A Brief Introduction to Java for C++ Programmers: Part 1
ENGI 5895: Software Design

Andrew Vardy

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January 11, 2017
Assumptions

- You already know C++
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- You understand that this presentation is just a feature overview. Only a fraction of Java’s features are presented and we barely scratch the surface of the Java API.
Programs written in Java are executed on a **Java Virtual Machine (JVM)**

- Java can be run any platform for which a JVM has been implemented
Java Overview

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- Code is written in .java files; These are converted into .class files (bytecode)
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Since 2008: Primary language for apps on Android

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- Approximately the same as other JIT compiled languages such as C#
- Much faster than pure interpreted scripting languages such as Perl, Python, and Ruby
Comparison with other Languages

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- Twice as fast as C++ (from “Thinking in Java”)
- Slower than scripting languages (Hard to find an objective source for this information)
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- Graphical User Interfaces (GUI): AWT, Swing, and JavaFX
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In Java, there is no code that exists outside of a class. Even the main method must appear within a class:

```java
public class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello World");
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Everything is an Object

In Java, there is no code that exists outside of a class. Even the main method must appear within a class:

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public class HelloWorld {
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```

Similar to C++

- Classes are similarly defined (although no .h and .cpp separation)
- `public` has roughly the same meaning, although here it is used twice for both the class and the main method

Different from C++

- `main` exists within a class.
Everything is an Object

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public class Point {
    private double x, y;

    /* Constructor. */
    public Point(double x, double y) {
        this.x = x;
        this.y = y;
    }

    public double getX() { return x; }
    public void setX(double inX) { x = inX; }
    // ...
A Point Class in C++

class Point {
private:
    double x, y;
public:
    /* Constructor. */
    Point(double x, double y) {
        this->x = x;
        this->y = y;
    }

    double getX() { return x; }
    void setX(double inX) { x = inX; }
    // ...
};
class Point {
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    double x, y;
public:
    /* Constructor. */
    Point(double x, double y) {
        this->x = x;
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    };

    doublegetX() { return x; };
    void setX(double inX) { x = inX; };
    // ...
};

In C++ we can implement methods within the .h file or the .cpp file. In Java there is only the .java file.
// No including type stuff required (yet)

public class TestPoint {
    public static void main(String[] args) {
        // Objects are always constructed on heap
        Point p = new Point(4, 10);
    }
}
Testing the Point Class in Java

// No including type stuff required (yet)

public class TestPoint {
    public static void main(String[] args) {

        // Objects are always constructed on heap
        Point p = new Point(4, 10);
        //

        // p is called a reference variable
        p.setX(5);
        //
    }
}
Testing the Point Class in Java

// No including type stuff required (yet)

public class TestPoint {
  public static void main(String[] args) {

    // Objects are always constructed on heap
    Point p = new Point(4, 10);

    // p is called a reference variable
    p.setX(5);

    // String concatenation with +
    System.out.println("x: " + p.getX());
  }
}

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Brief Intro. to Java: Part 1
#include <iostream>
#include "Point.h"
using namespace std;

int main(int argc, char **argv) {

    // Here we construct the object on the stack.
    Point p(4, 10);

    // Calling a public method
    p.setX(5);

    // Using the overloaded "<<" to concatenate.
    cout << "x: " << p.getX() << endl;
}

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All variables are either primitive types or references.

Primitive Types (most common in bold):

- int: 32-bit integers from -2,147,483,648 to 2,147,483,647
- double: 64-bit floating-point numbers; range of about ±1.7 × 10^308
- boolean: Boolean value written as true or false
- char: 16-bit characters
All variables are either primitive types or references. Primitive Types (most common in bold):

- byte, short, **int**, long, float, **double**, **boolean**, char.
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Usage of Primitives Similar to C++

```java
public class Primitives1 {
    public static void main(String[] args) {
        // Declare and utilize as in C++.
        int i = 4;
        i++;
        System.out.println("i: " + i);
    }
}
```
public class Primitives1 {
    public static void main(String[] args) {
        // Declare and utilize as in C++.
        int i = 4;
        i++; 
        i++; 
        System.out.println("i: " + i);
    
        // Error to use an uninitialized value!
        // double x;
        // System.out.println("x: " + x);
    }
}
public class Primitives1 {
    public static void main(String[] args) {
        // Declare and utilize as in C++. 
        int i = 4;
        i++;
        System.out.println("i: " + i);
        // Error to use an uninitialized value!
        double x;
        // System.out.println("x: " + x);
        // Logic and comparison.
        boolean a = false;
        boolean output = a && (i < 100); // Lazy!
        System.out.println("output: " + output);
    }
}
Primitive members initialized to 0 (false for booleans).

```java
public class Primitives2 {
    private int i, j; // Will be initialized to 0
    private long k = 12;

    public Primitives2() {
        j = 7; // j was already initialized to 0.
    }
}
```
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public class Primitives2 {
    private int i, j; // Will be initialized to 0
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    public void printOut() {
        System.out.println("i: " + i + ", j: " + j + ", k: " + k);
    }
}
```

//
Initialization of Primitive Data Members

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    public void printOut() {
        System.out.println("i: " + i + ", j: " + j + ", k: " + k);
    }

    public static void main(String[] args) {
        Primitives2 p2 = new Primitives2();
        p2.printOut(); // A method call!
    }
}
```
Conversion between Primitive Types

You can convert between types where the appropriate widening relationships exist:

\[
\text{long} \gggg \text{int} \gggg \text{short} \gggg \text{byte} \quad \text{double} \gggg \text{float}
\]

```java
public class Primitives3 {
    public static void main(String[] args) {
        // Maximum values for each type.
        byte b = 127;
        long l = 9223372036854775807L; // Suffix l
        ...
    }
}
```
Conversion between Primitive Types

You can convert between types where the appropriate widening relationships exist:

\[
\begin{align*}
\text{long} & \quad > \quad \text{int} \quad > \quad \text{short} \quad > \quad \text{byte} \\
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        l = b;
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        l = b; //
        // b = l - 1; // Can't do this
        //
        // If you know the loss of precision is
        // acceptable you can cast between types.
        b = (byte) (l - 1);
    }
}
```
int: 10 digits max., long: 19 digits max.
float 6-7 significant digits, double 15 significant digits

public class Primitives4 {
    public static void main(String[] args) {
        long l = 9223372036854775807L;
        float f = 2.0F; // Use suffix F for floats
        //
Conversion Issues

int: 10 digits max., long: 19 digits max.
float 6-7 significant digits, double 15 significant digits

public class Primitives4 {
    public static void main(String[] args) {
        long l = 92233720368547758071;
        float f = 2.0F; // Use suffix F for floats
        // Loss of precision!
        f = l;
        System.out.println("l: " + l);
        System.out.println("f: " + f);
    }
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```java
public class Primitives4 {
    public static void main(String[] args) {
        long l = 9223372036854775807L;
        float f = 2.0F; // Use suffix F for floats

        // Loss of precision!
        f = l;
        System.out.println("l: " + l);
        System.out.println("f: " + f);

        // System.out.println("l == f: " + (l == f));
        // The long is converted to a float
        // in the comparison, so the result is true!
    }
}
```
public class ControlFlow {
    public static void main(String[] args) {
        // Loops, if-else, statements, all as C++
        for (int i=0; i<3; i++)
            System.out.println("i: "+i);
    }
}
public class ControlFlow {
    public static void main(String[] args) {
        // Loops, if–else, statements, all as C++
        for (int i = 0; i < 3; i++)
            System.out.println("i: " + i);

        // But the conditions for these statements
        // only accept booleans!
        int i = 3;
        // while (i) { // Can't do this
        while (i > 0) {
            System.out.println("i: " + i);
            i--;
        }
    }
}

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Brief Intro. to Java: Part 1
Reference Variables

Objects are referred to through reference variables, which are essentially pointers without the horrible syntax.

```java
public class References {
    public static void main(String[] args) {
        // Declare a reference to a new Point
        Point a = new Point(0, 0);
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        // Another reference 'pointing' at
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        Point b = a;

        b.setX(42);
        System.out.println("a.getX(): " + a.getX());
    }
}
```
Local variables, including both primitive types and references live on the stack.
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Objects (but not references) are allocated with new and live on the heap.
Local variables, including both primitive types and references live on the **stack**.

Objects (but not references) are allocated with **new** and live on the **heap**.

There is no **delete** keyword! When there are no references to an object remaining, the object becomes available to the **garbage collector** (GC).
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Objects (but not references) are allocated with new and live on the heap.

There is no delete keyword! When there are no references to an object remaining, the object becomes available to the garbage collector (GC).

The GC uses its own logic to determine when to re-claim unused memory. Therefore, you should not make any assumptions about when your object is deleted.
- Local variables, including both primitive types and references live on the **stack**.
- Objects (but not references) are allocated with **new** and live on the **heap**.
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  - The GC uses its own logic to determine when to re-claim unused memory. Therefore, you should not make any assumptions about when your object is deleted.
  - There is no destructor in Java, but there is a **finalize** method that is used in unusual circumstances to de-allocate memory allocated using a non-standard mechanism (e.g. via C++).
Garbage collection may occur when no references to an object remain. References can go away by going out of scope or by being explicitly set to `null`. (Aside: Uninitialized ref’s are set to `null`).

```java
public class GarbageCollection {
    public static void main(String[] args) {
        Point a = new Point(0, 0);
        //
```

```java
    Point b = a;
    //
```

```java
    Point c = b;
    //
```

```java
    Now three ref’s to object
    //
```

```java
    a = null;
    //
```

```java
    Now two
    //
```

```java
    No ref’s to object. It can
    //
```

```java
    be garbage
    //
```

```java
    collected. (But don’t count
    //
```

```java
    on it!)}
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                //
            }
            //
        }
        //
    }
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public class GarbageCollection {
    public static void main(String[] args) {
        Point a = new Point(0, 0);  //
        {
            Point b = a;              //
            {
                Point c = b;          // Now three ref’s to object
            }
        }  // Now two
        a = null;  // Now just one
    }
}
```
Garbage collection may occur when no references to an object remain. References can go away by going out of scope or by being explicitly set to \texttt{null}. (Aside: Uninitialized ref’s are set to \texttt{null}).

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                // Now three ref’s to object
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            // Now two
            a = null; // Now just one
        }
        // No ref’s to object. It can be garbage
        // collected. (But don’t count on it!)
    }
}
```
If a comparison operator such as `==` is applied to a reference variable, it is applied to the reference, not the object.

```java
public class RefEquiv {
    public static void main(String[] args) {
        Point p1 = new Point(2, 0);
        Point p2 = new Point(2, 0);
        Point alias1 = p1;
        //
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        // p1 and alias1 refer to same object
        System.out.println("p1 == alias1: " + (p1 == alias1));

        // p1 and alias1 refer to different objects
        System.out.println("p1 == p2: " + (p1 == p2));
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Reference Equivalence vs. Object Equivalence

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        // p1 and alias1 refer to different objects
        System.out.println("p1 == p2: " + (p1 == p2));

        // Output:
        // p1 == alias1: true
        // p1 == p2: false
    }
}
```
The Java class hierarchy, including standard Java API classes and your classes, all inherit from the `Object` class. This provides several useful methods that can be applied to any object.

```java
public class ObjectExample {
    public static void main(String[] args) {
        Point p = new Point(2, 0);
        // System.out.println(p.toString());
        // Output: Point@6d06d69c
        System.out.println(p.getClass().getName());
        // Output: Point
    }
}
```
Singly-Rooted Hierarchy

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    public static void main(String[] args) {
        Point p = new Point(2, 0);
        //
        System.out.println(p.toString());
        // Output: Point@6d06d69c
        Class pClass = p.getClass();
        System.out.println(pClass.getName());
        // Output: Point
    }
}
```
Arrays in Java: (1) They are actual objects and have a public length data member; (2) Arrays of primitives are automatically initialized; (3) Out-of-bounds access generates an exception.

```java
public class Arrays1 {
    public static void main(String[] args) {
        // Array declaration and initialization
        int[] array = new int[10];
        // Java arrays check their index!
        int i = array[10];
        // Exception thrown
    }
}
```
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        for (int i=0; i < array.length; i++)
            assert array[i] == 0;
    }
}
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Creating an array of objects does not create the actual objects.

```java
public class Arrays2 {
    public static void main(String[] args) {
        String[] array = new String[3];
        // No actual strings have been created!
    }
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        for (String s : array)
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        for (int i = 0; i < array.length; i++)
            array[i] = new String("string #" + i);
        // OR array[i] = "string #" + i;
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            System.out.println(s); // Prints null!

        for (int i = 0; i < array.length; i++)
            array[i] = new String("string #" + i);
            // OR array[i] = "string #" + i;

        // Aggregate initialization is possible
        Point[] points = {
            new Point(1,1),
            new Point(2,2)
        };
    }
}
```
Two uses: (1) Refer to current object; (2) Call other constructor

```java
public class Rectangle {
    private int x, y, width, height;

    public Rectangle(int x, int y, int w, int h) {
        this.x = x;
        this.y = y;
        width = w;  // 'this' not needed here
        height = h;
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}
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this keyword

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