Chapter Two

Organization of the Computer System

Addis Ababa Science and Technology University

Compiled by: Lemma Nigussie
2007 E.C.

CHAPTER TWO
ORGANIZATION OF THE COMPUTER SYSTEM

INTRODUCTION

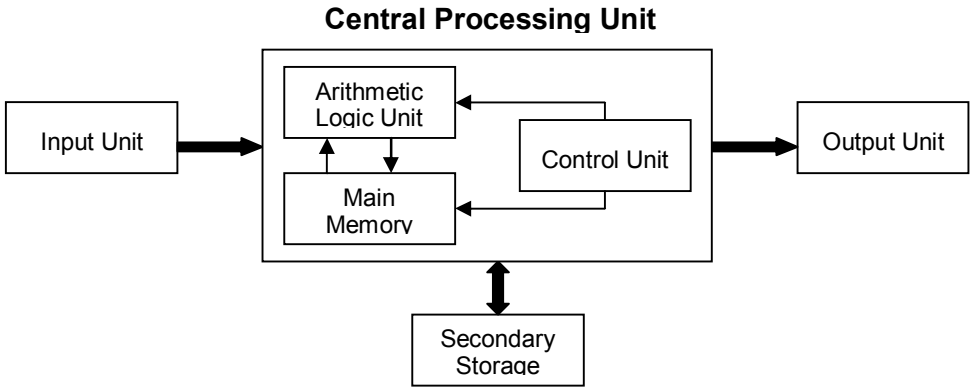
The computer has a structure through which its internal circuits and components are organized and interconnected. External inputs (in the form of data) are received for processing. There are Input/Output (I/O) units to perform this task. Data is then received by the main processor (microprocessor, for most PCs) and processing is carried out. Again the user can see the results of processing, carried out by I/O units.

These notions are truly understood through study of Computer Architecture (and Organization). Computer Architecture is the science of selecting, and interconnecting hardware components to create computers that meet functional, performance and cost goals. It is the logical structure of the computer system.

COMPONENTS OF A COMPUTER

The computer system essentially comprises three important parts – input unit, central processing unit (CPU) and the output unit. The CPU itself is made of three components namely, the arithmetic logic unit (ALU), memory unit, and the control unit.

In addition to these, auxiliary storage/secondary storage devices are used to store data and instructions on a long-term basis.



Schematic Representation of a Computer

1. Input Unit

Data and instructions must be entered into the computer system for processing, and results obtained from computations must be displayed or recorded for the user. The input device serves the purpose of receiving data and instructions in a form that can be understood by the computer.

2. Central Processing Unit

Data and instructions (programs) are stored in the computer's memory after which all the major calculations and computations are carried out within the CPU. The CPU is also responsible for controlling the operations of various units of the computer system.

a) Arithmetic Logic Unit (ALU)

As the name suggests, the arithmetic logical unit carries out arithmetic and logical operations on the data made available to it. For simple understanding, the ALU can be divided in to arithmetic unit and logical unit.

Arithmetic Unit: contains the circuitry that is responsible for performing the actual computing and carrying out the arithmetic calculations, such as addition, subtraction, multiplication, and division. It can perform these operations at a very high speed.

Logical Unit: the importance of the logical unit is the ability it provides to the CPU to make logical operations based on the instructions provided to it. Logical unit uses statements such as AND, OR, and NOT. This is useful when you have a set of instructions to execute only if certain conditions are true.

Registers: are special purpose, high speed temporary memory unit. They hold varies types of information such as data, instructions, addresses, and the intermediate results of calculations. Essentially, they hold the information that the CPU is currently working on. Registers can be thought of as CPU's working memory. As the size of the registers increase, the computer processing activities also increase. To execute an instruction, the control unit receives it from the main memory and places in to the register.

- *Registers are paths or conduits that connect the Arithmetic Logic Unit to the main memory.*
- *When an instruction is loaded from main memory, it is placed first in the register to wait instructions from the control unit.*
- *Data are also stored in registers prior to execution in the ALU.*

b) Main Memory

The main memory holds data and instructions after input, till they are needed. It also holds the processed results that are awaiting output.

c) Control Unit

The function of the control unit is to execute the instructions of a program, one by one, in the desired sequence. It interprets each instruction and then prompts its execution by one of the units like input, output, ALU or storage.

For example, a comparison of two numbers (a logical operation) to be performed by the ALU may require loading the two numbers into the main memory which is a function performed by the control unit. It will then pass on the execution of the 'compare' function to the ALU.

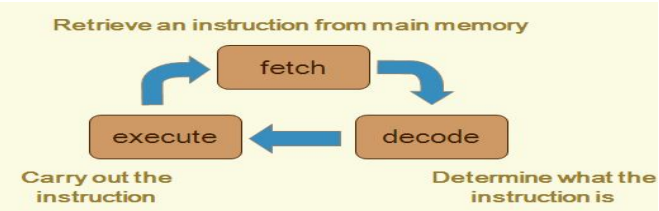
The control unit can be thought of as the heart of the CPU. It controls the I/O devices and transfer of data to and from the primary storage. It reads and interprets instructions that retrieve from the main memory. It controls the flow of instructions from memory to CPU or from ALU to registers. The control unit repeats a set of four basic operations: fetching, decoding, executing, and storing.

Fetching: is the process of obtaining a program instruction or data item from memory.

Decoding: is the process of translating the instruction in to commands the computer can execute.

Executing: is the process of carrying out the commands.

Storing: is the process of writing the result to memory.



Generally, it performs all the control functions of the computer.

- *It retrieves the instruction from memory.*
- *Translates those instructions into computer functions and sends signals to other computer hardware units to carry out those functions.*
- *It is also responsible for determining the next instruction to be executed by the computer.*
- *In general it serves as the computer traffic cope.*

3. Output Unit

The processed data, stored in the memory of the computer is sent to the output unit, which then converts it into a form that can be understood by the user. The output is usually produced in one of the two ways – on the display device, or on storage devices (soft copy), or on paper, printed (hard copy).

BITS AND BYTES

All information in the computer is handled using electrical components like the integrated circuits, semiconductors, all of which can recognize only two states – presence or absence of an electrical signal. Two symbols used to represent these two states are **0** and **1**, and are known as BITS (an abbreviation for **BI**nary Digi**TS**). **0** represents the absence of a signal, **1** represents the presence of a signal. A BIT is, therefore, the smallest unit of data in a computer and can either store a **0** or **1**.

Since a single bit can store only one of the two values, there can possibly be only four unique combinations:

00 01 10 11

Bits are, therefore, combined together into larger units in order to hold greater range of values.

BYTES are typically a sequence of eight bits put together to create a single computer alphabetical or numerical character. More often referred to in larger multiples, bytes may appear as Kilobytes (1,024 bytes), Megabytes (1,048,576 bytes), GigaBytes (1,073,741,824), TeraBytes (approx. 1,099,511,000,000 bytes), or PetaBytes (approx. 1,125,899,900,000,000 bytes).

Bytes are used to quantify the amount of data digitally stored (on disks, tapes) or transmitted (over the internet), and are also used to measure the memory and document size.

COMPUTER HARDWARE

Computers work through an interaction of hardware and software. Hardware refers to the parts of a computer that you can see and touch, including the case and everything inside it. The most important piece of hardware is a tiny rectangular chip inside your computer called the central processing unit (CPU), or microprocessor. It's the "brain" of your computer - the part that translates instructions and performs calculations. Hardware items such as your monitor, keyboard, mouse, printer, and other components are often called hardware devices, or devices.

INPUT AND OUTPUT DEVICES

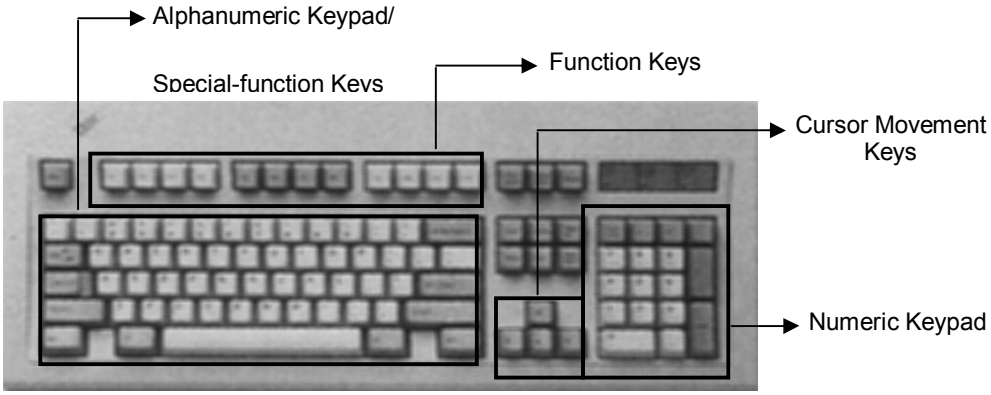
The computer will be of no use unless it is able to communicate with the outside world. Input/Output devices are required for users to communicate with the computer. In simple terms, input devices bring information INTO the computer and output devices bring information OUT of a computer system. These input/output devices are also known as **peripherals** since they surround the CPU and memory of a computer system.

Some commonly used Input/Output devices are listed in table below.

Input Devices	Output Devices
Keyboard	Monitor
Mouse	LCD
Joystick	Printer
Scanner	Plotter
Light Pen	Speaker
Touch Screen	

Some Input Devices

Keyboard: It is a text base input device that allows the user to input alphabets, numbers and other characters. It consists of a set of keys mounted on a board.



Typical Keyboard Layout

Alphanumeric Keypad: It consists of keys for English alphabets, 0 to 9 numbers, and special characters like + – / * ( ) etc.

Function Keys: There are twelve function keys labeled F1, F2, F3, … , F12. The functions assigned to these keys differ from one software package to another. These keys are also user programmable keys.

Special-function Keys: These keys have special functions assigned to them and can be used only for those specific purposes Some of the important keys are. Examples are *Enter, Spacebar, Backspace and Delete.*

Mouse: The mouse is a small device used to point to a particular place on the screen and select in order to perform one or more actions. It can be used to select menu commands, size windows, start programs etc.

Joystick: The joystick is a vertical stick which moves the graphic cursor in a direction the stick is moved. It typically has a button on top that is used to select the option pointed by the cursor. Joystick is used as an input device primarily used with video games, training simulators and controlling robots.

Scanner: Scanner is an input device used for direct data entry from the source document into the computer system. It converts the document image into digital form so that it can be fed into the computer. Hand-held scanners are commonly seen in big stores to scan codes and price information for each of the items.

Light Pen: It is a pen shaped device used to select objects on a display screen. It is quite like the mouse (in its functionality) but uses a light pen to move the pointer and select any object on the screen by pointing to the object. Users of Computer Aided Design (CAD) applications commonly use the light pens to directly draw on screen.

Touch Screen: It allows the user to operate/make selections by simply touching the display screen. Common examples of touch screen include information kiosks, and bank ATMs.

Common Output Devices

Monitor: Monitor is an output device that resembles the television screen and uses a Cathode Ray Tube (CRT) to display information. The monitor is associated with a keyboard for manual input of characters and displays the information as it is keyed in. It also displays the program or application output.

Liquid Crystal Display (LCD): LCD was introduced in the 1970s and is now applied to display terminals also. Its advantages like low energy consumption, smaller and lighter have paved its way for usage in portable computers (laptops).

Printer: Printers are used to produce paper (commonly known as hardcopy) output. Based on the technology used, they can be classified as **Impact** or **Non-impact** printers.

Impact printers use the typewriting printing mechanism wherein a hammer strikes the paper through a ribbon in order to produce output. Dot-matrix and Character printers fall under this category.

Non-impact printers do not touch the paper while printing. They use chemical, heat or electrical signals to etch the symbols on paper. Inkjet, Deskjet, Laser, Thermal printers fall under this category of printers.

Plotter: Plotters are used to print graphical output on paper. It interprets computer commands and makes line drawings on paper using multicoloured automated pens. It is capable of producing graphs, drawings, charts, maps etc. Computer Aided Engineering (CAE) applications like CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing) are typical usage areas for plotters.

MEMORY OF THE COMPUTER

Memory or storage capacity is one of the important components of a computer. Any storage unit of a computer system is classified on the basis of the following criteria:

1. ***Access time***: This is the time required to locate and retrieve stored data from the storage unit in response to program instructions.
2. ***Storage capacity***: It is the amount of data that can be stored in the storage unit.
3. ***Cost*** per bit of storage.

Units of memory:

The computer stores a character in the storage cells with binary (0, 1) mechanism. Thus the basic unit of memory is a ***bit*** (binary digit – 0, 1). To store a character, a computer requires 8 bits or 1 byte. This is called the ***word length*** of the storage unit.

Hence the storage capacity of the computer is measured in the number of words it can store and is expressed in terms of bytes. The different units of measurement are

8 Bits = 1 Byte
2^{10} (or) 1024 Bytes = 1 Kilo Byte (KB)
2^{10} (or) 1024 KB = 1 Mega Byte (MB)
2^{10} (or) 1024 MB = 1 Gega Byte (GB)
2^{10} (or) 1024 GB = 1 Tera Byte (TB)

Types of Memory:

A computer memory is of ***two*** types;

1. **Primary Memory (Internal Storage)**: Primary memory is also called internal memory and is an important part of a computer. It is the main area in a computer where the data is stored. The stored data can be recalled instantly and correctly whenever desired. This memory can be quickly accessed by the CPU for reading or storing information. Primary memory is further classified into two types:
    - Random Access Memory (RAM)
    - Read- Only Memory (ROM)

RAM: RAM is also known as read/write memory as information can be read from and written onto it. RAM is a place in a computer that holds instructions for the computer, its programs and the data. The CPU can directly access the data from RAM almost immediately. However, the storage of data and instructions in RAM is temporary, till the time the computer is running. It disappears from RAM as soon as the power to the computer is switched off i.e. it is volatile memory.

There are two types of RAM

- **Dynamic RAM (DRAM)**: holds data in dynamic (keeping on refreshing) manner with the help of a refresh circuity.
- **Static RAM (SRAM)**: along with DRAM, is essential for a system to run optimally.

ROM: It is called Read-only memory as information can only be read from and not written or changed onto ROM. ROM is the built-in-memory of a computer. It stores some basic input – output instructions put by the manufacturer to operate the computer. The storage of data and instructions in ROM is permanent. It does not depend on the power supply i.e. it is non-volatile memory.

Read-only memories can be manufacturer-programmed or user-programmed. While manufacturer–programmed ROMs have data burnt into the circuitry, user-programmed ROMs can have the user load and then store read-only programs. PROM or Programmable ROM is the name given to such ROMs. Information once stored on the ROM or PROM chip cannot be altered. However, another type of memory called EPROM (Erasable PROM) allows a user to erase the information stored on the chip and reprogram it with new information. EEPROM (Electrically EPROM) and UVEPROM (Ultra Violet EPROM) are two types of EPROMs.

Cache memory: a piece of very fast memory made from high speed SRAM that reduces the access time of data. Cache memory is generally incorporated in the processor and is relatively expensive.

2. **Secondary Memory (External storage):** The primary memory which is faster (and hence expensive) is generally not sufficient for large storage of data. As a result, additional memory, called the auxiliary or secondary memory is used. It is also referred as backup storage as it is used to store large volume of data on a permanent basis which can be transferred to the primary memory whenever required for processing. Data are stored in secondary storage in the same binary codes as in the main (primary memory) storage. Some of the devices of secondary storages are Floppy Disk, Hard Disk, CD-ROM, DVD and Flash drive.

RAM is volatile memory having a limited storage capacity. Secondary/auxiliary storage is storage other than the RAM. These include devices that are peripheral and are connected and controlled by the computer to enable permanent storage of programs and data.

Magnetic medium was found to be fairly inexpensive and long lasting medium and, therefore, became the preferred choice for auxiliary storage. Floppy disks and hard disks fall under this category. Examples are optical storage devices like CDs, DVDs, Pen drive, Zip drive etc.

Floppy Disk: These are small removable disks that are plastic coated with magnetic recording material. Floppy disks are typically 3.5″ in size (diameter) and can hold 1.44 MB of data. This portable storage device is a rewritable media and can be reused a number of times.

Floppy disks are commonly used to move files between different computers. The main disadvantage of floppy disks is that they can be damaged easily and, therefore, are not very reliable.

Hard Disk: Hard disks are made up of rigid material and are usually a stack of metal disks sealed in a box. The hard disk and the hard disk drive exist together as a unit and are a permanent part of the computer where data and programs are saved.

These disks have storage capacities ranging from 1GB to 1 TB and more. Hard disks are also rewritable and are more reliable when compared with floppies.

Depending on the way they are packaged, hard disks can be classified as **Disk packs** or **Winchester disks**. Disk packs are removable, in the sense that they can be removed and kept offline when not in use. They must be mounted on the disk drive before use. Winchester disks on the other hand, consist of disk platters sealed in a contamination-free container and form a permanent component of the computer.

CD: Compact Disk (CD) is portable disk having data storage capacity between 650-700 MB. It can hold large amount of information such as music, full-motion videos, and text etc. It contains digital information that can be read, but cannot be rewritten. Separate drives exist for reading and writing CDs. Since it is a very reliable storage media, it is very often used as a medium for distributing large amount of information to large number of users. In fact today most of the software is distributed through CDs.

DVD: Digital Versatile Disk (DVD) is similar to a CD but has larger storage capacity and enormous clarity. Depending upon the disk type it can store several Gigabytes of data (as opposed to around 650MB of a CD). DVDs are primarily used to store music or movies and can be played back on your television or the computer too. They are not rewritable media.

Benefits of Secondary Storage devices

Compared to primary storage devices, secondary storage devices

- *Are non volatile*
- *Have better capacity*
- *Are less expensive*
- *Are portable*
- *Have better reliability*
- *Have better convenience*
- *Have better reusability*

COMPUTER SOFTWARE

Software: refers to the instructions, or programs, that tell the hardware what to do. The most important software on the computer is the operating system, which controls and manages the hardware connected to your computer. The operating system provides an interface that helps you to interact with the computer. A word processing program that you can use to write letters on your computer is a type of software.

Categories of software

Depending on the target use, there are three categories of software:

a) ***Systems Software***: These are programs that coordinate the activities and functions of the hardware and other programs. The system software acts as a mediator between application programs and the computer system's hardware, as well as between the PC and the user. The system software makes the physical machine do work. E.g. Operating Systems, translators etc.

There are three types of System software

i) **Operating System (OS)**: A program or set of programs that manage the computer system resources and controls its overall functionings. E.g. Microsoft Windows (2008, 2007, xp, …), Macintosh, Unix operating systems.

ii) **Language Translators:** translate application programs written in high-level language or assembly language into machine language. Includes**:**

- **Assemblers:** translate assembly language into machine language. E.g. Macro Assembler (MASM)
- **Compilers:** translate high level languages into machine language directly. E.g. C++ compilers
- **Interpreters:** converts high level languages into intermediate forms. E.g. The Java Virtual Machine (JVM)

iii) ***Utility Software:*** It is system software designed to help analyze, configure, optimize or maintain a computer. A single piece of utility software is usually called a **utility** or **tool**. Utility software usually focuses on how the computer infrastructure (including the computer hardware, operating system, and application software and data storage) operates. E.g. Anti-virus utilities, disk defragmenters, disk checkers, Data compression utilities etc.

b) **Application Software**: allows users to do things like creating text documents, playing games, listening to music or viewing websites. They help users solve particular computing problems or allow them to perform specific tasks on a computer. The application software makes the system software do work. Examples are,

- *Microsoft Office*
- *Adobe Photoshop*
- *Windows and other Media Players*
- *Web Browsers like Internet Explorer, Firefox and Google Chrome*