Ref: 'Online course on EE-390', KFUPM

Extra Handout No 1

By Dr Sheikh Sharif Iqbal

Introduction to Digital Computer System

Objective:

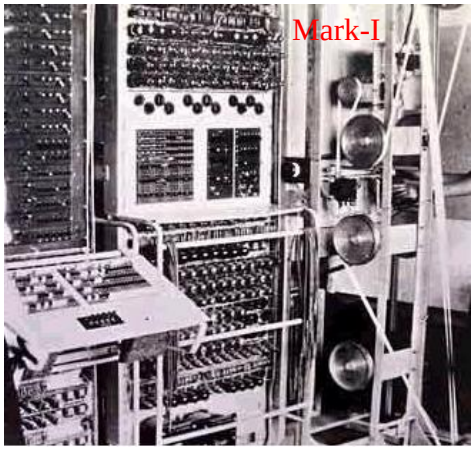
- To review the evolution of Digital computer systems

- To introduce the general architecture of micro-computer system

- To become familiar with the Key-terminologies

Slide 1: Evolution of Digital Computers

- Early computing devices were mechanical machines with gears and levers *(such as Abacus and slide-rule, that is also available today as toys)*



- "Colossus Mark-I" was the 1st electronic computer, used during World War 2 (1943) to decipher military codes. It had 1500 Vacuum tubes and could process 5000 characters/second.

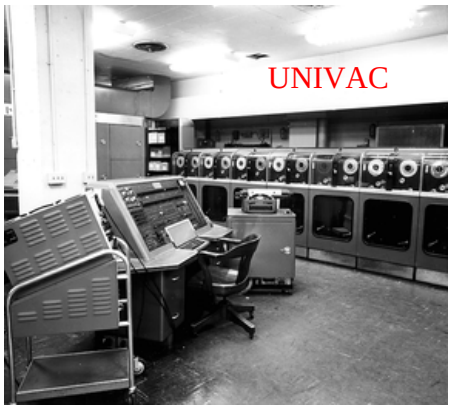
- "ENIAC" was a reprogrammable digital computer, built in 1946 to calculate the artillery firing tables of US army. This huge device had 17468 vacuum tubes, 1500 relays, 70000 resistors, 10000 capacitors and consumed almost 150 kilowatt power.
(ENIAC was able to store a maximum of twenty 10-digit decimal numbers and could discriminate the sign of a number, compare quantities for equality, add, subtract, multiply, divide, and extract square roots)

Hyperlinked data: Vacuum tube looks like light bulbs and generally used to amplify, or otherwise modify, a signal by controlling the movement of electrons in an evacuated space. Currently the vacuum tube has been replaced by the much smaller and less expensive transistor, either as a discrete device or in an integrated circuit.

Hyperlinked data: Electronic Numerical Integrator and Computer

Slide 2: **Evolution of Digital Computers (cont'd)**

- "UNIVAC" was the 1st commercial mainframe computer used by US government in 1951. It used 5200 vacuum tubes that required 125 kW of power to perform 1900 operations per second. *(It was able to store 1000 words of 12 characters and running on a clock of 2.25 MHz. This 13 ton device was priced in the range of 100's of thousands of dollar)*



UNIVAC = UNIVersal Automatic Computer

- "IBM 650" was the 1st mass produced computer as 2000 of this computers were manufactured and supplied from 1953 to 1962. *(It consisted of a console unit, power unit, rotating drum memory and a card reader unit and processed 17,000 instructions per second.)*

Complete History: http://library.thinkquest.org/18268/History/hist_c_50s.htm
(In that same period, several other companies in different countries were also involved in the development process of digital computers and a complete description can be found in the given URL:

Slide 3: **Evolution of Digital Computers (cont'd)**

- In 1954, the advent of commercial silicon based junction transistors introduced the 2nd generation of computers, where vacuum tubes were replaced with junction transistors.

- In 1955, the 1st fully transistorized digital computer, "TRADIC", was manufactured using almost 700-800 transistors and 10000 diodes. *(This 3 cubic feet device was about twenty times faster than the vacuum tube computers and required less than 100 watts of power)*

TRADIC = **TRA**nsistor **DI**gital **C**omputer or **TR**ansistorized **A**irborne **DI**gital **C**omputer

- IBM 7000 series was the 1st transistorized computer made by IBM with one million instructions per second capabilities.

- In 1958, the invention of integrated cirucits (IC's) by Jack Kilby and semiconductor IC's by Robert Noyce (1959) led to a new generation of commercial computers called Mini-computers.
(Through 1960's this scaled-down versions main-frame computers, equipped with keyboard and monitors, were popular due to its reasonable price (USD 10,000 and upwards), acceptable size and performance)

Slide 4: **Evolution of Digital Computers (cont'd)**

- In 1971, the release of 1st commercial microprocessor (Intel 4004) revolutionized the computer industry and resulted in a new generation of micro-computers, also known as personal computers (PC's).
(Later In 1973, a French company developed "Micral", a low precession personal computer. Due to its high cost of $1,750, this computer was never marketed

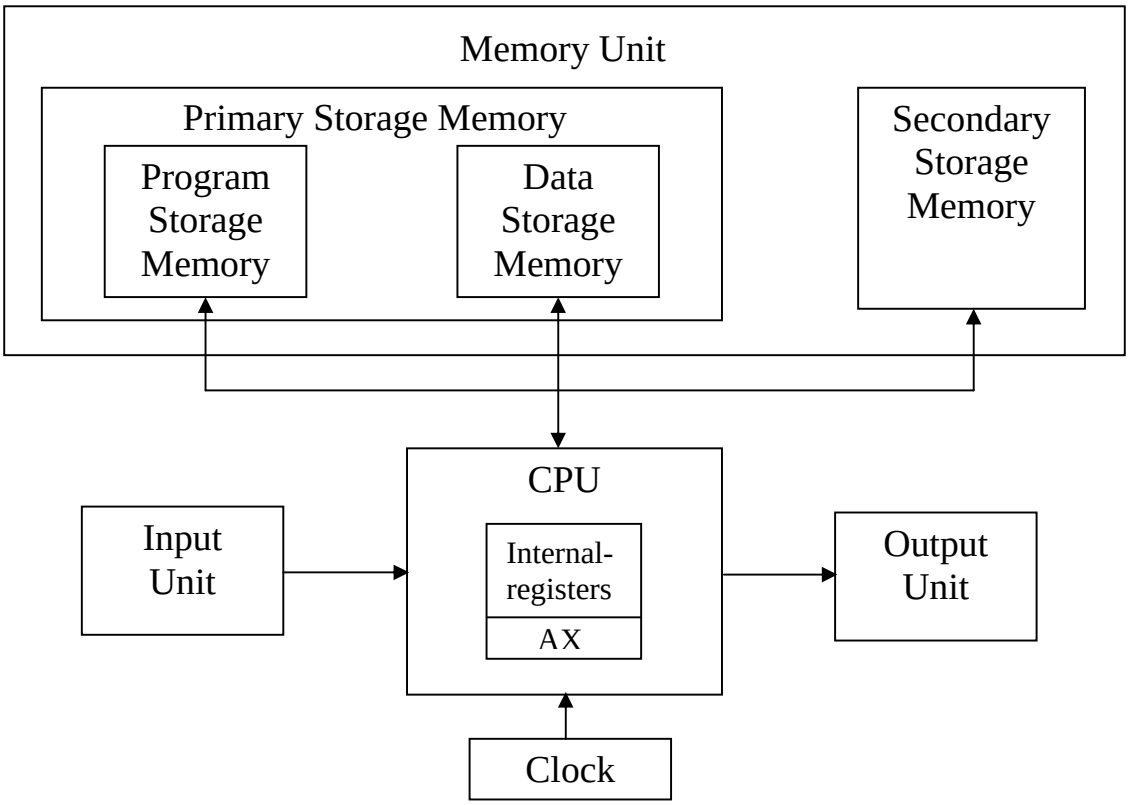
Microprocessor: Also known as central processing unit (CPU) or the brain of the personal computer. It is an integrated circuit built on a tiny piece of silicon and contains thousands, or even millions, of transistors, which are interconnected via superfine traces of aluminum. These transistors work together to store and manipulate data so that the microprocessor can perform a wide variety of useful functions as dictated by software.

- In 1977, 1st desktop computer, "TRS-80", was released with most of the required accessories and an inbuilt programming language "BASIC".
(At a price 600 USD, nearly 10,000 of these machines were sold around the world)

- In 1981, IBM's 1st PC was marketed. It ran on Intel's 4.77 MHz 8088 microprocessor and came with MS-DOS operating system. The main components of PC's are briefly introduced in the next slide.

Technical specifications of Intel 4004: (1) Maximum clock speed is 740 kHz and executed ≈60000 instructions/sec. (2) Register set contains 16 registers of 4 bits each (3) Separate program and data storage with single multiplexed 4-bit bus for transferring: 12-bit addresses, 8-bit instructions and 4-bit data words. (4) Instruction set contains 46 instructions. (5) A Japanese company used them to build calculators.

Slide 5: **Basic Hardware Architecture of a Microcomputer**



- Typically a microcomputer (PC) is divided into four functional sections, such as Input unit, CPU, Memory unit and output unit.

- Typically a microcomputer can be divided into four functional sections such as Input unit, CPU, Memory unit and output unit. Brief introduction of these sections are given here. :

- The CPU (Central Processing Unit), which mainly consist of microprocessor IC and acts a coordinator all activities within the computer. It mainly consist of general-purpose and reserved registers made of flips-flops. The accumulator (AX) for example is reserved register for performing complex mathematical operations (multiply and divide) and isolated input/output operation.
The CPU is connected with a clock generator circuit, which provides oscillating square wave pulses to control and synchronize the basic timing of the computer.

- The memory unit: the main memory of a microcomputer consist of temporary storage locations, called "RAM" (Random Access Memory), each with individual physical address. For permanent storage, microcomputers use external devices like floppy, CD, DVD and Hard drives. Another type of memory called ROM is programmed by the manufacturer to initiate start-up process of the operating system..

- The Input and Output devices allow the computer to input information for processing and then output the result. Mainly Keyboard, mouse, scanner, microphone, permanent memory storage devices, monitor and printers are used for this purposes.

Slide 6: **Basic Hardware Architecture (cont'd)**

- **Input output (I/O) devices**: I/O devices also known as peripheral devices, are used to enter information (code/data) into the computer and display the processed information.
(Commonly used input devices are, keyed inputs, pointing devices, data scanners, voice and picture recognizers etc, whereas the common output devices are, monitors, audio outputs, printers, plotters, permanent-storages, robots etc.)

- Some of the peripherals require additional hardware (plug-in cards) and drivers to interface them with the microcomputer (such as, SCSI, sound, scanner, picture-grabber cards etc.)

- Detail discussion related to microcomputer input/output operation is available in the later module of this course.

Slide 7: **Basic Hardware Architecture (cont'd)**

- **Memory subsystem**: It is an essential part of a computer to store initial and processed information. Typically microcomputers have two types of memories; primary and secondary. *(Although these memories are briefly introduced here, detail discussion about them will follow in later lectures)*

- Primary memory is normally smaller in size and temporarily stores active information. *(such as the operating system (windows), programs that are currently being run, data that are currently being processed by computer etc)*

- Secondary memory is normally large and used for long-term storage of information that is not currently being used by the PC. Typically this memory represents the external storage media and hard disks. *(Such as magnetic tapes like, Floppy disks (≈1.44 Mbytes), Zip disks (≈100 Mbytes), Optical media like, Read-only Compact Disk (CD of ≈600 Mbytes), Read/write Compact Disk (CD-RW), Digital Video Disk (DVD of ≈2 Gbytes) etc)*

- Typically primary storage is implemented using CPU-registers, Caches, Random access memories (RAM), Read only memories (ROM) etc. *(Except ROM, information stored in primary memory is erased when the computer is switched off)*

CPU Registers: Fastest storage elements, where frequently used temporary data is stored and accessed by specifying the register name (not addresses). Although general purpose registers can be accessed by the programmer, special purpose registers are only used by the computer.

Cache: is a very fast type of RAM that is used to store information that is most frequently or recently used by the computer. Recent computers have 2-levels of cache; the first level is faster but smaller in size (usually called internal cache), and the second level is slower but larger in size (external cache

Read-Only-Memory (ROM): stores information permanently and also can randomly access the stored information. ROM is usually used to store the information required by the computer to start-up or initiate the booting sequence. Recent types of ROMs that are used in micro-computers are also called FLASH or CMOS

Random-Access Memory (RAM): Usually called the main memory of PC, where addressed memory locations are used to temporarily store (write) information which can be accessed (read) in any order at equal time periods (hence the name random access). RAM is typically implemented using IC's, often called memory sticks (such as DIP 16-pin, SIPP, SIMM 30-pin, SIMM 72-pin, SDRAM DIMM, DDR DIMM).

Slide 8: **Basic Hardware Architecture (cont'd)**

- **Central Processing unit (CPU)**: In today's computer, the CPU circuits have been reduced to a general purpose processing unit, built into a single semiconductor integrated circuit called Microprocessor. *(Before this, electronic CPUs were typically made from bulky discrete switching devices implemented using vacuum tubes, discrete transistors and later small-scale integrated (SSI) circuits)*

- In recent days, microprocessors (µP) are implemented using very-large-scale integrated (VLSI) circuit technology, where millions of transistors are interconnected via superfine traces of aluminum and works together to store and manipulate information as dictated by the controlling software.

- The evolution of microprocessors has been known to follow Moore's Law and from the humble beginning as processors in calculators (Intel 4004), microprocessors today dominates most of the digital systems from mainframes to the smallest handheld computers.

Moore's Law: Gordon E. Moore was the co-founder of "Intel". His empirical observation that appeared in the "*Electronics Magazine* of 19 April 1965" stated that the complexity of integrated circuits, with respect to minimum component cost, doubles every 24 months and in fiture all the components of a CPU can be built on a single wafer. This rule is generally followed, unconsciously, since early 1970.

Slide 9: **Key Terminologies related to Hardware**

- **Hardware** refers to objects that you can actually touch, like disks, display screens, connecting wires or Buses, motherboards and chips. Some important hardware related terminologies are:

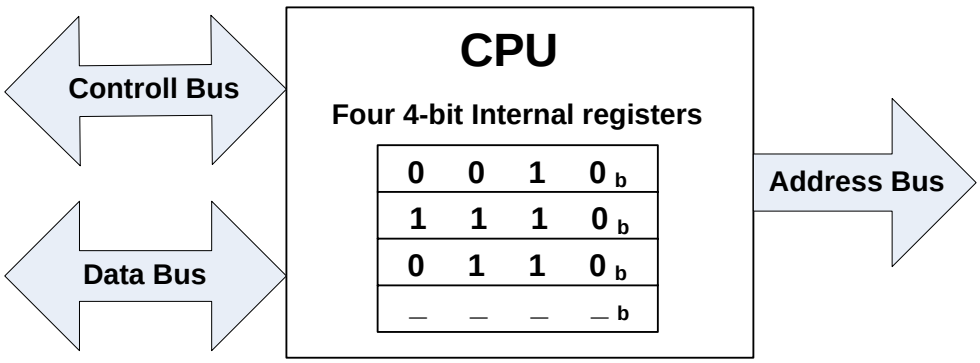
  - Memory subsystem: Internal physical storage areas in the computer as introduced previously (such as RAM, Cache etc).

  - Peripheral Devices: Input/output devices that are not part of the computer (i.e. CPU, main memory). Peripheral devices can be internal (plug-in interface cards) and external (mouse, keyboard, monitor etc).

  - CPU internal registers: few binary-digit (bit) long temporary storage locations, typically used to perform data transfer, arithmetic, logical and shift operations. Thus a 4-bit internal registers mean the related CPU can perform 4-bit by 4-bit data operation. (*see next figure*)

(Although most of the internal registers are available to programmer, some of them are kept reserved)

Slide 10: **Key Terminologies related to Hardware (Cont'd)**



- Bus System: is a collection of wires that carries electrical signals (Logic '0' or '1') in and out of CPU. As per the information carried by these set of wires (or Bus), the Bus architecture is divided into:
  - Address-bus that carries physical address of memory or I/O storage locations),
  - Data-bus that carries data to be read or written into the memory or I/O location. **Internal bus is twice than ext. one.**
  - Control-bus that carries information that controls the read or write operation.

  (In each case, the total number of wires available for the task determines the width of that bus. Thus, a 4-bit data bus means four electrical lines (outside the CPU) are available to carry four binary digits (bits) of data from or into the CPU)

Slide 11: **Key Terminologies related to Software**

- **Software** refers to computer instructions or data that is stored electronically and cannot be physically touched. Some important software related terminologies are:

(As an analogy we can consider a book, where the pages and the ink are the hardware, while the words, sentences, paragraphs, and the overall meaning are the software)

- Instruction: Is basic command to the computer to perform a specific task. An instruction set represents all recognizable instructions by the instruction decoder of the PC. Two popular instruction sets are CISC (Complex Instruction Set) and RISC (Reduced Instruction Set), which is mostly used in servers.

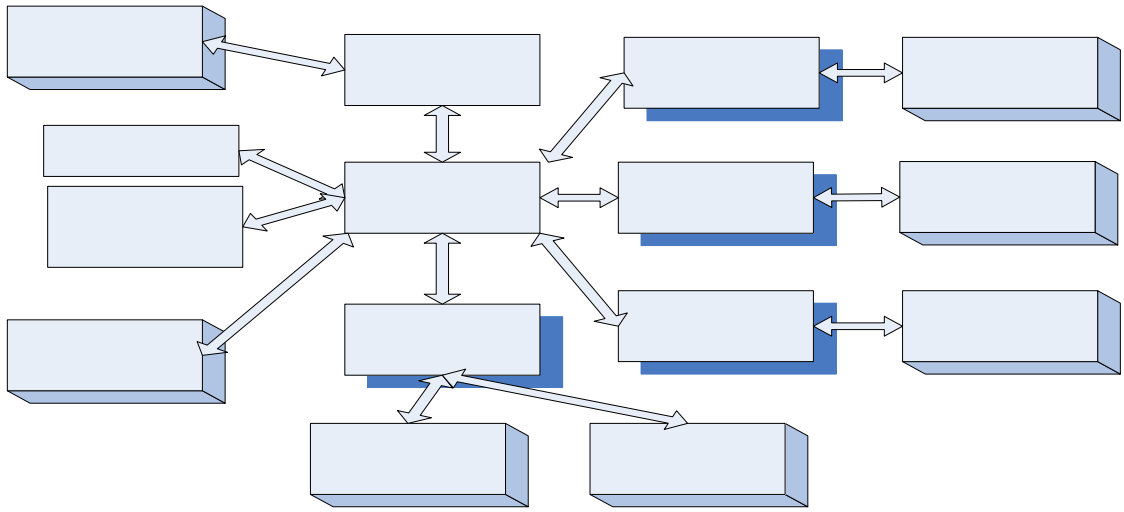
- Programs: An organized list of instructions that, when executed, causes the computer to behave in a predetermined manner and process a set of data.

- Virtual Memory: An imaginary memory that uses virtual address and are supported by operating system to enlarge the memory sub-system.

Slide 12: **Basic Hardware setup of a microcomputer:**

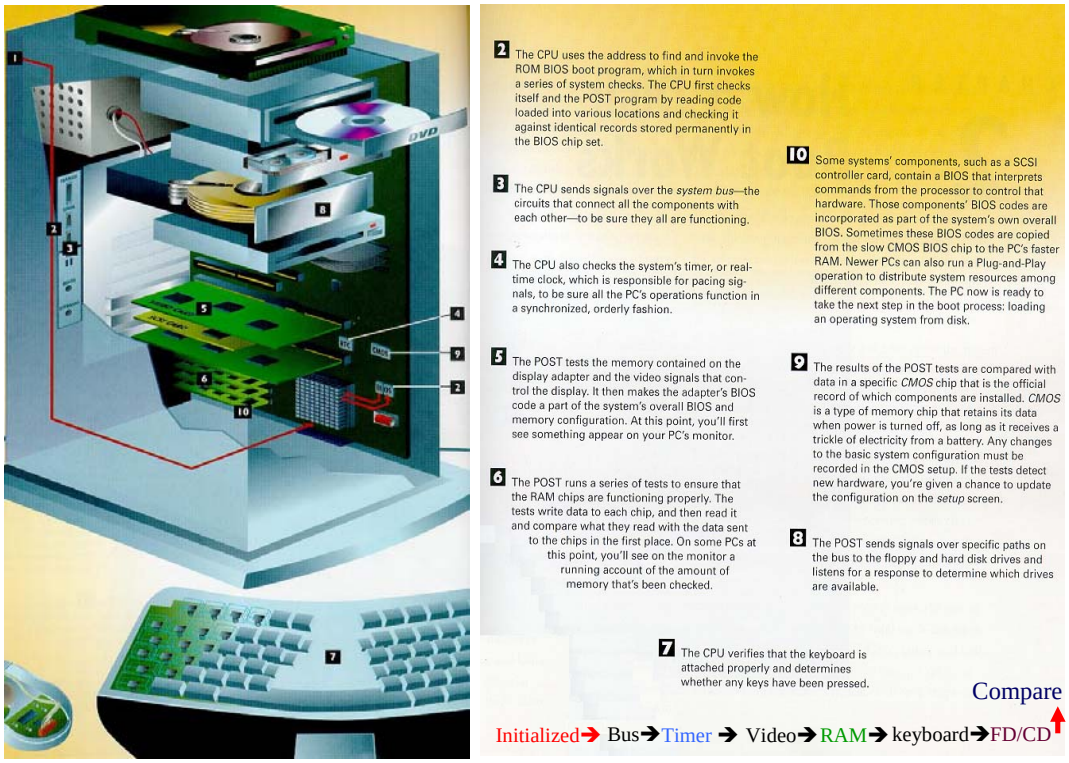
- The picture below shows the basic hardware arrangements of PC's

- The PC consist of CUP, ROM-RAM, Controllers IC's and interface hardwires. The external devices (monitor, printer, keyboard etc) are connected to this driver cards.



Slide 13: **POST: Power On Self Test of a Micro-computer**

- In this slide, we will show how the Power On Self Test (POST) works after the PC is turned on.



Slide 14: **Exercise: Find the correct answers**

Question 1: The 1st generation of computers used _____

(a) Vacuum Tubes, (b) Transistors, (c) Integrated circuits

Question 2: The 1st microprocessor (Intel 4004) invented in 1971 was intended for a _____

(a) Personal computer, (b) Cash register, (c) Calculator

Question 3: Name the four functional sections of a microcomputer.

_____

Question 4: What is predicted by Moore's Law: _____

_____

Question 5: in recent computers, a CPU can be characterized by:

(a) Width of internal registers, (b) Width of data-bus,

(c) Manufacturing company, (d) Physical dimension

(*This question may have multiple answers*)

Question 6: RISC instruction is generally used in _____