Chapter 5
Control Statements: Part 2; Logical Operators

Java How to Program, 11/e

Questions? E-mail paul.deitel@deitel.com

OBJECTIVES

In this chapter you'll:

- Learn the essentials of counter-controlled iteration.
- Use the `for` and `do…while` iteration statements to execute statements in a program repeatedly.
- Understand multiple selection using the `switch` selection statement.

OBJECTIVES (cont.)

- Implement an object-oriented `AutoPolicy` case study using `Strings` in `switch` statements.
- Alter the flow of control with the `break` and `continue` program-control statements.
- Use the logical operators to form complex conditional expressions in control statements.

OUTLINE

OUTLINE (cont.)

5.5 `do…while` Iteration Statement

5.6 `switch` Multiple-Selection Statement

5.7 Class `AutoPolicy` Case Study: `String`s in `switch` Statements

5.8 `break` and `continue` Statements

5.8.1 `break` Statement

5.8.2 `continue` Statement

OUTLINE (cont.)

5.9 Logical Operators

5.9.1 Conditional AND (&&) Operator
5.9.2 Conditional OR (||) Operator
5.9.3 Short-Circuit Evaluation of Complex Conditions
5.9.4 Boolean Logical AND (&) and Boolean Logical Inclusive OR (|) Operators
5.9.5 Boolean Logical Exclusive OR (^)
5.9.6 Logical Negation (!) Operator
5.9.7 Logical Operators Example

OUTLINE (cont.)

5.1 Introduction

- `for` iteration statement
- `do…while` iteration statement
- `switch` multiple-selection statement
- `break` statement
- `continue` statement
- Logical operators
- Control statements summary.

5.2 Essentials of Counter-Controlled Iteration

- Counter-controlled iteration requires
  - a **control variable** (or loop counter)
  - the **initial value** of the control variable
  - the **increment** by which the control variable is modified each time through the loop (also known as **each iteration of the loop**)
  - the **loop-continuation condition** that determines if looping should continue.

```java
// Fig. 5.1: WhileCounter.java
// Counter-controlled iteration with the while iteration statement.

public class WhileCounter {
   public static void main(String[] args) {
      int counter = 1; // declare and initialize control variable

      while (counter <= 10) { // loop-continuation condition
         System.out.printf("%d  ", counter);
         ++counter; // increment control variable
      }

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

```
1  2  3  4  5  6  7  8  9  10
```

Fig. 5.1 | Counter-controlled iteration with the `while` iteration statement.

5.2 Essentials of Counter-Controlled Iteration (Cont.)

- In Fig. 5.1, the elements of counter-controlled iteration are defined in lines 6, 8 and 10.
- Line 6 *declares* the control variable (`counter`) as an `int`, *reserves space* for it in memory and sets its *initial value* to `1`.
- The loop-continuation condition in the `while` (line 8) tests whether the value of the control variable is less than or equal to `10` (the final value for which the condition is `true`).
- Line 10 *increments* the control variable by 1 for each iteration of the loop.

Common Programming Error 5.1

Because floating-point values may be approximate, controlling loops with floating-point variables may result in imprecise counter values and inaccurate termination tests.

Error-Prevention Tip 5.1

Use integers to control counting loops.

5.3 for Iteration Statement

- **`for` iteration statement**
  - Specifies the counter-controlled-iteration details in a single line of code.
  - Figure 5.2 reimplements the application of Fig. 5.1 using `for`.

```java
// Fig. 5.2: ForCounter.java
// Counter-controlled iteration with the for iteration statement.

public class ForCounter {
   public static void main(String[] args) {
      // for statement header includes initialization,
      // loop-continuation condition and increment
      for (int counter = 1; counter <= 10; counter++) {
         System.out.printf("%d  ", counter);
      }

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

```
1  2  3  4  5  6  7  8  9  10
```

Fig. 5.2 | Counter-controlled iteration with the `for` iteration statement.

5.3 `for` Iteration Statement (Cont.)

- When the `for` statement begins executing, the control variable is *declared* and *initialized*.
- Next, the program checks the loop-continuation condition, which is between the two required semicolons.
- If the condition initially is true, the body statement executes.
- After executing the loop's body, the program increments the control variable in the increment expression, which appears to the right of the second semicolon.
- Then the loop-continuation test is performed again to determine whether the program should continue with the next iteration of the loop.
- A common *logic error* with counter-controlled iteration is an **off-by-one error.**

Common Programming Error 5.2

Using an incorrect relational operator or an incorrect final value of a loop counter in the loop-continuation condition of an iteration statement can cause an off-by-one error.

Error-Prevention Tip 5.2

Using the final value and operator `<=` in a loop's condition helps avoid off-by-one errors. For a loop that outputs 1 to 10, the loop-continuation condition should be `counter <= 10` rather than `counter < 10` (which causes an off-by-one error) or `counter < 11` (which is correct). Many programmers prefer so-called zero-based counting, in which to count 10 times, `counter` would be initialized to zero and the loop-continuation test would be `counter < 10`.

Error-Prevention Tip 5.3

As Chapter 4 mentioned, integers can overflow, causing logic errors. A loop's control variable also could overflow. Write your loop conditions carefully to prevent this.

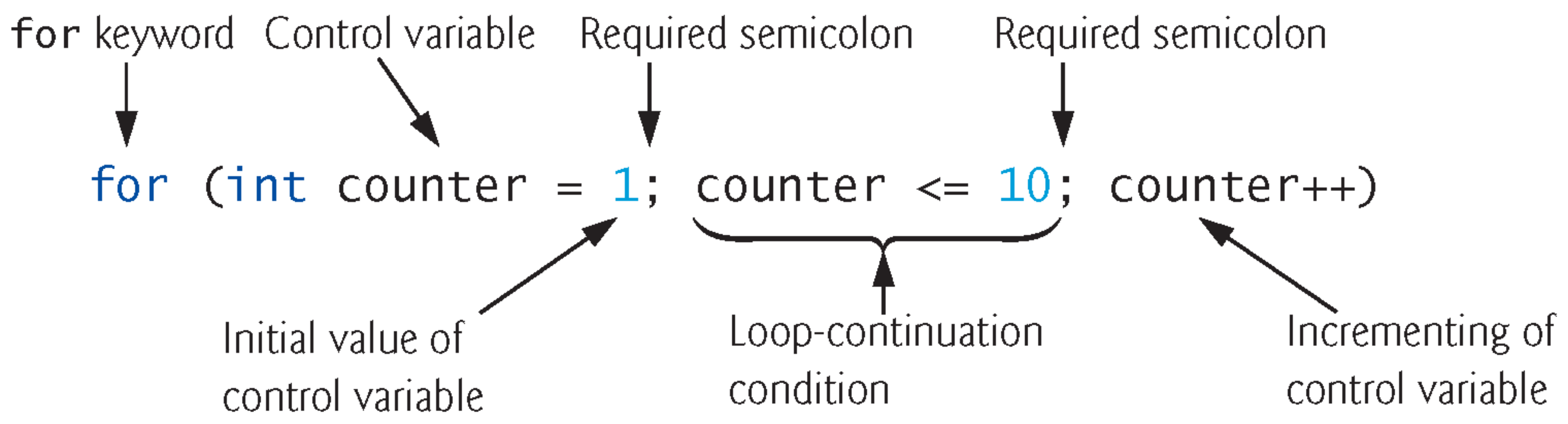


Fig. 5.3 | `for` statement header components.

5.3 `for` Iteration Statement (Cont.)

- The general format of the `for` statement is

```
for (initialization; loopContinuationCondition; increment) {
    statement
}
```

  - the *initialization* expression names the loop's control variable and optionally provides its initial value
  - *loopContinuationCondition* determines whether the loop should continue executing
  - *increment* modifies the control variable's value, so that the loop-continuation condition eventually becomes false.
- The two semicolons in the `for` header are required.

5.3 for Iteration Statement (Cont.)

- The `for` statement often can be represented with an equivalent `while` statement as follows:

```
initialization;
while (loopContinuationCondition) {
   statement
   increment;
}
```

- Typically, `for` statements are used for counter-controlled iteration and `while` statements for sentinel-controlled iteration.
- If the *initialization* expression in the `for` header declares the control variable, the control variable can be used only in that `for` statement.

5.3 for Iteration Statement (Cont.)

- A variable's **scope** defines where it can be used in a program.
  - A *local variable* can be used *only* in the method that declares it and *only* from the point of declaration through the end of the method.

Common Programming Error 5.3

When a `for` statement's control variable is declared in the initialization section of the `for`'s header, using the control variable after the `for`'s body is a compilation error.

5.3 `for` Iteration Statement (Cont.)

- All three expressions in a `for` header are optional.
  - If the *loopContinuationCondition* is omitted, the condition is always true, thus creating an infinite loop.
  - You might omit the *initialization* expression if the program initializes the control variable before the loop.
  - You might omit the *increment* if the program calculates it with statements in the loop's body or if no increment is needed.
- The increment expression in a `for` acts as if it were a standalone statement at the end of the `for`'s body, so

```
counter = counter + 1
counter += 1
++counter
counter++
```

are equivalent increment expressions in a `for` statement.

Common Programming Error 5.4

Placing a semicolon immediately to the right of the right parenthesis of a `for` header makes that `for`'s body an empty statement. This is normally a logic error.

Error-Prevention Tip 5.4

Infinite loops occur when the loop-continuation condition in an iteration statement never becomes `false`. To prevent this situation in a counter-controlled loop, ensure that the control variable is modified during each iteration of the loop so that the loop-continuation condition will eventually become `false`. In a sentinel-controlled loop, ensure that the sentinel value is able to be input.

5.3 for Iteration Statement (Cont.)

- The initialization, loop-continuation condition and increment can contain arithmetic expressions.
- For example, assume that `x = 2` and `y = 10`. If `x` and `y` are not modified in the body of the loop, the statement

```
for (int j = x; j <= 4 * x * y; j += y / x)
```

- is equivalent to the statement

```
for (int j = 2; j <= 80; j += 5)
```

- The increment of a `for` statement may be *negative*, in which case it’s a decrement, and the loop counts *downward*.

Error-Prevention Tip 5.5

Although the value of the control variable can be changed in the body of a `for` loop, avoid doing so, because this practice can lead to subtle errors.

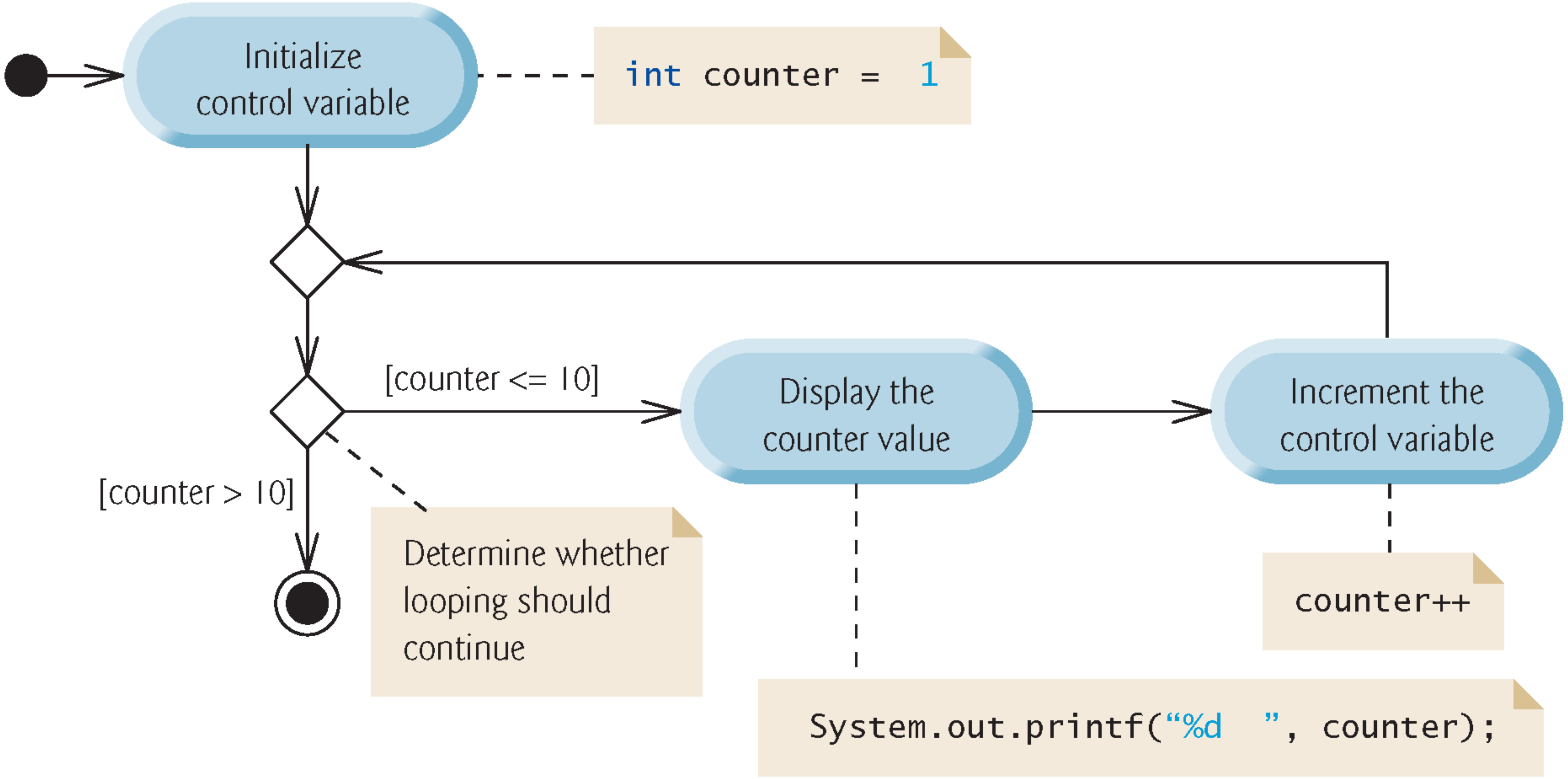


Fig. 5.4 | UML activity diagram for the `for` statement in Fig. 5.2.

5.4 Examples Using the for Statement

- a)Vary the control variable from 1 to 100 in increments of 1.

```
for (int i = 1; i <= 100; i++)
```

- b)Vary the control variable from 100 to 1 in decrements of 1.

```
for (int i = 100; i >= 1; i--)
```

- c)Vary the control variable from 7 to 77 in increments of 7.

```
for (int i = 7; i <= 77; i += 7)
```

5.4 Examples Using the for Statement (Cont.)

- d)Vary the control variable from `20` to `2` in decrements of `2`.

```
for (int i = 20; i >= 2; i -= 2)
```

- e)Vary the control variable over the values `2`, `5`, `8`, `11`, `14`, `17`, `20`.

```
for (int i = 2; i <= 20; i += 3)
```

- f)Vary the control variable over the values `99`, `88`, `77`, `66`, `55`, `44`, `33`, `22`, `11`, `0`.

```
for (int i = 99; i >= 0; i -= 11)
```

Common Programming Error 5.5

Using an incorrect relational operator in the loop-continuation condition of a loop that counts downward (e.g., using `i <= 1` instead of `i >= 1` in a loop counting down to 1) is usually a logic error.

Common Programming Error 5.6

Do not use equality operators (`!=` or `==`) in a loop-continuation condition if the loop's control variable increments or decrements by more than 1. For example, consider the `for` statement header:

```
for (int counter = 1; counter != 10; counter += 2)
```

The loop-continuation test `counter != 10` never becomes `false` (resulting in an infinite loop) because `counter` increments by 2 after each iteration.

Error-Prevention Tip 5.6

Counting loops are error prone. In subsequent chapters, we'll introduce lambdas and streams—technologies that you can use to eliminate such errors.

```java
// Fig. 5.5: Sum.java
// Summing integers with the for statement.

public class Sum {
   public static void main(String[] args) {
      int total = 0;

      // total even integers from 2 through 20
      for (int number = 2; number <= 20; number += 2) {
         total += number;
      }

      System.out.printf("Sum is %d%n", total);
   }
}
```

```
Sum is 110
```

Fig. 5.5 | Summing integers with the for statement.

5.4 Examples Using the for Statement (Cont.)

- The *initialization* and *increment* expressions can be comma-separated lists that enable you to use multiple initialization expressions or multiple increment expressions.
- *Although this is discouraged,* the body of the `for` statement of Fig. 5.5 could be merged into the increment portion of the `for` header by using a comma as follows:

```
for (int number = 2; number <= 20; total += number, number += 2) {
    ; // empty statement
}
```

Good Programming Practice 5.1

For readability limit the size of control-statement headers to a single line if possible.

5.4 Examples Using the for Statement (Cont.)

- Compound interest application
- *A person invests $1,000 in a savings account yielding 5% interest. Assuming that all the interest is left on deposit, calculate and print the amount of money in the account at the end of each year for 10 years. Use the following formula to determine the amounts:*

  $a = p\,(1 + r)^n$

  where

  p is the original amount invested (i.e., the principal)
  r is the annual interest rate (e.g., use 0.05 for 5%)
  n is the number of years
  a is the amount on deposit at the end of the nth year.

5.4 Examples Using the for Statement (Cont.)

- The solution to this problem (Fig. 5.6) involves a loop that performs the indicated calculation for each of the 10 years the money remains on deposit.
- Java treats floating-point constants like `1000.0` and `0.05` as type `double`.
- Java treats whole-number constants like `7` and `-22` as type `int`.

```java
// Fig. 5.6: Interest.java
// Compound-interest calculations with for.

public class Interest {
   public static void main(String[] args) {
      double principal = 1000.0; // initial amount before interest
      double rate = 0.05; // interest rate

      // display headers
      System.out.printf("%s%20s%n", "Year", "Amount on deposit");

      // calculate amount on deposit for each of ten years
      for (int year = 1; year <= 10; ++year) {
         // calculate new amount on deposit for specified year
         double amount = principal * Math.pow(1.0 + rate, year);

         // display the year and the amount
         System.out.printf("%4d%,20.2f%n", year, amount);
      }
   }
}
```

Fig. 5.6 | Compound-interest calculations with `for`. (Part 1 of 2.)

```
Year   Amount on deposit
   1            1,050.00
   2            1,102.50
   3            1,157.63
   4            1,215.51
   5            1,276.28
   6            1,340.10
   7            1,407.10
   8            1,477.46
   9            1,551.33
  10            1,628.89
```

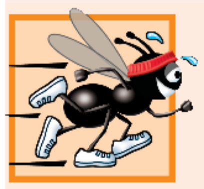
Fig. 5.6 | Compound-interest calculations with `for`. (Part 2 of 2.)

5.4 Examples Using the for Statement (Cont.)

- In the format specifier `%20s`, the integer `20` between the `%` and the conversion character `s` indicates that the value output should be displayed with a **field width** of 20—that is, `printf` displays the value with at least 20 character positions.
- If the value to be output is less than 20 character positions wide, the value is **right justified** in the field by default.
- If the `year` value to be output were more thanhas more characters than the field width, the field width would be extended to the right to accommodate the entire value.
- To indicate that values should be output **left justified**, precede the field width with the **minus sign (–) formatting flag** (e.g., `%-20s`).

5.4 Examples Using the for Statement (Cont.)

- Classes provide methods that perform common tasks on objects.
- Most methods must be called on a specific object.
- Someclasses also provide methods that perform common tasks and do *not* require you to first create objects of those classes. These are called `static` methods.
- Java does not include an exponentiation operator—`Math` class `static` method `pow` can be used for raising a value to a power.
- You can call a `static` method by specifying the class name followed by a dot (`.`) and the method name, as in
  - *ClassName*`.`*methodName*`(`*arguments*`)`
- `Math.pow(`*x*`,` *y*`)` calculates the value of x raised to the y^{th} power. The method receives two `double` arguments and returns a `double` value.



Performance Tip 5.1

In loops, avoid calculations for which the result never changes—such calculations should typically be placed before the loop. Many of today's sophisticated optimizing compilers will place such calculations outside loops in the compiled code.

5.4 Examples Using the for Statement (Cont.)

- In the format specifier `%,20.2f`, the **comma (,) formatting flag** indicates that the floating-point value should be output with a **grouping separator.**
- Separator is specific to the user's locale (i.e., country).
- In the United States, the number will be output using commas to separate every three digits and a decimal point to separate the fractional part of the number, as in 1,234.45.
- The number `20` in the format specification indicates that the value should be output right justified in a field width of 20 characters.
- The `.2` specifies the formatted number's precision—in this case, the number is rounded to the nearest hundredth and output with two digits to the right of the decimal point.

Error-Prevention Tip 5.7

Do not use variables of type `double` (or `float`) to perform precise monetary calculations. The imprecision of floating-point numbers can lead to errors. In the exercises, you'll learn how to use integers to perform precise monetary calculations—Java also provides class `java.math.BigDecimal` for this purpose, which we demonstrate in Fig. 8.16.

Error-Prevention Tip 5.8

In a global economy, dealing with currencies, monetary amounts, conversions, rounding and formatting is complex. The new JavaMoney API (`http://javamoney.github.io`) was developed to meet these challenges. At the time of this writing, it was not yet incorporated into the JDK. Chapter 8 suggests a JavaMoney project exercise.

5.5 do…while Iteration Statement

- The `do…while` **iteration statement** is similar to the `while` statement.
- In the `while`, the program tests the loop-continuation condition at the *beginning* of the loop, *before* executing the loop's body; if the condition is *false*, the body *never* executes.
- The `do…while` statement tests the loop-continuation condition *after* executing the loop's body; therefore, *the body always executes at least once*.
- When a `do…while` statement terminates, execution continues with the next statement in sequence.

```java
// Fig. 5.7: DoWhileTest.java
// do...while iteration statement.

public class DoWhileTest {
   public static void main(String[] args) {
      int counter = 1;

      do {
         System.out.printf("%d  ", counter);
         ++counter;
      } while (counter <= 10);

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

```
1  2  3  4  5  6  7  8  9  10
```

Fig. 5.7 | do...while iteration statement.

5.5 do…while Iteration Statement (Cont.)

- Figure 5.8 contains the UML activity diagram for the `do…while` statement.
- The diagram makes it clear that the loop-continuation condition is not evaluated until *after* the loop performs the action state *at least once*.

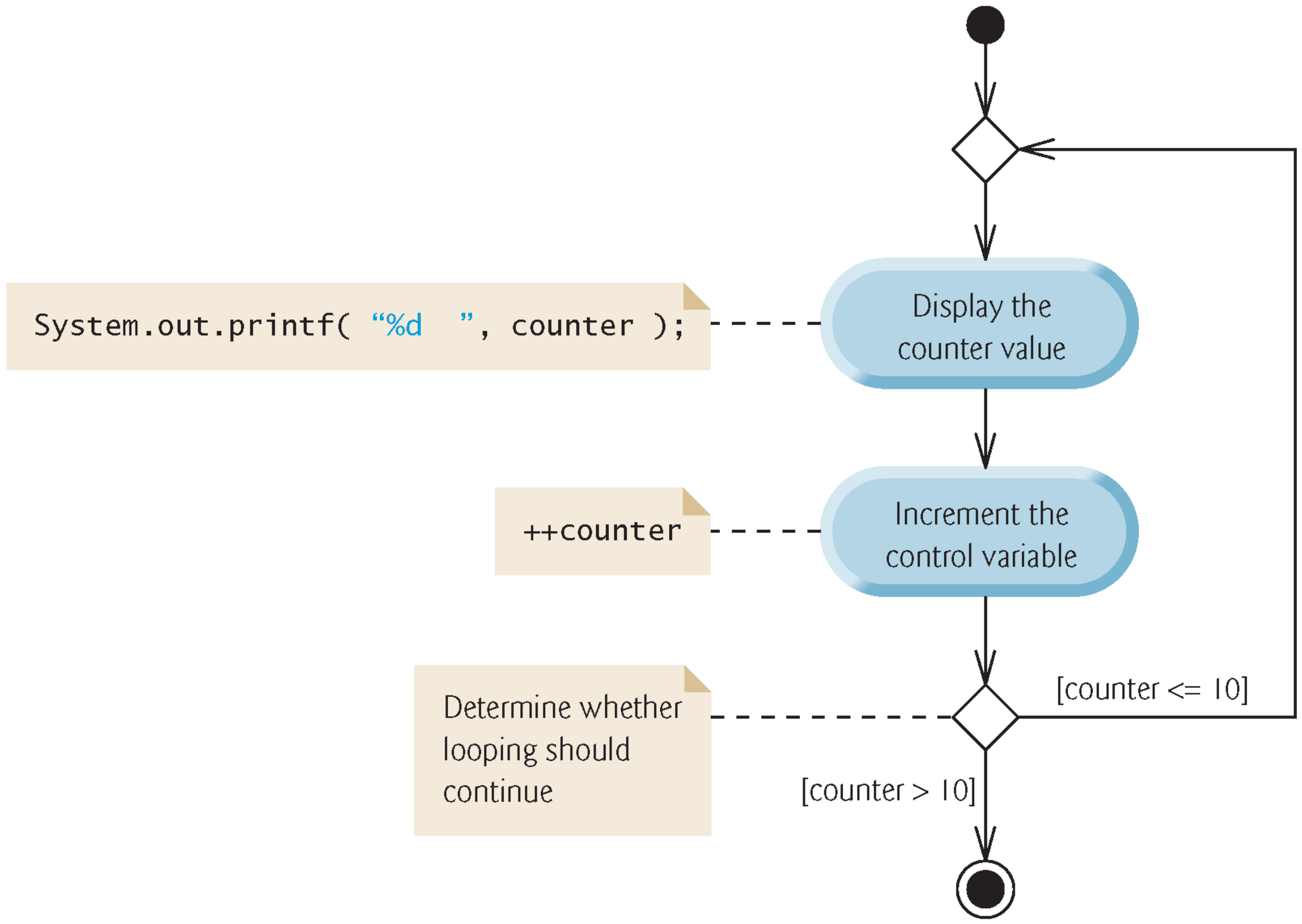


Fig. 5.8 | `do...while` iteration statement UML activity diagram.

5.6 `switch` Multiple-Selection Statement

- `switch` **multiple-selection statement** performs different actions based on the possible values of a **constant integral expression** of type `byte`, `short`, `int` or `char`.

5.6 `switch` Multiple-Selection Statement (Cont.)

- The **end-of-file indicator** is a system-dependent keystroke combination which the user enters to indicate that there is *no more data to input*.
- On UNIX/Linux/Mac OS X systems, end-of-file is entered by typing the sequence
  - *<Ctrl> d*
- on a line by itself. This notation means to simultaneously press both the *Ctrl* key and the *d* key.
- On Windows systems, end-of-file can be entered by typing
  - *<Ctrl> z*
- On some systems, you must press *Enter* after typing the end-of-file key sequence.
- Windows typically displays the characters `^Z` on the screen when the end-of-file indicator is typed.

```java
// Fig. 5.9: LetterGrades.java
// LetterGrades class uses the switch statement to count letter grades.
import java.util.Scanner;

public class LetterGrades {
   public static void main(String[] args) {
      int total = 0; // sum of grades
      int gradeCounter = 0; // number of grades entered
      int aCount = 0; // count of A grades
      int bCount = 0; // count of B grades
      int cCount = 0; // count of C grades
      int dCount = 0; // count of D grades
      int fCount = 0; // count of F grades

      Scanner input = new Scanner(System.in);

```

Fig. 5.9 | `LetterGrades` class uses the `switch` statement to count letter grades. (Part 1 of 6.)

```java
      System.out.printf("%s%n%s%n   %s%n   %s%n",
         "Enter the integer grades in the range 0-100.",
         "Type the end-of-file indicator to terminate input:",
         "On UNIX/Linux/macOS type <Ctrl> d then press Enter",
         "On Windows type <Ctrl> z then press Enter");

      // loop until user enters the end-of-file indicator
      while (input.hasNext()) {
         int grade = input.nextInt(); // read grade
         total += grade; // add grade to total
         ++gradeCounter; // increment number of grades

```

Fig. 5.9 | `LetterGrades` class uses the `switch` statement to count letter grades. (Part 2 of 6.)

```
         //  increment appropriate letter-grade counter
         switch (grade / 10) {
            case 9:  // grade was between 90
            case 10: // and 100, inclusive
               ++aCount;
               break; // exits switch
            case 8: // grade was between 80 and 89
               ++bCount;
               break; // exits switch
            case 7: // grade was between 70 and 79
               ++cCount;
               break; // exits switch
            case 6: // grade was between 60 and 69
               ++dCount;
               break; // exits switch
            default: // grade was less than 60
               ++fCount;
               break; // optional; exits switch anyway
         }
      }
```

Fig. 5.9 | `LetterGrades` class uses the `switch` statement to count letter grades. (Part 3 of 6.)

```java

      // display grade report
      System.out.printf("%nGrade Report:%n");

      // if user entered at least one grade...
      if (gradeCounter != 0) {
         // calculate average of all grades entered
         double average = (double) total / gradeCounter;

         // output summary of results
         System.out.printf("Total of the %d grades entered is %d%n",
            gradeCounter, total);
         System.out.printf("Class average is %.2f%n", average);
         System.out.printf("%n%s%n%s%d%n%s%d%n%s%d%n%s%d%n%s%d%n",
            "Number of students who received each grade:",
            "A: ", aCount,   // display number of A grades
            "B: ", bCount,   // display number of B grades
            "C: ", cCount,   // display number of C grades
            "D: ", dCount,   // display number of D grades
            "F: ", fCount); // display number of F grades
      }
```

Fig. 5.9 | `LetterGrades` class uses the `switch` statement to count letter grades. (Part 4 of 6.)

```java
      else { // no grades were entered, so output appropriate message
         System.out.println("No grades were entered");
      }
   }
}
```

```
Enter the integer grades in the range 0-100.
Type the end-of-file indicator to terminate input:
   On UNIX/Linux/macOS type <Ctrl> d then press Enter
   On Windows type <Ctrl> z then press Enter
99
92
45
57
63
71
76
85
90
100
^Z
```

Fig. 5.9 | `LetterGrades` class uses the `switch` statement to count letter grades. (Part 5 of 6.)

```
Grade Report:
Total of the 10 grades entered is 778
Class average is 77.80

Number of students who received each grade:
A: 4
B: 1
C: 2
D: 1
F: 2
```

Fig. 5.9 | `LetterGrades` class uses the `switch` statement to count letter grades. (Part 6 of 6.)

Portability Tip 5.1

The keystroke combinations for entering end-of-file are system dependent.

5.6 `switch` Multiple-Selection Statement (Cont.)

- `Scanner` method `hasNext` determine whether there is more data to input. This method returns the `boolean` value `true` if there is more data; otherwise, it returns `false`.
- As long as the end-of-file indicator has not been typed, method `hasNext` will return `true`.

5.6 `switch` Multiple-Selection Statement (Cont.)

- The `switch` statement consists of a block that contains a sequence of **`case` labels** and an optional **`default` case**.
- The program evaluates the **controlling expression** in the parentheses following keyword `switch`.
- The program compares the controlling expression's value (which must evaluate to an integral value of type `byte`, `char`, `short` or `int`, or to a `String`) with each `case` label.
- If a match occurs, the program executes that `case`'s statements.
- The **`break` statement** causes program control to proceed with the first statement after the `switch`.

5.6 `switch` Multiple-Selection Statement (Cont.)

- `switch` does *not* provide a mechanism for testing ranges of values—every value must be listed in a separate `case` label.
- Note that each `case` can have multiple statements.
- `switch` differs from other control statements in that it does not require braces around multiple statements in a `case`.
- Without `break`, the statements for a matching case and subsequent cases execute until a `break` or the end of the `switch` is encountered. This is called "falling through."
- If no match occurs between the controlling expression's value and a `case` label, the `default` case executes.
- If no match occurs and there is no `default` case, program control simply continues with the first statement after the `switch`.

Common Programming Error 5.7

Forgetting a `break` statement when one is needed in a `switch` is a logic error.

Error-Prevention Tip 5.9

In a `switch` statement, ensure that you test all possible values of the controlling expression.

5.6 switch Multiple-Selection Statement (Cont.)

- Figure 5.10 shows the UML activity diagram for the general `switch` statement.
- Most `switch` statements use a `break` in each `case` to terminate the `switch` statement after processing the `case`.
- The `break` statement is not required for the `switch`'s last `case` (or the optional `default` case, when it appears last), because execution continues with the next statement after the `switch`.

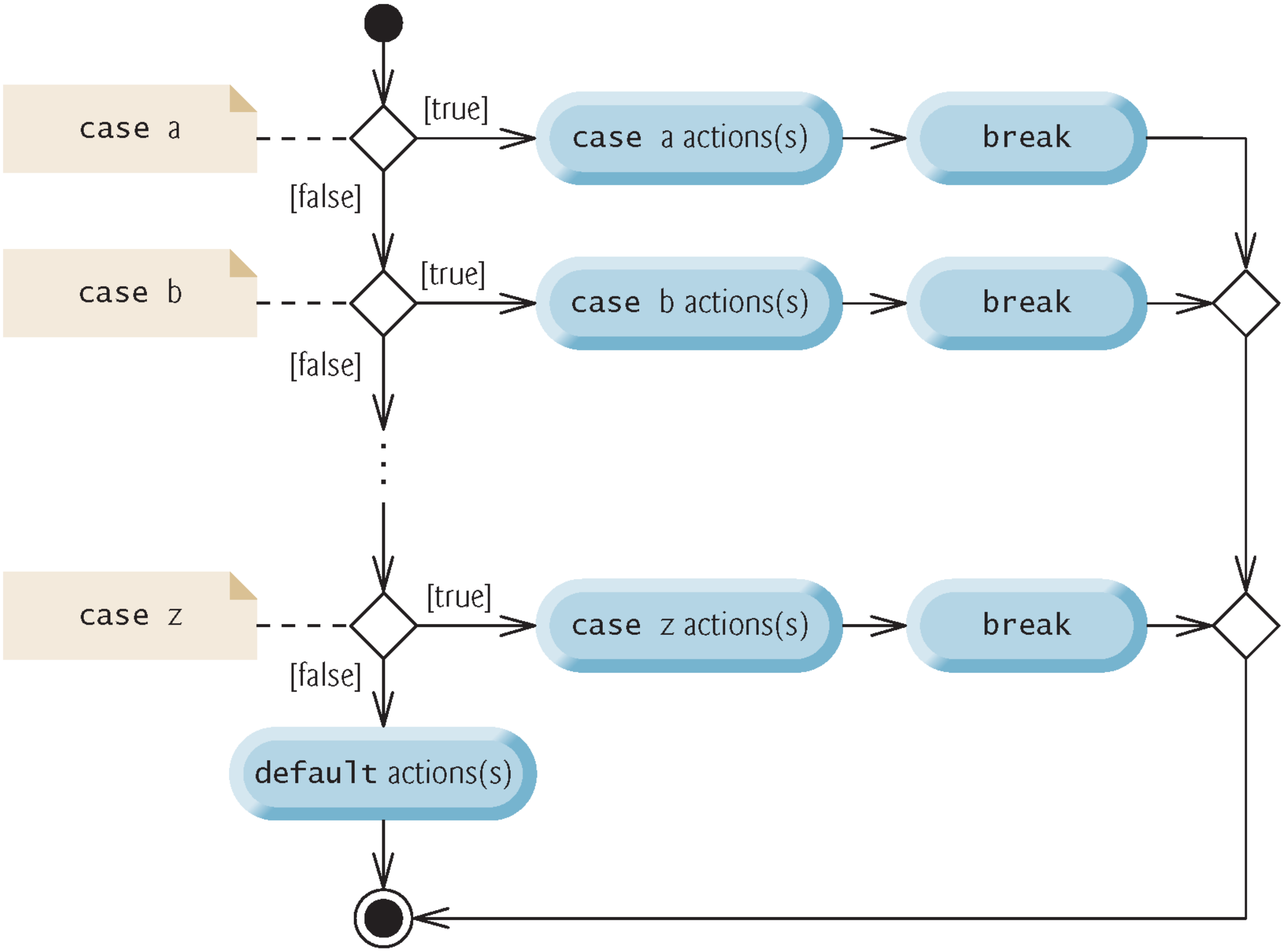


Fig. 5.10 | `switch` multiple-selection statement UML activity diagram with `break` statements.

Error-Prevention Tip 5.10

Provide a `default` case in `switch` statements. This focuses you on the need to process exceptional conditions.

Good Programming Practice 5.2

Although each `case` and the `default` case in a `switch` can occur in any order, place the `default` case last. When the `default` case is last, the `break` for that case is not required.

5.6 `switch` Multiple-Selection Statement (Cont.)

- When using the `switch` statement, remember that each `case` must contain a constant integral expression.
- An integer constant is simply an integer value.
- In addition, you can use **character constants**—specific characters in single quotes, such as `'A'`, `'7'` or `'$'`—which represent the integer values of characters.
- The expression in each `case` can also be a **constant variable**—a variable that contains a value which does not change for the entire program. Such a variable is declared with keyword `final`.
- Java has a feature called `enum` types—`enum` type constants can also be used in `case` labels.

5.7 Class AutoPolicy Case Study: Strings in switch Statements

- `String`s can be used as controlling expressions in switch statements, and `String` literals can be used in case labels.
- App requirements:
  - You've been hired by an auto insurance company that serves these northeast states—Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont. The company would like you to create a program that produces a report indicating for each of their auto insurance policies whether the policy is held in a state with "no-fault" auto insurance—Massachusetts, New Jersey, New York and Pennsylvania.

5.7 Class AutoPolicy Case Study: Strings in switch Statements (Cont.)

- Class `AutoPolicy` represents an auto insurance policy. The class contains:
- `int` instance variable `accountNumber` to store the policy's account number
- `String` instance variable `makeAndModel` to store the car's make and model (such as a `"Toyota Camry"`)
- `String` instance variable `state` to store a two-character state abbreviation representing the state in which the policy is held (e.g., `"MA"` for Massachusetts)
- a constructor that initializes the class's instance variables

```java
// Fig. 5.11: AutoPolicy.java
// Class that represents an auto insurance policy.
public class AutoPolicy {
   private int accountNumber; // policy account number
   private String makeAndModel; // car that the policy applies to
   private String state; // two-letter state abbreviation

   // constructor
   public AutoPolicy(int accountNumber, String makeAndModel,
      String state) {
      this.accountNumber = accountNumber;
      this.makeAndModel = makeAndModel;
      this.state = state;
   }

   // sets the accountNumber
   public void setAccountNumber(int accountNumber) {
      this.accountNumber = accountNumber;
   }
```

Fig. 5.11 | Class that represents an auto insurance policy. (Part 1 of 4.)

```java

    // returns the accountNumber
    public int getAccountNumber() {
       return accountNumber;
    }

    // sets the makeAndModel
    public void setMakeAndModel(String makeAndModel) {
       this.makeAndModel = makeAndModel;
    }

    // returns the makeAndModel
    public String getMakeAndModel() {
       return makeAndModel;
    }

```

Fig. 5.11 | Class that represents an auto insurance policy. (Part 2 of 4.)

```java
   // sets the state
   public void setState(String state) {
      this.state = state;
   }

   // returns the state
   public String getState() {
      return state;
   }

```

Fig. 5.11 | Class that represents an auto insurance policy. (Part 3 of 4.)

```java
    // predicate method returns whether the state has no-fault insurance
    public boolean isNoFaultState() {
       boolean noFaultState;

       // determine whether state has no-fault auto insurance
       switch (getState()) { // get AutoPolicy object's state abbreviation
          case "MA": case "NJ": case "NY": case "PA":
             noFaultState = true;
             break;
          default:
             noFaultState = false;
             break;
       }

       return noFaultState;
    }
 }
```

Fig. 5.11 | Class that represents an auto insurance policy. (Part 4 of 4.)

5.7 Class AutoPolicy Case Study: Strings in switch Statements (Cont.)

- methods `setAccountNumber` and `getAccountNumber` to set and get an `AutoPolicy`'s `accountNumber` instance variable
- methods `setMakeAndModel` and `getMakeAndModel` to set and get an `AutoPolicy`'s `makeAndModel` instance variable
- methods `setState` and `getState` to *set* and *get* an `AutoPolicy`'s state instance variable
- method `isNoFaultState` to return a boolean value indicating whether the policy is held in a no-fault auto insurance state; note the method name—the naming convention for a *get* method that returns a boolean value is to begin the name with `"is"` rather than `"get"` (such a method is commonly called a *predicate method*).

5.7 Class AutoPolicy Case Study: Strings in switch Statements (Cont.)

- Class `AutoPolicyTest` (Fig. 5.12) creates two `AutoPolicy` objects.

```java
// Fig. 5.12: AutoPolicyTest.java
// Demonstrating Strings in switch.
public class AutoPolicyTest {
   public static void main(String[] args) {
      // create two AutoPolicy objects
      AutoPolicy policy1 =
         new AutoPolicy(11111111, "Toyota Camry", "NJ");
      AutoPolicy policy2 =
         new AutoPolicy(22222222, "Ford Fusion", "ME");

      // display whether each policy is in a no-fault state
      policyInNoFaultState(policy1);
      policyInNoFaultState(policy2);
   }

```

Fig. 5.12 | Demonstrating `Strings` in `switch`. (Part 1 of 2.)

```java
   // method that displays whether an AutoPolicy
   // is in a state with no-fault auto insurance
   public static void policyInNoFaultState(AutoPolicy policy) {
      System.out.println("The auto policy:");
      System.out.printf(
         "Account #: %d; Car: %s;%nState %s %s a no-fault state%n%n",
         policy.getAccountNumber(), policy.getMakeAndModel(),
         policy.getState(),
         (policy.isNoFaultState() ? "is": "is not"));
   }
}
```

```
The auto policy:
Account #: 11111111; Car: Toyota Camry;
State NJ is a no-fault state

The auto policy:
Account #: 22222222; Car: Ford Fusion;
State ME is not a no-fault state
```

Fig. 5.12 | Demonstrating Strings in switch. (Part 2 of 2.)

5.8 break and continue Statements

- The `break` statement, when executed in a `while`, `for`, `do…while` or `switch`, causes immediate exit from that statement.
- Execution continues with the first statement after the control statement.
- Common uses of the `break` statement are to escape early from a loop or to skip the remainder of a `switch`.

```java
// Fig. 5.13: BreakTest.java
// break statement exiting a for statement.
public class BreakTest {
   public static void main(String[] args) {
      int count; // control variable also used after loop terminates

      for (count = 1; count <= 10; count++) { // loop 10 times
         if (count == 5) {
            break; // terminates loop if count is 5
         }

         System.out.printf("%d ", count);
      }

      System.out.printf("%nBroke out of loop at count = %d%n", count);
   }
}
```

```
1 2 3 4
Broke out of loop at count = 5
```

Fig. 5.13 | break statement exiting a for statement.

5.8 break and continue Statements (Cont.)

- The `continue` statement, when executed in a `while`, `for` or `do`…`while`, skips the remaining statements in the loop body and proceeds with the *next iteration* of the loop.
- In `while` and `do`…`while` statements, the program evaluates the loop-continuation test immediately after the `continue` statement executes.
- In a `for` statement, the increment expression executes, then the program evaluates the loop-continuation test.

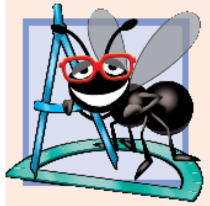
```java
// Fig. 5.14: ContinueTest.java
// continue statement terminating an iteration of a for statement.
public class ContinueTest {
   public static void main(String[] args) {
      for (int count = 1; count <= 10; count++) { // loop 10 times
         if (count == 5) {
            continue; // skip remaining code in loop body if count is 5
         }

         System.out.printf("%d ", count);
      }

      System.out.printf("%nUsed continue to skip printing 5%n");
   }
}
```

```
1 2 3 4 6 7 8 9 10
Used continue to skip printing 5
```

Fig. 5.14 | continue statement terminating an iteration of a for statement.

Software Engineering Observation 5.1

Some programmers feel that `break` and `continue` violate structured programming. The same effects are achievable with structured-programming techniques, so these programmers do not use `break` or `continue`.



Software Engineering Observation 5.2

There's a tension between achieving quality software engineering and achieving the best-performing software. Sometimes one of these goals is achieved at the expense of the other. For all but the most performance-intensive situations, apply the following guideline: First, make your code simple and correct; then make it fast and small, but only if necessary.

5.9 Logical Operators

- Java's **logical operators** enable you to form more complex conditions by combining simple conditions.
- The logical operators are
  - && (conditional AND)
  - || (conditional OR)
  - & (boolean logical AND)
  - | (boolean logical inclusive OR)
  - ^ (boolean logical exclusive OR)
  - ! (logical NOT).
- [*Note:* The &, | and ^ operators are also bitwise operators when they are applied to integral operands.]

5.9 Logical Operators (Cont.)

- The & (**conditional AND**) operator ensures that two conditions are *both true* before choosing a certain path of execution.
- The table in Fig. 5.15 summarizes the && operator. The table shows all four possible combinations of `false` and `true` values for *expression1* and *expression2.*
- Such tables are called **truth tables**. Java evaluates to `false` or `true` all expressions that include relational operators, equality operators or logical operators.

expression1	expression2	expression1 && expression2
`false`	`false`	`false`
`false`	`true`	`false`
`true`	`false`	`false`
`true`	`true`	`true`

Fig. 5.15 | && (conditional AND) operator truth table.

5.9 Logical Operators (Cont.)

- The || (**conditional OR**) operator ensures that *either or both* of two conditions are true before choosing a certain path of execution.
- Figure 5.16 is a truth table for operator conditional OR (||).
- Operator && has a higher precedence than operator ||.
- Both operators associate from left to right.

expression1	expression2	expression1 || expression2
false	false	false
false	true	true
true	false	true
true	true	true

Fig. 5.16 | || (conditional OR) operator truth table.

5.9 Logical Operators (Cont.)

- The parts of an expression containing && or || operators are evaluated only until it's known whether the condition is true or false. T
- This feature of conditional AND and conditional OR expressions is called **short-circuit evaluation**.

Common Programming Error 5.8

In expressions using &&, a condition—we'll call this the dependent condition—may require another condition to be `true` for the dependent condition's evaluation to be meaningful. In this case, the dependent condition should be placed after the && operator to prevent errors. Consider the expression `(i != 0) && (10 / i == 2)`. The dependent condition `(10 / i == 2)` must appear after the && to prevent the possibility of division by zero.

5.9 Logical Operators (Cont.)

- The **boolean logical AND** (**&**) and **boolean logical inclusive OR (|)** operators are identical to the && and || operators, except that the & and | operators *always evaluate both of their operands* (i.e., they do not perform short-circuit evaluation).
- This is useful if the right operand has a required **side effect**—a modification of a variable’s value.

Error-Prevention Tip 5.11

For clarity, avoid expressions with side effects (such as assignments) in conditions. They can make code harder to understand and can lead to subtle logic errors.

Error-Prevention Tip 5.12

Assignment (=) expressions generally should not be used in conditions. Every condition must result in a `boolean` value; otherwise, a compilation error occurs. In a condition, an assignment will compile only if a `boolean` expression is assigned to a `boolean` variable.

5.9 Logical Operators (Cont.)

- A simple condition containing the **boolean logical exclusive OR** (^) operator is `true` *if and only if* one of its operands is `true` and the other is `false`.
- If both are `true` or both are `false`, the entire condition is `false`.
- Figure 5.17 is a truth table for the boolean logical exclusive OR operator (^).
- This operator is guaranteed to evaluate both of its operands.

expression1	expression2	expression1 ^ expression2
false	false	false
false	true	true
true	false	true
true	true	false

Fig. 5.17 | ^ (boolean logical exclusive OR) operator truth table.

5.9 Logical Operators (Cont.)

- The `!` (**logical NOT**, also called **logical negation** or **logical complement**) operator "reverses" the meaning of a condition.
- The logical negation operator is a *unary* operator that has only one condition as an operand.
- The logical negation operator is placed *before* a condition to choose a path of execution if the original condition (without the logical negation operator) is `false`.
- In most cases, you can avoid using logical negation by expressing the condition differently with an appropriate relational or equality operator.
- Figure 5.18 is a truth table for the logical negation operator.

expression	! expression
`false`	`true`
`true`	`false`

Fig. 5.18 | `!` (logical NOT) operator truth table.

5.9 Logical Operators (Cont.)

- Figure 5.19 produces the truth tables discussed in this section.
- The `%b` **format specifier** displays the word "true" or the word "false" based on a `boolean` expression's value.

```java
// Fig. 5.19: LogicalOperators.java
// Logical operators.

public class LogicalOperators {
   public static void main(String[] args) {
      // create truth table for && (conditional AND) operator
      System.out.printf("%s%n%s: %b%n%s: %b%n%s: %b%n%s: %b%n%n",
         "Conditional AND (&&)", "false && false", (false && false),
         "false && true", (false && true),
         "true && false", (true && false),
         "true && true", (true && true));

      // create truth table for || (conditional OR) operator
      System.out.printf("%s%n%s: %b%n%s: %b%n%s: %b%n%s: %b%n%n",
         "Conditional OR (||)", "false || false", (false || false),
         "false || true", (false || true),
         "true || false", (true || false),
         "true || true", (true || true));
```

Fig. 5.19 | Logical operators. (Part 1 of 5.)

```java

      // create truth table for & (boolean logical AND) operator
      System.out.printf("%s%n%s: %b%n%s: %b%n%s: %b%n%s: %b%n%n",
         "Boolean logical AND (&)", "false & false", (false & false),
         "false & true", (false & true),
         "true & false", (true & false),
         "true & true", (true & true));

      // create truth table for | (boolean logical inclusive OR) operator
      System.out.printf("%s%n%s: %b%n%s: %b%n%s: %b%n%s: %b%n%n",
         "Boolean logical inclusive OR (|)",
         "false | false", (false | false),
         "false | true", (false | true),
         "true | false", (true | false),
         "true | true", (true | true));
```

Fig. 5.19 | Logical operators. (Part 2 of 5.)

```java

      // create truth table for ^ (boolean logical exclusive OR) operator
      System.out.printf("%s%n%s: %b%n%s: %b%n%s: %b%n%s: %b%n%n",
         "Boolean logical exclusive OR (^)",
         "false ^ false", (false ^ false),
         "false ^ true", (false ^ true),
         "true ^ false", (true ^ false),
         "true ^ true", (true ^ true));

      // create truth table for ! (logical negation) operator
      System.out.printf("%s%n%s: %b%n%s: %b%n", "Logical NOT (!)",
         "!false", (!false), "!true", (!true));
   }
}
```

Fig. 5.19 | Logical operators. (Part 3 of 5.)

```
Conditional AND (&&)
false && false: false
false && true: false
true && false: false
true && true: true

Conditional OR (||)
false || false: false
false || true: true
true || false: true
true || true: true

Boolean logical AND (&)
false & false: false
false & true: false
true & false: false
true & true: true
```

Fig. 5.19 | Logical operators. (Part 4 of 5.)

```
Boolean logical inclusive OR (|)
false | false: false
false | true: true
true | false: true
true | true: true

Boolean logical exclusive OR (^)
false ^ false: false
false ^ true: true
true ^ false: true
true ^ true: false

Logical NOT (!)
!false: true
!true: false
```

Fig. 5.19 | Logical operators. (Part 5 of 5.)

<table>
<tr><th>Operators</th><th>Associativity</th><th>Type</th></tr>
<tr><td>++ --</td><td>right to left</td><td>unary postfix</td></tr>
<tr><td>++ -- + - ! (type)</td><td>right to left</td><td>unary prefix</td></tr>
<tr><td>* / %</td><td>left to right</td><td>multiplicative</td></tr>
<tr><td>+ -</td><td>left to right</td><td>additive</td></tr>
<tr><td>< <= > >=</td><td>left to right</td><td>relational</td></tr>
<tr><td>== !=</td><td>left to right</td><td>equality</td></tr>
<tr><td>&</td><td>left to right</td><td>boolean logical AND</td></tr>
<tr><td>^</td><td>left to right</td><td>boolean logical exclusive OR</td></tr>
<tr><td>|</td><td>left to right</td><td>boolean logical inclusive OR</td></tr>
<tr><td>&&</td><td>left to right</td><td>conditional AND</td></tr>
<tr><td>||</td><td>left to right</td><td>conditional OR</td></tr>
<tr><td>?:</td><td>right to left</td><td>conditional</td></tr>
<tr><td>= += -= *= /= %=</td><td>right to left</td><td>assignment</td></tr>
</table>

Fig. 5.20 | Precedence/associativity of the operators discussed so far.

5.10 Structured Programming Summary

- Figure 5.21 uses UML activity diagrams to summarize Java's control statements.
- Java includes only single-entry/single-exit control statements—there is only one way to enter and only one way to exit each control statement.
- Connecting control statements in sequence to form structured programs is simple. The final state of one control statement is connected to the initial state of the next—that is, the control statements are placed one after another in a program in sequence. We call this control-statement stacking.
- The rules for forming structured programs also allow for control statements to be nested.

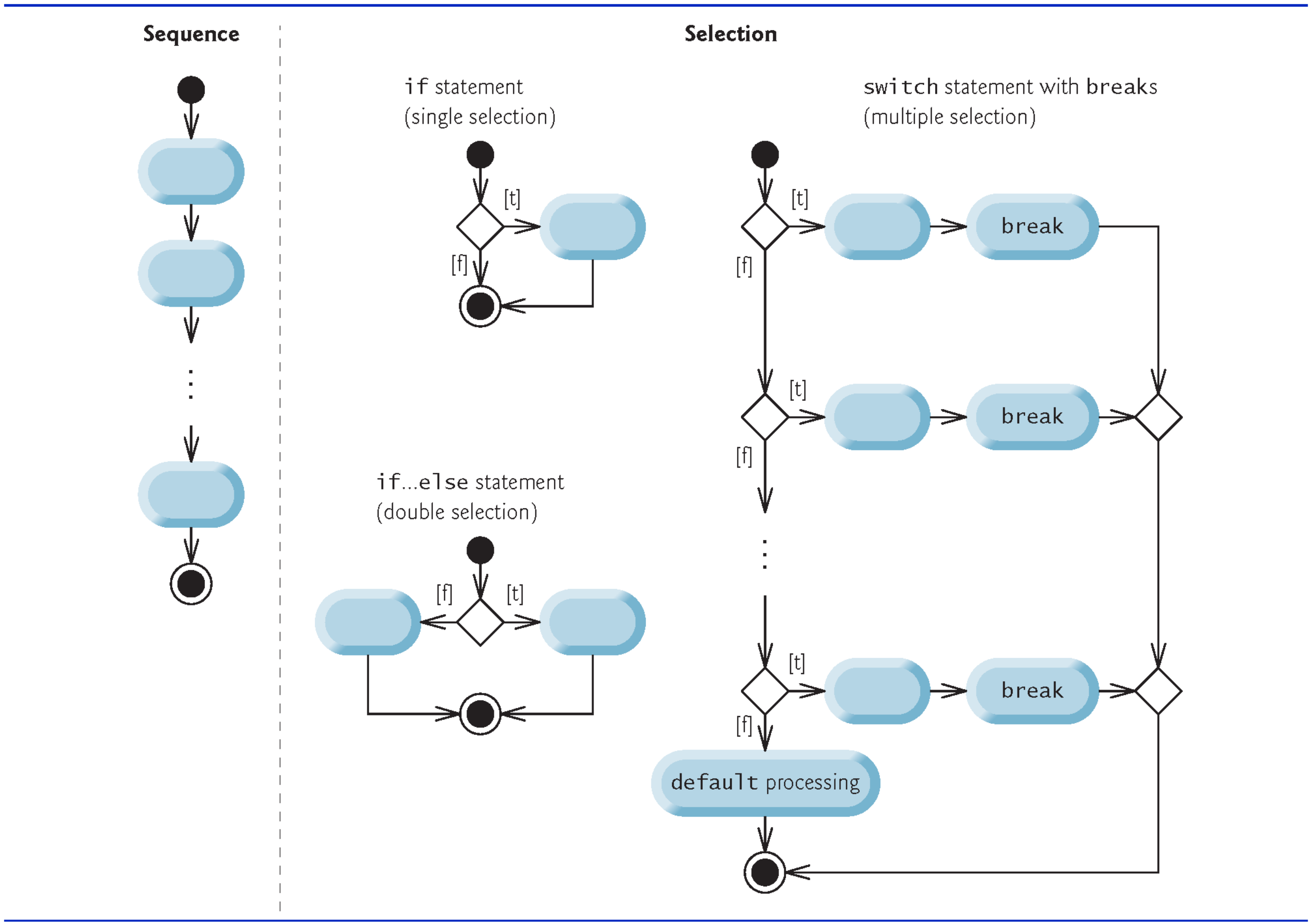


Fig. 5.21 | Java's single-entry/single-exit sequence, selection and iteration statements.

Repetition

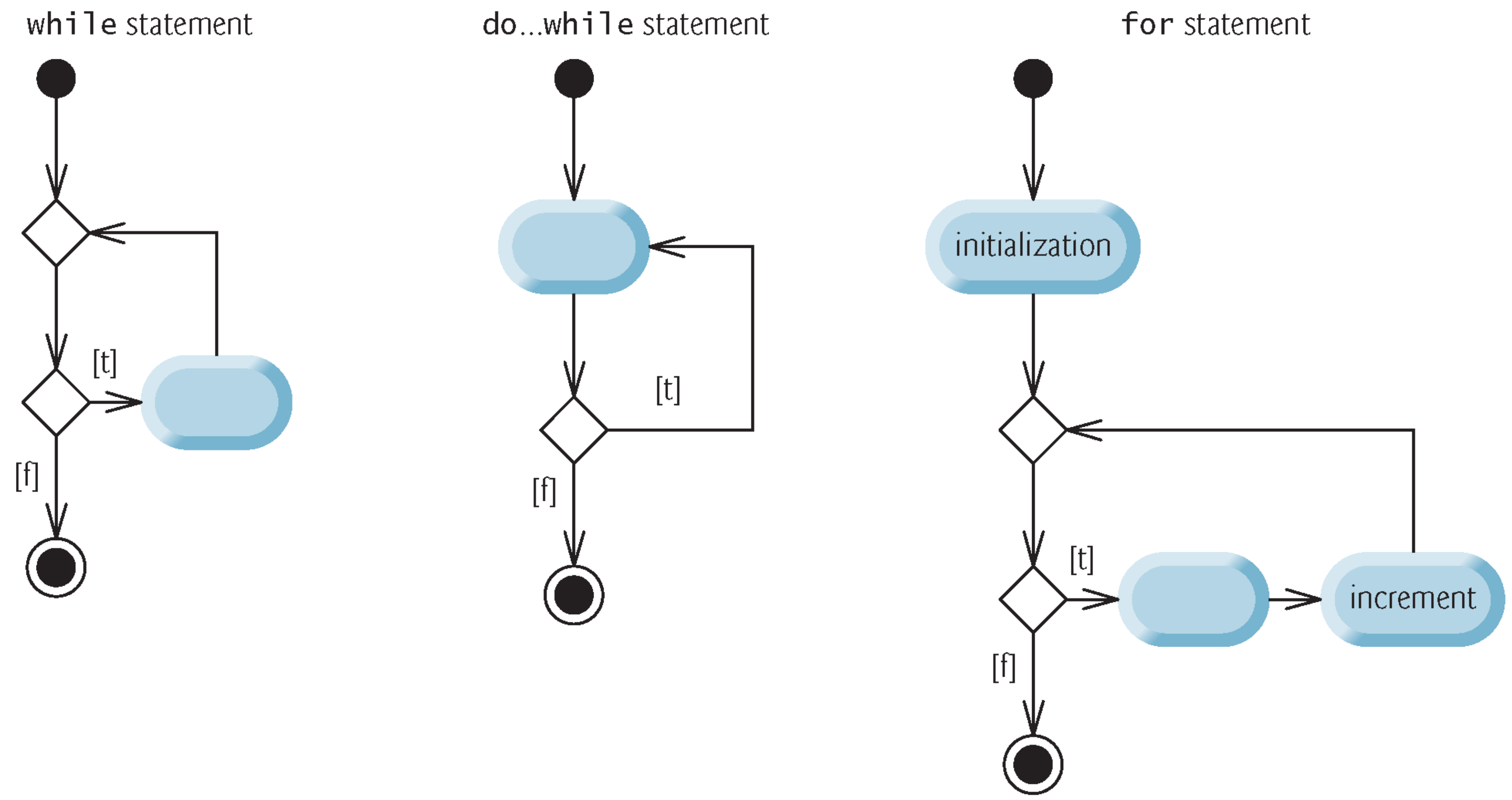


Fig. 5.21 | Java's single-entry/single-exit sequence, selection and iteration statements.

Rules for forming structured programs	
1.	Begin with the simplest activity diagram (Fig. 5.23).
2.	Any action state can be replaced by two action states in sequence.
3.	Any action state can be replaced by any control statement (`if`, `if...else`, `switch`, `while`, `do...while` or `for`).
4.	Rules 2 and 3 can be applied as often as you like and in any order.

Fig. 5.22 | Rules for forming structured programs.

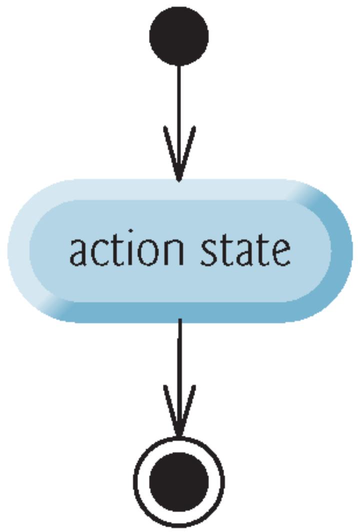


Fig. 5.23 | Simplest activity diagram.

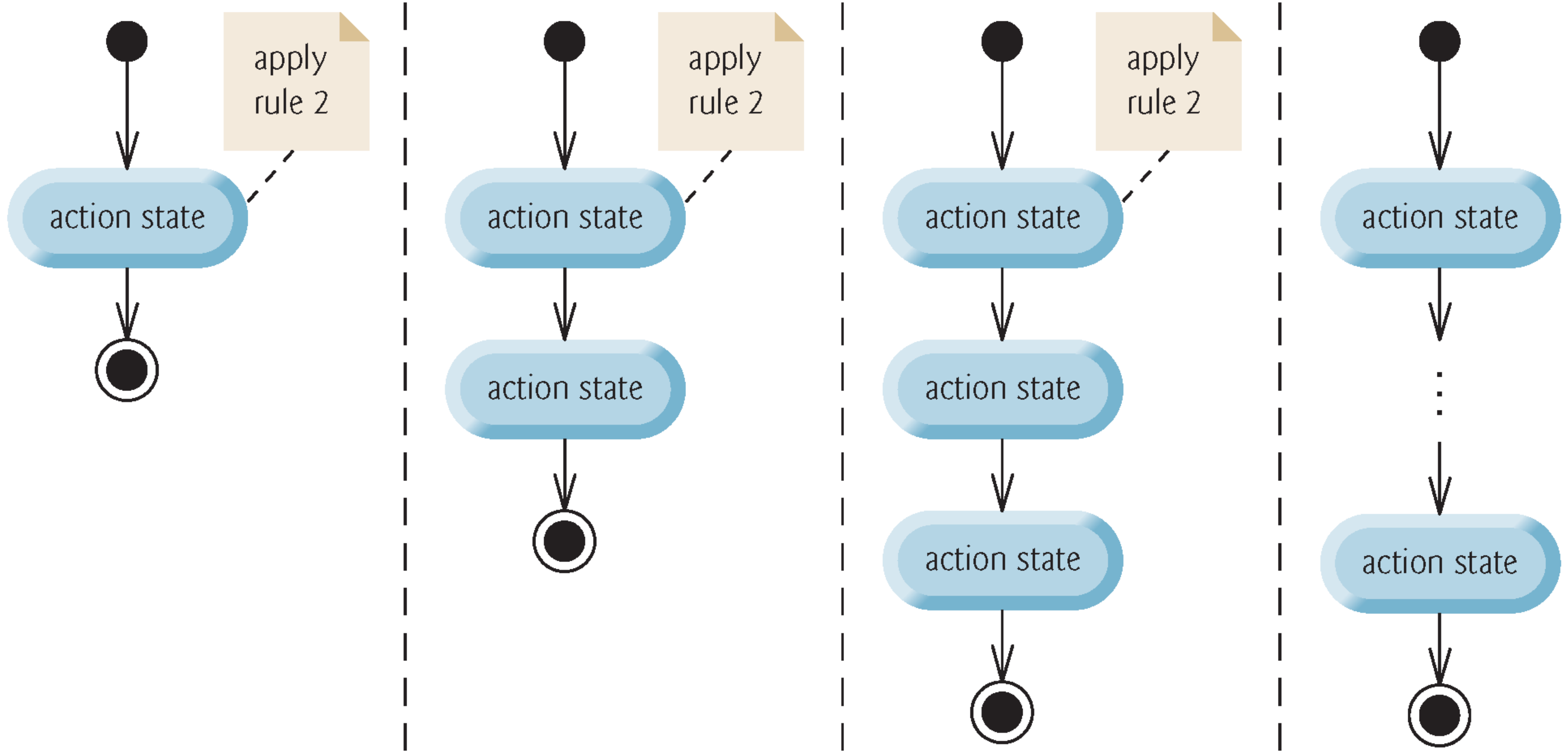


Fig. 5.24 | Repeatedly applying rule 2 of Fig. 5.22 to the simplest activity diagram.

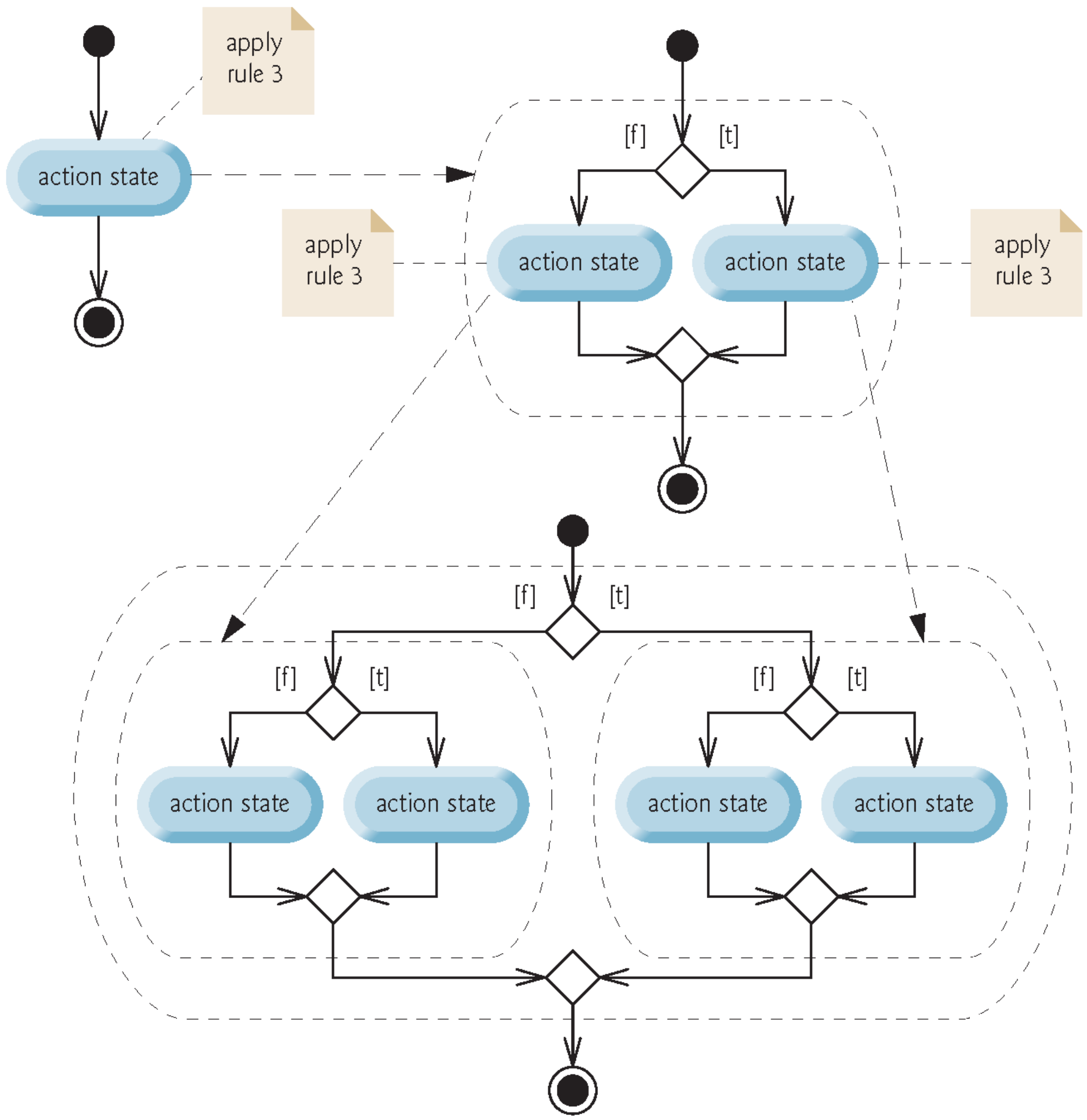


Fig. 5.25 | Repeatedly applying rule 3 of Fig. 5.22 to the simplest activity diagram.

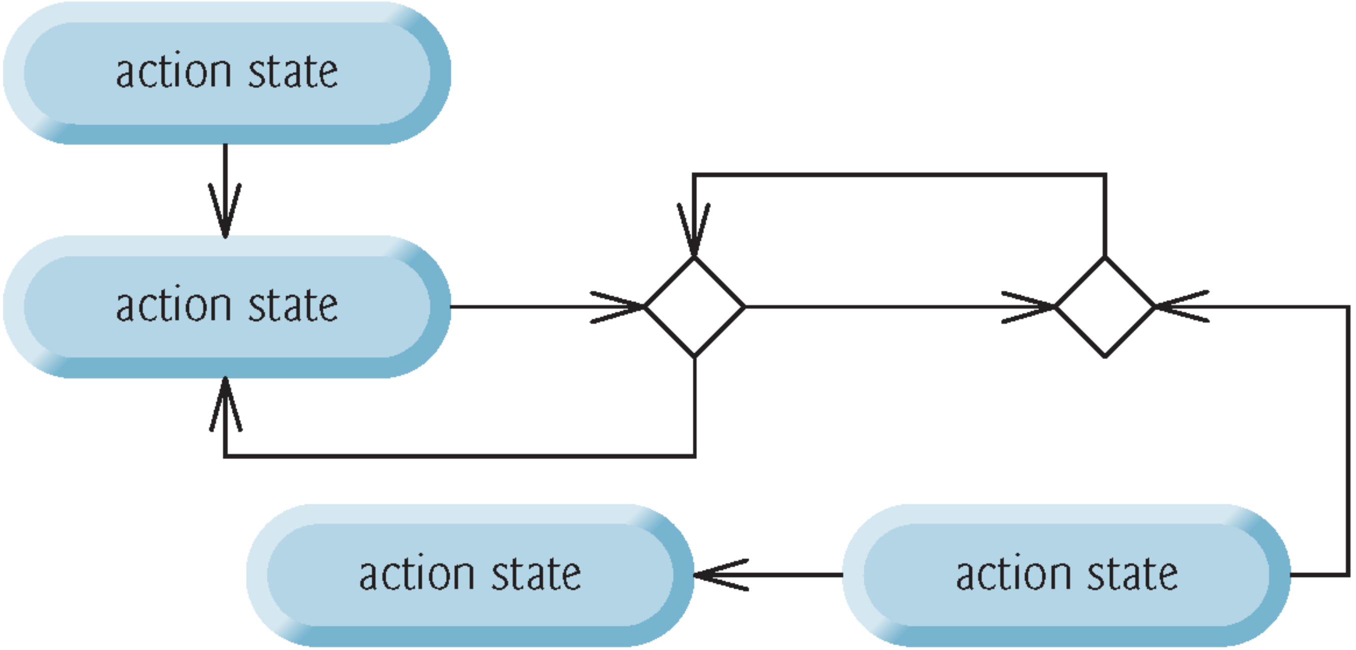


Fig. 5.26 | "Unstructured" activity diagram.

5.10 Structured Programming Summary (Cont.)

- Structured programming promotes simplicity.
- Bohm and Jacopini: Only three forms of control are needed to implement an algorithm:
  - sequence
  - selection
  - iteration
- The sequence structure is trivial. Simply list the statements to execute in the order in which they should execute.

5.10 Structured Programming Summary (Cont.)

- Selection is implemented in one of three ways:
  - `if` statement (single selection)
  - `if`…`else` statement (double selection)
  - `switch` statement (multiple selection)
- The simple `if` statement is sufficient to provide any form of selection—everything that can be done with the `if`…`else` statement and the `switch` statement can be implemented by combining `if` statements.

5.10 Structured Programming Summary (Cont.)

- Iteration is implemented in one of four ways:
  - `while` statement
  - `do…while` statement
  - `for` statement
  - Enhanced `for` statement
- The `while` statement is sufficient to provide any form of iteration. Everything that can be done with `do…while` and `for` can be done with the `while` statement.

5.10 Structured Programming Summary (Cont.)

- Combining these results illustrates that any form of control ever needed in a Java program can be expressed in terms of
  - sequence
  - `if` statement (selection)
  - `while` statement (iteration)

  and that these can be combined in only two ways—stacking and nesting.

5.11 (Optional) GUI and Graphics Case Study: Drawing Rectangles and Ovals

```java
// Fig. 5.27: DrawShapesController.java
// Using strokeRect and strokeOval to draw rectangles and ovals.
import javafx.event.ActionEvent;
import javafx.fxml.FXML;
import javafx.scene.canvas.Canvas;
import javafx.scene.canvas.GraphicsContext;

public class DrawShapesController {
   @FXML private Canvas canvas;

   // when user presses Draw Rectangles button, call draw for rectangles
   @FXML
   void strokeRectanglesButtonPressed(ActionEvent event) {
      draw("rectangles");
   }

```

Fig. 5.27 | Using `strokeRect` and `strokeOval` to draw rectangles and ovals. (Part 1 of 4.)

```java
    // when user presses Draw Ovals button, call draw for ovals
    @FXML
    void strokeOvalsButtonPressed(ActionEvent event) {
       draw("ovals");
    }

    // draws rectangles or ovals based on which Button the user pressed
    public void draw(String choice) {
       // get the GraphicsContext, which is used to draw on the Canvas
       GraphicsContext gc = canvas.getGraphicsContext2D();

       // clear the canvas for next set of shapes
       gc.clearRect(0, 0, canvas.getWidth(), canvas.getHeight());

       int step = 10;

```

Fig. 5.27 | Using `strokeRect` and `strokeOval` to draw rectangles and ovals. (Part 2 of 4.)

```
        // draw 10 overlapping shapes
        for (int i = 0; i < 10; i++) {
           // pick the shape based on the user's choice
           switch (choice) {
              case "rectangles": // draw rectangles
                 gc.strokeRect(10 + i * step, 10 + i * step,
                    90 + i * step, 90 + i * step);
                 break;
              case "ovals": // draw ovals
                 gc.strokeOval(10 + i * step, 10 + i * step,
                    90 + i * step, 90 + i * step);
                 break;
           }
        }
     }
  }
```

Fig. 5.27 | Using `strokeRect` and `strokeOval` to draw rectangles and ovals. (Part 3 of 4.)

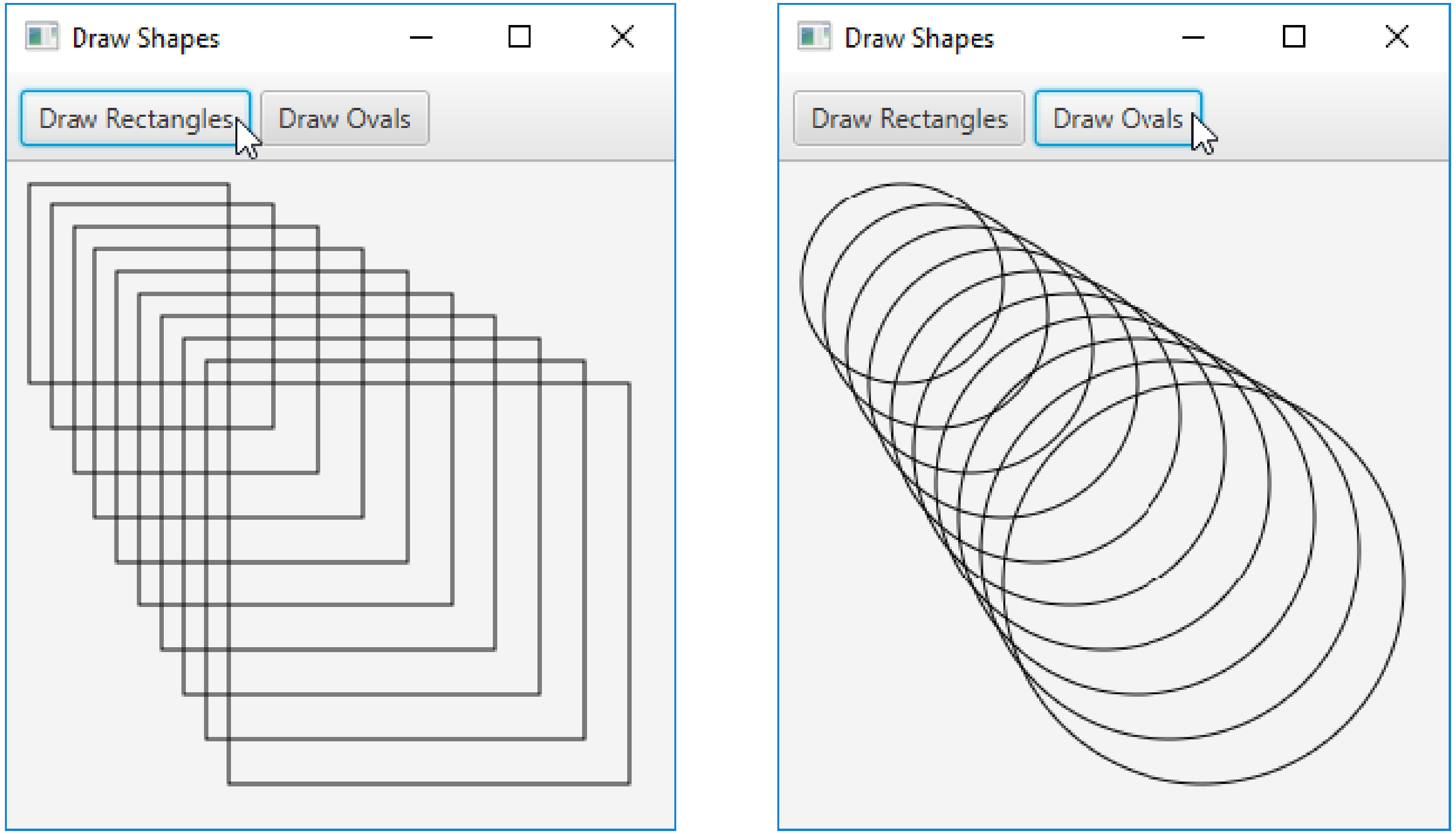


Fig. 5.27 | Using `strokeRect` and `strokeOval` to draw rectangles and ovals. (Part 4 of 4.)

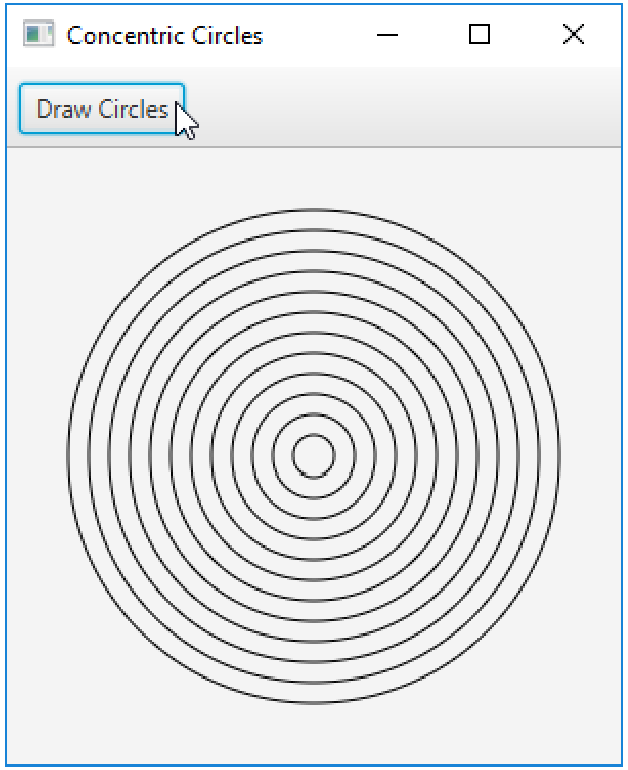


Fig. 5.28 | Drawing concentric circles.

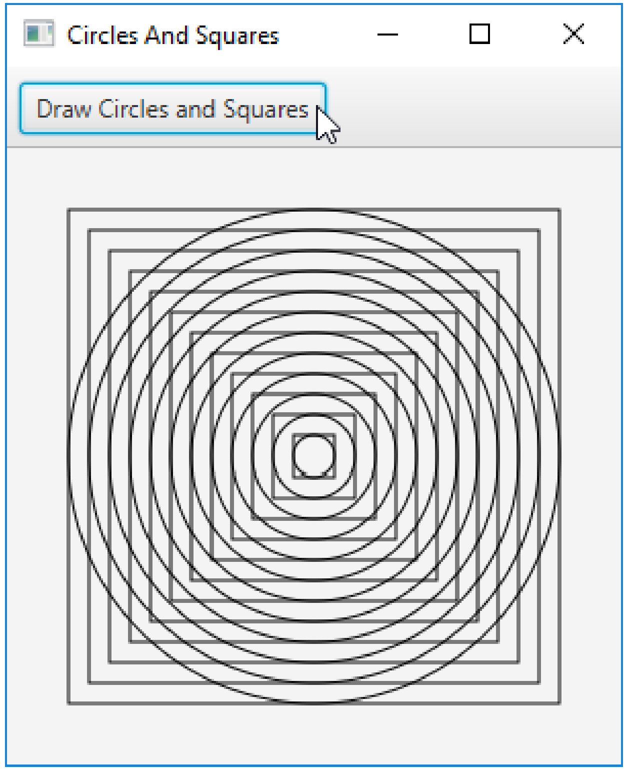


Fig. 5.29 | Drawing concentric circles and their bounding squares.