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Computer Organization and Architecture

Chapter 5
External Memory

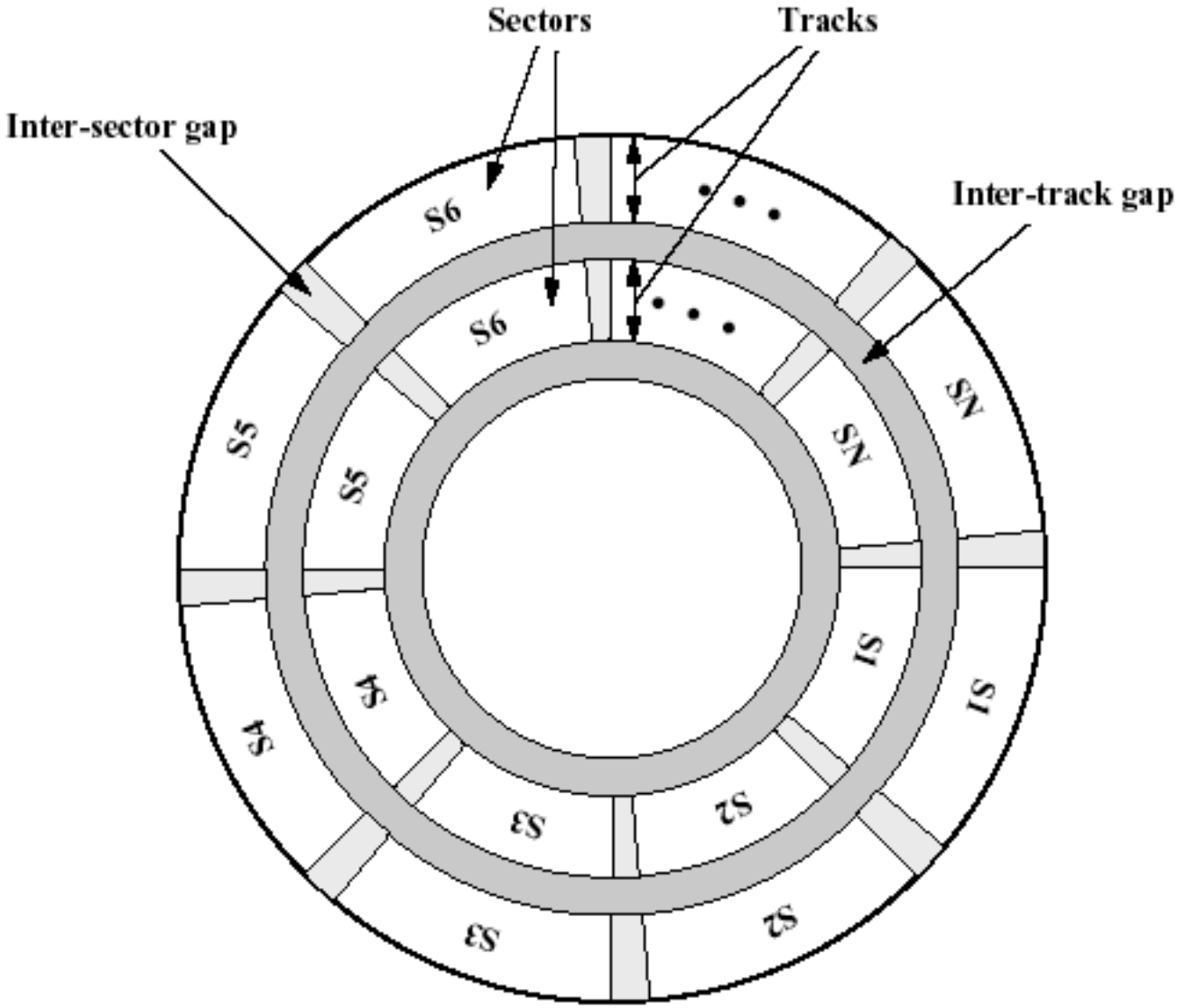
Types of External Memory

- Magnetic Disk
  - Fixed/Removable
  - RAID
- Magnetic Tape
- Optical
  - CD-ROM
  - CD-R
  - CD-RW
  - DVD

Magnetic Disk

- Metal or plastic disk coated, on one or both sides, with magnetizable material (iron oxide, i.e. rust)
- Data read and written through a magnetic head (coil) by means of induction
- Range of packaging
  - Floppy
  - "Winchester" hard disk
  - Removable hard disk

Disk Data Layout



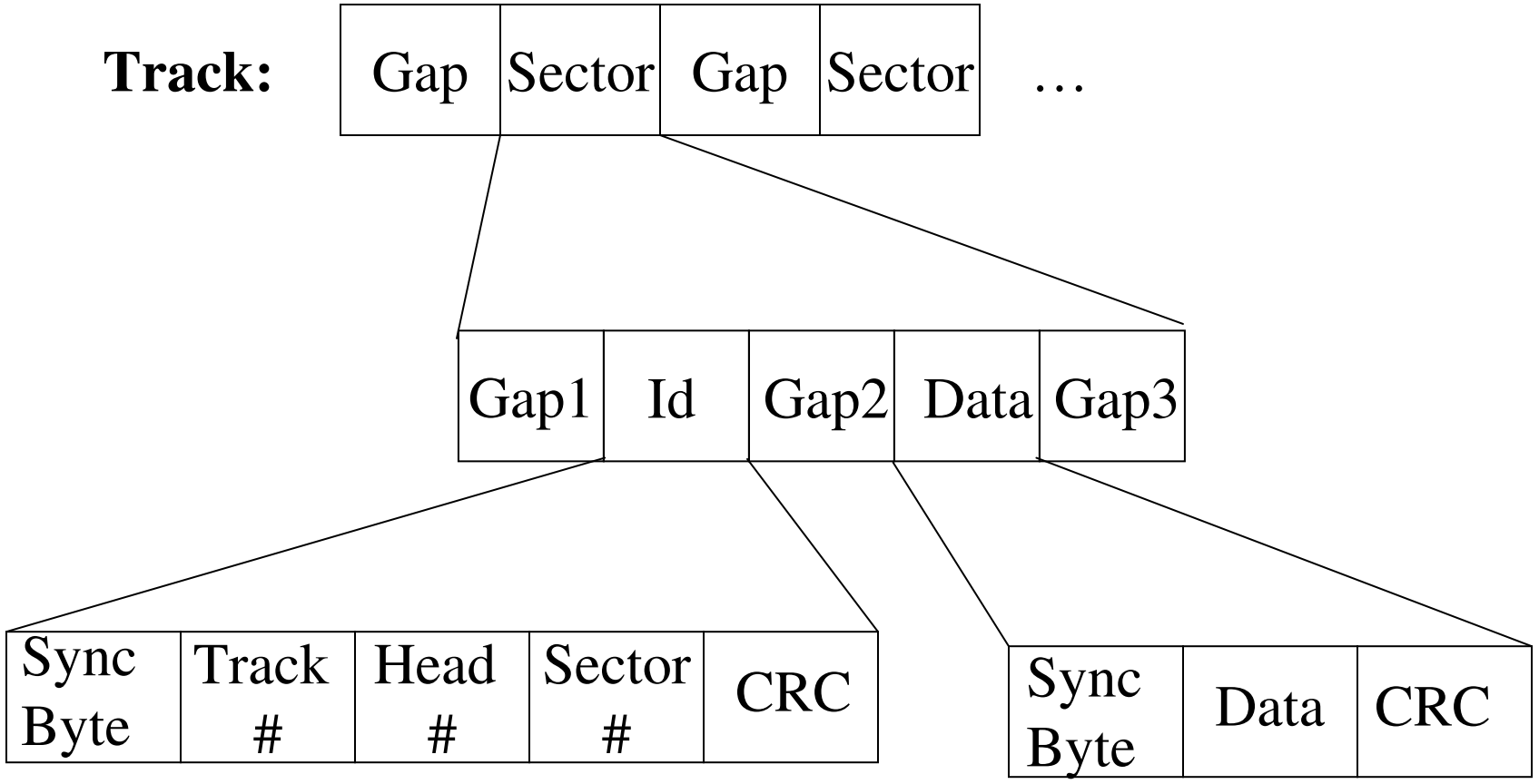
Data Organization and Formatting

- Concentric rings or tracks
  - Gaps between tracks
  - Reduce gap to increase capacity
  - Same number of bits per track (variable density)
  - Constant angular velocity
- Tracks divided into sectors
- Data read/written in blocks
  - Minimum block size is one sector
  - May have more than one sector per block

Finding Sectors

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

An example format



Characteristics of magnetic disks

- Removable or fixed
- Fixed or movable head
- Single or double (usually) sided
- Single or multiple platter
- Speed
- Head mechanism
  - Contact (Floppy)
  - Fixed gap
  - Aerodynamic gap or flying head (Winchester)

Removable or Not

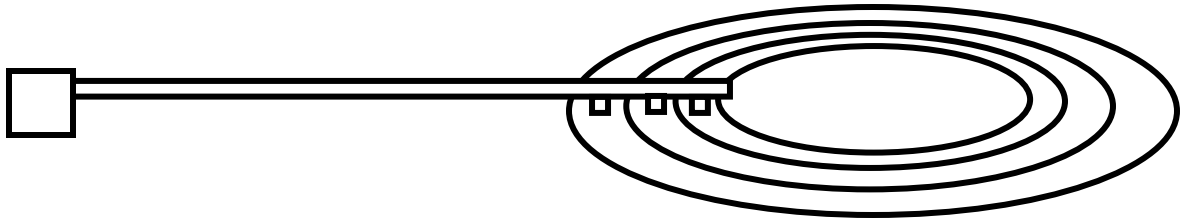
- Removable disk
  - Can be removed from drive and replaced with another disk
  - Provides unlimited storage capacity (by changing disk)
  - Easy data transfer between systems
- Nonremovable disk
  - Permanently mounted in the drive

Removable Hard Disk

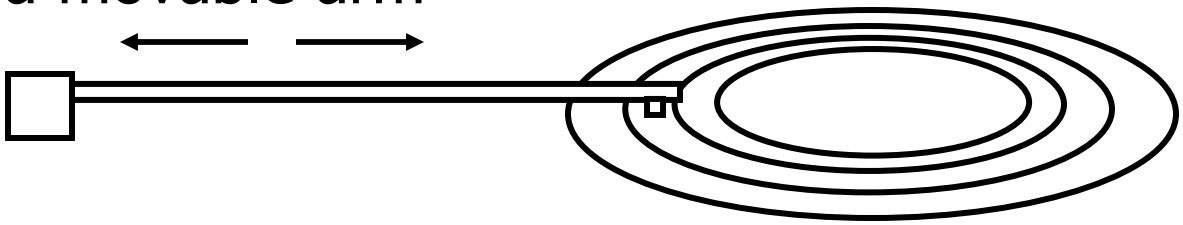
- ZIP
  - Cheap
  - Very common
  - Only 100M
- JAZ
  - Not cheap
  - 1G

Fixed/Movable Head Disk

- Fixed head
  - One read/write head per track
  - Heads mounted on a fixed arm

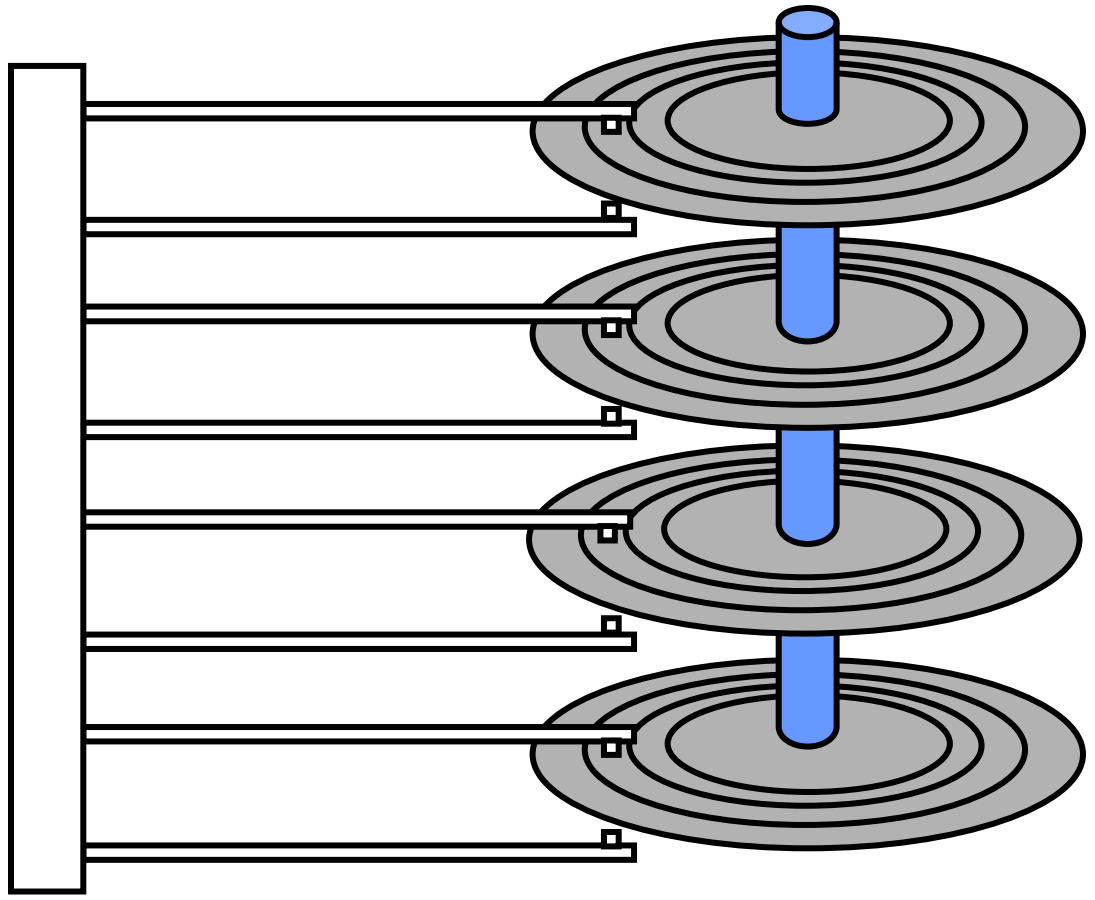


- Movable head
  - One read/write head per side
  - Mounted on a movable arm



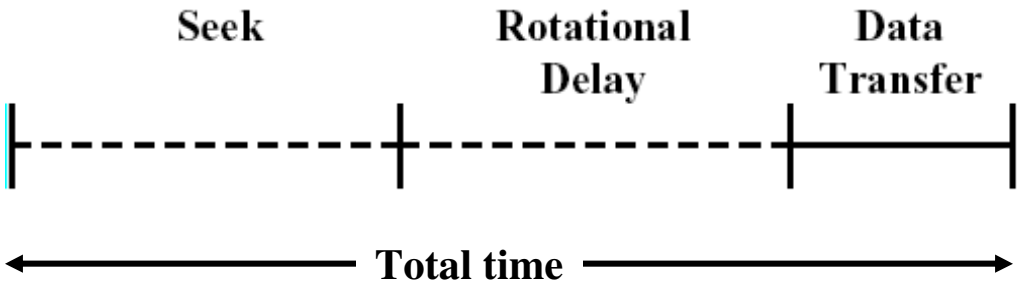
Multiple Platters

- 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)



Speed

- Seek time
  - Moving head to the right track
- (Rotational) latency
  - Waiting for data to rotate under head
- Access time = Seek + Latency
- Transfer rate: speed of copying bytes from disk



Floppy Disk

- 8” (very old), 5.25” (old), 3.5”
- Small capacity
  - Up to 1.44Mbyte (2.88M never popular)
- Slow
- Universal
- Very cheap

Winchester Hard Disk (1)

- Developed by IBM in Winchester (USA)
- Sealed unit
- One or more platters (disks)
- Heads fly on boundary layer of air as disk spins
- Very small head-to-disk gap
- Getting more robust

Winchester Hard Disk (2)

- Universal
- Cheap
- Fastest external storage
- Getting larger all the time
  - Multiple Gigabyte now usual

RAID

- Redundant Array of **Independent** Disks, originally Redundant Array of **Inexpensive** Disks
- At least 7 different versions in common use (Not a hierarchy)
- Set of physical disks viewed as single logical drive by the operating system
- Data distributed (**striped**) across physical drives
- Can use redundant capacity to store parity information and provide fault tolerants
- Used in servers

Magnetic Tape

- Only sequential access
- Slower than magnetic and optical disks
- Very very cheap
- Backup and archive

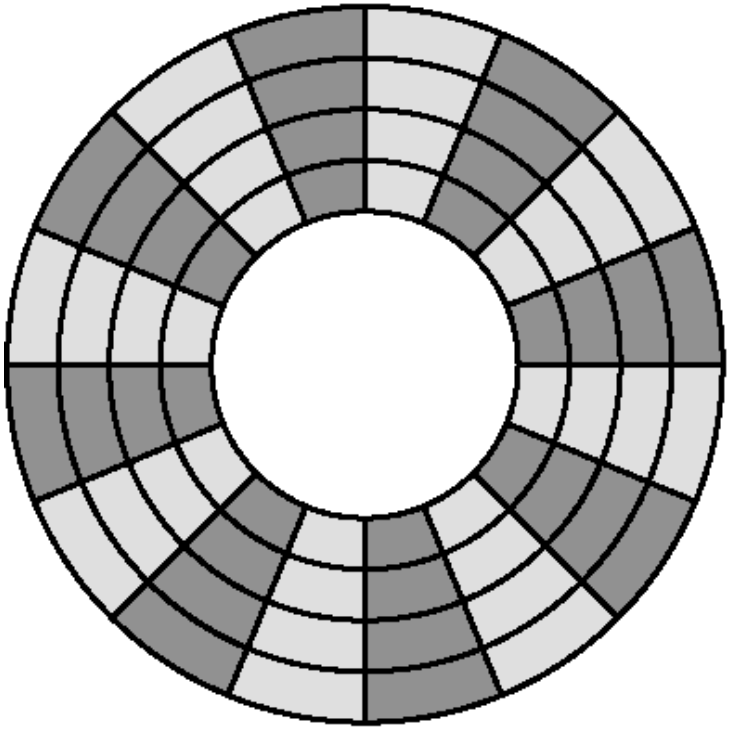
Digital Audio Tape (DAT)

- Uses rotating head (like video)
- High capacity on small tape
  - 4 Gbyte uncompressed
  - 8 Gbyte compressed
- Backup of PC/network servers

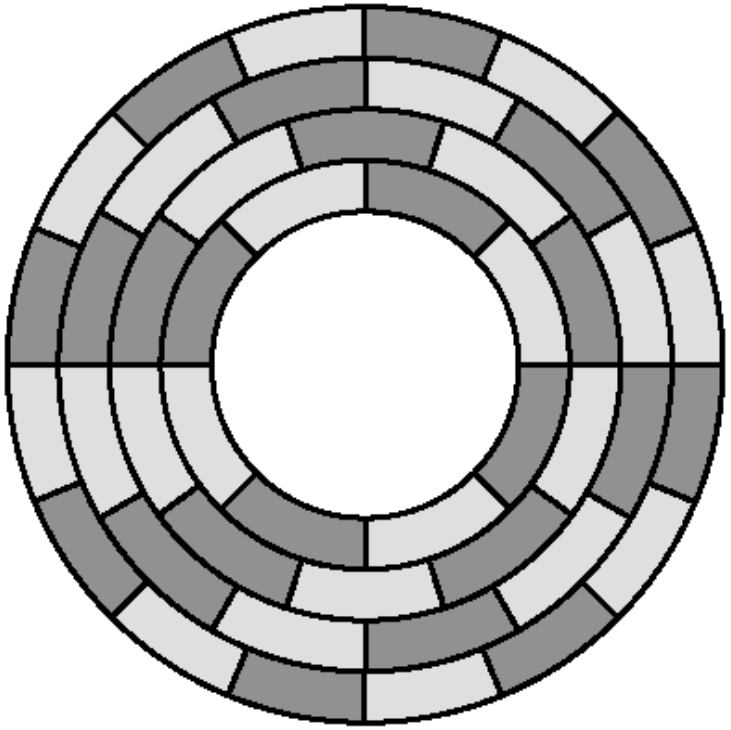
Optical Storage: CD-ROM

- Originally for audio
- 650 Mbytes giving over 70 minutes audio
- Polycarbonate coated with highly reflective coat, usually aluminum
- Data stored as pits
- Read by reflecting laser
- Constant packing density
- Constant linear velocity

Comparison of variable/fixed density



(a) Constant angular velocity



(b) Constant linear velocity

CD-ROM Drive Speeds

- Audio is single speed
  - Constant linear velocity
  - 1.2 m/s
  - Track (spiral) is 5.27km long
  - Gives 4391 seconds = 73.2 minutes
- Other speeds are quoted as multiples, e.g. 24x
- The quoted figure is the maximum the drive can achieve

Random Access on CD-ROM

- Difficult, due to constant density and single track
- Move head to rough position
- Set correct speed
- Read address
- Adjust to required location

CD-ROM for & against

- Large capacity
- Easy to mass produce
- Removable
- Robust

- Expensive for small runs
- Slower than magnetic disk
- Read only

Other Optical Storage

- CD-R (for Recordable)
  - Writable, but ... Write Once Read Many (WORM)
  - Now affordable
  - Compatible with CD-ROM drives
- CD-RW (for ReWritable)
  - Erasable, hence writable many times (~1000)
  - Different technology (phase change vs pit)
  - Getting cheaper
  - Mostly, but not always, CD-ROM drive compatible

DVD - Digital Video/Versatile Disk

- Optical (CD-sized) disk with a very high capacity:
  - 4.7 GB per layer (smaller pits and closer tracks)
  - Up to 2 layers on each of the 2 sides (total 17 GB)
- Full length movie on single disk
  - Using MPEG-2 compression
- Drives are CD-ROM compatible
- Also writable (DVD-R, DVD-RW), but not yet fully standardized

HD-ROM - the future ?

- High-Density ROM
- Very narrow laser beam (50 nm vs 350 for DVD and 800 for CD)
- Capable to store up to 165 GB on a CD-sized disk