CSE 451: Operating Systems
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Module 21
Distributed File Systems

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Distributed File Systems

- The most common distributed services:
  - printing
  - email
  - files
- Basic idea of distributed file systems
  - support network-wide sharing of files and devices (disks)
- Generally provide a “traditional” view
  - a centralized shared local file system
- But with a distributed implementation
  - read blocks from remote hosts, instead of local disks

Issues

- What is the basic abstraction
  - remote file system?
    - open, close, read, write, …
  - remote disk?
    - read block, write block
- Naming
  - how are files named?
  - are those names location transparent?
    - is the file location visible to the user?
  - are those names location independent?
    - do the names change if the file moves?
    - do the names change if the user moves?

- Caching
  - caching exists for performance reasons
  - where are file blocks cached?
    - on the file server?
    - on the client machine?
    - both?
- Sharing and coherency
  - what are the semantics of sharing?
  - what happens when a cached block/file is modified
  - how does a node know when its cached blocks are out of date?

- Replication
  - replication can exist for performance and/or availability
  - can there be multiple copies of a file in the network?
  - if multiple copies, how are updates handled?
  - what if there’s a network partition and clients work on separate copies?
- Performance
  - what is the cost of remote operation?
  - what is the cost of file sharing?
  - how does the system scale as the number of clients grows?
  - what are the performance limitations: network, CPU, disks, protocols, data copying?

Example: SUN Network File System (NFS)

- The Sun Network File System (NFS) has become a common standard for distributed UNIX file access
- NFS runs over LANs (even over WANs – slowly)
- Basic idea
  - allow a remote directory to be “mounted” (spliced) onto a local directory
  - Gives access to that remote directory and all its descendants as if they were part of the local hierarchy
- Pretty much exactly like a “local mount” or “link” on UNIX
  - except for implementation and performance …
  - no, we didn’t really learn about these, but they’re obvious ☺

- For instance:
  - I mount /u4/lazowska on Node1 onto /students/foo on Node2
  - users on Node2 can then access this directory as /students/foo
  - if I had a file /usr/lazowska/myfile, users on Node2 see it as /students/foo/myfile
- Just as, on a local system, I might link
  - /cse/www/education/courses/451/05sp/

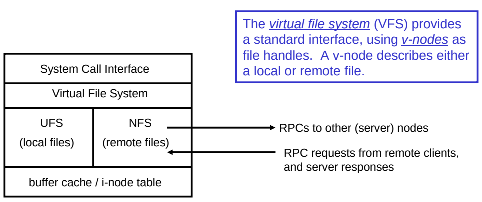
  as
  - /u4/lazowska/451

  to allow easy access to my web data from my home directory

NFS implementation

- NFS defines a set of RPC operations for remote file access:
  - searching a directory
  - reading directory entries
  - manipulating links and directories
  - reading/writing files
- Every node may be both a client and server

- NFS defines new layers in the Unix file system



NFS caching / sharing

- On an open, the client asks the server whether its cached blocks are up to date.
- Once a file is open, different clients can write it and get inconsistent data.
- Modified data is flushed back to the server every 30 seconds.

Example: CMU's Andrew File System (AFS)

- Developed at CMU to support all of its student computing
- Consists of workstation clients and dedicated file server machines (differs from NFS)
- Workstations have local disks, used to cache files being used locally (originally whole files, now 64K file chunks) (differs from NFS)
- Andrew has a single name space – your files have the same names everywhere in the world (differs from NFS)
- Andrew is good for distant operation because of its local disk caching: after a slow startup, most accesses are to local disk

AFS caching/sharing

- Need for scaling required reduction of client-server message traffic
- Once a file is cached, all operations are performed locally
- On close, if the file has been modified, it is replaced on the server
- The client assumes that its cache is up to date, unless it receives a *callback* message from the server saying otherwise
  - on file open, if the client has received a callback on the file, it must fetch a new copy; otherwise it uses its locally-cached copy (differs from NFS)

Example: Berkeley Sprite File System

- Unix file system developed for *diskless* workstations with large memories at UCB (differs from NFS, AFS)
- Considers memory as a huge cache of disk blocks
  - memory is shared between file system and VM
- Files are permanently stored on servers
  - servers have a large memory that acts as a cache as well
- Several workstations can cache blocks for read-only files
- If a file is being written by more than 1 machine, client caching is turned off – all requests go to the server (differs from NFS, AFS)

Summary

- There are a number of issues to deal with:
  - what is the basic abstraction
  - naming
  - caching
  - sharing and coherency
  - replication
  - performance
- No right answer! Different systems make different tradeoffs!

- Performance is always an issue
  - always a tradeoff between performance and the semantics of file operations (e.g., for shared files).
- Caching of file blocks is crucial in any file system
  - maintaining coherency is a crucial design issue.
- Newer systems are dealing with issues such as disconnected operation for mobile computers