Chapter 3: Program Statements

Presentation slides for

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Foundations of Program Design
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by John Lewis and William Loftus

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Program Statements

We will now examine some other program statements

Chapter 3 focuses on:

- the flow of control through a method
- decision-making statements
- operators for making complex decisions
- repetition statements
- software development stages
- more drawing techniques

Flow of Control

- Unless indicated otherwise, the order of statement execution through a method is linear: one after the other in the order they are written
- Some programming statements modify that order, allowing us to:
  - decide whether or not to execute a particular statement, or
  - perform a statement over and over repetitively
- The order of statement execution is called the flow of control

Conditional Statements

- A conditional statement lets us choose which statement will be executed next
- Therefore they are sometimes called selection statements
- Conditional statements give us the power to make basic decisions
- Java’s conditional statements are the if statement, the if-else statement, and the switch statement

The if Statement

- The if statement has the following syntax:

```java
if (condition) 
  statement;
```

  If the condition is true, the statement is executed.
  If it is false, the statement is skipped.

An example of an if statement:

```java
if (sum > MAX) 
  delta = sum - MAX;
  System.out.println ("The sum is “ + sum);
```

First, the condition is evaluated. The value of sum is either greater than the value of MAX, or it is not.

- If the condition is true, the assignment statement is executed.
- If it is not, the assignment statement is skipped.

Either way, the call to println is executed next.

See Age.java (page 112)
**Logic of an if statement**

- A condition is evaluated as true or false.
- If the condition is true, the statement is executed.
- If the condition is false, the else statement is executed.

**Boolean Expressions**

- A condition often uses one of Java's equality operators or relational operators, which all return boolean results:
  - `==` equal to
  - `!=` not equal to
  - `<` less than
  - `>` greater than
  - `<=` less than or equal to
  - `>=` greater than or equal to

- Note the difference between the equality operator (`==`) and the assignment operator (`=`).

**The if-else Statement**

- An else clause can be added to an if statement to make it an if-else statement:
  ```java
  if (condition)
  statement1;
  else
  statement2;
  ```
- If the condition is true, statement1 is executed; if the condition is false, statement2 is executed.
- One or the other will be executed, but not both.
- See Wages.java (page 116)

**Block Statements**

- Several statements can be grouped together into a block statement.
- A block is delimited by braces `{ ... }`.
- A block statement can be used wherever a statement is called for in the Java syntax.
- For example, in an if-else statement, the if portion, or the else portion, or both, could be block statements.
- See Guessing.java (page 117)

**Nested if Statements**

- The statement executed as a result of an if statement or else clause could be another if statement.
- These are called nested if statements.
- See MinOfThree.java (page 118)
- An else clause is matched to the last unmatched if (no matter what the indentation implies).
## Comparing Characters

+ We can use the relational operators on character data
+ The results are based on the Unicode character set
+ The following condition is true because the character '+' comes before the character 'J' in Unicode:

```java
if ('+' < 'J')
    System.out.println("+ is less than J");
```
+ The uppercase alphabet (A-Z) and the lowercase alphabet (a-z) both appear in alphabetical order in Unicode

## Comparing Strings

+ Remember that a character string in Java is an object
+ We cannot use the relational operators to compare strings
+ The `equals` method can be called on a string to determine if two strings contain exactly the same characters in the same order
+ The String class also contains a method called `compareTo` to determine if one string comes before another alphabetically (as determined by the Unicode character set)

## Comparing Floating Point Values

+ We also have to be careful when comparing two floating point values (`float` or `double`) for equality
+ You should rarely use the equality operator (`==`) when comparing two floats
+ In many situations, you might consider two floating point numbers to be "close enough" even if they aren't exactly equal
+ Therefore, to determine the equality of two floats, you may want to use the following technique:

```java
if (Math.abs(f1 - f2) < 0.00001)
    System.out.println("Essentially equal.");
```

## The switch Statement

+ The general syntax of a switch statement is:

```java
switch (expression)
{
    case value1:
        statement-list1
        break;
    case value2:
        statement-list2
        break;
    case value3:
        statement-list3
        break;
    ...  
}
```
+ Often a `break` statement is used as the last statement in each case’s statement list
+ A break statement causes control to transfer to the end of the switch statement
+ If a break statement is not used, the flow of control will continue into the next case
+ Sometimes this can be helpful, but usually we only want to execute the statements associated with one case
The switch Statement

- A switch statement can have an optional default case as the last case in the statement.
- The default case has no associated value and simply uses the reserved word default.
- If the default case is present, control will transfer to it if no other case value matches.
- If there is no default case, and no other value matches, control falls through to the statement after the switch.

The expression of a switch statement must result in an integral data type, like an integer or character; it cannot be a floating point value.

Note that the implicit boolean condition in a switch statement is equality - it tries to match the expression with a value.

You cannot perform relational checks with a switch statement.

See GradeReport.java (page 121).

Logical Operators

- Boolean expressions can also use the following logical operators:
  - \(!\) Logical NOT
  - \(\&\&\) Logical AND
  - \(||\) Logical OR
- They all take boolean operands and produce boolean results.
- Logical NOT is a unary operator (it has one operand), but logical AND and logical OR are binary operators (they each have two operands).

Logical NOT

- The logical NOT operation is also called logical negation or logical complement.
- If some boolean condition \(a\) is true, then \(!a\) is false; if \(a\) is false, then \(!a\) is true.
- Logical expressions can be shown using truth tables.

<table>
<thead>
<tr>
<th>a</th>
<th>(!a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
</tr>
</tbody>
</table>

Logical AND and Logical OR

- The logical and expression \(a \&\& b\)
  is true if both \(a\) and \(b\) are true, and false otherwise.

- The logical or expression \(a || b\)
  is true if \(a\) or \(b\) or both are true, and false otherwise.

Truth Tables

- A truth table shows the possible true/false combinations of the terms.
- Since \(\&\&\) and \(||\) each have two operands, there are four possible combinations of true and false.

| a | b | a \&\& b | a || b |
|---|---|---------|--------|
| true| true| true    | true   |
| true| false| false   | false  |
| false| true| false   | true   |
| false| false| false   | false  |
Conditions in selection statements and loops can use logical operators to form complex expressions:

```java
if (total < MAX && !found)
    System.out.println("Processing...");
```

Logical operators have precedence relationships between themselves and other operators.

Specific expressions can be evaluated using truth tables:

| total < MAX | found | !found | total < MAX || found |
|-------------|-------|--------|-------------|----------------|
| false       | false | true   | false       | false          |
| false       | true  | false  | false       | false          |
| true        | false | true   | true        | true           |
| true        | true  | false  | true        | true           |

The increment and decrement operators are arithmetic and operate on one operand:

- The increment operator (++ adds one to its operand
- The decrement operator (--) subtracts one from its operand
- The statement
  ```java
count ++;
  ```
  is essentially equivalent to
  ```java
count = count + 1;
  ```

In both cases the variable is incremented (decremented) but the value used in the larger expression depends on the form:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Operation</th>
<th>Value of Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>count ++</td>
<td>add 1</td>
<td>old value</td>
</tr>
<tr>
<td>+count</td>
<td>add 1</td>
<td>new value</td>
</tr>
<tr>
<td>count --</td>
<td>subtract 1</td>
<td>old value</td>
</tr>
<tr>
<td>--count</td>
<td>subtract 1</td>
<td>new value</td>
</tr>
</tbody>
</table>
Increment and Decrement Operators

+ If count currently contains 45, then
  \[ \text{total} = \text{count}++; \]
  assigns 45 to total and 46 to count
+ If count currently contains 45, then
  \[ \text{total} = ++\text{count}; \]
  assigns the value 46 to both total and count

Assignment Operators

+ Often we perform an operation on a variable, then store the result back into that variable
+ Java provides assignment operators to simplify that process
+ For example, the statement
  \[ \text{num} += \text{count}; \]
  is equivalent to
  \[ \text{num} = \text{num} + \text{count}; \]

Assignment Operators

+ There are many assignment operators, including the following:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Example</th>
<th>Equivalent To</th>
</tr>
</thead>
<tbody>
<tr>
<td>+=</td>
<td>( x += y )</td>
<td>( x = x + y )</td>
</tr>
<tr>
<td>-=</td>
<td>( x -= y )</td>
<td>( x = x - y )</td>
</tr>
<tr>
<td>*=</td>
<td>( x *= y )</td>
<td>( x = x \times y )</td>
</tr>
<tr>
<td>/=</td>
<td>( x /= y )</td>
<td>( x = x / y )</td>
</tr>
<tr>
<td>%=</td>
<td>( x %= y )</td>
<td>( x = x % y )</td>
</tr>
</tbody>
</table>

Assignment Operators

+ The right hand side of an assignment operator can be a complete expression
+ The entire right-hand expression is evaluated first, then the result is combined with the original variable
+ Therefore
  \[ \text{result} /= (\text{total-\text{MIN}}) \mod \text{num}; \]
  is equivalent to
  \[ \text{result} = \text{result} / ((\text{total-\text{MIN}}) \mod \text{num}); \]

The Conditional Operator

+ Java has a conditional operator that evaluates a boolean condition that determines which of two other expressions is evaluated
+ The result of the chosen expression is the result of the entire conditional operator
+ Its syntax is:
  \[ \text{condition} \ ? \ \text{expression1} : \ \text{expression2} \]
+ If the condition is true, expression1 is evaluated; if it is false, expression2 is evaluated

The Conditional Operator

+ The conditional operator is similar to an if-else statement, except that it is an expression that returns a value
+ For example:
  \[ \text{larger} = (\text{num1} > \text{num2}) \ ? \ \text{num1} : \ \text{num2}; \]
+ If num1 is greater than num2, then num1 is assigned to larger; otherwise, num2 is assigned to larger
+ The conditional operator is ternary, meaning that it requires three operands
**The Conditional Operator**

Another example:

```java
System.out.println ("Your change is " + count + 
    (count == 1) ? "Dime" : "Dimes");
```

- If `count` equals 1, then "Dime" is printed.
- If `count` is anything other than 1, then "Dimes" is printed.

**Repetition Statements**

- Repetition statements allow us to execute a statement multiple times repetitively.
- They are often simply referred to as loops.
- Like conditional statements, they are controlled by boolean expressions.
- Java has three kinds of repetition statements: the `while` loop, the `do` loop, and the `for` loop.
- The programmer must choose the right kind of loop for the situation.

**The while Statement**

- The `while` statement has the following syntax:

  ```java
  while (condition) 
  statement;
  ```

  - `while` is a reserved word.
  - `condition` is a boolean expression.
  - `statement` is the body of the loop.

- The `while` statement is executed repetitively until the condition becomes false.

**Logic of a while loop**

- The body of a while loop must eventually make the condition false.
- If not, it is an infinite loop, which will execute until the user interrupts the program.
- This is a common type of logical error.
- You should always double check to ensure that your loops will terminate normally.

**The while Statement**

- Note that if the condition of a while statement is false initially, the statement is never executed.
- Therefore, the body of a while loop will execute zero or more times.
- See `Counter.java` (page 133)
- See `Average.java` (page 134)
- See `WinPercentage.java` (page 136)
**Nested Loops**

- Similar to nested if statements, loops can be nested as well.
- That is, the body of a loop could contain another loop.
- Each time through the outer loop, the inner loop will go through its entire set of iterations.
- See `PalindromeTester.java` (page 137).

**The do Statement**

- The *do statement* has the following syntax:

  ```java
  do {
  statement;
  } while (condition);
  ```

  The statement is executed once initially, then the condition is evaluated.
  The statement is repetitively executed until the condition becomes false.

**Logic of a do loop**

- **True**
  - Condition evaluated
  - Statement
  - False

**Comparing the while and do loops**

- **While loop**
  - Condition evaluated
  - Statement
  - True
  - False
- **Do loop**
  - Condition evaluated
  - Statement
  - True
  - False

**The for Statement**

- The *for statement* has the following syntax:

  ```java
  for (initialization; condition; increment) {
  statement;
  }
  ```

  The initialization portion is executed once before the loop begins.
  The statement is executed until the condition becomes false.
  The increment portion is executed at the end of each iteration.

- The logic of a for loop is similar to a while loop, except that the condition is evaluated after the body of the loop is executed.
- Therefore the body of a for loop will execute at least one time.
- See `Counter2.java` (page 143).
- See `ReverseNumber.java` (page 144).
The for Statement

A for loop is equivalent to the following while loop structure:

```java
initialization;
while (condition )
{
    statement;
    increment;
}
```

Logic of a for loop

The for Statement

- Like a while loop, the condition of a for statement is tested prior to executing the loop body
- Therefore, the body of a for loop will execute zero or more times
- It is well suited for executing a specific number of times that can be determined in advance
- See Counter3.java (page 146)
- See Multiples.java (page 147)
- See Stars.java (page 150)

The for Statement

- Each expression in the header of a for loop is optional
  - If the initialization is left out, no initialization is performed
  - If the condition is left out, it is always considered to be true, and therefore creates an infinite loop
  - If the increment is left out, no increment operation is performed
- Both semi-colons are always required in the for loop header

Program Development

- The creation of software involves four basic activities:
  - establishing the requirements
  - creating a design
  - implementing the code
  - testing the implementation
- The development process is much more involved than this, but these basic steps are a good starting point

Requirements

- Requirements specify the tasks a program must accomplish (what to do, not how to do it)
- They often include a description of the user interface
- An initial set of requirements are often provided, but usually must be critiqued, modified, and expanded
- It is often difficult to establish detailed, unambiguous, complete requirements
- Careful attention to the requirements can save significant time and money in the overall project
**Design**

- An **algorithm** is a step-by-step process for solving a problem
- A program follows one or more algorithms to accomplish its goal
- The **design** of a program specifies the algorithms and data needed
- In object-oriented development, the design establishes the classes, objects, and methods that are required
- The details of a method may be expressed in **pseudocode**, which is code-like, but does not necessarily follow any specific syntax

**Implementation**

- **Implementation** is the process of translating a design into source code
- Most novice programmers think that writing code is the heart of software development, but it actually should be the least creative step
- Almost all important decisions are made during requirements analysis and design
- Implementation should focus on coding details, including style guidelines and documentation
- See ExamGrades.java (page 155)

**Testing**

- A program should be executed multiple times with various input in an attempt to find errors
- **Debugging** is the process of discovering the cause of a problem and fixing it
- Programmers often erroneously think that there is "only one more bug" to fix
- Tests should focus on design details as well as overall requirements

**More Drawing Techniques**

- Conditionals and loops can greatly enhance our ability to control graphics
- See Bullseye.java (page 157)
- See Boxes.java (page 159)
- See BarHeights.java (page 162)