Java for C++ Programmers

Why Java?

- **Object-oriented** (even though not purely…)
- **Portable -** programs written in the Java language are platform independent
- **Simpler development –** clever compiler: strong and static typing, garbage collection…
- **Familiar –** took the best out of C++.

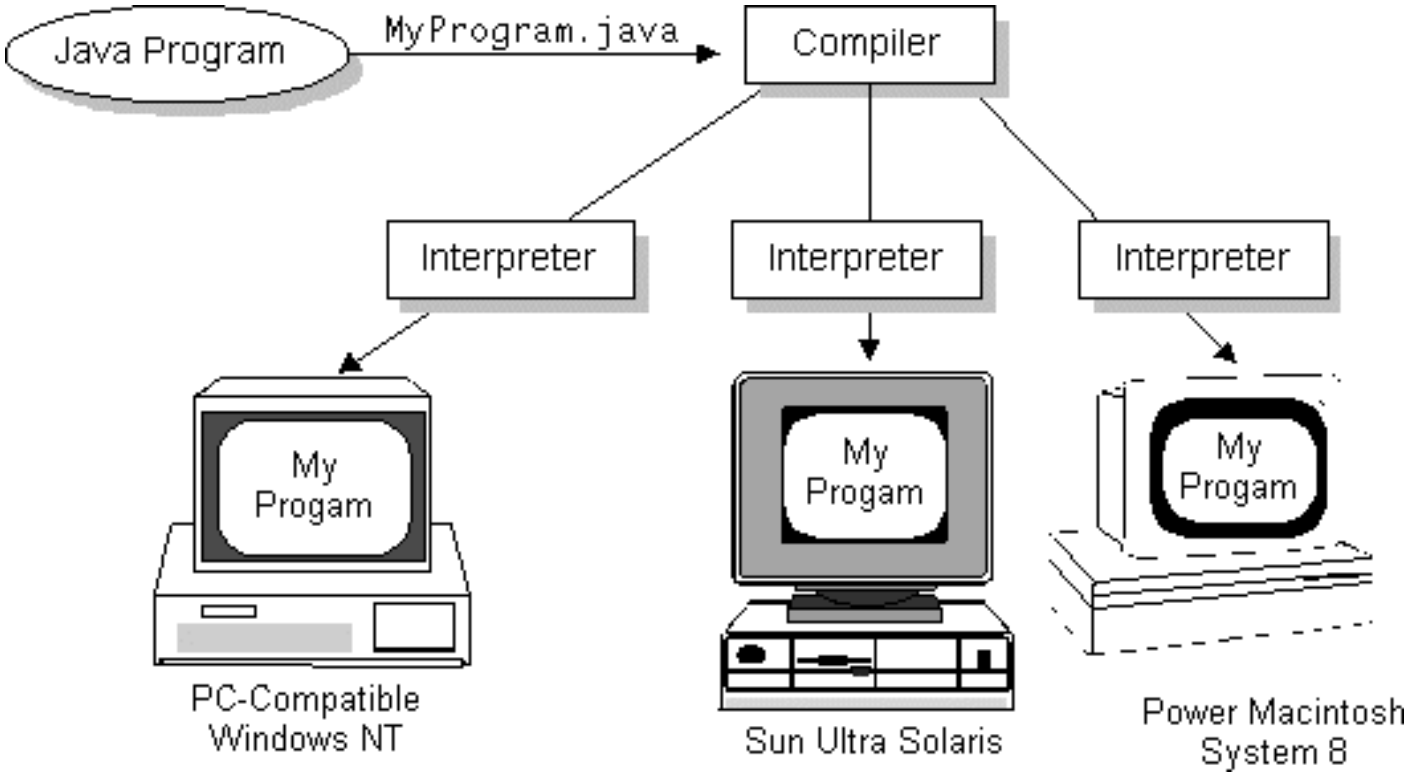
Java highlights

- Static typing
- Strong typing
- Encapsulation
- Reference semantics by default
- One common root object
- Single inheritance of implementation
- Multiple inheritance of interfaces
- Dynamic binding

JVM – Java Virtual Machine

- JVM is an interpreter that translates Java bytecode into real machine language instructions that are executed on the underlying, physical machine
- A Java program needs to be compiled down to bytecode only once; it can then run on any machine that has a JVM installed

Java Virtual Machine



Running Java Programs

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

> javac HelloWorld.java

The compilation phase: This command will produce the java bytecode file HelloWord.class

> java HelloWorld

The execution phase (on the JVM): This command will produce the output "Hello World!"

The main() method

- Like C and C++, Java applications must define a `main()` method in order to be run.
- In Java, the `main()` method must follow a strict naming convention.
  - **`public static void`** `main(String[] args)`
- The `main()` method is always a *member function* of a class
  - No global functions

Types

- There are two types of variables in Java, *primitive* types (int, long, float etc.) and *reference* types (objects)
- In an assignment statement, the value of a primitive typed variable is copied
- In an assignment statement, the pointer of a reference typed variable is copied

Primitive Types

The Java programming language guarantees the size, range, and behavior of its primitive types

Type	Values
boolean	true,false
char	16-bit unicode charecter
byte	8-bit signed integers
short	16-bit signed integers
int	32-bit signed integers
long	64-bit signed integers
float	32-bit floating point
double	64-bit floating point
void	-

The default value for primitive typed variables is zero bit pattern

Reference Types

- Reference types in Java are *objects:*
  - Identity: location on *heap*
  - State: Set of *fields*
  - Behaviour: Set of *methods*

- The default value of reference typed variables is *null*

Arrays

- Java arrays are objects, so they are declared using the new operator
- The size of the array is fixed

```
Animal[] arr; // nothing yet …
arr = new Animal[4]; // only array of pointers
for(int i=0 ; i < arr.length ; i++) {
      arr[i] = new Animal();
// now we have a complete array
```

- The length of the array is available using the field `length`.

Multidimensional arrays

- Multidimensional array is an array of arrays
- Size of arrays may not be the same

```
Animal[][] arr; // nothing yet …
arr = new Animal[4][]; // array of array pointers
for(int i = 0; i < arr.length; i++) {
  arr[i] = new Animal[i+1];
  for (int j = 0; j < arr[i].length; j++){
    arr[i][j]=new Animal();
  }
}
```

Strings

- All string literals in Java programs, such as "abc", are instances of `String` class
- Strings are immutable
  - their values cannot be changed after they are created
- Strings can be concatenated using operator+
- All objects can be converted to `String`
  - Using `toString()` method defined in `Object`
- The class `String` includes methods such as:
  - `charAt()` examines individual character
  - `compareTo()` compares strings
  - `indexOf()` Searches strings
  - `toLowerCase()` Creates a lowercase copy

Flow control

Just like C/C++:

if/else

```
if(x==4) {
  // act1
} else {
  // act2
}
```

do/while

```
int i=5;
do {
  // act1
  i--;
} while(i!=0);
```

for

```
int j;
for(int i=0;i<=9;i++)
{
  j+=i;
}
```

switch

```
char
c=IN.getChar();
switch(c) {
  case 'a':
  case 'b':
    // act1
    break;
  default:
    // act2
}
```

Java 1.5 – new **for-each** loop

```
int[] array=new int[10];
// calculate the sum of array elements
for (int curr:array){
      sum += curr;
}
```

Classes in Java

- In a *Java program*, everything must be in a class.
  - There are no global functions or global data
- Classes have *fields* (data members) and *methods* (member functions)
- Fields and can be defined as one-per-object, or one-per-class (static)
- Methods can be associated with an object, or with a class (static)
  - Anyway, methods are defined by the class for all its instances
- Access modifiers (private, protected, public) are placed on each definition for each member (not blocks of declarations like C++)

Class Example

```
package example;
public class Rectangle {

  public int width = 0;
  public int height = 0;
  public Point origin;

  public Rectangle() {
    origin = new Point(0, 0);
  }
  public Rectangle(int w, int h) {
    this(new Point(0, 0), w, h);
  }
  public Rectangle(Point p, int w, int h) {
    origin = p; width = w; height = h;
  }
  public void setWidth(int width) {
    this.width = width;
  }
}
```

fields

constructors

a method

Inheritance

- It is possible to inherit only from *one* class.
- All methods are virtual by default

```
class Base {
  void foo() {
    System.out.println("Base");
  }
}
class Derived extends Base {
  void foo() {
    System.out.println("Derived");
  }
}
public class Test {
  public static void main(String[] args) {
    Base b = new Derived();
    b.foo();  // Derived.foo() will be activated
  }
}
```

Interfaces

- Defines a *protocol* of communication between two objects
- Contains *declarations* but no implementations
  - All methods are implicitly public and abstract
  - All fields are implicitly public, static and final (constants).
- An interface can *extend* any number of interfaces.
- Java's compensation for removing multiple inheritance. A class can *implement* many interfaces.

Interfaces - Example

```
interface ISinger {
    void sing(Song);
}
```

```
interface IDancer {
    void dance();
}
```

```
class Actor implements ISinger, IDancer {
        // overridden methods MUST be public
        // since they were declared public in super class
        public void sing() { … }
        public void dance () { … }
}
```

Abstract Classes

- *abstract method* means that the method does not have an implementation
  - `abstract void draw();`
- *abstract class* a class that has at least one abstract method
  - Must be declared `abstract`
  - An abstract class is not-complete. Some parts of it need to be defined by subclasses.
  - Can't create an object of an incomplete class: some of its messages will not have a behavior

Final

- ***final* data member**
  Constant member
- ***final* method**
  The method can't be overridden.
- ***final* class**
  'Base' is final, thus it can't be extended

```
final class Base {
  final int i=5;
  final void foo() {
  }
}

class Derived extends Base { // Error
  // another foo ...
  void foo() {

  }
}
```

Static Data Members

- Same data is shared between all the instances (objects) of a Class.
- Assignment performed on the first access to the Class.

```
class A {
   public static int x_ = 1;
};

A a = new A();
A b = new A();
System.out.println(b.x_);
a.x_ = 5;
System.out.println(b.x_);
A.x_ = 10;
System.out.println(b.x_);
```

Output:

1
5
10

Static Methods

- Static method can access only static members
- Static method can be called without an instance.

```
Class TeaPot {
        private static int numOfTP = 0;
        private Color myColor_;
        public TeaPot(Color c) {
                myColor_ = c;
                numOfTP++;
        }
        public static int howManyTeaPots()
                { return numOfTP; }

        public static Color getColor()
                { return myColor_; } // error
}
```

Java Program Organization

- Java program
  - One or more Java *source files*
- Source file
  - One or more class and/or interface declarations.
  - If a class/interface is *public* the source file must use the *same (base) name*
    - So, only one public class/interface per source file
- Packages
  - When a program is large, its classes can be organized hierarchically into *packages*
    - A collection of related classes and/or interfaces
    - Classes are placed in a directory with the package name

Using Packages

- Use *fully qualified* name
  - A qualified name of a class includes the class' package
  - Good for one-shot uses: `p1.C1 myObj = new p1.C1();`
- Use `import` statement
  - at the beginning of the file, after the package statement
  - Import the package member class:

```
import p1.C1;
     ...
C1 myObj = new C1();
```

  - Import the entire package (may lead to name ambiguity)

```
import p1.*;
```

- classes from package `java.lang` are automatically imported into every class
- To associate a class with a package, put `package p` as the first non-comment statement in a source file

Visibility of Classes

- A class can be declared:
  - **public** : new is allowed from All packages
  - Default: new is allowed only from the same package

```
package P1;
public class C1 {
}
class C2 {
}
```

```
package P2;
  class C3 {
}
```

```
package P3;
import P1.*;
import P2.*;

public class DO {
  void foo() {
      C1 c1 = new C1();
      C2 c2 = new C2(); // error
      C3 c3;            // error
  }
}
```

Visibility of Members

- A definition in a class can be declared as:
  - ***public***
    - Can be accessed from outside the package.
  - ***protected***
    - Can be accessed from derived classes
  - ***private***
    - Can be accessed only from the current class
  - ***default*** **(if no access modifier is stated)**
    - Usually referred to as "Package access".
    - Can be called/modified/instantiated only from within the same package.

The `Object` Class

- Root of the class hierarchy
- Provides methods that are common to all objects
  - **`boolean equals(Object o)`**
  - **`Object clone()`**
  - **`int hashCode()`**
  - **`String toString()`**
  - **`...`**

Testing Equality

- The equality operator **==** returns true if and only if both its operands have the same value.
  - Works fine for primitive types
  - Only compares the *identity* of objects:

```
Integer i1 = new Integer("3");
Integer i2 = new Integer("3");
Integer i3 = i2;

i1 == i1; // Result is true
i1 == i2; // Result is False
i2 == i3; // Result is true
```

Object Equality

- To compare between two *objects* the **`boolean equals(Object o)`** method is used:
  - Default implementation compares using the equality operator.
  - Most Java API classes provide a specialized implementation.
  - Override this mehtod to provide your own implementation.

```
i1.equals(i1)  // Result is true
i1 == i2;      // Result is false
i1.equals(i2)  // Result is true
```

Example: Object Equality

```
public class Name
{
   String firstName;
   String lastName;
   ...
   public boolean equals(Object o)
   {
      if (!(o instanceof Name))
        return false;
      Name n = (Name)o;
      return firstName.equals(n.firstName) &&
             lastName.equals(lastName);
   }
}
```

More on the subtleties of `equals()` later in the course…

Wrappers

- Java provides objects which wrap primitive types.

```
Integer n = new Integer(4);
int m = n.intValue(); // java 1.4
int k=n;              // java 1.5 - autoboxing

int l = Integer.parseInt("123");   // l is 123
String s1 = n.toString();          // s1 is "4"
String s2 = "" + n;                // s2 is "4"
```

- There is a wrapper class in `java.lang` package for every primitive type
  - `Byte`, `Short`, `Integer`, `Float`, `Long`, `Double`, `Character`

Garbage Collection

- C++: `delete` operator releases allocated memory.
  - Not calling it means memory leaks
- Java: no `delete`
  - Objects are freed automatically by the *garbage collector* when it is clear that the program cannot access them any longer.
  - Thus, there is no "dangling reference" problem.
  - Logical memory leaks may still occur if the program holds unnecessary objects.

Handling input/output

- `Class System` provides access to the native operating system's environment through *static* methods and fields.
- It has three fields:
  - The `out` field is the standard output stream
    - Default is the same console, can be changed
    - Example: `System.out.print("Hello");`
  - The `err` filed is the standard error output stream.
    - Used to display error messages
  - The `in` filed is the standard input stream.
    - use it to accept user keyboard input.
    - Example: `char c = (char) System.in.read();`

Scanner Class

- Scanner objects parse primitive types and strings using regular expressions
- To use Scannner: `import java.util.Scanner;`
- To create a scanner object: `new Scanner(input_source)`
  - Input source can be keyboard (System.in), files, string variables, etc.

- Operations
  - `nextInt()`, `nextBoolean()` - Returns value of indicated type
  - `next()` Returns sequence of characters up to next whitespace
  - `findInLine` () – looks for a specified pattern
  - `hasNext()` - Returns true if this scanner has a token in its input.
    - Can be used to detect EOF.

Scanner Example

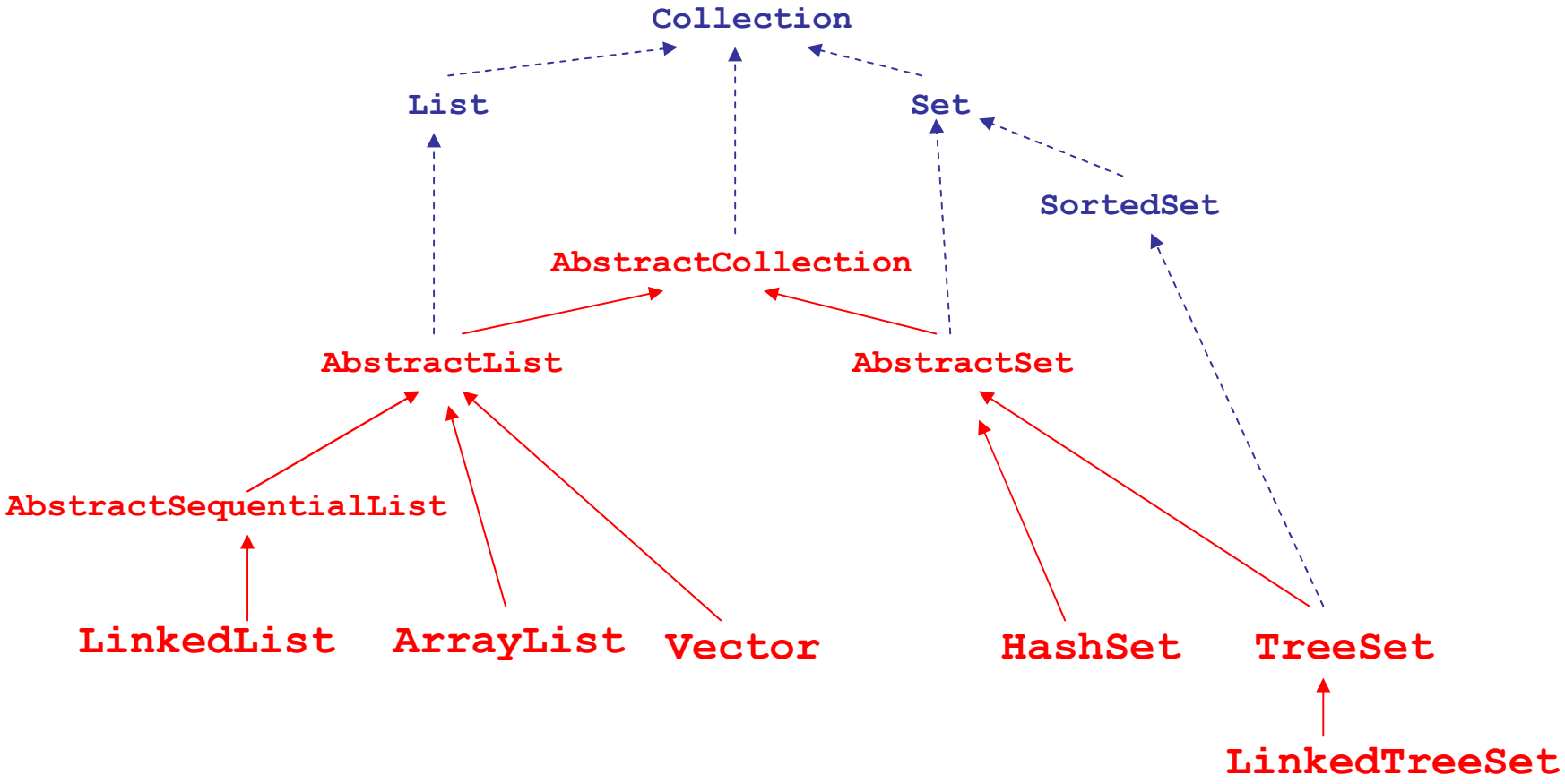
```
int i;
double d;
String s1, s2;
Scanner sc = new Scanner(System.in);
System.out.print("Enter an integer: ");
i = sc.nextInt();
System.out.print("Enter a floating point value: ");
d = sc.nextDouble();
System.out.print("Enter a string: ");
s1 = sc.next();
System.out.print("Enter a string terminated by a new
  line: ");
s2 = sc.nextLine();

System.out.println("Here is what you entered: ");
System.out.println(i);
System.out.println(d);
System.out.println(s1);
System.out.println(s2);
```

Collections

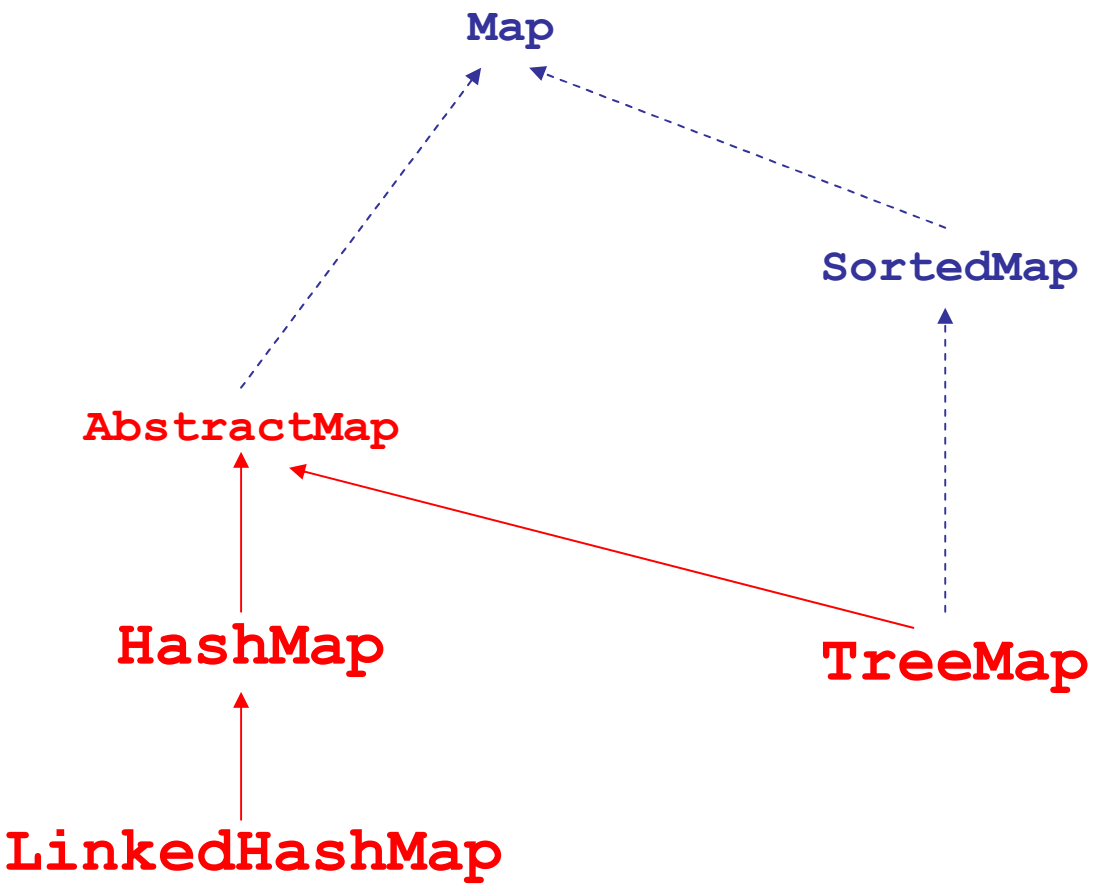
- A collection (a *container* in C++) is an object that groups multiple elements into a single unit.
- Containers can contain only objects
  - Autoboxing can help!
- The Java Collections Framework provides:
  - ***Interfaces***: abstract data types representing collections.
    - allow collections to be manipulated independently of the details of their representation.
  - ***Implementations***: concrete implementations of the collection interfaces.
    - reusable data structures.
  - ***Algorithms***: methods that perform useful computations, like searching and sorting, on objects that implement collection interfaces.

Collection Interfaces and Classes



- `Vector` and `HashTable` are old collection classes
  - Not deprecated for backward compatibility reasons
  - Use `ArrayList` and `HashMap` instead.

Map Interfaces and Classes



Iterate Through Collections

- An object that implements the **`Iterator`** interface generates a series of elements, one at a time
  - Successive calls to the **`next()`** method return successive elements of the series.
  - The **`hasNext()`** method returns true if the iteration has more elements
  - The **`remove()`** method removes from the underlying collection the last element that was returned by `next()`.

Set Example

```
Set set = new HashSet(); // instantiate a concrete set
set.add(obj); // insert an elements
int n = set.size(); // get size
if (set.contains(obj)) {...} // check membership

// iterate through the set using iterator
Iterator iter = set.iterator();
while (iter.hasNext()) {
  Object e = iter.next();
  …
}

// iterate through the set using enhanced for loop
for (Object e  : set) {
  …
}
```

Class `Collections`

- Provides *static* methods for manipulating collections
  - `binarySearch()` searches a sorted list
  - `copy()` copies list
  - `fill()` replaces all list elements with a specified value
  - `indexOfSubList()` – looks for a specified sublist within a source list
  - `max()` returns the maximum element of a collection
  - `sort()` sorts a list

Class `Arrays`

- Provides *static* methods for manipulating arrays
  - `binarySearch()` searches a sorted array
  - `equals()` compares arrays
  - `fill()` places values into an array
  - `sort()` sorts an array

Resources

Java Tutorial -
http://java.sun.com/docs/books/tutorial/

Java 6 API Spec -
http://java.sun.com/javase/6/docs/api/