CS209 Computer Architecture

Storage(Secondary)

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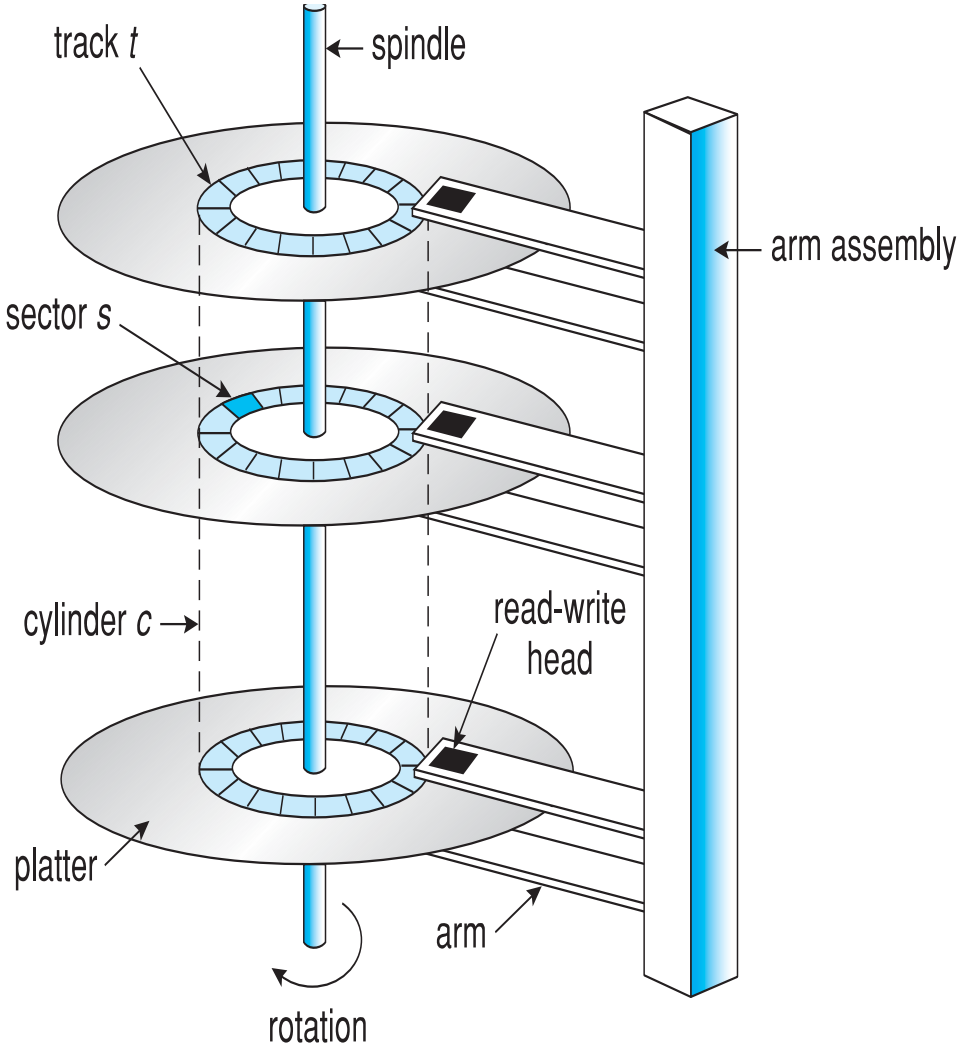
External Memory: Magnetic Disk

- Disk is a circular platter constructed with substrate coated with magnetisable material (iron oxide…rust)

Substrate:
used to be aluminium
Now glass
- Improve magnetic film surface uniformity
- Increases reliability
- Reduction in surface defects
- Reduced read/write errors
- Better shock/damage resistance

A Multi-Platter Disk

- Externally, hard drives expose a large number of sectors (blocks)
  - Typically 512 or 4096 bytes
  - Sectors arranged into tracks
  - A cylinder is a particular track on multiple platters
  - A disk may have multiple, double-sided platters
- Drive motor spins the platters at a constant rate
  - Measured in revolutions per minute (RPM)



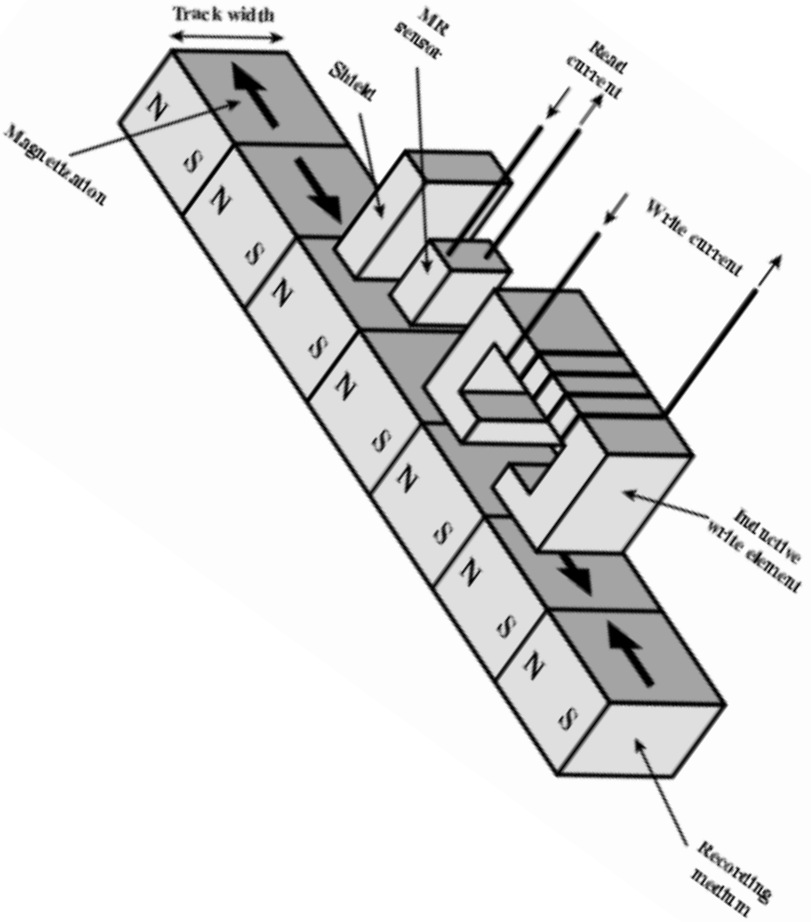
Write Mechanisms

- 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

  - Send Electric Pulses to the head
  - Record the Magnetic pattern on the surface below

MR: Magneto-resistive



Read Mechanism

- Read (traditional)
  - Magnetic field moving relative to coil produces current
  - Place the surface under the head
  - Observe the current (on the same polarity it is recorded)

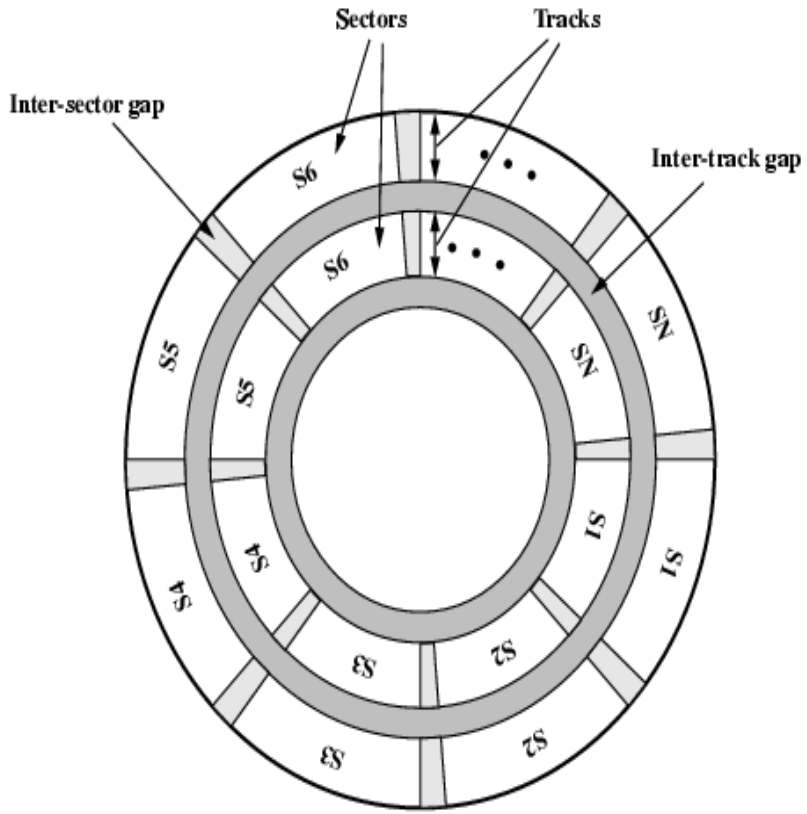
  - Coil is the same for read and write

- Read (contemporary)
  - Separate read head, close to write head
  - Head consists of Partially shielded magneto resistive sensor
  - Electrical resistance depends on direction of magnetic field
  - Passing current through the MR sensor resistance changes are detected as voltage signal

  - High frequency operation

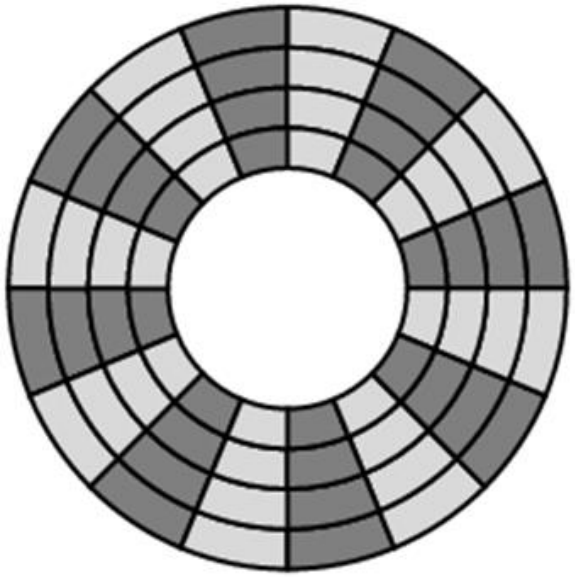
Data Organization and Formatting

- Concentric rings or tracks
  - Each track has the same width of the head
  - Gaps between tracks
    - Reduce gap to increase capacity
- Tracks divided into sectors
    - Data transfer occurs in sector wise
    - Sector size is generally fixed 512 bytes
      - (may be variable also)



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
- Rotate disk at constant angular velocity (CAV)
  - Individual tracks and sectors are addressable
  - Move head to given track and
    - wait for given sector
  - Regardless of head position, sectors pass beneath it at the same (constant) speed
  - Waste of space on outer tracks
    - Lower data density



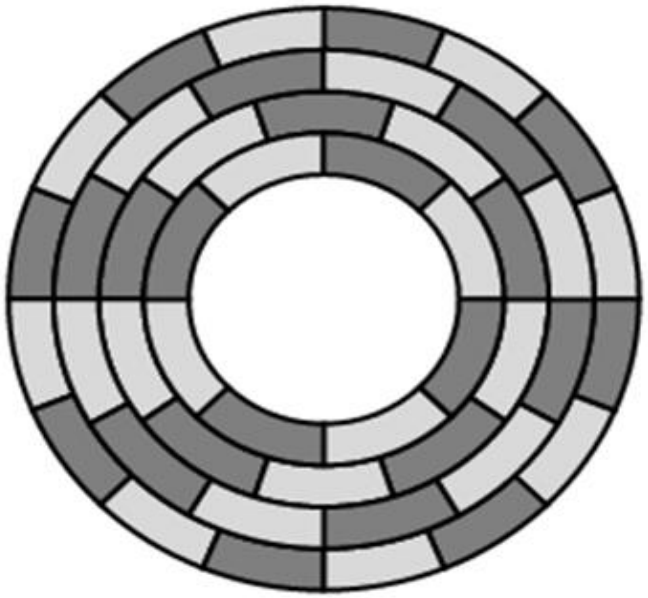
Constant angular velocity

Multiple Zone Reading

- Surface is divided into a number of concentric zones
  - Each zone has fixed bits/sectors per track
  - Zones farthest from the centre contains more bits (more sectors) then zones close to the centre

- MZR increases capacity

More complex circuitry to adjust different data rates as heads move farther out.



Multiple zoned recording

Finding Sectors

- Must be able to identify start of track and sector
- Format disk
  - Control information recorded on the disk
  - Additional information not available to user used only by the disk drives
  - Marks tracks and sectors

Characteristics

- Disk Portability
  - Removable or fixed
- Sides
  - Single or double (usually) sided
- Platters
  - Single or multiple platter

- Head Motion
  - Fixed or movable head
- Head mechanism
  - Contact (Floppy)
  - Fixed gap
  - Flying (Winchester)

Head Mechanism

- Head: Performs read or write portion of the platter under it
- Drive performance is affected by
  - Head size
  - Distance of head from platter
- Head must be able to generate and sense the E.M field in proper
- Smaller heads allow for higher densities, but force head to be closer to the disk
- The closer the head, the greater risk of "crashes"

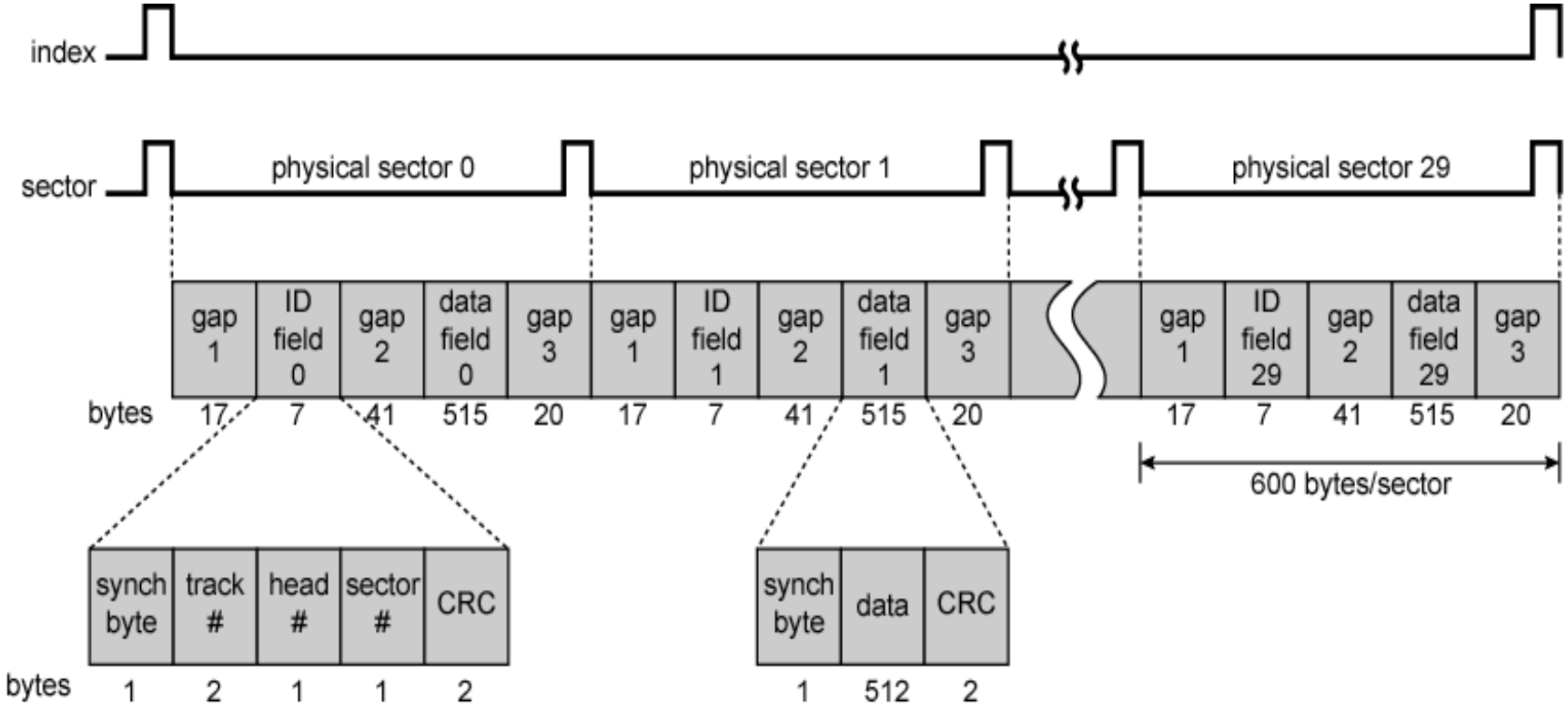
Winchester Hard Disk

- Developed by IBM in Winchester (USA)
- Sealed unit
- One or more platters (disks)

- Flying Head
  - Head rests on platter at rest
  - When platter spins, air pressure lifts head from platter
- Getting more robust

- Currently
  - Universal
  - Cheap
  - Fastest external storage
  - Getting larger all the time

Winchester Disk Format
Seagate ST506



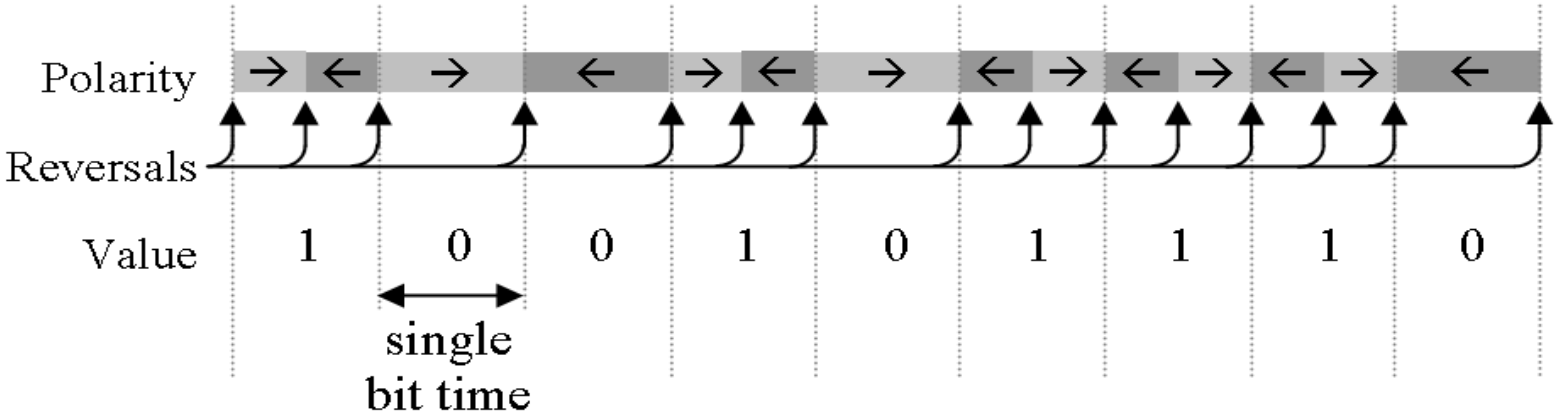
SYNCH byte delimits the beginning of the field

Data Encoding

- Data is not stored as two directions of magnetic polarization corresponding to two values, 1 and 0.
- Reasons:
  - Difficult to read large blocks of all ones or all zeros – eventually controller would lose synchronization
- Hard drive heads detect the *changes* in magnetic direction, not the direction of the field
- One method for storing data uses a clock to define the bit positions, and by watching how the magnetic field changes with respect to that clock indicates presence of 1 or 0.

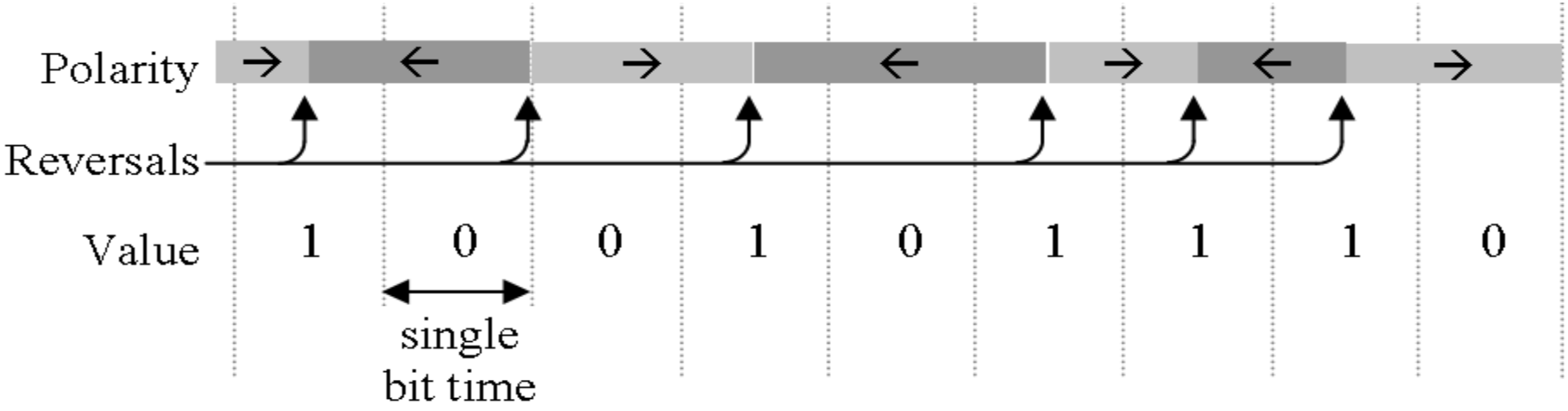
FM Encoding

- A magnetic field change at the beginning and middle of a bit time represents a logic one
- A magnetic field change only at the beginning represents a logic zero
- Referred to as *Frequency Modulation* (FM)



MFM Encoding

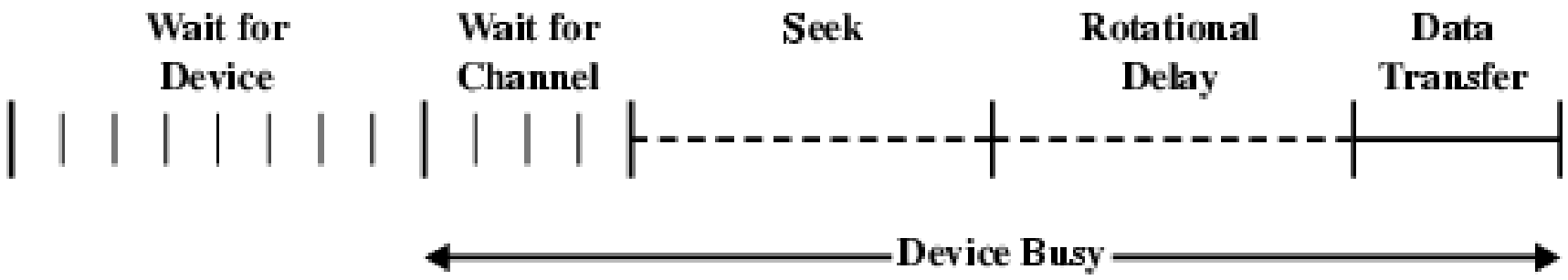
- Just like FM except that changes at beginning of bit time are removed unless two 0's are next to each other
- Called *Modified Frequency Modulation* (MFM)



Timing of Disk I/O Transfer

Queuing time – waiting for I/O device to be useable

Waiting for device – if device is serving another request
Waiting for channel – if device shares a channel with other devices (multiplexing)



Speed

- Seek time (Ts)
  - Moving head to correct track
- (Rotational) latency
  - Waiting for data to rotate under head (Average rotational delay is 1/2 time for full rotation = 1/2r)
- Access time = Seek + Latency
- Transfer time (T)
  - T = b/rN

  b:the number of bytes to be transferred

  r: rotation speed

  N: number of bytes on a track
- Total Average access time
  - Ta = Ts + 1/2r + b/rN

- Ex.: Consider a disk with an average seek time of 4 ms, rotation speed of 15,000 rpm, and 512-byte sectors. Estimate the total time for the transfer, if we wish to read a file consisting of 2500 sectors (occupied in adjacent track) with 500 sectors per track. Estimate the time require to access that file in sequential organization.

Ans.: 34ms
Ts =4ms
Tr = 1/2r = 2ms

Total rotational delay = (60/15000) =0.004s =4ms

Sequential org.
Total time for first track = 4 +2 +4 =10ms
Next (5-1) 4 tracks don't require access time so total time = 4 * 6 =24ms
Total Acess time for 2500 sectors = 10+24 =34ms