External Memory

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Types of External Memory

A. Magnetic Disk
   - RAID
   - Removable

B. Optical
   - CD-ROM
   - CD-Recordable (CD-R)
   - CD-R/W
   - DVD

C. Magnetic Tape

Magnetic Disk

- Magnetic disks are the foundation of external memory on virtually all computer systems.
- Both removable and fixed, or hard, disks are used in systems ranging from personal computers to mainframes and supercomputers.
- A disk is a circular platter constructed of nonmagnetic material, called the *substrate*.
- Disk substrate is coated with magnetizable material (iron oxide…rust).
- Substrate is used to be aluminium or aluminum alloy material.
- More recently, glass substrates have been introduced.
- The glass substrate has a number of benefits, including the following:
  - Improved surface uniformity - Increases reliability
  - Reduction in surface defects - Reduced read/write errors
  - Lower flight heights
  - Better stiffness
  - Better shock/damage resistance

Read and Write Mechanisms

- Recording & retrieval of data via conductive coil called a *head*.
- May be single read/write head or separate ones.
- During read/write, head is stationary, platter rotates.
- Write Operation
  - Current through coil produces magnetic field
  - Pulses sent to head
  - Magnetic pattern recorded on surface below
- Read Operation (traditional)
  - Magnetic field moving relative to coil produces current
  - Coil is the same for read and write
- Read Operation (contemporary)
  - Separate read head, close to write head
  - Partially shielded magneto resistive (MR) sensor
  - Electrical resistance depends on direction of magnetic field
  - High frequency operation - Higher storage density and speed

Data Organization and Formatting

- The *head* is a relatively small device capable of reading from or writing to a portion of the platter rotating beneath it.
- This gives rise to the organization of data on the platter in a concentric set of rings, called **tracks**.
- Each track is the same width as the head.
- There are thousands of tracks per surface.
- Concentric rings or tracks
  - Maintain Gaps between tracks
  - Reduce gap to increase capacity
  - Same number of bits per track (variable packing density)
  - Constant angular velocity
- Tracks divided into sectors.
- Data are transferred to and from the disk in **sectors.**
- Typically hundreds of sectors per track, and these may be of either fixed or variable length.

Disk Data Layout

- Minimum block size is one sector.
- May have more than one sector per block.
- Fig. 1 describes the layout of Disk Data.

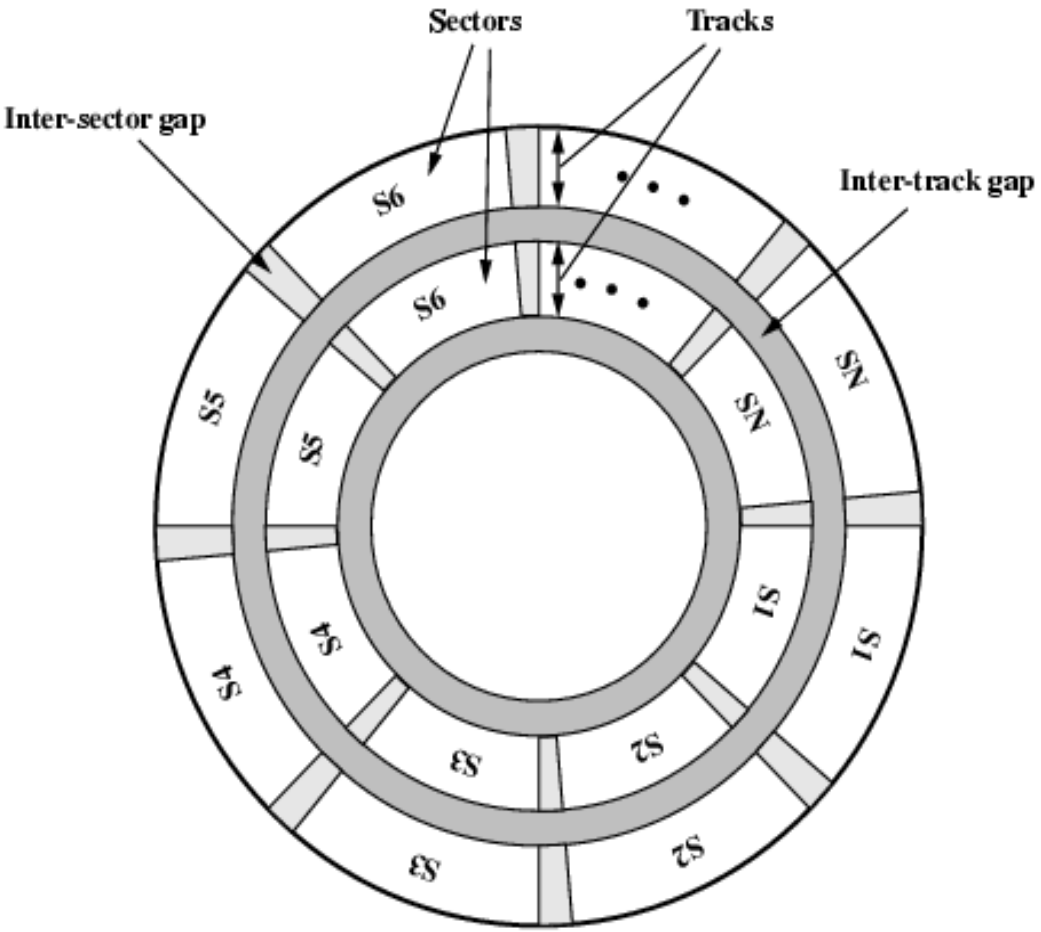


Fig. 1: Disk Data Layout

Disk Velocity

- Bit near centre of rotating disk passes fixed point slower than bit on outside of disk
- Increase spacing between bits in different tracks
- Rotating a disk at constant angular velocity is **constant angular velocity** (CAV)
  - Gives pie shaped sectors and concentric tracks
  - Individual tracks and sectors addressable
  - Move head to given track and wait for given sector
  - Waste of space on outer tracks - Lower data density
  - Fig. 2a shows the layout of a disk using CAV.
- To increase density, modern hard disk systems use a technique known as **multiple zone recording.(MZR).**

Disk Layout Methods Diagram

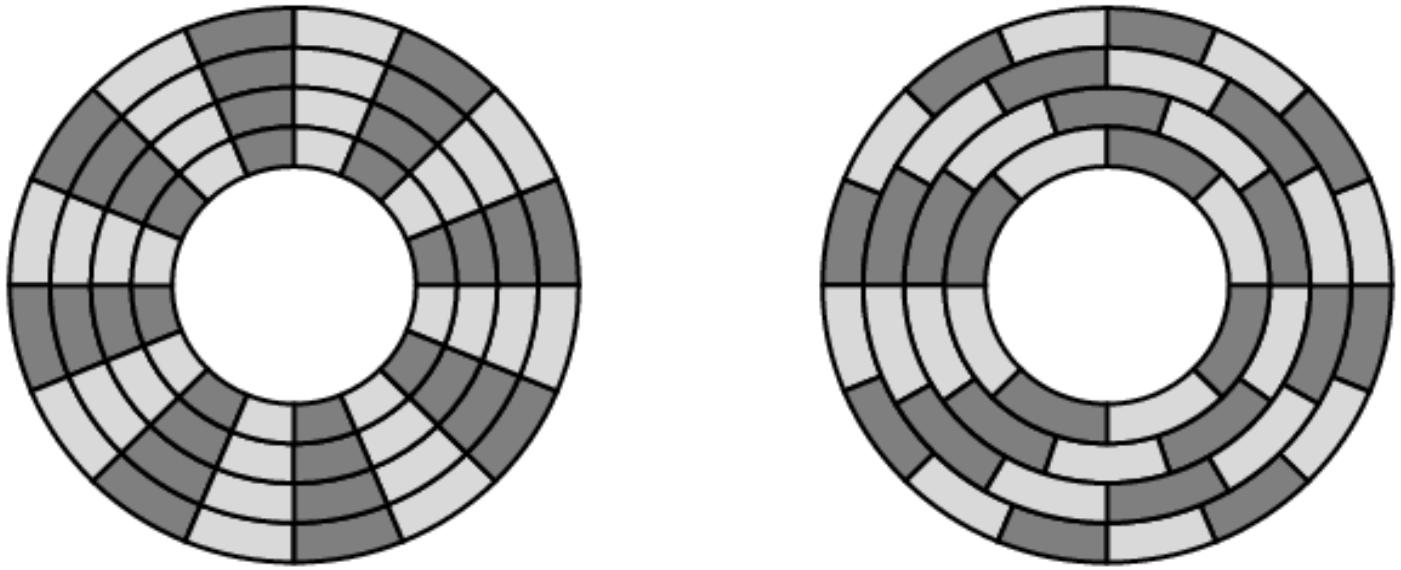


Fig. 2: Comparison of Disk Layout Methods

- MZR can use zones to increase capacity
  - Each zone has fixed bits per track
  - More complex circuitry
  - Fig. 2b shows the layout of a disk using MZR

Finding Sectors

- Must be able to identify start of track and sector
- Format disk
  - Additional information not available to user
  - Marks tracks and sectors

Physical Characteristics

- Following major characteristics differentiate among the various types of magnetic disks.

a) Head Motion - Fixed head (one per track) and Movable head (one per surface).

b) Disk Portability - Removable or fixed disk.

c) Sides - Single or double (usually) sided

d) Platters - Single or multiple platter

e) Head mechanism
   - Contact (Floppy)
   - Fixed gap
   - Flying or Aerodynamic gap (Winchester)

Fixed/Movable Head Disk

A. Fixed head
   - One read write head per track
   - Heads mounted on fixed ridged arm

B. Movable head
   - One read write head per side
   - Mounted on a movable arm

Removable or Not

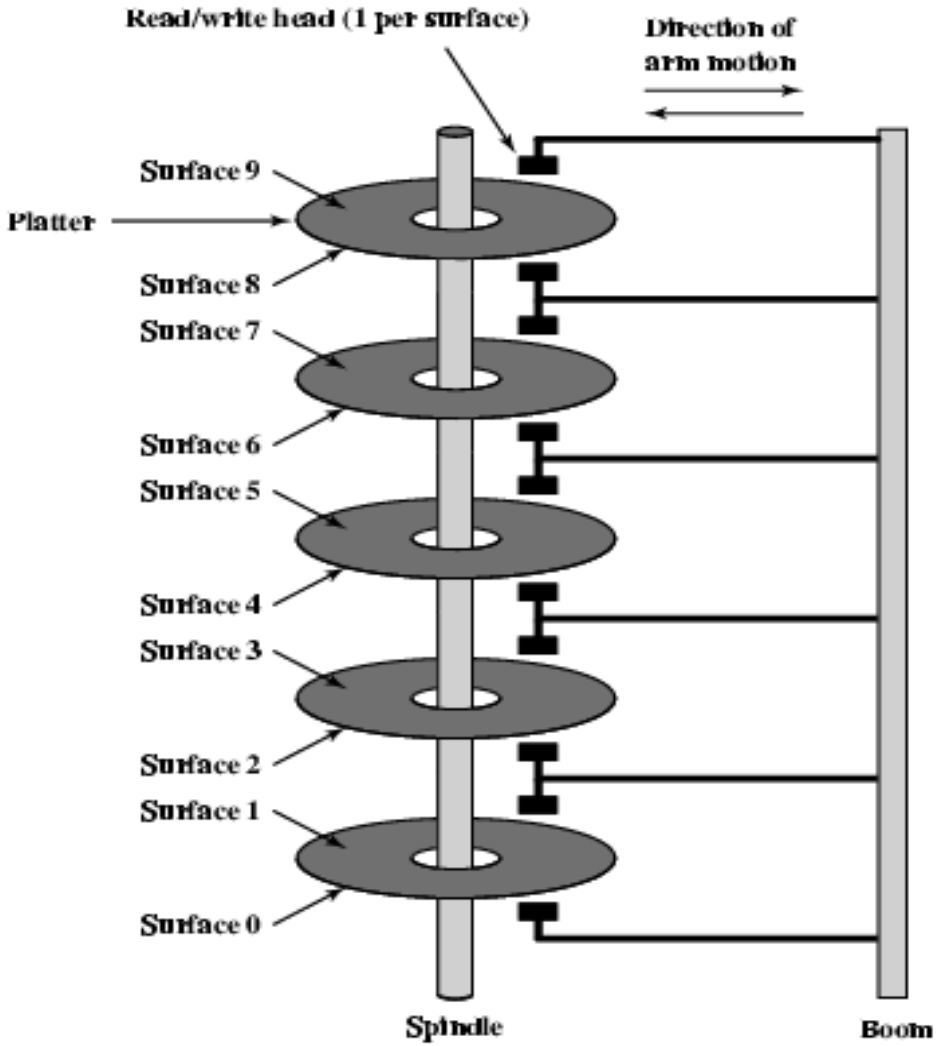
A. Removable disk
   - Can be removed from drive and replaced with another disk
   - Provides unlimited storage capacity
   - Easy data transfer between systems

B. Nonremovable disk
   - Permanently mounted in the drive

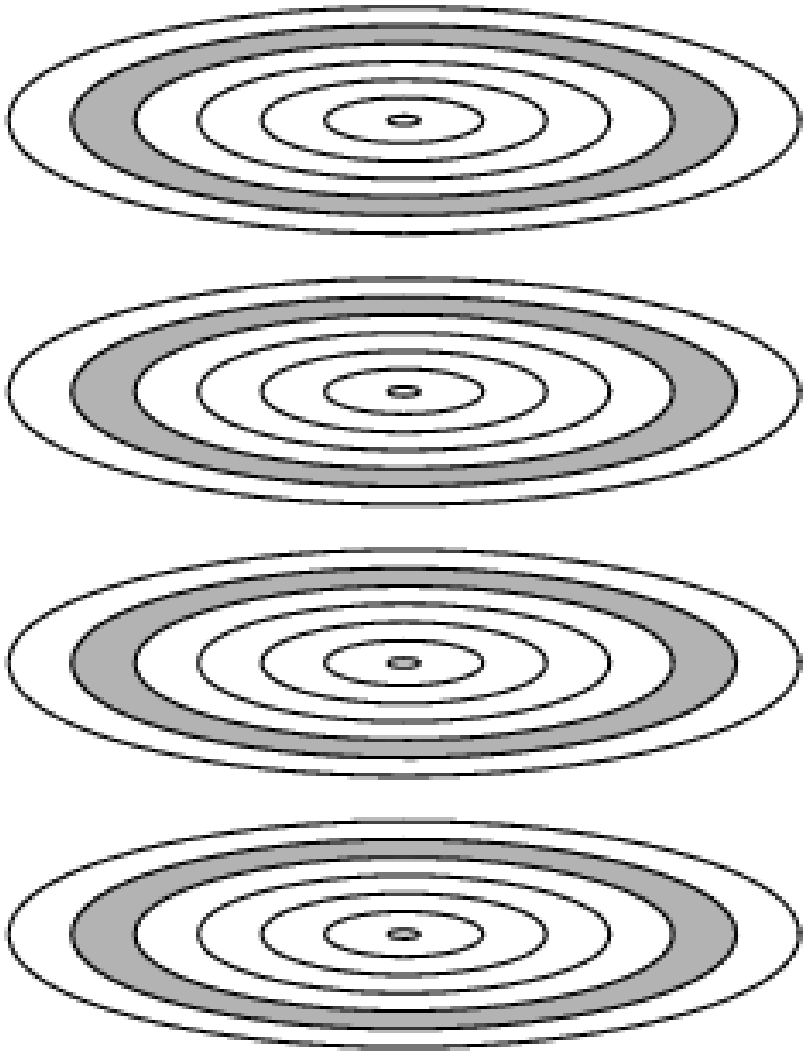
Multiple Platter

- One head per side
- Heads are joined and aligned
- Aligned tracks on each platter form cylinders
- Data is striped by cylinder
  - Reduces head movement
  - Increases speed (transfer rate)

Multiple Platters Diagram



Tracks and Cylinders Diagram



Floppy Disk

- Size range: 8”, 5.25”, 3.5”
- Small capacity - Up to 1.44Mbyte (2.88M never popular)
- Slow
- Universal
- Cheap
- Obsolete?

Disk Performance Parameters

- Seek time - On a movable head system, the time it takes to position the head at the track, i.e., moving head to correct track.
- Rotational delay/latency - The time the disk controller takes for the beginning of the sector to reach the head , i.e., waiting for data to rotate under head.
- Access time = Seek time + Latency
- Transfer time - the time required for the transfer while the read or write operation is performed as the sector moves under the head.

Disk Performance Parameters Contd..

- The transfer time T to or from the disk depends on the rotation speed of the disk in the following fashion:

$$T = b / rN$$

Where,

- b number of bytes to be transferred
- N number of bytes on a track
- r rotation speed, in revolutions per second

- Thus the total average access time T_a can be expressed as:

$$T_a = T_s + 1/2r + T$$, here T_s is the average seek time.

- Note that on a zoned drive, the number of bytes per track is variable, complicating the calculation.

RAID

- The rate in improvement in secondary storage performance has been considerably less than the rate for processors and main memory.
- In the case of disk storage, this leads to the development of arrays of disks that operate independently and in parallel.
- With multiple disks, separate I/O requests can be handled in parallel, as long as the data required reside on separate disks.
- A standardized scheme for multiple-disk database design is known as Redundant Array of Independent Disks (RAID).
- The RAID scheme consists of seven levels, zero through six.
- These levels do not imply a hierarchical relationship.
- Different design architectures share three common characteristics:
  - Set of physical disks viewed as single logical drive by O/S.
  - Data distributed across physical drives.
  - Can use redundant capacity to store parity information.

Magnetic Tape

- Tape systems use the same reading and recording techniques as disk systems.
- The medium is flexible polyester (similar to that used in some clothing) tape coated with magnetizable material.
- Tape widths vary from 0.38 cm (0.15 inch) to 1.27 cm (0.5 inch).
- Tapes used to be packaged as open reels that have to be threaded through a second spindle for use.
- Today, virtually all tapes are housed in cartridges.
- Data on the tape are structured as a number of parallel tracks running lengthwise.
- Earlier tape systems typically used nine tracks.
- This made it possible to store data one byte at a time, with an additional parity bit as the ninth track.
- This was followed by tape systems using 18 or 36 tracks, corresponding to a digital word or double word.
- The recording of data in this form is referred to as *parallel recording*.

Magnetic Tape Contd...

- Most modern systems instead use **serial recording**, in which data are laid out as a sequence of bits along each track, as is done with magnetic disks.
- As with the disk, data are read and written in contiguous blocks, called *physical records,* on a tape.
- Blocks on the tape are separated by gaps referred to as *interrecord* gaps.
- As with the disk, the tape is formatted to assist in locating physical records.
- The typical recording technique used in serial tapes is referred to as **serpentine recording**.
- In this technique, when data are being recorded, the first set of bits is recorded along the whole length of the tape.
- When the end of the tape is reached, the heads are repositioned to record a new track, and the tape is again recorded on its whole length, this time in the opposite direction.
- The process continues, back and forth, until the tape is full.

Magnetic Tape Contd...

- Serial access - A tape drive is a sequential-access device.
- In contrast to the tape, the disk drive is referred to as a *direct-access* device. A disk drive need not read all the sectors on a disk sequentially to get to the desired one.
- Magnetic tape was the first kind of secondary memory.
  - Slow
  - Low cost, i.e., Very cheap
  - Used for Backup and archive
- The dominant tape technology today is a cartridge system known as linear tape-open (LTO).
  - Developed late 1990s
  - Open source alternative to proprietary tape systems

Thank You