Module 1

Computer Architecture and Organization

**Computer Architecture** refers to the structure of all or part of a computer system and the details needed to make it functional. This takes into consideration the design of system software, such as the operating system, as well as the combination of hardware and basic software that links the machines on a computer network.

Computer architecture therefore covers computer systems, microprocessors, circuits, and system programs.

**A computer system is comprised of two main components:**

**1. Hardware –** this refers to the equipment required for the functioning of the computer system. It entails any component that can be physically handled.

**2. Software** – this refers to the set of instructions required to manipulate data in a computer system. Software governs the way hardware is used. Without software, hardware would be useless.

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Input/Output Devices

An **Input Device** is a piece of hardware capable of only providing information to a computer. Examples of input devices are keyboard, mouse, joystick and scanner.

An **Output Device** is a piece of hardware capable of only receiving information from a computer. Examples include printer, monitor and speakers.

An **Input/Output Device** is one which is capable of providing information to a computer and also receiving information from it. One example of an input/output device is a disk drive.

**Port Connectivity** refers to a location on a computer system for passing data into and out of a system, such as a USB port for connecting *peripheral* devices, eg printers.

**Speed** refers to the rate at which information is transferred between a computer’s CPU and an input or output device.

**Quality of Output** refers to the extent to which a particular aspect of the output of an output device meets the standards of a particular time period. Example, what was considered good quality resolution on a monitor ten years ago will be different than what is considered good quality output today.

**Specialized Devices** are input or output devices with additional features not pertaining to their main function, example, a printer that can fax.

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Memory Types

**Computer Memory** refers to a hardware device that stores data for use by a computer. These devices may be capable of storing the data temporarily or permanently and are therefore grouped as such.

**1. Temporarily.**

These devices store the data up until the electricity supply to them is cut, after which, the data is lost. This is known as being *volatile*.

**Random Access Memory (RAM)** is volatile. RAM is referred to as main memory as it is the primary memory used by the CPU when processing information. The contents of RAM can be altered, that is, data can be read from it or old data can be erased to make room for new data.

**2. Permanently.**

These devices store data even after power to them is cut.

**Read Only Memory (ROM)** is non-volatile. ROM chips contain information wich *cannot* be modified or deleted. Information can only be read. ROM is used to store items that the computer needs to execute when it is first turned on. A set of instructions called the basic-input-output-system (BIOS) which is needed to start up the operating system is stored in ROM.

**Erasable Programmable Read Only Memory (EPROM)** is also non-volatile. It is used by hardware vendors to put variable or constantly changing code into a prototype system. EPROM is similar to ROM but is however able to have its contents changed. This is done by removing the EPROM chip from the computer, removing its protective covering and exposing the chip to ultraviolet light. This erases the chip’s contents.

**Electrically Erasable Programmable Read Only Memory (EEPROM)** is similar to EPROM, but instead of removing the EEPROM chip from the computer to erase its contents, an electrical pulse is passed through it.

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Memory Features

There are certain attributes which can be used to differentiate one type of memory from another.

**These attributes include:**

**1. Speed –** this refers to how fast data can be retrieved from or accessed on a device. The CPU is faster than cache which is faster than RAM which is faster than the hard disk which is faster than any secondary storage device such as a jump-drive.

**2. Size –** this refers to how many bits of data a memory device is capable of storing. A hard disk can store up to 1 TB; a jump drive can store up to 64 GB; a modern RAM chip can store up to 8 GB and a standard floppy disk can store up to 1.44 MB.

**3. Word Size** – this describes the number of bits a word contains. A **word** is the number of bits a CPU can process in one instruction cycle. Modern processors can process up to 64 bits in one cycle.

**4. Volatility** – this refers to the loss of data when power to the memory device is cut. RAM is a volatile memory while hard is a non-volatile memory.

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Storage Devices

**Storage Devices** are hardware components which are used to deposit, retain or retrieve computer data. There are certain distinctive characteristics which can be used to compare one storage device to another.

**These features include:**

**1. Storage Capacity** – this refers to how much data a device can store. This is measured in bytes. Modern storage devices, such as jump drives, can store from 1 GB up to 64 GB.

**2. Access Speed** – this refers to the time taken for a drive on the computer (hard drive, CD drive etc.) to find a particular piece of data on a storage medium and send it to main memory. It is usually measured in nanoseconds (ns) for main memory and milliseconds (ms) for secondary storage devices; main memory is faster than secondary storage.

**3. Access Method –** this refers to how data is written or read from a particular place on a storage medium. There are three (3) access methods:

**I. Sequential Access** – in this scenario, a certain piece of datum can only be accessed by reading all the data that come before it. Example, to access the 35th record, you have to read the 34 records that come before it. This is the slowest access method.

**II. Direct Access –** this method allows you to access a particular piece of datum without first having to read all the data that comes before it. Example, if you wanted to access the 35th record, you *wouldn’t* have to go through the 34 before it. However, it is usually necessary to scan some [but not all] of the data before the required one.

The time it takes to access a piece of datum is somewhat dependent on the mechanism involved.

**III. Random Access** – this method allows for a piece of datum to be accessed from anywhere on a storage medium without first having to read the preceding data. The access time is independent of the mechanism involved and it is the fastest access method of the three.

**4. Portability** – this refers to the ability of the storage device to be transported from one computer to another. Storage devices such as jump drives, SD cards and micro-SD cards possess the advantage of being extremely portable but due to their minute sizes, are susceptible to misplacement!

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Security

**Security devices** are those hardware components set up to protect the computer system, the data stored on it and also the computer user. There are various security devices which computer user must have if they value their computer system and the data stored on it.

**1. Surge Protector –** this is a piece of equipment which is used to protect several connected devices from power surges and spikes. A power surge is an increase in voltage significantly above the stipulated level in the flow of electricity for 3 or more nanoseconds. A power spike is similar, but only lasts for 1 – 2 nanoseconds. High enough surges and spikes in voltage can cause severe damage to machines. Even if the increased voltage does not immediately destroy the machine, it may put excess strain on the sensitive components, causing them to deteriorate over time. A surge protector works by routing any excess current to ground.

**2. Voltage Regulator** – this is a device which is capable of automatically maintaining a constant voltage level in an electrical circuit. If the input voltage is too low or too high, it will adjust the voltage to be the stipulated voltage. If the input voltage is too high above he stipulated voltage however, some voltage regulators will prevent any further current from passing through, limit the amount of current passing through or simply cease function.

**3. Interruptible Power Supply (UPS) –** this is a piece of equipment which primary protects a computer system from data loss resulting from power cuts. UPS’s work by running the computer system off power stored in its battery when there’s a power cut. The UPS is always connected to the computer system, so when the main power is terminated, it quickly switches to its battery to supply power. UPS’s also serve other functions. They serve as voltage regulators, as surge protectors and as frequency regulators.

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Types of Computers

A computer is a device which can accept, process and store data and produce some form of output. The size, computational power, speed, memory, and expected use of the computer however determines the *type* of the computer.

**There are five (5) general types of computers:**

**1. Supercomputers** – are computers which utilize the best technology available to perform as many mathematical calculations in the least possible time so as to solve extremely complex problems.

Supercomputers, unlike other computers, are designed to devote all their resources to the solving of a single problem at a time. They have hundreds of processing units which are linked together in parallel to allow for multiple calculations to be performed simultaneously. Due to the large amount of heat generated by supercomputers, they have to be equipped with special cooling devices.

These computers are extremely large and expensive, costing millions of US dollars. They are used in weather and climate forecasting, designing aircrafts and spacecrafts, designing new drugs and chemical compounds and in military weapons and defense systems research.

**2. Mainframes** – are very large computers capable of supporting thousands of users simultaneously. These computers are similar to supercomputers in power but utilize this power to execute a vast amount of programs concomitantly. These are used in businesses and industries where multiple persons need to contemporaneously gain access to information located on a server. They are used in banks, colleges and supermarkets.

**3. Microcomputers** – otherwise called personal computers (PCs), are relatively inexpensive computers designed for general use by a single person. They come equipped with a single silicon chip microprocessor which serves as the central processing unit. Microcomputers come in various sizes, ranging from relatively large desktop computers to smaller tablets.

Microcomputers are used to perform more commonplace tasks such as word processing, accounting, desktop publishing, running spreadsheet and database management applications, playing games and surfing the Internet.

**4. Laptops** – are small, light-weight, portable personal computers that have a flat display screen. They are as powerful as or even more powerful than PC’s but have the advantage of being portable. They rely on rechargeable batteries to power them.

**5. Personal Digital Assistants (PDAs)** – are small hand-held computers which are designed to electronically organize a user’s personal information. PDAs are capable of taking notes, scheduling appointments, sending faxes and sending and receiving electronic mails.

Most PDAs are capable of using pen-like devices to write on a screen rather than utilizing a keypad. When combined with a cellular phone, they have the capability of connecting to the Internet and doing almost anything that a personal computer would be capable of doing. Due to their small size and limited battery life, they aren’t a replacement for laptops.

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Logic Gates & Truth Tables

A **Logic Gate** is a minute digital switch which performs a logical operation on one or more logic inputs and produces a single logic output. Logic gates are used to construct microprocessors. The more logic gates that are packed onto a computer chip, the faster the computer can process data.

**Logic gates are represented by specific symbols depending on their specific function:**

* **AND Gate**

Output is true only if both inputs are true.

<insert image>

* **OR Gate**

Output is true if at least one input is true.

<insert image>

* **NOT Gate**

Output is the complement of the input.

<insert image>

* **NAND Gate**

Output is only true if at least one of the inputs is false.

<insert image>

* **NOR Gate**

Output is true only if both of the inputs are false.

<insert image>

* **EX-OR Gate**

Output is true only if one of the inputs is true, not both.

<insert image>

* **EX-NOR Gate**

Output is true if both inputs are the same (true-true or false-false).

<insert image>

A **Truth Table** is a table used to specify the value of the output signal from a logic circuit/gate or device for every possible input. A truth table consists of columns for the inputs and a single column for the output.

**Truth tables for the logic gates are:**

* **AND Gate**

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q** |
| 1 | 1 | 1 |
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 0 | 0 | 0 |

* **OR Gate**

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q** |
| 1 | 1 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 0 |

* **NOT Gate**

|  |  |
| --- | --- |
| **A** | **Q** |
| 1 | 0 |
| 0 | 1 |

* **NAND Gate**

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q** |
| 1 | 1 | 0 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 1 |

* **NOR Gate**

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q** |
| 1 | 1 | 0 |
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 0 | 0 | 0 |

* **EX-OR Gate**

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q** |
| 1 | 1 | 0 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 0 |

* **EX-NOR Gate**

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q** |
| 1 | 1 | 1 |
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 0 | 0 | 1 |

The CAPE Computer Science Examination may present the student with a truth table and ask for a logic circuit to be constructed. The truth table **will not** be for one of the primary logic gates.

*The following example shows how such a question should be approached.*

*The following truth table represents a particular circuit:*

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q** |
| 1 | 1 | 0 |
| 1 | 0 | 0 |
| 0 | 1 | 1 |
| 0 | 0 | 1 |

* The first thing to do is to consider how each positive output would be arrived at if the false input is converted to a true input, that is, so that both inputs can be true and meet the AND Gate condition.

|  |  |  |  |
| --- | --- | --- | --- |
| **A** | **B** | **Q** |  |
| 1 | 1 | 0 |  |
| 1 | 0 | 0 |  |
| 0 | 1 | 1 |  |
| 0 | 0 | 1 |  |

* ***Q*** *will be either condition 1 or condition 2, therefore construct 2 AND Gates and connect them to an OR Gate.*

<insert image>

* *Place NOT Gates at appropriate positions on either input line to satisfy each condition; one condition should be dealt with on each AND Gate.*

<insert image>