greater or equal than
- != : not equal

Local variables

- Fields are one sort of variable.
  - They store values through the life of an object.
  - They are accessible throughout the class.
- Methods can include shorter-lived variables.
  - They exist only as long as the method is being executed.
  - They are only accessible from within the method.

Local variables



Review

- Class bodies contain fields, constructors and methods.
- Fields store values that determine an object's state.
- Constructors initialize objects.
- Methods implement the behavior of objects.
- Constructors are methods which do not return anything.

Review

- Fields, parameters and local variables are all variables.
- Fields persist for the lifetime of an object.
- Parameters are used to receive values into a constructor or method.
- Local variables are used for short-lived temporary storage.

Review

- Objects can make decisions via conditional (if) statements.
- A true or false test allows one of two alternative courses of actions to be taken.

Coding Convention

- If statement
  - Always use { , even if there is only one statement
  - In case there is an else statement, start on a new line and use {
- Indentation
  - Always indent your code, even if your text editor does not do it automatically
- Document your code, the sooner the better.

Terms

- Instance variables
- Local variables
- Parameters
- Formal Parameters
- Actual Parameters
- Scope
- Lifetime
- Constructors
- Methods
- If-statement
- Assignment
- =
- +=
- <=, >=, <, >, !=, ==

Object interaction

Creating cooperating objects

Main concepts to be covered

- Abstraction
- Modularization
- Class and Object Diagrams
- Call-by-reference and Call-by-value
- Overloading
- Internal and External method calls
- this keyword
- Debugging

A digital clock

11:03

Abstraction and modularization

- **Abstraction** is the ability to ignore details of parts to focus attention on a higher level of a problem.
- **Modularization** is the process of dividing a whole into well-defined parts, which can be built and examined separately, and which interact in well-defined ways.

Modularizing the clock display

11:03 One four-digit display?

Or two two-digit displays? 11 03

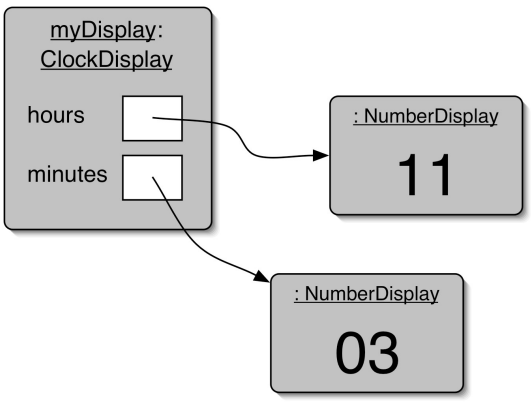
Implementation: NumberDisplay

```
public class NumberDisplay
{
    private int limit;
    private int value;

    Constructor and
    methods omitted.
}
```

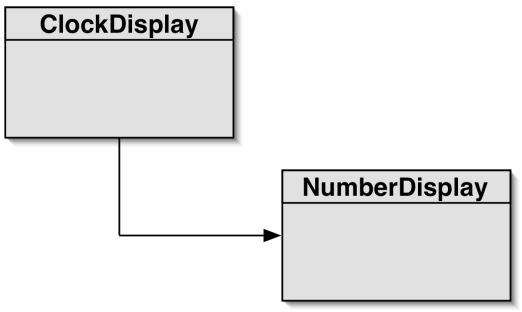
Implementation ClockDisplay

```
public class ClockDisplay
{
    private NumberDisplay hours;
    private NumberDisplay minutes;

    Constructor and
    methods omitted.
}
```

Object diagram



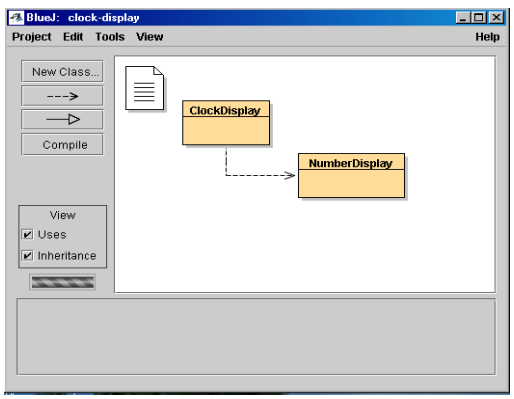
Class diagram



Diagrams

- Class Diagrams
  - Shows the classes of an application and the relationships between them
  - Gives information about the source code
  - Static view of the program
- Object Diagrams
  - Shows objects and their relationships at one moment in time during the execution of the program
  - Dynamic view of the program

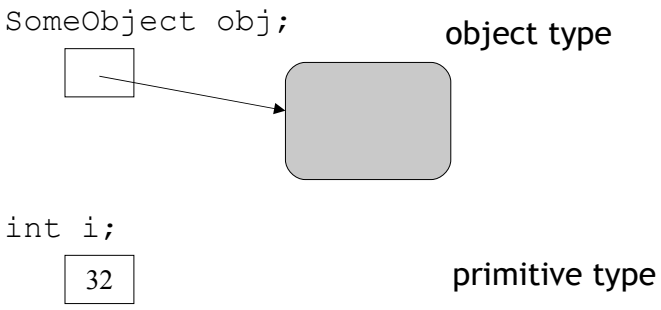
BlueJ and Diagrams



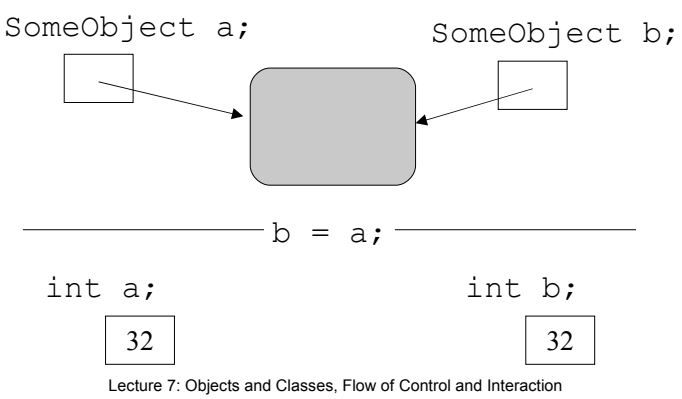
Primitive types vs. object types

- Java defines two very different kinds of type: primitive types and object types.
- Primitive types are predefined by Java.
- Object types originate from classes.
- Variables and parameters store references to objects.
- The primitive types are non-object types.

Primitive types vs. object types



Primitive types vs. object types



Call-by-reference and Call-by-value

- There are two ways of passing arguments to methods in many programming languages: call-by-value and call-by-reference.
- Call-by-value: A copy of the actual parameter is passed to the formal parameter of the called method. Any change made to the formal parameter will have no effect on the actual parameter.

Call-by-reference and Call-by-value

- Call-by-reference: the caller gives the called method the ability to directly access to the caller's data and to modify that data if the called method so chooses.
- Java uses call-by-value for primitive data types and call-by-reference for object types.

Source code: NumberDisplay

```
public class NumberDisplay
{
    private int limit;
    private int value;

    public NumberDisplay(int rollOverLimit)
     {
         limit = rollOverLimit;
         value = 0;
     }
```

Source code: NumberDisplay

```
public int getValue()
    {
        return value;
    }

public void setValue(int replacementValue)
    {
        if((replacementValue >= 0) &&
           (replacementValue < limit))
            value = replacementValue;
    }
```

Logical Operators

- && : and, operands are tested, left to right, until conclusion can be reached
- || : or, operands are tested, left to right, until conclusion can be reached
- ! : not
- & : and, both operands are tested
- | : or, both operands are tested

Source code: NumberDisplay

```
    public String getDisplayValue()
    {
        if(value < 10)
            return "0" + value;
        else
            return "" + value;
    }

    public void increment()
        {
            value = (value + 1) % limit;
        }
}
```

String Concatenation

- Addition:
  - 12 + 24
- String Concatenation:
  - “Java” + “with BlueJ” -> “Javawith BlueJ”
  - “answer: ” + 42 -> “answer: 42”

String toString() method

- String toString() method: Java provides a way of transforming every Object into a String. To tailor this to your own preference write a method toString() returning a String representation of your class/object.

```
public String toString()
{
   return “value: “ + value + “ with limit ” + limit;
}
```

The Modulo Operator

- % : the modulo operator calculates the remainder of an integer division
  - 27 & 4 -> 3
- Division in Java: if both arguments are integers, division will result in an integer.
  - double res = 5 / 2 -> res = 2
  - double res = 5 / (2.0) or 5 / (2 * 1.0)
    -> res = 2.5

Objects creating objects

```
public class ClockDisplay
{
    private NumberDisplay hours;
    private NumberDisplay minutes;
    private String displayString;

    public ClockDisplay()
    {
        hours = new NumberDisplay(24);
        minutes = new NumberDisplay(60);
        updateDisplay();
    }
}
```

Objects creating objects

1. new ClassName(parameter-list)
   - It creates a new object of the named class
     - here NumberDisplay
     - this involves creating sufficient memory to store the values of primitive instance variables and references to object instance variables.
2. It executes the constructor of that class

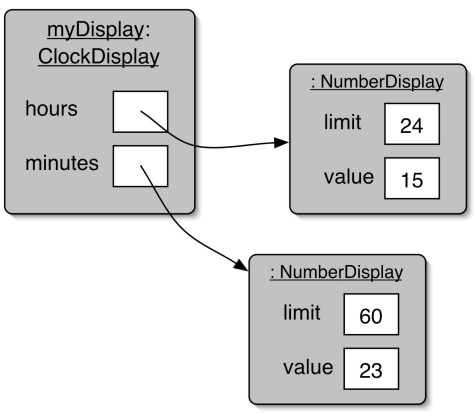
formal parameter

public NumberDisplay(int rollOverLimit)

actual parameter

new NumberDisplay(24)

ClockDisplay object diagram



Method Overloading

- Multiple Constructors of ClockDisplay:
  - new Clockdisplay()
  - new Clockdisplay(hour, minute)
- It is common for class definitions to contain alternative versions of constuctors or methods that provide various ways of achieving a particular task via their distinctive sets of parameters.
- This is known as **overloading**.

Method calling

```
public void timeTick()
{
    minutes.increment();
    if(minutes.getValue() == 0) {
        // it just rolled over!
        hours.increment();
    }
    updateDisplay();
}
```

Internal method

```
/**
 * Update the internal string that
 * represents the display.
 */
private void updateDisplay()
{
    displayString =
        hours.getDisplayValue() + ":" +
        minutes.getDisplayValue();
}
```

Method calls

- internal method calls

```
updateDisplay();
private void updateDisplay()
```

  - methodName(parameter-list)

- external method calls

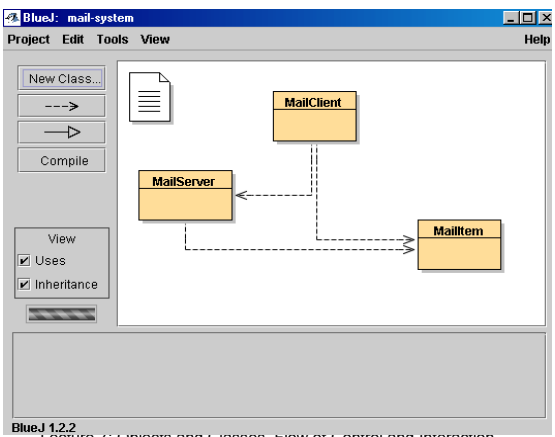
```
minutes.increment();
```

  - object.methodName(parameter-list)

Public and Private Methods

- Public methods:
  - public void increment()
  - can be called externally
- Private methods
  - private void updateDisplay()
  - can only be called internally
  - used for auxiliary methods

The Mail System



The this Keyword

```
public class MailItem
{
   private String from;
   private String to;
   private String message;

   public MailItem(String from, String to,
                   String message)
     {
         this.from = from;
         this.to = to;
         this.message = message;
     }
```

The this Keyword

- this.from = from
  - **name overloading:** the same name is used for two different entities: instance variable and formal parameter.
  - this is used to go out of the scope of the constructor to class level
  - this always refers to the current object.
  - can also used for methods
  - for internal methods calls and access to instance fields Java automatically inserts this
  - updateDisplay -> this.updateDisplay

Concepts

- abstraction
- modularisation
- call-by-value
- call-by-reference
- logical operators/modulo
- this
- class/object diagram
- primitive types
- object types
- object creation
- overloading
- internal/external method calls
- private methods
- debugging