CS 222 Computer Organization & Architecture

Lecture 33 [23.04.2019]

Secondary Storage Systems

John Jose

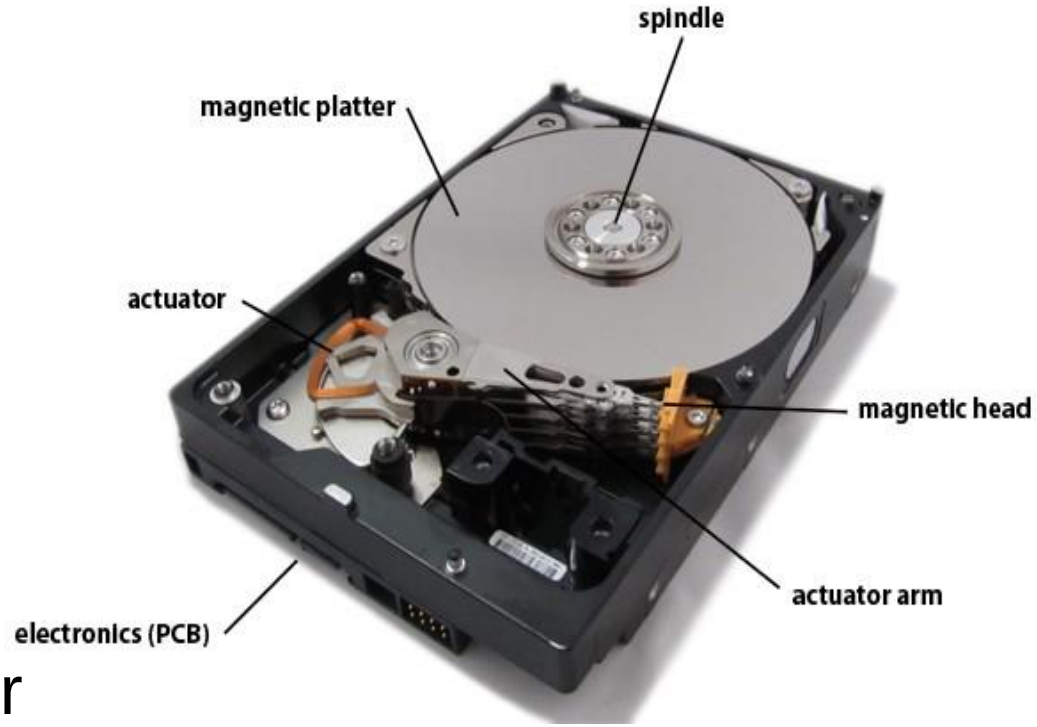
Assistant Professor

Department of Computer Science & Engineering

Indian Institute of Technology Guwahati, Assam.

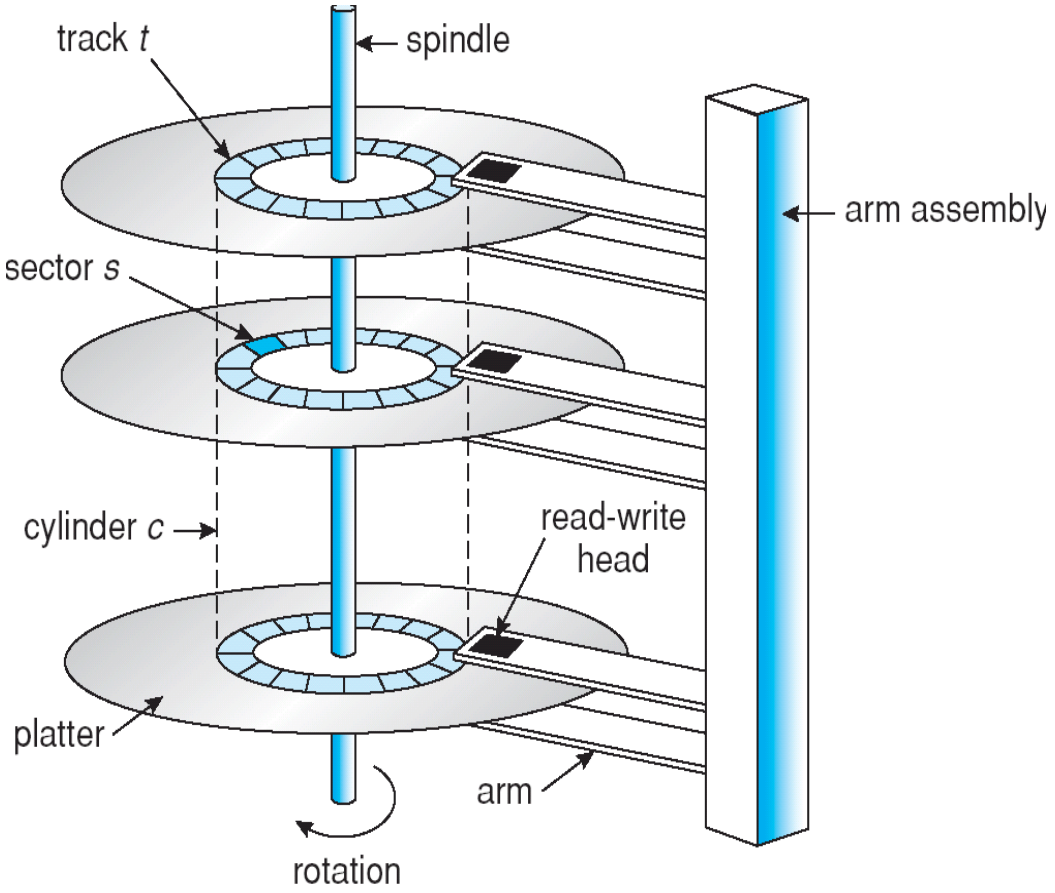
Mass Storage - Hard Disk Drive

- Systems today need to store many terabytes of data.
- Primary level of permanent storage is hard disk.
- Electromechanical
  - Rotating disks
  - Arm assembly
- Electronics
  - Disk controller
  - Cache
  - Interface controller



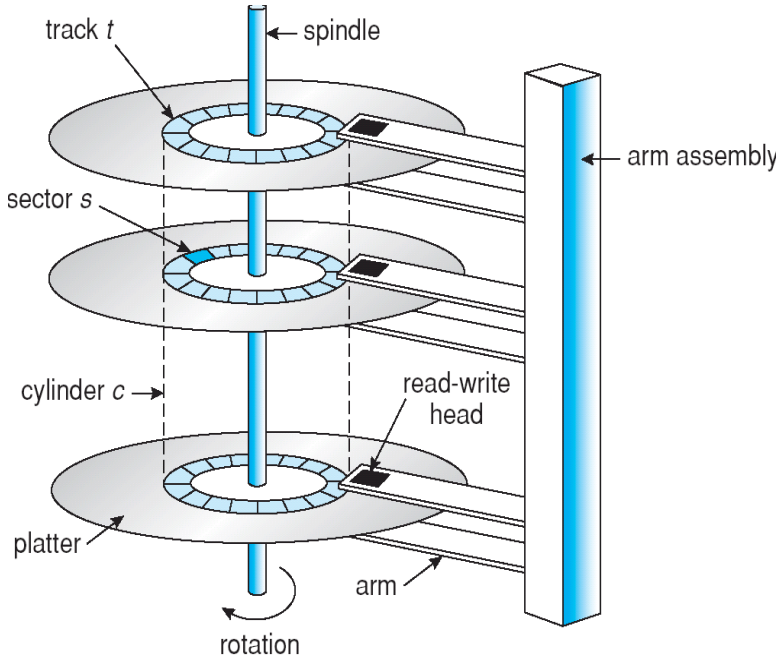
Hard Disk Drive Organization

- Hard disk drive consists of spinning disks with heads that move over the disks and store data in tracks and sectors.
- The heads read and write data in concentric rings called tracks.
- Tracks are divided into sectors, which normally store 512 bytes each.



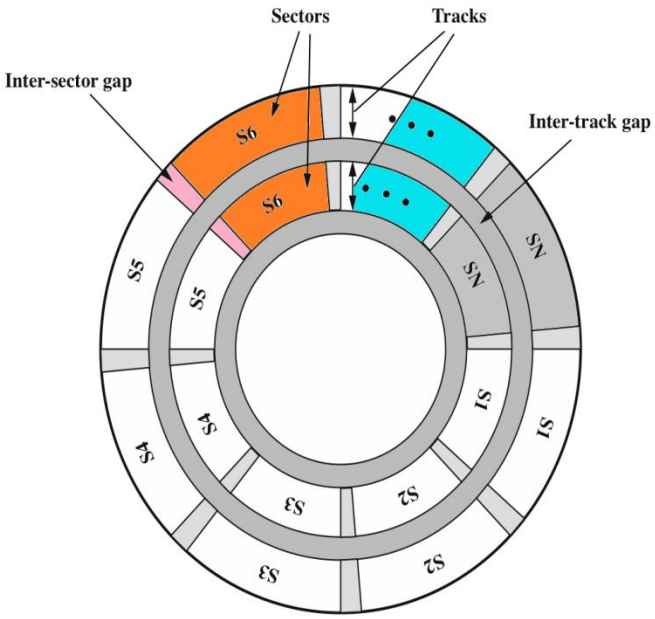
Hard Disk Drive Organization

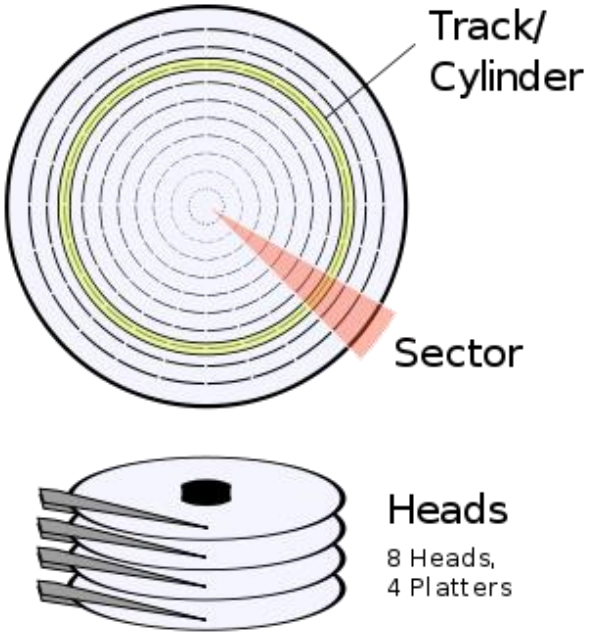
- Platter diameters: 3.7”, 3.3”, 2.6”
- RPMs: 5400, 7200, 10000, 15000 [0.5 to 1%variation]
- Number of platters: 1-5
- Power proportional to: $(Platters)*(RPM)^{2.8}(Diameter)^{4.6}$
- Read/write head



Hard Disk Drive Operation

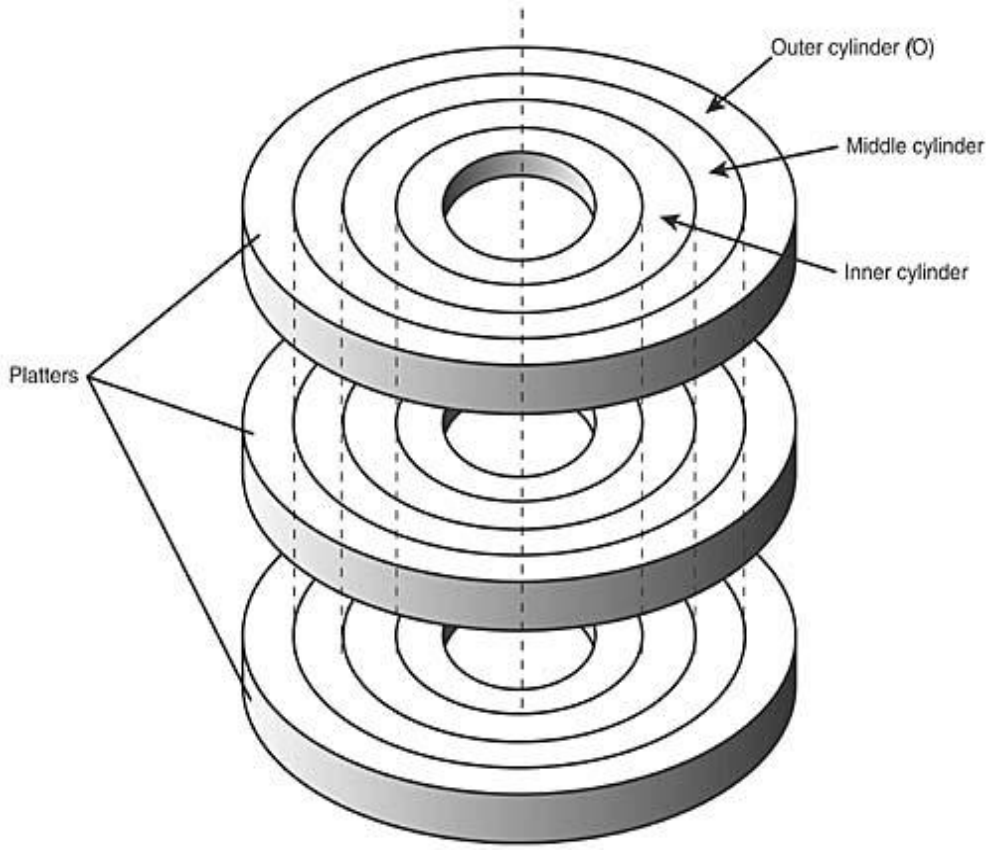
- One side of a platter is called a head.
- HDD can have multiple platters, depending on their design and storage capacity.
- On the heads, there are concentric rings (tracks) and pieces of rings (sectors)





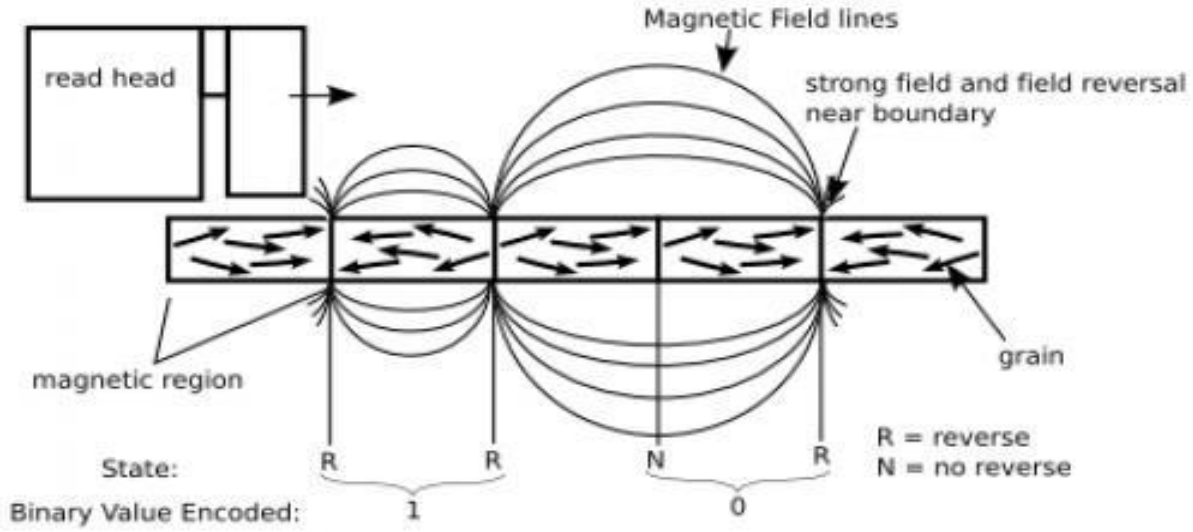
Hard Disk Drive Organization

- Cylinder: 3D collection of track ‘n’of each surface of all platters.

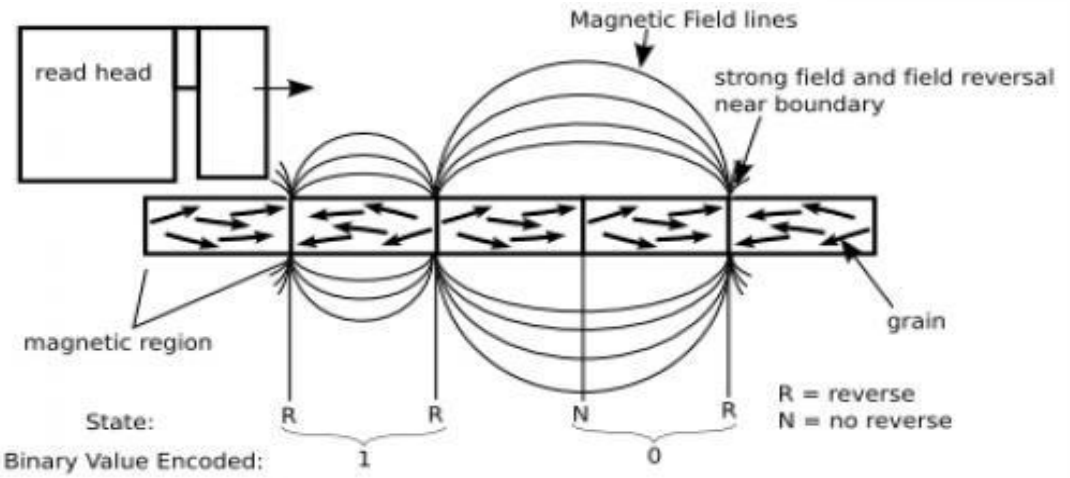


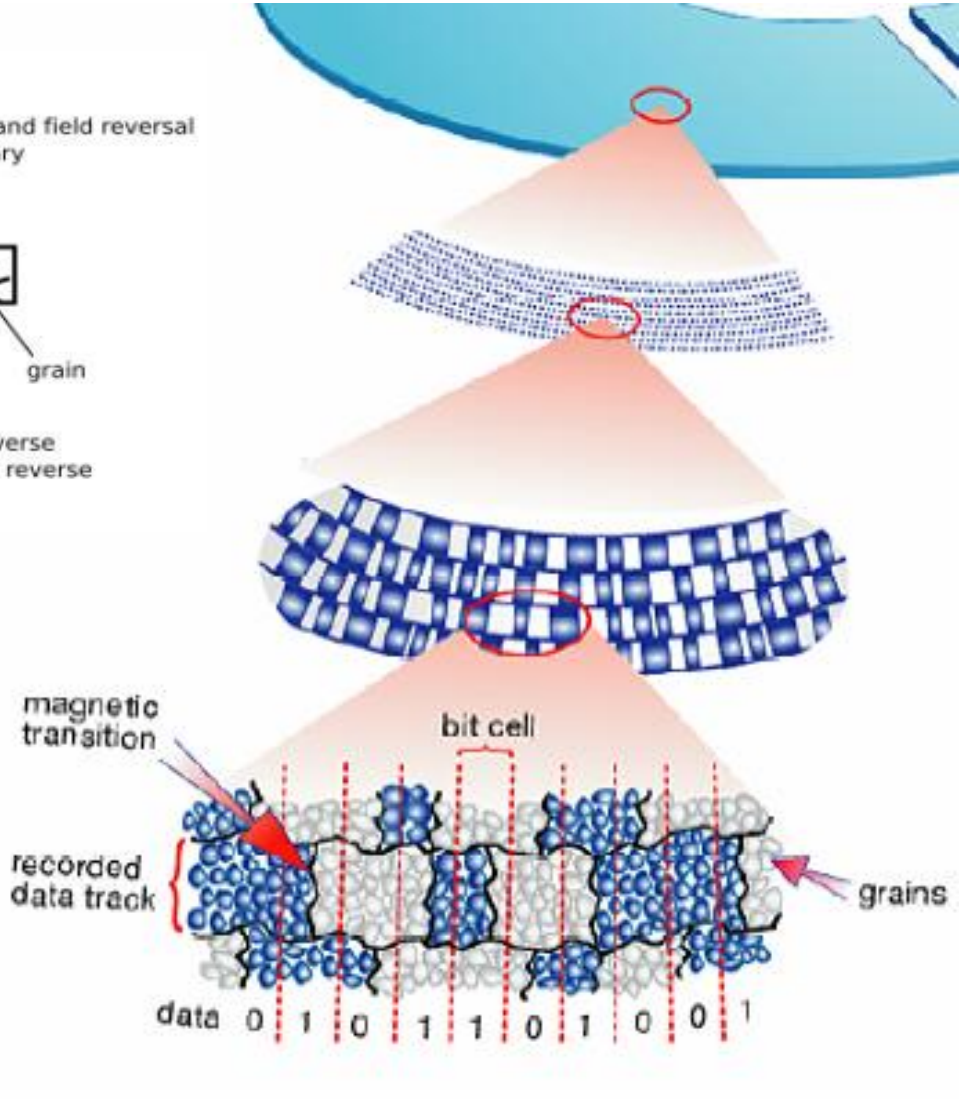
Logic storage in Hard Disk Drive

- Bit-cell composed of magnetic grains : 50-100 grains/bit
- Size of grains is order of 10 nm.
- **‘0’** Region of grains of uniform magnetic polarity
- **‘1’** Boundary between regions of opposite magnetization
- The read-and-write head is used to detect and modify the magnetization of the material immediately under it.



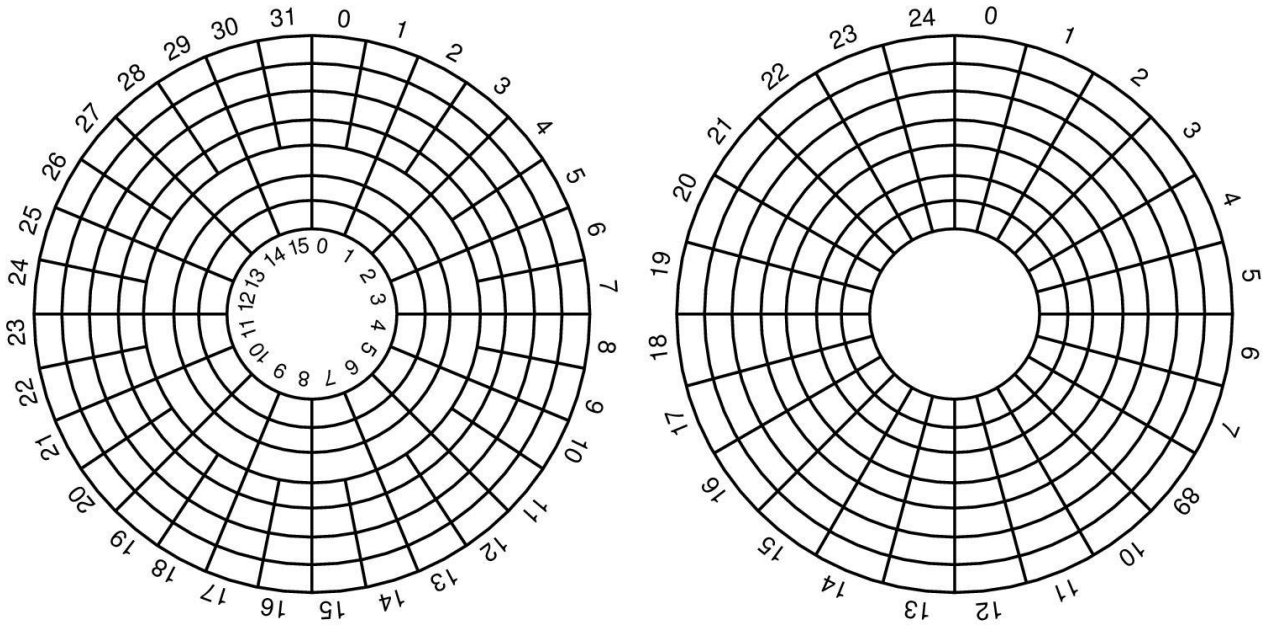
Logic storage in Hard Disk Drive





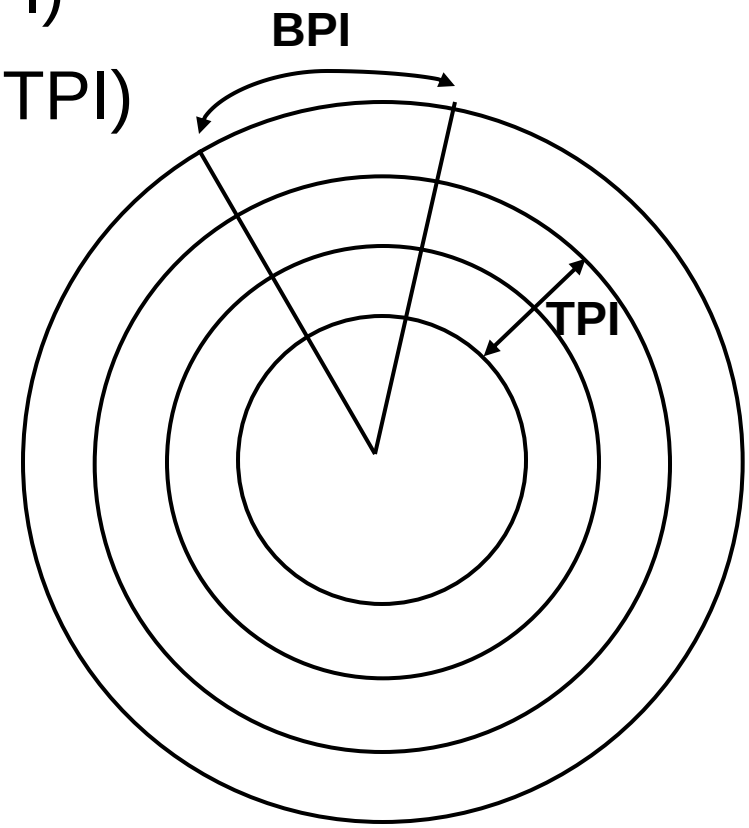
HDD- Bit Density

- Reduce bit density per track for outer layers. Constant Linear Velocity.
- Have more sectors per track on the outer layers, and increase rotational speed when reading from outer tracks. Constant Angular Velocity.

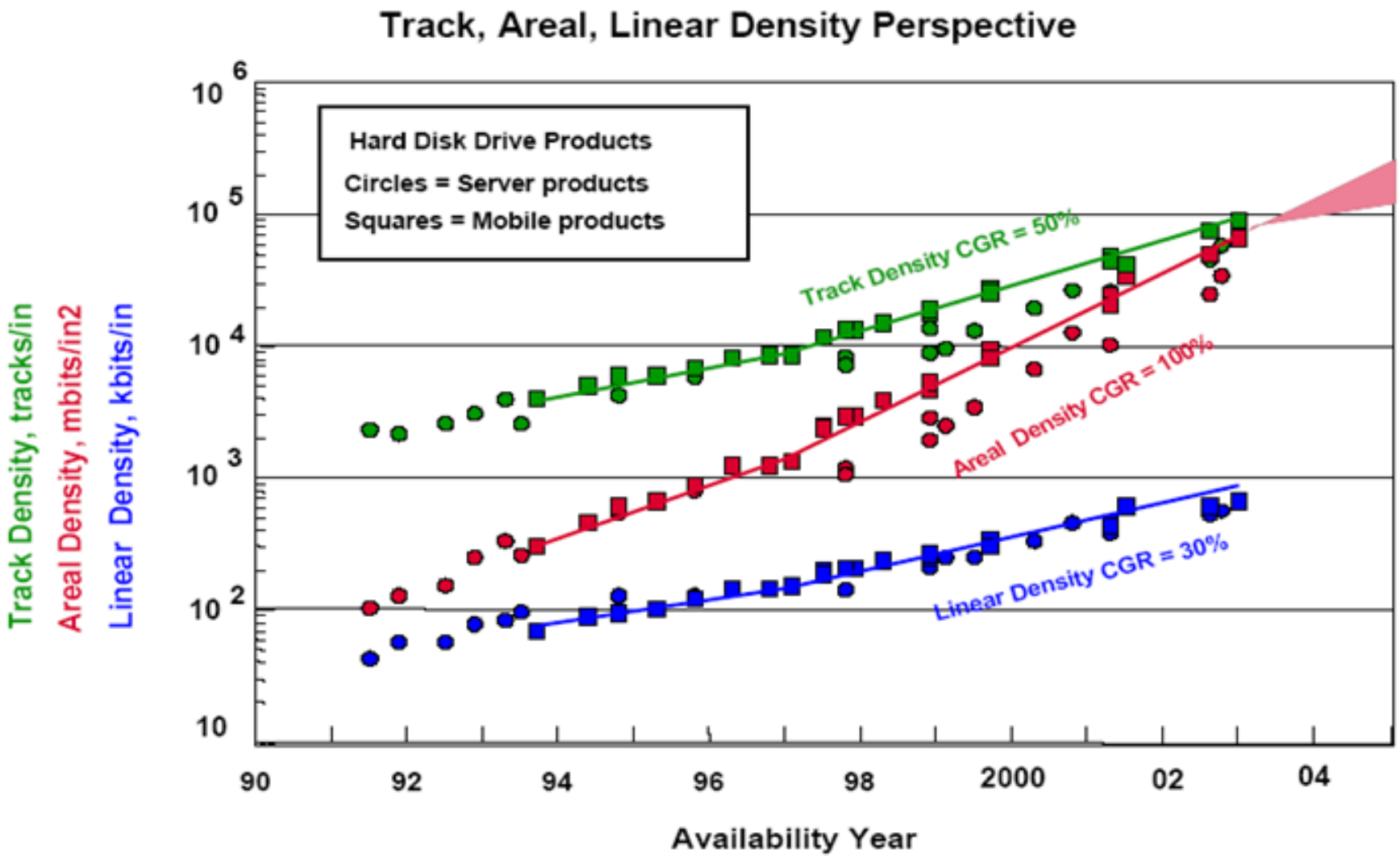


Storage Density

- Determines both capacity and performance
- Density Metrics
  - Linear density (Bits/inch or BPI)
  - Track density (Tracks/inch or TPI)
  - Areal Density = BPI x TPI

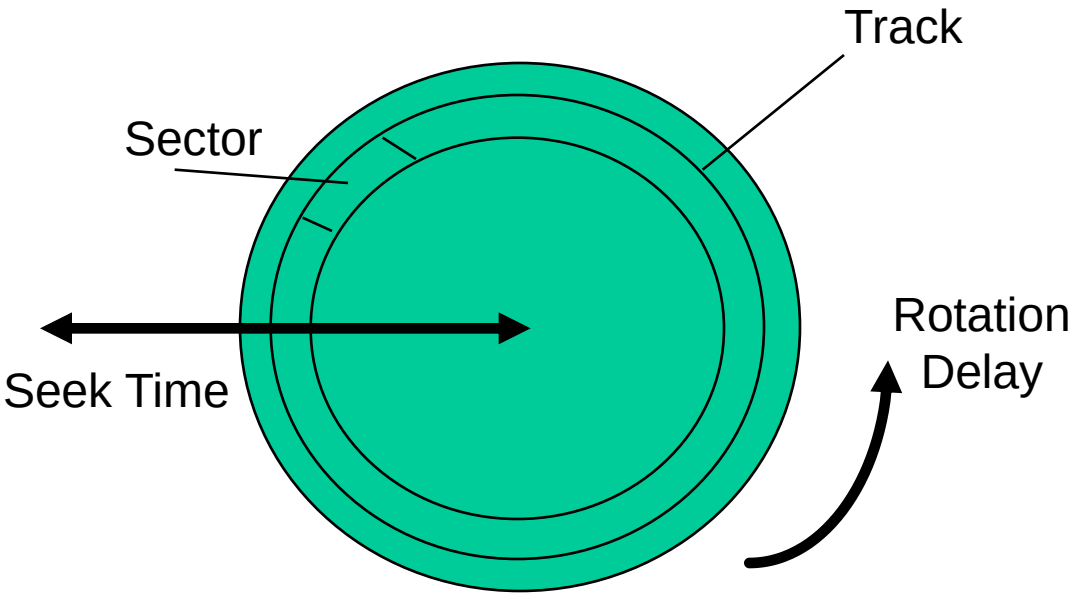


Storage Density Trends



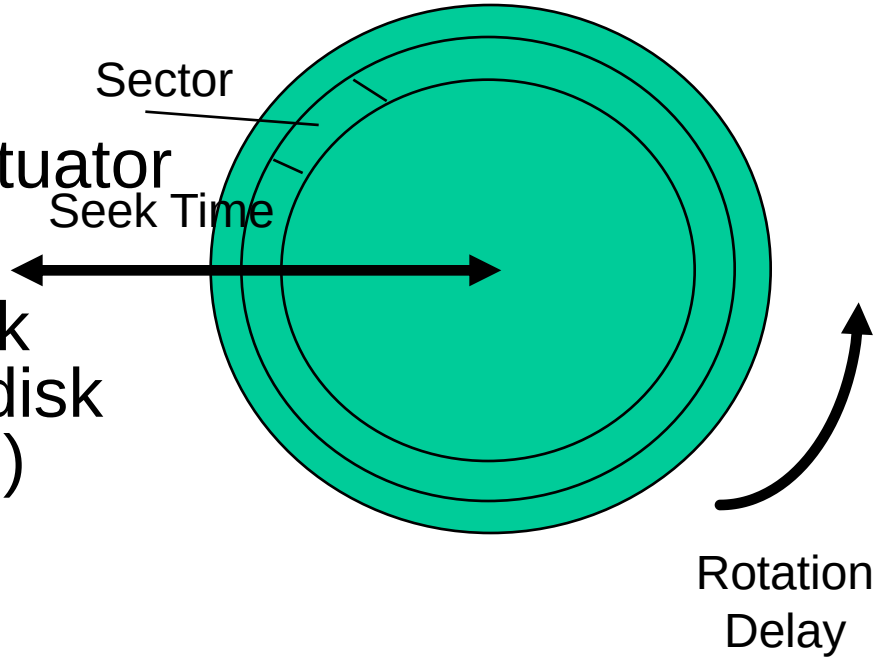
Disk Access Time

- To read from disk, we must specify:
  - cylinder #, surface #, sector #, size, memory address
- Transfer time includes:
  - Seek time: to get to the track
  - Rotational Latency: to get to the sector and
  - Transfer time: get bits off the disk



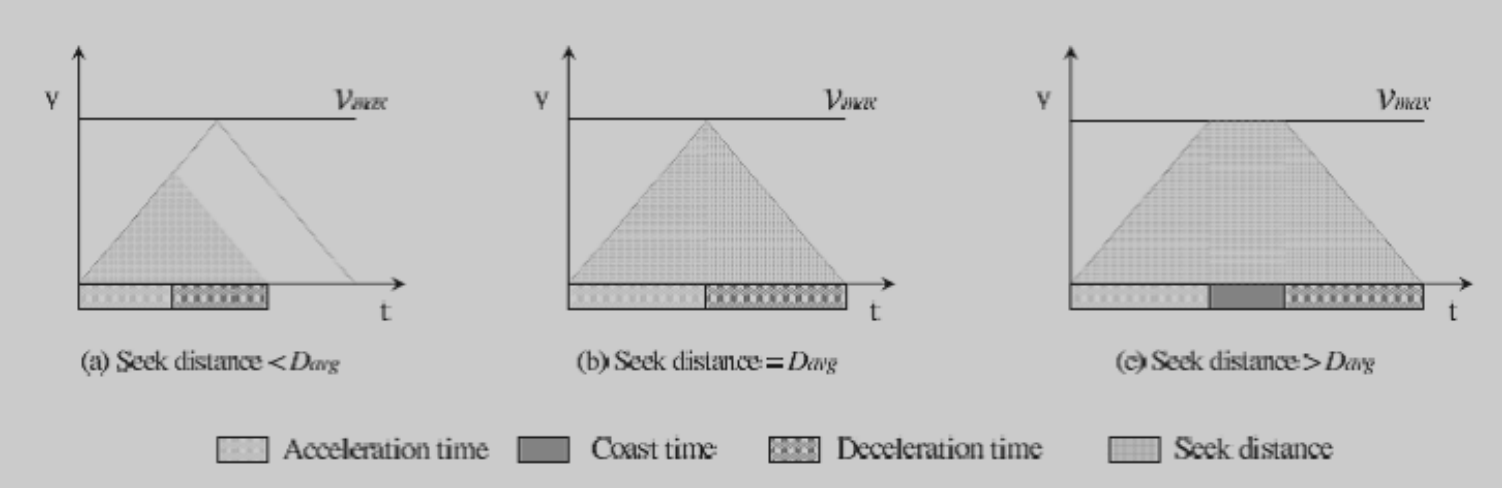
Seek Time

- **Seek time depends on:**
  - Inertial power of the arm actuator motor
  - Distance between outer-disk recording radius and inner-disk recording radius (data-band)
  - Depends on platter-size



- **Components of a seek:**
- Speedup: Arm accelerates
- Coast: Arm moving at maximum velocity (long seeks)
- Slowdown: Arm brought to rest near desired track
- Settle: Head is adjusted to reach the access the desired location

Variations in Seek Time



- Very short seeks (2-4 cylinders)
  - Settle-time dominates
- Short seeks (100-200 cylinders)
  - Speedup/Slowdown-time dominates
- Longer seeks (> 200 cylinders)
  - Coast-time dominates
- With smaller platter-sizes and higher TPI
  - Settle-time becoming more important

Disk Scheduling

- Access time has two major components
  - **Seek time** is time to move the heads to the cylinder containing the desired sector
  - **Rotational latency** is additional time waiting to rotate the desired sector to the disk head.
- Minimize seek time
- Disk bandwidth is total number of bytes transferred, divided by the total time between the first request for service and the completion of the last transfer.

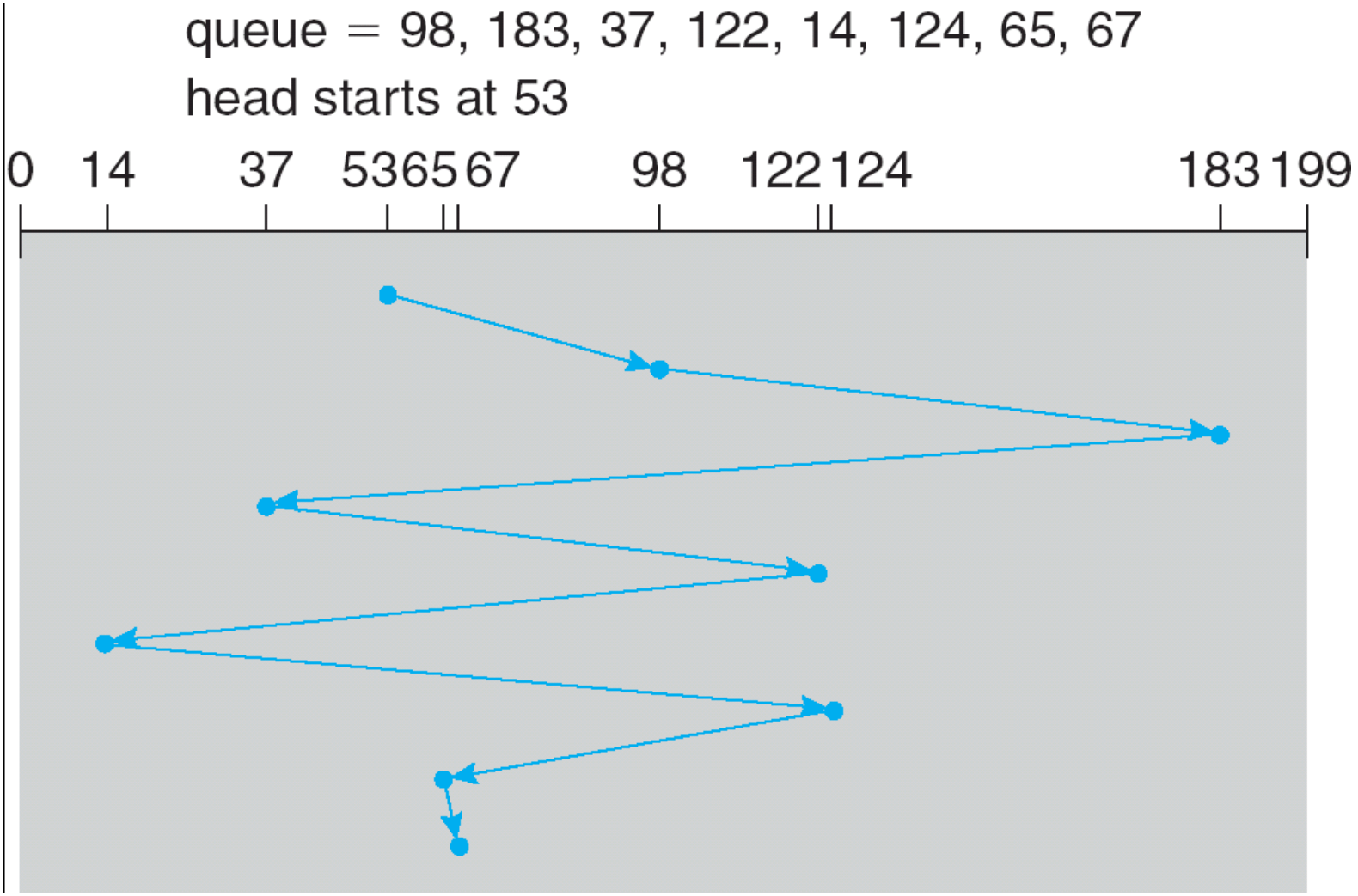
Disk Scheduling Algorithms

- The order in which disk cylinder request are serviced so as to optimize average seek time.
  - **FCFS**
  - **SSTF**
  - **SCAN**
  - **C-SCAN**
  - **C-LOOK**

- Illustration total 200 cylinders 0-199
- Request order- 98, 183, 37, 122, 14, 124, 65, 67
- Head pointer 53

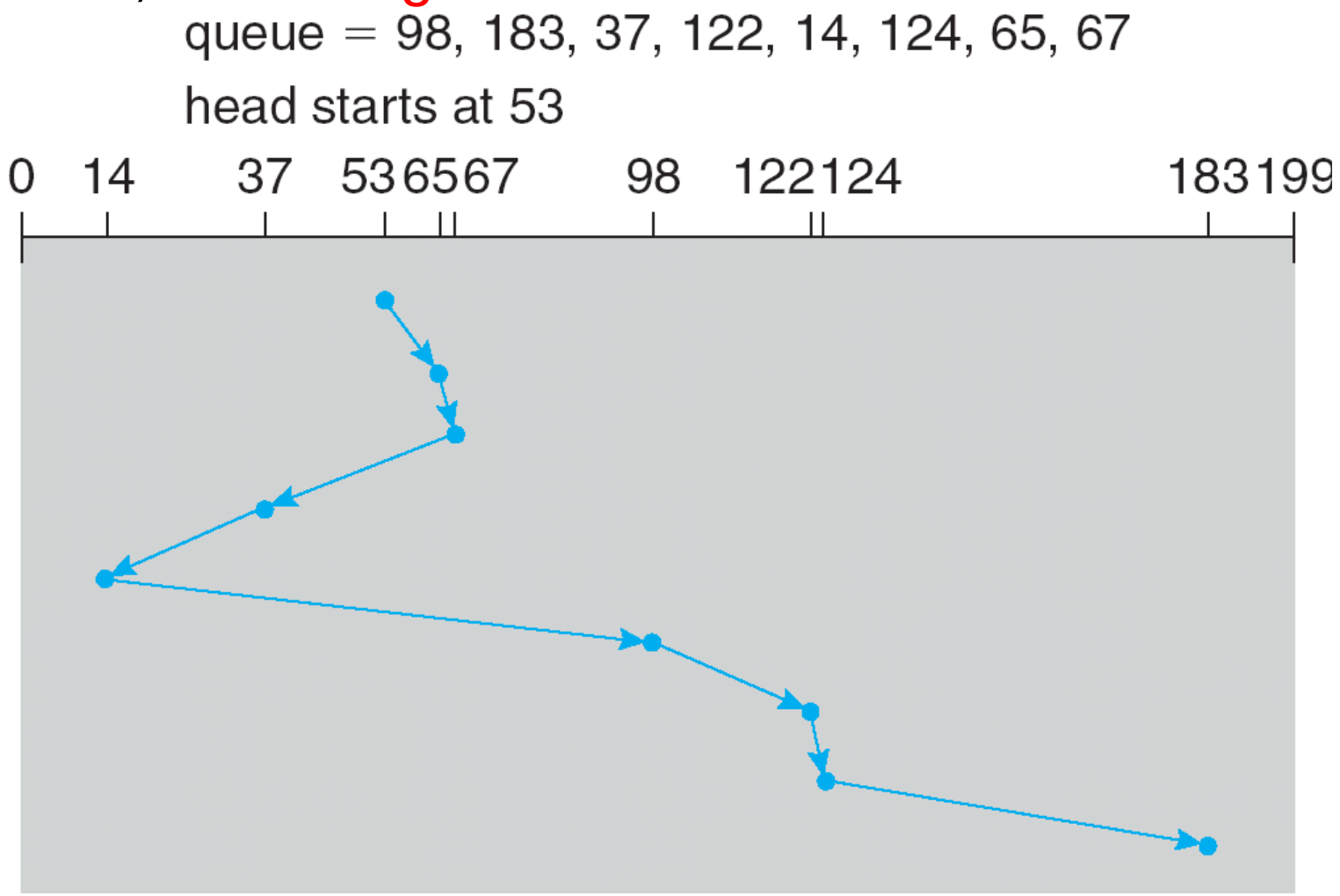
Disk Scheduling Algorithm: FCFS

Total head movements = 640



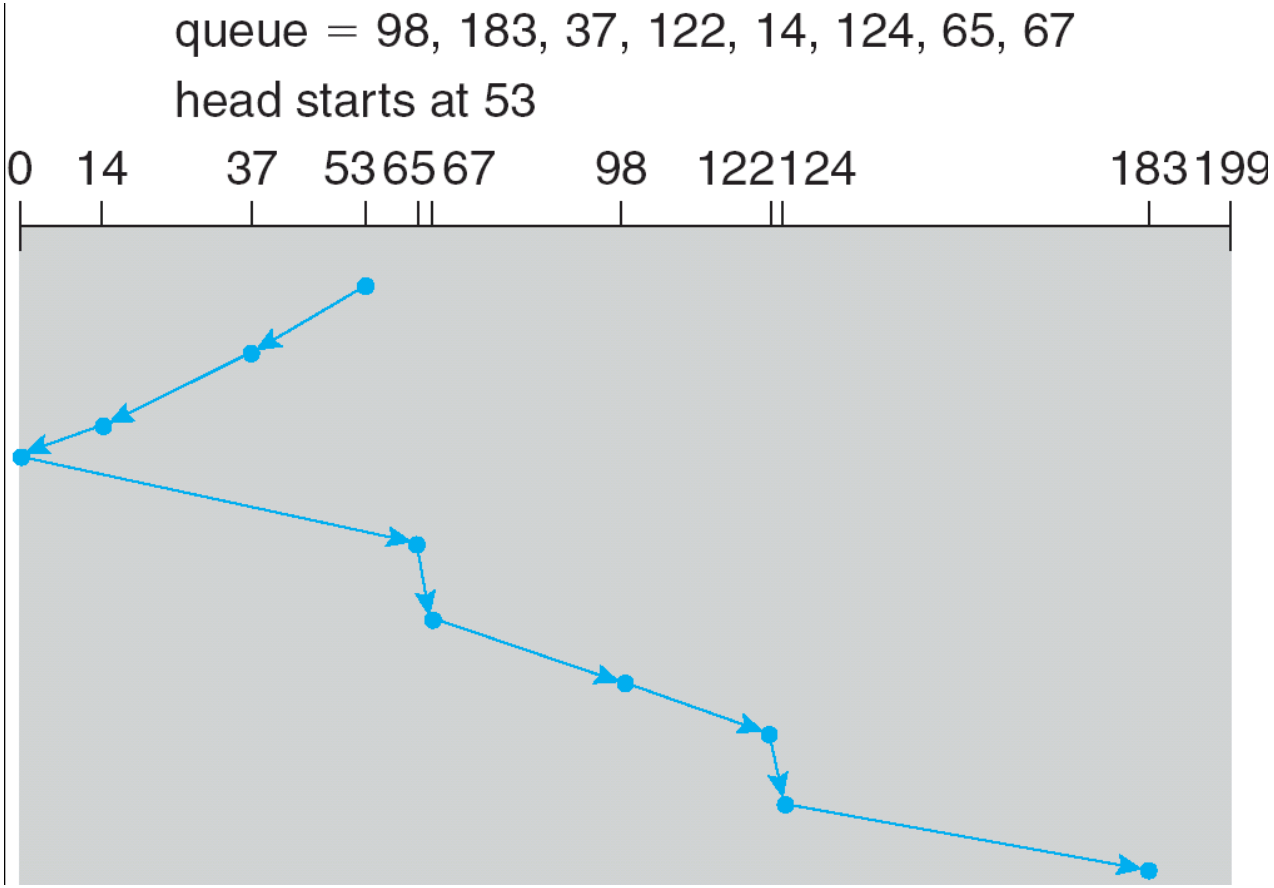
Disk Scheduling Algorithm: SSTF

- Selects request with minimum seek time from current head position, here we get 236 head movements.



Disk Scheduling Algorithm: SCAN

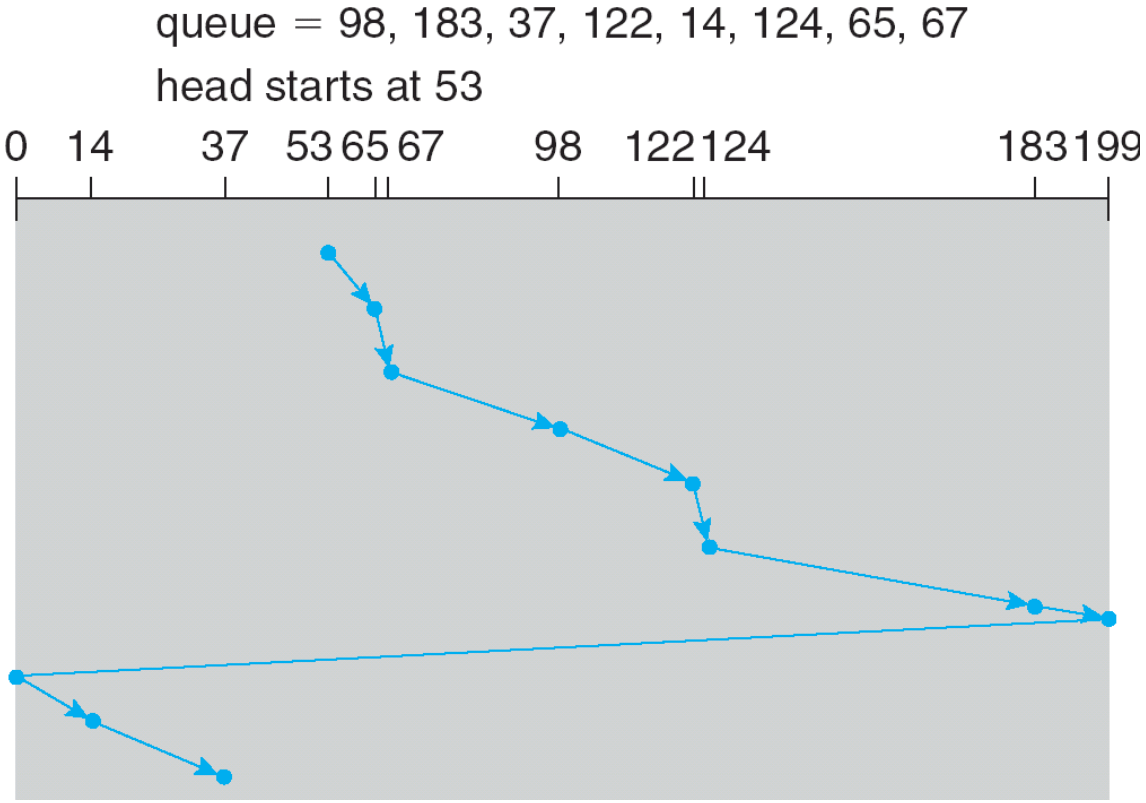
- The disk arm moves toward one end servicing requests
- Head movement is reversed when it reach the end and servicing continues. [Also known as elevator algorithm].



Total head movement of 208 cylinders

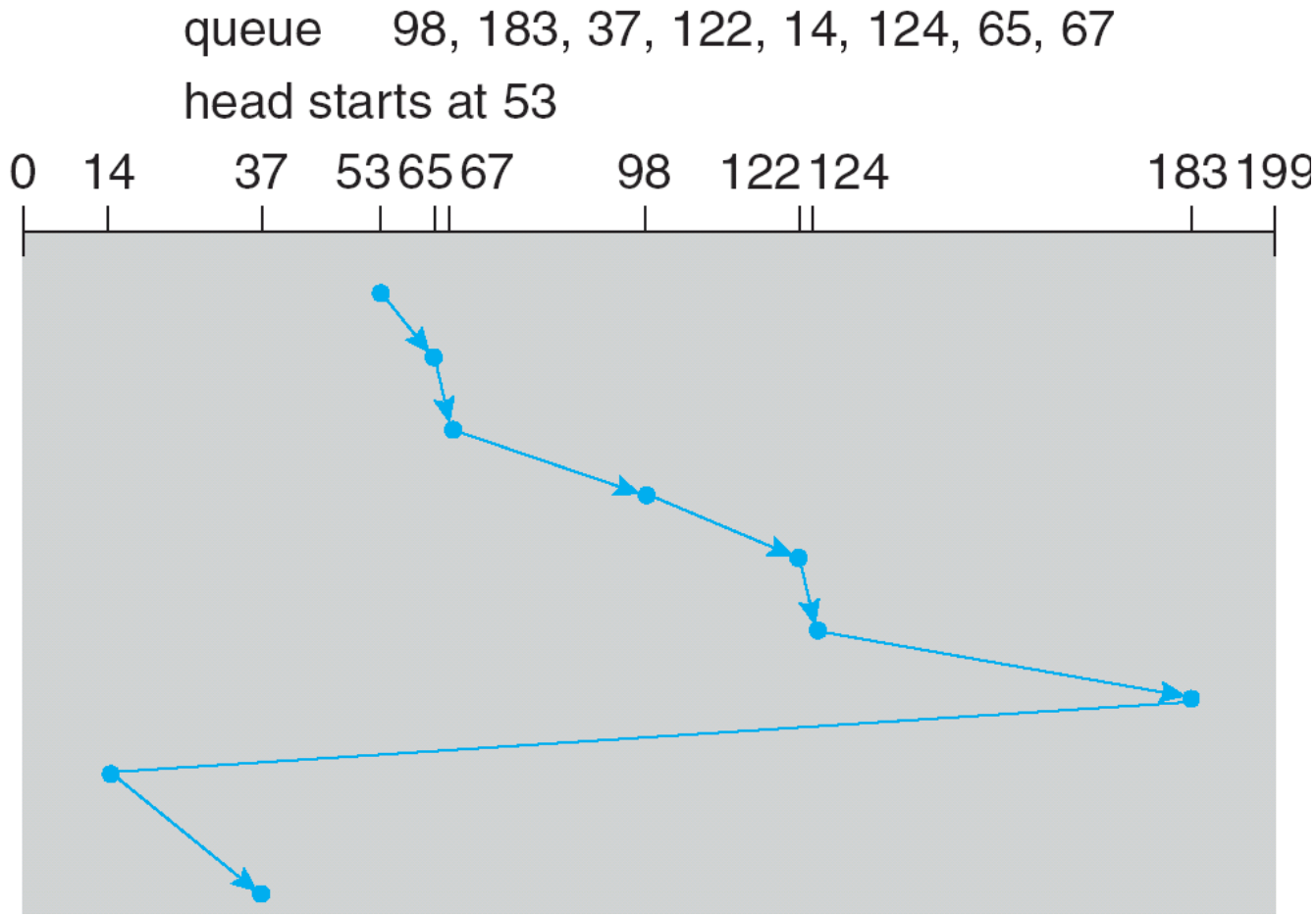
Disk Scheduling Algorithm : C-SCAN

- The head moves from one end of the disk to the other and service the requests as it goes.
- When it reaches the other end it immediately returns to beginning of the disk, No servicing on the return trip.



Disk Scheduling Algorithm : C-LOOK

- Version of C-SCAN
- Arm only goes as far as last request in each direction, then reverses direction immediately,



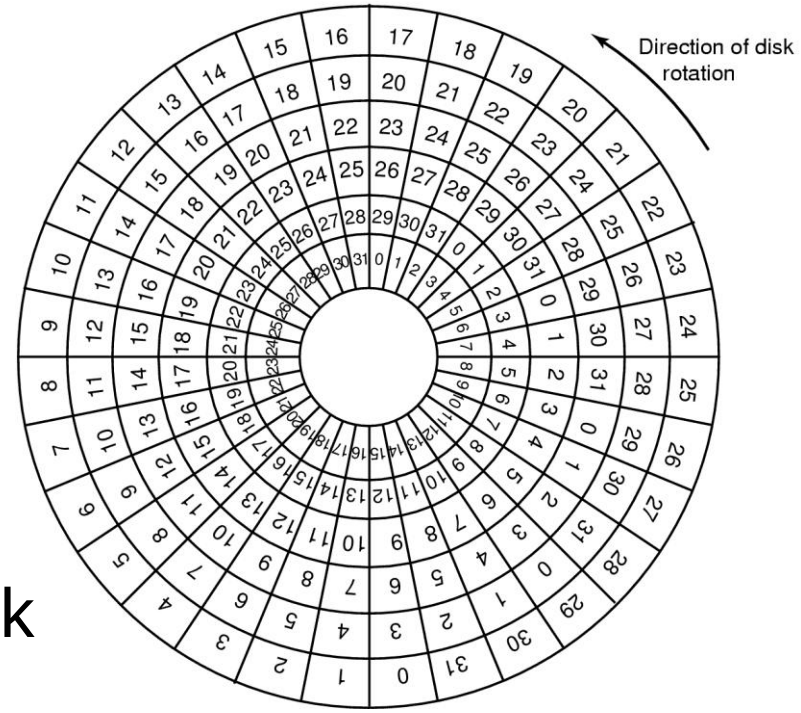
Disk Formatting

- **Low-level formatting** is the process of outlining the positions of the tracks and sectors on the hard disk, and writing the control structures that define where the tracks and sectors. Latest hard disks are LLF at factory.

- **High-level formatting** is the process of initializing portions of the hard disk and creates the file system structures on the disk, such as the master boot record and the file allocation tables. High-level formatting is typically done to erase the hard disk and reinstall the operating system back onto the disk drive.

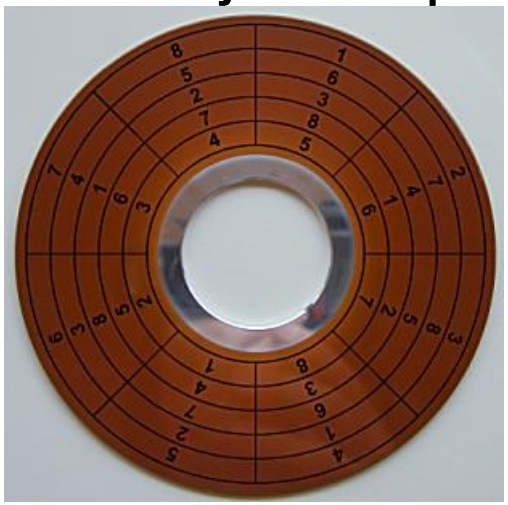
Cylinder Skew

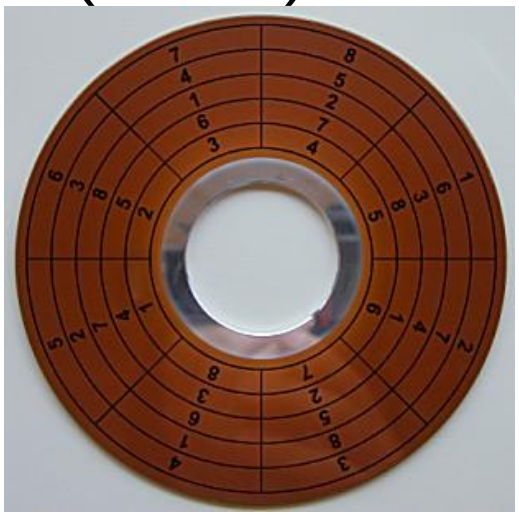
- Why cylinder skew?
- Offsetting the start sector of adjacent tracks to minimize the likely wait time (rotational latency) when switching tracks
- How much skew?
- Example, if 10000 rpm disk drive rotates in 6 ms.
  - Track has 300 sectors
  - New sector every 20 µs
  - If track seek time 800 µs
    - 40 sectors pass on seek
- Cylinder skew: 40 sectors



Head Skew

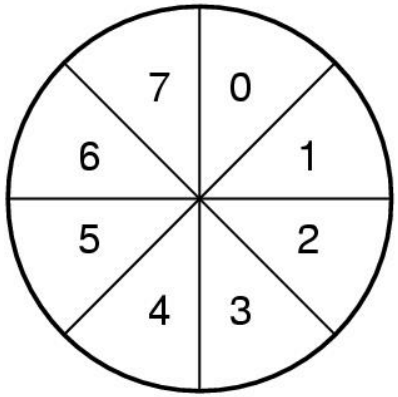
- Occurs when we change heads within a cylinder, but different platter surfaces.
- Here there is no physical movement of arm assembly.
- But it still takes time for the switch from reading one head to reading another.
- Head skew is the offsetting done on the start sector of tracks of adjacent platters (heads) of same cylinder.





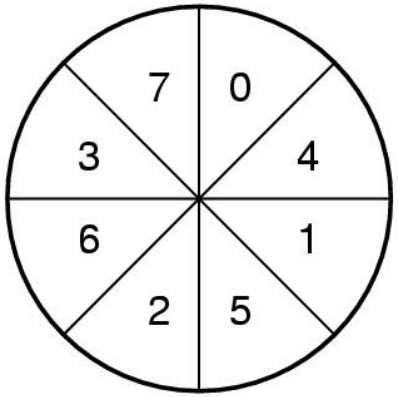
Sector Interleaving

- To ensure that sector #n+1 didn't rotate past the head while sector #n was being processed.



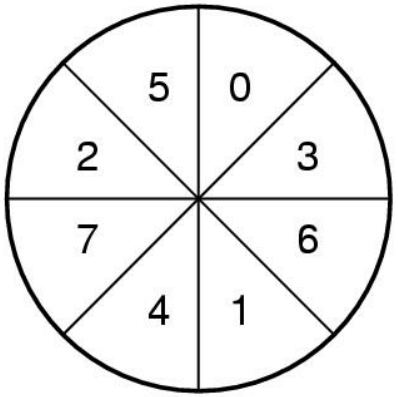
(a)

No interleaving



(b)

Single interleaving

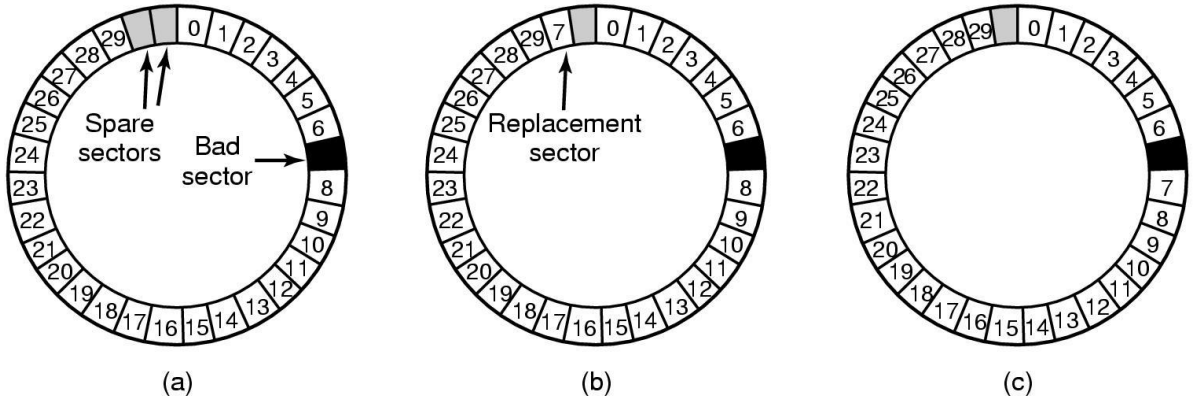


(c)

Double interleaving

Bad sector management in disks

- **Bad sector** is a sector on disk that is either inaccessible or un-writeable due to permanent damage.
- Bad sectors are usually detected by LLF or HLF or by utility software such as CHKDSK or SCANDISK .
- The sectors unusable are not used for storage.
- If a file uses a sector which is marked as bad then the bad sector of the file is remapped to a free sector.
- 2 approaches- Sector slipping & Sector forwarding



johnjose@iitg.ac.in
http://www.iitg.ac.in/johnjose/