CS 126 Lecture S1: Introduction to Java

“Systems” Part of the Class

• What is the “system”?
  - Loosely defined as anything that’s not your application

• Why should you care?
  - Learn more about the pieces that constitute a large part of your daily computing life: compilers, operating systems, ...
  - The boundaries between the different pieces are becoming increasingly fussy in this age, so an “application” can have elements of compilers and OS built in.
  - For example, a browser that has a Java Virtual Machine and a Just-In-Time compiler built in is simultaneously an application, a compiler, and to some extent, an OS!
  - Synthesis of much stuff that we learned about programming, hardware, and theory
Roadmap

• S1-S2: Java
  - More like a continuation of the programming part of the class
  - So, really, it’s an excuse to teach you some Java :-) 
  - But, there is a profound connection between Java and OS, as we shall see: fundamental question of how to structure a system in terms of issues such as protection. So Java is far more than just another programming language

• S3: Compilers
  - A good meeting place of three previous pieces: programming, hardware, and theory

• S4: Operating systems
  - The missing link between hardware and applications

Outline

• Introduction
  - History
  - Java vs. C
  - How to learn

• The basics
• Object-oriented niceties
• Conclusions
History

- Bill Joy and Sun
  - BSD god at Berkeley
  - Founding of Sun (early 80s)
  - “The network is the computer” (a little ahead of its time)
  - Missed the boat on PC revolution
  - Sun Aspen Smallworks (1990)
- James Gosling
  - Early fame as the author of “Gosling Emacs” (killed by GNU)
  - Then onto Sun’s “NeWS” window system (killed by X)
  - Lesson 1: keeping things proprietary is kiss of death
  - Lesson 2: power of integrating three things:
    + an expressive language
    + network-awareness, and
    + a GUI (graphical user interface)

History (cont.)

- Joy and Gosling joined forces, FirstPerson, Inc. (1992)
  - Targeting consumer electronics: PDAs, appliances, phones, all with cheap infra-red kind of networks
- Need a language that’s small, robust, safe, secure, wired
  - Started working on C++
  - Soon gave up hope, decided to start from scratch
- Again, a little ahead of its time
  - PDAs died with the demise of Apple Newton
  - Switched to interactive TV (ITV)
  - The resulting language was called “Oak”
  - Then ITV died too
- The net exploded in 1993
  - Oak became Java!
History (cont.)

• Many success stories in CS
  - Very much like what we said about Unix
  - Not a technological breakthrough
  - All of the features of Java were present in earlier research systems
  - The “genius” lies in the good taste of assembling a small and elegant set of powerful primitives that fit together well and tossing everything else!

• Luck helps a lot too!

Java vs. C

• Comparison inevitable, but...
• “Java is best taught to people not contaminated by C”
  - Important to “think Java”, instead of “translating C to Java”
• Similarities between C and Java are skin-deep
  - Syntatic sugar to make it easy to swallow
  - Terseness is good
  - Underlying philosophies are like day and night
• Theme of this class: levels of abstraction
  - C exposes the raw machine
  - Java hides a lot of it
Java vs. C (cont.)

- Bad things you can do in C that you can’t do in Java
  - Shoot yourself in the foot (safety)
  - Others shoot you in the foot (security)
  - Ignoring wounds (error handling)
- Dangerous things you have to do in C that you don’t in Java
  - Handling ammo (memory management: malloc/free)
- Good things that you can do in C but you don’t; Java makes you
  - Good hunting practices (objected-oriented methodology)
- Good things that you can’t do in C but you can now
  - Kills with a single bullet (portability)
- An interesting lesson in abstraction (and politics?): making things better by “taking away” power
- [We will revisit these differences after we learn more about Java]

How to Learn

- The best language to learn on-line, which is the best way to learn Java!
  - http://www.javasoft.com
  - http://java.sun.com/products/jdk/1.1/docs/api/packages.html
- Start with existing code, read code, read docs
- Experiment by making small changes and adding functionality progressively
- My personal opinion: learning a second programming language in a class is a waste of time :-(
- So, it’s really just a highlight
Outline

- Introduction
- The basics
  - First Java program and tools of trade
  - Classes, methods, and objects
  - Arrays
  - “Pointers”
  - Libraries
- Object-oriented niceties
- Conclusions

Your First Java Program

```java
mocha:tmp% cat > hello.java

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

mocha:tmp% javac hello.java

mocha:tmp% ls hello.*
```
hello.class  hello.java
```

mocha:tmp% java hello

Hello World!

- Source file: “hello.java”
- Java compiler: javac
- Byte code: “hello.class”
- Java interpreter: java
- Can install JDK on any machine, including your PC
- Other tools in JDK: jdb, javadoc
Compiling vs. Interpreting

- Interpreter: a level of abstraction: the “virtual machine”
- The advantage of interpreting is beyond portability
- A convenient place to exercise all sorts of control
- Disadvantage: slower

Classes, Methods, and Objects

- (Don’t need to understand everything in this code, yet)
- A program is a sequence of classes (no .h files!)
- A class is like a struct, one difference: methods: operations that act on the data that makes up the class
- A method is like a function. (Note how they are invoked.)
- An object to a class in Java is like a variable to a type in C
More Thoughts/Details on This Example

- Other than the primitives such as `int`, `char`, `boolean`, all variables are objects
- Concepts of object declaration, allocation, and a constructor
- How to design a Java program: think objects!
  - What objects do I break the problem into?
  - What operations do they allow?
  - How do I implement them using even smaller objects?

```java
public class MyStack {
    Object[] items;
    int n;

    public MyStack() {
        items = new Object[1000];
        n = 0;
    }
    public void push(Object item) {
        items[n++] = item;
    }
    public Object pop() {
        return items[--n];
    }
    public boolean empty() {
        return n == 0;
    }
}
```

```java
import MyStack;

class StackTest {
    public static void main(String[] args) {
        MyStack s = new MyStack();
        s.push("first");
        s.push("second");
        s.push("third");
        while (!s.empty())
            System.out.println(s.pop());
    }
}
```

Arrays (still same example)

- Arrays are first class citizen of Java.
- No other back-doors of accessing them, for example, no pointer arithmetic
- Array reference bounds are checked at run time
  - No seg faults possible, tremendous help in reducing headaches
  - Also important implications for safety, security, and encapsulation
**Pointers and Linked List**

- Officially no pointers anywhere, behind the scene, each object is a pointer, called a reference, special `null` reference part of language
- No pointer arithmetic, no `*`, no `->`, no `free()`, no pointer bugs, no pain
- Reimplement stack using a linked list
  - `push()` code tricky: it allocates a new node, made by calling the constructor, which puts the old list head into the next field of the new node.

```java
class MyNode {
    Object item;
    MyNode next;
    MyNode(Object item, MyNode next) {
        this.item = item;
        this.next = next;
    }
}

class MyStack {
    MyNode list = null;
    public MyStack() {}
    public void push(Object item) {
        list = new MyNode(item, list);
    }
    public Object pop() {
        Object obj = list.item;
        list = list.next;
        return obj;
    }
    public boolean empty() {
        return list == null;
    }
}
```

**Java Libraries (Packages)**

- **Huge** number of pre-written libraries
- **Always** check before you reinvent something of your own
- Watch out for version differences
  - http://java.sun.com/products/jdk/1.1/docs/api/packages.html
  - Reading these docs is a major part of learning/programming Java
  - Get a big picture of what they are but read details on-demand
- 1.2 is a significant improvement, for CS126, the “java.util” library has everything you can ask for: linked list, stacks, ...
- On the next slide, I will give a third implementation of the stack using a library class: Vector is an array that doesn’t require you to pre-specify a size and doesn’t fill up!
Example Use of Library

```java
import java.util.*;

public class MyStack {
    Vector items;
    public MyStack() {
        items = new Vector();
    }
    public void push(Object item) {
        items.addElement(item);
    }
    public Object pop() {
        int end = items.size()-1;
        Object obj = items.elementAt(end);
        items.removeElementAt(end);
        return obj;
    }
    public boolean empty() {
        return items.isEmpty();
    }
}
```

MyStack.java

Sort of like `#include`

Vector is a class implemented by the java.util library, called a package

All of these are operations implemented by the package. You find out about them by reading the documentation, which you can download as a whole or read online.

Outline

• Introduction

• The basics

• Object-oriented niceties
  - Inheritance
  - Encapsulation
  - Code reuse
  - Multiple implementations

• Conclusions
Inheritance

```java
public class MyImprovedStack extends MyStack {
    public Object pop() {
        if (n <= 0) {
            return null;
        }
        return items[--n];
    }
    public Object peek() {
        if (n <= 0) {
            return null;
        }
        return items[n-1];
    }
}
```

- **MyImprovedStack** is a subclass of **MyStack**
- This example: adding functionality
- Another example use: “specialization”--a student class inherits from a person class

Encapsulation and Access Control

```java
public class MyStack {
    protected Object[] items;
    protected int n;
    public MyStack() {
        items = new Object[1000];
        n = 0;
    }
    public void push(Object item) {
        items[n++] = item;
    }
    public Object pop() {
        return items[--n];
    }
    public boolean empty() {
        return n == 0;
    }
}
```

- User of this class sees only what he’s allowed to see
- Three key words:
  - **private**: accessible only by this class
  - **protected**: subclasses can see it too
  - **public**: accessible to all
  - (additional deals for “packages”, read about them on-line if you care)
**Code Reuse**

```java
import MyStack;
class StackTest {
    public static void main(String[] args) {
        MyStack s1 = new MyStack();
        s1.push("first"); s1.push("second");
        while (!s1.empty()) System.out.println(s1.pop());
        MyStack s2 = new MyStack();
        s2.push(new Integer(1)); s2.push(new Integer(2));
        while (!s2.empty()) System.out.println(s2.pop());
    }
}
```

- This example: no need to write different codes for stack of Strings and stack of Integers

**Multiple Implementations**

```java
import MyStack;
import MyArrStack;
import MyListStack;
class StackTest {
    public static void main(String[] args) {
        MyStack s;
        s = new MyArrStack();
        s.push("first"); s.push("second");
        while (!s.empty()) System.out.println(s.pop());

        s = new MyListStack();
        s.push("first"); s.push("second");
        while (!s.empty()) System.out.println(s.pop());
    }
}
```

- As long as a common interface is agreed upon
- We can pick and choose different implementations
- How’s this done? Next slide...
Abstract Classes

```java
public abstract class MyStack {
    public abstract void push(Object item);
    public abstract Object pop();
    public abstract boolean empty();
}
```

MyStack.java

```java
import MyStack;
public class MyArrStack extends MyStack {
    ......
}
```

MyArrStack.java

```java
import MyStack;
public class MyListStack extends MyStack {
    ......
}
```

MyListStack.java

- Abstract classes specify interfaces, no implementation
- Implementations inherit abstract classes and fill in implementation details

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Java vs. C (Revisit)

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Closing

• These are highlights, by no means complete
• Best way of learning
  - Study the tutorial online
  - Read and experiment with existing code
  - Read docs
• I don’t expect people to memorize or be able to reproduce syntatic details
• I do expect people to be able to read and understand given code and concepts discussed