**Assumptions**

- You already know C++
- 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.

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**Java Overview**

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
  - “Write once, run anywhere”
- Java is compiled to an intermediate language called **bytecode**
  - Bytecode is either interpreted, instruction by instruction by the JVM (slow), or sent through a Just-in-time compiler (JIT) which translates some of it into machine code just prior to execution (much faster!)
- Code is written in .java files; These are converted into .class files (bytecode)

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**History**

- Designed in the early 90’s by Sun Microsystems (now part of Oracle)
- Motivations:
  - Provide an alternative to C++ which reduced developer errors:
    - Cleaner syntax (no pointers!)
    - Garbage collection vs. manual memory management
    - Pure object-oriented language (no global code or data)
  - Execute on a wide range of devices
  - Execute code directly on a web page
  - Java Applets (deprecated); now Java Web Start
- Since 2008: Primary language for apps on Android
### Comparison with other Languages

  - 1-4 times slower than C/C++
  - Approximately the same as other JIT compiled languages such as C#
  - Much faster than pure interpreted scripting languages such as Perl, Python, and Ruby

- Development time:
  - Twice as fast as C++ (from “Thinking in Java”)
  - Slower than scripting languages
  - (Hard to find an objective source for this information)

### API

The two components of the Java Platform are the JVM and the Java API. The API provides a massive set of classes for numerous applications:

- String processing
- Data structures
- Networking
- Handling media files (images, video, audio, ...)
- Graphical User Interfaces (GUI): AWT, Swing, and JavaFX
- ...etc

### 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:

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

### A Point Class in Java

```java
public class Point {
    private double x, y;

    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; };
    // ...
};

In C++ we can implement methods within the .h file or the .cpp file. In Java there is only the .java file.

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());
    }
}

Variables: Primitive Types

All variables are either primitive types or references. Primitive Types (most common in bold):

- byte, short, int, long, float, double, boolean, char.
- int: 32-bit integers from -2,147,483,648 to 2,147,483,647
- double: 64-bit rational numbers
  - 15 significant decimal digits; range of about $\pm 1.7 \times 10^{308}$
- boolean: Boolean values written as true or false
- char: 16-bit characters

Testing the Point Class in C++

#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;
}
Usage of Primitives Similar to C++

```java
public class Primitives1 {
    public static void main(String[] args) {
        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);
    }
}
```

Initialization of Primitive Data Members

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.
    }

    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:

- long >>>> int >>>> short >>>> byte
- double >>>> float

```java
public class Primitives3 {
    public static void main(String[] args) {
        // Maximum values for each type.
        byte b = 127;
        long l = 9223372036854775807L; // Suffix L
        // Suffix l
        l = b;
        // Can't do this
        // If you know the loss of precision is acceptable you can cast between types.
        b = (byte) (l - 1);
    }
}
```

Conversion Issues

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

```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);
        // The long is converted to a float
        // in the comparison, so the result is true
    }
}
```
Control Flow Statements

```java
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--;
        }
    }
}
```

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);
        // Another reference ’pointing’ at
        // the same object
        Point b = a;
        b.setX(42);
        System.out.println("a.getX(): "+a.getX());
    }
}
```

Where Variables Live and Garbage Collection

- 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).
  - 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); //
        {
            Point b = a; //
            {
                Point c = b; // Now three ref’s to object
            } // Now two
            a = null; // Now just one
        } // No ref’s to object. It can be garbage
        // collected. (But don’t count on it!)
    }
}
```
Reference Equivalence vs. Object Equivalence

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;

        // p1 and alias1 refer to same object
        System.out.println("p1 == alias1: " + (p1 == alias1));
        // Output: p1 == alias1: true

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

Arrays

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];

        // Array access. Also, use of length
        for (int i=0; i<array.length; i++)
            assert array[i] == 0;

        // Java arrays check their index!
        int i = array[10]; // Exception thrown
    }
}
```

Singly-Rooted Hierarchy

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@6d0d06d0
        //
        Class pClass = p.getClass();
        System.out.println("pClass.getName()");
        // Output: Point
    }
}
```

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!
        //
        // The for–each construct
        for (String s : array)
            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;
    }
    //
    public Rectangle() {
        this(0, 0, 0, 0);  // Unnecessary
    }
    //
    public Rectangle(int width, int height) {
        this(0, 0, width, height);
    }
    //
}
```