University of Technology

Computer Engineering Department

Computer Principles

Lecture 2

Computer Hardware

Lecture Layout:

- System Unit
- Electronic Data and Instructions
- System Board
- Microprocessor
- Memory
- System Clock
- Expansion Slots and Cards
- Bus Lines
- Ports
- Power Supply

➢ System Unit

The system unit, also known as the **system cabinet**, is a container that houses most of the electronic components that make up a computer system. All computer systems have a system unit. For microcomputers, there are four basic types:

- **Desktop system unit:** typically contain the system's electronic components and selected secondary storage devices. Input and output devices, such as mouse, keyboard and monitor are located outside the system unit. This type of system unit is designed to be placed either horizontally or vertically. Vertical units are often called tower models.

- **Notebook system unit:** are portable and much smaller. These system units contain the electronic components, selected secondary storage devices and input devices (keyboard and pointing device). Located outside the system unit, the monitor is attached by hinges. Notebook system units are often called laptops.

- **Tablet PC system unit:** are similar to notebook system units. Tablet PCs are highly portable devices that support the use of a pen to input commands and data. There are two basic categories: convertible and slate.

- **Handheld computer system unit:** are the smallest and are designed to fit into the palm of one hand. Also known as **palm computers,** these systems contain an entire computer system, including the electronic components, secondary storage and input and output devices. **Personal Digital Assistants (PDAs)** are the most widely used handheld computers.

While the actual size may vary, each type of system unit has the same basic system components including system board, microprocessor and memory.

➢ Electronic Data and Instructions

Data and instructions are represented electronically with a binary, or two-state, numbering system. It is because computers cannot recognize information in the same way as human beings. People follow instructions and process data using letters, numbers and special characters.

People voices create analog or continuous signals that vary to represent different tones, pitches and volume. Computers can recognize only digital electronic signals. Before any processing can occur within the system unit, a conversion must occur from analog signals to digital signals (what the system unit can electronically process). There are many forms of technology that explain the two-state, on/off, yes/no or an electronic circuit open or closed. A specific location on a tape or disk may have a positive or a negative charge. This is the reason that a two-state or binary system is used to represent data and instructions.

The decimal system that all are familiar with has 10 digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9). The binary system consists of two digits 0 1nd 1. Each 0 or 1 is called a bit abbreviated for binary digit. In the system unit, the 0 can be represented by electricity being off and the 1 by electricity being on. In order to represent numbers, letters and special characters, bits are combined into groups of eight called bytes. Each byte typically represents one character.

Binary Coding Schemes

Binary coding schemes are used to represent characters as 0s and 1s ("off" and "on" electrical states) in the computer. Two of the most popular binary coding schemes use eight bits or one byte. These two codes are ASCII and EBCDIC. A recently developed code, Unicode, uses sixteen bits.

- **ASCII:** stands for American Standard Code for Information Interchange. This is the most widely used binary code for microcomputers. For example, the number 3 is represented in ASCII code as 00110011.
- **EBCDIC:** stands for Extended Binary Coded Decimal Interchange Code. It was developed by IBM and is used primarily for large computers. For example, the number 3 is represented in EBCDIC code as 11110011.
- **Unicode:** is a 16-bit code designed to support international languages like Chinese and Japanese. These languages have too many characters to be represented by the eight-bit ASCII and EBCDIC codes.

SYSTEM	CHAR	HEX	DEC	8	4	2	1	8	4	2	1	
ASCII	'H'	48	72	0	1	0	0	0	0	0	1	1 byte
ASCII	'E'	45	69	0	1	0	0	0	1	0	1	1 byte
ASCII	'L'	4C	76	0	1	0	0	1	1	0	0	1 byte
ASCII	'L'	4C	76	0	1	0	0	1	1	0	0	1 byte
ASCII	'O'	4F	79	0	1	0	0	1	1	1	1	1 byte

SYSTEM	CHAR	HEX	DEC	8	4	2	1	8	4	2	1
EBCDIC	'H'	C8	200	1	1	0	0	1	0	0	0
EBCDIC	'E'	C5	197	1	1	0	0	0	1	0	1
EBCDIC	'L'	D3	211	1	1	0	1	0	0	1	1
EBCDIC	'L'	D3	211	1	1	0	1	0	0	1	1
EBCDIC	'O'	D6	214	1	1	0	1	0	1	1	0

When a key is pressed on the keyboard, a character is automatically converted into a series of electronic pulses that the system can recognize. For example, pressing the character “Z” on a keyboard causes an electronic signal to be sent to the microcomputer’s system unit where it is converted to the ASCII code of 01011010.

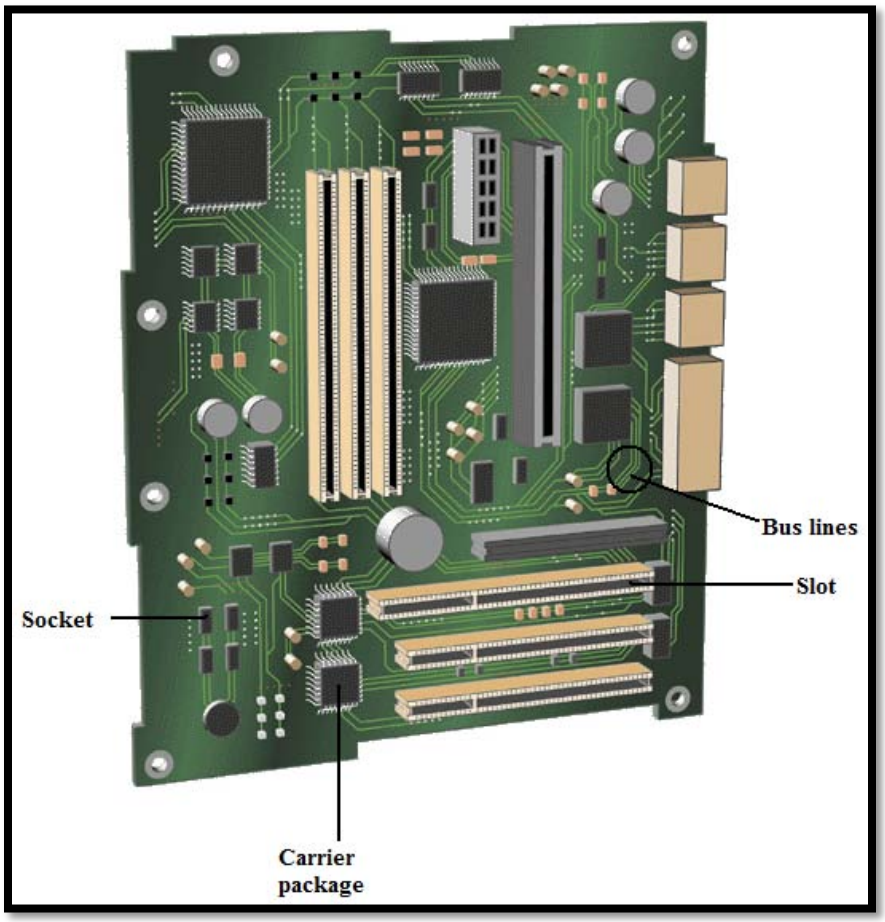
➢ System Board

The system board is also known as the **main board** or **motherboard**. The system board is the communications medium for entire computer system. Every component of the system unit connects to the system board. It acts as a data path allowing the various components to communicate with one another. External devices such as the keyboard, mouse and monitor could not communicate with the system unit without the system board.

On a desktop computer, the system board is 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.

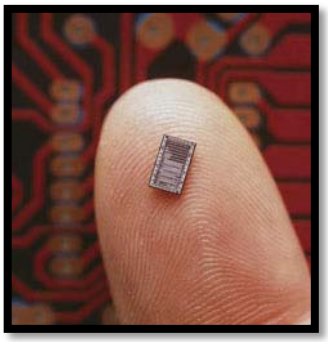
- **Sockets:** provided a connection point for small specialized electronic parts called chips. **Chips** consist of tiny circuit boards etched onto squares of sand like material called silicon. These circuit boards can be smaller than the tip of a finger. A chip is also called a silicon chip, semiconductor or integrated circuit. Chips are mounted on **carrier packages.** These packages either plug directly into sockets on the system board or onto cards that are then plugged into slots on the system board. Sockets are used to connect the system board to a

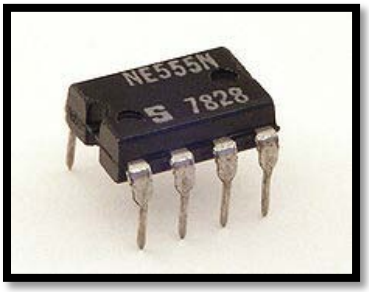
variety of different types of chips, including microprocessor and memory chips.



- **Slots:** provide a connection point for specialized cards or circuit boards. These cards provide expansion capability for a computer system. For example, a modem card plugs into a slot on the system board to provide a connection to the Internet.
- Connection lines called **bus lines** provide pathways that support communication among the various electronic components that are either located in the system board or attached to the system board.

Notebook, tablet PC and handheld system boards are smaller than desktop system boards. However, they perform the same functions as desktop system boards.





➢ Microprocessor

In a microcomputer system, the **central processing unit (CPU)** or **processor** is contained on a single chip called the **microprocessor.** The microprocessor is either mounted onto a carrier package that plugs into the system board or contained within a cartridge that plugs into a special slot on the system board. The microprocessor is the “brains” of the computer system. It has two basic components: the control unit and 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: arithmetic and logical.

Arithmetic operations are the fundamental math operations: addition, subtraction, multiplication and division. **Logical operations** consist of comparisons such as equal to (=), less than (<) or greater than (>).

Microprocessor Chips

Chip 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 powerful and faster the computer is. As mentioned previously, eight bits group 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 is faster.

Older microcomputers typically process data and instructions in millions of a second, or **microseconds**. Newer microcomputers are much faster and process data and instructions in billionths of a second, or **nanoseconds**. Super computers operate at speeds measured in **picoseconds** (trillionth of a second), which are 1000 times as fast as microcomputers. There are two types of microprocessor chips:

- **CISC chips:** The most common type of microprocessor is the **Complex Instruction Set Computer (CISC) chip.** This design was popularized by Intel. It is the most widely used chip design with thousands of programs written specially for it. Intel's Pentium microprocessors are CISC chips. While Intel is the leading manufacturer of microprocessors, other manufacturers produce microprocessors using a nearly identical design. These chips referred to as **Intel-compatible** processors, are able to process programs originally written specifically for Intel chips.
- **RISC chips: Reduced Instruction Set Computer (RISC) chips** use fewer instructions. This design is simpler and less costly than CISC chips. The PowerPC is a RISC chip produced by Motorola. These chips are used in many of today's most powerful microcomputers known as **workstations.**

Specialty Processors

In addition to microprocessor chips, a variety of more specialized processing chips have been developed. One of the most common is coprocessors. **Coprocessors** are specialty chips designed to improve specific computing operations. One of the most widely used is the **graphics coprocessor.** These processors are specifically designed to handle the processing requirements related to displaying and manipulating 2-D and 3-D graphics images.

Another specialty processor is the **parallel processor.** These processors work with one or more other parallel processor chips to run or process large programs. The processors use special software that takes a

large program, breaks it down into parts, and assigns the parts to separate processors. The processors then work on their respective parts simultaneously and share results as required by the program. This approach is called **parallel processing.** Parallel processing is commonly used by supercomputers to run very large and complex programs.

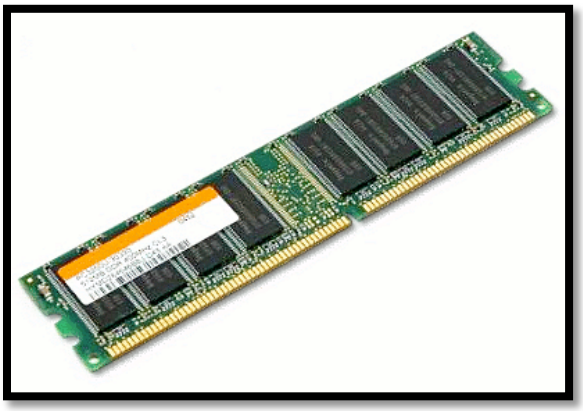
Smart cards use another type of specialty processor. **A smart card** is essentially a plastic card the size of a regular credit card that has an embedded chip. Visa and MasterCard have introduced their smart cards to millions of users.

➢ 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)** 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 microcomputer is turned off. It is also lost if there is a power failure or other disruption of the electric current going to the microcomputer. Secondary storage which will be

explained later, does not lose its contents. It is permanent or nonvolatile storage, such as data stored on CDs.



Cache memory or **RAM cache** improves processing by acting as a temporary high-speed holding area between memory and the CPU. In a computer with a cache (not all machines have one), the computer detects which information in RAM is most frequently used. It then copies that information into the cache. When needed, the CPU can quickly access the information from the cache.

Flash RAM or **flash memory** chips can retain data even if power is disrupted. This type of RAM is the most expensive and used primarily for special applications such as for digital cell telephones, digital video cameras and portable computers.

Having enough RAM is important. For example, to effectively use Excel requires 32 Megabyte (MB 1 million bytes) of RAM and additional RAM is needed to hold any data or other applications.

Even if there is no enough RAM to hold a program, it might be able to run 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 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.

- **Read Only Memory** chips have programs built into them at the factory. Unlike RAM chips, ROM chips are not volatile and cannot be changed by the user. “Read only” means that the CPU can read, or retrieve data and programs written on the ROM chip. However, the computer cannot write or change the information or instructions in ROM.

  ROM chips typically contain special instructions for detailed computer operations. For example, ROM instructions are needed to start a computer, give keyboard keys their special control capabilities and put characters on screen. ROMs are also called **firmware**.

- **Complementary Metal Oxide Semiconductor (CMOS)** chip provides flexibility and expandability for a computer system. It contains essential information that is required every time the computer system is turned on. The chip supplies such information as the current date and time, amount of RAM, type of keyboard, mouse, monitor and

disk drives. Unlike RAM, it is powered by a battery and does not lose its contents when the power is turned off. Unlike ROM, its contents can be changed to reflect changes in the computer system such as increased and new hardware devices.

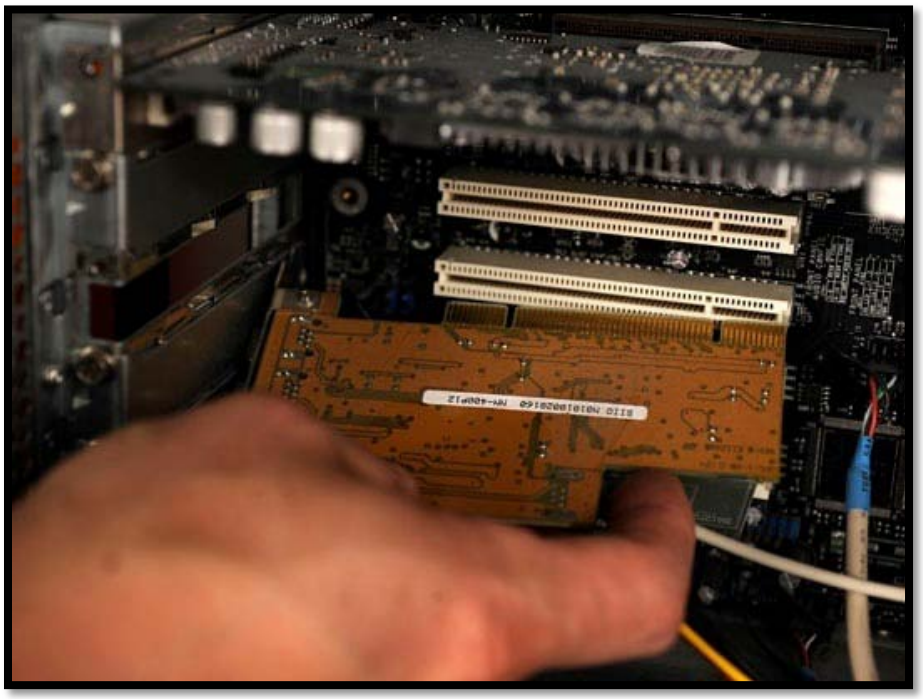
➢ System Clock

The **system clock** is a device that generates periodic, accurately spaced signals used for several purposes such as regulation of the operations of a processor or generation of interrupts. The system clock is located on a small specialized chip that produces precisely timed electrical beats or impulses. The clock circuit uses the fixed vibrations generated from quartz crystal to deliver a steady stream of pulses to the processor. The system clock controls the speed of all the operations within a computer. It has a fixed speed that cannot be varied. For that reason, a computer's system clock speed is an important measurement indicating the speed of processing or power of a computer system. The **clock speed** or **clock rate** for powerful microcomputers is measured in **gigahertz (GHz)** or billions of beats per second. The faster the clock, the faster the computer can process instructions.

➢ Expansion Slots and Cards

Computers are known for having different kinds of "architectures". Machines that have closed architecture are manufactured in such a way that users cannot easily add new devices. Most microcomputers have open architecture. They 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.



Expansion cards are also called **plug-in boards, controller cards, adapter cards** and **interface cards.** They plug into slots located on the system board. Ports on the cards allow cables to be connected from the expansion cards to devices outside the system unit. There are a wide range of different types of expansion cards. Some of the most commonly used expansion cards are:

- **Video cards:** Also known as **graphics cards,** these cards connect the system board to the computer's monitor. The cards convert the internal electronic signals to video signals so they can be displayed on the monitor.
- **Sound cards:** These cards accept audio input from a microphone and convert it into a form that can be processed by the computer. Also,

these cards convert internal electronic signals to audio signals so they can be heard from external speakers.

- **Modem cards:** Also known as **internal modems,** these cards allow distant computers to communicate with one another by converting electronic signals from the system unit into electronic signals that can travel over telephone lines and other types of connections.
- **Network interface cards (NIC):** These cards, also known as network adapter cards, are used to connect a computer to one or more other computers. This forms a communication network whereby users can share data, programs and hardware. The network adapter card typically connects the system unit to a cable that connects to the network.

Plug and Play is a set of hardware and software standards developed by Intel, Microsoft and others. It is an effort by hardware and software vendors to create operating systems, processing units and expansion boards as well as other devices that are able to configure themselves. Ideally, to

install a new expansion board, all users have to do is to insert the board and turn on the computer. As the computer start up, it will search for these Plug and Play devices and automatically configure the devices and the computer system.

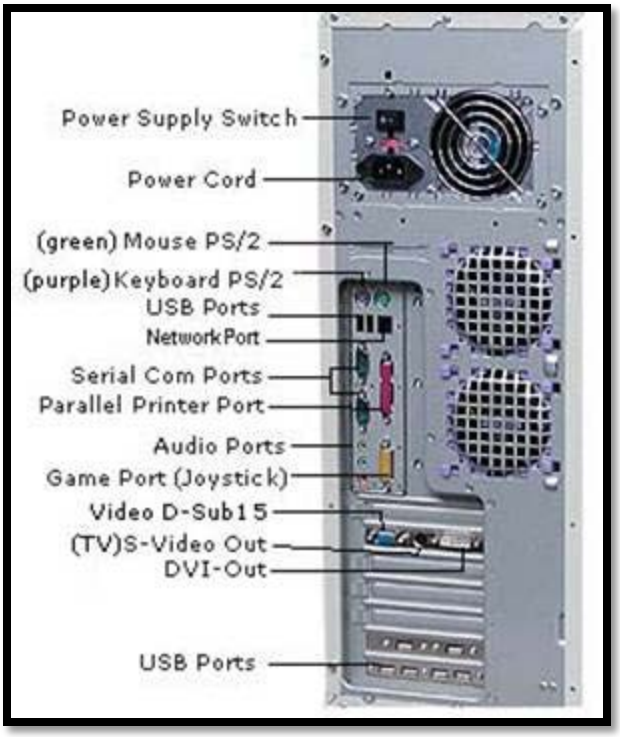
➢ Bus Lines

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. A bus line with more bus width can move traffic (data and instructions) faster. For example, a 64-bit bus is twice as fast as a 32-bit bus. A bus line is important 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 boards will work with one type of bus.

➢ Ports

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



Standard Ports

Many ports, like the mouse, keyboard and video ports are for specific devices. Others, like those listed below, can be used for a variety of different devices.

- **Serial ports:** are used for a wide variety of purposes. They are often used to connect a mouse, keyboard, modem and many other devices to the system unit. Serial ports send data one bit at a time and very good for sending information over a long distance.
- **Parallel ports:** are used to connect external devices that need to send or receive a lot of data over a short distance. These ports typically send eight bits of data simultaneously across eight parallel wires. Parallel ports are mostly used to connect printers to the system unit.

- **Universal serial bus (USB) ports:** are gradually replacing serial and parallel ports. They are faster and one USB port can be used to connect several devices to the system unit.
- **FireWire ports:** also known as **high performance serial bus (HPSB) ports** are as fast as USB 2.0 ports and provide connections to specialized FireWire devices such as camcorders.

Cables: are used to connect exterior devices to the system unit via ports. One end of the cable is attached to the device and the other end has a connector that is attached to a matching connector on the port.

➢ Power Supply

Computers require **direct current (DC)** to power their electronic components and represent data and instructions. DC power can be provided indirectly by converting **alternating current (AC)** from standard wall outlets or directly from batteries.

- Desktop computers have a power supply unit located within the system unit. This unit plugs into a standard wall outlet, converts AC to DC and provides the power to drive all of the system unit components.
- Notebook computers use **AC adapters** that are typically located outside the system unit. AC adapters plug into a standard wall outlet, convert AC to DC, provide power to drive the system unit components and can recharge batteries. Notebook computers can be operated either using an AC adapter plugged into a wall outlet or using battery power. Notebook batteries typically provide sufficient power for 2 to 4 hour before they need to be recharged.

- Like a notebook computers, handheld computers use AC adapters located outside the system unit. Unlike notebook computers, however handheld computers typically operate only using battery power. The AC adapter is used to recharge batteries.