

CSC 4103 - Operating Systems
Spring 2007

LECTURE - XVI
FILE SYSTEMS - II

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Free Space Management

- Disk space limited
- Need to re-use the space from deleted files
- To keep track of free disk space, the system maintains a **free-space list**
 - Records all free disk blocks
- Implemented using
 - Bit vectors
 - Linked lists

Free-Space Management (Cont.)

- Bit vector (n blocks)
 - Each block is represented by 1 bit
 - 1: free, 0: allocated



$$\text{bit}[i] = \begin{cases} 0 \Rightarrow \text{block}[i] \text{ free} \\ 1 \Rightarrow \text{block}[i] \text{ occupied} \end{cases}$$

- Special instructions to return the offset in a word of the first bit with value 1
- Block number calculation:

$$\begin{aligned} & (\text{number of bits per word}) * \\ & (\text{number of 0-value words}) + \\ & \text{offset of first 1 bit} \end{aligned}$$

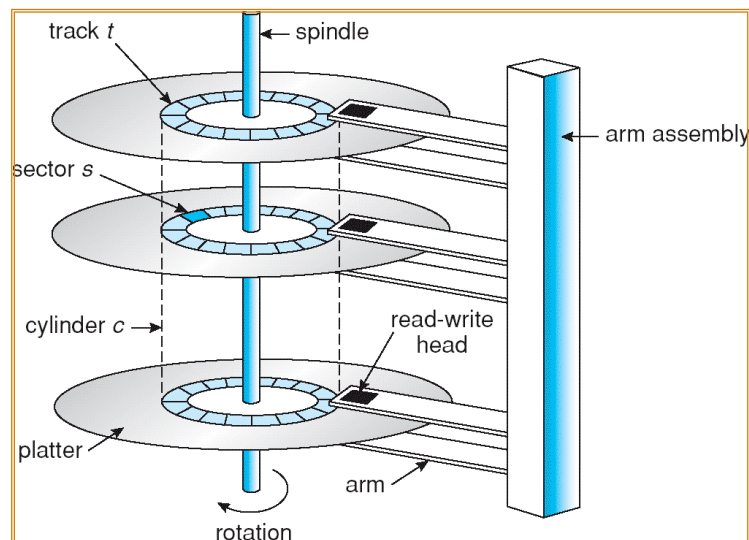
Free-Space Management (Cont.)

- Bit map requires extra space
 - Example:
 - block size = 2^{12} bytes
 - disk size = 2^{30} bytes (1 gigabyte)
 - $n = 2^{30}/2^{12} = 2^{18}$ bits (or 32K bytes)
- Easy to get contiguous files
- **Linked list (free list)**
 - Cannot get contiguous space easily
 - requires substantial I/O
- **Grouping**
 - Modification of free-list
 - Store addresses of n free blocks in the first free block
- **Counting**
 - Rather than keeping list of n free addresses:
 - Keep the address of the first free block
 - And the number n of free contiguous blocks that follow it

Overview of Mass Storage Structure

- Magnetic disks provide bulk of secondary storage of modern computers
 - Drives rotate at 60 to 200 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

Moving-head Disk Mechanism



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

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.

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.)

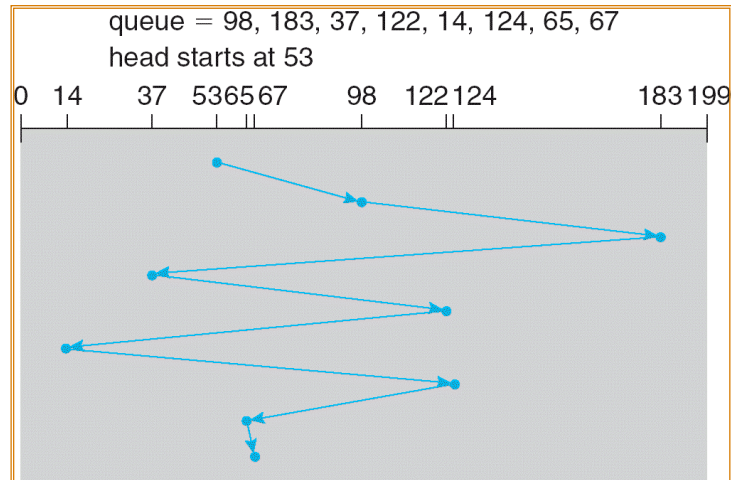
- Several algorithms exist to schedule the servicing of disk I/O requests.
- We illustrate them with a request queue (0-199).

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

Head pointer 53

FCFS

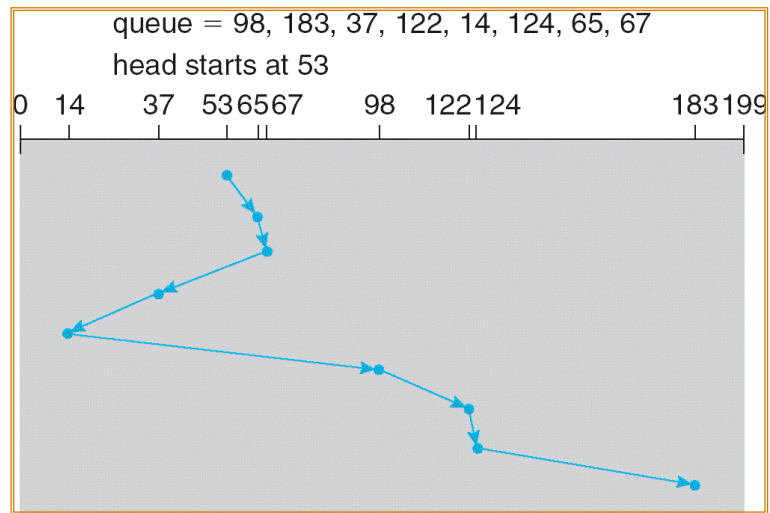
Illustration shows total head movement of 640 cylinders.



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.

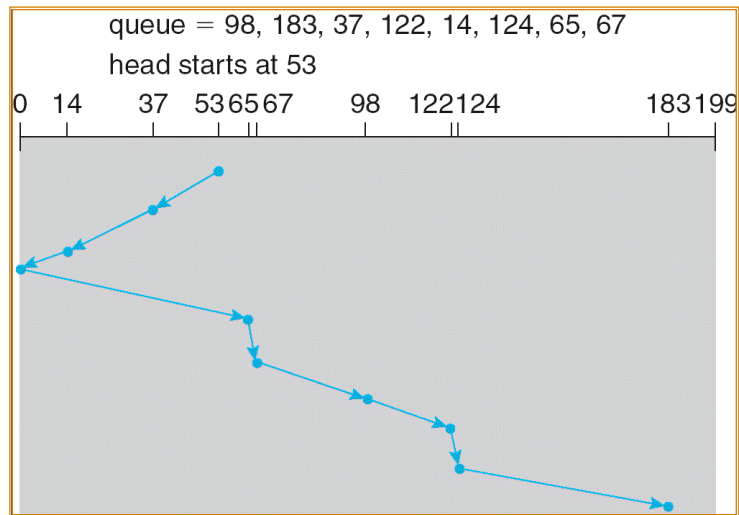
SSTF (Cont.)



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.

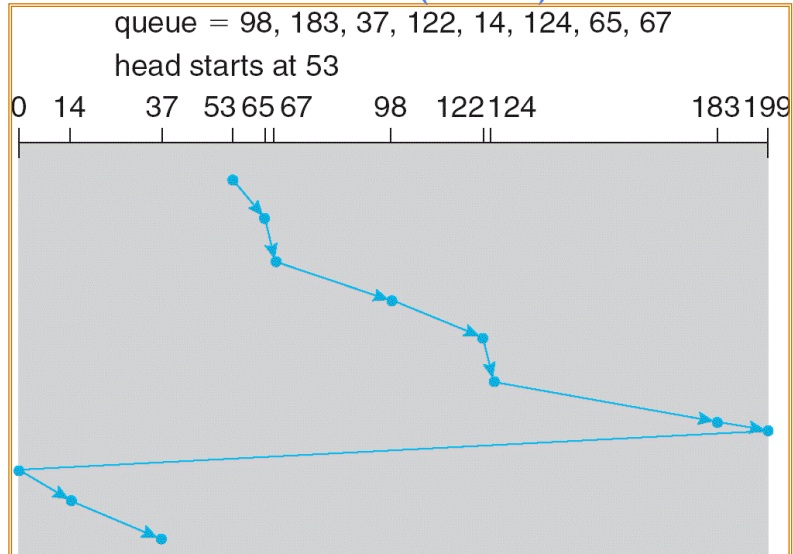
SCAN (Cont.)



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.

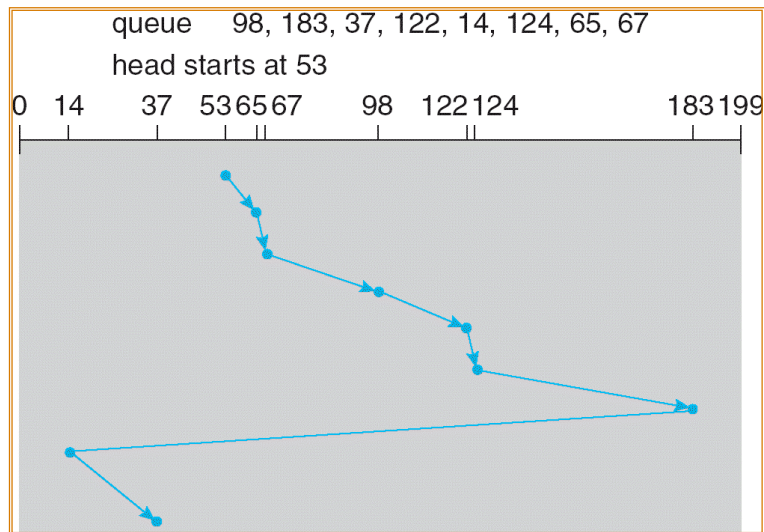
C-SCAN (Cont.)



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.)



Selecting a Disk-Scheduling Algorithm

- SSTF is common since it increases performance over FCF, 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.

Any Questions?



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Reading Assignment

- Read chapter 11 from Silberschatz.

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Acknowledgements

- “Operating Systems Concepts” book and supplementary material by Silberschatz, Galvin and Gagne.