Module 4

Expressions and Flow Control

Objectives

- Distinguish between instance and local variables
- Describe how to initialize instance variables
- Identify and correct a `Possible reference before assignment` compiler error
- Recognize, describe, and use Java software operators
- Distinguish between legal and illegal assignments of primitive types

Objectives

- Identify `boolean` expressions and their requirements in control constructs
- Recognize assignment compatibility and required casts in fundamental types
- Use `if`, `switch`, `for`, `while`, and `do` constructions and the labelled forms of `break` and `continue` as flow control structures in a program

Relevance

- What types of variables are useful to programmers?
- Can multiple classes have variables with the same name and, if so, what is their scope?
- What types of control structures are used in other languages? What methods do these languages use to control flow?

Variables and Scope

Local variables are:

- Variables that are defined inside a method and are called *local*, *automatic*, *temporary*, or *stack* variables
- Variables that are created when the method is executed are destroyed when the method is exited

Variable initialization comprises the following:

- Local variables require explicit initialization.
- Instance variables are initialized automatically.

Variable Scope Example

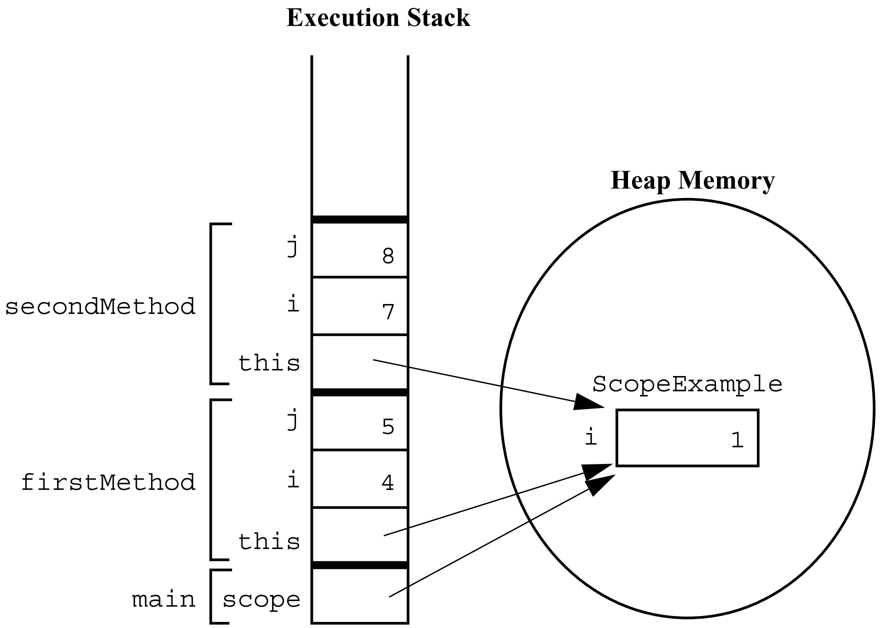
```
public class ScopeExample {
  private int i=1;

  public void firstMethod() {
    int i=4, j=5;

    this.i = i + j;
    secondMethod(7);
  }
  public void secondMethod(int i) {
    int j=8;
    this.i = i + j;
  }
}


public class TestScoping {
  public static void main(String[] args) {
    ScopeExample scope = new ScopeExample();

    scope.firstMethod();
  }
}
```



Variable Initialization

Variable	Value
`byte`	`0`
`short`	`0`
`int`	`0`
`long`	`0L`
`float`	`0.0F`
`double`	`0.0D`
`char`	`'\u0000'`
`boolean`	`false`
All reference types	`null`

Initialization Before Use Principle

The compiler will verify that local variables have been initialized before used.

```
3     public void doComputation() {
4       int x = (int)(Math.random() * 100);
5       int y;
6       int z;
7       if (x > 50) {
8         y = 9;
9       }
10      z = y + x;  // Possible use before initialization
11    }
```

```
javac TestInitBeforeUse.java
TestInitBeforeUse.java:10: variable y might not have been initialized
    z = y + x;  // Possible use before initialization
        ^

1 error
```

Operator Precedence

Operators	Associative
++ -- + *unary* - *unary* ~ ! (<data_type>)	R to L
* / %	L to R
+ -	L to R
<< >> >>>	L to R
< > <= >= instanceof	L to R
== !=	L to R
&	L to R
^	L to R
|	L to R
&&	L to R
||	L to R
<boolean_expr> **?** <expr1> **:** <expr2>	R to L
= *= /= %= += -= <<= >>= >>>= &= ^= |=	R to L

Logical Operators

- The `boolean` operators are:

```
! - NOT    & - AND
| - OR     ^ - XOR
```

- The short-circuit `boolean` operators are:

```
&& - AND   || - OR
```

- You can use these operators as follows:

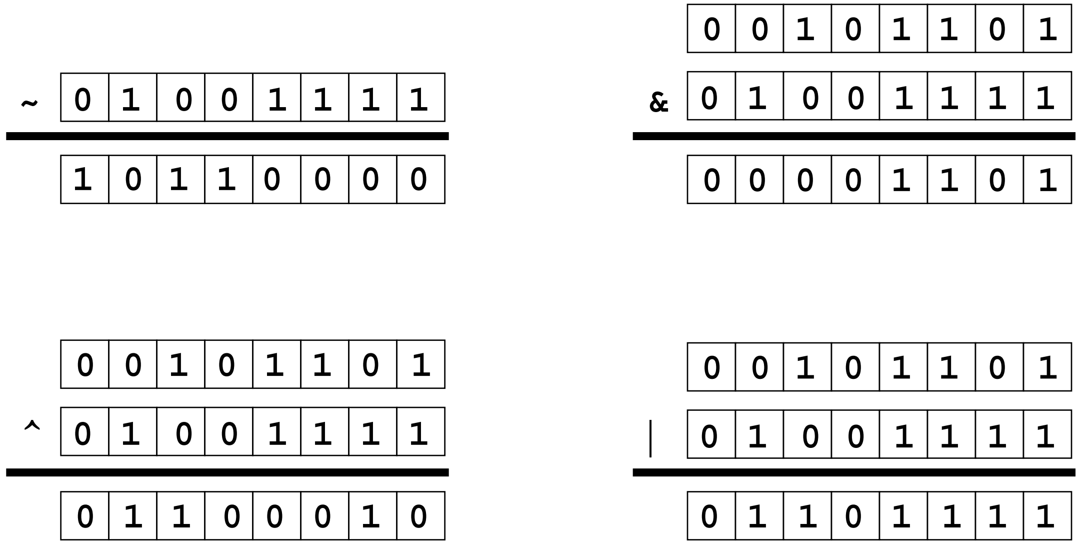
```
MyDate d = reservation.getDepartureDate();
if ( (d != null) && (d.day > 31) {
  // do something with d
}
```

Bitwise Logical Operators

- The integer *bitwise* operators are:

```
~ - Complement  & - AND
^ - XOR         | - OR
```

- Byte-sized examples include:



```
~ 0 1 0 0 1 1 1 1          0 0 1 0 1 1 0 1
  ---------------        & 0 1 0 0 1 1 1 1
  1 0 1 1 0 0 0 0          ---------------
                           0 0 0 0 1 1 0 1

  0 0 1 0 1 1 0 1          0 0 1 0 1 1 0 1
^ 0 1 0 0 1 1 1 1        | 0 1 0 0 1 1 1 1
  ---------------          ---------------
  0 1 1 0 0 0 1 0          0 1 1 0 1 1 1 1
```

Right-Shift Operators >> and >>>

- *Arithmetic* or *signed* right shift (>>) operator:
  - Examples are:

    `128 >> 1  returns` $128/2^{1} = 64$
    `256 >> 4  returns` $256/2^{4} = 16$
    `-256 >> 4 returns` $-256/2^{4} = -16$

  - The sign bit is copied during the shift.
- *Logical* or *unsigned right-shift* (>>>) operator:
  - This operator is used for bit patterns.
  - The sign bit is not copied during the shift.

Left-Shift Operator <<

- Left-shift (<<) operator works as follows:

```
128 << 1 returns 128 * 2^1 = 256
16  << 2 returns  16 * 2^2 = 64
```

Shift Operator Examples

1357 =	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	1	0	1
-1357 =	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	1	1
1357 >> 5 =	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
-1357 >> 5 =	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1
1357 >>> 5 =	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
-1357 >>> 5 =	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1
1357 << 5 =	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	1	0	1	0	0	0	0	0
-1357 << 5 =	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	1	1	0	0	0	0	0

String Concatenation With +

- The + operator works as follows:
  - Performs `String` concatenation
  - Produces a new `String`:

```
String salutation = "Dr.";
String name = "Pete" + " " + "Seymour";
String title = salutation + " " + name;
```

- One argument must be a `String` object.
- Non-strings are converted to `String` objects automatically.

Casting

- If information might be lost in an assignment, the programmer must confirm the assignment with a cast.
- The assignment between `long` and `int` requires an explicit cast.

```
long bigValue = 99L;
int squashed = bigValue;        // Wrong, needs a cast
int squashed = (int) bigValue; // OK

int squashed = 99L;             // Wrong, needs a cast
int squashed = (int) 99L;       // OK, but...
int squashed = 99;              // default integer literal
```

Promotion and Casting of Expressions

- Variables are promoted automatically to a longer form (such as `int` to `long`).
- Expression is *assignment-compatible* if the variable type is at least as large (the same number of bits) as the expression type.

```
long bigval = 6;     // 6 is an int type, OK
int smallval = 99L;  // 99L is a long, illegal

double z = 12.414F;  // 12.414F is float, OK
float z1 = 12.414;   // 12.414 is double, illegal
```

Simple `if, else` Statements

The `if` statement syntax:

```
if ( <boolean_expression> )
  <statement_or_block>
```

Example:

```
if ( x < 10 )
  System.out.println("Are you finished yet?");
```

or (*recommended*):

```
if ( x < 10 ) {
  System.out.println("Are you finished yet?");
}
```

Complex `if, else` Statements

The `if-else` statement syntax:

```
if ( <boolean_expression> )
  <statement_or_block>
else
  <statement_or_block>
```

Example:

```
if ( x < 10 ) {
  System.out.println("Are you finished yet?");
} else {
  System.out.println("Keep working...");
}
```

Complex if, else Statements

The if-else-if statement syntax:

```
if ( <boolean_expression> )
  <statement_or_block>
else if ( <boolean_expression> )
  <statement_or_block>
```

Example:

```
int count = getCount(); // a method defined in the class
if (count < 0) {
  System.out.println("Error: count value is negative.");
} else if (count > getMaxCount()) {
  System.out.println("Error: count value is too big.");
} else {
  System.out.println("There will be " + count +
                     " people for lunch today.");
}
```

Switch Statements

The `switch` statement syntax:

```
switch ( <expression> ) {
  case <constant1>:
    <statement_or_block>*
    [break;]
  case <constant2>:
    <statement_or_block>*
    [break;]
  default:
    <statement_or_block>*
    [break;]
}
```

Switch Statements

A switch statement example:

```
switch ( carModel ) {
  case DELUXE:
    addAirConditioning();
    addRadio();
    addWheels();
    addEngine();
    break;
  case STANDARD:
    addRadio();
    addWheels();
    addEngine();
    break;
  default:
    addWheels();
    addEngine();
}
```

Switch Statements

This `switch` statement is equivalent to the previous example:

```
switch ( carModel ) {
  case DELUXE:
    addAirConditioning();
  case STANDARD:
    addRadio();
  default:
    addWheels();
    addEngine();
}
```

Without the `break` statements, the execution falls through each subsequent `case` clause.

Looping Statements

The `for` loop:

```
for ( <init_expr>; <test_expr>; <alter_expr> )
  <statement_or_block>
```

Example:

```
for ( int i = 0; i < 10; i++ )
  System.out.println(i + " squared is " + (i*i));
```

or (*recommended*):

```
for ( int i = 0; i < 10; i++ ) {
  System.out.println(i + " squared is " + (i*i));
}
```

Looping Statements

The `while` loop:

```
while ( <test_expr> )
  <statement_or_block>
```

Example:

```
int i = 0;
while ( i < 10 ) {
  System.out.println(i + " squared is " + (i*i));
  i++;
}
```

Looping Statements

The do/while loop:

```
do
  <statement_or_block>
while ( <test_expr> );
```

Example:

```
int i = 0;
do {
  System.out.println(i + " squared is " + (i*i));
  i++;
} while ( i < 10 );
```

Special Loop Flow Control

- The **`break`** *`[<label>]`*`;` command
- The **`continue`** *`[<label>]`*`;` command
- The *`<label>`* **`:`** *`<statement>`* command, where *`<statement>`* should be a loop

The break Statement

```
do {
  statement;
  if ( condition ) {
    break;
  }
  statement;
} while ( test_expr );
```

The continue Statement

```
do {
  statement;
  if ( condition ) {
    continue;
  }
  statement;
} while ( test_expr );
```

Using `break` Statements with Labels

```
outer:
  do {
    statement1;
    do {
      statement2;
      if ( condition ) {
        break outer;
      }
      statement3;
    } while ( test_expr );
    statement4;
  } while ( test_expr );
```

Using continue Statements with Labels

```
test:
  do {
    statement1;
    do {
      statement2;
      if ( condition ) {
        continue test;
      }
      statement3;
    } while ( test_expr );
    statement4;
  } while ( test_expr );
```