Flow of Control: Loops

Chapter 4

*JAVA: An Introduction to Problem Solving & Programming, 7*th Ed. By Walter Savitch
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Objectives

- Design a loop
- Use **`while`**, **`do`**, and **`for`** in a program
- Use the **`for-each`** with enumerations
- Use assertion checks
- Use repetition in a graphics program
- Use **`drawString`** to display text in a graphics program

Java Loop Statements

- A portion of a program that repeats a statement or a group of statements is called a *loop.*
- The statement or group of statements to be repeated is called the *body* of the loop.
- A loop could be used to compute grades for each student in a class.
- There must be a means of exiting the loop.

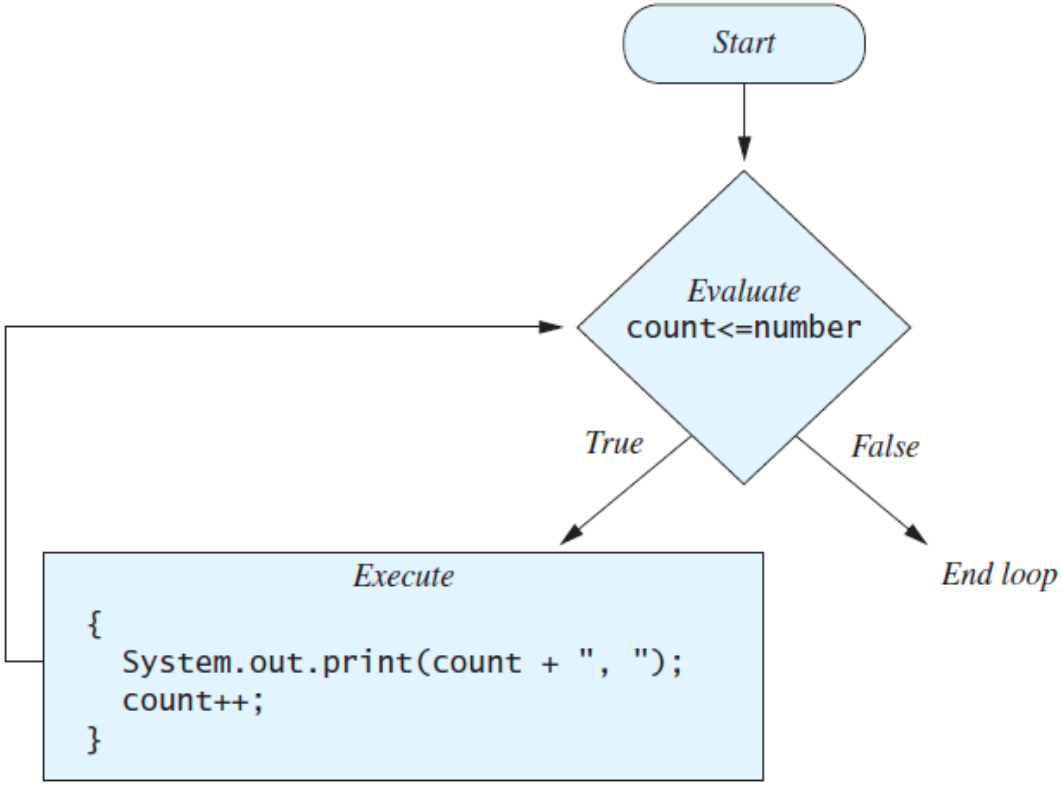
The `while` Statement

- Also called a `while` loop
- A `while` statement repeats while a controlling boolean expression remains true
- The loop body typically contains an action that ultimately causes the controlling boolean expression to become false.

The `while` Statement

- Figure 4.1
  The action of the `while` loop in Listing 4.1

```
while (count <= number)
{
   System.out.print(count + ", ");
   count++;
}
```



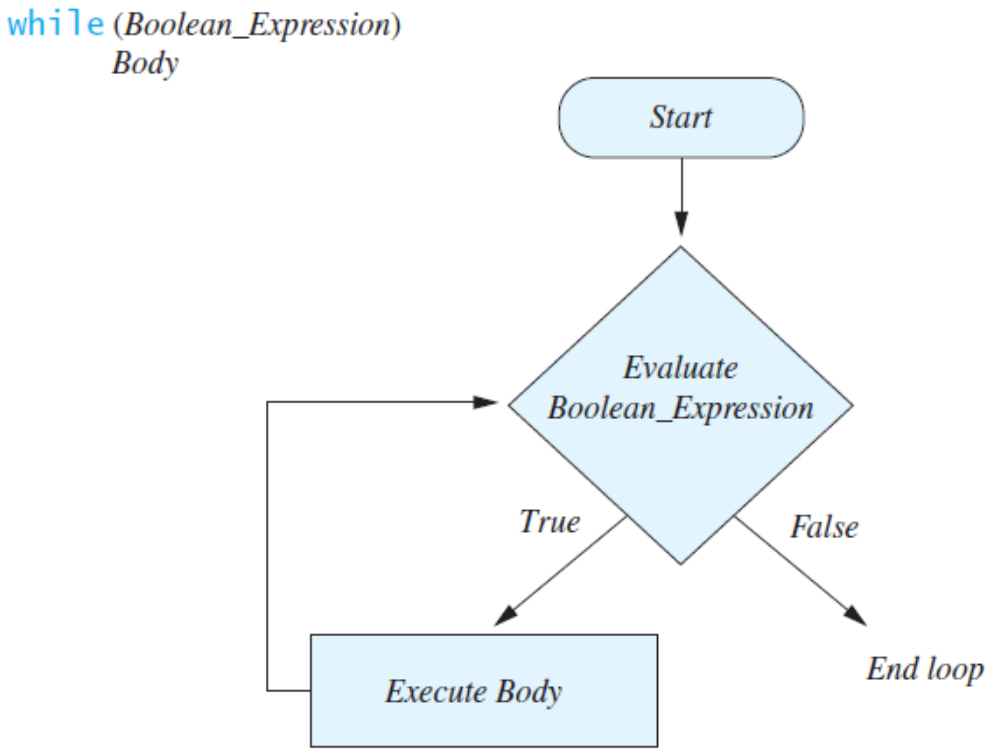
The `while` Statement

- Syntax

```
while (Boolean_Expression)
  Body_Statement
or
while (Boolean_Expression)
{
  First_Statement
  Second_Statement
  …
}
```

The `while` Statement

- Figure 4.2
  Semantics of the `while` statement



The `do-while` Statement

- Also called a **`do-while`** loop
- Similar to a **`while`** statement, except that the loop body is executed at least once
- Syntax

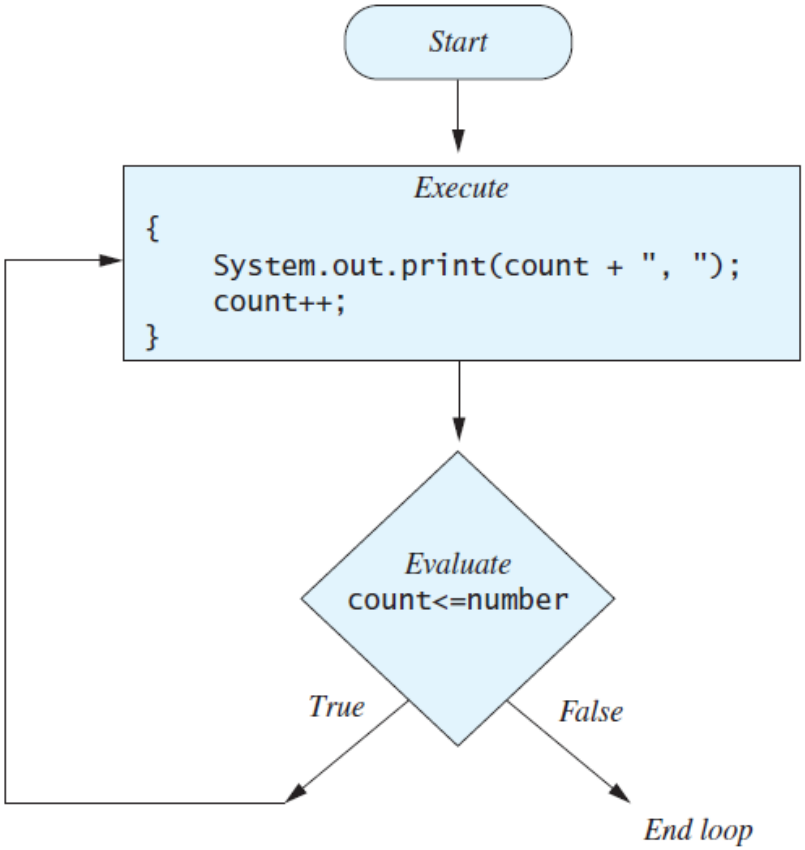
```
do
   Body_Statement
while (Boolean_Expression);
```

- Don't forget the semicolon!
- Test is at the end (in source and execution)

The `do-while` Statement

- Figure 4.3 The Action of the `do-while` Loop in Listing 4.2

```
do
{
   System.out.print(count + ", ");
   count++;
} while (count <= number);
```



The `do-while` Statement

- First, the loop body is executed.
- Then the boolean expression is checked.
  - As long as it is true, the loop is executed again.
  - If it is false, the loop is exited.
- Equivalent `while` statement

```
Statement(s)_S1
while (Boolean_Condition)
    Statement(s)_S1
```

Programming Example: Bug Infestation

- Given
  - Volume a roach: 0.002 cubic feet
  - Starting roach population
  - Rate of increase: 95%/week
  - Volume of a house
- Find
  - Number of weeks to exceed the capacity of the house
  - Number and volume of roaches

Programming Example: Bug Infestation

Variables Needed

`GROWTH_RATE` —weekly growth rate of the roach population (a constant 0.95)

`ONE_BUG_VOLUME` —volume of an average roach (a constant 0.002)

`houseVolume` — volume of the house

`startPopulation` —initial number of roaches

ctd. …

Programming Example: Bug Infestation

Variables Needed

`countWeeks` —week counter

`Population` —current number of roaches

`totalBugVolume` —total volume of all the roaches

`newBugs` —number of roaches hatched this week

`newBugVolume` —volume of new roaches

Infinite Loops

- A loop which repeats without ever ending is called an *infinite loop.*
- If the controlling boolean expression never becomes false, a **`while`** loop or a **`do-while`** loop will repeat without ending.
- A negative growth rate in the preceding problem causes **`totalBugVolume`** always to be less than **`houseVolume`**, so that the loop never ends.

Nested Loops – Exam Averagers, multiple Exams

```
Want to average another exam?
Enter yes or no.
yes

Enter all the scores to be averaged.
Enter a negative number after
you have entered all the scores.
90
70
80
-1
The average is 80.0
Want to average another exam?
Enter yes or no.
no
```

Sample screen output

Nested Loops

- The body of a loop can contain any kind of statements, including another loop.
- In the previous example
  - The average score was computed using a **`while`** loop.
  - This **`while`** loop was placed inside a **`do-while`** loop so the process could be repeated for other sets of exam scores.

The `for` Statement

- A `for` statement executes the body of a loop a fixed number of times.
- Example

```
for (count = 1; count < 3; count++)
    System.out.println(count);
```

The `for` Statement

- Syntax

```
for (Initialization, Condition, Update)
   Body_Statement
```

- `Body_Statement` can be either a simple statement or a compound statement in `{}`.
- Corresponding `while` statement

```
Initialization
while (Condition)
   Body_Statement_Including_Update
```

The `for` Statement – Countdown to Liftoff

- View sample program, Listing 4.4

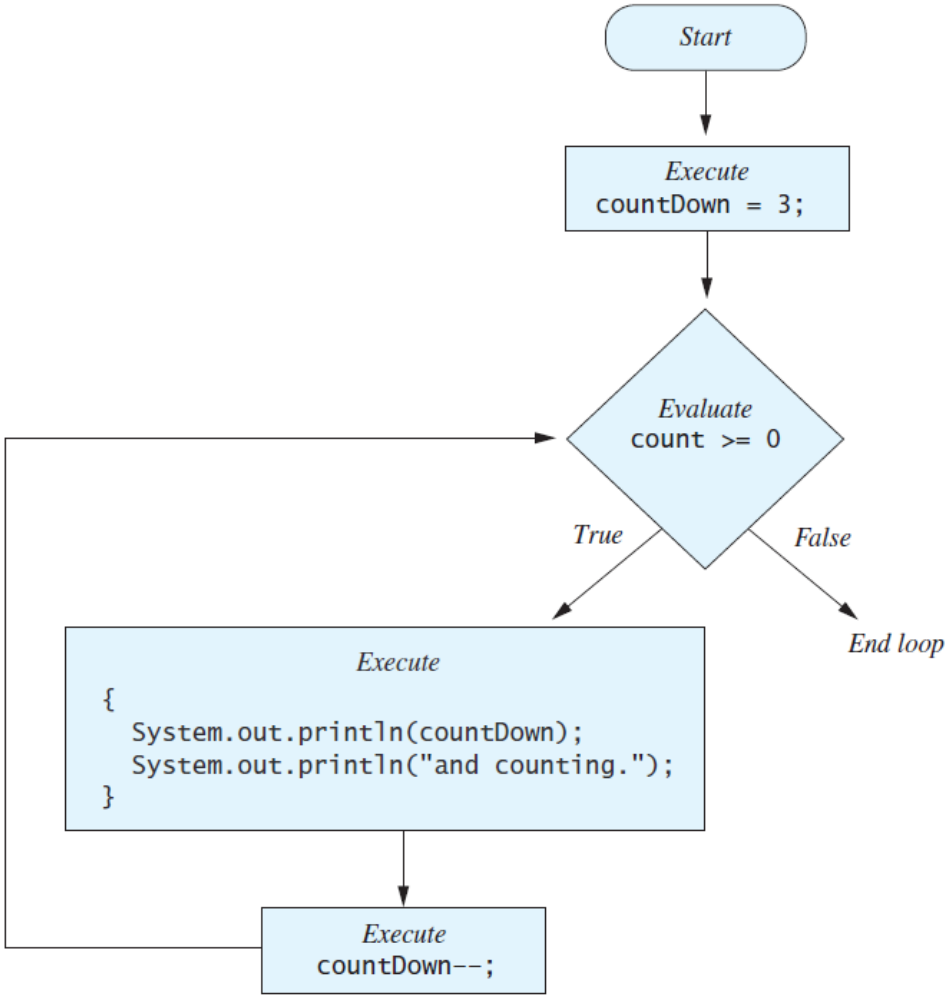
  `class ForDemo`

```
3
and counting.
2
and counting.
1
and counting.
0
and counting.
Blast off!
```

Sample screen output

The `for` Statement

- Figure 4.5 The action of the `for` loop in listing 4.5

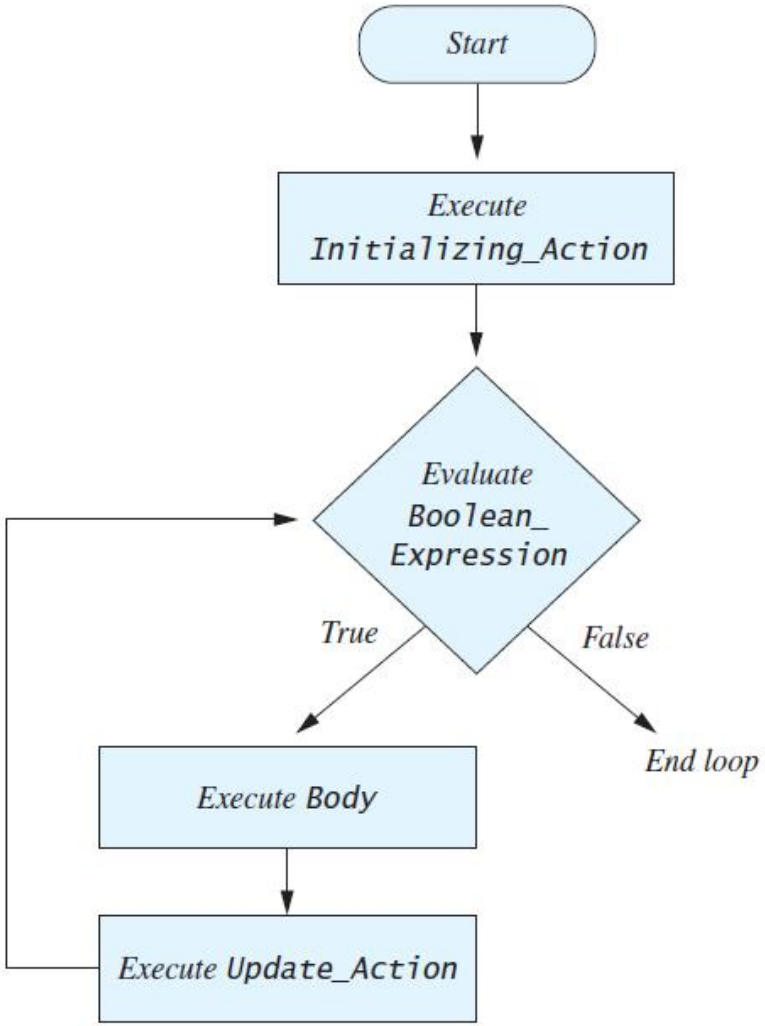



```
for (countDown = 3; countDown >= 0; countDown--)
{
    System.out.println(countDown);
    System.out.println("and counting.");
}
```

The `for` Statement

- Figure 4.6 The semantics of the `for` statement

```
for (Initializing_Action; Boolean_Expression; Update_Action)
    Body
```



The `for` Statement

- Possible to declare variables within a `for` statement

```
int sum = 0;
for (int n = 1 ; n <= 10 ; n++)
    sum = sum + n * n;
```

- Note that variable `n` is local to the loop

The `for` Statement

- A comma separates multiple initializations
- Example

```
for (n = 1, product = 1; n <= 10; n++)
    product = product * n;
```

- Only one boolean expression is allowed, but it can consist of `&&`s, `||`s, and `!`s.
- Multiple update actions are allowed, too.

```
for (n = 1, product = 1; n <= 10;
        product = product * n, n++);
```

The `for-each` Statement

- Possible to step through values of an enumeration type
- Example

```
enum Suit {CLUBS, DIAMONDS, HEARTS, SPADES}
for (Suit nextSuit : Suit.values())
System.out.print(nextSuit + " ");
System.out.println();
```

Programming with Loops: Outline

- The Loop Body
- Initializing Statements
- Controlling Loop Iterations
- `break` and `continue` statements
- Loop Bugs
- Tracing Variables
- Assertion checks

The Loop Body

- To design the loop body, write out the actions the code must accomplish.
- Then look for a repeated pattern.
  - The pattern need not start with the first action.
  - The repeated pattern will form the body of the loop.
  - Some actions may need to be done after the pattern stops repeating.

Initializing Statements

- Some variables need to have a value before the loop begins.
  - Sometimes this is determined by what is supposed to happen after one loop iteration.
  - Often variables have an initial value of zero or one, but not always.
- Other variables get values only while the loop is iterating.

Controlling Number of Loop Iterations

- If the number of iterations is known before the loop starts, the loop is called a *count-controlled loop.*
  - Use a `for` loop.
- Asking the user before each iteration if it is time to end the loop is called the *ask-before-iterating technique.*
  - Appropriate for a small number of iterations
  - Use a `while` loop or a `do-while` loop.

Controlling Number of Loop Iterations

- For large input lists, a *sentinel value* can be used to signal the end of the list.
  - The sentinel value must be different from all the other possible inputs.
  - A negative number following a long list of nonnegative exam scores could be suitable.

```
90
0
10
-1
```

Controlling Number of Loop Iterations

- Example - reading a list of scores followed by a sentinel value

```
int next = keyboard.nextInt();
while (next  >= 0)
{
  Process_The_Score
  next = keyboard.nextInt();
}
```

Controlling Number of Loop Iterations

- Using a boolean variable to end the loop
- View sample program, listing 4.6

```
class BooleanDemo
```

```
Enter nonnegative numbers.
Place a negative number at the end
to serve as an end marker.
1 2 3 -1
The sum of the numbers is 6
```

Sample screen output

Programming Example

- Spending Spree
  - You have $100 to spend in a store
  - Maximum 3 items
  - Computer tracks spending and item count
  - When item chosen, computer tells you whether or not you can buy it
- Client wants adaptable program
  - Able to change amount and maximum number of items
- View sample algorithm

Programming Example

- View sample program, listing 4.7

class SpendingSpree

```
You may buy up to 3 items
costing no more than $100.
Enter cost of item #1: $80
You may buy this item.
You spent $80 so far.
You may buy up to 2 items
costing no more than $20.
Enter cost of item #2: $20
You may buy this item.
You spent $100 so far.
You are out of money.
You spent $100, and are done shopping.
```

Sample screen output

The `break` Statement in Loops

- A `break` statement can be used to end a loop immediately.
- The `break` statement ends only the **innermost** loop or switch statement that contains the `break` statement.
- `break` statements make loops more difficult to understand.
- Use `break` statements sparingly (if ever).

The **break** Statement in Loops

- Note program fragment, ending a loop with a **break** statement, listing 4.8

```
while (itemNumber <= MAX_ITEMS)
{
    . . .
    if (itemCost <= leftToSpend)
    {
        . . .
        if (leftToSpend > 0)
            itemNumber++;
        else
        {
            System.out.println("You are out of money.");
            break;
        }
    }
    else
        . . .
}

System.out.println( . . . );
```

The `continue` Statement in Loops

- A `continue` statement
  - Ends current loop iteration
  - Begins the next one
- Text recommends avoiding use
  - Introduce unneeded complications

Tracing Variables

- *Tracing variables* means watching the variables change while the program is running.
  - Simply insert temporary output statements in your program to print of the values of variables of interest
  - Or, learn to use the debugging facility that may be provided by your system.

Assertion Checks

- Assertion : something that says something about the state of the program
  - Can be true or false
  - Should be true when no mistakes in running program

Assertion Checks

- Example found in comments

```
//n == 1
 while (n < limit)
 {
 n = 2 * n;
 }
//n >= limit
//n is the smallest power of 2 >= limit
```

- Syntax for assertion check

```
Assert Boolean_Expression;
```

Assertion Checks

- Equivalent example using **assert**

```
assert n == 1;
while (n < limit)
{
n = 2 * n;
}
assert n >= limit;
//n is the smallest power of 2 >= limit.
```

Loop Bugs

- Common loop bugs
  - Unintended infinite loops
  - Off-by-one errors
  - Testing equality of floating-point numbers
- Subtle infinite loops
  - The loop may terminate for some input values, but not for others.
  - For example, you can't get out of debt when the monthly penalty exceeds the monthly payment.

Summary

- A loop is a programming construct that repeats an action
- Java has the **`while`**, the **`do-while`**, and the **`for`** statements
- The **`while`** and **`do-while`** repeat the loop while a condition is true
- The logic of a **`for`** statement is identical to the while

Summary

- Loops may be ended using a sentinel value or a boolean value
- Typical loop bugs include infinite loops or loops which are off by 1 iteration
- Variables may be traced by including temporary output statements or a debugging utility
- The `assert` statement can be used to check conditions at run time