

# CS 223 Computer Architecture & Organization

## External Memory



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# Physical Types

- Semiconductor
  - RAM/Solid State Storage
- Magnetic
  - Disk & Tape
- Optical
  - CD & DVD

# Types of External Memory

- Magnetic Disk
  - RAID
  - Removable
- Optical
  - CD-ROM
  - CD-Recordable (CD-R)
  - CD-R/W
  - DVD
- Magnetic Tape

# Magnetic Disk

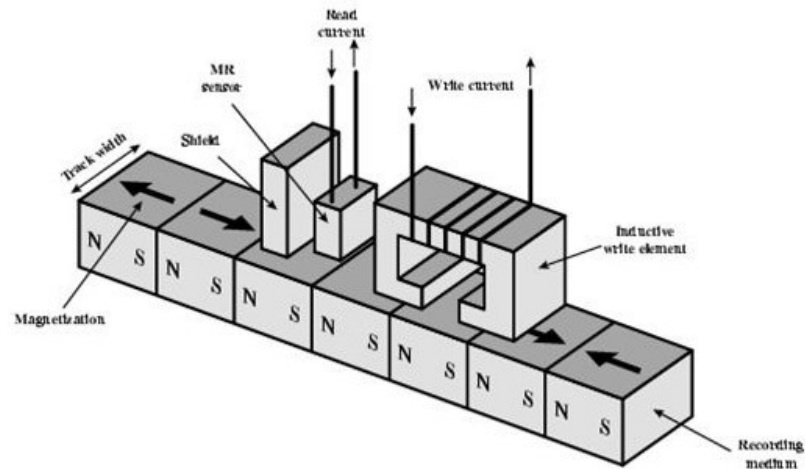
- Disk substrate coated with magnetisable material (iron oxide)
- Substrate used to be aluminium
- Now glass
  - Improved surface uniformity
    - Increases reliability
  - Reduction in surface defects
    - Reduced read/write errors
  - Better stiffness
  - Better shock/damage resistance

# Read and Write Mechanisms

- Recording & retrieval via conductive coil called a head
- May be single read/write head or separate ones
- During read/write, head is stationary, platter rotates
- Write
  - Current through coil produces magnetic field
  - Pulses sent to head
  - Magnetic pattern recorded on surface below
- Read (traditional)
  - Magnetic field moving relative to coil produces current
  - Coil is the same for read and write
- Read (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

# Read and Write Mechanisms

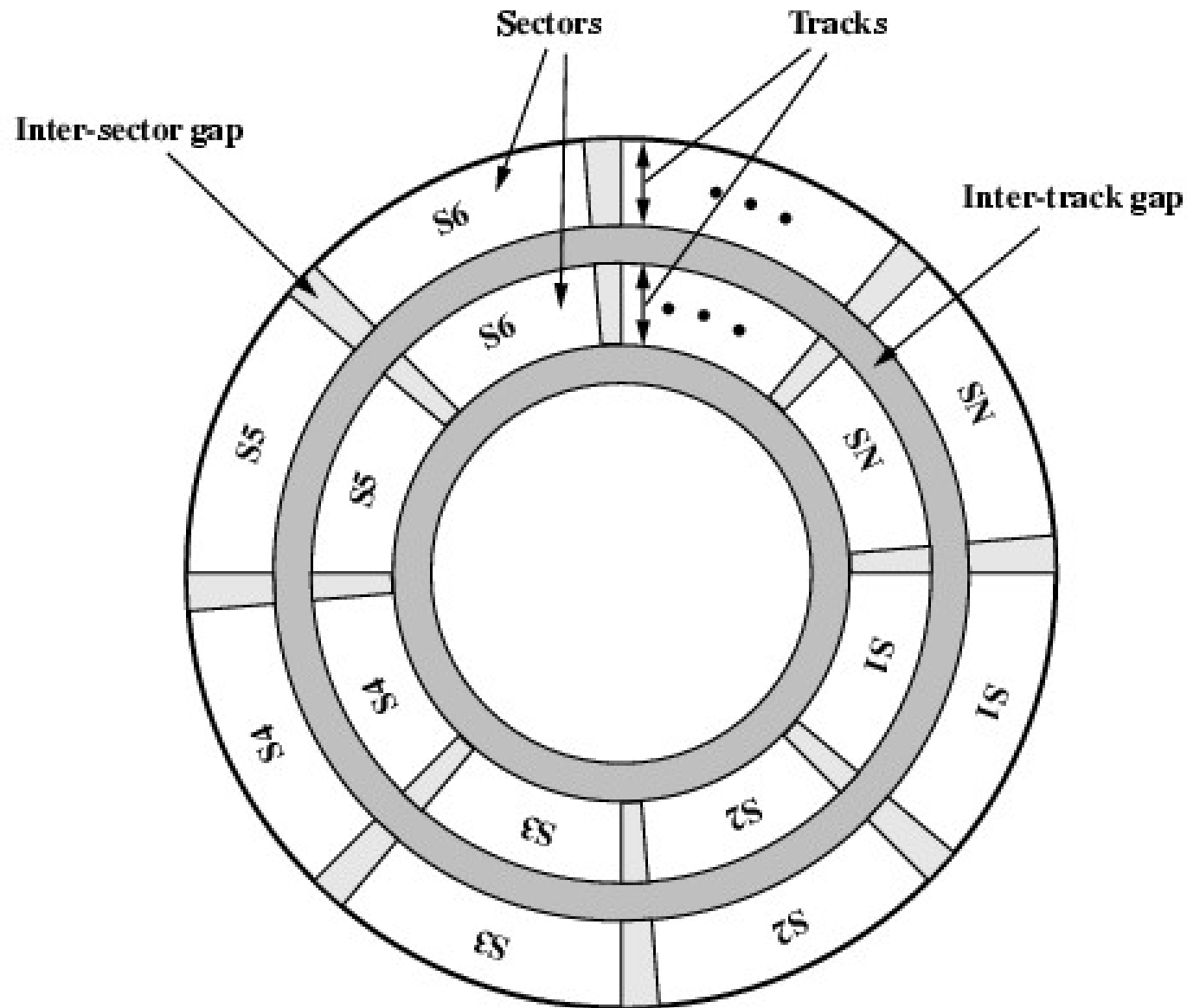
- Mechanisms
  - Recording & retrieval via conductive coil called a head
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# Data Organization and Formatting

- Concentric rings or tracks
  - Gaps between tracks
  - Reduce gap to increase capacity
  - Same number of bits per track (variable packing density)
  - Constant angular velocity
- Tracks divided into sectors
- Minimum block size is one sector

# Disk Data Layout

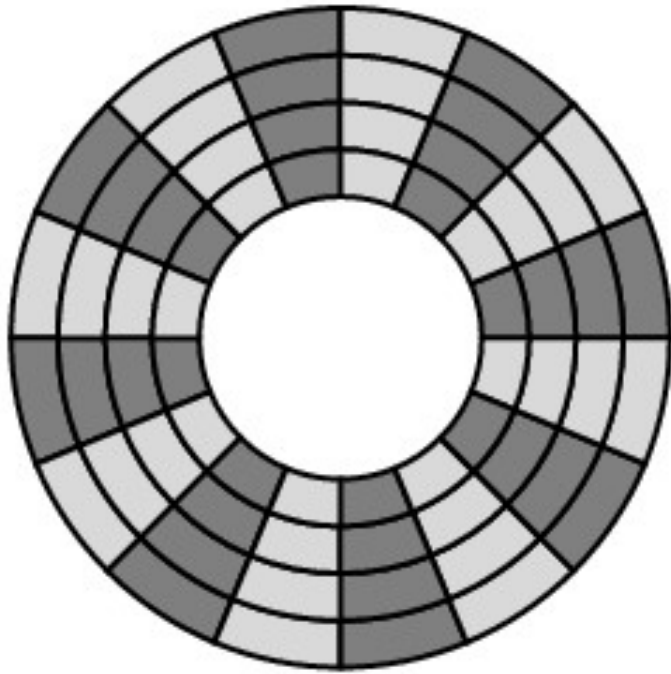




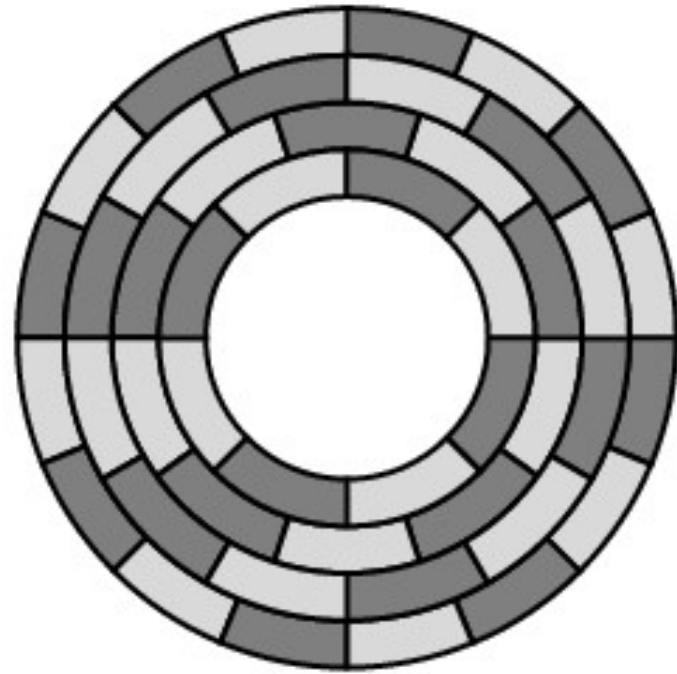
# Disk Velocity

- Rotate disk at 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
- Can use zones to increase capacity
  - Each zone has fixed bits per track
  - More complex circuitry

# Disk Layout Methods Diagram



**(a) Constant angular velocity**



**(b) Multiple zoned recording**

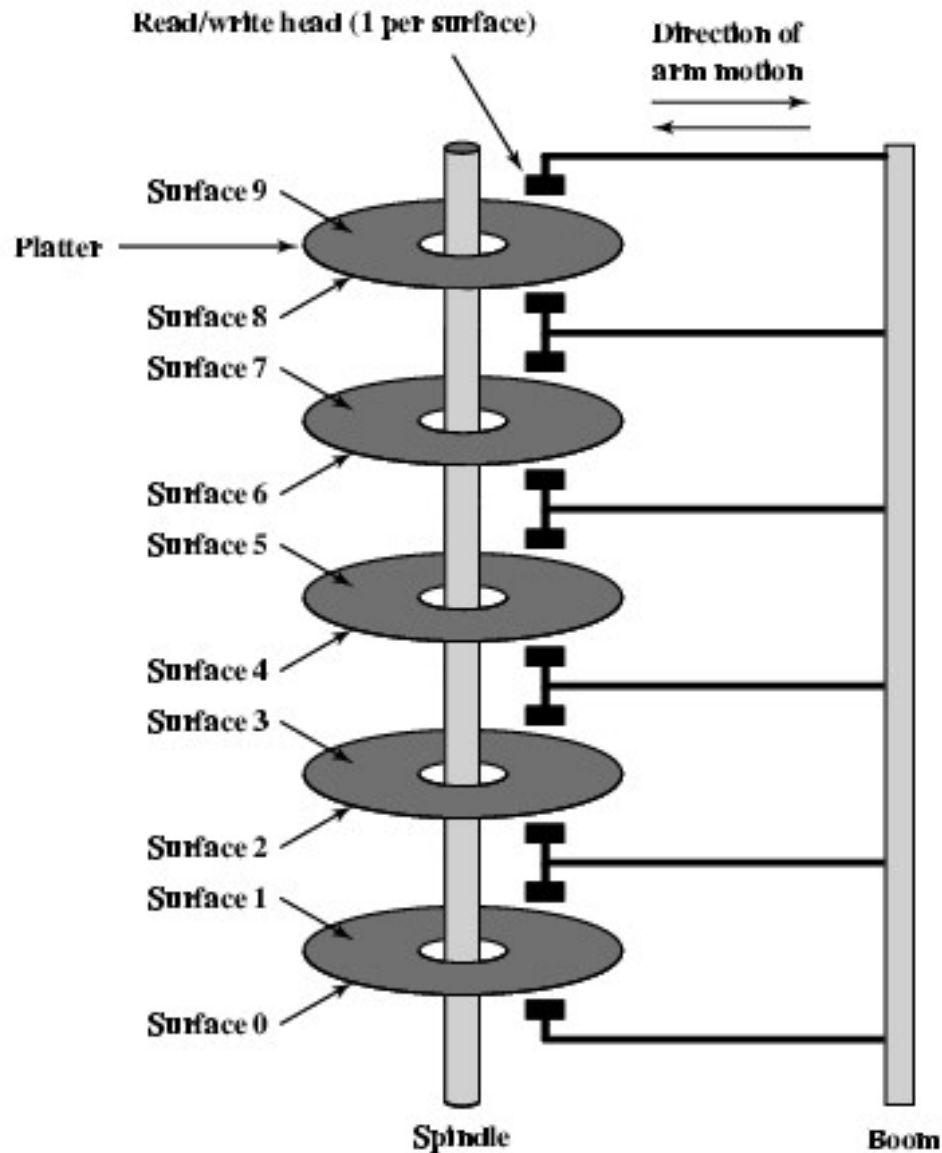
# Finding Sectors

- Must be able to identify start of track and sector
- Format disk
  - Marks tracks and sectors

# Characteristics

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

# Multiple Platters



# Fixed/Movable Head Disk

- Fixed head
  - One read write head per track
  - Heads mounted on fixed ridged arm
- Movable head
  - One read write head per side
  - Mounted on a movable arm

# Removable or Not

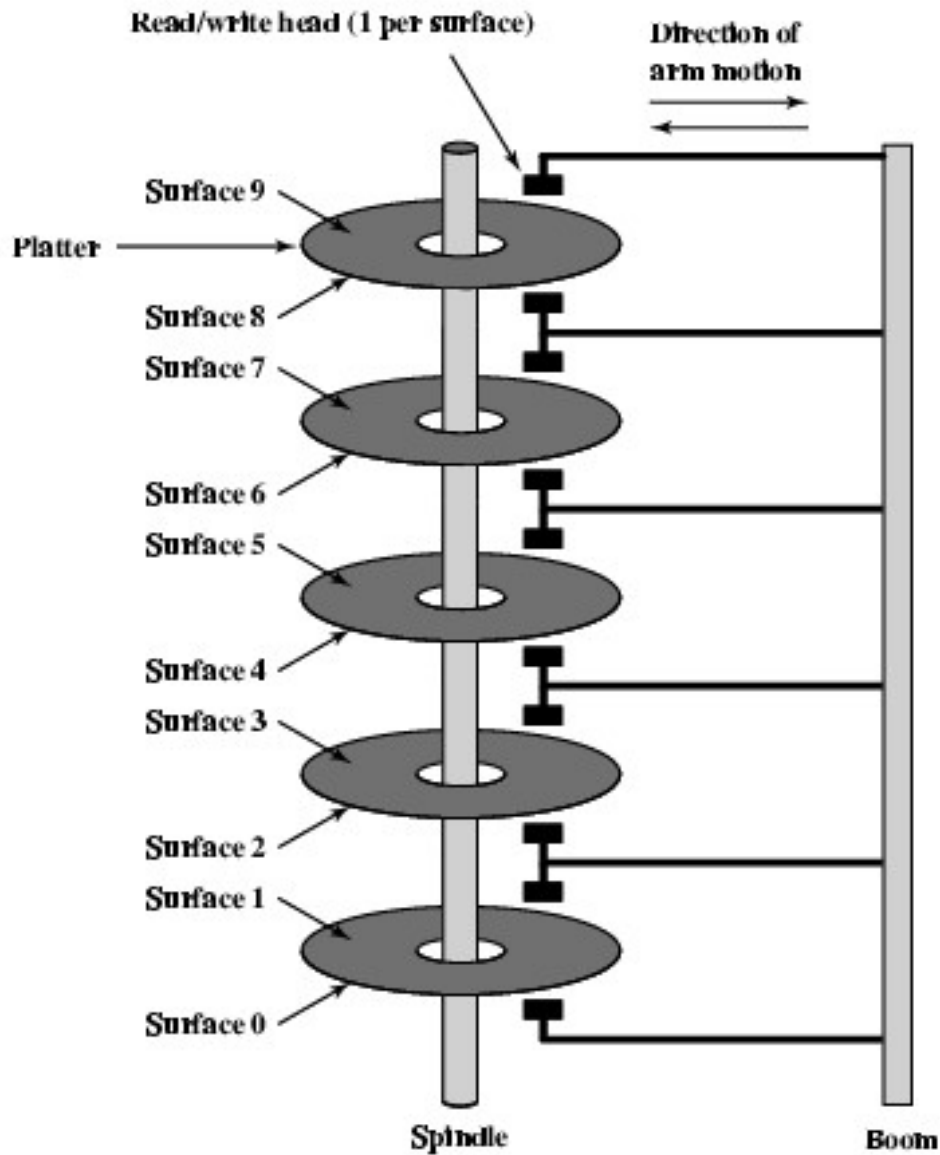
- Removable disk
  - Can be removed from drive and replaced with another disk
  - Provides unlimited storage capacity
  - Easy data transfer between systems
- Nonremovable disk
  - Permanently mounted in the drive

# Multiple Platter

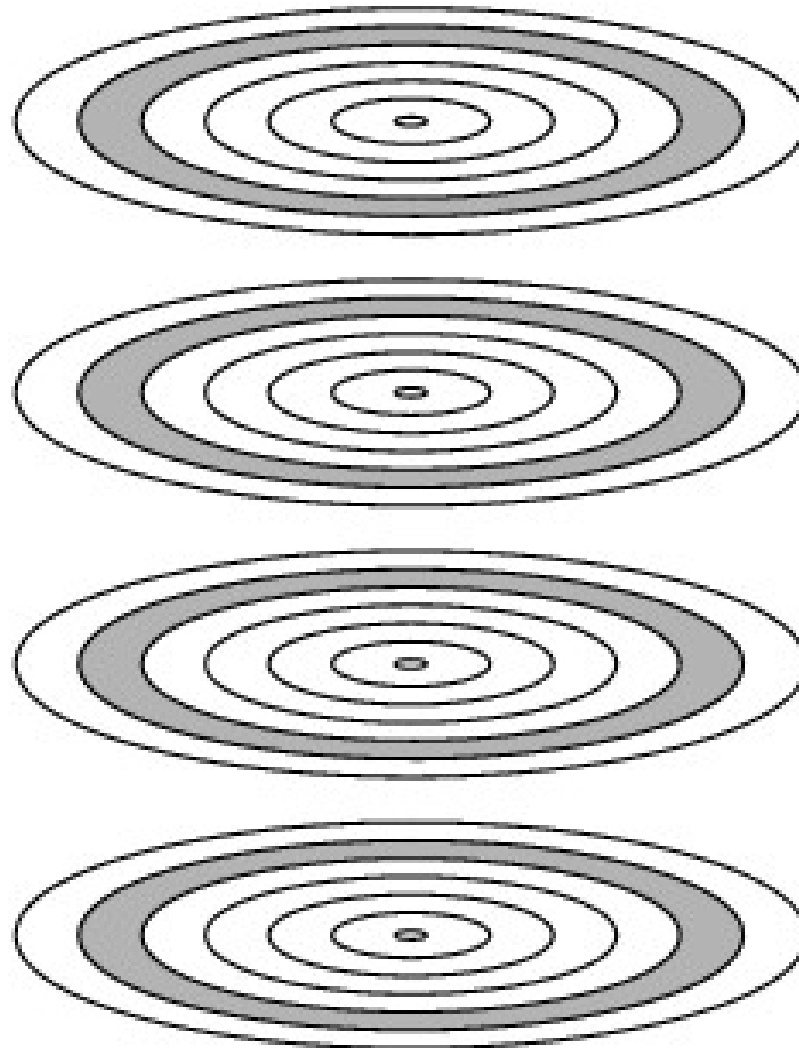
- One head per side
- Heads are joined and aligned
- Aligned tracks on each platter form cylinders
- Data is striped by cylinder
  - reduces head movement
  - Increases speed (transfer rate)



# Multiple Platters



# Tracks and Cylinders



# Disk Addressing

- Need to know
  - Sector No.
  - Track No.
  - Surface No. (Head No.)
- Option I
  - track : surface : sector
- Option II
  - surface : track : sector

# Speed

- Seek time
  - Moving head to correct track
- (Rotational) latency
  - Waiting for data to rotate under head
- Access time = Seek + Latency
- Transfer rate

# Performance

- Access time
  - Time between presenting the address and getting the valid data
- Memory Cycle time
  - Time may be required for the memory to “recover” before next access
  - Cycle time is access + recovery
- Transfer Rate
  - Rate at which data can be moved

# Time requirements

- Transfer Time:

- The transfer time to or from the disk depends on the rotation speed of the disk as:

- $T = b/rN$
    - Where
    - $T$  = Transfer time
    - $b$  = number of bytes to be transferred
    - $N$  = number of bytes on a track
    - $r$  = rotational speed, in revolution per second

Total Time =  $T_s + 1/2r + b/rN$  ( $T_s$ : Average seek time,  $1/2r$ : Average Rotational Delay)

# Time requirements

- Consider a disk pack: rotational speed = 15000 rpm, 512 bytes per sector with 500 sectors per track. Average seek time is 4 ms. Consider a file containing 2500 sectors, so file size is 1.28 Mbytes
  - Average seek time: 4 ms
  - Average rotational delay =  $1/(2 \times 15000) = 2\text{ms}$
  - Time to read one sector =  $4/500 = 0.008\text{ ms}$
  - Time to read one track =  $0.008 \times 500 = 4\text{ ms}$
  - File type: Sequential and Random

# Reference

Computer Organization and Architecture –  
Designing for Performance  
William Stallings, Seventh Edition

Chapter 6: External Memory

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