ECE437/CS481

M06C: VIRTUAL FILE SYSTEM & NETWORK FILE SYSTEM

CHAPTER 12.8

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Virtual File System

❑ Lots and lots of file system types

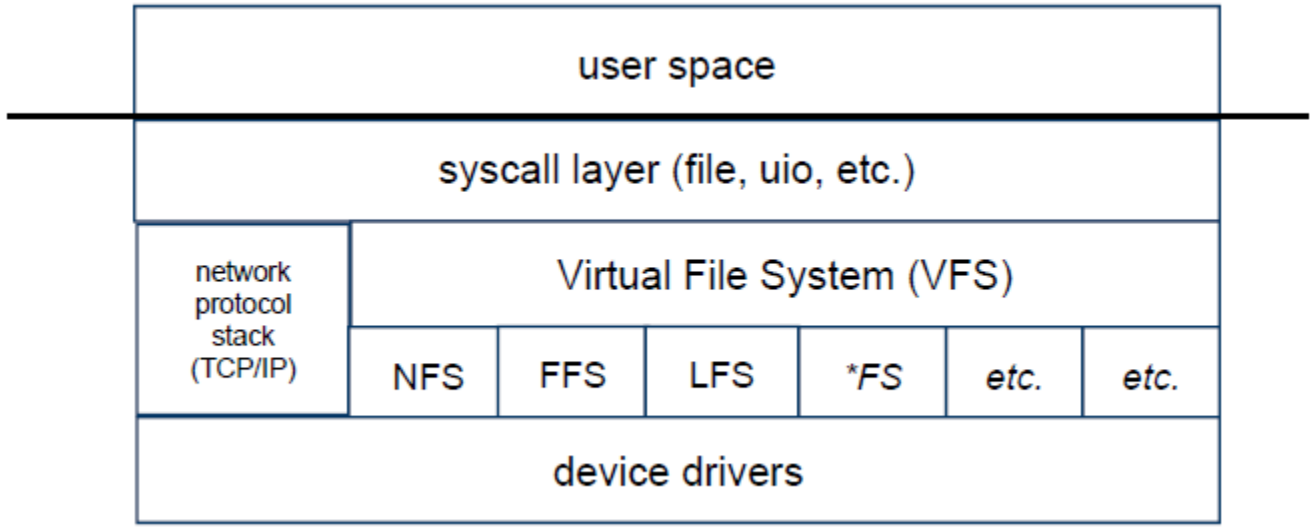
- ➢ Different file systems may have different directory structures, block sizes, etc.
- ➢ Is it possible to support more than one file system types on a single OS?

File System	Windows XP	Windows 7/8/10	macOS (10.6.4 and earlier)	macOS (10.6.5 and later)	Ubuntu Linux	Playstation 4	Xbox 360/One
NTFS	Yes	Yes	Read Only	Read Only	Yes	No	No/Yes
FAT32	Yes	Yes	Yes	Yes	Yes	Yes	Yes/Yes
exFAT	Yes	Yes	No	Yes	Yes (with ExFAT packages)	Yes (with MBR, not GUID)	No/Yes
HFS+	No	(read-only with Boot Camp)	Yes	Yes	Yes	No	Yes
APFS	No	No	No	Yes (macOS 10.13 or greater)	No	No	No
EXT 2, 3, 4	No	Yes (with third-party software)	No	No	Yes	No	Yes

Virtual File System

❑ Virtual file system

- A kernel software layer that handles all system calls related to file systems. Its main strength is providing a **common interface** to several kinds of file systems.



- ✓ Processes make system calls to VFS rather than specific file system interfaces.
- ✓ VFS separates file-system generic operations from implementation details, and then dispatches operations to appropriate file system implementation routines.

Virtual File System

- VFS system calls (~100)
  - filesystem operations – mounting, info, chroot, pivot_root
  - directory operations – chdir, getcwd, link, unlink, rename, symlink
  - file operations – open/close, read/write, stat, permissions, seek
    - chmod, chown, stat, creat, umask, dup, fcntl, truncate
    - read/write, readv/writev, pread/pwrite
  - memory mapping files – mmap, munmap, madvise, mlock
  - wait for input – poll, select
  - flushing – synch, fsync, msync, fdatasync
  - file locking – flock

Network File System

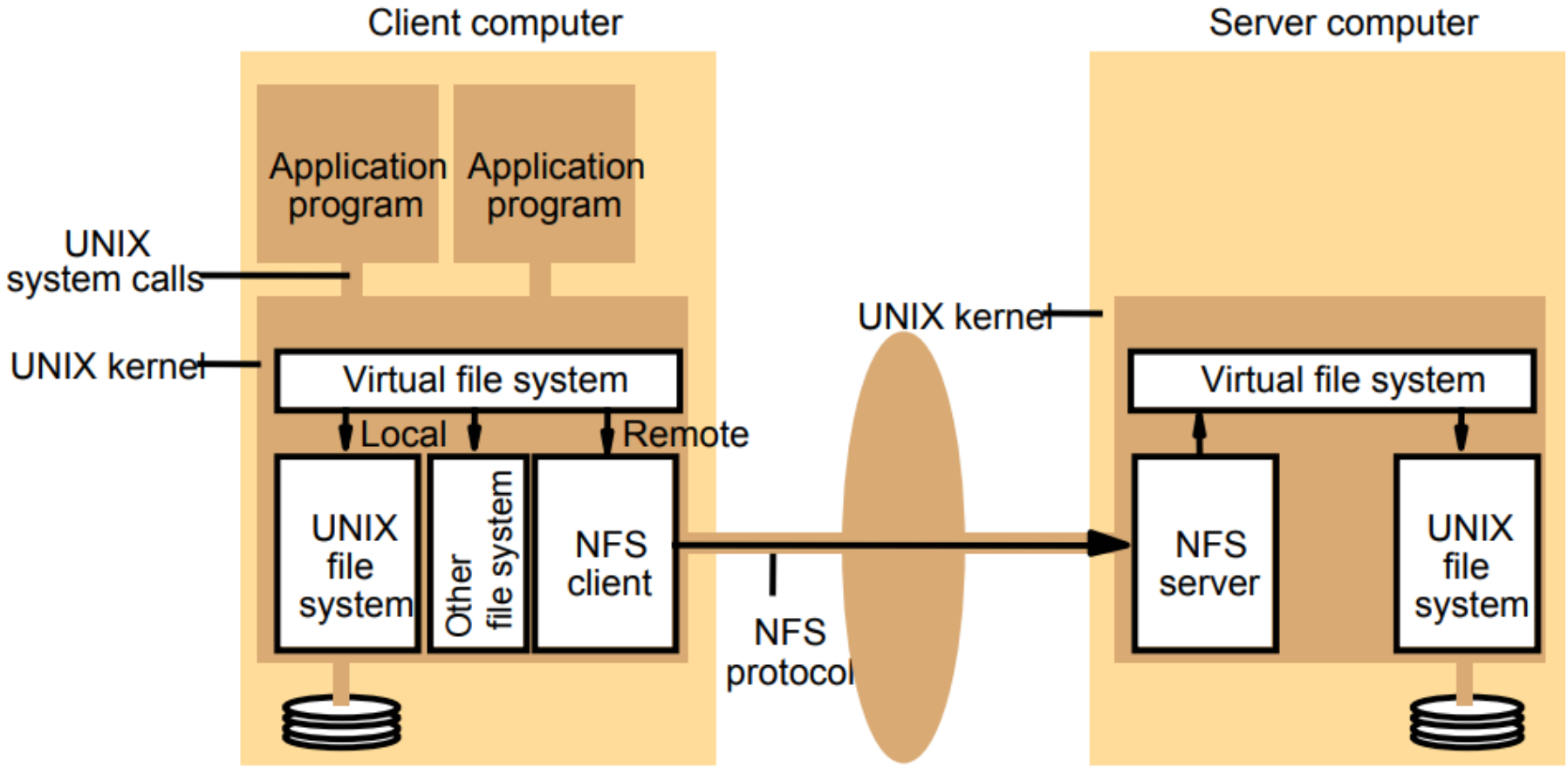
- Purpose: access disks attached to other computers

- NFS is a protocol for remote access to a file system
  - Does not implement a file system per se
  - NFS is a network protocol layer over TCP/UDP
    - ✓ Original implementations use UDP a transport layer protocol for low overhead.
    - ✓ Some newer implementations use TCP as a transport layer protocol for reliable communications.
  - Remote access is transparent to applications

- File system, OS, and architecture independent

- Implemented as a client/server architecture
  - Local file system (i.e. client) requests are forwarded to a remote server
  - Requests are implemented as remote procedure calls (RPCs)

Network File System

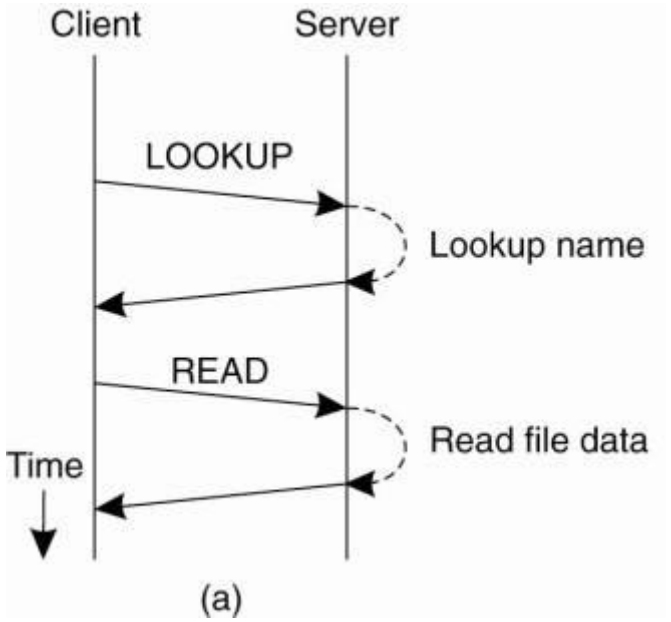


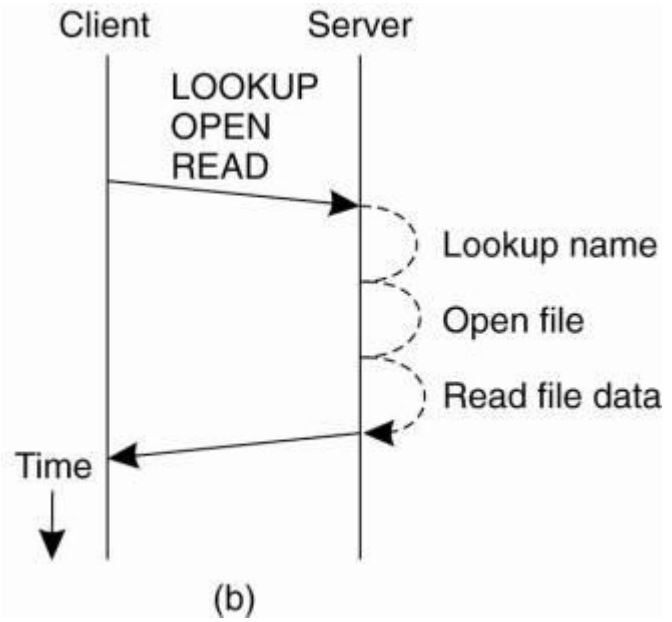
- NFS server check identity (e.g., uid, gid) for each access.
- NFS server is stateless, doesn't keep open files for clients
  - ✓ In NFS v4, stateful server are used

Network File System

❑ Communications in NFS

- ✓ The communications between a server and a client is based on the Open Network Computing RPC protocol.
- ✓ Every NFS operation (e.g., open(), read(), write()) can be implemented as a single remote procedure call to a file server.
- ✓ In order to reduce the communications overhead (i.e., reduce the number of RPCs), compound procedures is applied (in NFS v4), where several RPCs can be grouped into a single request.



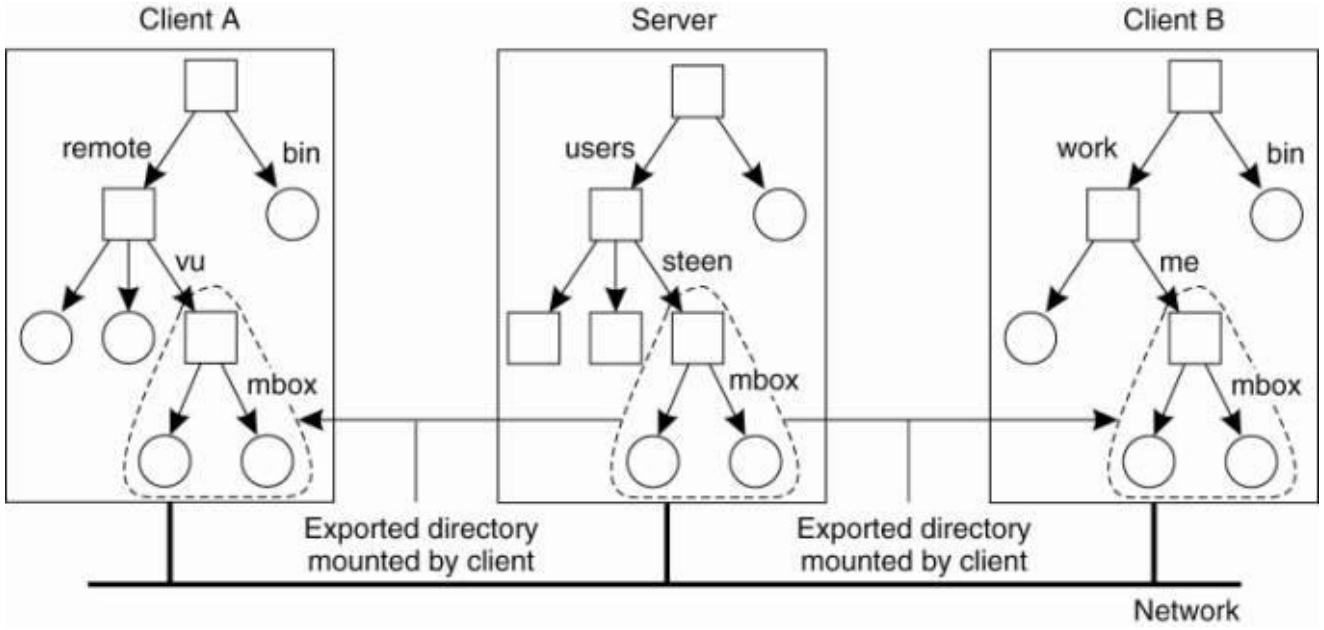


Network File System

❑ Naming in NFS

- The fundamental idea underlying the NFS naming model is to provide clients complete transparent access to a remote file system as maintained by a server. This transparency is achieved by letting a client be able to mount (part of) a remote file system into its own local file system.

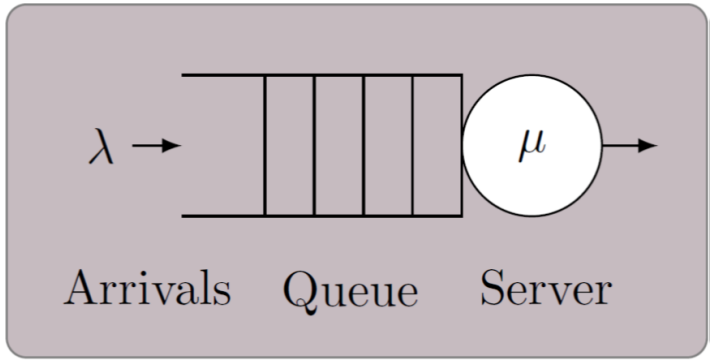
- A server exports a directory to a client, and the client mount the exported directory to its local name space.



Network File System

❑ Synchronization in NFS

- Different clients mount the same part of file system in the server → files are shared among the clients.
- How to achieve synchronization if many clients try to read/write the same file?
- If all the reads and writes go directly to the file server, the server can easily achieve the synchronization by processing them strictly sequentially.



- However, enabling the server t process every read and write many degrade the performance (in terms of throughput) of NFS, involving too many RPCs.

Network File System

❑ Synchronization in NFS

- In order to improve the performance, clients are allow to maintain local copies of heavily-used files in their private local caches. Thus, clients can read/write their local copies, and flush back the cached data to server when files are closed.
- If a client locally modifies a cached file and shortly thereafter another client reads the file from the server, the second client will get an obsolete file.
- There is no way to guarantee clients can read the up-to-date file in NFS.
  - ✓ Rule: changes to an open file are initially visible only to the client that modified the file. Only when the file is closed are the changes made visible to other clients.