Competency 02

2.2 Explores the functionality of a computer in relation to the hardware and their interfaces.

Time: 6 periods

Learning Outcomes

- Identifies hardware peripherals and their relevant interfaces.
- Identifies the advantages of direct entry input devices over keyboard entry input devices.
- Describes the evolution of CPU and its compatibility with motherboard.
- Categorizes the storage devices.
- Briefly explains the features of each storage device.
- Identifies the need for parallel and grid computing

Input Devices

These are used to feed data and instructions to a computer system.

Key board

Pointing devices

Mouse

Touch pad

Remote control

Touch screen

Direct entry input devices

Magnetic stripe reader

Bar code reader

Video Camera

Digital Camera

CCTVS

Webcam

Smart card reader

Image and video input devices

MICR

OMR

OCR

Graphic tablet

Digitizer

Microphone

Scanning devices

Flatbed Scanner

Key board

Pointing devices

Graphic tablet

Digitizer

Microphone

Mouse

Direct entry input devices

Magnetic stripe reader

Bar code reader

Smart card reader

Image and video input devices

Video Camera

Digital Camera

Webcam

CCTV

Scanning devices

Flatbed Scanner

MICR

OMR

OCR

Advantages of direct entry input device over key board entry input device

- Automatically capture data, images or videos. No need human
- involvement to input data into the system. Therefore, data entry cost is reduced.
- Accurate – The data can be input without any human errors.
- Less time – Data input process is more efficient.

Output devices

Monitor

1. CRT Monitor (Cathode Ray Tube Monitor)

2. LCD Monitor (using Thin Film Transistor-TFT)
   A display screen made with TFT technology is a Liquid Crystal Display (LCD) that has a transistor for each pixel, LCD monitors are widely used in notebook and laptop computers.

3. LED Monitor (Light Emitting Diode Monitor)

Advantages of LED Monitor

- Less expensive
- More reliable
- Generate low heat and consume less power
- Higher dynamic contrast ratio
- Longer lifespan and less environmental impact

Printer

Printer is used to produce a hard copy output.

1. Dot matrix printer
2. Inkjet printer
3. Laser printer
4. Graphic plotter
5. 3D printer

System Unit

The system unit, also known as the **system chassis**, is a container that houses most of the electronic components that make up a computer system.

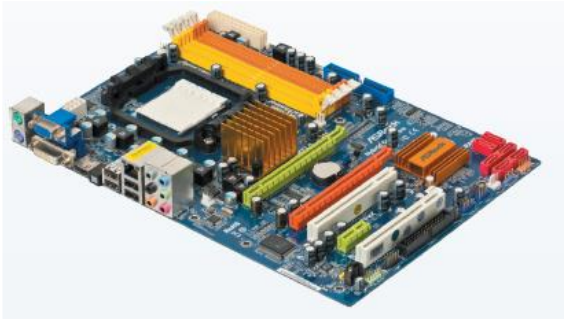
At one time all system units were in a separate case. Advances in the miniaturization of electronic components, however, have led to smaller and smaller computer with system units that share containers with other parts of the computer system.

As we have previously discussed, a personal computer is the most widely used type of computer. It is the most affordable and designed to be operated directly by an end user. The five most common types are desktop, laptop, tablet, smartphones, and wearable computers. Each has a unique type of system unit.

Contains most of the electronic components and circuitry that make up computer

- System board
- Microprocessor
- Memory
- Expansion cards
- Ports
- Bus

System Board



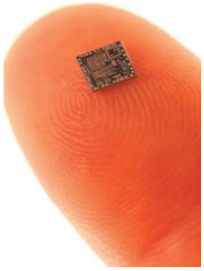
The system board is also known as the **mainboard or motherboard**.

The system board controls communications for the entire computer system.

All devices and components connect to the system board, including external devices like keyboards and monitors and internal components like hard-disk drives and microprocessors. The system board acts as a data path and traffic monitor, allowing the various components to communicate efficiently with one another.

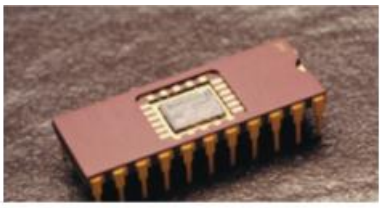
On a desktop computer, the system board is typically located at the bottom of the system unit or along one side. It is a large flat circuit board covered with a variety of different electronic components including **sockets, slots, and bus lines.**

• **Sockets** provide a connection point for small specialized electronic parts called **chips** made of **silicon.** Chips consist of tiny circuit boards. These circuit boards can be smaller than the tip of your finger.



A chip is also called a silicon chip, semiconductor, or integrated circuit.

Chips typically are mounted onto chip carriers. These carriers plug either directly into sockets on the system board or onto cards that are then plugged into slots on the system board.



Chip mounted onto a chip carrier

Sockets are used to connect the system board to a variety of different types of chips, including microprocessor and memory chips.

• **Slots** provide a connection point for specialized cards or circuit boards. These cards provide expansion capability for a computer system. For example, a wireless networking card plugs into a slot on the system board to provide a connection to a local area network.

• Connecting lines called **bus lines** provide pathways that support communication among the various electronic components that are either located on the system board or attached to the system board.

Generally, the system board found on a desktop is larger than that found on a laptop, and much larger than one found on a tablet, smartphone, or wearable computer.

Although these system boards vary in size, they nevertheless all perform the same function of communicating between the components of the personal computer.

Microprocessor (Central Processing Unit –CPU)

In most personal computer systems, the central processing unit (CPU) or processor is contained on a single chip called the microprocessor. The microprocessor is the **"brain"** of the computer system. It has **two** basic components:

1. The control unit
2. The arithmetic-logic unit

• **Control unit**: The control unit tells the rest of the computer system how to carry out a program's instructions. It directs the movement of electronic signals between memory, which temporarily holds data, instructions, and processed information, and the arithmetic-logic unit. It also directs these control signals between the CPU and input and output devices.

• **Arithmetic-logic unit**: The arithmetic-logic unit, usually called the ALU, performs two types of operations:

1. Arithmetic operations
2. Logical operations

Arithmetic operations are the fundamental math operations: addition, subtraction, multiplication, and division.

Logical operations consist of comparisons such as whether one item is equal to (=), less than (<), or greater than (>) the other.

Microprocessor Chips

Chip processing capacities are often expressed in **word sizes**. A **word is the number of bits (such as 16, 32, or 64) that can be accessed at one time by the CPU**. The more bits in a word, the more data a computer can process at one time. Eight bits group together to form a byte. A 32-bit-word computer can access 4 bytes at a time. A 64-bit-word computer can access 8 bytes at a time. Therefore, the computer designed to process 64-bit words has greater processing capacity. Other factors affect a computer's processing capability including how fast it can process data and instructions.

The **processing speed** of a microprocessor is typically represented by its **clock speed**, which is related to the number of times the CPU can fetch and process data or instructions in a second. Older personal computers typically process data and instructions in millionths of a second, or microseconds. Newer personal computers are much faster and process data and instructions in billionths of a second, or nanoseconds.

Supercomputers, by contrast, operate at speeds measured in picoseconds—

1,000 times as fast as personal computers. In the near future, we can expect processor speeds to be 1,000 times faster than that, operating at speeds measured in femtoseconds.

Unit	Speed
Microsecond	Millionth of a second
Nanosecond	Billionth of a second
Picosecond	Trillionth of a second
Femtosecond	Quadrillionth of a second

Processing speeds

At one time, personal computers were limited by **microprocessors** that could support a single CPU that controlled operations. These computers were limited to processing one program at a time.

Now, many personal computers have **multicore processors** that can provide two or more separate and independent CPUs on one chip.

For example, a quad-core processor could have one core computing a complex Excel spreadsheet, a second core creating a report using Word, a third core locating a record using Access, and a fourth core running a multimedia presentation all at the same time.

More significantly, however, is the potential for personal computers to run very large, complex programs that previously required expensive and specialized hardware.

For multicore processors to be used effectively, computers must understand how to divide tasks into parts that can be distributed across each core—an operation called **parallel processing**.

Operating systems such as Windows 8 and Mac OS X support parallel processing.

Software developers use this technology for a wide range of applications from scientific programs to sophisticated computer games.

Processor	Manufacturer
A-Series	AMD
Cortex-A series	ARM
Edison	Intel
i7	Intel

Popular microprocessors

Specialty Processors

In addition to microprocessor chips, a variety of more specialized processing chips have been developed.

- **Coprocessors** are specialty chips designed to improve specific computing operations.

- One of the most widely used is the **graphics coprocessor, also called a GPU (graphics processing unit)**. These processors are designed to handle a variety of specialized tasks such as displaying 3D images and encrypting data. Powerful **GPUs are a standard feature in gaming computers** to support fast processing of virtual environments.

- Many cars have more than 70 separate specialty processors to control nearly everything from fuel efficiency to satellite entertainment and tracking systems.

- Did you know that one type of specialty processor is devoted exclusively to protecting your privacy? Called **cryptoprocessor**s, these microchips perform encoding and decoding of data faster and more securely than a CPU. These specialized chips exist in **ATMs, TV set-top boxes, and smartcards.**

CPU and its compatibility with motherboard

1. Socket support.

The CPU has to be compatible with your motherboard's socket.

2. Chipset support.

Need to know about the chipset to find the CPUs compatible with that chipset. Chipset manufacturers include AMD, Intel and Nvidia.

3. Motherboard wattage support must support the Thermal Design Power (TDP) of a given CPU. Need to find out the wattage of the motherboard to determine the support from that to the CPU

4. BIOS support.

If necessary BIOS need to be upgraded to support the CPU

Memory

Memory is a holding area for data, instructions, and information.

Like microprocessors, memory is contained on chips connected to the system board. There are three well-known types of memory chips:

- Random-access memory(RAM)
- Read-only memory (ROM
- Flash memory

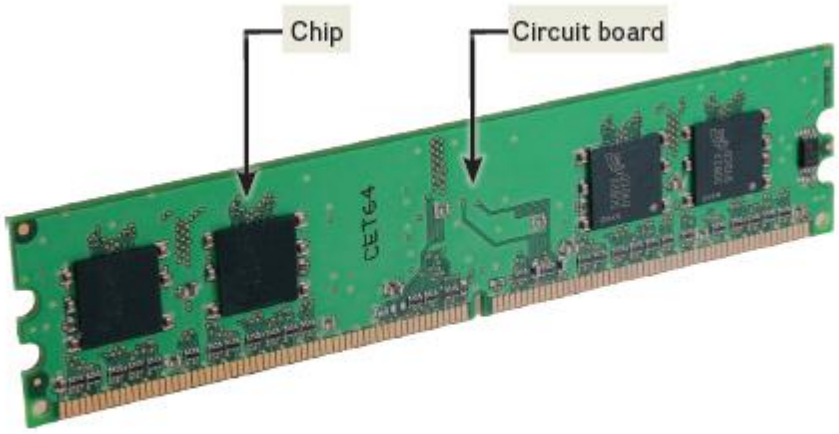
Memory Capacity measured in Gigabytes (GBs).

RAM

- Random-access memory (RAM) chips hold the program (sequence of instructions) and data that the CPU is presently processing.

- RAM is called temporary or volatile storage because everything in most types of RAM is lost as soon as the computer is turned off.

- It is also lost if there is a power failure or other disruption of the electric current going to the computer.



RAM chips mounted on circuit board

Cache

- Cache (pronounced "cash") memory improves processing by acting as a **temporary high-speed holding area between the memory and the CPU**.

- The computer detects which information in RAM is **most frequently used** and then copies that information into the cache. When needed, the CPU can quickly access the information from the cache. Hence **optimize the performance** of processing.

Having enough RAM is important! For example, to use the standard version of Microsoft Office 2016, you need 2 GB, or 2 billion bytes, of RAM. Some applications, such as photo editing software, may require even more.

Fortunately, additional RAM can be added to a computer system by **inserting an expansion module called a DIMM (dual in-line memory module)** into the system board. The capacity or amount of RAM is expressed in bytes. There are three commonly used units of measurement to describe memory capacity.

Unit	Capacity
Megabyte (MB)	1 million bytes
Gigabyte (GB)	1 billion bytes
Terabyte (TB)	1 trillion bytes

Memory capacity

Even if your computer does not have enough RAM to hold a program, it might be able to run the program using **virtual memory**. Most of today's operating systems support virtual memory. With virtual memory, large programs are divided into parts and the parts are stored on a secondary device, usually a hard disk. Each part is then read into RAM only when needed. In this way, computer systems are able to run very large programs.

ROM

Read-only memory (ROM) chips have information stored in them by the manufacturer. Unlike RAM chips, ROM chips are not volatile and Contents are either not changeable or require special operations to change.

"Read only" means that the CPU can read, or retrieve, data and programs written on the ROM chip. However, the computer cannot write—encode or change—the information or instructions in ROM.

Four kinds of ROM chips.

- Mask ROM
- PROM
- EPROM
- EEPROM

Not long ago, ROM chips were typically used to contain almost all the instructions for basic computer operations. For example, ROM instructions are needed to start a computer, to access memory, and to handle keyboard input. Recently, however, flash memory chips have replaced ROM chips for many applications.

Flash Memory

Flash memory offers a combination of the features of RAM and ROM.

Like RAM, it can be updated to store new information.

Like ROM, it does not lose that information when power to the computer system is turned off.

Flash memory is used for a wide range of applications. For example, it is used to store the start-up instructions for a computer.

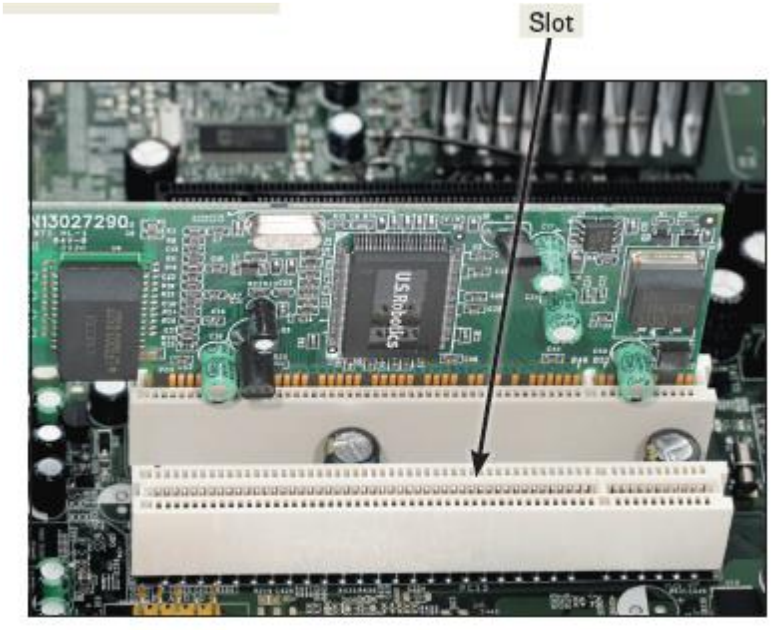
This information is called the system's BIOS (basic input/output system). This information would include the specifics concerning the amount of RAM and the type of keyboard, mouse, and secondary storage devices connected to the system unit. If changes are made to the computer system, these changes are reflected in flash memory.

A summary of the three types of memory.

Type	Use
RAM	Programs and data
ROM	Fixed start-up instructions
Flash	Flexible start-up instructions

Expansion Slots and Cards

As previously mentioned, many personal computers allow users to expand their systems by providing expansion slots on the system board. Users can insert optional devices known as expansion cards into these slots. Ports on the cards allow cables to be connected from the expansion cards to devices outside the system unit.



Expansion cards fit into slots on the system board

There are a wide range of different types of expansion cards. Some of the most commonly used expansion cards are

- Graphics cards, which provide high-quality 3D graphics and animation for games and simulations.
- Network interface cards (NIC), also known as network adapter cards, which are used to connect a computer to a network.
- Wireless network cards allow computers to be connected without cables.

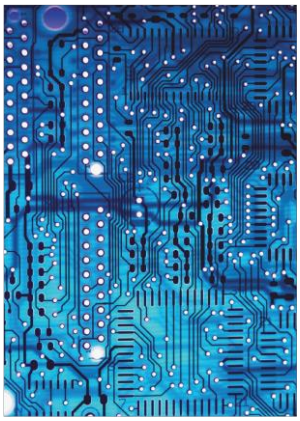
Expansion card with three ports

Network interface card

To meet the size constraints of laptop computers, tablets, and smartphones, fingernail-size expansion cards known as SD cards have been developed. These cards plug into expansion slots located within many laptops, tablets, and smartphones.

SD card

Bus Lines



A bus line—also known simply as a bus—**connects the parts of the CPU to each other.** Buses also link the CPU to various other components on the system board. A bus is a pathway for bits representing data and instructions. **The number of bits that can travel simultaneously down a bus is known as the bus width.**

A bus is similar to a multilane highway that moves bits rather than cars from one location to another. The number of traffic lanes determines the bus width. A highway (bus line) with more traffic lanes (bus width) can move traffic (data and instructions) more efficiently.

For example, a 64-bit bus can move twice as much information at a time as a 32-bit bus. Why should you even care about what a bus line is? Because as microprocessor chips have changed, so have bus lines. Bus design or bus architecture is an important factor relating to the speed and power for a particular computer. Additionally, many devices, such as expansion cards, will work with only one type of bus.

Every computer system has **two basic categories of buses**.

1. System buses, connects the CPU to memory on the system board.

2. Expansion buses, connects the CPU to other components on the system board, including expansion slots.

Expansion Buses

Computer systems typically have a combination of different types of expansion buses. The principal types are,

- USB
- FireWire
- PCIe.

• **Universal serial bus (USB)** is widely used today. External USB devices are connected from one to another or to a common point or hub and then onto

the USB bus. The USB bus then connects to the PCI bus on the system board. The current USB standard is USB 3.1.

• **FireWire buses** are similar to USB buses but more specialized. They are used primarily to connect audio and video equipment to the system board.

• **PCI Express (PCIe)** is widely used in many of today's most powerful computers. Unlike most other buses that share a single bus line or path with several devices, the PCIe bus provides a single dedicated path for each connected device.

Ports

A port is a socket for external devices to connect to the system unit. Some ports connect directly to the system board, while others connect to cards that are inserted into slots on the system board. Some ports are standard features of most computer systems, and others are more specialized.

Storage Devices

1. **Fixed internal magnetic hard disk**
   Hard disk is a data storage device that uses magnetic storage to store and retrieve digital information using one or more rigid rapidly rotating disks (platters) coated with some magnetic material.

2. **External hard disk**
   An external hard drive is a portable storage device that can be attached to a computer through a USB Port

3. **Magnetic tape**

   Magnetic tape is one of the oldest technologies for electronic data storage on a magnetic surface. Tape has largely been displaced as a primary and backup storage medium, but it remains well-suited for archiving because of its high capacity, low cost and long durability. It is a sequential recording system that is not good for random access. With tape archiving, there is no online copy for quick retrieval, as everything is vaulted for the long term.

4. **Optical discs**
   An optical disc is an electronic data storage medium that can be written to and read using a low-powered laser beam.

Type	Capacity
CD-ROM	650-900 MB
CD-R	
CD-RW	
DVD-ROM	4.7-9.4 GB
DVD-R	
DVD-RW	
DVD-RAM	
Blu-Ray	25-128 GB

DVD-RAM - DVD-RAM is like ordinary Random Access Memory (RAM), it can be repeatedly read, written to, and erased. DVD-RAM discs can be rewritten 100 times more than a DVD-RW.

5. **Flash drive**

6. **Memory card**

Flash drives and memory cards use Electrically Erasable Programmable Read Only Memory (EEPROM) technology to store data on one or more semiconductor chips.

Parallel computing

Parallel computing is a type of computation in which many programs or processes are done simultaneously. Large problems can often be divided into smaller ones, which can then be solved at the same time.

In simple terms, parallel computing is breaking up a task into smaller pieces and executing those pieces at the same time, each on their own processor or on a set of computers that have been networked together.

The following example displays the difference between single processor and parallel processor

- Y = (4 x 5) + (1 x 6) + (5 x 3)

On a single processor, the steps needed to calculate a value for Y might look like:

- Step 1: Y = 20 + (1 x 6) + (5 x 3)
- Step 2: Y = 20 + 6 + (5 x 3)
- Step 3: Y = 20 + 6 + 15
- Step 4: Y = 41

In a parallel computing scenario, with three processors or computers, the steps look something like:

- Step 1: Y = 20 + 6 + 15
- Step 2: Y = 41

The main performance characteristic is the increase in speed. If you use a single computer, and it takes X amount of time to perform a task, then using

two similar computers should cut the time taken to perform that same task in half. If you use three, then it should take a third of the time for the same task, and so on.

However, in practical terms, this is not always true. Because:

- Some task might not be divisible.
- Some task may not be able divide equally.
- It is necessary to take overhead associated with splitting the task up also into account.

So, while there is usually a performance increase, that increase does not follow any set formula.

Grid computing

Grid computing is a distributed architecture of large numbers of computers connected to solve a complex problem. In the grid computing model, servers or personal computers run independent tasks and are loosely linked by the Internet or low-speed networks. Computers may connect directly or via scheduling systems. In Grid computing inter-connected computer systems utilize the same resources collectively. Grid computing usually consists of one main computer that distributes information and tasks to a group of networked computers to accomplish a common goal. Grid computing is often used to complete complicated or tedious mathematical or scientific calculations.

Examples of Grid Applications

- Application partitioning that involves breaking the problem into discrete pieces
- Discovery and scheduling of tasks and workflow
- Data communications distributing the problem data where and when it is required
- Provisioning and distributing application codes to specific system nodes
- Results management assisting in the decision processes of the environment
- Autonomic features such as self-configuration, self-optimization, self-recovery, and self-management

The following is an example for a grid application and its usage patterns.

Schedulers

Schedulers are types of applications responsible for the management of jobs, such as allocating resources needed for any specific job, partitioning of jobs to schedule parallel execution of tasks, data management, event correlation, and service-level management capabilities. These schedulers then form a hierarchical structure, with meta-schedulers that form the root and other lower level schedulers, while providing specific scheduling capabilities that form the leaves. These schedulers may be constructed with a local scheduler implementation approach for specific job execution, or another meta-scheduler or a cluster scheduler for parallel executions.

References

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T. O'Leary, L. O'Leary and D. O'Leary, Computing Essentials 2017: Making IT work for you, 26th Edition, pp. 116 - 128, McGraw-Hill, 2017