

Java Just in Time: Collected concepts after chapter 02

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April 15, 2011

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1 Computer basics

1.1 Computer basics: hardware (page 3)

The physical parts of a computer are known as **hardware**. You can see them, and touch them.

1.2 Computer basics: hardware: processor (page 3)

The **central processing unit (CPU)** is the part of the **hardware** that actually obeys instructions. It does this dumbly – computers are not inherently intelligent.

1.3 Computer basics: hardware: memory (page 3)

The **computer memory** is part of the computer which is capable of storing and retrieving **data** for short term use. This includes the **machine code** instructions that the **central processing unit** is obeying, and any other data that the computer is currently working with. For example, it is likely that an image from a digital camera is stored in the computer memory while you are editing or displaying it, as are the machine code instructions for the image editing program.

The computer memory requires electrical power in order to remember its data – it is **volatile memory** and will forget its contents when the power is turned off.

An important feature of computer memory is that its contents can be accessed and changed in any order required. This is known as **random access** and such memory is called **random access memory** or just **RAM**.

1.4 Computer basics: hardware: persistent storage (page 3)

For longer term storage of **data**, computers use **persistent storage** devices such as **hard discs** and **DVD ROMs**. These are capable of holding much more information than **computer memory**, and are persistent in that they do not need power to remember the information stored on them. However, the time taken to store and retrieve data is *much* longer than for computer memory. Also, these devices cannot as easily be accessed in a random order.

1.5 Computer basics: hardware: input and output devices (page 3)

Some parts of the **hardware** are dedicated to receiving input from or producing output to the outside world. Keyboards and mice are examples of **input devices**. Displays and printers are examples of **output devices**.

1.6 Computer basics: software (page 3)

One part of a computer you cannot see is its **software**. This is stored on **computer media**, such as **DVD ROMs**, and ultimately inside the computer, as lots of numbers. It is the instructions

that the computer will obey. The closest you get to seeing it might be if you look at the silver surface of a DVD ROM with a powerful magnifying glass!

1.7 Computer basics: software: machine code (page 3)

The instructions that the **central processing unit** obeys are expressed in a language known as **machine code**. This is a very **low level language**, meaning that each instruction gets the computer to do only a very simple thing, such as the **addition** of two numbers, or sending a **byte** to a printer.

1.8 Computer basics: software: operating system (page 4)

A collection of **software** which is dedicated to making the computer generally usable, rather than being able to solve a *particular* task, is known as an **operating system**. The most popular examples for modern personal computers are Microsoft Windows, Mac OS X and Linux. The latter two are implementations of Unix, which was first conceived in the early 1970s. The fact it is still in widespread use today, especially by computer professionals, is proof that it is a thoroughly stable and well **designed** and integrated platform for the expert (or budding expert) computer scientist.

1.9 Computer basics: software: application program (page 4)

A piece of **software** which is dedicated to solving a particular task, or application, is known as an **application program**. For example, an image editing program.

1.10 Computer basics: data (page 3)

Another part of the computer that you cannot see is its **data**. Like **software** it is stored as lots of numbers. Computers are processing and producing data all the time. For example, an image from a digital camera is data. You can only see the picture when you display it using some image displaying or editing software, but even this isn't showing you the actual data that makes up the picture. The names and addresses of your friends is another example of data.

1.11 Computer basics: data: files (page 5)

When **data** is stored in **persistent storage**, such as on a **hard disc**, it is organized into chunks of related information known as **files**. Files have names and can be accessed by the computer

through the **operating system**. For example, the image from a digital camera would probably be stored in a jpeg file, which is a particular type of image file, and the name of this file would probably end in .jpg or .jpeg.

1.12 Computer basics: data: files: text files (page 5)

A **text file** is a type of **file** that contains **data** stored directly as **characters** in a human readable form. This means if you were to send the raw contents directly to the printer, you would (for most printers) be immediately able to read it. Examples of text files include `README.txt` that sometimes comes with **software** you are installing, or source text for a document to be processed by the `LATEX`[6] document processing system, such as the ones used to produce this book (prior to publication). As you will see shortly, a more interesting example for you, is computer program **source code** files.

1.13 Computer basics: data: files: binary files (page 5)

A **binary file** is another kind of **file** in which **data** is stored as **binary** (base 2) numbers, and so is not human readable. For example, the image from a digital camera is probably stored as a jpeg file, and if you were to look directly at its contents, rather than use some **application program** to display it, you would see what appears to be nonsense! An interesting example of a binary file is the **machine code** instructions of a program.

2 Java tools

2.1 Java tools: text editor (page 5)

A **text editor** is a program that allows the user to type and edit **text files**. You may well have used notepad under Microsoft Windows; that is a text editor. More likely you have used Microsoft Word. If you have, you should note that it is not a text editor, it is a **word processor**. Although you can save your documents as text files, it is more common to save them as .doc **files**, which is actually a **binary file** format. Microsoft Word is not a good tool to use for creating program **source code** files.

If you are using an **integrated development environment** to support your programming, then the text editor will be built in to it. If not, there are a plethora of text editors available which are suited to Java programming.

2.2 Java tools: javac compiler (page 9)

The Java **compiler** is called javac. Java program source is saved by the programmer in a **text file** that has the suffix `.java`. For example, the text file `HelloWorld.java` might contain the source text of a program that prints `Hello world!` on the **standard output**. This text file can then be **compiled** by the Java compiler, by giving its name as a **command line argument**. Thus the command

```
javac HelloWorld.java
```

will produce the **byte code** version of it in the **file** `HelloWorld.class`. Like **machine code** files, byte code is stored in **binary files** as numbers, and so is not human readable.

2.3 Java tools: java interpreter (page 9)

When the end user wants to run a Java program, he or she invokes the java **interpreter** with the name of the program as its **command line argument**. The program must, of course, have been **compiled** first! For example, to run the `HelloWorld` program we would issue the following command.

```
java HelloWorld
```

This makes the **central processing unit** run the interpreter or **virtual machine** java, which itself then **executes** the program named as its first argument. Notice that the suffix `.java` is needed when compiling the program, but no suffix is used when **running** it. In our example here, the virtual machine finds the **byte code** for the program in the **file** `HelloWorld.class` which must have been previously produced by the **compiler**.

3 Operating environment

3.1 Operating environment: programs are commands (page 7)

When a program is **executed**, the name of it is passed to the **operating system** which finds and loads the **file** of that name, and then starts the program. This might be hidden from you if you are used to starting programs from a menu or browser interface, but it happens nevertheless.

3.2 Operating environment: standard output (page 7)

When programs **execute**, they have something called the **standard output** in which they can produce text results. If they are **run** from some kind of **command line interface**, such as a Unix **shell** or a Microsoft Windows **Command Prompt**, then this output appears in that interface while the program is running. (If they are invoked through some **integrated development environment**, browser, or menu, then this output might get displayed in some pop-up box, or special console window.)

3.3 Operating environment: command line arguments (page 8)

Programs can be, and often are, given **command line arguments** to vary their behaviour.

4 Class

4.1 Class: programs are divided into classes (page 16)

In Java, the source text for a program is separated into pieces called **classes**. The source text for each class is (usually) stored in a separate **file**. Classes have a name, and if the name is HelloWorld then the text for the class is saved by the programmer in the **text file** HelloWorld.java.

One reason for dividing programs into pieces is to make them easier to manage – programs to perform complex tasks typically contain thousands of lines of text. Another reason is to make it easier to share the pieces between more than one program – such **software reuse** is beneficial to programmer productivity.

Every program has at least one class. The name of this class shall reflect the intention of the program. By convention, class names start with an upper case letter.

4.2 Class: public class (page 16)

A **class** can be declared as being **public**, which means it can be accessed from anywhere in the running Java environment; in particular the **virtual machine** itself can access it. The source text for a public class definition starts with the **reserved word** **public**. A reserved word is one which is part of the Java language, rather than a word chosen by the programmer for use as, say, the name of a program.

4.3 Class: definition (page 16)

After stating whether it has **public** access, a **class** next has the **reserved word class**, then its name, then a left brace (`{`), its body of text and finally a closing right brace (`}`).

```
public class MyFabulousProgram
{
    ... Lots of stuff here.
}
```

5 Method

5.1 Method: main method: programs contain a main method (page 17)

All Java programs contain a section of code called **main**, and this is where the computer will start to **execute** the program. Such sections of code are called **methods** because they contain instructions on how to do something. The **main method** always starts with the following heading.

```
public static void main(String[] args)
```

5.2 Method: main method: is public (page 17)

The **main method** starts with the **reserved word public**, which means it can be accessed from anywhere in the running Java environment. This is necessary – the program could not be **run** by the **virtual machine** if the starting point was not accessible to it.

```
public
```

5.3 Method: main method: is static (page 17)

The **main method** of the program has the **reserved word static** which means it is allowed to be used in the **static context**. A context relates to the use of **computer memory** during the **running** of the program. When the **virtual machine** loads a program, it creates the static context for it, allocating computer memory to store the program and its **data**, etc.. A **dynamic context** is a certain kind of allocation of memory which is made later, during the running of the program. The program would not be able to start if the main method was not allowed to run in the static context.


```
public static
```

5.4 Method: main method: is void (page 17)

In general, a **method** (section of code) might calculate some kind of **function** or formula, and **return** the answer as a result. For example, the result might be a number. If a method returns a result then this must be stated in its heading. If it does not, then we write the **reserved word** `void`, which literally means (among other definitions) ‘without contents’. The **main method** does not return a value.

```
public static void
```

5.5 Method: main method: is the program starting point (page 17)

The starting part, or **main method**, of the program is always called `main`, because it is the main part of the program.

```
public static void main
```

5.6 Method: main method: always has the same heading (page 18)

The **main method** of a Java program must always have a heading like this.

```
public static void main(String[] args)
```

This is true even if we do not intend to use any **command line arguments**. So a typical single **class** program might look like the following.

```
public class MyFabulousProgram
{
    public static void main(String[] args)
    {
        ... Stuff here to perform the task.
    }
}
```

6 Command line arguments

6.1 Command line arguments: program arguments are passed to main (page 17)

Programs can be given **command line arguments** which typically affect their behaviour. Arguments given to a Java program are strings of text **data**, and there can be any number of them in a **list**. In Java, `String[]` means ‘list of strings’. We have to give a name for this list, and usually we call it `args`. The chosen name allows us to refer to the given data from within the program, should we wish to.

```
public static void main(String[] args)
```

6.2 Command line arguments: program arguments are accessed by index (page 26)

The **command line arguments** given to the **main method** are a **list** of strings. These are the **text data string** arguments supplied on the **command line**. The strings are **indexed** by **integers** (whole numbers) starting from zero. We can access the individual strings by placing the index value in square brackets after the name of the list. So, assuming that we call the list `args`, then `args[0]` is the first command line argument given to the program, if there is one.

7 Type

7.1 Type: String: literal (page 18)

In Java, we can have a **string literal**, that is a fixed piece of text to be used as **data**, by enclosing it in double quotes. It is called a string literal, because it is a **type** of data which is a string of **characters**, exactly as listed. Such a piece of data might be used as a message to the user.

```
"This is a fixed piece of text data -- a string literal"
```

7.2 Type: String: literal: must be ended on the same line (page 21)

In Java, **string literals** must be ended on the same line they are started on.

7.3 Type: String: concatenation (page 26)

The **+** operator, when used with two string operands, produces a string which is the **concatenation** of the two strings. For example "Hello " + "world" produces a string which is Hello (including the space) concatenated with the string world, and so has the same value as "Hello world".

There would not be much point concatenating together two **string literals** like this, compared with having one string literal which is already the text we want. We would be more likely to use concatenation when at least one of the operands is not a fixed value, i.e. is a **variable** value. For example, "Hello " + args[0] produces a string which is Hello (including the space) concatenated with the first **command line argument** given when the program is **run**.

The resulting string can be used anywhere that a single string literal could be used. For example System.out.println("Hello " + args[0]) would print the resulting string on the **standard output**.

8 Standard API

8.1 Standard API: System: out.println() (page 18)

The simplest way to print a message on **standard output** is to use:

```
System.out.println("This text will appear on standard output");
```

System is a **class** (that is, a piece of code) that comes with Java as part of its **application program interface (API)** – a large number of classes designed to support our Java programs. Inside System there is a thing called out, and this has a **method** (section of code) called println. So overall, this method is called System.out.println. The method takes a string of text given to it in its brackets, and displays that text on the standard output of the program.

9 Statement

9.1 Statement (page 18)

A command in a programming language, such as Java, which makes the computer perform a task is known as a **statement**. System.out.println("I will output whatever I am told to") is an example of a statement.

9.2 Statement: simple statements are ended with a semi-colon (page 18)

All simple **statements** in Java must be ended by a semi-colon (;). This is a rule of the Java language **syntax**.

10 Error

10.1 Error (page 20)

When we write the **source code** for a Java program, it is very easy for us to get something wrong. In particular, there are lots of rules of the language that our program must obey in order for it to be a valid program.

10.2 Error: syntactic error (page 20)

One kind of error we might make in our programs is **syntactic errors**. This is when we break the **syntax** rules of the language. For example, we might miss out a closing bracket, or insert an extra one, etc.. This is rather like missing out a word in a sentence of natural language, making it grammatically incorrect. The sign below, seen strapped to the back of a poodle, contains bad grammar – it has an *is* missing.

My other dog an Alsatian.

Syntactic errors in Java result in the **compiler** giving us an error message. They can possibly confuse the compiler, resulting in it thinking many more things are wrong too!

10.3 Error: semantic error (page 22)

Another kind of error we might make is a **semantic error**, when we obey the rules of the **syntax** but what we have written does not make any sense – it has no semantics (meaning). Another sign on a different poodle might say

My other dog is a Porsche.

which is senseless because a Porsche is a kind of car, not a dog.

10.4 Error: compile time error (page 22)

Java **syntactic errors** and many **semantic errors** can be detected for us by the **compiler** when it processes our program. Errors that the compiler can detect are called **compile time errors**.

10.5 Error: run time error (page 24)

Another kind of error we can get with programs is **run time errors**. These are errors which are detected when the program is **run** rather than when it is **compiled**. In Java this means the errors are detected and reported by the **virtual machine**, java.

Java calls run time errors **exceptions**. Unfortunately, the error messages produced by java can look very cryptic to novice programmers. A typical one might be as follows.

```
Exception in thread "main" java.lang.NoSuchMethodError: main
```

You can get the best clue to what has caused the error by just looking at the words either side of the colon (:). In the above example, the message is saying that java cannot find the **method** called `main`.

10.6 Error: logical error (page 29)

The most tricky kind of error we can make in our programs is a **logical error**. For these mistakes we do not get an error message from the **compiler**, nor do we get one at **run time** from the **virtual machine**. These are the kind of errors for which the Java program we have written is meaningful as far as Java is concerned, it is just that our program does the wrong thing compared with what we wanted. There is no way the compiler or virtual machine can help us with these kinds of error: they are far, far too stupid to understand the *problem* we were trying to solve with our program.

For this reason, many logical errors, especially very subtle ones, manage to slip through undetected by human program testing, and end up as **bugs** in the final product – we have all heard stories of computer generated demands for unpaid bills with *negative* amounts, etc..

11 Execution

11.1 Execution: sequential execution (page 23)

Programs generally consist of more than one **statement**, in a list. We usually place these on separate lines to enhance human readability, although Java does not care about that. Statements in such a list are **executed** sequentially, one after the other. More correctly, the Java **compiler** turns each one into corresponding **byte codes**, and the **virtual machine** executes each collection of byte codes in turn. This is known as **sequential execution**.

12 Code clarity

12.1 Code clarity: layout (page 31)

Java does not care how we lay our code out, as long as we use some **white space** to separate adjacent symbols that would otherwise be treated as one symbol if they were joined. For example `public void` with no space between the words would be treated as the single symbol `publicvoid` and no doubt cause a **compile time error**. So, if we were crazy, we could write all our program **source code** on one line with the minimum amount of space between symbols!

```
public class HelloSolarSystem{public static void main(String[] args){System.out.println("Hello Mercury!");System.out.println("H
```

Oh dear – it ran off the side of the page (and that was with a smaller font too). Let us split it up into separate lines so that it fits on the page.

```
public class HelloSolarSystem{public static void main(String[] args){
System.out.println("Hello Mercury!");System.out.println(
"Hello Venus!");System.out.println("Hello Earth!");System.out.println
("Hello Mars!");System.out.println("Hello Jupiter!");System.out.
println("Hello Saturn!");System.out.println("Hello Uranus!");System.
out.println("Hello Neptune!");System.out.println("Goodbye Pluto!");}}
```

Believe it or not, this program would still **compile** and **run** okay, but hopefully you will agree that it is not very easy for *us* to read. Layout is very important to the human reader, and programmers must take care and pride in laying out their programs as they are written. So we split our program *sensibly*, rather than arbitrarily, into separate lines, and use **indentation** (i.e. spaces at the start of some lines), to maximize the readability of our code.

12.2 Code clarity: layout: indentation (page 32)

A **class** contains structures **nested** within each other. The outer-most structure is the class itself, consisting of its heading and then containing its body within the braces. The body contains items such as the **main method**. This in turn consists of a heading and a body contained within braces.

The idea of **indentation** is that the more nested a part of the code is, the more space it has at the start of its lines. So the class itself has no spaces, but its body, within the braces, has two or three. Then the body of the main method has two or three more. You should be consistent: always use the same number of spaces per nesting level. It is also a good idea to avoid using **tab characters** as they can often look okay on your screen, but not line up properly when the code is printed.

In addition, another rule of thumb is that opening braces ({) should have the same amount of indentation as the matching closing brace (}). You will find that principle being used throughout this book. However, some people prefer a style where opening braces are placed at the end of lines, which this author believes is less clear.

```
public class HelloWorld {  
  
    public static void main(String[] args) {  
        System.out.println("Hello world!");  
    }  
}
```