CMPSCI 187: Programming With Data Structures

Lecture #3: Java Overview

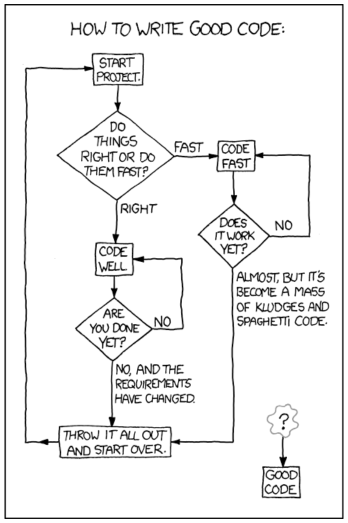
10 September 2012

Java Overview

- The Von Neumann Machine Model
- Primitive Data in Java
- Objects and Pointers
- Arrays and Strings
- Methods and Scope
- The Call Stack and Exceptions

Obligatory xkcd Commentary

- If you don't regularly read **xkcd**, a web comic written by Randall Munroe, you should.
- He is interested in many things other than computer science, but he is very good at getting to the essence of a point in a funny way.
- There are now 1103 of them (three per week for several years) and the backlist provides a wonderful opportunity to be distracted from work.


HOW TO WRITE GOOD CODE:
START PROJECT.
DO THINGS RIGHT OR DO THEM FAST?
FAST
CODE FAST
DOES IT WORK YET?
NO
ALMOST, BUT IT'S BECOME A MASS OF KLUDGES AND SPAGHETTI CODE.
RIGHT
CODE WELL
ARE YOU DONE YET?
NO
NO, AND THE REQUIREMENTS HAVE CHANGED.
THROW IT ALL OUT AND START OVER.
?
GOOD CODE

The Von Neumann Machine Model

- Most computers have a **word size**, **home registers**, other **registers**, and an **instruction set**.
- These days 64-bit words can be numbers (fixed or floating point), characters, **pointers**, or instructions.
- An instruction normally either **moves** a word to or from a register or carries out some **operation** on a word in a home register.
- The program is a sequence of instructions, with control flow by **branch** and **goto** statements.

High-Level Languages, Compilers, Interpreters

- High-level languages like Java let us write programs without knowing the details of our machine, and give us a richer vocabulary of instructions.
- A Java program (one or more classes) is **compiled** into class files.
- When you run the program, an **interpreter** creates the machine-language program that the machine actually runs.
- We give up some efficiency and some care in memory management by going to a higher-level language, but we make up for it in programming power.

Primitive Data

- All data in Java eventually reduces to **primitive** values, usually stored in single machine words.
- There are several fixed-point primitive types (**byte**, **short**, **int**, **long**), two floating-point types (**float** and **double**), the Unicode character type **char**, and the **boolean** type.
- There are lots of arithmetic operations on these that you may look up.
- Some automatic **type casts** occur from some of these to others.
- Each primitive type has a **wrapper class** to allow them to be used as objects.

Objects and Pointers

- The basic unit of data in Java is an **object**, a collection of data with associated methods.
- Objects come from **classes**, and the **class definition** indicates what sort of data the object has and includes the code for its methods.
- Each object is stored somewhere out in memory, in a place chosen at run time. A **pointer** or **reference** is the address where an object is, stored in a machine word.
- While primitives are passed as parameters **by value**, objects are passed by **reference**. It is possible for two or more variables to refer to the same object, so that changes to one variable will affect the other -- this is called **aliasing**.

Dynamic Typing

- Look up “Haddock’s Eyes” in Wikipedia -- “the name of the song is called...”
- An object has a **type** (what it is called) and a **class** (what it is).
- It gets a class when it is created with a **new** statement, and this never changes as the object is used.
- It can be referred to by a variable of any compatible type, e.g., a Dog variable could contain a Rottweiler or a Terrier object.
- When an **overloaded instance method** is called from an object, the version for the **class** is what gets run.

Dynamic Typing Example

```
public class Dog {
   public void bark {
      System.out.println(“Woof!”);}}
public class Terrier extends Dog {
   public void bark {
      System.out.println(“Yip!”);}
   public void dig {}}

Dog cardie = new Dog();
Dog duncan = new Terrier();
cardie.bark(); // Woof!
duncan.bark(); // Yip!
cardie.dig(); // won’t compile
duncan.dig(); // won’t compile
Terrier d = (Terrier) duncan;
d.dig(); // works
d.bark(); // Yip!
Terrier c = (Terrier) cardie; // compiles, ClassCastException
```

Arrays

- An array is a structure made up of primitives or objects of the same type.
- If T is any type, T[ ] is the type of arrays made from T objects.
- We can have two-dimensional arrays, or worse, with types like T [ ] [ ] [ ].
- Arrays of primitives are in consecutive locations -- arrays of objects are arrays of pointers, pointer to created objects (*picture*).
- Arrays are created like objects with **new** and have a given **length**. A method need not know the length of an array to use it.
- Shallow versus deep copying -- a new array with the same objects is aliased.

Strings

- Strings are more or less arrays of **char** but are a class of objects with many useful methods (see the API for reference).

- Strings are immutable -- once created they can only be overwritten with new strings, not edited. (Though if this happens within a method it looks like editing.)

- Remember that “=”, as for objects, means “the same copy of the same String”, while “.equals” means “the same characters in the same order”.

- The “+” operator on Strings is concatenation, sometimes casting other things into Strings.

- All objects have “toString” methods.

Methods and Scope

- The commands that cause Java programs to actually do things all occur within **methods**.
- A class may have a **main method**, which can be run by the operating system.
- A main method may call other methods, which are either instance or class methods. A method call runs until a **return statement**, which resumes the calling method at the point after the call.
- Methods may have **return values** (of the type given in their signature) and/or **side effects**.
- Side effects could include changes in fields of objects, or creation of new objects.
- Variables declared in a method are only meaningful there, not in any calls.

Scope of Variables

- A field of an object is normally only modified by a method of that object’s class (often called by some other method).
- A class may have **class variables**, also normally only modified by methods of the class.
- A variable declared within a method is meaningful only there, not outside and not within another method called from there.
- A method may have **parameters**, with names and types given by the method’s **signature**.
- Methods and fields may be designated **public** or **private**.

The Call Stack and Exceptions

- When one method calls another, the context of the first is saved to return to.
- If that second method calls a third, both must be saved. When we restore context, we return to the one **that was saved last.**
- When we save a bunch of things and only want to access the last-saved one first, we need a **stack**.
- An exception interrupts a method. If the exception can be thrown, it goes to the calling method, where it might stop execution or be thrown to the method calling that, and so on.
- The operating system prints the **call stack** when an exception stops execution -- which methods were in progress when the exception happened.