Java for C++ Programmers

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Why Java?

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

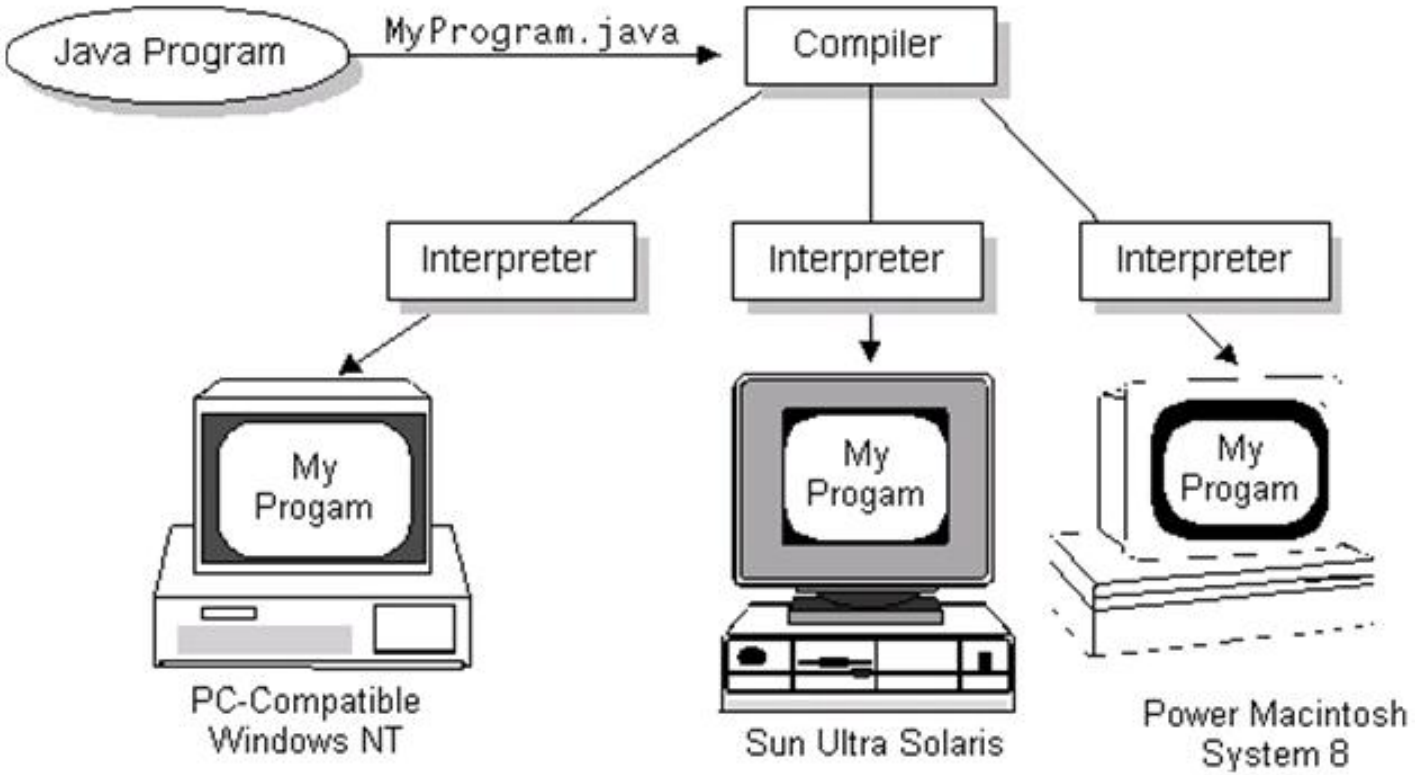
Java highlights

- 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)`
- main() is always a method ("member function" in C++ terminology).
  - 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 character
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 pattern bit

Reference Types

- Reference types in Java are objects:
  - Identity: location on heap
  - State: set of fields
  - Behavior: set of methods
- The default value of reference typed variables is null

Arrays

```
Animal[] arr; // Nothing yet, just a reference.
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
```

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

Multidimensional arrays

```
Animal[][] arr; // Nothing yet, just a reference.
arr = new Animal[4][]; // Only 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();
        }
}
// Now we have a complete array
```

- Multidimensional array is an array of arrays
- Size of inner arrays can vary.
- Add more [] for more dimensions.
  - `Animal[][][] arr3D;`

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 the + 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':
        // fall through
     case 'b':
        // act1
        break;
     default:
        // act2
}
```

For-each loop

```
int[] array = new int[10];
int sum = 0;

// calculate the sum of array elements
for (int element : array){
        sum += element;
}
```

- Iterates over a the elements in a collection (or array).
- Preserves type safety, while removing the clutter of conventional loops.
- The loop above reads as “for each int element in array”.
- Added to C++11 as well.

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 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

"this" used to call another constructor (must be placed in the first row)

Inheritance

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

```
public class Base {
        void foo() { System.out.println("Base"); }
}
public class Derived extends Base {
        @Override
        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

Declaration

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

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

Implementation

```
class Actor implements Singer, Dancer {
// overridden methods MUST be public since they were declared
// public in super class
     @Override public void sing(Song s) { }
     @Override public void dance() { }
}
```

Usage

```
Dancer d = new Actor();
d.dance();
```

Abstract Classes

- An abstract method means that the method does not have an implementation
  - `abstract void draw();`
- An abstract class is a class that is declared as being `abstract`.
  - Must be so if has at least one abstract method (a class can be abstract even if it has no abstract methods, but that's rare).
  - An abstract class is incomplete. 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
  - Abstract classes don't have to implement interface functions

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[] x = new int[10];
        final void foo() {
                x = new int[9]; // Error
                x[9] = 3;       // OK
        }
}

class Derived extends Base {
        @Override
        void foo() {}           // Error
}
```

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; // works, but confusing
System.out.println(b.x_);
A.x_ = 10; // that's the way to go
System.out.println(b.x_);
```

Output

```
1
5
10
```

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: visible to all packages
  - default: visible only to 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; // ok
    C2 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 and classes in the same package (different than C++).
  - **private**
    - can be accessed only from the current class
  - **default (if no access modifier is stated)**
    - also known as "Package private".
    - Can be called/modified/instantiated only from within the same package.

Visibility of Classes

Modifier	Same class	Same package	Subclass	Universe
`private`	✓			
default	✓	✓		
`protected`	✓	✓	✓	
`public`	✓	✓	✓	✓

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()`
  - …

Operator ==

- The equality operator == returns true if and only if both its operands are the same.
  - Compares values of primitive types.
  - Compares identities 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 method 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;

  @Override
  public boolean equals(Object o) {
    if (!(o instanceof Name)) return false;
    Name other = (Name)o;
    return firstName.equals(other.firstName) &&
           lastName.equals(other.lastName);
  }
}
```

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

Wrapper Classes

- Java provides wrapper classes for each of the primitive data types. These classes "wrap" the primitive in an object.

```
// Boxing - conversion from primitive types to their
// corresponding wrapper classes
Character ch = new Character('a'); // boxing example
Character ch = 'a'; // auto-boxing example

// Unboxing - conversion between wrapper
// classes and their corresponding
// primitive types
Integer n = new Integer(4);
int m = n.intValue(); // unboxing example
int k = n; // auto-unboxing example

int i = Integer.parseInt("42"); // i is 42
String s1 = n.toString(); // s1 is "4"
String s2 = "a" + n; // s2 is a4
```

Primitive type	Wrapper class
boolean	Boolean
byte	Byte
char	Character
float	Float
int	Integer
long	Long
short	Short

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` field is the standard error output stream.
    - Used to display error messages
  - The `in` field is the standard input stream.
    - use it to accept user keyboard input.
    - Example: `char c = (char) System.in.read();`

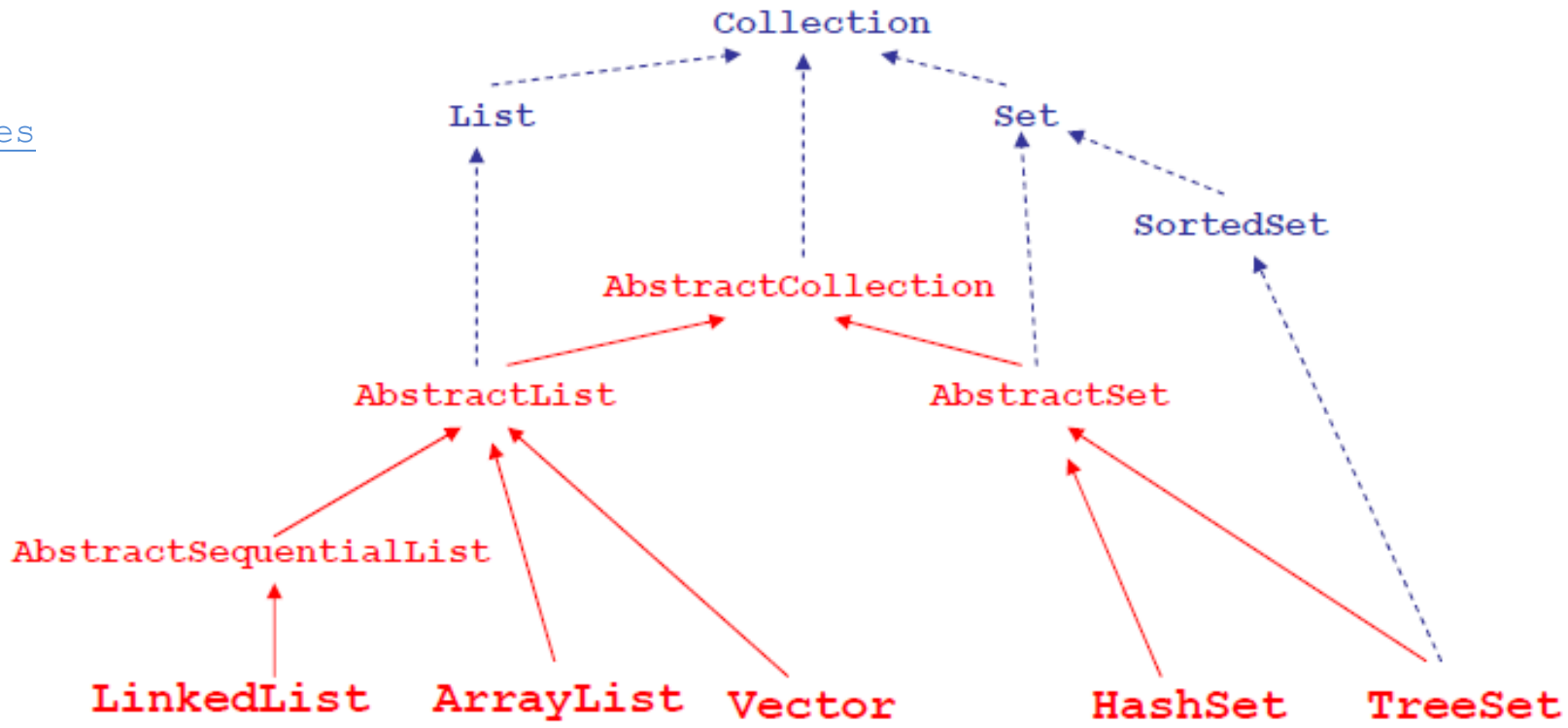
Collections

- A collection (container in C++) is an object that groups multiple elements into a single unit.
- Containers can contain only objects
  - Auto-boxing 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

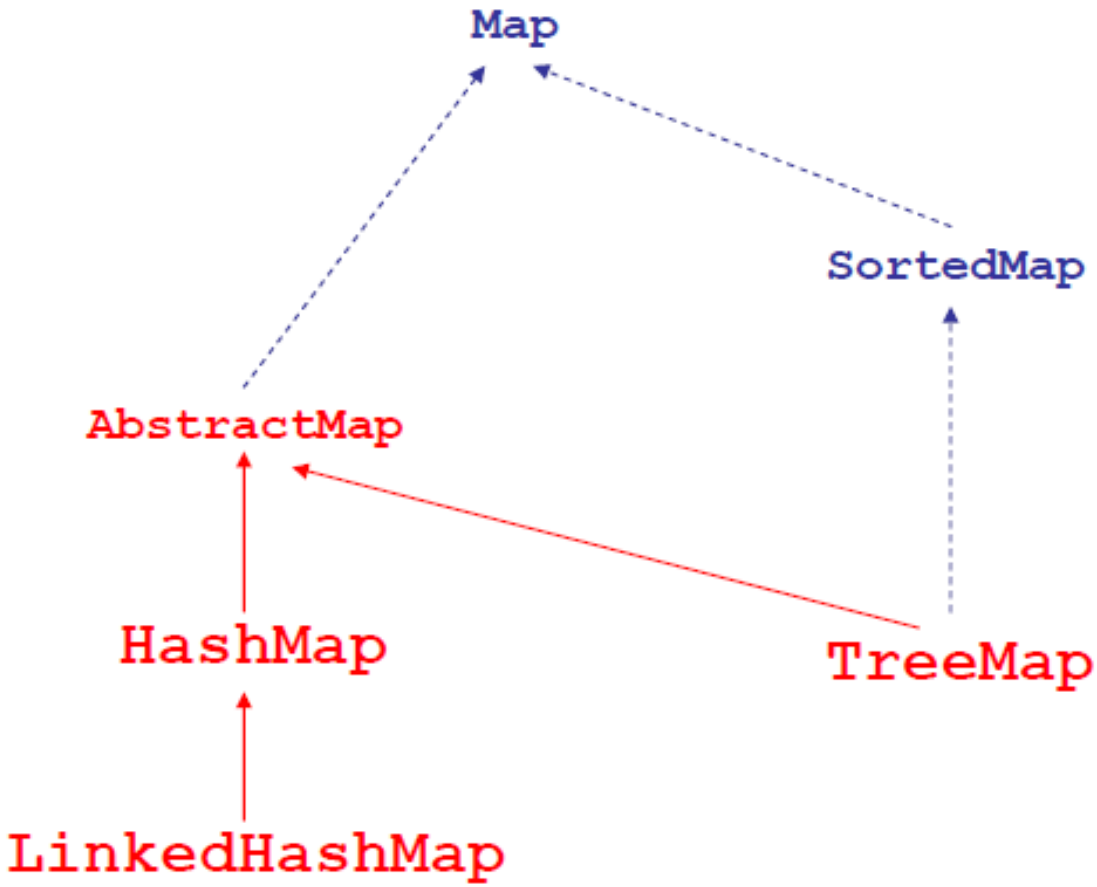
interfaces

Abstract Classes



Complete Implementations

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 the last element that was returned by `next()` from the underlying collection.

Set Iteration Example

```
// instantiate a concrete set
Set<Integer> set = new HashSet<Integer>();

set.add(1); // insert an elements. note the auto-boxing
int n = set.size(); // get size
if (set.contains(1)) {...} // check membership

// iterate through the set using iterator
Iterator iter = set.iterator();
while (iter.hasNext()) {
  int number = iter.next(); // note the auto-unboxing
  // do work
}

// iterate through the set using enhanced for-each loop
for (int number : set) {
  // do work
}
```

Iterable Collection Example

- Define a collection of continuous intervals of integers:
  - define an iterator class that iterates through all the integers in the interval.

```
class Interval implements Iterable<Integer> {
  final private int start, stop, step;
  Interval(int start, int stop, int step) {
    this.start = start;
    this.stop = stop;
    this.step = step;
  }
  @Override Iterator<Integer> iterator() {
    return new IntervalIterator(start, stop, step);
  }
}
```

Iterable Collection Example (2)

```
class IntervalIterator implements Iterator<Integer>{
  //start stepping through the array from the beginning
  private int next; private int stop; private int step;

  IntervalIterator(int start, int stop, int step){
    this.next = start; this.stop = stop; this.step = step;
  }
  @Override public boolean hasNext() {
    //check if a current number is the last in the interval
    return (next <= stop);
  }
  @Override public Integer next() {
    int retValue = next; next += step; return retValue;
  }
  // implement remove as well
}
```

```
for (int i : new Interval(0, 10, 2)) {
  System.out.println(i);
}
```

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
- These methods receive collections as parameters

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
- These methods receive arrays as parameters

Resources

- Java Tutorial - http://docs.oracle.com/javase/tutorial/index.html
- Java 7 API Spec - http://docs.oracle.com/javase/7/docs/api/