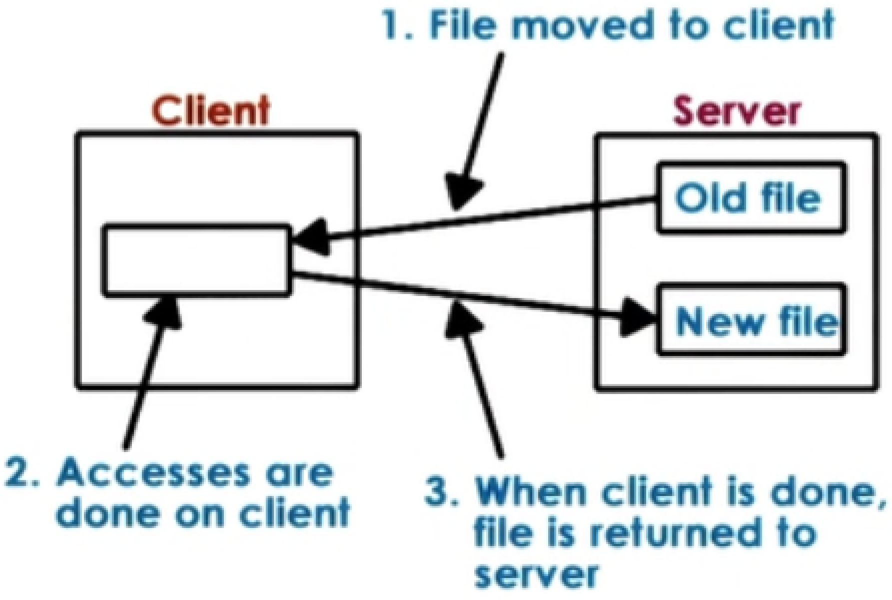
Distributed File Systems

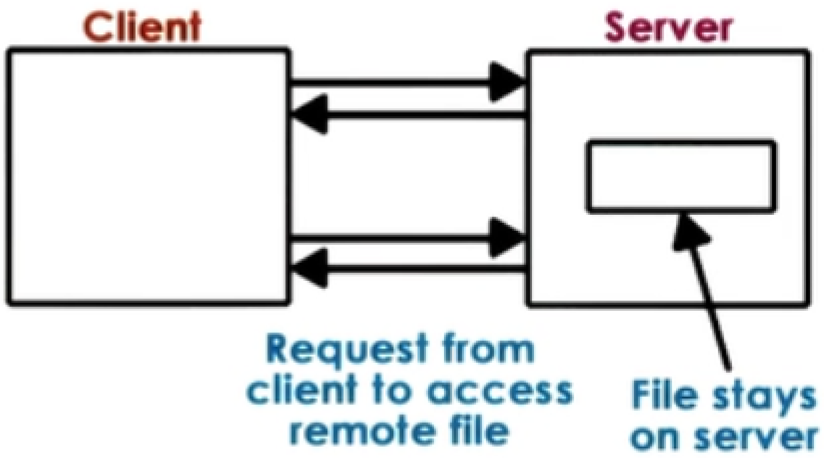
- Accessed via well defined interface
  - access via Virtual File Systems
- Focus on consistent state
  - tracking state, file update, cache coherence
- Mixed distribution models possible
  - replicates vs partitioned, peer-like systems

DFS models

- Client Server on different machines
- File server distributed on multiple machines
  - replicated (each server : all files)
  - partitioned (each server : parts of files)
  - both (files partitioned, each partition replicates)
- Files stored on and served from all machines (peers)
  - blurred distinction between clients and servers

Remote File Service : Extremes





1. Extreme1 : Upload/Download
    - like FTP, SVN
    - **+** local read/writes at client
    - **-** entire file download/upload evn for small accesses
    - **-** server gives up contro;
2. Extreme2 : True Remote File Access
    - Every access to remote file, nothing done locally
    - **+** file access centralized, easy to reason about consistency
    - **-** every file operation pays network cost, limits server scalablity

Remote File Service : A compromise

A more practical Remote File access (with Caching)

1. Allow clients to store parts of files locally (blocks)
    - **+** low latency on file operations
    - **+** server load reduces => more scalable
2. Force clients to interact with server (frequently)
    - **+** server has insights into what clients are doing
    - **+** server has control into which accesses can be permitted => easier to maintain consistency
    - **-** server more complex, requires different file sharing semantics

Stateless vs Stateful File server

Stateless	Stateful
Keeps no state; Okay with extreme models, but can't support 'practical' model	Keeps client state needed for 'practical' model to track what is cached/accessed
- Can't support caching and consistency management	**+** Can support locking, caching, incremental operations
- Every request self-contained. => more bits transferred	**-** Overheads to maintain state and consistency. Depends on caching mechanism and consistency protocol.
+ No resources are used on server side (CPU, MM). On failure just restart	**-** On failure, need checkpoining and recovery mechanisms

Caching state in a DFS

- Locally clients maintain portion of state (e.g. file blocks)
- Locally clients perform operations on cached state (e.g. open/read/write)
- requires coherent mechanisms

System	How	When
SMP	Write-update/Write-invalidate	On write
DFS	Client/Server-driven	On demand, periodically, on open..

- Files or File blocks can be (with 1 server and multiple clients) cached in:
  - in client memory
  - on client storage device (HDD/SDD)
  - in buffer cache in memory on server
    - (usefulness will depend on client load, request interleaving)
- File Sharing Semantics in DFS
- Session semantics (between open-close => Session)
  - write-back on close(), update on open()
  - easy to reason, but may be insufficient
- Periodic updates
  - client writes-back periodically
    - clients have a "lease" on cached data (not exclusively necessary)
  - servers invalidates periodically => provides biunds on "inconsistency"
  - augment with flush()/sync() API
- Immutable files => never modify, new files created
- Transactions => all changes atomic

Replication vs Partitioning

	Replication	Partitioning
	Each machine holds all files	Each machine has subset of files
Advantages	Load balancing, availibility, fault tolerance	Availibility vs single server DFS; Scalability with file system size; single file writes simpler
Disadvantages	Write becomes more complex - Synchronous to all - or, write to one, then	On failure, lose portion of data load balancing harder, if not balanced, then hot-spots possible

	propagate to others replicas must be reconciled e.g. Voting	

- Can combine both techniques
  - Replicate each partition!