Chapter III

Understanding computer hardware

Chapter objectives

- Getting in touch with computer evolution
- Digital electronics and computers
- Computer architecture
- Different input technologies
- Processor, machine cycle, clock and processor speed and technologies used to enhance processor speed.
- Different output technologies
- Different storage technologies
- Future storage technologies
Computer evolution

- Computation is a basic human need and the search for help started since the dawn of civilization
- Abacus (plural Abaci).
- The counting frame consists of rows of beads sliding on metal wires or rods.
- Binary Abacus was used by Robert Good Jr. in teaching Math.
- Cranmer Abacus for the blinds was developed in the early 80s.
- 1645 B. Pascal developed the Pascaline (mechanical calculator)
- 1937: First digital electronics computer ABC (Atanasoff-Berry-Computer)
- 1943 ENIAC (Electronic Numerical integrator and Computer (18000 tubes 150 kilowatts)
Digital electronics/computers

- A computer is necessarily a digital electronic device but a digital electronic device is not necessarily a computer.
- Digital electronics items are installed in most devices used by human and his surrounding environment to control most of the functions of devices.
- Automobile industry
- Airplane industry
- Sea an naval industry
- Appliances
- Hospital and health machinery
- Smart weapon and military industry
Data origin and computer components

- Data origin: The following generate data
  - Social life and living environment.
  - Business and education environment
  - Knowledge and entertainment
  - Global variables

- Computer environment can be classified under 3 categories:
  - Computer hardware
  - Computer software
  - Computer malware
Computer hardware

Figure 3: computer components
Input

- Input instructions and data necessary for the computer to perform and execute applications.

- Input importance is highlighted by GIGO (Garbage In Garbage Out) Jargon that we use to warn about the need of clean healthy input

- **Keyboard**: Each key represents the ASCII code of 2 or more characters:
  - **QUERTY**: Six letters of the first row
  - **AZERTY**: Six letters of the first row
  - **Coleman**: Most frequently used characters correspond to strongest fingers and fewer hand jumps.
  - **Chorded keyboard**: Has fewer keys work like piano or organ (press more then one key for each characters.
  - **Optical keyboard**: Uses light board and sensors. Pressed key blocs light and activate character code.
Motion and touch detection

• Motion detection:
  • Mouse slid over smooth surface move cursor over clickable object or text.
  • Rotating trackball into socket activate sensors in the socket and moves the cursor on the screen: CAD (computer aided design commonly use it)
  • Joystick: Apply pressure while moving a stick (commonly used in games)

• Touch detection:
  • Uses layers of electrodes to detect finger contact and click in tapping the pad:
    • Touch pad
  • Graphics tablet used in tablet computers and signature digitizing devices wherever they are used: Banks and other businesses.
  • Touch screen: sophisticated technology that consists of embedding a highly sensitive e-device into the screen. Used in Ipad. Android, etc...
    • Screen touch change the current and code of the affected area is reported to the processor which determine the course of action.
Gaming input

• Gaming technology pressured computer industry to come up with several devices necessary to play the games:
  • Light pen and light gun for the shooting in war games
  • Steering wheel and paddle for race simulators
  • Yoke and other devices for aircraft simulator
  • Game controller and gamepad

• **Wii remote controller**
  • Uses motion detection technology
  • Created by Nintendo for its video games.
  • Uses Bluetooth to connect with game devices.
Multimedia input

• Live pictures: Digital cameras capture live pictures and make them available for people and businesses, stores the pictures on flash memory prior to downloading them to the computer later.

• Printed pictures and documents
  • Flatbed scanner digitize pictures available in its bed and form a bitmap file for each document or picture.
  • WAND scanner
    • Moves over the surface of the document or image.
    • WAND is the magic stick used by Egypt’s Pharaohs.
Other special scanners

- 3D scanner: Used for industrial design in engineering projects
- Drum scanner: Use photo-multiplier tube as image sensor
- DNA scanner: uses CCD (Charge Coupled Device) or photo-multipliers to detect microscopic DNA arrays
Video input

• Digital camcorder captures and digitizes clip footage so they can be played later

• The digital camera embedded in the smart phone is very convenient to shoot and email digital pictures and video clips while they are happening contributing to the greatness of this convergence device.

• Webcam linked to the computer shoots and converts live clip footage instantly and feed them into the system so they can be used in video telephony and teleconferencing and live TV news reporting.

• Traffic cameras mounted along freeways and highways are the base of many traffic applications. (I4 traffic awareness system)
  • TIS (Traffic Intelligent system)
Audio input

- **Microphone** captures voice, sound and music and transfers them to an audio device where they are digitized and used in the context of their happening.
- **MIDI (Musical Instrument Digital Interface)** captures notes and encodes them as digital messages into the computer processor and synchronizes the rhythm of multiple devices.
- **MIDI protocol** ensures that many music devices communicate with each other and with the computer system.

**Bare voice input recognition**

- Computer can be taught to recognize spoken words.
- Words must correspond to vocabulary of its dictionary.
- Software application helps complete the performance.
Medical input technology

- **MRI (Magnetic resonance imaging)** use huge magnet surrounding a bed where the body is subject to resonance produced by short electromagnetic field. The resonance causes protons in the body water to align and then to rest. The measurement of these protons gives clear panorama of the inspected region and precisely shows abnormal aspects.

- **Computed tomography (CT)** inputs many sectional X-rays for any penetrating wave processed by the computer to create high precision tomograms for the inspected part of the body.
Other medical input

- **Ultrasonography:**
  - use frequencies that are not audible as input (2 to 18 MHz)
  - the computer processes the waves and their influence on the body and produces scans that are easily interpreted by specialists and handily viewed by people.
  - An example is the pregnancy sonogram.

- Tiny digital camera introduced into human or animal veins and organs input pictures processed by computers to locate
  - Obstructions.
  - Tumors
  - lesions
Other input

- **Network and Internet input**
  - Using indirect input forms designed to collect needed data for processing
  - Using several technologies of direct input made available by several internet services: Example the virtual keyboards and the scripts.

- **Internal input:**
  - Information from files and folders on the hard disk.
  - Information from files saved on several storage media.

- **Paper input technology:**
  - Uses perforation or marks like the barcode tag attached to all merchandise items available in stores.

- **Input technologies that feed computer system with data to produce information highlights the importance of business employees to be literate, knowledgeable and vigilant so they can contribute in designing the needed tools for their company.**
Processing

- **Motherboard:** is the main circuit board of the computer and houses all computer components.
  - Processing components and processor
  - The complementary electronic elements
  - The wiring that provides the internal link between them and the external link with outside
  - Expansion slots to fit different components
  - The ports that serve as interfaces with other computers and devices.

- **Processor (CPU: Central processing unit)**
  - The control unit CU that performs the readiness, supervision and control roles
  - The arithmetic and logic unit ALU completes the necessary computing under the supervision of the control unit.
Computer clock

- Processing speed is the most important characteristic of the processor.
- It is determined by the processor clock and defined as the number of machine cycles a processor can perform in one second.
- The clock of the computer can be compared to the heart in the human body.
  - The heart synchronizes the blood circulation cycle in the body.
  - During each pulse of the heart a blood circulation cycle is completed.
  - Similarly, during each tick of the computer clock, at least one machine cycle should be completed.
Machine cycle

• comprises 4 steps that are, in the order: Fetch, decode, execute and store

• Machine cycle steps are in turn divided into two operational steps:
  • The instruction operational step: Fetch and decode.
  • The execution operational step: Execute and store.
What is the system clock?

Synchronizes all computer operations
Compared to the human heart

Each tick is a Machine cycle

Faster clock speed means the CPU can execute more instructions each second

Clock speed (clock rate) measured in megahertz (MHz) and gigahertz (GHz)

MHz - one million ticks of the system clock
GHz – one billion ticks of the system clock
Word size

• The **word size** (also: word width or word length)
• refers to the processing and addressing unit (it is the number of bytes (or bits) that are processed by the instruction set as one unit).
• Modern computers have word size of 32 bits (4 bytes) or 64 bits (8 bytes). While some modern electronic devices have word size of 8, 16, 24, etc...
• The word size affects the software used in the computer.
Pipelining?
- CPU begins executing a new instruction before completing the first one
- Results in faster processing

Machine Cycle (without pipelining)

Machine Cycle (with pipelining)
parallel processing?

- Using multiple processors simultaneously to execute a program
- Speeds processing time
- Requires special software to divide up a problem and bring the results back together again
Co-processing

• This technology assigns some sophisticated time consuming processing to specific processors that help the main processor to tackle these specific tasks.

• floating point math
  • $54321.1234 + 555.444 = (5.43211234 \times 10^{4}) + (0.05554440 \times 10^{4})$
  • $= (5.43211234 + 0.0555444) \times 10^{4} = 5.487665674 \times 10^{4}$
  • $= 54876.65674$

• GPU (graphics processing unit)
  • Is a co-processor that, working together with the main processor, accelerates the processing of multimedia and scientific applications.
  • Example: NVIDIA graphics processor.
Multi-core processor

• **Multi-core technology:**
  • While parallel processing technology use only one processor on each chip, multi-core technology consists of putting two or more processors on one chip where they form one integrated circuit and they time share its electronic components.
  • Intel launched the first core-2 duo in 2006 and the quad-core i7 in 2008 with 4 processors on the same chip i7.
  • In 2010 SUN/ORACLE launched the SPARC T3 processor that has 16 processors on one chip that is a thumbnail size.
  • In 2012 AMD launched an 8-core with eight processors on the same chip.

• Supercomputers use a combined technology of thousands of multicore processors grouped in parallel to form an ultra-powerful ultra-fast processor
Computer output

• What is output?
  • Computer output is information or action people and businesses want to get out of a computer as a result of processing input data and information.

• An output device is a computer component or device linked to a computer that is capable to:
  • Convey processed information to the user.
  • Complete an action required by the user.

• Employees of each department of a company should be able to define their output needs and coordinate with IT people to have these needs satisfied to the best possible.

• Output categories:
  • Printed output
  • Audio output
  • Video output
    • Scanning technology: Interlacing and progressive
    • Display technology (CRT)
LCD (liquid Crystal Display)

• This technology uses a natural liquid that have the properties of any available liquid but its particles or molecules can be oriented and polarized like those of crystal. Liquid crystal can be found in proteins and living cells.

• Pros:
  • Low power needs.
  • Can be tailored to any size: small or large
  • Excellent quality resolution
  • Very compact and light weight.

• Cons:
  • Highly influenced by temperature and light
  • Viewing angle is very limited
  • Dead pixels resulting of extensive use lower the image quality.
  • Very heavy and big volume: Prohibitive in large and wide displays.
Plasma

• This technology uses a layer of ionized gas particles similar to that of florescent lamps (vacuum bulbs) as a flat panel comprised between two layers of glass

• Pros
  • Excellent color due to very high contrast ratio: (10,000 : 1)
  • Very fast activation response
  • Good viewing angle
  • Highly scalable (up to 150” : world largest screen)
Plasma

• Cons:
  • Large size screen (42 inches and over) required for good quality because of the large pixel pitch needed.
  • Glass screen used in this technology may results often in glare and reflections.
  • Heavier than LCD because of the glass weight.
  • Extended use produce deteriorated phosphoric pixels that lower the quality of gas plasma display earlier than that of LCD and LED and even CRT.
  • Consume more power than LCD
LED (Light Emitting Diodes)

• This technology is based on a cluster of red green and blue diodes working together to produce the right color of each pixel. When the emissive layer used in the diode is a film of organic compound LED becomes OLED (Organic Light-Emitting Diode).

• Pros:
  • Lighter weight than all other displays
  • Very short image response time
  • Excellent color because no back light is used.
  • Wide viewing angle
  • Excellent contrast (more than 1000,000 to 1)
  • Because of its light weight, high quality and adaptability to any display size this display technology is used in small displays and advertisement and traffic displays
LED

• Cons
  • Blue deteriorate faster than other color causing bad image quality with extensive use
  • The organic material can be damaged from water and vapor.
  • Long time exposure to sun light damages the quality of the display.
  • Cost of production is higher than other displays
Resolution

• All types of display are designed so that the display is divided into cells called pixels.

• There are hundreds of columns and hundreds of rows that intersect in cells forming a grid superposed on the display.

• Each cell or pixel has its own coordinate and its own RGB (red, green and blue) color components.

• Resolution = columns x rows

= Number of pixels
Resolution

• The higher the resolution the better the quality of the image and the lower the resolution the lower the quality is.
• The resolution doesn’t change with the size of the screen because it is always a fixed product of the columns and the cells.
• Higher resolution requires higher image file volume and faster Internet access to upload and download it.
Printed output

• A printer is a peripheral device that produces permanent readable hard copy
• Business needs for hard copy printout include:
  • Documents: reports, letters issued by the business, etc..
  • Special documents: Paychecks, cards, etc…
  • Pictures, flyers, brochures, etc…

• 4 types of printers:
  • Dot-matrix or impact magnetic printer
    • Prints one line at a time.
    • Very slow
  • Inkjet printer: Most commonly used
    • Continuous technology uses high pressure pump of tiny ink particles
    • DOD (Drop On Demand) uses thermal double-jet (Canon) or software to create ink bubbles (Epson and Brothers printers).
Printer technology

- Laser Jet: Much faster and better quality than previous technologies.
  - uses laser beam, dry ink (toner) and a rotating drum coated with selenium
  - The laser beam projects the image of the page on the drum
  - Particles of the toner spread function of the light density
  - Heated drum print the image by fusing the toner to the paper.
- LED printers: (Invented by Casio)
  - Similar to the Laser but instead of laser beam, this technology uses light emitting diodes.
  - More reliable and more efficient because they have less moving parts and less mechanical wear.
  - Faster
  - Less expensive
Temporary Storage

• RAM (Random Access Memory):
  • More than 100 GIG in most modern computers
  • Solid state technology uses microscopic semi-conductors that need power to store the digits
  • It is volatile (lose its contents when power is off).
• OS divides RAM into many compartments:
  • OS compartment
  • Input and output compartments
  • Processing results and interfaces compartment
  • It is a must visit and temporary stay or waiting area for everything that happen in the computer system.
• Cache
  • Small volatile fast memory checked first by the processor
  • May be dispersed over 2 or 3 levels
  • Used to store most recently and most frequently used items.
Permanent memory

- **ROM (Read Only Memory)**
  - Small chip recorded in the factory and unlike RAM, ROM keeps its content when the power is off. It is permanent memory
  - Holds the BIOS instructions used to boot the computer
  - Smart phones don’t need booting because their OS is already recorded on a chip.

- **CMOS (Complementary Metal-Oxide Semi-conductor)**
  - Powered by rechargeable battery in the motherboard
  - Keeps the following items
    - Configuration of the computer system to help in the booting process
    - Date and time and their programs.

- **Virtual memory**: which is a part of the hard disk used as extension to RAM
  - Slow because of the mechanic spin of the hard disk
  - Used to store the least recently and frequently used data because it is the last to check by the processor