More on Disk Storage and File System

CS 256/456

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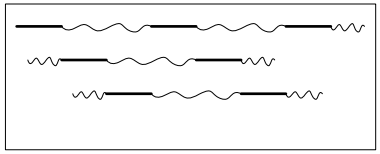
Recap of the Last Class: Disk Storage

- Disk drive
  - mechanical parts (cylinders, tracks, sectors) and how they move to access disk data
  - electronic part (disk controller main) exposes an one-dimensionally addressable set of blocks
  - large seek/rotation time
- Disk scheduling
  - goals: overall efficiency; fairness (no starvation)
  - FCFS, SSTF, SCAN, C-SCAN, LOOK

Concurrent I/O

- Consider multiple request handlers in a Web server
  - each accesses a different stream of sequential data (a file) on disk;
  - each reads a chunk (the buffer size) at a time; does a little CPU processing; and reads the next chunk
- What happens?



How to Deal with It?

- Aggressive prefetching
- Anticipatory scheduling [Iyer & Druschel, SOSP 2001]
  - at the completion of an I/O request, the disk scheduler will wait a bit (despite there is other work to do), in anticipation that a new request with strong locality will be issued. go ahead to schedule another request if no such new request appears before timeout.
  - included in Linux 2.6

Scheduling at Disk and OS

- Some disks are smart (support scheduling of its own)
  - SCSI vs. IDE disks
- Scheduling at disk vs. at OS
  - FCFS, SSTF, elevator, anticipatory
- How does an OS balance it?

File System Abstraction

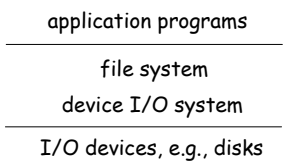
- File system is the OS abstraction for storage resources
  - File is a logical storage unit in the OS abstract interface for storage resources
  - Directory is a logical "container" for a group of files
- File attribute:
  - name, size, access time, sharing/protection, location
- File access:
  - sequential: open()/read()
  - random: seek()
- File structure (mostly concerns of user programs)
  - None - sequence of words, bytes
  - Complex Structures
    - records/formatted document/executable file

File Sharing and Protection

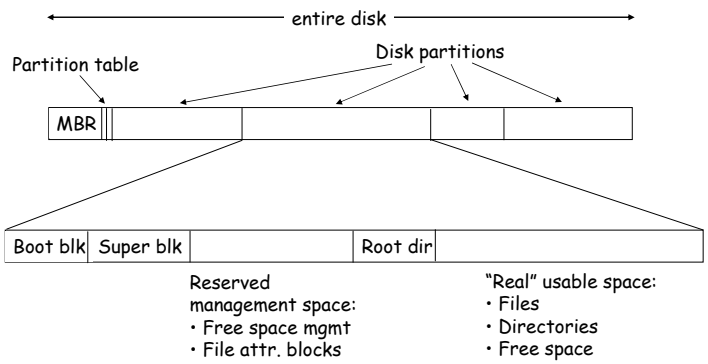
- Sharing of files on multi-user systems is desirable.
- Sharing must accompany a *protection* scheme.
  - In general, a protection scheme specifies whether any specific user can access any specific file.
  - What is it done right now?
  - Is it flexible enough?

File System Implementation

- Abstractions:
  - file: storage unit
  - directory: container of files
- OS responsibility for file management:
  - Manipulation of files and directories.
  - Map files onto (nonvolatile) secondary storage - disks.



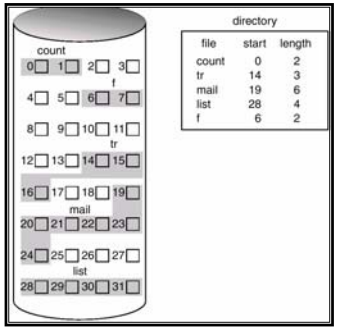
File System Layout



File on the Disk

- Disk basic allocation unit is a block (e.g., 512 bytes)
- File system may choose to use a larger block size (e.g., 4KB)
- File allocation methods
  - How disk blocks are allocated for files
  - Contiguous allocation, linked allocation, indexed allocation
  - Metrics: access speed (sequential & random), space utilization

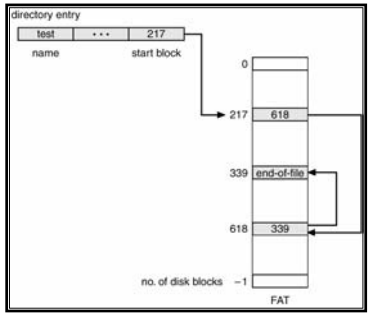
Contiguous File Allocation



- Each file occupies a set of contiguous blocks on the disk.
- Advantage:
  - Simple – only starting location (block #) and length (number of blocks) are required.
  - Fast sequential; also quite fast random access.
- Disadvantage:
  - External fragmentation
  - Inflexible when appending to a file

Linked File Allocation

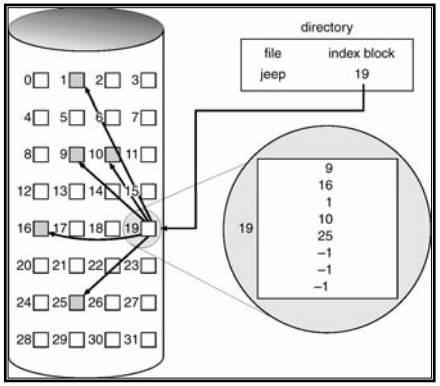
- Each file is a linked list of disk blocks
  - each block contains a next pointer
  - directory only needs to store the pointer to the first block
  - blocks may be scattered anywhere on the disk.



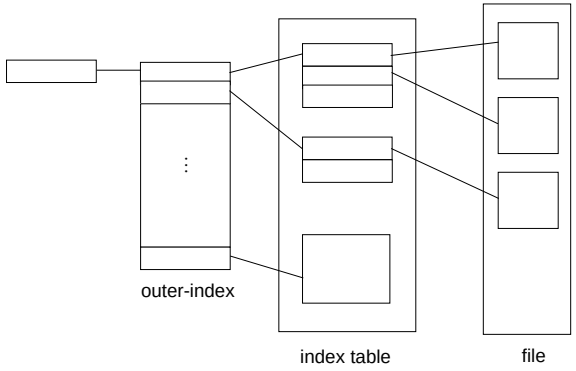
- Advantage
  - Space efficient
  - Flexible in appending
- Disadvantage:
  - Poor access speed (sequential & random)

Indexed File Allocation

- Brings all pointers together into the *index block.*



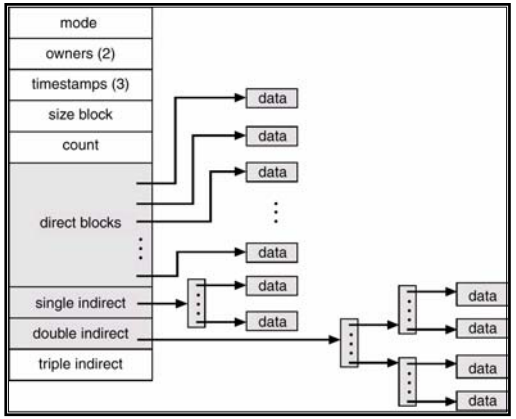
Multi-level Indexed File Allocation



Indexed Allocation (pros and cons)

- Space efficiency
  - no external fragmentation
  - overhead of index blocks
- Access speed
  - random access
  - sequential access

UNIX (4K bytes per block)



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