SWEN20003
Object Oriented Software Development

A Quick Tour of Java

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The Road So Far

Lectures

- Subject Introduction

Learning Outcomes

Upon completion of this topic you will be able to:

- Identify some of the key Java features
- Understand the following in context of Java:
  - Identifiers, Data Types, Variables and Constants
  - Operators and Expressions
  - Flow of control
- Write simple Java programs

A Brief History of Java

- A programming language developed by Sun Microsystems
- The project started in 1991 by a team led by James Gosling

James Gosling

- The goal of the project at the time was to develop a language that was suitable for the next wave in computing which was expected to be the digitally controlled consumer devices (embedded systems)
- The language was then named Oak

A Brief History of Java cont..

- In 1993, there was a demise in digital consumer devices and the direction was re-focussed
- The team focussed on the “next-wave” - the Internet
- They decided to work on an embedded language for the web browser named it an *applet* (a small application)
- *JavaScript, although the name has similarities has nothing to do with Java*

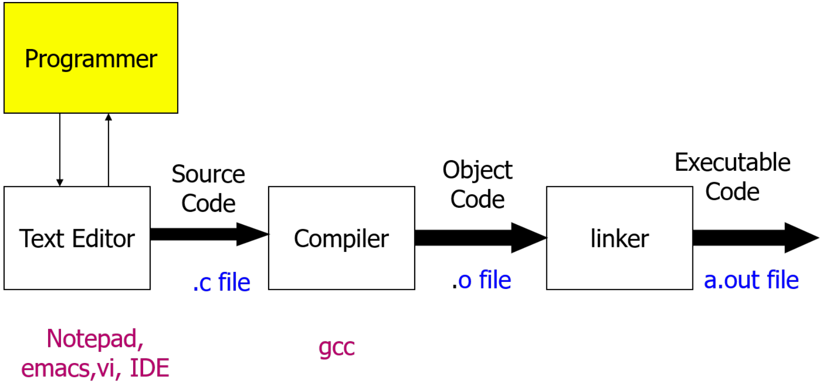
Java Features

Following are some the key features of Java which we will introduce in this topic:

- Compiled and Interpreted
- Platform-Independent and Portable
- Object Oriented

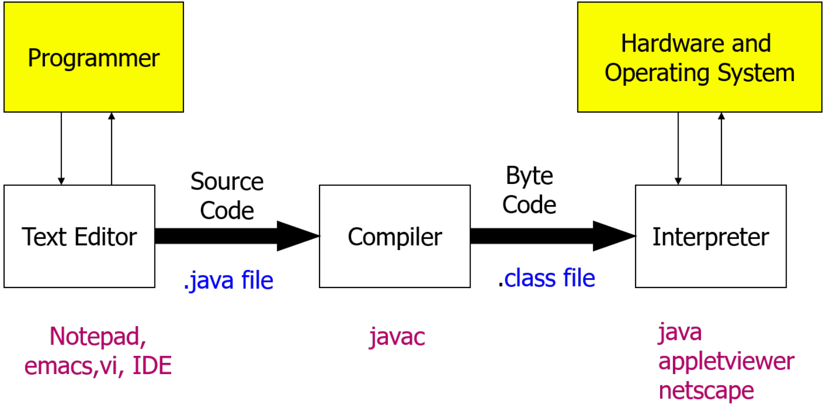
We will introduce more features as we learn new topics during the lectures.

Compiled Languages (example C)



IDE Integrated Development Environment

Java is Compiled and Interpreted



Java is Compiled and Interpreted

compiled and interpreted language is slower than
compiled and lined lanaged

Java Compiler converts java *source code* (file with extension .java) to *bytecode* (file with extension .class).

Bytecode is an intermediate form, closer to machine representation.

easily interpreted, give you some advantage of speed.

An Interpreter (virtual machine) on any target platform **interprets the bytecode.**

Porting a java system to any new platform involves writing an interpreter.

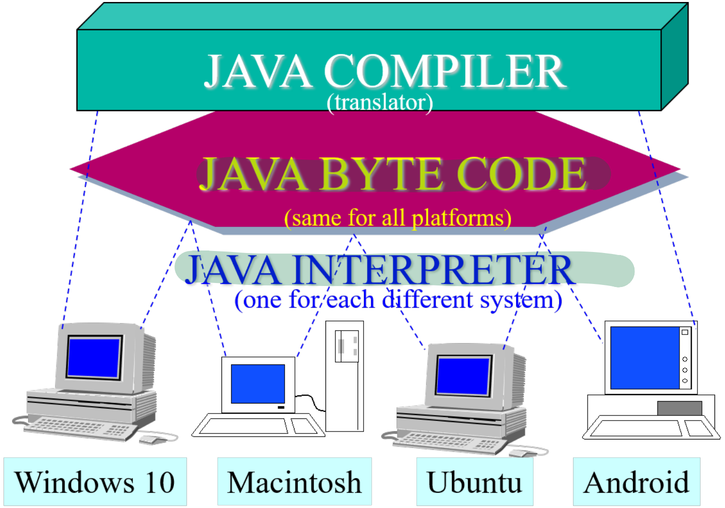
The interpreter will figure out the equivalent machine dependent code to run.

Java Features

- Compiled and Interpreted
- Platform-Independent and Portable
- Object Oriented

Platform Independent

for C, you need to change from one linker to another



Java Features

- Compiled and Interpreted
- Platform-Independent and Portable
- Object Oriented

Object Oriented

Java is an *Object Oriented Programming (OOP)* language.

Common programming constructs are: Classes, Objects, Methods etc.

We will learn more in the coming lectures!

Applications vs Applets

There are two types of Java programs:

- Application
  - Is a stand-alone program. → use command line / IDE
  - Has a main method.
  - Can be invoked from command line using the Java interpreter.
- Applet
  - A program embedded in a web page.
  - Has no main method.
  - Can be be run by a Java enabled web browser.

In the context of this subject we will only study Java Applications; Java Applets is a bit of an outdated technology - hardly used today.

Building your first Java Program

Let us try it out!

Hello World in Java

comment

```java
// HelloWorld.java: Display "Hello World!" on the screen

import java.lang.*;

public class HelloWorld {

    public static void main(String args[]) {

        System.out.println("Hello World!");

    }

}
```

小写 l

Program Output:

```
Hello World!
```

Hello World in Java and compared with C

```
// HelloWorld.java: Display "Hello World!" on the screen
import java.lang.*;
public class HelloWorld {
    public static void main(String args[]) {
        System.out.println("Hello World!");
        return;
    }
}
```

optional

name

return type. void mean return nothing

main method

[?]

method

argument as a array

array has fix length.

String args[]

or String[] args

```
/* helloworld.c: Display "Hello World!" on the screen */
#include <stdio.h>

int main(int argc, char *argv[]) {
    printf("Hello World! \n");
    return 0;
}
```

Hello World - Line by Line

Line 1:

- This is a comment in Java, similar to line 1 of the C program
- Java supports 3 types of comments:
  - /* */ - Usually used from multi-line comments, similar to C.
  - // - Used for single line comments.
  - /** */ - Documentation comments, will learn more later.

c-type comment
single-line comment
documentation comment

Line 2: `import java.lang.*;`

- Serves the same purpose as the `#include` statement used in C.
- Is used to import additional *classes* (similar to libraries used in C).
- In Java, classes are grouped into *packages*.
- Packages may be defined by different people and may even have same class and method names, but they differ by package name (will learn more later): e.g. `ibm.mathlib.*`, `microsoft.mathlib.*`
- By default Java imports `java.lang.*` package, therefore, this statement is optional.

Hello World - Line by Line

Line 3: `public class HelloWorld {`

- Class definition - in Java everything is defined in a class (we will learn more about classes, and the keyword `public` later).
- The name of the class must be the same as the Java file name (`HelloWorld` class must be saved in a file `HelloWorld.java`)

Line 4: `public static void main(String args[])`

- Definition of the `main` method, very similar to C.
- A standalone Java program must have a `main` method.
- A class can have only one `main()` method.
- We will learn about keywords `public` and `static` later.
- `String args[]`: Defines command line arguments, similar to C.

Hello World - Line by Line

Line 5: `System.out.println("Hello World!");`

- Serves the same purpose as the `printf` function in C, except `println` is called a *method*, as opposed to a *function* in C.
- `System.out`: `out` is an *object* in the *class* `System`; this class is defined in the `java.lang` package - you will learn more about classes, objects, methods and packages in the coming lectures.

Line 6: `return`

- This is optional, and usually not included, just included here for comparison with C.

Compiling and Running `HelloWorld.java`

name of file must match the name of class

1. Write the Java program using a text editor (e.g. notepad, vim), and save in a file `HellowWorld.java` - you will learn to use an Integrated Development Program (IDE) later
2. Ensure that the java build and runtime environment is installed on the machine.
   - Open a command window and type the commands:

compiler ← `javac -version`, `java -version` → intepreter

3. Compile the program using the following command:

```
javac HelloWorld.java
```

   The command if successful will generate a file `HelloWorld.class`

4. Run the program using the following command:

```
java HelloWorld
```

   You should see the following output:

```
Hello World!
```

Command Line Arguments

If you run java HelloWorld with command line arguments as follows:

```
java HelloWorld Asutralia England France
```

args[] (defined in public static void main(String args[])) will contain the command line argements:

```
args[0] -> Australia
args[1] -> England
args[2] -> France
```

array

string array

Command Line Arguments - Example

```java
// CommandLineTest.java - Program with command line arguments
public class CommandLineTest {
    public static void main(String args[]) {
        int count, i=0;
        count = args.length;
        System.out.println("Number of arguments = " +  count);
        while(i < count) {
            System.out.println("arg[" + i + "]: "    + args[i]);
            i = i + 1;
        }
    }
}
```

→ how many command line arguments

contain count in the string

concatenate to string

If you run: `java CommandLineTest Australia England France`

Program Output:

```
Number of arguments = 3
arg[0]: Australia
arg[1]: England
arg[2]: France
```

Differences between Java and C

Java is an Object Oriented language : C is a Procedural Language.

Java has no goto, sizeof and typedef statements.

Java has no structures and unions.

Java has no explicit pointer type.

Java has no Preprocessor: no `#define`, `#include`, `#indef`

Java is safe and well defined: e.g. memory is managed by the virtual machine not by the programmer.

Identifiers, Data Types, Variables and Constants

Identifiers

Keyword

Identifier: A name that uniquely identifies a program element such as a class, object, variable, method.

Java identifier **rules**:

- must not start with a digit
- all the characters must be letters, digits, or the underscore symbol
- can theoretically be of any length
- are case-sensitive: `Rate`, `rate`, and `RATE` are different variables

Java identifier **conventions**:

- variables, methods, and objects: start with a lower case letter, indicate "word" boundaries with an uppercase letter, and restrict the remaining characters to digits and lowercase letters (e.g. `topSpeed`, `bankRate`, `timeOfArrival`)
- classes: start with an upper case letter and, otherwise, adhere to the rules above (e.g. `PrintDemo`, `HelloWorld`)

Identifiers

Identifiers that have a predefined meaning in Java, such as **keywords** and **reserved words**, must not be used as as identifiers in your programs: e.g. `public, class, void, static`

Identifiers that are defined in libraries required by the Java language standard packages are **predefined identifiers**;

- although they can be redefined, this could be confusing and dangerous because doing so would change their standard meaning. e.g `System, String, println`

Java Data Types

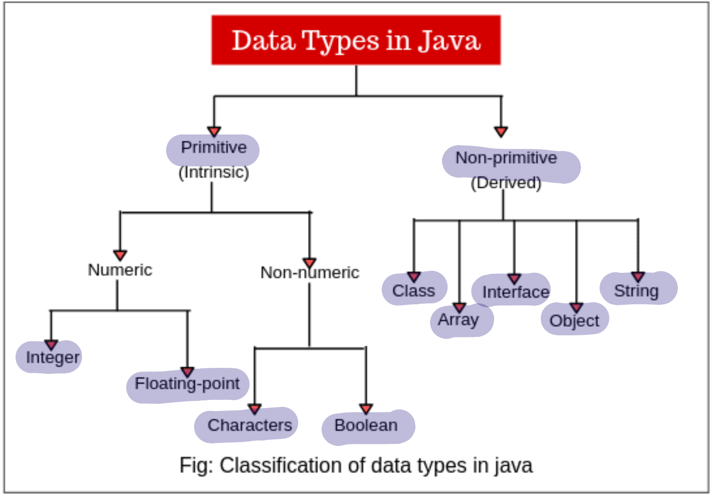
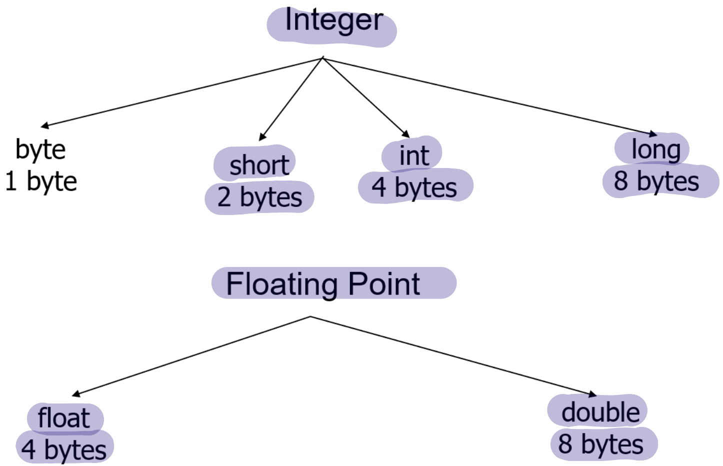


Fig: Classification of data types in java

From: `https://www.scientecheasy.com/2018/06/data-types-in-java-primitive-example.html`

Java Data Types

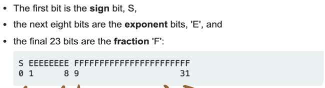


if (a<b) c=1;

不用括号 (one condition)

Java Data Types

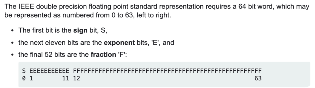
single-precision



- The first bit is the **sign** bit, S,
- the next eight bits are the **exponent** bits, 'E', and
- the final 23 bits are the **fraction** 'F':

```
S EEEEEEEE FFFFFFFFFFFFFFFFFFFFFFF
0 1      8 9                    31
```

double-precision



The IEEE double precision floating point standard representation requires a 64 bit word, which may be represented as numbered from 0 to 63, left to right.

- The first bit is the **sign** bit, S,
- the next eleven bits are the **exponent** bits, 'E', and
- the final 52 bits are the **fraction** 'F':

```
S EEEEEEEEEEE FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
0 1        11 12                                                63
```

Floating point numbers:

- `float` type has single-precision.
- `double` type has double-precision.
- Generally, floating point numbers are treated as double-precision numbers. To force them to be in single precision we must append f or F to the number:

  e.g. `float a = 2.3F; double b = 6.7;`

reason to use float is to save space

float ~~c=1.7~~;

float c=1.7F;

Float is not a primitive data type.

↓

derived data type

wrapper class

String is a derived data type.

Array

Boolean numbers:

- Java `boolean` type variables can hold a `true` or `false`:

  e.g. `boolean x = true;`

final char CONST = ~~"Z"~~ ;

'Z';

boolean ~~c=0;~~ → compilation error

Variables

Keyword

Variable: Refers to information that is stored in program memory that can be changed; a variable has a memory location and an identifier.

- Variables must be *declared* and *initialized* before use.
  Syntax:

```
    <type> <variable name> = <initial value>;
```

Examples:

```
    int   count = 1;
    float length = 2.3F;
    double height = 6.7;
    boolean status = true;
```

three variable types

instance variable

static (or class)

local variable

↓

define inside the method.

does not exist out of method

Variables

- *Assignment operator* (=) is used to change the value of a variable. Syntax:

```
<variable name> = <other variable name> OR  <value> OR <expression>;
```

Examples:

```
int countX = 1, countY = 2;
countX = countY;
countY = countY + countX;
countX += 3; // Shorthand operator countX = countX + 3;
```

- In general, the value of one type cannot be stored in a variable of another type, but there are exceptions: Examples:

float
double cannot save in int
but int can save as double

```
int intVariable = 2.99; // Not a valid assignment
double doubleVariable = 2; // Is a valid assignment
```

[?] so what does this really save is 2.000... ?

Variables

- A value of any type in the following list can be assigned to a variable of any type that appears to the right of it:

left → right   V.

right → left   typecast

```
byte -> short -> int -> long -> float -> double
char -> int
```

- An explicit **type cast** is required to assign a value of one type to a variable whose type appears to the left of it on the above list (e.g., double to int).

  Examples:

[1] cut the fraction part

```
int x = 2.99; // Not a valid assignment
int y = (int)2.99; // Is a valid assignment; y will be 2 not 3
```

- Variables of type `int` cannot be assigned to a variable of type `boolean`, nor can a variable of type `boolean` be assigned to a variable of type `int`.

Variables

- Java variables are classified into three categories.
  - **instance** variables
  - **static** (or **class**) variables
  - **local** variables

Keyword

Local Variables: Variables defined inside a Java method.

We will introduce *instance* and *static* variables in the coming lectures.

Constants

Keyword

Constant: A value that does not change during the execution of the program; also called READ only values.

- Constants are declared with the Java key word `final`. Examples:

```
final  int MAX_LENGTH = 420;
final  double  PI = 3.1428;
final  char   CHAR_CONSTANT = 'Z';
final  boolean BOOL_CONSTANT = true;
final  String STRING_CONSTANT = "Welcome to Java";
```

- By convention upper case letters are used for defining constants.
- Data type must be explicitly specified when defining constants; this is not required in C.

Variables and Constants - Example Program

```java
// ConstantsVariablesExample.java
// Demonstrates the use of constants and variables
public class ConstantsVariablesExample {
    public static void main(String args[]) {
        final double PI = 3.1428;
        // All the variables below are local variables
        float radius = 5.5F;
        double area;
        boolean x = true;
        area = PI * radius * radius;
        System.out.println("Circle Radius = "
                    + radius + " Area = " + area);
        System.out.println("Boolean Value = " + x);
    }
}
```

Program Output:

```
Circle Radius = 5.5 Area = 95.0697
Boolean Value = true
```

Operators and Expressions

average of two floating point number

Java method

```
static float calculateAvg ( float a , float b ) {
    float result ;
    result = (a+b) /2 ;
    return result;
}
```

public - accessible in your whole program

static

Operators

Java Operators can be classified into the following related categories.

- Arithmetic
- Relational
- Logical
- Assignment
- Increment and decrement
- Conditional
- Bitwise
- Special

Arithmetic Operators

Operator	Meaning
$+$	Addition and unary plus
$-$	Subtraction or unary minus
$*$	Multiplication
$/$	Division
%	Modulo division

real operand [?]

Note: When one of the operands is real and the other is an integer, the expression is called a mixed-mode arithmetic expression. If either operand is of real type, then the other operand is also converted to real and real arithmetic is performed.

Arithmetic Operators - Example

```java
// ArithmeticExample.java - Using arithmetic operators
public class ArithmeticExample {
    public static void main(String args[]) {
        float a = 20.5F, b = 6.4F;
        int c = 11, d = 5;
        System.out.println("a + b = " + (a+b));
        System.out.println("a - b = " + (a-b));
        System.out.println("a*b = " + (a*b) );
        System.out.println("a/b = " + (a/b));
        System.out.println("c%d = " + (c%d));
    }
}
```

Program Output:

```
    a + b = 26.9
    a - b = 14.1
    a*b = 131.2
    a/b = 3.203125
    c%d = 1
```

Relational Operators

Operator	Meaning
<	Is less than
<=	Is less than or equal to
>	Is greater than
>=	Is greater than or equal to
==	Is equal to
! =	Is not equal to

Note: The result of a relational operator is type `boolean`.

→ true

→ false

Relational Operators - Example

```java
// RelationalExample.java - Using relational operators
public class RelationalExample {
    public static void main(String args[]) {
        int a = 3, b = 5;
        System.out.println("a < b = " + (a<b));
        System.out.println("a > b = " + (a>b));
        System.out.println("a <= b = " + (a<=b));
        System.out.println("a >= b = " + (a>=b));
        System.out.println("a == b = " + (a==b));
        System.out.println("a != b = " + (a!=b));
    }
}
```

Program Output:

```
a < b = true
a > b = false
a <= b = true
a >= b = false
a == b = false
a != b = true
```

Logical Operators

Operator	Meaning
&&	Logical AND
||	Logical OR
!	Logical NOT

op1	op2	op1 && op2	op1 || op2	!op1
true	true	true	true	false
true	false	false	true	false
false	true	false	true	true
false	false	false	false	true

Bitwise Operators → transfer to binary and do bit by bit

difference between logical and bitwise operation

Operator	Meaning
&	Bitwise AND
!	Bitwise OR
^	Bitwise exclusive OR
~	One's compliment
<<	Shift Left
>>	Shift Right
>>>	Shift Right with zero fill

→ XOR

Other Operators

Increment and Decrement Operators:

- ++ and −−

  Example:

```
    ++x; x++; --x; x--;
```

Conditional Operators:

- exp1 ? exp2 : exp3

  Example:

```
    x = (a > b) ? a : b;
```

This is the same as:

```
    if  (a > b)
        x = a;
    else
        x = b;
```

Mathematical Functions

Java supports mathematical functions such as `cos`, `sin`, `log` using the Math class, defined in the `java.lang` package.
The functions should be used as follows:

- `Math.method_name();`
  Example:

```
double y, z;
y = Math.sqrt(x);
z = Math.cos(y);
```

Note: Refer to Java documentation for a complete list of methods supported.

Mathematical Functions - Example

```java
// MathSqrtExample.java - Compute the square root of a number
class MathSqrtExample {
    public static void main(String args[]) {
        double x = 4;
        double y;
        y = Math.sqrt(x);
        System.out.println("The square root of " + x + " is " + y);
    }
}
```

Program Output:

```
The square root of 4.0 is 2.0
```

Flow of Control

Flow of Control

Keyword

Flow of Control: Refers to branching and looping mechanisms in the Java language.

Most branching and looping statements are controlled by boolean expressions:

- A boolean expression evaluates to either true or false.
- The primitive type boolean may only take the values true or false

Branching

Java supports the following branching statements:

- `if-else` statement
- multi-way `if-else` statement
- `switch` statement
- two way decision expression

The if-else and multi-way if-else Statements

```
if (Boolean_Expression) {
    Yes_Statements
} else {
    No_Statements
}
```

```
if (Boolean_Expression) {
    Yes_Statements_1
} else if (Boolean_Expression) {
    Yes_Statements_2
} else if (Boolean_Expression) {
    Yes_Statements_3
} else {
    Statements_For_All_Other_Possibilities
}
```

The if-else Statement - Example

```java
//IfElseExample.java - Demonstrates  if-else control flow
public class IfElseExample {
    public static void main(String args[]){
        int i = 5;
        if (i < 10) {
            System.out.println("i is less than 10");
        }
        else {
            System.out.println("i is greater than or equal to 10");
        }
    }
}
```

Program Output:

```
i is less than 10
```

The switch Statement

The switch statement supports *multi-way branching*:

```
switch (Controlling_Expression)
{
    case Case_Label_1:
        Statement_Sequence_1
        break;
    case Case_Label_2:
        Statement_Sequence_2
        break;
    case Case_Label_n:
        Statement_Sequence_n
        break;
    default:
        Default_Statement Sequence
        break;
}
```

The switch Statement - Example

```java
//SwitchExample.java - Demonstrates the switch statement
public class SwitchExample {
    public static void main (String args[]) {
        char x = 'b';
        switch(x) {
            case 'a':
                System.out.println("Chracter = a");
                break;
            case 'b':
                System.out.println("Character = b");
                break;
            default:
                System.out.println("Other character");
                break;
        }
    }
}
```

Program Output:

```
Character = b
```

The Two-way Decision Statement - Example

```
// TwoWayExample.java - Demonstrates two way decision making
class TwoWayExample {
    public static void main(String args[]) {
        int i = 5;
        int flag;
        flag = (i < 10) ? 0 : 1;
        System.out.println("Flag = " + flag);
    }
}
```

assign if condition is true

→ assign if condition is true

```
if i<10 :
    flag=0
else
    flag=1
```

Program Output:

```
Flag = 0
```

Loops

Loops in Java are similar to those in other high-level languages.

- The code that is repeated in a loop is called the body of the loop.
- Each repetition of the loop body is called an iteration of the loop.
- Loops can be nested similar to other programming languages.

Java supports the following looping statements.

- `while` statement
- `do-while` statement
- `for` statement

The while and do-while Statements

```
while (Boolean_Expression) {
    Statement_1
    Statement_2
    ....
    Statement_Last
}
```

```
do {
    Statement_1
    Statement_2
    ...
    Statement_Last
}  while (Boolean_Expression);
```

The while Statement - Example

```
// WhileExample.java - Demonstrates the use of the while statement
public class WhileExample {
    public static void main(String args[]) {
        int sum = 0, n = 1;
        while (n <= 10) {
            sum = sum + n;
            n = n + 1;
        }
        System.out.println("Sum = " + sum);
    }
}
```

Program Output:

```
Sum = 55
```

The do-while Statement - Example

```java
// DoWhileExample.java - Demonstrates the use of the do-while statement
public class DoWhileExample {
    public static void main(String[] args) {
        int sum = 0, n = 1;
        do {
            sum = sum + n;
            n = n +1;
        } while ( n <= 10);
        System.out.println("Sum = " + sum);
    }
}
```

Program Output:

```
Sum = 55
```

The for Statement

```
for (Initialize_Expressions; Terminate_Expression; Update_Expressions) {
    Statement_1
    Statement_2
    ....
    Statement_Last
}
```

Contains three types of expressions within the parentheses related to controlling variables:

- `Initialize_Expressions` - determine how the control variable or variables are *initialized* or *declared and initialized* before the first iteration
- `Terminate_Expression` - determines when the loop should end, based on the evaluation of a Boolean expression *before* each iteration
- `Update_Expressions` - determine how the control variable or variables are *updated* after each iteration of the loop body

The for Statement - Example

```java
// ForExample.java - Demonstrates the for loop
public class ForExample {
    public static void main(String[] args) {
        for (int n = 0; n < 5; n++) {
            System.out.println(" n = " + n);
        }
    }
}
```

Program Output:

```
n = 0
n = 1
n = 2
n = 3
n = 4
```

The break Statement

The break statement causes to exit the loop (while, do or for).

```
1      while(.....) {
2          ........
3          if (condition)
4              break;    // Will go to line 7    → exit the while loop
5          ........
6      }
7      ....
```

```
1      loop1: while(.....) {
2          .......
3          loop2:    while (.....) {
4              ........
5              if (condition)
6                  break loop1; // Will go to line 11    → exit loop 1 (including loop 2).
7              ........
8          }
9          ..........
10     }
11     .............
```

The break Statement - Example

you can label the loop

```
// BreakExample.java - Demonstrates the use of the break statement
public class BreakExample {
    public static void main(String[] args) {
        loop1: for (int i = 0; i < 3; i++) {
            loop2: for (int j = 0; j < 3; j++) {
                System.out.println("i=" + i + " j=" +j);
                if (j == 1)
                    break loop1;
            }
        }
    }
}
```

> if "if statement" only have one line to exeute, don't need {}

also apply to while statement

Program Output:

```
i=0 j=0
i=0 j=1
```

The continue Statement

The continue statement skips the rest of the statements in the loop (while, do or for).

```
1       while (.....) {
2           ........
3           ........
4           if (condition)
5               continue; // Will goto line 1   → still in while loop
6           ........                              skip the content in if
7           ........
8       }
9       .............
```

The continue Statement - Example

```java
// ContinueExample.java - Demonstrates the use of the continue statement
public class ContinueExample {
    public static void main(String[] args) {
        for (int i = 0; i < 3; i++) {
            for (int j = 0; j < 3; j++) {
                if (j == 1)
                    continue;
                System.out.println("i=" + i + " j=" +j);
            }
        }
    }
}
```

Program Output:

```
    i=0 j=0
    i=0 j=2
    i=1 j=0
    i=1 j=2
    i=2 j=0
    i=2 j=2
```

Learning Outcomes

Upon completion of this topic you will be able to:

- Identify some of the key Java features
- Understand the following in context of Java:
  - Identifiers, Data Types, Variables and Constants
  - Operators and Expressions
  - Flow of control
- Write simple Java programs

References

- Absolute Java by Water Savitch (Fourth Edition), Chapters 1 & 3