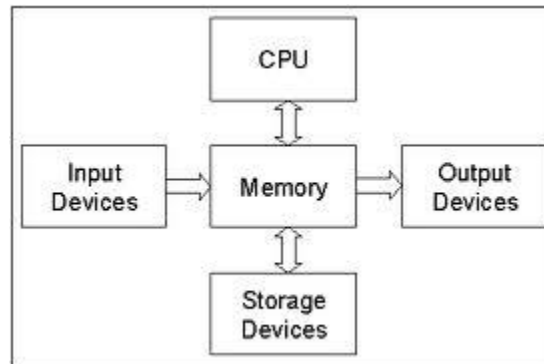


## Components of a Computer

The five classic components of a computer are briefly described below.  
The operation of the processor is best understood in terms of these components.



A computer system consists of both hardware and information stored on hardware. Information stored on computer hardware is often called *software*.

The **hardware** components of a computer system are the electronic and mechanical parts.

The **software** components of a computer system are the data and the computer programs.

The major hardware components of a computer system are:

- Processor(CPU)
- Main memory
- Secondary memory
- Input devices
- Output devices

For typical desktop computers, the processor, main memory, secondary memory, power supply, and supporting hardware are housed in a metal case. Many of the components are connected to the main circuit board of the computer, called the *motherboard*. The *power supply* supplies power for most of the components. Various input devices (such as the keyboard) and output devices (such as the monitor) are attached through connectors at the rear of the case.

The terms *input* and *output* say if data flow into or out of the computer. The picture shows the major hardware components of a computer system. The arrows show the direction of data flow.

A **bus** is a group of wires on the main circuit board of the computer. It is a pathway for data flowing between components. Most devices are connected to the bus through a **controller** which coordinates the activities of the device with the bus.

The **processor** is an electronic device about a one inch square, covered in plastic. Inside the square is an even smaller square of silicon containing millions of tiny electrical parts. A processor may contain 100 million transistors. It does the fundamental computing within the system, and directly or indirectly controls all the other components.

The processor is sometimes called the **Central Processing Unit** or **CPU**. A particular computer will have a particular type of processor, such as a Pentium chip or a SPARC chip.

## Memory

The processor performs all the fundamental computation of the computer system. Other components contribute to the computation by doing such things as storing data or moving data into and out of the processor. But the processor is where the fundamental action takes place.

A processor chip has relatively little memory. It has only enough memory to hold a few instructions of a program and the data they process. Complete programs and data sets are held in memory external to the processor. This memory is of two fundamental types: main memory, and secondary memory.

Main memory is sometimes called **volatile** because it loses its information when power is removed. Secondary memory is usually nonvolatile because it retains its information when power is removed. (However, it needs power when information is stored into memory or retrieved from it.)

- **Main memory:**
  - closely connected to the processor.
  - stored data are quickly and easily changed.
  - holds the programs and data that the processor is actively working with.
  - interacts with the processor millions of times per second.

- needs constant electric power to keep its information.
- **Secondary memory:**
  - connected to main memory through the bus and a controller.
  - stored data are easily changed, but changes are slow compared to main memory.
  - used for long-term storage of programs and data.
  - before data and programs can be used, they must be copied from secondary memory into main memory.
  - does not need electric power to keep its information.

## **Main Memory**

Main memory is where programs and data are kept when the processor is actively using them. When programs and data become active, they are copied from secondary memory into main memory where the processor can interact with them. A copy remains in secondary memory.

Main memory is intimately connected to the processor, so moving instructions and data into and out of the processor is very fast. Main memory is sometimes called **RAM**. RAM stands for **Random Access Memory**. "Random" means that the memory cells can be accessed in any order.

When people say that a computer has "512 megabytes of RAM" they are talking about how big its main memory is. One megabyte of memory is enough to hold approximately one million ( $10^6$ ) characters of a word processing document. (There will be more about bytes and megabytes later on in these notes.)

Nothing permanent is kept in main memory. Sometimes data are placed in main memory for just a few seconds, only as long as they are needed.

## **Secondary Memory**

Secondary memory is where programs and data are kept on a long-term basis. Common secondary storage devices are the hard disk and optical disks.

- The hard disk has enormous storage capacity compared to main memory.
- The hard disk is usually contained inside the case of a computer.
- The hard disk is used for long-term storage of programs and data.
- Data and programs on the hard disk are organized into files.
- A **file** is a section of the disk that has a name.

A hard disk might have a storage capacity of 500 gigabytes (room for about  $500 \times 10^9$  characters). This is about 100 times the capacity of main memory. A hard disk is slow compared to main memory. If the disk were the only type of memory the computer system would slow down to a crawl. The reason for having two types of storage is this difference in speed and capacity.

Large blocks of data are copied from disk into main memory. The operation is slow, but lots of data is copied. Then the processor can quickly read and write small sections of that data in main memory. When it is done, a large block of data is written to disk.

Often, while the processor is computing with one block of data in main memory, the next block of data from disk is read into another section of main memory and made ready for the processor. One of the jobs of an operating system is to manage main storage and disks this way.

### **Primary memory**

- Fast
- Expensive
- Low capacity
- Works directly with the processor

### **Secondary memory**

- Slow
- Cheap
- Large capacity
- Not connected directly to the processor

## **Input and Output Devices**

Input and output devices allow the computer system to interact with the outside world by moving data *into* and *out of* the system. An *input device* is used to bring data into the system. Some input devices are:

- Keyboard
- Mouse
- Microphone
- Bar code reader
- Graphics tablet

An *output device* is used to send data out of the system. Some output devices are:

- Monitor
- Printer
- Speaker

A network interface acts as both input and output. Data flows from the network into the computer, and out of the computer into the network.

## **I/O**

Input/output devices are usually called I/O devices. They are directly connected to an electronic module attached to the motherboard called a **device controller**. For example, the speakers of a multimedia computer system are directly connected to a device controller called an audio card, which in turn is plugged into a bus on the motherboard.

Sometimes secondary memory devices like the hard disk are called I/O devices (because they move data in and out of main memory). What counts as an I/O device depends on context. To a user, an I/O device is something outside of the computer case. To a programmer, anything outside of the processor and main memory is an I/O device. To an engineer working on the design of a processor everything outside of the processor is an I/O device.

## **Software**

Computer software consists of both *programs* and *data*. Programs consist of instructions for the processor. Data can be any information that a program needs: character data, numerical data, image data, audio data, and countless other types. The distinction between programs and data is not as clear-cut as you might think, however.

**Fundamental Idea:** Both programs and data are saved in computer memory in the same way. The electronics of computer memory (both main memory and secondary memory) make no distinction between programs and data.

The insight that both programs and data can be saved using the same electronic methods is an important concept in computer science. Computer systems use memory for either programs or data, as needed.

## Types of Programs

There are two categories of programs. **Application** programs (usually called just "applications") are programs that people use to get their work done. Computers exist because people want to run these programs. **Systems** programs keep the hardware and software running together smoothly. The difference between "application program" and "system program" is fuzzy. Often it is more a matter of marketing than of logic.

The most important systems program is the **operating system**. The operating system is always present when a computer is running. It coordinates the operation of the other hardware and software components of the computer system. The operating system is responsible for starting up application programs, running them, and managing the resources that they need. When an application program is running, the operating system manages the details of the hardware for it. For example, when you type characters on the keyboard, the operating system determines which application program they are intended for and does the work of getting them there.

Some embedded systems do not use an operating system, but run their programs directly on the processor.

Modern operating systems for desktop computers come with a **user interface** that enables users to easily interact with application programs (and with the operating system itself) by using windows, buttons, menus, icons, the mouse, and the keyboard. Examples of operating systems are Unix, Linux, Windows XP, and System 10.

### Application Programs

- Word processors
- Game programs
- Spreadsheets
- Data base systems
- Graphics programs
- Web browsers

### Systems Programs

- Operating system
- Networking system
- Programming language software
- Web site server
- Data backup

## **Operating Systems**

An operating system is a complex program that keeps the hardware and software components of a computer system coordinated and functioning. It is like the owner of a small shop, who keeps everything in order by attending to customers, accepting deliveries, stocking the shelves, doing the bookkeeping, and so on. The shopkeeper must promptly attend to tasks as they arise. Without the shopkeeper the shop could not function.

Most computer systems can potentially run any of several operating systems. For example, most Pentium-based computers can run either Linux or a Windows operating systems. Usually only one operating system is installed on a computer system, although some computers have several. In any case, only one operating system at a time can be in control of the computer system. The computer user makes a choice when the computer is turned on, and that operating system remains in control until the computer is turned off.