File System

CS 256/456

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Recap of the Last Class: Storage Systems

- Disk Structure
  - 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
- Disk Scheduling
  - goals: overall efficiency; fairness (no starvation)
  - FCFS, SSTF, SCAN, C-SCAN, LOOK

Deadline Scheduling in Linux

- A regular elevator-style scheduler similar to C-LOOK
- Additionally, all I/O requests are put into a FIFO queue with an expiration time (e.g., 500ms)
- When the head request in the FIFO queue expires, it will be executed next (even if it is not next in line according to C-LOOK).
- A mix of performance and fairness.

Concurrent I/O

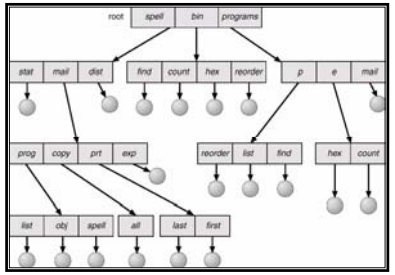
- Consider two request handlers in a Web server
  - each accesses a different stream of sequential data (a file) on disk;
  - each reads a chunk (the buffer size) at a time; does a little CPU processing; and reads the next chunk
- What happens?
- How to deal with it?
- Anticipatory scheduling [Iyer & 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.
  - default I/O scheduler in Linux 2.6

File System

- File system is the OS abstraction for storage resources
- What is a file?
  - File is a logical storage unit in the OS abstract interface for storage resources
- File structure (mostly concerns of user programs)
  - None - sequence of words, bytes
  - Simple record structure
    - lines/fixed length/variable length
  - Complex Structures
    - formatted document/relocatable load file

Directory

- What is a directory?
  - Part of the file system abstract interface
  - A logical "container" or "cabinet" for a group of files
  - A directory includes file attribute information for files residing in the directory
  - Both the directory structure and the files reside on disk.
- Directory structure:



File Attributes

- **Name** – file identification in human-readable form.
- **Location** – pointer to file location on device.
- **Size** – current file size.
- **Protection** – controls who can do reading, writing, executing.
- **Time**, **date**, **and user identification** – data for protection, security, and usage monitoring.
- Information about a file is kept in a file control block (in the directory structure), which is maintained on the storage device.

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 Structure

- 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.

application programs

file system

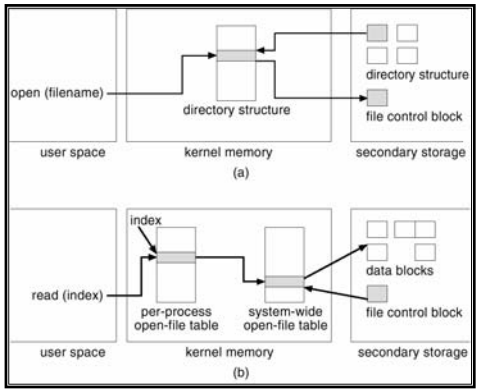
device I/O system

I/O devices, e.g., disks

File Access Model

- Sequential access
  - read all bytes/records from the beginning
  - used in many applications that access a whole file at a time
  - open()/read()/write()/close()
- Random access
  - bytes/records read in any order
  - essential for database systems
  - seek()

In-Memory File System Structures

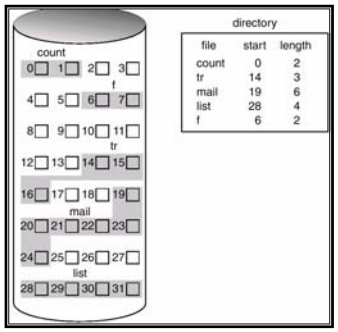


- System-wide info for each file (inode):
  - file open count
  - disk location
- Per-process info for each file (open file):
  - a pointer to the in-memory inode
  - file access offset
  - access rights

Implementation on the Disk

- Directory implementation
  - Linear list of file names with pointer to the data blocks.
    - time-consuming to search an item
  - Hash Table – linear list with hash data structure.
    - decreases directory search time
    - a little waste of space
- File allocation methods
  - How disk blocks are allocated for files
  - Contiguous allocation, linked allocation, indexed allocation
  - Metrics: access speed (sequential & random), space utilization

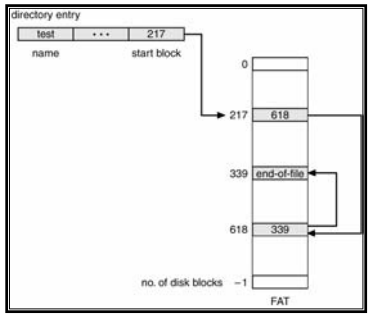
Contiguous Allocation



- 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/random access.
- Disadvantage:
  - Inflexible
  - External fragmentation

Linked Allocation

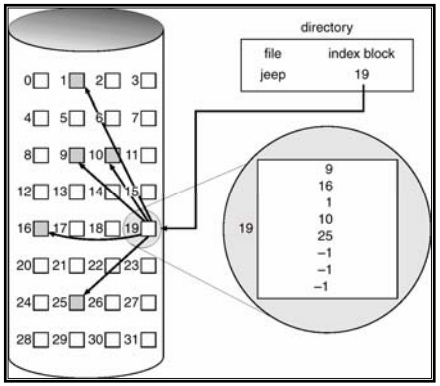
- Each file is a linked list of disk blocks
  - each block contains a next pointer
  - directory only needs to store the pointer to the first block
  - blocks may be scattered anywhere on the disk.



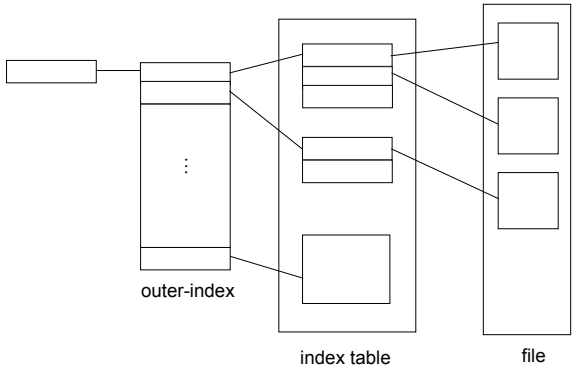
  - Advantage
    - Simple – need only starting address
    - Space efficient
  - Disadvantage:
    - Poor access speed (sequential & random)

Indexed Allocation

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



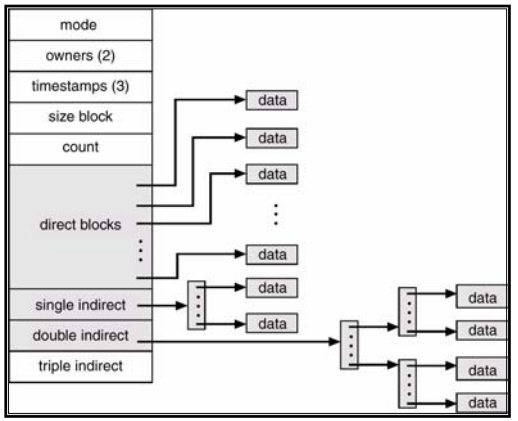
Multi-level Indexed Allocation



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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