Even More on File System

CS 256/456

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Recap of File System

- File system interface
  - files/directories
  - access models and operations
- Space allocation for disk files
  - contiguous allocation, linked allocation, indexed allocation
  - compare on space efficiency and random access efficiency
- Free space management
  - bit map, linked list, grouping
- I/O buffer management
  - caching and prefetching

Recovery from Machine Crash

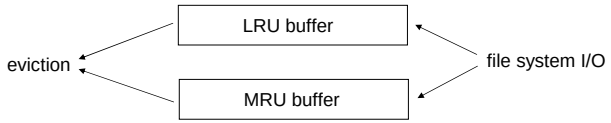
- File system operations are not atomic; a sudden machine crash may leave the file system in an inconsistent state
- Consistency checking and fix takes too long
- Journaling file system: Ext3, ReiserFS, NTFS
  - maintain a dedicated journal that logs all operations
  - the logging happens before the 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

I/O Buffer Management

- buffer cache replacement policy
  - non-repetitive sequential file access – MRU
  - potentially repetitive access with locality – LRU



- how to allocate space between the two buffers?
  - objective: minimize system-wide miss rate
  - assume continuous buffer size to miss rate function for each buffer, locate a point of equal marginal gain for both buffers

Speculative I/O Prefetching

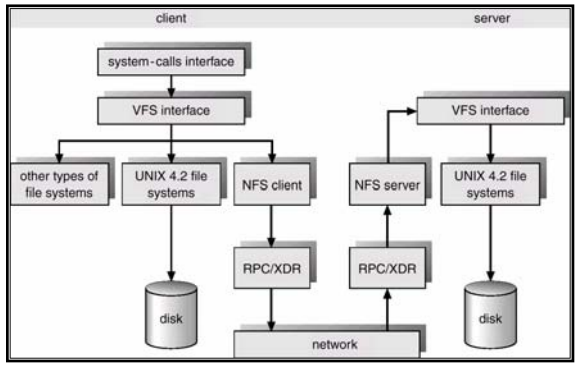
- Prefetching is effective to reduce wait time on I/O
  - that is, when you prefetch the right data
- Speculative I/O prefetching [Chang & Gibson OSDI1999]
  - have a speculative execution of the program running ahead of the actual execution
  - when the speculative execution reads, it issues the read request and then proceeds without waiting for the data to return
    - now you understand why it runs "ahead" of the actual execution
  - when the actual execution reaches the read operation, the data is likely already there – prefetching!
  - problems?
    - speculative execution may not run the same way as the actual execution if it depends on the returned I/O data
    - double changes of persistent system state

Distributed-File Systems

- Distributed file system (DFS) – unified file system managing distributed storage resources.
- Purpose of DFSs
  - larger file system
  - performance through parallel & concurrent I/O
  - availability/fault-tolerance through replication

Network File System (NFS)

NFS: a mechanism to transparently access remote files.



Distribution & Access Granularity

- Distribution granularity:
  - File-level distribution
  - Block/chunk-level distribution
    - tradeoff of large/small block/chunks
    - management overhead vs. storage flexibility
- Access granularity:
  - Data accesses are in block/chunks
    - tradeoff of large/small block/chunks
    - management overhead vs. unnecessary fetching and false sharing

Remote File Caching

- Reduce network traffic by retaining recently accessed disk blocks in a cache
  - repeated accesses to the same information can be handled locally.
  - if needed data not already cached, a copy of data is brought from the server to the user.
- Cached on disk or in main memory?
  - advantages of disk caches:
    - larger and can survive power down
  - memory cache:
    - faster
    - allow integrated management of local file system cache and distributed file system cache

Cache Consistency

- Cache consistency
  - keeping the cached copies consistent with the master copy
- Client-initiated approach
  - client initiate a validity check
  - server checks whether the local data is consistent with the master copy
- Server-initiated approach
  - server records, for each client, the files it caches
  - whenever there is a change, the server notifies clients
- Compare them
  - consistency
  - robustness

Stateful vs. Stateless Designs

- Stateful file management
  - Server maintains state (e.g., set of opened files, file access pointers, file access pattern) for each connection
- Stateless file management
  - Avoids state info by making each request self-contained
- Stateful management is more efficient, stateless management is more robust and less complex
- Soft-state
  - the server maintains per-client state
  - each client has to continuously send refresh messages to the server to keep them alive

File Replication

- File replication
  - Replicas of the same file reside on failure-independent machines.
  - Improves availability and throughput.
  - Directory mechanism maps a file name to the set of replicas.
- For read-only accesses
  - one copy needs to be accessed
- For updates
  - update must be reflected on all replicas
  - consistency?

Replication Consistency

- Primary-secondary replication
  - updates first go to one replica; then propagated to others
  - problem: low update availability
- Optimistic update anywhere
  - updates can first go anywhere and then gradually propagated to others
  - resolve inconsistencies when they occur
    - logging and undoing
    - commutative updates; total updates

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