Introduction to Computers, Programs, and Java

CSE 114, Computer Science 1
SUNY Korea

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A computer consists of a CPU, memory, hard disk, monitor, printer, and communication devices.
CPU

• central processing unit (CPU)

  • retrieves instructions from memory and executes them
  • the CPU speed is measured in megahertz (MHz)

• 1 megahertz = 1 million pulses per second
Memory

• stores data and program instructions for CPU to execute

• ordered sequence of bytes (8 bits – binary base unit)
How Data is Stored?

- **What’s binary?**
  - a base-2 number system

- **What do humans use?**
  - base-10

- **Why?**

- **Why do computers like binary?**
  - electronics
  - easier to make hardware that stores and processes binary numbers than decimal numbers
  - more efficient: space & cost

<table>
<thead>
<tr>
<th>Memory address</th>
<th>Memory content</th>
<th>Encoding</th>
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<tbody>
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<td>Encoding for character ‘a’</td>
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<tr>
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<td>Encoding for character ‘v’</td>
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<td>Encoding for character ‘a’</td>
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<td>2004</td>
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<td>Encoding for number 3</td>
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## Number Systems

<table>
<thead>
<tr>
<th>System</th>
<th>Symbols</th>
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<tr>
<td>Binary</td>
<td>0, 1</td>
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<tr>
<td>Hexadecimal</td>
<td>0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F</td>
</tr>
</tbody>
</table>
Computers use binary numbers internally because storage devices like memory and disk are designed to store 0s and 1s.

- A number or a text inside a computer is stored as a sequence of 0s and 1s.
- Each 0 and 1 is called a bit (short for binary digit).

Binary numbers are not intuitive, since we use decimal numbers in our daily life.

- When you write a number like 20 in a program, it is assumed to be a decimal number.
  - Internally, computer software is used to convert decimal numbers into binary numbers, and vice versa.
Number Systems

• The digits in the **decimal number system** are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.
• A decimal number is represented using a sequence of one or more of these digits.
• The value that each digit in the sequence represents depends on its position.
• A position in a sequence has a value that is an integral power of 10.
• e.g., the digits 7, 4, 2, and 3 in decimal number **7423** represent 7000, 400, 20, and 3, respectively:

\[
\begin{array}{cccc}
7 & 4 & 2 & 3 \\
10^3 & 10^2 & 10^1 & 10^0 \\
\end{array}
\]

\[
= 7 \times 10^3 + 4 \times 10^2 + 2 \times 10^1 + 3 \times 10^0
\]

\[
= 7000 + 400 + 20 + 3 = 7423
\]

• We say that 10 is the **base** or **radix** of the decimal number system.
• The base of the binary number system is 2 since the binary number system has two digits
• The base of the hex number system is 16 since the hex number system has sixteen digits.
Number Systems

• Binary numbers tend to be very long and cumbersome:
  • For example: 101010101010

• Hexadecimal numbers are often used to abbreviate binary numbers:
  • For example: AAA

• The hexadecimal number system has 16 digits:
  0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F.

  • The letters A, B, C, D, E, and F correspond to the decimal numbers 10, 11, 12, 13, 14, and 15.
Given a binary number $b_n b_{n-1} b_{n-2} ... b_2 b_1 b_0$
the equivalent decimal value is

$$b_n \times 2^n + b_{n-1} \times 2^{n-1} + b_{n-2} \times 2^{n-2} + ... + b_2 \times 2^2 + b_1 \times 2^1 + b_0 \times 2^0$$

10 in binary $1 \times 2^1 + 0 = 2$ in decimal

1010 in binary $1 \times 2^3 + 0 \times 2^2 + 1 \times 2 + 0 = 10$ in decimal

10101011 in binary $1 \times 2^6 + 0 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2 + 1 = 171$ in decimal
Decimals => Binary

- To convert a decimal number d to a binary number is to find the binary digits \( b_n, b_{n-1}, b_{n-2}, ..., b_2, b_1, b_0 \) such that

\[
d = b_n \times 2^n + b_{n-1} \times 2^{n-1} + b_{n-2} \times 2^{n-2} + ... + b_2 \times 2^2 + b_1 \times 2^1 + b_0 \times 2^0
\]

- These numbers can be found by successively dividing d by 2 until the quotient is 0. The remainders are \( b_n, b_{n-1}, b_{n-2}, ..., b_2, b_1, b_0 \)

For example, the decimal number 123 is 1111011 in binary. The conversion is conducted as follows:

\[
\begin{array}{cccccccccccc}
2 & 1 & 3 & 7 & 15 & 30 & 61 & 123 \\
0 & 2 & 6 & 14 & 30 & 60 & 122 & 244 \\
0 & 1 & 1 & 0 & 1 & 1 & 1 & 2 \\
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
\end{array}
\]

Quotient: 0, 1, 2, 2, 2, 2, 2

Remainder: 0, 1, 1, 1, 0, 1, 1
The Windows Calculator is a useful tool for performing number conversions. To run it, choose *Programs, Accessories, and Calculator* from the Start button.
Hexadecimals => Decimals

• The hexadecimal number system has sixteen digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F.
• The letters A, B, C, D, E, and F correspond to the decimal numbers 10, 11, 12, 13, 14, and 15.
• Given a hexadecimal number $h_nh_{n-1}h_{n-2}...h_2h_1h_0$
The equivalent decimal value is

$$h_n \times 16^n + h_{n-1} \times 16^{n-1} + h_{n-2} \times 16^{n-2} + ... + h_2 \times 16^2 + h_1 \times 16^1 + h_0 \times 16^0$$

7F in hex $7 \times 16^1 + 15 = 127$ in decimal

FFFF in hex $15 \times 16^3 + 15 \times 16^2 + 15 \times 16 + 15 = 65535$ in decimal
Decimals => Hexadecimals

To convert a decimal number $d$ to a hexadecimal number is to find the hexadecimal digits $h_n, h_{n-1}, h_{n-2}, \ldots, h_2, h_1, h_0$ such that

$$d = h_n \times 16^n + h_{n-1} \times 16^{n-1} + h_{n-2} \times 16^{n-2} + \ldots + h_2 \times 16^2 + h_1 \times 16^1 + h_0 \times 16^0$$

These numbers can be found by successively dividing $d$ by 16 until the quotient is 0. The remainders are $h_0, h_1, h_2, \ldots, h_{n-2}, h_{n-1}, h_n$

For example, the decimal number 123 is 7B in hexadecimal. The conversion is conducted as follows:

![Diagram showing the conversion process with remainders and quotients labeled as Quotient and Remainder.]
## Hexadecimals <=> Binary

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<th>Hex</th>
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<tr>
<td>1111</td>
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<td>15</td>
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</tbody>
</table>

To convert a hexadecimal number to a binary number, simply convert each digit in the hexadecimal number into a four-digit binary number.

To convert a binary number to a hexadecimal, convert every four binary digits from right to left in the binary number into a hexadecimal number. For example,
Memory: What goes in each memory segment?

- **Stack Segment**
  - temporary variables declared inside methods
  - removed from memory when a method returns

- **Heap Segment**
  - for dynamic data (whenever you use `new`)
  - data for constructed objects
  - persistent as long as an existing object variable references this region of memory

- **Global Segment**
  - data that can be reserved at compile time
  - global data (like static data)
How objects are stored?

• You must understand that in Java, every object/reference variable stores a memory address
  • 32 bit numbers (4 bytes)
  • 64 bit numbers (8 bytes)

OR

• These addresses point to memory locations where the objects’ data is stored
So Hardware stores 0s & 1s

- 0101010101010101010101010101 …
- Data is byte addressable
  - we can access or change any byte (group of 8 bits) independently as needed
- How do we store text?
  - Numerically (using its code)
  - Each character is stored in memory as a number
  - Standard character sets: ASCII & Unicode
    - ASCII uses 1 byte per character
      - ‘A’ is 65
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Programming Languages

Machine Language  Assembly Language  High-Level Language

- Machine language is a set of instructions executed directly by a computer's central processing unit (CPU).
- A program called assembler is used to convert assembly language programs into machine code.

For example, to add two numbers, you might write an instruction in assembly code like this:

ADD F3 R1, R2, R3
Programming Languages

Machine Language    Assembly Language    High-Level Language

**assembly**: Far easier to use than binary
**BUT**: not very user friendly, very low-level operations, programming is time consuming

High Level programming Languages (HLL):
– more user friendly, easy to use
– more flexible
– platform independent
Popular High-Level Languages

• COBOL (COmmon Business Oriented Language)
• FORTRAN (FORmula TRANslatation)
• BASIC (Beginner All-purpose Symbolic Instructional Code)
• Pascal (named for Blaise Pascal)
• Ada (named for Ada Lovelace)
• C (whose developer designed B first)
• Visual Basic (Basic-like visual language developed by Microsoft)
• Delphi (Pascal-like visual language developed by Borland)
• C++ (an object-oriented language, based on C)
• C# (a Java-like language developed by Microsoft)
• Java
What’s a compiler?

• A software program
  • Input: High Level Language source code
  • Output: Assembly Code
• It is typically integrated with an assembly
  • together they can make an executable or binary program
The *operating system* (OS) is a program that manages and controls a computer's activities.

- *Windows XP*,
- *Vista, 7 and 8*
- *Mac OsX*
- *Android*
- *Linux*
Java is somewhat different
Java has a principle, “write once, run anywhere”
What does that mean?
Platform independence for compiled Java code
How?
The Java Virtual Machine
Java programs are compiled into Java bytecode
bytecode is executed by the
Java Virtual Machine (JVM)
• **Java Virtual Machine**
  • A program that runs Java programs and manages memory for Java programs.

• **Why?**
  • Each platform is different (Mac/PC/Linux/etc.)
  • Java can be used to develop Web applications.
  • Java Applets
  • Java Web Applications
  • Java can also be used to develop applications for handheld devices such as Palm and cell phones
JDK Versions

- JDK 1.02 (1995)
- JDK 1.1 (1996)
- JDK 1.2 (1998)
- JDK 1.3 (2000)
- JDK 1.4 (2002)
- JDK 1.5 (2004) a. k. a. JDK 5 or Java 5
- JDK 1.6 (2006) a. k. a. JDK 6 or Java 6
- JDK 1.7 (2011) a. k. a. JDK 7 or Java 7
- JDK 1.8 (2014) a. k. a. JDK 8 or Java 8
JDK Editions

- Java Standard Edition (J2SE)
  - J2SE can be used to develop client-side standalone applications or applets.

- Java Enterprise Edition (J2EE)
  - J2EE can be used to develop server-side applications such as Java servlets and Java ServerPages.

- Java Micro Edition (J2ME).
  - J2ME can be used to develop applications for mobile devices such as cell phones.

Textbook uses J2SE to for Java programming
//This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
Creating, Compiling, and Running Programs

Source code (developed by the programmer)

```java
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```

Byte code (generated by the compiler for JVM to read and interpret, not for you to understand)

```java
... Method Welcome()
    0 aload_0
    ...
Method void main(java.lang.String[])
    0 getstatic #2 ...
    3 ldc #3 <String "Welcome to Java!">
    5 invokevirtual #4 ...
    8 return
...```

Create/Modify Source Code

Compile Source Code

i.e., javac Welcome.java

Saved on the disk

Source Code

Run Byteode

i.e., java Welcome

Result

If compilation errors

If runtime errors or incorrect result

Bytecode

stored on the disk

Run Byteode

i.e., java Welcome
Running Programs from command line

pde@compserv ~$ emacs Welcome.java
//This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}

pde@compserv ~$ javac Welcome.java

pde@compserv ~$ java Welcome
Welcome to Java!
Compiling and Running Java from the Command Window

• Set path to JDK bin directory
  • set PATH=c:\Program Files\Java\jdk1.8.0\bin
  • check Java path

• Set classpath to include the current directory
  • set classpath=.

• Compile
  • javac Welcome.java

• Run
  • java Welcome
Running Programs in Eclipse

```java
package paul;

public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```
// This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}

Enter main method
Trace a Program Execution

//This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
//This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
Anatomy of a Java Program

- Comments
- Reserved words
- Modifiers
- Statements
- Blocks
- Classes
- Methods
- The main method
Three types of comments in Java.

*Line comment*: A line comment is preceded by two slashes (//) in a line.

*Paragraph comment*: A paragraph comment is enclosed between /* and */ in one or multiple lines.

*javadoc comment*: javadoc comments begin with /** and end with */. They are used for documenting classes, data, and methods. They can be extracted into an HTML file using JDK's javadoc command.
Reserved Words

Reserved words or keywords are words that have a specific meaning to the compiler. They cannot be used for other purposes in the program.

- **Example:** `class`
  - The word after `class` is the name for the class.
Java Vocabulary Words (Keywords)

abstract, assert, boolean, break, byte, case, catch, char, class, const, continue, default, do, double, else, enum, extends, false, final, finally, float, for, goto, if, implements, import, instanceof, int, interface, long, native, new, null, package, private, protected, public, return, short, static, strictfp, super, switch, synchronized, this, throw, throws, transient, true, try, void, volatile, while

http://docs.oracle.com/javase/tutorial/java/nutsandbolts/_keywords.html
Modifers

Java uses certain reserved words called modifiers that specify the properties of the data, methods, and classes and how they can be used.

- Examples: public, static, private, final, abstract, protected
- A public datum, method, or class can be accessed by other programs
- A private datum or method cannot be accessed by other programs
Statements

A statement represents an action or a sequence of actions

System.out.println("Welcome to Java!");

is a statement to display the greeting "Welcome to Java!"

- Every statement in Java ends with a semicolon (;)
Blocks

A pair of braces in a program forms a block that groups components of a program.

```java
public class Test {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```
Variable, class, and method names

- What’s an API?
  - Application Programming Interface
  - a library of code to use

- Names (variables, classes, and methods)
  - From 2 sources:
    - your own classes, variables, and methods
    - the Oracle/Sun (or someone else’s) API

- Your Identifiers (Names) – Why name them?
  - they are your data and commands
  - you’ll need to reference them elsewhere in your program

```java
int myVariable = 5;  // Declaration
...  // Using the variable
myVariable = myVariable + 1;
```
Rules for Identifiers

- Should contain only letters, numbers, & ‘_’
- Cannot begin with a digit
- Uppercase and lowercase letters are considered to be different characters
- $ is allowed, but only for special use.
- Examples:
  - Legal: `myVariable, my_class, my4Var`
  - Illegal: `4myVariable, my class, my!Var, @#$myClass`
Common Java Naming Conventions

- Variables & Methods start with lower case letters: `x`, `toString`
- Classes start with upper case letters: `Person`
- Variables and Class identifiers should generally be nouns
- Method identifiers should be verbs
- Use Camel notation: `myVariable`, `MyClass`
- Although it is legal, do not begin with `'_` (underscore).
- Use descriptive names: `LinkedList`, `compareTo`

```
area = PI * radius * radius;
```