# OO Concepts in Java

- Classes define the characteristics of instances and bring together in one place both state (attributes) and behavior (methods). This is called encapsulation.

- The state of instances is kept private to the instance and only accessed or modified through public methods. This is called information hiding.

# OO Concepts in Java (2)

- The state of an instance is accessed or modified by calling a public method defined within the instances class. This is referred to as message passing.

- The set of public methods defined in a class is called the class's interface to its clients.

# OO Concepts in Java (3)

- Any number of instances may simultaneously exist and each has its own private and independent state.

- Instances are created by calling the constructor method, which both creates and initializes the instance. A default constructor is provided in a class unless a user defines one (or more).

# OO Concepts in Java (4)

- Any number of constructors may be defined so long as they all have different numbers and / or types of parameters. The same applies to other identically named methods within a class. This is called overloading.

# Packages

- Java programs consist of one or more packages.
- Packages contain one or more classes.
- Every source file in Java is part of a package.
- A source file can begin with a ***package*** statement, which indicates what package the source file belongs to.

# Packages (2)

- If a source file does not begin with a ***package Packagename;*** statement, the file is assumed to be part of the default, unnamed package, which includes the compiled classes in the current directory.
- The ***import java.awt.*;*** statement is how to have the java compiler import all the source files in the subdirectory ***awt*** which is in the directory ***java***.

# Packages (3)

Helps manage software complexity:

- Separate namespace for each package – package name may added in front of actual name.
- Put generic / utility classes in packages – avoid code duplication.

# Package – Import

- Import:
  - Make classes from package available for use.
  - Java API
    - java.* (core)
    - javax.* (optional)
- Example:

```
import java.util.Random;    // import single class
import java.util.*;         // all classes in package
…                           // class definitions
```

# C++ Namespaces

- Namespaces are kind of like packages in Java.
- A mechanism for logically grouping declarations and definitions into a common declarative region.
- Reduces naming conflicts.

# C++ Namespaces (2)

- The contents of the namespace can be accessed by code inside or outside the namespace:
  - Use the scope resolution operator to access elements from outside the namespace.
  - Alternatively, the ***using*** declaration allows the names of the elements to be used directly.

# C++ Namespaces (3)

- Creating a namespace:

```
namespace smallNamespace
{
        int count = 0;
        void abc();
} // end smallNamespace
```

- Using a namespace:

```
using namespace smallNamespace;
count +=1;
abc();
```

# C++ Namespaces (4)

- Items declared in the C++ Standard Library are declared in the *std* namespace.
- C++ *include* files for several functions are in the *std* namespace:
  - to include input and output functions from the C++ library, write

```
#include <iostream>

using namespace std;
```

- Any standard C routines (*malloc*, *printf*, etc.) are defined in the global namespace because C does not have namespaces.

# using namespace

```
#include <iostream>
...
std::string question =
     “How do I list directory content?”;
std::cout << question << std::endl;

using namespace std;

string answer = “Type ls.”;
cout << answer << endl;
```

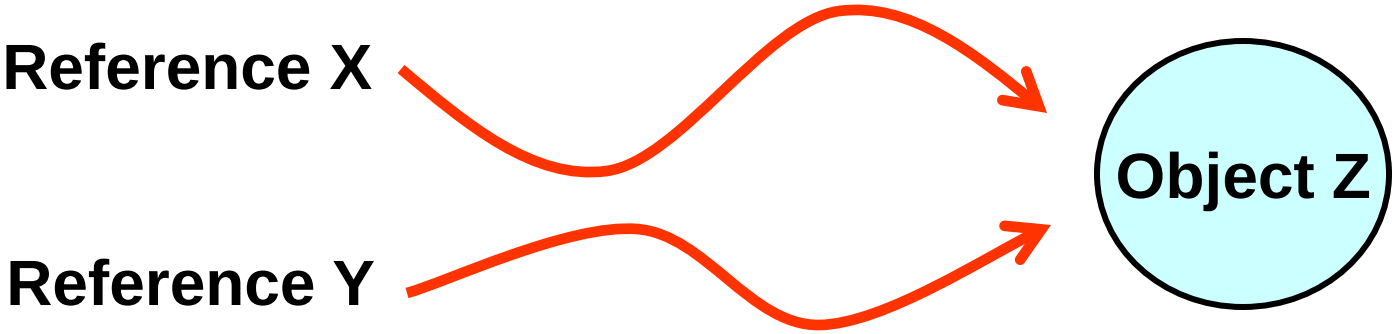
# Classes

- A class is a blueprint or prototype that defines the variables and methods common to all objects of a certain kind.

- An object is an instance of a class.

# References & Aliases

- Reference:
  - A way to get to an object, not the object itself.
  - All variables in Java are references to objects.
- Alias:
  - Multiple references to same object.
  - "**X == Y**" operator tests for alias.
  - **X.equals(Y)** tests contents of object.



# References & Aliases – Issues

- **Copying:**
  - References

```
X = new Object();
Y = X;                  // Y refers to same object as X
```

  - Objects

```
X = new Object();
Y = X.clone();          // Y refers to different object
                        // (a duplicate)
```

# “this” Reference

- Description:
  - Reserved keyword.
  - Refers to object through which method was invoked.
  - Allows object to refer to itself.
  - Use to refer to instance variables of object.

# “this” Reference – Example

```
class Node {
    value val1;
    value val2;

    void foo(value val2) {
        … = val1;          // same as this.val1 (implicit this)
        … = val2;          // parameter to method
        … = this.val2;     // instance variable for object
        bar( this );       // passes reference to object
    }
}
```

# Inheritance

- Definition:
  - Relationship between classes when state and behavior of one class is a subset of another class.
- Terminology:
  - **Superclass** / parent (base) $\Rightarrow$ More general class.
  - **Subclass** (derived) $\Rightarrow$ More specialized class.
- Forms a class hierarchy.
- Helps promote code reuse.

- Subclass
  = special case
  = fewer entities
  = more properties.

# “super” Reference

- **Description:**
  - Reserved keyword.
  - Refers to superclass.
  - Allows object to refer to methods / variables in superclass.

- **Examples:**
  - super.x // accesses variable x in superclass
  - super() // invokes constructor in superclass
  - super.foo() // invokes method foo() in superclass

# Class Variables

- Declared insides the class and outside the methods.

- The values of class variable may be inherited by subclasses and overridden.

# Class Methods

- ***Class method***: a method which is inherited by all subclasses of the class it belongs to and which defines the behavior of the collective of instances rather than individual ones.
- An operation targeted to a class and not to an individual object. In C++, class methods are called static member functions.

# Class Definition

*class classname {*

*[ variable declaration; ]*

*[ method declaration; ]*

*}*

Methods:

*[ class-modifiers ] return-type method-name ( parameter list ) { [ body; ] }*

# Using Classes

- Declaring object variables:

  ***classname variablename;***
- Creating objects:

  ***variable = new classname();***
- Accessing variable members:

  ***variable.v_member***
- Accessing method members:

  ***variable.method()***

# Deriving Classes

*class classname extends parent-class {*

*[ variable declaration; ]*

*[ method declaration; ]*

*}*

- Inheritance
- Overriding methods

# Constructors / Creation Methods

*public void classname ( [ parameters ] )*
*{ body; }*

# Constructor Methods

- Every class in Java has a least one constructor method.
- Constructor method has the same name as the class.
- Purpose of constructor is to perform any necessary initialization.
- The return type is implicitly an instance of the class.

# Constructor Methods (cont)

- Can have multiple constructors if want to initialize an object in different ways.

- Implicit invokes constructor for superclass (if not explicitly included).

# Initialization Block

- Definition:
  - Block of code used to initialize **static** & **instance** variables for class.

- Motivation:
  - Enable complex initializations for static variables.
  - Share code between **multiple** constructors for same class.

# Initialization Block Types

- **Static initialization block:**
  - Code executed when class loaded.
- **Initialization block:**
  - Code executed when each object created (at beginning of call to constructor).

- Example:

```
class foo {
    static { A = 1; }        // static initialization block
    { A = 2; }               // initialization block
}
```

# Variable Initialization

- Variables may be initialized:
  - At time of declaration.
  - In initialization block.
  - In constructor.
- Order of initialization:
  1. Declaration, initialization block
     (in the same order as in the class definition)
  2. Constructor.

# Variable Initialization – Example

```
class Foo {
    static { A = 1; }          // static initialization block
    static int A = 2;          // static variable declaration
    static { A = 3; }          // static initialization block
    { B = 4; }                 // initialization block
    private int B = 5;         // instance variable declaration
    { B = 6; }                 // initialization block
    Foo() {                    // constructor
        A = 7;
        B = 8;
    }                          // now A = 7, B = 8
}           // initializations executed in order of number
```

# Garbage Collection

- **Concepts:**
  - All interactions with objects occur through reference variables.
  - If no reference to object exists, object becomes garbage (useless, no longer affects program).

- **Garbage collection:**
  - Reclaiming memory used by un-referenced objects.
  - Periodically performed by Java.
  - Not guaranteed to occur.
  - Only needed if running low on memory.

# Destructor

- **Description:**
  - Method with name finalize().
  - Returns **void**.
  - Contains action performed when object is freed.
  - Invoked automatically by garbage collector
    - Not invoked if garbage collection does not occur.
  - Usually needed only for non-Java methods.

- **Example:**

```
class foo {
    void finalize() { … }          // destructor for foo
}
```

# Overloading Methods

- Java supports method name overloading (borrowed from C++).

- Declared multiple methods with same name.

# Overloading Methods (2)

- Each one can have a different type of parameter passed.
- Or each one can have a different number of arguments passed.
- Or each one can have the same arguments but in a different order.

# Overloading Methods (3)

- Sources of overloading:
  - Constructors frequently overloaded.

- Example:

```
class foo {
    foo() { … }          // constructor for foo
    foo(int n) { … }     // 2nd constructor for foo
}
```

# Overriding Methods

- Create a subclass with the keyword "***extends***".
- To override a method, the new method must have the same name, argument types, and return type as the method in the superclass.
- For example, say you want a window with a border.

# Overriding Methods (cont)

- ***public class WindowWithBorder extends Window {***

- Now the ***WindowWithBorder*** class inherits everything from the ***Window*** class.
- Then declare the new method.

    ***private void drawBorder() {***

# Class Modifiers

- Access modifiers:

  “***default***” (not explicitly specified),

  ***public***, ***private***, ***protected***.
- The ***static*** modifier.
- The ***final*** modifier.
- The ***synchronized*** modifier.
- The ***native*** modifier.

# Modifier – Examples

```
public class foo {
    private static int count;
    private final int increment = 5;
    protected void finalize { … }
}

public abstract class bar {
    abstract int go() { … }
}
```

# Modifying Methods

- ***Method modifiers*** in Java can be divided into two groups.

- Those that affect the scope of a method (scope refers to the region of a program that an item can be accessed).

- And those that do not affect the scope.

# Scope

- **Scope:**
  - Part of program where a variable may be referenced.
  - Determined by location of variable declaration
    - Boundary usually demarcated by { }
- **Example:**

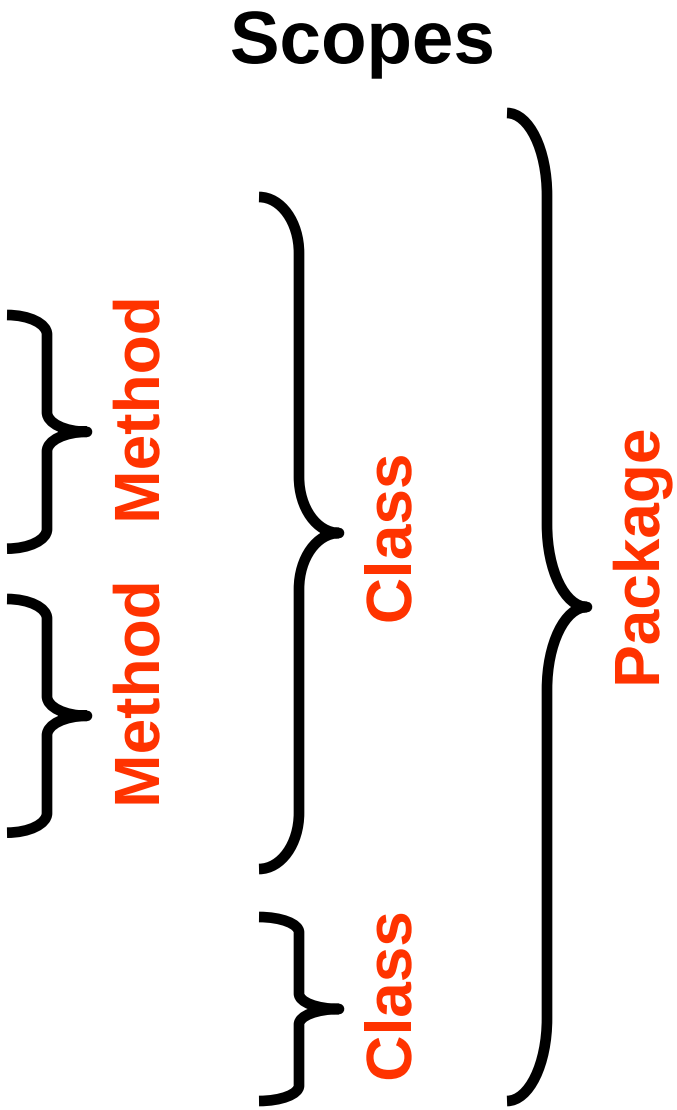
```
public MyMethod1() {
      int myVar;
      ...
}
```

myVar accessible in method between { }

# Scope – Example

- **Example:**

```
package edu.ccu.cs ;
public class MyClass1 {
    public void MyMethod1() {
        ...
    }
    public void MyMethod2() {
        ...
    }
}
public class MyClass2 {
}
```



# Visibility Modifier

- Properties:
  - Controls access to class members.
  - Applied to instance variables & methods.
- Four types of access in Java:
  - Public
  - Protected
  - Package
    - Default if no modifier specified
  - Private

Most visible

Least visible

# Visibility Modifier – Where Visible

- "**public**"
  - Referenced anywhere (i.e., outside package).
- "**protected**"
  - Referenced within package, or by subclasses outside package.
- **None specified** (package)
  - Referenced only within package.
- "**private**"
  - Referenced only within class definition.
  - Applicable to class fields & methods.

# Visibility Modifier

- For **instance variables**:
  - Should usually be private to enforce encapsulation.
  - Sometimes may be protected for subclass access.

- For **methods**:
  - Public methods – provide services to clients.
  - Private methods – provide support other methods.
  - Protected methods – provide support for subclass.

# Summary: Affect-the-Scope Modifiers

- public: the method can be accessed by any class.
- private: the method can be accessed only by methods within the same class.
- Not explicitly specified: the method can be accessed by methods in the class or methods in other classes in the same package.

# Affect-the-Scope Modifiers (cont)

- protected: the method can be accessed by methods in the subclasses of the class.

# Not-Affect-the-Scope Modifiers

- final: the method cannot be overridden by a method in a subclass.
- static: the method is a class method.
- native: the method body will be written in C and linked into the interpreter.
- abstract: the method is not defined in the class. It must be defined in a **subclass**.

# Not-Affect-the-Scope Modifiers (cont)

- synchronized: the method will acquire a lock on the instance (or on the class, if it is a class method) before running and will relinquish the lock when it completes.

# Modifier – Static

- Static variable:
  - Single copy for class.
  - Shared among all objects of class.

- Static method:
  - Can be invoked through **class name**.
  - Does not need to be invoked through object.
  - Can be used even if no objects of class exist.
  - Can not reference instance variables.

# Modifier – Final

- Final variable:
  - Value can not be changed.
  - Must be **initialized** in every constructor.
  - Attempts to modify **final** are caught at compile time.

- Final static variable:
  - Used for constants.
  - Example:

    ***final static int Increment = 5;***

# Modifier – Final (2)

- Final method:
  - Method cannot be overridden by subclass.
  - Private methods are implicitly **final**.

- Final class:
  - Class cannot be a superclass (extended).
  - Methods in final class are implicitly **final**.

# Modifier – Final (3)

- Using **final** classes:
  - Prevents inheritance / polymorphism.
  - May be useful for
    - Security
    - Object oriented design

- Example – class String is **final**.
  - Programs can depend on properties specified in Java library API.
  - Prevents subclass that may bypass security restrictions.

# Modifier – Abstract

- **Description:**
  - Represents generic concept.
  - Can not be instantiated.
- **Abstract class:**
  - Placeholder in class hierarchy.
  - Can be partial description of class.
  - Can contain non-abstract methods.
  - Required if any method in class is abstract.
- **Example:**

```
abstract class foo {                  // abstract class
    abstract void bar() { … }         // abstract method
```

# Interface

- **Description:**
  - Collection of
    - Constants
    - Abstract methods
  - Can not be instantiated.
- Classes can implement interface:
  - Must implement all methods in interface.
  - Example:

    ***class foo implements bar { … }*** // interface bar
- Similar to abstract class:
  - But class can “inherit” from multiple interfaces.