Chapter 3: Selection

3.1. Introduction

Selection statements are used to make decisions in a program based on certain conditions. They allow the program to choose between different paths of execution based on the evaluation of a boolean expression.

Types of Selection Statements

- **if Statement**: Executes a block of code if a specified condition is true.
- **if-else Statement**: Executes one block of code if a condition is true, and another block if it is false.
- **switch Statement**: Allows a variable to be tested for equality against a list of values, each with its own block of code.
- **Conditional Operator (`?:`)**: A shorthand for `if-else` that returns one of two values based on a condition.

Advantages

- **Control Flow Management**: Selection statements allow for better control over the flow of a program, enabling it to make decisions and execute different code paths based on conditions.
- **Readability**: They improve the readability of the code by clearly defining the conditions under which certain blocks of code will be executed.
- **Maintainability**: By using selection statements, code becomes easier to maintain and update, as changes to the decision-making logic can be made in one place.

- **Flexibility**: They provide flexibility in programming, allowing for complex decision-making processes and the ability to handle various scenarios.
- **Error Handling**: Selection statements can be used to handle errors and exceptional cases gracefully, ensuring the program behaves correctly under different conditions.
- **Efficiency**: They can improve the efficiency of a program by avoiding unnecessary computations and executing only the relevant code blocks.

3.2. boolean:
Data Type, Values, and Expressions

Boolean Data Type

The boolean data type in Java is used to declare variables that can hold one of two values: `true` or `false`. These values are not keywords but are considered reserved words and cannot be used as identifiers.

Relational Operators

Relational operators are used to compare two values. The result of a relational operation is a boolean value (`true` or `false`).

- `<` **(Less than)**: Checks if the value on the left is less than the value on the right.
- `<=` **(Less than or equal to)**: Checks if the value on the left is less than or equal to the value on the right.
- `>` **(Greater than)**: Checks if the value on the left is greater than the value on the right.

- `>=` **(Greater than or equal to)**: Checks if the value on the left is greater than or equal to the value on the right.
- `==` **(Equal to)**: Checks if the value on the left is equal to the value on the right.
- `!=` **(Not equal to)**: Checks if the value on the left is not equal to the value on the right.

Boolean Variables

Boolean variables is a variable that holds a boolean value.

Example:

```
boolean isRaining = true;
boolean isSunny = false;
```

Boolean Expressions

Boolean expression is an expression that results in a boolean value (`true` or `false`).

Example:

```
int x = 5;
int y = 3;
boolean result = x > y; // Evaluates to true
```

3.3. One-Way If Statements

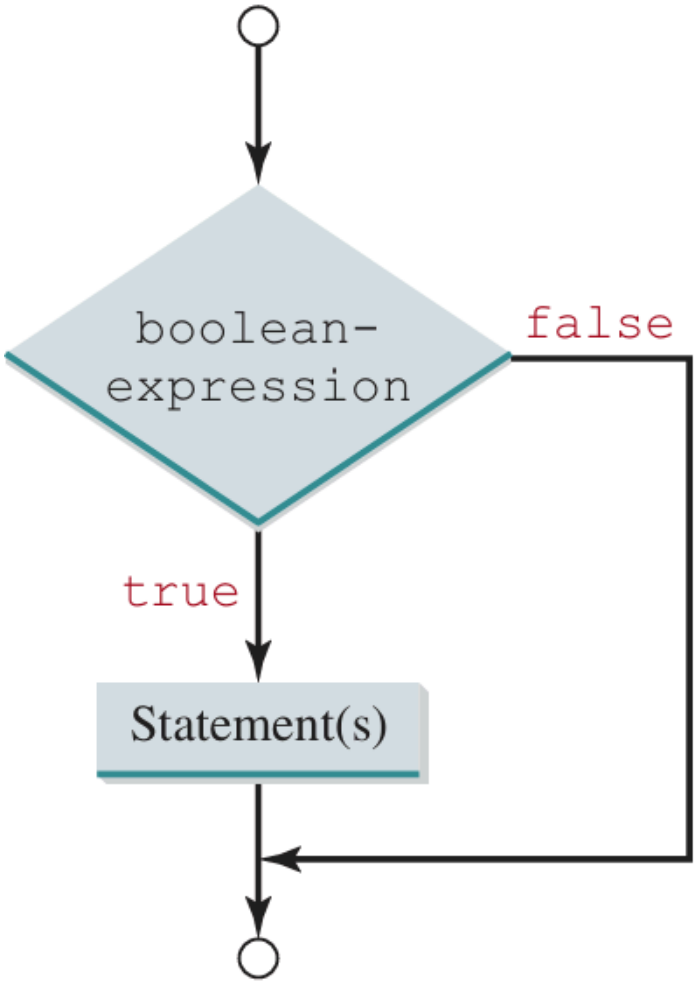
The `if` statement is used to execute a block of code if a specified condition is true.

Syntax:

```
if (boolean-expression) {
  // statement(s)
}
```

Note: If the `boolean-expression` is true, the statement(s) inside the if block are executed.

Flowchart for One-Way If Statements



- A flowchart is used to describe the decision-making process of an if statement.
- The decision is represented as a diamond shape, and the flow of control is shown with arrows.

Example:

```
if (radius >= 0) {
  area = radius * radius * PI;
  System.out.println("The area for the circle of radius " + radius + " is " + area);
}
```

Note: If the `radius` is greater than or equal to 0, the program calculates and displays the area.

Common Mistakes

- Forgetting to include parentheses around the boolean expression.
- Misplacing the braces which group multiple statements inside the if block.

Example: Forgetting Parentheses

- Incorrect:

```
if i > 0 {
  System.out.println("i is positive");
}
```

- Correct:

```
if (i > 0) {
  System.out.println("i is positive");
}
```

Example: Misplacing Braces

- Not Realiable:

```
if (i > 0)
  System.out.println("i is positive");
  System.out.println("i is integer");
```

- Realiable:

```
if (i > 0) {
  System.out.println("i is positive");
  System.out.println("i is integer");
}
```

Simplifying Code

Braces can be omitted if the if block contains only one statement.

Example: Simplified if statement

```
if (i > 0)
  System.out.println("i is positive");
```

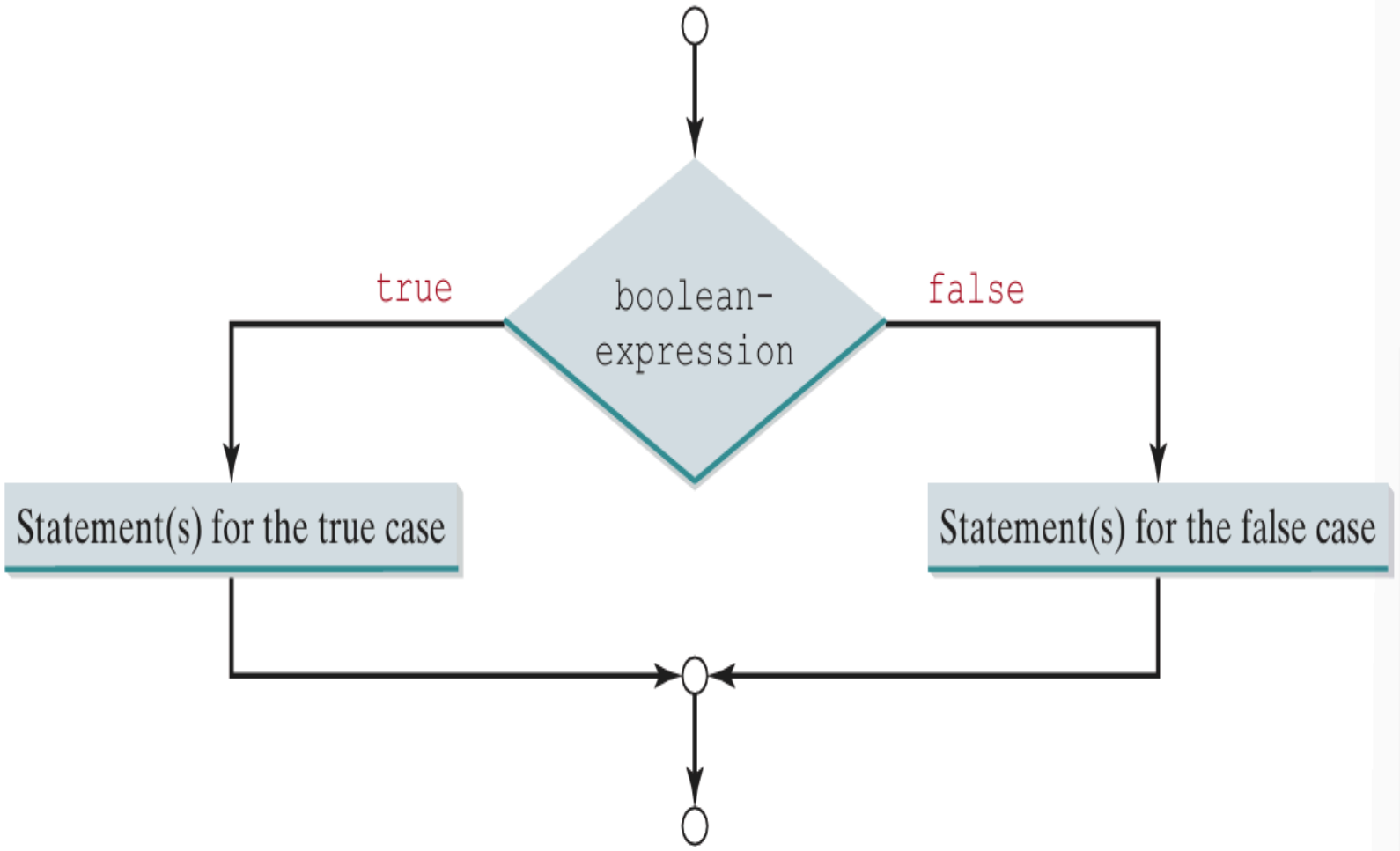
3.4. Two-Way if-else Statements

The `if-else` statement is used to execute one block of code if a specified condition is `true` and another block if the condition is `false`.

Syntax:

```
if (boolean-expression) {
  // statement(s)-for-the-true-case
}
else {
  // statement(s)-for-the-false-case
}
```

Flowchart


true
boolean-
expression
false
Statement(s) for the true case
Statement(s) for the false case

Explanation:

- If the `boolean-expression` is true, the statements for the true case are executed.
- If the `boolean-expression` is false, the statements for the false case are executed.

Example:

```
if (radius >= 0) {
  area = radius * radius * PI;
  System.out.println("The area for the circle of radius " + radius + " is " + area);
}
else {
  System.out.println("Negative input");
}
```

Explanation:

- If the `radius` is greater than or equal to 0, the program calculates and displays the area.
- If the `radius` is negative, the program displays an error message.

Common Mistakes

Example:

Misusing the `if` statement without an `else` can result in incomplete logic.

- Incorrect:

```
if (number % 2 == 0)
  System.out.println(number + " is even.");
```

- Correct:

```
if (number % 2 == 0)
  System.out.println(number + " is even.");
else
  System.out.println(number + " is odd.");
```

Example:

Misplacing the `else` statement can lead to logical errors.

- Incorrect:

```
if (number % 2 == 0)
  System.out.println(number + " is even.");
  System.out.println(number + " is odd.");
```

- Correct:

```
if (number % 2 == 0)
  System.out.println(number + " is even.");
else
  System.out.println(number + " is odd.");
```

Example:

Using the assignment operator `=` instead of the equality operator `==` in the condition.

- Incorrect:

```
if (number = 0)
  System.out.println("The number is zero.");
```

- Correct:

```
if (number == 0)
  System.out.println("The number is zero.");
```

3.5. Nested if and Multi-Way if-else Statements

Nested if Statement

Nested if statement is an `if` statement inside another `if` statement.

Example:

```
if (i > k) {
  if (j > k)
    System.out.println("i and j are greater than k");
}
else
  System.out.println("i is less than or equal to k");
```

Explanation:

- The `if (j > k)` statement is nested inside the `if (i > k)` statement.
- The program checks if `i` is greater than `k`.
- If true, it checks if `j` is also greater than `k`.
- If false, it prints that `i` is less than or equal to `k`.

Multi-Way if-else Statements

Multi-way if-else statement is used to test multiple conditions in sequence.

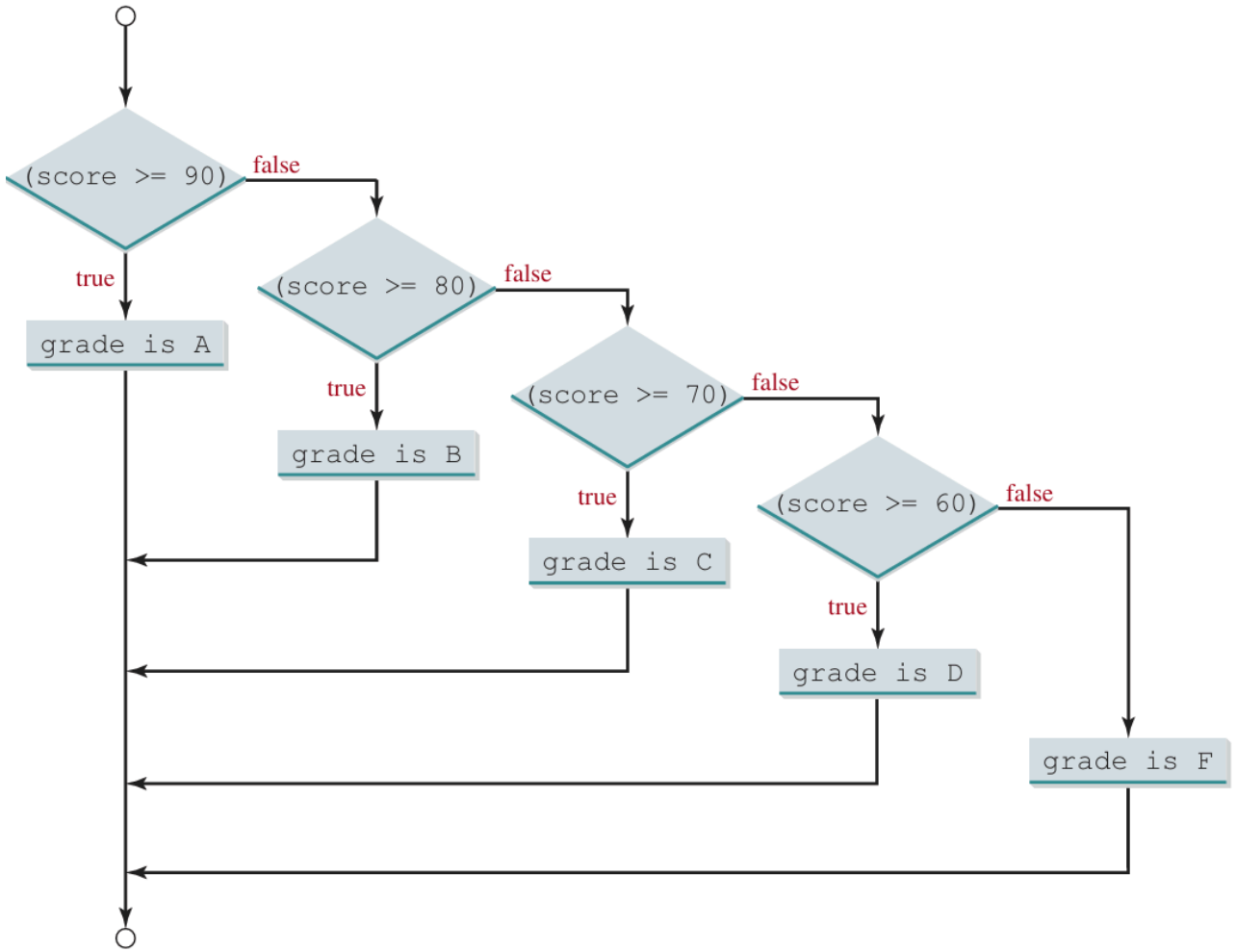
Example:

```
if (score >= 90)
  System.out.print("A");
else if (score >= 80)
  System.out.print("B");
else if (score >= 70)
  System.out.print("C");
else if (score >= 60)
  System.out.print("D");
else
  System.out.print("F");
```

Explanation:

- The program tests multiple conditions in sequence.
- The first condition `score >= 90` is checked.
- If false, the next condition `score >= 80` is checked, and so on.
- This avoids deep indentation and keeps the code readable.

Flowchart


(score >= 90)
false
true
grade is A
(score >= 80)
false
true
grade is B
(score >= 70)
false
true
grade is C
(score >= 60)
false
true
grade is D
grade is F

Flowchart: Describes the decision-making process of a multi-way if-else statement.

- If a condition is true, the corresponding block of code is executed.
- If all conditions are false, the final else block is executed.

3.6. Common Errors and Pitfalls

Forgetting Necessary Braces

Example: Forgetting Necessary Braces

- Incorrect :

```
if (radius >= 0)
  area = radius * radius * PI;
  System.out.println("The area is " + area);
```

- Correct :

```
if (radius >= 0) {
  area = radius * radius * PI;
  System.out.println("The area is " + area);
}
```

Wrong Semicolon at the if Line

Example: Wrong Semicolon at the if Line

- Incorrect :

```
if (radius >= 0); { // Incorrect
  area = radius * radius * PI;
  System.out.println("The area is " + area);
}
```

- Correct :

```
if (radius >= 0) { // Correct
  area = radius * radius * PI;
  System.out.println("The area is " + area);
}
```

Redundant Testing of Boolean Values

Example: Redundant Testing of Boolean Values

- Redundant :

```
boolean even = true;
if (even == true) // Redundant
  System.out.println("It is even.");
```

- Better approach :

```
boolean even = true;
if (even) // Correct
  System.out.println("It is even.");
```

Misunderstanding the if-else Structure

Example: Misunderstanding the if-else Structure

- Misunderstanding :

```
if (i > j)
  if (i > k)
    System.out.println("A");
  else
    System.out.println("B"); // Matches the second if
```

- Understanding :

```
if (i > j) {
  if (i > k)
    System.out.println("A");
}
else
  System.out.println("B"); // Matches the first if
```

Equality Test of Two Floating-Point Values

Example: Equality Test of Two Floating-Point Values

- Unreliable approach:

```
double x = 1.0 - 0.1 - 0.1 - 0.1 - 0.1 - 0.1;
System.out.println(x == 0.5);
```

- Better approach:

```
final double EPSILON = 1E-14; // 1x10^-14
if (Math.abs(x - 0.5) < EPSILON)
  System.out.println(x + " is approximately 0.5");
```

Simplifying Boolean Variable Assignment

Example: Simplifying Boolean Variable Assignment

- Traditional version:

```
boolean even;
if (number % 2 == 0)
{
    even = true;
}
else
{
  even = false;
}
```

- Simplified version:

```
boolean even = (number % 2 == 0);
```

Avoiding Duplicate Code in Different Cases

Example: Avoiding Duplicate Code in Different Cases

- Traditional version:

```
if (inState) {
  tuition = 5000;
  System.out.println("The tuition is " + tuition);
} else {
  tuition = 15000;
  System.out.println("The tuition is " + tuition);
}
```

- Improved version:

```
if (inState) {
  tuition = 5000;
} else {
  tuition = 15000;
}
System.out.println("The tuition is " + tuition);
```

3.7. Generating Random Numbers

The `Math.random()` method returns a random double value between 0.0 (inclusive) and 1.0 (exclusive).

Example:

```
double randomValue = Math.random();
```

Explanation: The value returned by `Math.random()` is a double value greater than or equal to 0.0 and less than 1.0.

Generating Random Integers

By multiplying the value returned by `Math.random()` by a certain range and casting it to an integer, you can generate random integers within a specified range.

Example: Generates a random integer between 0 and 9

```
int randomInt = (int)(Math.random() * 10);
```

To generate random integers in a different range, you can adjust the scaling and shifting accordingly.

Example: Generates a random integer between 50 and 99

```
int randomInt = (int)(Math.random() * 50) + 50;
```

3.8. Case Study: Computing Body Mass Index

Practice.

3.9. Case Study: Computing Taxes

Practice.

3.10. Logical Operators

- **Logical AND (`&&`)**: Returns `true` if both operands are true.
- **Logical OR (`||`)**: Returns `true` if at least one of the operands is true.
- **Logical NOT (`!`)**: Inverts the value of a boolean expression.
- **Logical XOR (`^`)**: Returns `true` if exactly one of the operands is true, but not both.

Truth Tables

- **Not Operator (`!`)**:
  - `!true` : `false`
  - `!false` : `true`
- **And Operator (`&&`)**:
  - `true && true` : `true`
  - `true && false` : `false`
  - `false && true` : `false`
  - `false && false` : `false`

- **Or Operator (`||`):**
  - `true || true` : `true`
  - `true || false` : `true`
  - `false || true` : `true`
  - `false || false` : `false`
- **Exclusive Or Operator (`^`):**
  - `true ^ true` : `false`
  - `true ^ false` : `true`
  - `false ^ true` : `true`
  - `false ^ false` : `false`

Short-Circuit Evaluation

- When evaluating `&&`, Java stops evaluation if the first operand is false.
- When evaluating `||`, Java stops evaluation if the first operand is true.

Example:

```
int x = 5;
int y = 0;
if (y != 0 && x / y > 2) {
  System.out.println("x / y is greater than 2");
}
```

Explanation:

- Since `y` is 0, the first operand `y != 0` is false.
- Java does not evaluate the second operand `x / y > 2` because the first operand is false.
- This prevents a division by zero error.

De Morgan's Laws

De Morgan's laws are used to simplify boolean expressions.

Syntax :

- `!(condition1 && condition2)` is the same as `!condition1 || !condition2`
- `!(condition1 || condition2)` is the same as `!condition1 && !condition2`

Example:

```
!(a && b) == (!a || !b)
!(a || b) == (!a && !b)
```

3.11. Case Study: Determining Leap Year

Practice.

3.12. Case Study: Lottery

Practice.

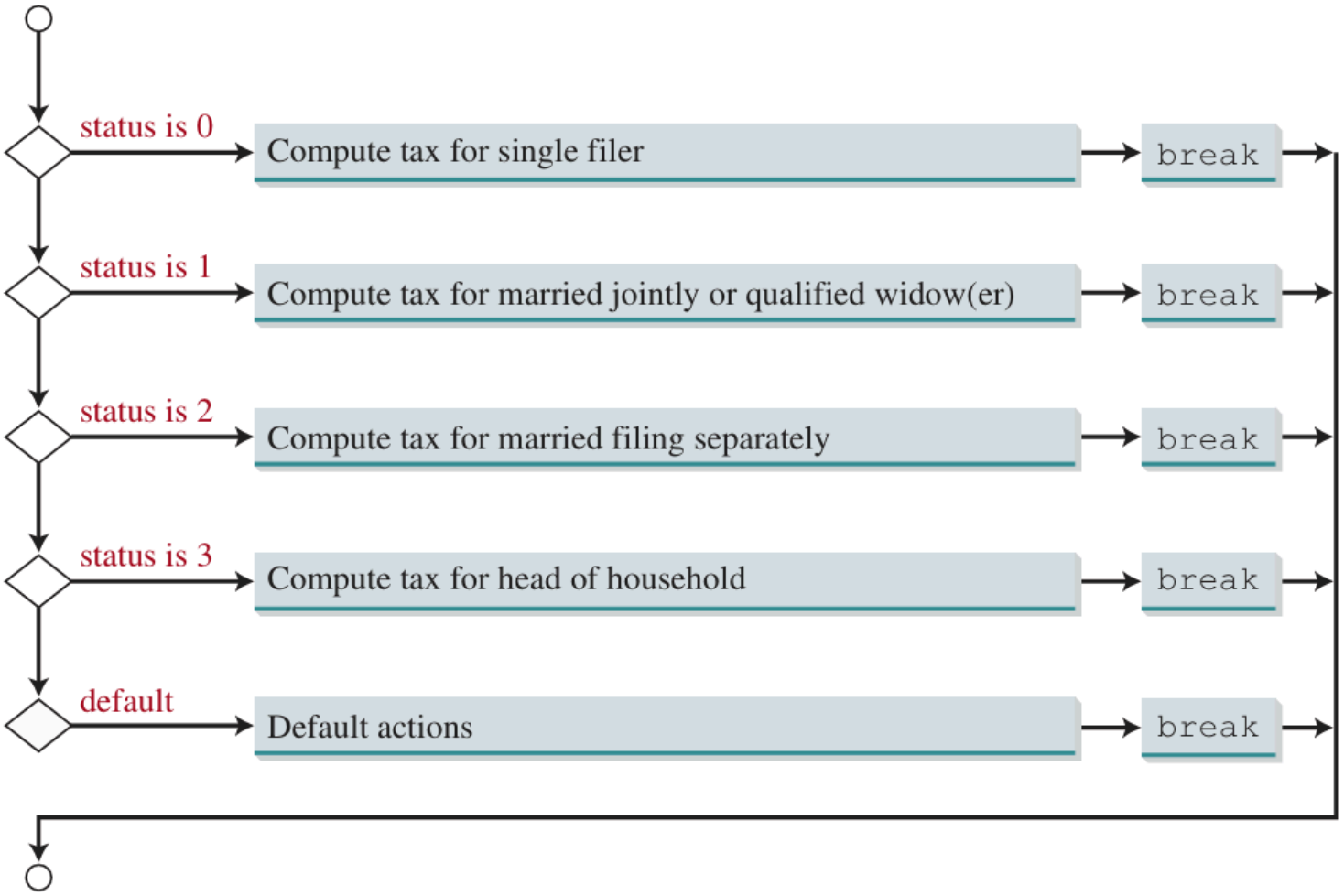
3.13. switch Statements

Switch statement is used to select one of many code blocks to be executed based on the value of an expression. It is an alternative to using multiple `if-else` statements.

Syntax:

```
switch (expression) {
  case value1:
    // statement(s)
    break;
  case value2:
    // statement(s)
    break;
  ...
  default:
    // statement(s)
}
```

Flowchart


status is 0
Compute tax for single filer
break
status is 1
Compute tax for married jointly or qualified widow(er)
break
status is 2
Compute tax for married filing separately
break
status is 3
Compute tax for head of household
break
default
Default actions
break

The flowchart shows how the switch statement checks all cases and executes the statements in the matched case.

Note: If no cases match, the default case is executed.

Key Rules

- The `switch-expression` must yield a value of `char`, `byte`, `short`, `int`, or `String`.
- The values in the case statements must have the same data type as the `switch-expression`.
- The `break` statement is used to end the switch statement and prevent fall-through behavior, where statements in subsequent cases are executed.

Example:

Printing the day of the week based on a number.

```
int day = 3;
switch (day) {
  case 1:
    System.out.println("Monday");
    break;
  case 2:
    System.out.println("Tuesday");
    break;
  case 3:
    System.out.println("Wednesday");
    break;
  default:
    System.out.println("Invalid day");
}
```

Explanation

If `day` is 3, the program prints "Wednesday". If `day` is not 1, 2, or 3, it prints "Invalid day".

Fall-Through Behavior

If the `break` statement is omitted, the program continues executing the statements in the subsequent cases until a `break` or the end of the switch statement is reached.

Example:

Printing the day of the week based on a number.

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5:
    System.out.println("Weekday");
    break;
  case 0:
  case 6:
    System.out.println("Weekend");
}
```

Explanation:

If `day` is 1, 2, 3, 4, or 5, the program prints "Weekday". If `day` is 0 or 6, it prints "Weekend".

3.14. Conditional Operators

Conditional operators are used to evaluate boolean expressions and return a value based on the result.

Syntax:

```
boolean-expression ? expression1 : expression2;
```

Note: If the `boolean-expression` evaluates to true, `expression1` is returned; otherwise, `expression2` is returned.

Example:

Comparing two numbers to find the maximum.

```
int x = 5;
int y = (x > 0) ? 1 : -1;
System.out.println(y); // Outputs: 1
```

Explanation:

If `x` is greater than 0, `y` is assigned the value 1; otherwise, it is assigned -1.

Example:

Traditional if-else statement vs ternary operator.

- Traditional if-else statement:

```
if (x > 0) {
  y = 1;
} else {
  y = -1;
}
```

- Ternary operator:

```
y = (x > 0) ? 1 : -1;
```

Nested Conditional Operators

Example:

Comparing three numbers to find the maximum.

```
int a = 3, b = 5, c = 7;
int max = (a > b) ? ((a > c) ? a : c) : ((b > c) ? b : c);
System.out.println(max); // Outputs: 7
```

Explanation:

- The nested conditional operator compares `a` with `c` if `a` is greater than `b`.
- If `a` is not greater than `b`, it compares `b` with `c`.
- The largest value among `a`, `b`, and `c` is assigned to `max`.
- In this case, `c` is the largest value.
- The program outputs `7`.

Using Conditional Operators in Output Statements

- They can be used directly in print statements for conditional outputs:

```
int num = 9;
System.out.println((num % 2 == 0) ? "Even" : "Odd"); // Outputs: Odd
```

3.15. Operator Precedence and Associativity

- **Operator Precedence**: Determines the order in which operators are evaluated in an expression. Operators with higher precedence are evaluated before those with lower precedence.
- **Operator Associativity**: Defines the order in which operators of the same precedence level are evaluated. Most operators are left-associative, meaning they are evaluated from left to right. Assignment operators are right-associative, meaning they are evaluated from right to left.

Operator Precedence

Java operators are categorized into different levels of precedence. Operators within the same category have the same precedence.

Level	Operator(s)	Type	Description
1	(), [], .	Parentheses/Access	Grouping, array access, member access
3	++, --, +, -, !, ~	Prefix/Unary	Pre-increment, pre-decrement, unary plus/minus, NOT
4	(type)	Cast	Type conversion
5	*, /, %	Multiplicative	Multiplication, division, remainder
6	+, -	Additive	Addition, subtraction
7	<, <=, >, >=	Relational	Comparison operators
8	==, !=	Equality	Equal to, not equal to
9	&, ^, |, &&, ||	Bitwise/Logical	Bitwise AND, XOR, OR; Logical AND, OR
10	?:	Conditional	Ternary conditional operator
11	=, +=, -=, *=, /=, %=	Assignment	Simple and compound assignment

Example:

Expression `3 + 4 * 4 > 5 * (4 + 3) - 1 && (4 - 3 > 5)`.

- **Step 1**: `3 + 16 > 5 * 7 - 1 && (4 - 3 > 5)`
- **Step 2**: `19 > 35 - 1 && (4 - 3 > 5)`
- **Step 3**: `19 > 34 && (4 - 3 > 5)`
- **Step 4**: `true && (1 > 5)`
- **Step 5**: `true && false`
- **Step 6**: `false`

Operator Associativity

- **Left-Associative**: Most binary operators, such as addition (`+`) and subtraction (`-`), are evaluated from left to right.
- **Right-Associative**: Assignment operators, such as `=` and `+=`, are evaluated from right to left.

Example:

Left-Associative Operator

```
int x = 5;
int y = 10;
int z = 15;
x = y + z;
System.out.println(x); // Outputs: 25
```

Explanation:

The addition operator `+` is left-associative, so the value of `y` (10) is added to `z` (15), and the result is assigned to `x`.

Example:

Right-associative operator

```
int x = 5;
int y = 10;
int z = 15;
x = y = z;
System.out.println(x); // Outputs: 15
```

Explanation:

The assignment operator `=` is right-associative, so the value of `z` (15) is assigned to `y`, and then the value of `y` is assigned to `x`.

3.16. Debugging

Debugging Process

Debugging is the process of finding and correcting errors in a program.

Steps

- **Identifying the Problem**: Understanding the issue and its impact on the program's behavior.
- **Locating the Error**: Determining the source of the error in the code.
- **Fixing the Error**: Modifying the code to correct the error.
- **Testing the Fix**: Verifying that the error has been resolved and the program behaves as expected.

Common Types of Errors

- **Syntax Errors**: Detected by the compiler, these errors are relatively easy to fix as the compiler provides information about their location and cause.
- **Runtime Errors**: These occur during program execution and are usually displayed on the console when the program aborts.
- **Logic Errors**: The most challenging to find, these errors do not cause the program to crash but result in incorrect output.

Debugging Techniques

- **Hand-Tracing**: Manually reading and tracing the program's execution to identify errors.
- **Print Statements**: Inserting print statements to display variable values and the flow of execution, helping to understand the program's behavior.

Using Debugger Tools

Utilizing debugging tools available in Integrated Development Environments (IDEs) like Eclipse and NetBeans to follow the program's execution. These tools provide features such as:

- **Executing Statements One at a Time**: Allows you to execute and observe each statement individually.
- **Stepping Into/Over Methods**: Lets you enter a method to debug it step-by-step or skip over it if it is known to work correctly.

- **Setting Breakpoints**: Pauses the program at specific statements to examine the current state and flow.
- **Displaying Variables**: Continuously updates and displays the values of selected variables during debugging.
- **Displaying Call Stacks**: Shows all method calls, providing a broader picture of the execution flow.
- **Modifying Variables**: Some debuggers allow you to change variable values during debugging to test different scenarios without modifying the code.