D.P.B.S PG COLLEGE ANOOPSHAHR ,BSR

Device Management

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Operating Systems

BCA -IV SEM

So far…

- We have covered CPU and memory management
- Computing is not interesting without I/Os
- ***Device management:*** the OS component that manages hardware devices
  - Provides a uniform interface to access devices with different physical characteristics
  - Optimizes the performance of individual devices

Basics of I/O Devices

- Three categories
  - A ***block device*** stores information in fixed-size blocks, each one with its own address
    - e.g., disks
  - A ***character device*** delivers or accepts a stream of characters, and individual characters are not addressable
    - e.g., keyboards, printers
  - A ***network device*** transmit data packets

Device Controller

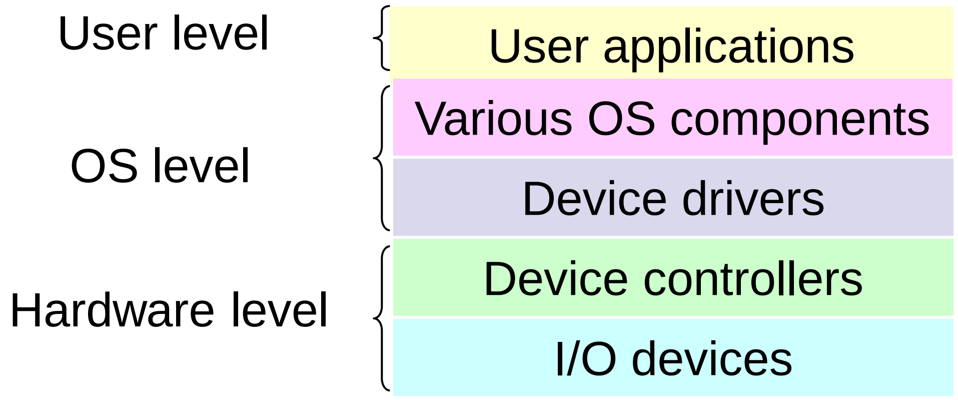
- Converts between serial bit stream and a block of bytes

- Performs error correction if necessary
- Components:
  - Device registers to communicate with the CPU
  - Data buffer that an OS can read or write

Device Driver

- An OS component that is responsible for hiding the complexity of an I/O device
- So that the OS can access various devices in a uniform manner

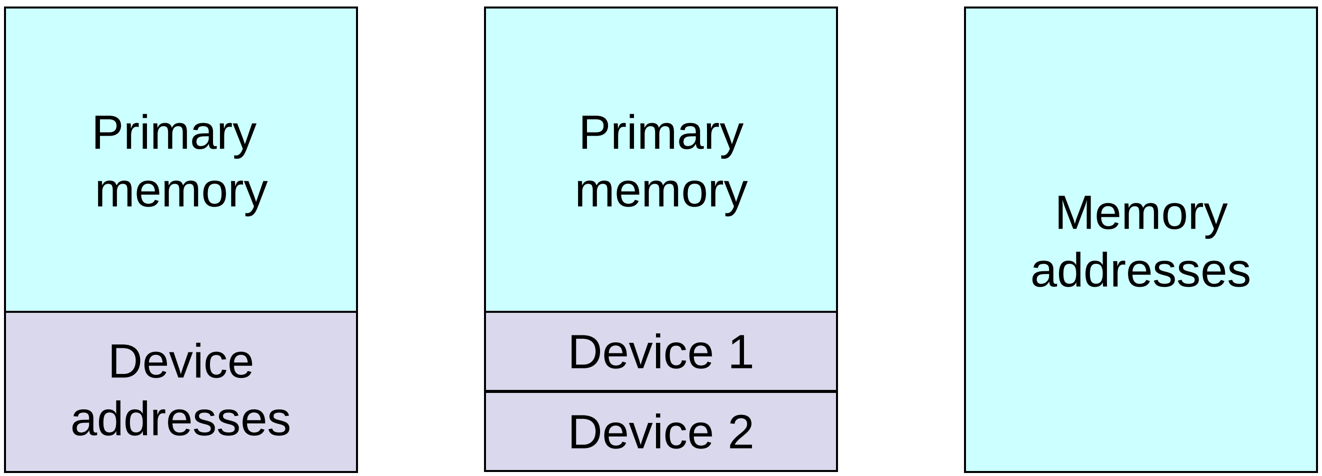
Device Driver Illustrated



Device Addressing

- Two approaches
  - Dedicated range of device addresses in the physical memory
    - Requires special hardware instructions associated with individual devices
  - ***Memory-mapped I/O:*** makes no distinction between device addresses and memory addresses
    - Devices can be access the same way as normal memory, with the same set of hardware instructions

Device Addressing Illustrated



Separate device addresses

Memory-mapped I/Os

Ways to Access a Device

- ***Polling:*** a CPU repeatedly checks the status of a device for exchanging data

  + Simple

  - Busy-waiting

Ways to Access a Device

- ***Interrupt-driven I/Os:*** A device controller notifies the corresponding device driver when the device is available

  + More efficient use of CPU cycles

  - Data copying and movements

  - Slow for character devices (i.e., one interrupt per keyboard input)

Ways to Access a Device

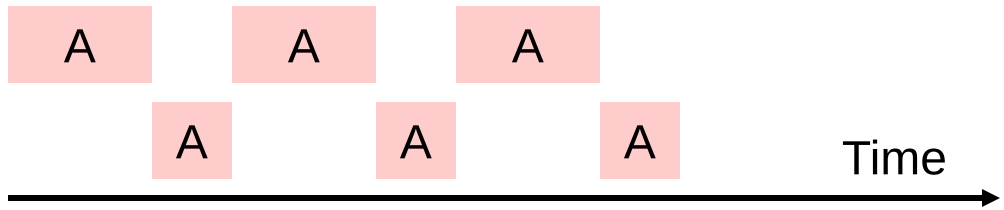
- ***Direct memory access (DMA):*** uses an additional controller to perform data movements
  - \+ CPU is not involved in copying data
  - \- A process cannot access in-transit data

Ways to Access a Device

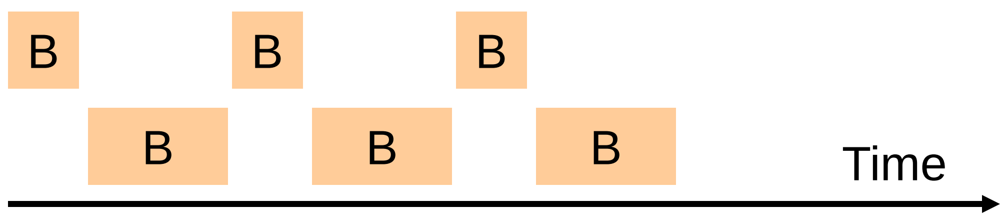
- ***Double buffering:*** uses two buffers. While one is being used, the other is being filled
  - Analogy: pipelining
  - Extensively used for graphics and animation
    - So a viewer does not see the line-by-line scanning

Overlapped I/O and CPU Processing

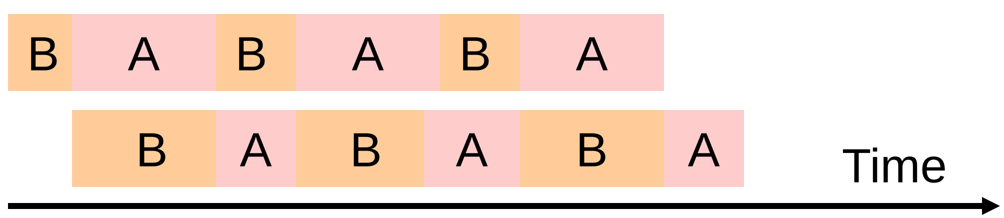
- Process A (infinite loop)
  - 67% CPU
  - 33% I/O



- Process B (infinite loop)
  - 33% CPU
  - 67% I/O



- SRTF
  - CPU
  - I/O

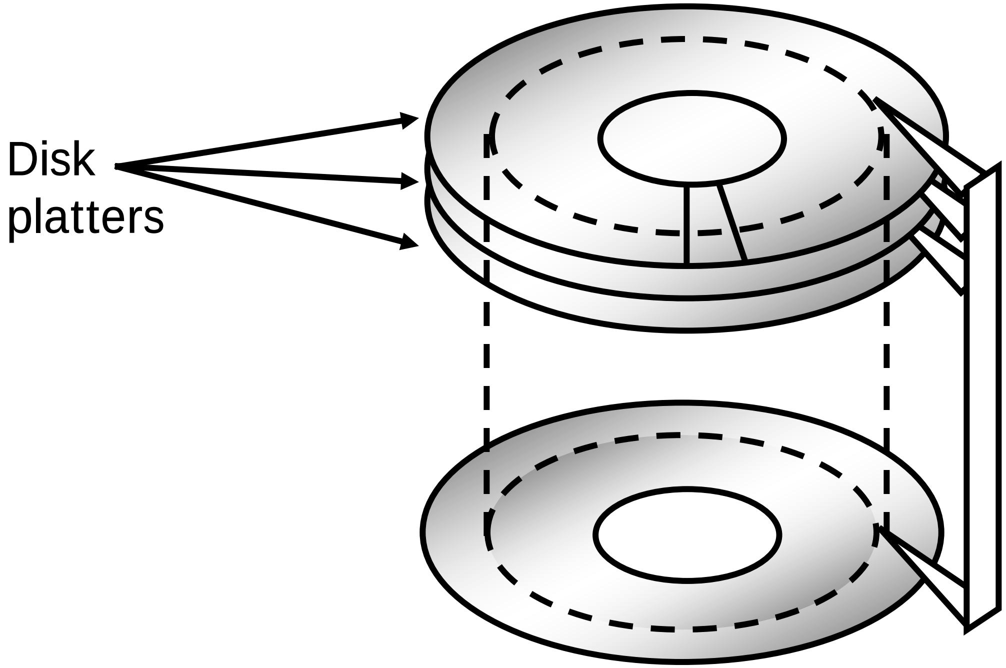


Disk as An Example Device

- 40-year-old storage technology
- Incredibly complicated
- A modern drive
  - 250,000 lines of micro code

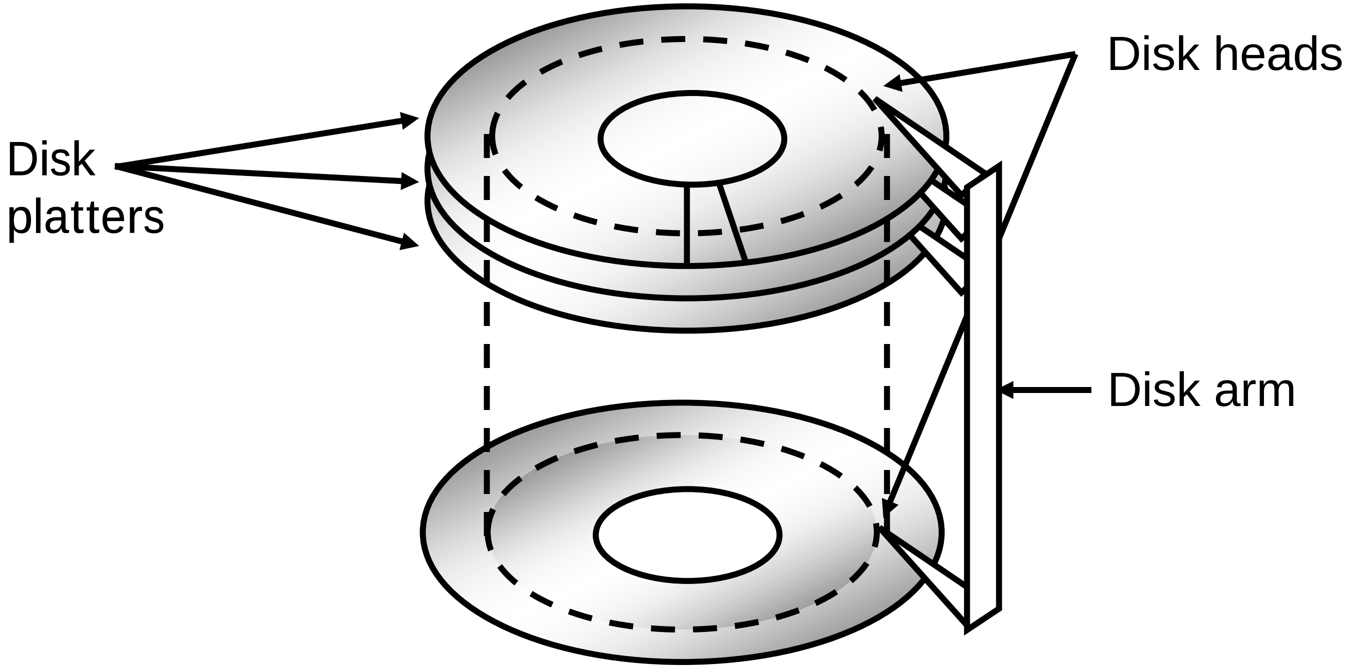
Disk Characteristics

- ***Disk platters:*** coated with magnetic materials for recording



Disk Characteristics

- ***Disk arm:*** moves a comb of ***disk heads***
  - Only one disk head is active for reading/writing

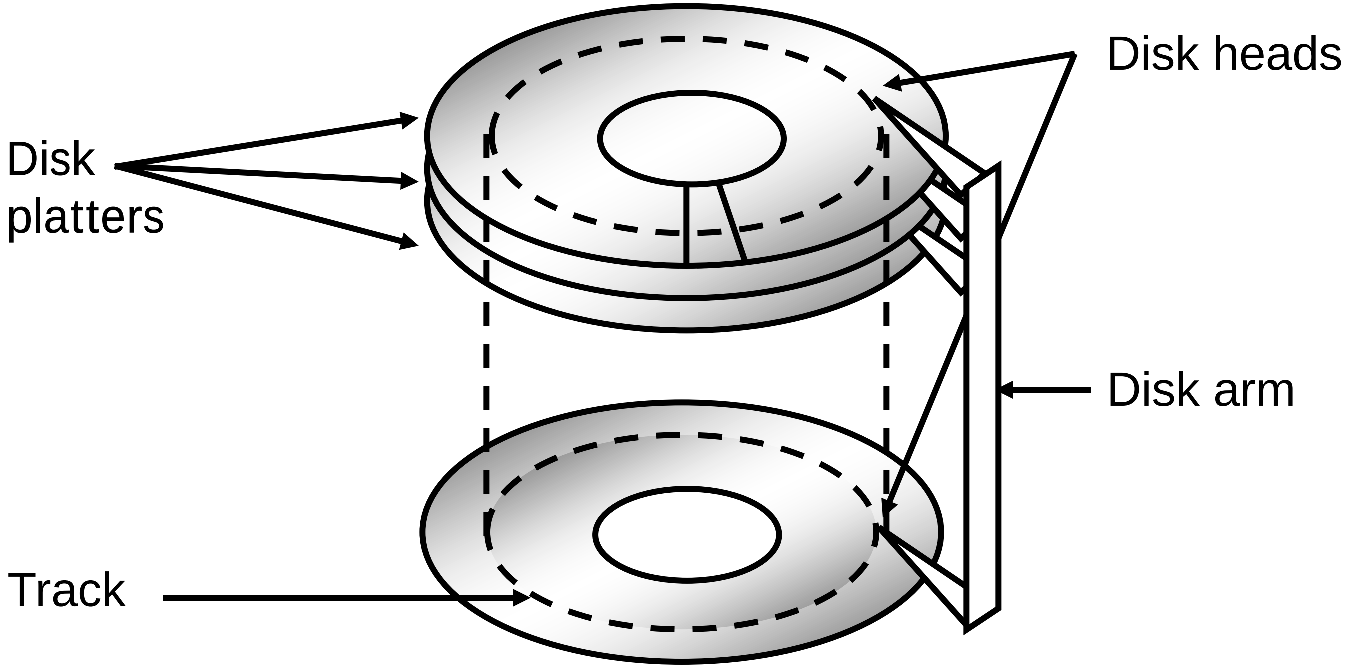


Hard Disk Trivia…

- Aerodynamically designed to fly
  - As close to the surface as possible
  - No room for air molecules
- Therefore, hard drives are filled with special inert gas
- If head touches the surface
  - Head crash
  - Scrapes off magnetic information

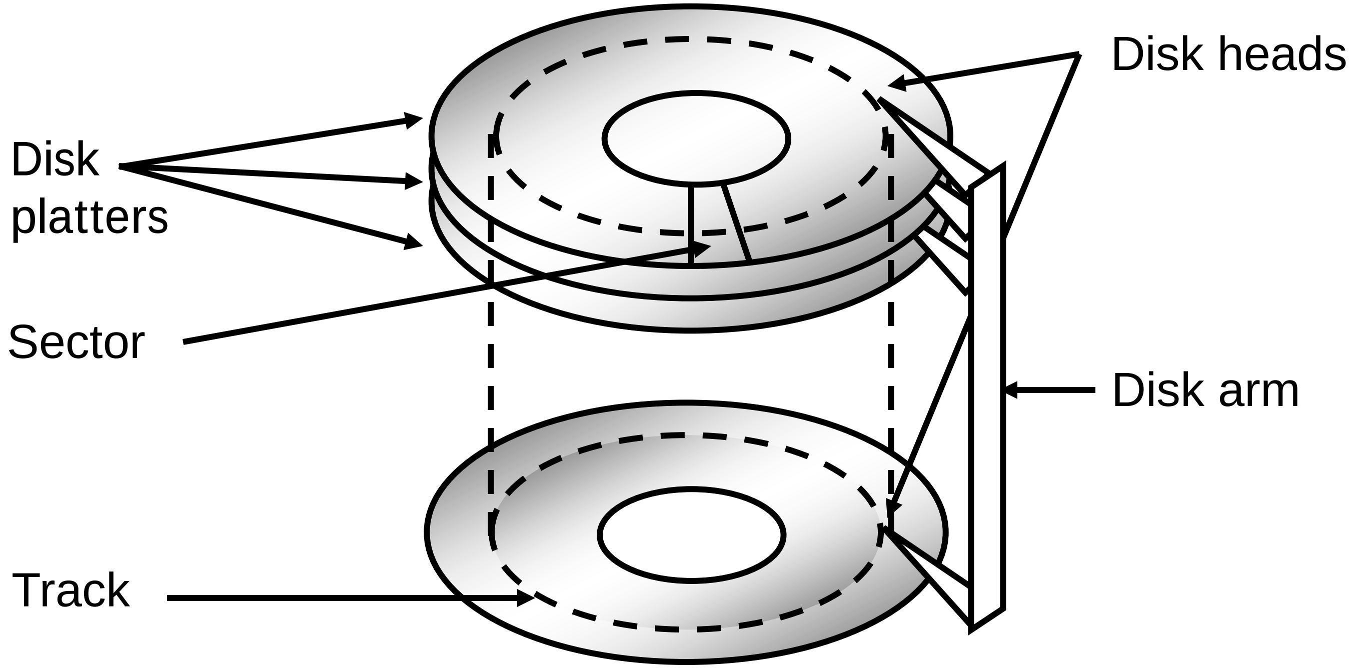
Disk Characteristics

- Each disk platter is divided into concentric ***tracks***



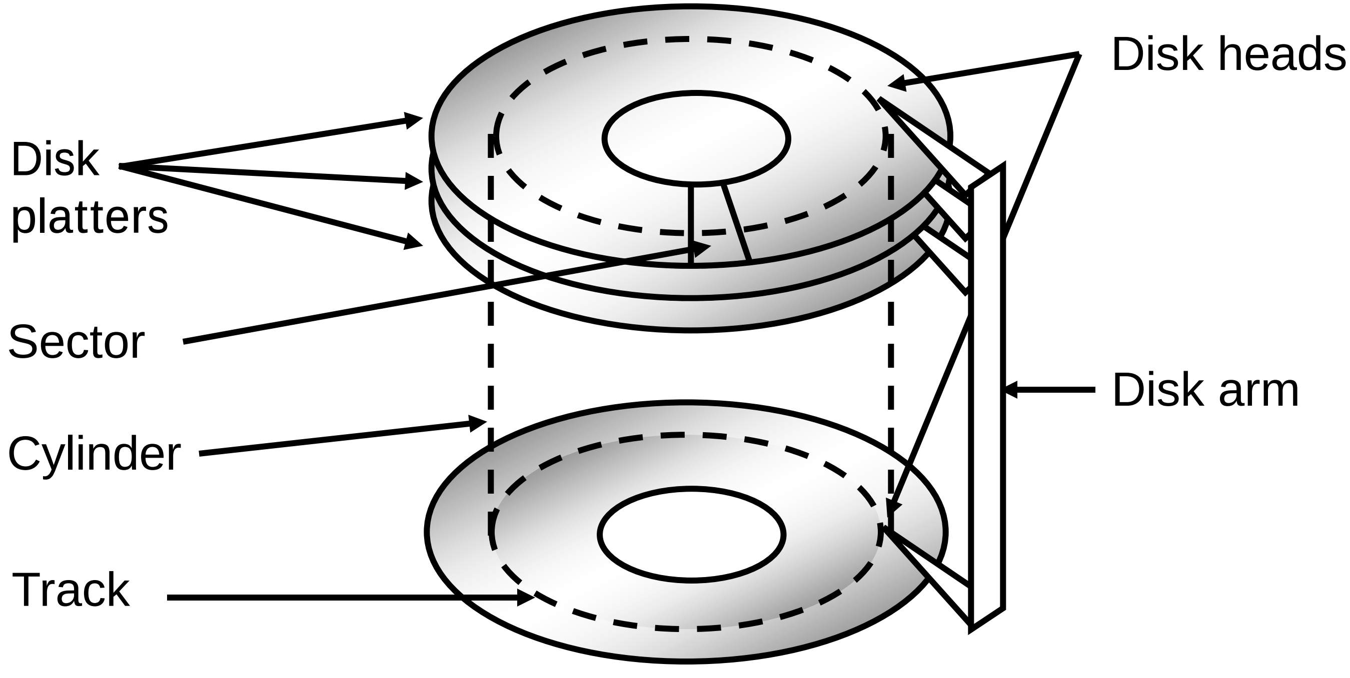
Disk Characteristics

- A track is further divided into ***sectors.*** A sector is the smallest unit of disk storage



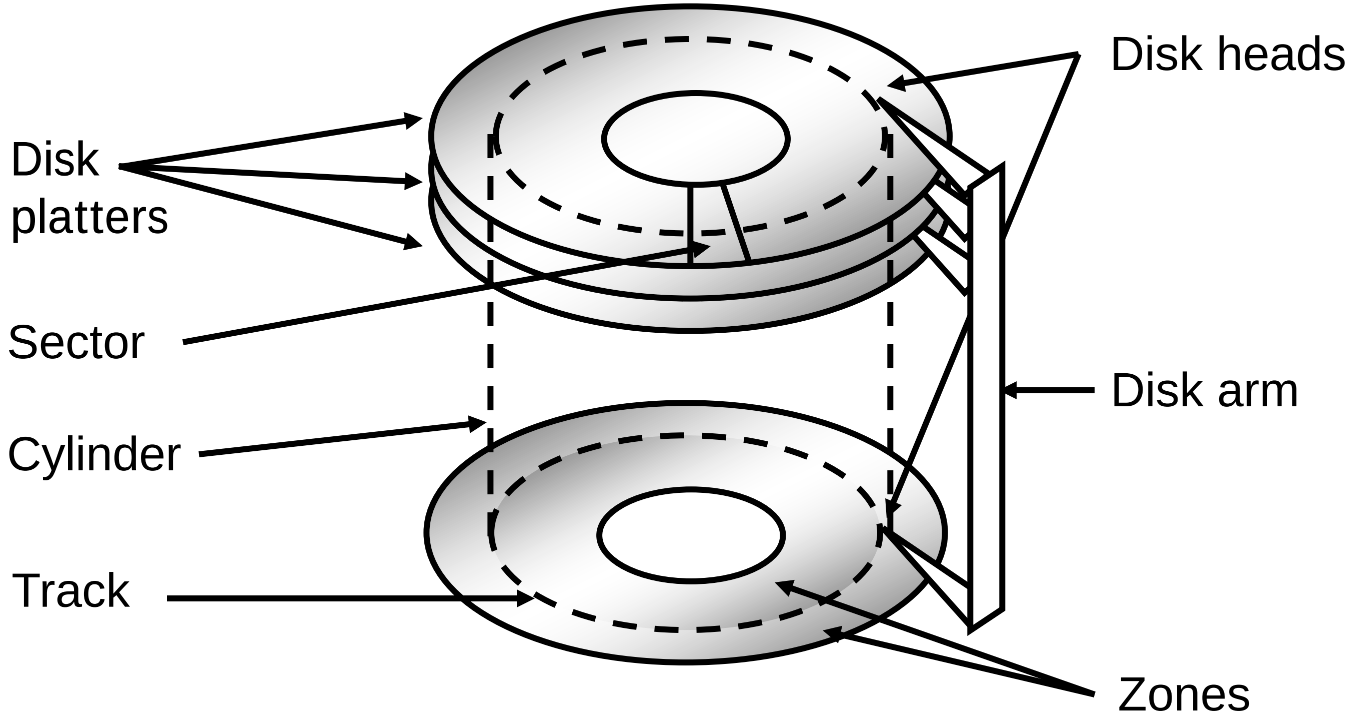
Disk Characteristics

- A ***cylinder*** consists of all tracks with a given disk arm position



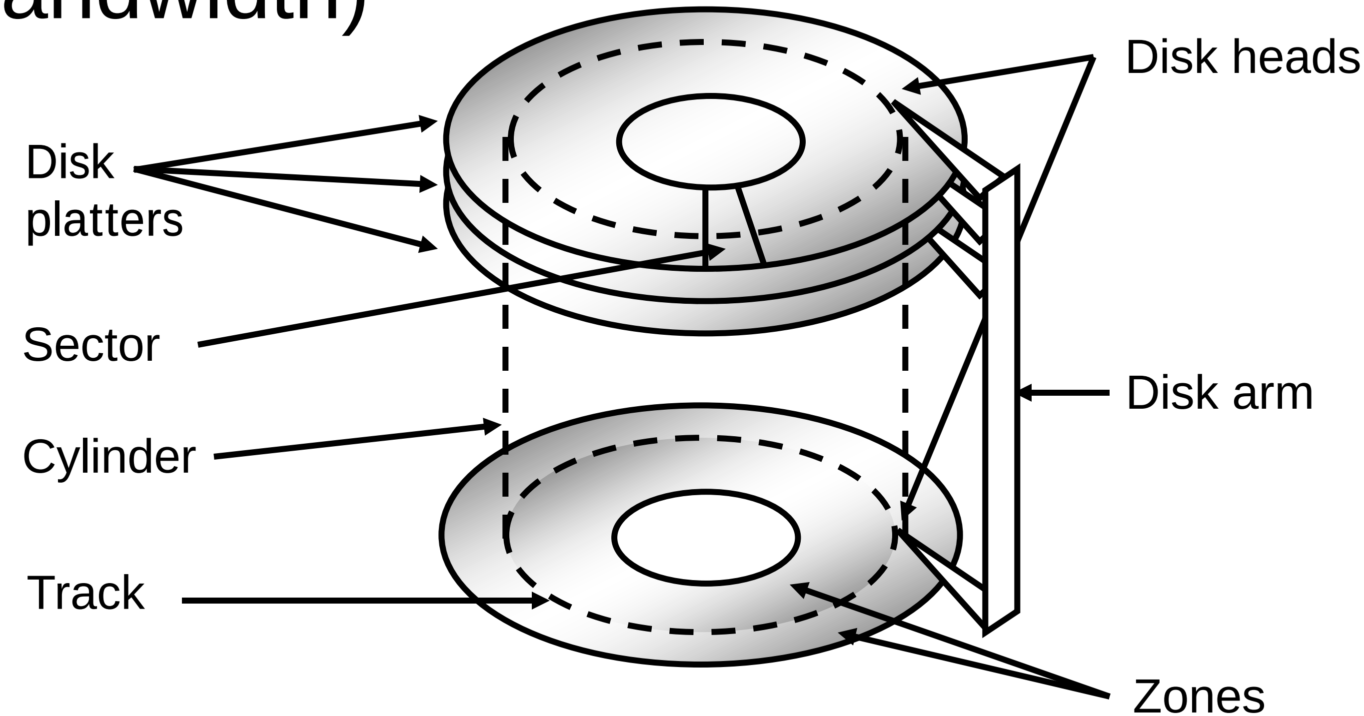
Disk Characteristics

- Cylinders are further divided into ***zones***



Disk Characteristics

- ***Zone-bit recording***: zones near the edge of a disk store more information (higher bandwidth)



More About Hard Drives Than You Ever Want to Know

- ***Track skew***: starting position of each track is slightly skewed
  - Minimize rotational delay when sequentially transferring bytes across tracks
- ***Thermo-calibrations:*** periodically performed to account for changes of disk radius due to temperature changes
- Typically 100 to 1,000 bits are inserted between sectors to account for minor inaccuracies

Disk Access Time

- ***Seek time:*** the time to position disk heads (~4 msec on average)
- ***Rotational latency:*** the time to rotate the target sector to underneath the head
  - Assume 7,200 rotations per minute (RPM)
  - 7,200 / 60 = 120 rotations per second
  - 1/120 = ~8 msec per rotation
  - Average rotational delay is ~4 msec

Disk Access Time

- ***Transfer time:*** the time to transfer bytes
  - Assumptions:
    - 58 Mbytes/sec
    - 4-Kbyte disk blocks
  - Time to transfer a block takes 0.07 msec
- ***Disk access time***
  - Seek time + rotational delay + transfer time

Disk Performance Metrics

- ***Latency***
  - Seek time + rotational delay
- ***Bandwidth***
  - Bytes transferred / disk access time

Examples of Disk Access Times

- If disk blocks are randomly accessed
  - Average disk access time = ~8 msec
  - Assume 4-Kbyte blocks
  - 4 Kbyte / 8 msec = ~500 Kbyte/sec
- If disk blocks of the same cylinder are randomly accessed without disk seeks
  - Average disk access time = ~4 msec
  - 4 Kbyte / 4 msec = ~ 1 Mbyte/sec

Examples of Disk Access Times

- If disk blocks are accessed sequentially
  - Without seeks and rotational delays
  - Bandwidth: 58 Mbytes/sec
- Key to good disk performance
  - Minimize seek time and rotational latency

Disk Tradeoffs

Sector size	Space utilization	Transfer rate
1 byte	8 bits/1008 bits (0.8%)	125 bytes/sec (1 byte / 8 msec)
4 Kbytes	4096 bytes/4221 bytes (97%)	500 Kbytes/sec (4 Kbytes / 8 msec)
1 Mbyte	(~100%)	58 Mbytes/sec (peak bandwidth)

- Larger sector size → better bandwidth
- Wasteful if only 1 byte out of 1 Mbyte is needed

Disk Controller

- Few popular standards
  - IDE (integrated device electronics)
  - ATA (advanced technology attachment interface)
  - SCSI (small computer systems interface)
  - SATA (serial ATA)
- Differences
  - Performance
  - Parallelism

Disk Device Driver

- Major goal: reduce seek time for disk accesses
  - Schedule disk request to minimize disk arm movements

Disk Arm Scheduling Policies

- ***First come, first serve (FCFS):*** requests are served in the order of arrival
  - + Fair among requesters
  - - Poor for accesses to random disk blocks
- ***Shortest seek time first (SSTF):*** picks the request that is closest to the current disk arm position
  - + Good at reducing seeks
  - - May result in starvation

Disk Arm Scheduling Policies

- ***SCAN:*** takes the closest request in the direction of travel (an example of elevator algorithm)

  + no starvation

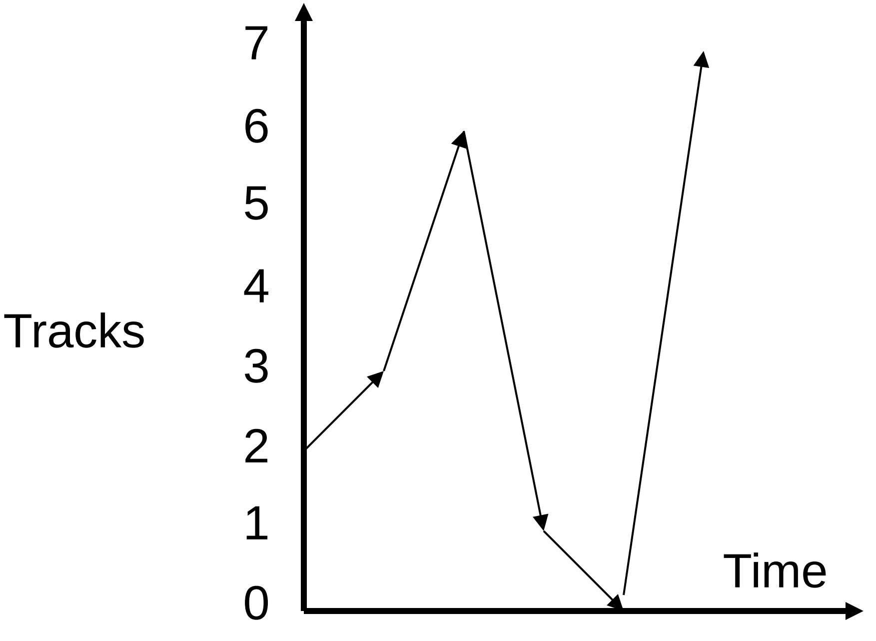
  - a new request can wait for almost two full scans of the disk

Disk Arm Scheduling Policies

- ***Circular SCAN (C-SCAN):*** disk arm always serves requests by scanning in one direction.
  - Once the arm finishes scanning for one direction
  - Returns to the 0^{th} track for the next round of scanning

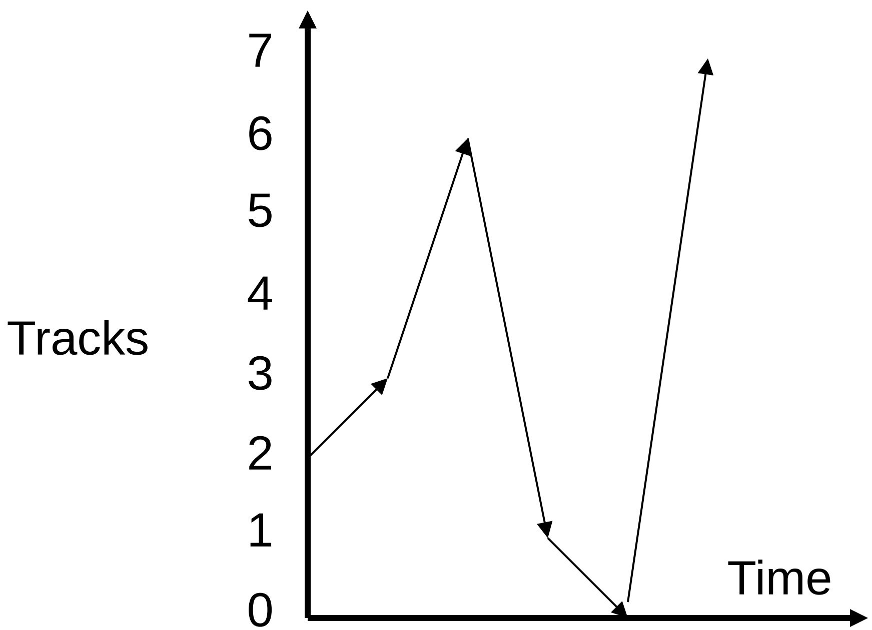
First Come, First Serve

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2



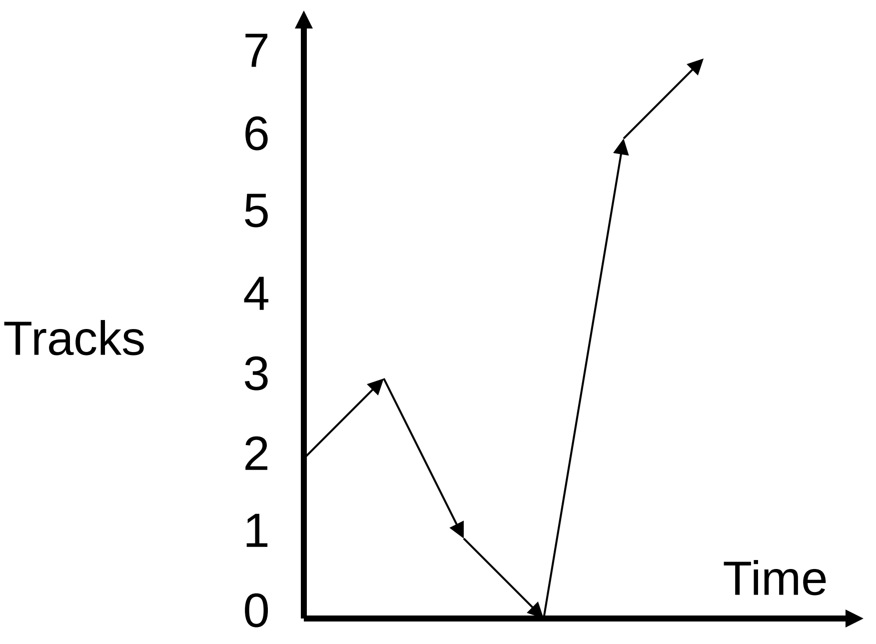
First Come, First Serve

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2
- Total seek distance: 1 + 3 + 5 + 1 + 7 = 17



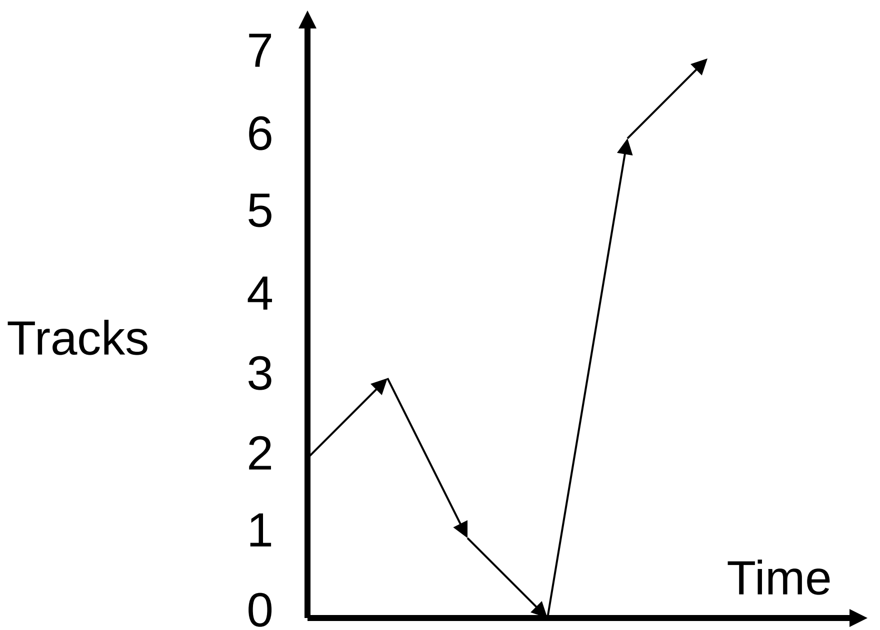
Shortest Seek Distance First

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2



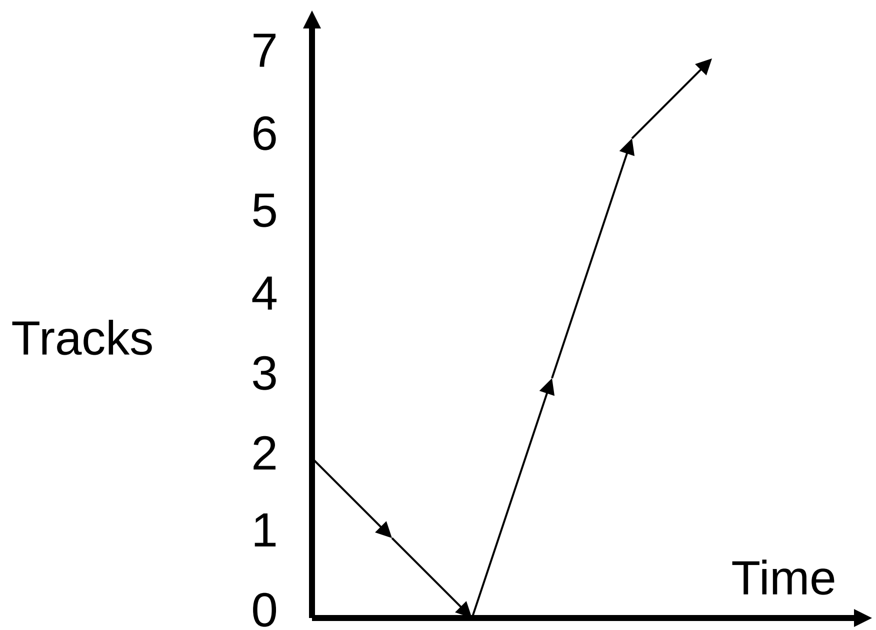
Shortest Seek Distance First

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2
- Total seek distance: 1 + 2 + 1 + 6 + 1 = 10



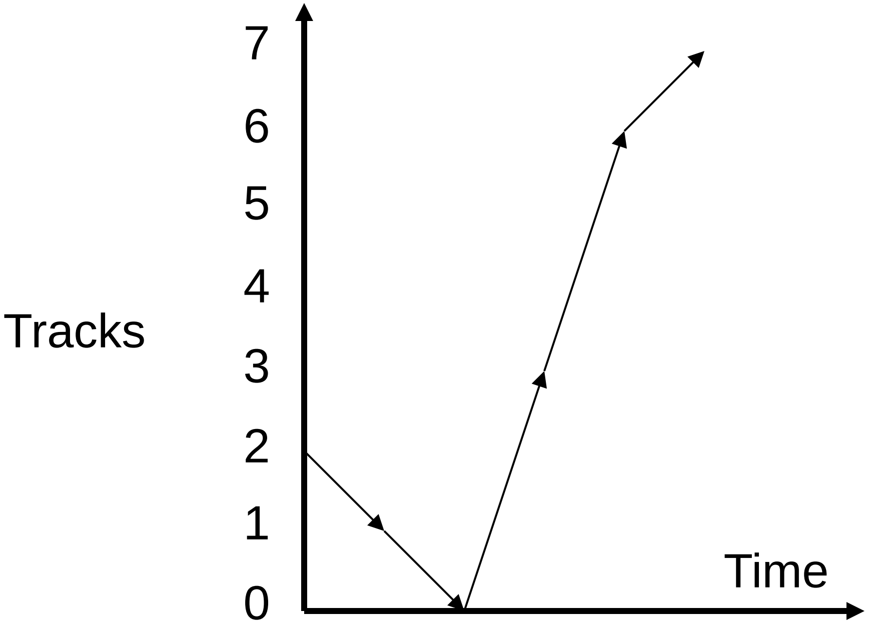
SCAN

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2



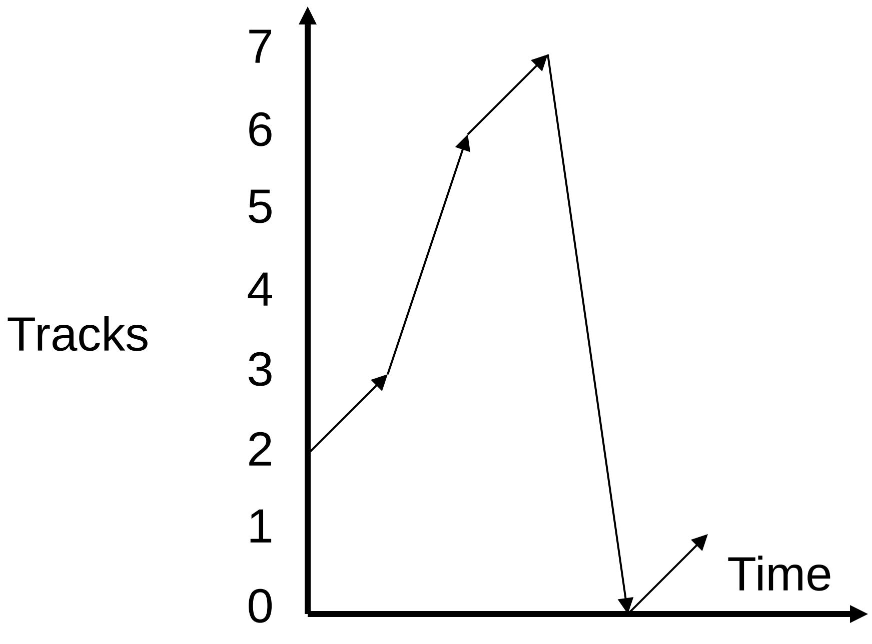
SCAN

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2
- Total seek distance: 1 + 1 + 3 + 3 + 1 = 9



C-SCAN

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2



C-SCAN

- Request queue: 3, 6, 1, 0, 7
- Head start position: 2
- Total seek distance: 1 + 3 + 1 + 7 + 1 = 13