Objectives

- Give a brief history of computers.
- Describe how hardware and software make up computer architecture.
- Understand the binary representation of data and programs in computers.
Objectives (cont.)

- Discuss the evolution of programming languages.
- Describe the software development process.
- Discuss the fundamental concepts of object-oriented programming.
Vocabulary

- Application software
- Bit
- Byte
- Central processing unit (CPU)
- Hardware
- Information hiding
- Object-oriented programming
Vocabulary (cont.)

- Primary memory
- Secondary memory
- Software
- Software development life cycle (SDLC)
- System software
- Ubiquitous computing
- Waterfall model
Scientists from the RAND Corporation have created this model to illustrate how a “home computer” could look like in the year 2004. However, the needed technology will not be economically feasible for the average home. Also, the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.
What was the first computer?

- Person who does math for a living
- Human error and speed caused severe problems

$375 \times 384 = ????
ABACUS

- Hand operated counting tool
- Introduced in 3rd century
- Mastered by Chinese in 12th century
Blaise Pascal

- In 1642 invented first gear driven counting machine (Mechanical Machine)

- Could add and subtract using interlocking wheels and gears
- Called Pascaline (over 50 versions)
- Pascal programming language named after him
Gottfried Wilhelm Leibniz

- German mathematician
- In 1671 developed first mechanical calculator
- Crank on side simplified multiplication and division
Charles Babbage

- English mathematician
- In 1834 developed first idea of computer
- Difference Engine no. 2 (Mechanical)
- First idea of a general purpose programmable computer
- Used punch cards to give instructions
- Never got built in his era
- Was constructed in modern era to see if it was possible to be built (it was!).
Herman Hollerith

- Developed first Electro-Mechanical device in 1880’s
- Built a machine using punch cards that would tabulate census figures
- Tabulated a census in 6 weeks, with a full statistical analysis in 2.5 years
- 1924 started Tabulating Machine Company which eventually became the International Business Machines Corp. (IBM)
Herman Hollerith
Electro-Mechanical device
Howard Aiken & Grace Hopper

- Mark I
- Machine built in 1944 by IBM to add and subtract large numbers
- Used electrical signals and mechanical gears
- 51 feet by 8 feet
Electronic Computers

• 1946 Electronic Numerical Integrator and Computer (ENIAC)
• John Mauchly & Joh Eckert
• No mechanical parts!
• Electronic switching devices and vacuum tubes
• 1000 times faster than Mark I
ENIAC
Electronic Computers

- **1950’s** Transistor replaced tubes (smaller, faster, and more reliable)

- **1960’s** Integrated Circuit called chip
  - Thin slice of photo-sensitive silicon where circuits have been inscribed
  - Smaller than dime
John Backus & IBM
1954

• **FORTRAN** Computer Programming Language
• The first successful high level programming language.
• Cobalt, Pascal, C, C++, Basic, Java, etc..
• More than 50 computer programming languages
Steve Russell & MIT
1962

- Spacewar Computer Game

- The first computer game invented
History of Computers

- 1940s: **ENIAC** (One of world’s first digital electronic computers)
- 1950s: IBM sells first business computers
- 1960s: Time-sharing computers
- 1970s: Networking takes hold
History of Computers (cont.)

- 1980s: Many PCs, LANs become popular
- 1990s: Explosion in computer use
  - Internet becomes prevalent
- 21st century: **Ubiquitous** computing
  - anywhere and everywhere
  - cell phones, cameras, music players, toys, etc
  - most of these items use Java.
What is an example of hardware?

1. Computer game
2. Keyboard
3. Windows
4. Excel
Computer Hardware and Software

- **Hardware:** Physical devices that you see on your desktop
- **Software:** Programs that give the hardware useful functionality
Computer Hardware

- Six major sub-systems:
  - **User interface**: Supports moment-to-moment communication between user and computer
    - Keyboard and mouse
  - **Auxiliary I/O devices**: Printers and scanners
  - **Auxiliary storage devices**: Secondary memory
    - Hard disks, CD-ROMS, flash memory sticks
Six major sub-systems (continued):

- **Network connection**: Connection to Internet
  - Modems
- **Internal memory**: Random access memory (RAM) or primary memory
  - Fast and relatively small
- **Central processing unit (CPU)**: Performs the work on a computer
  - Consists of billions of transistors
What does CPU stand for?

1. Calculate, Process, Understand
2. Cellular Program Unit
3. Computer Program Unit
4. Central Processing Unit
CPU and Main Memory

- **Central Processing Unit (CPU)**: Chip that executes program commands.
  - Intel Pentium 4 or Sun ultraSPARC III Processor

- **Main Memory**: Primary storage area for programs and data that are in active use.
  - Synonymous with RAM.
Secondary Memory Devices

Main Memory

Central Processing Unit

Information is moved between main memory and secondary memory as needed

BUS: path on which data travels

Hard Disk

Jump Drive

Secondary memory devices provide long-term storage

Active Memory

Volatile!

cache

small memory location for most often used data
(L1, L2, L3)
Input / Output Devices

Peripherals: external parts that are added to a computer

Monitor screen
Keyboard
Mouse
Joystick
Printer

I/O devices facilitate user interaction

Central Processing Unit
Main Memory
Hard Disk
Floppy Disk
The Central Processing Unit

- A CPU is on a chip called a *microprocessor*
- It continuously follows the *fetch-decode-execute cycle*:

  - **fetch**: Retrieve an instruction from main memory
  - **decode**: Determine what the instruction is
  - **execute**: Carry out the instruction

Retrieve an instruction from main memory

Determine what the instruction is

Carry out the instruction
The Central Processing Unit

The CPU contains:

- Arithmetic / Logic Unit: Performs calculations and makes decisions
- Control Unit: Coordinates processing steps
- Registers: Small storage areas
In what decade did personal computers become popular?

1. 1970’s
2. 1980’s
3. 1990’s
4. 2000’s
RAM is synonymous with…?

1. storage
2. Hard drive
3. main memory
4. secondary memory
The speed of the CPU is what determines the efficiency of the computer

1. true
2. false
The CPU has what three parts in it?

1. Logic/arithmetic unit, control unit, registers
2. Fetching unit, dog unit, barking unit
3. Ram, control unit, cache
Computer Software: System Software

- Supports basic operations of a computer and allows human interaction
  - Operating system
  - Communications software
  - Compilers
  - User interface subsystem
Computer Software: Application Software

- Allows human users to accomplish specialized tasks
  - Word processors
  - Spreadsheets
  - Database systems
  - Multimedia software
Analog vs. Digital

There are two basic ways to store and manage data:

- **Analog**
  - continuous, in direct proportion to the data represented
  - music on a record album - a needle rides on ridges in the grooves that are directly proportional to the voltages sent to the speaker

- **Digital**
  - the information is broken down into pieces, and each piece is represented separately
  - music on a compact disc - the disc stores numbers representing specific voltage levels sampled at specific times
Binary Representation of Information & Computer Memory

- Computer memory stores patterns of electronic signals.
  - CPU reads, manipulates, and transforms patterns.
  - Patterns can be stored/viewed as strings of bits.
    - Sequences of 1s and 0s
  - To determine what a sequence of bits represents, you must know the context.
Bits and Bytes

- **Bit (binary digit):** Smallest unit of information processed by a computer
  - A single 0 or 1
- **Byte:** 8 adjacent bits
- Capacity of computer memory and storage devices usually expressed in bytes
Computer Memory

- **Address**: A byte’s location in memory
  - Numbered from 0 to 1 less than the number of bytes of memory installed on the computer
  - Adjacent bytes may store different types of data.
  - Depends on context
Computer Memory (cont.)

Figure 1-5: A 32MB RAM
Integers

- Computers use binary (base 2) notation.
  - $10011_2 = (1 \times 2^4) + (0 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$

- Computer scientists use binary, octal (base 8), and hexadecimal (base 16) notation.
Integers (cont.)

Table 1-2: Some base 10 numbers and their base 2 equivalents

<table>
<thead>
<tr>
<th>BASE 10</th>
<th>BASE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>101</td>
</tr>
<tr>
<td>6</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>111</td>
</tr>
<tr>
<td>43</td>
<td>101011</td>
</tr>
</tbody>
</table>
Floating-Point Numbers

- Numbers with a fractional part
- **Mantissa/exponent notation:** Number is rewritten as a value between 0 and 1 times a power of 10.
  \[354.9810 = 3.549810 \times 10^2\]
  \[.004076 = 4.076 \times 10^{-3}\]
- **IEEE standard:** Mantissa contains one digit before the decimal point.
Characters and Strings

- **ASCII (American Standard Code for Information Interchange) encoding scheme:** Each character represented as a pattern of 8 bits (1 byte)
  - 256 characters may be represented
- **Java uses Unicode encoding scheme:**
  - 2 bytes used to represent a character
  - 65,536 characters may be represented
### Table 1-3: Some characters and their corresponding ASCII bit patterns

<table>
<thead>
<tr>
<th>CHARACTER</th>
<th>BIT PATTERN</th>
<th>CHARACTER</th>
<th>BIT PATTERN</th>
<th>CHARACTER</th>
<th>BIT PATTERN</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0100 0001</td>
<td>a</td>
<td>0110 0001</td>
<td>0</td>
<td>0011 0000</td>
</tr>
<tr>
<td>B</td>
<td>0100 0010</td>
<td>b</td>
<td>0110 0010</td>
<td>1</td>
<td>0011 0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>0101 1010</td>
<td>z</td>
<td>0111 1010</td>
<td>9</td>
<td>0011 1001</td>
</tr>
</tbody>
</table>

Characters and Strings (cont.)
## Bit Permutations

<table>
<thead>
<tr>
<th>1 bit</th>
<th>2 bits</th>
<th>3 bits</th>
<th>4 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>00</td>
<td>000</td>
<td>0000</td>
</tr>
<tr>
<td>1</td>
<td>01</td>
<td>001</td>
<td>0001</td>
</tr>
<tr>
<td>10</td>
<td>010</td>
<td>010</td>
<td>0010</td>
</tr>
<tr>
<td>11</td>
<td>011</td>
<td>011</td>
<td>0011</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>0100</td>
<td>1010</td>
</tr>
<tr>
<td></td>
<td>101</td>
<td>0101</td>
<td>1101</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>0110</td>
<td>1110</td>
</tr>
<tr>
<td></td>
<td>111</td>
<td>0111</td>
<td>1111</td>
</tr>
</tbody>
</table>

Each additional bit doubles the number of possible permutations.
Bit Permutations

- Each permutation can represent a particular item
- There are $2^N$ permutations of $N$ bits
- Therefore, $N$ bits are needed to represent $2^N$ unique items

How many items can be represented by

- 1 bit? $2^1 = 2$ items
- 2 bits? $2^2 = 4$ items
- 3 bits? $2^3 = 8$ items
- 4 bits? $2^4 = 16$ items
- 5 bits? $2^5 = 32$ items
Storage Capacity

- Every memory device has a storage capacity, indicating the number of bytes it can hold.
- Capacities are expressed in various units:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Symbol</th>
<th>Number of Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilobyte</td>
<td>KB</td>
<td>$2^{10} = 1024$</td>
</tr>
<tr>
<td>megabyte</td>
<td>MB</td>
<td>$2^{20}$ (over 1 million)</td>
</tr>
<tr>
<td>gigabyte</td>
<td>GB</td>
<td>$2^{30}$ (over 1 billion)</td>
</tr>
<tr>
<td>terabyte</td>
<td>TB</td>
<td>$2^{40}$ (over 1 trillion)</td>
</tr>
</tbody>
</table>
Computer store everything

1. digitally
2. Analog signals
How many bits in a byte?

1. 1
2. 2
3. 4
4. 8
1KB is equal to...

1. 1000 bits
2. 1024 bits
3. 8000 bits
4. 8192 bits
3 bits could store how many different types of information?

1. 3
2. 6
3. 8
4. 9
Java uses the Unicode character set which uses 2 bytes of memory. How many different characters are possible?

1. 16
2. 256
3. 1024
4. 65,536
Sound

- Information contained in sound is **analog**.
  - Continuous waveform
- In order to represent in a computer, sound must be digitized.
  - Sampled at regular intervals on the waveform
  - Standard sampling rate is 44,000 samples per second
- Requires large amount of storage
Sound (cont.)

Amplitude measures the volume measured between 0 to 65,535 (16 bits)
Frequency measures the pitch
44,000 samples per second
1 hour of music conversion on page 14
Sound encoding schemes use data compression techniques to reduce the size without quality loss.
Compact Discs

- A CD-ROM is portable read-only memory
- A microscopic pit on a CD represents a binary 1 and a smooth area represents a binary 0
- A low-intensity laser reflects strongly from a smooth area and weakly from a pit
- A CD-Recordable (CD-R) drive can be used to write information to a CD once
- A CD-Rewritable (CD-RW) can be erased and reused
- The speed of a CD drive describes how fast it can write information to a CD-R (24x), a CD-RW (10x), and how fast it can read (40x)
A DVD is the same size as a CD, but can store much more information.

The format of a DVD stores more bits per square inch.

A CD can store 650 MB, while a standard DVD can store 4.7 GB.
- A double sided DVD can store 9.4 GB.
- Other advanced techniques can bring the capacity up to 17.0 GB.

There are various recordable DVD technologies – the market will determine which will dominate.
Images

- Also analog information
  - Set of color and intensity values spread across a two-dimensional space
  - Sampling devices: Scanners and digital cameras
  - Measure discrete values at **pixels** on a grid
    - Black-and-white: 2 bits per pixel
    - Grayscale: 8 bits per pixel for 256 shades of gray
    - True color (RGB): 24 bits per pixel
Video

- Consists of a soundtrack and **frames**
  - Sets of images recorded in sequence during a given time interval
- Primary challenge in digitizing video is data compression
Program Instructions

- Represented as a sequence of bits in RAM
- Example:
  - 0000 1001 / 0100 0000 / 0100 0010 / 0100 0100
  - First 8 bits represent the ADD command
    - Operation code or opcode
  - Second 8 bits represent first operand
  - Third 8 bits represent second operand
  - Fourth 8 bits used to store sum
Programming Languages

- **Generation 1—machine languages:**
  Program data entered directly into RAM in form of 1s and 0s
  - Using switches and, later, punch cards
  - Error prone, tedious, and slow
Programming Languages (cont.)

- Generation 2—assembly languages: Mnemonic symbols represent instructions and data.
  - One-to-one correspondence with machine-language instructions
  - **Assembler**: Translates to machine language
  - **Loader**: Loads machine language into memory
Programming Languages (cont.)

- **Generation 3**—high-level languages:
  Designed to be easy to write, read, and manipulate.
  - C, C++, Java
  - High-level instructions may represent many machine-language instructions.
  - **Compiler** translates high-level language into machine language.
Why Java?

- Other prog languages
- Java

### Other prog languages

- Source Code
- Compiler
- Machine Code

### Java

- Source Code
- Compiler
- BYTECODE
- Interpreter (JVM)
- Machine Code
The Software Development Process

- **Software development life cycle (SDLC):** A view of software development in which phases of development occur incrementally

- Standardizes software development
  - Simplifies understanding the project scope
  - Minimizes software flaws
The Software Development Process (cont.)

- **Waterfall model**: A version of the SDLC
  - Phases:
    - Customer request
    - Analysis
    - Design
    - Implementation
    - Integration
    - Maintenance
The Software Development Process (cont.)

Figure 1-6: Waterfall model of the software development life cycle
The Software Development Process (cont.)

Figure 1-7: Relative costs of repairing mistakes when found in different phases
The Software Development Process (cont.)

Figure 1-8: Percentage of total cost incurred in each phase of the development process
Java is an example of a

1. High level language
2. Machine language
3. Assembly language
4. Foreign language

Fundamentals of Java
Java is different from other languages because of its...

1. color
2. speed
3. bytecode
4. sophistication
Summary

- The modern computer age began in the late 1940s with the development of ENIAC. Business computing became practical in the 1950s, and time-sharing computers advanced computing in large organizations in the 1960s and 1970s. The 1980s saw the development and first widespread sales of personal computers, and the 1990s saw personal computers connected in networks.
Summary (cont.)

- Modern computers consist of two primary components: hardware and software. Computer hardware is the physical component of the system. Computer software consists of programs that enable us to use the hardware.
Summary (cont.)

- All information used by a computer is represented in binary form. This information includes numbers, text, images, sound, and program instructions.

- Programming languages have been developed in the course of three generations: generation 1 is machine language, generation 2 is assembly language, and generation 3 is high-level language.
Summary (cont.)

- The software development process consists of several standard phases: customer request, analysis, design, implementation, integration, and maintenance.