07. Flow of Control: Branching

[ITP20003] Java Programming

Agenda

- The if-else statement
- The type boolean
- The switch statement

Flow of Control

- Flow of control is the order in which a program performs actions.
  - By default, the order has been sequential.
- A branching statement chooses between two or more possible actions.
- A loop statement repeats an action until a stopping condition occurs.
  - ➔ Learn it in the next class

The if-else Statement

- A branching statement that chooses between two possible actions.

- Syntax

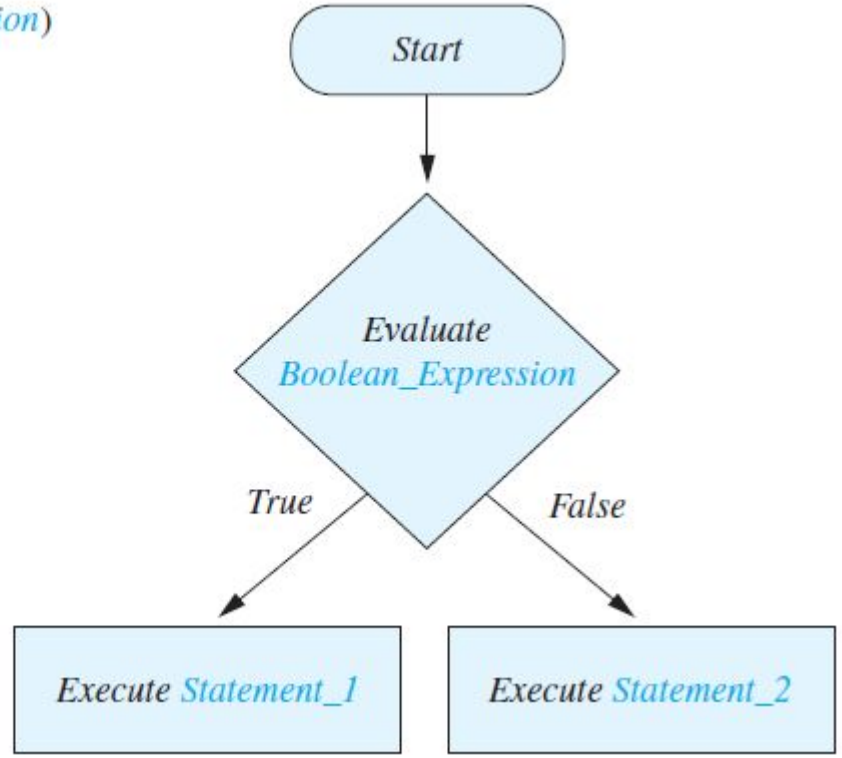
```
if (Boolean_Expression)
    Statement_1
[else                    // else part can be omitted
    Statement_2]
```

Ex)

```
if (balance >= 0)
    balance = balance + (INTEREST_RATE * balance) / 12;
else
    balance = balance - OVERDRAWN_PENALTY;
```

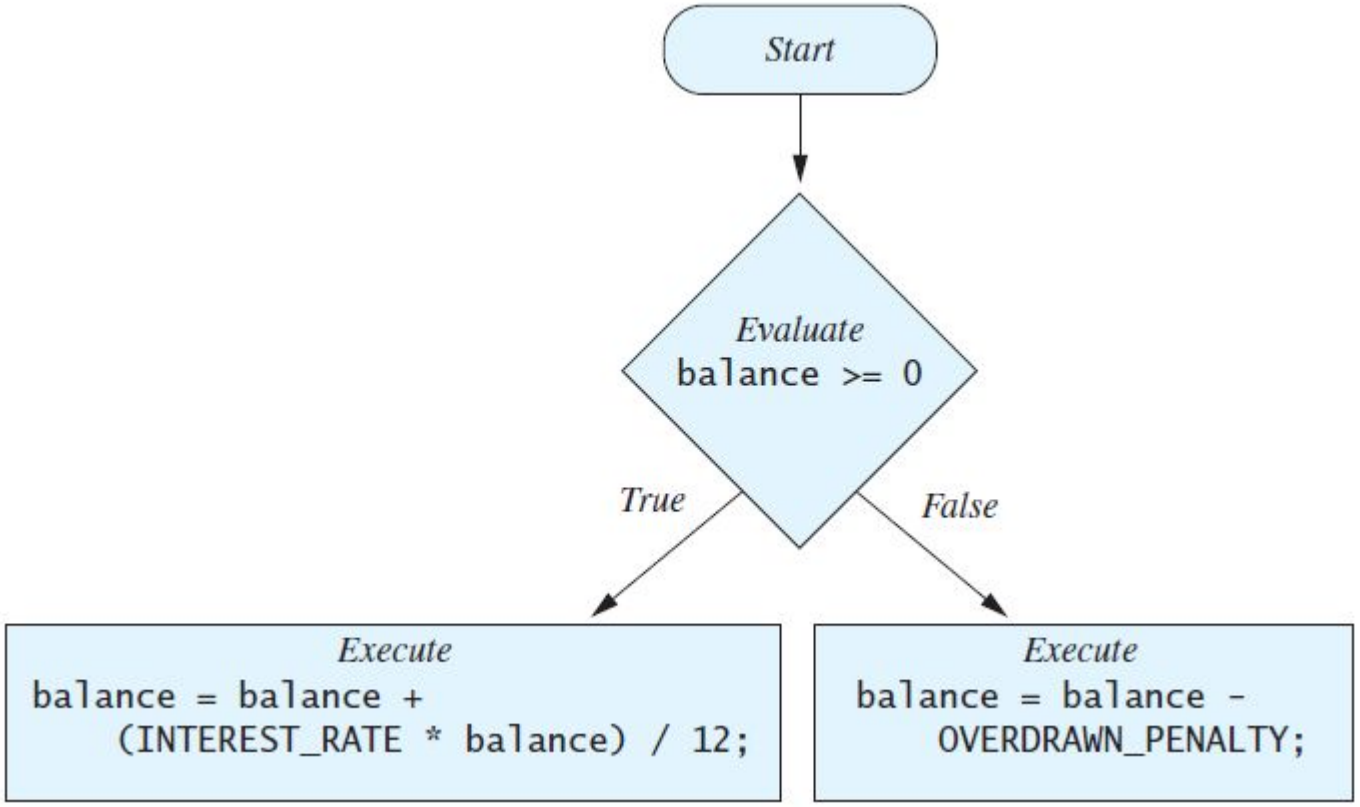
The if-else Statement

```
if (Boolean_Expression)
    Statement_1
else
    Statement_2
```



The if-else Statement

Ex) Calculating balance of a bank account



BankBalance

```
import java.util.Scanner;
public class BankBalance
{
    public static final double OVERDRAWN_PENALTY = 8.00;
    public static final double INTEREST_RATE = 0.02;              // 2% annually
    public static void main (String [] args)
    {
        double balance;
        System.out.print ("Enter your checking account balance: $");
        Scanner keyboard = new Scanner (System.in);
        balance = keyboard.nextDouble ();
        System.out.println ("Original balance $" + balance);
        if (balance >= 0)
            balance = balance + (INTEREST_RATE * balance) / 12;
        else
            balance = balance - OVERDRAWN_PENALTY;
        System.out.print ("After adjusting for one month ");
        System.out.println ("of interest and penalties,");
        System.out.println ("your new balance is $" + balance);
    }
}
```

The if-else Statement

```
Enter your checking account balance: $505.67
Original balance $505.67
After adjusting for one month of interest and penalties,
your new balance is $506.51278
```

```
Enter your checking account balance: $-15.53
Original balance $-15.53
After adjusting for one month of interest and penalties,
your new balance is $-23.53
```

Compound Statements

- To include multiple statements in a branch, enclose the statements in braces.

```
if (count < 3)
{
        total = 0;
        count = 0;
}
```

or

```
if (count < 3) {
        total = 0;
        count = 0;
}
```

Boolean Expressions

- The value of a boolean expression is either true or false.

Examples

- time < limit
- balance <= 0

- Comparison operators

Math Notation	Name	Java Notation	Java Examples
=	Equal to	==	`balance == 0` `answer == 'y'`
≠	Not equal to	!=	`income != tax` `answer != 'y'`
>	Greater than	>	`expenses > income`
≥	Greater than or equal to	>=	`points >= 60`
<	Less than	<	`pressure < max`
≤	Less than or equal to	<=	`expenses <= income`

Boolean Operators

Name	Java Notation	Java Examples
Logical *and*	&&	`(sum > min) && (sum < max)`
Logical *or*	||	`(answer == 'y') || (answer == 'Y')`
Logical *not*	!	`!(number < 0)`

Value of *A*	Value of *B*	Value of *A* && *B*	Value of *A* || *B*	Value of ! (*A*)
true	true	true	true	false
true	false	false	true	false
false	true	false	true	true
false	false	false	false	true

Compound Boolean Expressions

Examples)

```
if ((score > 0) && (score <= 100))
   …
if ((quantity > 5) || (cost < 10))
   ...
```

- Wrong example

```
if (0 < score <= 100)
```

- Note! & and | are used for other purpose (bitwise and/or)

Exclusive OR Operator

- XOR (^)
  - Allows one or the other, but not both to be true.
    - true ^ true = false
    - true ^ false = true
    - false ^ true = true
    - false ^ false = false

Using == Operator

- == is appropriate for determining if two integers or characters have the same value.

  if (a == 3)

  - where a is an integer type

- == is not appropriate for determining if two floating points values are equal. Use < and some appropriate tolerance instead.

  if (Math.abs(b - c) < epsilon)

  - where b, c, and epsilon are floating point types

Using == Operator

- == is not appropriate for determining if two objects have the same value.
  - if (s1 == s2), where s1 and s2 refer to strings, determines only if s1 and s2 refer the a common memory location.

Ex)

```
public class Test {
    public static void main(String args[]){
Scanner keyboard = new Scanner(System.in);

String s1 = keyboard.nextLine();    // user types “Hello”
String s2 = keyboard.nextLine();    // user types “Hello”

System.out.println("s1 = " + s1);
System.out.println("s2 = " + s2);
System.out.println("Expression s1 == s2 is " + (s1==s2));     }
}
```

Using == Operator

- == is not appropriate for determining if two objects have the same value.
  - if (s1 == s2), where s1 and s2 refer to strings, determines only if s1 and s2 refer the a common memory location.

Ex)

```
public class Test {
    public static void main(String args[])
Scanner keyboard = new Scanner(

String s1 = keyboard.nextLine();    //
String s2 = keyboard.nextLine();    // user types "Hello"

System.out.println("s1 = " + s1);
System.out.println("s2 = " + s2);
System.out.println("Expression s1 == s2 is " + (s1==s2));     }
}
```

```
s1 = Hello
s2 = Hello
Expression s1 == s2 is false
```

String Comparison

- To test the equality of objects of class String, use method equals.

  String.equals(*other_String*)

  Ex)

  s1.equals(s2)

  or

  s2.equals(s1)

- To test for equality ignoring case, use method equalsIgnoreCase.

  String.equalsIgnoreCase(Other_String)

  Ex) "Hello".equalsIgnoreCase("hello")

Testing Strings for Equality

```
import java.util.Scanner;
public class StringEqualityDemo
{
   public static void main (String [] args)
   {
      String s1, s2;
      System.out.println ("Enter two lines of text:");
      Scanner keyboard = new Scanner (System.in);
      s1 = keyboard.nextLine ();
      s2 = keyboard.nextLine ();
      if (s1.equals (s2))
         System.out.println ("The two lines are equal.");
      else
         System.out.println ("The two lines are not equal.");
      if (s2.equals (s1))
         System.out.println ("The two lines are equal.");
      else
         System.out.println ("The two lines are not equal.");
      if (s1.equalsIgnoreCase (s2))
         System.out.println (
               "But the lines are equal, ignoring case.");
      else
         System.out.println (
               "Lines are not equal, even ignoring case.");
   }
}
```

Testing Strings for Equality

- Result

```
Enter two lines of text:
Java is not coffee.
Java is NOT COFFEE.
The two lines are not equal.
The two lines are not equal.
But the lines are equal, ignoring case.
```

Comparing Strings

- Strings can be compared using method compareTo.
- String.compareTo method
  - Syntax
    - String_1.compareTo(String_2)
  - Returns
    - a negative number if String_1 precedes String_2
    - zero if the two strings are equal
    - a positive number of String_2 precedes String_1.

Comparing Strings

- compareTo can be combined with methods toUpperCase or toLowerCase.

  Ex) String1.toUpperCase().compareTo(String2.toUpperCase())

Ex)

```
String s1 = "Hello";
String lowerS1 = s1.toLowerCase();
String s2 = "hello";
if (s1.compareTo(s2)) == 0)
        System.out.println("Equal!");
```

Nested Statements

- An if-else statement can contain any sort of statement within it.

```
if (Boolean_Expression_1)
        if (Boolean_Expression_2)
                Statement_1;
        else
                Statement_2;
else
       if (Boolean_Expression_3)
                Statement_3;
        else
                Statement_4;;
```

Nested Statements

- Each *else* is paired with the nearest unmatched if.
- If used properly, indentation communicates which *if* goes with which *else*.
- Braces can be used like parentheses to group statements.

Nested Statements

- Subtly different forms

First Form

```
if (a > b)
{
    if (c > d)
        e = f
}
    else
        g = h;
```

Second Form

```
if (a > b)
    if (c > d)
        e = f
    else
        g = h;

// oops
```

Compound Statements

- When a list of statements is enclosed in braces ({}), they form a single compound statement.

- A compound statement can be used wherever a statement can be used.

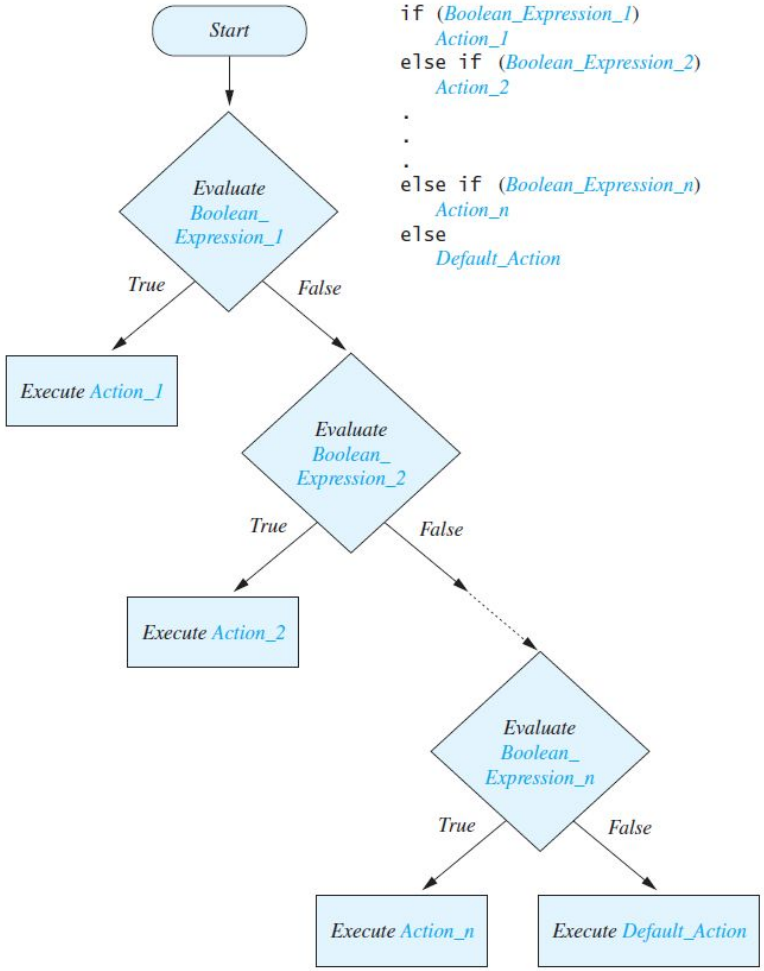
Ex)

```
if (total > 10)
{
        sum = sum + total;
        total = 0;
}
```

Multibranch if-else Statements

- Syntax

```
if (Boolean_Expression_1)
        Statement_1
else if (Boolean_Expression_2)
        Statement_2
else if (Boolean_Expression_3)
        Statement_3
else if …
        …
else
        Default_Statement
```



Multibranch if-else Statements

```
import java.util.Scanner;
public class Grader
{
    public static void main (String []
args)
    {
        int score;
        char grade;
        System.out.println ("Enter your
score: ");
        Scanner keyboard = new
Scanner (System.in);
        score = keyboard.nextInt ();
        if (score >= 90)
            grade = 'A';
        else if (score >= 80)
            grade = 'B';
        else if (score >= 70)
            grade = 'C';
        else if (score >= 60)
            grade = 'D';
        else
            grade = 'F';
        System.out.println (
              "Score = " + score);
        System.out.println (
                    "Grade = " + grade);
    }
}
```

Multibranch if-else Statements

- Result

```
Enter your score:
85
Score = 85
Grade = B
```

Multibranch if-else Statements

- Equivalent code

```
if (score >= 90)
    grade = 'A';
else if ((score >= 80) && (score < 90))
    grade = 'B';
else if ((score >= 70) && (score < 80))
    grade = 'C';
else if ((score >= 60) && (score < 70))
    grade = 'D';
else
    grade = 'F';
```

The Conditional Operator

```
if (n1 > n2)
        max = n1;
else
        max = n2;
```

can be written as

```
max = (n1 > n2) ? n1 : n2;
```

- The ? and : together are call the conditional operator (ternary operator)

- The conditional operator is useful with print and println statements.

```
System.out.print("You worked " + hours + ((hours > 1) ? "hours" : "hour"));
```

The *exit* Method

- Sometimes a situation arises that makes continuing the program pointless.

- A program can be terminated normally by System.exit(0).

```
if (numberOfWinners == 0) {
    System.out.println("Error: Dividing by zero.");
    System.exit(0);
} else {
    oneShare = payoff / numberOfWinners;
    System.out.println("Each winner will receive $" + oneShare);
}
```

Agenda

- The if-else statement
- The type boolean
- The switch statement

The Type boolean

- The type boolean is a primitive type with only two values: true and false.

- Boolean variables can make programs more readable.

```
if (systemsAreOK)
```

instead of

```
if((temperature <= 100) && (thrust >= 12000)
    && (cabinPressure > 30) && …)
```

Boolean Expressions and Variables

- Variables, constants, and expressions of type boolean all evaluate to either true or false.

- A boolean variable can be given the value of a boolean expression by using an assignment operator.

```
boolean isPositive = (number > 0);
...
if (isPositive) ...
```

- Naming boolean variable
  - Good examples - isPositive or systemsAreOk
  - Bad examples - numberSign or systemStatus

Precedence Rules

- Parentheses should be used to indicate the order of operations.
- When parentheses are omitted, the order of operation is determined by precedence rules.
  - Operations with higher precedence are performed before operations with lower precedence.
- Operations with equal precedence are done left-to-right (except for unary operations which are done right-to-left).

Precedence Rules

Highest Precedence

First: the unary operators +, −, ++, −−, and !

Second: the binary arithmetic operators *, /, %

Third: the binary arithmetic operators +, −

Fourth: the boolean operators <, >, <=, >=

Fifth: the boolean operators ==, !=

Sixth: the boolean operator &

Seventh: the boolean operator |

Eighth: the boolean operator &&

Ninth: the boolean operator ||

Lowest Precedence

Precedence Rules

- In what order are the operations performed?

```
score < min/2 - 10 || score > 90
```

Short-circuit Evaluation

- Sometimes only part of a boolean expression needs to be evaluated to determine the value of the entire expression.
  - If the first operand associated with an || is true, the expression is true.
  - If the first operand associated with an && is false, the expression is false.

- This is called short-circuit or lazy evaluation.

Short-circuit Evaluation

- Short-circuit evaluation is not only efficient, but sometimes essential!
  - A run-time error can result, for example, from an attempt to divide by zero.
    - if(sum/number > 5)
    - if((number != 0) && (sum/number > 5))

Input and Output of Boolean Values

Ex)

```
boolean booleanVar = false;
System.out.println(booleanVar);
System.out.println("Enter a boolean value:");
Scanner keyboard = new Scanner(System.in);
booleanVar = keyboard.nextBoolean();
System.out.println("You entered " + booleanVar);
```

- Result

```
false
Enter a boolean value: true  // the user typed true
You entered true
```

Agenda

- The if-else statement
- The type boolean
- The switch statement

The *switch* Statement

- The switch statement is a multiway branch that makes a decision based on an integral (integer or character) expression.
  - Java 7 allows String expressions

```
switch(Controlling_Expression)
{
    case Case_Label:
      Statements;
      break;
    case Case_Label:
      …
    default:
      …
}
```

The *switch* Statement

- The list is searched for a case label matching the controlling expression.
  - The action associated with a matching case label is executed.
  - The action for each case typically ends with the word break.
- If no match is found, the case labeled default is executed.
  - The default case is optional, but recommended, even if it simply prints a message.
- Repeated case labels are not allowed.

Enumerations

- Consider a need to restrict contents of a variable to certain values

  Ex) days in a week, HGU building names, …

- An enumeration lists the values a variable can have

  Ex)

```
enum MovieRating { E, A, B }

MovieRating rating;
rating = MovieRating.A;
```

  - Internally, enumeration values are treated as integers.

    ➔ Can be used for controlling expression of switch statement

Enumerations

- Now possible to use in a switch statement

```
switch (rating)
{
   case E: //Excellent
      System.out.println("You must see this movie!");
      break;
   case A: //Average
      System.out.println("This movie is OK, but not great.");
      break;
   case B: // Bad
      System.out.println("Skip it!");
      break;
   default:
      System.out.println("Something is wrong.");
}
```

Reading enum with Scanner Object

```
import java.util.Scanner;

public class Test {
    enum Days { SUN, MON, TUE, WED, THU, FRI, SAT };

    public static void main(String args[]){
        Days a;
        System.out.println("What's your favorite day? ");
        Scanner keyboard = new Scanner(System.in);
        a = Days.valueOf(keyboard.next());

        System.out.println("Your favorite day is " + a);
    }
}
```