Introduction To Java
What Is Java?

- New object-oriented programming (OOP) language developed by SUN Microsystems
- Similar to C and C++, except without some of the confusing, poorly understood features of C++
- Extensive networking facilities
- Extensive set of APIs for GUIs, distributed computing, 2D/3D graphics, mail, and others
- Portable: Write Once, Run Anywhere
- Multithreading support built into the language
Java Features

- Automatic garbage collection
  - No manual memory allocation and deallocation
  - Never have to worry about memory leaks
- No pointers or pointer arithmetic
  - No off-by-one bugs
- Arrays are first-class objects
  - Array bounds are always checked
- Multiple inheritance replaced by interfaces
  - Eliminates complexities of multiple inheritance

Improves software reliability
Increases programmer productivity
Features Removed From C/C++

- No typedefs, defines or preprocessor
- No header files
- No structures or unions
- No enums
- No functions - only methods in classes
- No multiple inheritance
- No goto
- No operator overloading (except “+” for string concatenation)
- No automatic type conversions (except for primitive types)
- No pointers
Java Virtual Machine

- Java is compiled into bytecodes
- Bytecodes are high-level, machine-independent instructions for a hypothetical machine, the Java Virtual Machine (JVM)
- The Java run-time system provides the JVM
- The JVM interprets the bytecodes during program execution
- Since the bytecodes are interpreted, the performance of Java programs slower than comparable C/C++ programs
- But the JVM is continually being improved and new techniques are achieving speeds comparable to native C++ code
Java Virtual Machine

- All Java programs run on top of the JVM
- The JVM was first implemented inside Web browsers, but is now available on a wide variety of platforms
- The JVM interprets the bytecodes defined in a machine-independent binary file format called a class file
Types Of Java Programs

- Application
  - Standalone Java program that can run independent of any Web browser

- Applet
  - Java program that runs within a Java-enabled Web browser

- Servlet
  - Java software that is loaded into a Web server to provide additional server functionality ala CGI programs
The Hello World Program

- Create source file: Hello.java

```java
public class Hello {
    public static void main (String args[]) {
        System.out.println("Hello World!");
    }
}
```

- Note that the name of the file is the name of the public class with a .java extension added

- Compile: javac Hello.java
  - Produces the class file Hello.class

- Run: java Hello
  - Starts up the JVM
  - Note that the .class extension is not specified
Basic Java Language Elements

- Primitive Types
  - byte (1 byte) -128 to +127
  - short (2 bytes) -32,768 to 32,767
  - int (4 bytes) -2.15E+9 to +2.15E+9
  - long (8 bytes) -4.61E+18 to +4.61E+18
  - float (4 bytes) 1.0E-38 to 1.0E+38
  - double (8 bytes) -1.0E-308 to 1.0E+308
  - char (2 bytes) 0 to 0xffff (Unicode)
  - boolean (1 byte) true and false
  - All numeric types are sign extended
Basic Java Language Elements

- Operators
  - Similar to C++
  - Differences between C++ and Java Operators:
    - + is used to concatenate strings
    - instanceof returns true or false depending on whether the left side object is an instance of the right side object
    - >>> shifts bits right, filling with zeros

- Decision Constructs
  - if-else (test expression must resolve into a boolean)
  - switch (switch expression must resolve to an int, short, byte or char)

- Loops
  - Same as C/C++
  - while, do-while
  - for
Some Java OO Terminology

- **Class** - collection of data (attributes) and methods that operate on that data
- **Member** - either an attribute or a method of a class
- **Public Member** - member which is accessible by any method in any class
- **Private Member** - member which is accessible only by methods defined within the class
- **Public Class** - class that is visible everywhere and can be used by any method in any class
- **Object** - instance of a class
- **Object Instantiation** - the creation of a new object
**Some Java OO Terminology**

- *Constructor* - method which performs object initialization (*not* creation!)
- *Object Reference* - variable that holds a reference to (really the memory address of) an object
- *Instance Variable* - attribute for which each object (instance) has its own copy
- *Class Variable* - attribute for which there is only one copy for the class. Each object (instance) shares this copy. Also called a *static variable*
Some Java OO Terminology

- **Instance Method** - method which operates on the attributes of an object (instance)
- **Class Method** - method which does not operate on a particular object, but performs some utility function or operates on static variables. Also called a *static method*.
- **Method Signature** - the number, type and order of arguments of a method
- **Method Overloading** - defining a method with the same name but different signature as another method in the same class
Simple Java Example: Point

/**
 * Class Point implements a geometric point.
 * @author Bob Tarr
 */

public class Point {

    private int x;  // X Coordinate
    private int y;  // Y Coordinate

    /**
     * Creates a new Point with coordinates 0,0.
     */
    public Point() {
        x = 0;
        y = 0;
        System.out.println("Point() constructor: " + this);
    }
}
Simple Java Example: Point (Continued)

/**
 * Creates a new Point with the specified coordinates.
 * @param x The x coordinate.
 * @param y The y coordinate.
 */

public Point(int x, int y) {
    this.x = x;
    this.y = y;
    System.out.println("Point(int,int) constructor: " + this);
}

/**
 * Returns the x coordinate.
 * @return The x coordinate.
 */

public int getX() {return x;}

// End of Simple Java Example: Point

/**
 * END***


Simple Java Example: Point (Continued)

/**
 * Returns the y coordinate.
 * @return The y coordinate.
 */
public int getY() {return y;}

/**
 * Sets the x coordinate.
 * @param x The x coordinate.
 */
public void setX(int x) {this.x = x;}

/**
 * Sets the y coordinate.
 * @param y The y coordinate.
 */
public void setY(int y) {this.y = y;}

Simple Java Example: Point (Continued)

/**
 * Converts a Point to a String.
 * @return The Point as a String.
 */

public String toString() {
    return ("[" + x + "," + y + "]");
}

}
Test Program For Point

- Test program for the Point class:

```java
// Test program for the Point class.
public class TestPoint {
    public static void main(String[] args) {
        // Create some Point objects.
        Point p1 = new Point();
        Point p2 = null;
        p2 = new Point(5, 10);

        // Test the accessors and mutators.
        p1.setX(22);
        System.out.println("P1 is now: " + p1);
        p2.setY(13);
        System.out.println("P2 is now: " + p2);
    }
}
```
Test Program For Point (Continued)

- Test program output:

  Point() constructor: [0,0]
  Point(int,int) constructor: [5,10]
  P1 is now: [22,0]
  P2 is now: [5,13]
Arrays

- Arrays are objects in Java
- Creating an array involves three steps: declaration, creation and initialization
- Declaration:

```java
Point data[];  // The variable data can hold a reference
               // to an array of Points
Point[] data;  // Same thing!
```

- Creation:

```java
data = new Point[10];  // Now the variable data refers to the
                       // array of 10 elements that can refer
                       // to a Point object. All the references
                       // in the array are null.
```
Arrays

- Initialization:

  ```java
data[0] = new Point(4, 5);  // First array element initialized.
  // It is now referring to the new
  // Point object.
  
  Declaration, creation and initialization can be combined:
```

- Declaration, creation and initialization can be combined:

  ```java
int[] values = {1,7,5,8,9};
Point[] points = {new Point(4,5), new Point(1,-3)};
```
Exceptions

- **Exception** - a signal that an error or special condition has occurred
- **Throw an exception** - to signal the error or special condition
- **Catch an exception** - to handle the error or special condition
- Exceptions propagate up the lexical block structure of the Java program until they are caught and handled
- If an exception is not handled, the Java interpreter will print an error message and stack trace and then exit
Exceptions

Exceptions handling is done within a try/catch block:

```java
try {
    // Try this code. If it generates an exception,
    // we'll handle it in a catch block.
}
catch (Exception1 e1) {
    // Handle exception type Exception1.
}
catch (Exception2 e2) {
    // Handle exception type Exception2.
}
finally {
    // Always execute this code.
}
```
Exceptions

- All exceptions in Java are objects derived from the Exception class.
- Exceptions are of two types:
  - Unchecked exceptions: These are exceptions that commonly occur, such as divide by zero. (They are instances of RuntimeException, a subclass of Exception).
  - Checked exceptions: These are less common exceptions, such as an I/O error.
- Checked exceptions must either be caught or specified, else a compiler error will result.
- A throws clause is used to indicate that the method may throw an exception up the call stack:

```java
public void someMethod() throws IOException { ... }
```
Inheritance

- Java supports single inheritance using the `extends` keyword:

  ```java
  public class B extends A
  ```

- The extended class is called a subclass of the class it extends
- The class that is extended is called its superclass or base class
- All classes implicitly extend the Object class
- A subclass can override a method in its superclass by providing a new definition for a method with the same name, return type and signature
- All method invocations in Java are polymorphic. The method called depends on the type of the object referred to by its object reference and not on the type of the object reference itself.
Inheritance

- A *protected member* of a class can be accessed by any method in the same class or a subclass. (It can also be access by any method in a class in the same package which will be described later.)

- UML Notation:
Inheritance Example

Here's the superclass:

```java
public class A {

    protected int aData;

    public A(int aData) {this.aData = aData;}

    public A() {aData = 0;}

    protected void f() {
        System.out.println("This is A's f");
    }

}
```
Inheritance Example (Continued)

- Here's the subclass:

```java
public class B extends A {

    protected int bData;

    public B(int bData) {this.bData = bData;}

    public B() {this(0);}

    protected void f() {
        System.out.println("This is B's f");
    }

    protected void g() {
        System.out.println("This is B's g");
    }
}
```
Inheritance Example (Continued)

Here's the test program:

```java
public class ABTest {

    public static void main(String[] argv) {

        // Polymorphism
        A a = new A();
        B b = new B();
        a.f();              // Invokes A's f()
        b.f();              // Invokes B's f()
        A a1 = b;           // Invokes B's f()
        a1.f();             // Invokes B's f()

        // Up Casting
        A a2 = (A) b;       // Ok
    }
}
```
Inheritance Example (Continued)

// Down Casting
//B b1 = a;          // Illegal at compile time,
//   explicit cast needed
//B b2 = (B) a;      // Ok at compile time,
//   exception at run time

// Other stuff
int i = a.aData;    // Ok, same package
//i = a.bData;       // Illegal at compile time,
//   bData not defined in A
//a.g();            // Illegal at compile time,
//   g() not found in A
**Constructor Chaining**

- Java always invokes a superclass constructor when a subclass object is created (since the superclass object is “part of” the subclass object)

- You can explicitly call a superclass constructor using a call to `super(...)` as the first line of a subclass constructor:

  ```java
  public B(int bData) {
      super();  // Explicitly call our superclass constructor
      this.bData = bData;
  }
  ```

- If you do not explicitly invoke a superclass constructor, then the no-arg superclass constructor is implicitly called for you. That is, Java inserts the call to "super()" for you automatically.
Constructor Chaining

- What? You don't have a no-arg superclass constructor? That's ok, provided you have *no* superclass constructors, in which case the default no-arg constructor for a class is supplied for you. (But if you have superclass constructors defined, and do not have a no-arg one, you'll get a compiler error when Java tries to insert the call to "super()" in the subclass constructor.)

- The default no-arg constructor supplied by Java does just one thing - it makes a call to the no-arg superclass constructor!

- One exception: If the first line of a constructor uses the "this(…)" syntax to invoke another constructor of the class, then Java does not automatically insert the call to "super()" in the constructor:

  ```java
  public B() {
      this(0);  // Call to super() not automatically inserted here.
  }
  ```
Abstract Methods And Classes

- An *abstract method* has no body
- It is like a pure virtual function in C++.
- The abstract method is expected to be overridden in a subclass with an actual implementation
- Any class with an abstract method is an *abstract class* and must be declared abstract
- An abstract class can not be instantiated
- If a subclass of an abstract class does not provide implementations for all of the abstract methods of its superclass, then the subclass itself is abstract
Abstract Class Example

// Class Shape is an abstract base class for a geometric shape.
public abstract class Shape {
    public abstract double area();
}

// Class Rectangle is a concrete implementation of a Shape.
public class Rectangle extends Shape {

    protected double w;
    protected double h;

    public Rectangle(double w, double h) {
        this.w = w;
        this.h = h;
    }

    public double area() { return (w * h); }
}
Interfaces

- In OO terminology, an *interface* is some subset of the public methods of a class. The *implementation* of a class is the code that makes up those methods.
- In Java an *interface* is just a specification of a set of abstract methods.
- A class that implements the interface must provide an implementation for all of the abstract methods in the interface.
- A class can implement many interfaces, but a class can only extend one class.
- So a Java interface expressly separates the idea of an OO interface from its implementation.
Interface Example

// Interface Drawable provides the specification for a drawable graphics object.
public interface Drawable {
    public void Draw();
}

// Class DrawableRectangle implements the Drawable interface.
public class DrawableRectangle
    extends Rectangle
    implements Drawable {

    // Other code here.

    public void Draw() {
        // Body of Draw()
    }

}
Differences Between Interfaces and Abstract Classes

- A class can implement more than one interface, but an abstract class can only subclass one class.
- An abstract class can have non-abstract methods. All methods of an interface are implicitly (or explicitly) abstract.
- An abstract class can declare instance variables; an interface cannot.
- An abstract class can have a user-defined constructor; an interface has no constructors.
- Every method of an interface is implicitly (or explicitly) public. An abstract class can have non-public methods.
Why Are Interfaces Important?

- An object's type essentially refers to the OO interface of its class.
- So, in Java, an object of a class that implements several interfaces has many types.
- And objects from many different classes can have the same type.
- This allows us to write methods that can work on objects from many different classes which can even be in different inheritance hierarchies:

```java
public void renderScreen(Drawable d) {
    // Render this Drawable on the screen.
    // It does not matter whether this is DrawableRectangle,
    // DrawableCircle, etc. Since the object is a Drawable, it
    // MUST implement the Draw method.
    d.Draw();
}
```
Packages

- Java classes can be grouped together into a *package*
- Packages have several advantages:
  - related classes can be grouped together
  - class names and member names need not be unique across the entire program
  - members can be accessible only to methods of classes in the same package
- The package statement must appear as the first statement of the Java source file:
  ```
  package BT.Tools.Graphics;
  ```
- If no package statement is present, the code is made part of the unnamed default package
Packages

- A fully qualified Java name for a class is:
  - `<Package Name>.<Class Name>`
  - For example, BT.Tools.Graphics.Point

- Class files must be stored in a directory that has the same components of the package name for the class
  - For example, the class BT.Tools.Graphics.Point must be in the BT/Tools/Graphics/Point.class file
  - This filename is interpreted relative to one of the directories specified in the CLASSPATH environment variable
**Packages**

- The CLASSPATH environment variable tells the Java interpreter where to look for user-defined classes. CLASSPATH is a colon-separated list of directories to search or the names of "zip" or "jar" files that contain the classes:
  - For example, setenv CLASSPATH
    ./home/bt/java:/usr/local/comms/classes.zip
  - Given the above CLASSPATH, if the Point.class file is in
    /home/bt/java/BT/Tools/Graphics, it will be successfully found by the Java run-time system
The Import Statement

- The import statement allows the use of abbreviated class names in a Java source file.
- Classes are always available via their fully-qualified names:
  
  ```java
  ```

- The import statement does not "read in" the class or "include" it; it just saves typing:
  
  ```java
  import BT.Tools.Graphics.Point;
  Point p = new Point();
  ```

- All of the classes of a package can be imported at one time using this form of the import statement:
  
  ```java
  import java.util.*;
  ```

  This imports all of the classes in the java.util package.
Visibility Modifiers

- We've already seen that a class member can be modified with the public, private or protected keywords.
- If none of these modifiers are used, the member has the default visibility or "package" visibility.
- A package member is only accessible from within the class that defines it or a class in the same package.
- Here's the definitive chart!

<table>
<thead>
<tr>
<th>ACCESSIBLE TO:</th>
<th>MEMBER VISIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>public</td>
</tr>
<tr>
<td>Same class</td>
<td>Yes</td>
</tr>
<tr>
<td>Class in same package</td>
<td>Yes</td>
</tr>
<tr>
<td>Subclass in different package</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-subclass in different package</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table from *Java In A Nutshell, 2nd Edition* by David Flanagan
Inner Classes

- Inner classes were added to the Java language in Java 1.1
- There are now five different types of Java classes and two different types of Java interfaces
- Top-level classes and interfaces
  - Package member class (or interface)
    - Ordinary class (or interface) that is a direct member of a package
    - The original, familiar Java 1.0 class (or interface)
  - Nested top-level class (or interface)
    - A class (or interface) declared static within another top-level class (or interface)
    - Can only access the static members of its containing class
    - Useful for helper classes (and interfaces) and provide a convenient way to group related classes (or interfaces)
Inner Classes (Continued)

- Inner classes
  - *Member class*
    - A class defined as a member of another class
    - Can not be declared static
    - Can not have any static members
    - Can access all members (even private) of its containing class
    - Also useful for helper classes
  - *Local class*
    - Class defined inside a block of code
    - Is visible only within the enclosing block
    - Analogous to a local variable
    - Can access all members (even private) of its enclosing class
    - Similar in use to a member class, but can be put close to the location in the code where it is actually used, thus improving readability
Inner Classes (Continued)

- Inner classes
  - Anonymous class
    - A local class which is defined and instantiated in one statement
    - Does not have a name!

- Inner classes are frequently used to implement the event listener objects required by the Abstract Window Toolkit (AWT) or Swing Java Foundation Classes GUI components
Member Class Example

// Member Class example.
public class ButtonDemo {
    public ButtonDemo() {
        // Create a button.
        Button button = new Button("Press me");
        // Register an ActionListener for the button.
        button.addActionListener(new ButtonActionHandler());
        ...
    }
    ...
    // Somewhere later in the file we have this member class which
    // defines the required ActionListener.
    class ButtonActionHandler implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            System.out.println("You pressed me, you pressed me!");
        }
    }
}

Introduction To Java

Design Patterns In Java

Bob Tarr
Local Class Example

// Local Class example.
public class ButtonDemo {
    public ButtonDemo() {
        // Create a button.
        Button button = new Button("Press me");
        // Register an ActionListener for the button.
        button.addActionListener(new ButtonActionHandler());

        // Let's put the definition of the required ActionListener right
        // here as a local class. That way, it is much closer in the
        // source file to its actual use.
        class ButtonActionHandler implements ActionListener {
            public void actionPerformed(ActionEvent e) {
                System.out.println("You pressed me, you pressed me!");
            }
        }
    }
}

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Anonymous Class Example

// Anonymous Class example.
public class ButtonDemo {
    public ButtonDemo() {
        // Create a button.
        Button button = new Button("Press me");

        // Instantiate an anonymous inner class that acts as the
        // ActionListener for the button.
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                System.out.println("You pressed me, you pressed me!");
            }
        });
    }
    ...
}
Anonymous vs Local

- Which one should you use? An anonymous class or a local class?
- It’s a matter of your own personal style
- But….  

- Prefer an anonymous class if
  - The class is very small
  - Only one instance of the class is needed
  - The class is to be used right after it is defined
  - Naming the class does not make your code any easier to read

- Prefer a local class if
  - More than one instance of the class is required