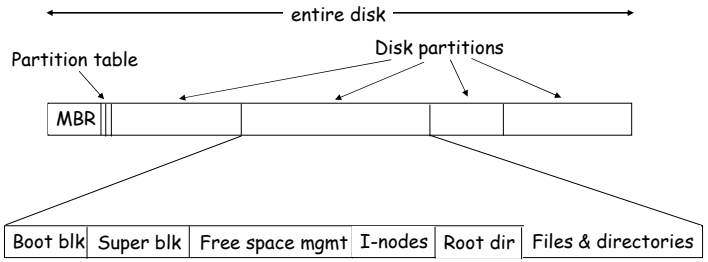
More on File System

CS 256/456

Dept. of Computer Science, University of Rochester

File System Layout

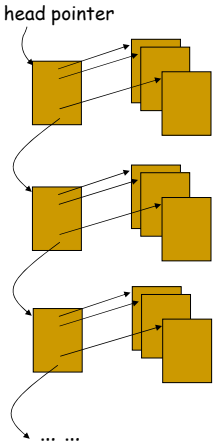


File Space Allocation on the Disk

- File allocation methods
  - contiguous allocation
  - linked allocation
  - indexed allocation
- Metrics:
  - access speed (sequential & random)
  - space utilization

Free-Space Management

- Free-space management for memory?
- Bit map
  - requires some extra space
  - efficiency?
    - getting the address of one free block
    - getting the addresses of a number of free blocks
- Linked list (free list)
  - no waste of space
  - efficiency?
- Grouping



File System Caching

- File content is cached in memory buffer for later reuse
  - what is the basic unit of such caching?
- Replacement policy for file system buffer cache
  - LRU replacement is one possibility; but sequential access is very likely in file system I/O
  - MRU or free-behind

File System Prefetching

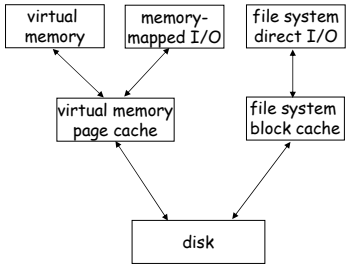
- File content is read ahead of time for anticipated use in the near future
  - often sequential (based on past access history on the file)
  - what is the advantage of file prefetching?
  - what is the danger of file prefetching?
- Linux 2.4 file prefetching
  - first prefetch 16KB
  - then gradually increase the prefetch size when the OS senses a sequential access pattern
  - the prefetch size does not go beyond 128KB
  - it falls back to 4KB read-ahead when the access is considered random

Beyond Past Access History

- Problems with prefetching based on "past access history"
  - not always accurate
  - can rarely recognize non-sequential patterns
- Ideas beyond past access history?
  - application I/O hints
  - automatic I/O hints based on speculative execution [Chang&Gibson 2000], [Fraser&Chang 2003]

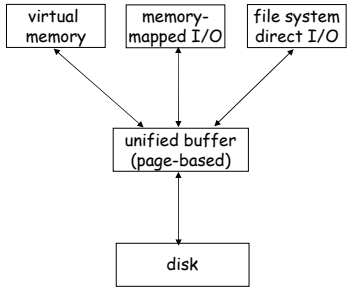
Buffer Cache in Main Memory

- Memory-mapped I/O naturally share page cache with the virtual memory system
- Problems:
  - double buffering
  - inconsistencies



Unified Buffer Cache & Unified Virtual Memory

- A unified buffer cache uses the same page cache to store
  - virtual memory pages
  - memory-mapped pages
  - file system direct I/O data



Multi-level I/O Buffer

- buffer cache in the main memory
- track cache on the disk controller

File Systems You Heard Of

- FAT
- NTFS
- ext2
- ext3
- ReiserFS

Recovery from Machine Crash

- File system operations are not atomic; a sudden machine crash may leave the file system in an inconsistent state
- Consistency checking and fix
  - it takes too long
- Journaling file system: Ext3, ReiserFS
  - maintain a dedicated journal that logs all operations
  - the logging happens before the real operation
  - each logging is made to be atomic
  - after the completion of an operation, its entry is removed from the journal
  - at the recovery time, only journal entries need to be examined ⇒ fast recovery
  - similar to transactions in database systems
  - performance impact?

Log-Structured File Systems

- With CPUs faster, memory larger
  - buffer caches can also be larger
  - most of read requests can come from the memory cache
  - thus, most disk accesses will be writes
  - poor disk performance when most writes are small
- LFS Strategy [Rosenblum & Ousterhout SOSP1991]
  - structures entire disk as a log
  - always write to the end of the disk log
  - when updates are needed, simply add new copies with updated content; old copies of the blocks are still in the earlier portion of the log
  - periodically purge out useless blocks

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