Unit 3, Part 3

Conditional Execution

Computer Science S-111
Harvard University

David G. Sullivan, Ph.D.

Review: Simple Conditional Execution in Java

```
if (<condition>) {
    <true block>
} else {
    <false block>
}
```

```
if (<condition>) {
    <true block>
}
```

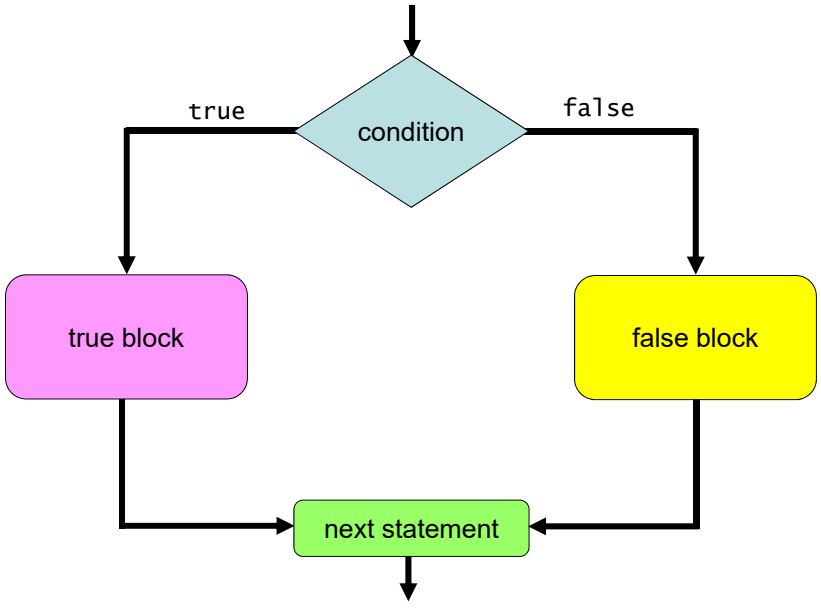
- If the condition is true:
  - the statement(s) in the true block are executed
  - the statement(s) in the false block (if any) are skipped
- If the condition is false:
  - the statement(s) in the false block (if any) are executed
  - the statement(s) in the true block are skipped

Example: Analyzing a Number

```
Scanner console = new Scanner(System.in);
System.out.print("Enter an integer: ");
int num = console.nextInt();

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

Flowchart for an `if-else` Statement



Common Mistake

- You should not put a semi-colon after an if-statement header:

```
if (num % 2 == 0); {
    System.out.println(…);
    ...
}
```

- The semi-colon ends the `if` statement.
  - thus, it has an empty true block
- The println and other statements are independent of the `if` statement, and always execute.

Choosing at Most One of Several Options

- Consider this code:

```
if (num < 0) {
    System.out.println("The number is negative.");
}
if (num > 0) {
    System.out.println("The number is positive.");
}
if (num == 0) {
    System.out.println("The number is zero.");
}
```

- All three conditions are evaluated, but at most one of them can be true (in this case, *exactly* one).

Choosing at Most One of Several Options (cont.)

- We can do this instead:

```
if (num < 0) {
    System.out.println("The number is negative.");
}
else if (num > 0) {
    System.out.println("The number is positive.");
}
else if (num == 0) {
    System.out.println("The number is zero.");
}
```

- If the first condition is true, it will skip the second and third.
- If the first condition is false, it will evaluate the second, and if the second condition is true, it will skip the third.
- If the second condition is false, it will evaluate the third, etc.

Choosing at Most One of Several Options (cont.)

- We can also make things more compact as follows:

```
if (num < 0) {
    System.out.println("The number is negative.");
} else if (num > 0) {
    System.out.println("The number is positive.");
} else if (num == 0) {
    System.out.println("The number is zero.");
}
```

- This emphasizes that the entire thing is one compound statement.

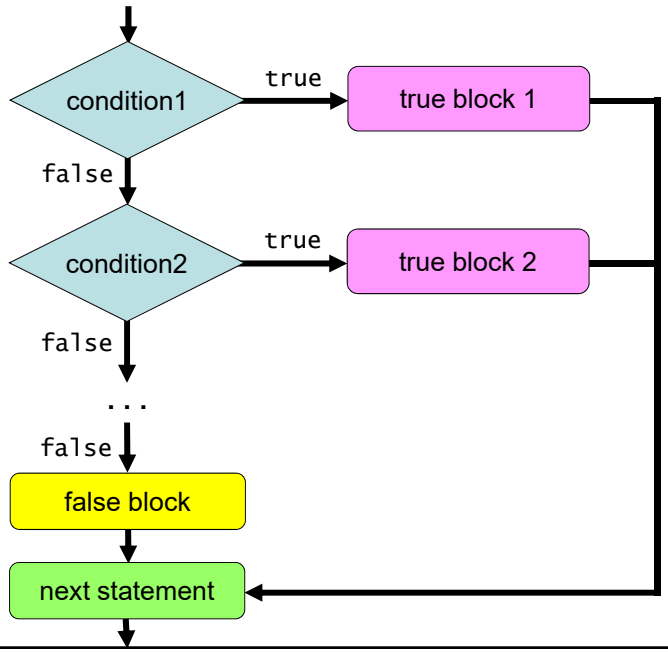
`if-else if` Statements

- Syntax:

```
if (<condition1>) {
    <true block for condition1>
} else if (<condition2>) {
    <true block for condition2>
}
…
} else {
    <false block for all of the conditions>
}
```

- The conditions are evaluated in order.
  The true block of the *first* true condition is executed.
  All of the remaining conditions and their blocks are skipped.
- If no condition is true, the false block (if any) is executed.

Flowchart for an `if-else if` Statement



Choosing Exactly One Option

- Consider again this code fragment:

```
if (num < 0) {
    System.out.println("The number is negative.");
} else if (num > 0) {
    System.out.println("The number is positive.");
} else if (num == 0) {
    System.out.println("The number is zero.");
}
```

- One of the conditions must be true, so we can omit the last one:

```
if (num < 0) {
    System.out.println("The number is negative.");
} else if (num > 0) {
    System.out.println("The number is positive.");
} else {
    System.out.println("The number is zero.");
}
```

Types of Conditional Execution

- If it want to execute **any number** of several conditional blocks, use **sequential `if` statements**:

```
if (num < 0) {
    System.out.println("The number is negative.");
}
if (num % 2 == 0) {
    System.out.println("The number is even.");
}
```

- If you want to execute **at most one (i.e., 0 or 1)** of several blocks, use an **`if-else if` statement ending in `else if`**:

```
if (num < 0) {
    System.out.println("The number is negative.");
} else if (num > 0) {
    System.out.println("The number is positive.");
}
```

- If you want to execute **exactly one** of several blocks, use an **`if-else if` ending in just `else`** (see bottom of last slide).

Find the Logic Error

```
Scanner console = new Scanner(System.in);

System.out.print("Enter the student's score: ");
int score = console.nextInt();

String grade;
if (score >= 90) {
    grade = "A";
}
if (score >= 80) {
    grade = "B";
}
if (score >= 70) {
    grade = "C";
}
if (score >= 60) {
    grade = "D";
}
if (score < 60) {
    grade = "F";
}
```

Review: Variable Scope

- Recall: the *scope* of a variable is the portion of a program in which the variable can be used.
- By default, the scope of a variable:
  - begins at the point at which it is declared
  - ends at the end of the innermost block that encloses the declaration
- Because of these rules, a variable cannot be used outside of the block in which it is declared.

Variable Scope and `if-else` statements

- The following program will produce compile-time errors:

```
public static void main(String[] args) {
    Scanner console = new Scanner(System.in);
    System.out.print("enter a positive int: ");
    int num = console.nextInt();
    if (num < 0) {
        System.out.println("number is negative;"
          + " using its absolute value");
        double sqrt = Math.sqrt(num * -1);
    } else {
        sqrt = Math.sqrt(num);
    }
    System.out.println("square root = " + sqrt);
}
```

- Why?

Variable Scope and `if-else` statements (cont.)

- To eliminate the errors, declare the variable outside of the true block:

```
public static void main(String[] args) {
    Scanner console = new Scanner(System.in);
    System.out.print("enter a positive int: ");
    int num = console.nextInt();
    double sqrt;
    if (num < 0) {
        System.out.println("number is negative;"
          + " using its absolute value");
        sqrt = Math.sqrt(num * -1);
    } else {
        sqrt = Math.sqrt(num);
    }
    System.out.println("square root = " + sqrt);
}
```

- What is the scope of `sqrt` now?

Review: Loop Patterns for n Repetitions

- Thus far, we've mainly used `for` loops to repeat something a definite number of times.
- We've seen two different patterns for this:
  - pattern 1:

```
for (int i = 0; i < n; i++) {
    <statements to repeat>
}
```

  - pattern 2:

```
for (int i = 1; i <= n; i++) {
    <statements to repeat>
}
```

Another Loop Pattern: Cumulative Sum

- We can also use a `for` loop to add up a set of numbers.
- Basic pattern (using pseudocode):

```
sum = 0
for (all of the numbers that we want to sum) {
    num = the next number
    sum = sum + num
}
```

Example of Using a Cumulative Sum

```
public class GradeAverager {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("number of grades? ");
        int numGrades = console.nextInt();

        if (numGrades <= 0) {
            System.out.println("nothing to average");
        } else {
            int sum = 0;
            for (int i = 1; i <= numGrades; i++) {
                System.out.print("grade #" + i + ": ");
                int grade = console.nextInt();
                sum = sum + grade;
            }

            System.out.println("The average is " +
              (double)sum / numGrades);
        }
    }
}
```

- Note the use of an `if-else` statement to handle invalid user inputs.

Tracing Through a Cumulative Sum

- Let's trace through this code.

```
int sum = 0;
for (int i = 1; i <= numGrades; i++) {
    System.out.print("grade #" + i + ": ");
    int grade = console.nextInt();
    sum = sum + grade;
}
```

assuming that the user enters these grades: 80, 90, 84.

`numGrades = 3`

i	i <= numGrades	grade	sum

Conditional Execution and Return Values

- With conditional execution, it's possible to write a method with more than one `return` statement.
  - example:

```
public static int min(int a, int b) {
    if (a < b) {
        return a;
    } else {
        return b;
    }
}
```

- Only one of the `return` statements is executed.
- As soon as you reach a return statement, the method's execution stops and the specified value is returned.
  - the rest of the method is not executed

Conditional Execution and Return Values (cont.)

- Instead of writing the method this way:

```
public static int min(int a, int b) {
    if (a < b) {
        return a;
    } else {
        return b;
    }
}
```

we could instead write it like this, without the `else`:

```
public static int min(int a, int b) {
    if (a < b) {
        return a;
    }
    return b;
}
```

- Why is this equivalent?

Conditional Execution and Return Values (cont.)

- Consider this method, which has a compile-time error:

```
public static int compare(int a, int b) {
    if (a < b) {
        return -1;
    } else if (a > b) {
        return 1;
    } else if (a == b) {
        return 0;
    }
}
```

- Because all of the `return` statements are connected to conditions, the compiler worries that no value will be returned.

Conditional Execution and Return Values (cont.)

- Here's one way to fix it:

```
public static int compare(int a, int b) {
    if (a < b) {
        return -1;
    } else if (a > b) {
        return 1;
    } else {
        return 0;
    }
}
```

Conditional Execution and Return Values (cont.)

- Here's another way:

```
public static int compare(int a, int b) {
    if (a < b) {
        return -1;
    } else if (a > b) {
        return 1;
    }

    return 0;
}
```

- Both fixes allow the compiler to know for certain that a value will *always* be returned.

Returning From a `void` Method

```
public static void repeat(String msg, int n) {
    if (n <= 0) {     // special cases
        return;
    }

    for (int i = 0; i < n; i++) {
        System.out.println(msg);
    }
}
```

- Note that this method has a return type of `void`.
  - it doesn't return a value.
- However, it still has a `return` statement.
  - used to break out of the method
  - note that there's nothing between the `return` and the `;`

Testing for Equivalent Primitive Values

- The `==` and `!=` operators are used when comparing primitives.
  - `int`, `double`, `char`, etc.
- Example:

```
Scanner console = new Scanner(System.in);
...
System.out.print("Do you have another (y/n)? ");
char choice = console.next().charAt(0);
if (choice == 'y') {    // this works just fine
    processItem();
} else if (choice == 'n') {
    return;
} else {
    System.out.println("invalid input");
}
```

Testing for Equivalent Objects

- The `==` and `!=` operators do *not* typically work when comparing *objects*. (We'll see why this is later.)
- Example:

```
Scanner console = new Scanner(System.in);
System.out.print("regular or diet? ");
String choice = console.next();
if (choice == "regular") {  // doesn't work
    processRegular();
} else {
    ...
}
```

- `choice == "regular"` compiles, but it evaluates to `false`, even when the user does enter `"regular"`!

Testing for Equivalent Objects (cont.)

- We use a special method called the `equals` method to test if two objects are equivalent.
  - example:

```
Scanner console = new Scanner(System.in);
System.out.print("regular or diet? ");
String choice = console.next();
if (choice.equals("regular")) {
    processRegular();
} else {
    ...
}
```

- `choice.equals("regular")` compares the string represented by the variable `choice` with the string `"regular"`
  - returns `true` when they are equivalent
  - returns `false` when they are not

equalsIgnoreCase()

- We often want to compare two strings without paying attention to the case of the letters.
  - example: we want to treat as equivalent:

```
"regular"
"Regular"
"REGULAR"
```

etc.

- The `String` class has a method called `equalsIgnoreCase` that can be used for this purpose:

```
if (choice.equalsIgnoreCase("regular")) {
    ...
}
```

Example Problem: Ticket Sales

- Different prices for balcony seats and orchestra seats
- Here are the rules:
  - persons younger than 25 receive discounted prices:
    - $20 for balcony seats
    - $35 for orchestra seats
  - everyone else pays the regular prices:
    - $30 for balcony seats
    - $50 for orchestra seats
- Assume only valid inputs.

Ticket Sales Program: `main` method

```
Scanner console = new Scanner(System.in);
System.out.print("Enter your age: ");
int age = console.nextInt();

if (age < 25) {
    // handle people younger than 25
    System.out.print("orchestra or balcony? ");
    String choice = console.next();

    int price;
    if (choice.equalsIgnoreCase("orchestra")) {
        price = 35;
    } else {
        price = 20;
    }

    System.out.println("The price is $" + price);
} else {
     // handle people 25 and older
     ...
}
```

Ticket Sales Program: `main` method (cont.)

```
...

} else {
    // handle people 25 and older
    System.out.print("orchestra or balcony? ");
    String choice = console.next();

    int price;
    if (choice.equalsIgnoreCase("orchestra")) {
        price = 50;
    } else {
        price = 30;
    }

    System.out.println("The price is $" + price);
}
```

Where Is the Code Duplication?

```
...
if (age < 25) {
    System.out.print("orchestra or balcony? ");
    String choice = console.next();

    int price;
    if (choice.equalsIgnoreCase("orchestra")) {
        price = 35;
    } else {
        price = 20;
    }

    System.out.println("The price is $" + price);
} else {
    System.out.print("orchestra or balcony? ");
    String choice = console.next();

    int price;
    if (choice.equalsIgnoreCase("orchestra")) {
        price = 50;
    } else {
        price = 30;
    }

    System.out.println("The price is $" + price);
}
```

Factoring Out Code Common to Multiple Cases

```
Scanner console = new Scanner(System.in);
System.out.print("Enter your age: ");
int age = console.nextInt();

System.out.print("orchestra or balcony? ");
String choice = console.next();

if (age < 25) {
     int price;
     if (choice.equalsIgnoreCase("orchestra")) {
         price = 35;
     } else {
         price = 20;
     }
} else {
     int price;
     if (choice.equalsIgnoreCase("orchestra")) {
         price = 50;
     } else {
         price = 30;
     }
}

System.out.println("The price is $" + price);
```

What Other Change Is Needed?

```
Scanner console = new Scanner(System.in);
System.out.print("Enter your age: ");
int age = console.nextInt();

System.out.print("orchestra or balcony? ");
String choice = console.next();

if (age < 25) {
     int price;
     if (choice.equalsIgnoreCase("orchestra")) {
         price = 35;
     } else {
         price = 20;
     }
} else {
     int price;
     if (choice.equalsIgnoreCase("orchestra")) {
         price = 50;
     } else {
         price = 30;
     }
}

System.out.println("The price is $" + price);
```

Now Let's Make It Structured

```
public static void main(String[] args) {
    …
    int age = console.nextInt();

    System.out.print("orchestra or balcony? ");
    String choice = console.next();
    int price;

    if (age < 25) {

        ____________________________________________________________;
    } else {
       …
    }

    System.out.println("The price is $" + price);
}
public static ________ discountPrice(___________________) {









}
```

Expanded Ticket Sales Problem

- One additional case:
  - **persons younger than 13 cannot buy a ticket**
  - persons whose age is **13-24** receive discounted prices:
    - $20 for balcony seats
    - $35 for orchestra seats
  - everyone else pays the regular prices:
    - $30 for balcony seats
    - $50 for orchestra seats

Here's the Unfactored Version

```
...
if (age < 13) {
     System.out.println("You cannot buy a ticket.");
} else if (age < 25) {
     System.out.print("orchestra or balcony? ");
     String choice = console.next();

     int price;
     if (choice.equalsIgnoreCase("orchestra")) {
         price = 35;
     } else {
         price = 20;
     }

     System.out.println("The price is $" + price);
} else {
     System.out.print("orchestra or balcony? ");
     String choice = console.next();

     int price;
     if (choice.equalsIgnoreCase("orchestra")) {
         price = 50;
     } else {
         price = 30;
     }

     System.out.println("The price is $" + price);
}
```

We now have code common to the 2nd and 3rd cases, but not the 1st.

Group the Second and Third Cases Together

```
...
if (age < 13) {
     System.out.println("You cannot buy a ticket.");
} else {
     if (age < 25) {
         System.out.print("orchestra or balcony? ");
         String choice = console.next();

         int price;
         if (choice.equalsIgnoreCase("orchestra")) {
             price = 35;
         } else {
             price = 20;
         }

         System.out.println("The price is $" + price);
     } else {
         System.out.print("orchestra or balcony? ");
         String choice = console.next();

         ...

         System.out.println("The price is $" + price);
     }
}
```

Then Factor Out the Common Code

```
...
if (age < 13) {
     System.out.println("You cannot buy a ticket.");
} else {
     System.out.print("orchestra or balcony? ");
     String choice = console.next();

     int price;
     if (age < 25) {
         if (choice.equalsIgnoreCase("orchestra")) {
             price = 35;
         } else {
             price = 20;
         }
     } else {
         if (choice.equalsIgnoreCase("orchestra")) {
             price = 50;
         } else {
             price = 30;
         }
     }

     System.out.println("The price is $" + price);
}
```

Case Study: Coffee Shop Price Calculator

- Relevant info:
  - brewed coffee prices by size:
    - tiny: $1.60
    - medio: $1.80
    - gigundo: $2.00
  - latte prices by size:
    - tiny: $2.80
    - medio: $3.20
    - gigundo: $3.60

    plus, add 50 cents for a latte with flavored syrup
  - sales tax:
    - students: no tax
    - non-students: 6.25% tax

Case Study: Coffee Shop Price Calculator (cont.)

- Developing a solution:
  1. Begin with an *unstructured* solution.
     - everything in the `main` method
     - use if-else-if statement(s) to handle the various cases
  2. Next, *factor out* code that is common to multiple cases.
     - put it either before or after the appropriate if-else-if statement
  3. Finally, create a fully *structured* solution.
     - use procedural decomposition to capture logical pieces of the solution

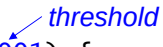
Case Study: Coffee Shop Price Calculator (cont.)

Optional: Comparing Floating-Point Values

- Because the floating-point types have limited precision, it's possible to end up with *roundoff errors*.
- Example:

```
double sum = 0.1 + 0.1 + 0.1 + 0.1 + 0.1;
sum = sum  +  0.1 + 0.1 + 0.1 + 0.1 + 0.1;
System.out.println(sum);
// get 0.9999999999999999!
```

- Thus when trying to determine if two floating-point values are equal, we usually do *not* use the == operator.
- Instead, we test if the difference between the two values is less than some small *threshold* value:




```
if (Math.abs(sum - 1.0) < 0.0000001) {
    System.out.println(sum + " == 1.0");
}
```

Optional: Another Cumulative Computation

- The same pattern can be used for other types of computations.
- Example: counting the occurrences of a character in a string.
- Let's write a static method called `numOccur` that does this.
  - examples:

```
numOccur('l', "hello") should return 2
numOccur('s', "Mississippi") should return 4
```

```
public static ___ numOccur(_____________________) {




}
```