Distributed File Systems

Hank Levy

Distributed File Systems

- One of the most common uses of distribution is to provide distributed file access through a distributed file system
- Basic idea: support sharing of files and sharing of devices (disks) network wide.
- Generally provides a “timesharing system” type view of a centralized file system, but with distr. Implementation.

Basic Issues

- File 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?

Basic Issues

- Caching
  - caching exists for performance reasons
  - where are file blocks cached?
    - On the file server?
    - On the client machine?
- Coherency
  - what happens when a cached block/file is modified
  - how does a node know when its cached blocks are out of date?

Issues

- Replication
  - replication can exist for performance of 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?
  - at what level is replication visible?

Issues

- 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 Systems: NFS

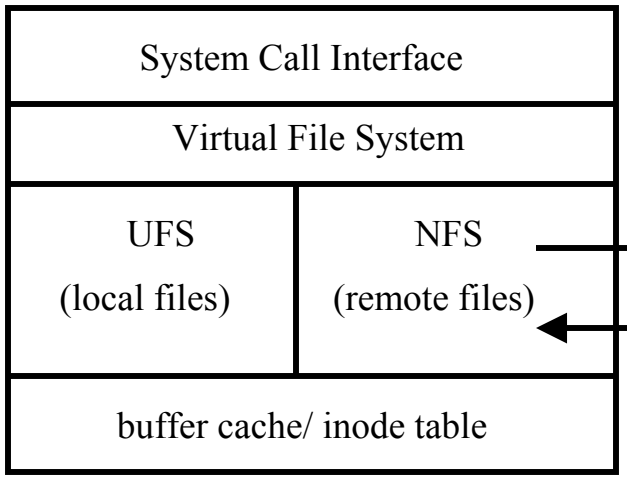
- The Sun Network File System (NFS) has become a common standard for distributed UNIX file access.
- NFS runs over LANS (even over WANs -- slowly).
- Basic idea: allow a remote directory to be "mounted" (spliced) onto a local directory, giving access to that remote directory and all its descendants as if they were part of the local hierarchy.
- Ex: I mount /usr/hank on Node1 onto /students/foo on Node2. Users on Node2 can then access my files as /students/foo. If I had a file /usr/hank/myfile, users on Node2 see it as /students/foo/myfile.

NFS

- 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 Implementation

- NFS defines new layers in the Unix file system



The *virtual file system* provides a standard interface, using vnodes as file handles. A vnode describes either a local or remote file.

RPCs to other (server) nodes

RPC requests from remote clients, and server responses

- Buffer cache caches remote file blocks and attributes

NFS

- 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.

The Andrew File System

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

AFS

- Need for scaling led to reduction of client-server message traffic.
- Once a file is cached, all operations are performed locally.
- On close, if the file is 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.

Sprite File System

- Unix file system developed for diskless workstations with large memories at UCB.
- Considers memory as a huge cache of disk blocks. Memory is shared between file system and VM.
- Files are stored on servers. Servers have a large memory that acts as a cache as well.
- On a read, the block may be found in local memory file cache, in server memory cache, or on disk.
- 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.

Distributed File Systems

- There are a number of issues to deal with here.
- Performance is always an issue; there is 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, distributed or otherwise. As memories get larger, most read requests can be serviced out of file buffer cache (local memory). Maintaining coherency of those caches is a crucial design issue.
- Newer systems are dealing with issues such as disconnected file operation for mobile computers.