Java and OO

CSCI 4448/5448: Object-Oriented Analysis & Design

Lecture 6

Acknowledgement & Materials Copyright

- I'd like to start by acknowledging Dr. Ken Anderson
- Ken is a Professor and the Chair of the Department of Computer Science
- Ken taught OOAD on several occasions, and has graciously allowed me to use his copyrighted material for this instance of the class
- Although I will modify the materials to update and personalize this class, the original materials this class is based on are all copyrighted © Kenneth M. Anderson; the materials are used with his consent; and this use in no way challenges his copyright

Before we start: Coding for class

- Usually, we talk about what we're looking for from code we'll be grading in the assignment, but here's a summary
- Make sure everything we asked for is there: code, output, README, team member names, etc.
- Comments – why, not what
  - Shouldn't duplicate code, should say why a class exists or why you're doing anything unclear
  - Nice commenting guidelines: https://stackoverflow.blog/2021/07/05/best-practices-for-writing-code-comments/
  - Especially Rule 6: Provide links to original sources of copied code!
- OO style – avoid lots of functionality in a "main", let the objects talk to each other to make things work
- Document your assumptions on how we wanted you to implement things
- For a nice Java specific style guide, see Google's: https://google.github.io/styleguide/javaguide.html

Goals of the Lecture

- Present a brief introduction to the Java programming language
- Coverage of the language will be INCOMPLETE
- Goal is to highlight some of Java's interesting and OO features

Disclaimer

- Although I've been writing a bit of Java now and again for years, I do not use it regularly and I am far from an expert
- Many of you likely have more recent experience with the language than I do
- Please feel free to ask questions, provide corrections or additions, or share other thoughts on the lecture topics with the class as we move through the review
- If I can't answer questions immediately, I'll get answers back to you

References

Some of the better Java books that I have:

- Head First Java by Sierra & Bates
- Think Java by Downey & Mayfield
  - Free at http://greenteapress.com/thinkjava/
- Effective Java by Bloch
- Thinking in Java by Eckel
- Java by Example by Jackson & McClellan

Also:

- Java Network Programming by Hughes et al.
- Java Network Programming by Harold

Plus hosts of on-line resources and tutorials, like:

- The Jenkov Tutorials: http://tutorials.jenkov.com/java/your-first-java-app.html
- Oracle's Tutorials: https://docs.oracle.com/javase/tutorial/
- A nice one page intro: https://learnxinyminutes.com/docs/java/
- A long but useful Java cheat sheet: https://introcs.cs.princeton.edu/java/11cheatsheet/
- A nice Java language class: https://java-programming.mooc.fi/
- Another set of PDF language reviews: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-092-introduction-to-programming-in-java-january-iap-2010/lecture-notes/
- StackOverflow.com
- Java.net

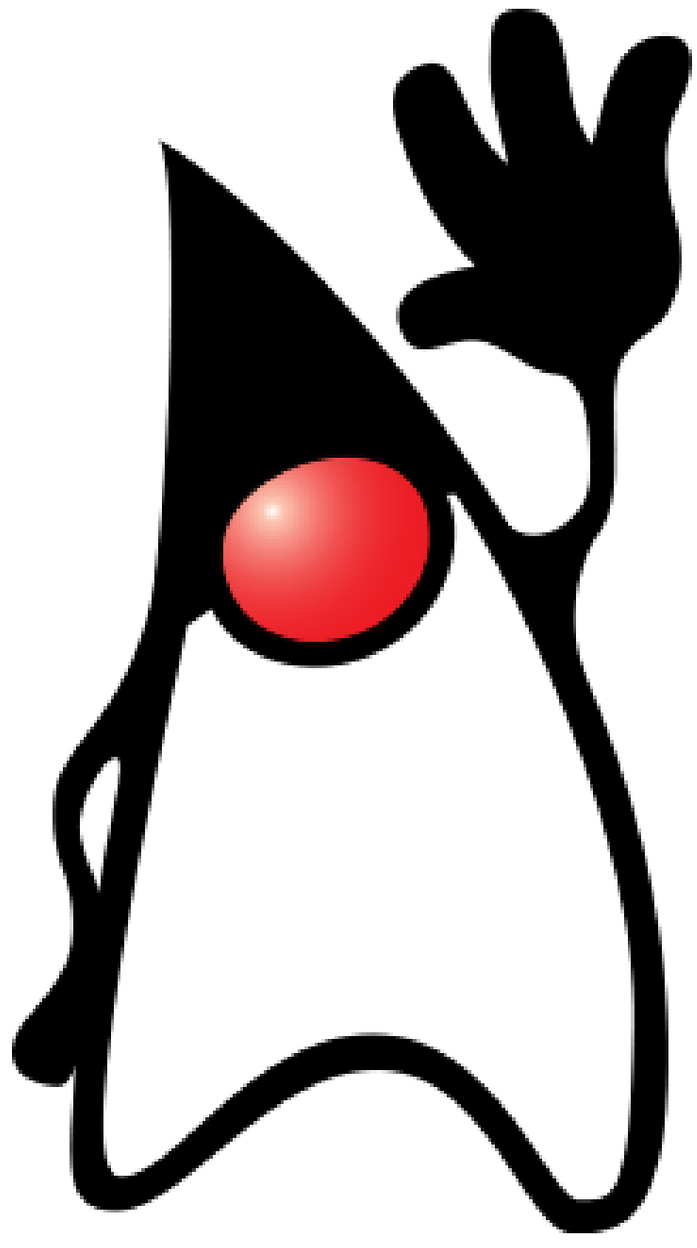
Also just happened to hit a nice article (with build-along examples) on Java (and the Spring framework) in Code magazine by Ted Neward, available online at: https://www.codemag.com/Article/1811081/Java

Java Tools

- Language
  - Open source Java SE implementation – https://openjdk.java.net/
  - ~~Sun's~~ Oracle's licensed Java – https://www.java.com/en/
    - Licensing not an issue for student use
- IDE
  - Many choices…
    - IntelliJ IDEA – JetBrains – Community (free) and commercial versions – https://www.jetbrains.com/idea/download/ OR for the full version free to students – https://www.jetbrains.com/community/education/#students
    - Eclipse – https://www.eclipse.org/downloads/packages/release/kepler/sr1/eclipse-ide-java-developers
    - BlueJ – interesting beginner IDE, shows UML of projects - https://www.bluej.org/
- Library Repository/Tools
  - JHipster – free application generator
  - Apache Maven – build tool and library repository
  - Apache Commons – repo of reusable Java components

History

- Java got started as a project in 1990 to create a programming language that could function as an alternative to the C and C++ programming languages
  - It made its big splash in 1994 when an alpha release was created that allowed Duke (Java's Mascot) → to be animated within a Web browser
  - This was a smart move; Java's Applet framework got developers to try out the language
- The first stable release JDK 1.0 came out in January 1996



Java Versions

- In 2004, Java J2SE 1.5 turned into Java SE 5, a new numbering scheme for releases
- Java SE 8 was released in March 2014 as an LTS (long term support) version that is supported through ~~March 2025~~ December 2030(!)
  - I'm using Java 8 for lectures (because the book does); you can use a later Java for class projects id you like
- Java SE 11 LTS was released in September 2018 with support through September 2026-2028?
- Java SE 16 – released March 2021
- Java SE 17 LTS – released September 2021
- Java SE 18 is out, Java 19 coming this September
- Java SE 20, 21 LTS are planed for later in 2022/2023
- Realize the OpenJDK release of a version tends to be months after Oracle's

History: Simpler and Safer

- James Gosling, one of Java's main designers at Sun, emphasized that Java was both **simpler** and **safer** than C++
- Java was simpler than C++ because
  - it removed language features that added complexity or were easily misused
    - pointers and pointer arithmetic
    - the notion of "friend" classes
    - ability to define new operators
  - no explicit memory management due to garbage collector
- Java was safer than C++ because
  - it was interpreted (runs in a protected virtual machine)
  - code downloaded from elsewhere was sandboxed
    - e.g. applet code could not access the host machine except in very clearly defined ways
  - built-in bounds checking and no pointers made it more difficult for malicious code to be written to "hack" the language's run-time system
- In addition, Java's goal was "write once, run anywhere"
  - The theory being that Java code could run wherever a Java Virtual Machine (JVM) existed, including for embedded devices

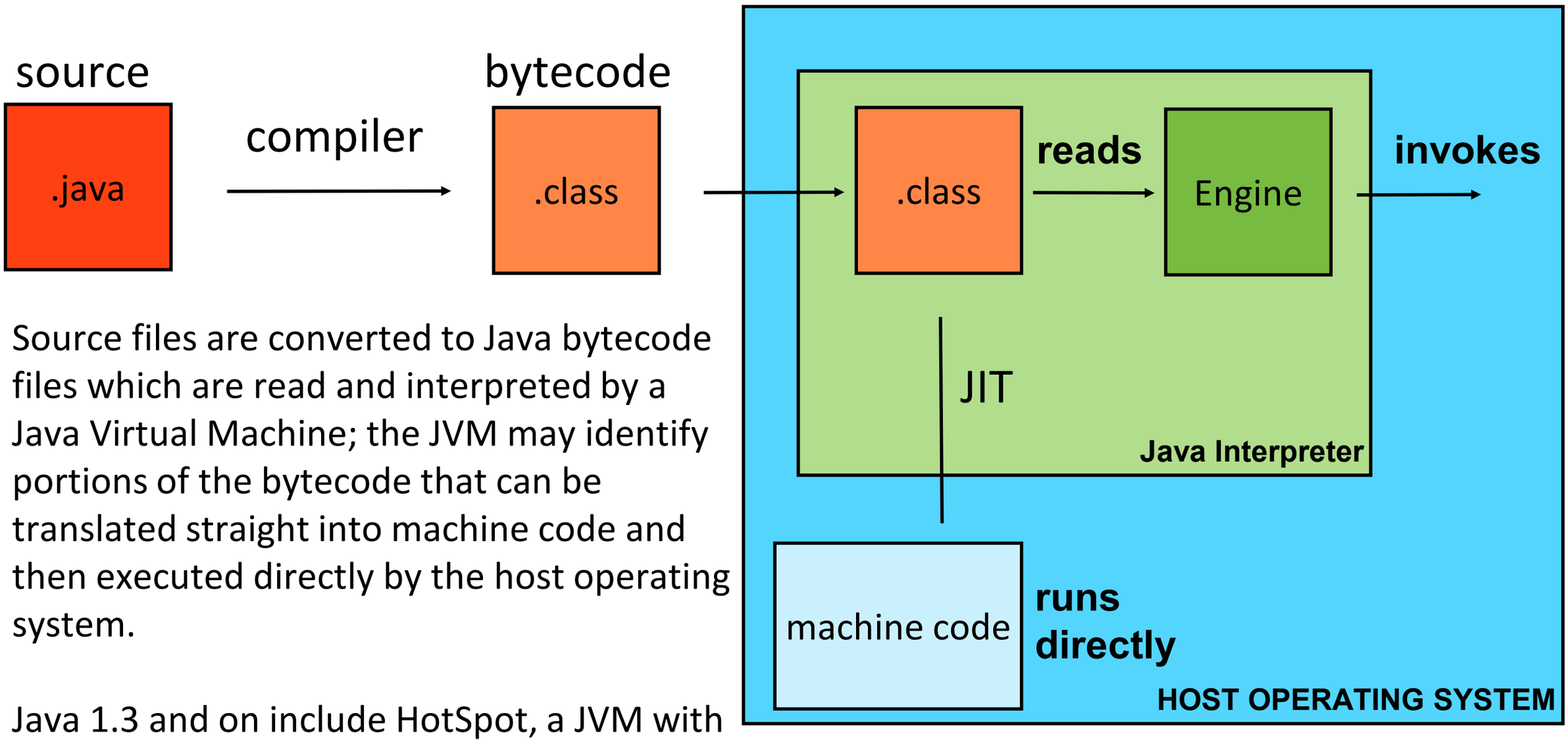
Support for Object Orientation

- More importantly for us
  - Java has a clean object model while still providing access to primitive types (ints, floats, etc.)
    - The initial hybrid compile/interpret approach was adopted for performance reasons that are now largely obsolete
  - Single inheritance object-oriented model plus interfaces
  - Extensive class library
    - lots of classes to create objects we can use in our own code
- Great language to clearly see OO in practice
  - Exceptions – multiple inheritance, extended interface capabilities

Opinion: Readability Matters

- Another reason I like Java is its generally very readable code
  - This makes it easier to understand, review, and maintain other's code
  - A goal of language design standards in organizations and standard tools
  - Related to "egoless programming"
  - C# is a direct descendant of Java, but has evolved differently
- I like Python for the same reason – generally readable
- I also like using Lint-type tools to clean code as part of a development cycle
  - Java – see PMD or Checkstyle; Python – pylint, pyFlakes, pycodestyle (pep8)
- C, C++, JavaScript/Node.js… Hmmm.
  - I think those can be MADE readable, but may be a little more work.
- Of course, you can also make unreadable Java and Python too
- For your reference:
  - Improving readability: https://dzone.com/articles/10-tips-how-to-improve-the-readability-of-your-sof
  - Egoless Programming: https://blog.codinghorror.com/the-ten-commandments-of-egoless-programming/
  - Google's certified readability experts for code reviews

Java is interpreted – sort of



Source files are converted to Java bytecode files which are read and interpreted by a Java Virtual Machine; the JVM may identify portions of the bytecode that can be translated straight into machine code and then executed directly by the host operating system.

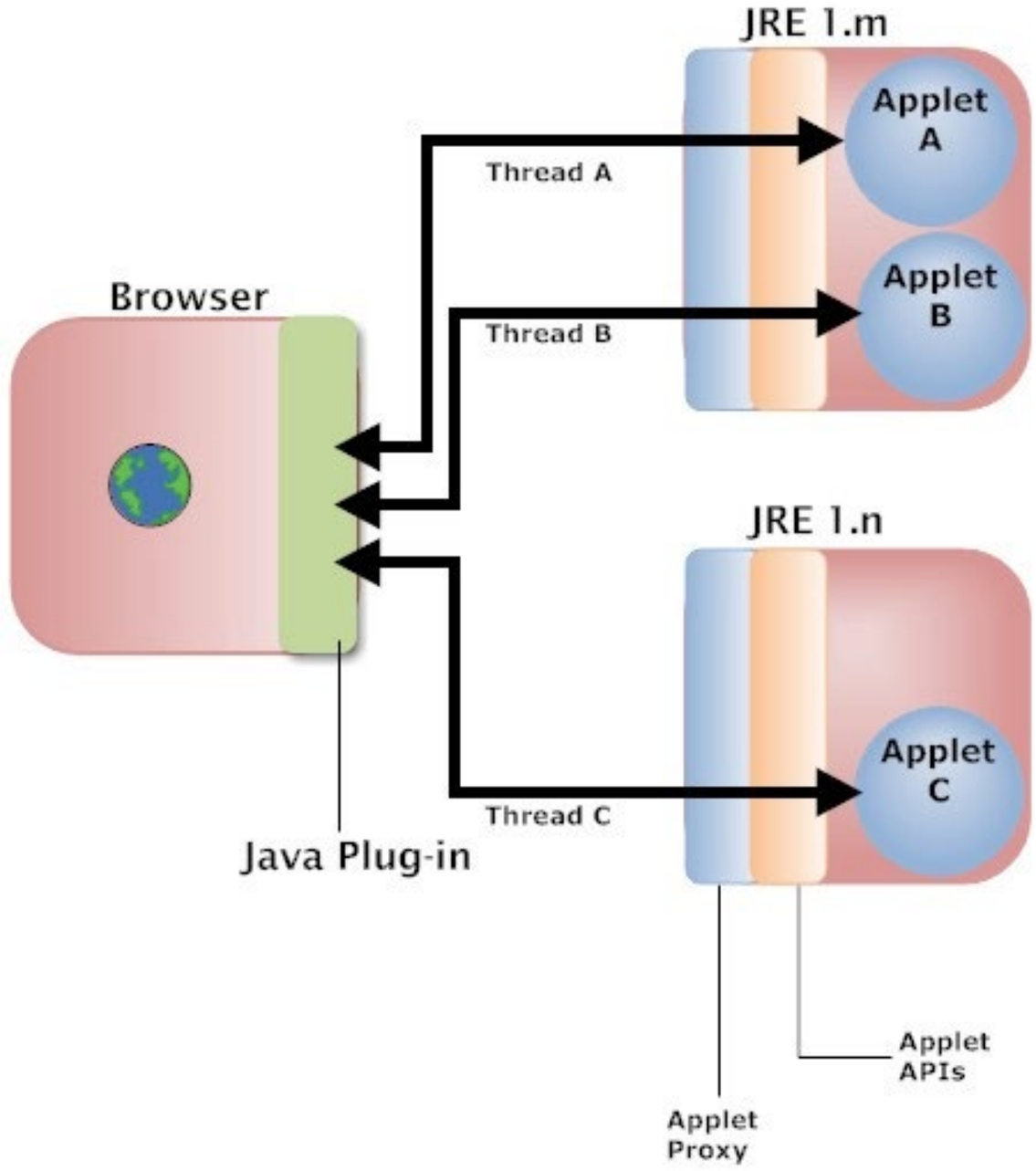
Java 1.3 and on include HotSpot, a JVM with Just In Time (JIT) compilation…

Java Performance

- Java suffered performance problems for many years when compared with code in other languages that had been directly compiled for a particular OS/machine
  - Now, extensive use of “just in time” compilation has largely eliminated these concerns
- Java provides excellent performance for many frameworks across many domains
- Provides native code interface (access to C libraries) to gain additional speed if needed
- Minecraft, for example, was originally written using Java, OpenGL, and the Lightweight Java Gaming Library (LWJGL)
  - Follow on versions have mostly been in C++

Java Applets – Rise and Fall

- Java applets were designed for web pages to run Java in a JVM in a browser.
- They required a browser plug-in to run vs. a Java application using a Java Runtime Environment (JRE)
- The Java browser plug-in, over time, proved to have security issues and identified exploits, leading to signed applets
- Java applets were depreciated in Java 9 and are removed from Java 11



https://docs.oracle.com/javase/7/docs/technotes/guides/jweb/applet/applet_execution.html

Fundamentals

- A Java program at its simplest is a collection of objects and a main program
  - The main program creates an object or two and sends messages to those objects to get the ball rolling
    - These objects communicate with more objects to achieve the objectives of the program
  - You typically have a non-OO main routine that bootstraps objects;
    - you are then in OO land until the end of the program

```
1  public class HelloWorld {
2
3    public static void main(String[] args) {
4      System.out.println("Hello, world!");
5    }
6
7  }
8
```

Anatomy (I)

Public class HelloWorld is contained in a file **HelloWorld.java**

```
1  public class HelloWorld {
2
3    public static void main(String[] args) {
4      System.out.println("Hello, world!");
5    }
6
7  }
8
```

Compiling this file produces a new file called **HelloWorld.class**

If Java's interpreter is passed the name HelloWorld, it looks for that name's associated class file and then looks for a static method called main that takes an array of strings; execution begins with the first line of that routine after any static init code

Anatomy (II)

```
1  public class HelloWorld {
2
3    public static void main(String[] args) {
4      System.out.println("Hello, world!");
5    }
6
7  }
8
```

main() is static because at the start of execution, no program-supplied objects have been created… there is no instance of HelloWorld to invoke methods on. Instead, the interpreter reads in the class, locates the statically available main() method, and invokes it

Anatomy (III)

```
1  public class HelloWorld {
2
3    public void sayItLikeYouMeanIt() {
4      System.out.println("HELLO, WORLD!");
5    }
6
7    public static void main(String[] args) {
8      System.out.println("Hello, world!");
9      // sayItLikeYouMeanIt();
10     HelloWorld hello = new HelloWorld();
11     hello.sayItLikeYouMeanIt();
12
13
14   }
15
16 }
17
```

This is a non-static method

You can't call a non-static method from a static method unless you have an object

Packages

- One mechanism for grouping classes is known as the **package**
- A class can declare itself to be part of a package with the package keyword followed by a dotted name, for example
  - package mypack.foo;
- The previous statement declares that there is a top-level package called “mypack” that contains a sub-package called “foo”. The class that uses this statement is a member of package “foo”
  - Top level packages “java” and “javax” are reserved;
  - java has some conventions around package names
- Packages enable the creation of large-scale software systems written in Java
- They prevent name clashes
  - import foo.Employee;
  - import bar.Employee;
- These two import statements refer to **two separate classes** both named Employee. They can both be used by the same program as long as you use the full class name

The import Statement

- The **import** statement brings names of classes into scope (from existing java packages that come with the SDK and user defined packages)
  - Import java.util.ArrayList;

  or
  - import foo.bar.Baz;
- The above makes Baz visible; we can then say things like
  - Baz b = new Baz();
- We can skip the import statement but then we would say
  - foo.bar.Baz b = new foo.bar.Baz();
- Classes in the same package can “see” each other with no need for an import statement

Jar files

- The jar command creates .jar files using a syntax that is similar to the Unix “tar” command
  - jar cvf <file.jar> directory
    - create a .jar file containing the contents of directory
  - jar tvf <file.jar>
    - prints a “table of contents” for .jar file
- The -classpath or -cp option is used by
  - javac: to allow files to access the classes in a jar file during compilation
  - java: to locate classes in jar files that are needed during runtime
- When used with the “java” command we must be sure to include all directories that we need, including the “current directory”, in order to ensure that the interpreter can find everything it needs to execute the given program

Java directory structures

- Java source directories usually include bin and src subdirectories - .class files (bytecode) are in bin; .java files (source code) are in src
- IDEs may automatically arrange file structures if not provided
- Here's a snapshot of the file system that Eclipse automatically creates for an example_3 project
  - based on package statements contained in source files

```
engr2-1-197-173-dhcp:workspace $ tree example_3
example_3
├── bin
│   ├── Test.class
│   └── ken
│       ├── Asker.class
│       └── students
│           ├── MastersStudent.class
│           ├── PhDStudent.class
│           ├── Student.class
│           └── Undergraduate.class
└── src
    ├── Test.java
    └── ken
        ├── Asker.java
        └── students
            ├── MastersStudent.java
            ├── PhDStudent.java
            ├── Student.java
            └── Undergraduate.java
```

Returning to HelloWorld

```
1  public class HelloWorld {
2
3    public static void main(String[] args) {
4      System.out.println("Hello, world!");
5    }
6
7  }
8
```

How does this work? What is System? What is “out”? System looks like a package name; out looks like an object reference that responds to the method println()

Discussion

- System is, in fact, an object; Google “java.lang.System”
- out is also an object. It provides methods for printing to stdout
- It turns out that System is a member of a package called java.lang
  - If that’s the case, why did the compiler let us access System without an import statement?: i.e., import java.lang.System
  - The answer is that everything in java.lang is automatically imported into all Java programs

Classes (I)

- You define a class in Java like this
  - **public class Employee {**
- This is the same as saying
  - **public class Employee extends java.lang.Object {**
- All classes in Java extend from java.lang.Object
  - It defines a set of methods that can be invoked on any Java object, including arrays
    - (Listed on next slide)
- For details
  - Java.lang.object documentation for Java 8
    - https://docs.oracle.com/javase/8/docs/api/java/util/Objects.html
  - Java 8 API documentation
    - https://docs.oracle.com/javase/8/docs/api/overview-summary.html

java.lang.Object's methods

- Copying objects
  - clone()
- Equality and Identity
  - equals(Object)
  - hashCode()
- Garbage Collection
  - finalize()
- Reflection
  - getClass()
- Threading
  - notify(), notifyAll(), wait()
- Printing/Debugging
  - toString()

Classes (II)

- After java.lang.Object, classes can extend via single inheritance
  - All Java classes have one and only one parent
- **Extends** is the inheritance keyword, **implements** is the interface reference keyword
- To allow a class to have more flexibility with respect to its type, Java provides the notion of interfaces
  - public class Dog extends Canine implements Pet {
- This says that Dog IS-A Canine but can also act as a Pet
  - Multiple interface names can appear after “implements” separated by commas “Pet, BedWarmer, BottomlessPit”
- Java also has an operator called instanceof
  - For a Dog object instanceof would return true
    - boolean isDog = aDog instanceof Canine

Classes (III)

- When a class implements an interface, the compiler requires that all methods defined in the interface appear in the class; if not the class must be declared abstract and a subclass must implement the missing methods

```
public interface Pet {
  public void takeForWalk();
}
```

- In this example, Dog must provide an implementation of takeForWalk() or else be declared abstract

- Note: Java 8 made some changes to interfaces, we'll discuss

Classes (IV)

- Constructors
  - When a new instance of a class is created, its constructor is called to perform initialization
  - A constructor looks like a method that has the same name as the class but with no return type specified
  - If you do not define a constructor, Java creates a default constructor with no arguments
    - This constructor simply calls the default constructor of the superclass
- These are equivalent

```
public class Foo {
}

// or

public class Foo {
   public Foo() {
      super();     //invoke or call parent class constructor
   }
}
```

Constructors (I)

- The purpose of constructors is to initialize an object
  - The JVM does some initialization for you
  - It will set all attributes to default values
    - primitive types (int, float, etc.) get set to zero
    - reference types (classes) get set to null
  - The constructor is then called to do any other initialization that you need

Constructors (II)

- Constructors can have arguments
  - (as you'll see in various examples this semester)
- If you want to use one of these you simply pass in the arguments when creating a new object
  - public PhDStudent(String name) {
- is invoked with the call
  - PhDStudent Gandalf = new PhDStudent("Gandalf");

Constructors (III)

- Funny (Difficult) Rules about Constructors
  - If you don’t define one, Java creates the default one
    - If you do define one, Java doesn’t create a default one
  - If you don’t call super() on the very first line of the constructor, then Java inserts a call to the default constructor of the superclass
    - If you do call super() or one of the other constructors of the superclass, Java doesn’t insert such a call
- Java is garbage collected – so no destructors, no guarantee when an object will be destroyed
  - You can use a method, finalize, that is called when an object is destructed, but when this happens is not under program control
  - There is a convention of creating a close method to indicate a class is closed and ready to be destructed

Accessibility

- Java supports several levels of accessibility for data and methods in classes
- By default the access is within the package
- Keywords include
  - Private – access only within the original class
    - For data attributes, get and set methods are often used to access information
  - Protected – access within original class and subclasses
  - Public – all access allowed

Java 8 Changes: Interfaces & Lambdas

- Pre-Java 8, Interfaces could only have method declarations
  - This is the traditional no implementation form of an Interface mentioned previously as the OO theory definition of an interface
- Java 8 introduced **default** and **static** methods for Interfaces
- Java 8 also introduced **lambda** expressions, which may change the way some interfaces are implemented

- Interface changes:
  - https://www.journaldev.com/2752/java-8-interface-changes-static-method-default-method
- Lambda example:
  - https://www.geeksforgeeks.org/lambda-expressions-java-8/

Java 8 Changes: Interface Default Methods

- Using the **default** keyword in an interface method definition tells the implementing class it is not mandatory to provide implementation
- Example:

```
public interface Interface1 {
        //to be defined by implementing class
        void method1(String str);

        //provided for implementing class
        default void log(String str) {
             System.out.println("I1 logging::"+str);
        }
}
```

Java 8 Changes: Interface Static Methods

- Using the **static** keyword in an interface method allows an implementing class to call the method directly from the interface, and also allows the interface to use the static method in default method implementations
- Example:

```
public interface MyData {
	default void print(String str) {
		if (!isNull(str))
			System.out.println("MyData Print:" + str);
	}
	static boolean isNull(String str) {
		System.out.println("Interface Null Check");
		return str == null ? true : "".equals(str) ? true :
false;
	}
}
```

- The implementing class could also call the static isNull directly from the interface:

```
boolean result = MyData.isNull("abc");
```

Java 8 Changes: The Diamond Problem

- Because Java allows multiple implementations of Interfaces in a class, it's possible to create a version of the Diamond Problem (usually seen in multiple inheritance of classes)
- For example, if two Interfaces both provided default methods for a method called log, the implementing class would have to override log to avoid a compile time error due to the multiple implementations

```
public class MyClass implements Interface1, Interface2 {
     @Override
     public void log(String str) {
          System.out.println("MyClass logging::"+str);
          Interface1.print("abc"); //static in Interface1
     }
}
```

Java 8 Changes: Lambda Expressions

- Lambda expressions are functional interfaces defined in-line
- They can be passed as objects and can be created without belonging to a class
- Example:

```
interface FunctionInterface
{
    void abstractFun(int x); // An abstract function
}

// Note that class Test is NOT implementing FunctionInterface
class Test
{
    public static void main(String args[])
    {
        // Lambda expression to implement above functional interface
        FunctionInterface fobj = (int x)->System.out.println(2*x);

        // This calls above Lambda expression and prints 10.
        fobj.abstractFun(5);
    }
}
```

Simple Anonymous Class Example

- Allows you to define a class “on the fly” to specify what happens when a particular event occurs

```
public class SuperClass {
  public void doIt() {
    System.out.println("SuperClass doIt()");
  }
}

SuperClass instance = new SuperClass() {
    public void doIt() {
        System.out.println("Anonymous class doIt()");
    }
};

instance.doIt();
```

Anonymous Class Example for Interface

```
public interface MyInterface {
  public void doIt();
}
```

```
MyInterface instance = new MyInterface() {
    public void doIt() {
        System.out.println("Anonymous class doIt()");
    }
};

instance.doIt();
```

Anonymous Classes

- Common when implementing a graphical user interface
  - A button gets clicked and we need an instance of java.awt.event.ActionListener to handle the event
  - We could implement this handler in a separate file as a class that implements ActionListener that specifies what to do
  - We would then create an instance of that class and associate it with the button
- The problem?
  - What if you have 10 buttons that all require different implementations of ActionListeners; you would have to create 10 different .java files to specify all the logic
  - This is not scalable
- The solution
  - Anonymous Classes
  - We create the ActionListener instance on the fly

Anonymous Classes continued

- Anonymous classes are defined “in line” by saying first
  - new
- because we are both defining a class AND creating an instance of it; we then provide
  - a classname or interface name with parens and an open bracket
- followed by method definitions and a closing bracket
- The compiler will then
  - define a new class,
  - compile it to bytecode
  - AND at run-time the interpreter will create an instance of this unnamed (i.e. anonymous) class
- It does this because this in-line definition occurs inside a method call
  - button.setActionListener(<ANONYMOUS CLASS>);
- or
  - button.setActionListener(new ActionListener() { … });

Anonymous Class Storage

- Where do these new classes get stored?
  - In the same directory that all the other .class files go
- Directory of the “with” example before we compile
  - ButtonExample.java
- Directory after we compile
  - ButtonExample$1.class ButtonExample.class
  - ButtonExample$2.class ButtonExample.java
- The $1 and $2 classes are the autogenerated anonymous classes

- Summing up: Anonymous classes are simpler, more compact and more expressive of our intentions

How to use Java Generics

- Java provides a way to do “generic” data structures
- The idea is fairly simple
  - In procedural languages, we used to have to implement collections like this
    - List of String, List of Integer, List of Employee
  - Each list (or data structure) was written with a specific type of content in mind
- This is not strictly necessary since the API and semantics of the data structure are independent of its contents

Java Generics

- Take a look at the definition of the List interface in java.util
  - Java documentation for List
    - https://docs.oracle.com/javase/8/docs/api/java/util/List.html

```
public interface List<E> extends Collection<E> {
   boolean add(E e);
   …
   E get(int index);
   …
}
```

- The E (which may stand for “element”) is a placeholder that says
  - We are defining the API for a List that contains elements of type E
  - If I add() an E, I can get() that E back
- Specifically, E is a placeholder for a type

Example: List of String

- I can create a List that holds Strings
  - List<String> strings = new LinkedList<String>();
- Passing “String” inside of the angle brackets, tells the interpreter to create a version of List where “E” gets replaced by “String”
- Thus
  - boolean add(E e);
- becomes
  - boolean add(String e);

List of List of String

- If I wanted a list in which each element is itself a List of Strings, I can now easily do that:

```
List<LinkedList<String>> crazy_list =
     new LinkedList<LinkedList<String>>();
```

- In this case E equals “LinkedList<String>” and get() would become

```
LinkedList<String> get(int index);
```

- meaning when I call get() on crazy_list, I get back a LinkedList that in turn contains Strings

Generic Map

- You should now understand the interface to Map
  - Java documentation for java.util.Map
    - https://docs.oracle.com/javase/8/docs/api/java/util/Map.html

```
public interface Map<K,V> {
   V get(Object key)
   V put(K key, V value)
   …
}
```

Map Example

```
Map<String, Integer> ages = new HashMap<String, Integer>();
ages.put(“Max”, 20);
ages.put(“Miles”, 30);
int ageOfMax = ages.get(“Max”);
System.out.println(“Age of Max: ” + ageOfMax);
```

- Produces: Age of Max: 20
- Note: “autoboxing” of int and Integer values
  - Autoboxing = automatic conversion that the **Java** compiler makes between primitive types and their corresponding object wrapper classes

Selected Java 9, 10, 11 Changes

- 9: Modules
  - a class is a container of fields and methods
  - a package is a container of classes and interfaces
  - a module is a container of packages
- 9: Private Methods in Interfaces
  - **private method** and **private static method** in interfaces
    - Private methods are generally used in interfaces to create functions used in other implemented methods
      - Code reuse within the interface itself
- 10/11: var for declaring variables via initialization
  - var i = “Fred”; //declares variable as a String
  - var i = 10; //declares variable as an integer
  - Can only be used in
    - Local variables with initializers
    - Indexes or locals in a for-loop

https://howtodoinjava.com/java-version-wise-features-history/

Selected Java 12-17 Changes

- 12/13/14:
  - Text blocks (a multiline string literal)
  - Updates to switch statements and expressions
- 15/16/17:
  - Sealed classes (restricts who can extend or implement)
  - Record classes (for plain data aggregates, includes a default constructor):

```
record Point(int x, int y) { }
```

  - Pattern matching for instanceof:

```
// an equals method for the Point class:
public boolean equals(Object o) {
    return (o instanceof Point other)
        && x == other.x
        && y == other.y;
}
// vs. prior versions:
public boolean equals(Object o) {
    if (!(o instanceof Point))
        return false;
    Point other = (Point) o;
    return x == other.x
        && y == other.y;
}
```

See: https://docs.oracle.com/en/java/javase/17/language/java-language-changes.html for a complete changes by version discussion

Why do we still see so much Java 8?

- As of January 2020, Java 8 was still the prevalent Java in use
  - Licensing, library/build/legacy compatibility
  - Java 8 in use by 58% of Java developers
  - IDEs: IntelliJ at 82%
  - https://www.jrebel.com/blog/2020-java-technology-report
- What's up with Java licensing?
  - Since January 2019, Oracle no longer issues public updates for commercial users of Java SE 8 which means free updates for commercial use are no more
  - If any of the following statements apply to you, you will likely require a paid Oracle license:
    - I use commercial features of Java SE
    - I use Oracle Java SE v11 +
    - I need support from Oracle
    - I use Java SE versions for longer than 6 months
    - I am running unsupported Java SE in my environment
  - If you want to use Java for free for commercial use, one way of doing it is to use an Oracle JDK, Oracle's OpenJDK builds and OpenJDK from other providers. This does not include support from Oracle, however.
- https://www.lakesidesoftware.com/blog/java-did-what-understanding-how-2019-java-licensing-changes-impact-you

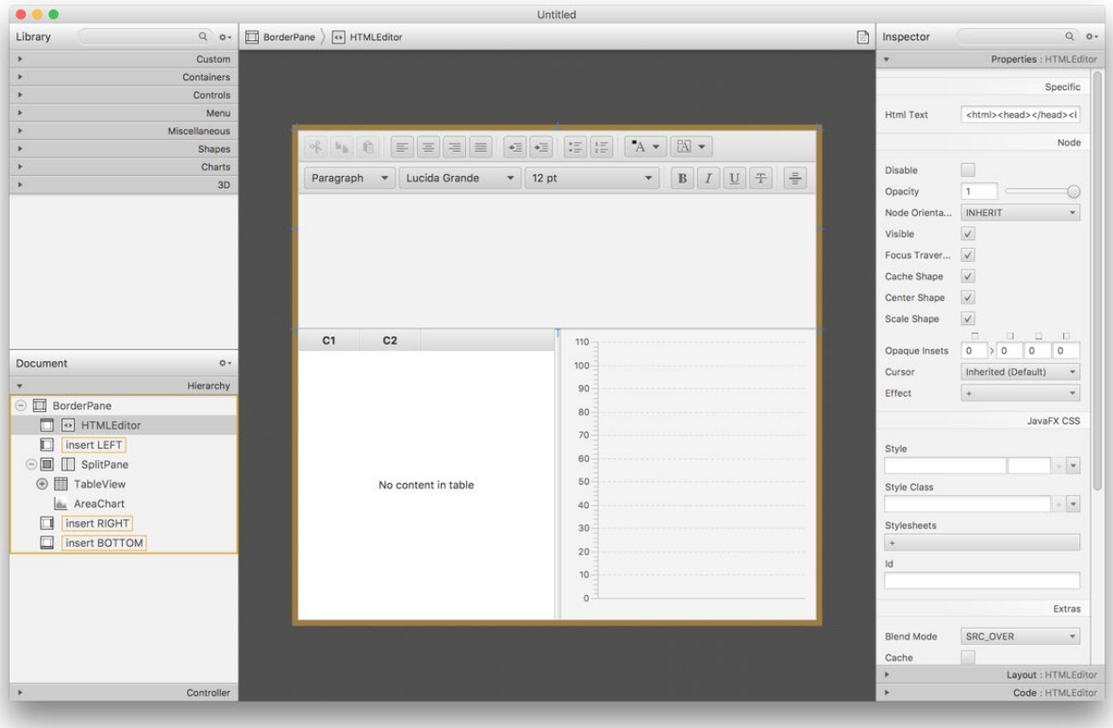
Recent Java Trends:

- Java 17 adoption increasing
- VSCode adoption increasing
- Spring alternatives (Micronaut, Quarkus) use is up
- Decreasing use of non-LTS versions

https://www.jrebel.com/blog/java-trends-watch-2022

Java GUI Tools

- JavaFX is the framework I'd recommend, including the WYSIWYG GUI design tool called Scene Builder →
  - Quick tutorial at https://coderslegacy.com/java/javafx-tutorial/ and more at https://openjfx.io/
  - Scene Builder is at https://gluonhq.com/products/scene-builder/
- The oldest Java native GUI framework is AWT, followed by Swing, which leverages some AWT elements
  - These tools are still in use due to legacy code. Info on Swing is here:
    - https://docs.oracle.com/javase/tutorial/uiswing/
- Other options:
  - Apache Pivot for Web applications https://pivot.apache.org/
  - Qt Jambi https://github.com/qtjambi/qtjambi



Summary

- Java Fundamentals
  - Packages and .jar files
  - Classes, constructors, interfaces
  - New Java 8 interface elements: default, static
  - New Java 8 lambda expressions
  - Anonymous classes
  - Generics
  - Newer Java versions, licensing
  - Java GUI tools

Next Steps

All staff now providing office hours:
Office hours are posted in Canvas Announcements and Piazza posts

- Latest
  - All class assignments and dates are loaded on Canvas – fixed Quiz due dates
  - Examples of graduate and semester projects posted…
  - No class Monday 9/5 – CU holiday
- Assignments
  - New participation discussion topic is up on Piazza, please respond – don't get behind on these – try to respond every week! It is 100 points of your grade…
  - Project 1 is up on Canvas – individual work!
    - Part 2 (code submission) is due next week – Wed 9/7
    - We'll talk about Project 2, the first team programming project on Wed 9/7
  - Quiz 2 will go up on 9/3
  - Graduate Research Project team topics are due on 9/16
- Stay Engaged
  - Make sure you sign up for Piazza and Canvas notifications
  - Make sure you can access the Head First Design Patterns textbook – no readings yet
  - Consider tutorials/resources for Git and Java especially, if you need them
- Coming up
  - Next up: the tools – Git/Markdown/Github, UML, Python, TDD
- Please come find us for any help you need or questions you have!