

CSC 4103 - Operating Systems  
Fall 2009

LECTURE - XXI  
MASS STORAGE & IO

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November 10th, 2009

## Overview of Mass Storage Structure

- Magnetic disks provide bulk of secondary storage of modern computers
  - Drives rotate at 90 to 300 times per second
  - **Transfer rate** is rate at which data flow between drive and computer
  - **Positioning time (random-access time)** is time to move disk arm to desired cylinder (**seek time**) and time for desired sector to rotate under the disk head (**rotational latency**)
  - **Head crash** results from disk head making contact with the disk surface
    - That's bad
- Disks can be removable
- Drive attached to computer via I/O bus
  - Busses vary, including **EIDE, ATA, SATA, USB, Fibre Channel, SCSI**
  - **Host controller** in computer uses bus to talk to **disk controller** built into drive or storage array

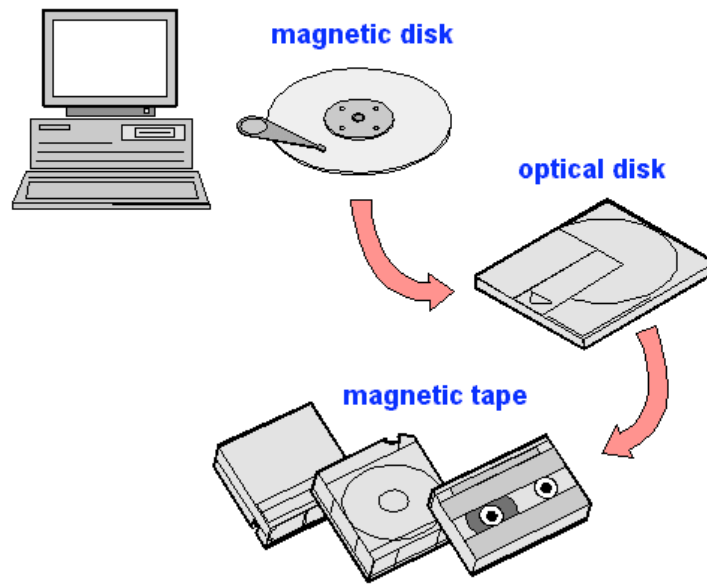
## Overview of Mass Storage Structure (Cont.)

- Magnetic tape
  - Was early secondary-storage medium
  - Relatively permanent and holds large quantities of data
  - Access time slow
  - Random access ~1000 times slower than disk
  - Mainly used for backup, storage of infrequently-used data, transfer medium between systems
  - Kept in spool and wound or rewound past read-write head
  - Once data under head, transfer rates comparable to disk
  - Hundreds of GB typical storage
  - Common technologies are 4mm, 8mm, 19mm, LTO-2 and SDLT

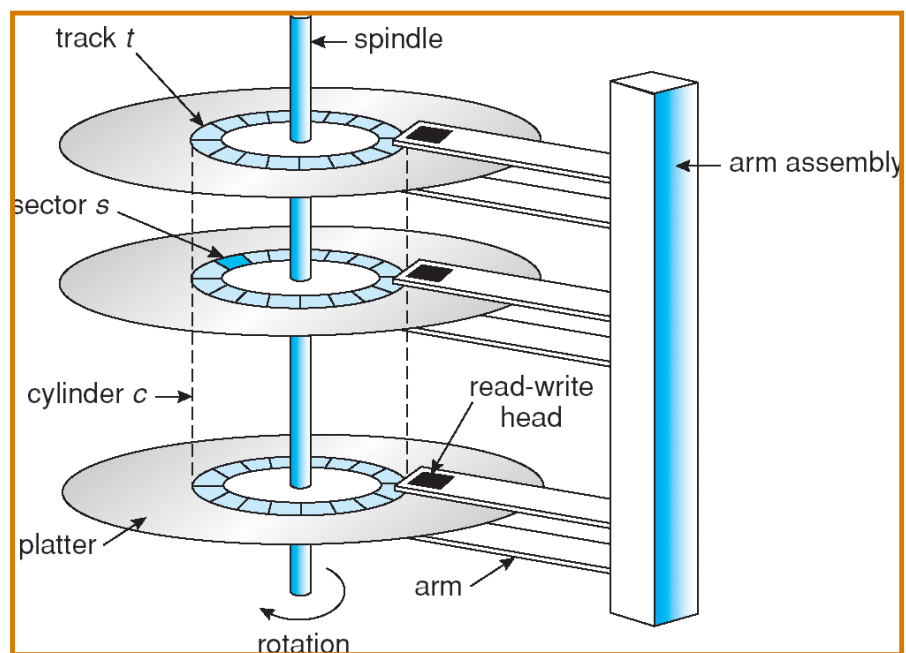
## Hierarchical Storage Management (HSM)

- A hierarchical storage system extends the storage hierarchy beyond primary memory and secondary storage to incorporate tertiary storage – usually implemented as a jukebox of tapes or removable disks.
- Usually incorporate tertiary storage by extending the file system.
  - Small and frequently used files remain on disk.
  - Large, old, inactive files are archived to the jukebox.
- HSM is usually found in supercomputing centers and other large installations that have enormous volumes of data.

# Hierarchical Storage Management

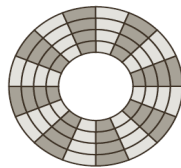


## Moving-head Disk Mechanism

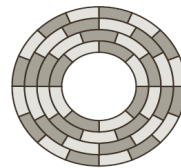


## Disk Structure

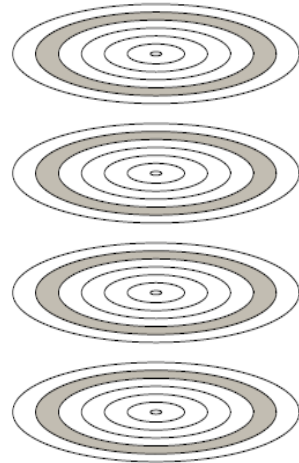
- Disk drives are addressed as large 1-dimensional arrays of *logical blocks*, where the logical block is the smallest unit of transfer.
- The 1-dimensional array of logical blocks is mapped into the sectors of the disk sequentially.
  - Sector 0 is the first sector of the first track on the outermost cylinder.
  - Mapping proceeds in order through that track, then the rest of the tracks in that cylinder, and then through the rest of the cylinders from outermost to innermost.



(a) Constant angular velocity



(b) Multiple zoned recording



## Disk Scheduling

- The operating system is responsible for using hardware efficiently — for the disk drives, this means having a fast access time and disk bandwidth.
- Access time has two major components
  - *Seek time* is the time for the disk are to move the heads to the cylinder containing the desired sector.
  - *Rotational latency* is the additional time waiting for the disk to rotate the desired sector to the disk head.
- Minimize seek time
- Seek time  $\approx$  seek distance
- Disk bandwidth is the 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 (Cont.)

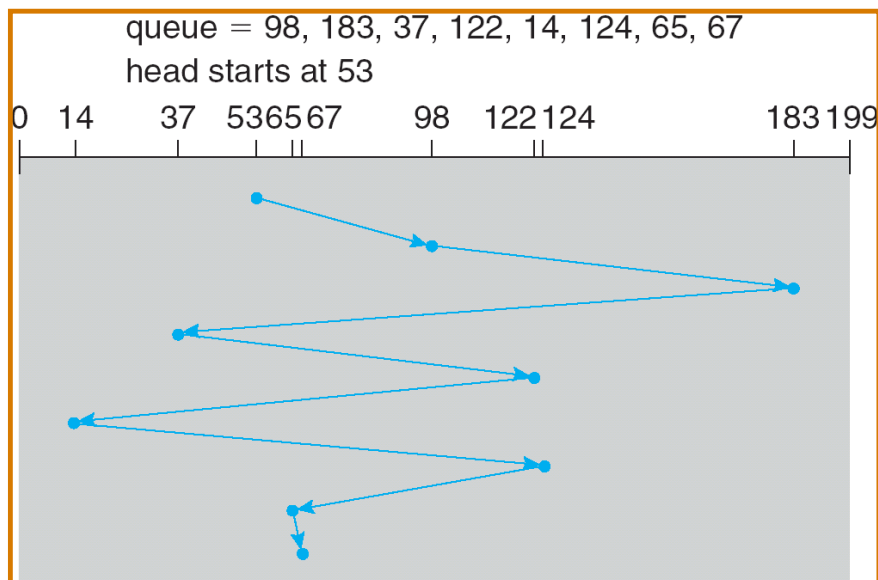
- Several algorithms exist to schedule the servicing of disk I/O requests.
- We illustrate them with a request queue (0-199).

98, 183, 37, 122, 14, 124, 65, 67

Head pointer at 53

## FCFS

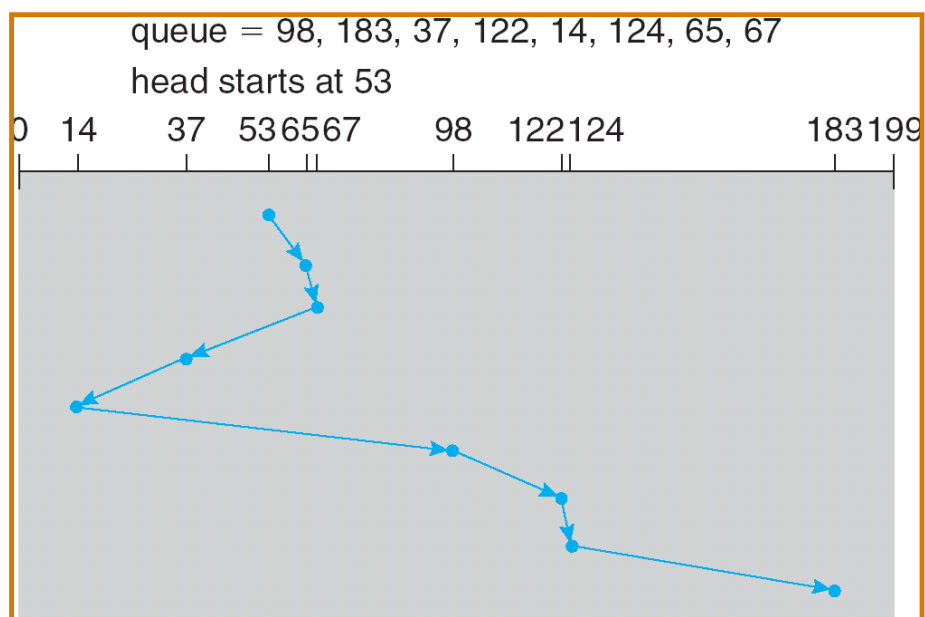
Illustration shows total head movement of 640 cylinders.



## SSTF

- SSTF: Shortest Seek Time First Algorithm
- Selects the request with the minimum seek time from the current head position.
- SSTF scheduling is a form of SJF scheduling; may cause starvation of some requests.
- Illustration shows total head movement of 236 cylinders.

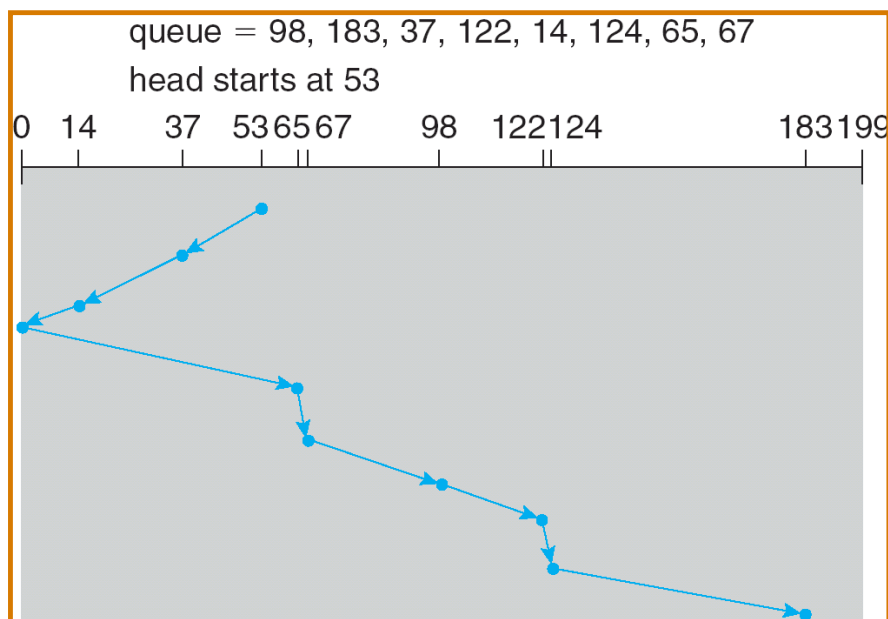
## SSTF (Cont.)



## SCAN

- The disk arm starts at one end of the disk, and moves toward the other end, servicing requests until it gets to the other end of the disk, where the head movement is reversed and servicing continues.
- Sometimes called the *elevator algorithm*.
- Illustration shows total head movement of 208 cylinders.

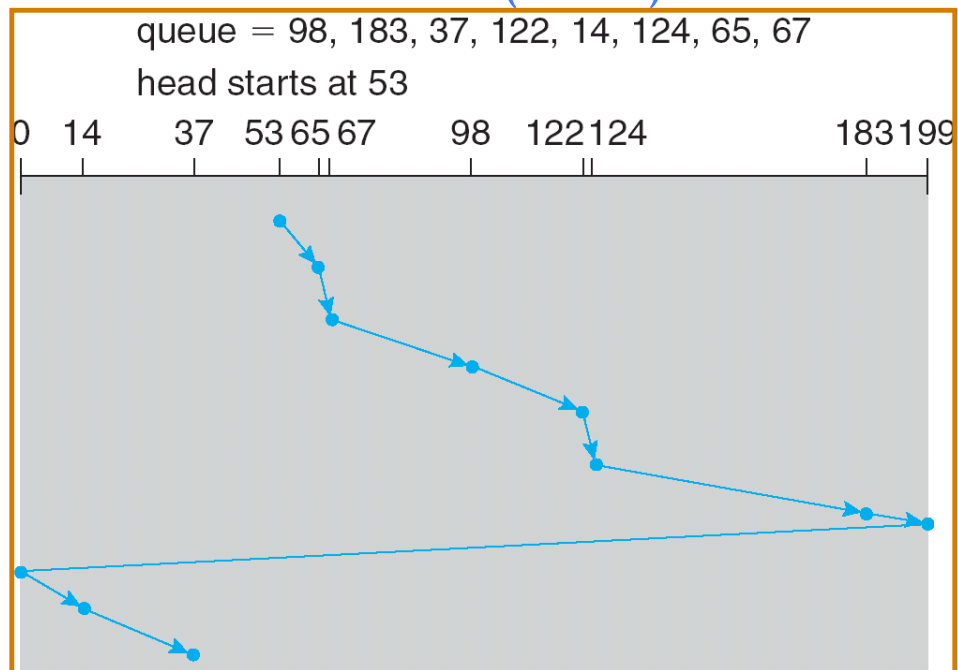
## SCAN (Cont.)



## C-SCAN

- Provides a more uniform wait time than SCAN.
- The head moves from one end of the disk to the other, servicing requests as it goes. When it reaches the other end, however, it immediately returns to the beginning of the disk, without servicing any requests on the return trip.
- Treats the cylinders as a circular list that wraps around from the last cylinder to the first one.

### C-SCAN (Cont.)

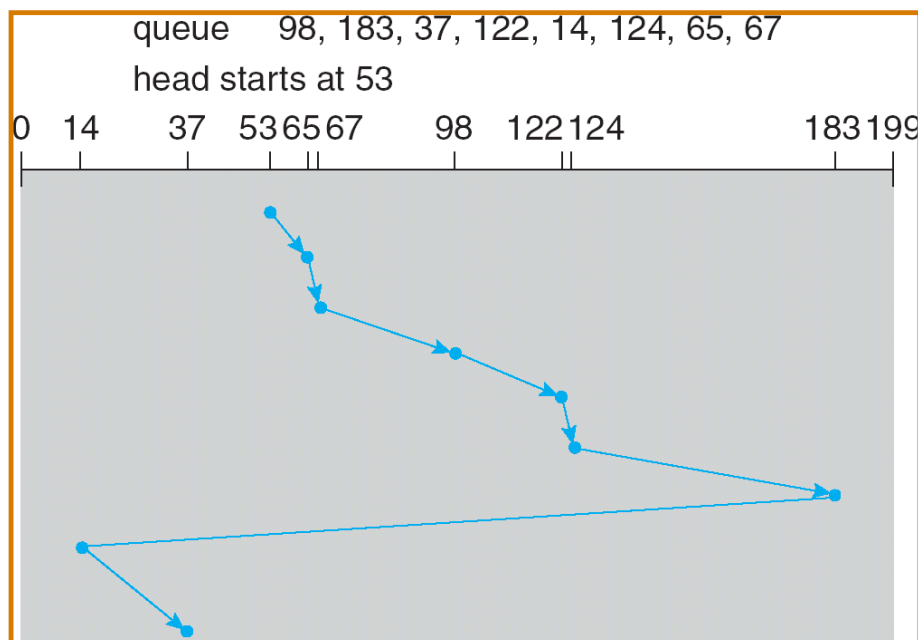




## C-LOOK

- Version of C-SCAN
- Arm only goes as far as the last request in each direction, then reverses direction immediately, without first going all the way to the end of the disk.

## C-LOOK (Cont.)



## Exercise

- ✓ assume sequence of requested tracks in order received by disk scheduler: 55, 58, 39, 18, 90, 160, 150, 38, 184
- ✓ assume disk head initially located at track #100
- ✓ disk has moved to track # 100 from track #44
- ✓ there are 200 total tracks on disk
  
- ✓ a) Show disk scheduling for FCFS, SSTF, SCAN, C-SCAN, LOOK, C-LOOK
- ✓ b) Compute total head movements for each

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## Selecting a Disk-Scheduling Algorithm

- **SSTF** is common since increases performance over **FCFS**, but may cause starvation.
- **SCAN** and **C-SCAN** perform better for systems that place a heavy load on the disk, prevent starvation.
- **LOOK** and **C-LOOK** optimize SCAN and S-SCAN further.
- Performance depends on the number and types of requests.
- Requests for disk service can be influenced by the file-allocation method.
- The disk-scheduling algorithm should be written as a separate module of the operating system, allowing it to be replaced with a different algorithm if necessary.
- Either **SSTF** or **LOOK** is a reasonable choice for the default algorithm.

## Exercise

- From elementary physics, we know that when an object is subjected to a constant acceleration  $a$ , the relationship between distance  $d$  and time  $t$  is given by  $d = \frac{1}{2} at^2$ . Suppose that, during a seek, the disk accelerates the disk arm at a constant rate for the first half of the seek, then decelerates the disk arm at the same rate for the second half of the seek. Assume that the disk can perform a seek to an adjacent cylinder in 1 millisecond and a full-stroke seek over all 5000 cylinders in 18 milliseconds.
- a. The distance of a seek is the number of cylinders that the head moves. Explain why the seek time is proportional to the square root of the seek distance.
  - b. Write an equation for the seek time as a function of the seek distance. This equation should be of the form  $t = x + y\sqrt{L}$ , where  $t$  is the time in milliseconds and  $L$  is the seek distance in cylinders.

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## Any Questions?



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## Acknowledgements

- “Operating Systems Concepts” book and supplementary material by A. Silberschatz, P. Galvin and G. Gagne
- “Operating Systems: Internals and Design Principles” book and supplementary material by W. Stallings
- “Modern Operating Systems” book and supplementary material by A. Tanenbaum
- R. Doursat and M. Yuksel from UNR