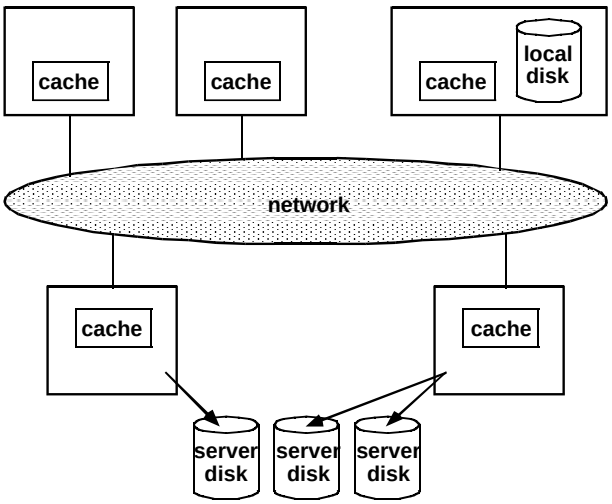
Distributed File Systems

- *Distributed file system* — a distributed implementation of a file system
  - *File service* — specification of the file system interface as seen by the clients
  - *File server* — a process running on some machine which helps implement the file service by supplying files
- Goals of a distributed file system
  - *Network transparency*
    - Provide same operations for accessing remote and local files
    - Ideally, clients should not have to know the location of files to access them
  - *Availability* / *robustness* — file service should be maintained even in the presence of partial system failures
  - *Performance* — should overcome bottlenecks of a centralized file system

Distributed File Systems (cont.)



- In principle, files in a distributed file system can be stored at any machine
  - However, a typical distributed environment has a few dedicated machines called *file servers* that store all the files

Distributed Naming Structures

- Need operations for name translation, support for multilevel directories and links
  - *Location transparency* — the name of the file does not reveal the physical storage location
    - True for many naming schemes
  - *Location independence* — the name of the file need not change if the file's storage location changes
    - False for most naming schemes
- Absolute names
  - Names of form: *machine* : *pathname*
  - Used by:
    - Old UNIX distributed file systems
    - Current web browsers (e.g., Netscape)

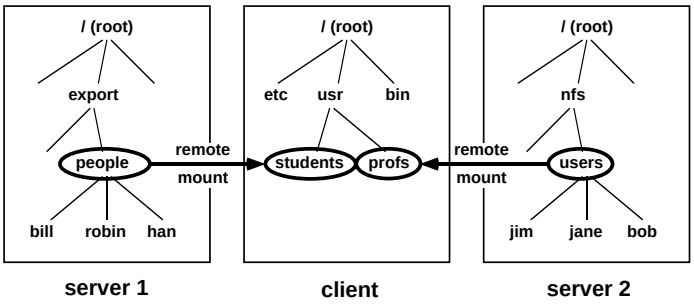
✔ User can use same tools and file operations for local and remote access

✘ Not location transparent or independent

Distributed Naming Structures (cont.)

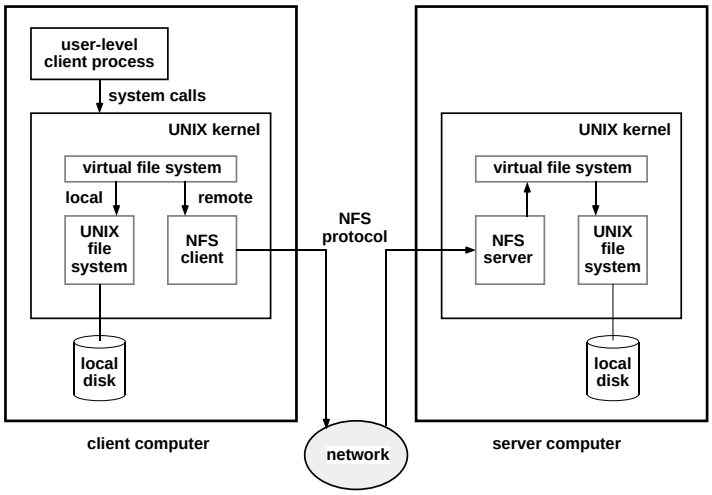
- Mount remote directories onto local directories (possibly on demand)
  - Client-maintained mount information:
    - Used by UNIX and NFS — Sun's Network File System
    - Client maintains:
      - A set of local names for remote locations
      - A *mount table* (/etc/fstab) that specifies a:
        - » < remote machine name : pathname >
        - » and < local pathname >
    - At boot time, the local name is bound to the remote name
      - Afterwards, users refer to local pathname as if it were local, and the distributed OS takes care of the mapping
      - Location transparent and independent after the mount operation, but not before
  - Server-maintained mount information:
    - If files are moved to a different server, mount information need only be updated at servers

Mounting Remote File Systems



- NFS supports mounting of remote file systems by client machines
  - Name space seen by each client may be different
  - Same file on server may have different path names on different clients
  - NFS does not enforce a single network-wide name space, but a uniform name space (and location transparency) can be established if desired

NFS Software Architecture



- Virtual file system:
  - Separates generic file-system operations from their implementation (can have different types of local file systems)
  - Based on a file descriptor called a vnode that is unique networkwide (UNIX inodes are only unique on a single file system)

NFS Protocol

- NFS protocol provides a set of RPCs for remote file operations
  - Looking up a file within a directory
  - Manipulating links and directories
  - Creating, renaming, and removing files
  - Getting and setting file attributes
  - Reading and writing files
- NFS is stateless
  - Servers do not maintain information about their clients from one access to the next
    - There are no open-file tables on the server
  - There are no open and close operations
    - Each request must provide a unique file identifier, and an offset within the file
  - Easy to recover from a crash, but file operations must be idempotent

NFS Protocol (cont.)

- Because NFS is stateless, all modified data must be written to the server's disk before results are returned to the client
  - Server crash and recovery should be invisible to client —data should be intact
  - ✘ Lose benefits of caching
    - Solution — RAM disks with battery backup (un-interruptable power supply), written to disk periodically
- A single NFS write is guaranteed to be atomic, and not intermixed with other writes to the same file
  - However, NFS does not provide concurrency control
    - A write system call may be decomposed into several NFS writes, which may be interleaved
    - Since NFS is stateless, this is not considered to be an NFS problem