Distributed Systems

Mahmoud Abou El-Magd Soliman
Department of Computer Science
Faculty of Computers and Artificial Intelligence
Sohag University

DEFINITION OF A DISTRIBUTED SYSTEM

Various definitions of distributed systems have been given in the literature:

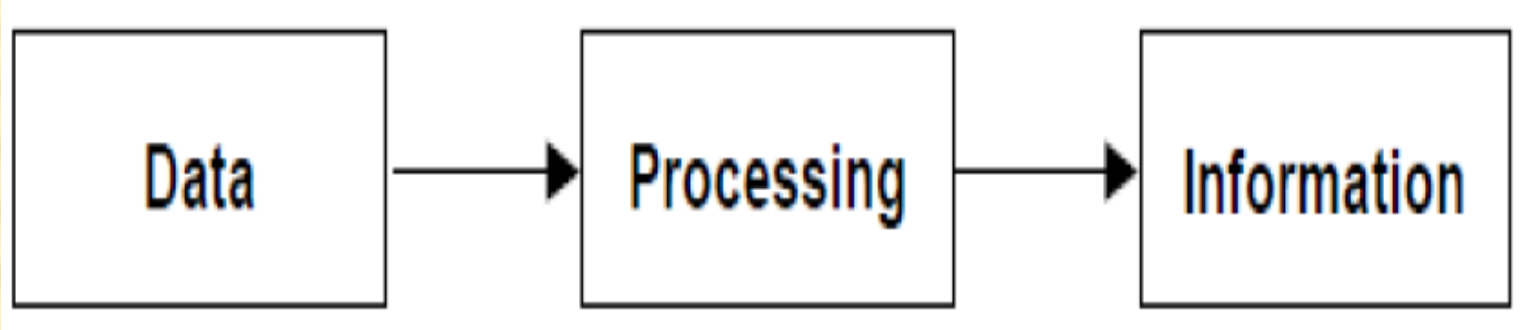
A distributed system is a collection of independent computers that appears to its users as a single coherent system.

Introducing Computer Systems

A modern computer consists of one or more processors, some main memory, disks, printers, a keyboard, a mouse, a display, network interfaces, and various other input/output devices. If every application programmer had to understand how all these things work in detail, no code would ever get written. For this reason, computers are equipped with a layer of software called the operating system, whose job is to provide user programs with a better, simpler, cleaner, model of the computer and to handle managing all resources.

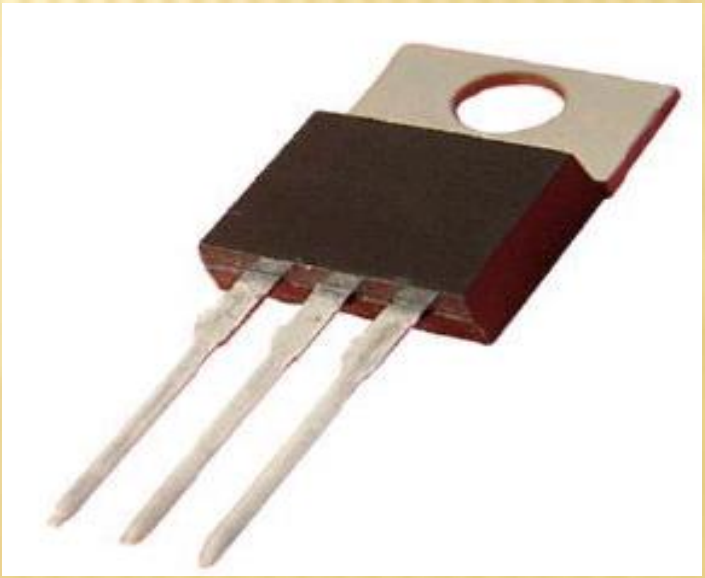
Introduction to Computer

A diagram to define a computer

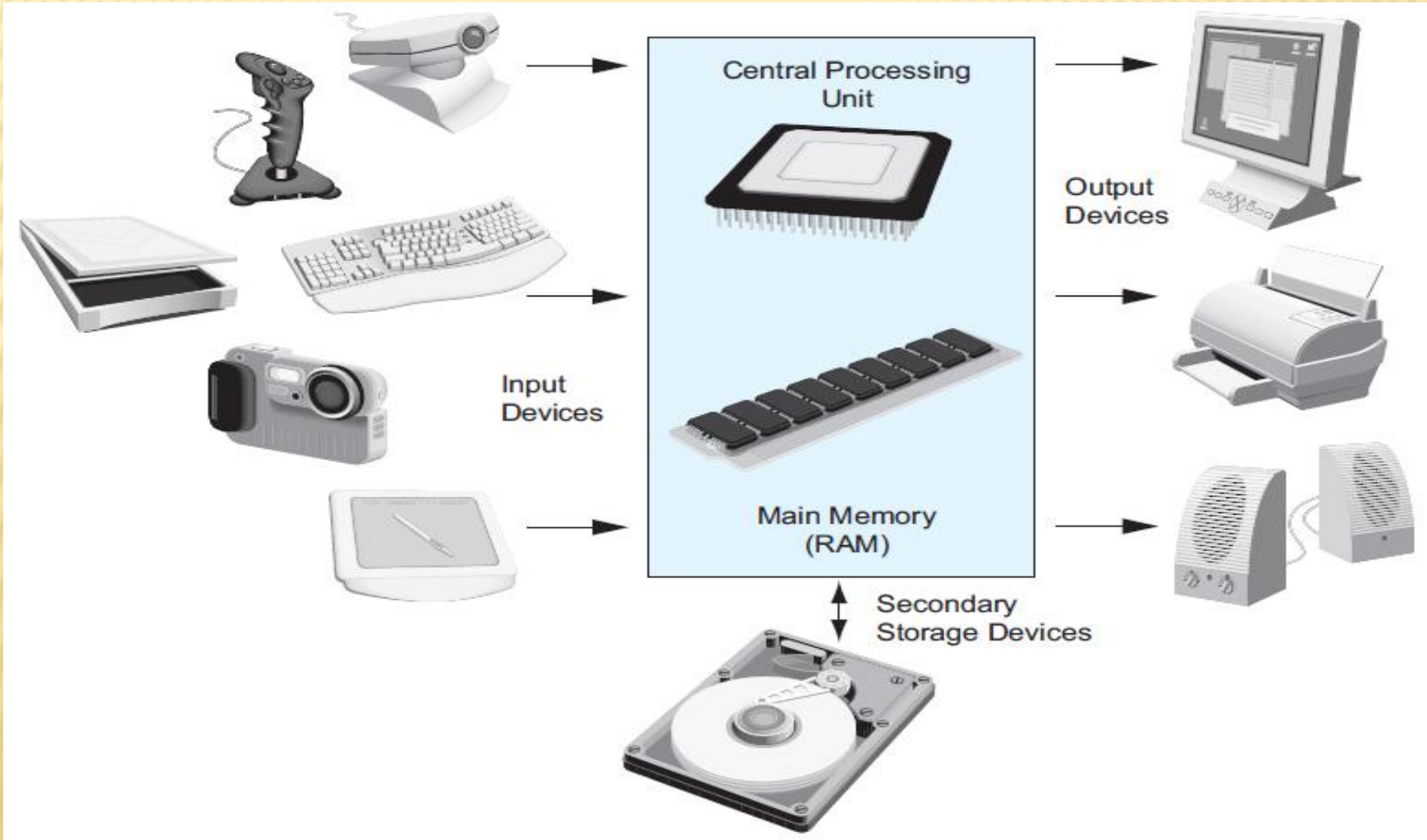


Vacuum Tube

Transistor



Typical Components of a Computer System (Computer Hardware)



Types of Computer

Super Computers:

- A super computer is the most powerful computer available at any given time. These machines are built to process huge amounts of information and do so very quickly.

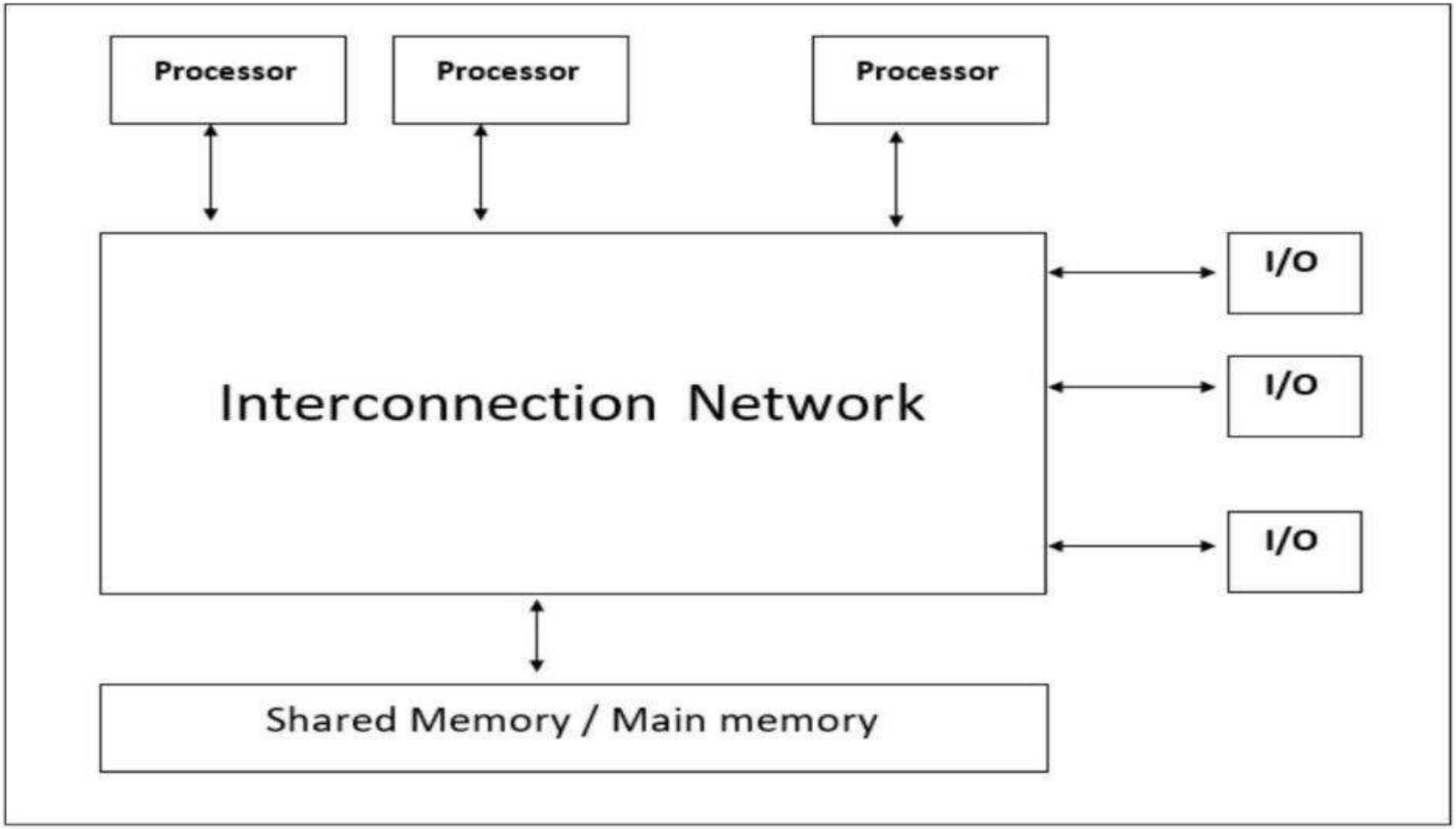
- Supercomputers are built specifically for researchers or scientists working on projects that demand very huge amounts of data variables; an example is in nuclear research, where scientists want to know exactly what will happen during every millisecond of a nuclear chain reaction. (To demonstrate the capability of super computers, for an air pollution control project that involves more than 500,000 variables, it will take a mini computer about 45 hours to complete the simulation process while it will take only 30 minutes in super computer).

Tightly-Coupled Systems

A tightly-coupled system usually refers to a multiprocessor.

- Communicate via shared memory.
- Complete connectivity between processor and memory.
- Useful for high speed real time processing
- Same OS runs in all the processing systems.
- This Connectivity accomplished by any interconnection network.

Tightly-Coupled Systems



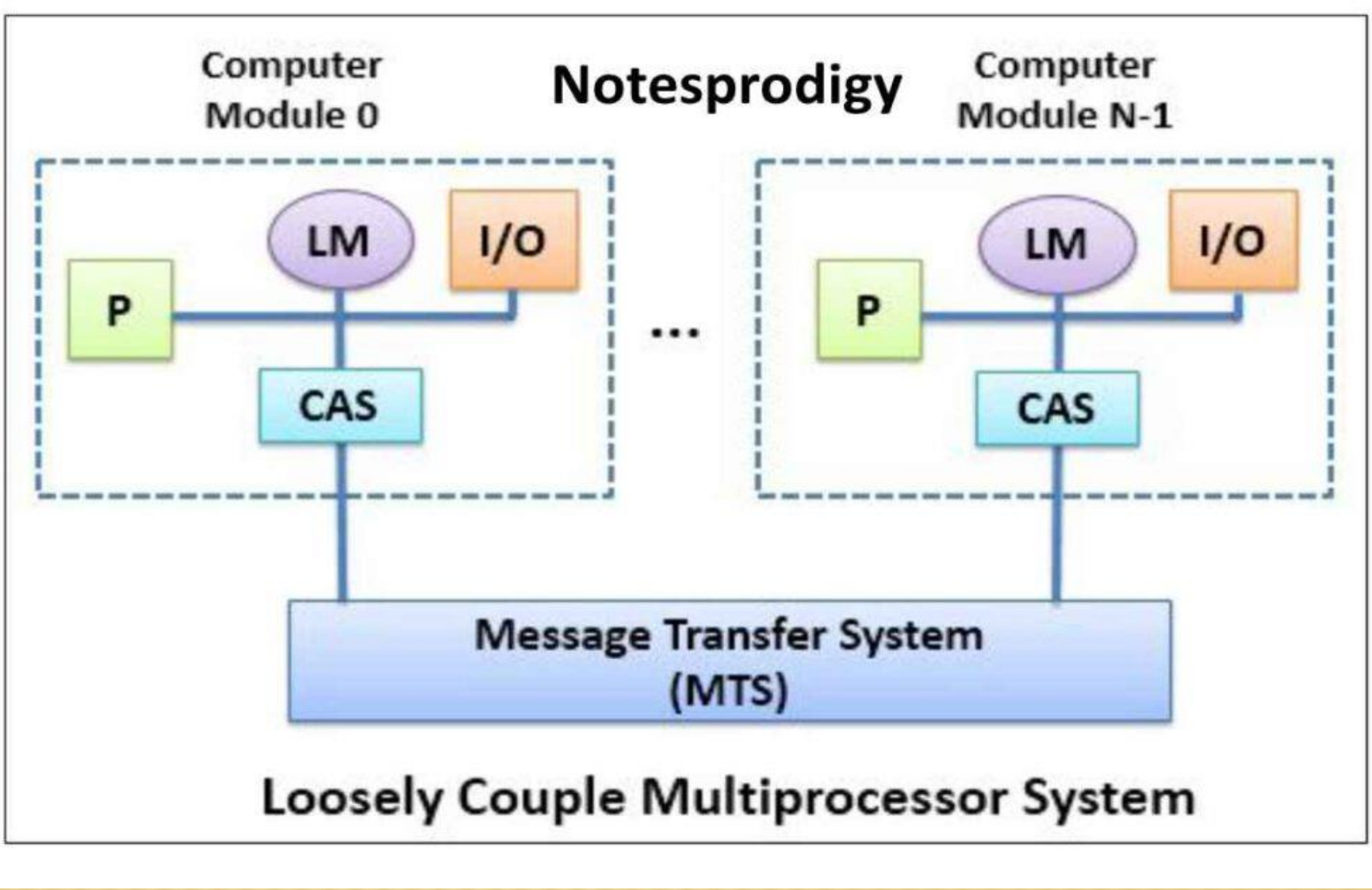
Notesprodigy

Loosely-Coupled Systems

A loosely-coupled system usually refers to a multiprocessor.

- Multiprocessors with local memories.
- Communication occurs through message passing
- Different OS can be implemented on different nodes.
- Mostly distributed systems.

Loosley-Coupled Systems



Types of Computer

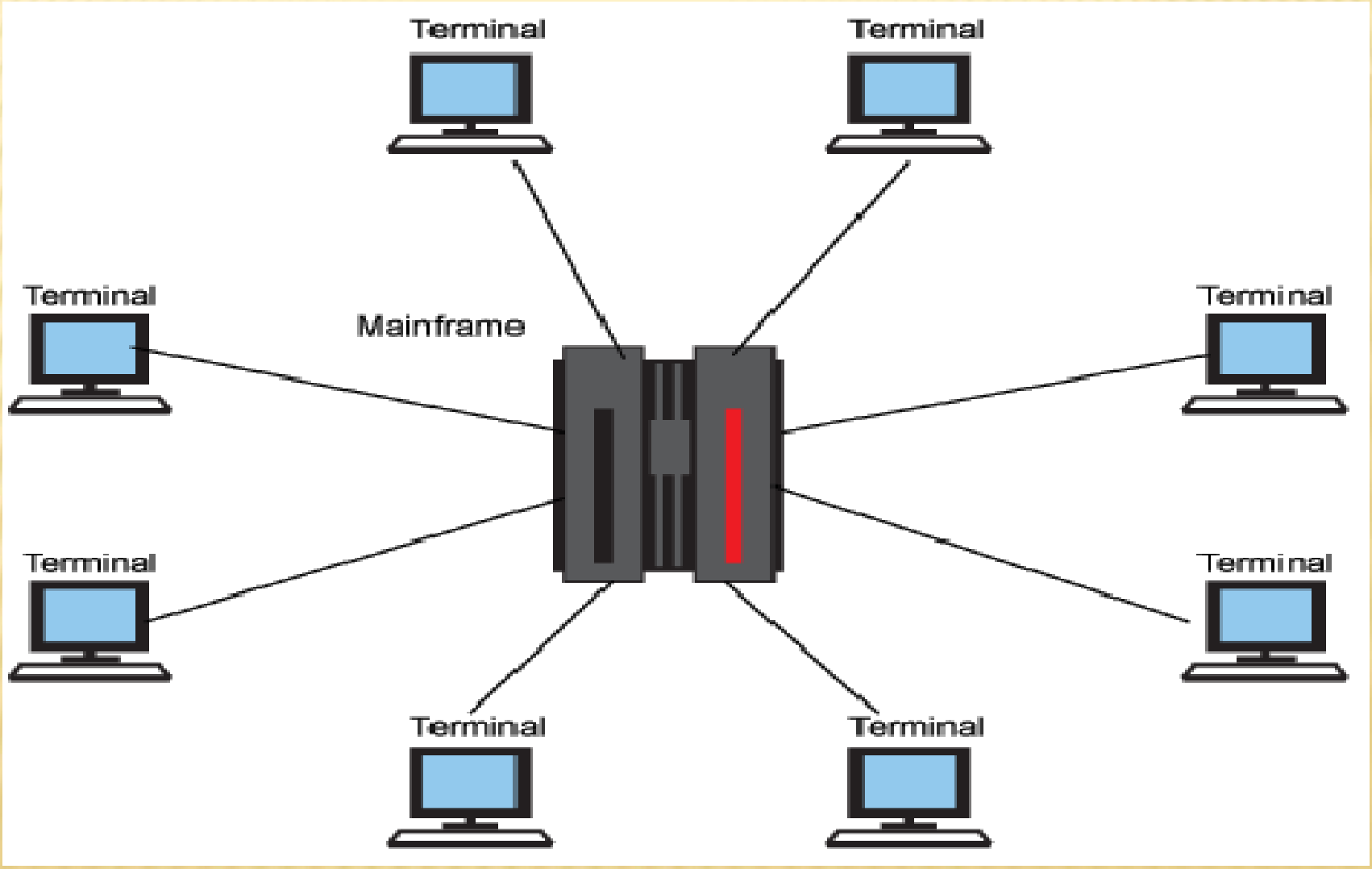
Mainframe Computers:

- The largest types of computers in common use are the mainframe computers. They are designed to handle tremendous amounts of input, output and storage.

- They are used mainly by large organization.

- Other users access mainframe computers through terminals. Terminals consist of a type of keyboard and a video display i.e. monitors. The mainframe is usually in the computer room.

Mainframe Computers



Types of Computer

Mini Computers:

- These are physically small compared to mainframes and are generally used for special purposes or small-scale general purposes.
- The best way to explain the capabilities of mini computers is to say they lie between mainframes and personal computers. Like mainframes, they can handle a great deal more input and output than personal computers.
- Although some minicomputers are designed for a single user, many can handle dozens or even hundreds of terminals.

Types of Computer

Workstations:

- Between mini computers and micro computers – in terms of processing power is a class of computers known as workstations.
- A workstation looks like a personal computer and is typically used by one person, although it is still more powerful than the average personal computer.
- They significantly differ from micro computers in two ways: the central processing unit (CPU) of workstations are designed differently to enable faster processing of instructions.
- Workstations [Reduced Instruction Set Computing (RISC)] use UNIX operating system or a variation of it.

Types of Computer

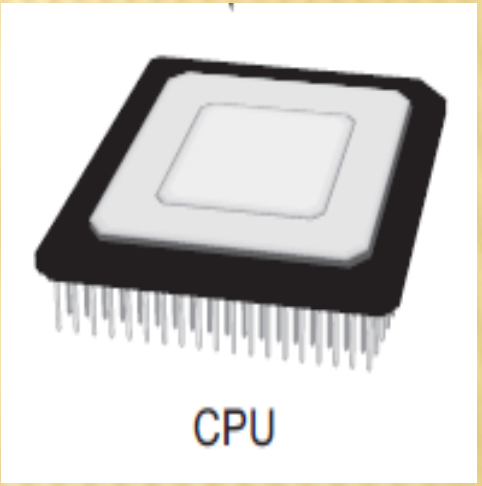
Micro Computers/Personal Computers:

- The term microcomputers and personal computers are used interchangeably to mean the small free-standing computers that are commonly found in offices, homes and classrooms.
- Many micro computers are built specially to be used in watches, clocks, and cameras. Today, PCs are seriously challenging mainframes and mini computers in many areas. In fact today PCs are more powerful than mainframes of just a few years ago, and competition is producing smaller, faster models every year.

Processing Devices

The Central Processing Unit (CPU):

The central processing unit (CPU) is a tiny electronic chip known as the micro processor located in the system unit. The CPU as the name implies is where information is processed within the computer. In this regard, you might think of the CPU (processor) as the brain of the computer. The CPU is otherwise known as microprocessor. Every CPU has at least two basic parts. The control unit (CU) and the Arithmetic Logic Unit (ALU). The control unit coordinates all the computer activities and contains the CPUs instruction to carry out commands. The ALU is responsible for carrying out arithmetic and logic functions.

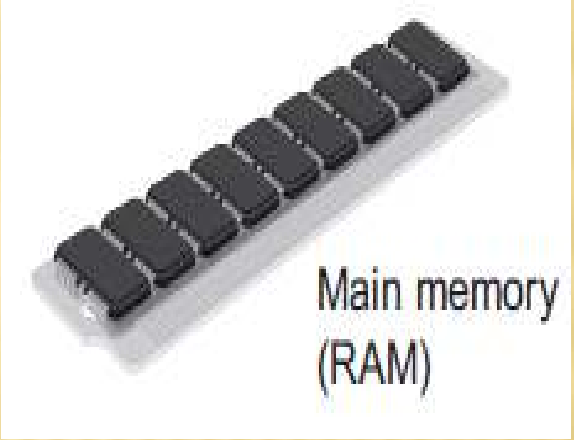


CPU

Processing Devices

Main Memory:

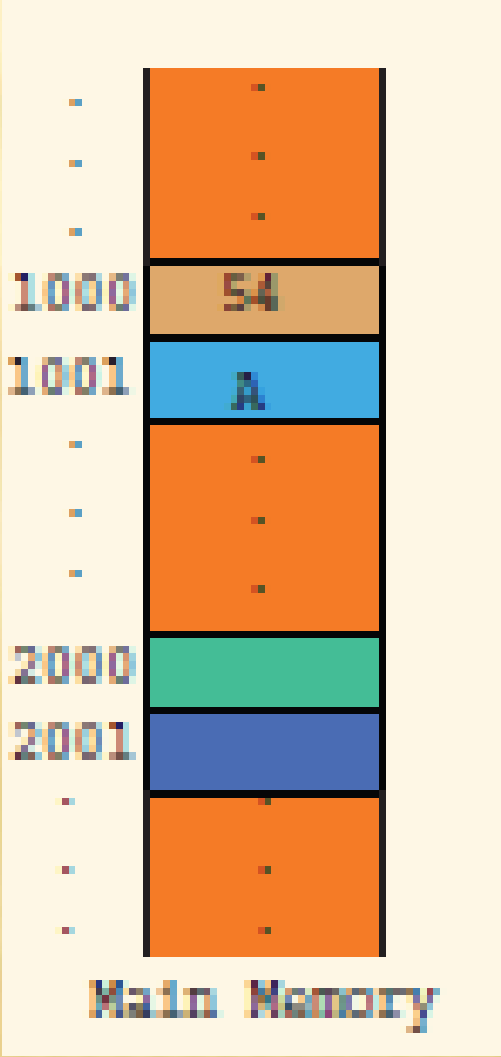
You can think of main memory as the computer's work area. This is where the computer stores a program while the program is running, as well as the data that the program is working with. Main memory is commonly known as random-access memory, or RAM. It is called this because the CPU is able to quickly access data stored at any random location in RAM. RAM is usually a volatile type of memory that is used only for temporary storage while a program is running. When the computer is turned off, the contents of RAM are erased.



Maim Memory (RAM)

RAM is similar in concept to a set of boxes in which each box can hold a 0 or a 1. Each box has a unique address that is found by counting across the columns and down the rows. A set of RAM boxes is called an array, and each box is known as a cell.

To find a specific cell, the RAM controller sends the column and row address down a thin electrical line etched into the chip. Each row and column in a RAM array has its own address line.

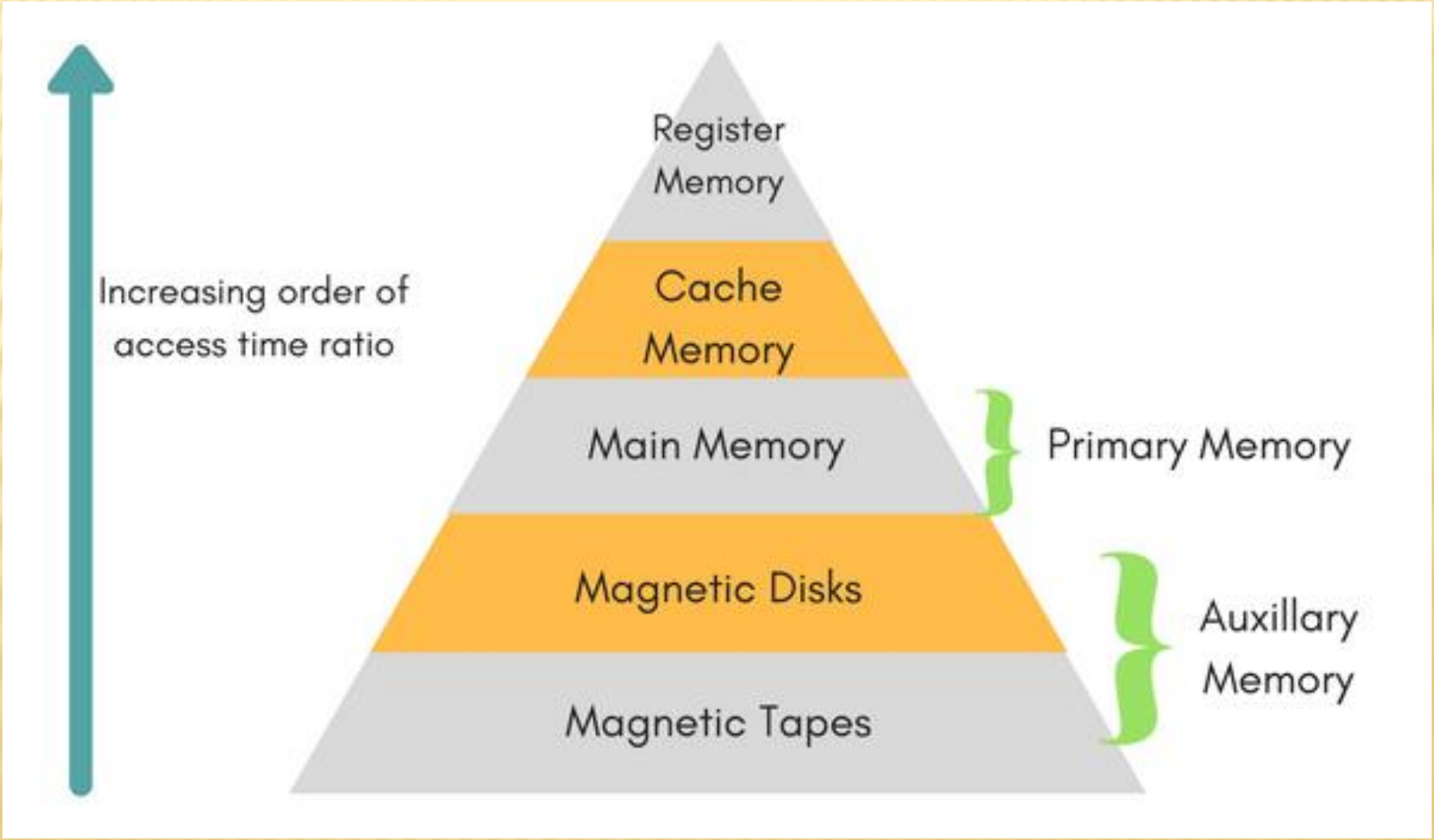


RAM vs. Virtual Memory

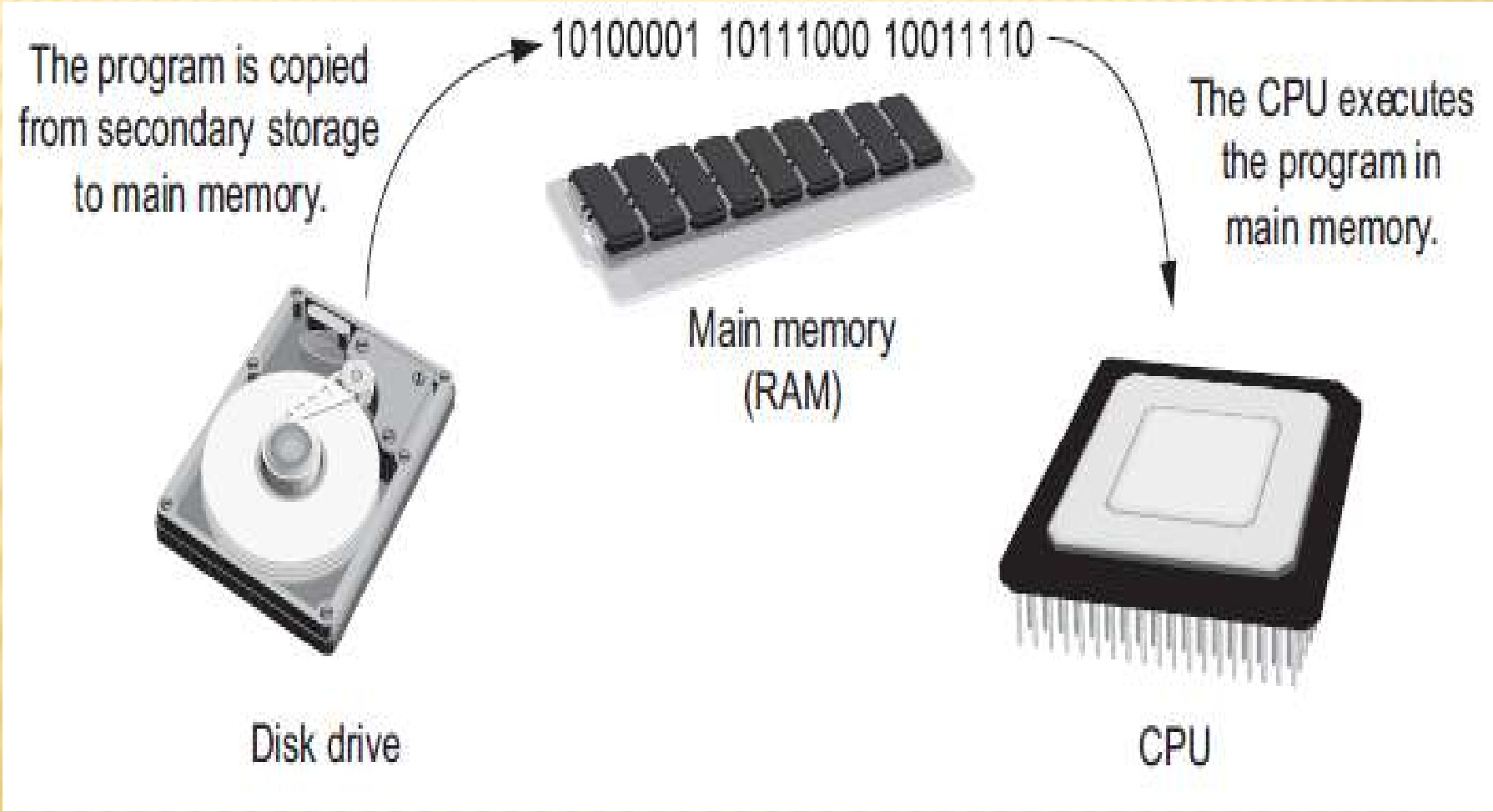
With virtual memory, data is temporarily transferred from RAM to disk storage, and virtual address space is increased using active memory in RAM and inactive memory in an HDD to form contiguous addresses that hold an application and its data. Using virtual memory, a system can load larger programs or multiple programs running at the same time, letting each operate as if it has infinite memory without having to add more RAM.

Virtual Memory = Main memory (RAM) + Extended Memory

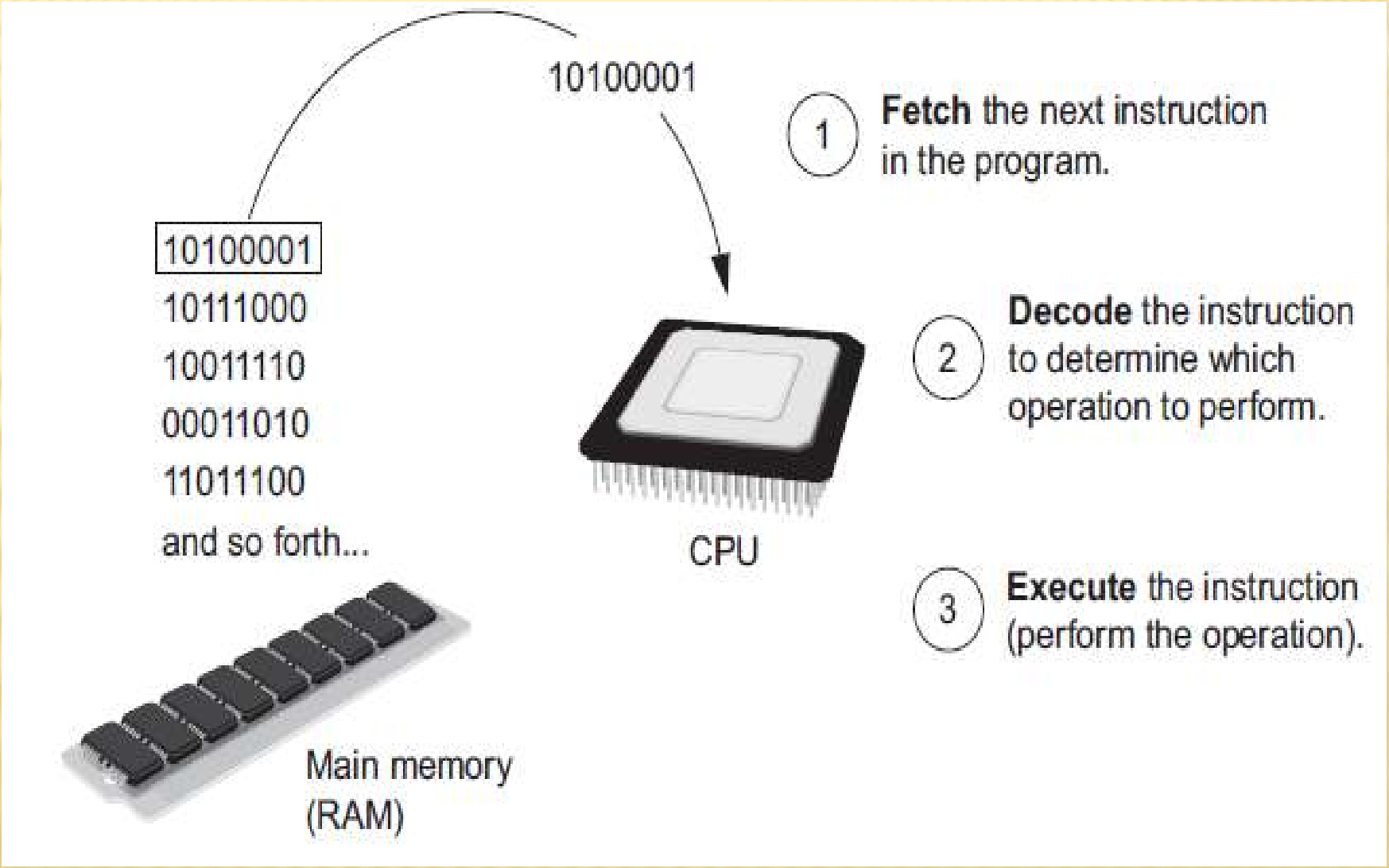
Memory Organization



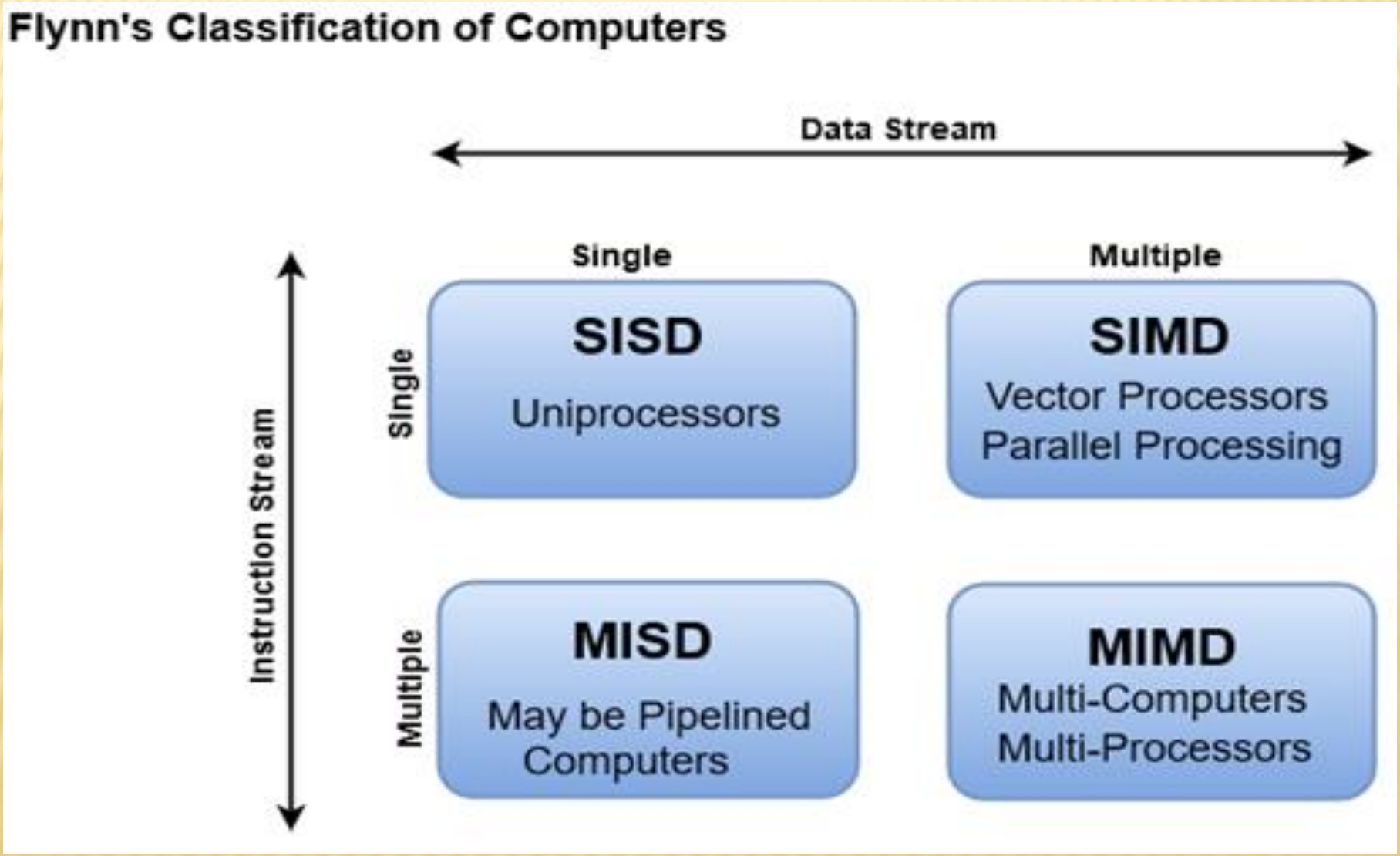
A program is copied in main memory and then executed



The fetch-decode-execute cycle



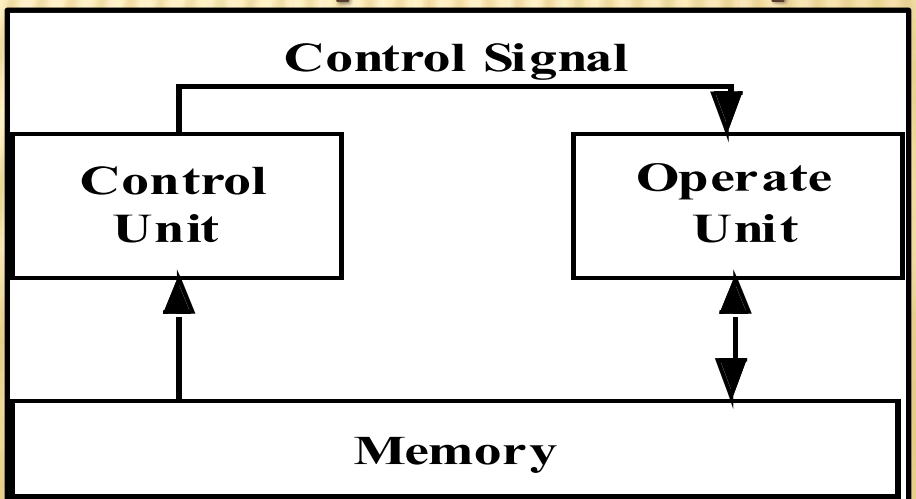
Flynn Taxonomy



Flynn's Classification of Computers

SISD Computer:

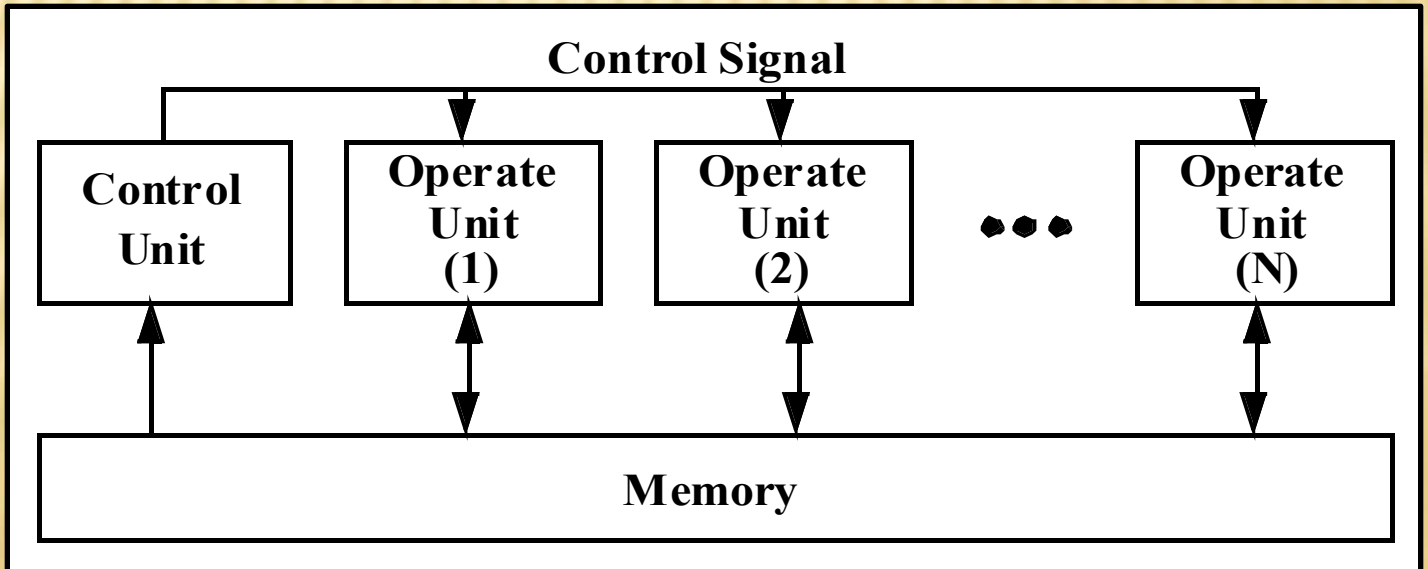
SISD stands for "Single Instruction and Single Data Stream". An SISD computing system is a uniprocessor machine capable of executing a single instruction, which operates on a single data stream. In SISD, machine instructions are processed sequentially; hence computers adopting this model are popularly called sequential computers.



Flynn's Classification of Computers

SIMD Computer:

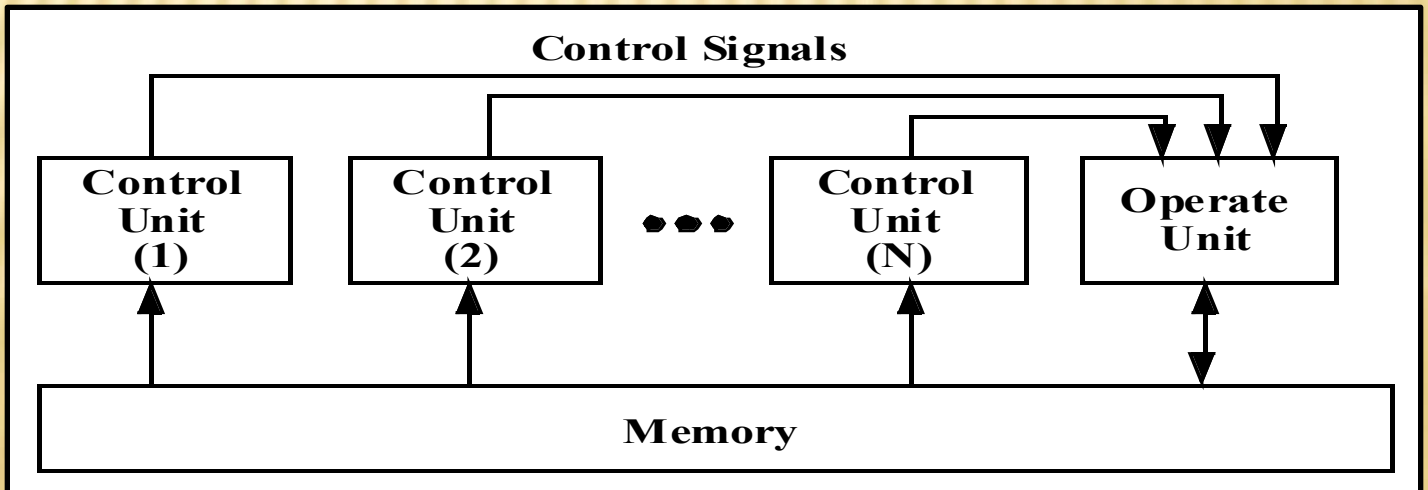
SIMD stands for 'Single Instruction and Multiple Data Stream'. It represents an organization that includes many processing units under the supervision of a common control unit. All processors receive the same instruction from the control unit but operate on different items of data.



Flynn's Classification of Computers

MISD Computer:

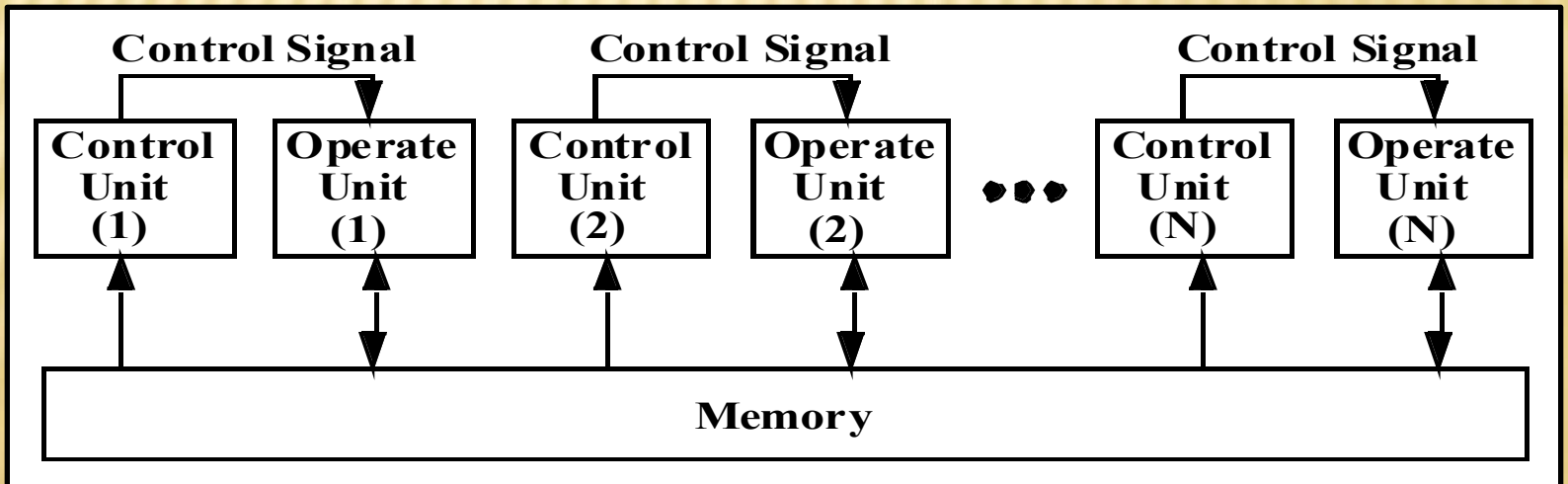
MISD stands for 'Multiple Instruction and Single Data stream'. MISD structure is only of theoretical interest since no practical system has been constructed using this organization. In MISD, multiple processing units operate on one single-data stream. Each processing unit operates on the data independently via separate instruction stream.



Flynn's Classification of Computers

MIMD Computer:

MIMD stands for 'Multiple Instruction and Multiple Data Stream'. In this organization, all processors in a parallel computer can execute different instructions and operate on various data at the same time. In MIMD, each processor has a separate program and an instruction stream is generated from each program.



Von-Neumann Model

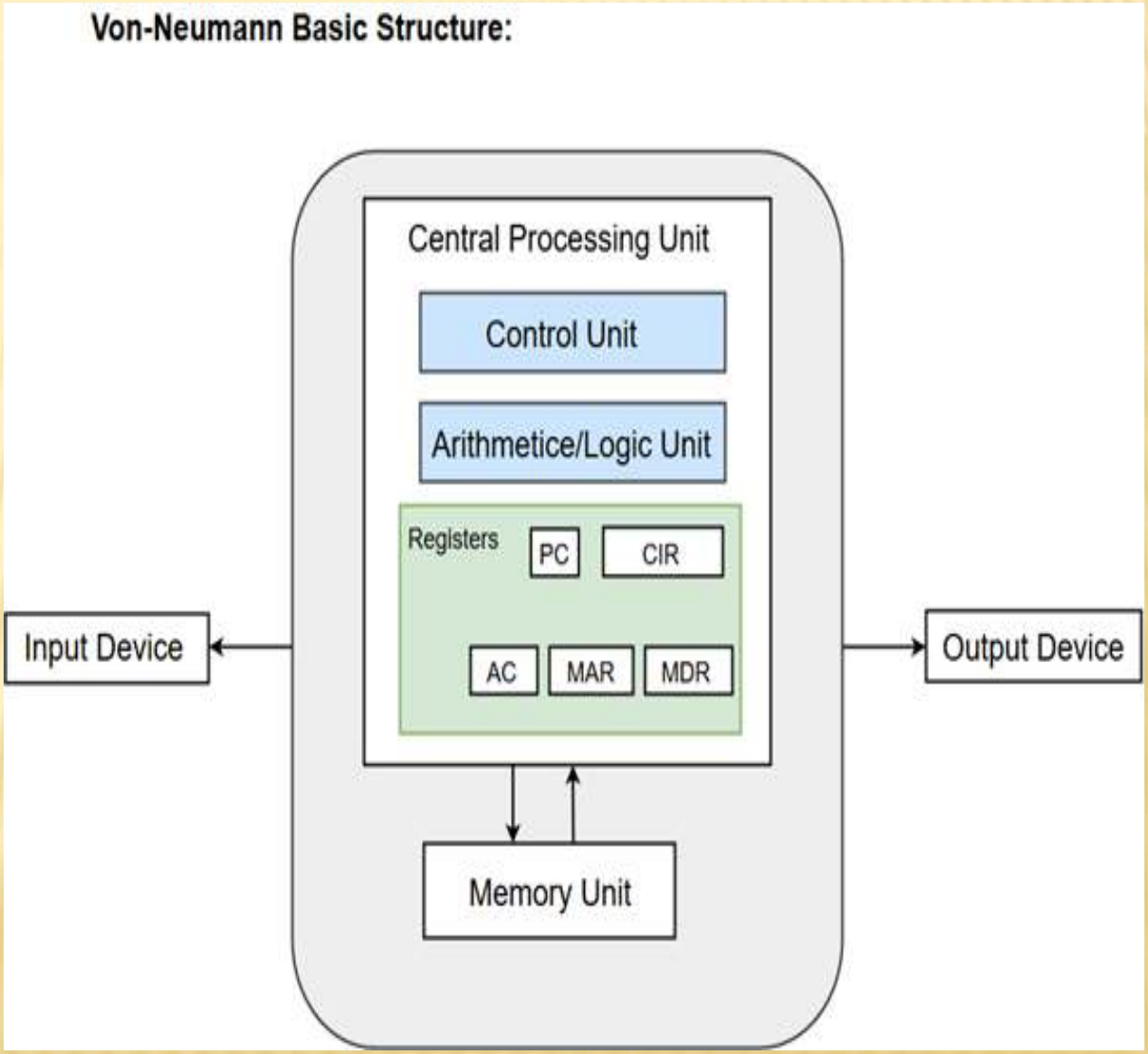
Von-Neumann Architecture:

Von-Neumann proposed his computer architecture design in 1945 which was later known as Von-Neumann Architecture. It consisted of a Control Unit, Arithmetic, and Logical Memory Unit (ALU), Registers and Inputs/Outputs. Von Neumann architecture is based on the stored-program computer concept, where instruction data and program data are stored in the same memory. This design is still used in most computers produced today.

Von-Neumann Model

A Von Neumann-based computer:

- Uses a single processor
- Uses one memory for both instructions and data.
- Executes programs following the fetch-decode-execute cycle



Computer architecture

Instruction Set Architecture (ISA):

The Instruction Set Architecture (ISA) is the part of the processor that is visible to the programmer or compiler writer. The ISA serves as the boundary between software and hardware.

Hardware Set Architecture (HAS):

The hardware set architecture is a view of the physical architecture, which represents the hardware components and their interrelationships.

RISC and CISC Processors

RISC Processor:

It is known as Reduced Instruction Set Computer. **It is a type of microprocessor that has a limited number of instructions. They can execute their instructions very fast because instructions are very small and simple. RISC chips require fewer transistors which make them cheaper to design and produce.**

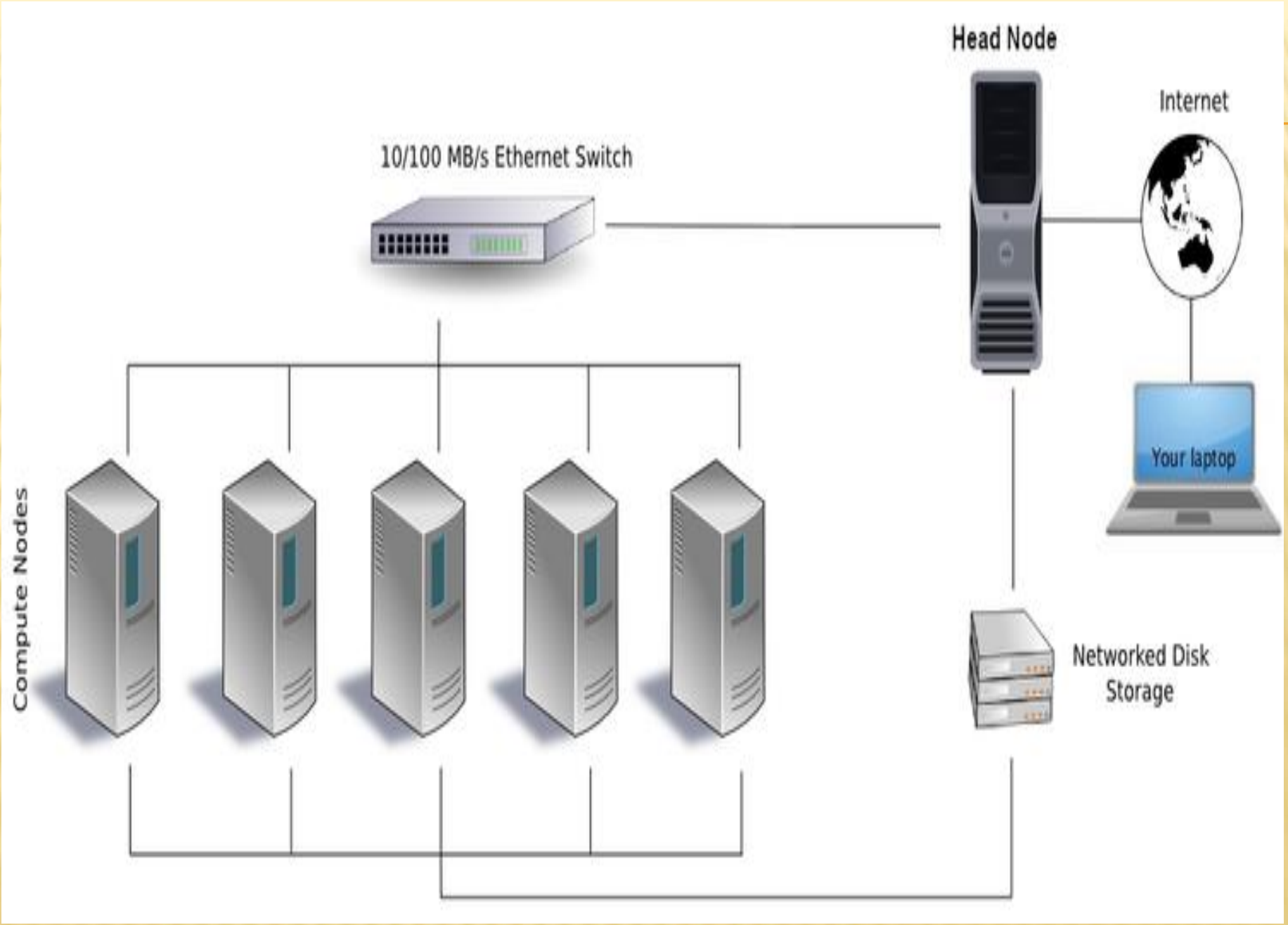
CISC Processor:

It is known as Complex Instruction Set Computer. **It contains large number of complex instructions.**

Computer Cluster

In simple terms, a computer cluster is a set of computers (nodes) that work together as a single system. **We can use clusters to enhance the processing power. In order to work correctly, a cluster needs management nodes that will:**

- coordinate the load sharing
- detect node failure and schedule its replacement


Head Node
Internet
10/100 MB/s Ethernet Switch
Your laptop
Compute Nodes
Networked Disk
Storage

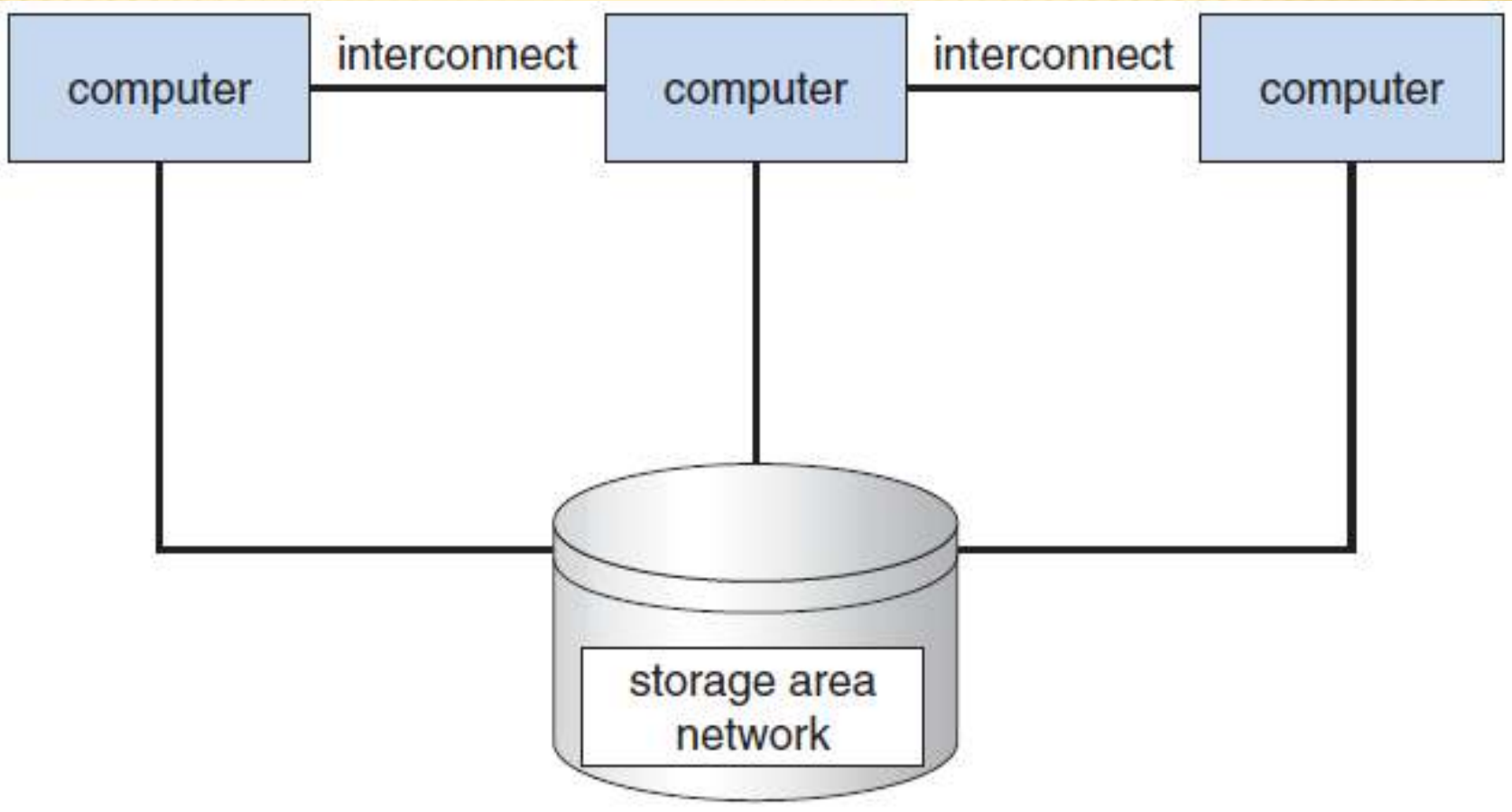
Beowulf Cluster

A Beowulf cluster is a computer cluster of what are normally identical, commodity-grade computers networked into a small local area network with libraries and programs installed which allow processing to be shared among them. The result is a high-performance parallel computing cluster from inexpensive personal computer hardware.

Beowulf Cluster

Computer-System Architecture

- Clustered Systems



General structure of a clustered system.

Programs

System Programs: System program is the type of software which is the interface between application software and system. System Software maintain the system resources and give the path for application software to run. An important thing is that without system software, system can not run. It is a general purpose software.

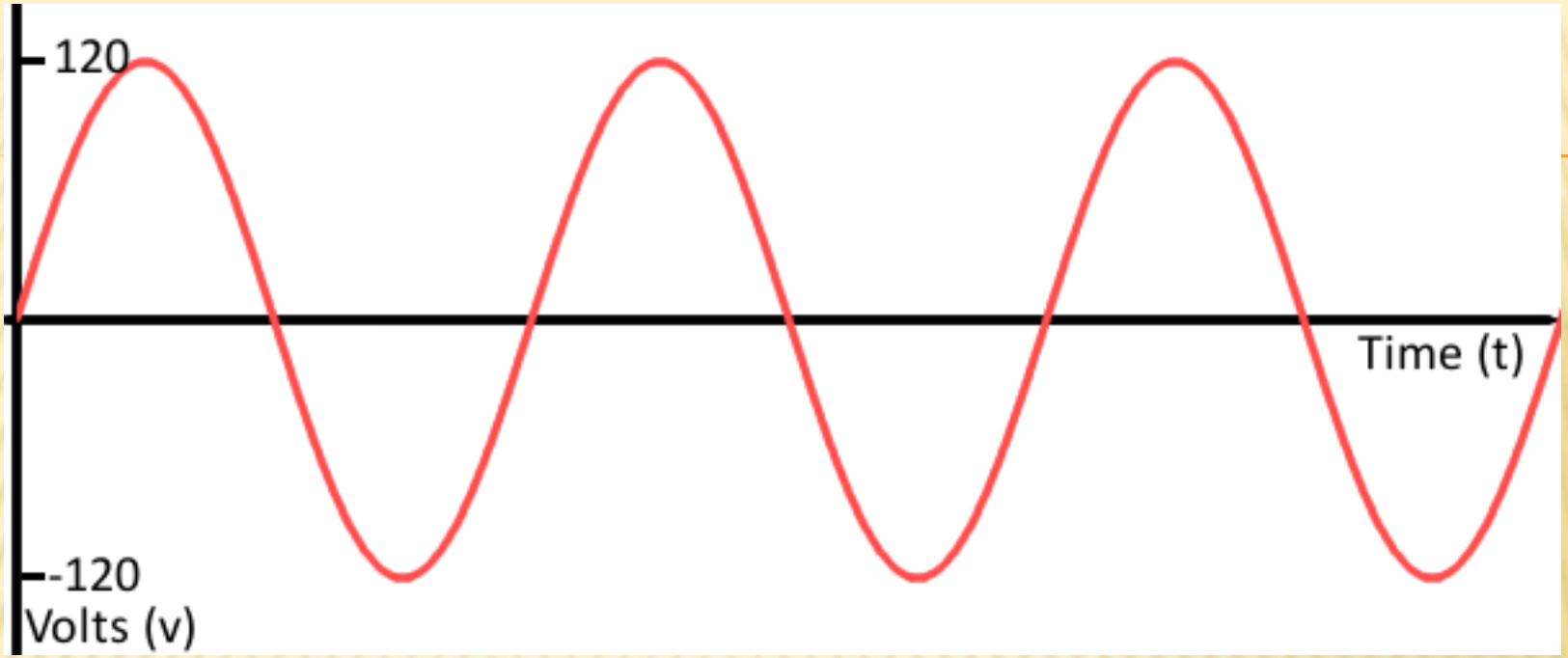
Application Programs: Application Program is the type of software which runs as per user request. It runs on the platform which is provide by system software. High level languages are used to write the application programs.

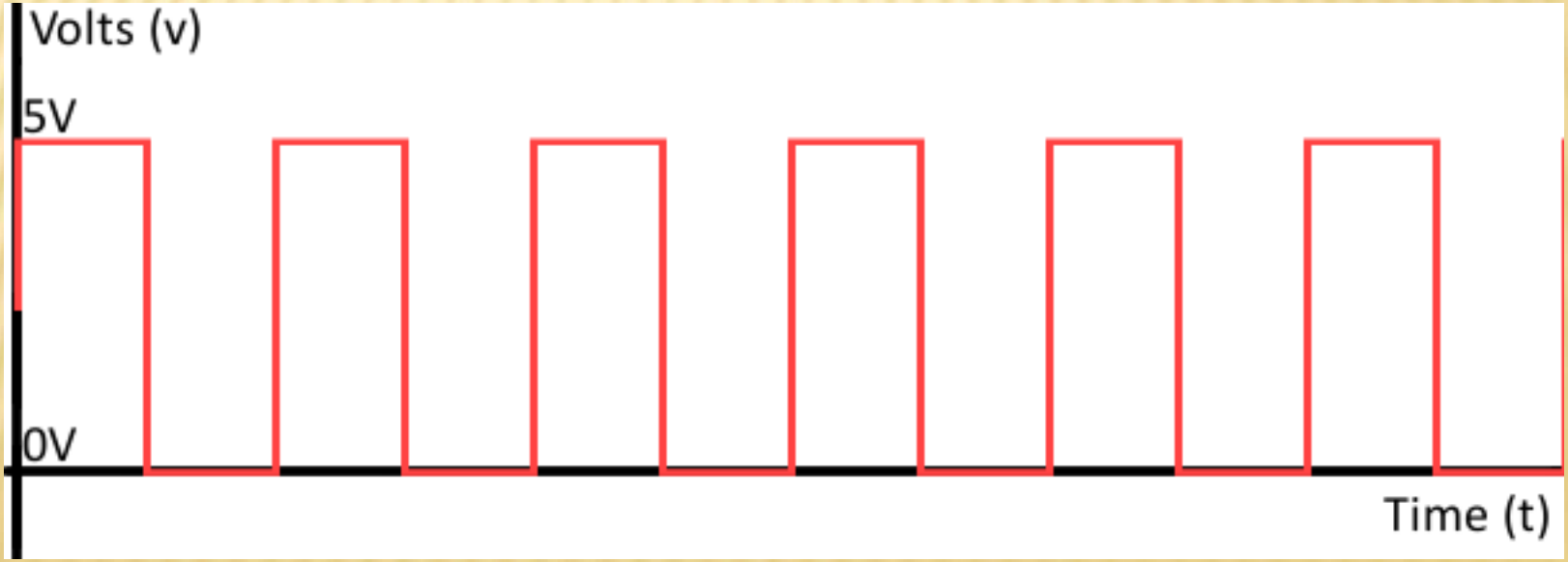
The main difference between System Program and Application Program is that without system program, system can not run on the other hand without application Program, system always runs.

The Language of the Computer

When you press A on your keyboard, the computer displays A on the screen. But what is actually stored inside the computer's main memory? What is the language of the computer? How does it store whatever you type on the keyboard?

Remember that a computer is an electronic device. Electrical signals are used inside the computer to process information. There are two types of electrical signals: analog and digital. Analog signals are continuously varying continuous wave forms used to represent such things as sound. Audio tapes, for example, store data in analog signals. Digital signals represent information with a sequence of 0's and 1's. A 0 represents a low voltage, and a 1 represents a high voltage.


120
-120
Volts (v)
Time (t)


Volts (v)
5V
0V
Time (t)

The Language of the Computer

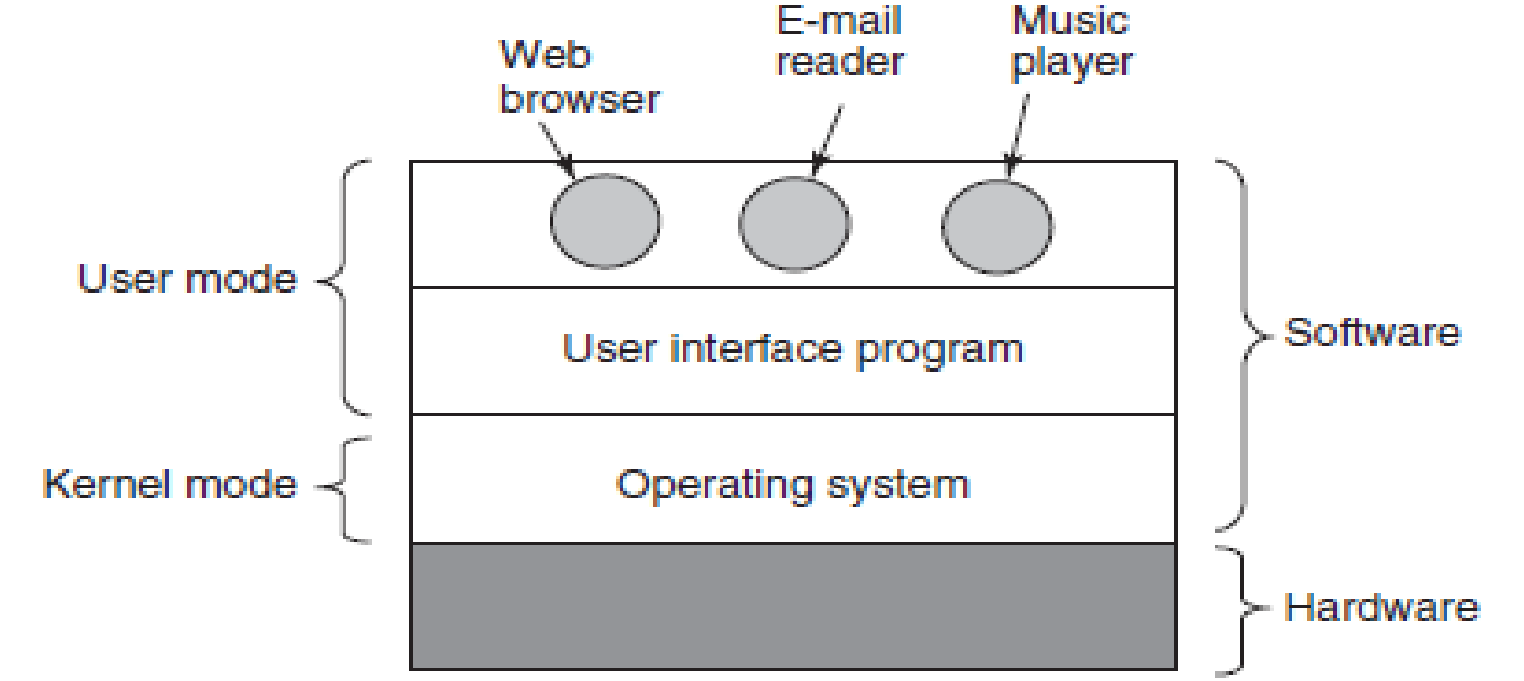
Because digital signals are processed inside a computer, the language of a computer, called machine language, is a sequence of 0's and 1's. The digit 0 or 1 is called a binary digit, or bit. Sometimes a sequence of 0's and 1's is referred to as a binary code or a binary number.

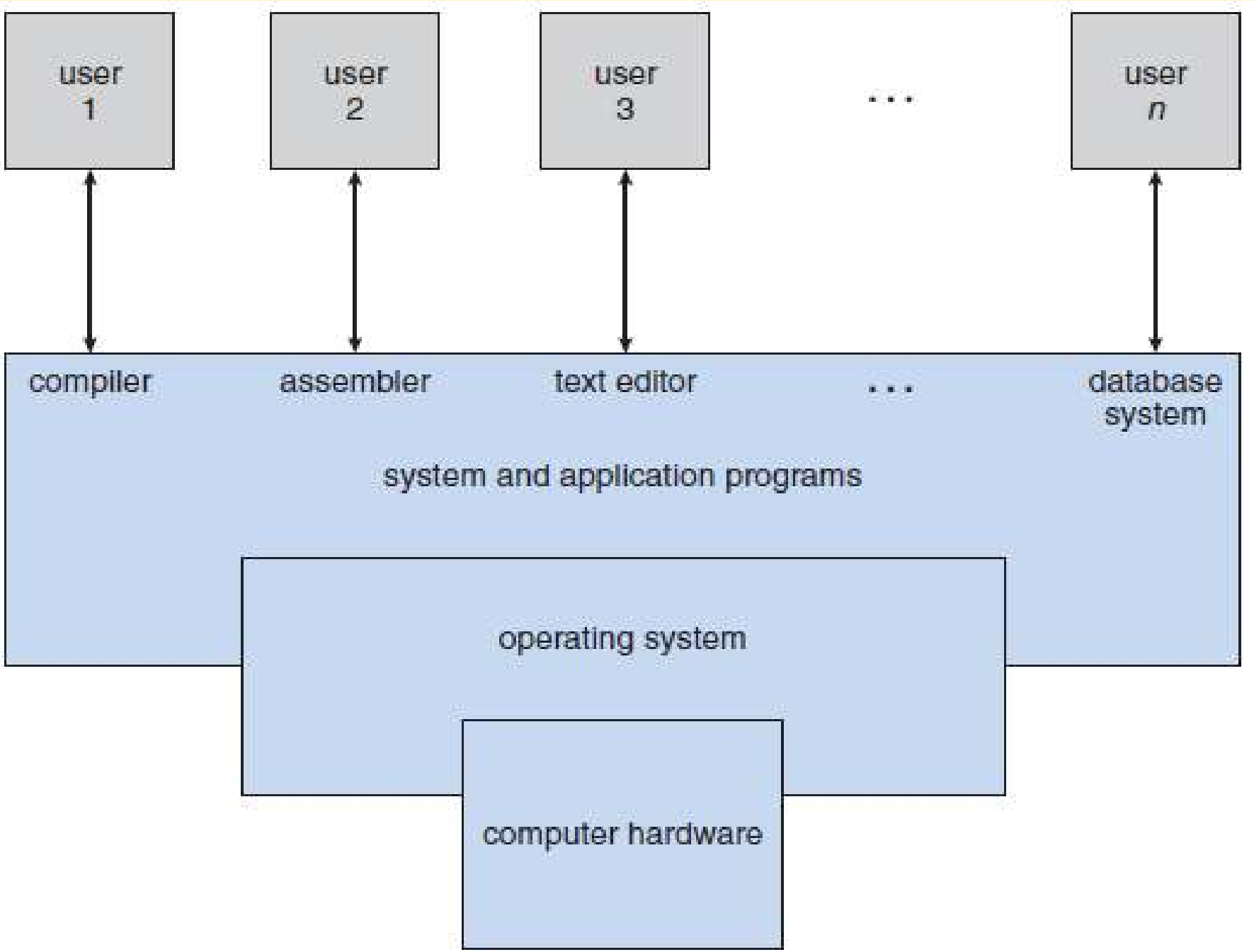
Bit: A binary digit 0 or 1.

A sequence of eight bits is called a Byte. Moreover, 1 KB = 1024 byte is called a kilobyte.

Introducing Operating Systems

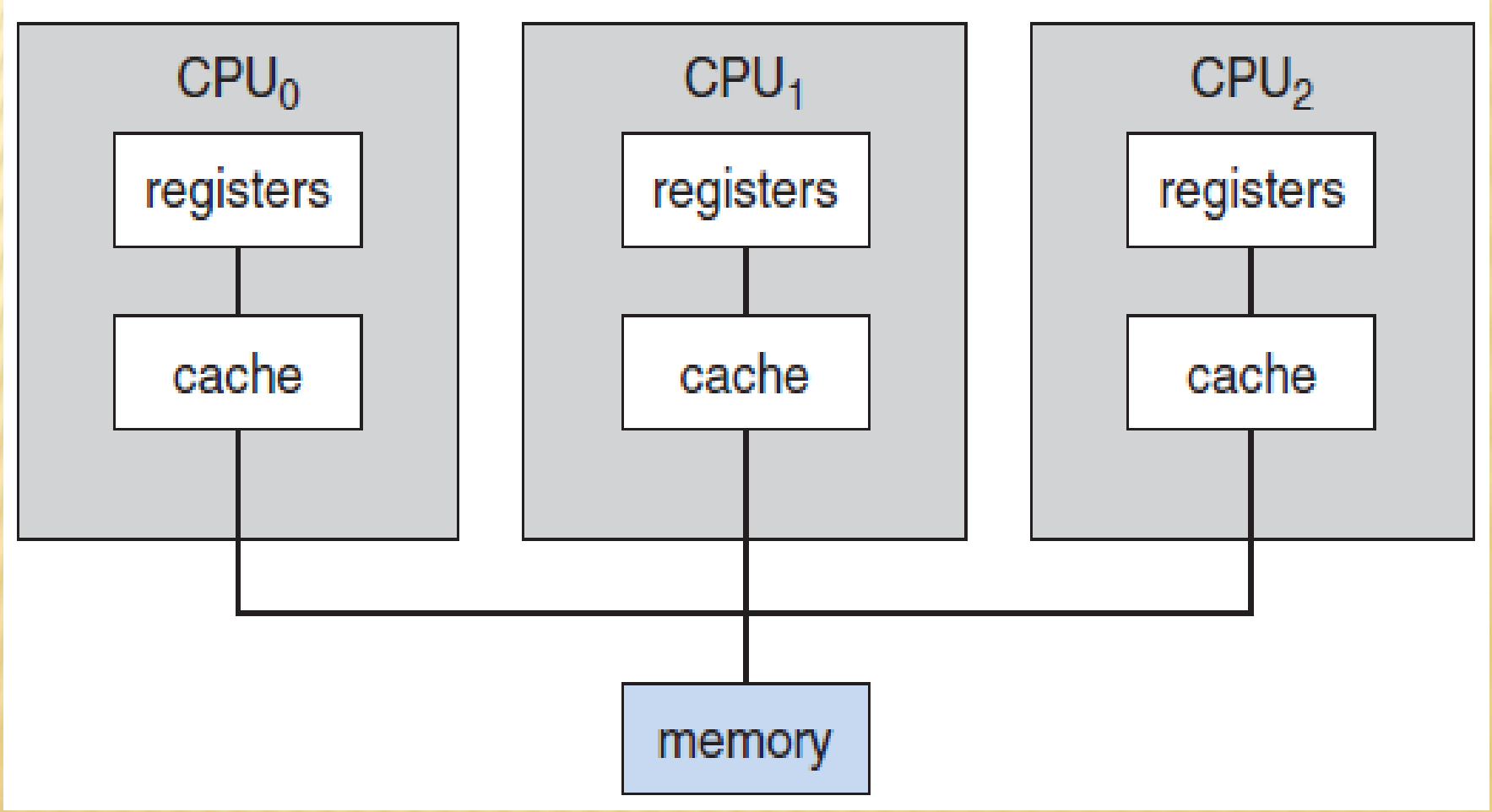
A simple overview of the main components of computer system is given in Figure. Here we see the hardware at the bottom. The hardware consists of chips, boards, disks, a keyboard, a monitor, and similar physical objects. On top of the hardware is the software.




user 1
user 2
user 3
...
user n
compiler
assembler
text editor
...
database system
system and application programs
operating system
computer hardware

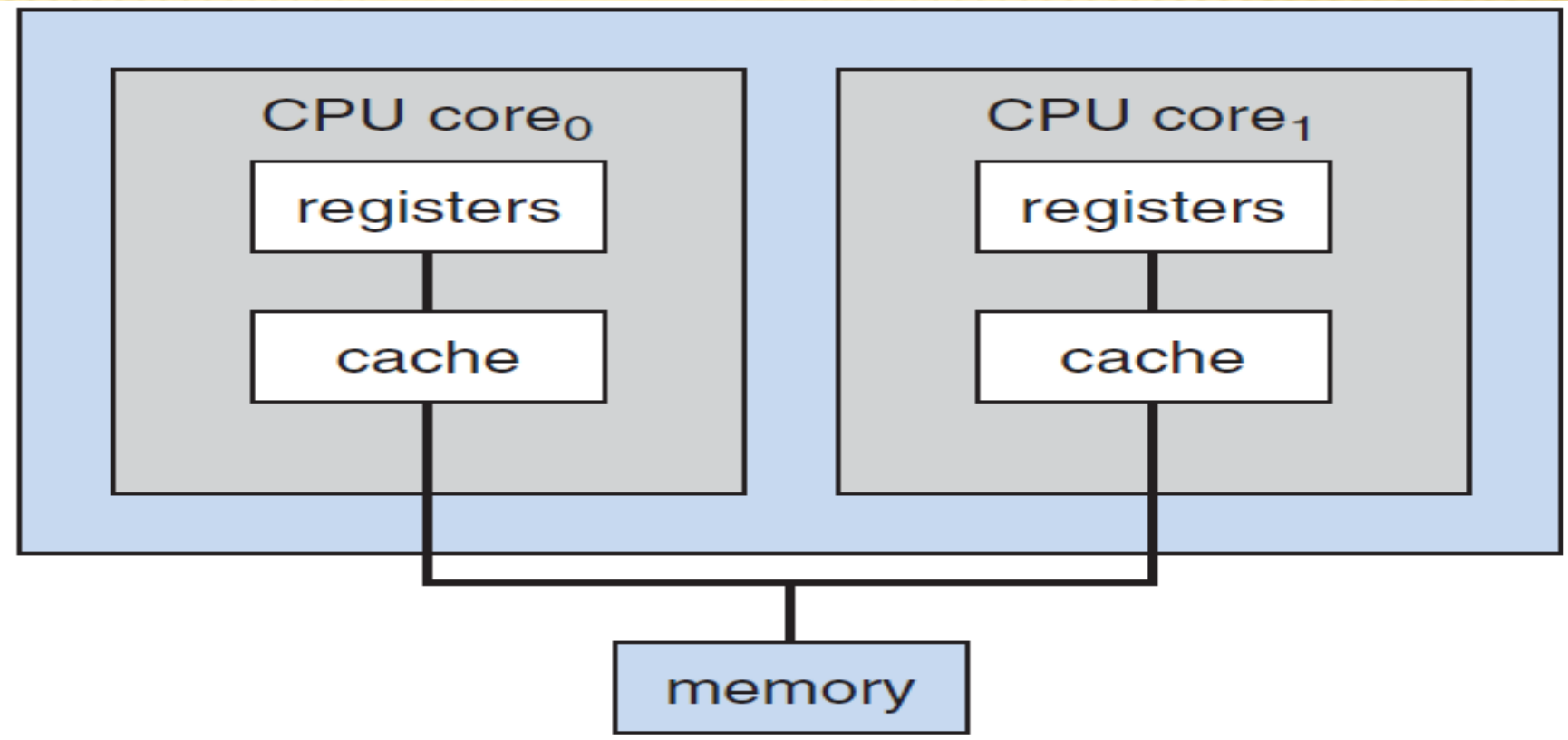
Computer-System Architecture

- Multiprocessor Systems



Computer-System Architecture

- Single-Processor Systems



A dual-core design with two cores placed on the same chip.

Computing Environments

- Traditional Computing

At home, most users once had a single computer with a slow modem connection to the office. Today, network-connection speeds once available only at great cost are relatively inexpensive in many places, giving home users more access to more data. These fast data connections are allowing home computers to serve up Web pages and to run networks that include printers, client PCs, and servers.

Computing Environments

- Mobile Computing

Mobile computing refers to computing on handheld smartphones and tablet computers. These devices share the distinguishing physical features of being portable and lightweight. Historically, compared with desktop and laptop computers, mobile systems gave up screen size, memory capacity, and overall functionality in return for handheld mobile access to services such as e-mail and web browsing.

Computing Environments

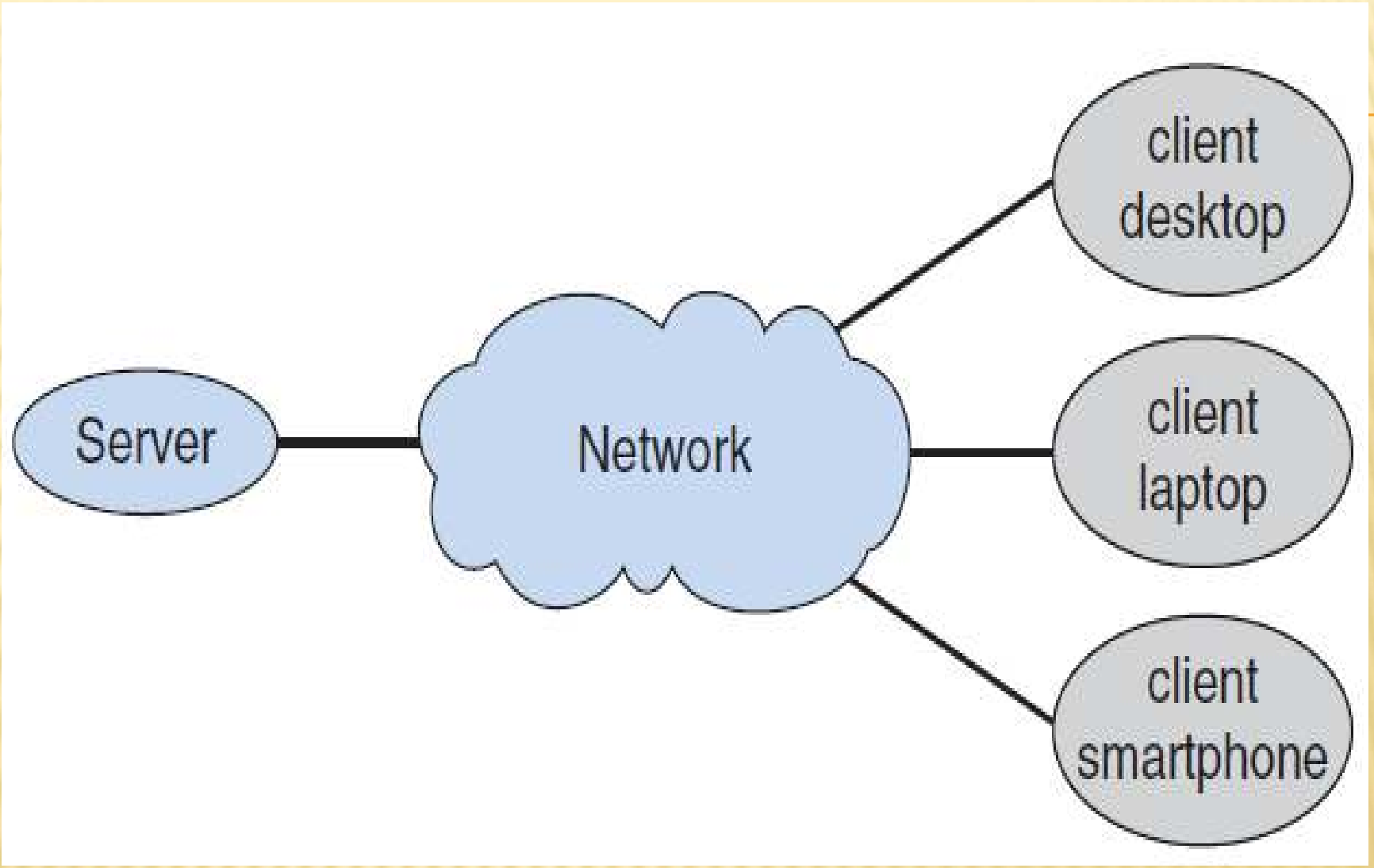
- Distributed Systems

A distributed system is a collection of physically separate, possibly heterogeneous, computer systems that are networked to provide users with access to the various resources that the system maintains. Access to a shared resource increases computation speed, functionality, data availability, and reliability.

Computing Environments

- Client–Server Computing

As PCs have become faster, more powerful, and cheaper, designers have shifted away from centralized system architecture. Terminals connected to centralized systems are now being supplanted by PCs and mobile devices. Correspondingly, user-interface functionality once handled directly by centralized systems is increasingly being handled by PCs, quite often through a web interface. As a result, many of today's systems act as server systems to satisfy requests generated by client systems.

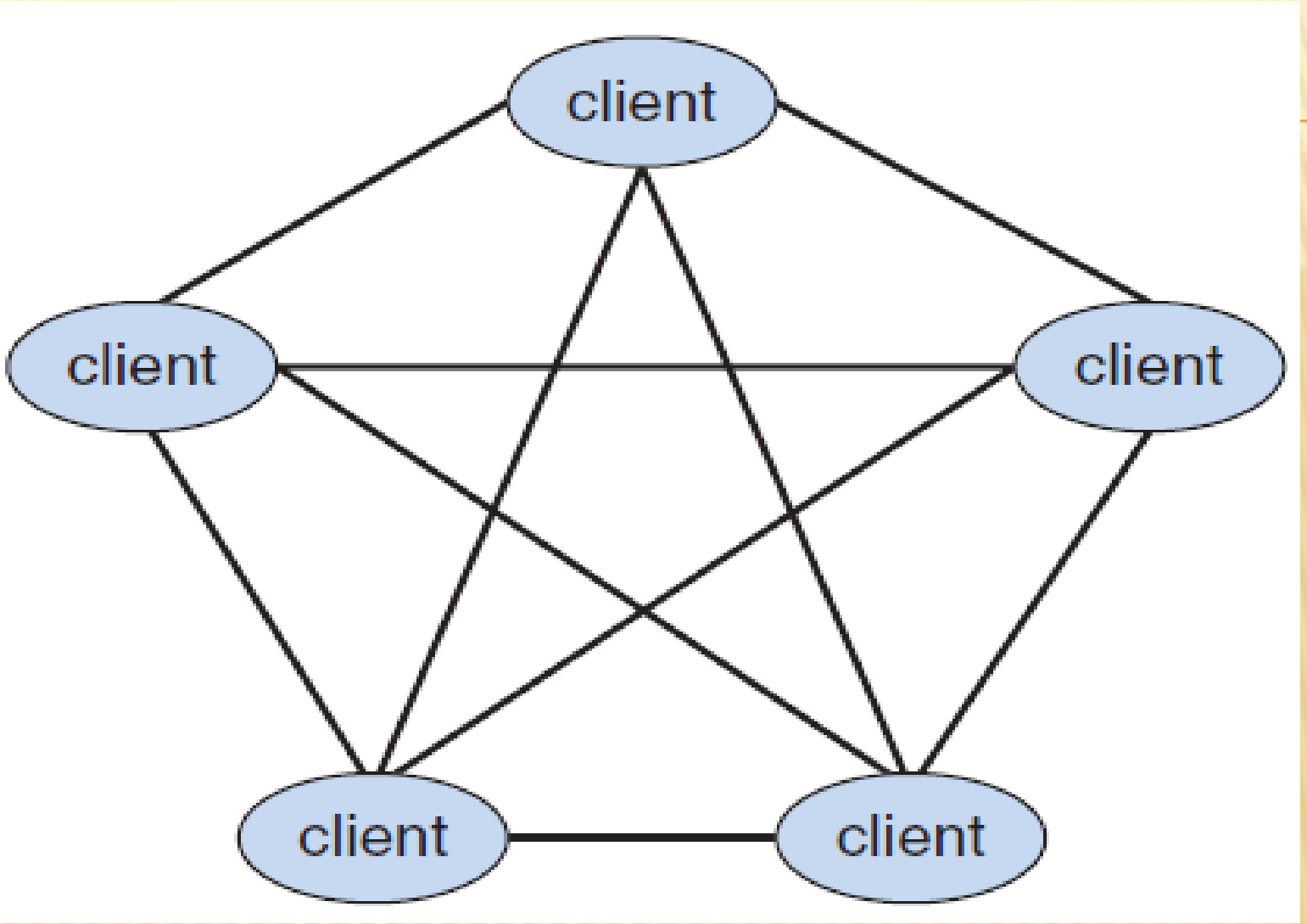


General structure of a client–server system

Computing Environments

- Peer-to-Peer Computing

Another structure for a distributed system is the peer-to-peer (P2P) system model. In this model, clients and servers are not distinguished from one another. Instead, all nodes within the system are considered peers, and each may act as either a client or a server, depending on whether it is requesting or providing a service. Peer-to-peer systems offer an advantage over traditional client-server systems. In a client-server system, the server is a bottleneck.

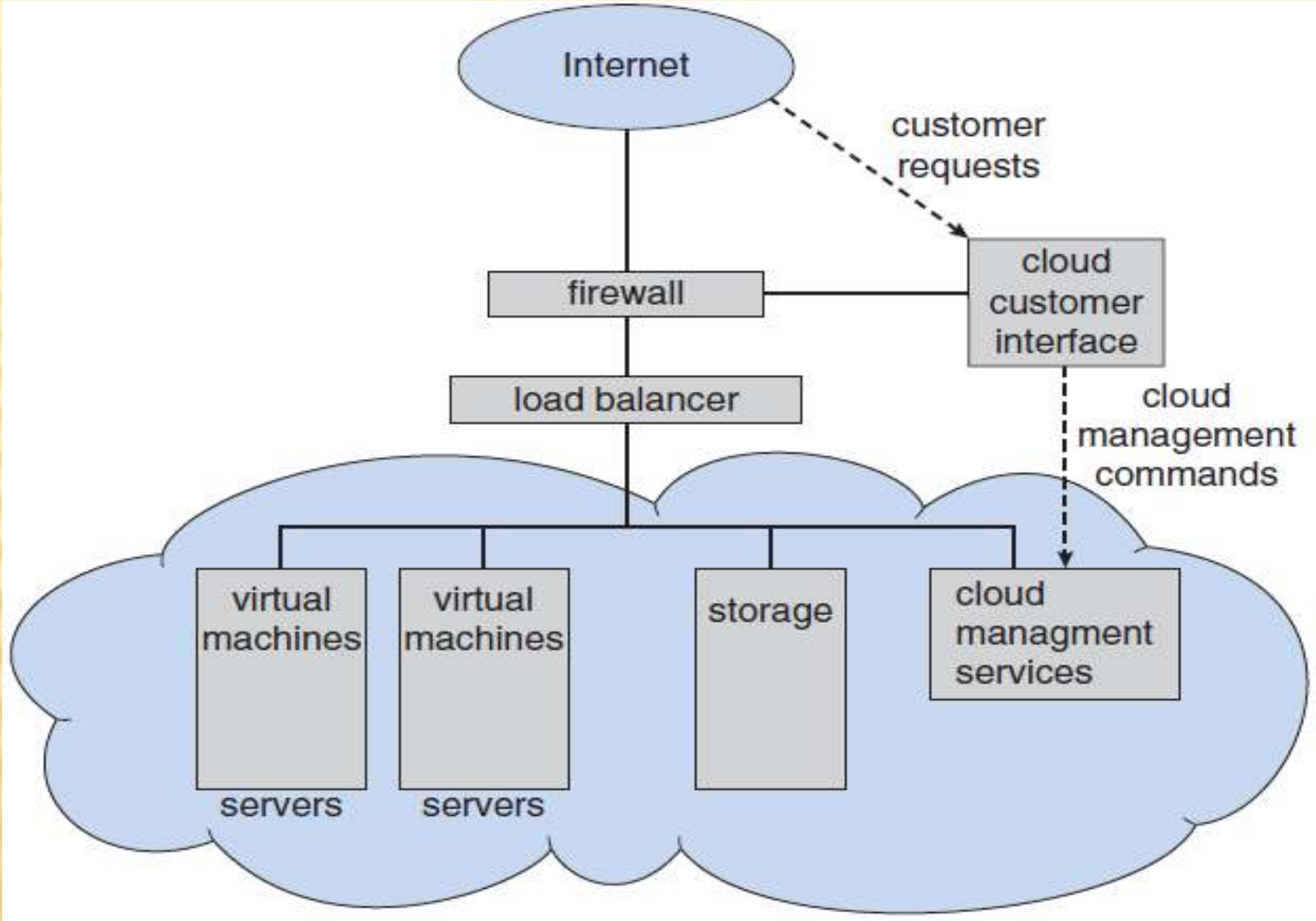


Peer-to-peer system with no centralized service

Computing Environments

- Cloud Computing

Cloud computing is a type of computing that delivers computing, storage, and even applications as a service across a network. For example, the Amazon Elastic Compute Cloud (EC2) facility has thousands of servers, millions of virtual machines, and petabytes of storage available for use by anyone on the Internet.



Cloud computing

Computing Environments

- Real-Time Embedded Systems

Embedded computers are the most prevalent form of computers in existence. These devices are found everywhere, from car engines and manufacturing robots to DVDs and microwave ovens. They tend to have very specific tasks. Usually, they have little or no user interface, preferring to spend their time monitoring and managing hardware devices, such as automobile engines and robotic arms.