Java Review

Lecture 2
CS211 – Fall 2006

Announcements

- Java Bootcamp (two identical sessions)
  - Tuesday, 8/29, 7:30-10:30pm, Upson B7
  - Wednesday, 8/30, 7:30-10:30pm, Upson B7
  - Tutorial & solutions are available online
- Assignment 1 has been posted and is due Thursday, Sept 7 at 4:30 PM
  - A1 companion files are online since last night
- Check that you appear correctly within CMS
  - Report any CMS problems to your Section TA (email is fine)
- It's *really* a good idea to start on A1 and check CMS *this week* (well before the assignment is due)

More Announcements

- Available help
  - Consulting starts *tonight*
  - TA office hours start *next week*
  - Instructor office hours have already started
- Watch the course web page for ongoing announcements
  www.cs.cornell.edu/Courses/cs211
- Registering for ENGRD211 or COM S211?
  - Engineering now says they don't care what Engineers sign up for
- Sections start *this week*
  - Section Notes (available online by Thurs) may be useful for A1

Today's Plan

- A short, biased history of programming languages
- Review some Java/OOP concepts
- Warn about some Java pitfalls

Machine Language

- Used with the earliest electronic computers (1940s)
  - Machines use vacuum tubes (instead of transistors)
- Programs are entered by setting switches or reading punch cards
- All instructions are numbers

- Example code

```
0110 0001 0000 0110
Add  Reg1       6
```

- Idea for improvement
  - Let's use "words" instead of numbers
  - Result: Assembly Language

Assembly Language

- Idea: Use a program (an *assembler*) to convert assembly language into machine code
- Early assemblers were some of the most complicated code of the time (1950s)

- Example code

```
ADD R1 6
MOV R1 COST
SET R1 0
JMP TOP
```

- Typically, an assembler used *2 passes*
- Idea for improvement
  - Let's make it easier for humans by designing a high-level computer language
  - Result: high-level languages

High-Level Language

- Idea: Use a program (a *compiler* or an *interpreter*) to convert high-level code into machine code
- Pro
  - Easier for humans to write, read, and maintain code
- Con
  - The resulting program will never be as efficient as good assembly-code
    - Waste of memory
    - Waste of time
- The whole concept was initially controversial
  - Thus, FORTRAN (mathematical FORmula TRANslating system) was designed with efficiency very-much in mind

FORTRAN

- Initial version developed in 1957 by IBM

- Example code

```
C       SUM OF SQUARES
        ISUM = 0
        DO 100 I=1,10
        ISUM = ISUM + I*I
    100 CONTINUE
```

- FORTRAN introduced many of the ideas typical of programming languages
  - Assignment
  - Loops
  - Conditionals
  - Subroutines

ALGOL

- ALGOL = ALGOrithmic Language
- Developed by an international committee
- First version in 1958 (not widely used)
- Second version in 1960 (widely used)
- Sample code

```
comment Sum of squares
begin
    integer i, sum;
    for i:=1 until 10 do
        sum := sum + i*i;
end
```

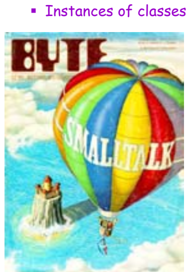
- ALGOL 60 included *recursion*
  - Pro: Makes it easy to design clear, succinct algorithms
  - Con: Too hard to implement; too inefficient

COBOL

- COBOL = COmmon Business Oriented Language
- Developed by the US government (about 1960)
  - Design was greatly influenced by Grace Hopper
- Goal: Programs should look like English
  - Idea was that *anyone* should be able to read and understand a COBOL program
- COBOL included the idea of *records* (a single data structure with multiple *fields*, each field holding a value)

Simula & Smalltalk

- These languages introduced and popularized *Object Oriented Programming* (OOP)
  - Simula was developed in Norway as a language for simulation (late 60s)
  - Smalltalk was developed at Xerox PARC in the 70s
- These languages included
  - Classes
  - Objects
  - Instances of classes



Java

- Java includes
  - Assignment statements, loops, conditionals from FORTRAN (but Java uses syntax from C)
  - Recursion from ALGOL
  - Fields from COBOL
  - OOP from Simula & Smalltalk

Classes

- A *class* defines how to make objects
  - Defines *fields*: variables that are part of object
  - Defines *methods*: named code operating on object

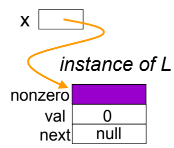
```
class L {
    int val;
    L next;
    L nonzero() {
        if (val != 0) return this;
        return next.nonzero();
    }
}
```

fields: int val; L next;

method: nonzero()

"this" refers to current object

```
L x = new L();
x.next = x;
```



Static (Class) Members

- A class can have fields and methods of its own
  - Declared as "static"
  - Do not need an instance of the class to use them
  - Only one copy in entire program; access by using class name

```
class L {
    int val;
    L next;
    L(int v) {
        num_created++;
    }
    static int num_created;
    static boolean any_exist() {
        return num_created != 0;
    }
}
```

```
if (L.any_exist()) {
   int n = L.num_created;
}
```

can't use "this" here

Parameters vs. Local Variables

- Methods have 0 or more parameters/arguments (i.e., inputs to the method code)
- Can declare local variables, too
- Both *disappear* when method returns

formal parameter

```
boolean findval(int y) {
    L here = this;
    while (here != null && here.val != y) {
        here = here.next;
    }
    return here;
}
```

local variable

actual parameter

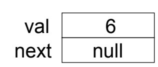
```
x.findval(23);
```

Constructors

- New instances of a class are created by calling a *constructor*
- Default constructor initializes all fields to default values (0 or null)
- Attached to class, not an instance method

```
class L {
    int val;
    L next;
    L(int v) {
        val = v+1;
        next = null;
    }
}
```

```
new L(5);
```



Programs

- A program is a collection of classes
  - Including built-in Java classes
- A running program does computation using instances of those classes.
- Program starts with a main method, declared as:

```
public static void main (String[] args) {
    ... body ...
}
```

Method must be named "main"

Parameters passed to program on command line

A class method; don't need an object to call it

Can be called from anywhere

Static vs. Instance Example

```
class Widget {
  static int nextSerialNumber = 10000;
  int serialNumber;

  Widget() {serialNumber = nextSerialNumber++;}

  Widget(int sn) {serialNumber = sn;}

      public static void main(String[] args) {
          Widget a = new Widget();
          Widget b = new Widget();
          Widget c = new Widget();
          Widget d = new Widget(42);
          System.out.println(a.serialNumber);
          System.out.println(b.serialNumber);
          System.out.println(c.serialNumber);
          System.out.println(d.serialNumber);
      }
  }
```

Names

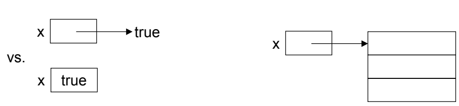
- Refer to fields, methods in own class by unqualified name
  - serialNumber
  - nextSerialNumber
- Refer to static fields in another class by qualified name
  - Widget.nextSerialNumber
- Refer to instance fields with qualified name
  - a.serialNumber
- Example
  - System.out.println(a.serialNumber)
    - out is a static field in class System
    - The value of System.out is an instance of a class that has a method println(int)
- If an object has to refer to itself, use `this`

Overloading of Methods

- A class can have several methods of the same name
  - But all methods must have different *signatures*
  - The *signature* of a method is its name plus types of its parameters
- Example: String.valueOf(...) in Java API
  - There are 9 of them:
    - valueOf(boolean);
    - valueOf(int);
    - valueOf(long);
    - ...
  - Parameter types are part of the method's signature

Primitive Types vs. Reference Types

- Primitive types
  - int, long, float, byte, char, boolean, ...
  - Efficiently implemented by storing directly into variable
  - Take a single word or 2 words of storage
  - Not considered Objects by Java: "unboxed"
- Reference types
  - Objects defined by classes, or arrays
    - String, int[ ], HashSet
  - Take up more memory, have higher overhead
  - Can have special value null
    - Can only compare null with ==, !=
    - Other uses cause NullPointerException



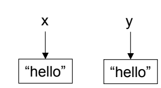
== vs. equals( )

- == tests whether variables hold identical values
- Works fine for primitive types
- For reference types (e.g., Strings), you usually want to use equals()
  - == means "are they the same box"
  - Usually *not* what you want!
- To compare object *contents*, define an equals() method

```
boolean equals(Object x);
```

- Two different strings,] with value "hello"!

```
x = "hello";
y = "hello";
x == y?
```

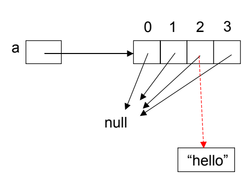


  - Use `x.equals("hello")`
  - Not `x == "hello"`

Arrays

- Arrays are reference types
- Array elements can be reference types or primitive types
  - E.g., int[] or String[]
- If a is an array, a.length is its length
- Its elements are a[0], a[1], ..., a[a.length - 1]
- The length is fixed for any one array

```
String[] a = new String[4];
         a[2] = "hello"
```

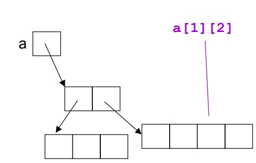



```
a.length = 4
```

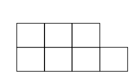
Multidimensional arrays

- Multidimensional arrays are really arrays of arrays
  - E.g., int[][] is an array of integer arrays (int[])
  - Multidimensional arrays can be ragged (i.e., all the arrays in the 2nd dimension need not be the same length)

```
int[][] a = new int[2][];
a[0] = new int[3];
a[1] = new int[4];
```



acts like:



The Class Hierarchy

- Classes form a hierarchy
- Class hierarchy is a tree
  - Object is at the root (top)
  - E.g., String and StringBuilder are subclasses of Object
- The hierarchy is a tree because
  - Each class has at most one superclass
  - Each class can have zero or more subclasses
- Can use a class where superclass is expected
- Within a class, methods and fields of its superclass are available
  - But must use super for access to *overridden* methods

Array vs. ArrayList vs. HashMap

- Three extremely useful constructs (see Java API)
- Array
  - Storage is allocated when array created; cannot change
- ArrayList (in java.util)
  - An "extensible" array
  - Can append or insert elements, access i^{th} element, reset to 0 length
  - Can get an iteration of the elements
- HashMap (in java.util)
  - Save data indexed by keys
  - Can lookup data by its key
  - Can get an iteration of the keys or the values

HashMap Example

- Create a HashMap of numbers, using the names of the numbers as keys:

```
HashMap numbers = new HashMap();
numbers.put("one", new Integer(1));
numbers.put("two", new Integer(2));
numbers.put("three", new Integer(3));
```

  To retrieve a number:

```
Integer n = (Integer)numbers.get("two");
if (n != null) System.out.println("two = " + n);
```

- Caveat: returns null if does not contain the key
  - Can use `numbers.containsKey(key)` to check this

Generics (New Feature of Java 1.5)

- Old

```
HashMap h = new HashMap();
h.put("one",new Integer(1));
Integer s = (Integer)h.get("one");
```

- New

```
HashMap<String, Integer> h =
     new HashMap<String,Integer>();
h.put("one", 1);
int s = h.get("one");
```

  Another new feature: Automatic boxing/unboxing

- No longer necessary to do a class cast each time you "box/unbox" an int

Experimentation and Debugging

- Don't be afraid to experiment if you don't know how things work
  - An *IDE* (*Interactive Development Environment*, e.g., DrJava or Eclipse) makes this easy
- Debugging
  - Think about what can cause the observed behavior
  - Isolate the bug using, for example, print statements combined with binary search
  - An IDE makes this easy by providing a *Debugging Mode*
    - Can step through the program while watching chosen variables