CS 61B: Lecture 6
Friday, September 10, 2010

Today's reading: Sierra & Bates pp. 282-285.

MORE ARRAYS

Automatic Array Construction

Last lecture, we used a loop to construct all the arrays that the top-level array references. This was necessary to construct a triangular array. But if you want a rectangular multi-dimensional array, rather than a triangular one, Java can create all of the arrays for you at once.

```
int[][] table = new int[x][y];
```

This declaration creates an array of x references to arrays. It also creates x arrays of y ints. The variable "table" references the array of arrays; and each entry in the array of arrays references one of the arrays of ints. All the arrays are created for you at once. Similarly, Java can create three- or ten-dimensional arrays for you, memory permitting.

We could have used a square array to store Pascal's Triangle, but that would have unnecessarily wasted memory. If you have enough memory, you might not care.

When you declare a variable, you can also create array entries by using initializers.

```
Human[] b = {kayla, rishi, new Human("Paolo")};
int[][] c = {{7, 3, 2}, {x}, {8, 5, 0, 0}, {y + z, 3}};
```

In the second example, Java constructs a non-rectangular two-dimensional array, composed of one array of arrays and four arrays of ints.

Sadly, you can only use this notation in a declaration. You can't write

```
d = {3, 7};                 // Compile-time ERROR.
f({1, 2, 3});               // Compile-time ERROR.
```

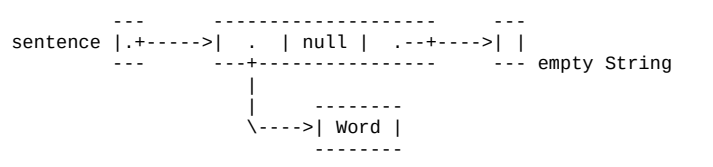
Another subtlety of array declarations is the following.

```
int[] a, b, c;                          // a, b, and c all reference arrays.
int a[], b, c[][];          // a is 1D; c is 2D; b is not a reference/array.
int[] a, b[];           // a references a 1D array; b references a 2D array.
```

Arrays of Objects

When you create a multi-dimensional array, Java can create all the arrays for you. But when you create an array of objects, Java does not create the objects automatically. The array contains space for references to the objects. You must create the objects yourself.

```
String[] sentence = new String[3];
sentence[0] = "Word";
sentence[2] = new String();
```



main()'s Parameter

What is the array of Strings that the main() method takes as a parameter? It's a list of command-line arguments sent to your Java program. Consider the following program.

```
class Echo {
  public static void main(String[] args) {
    for (int i = 0; i < args.length; i++) {
      System.out.println(args[i]);
    }
  }
}
```

If we compile this and type "java Echo kneel and worship Java", java prints

```
kneel
and
worship
Java
```

MORE LOOPS

"do" Loops

A "do" loop has just one difference from a "while" loop. If Java reaches a "do" loop, it _always_ executes the loop body at least once. Java doesn't check the loop condition until the end of the first iteration. "do" loops are appropriate for any loop you always want executed at least once, especially if the variables in the condition won't have meaningful assignments until the loop body has been executed.

```
do {
  s = keybd.readLine();
  process(s);
} while (s.length() > 0);              // Exit loop if s is an empty String.
```

The "break" and "continue" Statements

A "break" statement immediately exits the innermost loop or "switch" statement enclosing the "break", and continues execution at the code following the loop or "switch".

In the loop example above, we might want to skip "process(s)" when s is a signal to exit (in this case, an empty String). We want a "time-and-a-half" loop--we want to enter the loop at a different point in the read-process cycle than we want to exit the loop at. Here are two alternative loops that do the right thing. They behave identically. Each has a different disadvantage.

```
s = keybd.readLine();
while (s.length() > 0) {
  process(s);
  s = keybd.readLine();
}
```

Disadvantage: The line "s = keybd..." is repeated twice. It's not really a disadvantage here, but if input took 100 lines of code, the duplication would make the code harder to maintain. Why? Because a programmer improving the code might change one copy of the duplicated code without noticing the need to change the other to match.

```
while (true) {       // Loop forever.
  s = keybd.readLine();
  if (s.length() == 0) {
    break;
  }
  process(s);
}
```

Disadvantage: Somewhat obfuscated for the reader, because the loop isn't aligned with its natural endpoint.

Some loops have more than one natural endpoint. Suppose we want to iterate the read-process loop at most ten times. In the example at left below, the "break" statement cannot be criticized, because the loop has two natural endpoints. We could get rid of the "break" by writing the loop as at right below, but the result is longer and harder to read.

```
for (int i = 0; i < 10; i++) {
  s = keybd.readLine();
  if (s.length() == 0) {
    break;
  }
  process(s);
}
```

```
int i = 0;
do {
  s = keybd.readLine();
  if (s.length() > 0) {
    process(s);
  }
  i++;
} while ((i < 10) &&
   (s.length() > 0));
```

There are anti-break zealots who will claim that the loop on the right is the "correct" way to do things. Some of them feel this way because "break" statements are a little bit like the "go to" statements found in some languages like Basic and Fortran (plus the "machine language" that microprocessors really execute). "go to" statements allow you to jump to any line of code in the program. It sounds like a good idea at first, but it invariably leads to insanely unmaintainable code. And what happens if you jump to the middle of a loop? Edsger Dijkstra wrote a famous article in 1968 entitled "Go To Statement Considered Harmful", which is part of the reason why most modern languages like Java don't have "go to" statements.

WARNING: It's easy to forget exactly where a "break" statement will jump to. For example, "break" does not jump to the end of the innermost enclosing "if" statement. An AT&T programmer introduced a bug into telephone switching software in a procedure that contained a "switch" statement, which contained an "if" clause, which contained a "break", which was intended for the "if" clause, but instead jumped to the end of the "switch" statement. As a result, on January 15, 1990, AT&T's entire U.S. long distance service collapsed for eleven hours. (That code was actually written in C, but Java's loop syntax and "break" semantics are identical.)

For this reason, Java (unlike C) allows you to attach labels to any kind of enclosing statement, including "if" statements and any group of statements placed { in braces }. Then, "break" can jump to the end of any labeled enclosure that encloses the "break" statement.

```
test:
if (x == 0) {
  loop:
  while (i < 9) {
    stuff: {
      switch(z[i]) {
      case 0: break;           // Jump to statement1
      case 1: break stuff;     // Jump to statement2
      case 2: break loop;      // Jump to statement4
      case 3: break test;      // Jump to statement5
      case 4: continue;        // Jump to location 3
      default: continue loop;  // Jump to location 3
      }
      statement1();
    }
    statement2();
    i++;
    // location 3
  }
  statement4();
}
statement5();
```

The "continue" statement is akin to the "break" statement, except
(1) it only applies to loops (so you can't write "continue stuff" or "continue test" above), and
(2) it doesn't necessarily exit the loop; another iteration may commence (if the condition of the "while"/"do"/"for" loop is satisfied).

Unless you want to work for AT&T, I suggest you always use labeled break and continue statements (except perhaps in uncomplicated "switch" statements).

Finally, I told you that "for" loops are identical to certain "while" loops, but there's actually a subtle difference when you use "continue". What's the difference between the following two loops?

```
int i = 0;
while (i < 10) {
  if (condition(i)) {
    continue;
  }
  call(i);
  i++;
}
```

```
for (int i = 0; i < 10; i++) {
  if (condition(i)) {
    continue;
  }
  call(i);
}
```

Answer: when "continue" is called in the "while" loop, "i++" is not executed. In the "for" loop, however, i is incremented at the end of _every_ iteration, even iterations where "continue" is called.

CONSTANTS
=========
Java's "final" keyword is used to declare a value that can never be changed. If you find yourself repeatedly using a numerical value with some "meaning" in your code, you should probably turn it into a "final" constant.

```
BAD:    if (month == 2) {

GOOD:   public final static int FEBRUARY = 2;    // Usually near top of class.
        ...
        if (month == FEBRUARY) {
```

Why? Because if you ever need to change the numerical value assigned to February, you'll only have to change one line of code, rather than hundreds.

If you ever after try to assign a value to FEBRUARY, you'll have a compiler error.

"final" is usually used for class variables (static fields), but it can be used for instance variables (non-static fields) and local variables too. (It only makes sense for an instance variable to be "final" if the variable is declared with an initializer that calls a method or constructor that doesn't always return the same value.)

The custom of rendering constants in all-caps is long-established and was inherited from C.

For any array x, "x.length" is a "final" field.