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CS 106A

Handout #15
January 15, 2016

Control Statements

Optional Movie

> And so even though we face the difficulties of today and tomorrow, I still have a dream. It is a dream deeply rooted in the American dream.
>
> I have a dream that one day this nation will rise up and live out the true meaning of its creed: "We hold these truths to be self-evident, that all men are created equal."

Martin Luther King, Jr.
"I Have a Dream"

TBA
Monday, January 18
10:30 A.M.

Statement Types in Java

- Programs in Java consist of a set of ***classes***. Those classes contain ***methods***, and each of those methods consists of a sequence of ***statements***.
- Statements in Java fall into three basic types:
  - Simple statements
  - Compound statements
  - Control statements
- ***Simple statements*** are formed by adding a semicolon to the end of a Java expression.
- ***Compound statements*** (also called ***blocks***) are sequences of statements enclosed in curly braces.
- ***Control statements*** fall into two categories:
  - ***Conditional statements*** that specify some kind of test
  - ***Iterative statements*** that specify repetition

Boolean Expressions

- The operators used with the `boolean` data type fall into two categories: ***relational operators*** and ***logical operators***.
- There are six relational operators that compare values of other types and produce a `boolean` result:

`==`	Equals	`!=`	Not equals
`<`	Less than	`<=`	Less than or equal to
`>`	Greater than	`>=`	Greater than or equal to

  For example, the expression `n <= 10` has the value `true` if `n` is less than or equal to 10 and the value `false` otherwise.
- There are also three logical operators:

`&&`	Logical AND	`p && q` means both `p` and `q`
`||`	Logical OR	`p || q` means either `p` or `q` (or both)
`!`	Logical NOT	`!p` means the opposite of `p`

Notes on the Boolean Operators

- Remember that Java uses `=` to denote assignment. To test whether two values are equal, you must use the `==` operator.
- It is not legal in Java to use more than one relational operator in a single comparison as is often done in mathematics. To express the idea embodied in the mathematical expression

  $$0 \le x \le 9$$

  you need to make both comparisons explicit, as in

  ```
  0 <= x && x <= 9
  ```
- The `||` operator means *either or both,* which is not always clear in the English interpretation of *or.*
- Be careful when you combine the `!` operator with `&&` and `||` because the interpretation often differs from informal English.

Short-Circuit Evaluation

- Java evaluates the `&&` and `||` operators using a strategy called ***short-circuit mode*** in which it evaluates the right operand only if it needs to do so.
- For example, if `n` is 0, the right hand operand of `&&` in

  ```
  n != 0 && x % n == 0
  ```

  is not evaluated at all because `n != 0` is `false`. Because the expression

  ```
  false && anything
  ```

  is always `false`, the rest of the expression no longer matters.
- One of the advantages of short-circuit evaluation is that you can use `&&` and `||` to prevent execution errors. If `n` were 0 in the earlier example, evaluating `x % n` would cause a "division by zero" error.

The `if` Statement

The simplest of the control statements is the `if` statement, which occurs in two forms. You use the first form whenever you need to perform an operation only if a particular condition is true:

```
if (condition) {
   statements to be executed if the condition is true
}
```

You use the second form whenever you want to choose between two alternative paths, one for cases in which a condition is true and a second for cases in which that condition is false:

```
if (condition) {
   statements to be executed if the condition is true
} else {
   statements to be executed if the condition is false
}
```

Common Forms of the `if` Statement

The examples in the book use only the following forms of the `if` statement:

Single line `if` statement

```
if (condition) statement
```

Multiline `if` statement with curly braces

```
if (condition) {
   statement
   . . . more statements . . .
}
```

`if`/`else` statement with curly braces

```
if (condition) {
   statements_true
} else {
   statements_false
}
```

Cascading `if` statement

```
if (condition_1) {
   statements_1
} else if (condition_2) {
   statements_2
. . . more else/if conditions . . .
} else {
   statements_else
}
```

The `?:` Operator

- In addition to the `if` statement, Java provides a more compact way to express conditional execution that can be extremely useful in certain situations. This feature is called the `?:` operator (pronounced *question-mark-colon*) and is part of the expression structure. The `?:` operator has the following form:

```
condition ? expression_1 : expression_2
```

- When Java evaluates the `?:` operator, it first determines the value of *condition,* which must be a `boolean`. If *condition* is `true`, Java evaluates *expression*$_1$ and uses that as the value; if *condition* is `false`, Java evaluates *expression*$_2$ instead.
- You could use the `?:` operator to assign the larger of `x` and `y` to the variable `max` like this:

```
max = (x > y) ? x : y;
```

The `switch` Statement

The `switch` statement provides a convenient syntax for choosing among a set of possible paths:

```
switch ( expression ) {
  case v_1:
     statements to be executed if expression = v_1
     break;
  case v_2:
     statements to be executed if expression = v_2
     break;
  . . . more case clauses if needed . . .
  default:
     statements to be executed if no values match
     break;
}
```

Example of the `switch` Statement

The `switch` statement is useful when the program must choose among several cases, as in the following example:

```
public run() {
   println("This program shows the number of days in a month.");
   int month = readInt("Enter numeric month (Jan=1): ");
   switch (month) {
     case 2:
       println("28 days (29 in leap years)");
       break;
     case 4: case 6: case 9: case 12:
       println("30 days");
       break;
     case 1: case 3: case 5: case 7: case 8: case 11:
       println("31 days");
       break;
     default:
       println("Illegal month number");
       break;
   }
}
```

The `while` Statement

The `while` statement is the simplest of Java's iterative control statements and has the following form:

```
while ( condition ) {
     statements to be repeated
}
```

When Java encounters a `while` statement, it begins by evaluating the condition in parentheses, which must have a `boolean` value.

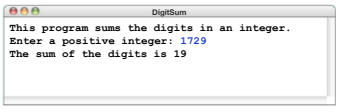
If the value of *condition* is `true`, Java executes the statements in the body of the loop.

At the end of each cycle, Java reevaluates *condition* to see whether its value has changed. If *condition* evaluates to `false`, Java exits from the loop and continues with the statement following the closing brace at the end of the `while` body.

The `DigitSum` Program

```
public void run() {
   println("This program sums the digits in an integer.");
   int n = readInt("Enter a positive integer: ");
   int dsum = 0;
   while ( n > 0 ) {
      dsum += n % 10;
      n /= 10;
   }
   println("The sum of the digits is " + dsum);
}
```

n	dsum
0	19



The `for` Statement

The `for` statement in Java is a particularly powerful tool for specifying the control structure of a loop independently from the operations the loop body performs. The syntax looks like this:

```
for ( init ; test ; step ) {
    statements to be repeated
}
```

Java evaluates a `for` statement by executing the following steps:

1. Evaluate *init*, which typically declares a ***control variable***.
2. Evaluate *test* and exit from the loop if the value is `false`.
3. Execute the statements in the body of the loop.
4. Evaluate *step*, which usually updates the control variable.
5. Return to step 2 to begin the next loop cycle.

Comparing `for` and `while`

The `for` statement

```
for ( init ; test ; step ) {
    statements to be repeated
}
```

is functionally equivalent to the following code using `while`:

```
init;
while ( test ) {
    statements to be repeated
    step;
}
```

The advantage of the `for` statement is that everything you need to know to understand how many times the loop will run is explicitly included in the header line.

Exercise: Reading `for` Statements

Describe the effect of each of the following `for` statements:

1.
```
for (int i = 1; i <= 10; i++)
```

2.
```
for (int i = 0; i < N; i++)
```

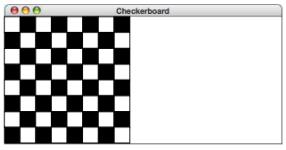
3.
```
for (int n = 99; n >= 1; n -= 2)
```

4.
```
for (int x = 1; x <= 1024; x *= 2)
```

The `Checkerboard` Program

```
public void run() {
   double sqSize = (double) getHeight() / N_ROWS;
   for (int i = 0; i < N_ROWS; i++) {
      for (int j = 0; j < N_COLUMNS; j++) {
         double x = j * sqSize;
         double y = i * sqSize;
         GRect sq = new GRect(x, y, sqSize, sqSize);
         sq.setFilled((i + j) % 2 != 0);
         add(sq);
      }
   }
}
```

sqSize	i	j	x	y	sq
30.0	8	8	210.0	210.0	



Simple Graphical Animation

The `while` and `for` statements make it possible to implement simple graphical animation. The basic strategy is to create a set of graphical objects and then execute the following loop:

```
for (int i = 0; i < N_STEPS; i++) {
    update the graphical objects by a small amount
    pause(PAUSE_TIME);
}
```

On each cycle of the loop, this pattern updates each animated object by moving it slightly or changing some other property of the object, such as its color. Each cycle is called a ***time step***.

After each time step, the animation pattern calls `pause`, which delays the program for some number of milliseconds (expressed here as the constant `PAUSE_TIME`). Without the call to `pause`, the program would finish faster than the human eye can follow.

The `AnimatedSquare` Program

```
public void run() {
   GRect square = new GRect(0, 0, SQUARE_SIZE, SQUARE_SIZE);
   square.setFilled(true);
   square.setFillColor(Color.RED);
   add(square);
   double dx = (getWidth() - SQUARE_SIZE) / N_STEPS;
   double dy = (getHeight() - SQUARE_SIZE) / N_STEPS;
   for (int i = 0; i < N_STEPS; i++) {
      square.move(dx, dy);
      pause(PAUSE_TIME);
   }
}
```

i	dx	dy	square
101	3.0	1.7