Applications of Information and Communications technology

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Lecture 04

Reference book

Charles S. Parker, Understanding Computers: Today and Tomorrow, Course Technology, 25 Thomson Place, Boston, Massachusetts 02210, USA

HARDWARE

The System Unit, Processing, and Memory

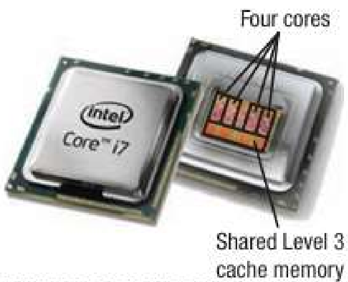
Processors

- Computers and mobile devices today contain one or more processors (such as CPUs and GPUs), which consist of a variety of circuitry and components that are packaged together and connected directly to the motherboard.
- The primary processor is the central processing unit (CPU)—also called the microprocessor when talking about personal computers— which does most of the processing for a computer. CPUs are typically designed for a specific type of computer, such as for desktop computers, servers, portable computers (like notebook and tablet computers), or mobile devices (like tablets and smartphones). Most desktop computers and servers today use Intel or Advanced Micro Devices (AMD) CPUs.
- Portable computers and mobile devices typically use an Intel or AMD mobile processor or a mobile processor manufactured by ARM or another company that makes mobile CPUs based on ARM CPU designs. In fact, many mobile processors (such as the Snapdragon 800 series processors from Qualcomm, the Tegra X1 from NVIDIA, the Exynos 7 Octa from Samsung, and the A8X from Apple) are based on ARM processors, such as the ARM Cortex-A72.

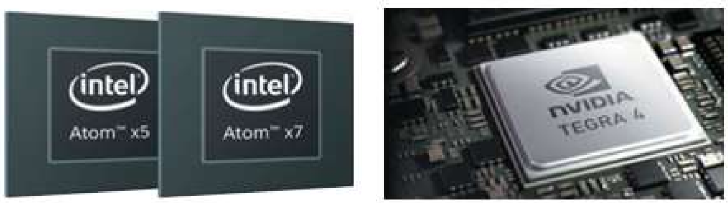
Most CPUs today are multi-core CPUs; that is, CPUs that contain the processing components or cores of multiple independent processors on a single CPU. For example, dual-core CPUs contain two cores and quad-core CPUs contain four cores. Up until just a few years ago, most CPUs designed for desktop computers had only a single core; as a result, a common way to increase the amount of processing performed by the CPU was to increase the speed of the CPU. However, heat constraints are making it progressively more difficult to continue to increase CPU speed, so CPU manufacturers today are focusing on multi-core CPUs to increase the amount of processing that a CPU can do in a given time period.

Multi-core CPUs allow computers to work simultaneously on more than one task at a time, such as burning a DVD while surfing the Web, as well as to work faster within a single application if the software is designed to take advantage of multiple cores. Another benefit of multi-core CPUs is that they typically experience fewer heat problems than single-core CPUs because each core typically runs slower than a single-core CPU, although the total processing power of the multi-core CPU is greater. Multi-core CPUs also increase the performance of mobile devices while, at the same time, delivering better battery life.

SERVER PROCESSORS



DESKTOP PROCESSORS



MOBILE PROCESSORS

TYPE OF CPU	NAME	NUMBER OF CORES
SERVER	Intel Xeon (E7 family) AMD Opteron (6300 series)	4–18 4–16
DESKTOP	Intel Core i7 (6th gen) AMD FX	4–8 4–8
MOBILE (NOTEBOOKS)	Intel Core M Intel Atom x7 Intel Celeron	2 4 1–4
MOBILE (MOBILE DEVICES)	Intel Atom x5 ARM Cortex-A17 NVIDIA Tegra 4*	4 4 4

* Based on ARM Cortex-A15

- **Processing speed**

CPU clock speed

One measurement of the processing speed of a CPU is the CPU clock speed, which is typically rated in megahertz (MHz) or gigahertz (GHz). A CPU with a higher CPU clock speed means that more instructions can be processed per second than the same CPU with a lower CPU clock speed. For instance, a Core i7 processor running at 3.2 GHz would be faster than a Core i7 processor running at 2.66 GHz if all other components remain the same. CPUs for the earliest personal computers ran at less than 5 MHz; today’s fastest CPUs designed for PCs have a clock speed of more than 5 GHz.

Benchmark tests

One measurement of overall processing speed is the maximum number of instructions the CPU can process per second—such as megaflops, gigaflops, and teraflops (millions, billions, and trillions of floating point operations per second, respectively). It is also common for experts associated with computer journals, technical Web sites, and other organizations to test the performance of CPUs. These tests—called benchmark tests—typically run the same series of programs on several computer systems that are identical except for one component (such as the CPU) and measure how long each task takes in order to determine the overall relative performance of the component being tested. Because the large number of factors affecting computer performance today makes it increasingly difficult for consumers to evaluate the performance of CPUs and computers, benchmark tests are becoming an extremely important resource for computer shoppers.

Computer word

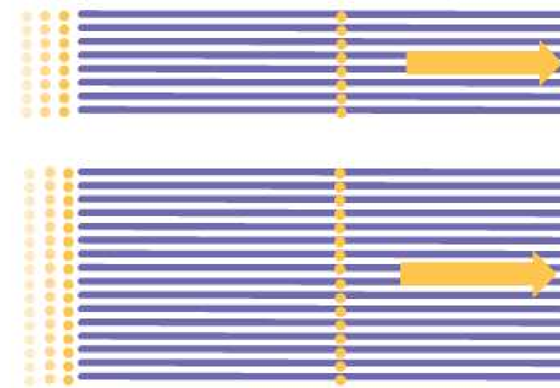
A computer word is the amount of data (typically measured in bits or bytes) that a CPU can manipulate at one time. In the past, CPUs used 32-bit words (referred to as 32-bit processors); today, most CPUs are 64-bit processors (that is, they can simultaneously process 64 bits, or 8 bytes, at one time). Usually, a larger word size allows for faster processing and the use of more RAM, provided the software being used is written to take advantage of 64-bit processing.

Cache memory

Cache memory is a special group of very fast memory circuitry usually built into the CPU. Cache memory is used to speed up processing by storing the data and instructions that may be needed next by the CPU in handy locations.

Cache memory today is usually internal cache (built right into the CPU chip). In the past, some cache memory was external cache (located close to, but not inside, the CPU), but that is less common today.

Bus width, Bus speed, and Bandwidth



- ***A bus*** is an electronic path over which data can travel. There are buses inside the CPU, as well as on the motherboard. You can picture a bus as a highway with several lanes; each wire in the bus acts as a separate lane, transmitting one bit at a time.

- The number of bits being transmitted at one time is dependent on the ***bus width***—the number of wires in the bus over which data can travel.

- ***Bus speed*** the amount of data that can be transferred via the bus in a given time period.

Buses

There are buses located within the CPU to move data between CPU components; there are also a variety of buses etched onto the motherboard to tie the CPU to memory and to peripheral devices.

Expansion buses

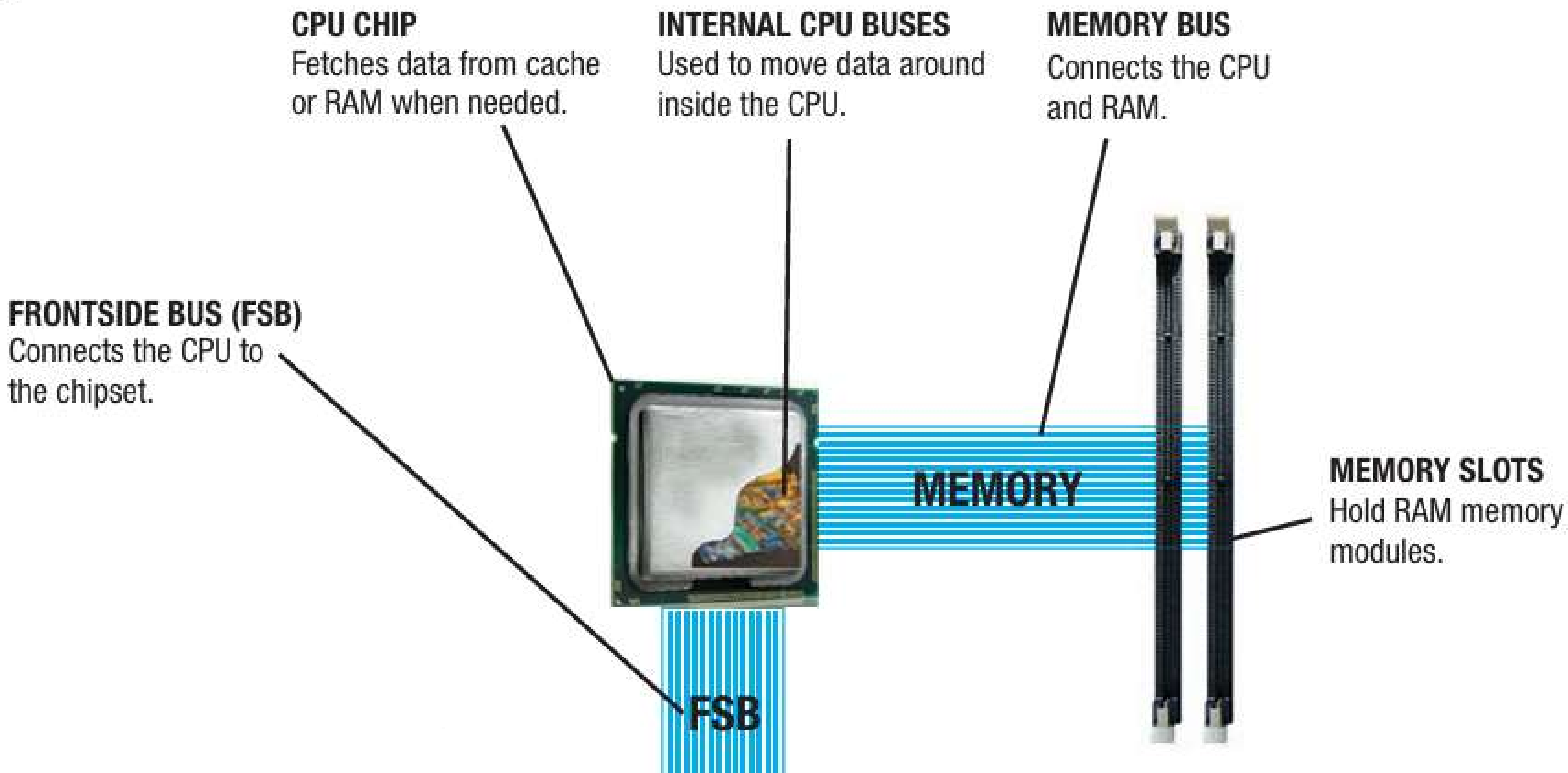
The buses that connect peripheral (typically input and output) devices to the motherboard are often called expansion buses.

- Memory Bus

One relatively recent change in the bus architecture used with most personal computers today is connecting the CPU directly to RAM. This change allows for increased performance; the bus used to connect the CPU to RAM is typically called the memory bus.

- Frontside Bus (FsB)

The frontside bus (FSB) connects the CPU to the chipset—a set of chips that connects the various buses together and connects the CPU to the rest of the bus architecture. Because of the importance of the FSB connection, CPU manufacturers typically use special high speed technologies; for instance, Intel uses its QuickPath Interconnect (QPI) technology and AMD uses its HyperTransport Technology.

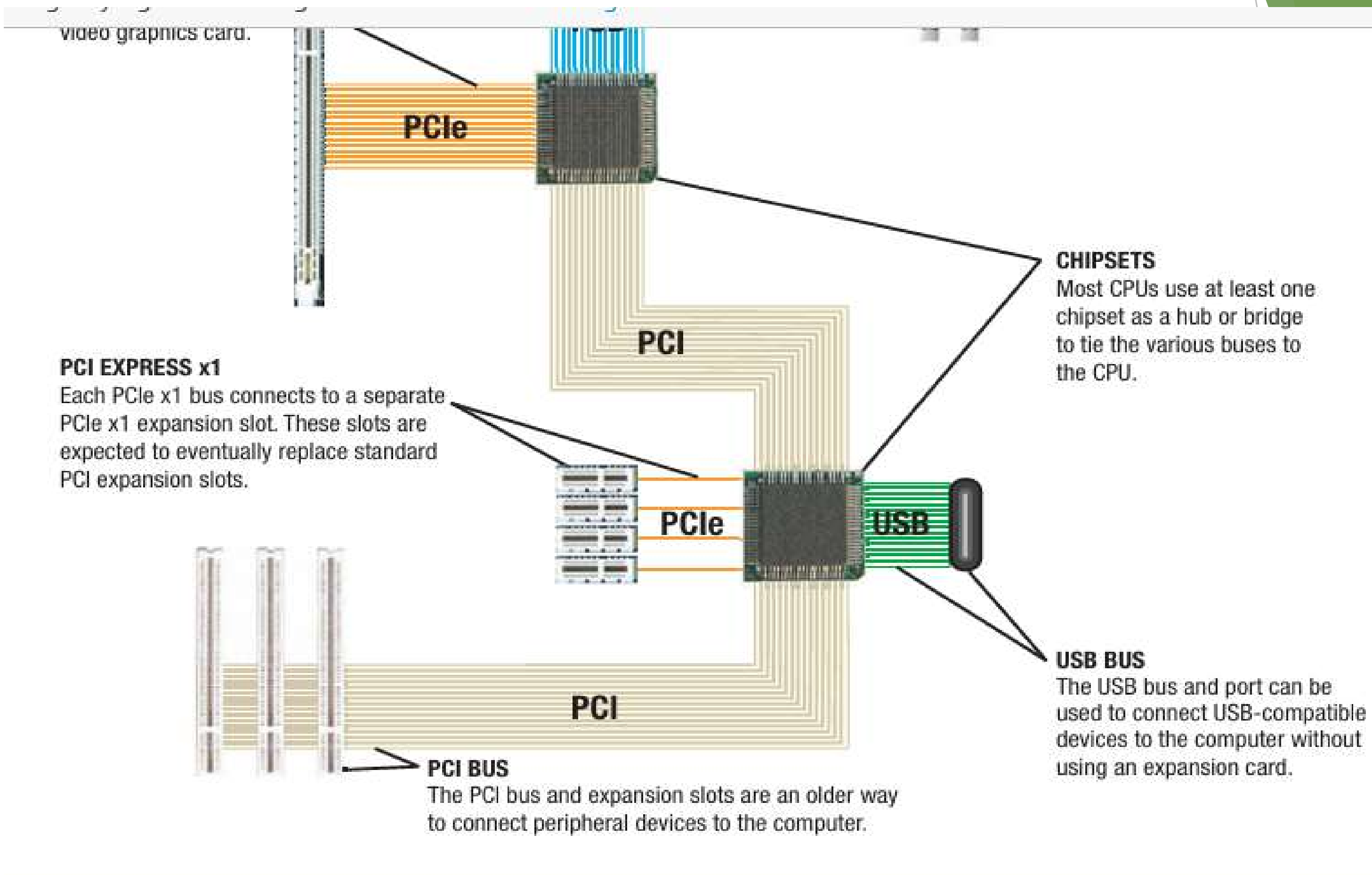

CPU CHIP
Fetches data from cache or RAM when needed.
INTERNAL CPU BUSES
Used to move data around inside the CPU.
MEMORY BUS
Connects the CPU and RAM.
FRONTSIDE BUS (FSB)
Connects the CPU to the chipset.
MEMORY
MEMORY SLOTS
Hold RAM memory modules.
FSB

- Pci and Pci express (Pcie) Bus

The PCI (Peripheral Component Interconnect) bus has been one of the most common types of expansion buses in past years. Today, however, the PCI Express (PCIe) bus (which connects to the PCI bus) is more often used for expansion. The PCIe bus is avail able in several different widths. The 16-bit version of PCIe (referred to as PCIe x16) is commonly used with video graphics cards to connect a monitor to a desktop computer; expansion cards for other peripherals often connect via the 1-bit PCIe bus (referred to as PCIe x1). PCIe is extremely fast—the current version (PCIe 4.0) transfers data at 16 Gbps (billions of bits per second) per lane, which is significantly faster than the standard PCI bus. For example, with 16 lanes, PCIe x16 transfers data at 256 Gbps.

- USB Bus

One of the more versatile bus architectures is the Universal Serial Bus (USB). The USB standard allows 127 different devices to connect to a computer via a single USB port on the computer’s system unit. The original USB standards, called USB 1.0 and 2.0, are relatively slow. They transfer data at 12 Mbps (millions of bits per second), and 480 Mbps, respectively. The newest USB 3.0 and 3.1 standards (also called SuperSpeed USB) are much faster (5 Gbps and 10 Gbps, respectively). USB 3 also supports faster and more powerful charging, so it can be used to charge larger devices (such as laptops and monitors) in addi tion to smartphones and other mobile devices. The convenience and universal support of USB have made it one of the most widely used standards for connecting peripherals (such as keyboards, mice, printers, and storage devices) today. In fact, some portable computers now come with only USB ports for connecting devices to the computer, as well as to power the computer. To help you identify USB 3 ports, they are colored blue.

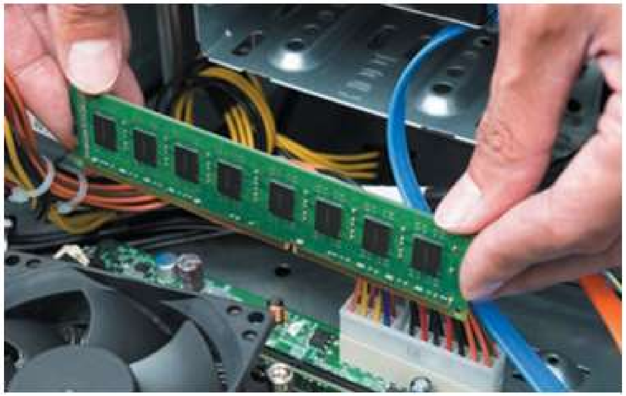

video graphics card.
PCIe
PCI
CHIPSETS
Most CPUs use at least one chipset as a hub or bridge to tie the various buses to the CPU.
PCI EXPRESS x1
Each PCIe x1 bus connects to a separate PCIe x1 expansion slot. These slots are expected to eventually replace standard PCI expansion slots.
PCIe
USB
PCI
USB BUS
The USB bus and port can be used to connect USB-compatible devices to the computer without using an expansion card.
PCI BUS
The PCI bus and expansion slots are an older way to connect peripheral devices to the computer.

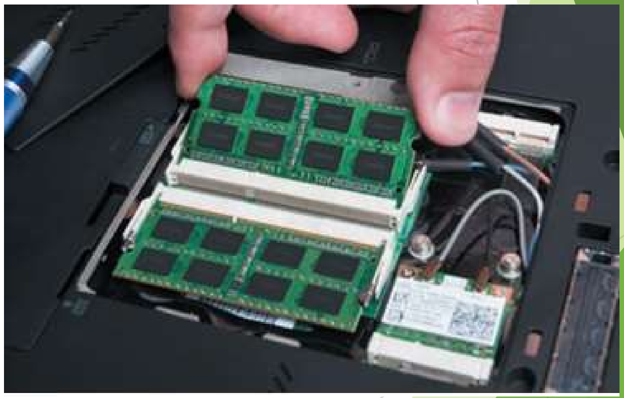
Memory

- Memory refers to chip-based storage. When the term memory is used alone, it refers to locations, usually inside the system unit (typically random access memory or RAM, dis cussed next) that a computer uses to store data on a temporary basis. In contrast, the term storage refers to the more permanent storage a computer uses—usually in the form of the computer's internal hard drive or removable storage media (such as DVDs and flash memory storage systems, which are discussed in the next chapter), but it can also be in the form of chip-based internal storage—especially in mobile devices.

RAM (random access memory),

Random access memory (ram) also called main memory or system memory, is used to store the essential parts of the operating system while the computer is running, as well as the programs and data that the computer is currently using.

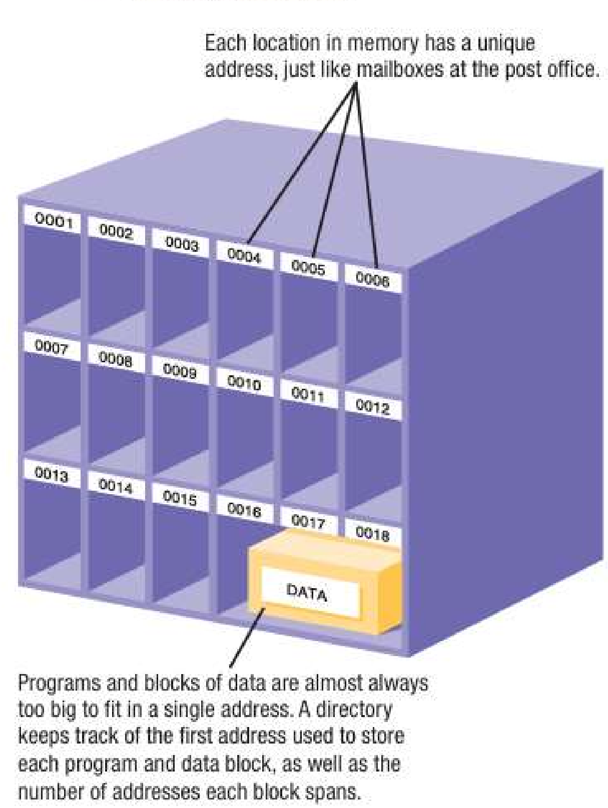




RAM capacity

RAM capacity is measured in bytes. The amount of RAM that can be installed in a computer depends on both the CPU in that computer and the operating system being used. For instance, while computers with older 32-bit CPUs can use up to only 4 GB of RAM, computers with 64-bit CPUs and a 64-bit operating system can use significantly more RAM. In addition, different versions of computers with 64-bit CPUs and a 64-bit operating system may support different amounts of RAM. Consequently, when you are considering adding more RAM to a computer, it is important to first determine that your computer can support it. More RAM allows more applications to run at one time and the computer to respond more quickly when a user switches from task to task. Most computers sold today for personal use have between 4 and 16 GB of RAM; mobile devices typically have between 1 and 4 GB of RAM.

Regardless of the type of RAM used, the CPU must be able to find data and programs located in memory when they are needed. To accomplish this, each location in memory has an address. Whenever a block of data, instruction, program, or result of a calculation is stored in memory, it is usually stored in one or more consecutive addresses, depending on its size. The computer system sets up and maintains directory tables that keep track of where data is stored in memory in order to facilitate the retrieval of that data. When the computer has finished using a program or set of data, it frees up that memory space to hold other programs and data. Therefore, the content of each memory location constantly changes.



Memory addressing.

- **Registers** A register is high-speed memory built into the CPU. Registers are used by the CPU to store data and intermediary results temporarily during processing. Registers are the fastest type of memory used by the CPU, even faster than Level 1 cache. Generally, more registers and larger registers result in increased CPU performance. Most CPUs contain multiple registers; registers are discussed in more detail later in this chapter.
- **ROM (read-only memory)** consists of nonvolatile chips that permanently store data or programs. Like RAM, these chips are attached to the motherboard inside the system unit, and the data or programs are retrieved by the computer when they are needed. An important difference, however, is that you can neither write over the data or programs in ROM chips (which is the reason ROM chips are called read-only) nor erase their content when you shut off the computer's power. Traditionally, ROM was used to store the permanent instructions used by a computer (referred to as firmware). However, ROM is increasingly being replaced with flash memory, as discussed next, for any data that may need to be updated during the life of the computer

- **Flash memory**

Flash memory consists of nonvolatile memory chips that can be used for storage by the computer or the user. Flash memory chips have begun to replace ROM for storing system information, such as a computer’s BIOS (basic input/output system) or, in recent versions of Windows, Unified Extensible Firmware Interface (UEFI), which is the sequence of instructions the computer follows during the boot process.