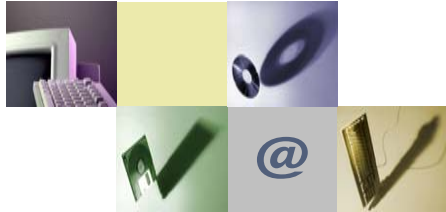# Computer Architecture (H/W)

Digital Computer Concept and Practice

Components of Computer System

- Input unit
  - Data or instructions entered into memory of computer
- Central Processing Unit (CPU)
  - A class of logic machines that can execute computer programs
- Output unit
  - Data that has been processed into a useful form, i.e. information
- Storage unit (secondary storage)
  - Holds data, instructions and information for future use
- I/O unit, secondary storage, multimedia devices
  - → Peripheral equipment

Computer System

- Computer Organization: Hardware + Software
  - Hardware
    - Electronic circuit and mechanism
    - I/O unit, central processing unit, storage unit
    - Bus: channel that allows devices inside computer to communicate with each component
  - Software
    - The programs that control the operation of the computer system.
    - Coded by using high-level programming languages, such as C, JAVA etc. (easier and more efficient for humans)

Description of Basic Components

- **Input Unit**
- **Central Processing Unit (CPU)**
- **Memory (Primary Storage)**
- **Output Unit**
- **Secondary Storage**
- **BUS**

Input Unit

- Input unit is any hardware component that allows users to enter data and instructions.

Input Unit

- Input device types
  - Typing: keyboard
  - Pointing: mouse, trackball
  - Scanning
    - Barcode reader, handheld/flatbed scanner
  - Terminal
    - Input device + Display + Sever Connector

Server
- a computer that provides services
  to other computers (clients), or
- the software that runs on it
  e.g. the internet sites like Google and Yahoo

Motherboard (Mainboard)

- Main circuit board in a system unit
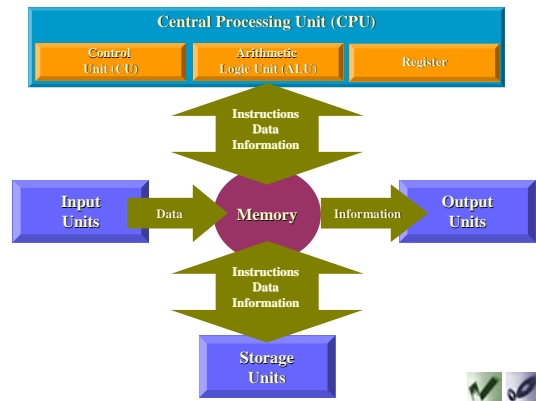- Contains adapter cards, processor chips and memory chips
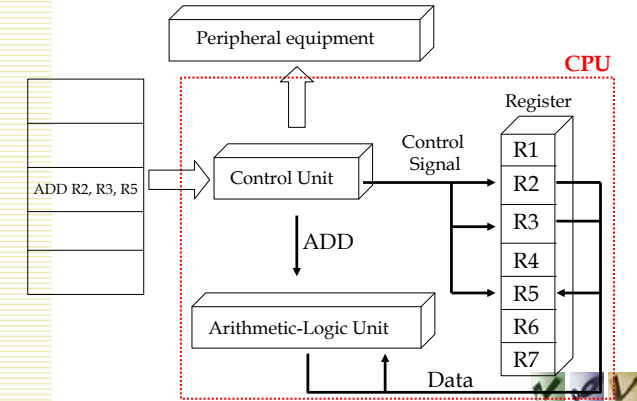

Processor

- Processor (CPU)
  - Interprets and carries out basic instructions that operate a computer
  - Control of input, output and storage units

The Components of a Processor

Central Processing Unit (CPU)

Control Unit (CU)	Arithmetic Logic Unit (ALU)	Register

Instructions
Data
Information

| Input Units | | Data | Memory | Information | | Output Units |

Instructions
Data
Information

Storage Units

CPU Process by a Program

Peripheral equipment

CPU

Register

ADD R2, R3, R5

Control Unit

Control Signal

ADD

Arithmetic-Logic Unit

Data

R1
R2
R3
R4
R5
R6
R7

The Components of a Processor

- CPU: ALU + CU + Register
  - Arithmetic-Logic Unit (ALU)
    - It performs arithmetic, comparison and logical operations.
  - Control Unit (CU)
    - It directs and coordinates operations in computer.
  - Register
    - Temporary high-speed storage area that holds data and instructions.

Clock

- What is the system clock?
  - Controls timing of all computer operations
  - The speed which a processor executes instructions
  - The faster the clock, the more instructions the CPU can execute per second.
  - Clock speeds are expressed in MHz or GHz

Read instructions   Decode instructions   Read data   Execute   Store results
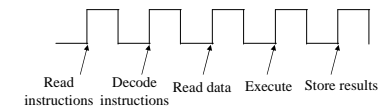
The Capacity and Performance of a PC

- Information processing performance
  - 8-bit Machine: 8 bits (1 byte) processing at a time
  - 64-bit Machine: 64 bits (8 bytes) processing at a time
- Computer processing speed
  - MHz/GHz: the number of machine cycles per second (1 GHz = one billion ticks of system clock per second)
  - MIPS (Million Instruction Per Second)
  - MFLOPS (Million Floating-point Operation Per Second)
  - GFLOPS, TFLOPS
    - Intel Pentium: 10 GFLOPS
    - IBM Cell (PS3): ~200 GFLOPS

Memory

- Primary storage (main memory unit)
- Consists of one or more chips on motherboard or other circuit board
- Memory capacity
  - Usually, 512MB ~ 1GB (MS Vista: 2GB~)

## The Capacity and Performance of a PC

- Memory capacity
  - Number of bytes a storage medium can hold
    - KB: 1 kilobytes = 2^{10} bytes = 1024 bytes
    - MB: 1 megabytes = 1024 x 1024 bytes
    - GB: 1 gigabytes = 1024 MB

Kilobyte (KB)	1 thousand
Megabyte (MB)	1 million
Gigabyte (GB)	1 billion
Terabyte (TB)	1 trillion
Petabyte (PB)	1 quadrillion
Exabyte (EB)	1 quintillion
Zettabyte (ZB)	1 sextillion
Yottabyte (YB)	1 septillion

Memory

- Electronic components that store instructions, data, and information
- Directly accessible by the CPU
- Stores the bits and bytes (instructions and data)
- Each byte stored in unique location called an address.
  - Read and write by 8/16/32/64 bits ➔ word
  - Access time: amount of time it takes processor to read data from memory
- Memory types: RAM + ROM
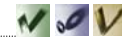
Memory Types: RAM

- Random Access Memory (RAM)
  - Temporary memory
  - Read/Write Memory
  - Any information stored in RAM is lost when the computer is turned off. ➔ volatile
    - Need a secondary memory device

Memory Types: ROM

- ROM (Read Only Memory)
  - Memory that is etched on a chip that has start-up directions for your computer.
  - Permanent memory
  - Any information stored is retained when the computer is turned off. ➔ non-volatile
- Types of ROM
  - PROM(Programmable ROM)
 - EPROM(Erasable PROM)
    - Rewritable

Memory Types: RAM

- Types
  - SRAM (Static RAM)
    - It does not need to be periodically refreshed.
    - It retains data bits in its memory as long as power is being supplied.
    - Expensive
  - DRAM (Dynamic RAM)
    - It needs to be periodically refreshed.
    - Structural simplicity
    - Cheaper than SRAM, comparatively
    - SDRAM (Synchronous DRAM), DDR (Double Data Rate) SDRAM, RDRAM (Rambus DRAM)
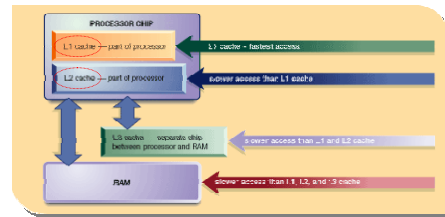
Cache Memory

- Helps speed computer processes by storing frequently used instructions and data.

Faster , Smaller capacity

Register
↕
Cache memory
↕
Primary storage
↕
Secondary storage

Cheaper
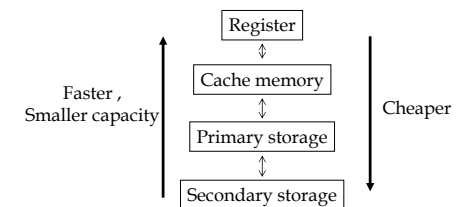
Cache Memory

- L1 cache built into processor
- L2 cache slower but has larger capacity

Output Unit: Monitor

- Display device
  - Output device that visually conveys information
  - Information on display device sometimes called soft copy
  - Monitor types
    - CRT (Cathode-Ray Tube)
   - LCD (Liquid Crystal Display)

Output Unit

- Data that has been processed into a useful form (information)
- Output device is any hardware component that can convey information to user.

Output Unit: Monitor

- Resolution
  - Number of horizontal and vertical pixels in a display device
  - Higher resolution makes image sharper, displays more text on screen, makes some elements smaller
    - e.g. 1024 x 768 vs. 1280 x 1024
    - 1920 x 1080 (HDTV)
    - 1920 x 1200 (HD computer monitor)
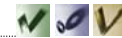
Output Unit: Monitor

- Video card
  - A board that plugs into a PC to give it display capabilities.
  - The display capabilities of a computer depend on both the logical circuitry (provided in the video card) and the display monitor.
- Video memory
  - The video card have its own video memory
  - The amount of video memory dictates the maximum resolution and color depth available.
  - e.g. representation of 1600 millions color (24 bits) by 1280 x 1024 resolution → required at least 4MB

Output Unit: Printer

- Printer
  - Output device that produces text and graphics on a physical medium
- Types
  - Resolution: 1200 DPI, 600 DPI
  - Color of contents: B/W, color
  - Printing ways: laser, ink-jet, dot matrix

Secondary Storage

- Used to store data and programs
- Mass storage available and more permanent
- It is required for two reasons.
  - The working memory of the CPU is limited in size and cannot always hold the amount of data required.
  - Data and programs in secondary storages do not disappear when the power is turned off.
- Secondary storage types
  - Magnetic disks (FDD, HDD)
  - Optical discs (CD, DVD)

FDD

- Floppy Disk Drive (Diskette)
  - Two types
    - 3.5 inch: 1.44MB
    - 5.25 inch: 1.2MB
  - Strength: cheap and portable
  - Weakness: reading and writing speed is slow

3.5 inch diskette

5.25 inch diskette
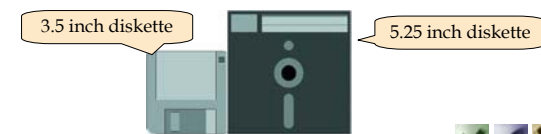
HDD

- Hard Disk Drive
  - Consists of several inflexible, circular platters that store items electronically
  - High-capacity storage
  - Hard disks are permanently mounted inside the computer and are not removable like diskettes.
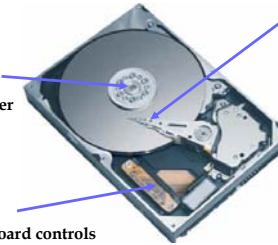
Hard disk installed in system unit

HDD

- How does a hard disk work?

Step 2.
Small motor spins platters while computer is running.

Step 3.
When software requests a disk access, read/write heads determine current or new location of data.

Step 1.
Circuit board controls movement of head actuator and a small motor.

HDD

Track
is narrow recording band that forms full circle on disk

Sector

- **Formatting** prepares disk for use and marks bad sectors as unusable

Optical Discs

- Flat, round, portable metal discs made of metal, plastic, and lacquer
- Types
  - CD-ROM: 700MB
  - DVD-ROM: 4.7~8.5GB
  - HD DVD: 15~30GB
  - Blu-ray Disc: 25~50GB

BUS

- Channel that allows devices inside computer to communicate with each other
- 'Bus width' determines number of bits transmitted at one time