

**Data Storage.**

Without a memory no information can be stored or retrieved in a computer. Computer memory has experienced a similar increase along a different dimension. While processing speed increases at the same rate that memory size increases, the gap between the speed of the processor and the speed of memory also increases.

As the gap between processor and memory speeds grows, architectural solutions help bridge the gap. A typical computer contains several types of memory, ranging from fast, expensive internal registers, to slow, inexpensive removable disks. The interplay between these different types of memory is exploited so that a computer behaves as if it has a single, large, fast memory, when in fact it contains a range of memory types that operate in a highly coordinated fashion.

**Memory Hierarchy**

Memory in a conventional digital computer is organized in a hierarchy as illustrated in Figure 5. At the top of the hierarchy are registers that are matched in speed to the CPU, but tend to be large and consume a significant amount of power. There are normally only a small number of registers in a processor, on the order of a few hundred or less. At the bottom of the hierarchy are secondary and off-line storage memories such as hard magnetic disks and magnetic tapes, in which the cost per stored bit is small in terms of money and electrical power, but the access time is very long when compared with registers. Between the

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registers and secondary storage are a number of other forms of memory that bridge the gap between the two.

Cache and main memory are built using solid-state semiconductor material. It is customary to call the fast memory level the **primary memory**. The solid-state memory is followed by larger, less expensive, and far slower magnetic memories that consist typically of the (hard) disk and the tape. It is customary to call the slower level the **secondary memory**. The objective behind designing a memory hierarchy is *to have a memory system that performs as if it consists entirely of the fastest unit and whose cost is dominated by the cost of the slowest unit*.

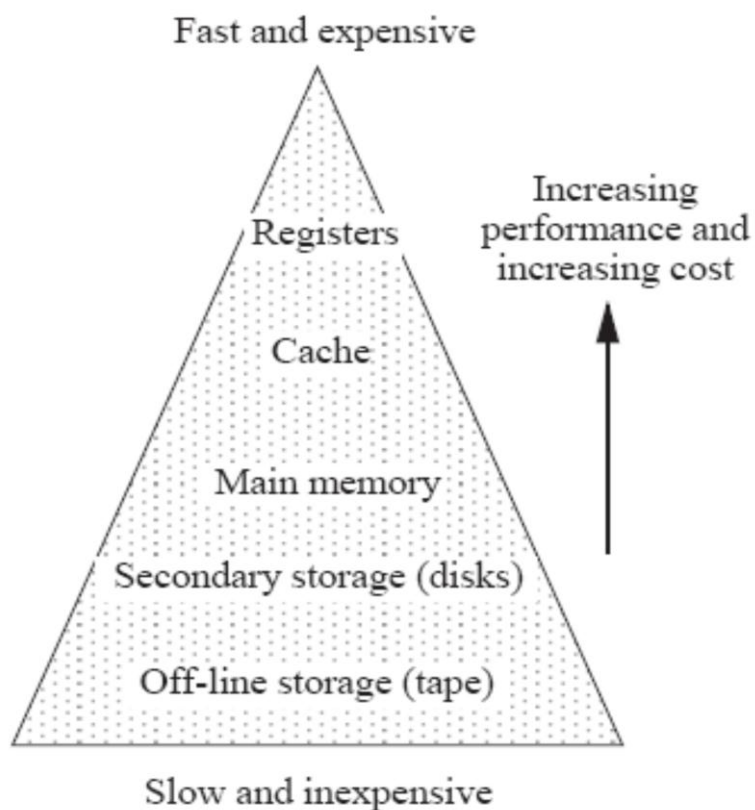


Figure 5: The memory hierarchy.

### External Storage:

External storage is normally the place where programs and data are stored when the power is turned off. This type of memory used for large-

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term memory storage than internal memory. The most common external storage devices are tape and disk devices.

External memory operates at *much slower speed than internal memory* and *it stores programs and data that are not currently being used by the CPU*. External storage is also known as **secondary storage** or **auxiliary storage**.

External storage devices can be classified either *mechanical* or *magnetic*:-

1. Mechanical storage devices: are punched paper card and punched paper tape. Both of these are less popular now than in the past.
2. Magnetic storage devices: This device store information as magnetic spots on oxide surfaces. It used now in the personal computer systems. Because the magnetic spots do not need a constant supply of power to “ **refresh** “ themselves ( as most RAM chips do ), external storage units provides *nonvolatile storage*. Also, *external storage is cheaper per unit of storage than the internal memory*.

The Three most common forms of magnetic media used on personal computer systems are **Magnetic tapes, floppy disks, and hard disks**. All of these can be *erased and rerecord again and again*.

As new information is written, it automatically covers-up whatever was there before. To avoid accident erasure, both cassette tapes and floppy disks can be *write-protected*. Tape recorders and floppy disk drives *will not write on write-protected media*. Most hard disks **cannot be write protected**.

The tape or disk drive reads and writes on tapes and disks by moving them past a **read/write head**. The head reads their magnetized

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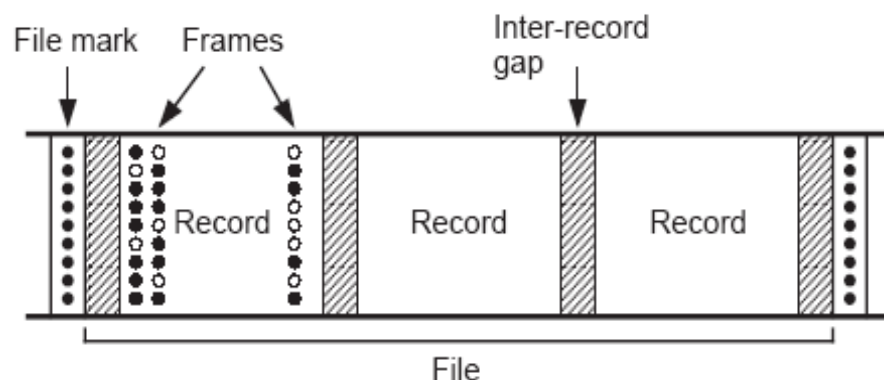
surfaces, converting the information into electrical impulses that it sends to the computer and vice versa.

### 1- Magnetic Tapes:

Magnetic tape has been widely used for many years as external storage. It is quite cheaper. A magnetic tape unit typically has a single read / write head, but may have separate heads for reading and writing. **The main disadvantage of Magnetic tape is that they are sequential access storage devices.** That is, to find information on the tape you must search through the tape sequentially. **Which means that to read the last item on a tape, you must *wind* the tape ( using Magnetic recorder ) past all the previous items.** The time it takes to begin reading the desired information from a storage device is called **the device's access-time**. A Magnetic tape recorder ***has poor access times*** because it can take several minutes to get to the right spot on the tape.

The rate at which data are read once an information transfer has begun is **the data transfer rate**. Standard Magnetic tape recorders have an effective data transfer rate between 300 and 1500 bits per second. For example, at a rate of 500 bits per second, it takes more than five minutes to load a 16k bits file into internal memory.

Information is stored on a tape in two-dimensional fashion, as shown in Figure 6.



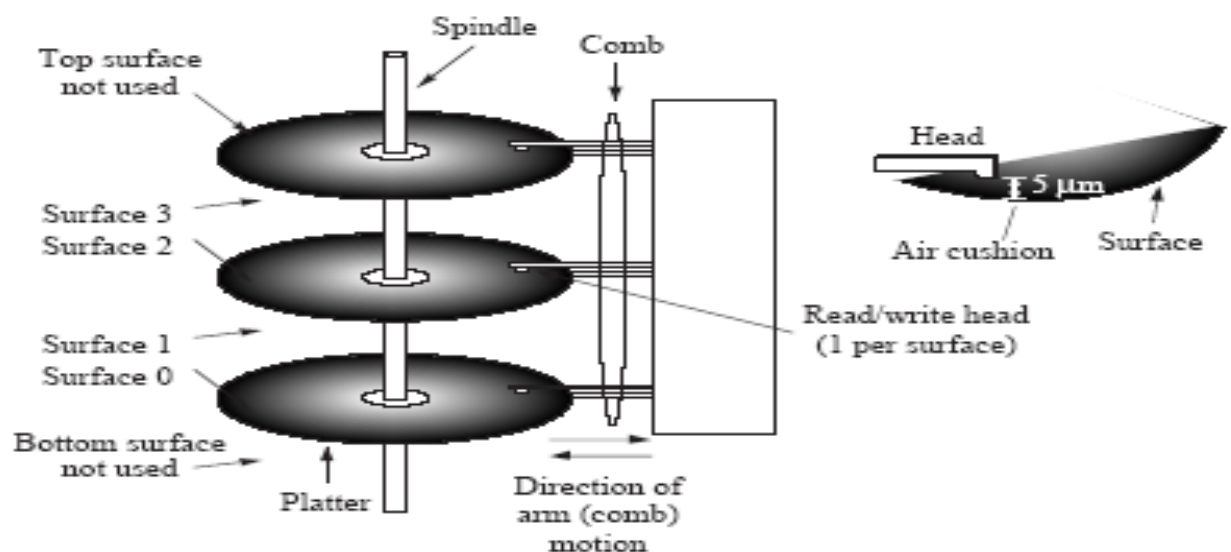
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Bits are stored across the width of the tape in **frames** and along the length of the tape in **records**. A file is made up of a collection of (typically contiguous) records. A record is the smallest amount of data that can be read from or written to a tape.

The combination of **sequential storage** and **slow data transfer** makes Magnetic tape *unsuitable* for most practical applications of PC.

## 2- Hard disks:

A hard disk is a device for storing information that supports a large storage density and a relatively fast access time. A **moving head** hard disk drive is composed of a stack of one or more **platters** that are spaced several millimeters apart and are connected to a **spindle**, as shown in Figure 7. Each platter has two **surfaces** made of aluminum or glass, which are coated with small particles of a magnetic material such as iron oxide, which is the essence of rust. This is why disk platters, floppy diskettes, audio tapes, and other magnetic media are brown. **Binary 1's and 0's are stored by magnetizing small areas of the material.**



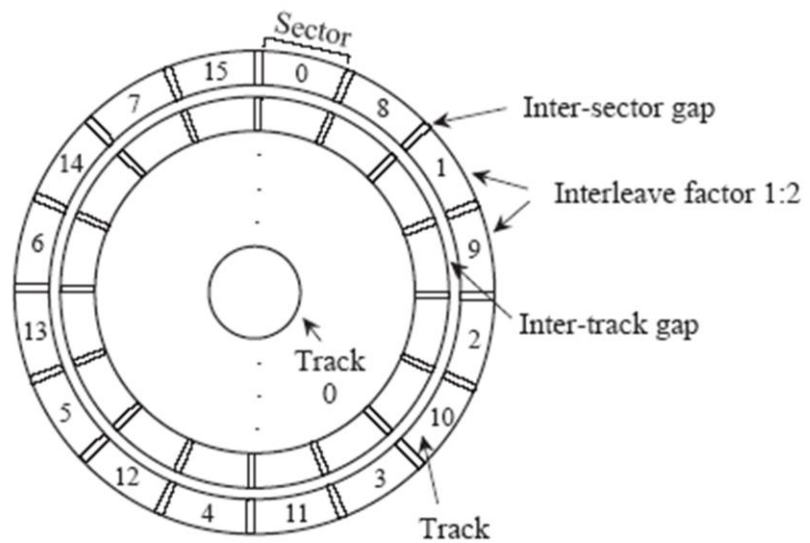
**Figure 5: A magnetic disk with three platters.**

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A single **head** is dedicated to each surface. Six heads are used in the example shown in Figure 7, for the six surfaces. The top surface of the top platter and the bottom surface of the bottom platter are sometimes not used on multi-platter disks because they are more susceptible to than the inner surfaces.

The heads are attached to a common **arm** (also known as a **comb**) which moves in and out to reach different portions of the surfaces. In a hard disk drive, the platters rotate at a constant speed of typically **3600 to 10,000 revolutions per minute (RPM)**. The heads read or write data by magnetizing the magnetic material as it passes under the heads when writing, or by sensing the magnetic fields when reading. Only a single head is used for reading or writing at any time, so data is stored in serial fashion even though the heads can in principle be used to read or write several bits in parallel. One reason that the parallel mode of operation is not normally used is that heads can become misaligned, which corrupts the way that data is read or written. A single surface is relatively insensitive to the alignment of the corresponding head because the head position is always accurately known with respect to reference markings on the disk.

A single surface contains several hundred concentric circles (called **tracks**) of data from the inside to the outside edge of the disk, which in turn are composed of **sectors** of typically 512 bytes in size, stored serially, as shown in Figure 8. Each sector is a pie-shaped wedge of one track. The sectors are spaced apart by **inter-sector gaps**, and the tracks are spaced apart by **inter-track gaps**, which simplify positioning of the head.

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**Figure 8: Organization of a disk with a 1:2 interleave factor.**

A set of corresponding tracks on all of the surfaces forms a **cylinder**. For instance, track 0 on each of surfaces 0, 1, 2, 3, 4, and 5 in Figure 7 collectively form cylinder 0. The number of bytes per sector is generally invariant across the entire platter.

**Disk drive capacities and speeds:**

If a disk has only a single zone, its storage capacity,  $C$ , can be computed from the number of bytes per sector,  $N$ , the number of sectors per track,  $S$ , the number of tracks per surface,  $T$ , and the number of platter surfaces that have data encoded in them,  $P$ , with the formula:

$$C = N * S * T * P.$$

A high-capacity disk drive may have  $N = 512$  bytes,  $S = 1,000$  sectors per track,  $T = 5,000$  tracks per surface, and  $P = 8$  platters. The total capacity of this drive is  $C = 512 \text{ bytes/sector} * 1000 \text{ sectors/track} * 5000 \text{ tracks/surface} * 8 \text{ platters} * 2 \text{ surfaces/platter}$  or 38 GB.

Maximum data transfer speed is governed by three factors: the time to move the head to the desired track, referred to as the head **seek time**, the time for the desired sector to appear under the read/write head, known as the **rotational latency**, and the time to transfer the sector from the disk

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platter once the sector is positioned under the head, known as the **transfer time**. Transfers to and from a disk are always carried out in complete sectors. Partial sectors are never read or written. A sector is the smallest unit of information sent between the disk drive and the CPU.

**3- Floppy disks:**

Unlike Magnetic tape devices, **floppy disk systems are random access storage devices**, their read/write heads can move in and out to quickly access information on any part of the disk. The disk drive is the unit that reads and writes on the floppy disk

A **floppy disk**, or **diskette**, contains a flexible plastic platter coated with a magnetic material like iron oxide. Although only a single side is used on one surface of a floppy disk in many systems, both sides of the disks are coated with the same material in order to prevent warping. Access time is generally slower than a hard disk because a flexible disk cannot spin as quickly as a hard disk. The rotational speed of a typical floppy disk mechanism is only **300 RPM**, and may be varied as the head moves from track to track to optimize data transfer rates. Such slow rotational speeds mean that access times of floppy drives are **250-300 ms**, roughly 10 times slower than hard drives. Capacities vary, but range up to **1.44 MB**.

Floppies are *inexpensive* because they can be removed from the drive mechanism and because of their small size. The head comes in physical contact with the floppy disk but this does not result in a head crash. It does, however, place wear on the head and on the media. For this reason, floppies only spin when they are being accessed.

The amount of information stored on floppy disk depends on **four factors**:

- 1) **The number of tracks.**

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- 2) **The number of sectors per track.**
- 3) **The number of bytes stored in each sector.** Double-density disks store twice as many bytes in the same size sector as single-density disks.
- 4) **Whether data is written on one or both sides of the disk, that is, whether storage is single or double sided.**