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 compliler, 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/docs/books/tutorial/index.html
    - http://java.sun.com/products/jdk/1.1/docs/api/packages.html
    - http://java.sun.com/products/jdk/1.2/docs/api/index.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

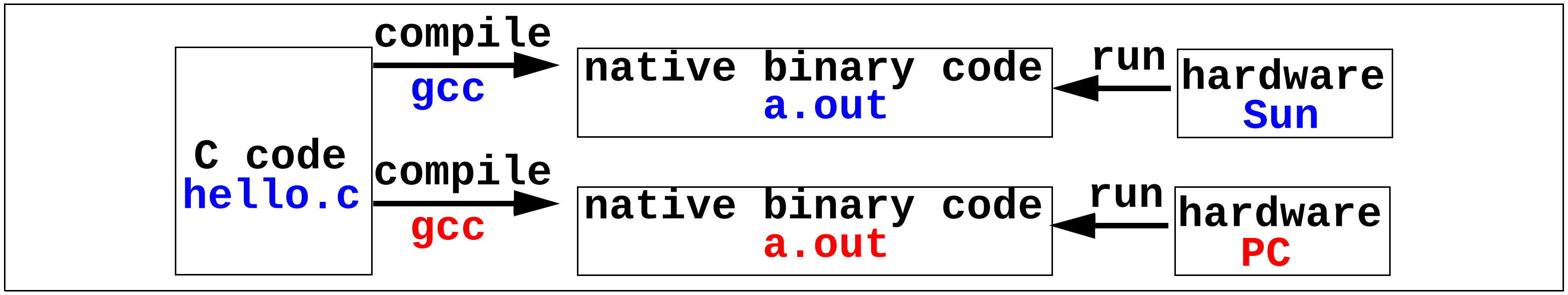
- ~~Introduction~~
- **The basics**
  - **First Java program and tools of trade**
  - **Classes, methods, and objects**
  - **Arrays**
  - **“Pointers”**
  - **Libraries**
- Object-oriented niceties
- Conclusions

Your First Java Program

```
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



C code
hello.c

compile
gcc

native binary code
a.out

run

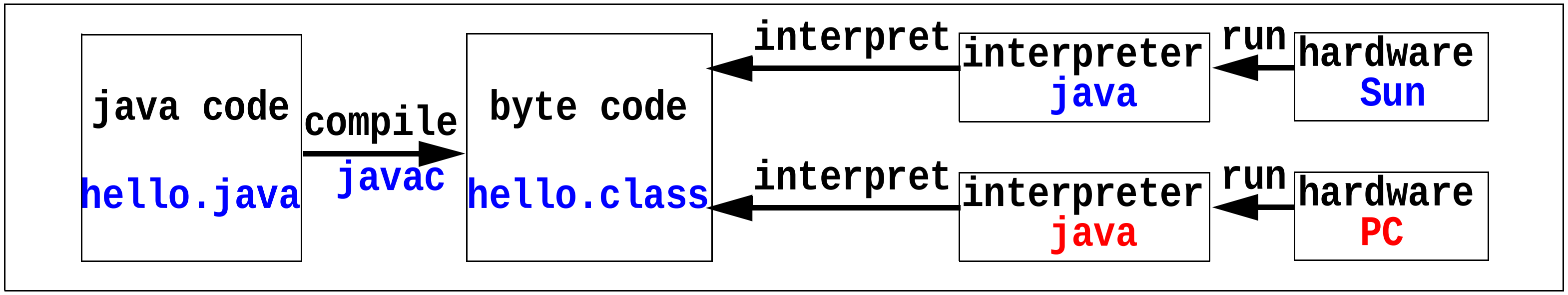
hardware
Sun

compile
gcc

native binary code
a.out

run

hardware
PC



java code
hello.java

compile
javac

byte code
hello.class

interpret

interpreter
java

run

hardware
Sun

interpret

interpreter
java

run

hardware
PC

- 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

```
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;
  }
```

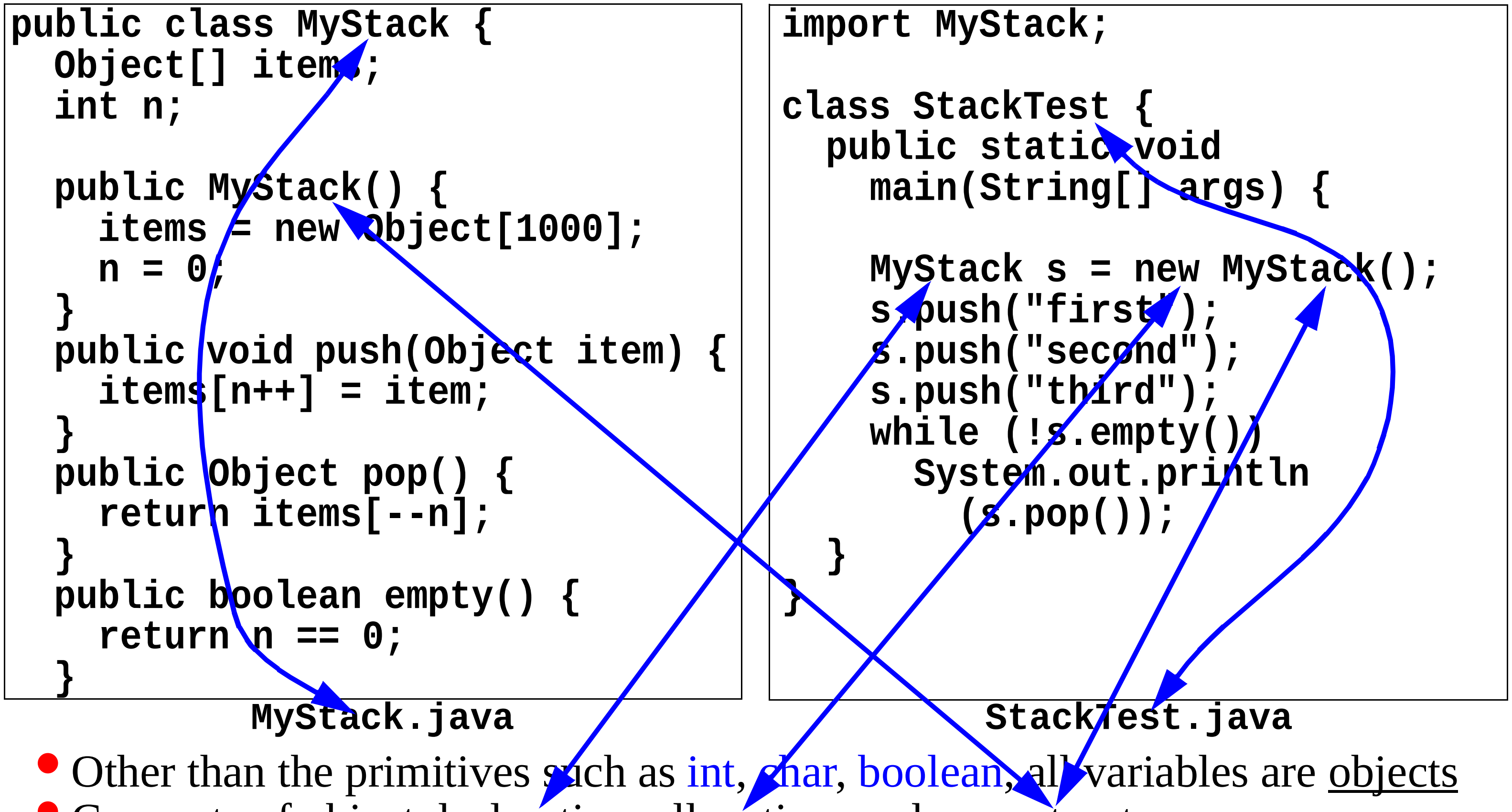
`MyStack.java`

```
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());
  }
}
```

`StackTest.java`

- (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



```
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;
  }
```

MyStack.java

```
import MyStack;

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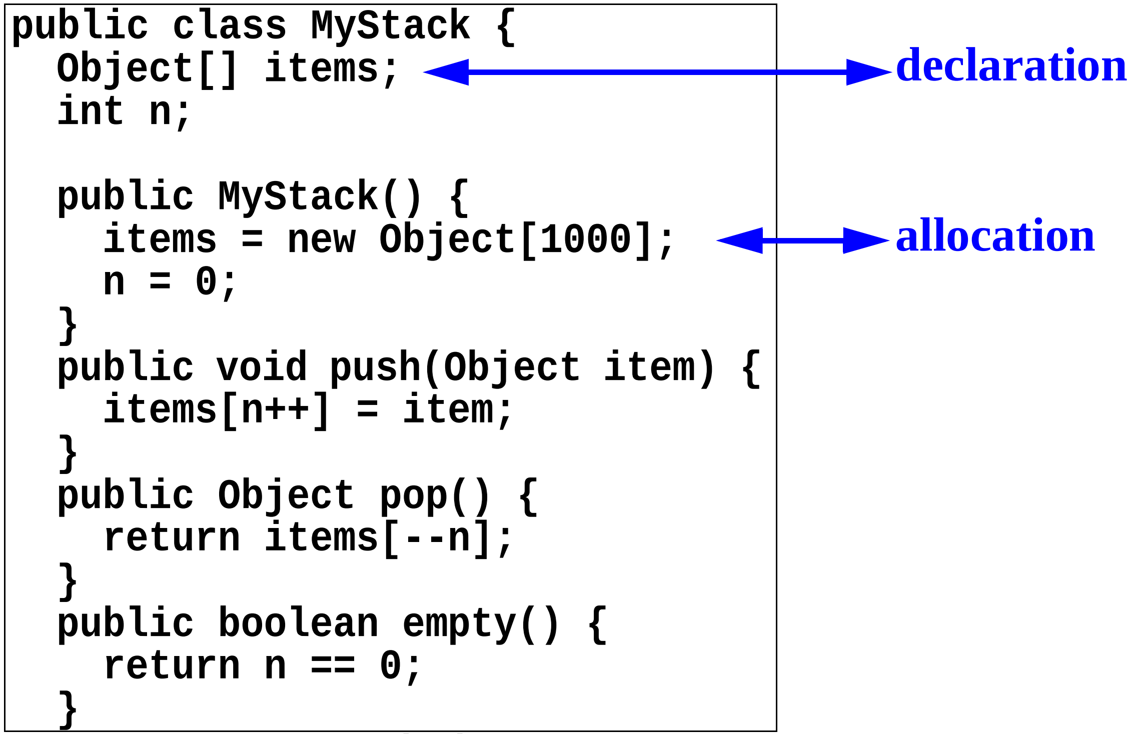

StackTest.java

- Other than the primitives such as int, char, boolean, all variables are <u>objects</u>
- Concepts of object <u>declaration</u>, <u>allocation</u>, and a <u>constructor</u>
- 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?

Arrays (still same example)



```
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;
  }
```

declaration

allocation

MyStack.java

- 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

```
class MyNode {
  Object item;
  MyNode next;

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

```
public 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;
  }
}
```

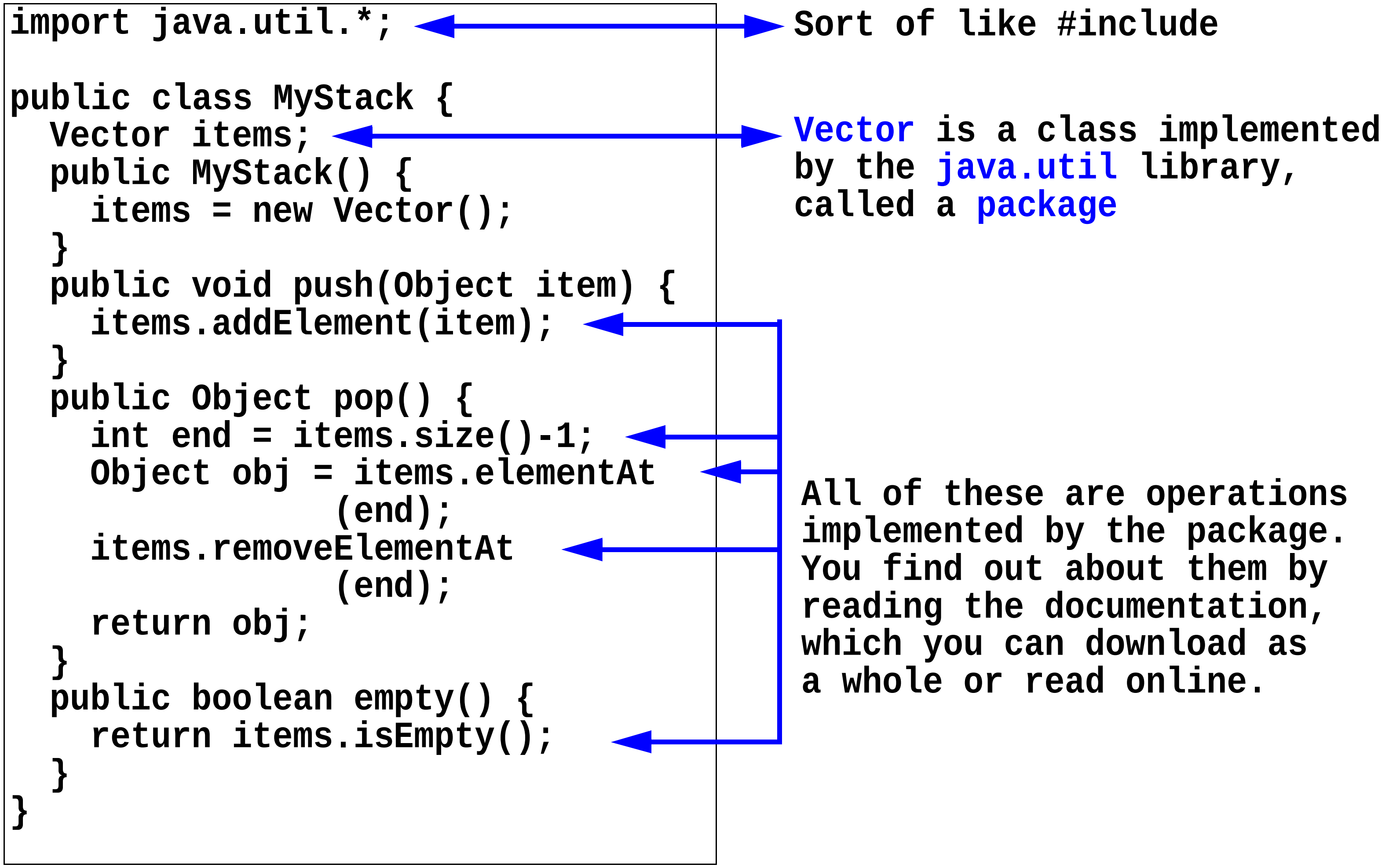
`MyStack.java`

- Officially no pointers anywhere, behind the scene, each object is a pointer, called a <u>reference</u>, 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 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
  - http://java.sun.com/products/jdk/1.2/docs/api/index.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



```
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

```
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];
  }
}
```

Inherits everything from MyStack

Overwrites old implementation

Adds new functionality

MyImprovedStack.java

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

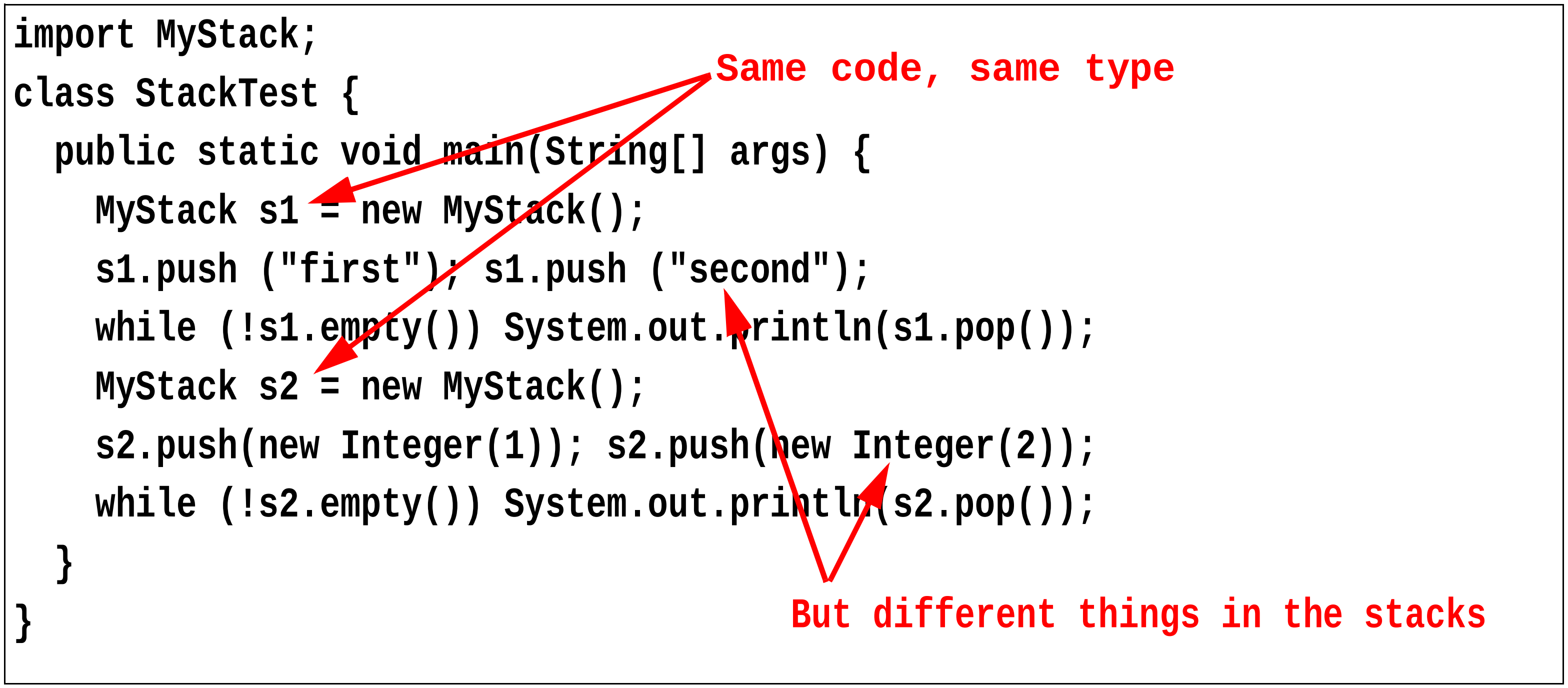
Encapsulation and Access Control

```
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;
  }
```

MyStack.java

- 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



```
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());
  }
}
```

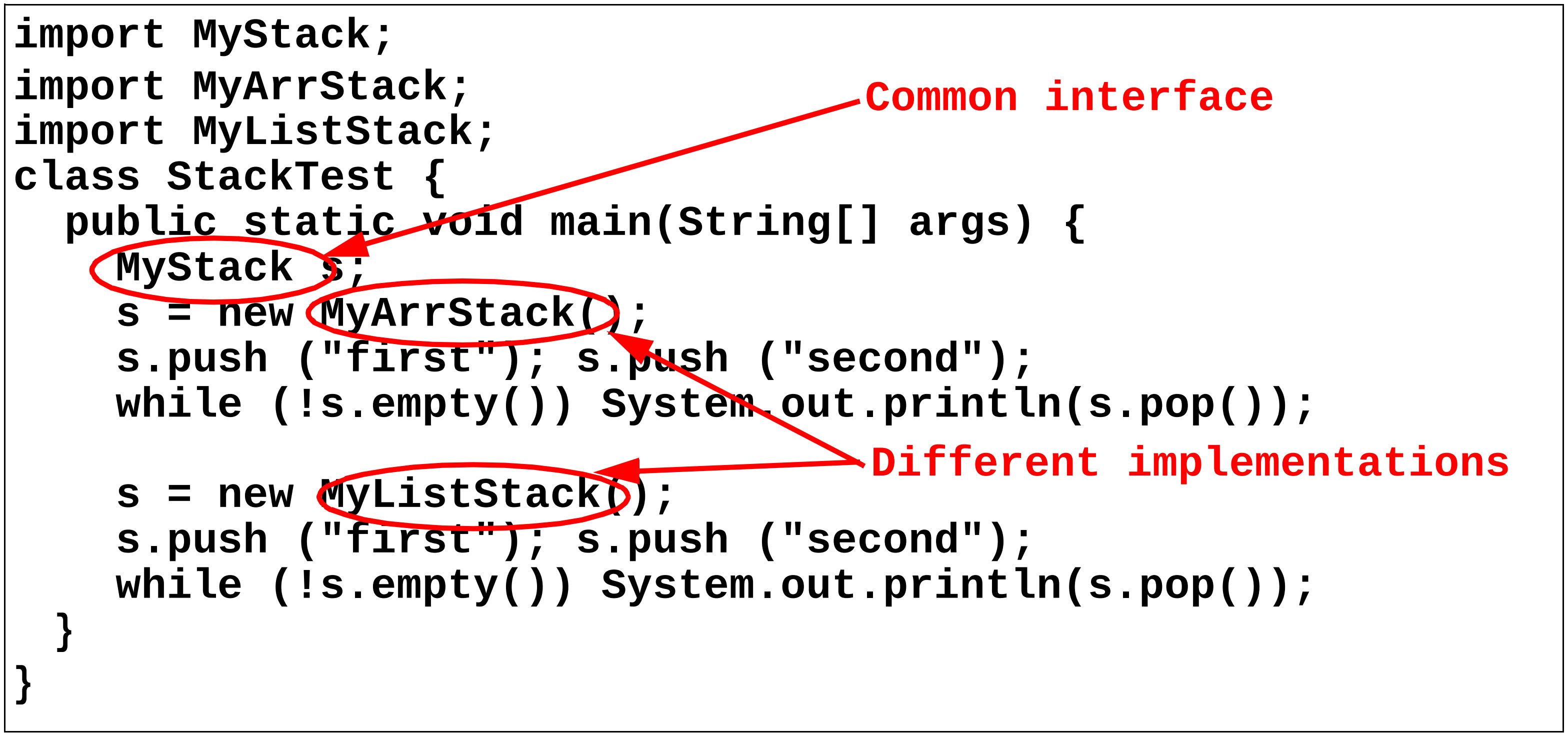
Same code, same type

But different things in the stacks

StackTest.java

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

Multiple Implementations



```
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());
  }
}
```

Common interface

Different implementations

StackTest.java

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

Abstract Classes

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

MyStack.java

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

MyArrStack.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

Outline

- ~~Introduction~~
- ~~The basics~~
- ~~Object-oriented niceties~~
- **Conclusions**

Java vs. C (Revisit)

- 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)

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