Introduction to Computers and Java

Chapter 1

Edited by JJ Shepherd, James O'Reilly

*JAVA: An Introduction to Problem Solving & Programming, 7*th Ed. By Walter Savitch
ISBN 0133862119

Objectives

- Syllabus and such
- Overview of computer hardware and software
- Introduce program design and object-oriented programming
- Overview of the Java programming language
- Go over a ton of terminology

Outline

- Computer Basics
- Designing Programs
- A Sip of Java

Computer Basics: Outline

- Hardware, Software, Data, and Memory
- Programs
- Programming Languages and Compilers
- Java Byte-Code

Hardware and Software

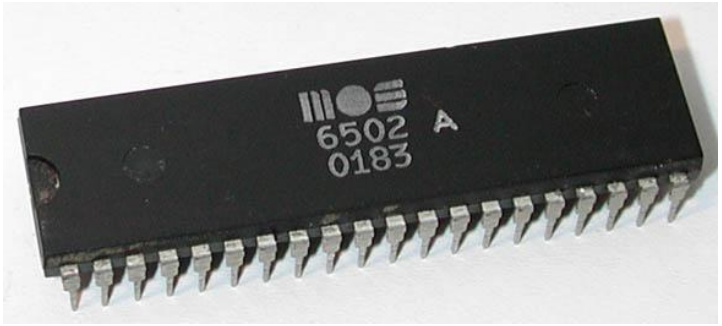
- Computer systems consist of ***hardware*** and ***software***, they often process ***data***.
  - Hardware includes the *tangible* parts of computer systems.
  - Software includes *programs* - sets of instructions for the computer to follow.
  - Data is information stored like Software to be processed.
- Familiarity with hardware basics helps us understand software.
- **Any text that is bold, red, and underlined may be important for an exam. HINT HINT**

Hardware and Memory

- Most modern computers have similar components including
  - Input devices (keyboard, mouse, etc.)
  - Output devices (display screen, printer, etc.)
  - A processor
  - Two kinds of memory (main memory and auxiliary memory).

The Processor

- Also called the *CPU* (central processing unit) or the *chip* (e.g. Pentium processor)
- The processor **processes** a program's instructions.
- It can process only very simple instructions.
- The power of computing comes from speed and program intricacy.



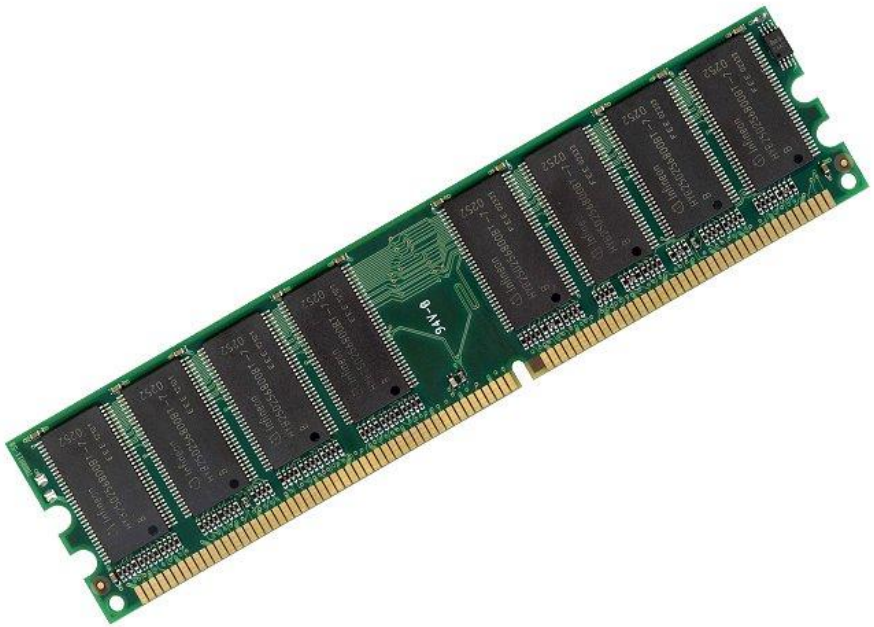
Memory

- Memory holds
  - programs
  - data for the computer to process
  - the results of intermediate processing.
- Two kinds of memory
  - main memory
  - auxiliary memory

Main memory

- Working memory used to store
  - The current program
  - The data the program is using
  - The results of intermediate calculations
- Usually measured in megabytes and few gigabytes (e.g. 8 gigabytes of RAM)
  - **RAM** is short for *random access memory*
  - A *byte* is a quantity of memory
- When I talk about memory I generally mean main memory

RAM



Auxiliary Memory

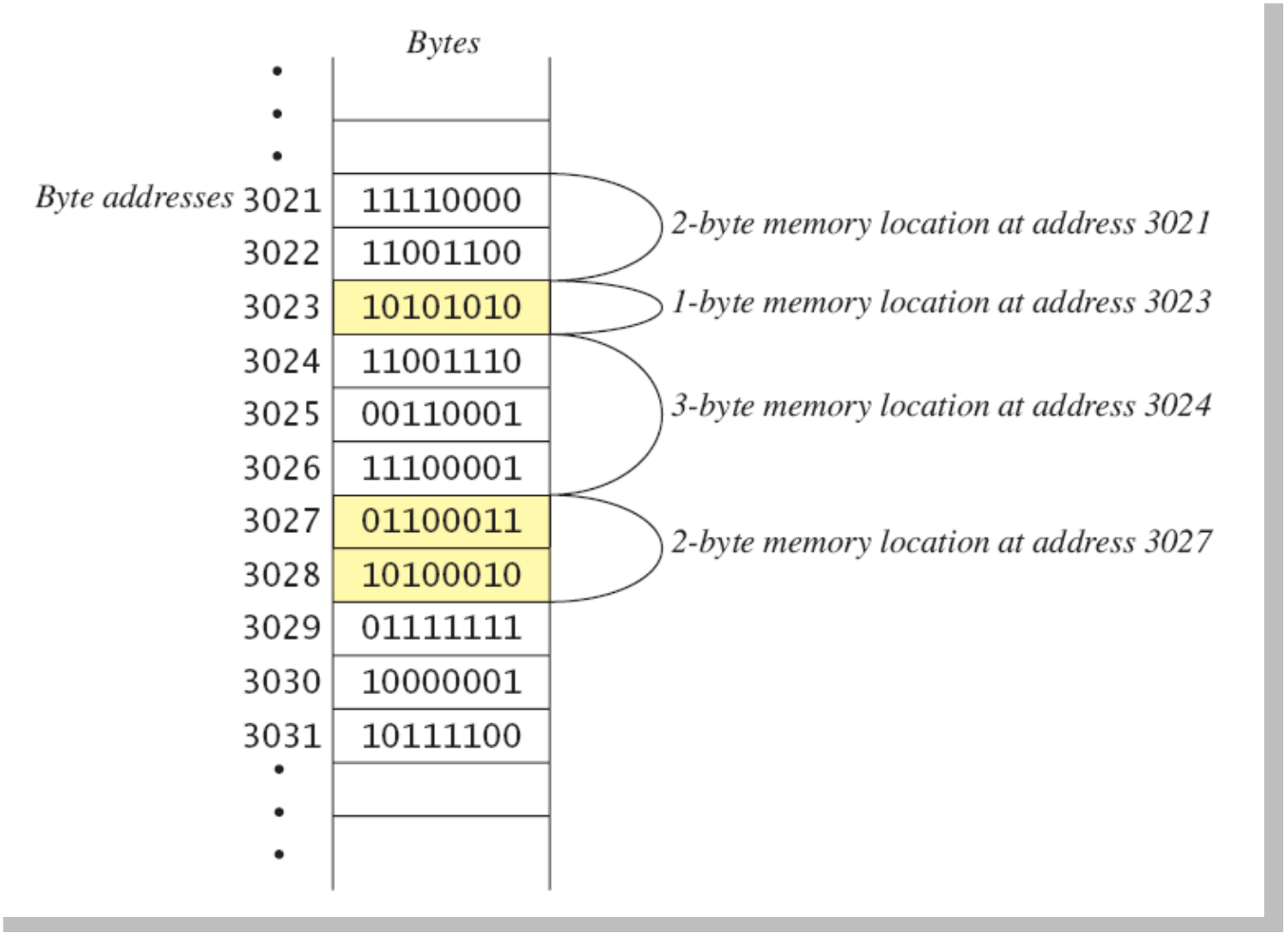
- Also called ***secondary memory***
- Disk drives, CDs, DVDs, flash drives, etc.
- More or less permanent (nonvolatile)
- Usually measured in gigabytes and terabytes (e.g. 50 gigabyte hard drive)

Bits, Bytes, and Addresses

- A ***bit*** is a digit with a value of either 0 or 1.
- A ***byte*** consists of 8 bits.
- A ***word*** consists of generally 4 or 8 bytes. (CPUs generally designed to work on words of data)
- Each byte in main memory resides at a numbered location called its ***address***.

Main Memory

- Figure 1.1



Storing Data

- Data of all kinds (numbers, letters, strings of characters, audio, video, even programs) are encoded and stored using 1s and 0s.
- When more than a single byte is needed, several adjacent bytes are used.
  - The address of the first byte is the address of the unit of bytes.
  - Information about the size also stored in programs

Files

- Large groups of bytes in auxiliary memory are called *files.*
- Files have names.
- Files are organized into groups called *directories* or *folders.*
- Java programs are stored in files.
- Programs files are copied from auxiliary memory to main memory in order to be run.

0s and 1s

- Machines with only 2 stable states are easy to make, but programming using only 0s and 1s is difficult.
- Fortunately, the conversion of numbers, letters, strings of characters, audio, video, and programs is done using standard tools, depending on type.

Programs

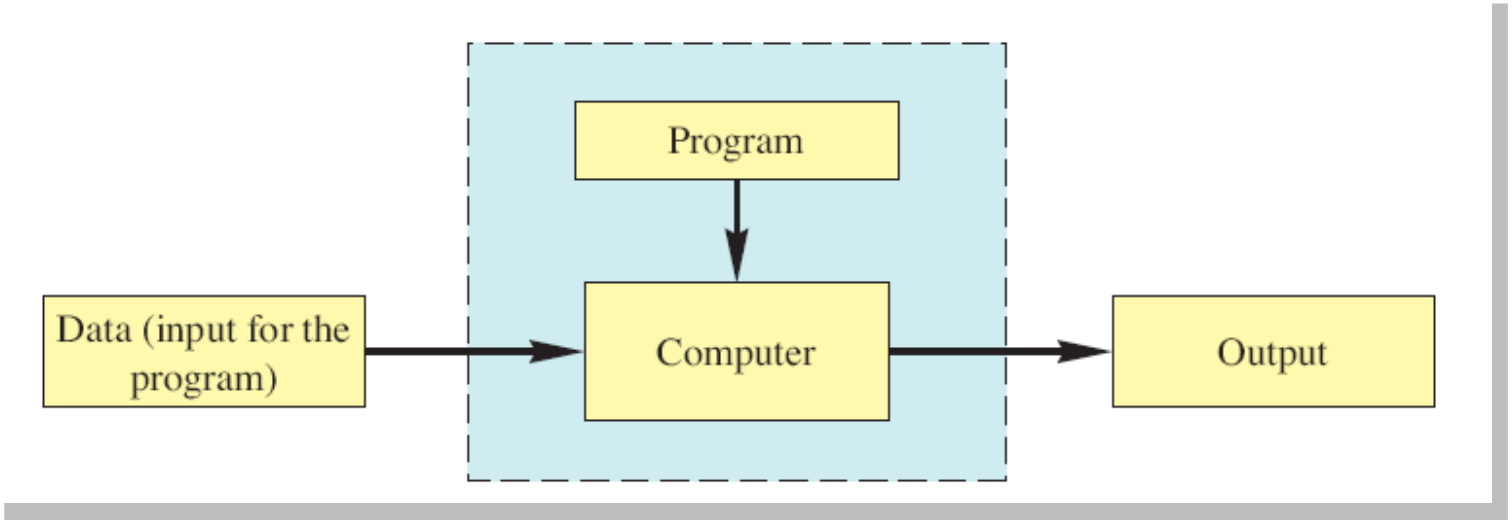
- A ***program*** is a set of instructions for a computer to follow.
- We use programs almost daily (email, word processors, video games, bank ATMs, etc.).
- Following the instructions is **called *running* or *executing*** the program.

Program Loading and Execution

- A computer processor is given a program as its "input":
  - The program may be given some basic information as well, e.g. a program that displays images/movies may be told what file to load
  - An executing program may, repeatedly in no predefined order:
    - Output data to output *devices* (screen, printer, auxiliary storage)
    - Request data from: input *devices*, auxiliary storage, etc.
    - The program may use additional memory to store intermediate values, often preprocessed data.

Running a Program

- Figure 1.2



- Sometimes the computer and the program are considered to be one unit.
  - Programmers typically find this view to be more convenient.
  - A program runs on a machine whose sole purpose is to run programs and do I/O (input and output)

The Operating System

- The ***operating system*** is a supervisory program that oversees the operation of the computer.
- The operating system retrieves and starts programs
- It also allocates memory to programs (HW also involved)
- Provides interface for Hardware – e.g. don't care what type of internet connection, as long as it exists.
- Well-known operating systems including: Microsoft Windows, Apple's Mac OS, Linux, and UNIX. Also, iOS and Android

Programming Languages

- ***High-level*** *languages* are relatively easy to use
  - Java, C#, C++, Visual Basic, Python, Ruby.
- Unfortunately, computer hardware does not understand high-level languages.
  - Therefore, a high-level language program must be translated into a ***low-level language***.
  - Low level language like assembly or machine code

Compilers

- A ***compiler*** translates a program from a high-level language to a low-level language the computer can run.
- You ***compile*** a program by running the compiler on the high-level-language version of the program called the *source program.*
- Compilers produce ***machine-* or *assembly-language*** programs called ***object programs***.

Compilers

- Most high-level languages need a different compiler for each type of computer and for each operating system.
- Most compilers are very large programs that are expensive to produce.
- Take CSCE 531 if you want to try your hand at creating one!

Java Byte-Code

- The Java *compiler* does not translate a Java program into *assembly language* or *machine language* for a particular computer.
- Instead, it translates a Java program into ***byte-code***.
  - Byte-code is the machine language for a hypothetical computer (or *interpreter*) called the Java Virtual Machine.

Java Byte-Code

- A byte-code program is easy to translate into machine language for any particular computer.
- A program called an ***interpreter*** translates each byte-code instruction, executing the resulting machine-language instructions on the particular computer before translating the next byte-code instruction.
- Most Java programs today are executed using a **Just-In-Time or *JIT*** compiler in which byte-code is compiled as needed and stored for later reuse without needing to be re-compiled.

Compiling, Interpreting, Running (Hello World)

- Use the compiler to translate the Java program into byte-code (done using the *javac* command).
- Use the Java virtual machine for your computer to translate each byte-code instruction into machine language and to run the resulting machine-language instructions (done using the *java* command).

Portability

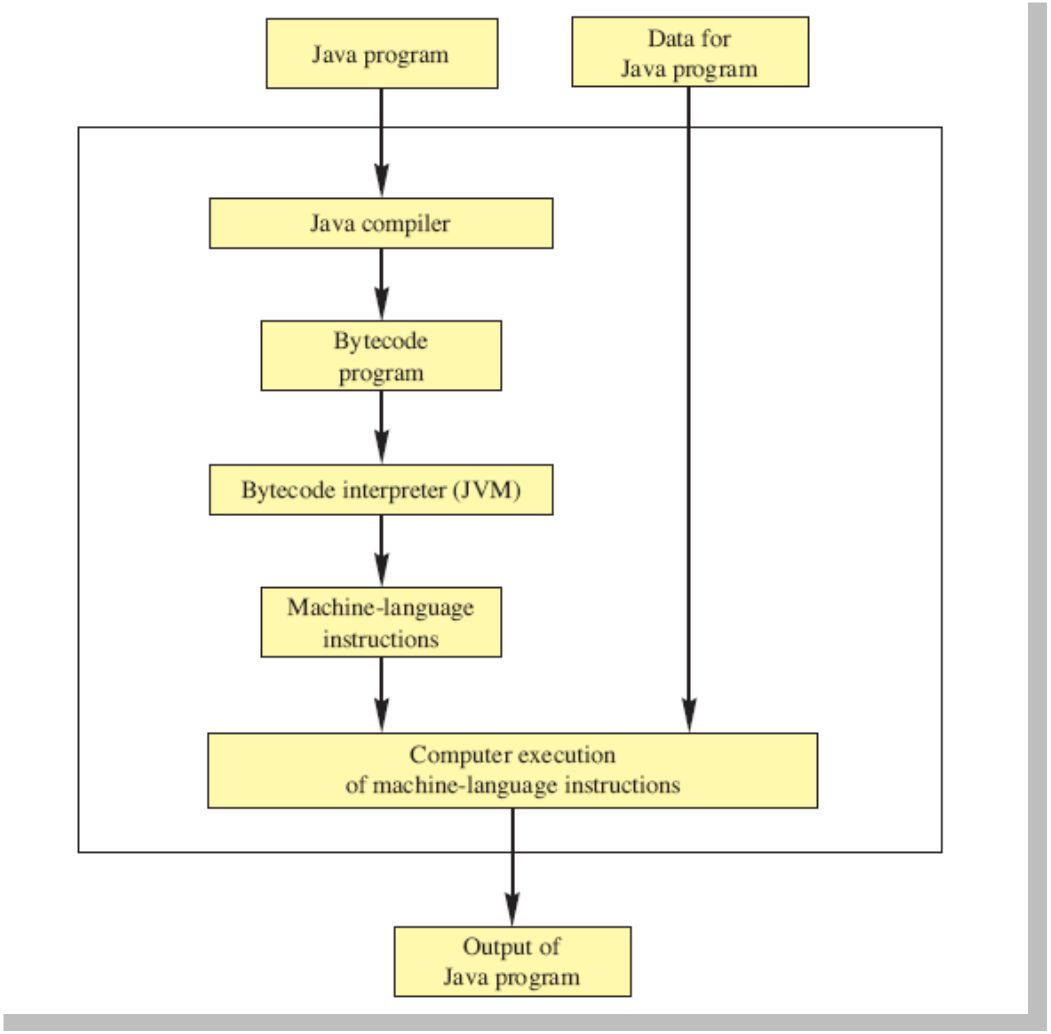
- After compiling a Java program into byte-code, that byte-code can be used on any computer with a byte-code interpreter and without a need to recompile.
- WORA- Write Once, Run anwhere
- Byte-code can be sent over the Internet and used anywhere in the world.
- This makes Java suitable for Internet applications.

Class Loader

- A Java program typically consists of several pieces called *classes.*
- Each class may have a separate author and each is compiled (translated into byte-code) separately.
- A *class loader* (called a *linker* in other programming languages) automatically connects the classes together.

Compiling and Running a Program

- Figure 1.3



A Sip of Java: Outline

- History of the Java Language
- Applications and Applets (and Servlets)
- A First Java Application Program
- Writing, Compiling, and Running a Java Program

Applications and Applets

- Two kinds of java programs: *applications* and *applets*
- **Applications**
  - Regular programs
  - Meant to be run on your computer
- **Applets**
  - Little applications
  - Meant to be sent to another location on the internet and run there
  - (on the way out)

A Simple Java Application

- EXAMPLE TIME!!!

```
Hello out there.
I will add two numbers for you.
Enter two whole numbers on a line:
12 30
The sum of those two numbers is
42
```

Sample screen output

Some Terminology

- The person who writes a program is called the ***programmer***.
- The person who interacts with the program is called the ***user***.
- A ***package*** is a library of classes that have been defined already.
  - `import java.util.Scanner;`

Some Terminology

- The item(s) inside parentheses are called ***argument(s)*** and provide the information needed by methods.
- A ***variable*** is something that can store data.
- An instruction to the computer is called a ***statement***; it ends with a semicolon (don't overthink this – some things called statements won't, may end in {…}, with a list of statements)
- The grammar rules for a programming language are called the ***syntax*** of the language.

Printing to the Screen

```
System.out.println ("Whatever you want to print");
```

- `System.out` is an object for sending output to the screen.
- `println` is a method to print whatever is in parentheses to the screen.

Printing to the Screen

- The object performs an action when you ***invoke*** or *call* one of its methods

```
objectName.methodName(argumentsTheMethodNeeds);
```

Compiling a Java Program or Class

- A Java program consists of one or more classes, which must be compiled before running the program.
- You need not compile classes that accompany Java (e.g. `System` and `Scanner`).
- Each class should be in a separate file.
- The name of the file should be the same as the name of the class (generally, it must be the same – careful about case)

Compiling and Running

- Use an ***IDE*** (integrated development environment) which combines a text editor with commands for compiling and running Java programs.
- When a Java program is compiled, the byte-code version of the program has the same name, but the ending is changed from `.java` to `.class`.

Compiling and Running

- A Java program can involve any number of classes.
- The class to run will contain the words

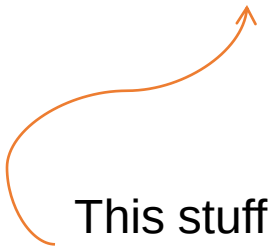
```
public static void main(String[] args)
```

somewhere in the file

- A program with multiple files will normally have only one main() method.

Programming Basics: Outline

- Object-Oriented Programming
- Algorithms
- Testing and Debugging
- Software Reuse



This stuff will definitely come back later in this course! So we're going to gloss over it for now.

Programming

- Programming is a creative process.
- Programming can be learned by discovering the techniques used by experienced programmers.
- These techniques are applicable to almost every programming language, including Java.

Object-Oriented Programming

- Our world consists of ***objects*** (people, trees, cars, cities, airline reservations, etc.).
- Objects can perform ***actions*** *(methods)* which affect themselves and other objects in the world.
- Object-oriented programming (*OOP*) treats a program as a collection of objects that interact by means of actions.
- (not all methods change some object – many may simply return a value)

OOP Terminology

- Objects, appropriately, are called *objects.*
- Actions are called ***methods***.
- Objects of the same kind have the same *type* and belong to the same *class.*
  - Objects within a class have a common set of methods and the same kinds of data
  - but each object can have its own data values.

OOP Design Principles

- OOP adheres to three primary design principles:
  - **Encapsulation**
  - **Polymorphism**
  - **Inheritance**

Introduction to Encapsulation

- The data and methods associated with any particular class are encapsulated ("put together in a capsule"), but only part of the contents is made accessible.
  - Encapsulation provides a means of using the class, but it omits the details of how the class works.
  - **Encapsulation often is called *information hiding*.**

Accessibility Example

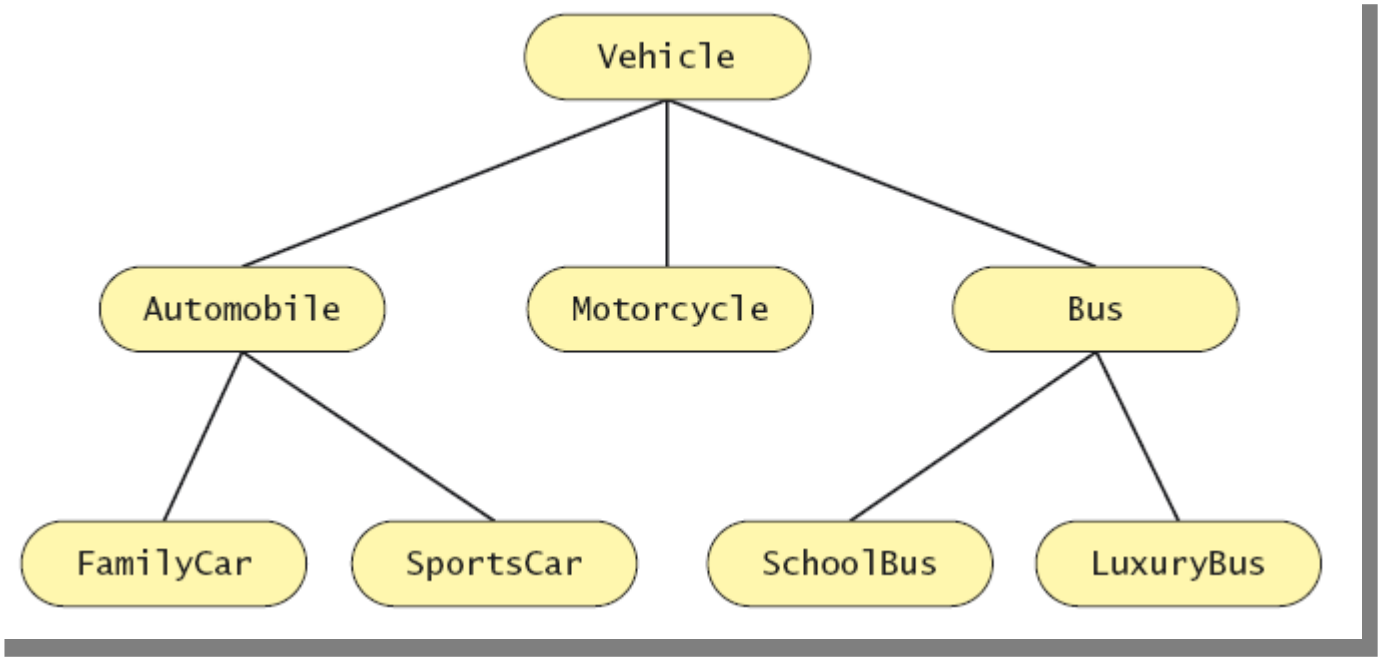
- An automobile consists of several parts and pieces and is capable of doing many useful things.
  - Awareness of the accelerator pedal, the brake pedal, and the steering wheel is important to the driver.
  - Awareness of the fuel injectors, the automatic braking control system, and the power steering pump is not important to the driver.

Introduction to Polymorphism

- From the Greek meaning “many forms”
- The same program instruction adapts to mean different things in different contexts.
  - A method name, used as an instruction, produces results that depend on the class of the object that used the method.
  - Everyday analogy: “play your favorite sport” causes different people to do different activities
- More about polymorphism in Chapter 8

Introduction to Inheritance

- Figure 1.4



Introduction to Inheritance

- Classes can be organized using *inheritance.*
- A class at lower levels inherits all the characteristics of classes above it in the hierarchy.
- At each level, classifications become more specialized by adding other characteristics.
- Higher classes are more inclusive; lower classes are less inclusive.

Inheritance in Java

- Used to organize classes
- “Inherited” characteristics do not need to be repeated.
- New characteristics are added.
- More about inheritance in chapter 8

Algorithms

- By designing methods, programmers provide actions for objects to perform.
- An ***algorithm*** describes a means of performing an action.
- Once an algorithm is defined, expressing it in Java (or in another programming language) usually is easy.

Algorithms

- An algorithm is a set of instructions for solving a problem that must be expressed completely and precisely.
- No “fall-through” cases, i.e. there should be a simple decision made at each step or an action taken
- More complicated algs. may call other algs. (like addition).
- Algorithms usually are expressed in English or in *pseudocode.*

Example: Total Cost of All Items

- Write the number 0 on the whiteboard.
- For each item on the list
  - Add the cost of the item to the number on the whiteboard
  - Replace the number on the whiteboard with the result of this addition.
- Announce that the answer is the number written on the whiteboard.

Reusable Components

- Most programs are created by combining components that exist already.
- Reusing components saves time and money.
- Reused components are likely to be better developed, and more reliable.
- New components should designed to be reusable by other applications.

Testing and Debugging

- Eliminate errors by avoiding them in the first place.
  - Carefully design classes, algorithms and methods.
  - Carefully code everything into Java.
- Test your program with appropriate test cases (some where the answer is known), discover and fix any errors, then retest.

Errors

- An error in a program is called a *bug.*
- Eliminating errors is called *debugging.*
- Three kinds of errors
  - **Syntax errors**
  - **Runtime errors**
  - **Logic errors**

Syntax Errors

- Grammatical mistakes in a program
  - The grammatical rules for writing a program are very strict
- The compiler catches syntax errors and prints an error message.
- Example: using a period where a program expects a comma

Runtime Errors

- Errors that are detected when your program is running, but not during compilation
- When the computer detects an error, it terminates the program and prints an error message.
- Example: attempting to divide by 0

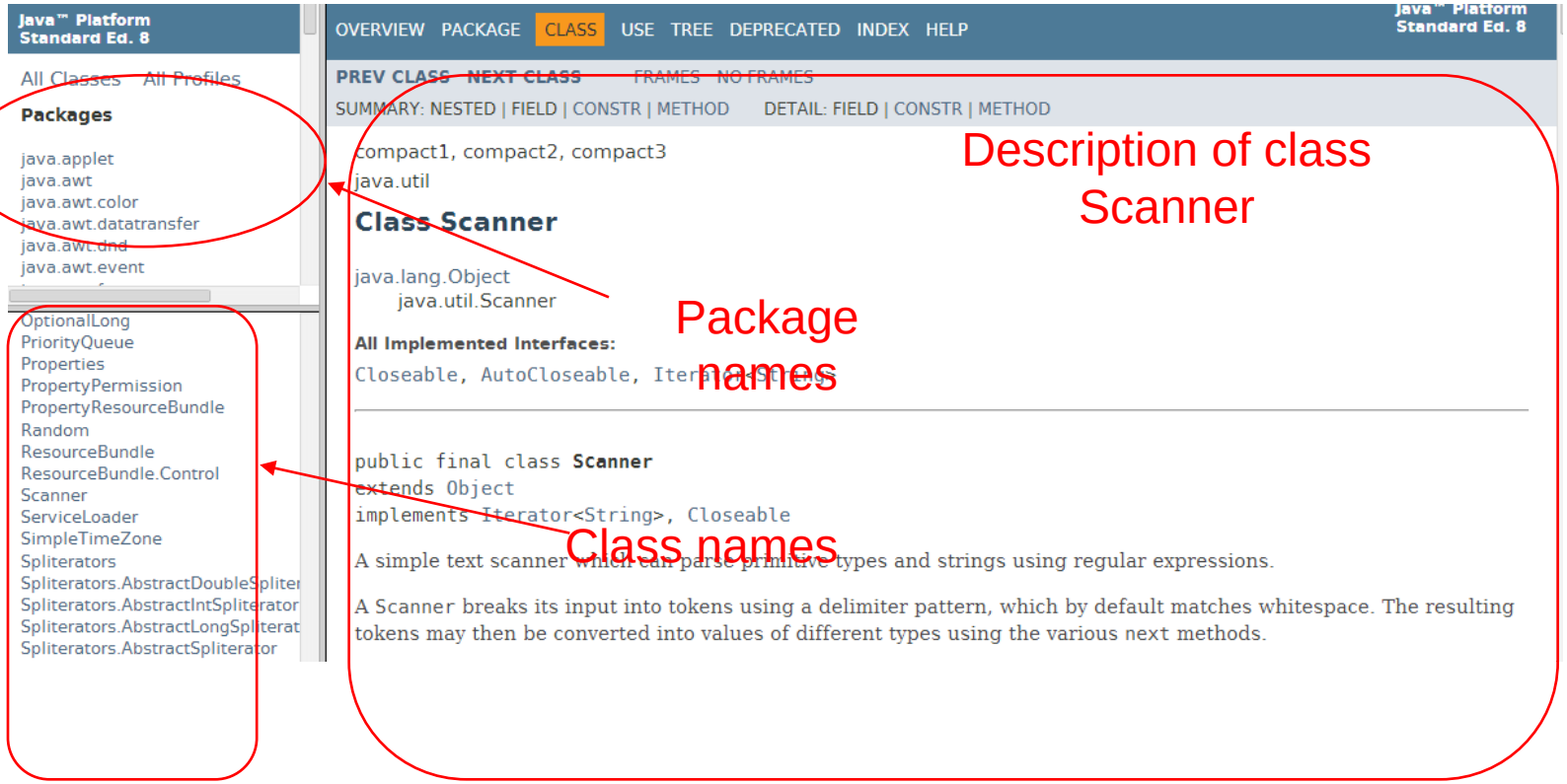
Logic Errors

- Errors that are not detected during compilation or while running, but which cause the program to produce incorrect results
- Example: an attempt to calculate a Fahrenheit temperature from a Celsius temperature by multiplying by 9/5 and adding 23 instead of 32

Software Reuse

- Programs not usually created entirely from scratch
- Most contain components which already exist
- Reusable classes are used
  - Design class objects which are general
  - Java provides many classes
  - Note documentation on following slide

Software Reuse



Summary

- You have completed an overview of computer hardware and software.
- You have been introduced to program design and object-oriented programming.
- You have completed an overview of the Java programming language.