MODULE 5
FILE SYSTEMS

Storage Management: *Overview of mass storage structure - disks and tapes. Disk Structure – Accessing disks. Disk Scheduling and Management. Swap Space.*
File System Interface: *File Concepts – Attributes – operations – types – structure – access mthods. File System Mounting. Protection. File System Implementation. Directory Implementation – allocation methods. Free Space Management.*
Protection **-** *Goals, Principles, Domain. Access Matrix.*

STORAGE MANAGEMENT

1. *Overview of Mass-Storage Structure*

- **Magnetic Disks**

Magnetic disks provide the bulk of secondary storage for modern computer systems. Conceptually, disks are relatively simple (Figure 12.1). Each disk platter has a flat circular shape, like a CD. Common platter diameters range from 1.8 to 5.25 inches. The two surfaces of a platter are covered with a magnetic material. We store information by recording it magnetically on the platters. A read-write head "flies" just above each surface of every platter. The heads are attached to a **disk arm** that moves all the heads as a unit. The surface of a platter is logically divided into circular **tracks,** which are subdivided into **sectors.** The set of tracks that are at one arm position makes up a **cylinder.** There may be thousands of concentric cylinders in a disk drive, and each track may contain hundreds of sectors. The storage capacity of common disk drives is measured in gigabytes.

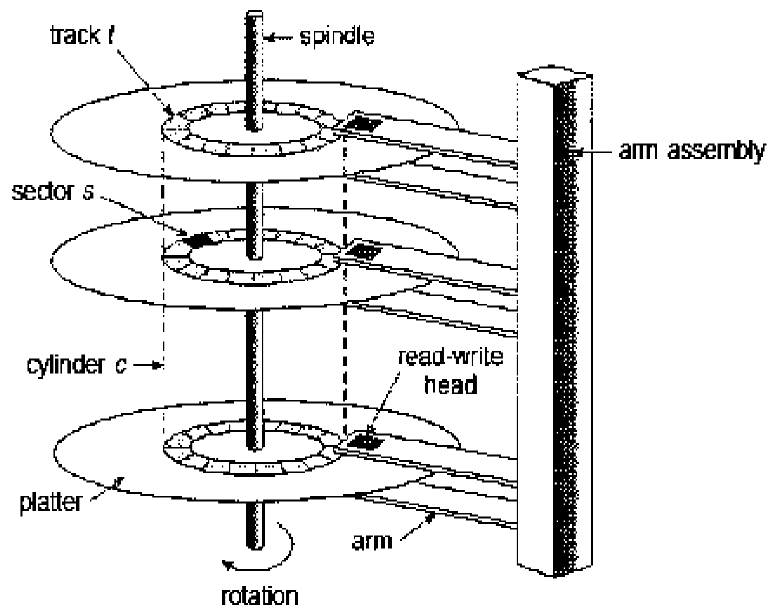

Figure 12.1 Moving-head disk mechanism.

When the disk is in use, a drive motor spins it at high speed. Most drives rotate 60 to 200 times per second. Disk speed has two parts. The **transfer rate** is the rate at which data flow between the drive and the computer. The **positioning time,** sometimes called the **random-access time,** consists of the time to move the disk arm to the desired cylinder, called the **seek time,** and the time for the desired sector to rotate to the disk head, called the **rotational**

latency. Typical disks can transfer several megabytes of data per second, and they have seek times and rotational latencies of several milliseconds. Because the disk head flies on an extremely thin cushion of air (measured in microns), there is a danger that the head will make contact with the disk surface. Although the disk platters are coated with a thin protective layer, sometimes the head will damage the magnetic surface. This accident is called a **head crash.** A head crash normally cannot be repaired; the entire disk must be replaced. A disk can be **removable,** allowing different disks to be mounted as needed. Removable magnetic disks generally consist of one platter, held in a plastic case to prevent damage while not in the disk drive.

Floppy disks are inexpensive removable magnetic disks that have a soft plastic case containing a flexible platter. The head of a floppy-disk drive generally sits directly on the disk surface, so the drive is designed to rotate more slowly than a hard-disk drive to reduce the wear on the disk surface. The storage capacity of a floppy disk is typically only 1.44 MB or so. Removable disks are available that work much like normal hard disks and have capacities measured in gigabytes.

A disk drive is attached to a computer by a set of wires called an I/O **bus.** Several kinds of buses are available, including **enhanced integrated drive electronics (EIDE), advanced technology attachment (ATA), serial ATA** (SATA), **universal serial bus (USB), fiber channel (FC),** and **SCSI** buses. The data transfers on a bus are carried out by special electronic processors called **controllers.** The **host controller** is the controller at the computer end of the bus. A **disk controller** is built into each disk drive. To perform a disk I/O operation, the computer places a command into the host controller, typically using memory-mapped I/O ports. The host controller then sends the command via messages to the disk controller, and the disk controller operates the disk-drive hardware to carry out the command. Disk controllers usually have a built-in cache. Data transfer at the disk drive happens between the cache and the disk surface, and data transfer to the host, at fast electronic speeds, occurs between the cache and the host controller.

- **Magnetic Tapes**

Magnetic tape was used as an early secondary-storage medium. Although it is relatively permanent and can hold large quantities of data, its access time is slow compared with that of main memory and magnetic disk. In addition, random access to magnetic tape is about a thousand times slower than random access to magnetic disk, so tapes are not very useful for secondary storage. Tapes are used mainly for backup, for storage of infrequently used information, and as a medium for transferring information from one system to another.

A tape is kept in a spool and is wound or rewound past a read-write head. Moving to the correct spot on a tape can take minutes, but once positioned, tape drives can write data at speeds comparable to disk drives. Tape capacities vary greatly, depending on the particular kind of tape drive. Typically, they store from 20 GB to 200 GB. Some have built-in compressions that can more than double the effective storage. Tapes and their drivers are usually categorized by width, including 4, 8, and 19 millimeters and 1/4 and 1/2 inch. Some are named according to technology, such as LTO-2 and SDLT.

2. ***Disk Structure***

Modern disk drives are addressed as large one-dimensional arrays of **logical blocks,** where the logical block is the smallest unit of transfer. The size of a logical block is usually 512 bytes, although some disks can be **low-level formatted** to have a different logical block size, such as 1,024 bytes. The one-dimensional array of logical blocks is mapped onto the sectors of the disk sequentially. Sector 0 is the first sector of the first track on the outermost cylinder. The mapping proceeds in order through that track, then through the rest of the tracks in that cylinder, and then through the rest of the cylinders from outermost to innermost. By using this mapping, we can—at least in theory—convert a logical block number into an old-style disk address that consists of a cylinder number, a track number within that cylinder, and a sector number within that track. In practice, it is difficult to perform, this translation, for two reasons. First, most disks have some defective sectors, but the mapping hides this by substituting spare sectors from elsewhere on the disk.

Second, the number of sectors per track is not a constant on some drives. On media that use **constant linear velocity** (CLV), the density of bits per track is uniform. The farther a track is from the center of the disk, the greater its length, so the more sectors it can hold. As we move from outer zones to inner zones, the number of sectors per track decreases. Tracks in the outermost zone typically hold 40 percent more sectors than do tracks in the innermost zone. The drive increases its rotation speed as the head moves from the outer to the inner tracks to keep the same rate of data moving under the head. This method is used in CD-ROM and DVD-ROM drives. Alternatively, the disk rotation speed can stay constant, and the density of bits decreases from inner tracks to outer tracks to keep the data rate constant. This method is used in hard disks and is known as **constant** angular **velocity (CAV).** The number of sectors per track has been increasing as disk technology improves, and the outer zone of a disk usually has several hundred sectors per track. Similarly, the number of cylinders per disk has been increasing; large disks have tens of thousands of cylinders.

- ***Disk scheduling***

Access time = Seek time + Rotational latency

Seek time: The seek time is the time for the disk arm to move the heads to the cylinder containing the desired sector.

Rotational latency: The rotational latency is the additional time for the disk to rotate the desired sector to the disk head.

The **disk bandwidth** is the total number of bytes transferred, divided by the total time between the first request for service and the completion of the last transfer. **We can improve**