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NFS Server-side Copy

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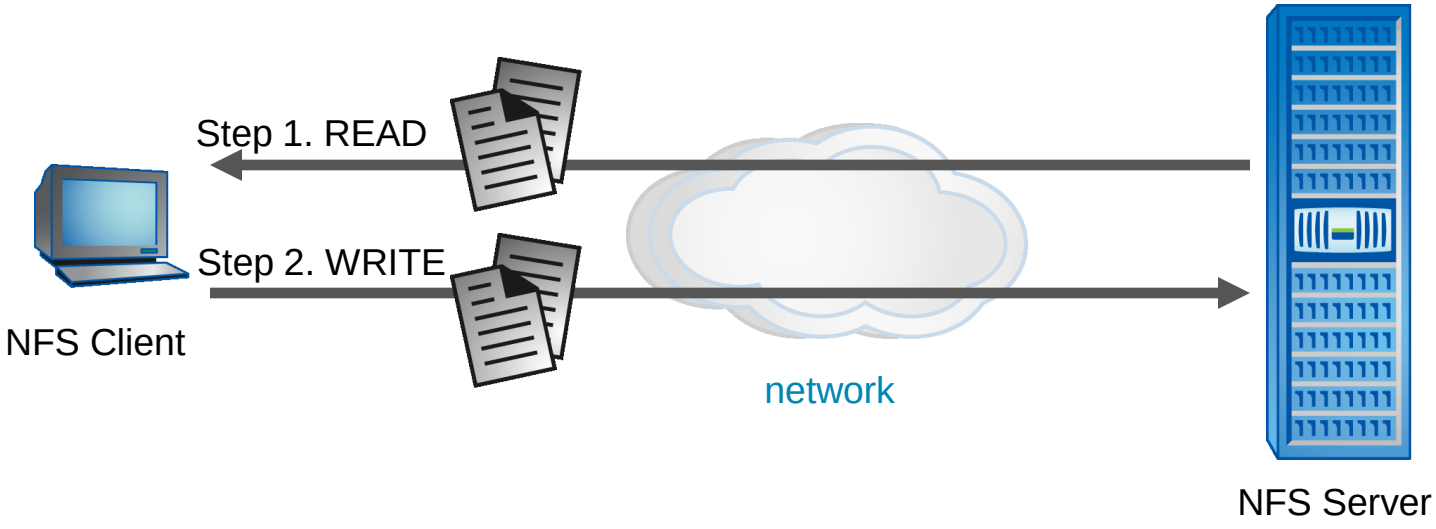
Summary

- NFS server-side copy offload is a set of operations that allow:
  - Copying a file on a single NFS server
  - Copying a file between two NFS servers.

- Server-side copy is a possible feature for NFSv4.2.

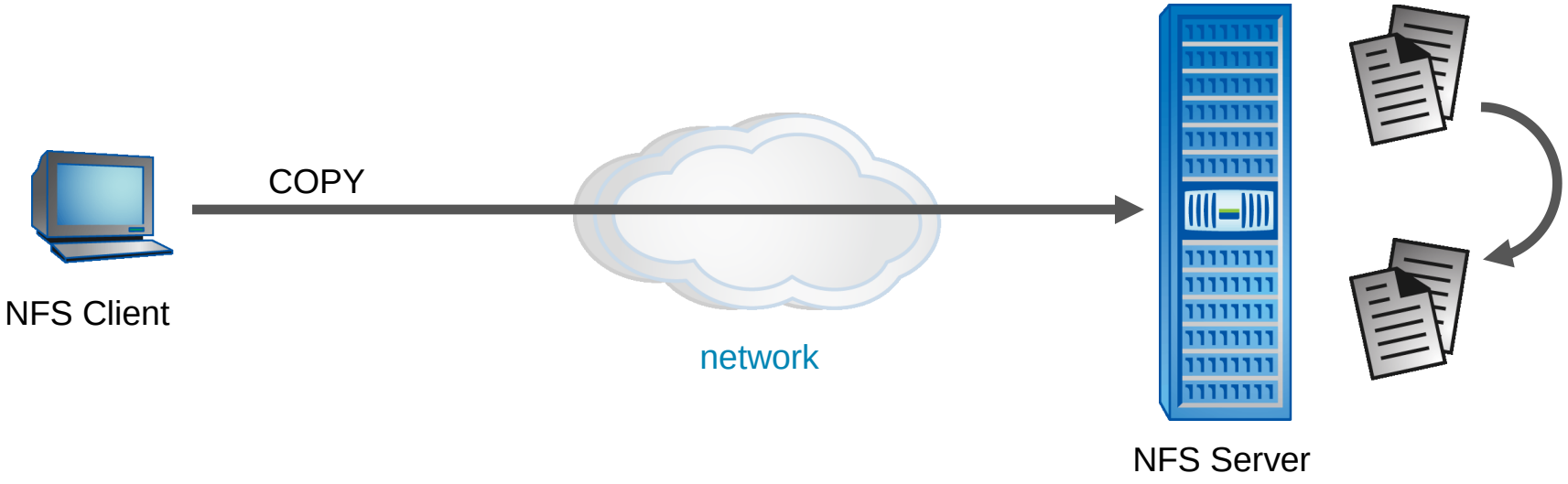
Copying with NFSv2/v3/v4[.1]

- The NFS client reads and writes the file over the network.
- Wastes client and network resources.



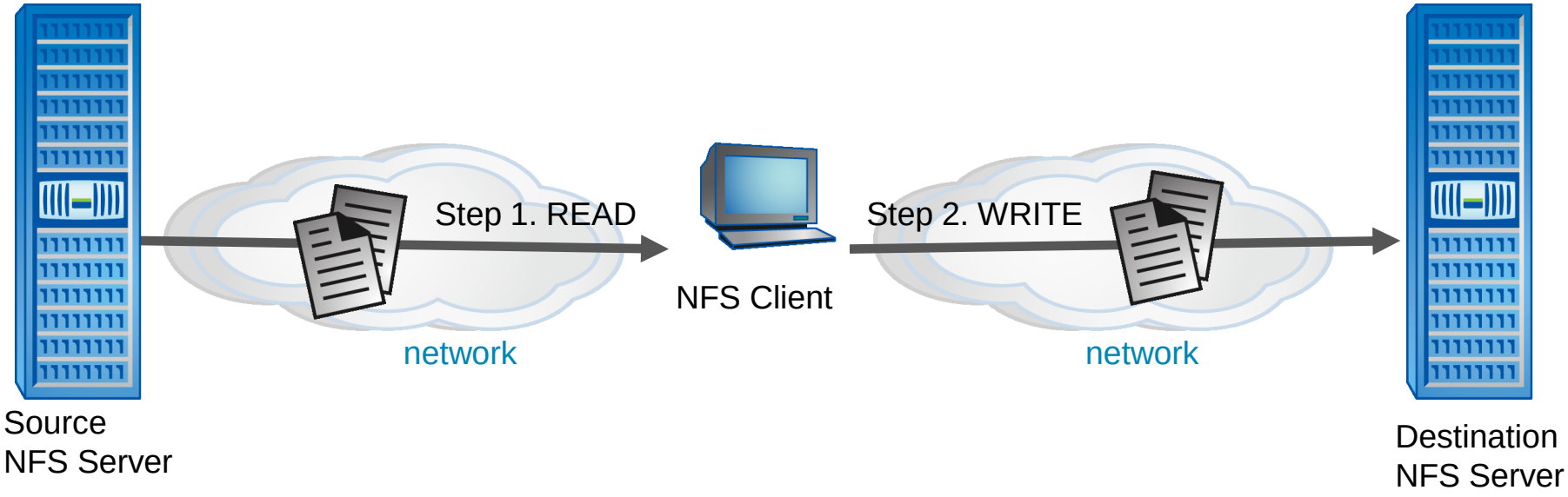
Copying with Server-side Offload

- The NFS client instructs the server to perform the copy.
- Saves client and network resources.



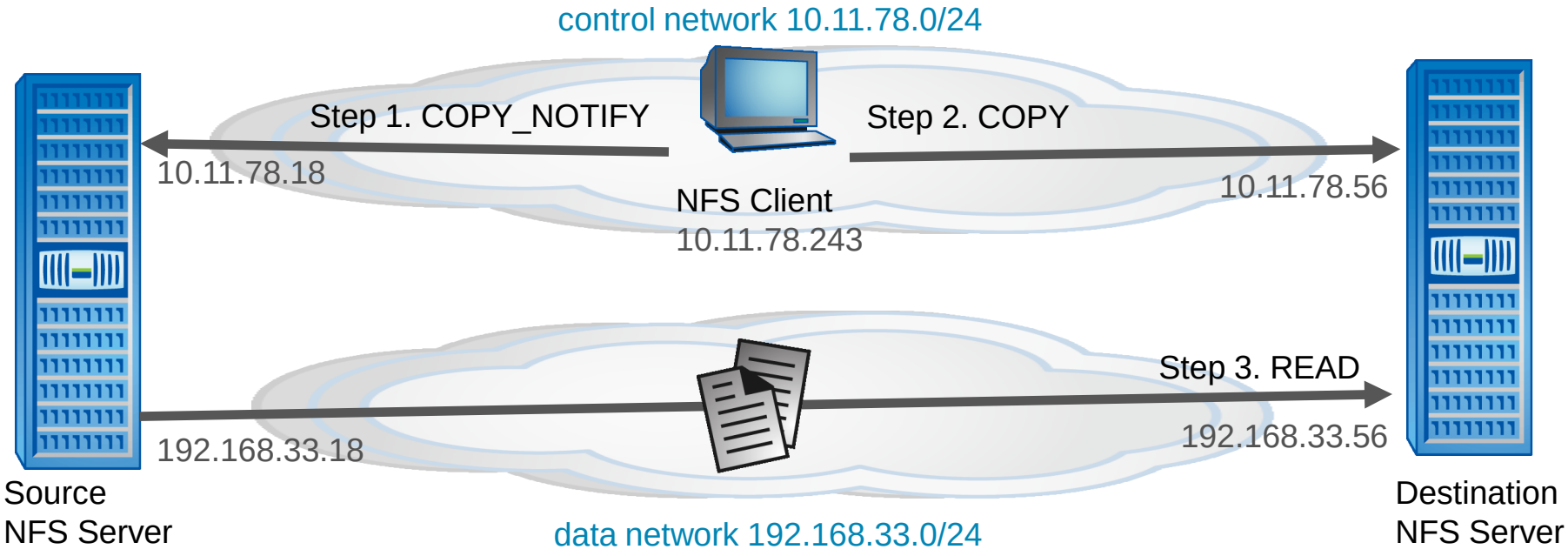
Copying between NFS Servers with NFSv2/v3/v4[.1]

- Client reads the file from the source server and writes the file to the destination server.
- Client is an extra network hop between the source and destination.



Copying between NFS Servers with Server-side Offload

- Client sets up the copy between the servers.
- Removes client hop and (optionally) allows a high performance server data network to be used.



Uses Cases

- In general, this feature is useful whenever data is copied from one location to another.
- **File Restore**: It is useful when copying the contents of a backup to the active file system.
- **Virtualized Environments:** Copy offload allows a hypervisor to efficiently:
  - Backup a VM's storage
  - Clone a VM's storage
  - Migrate a VM's storage

Protocol

Operations

server-to-server

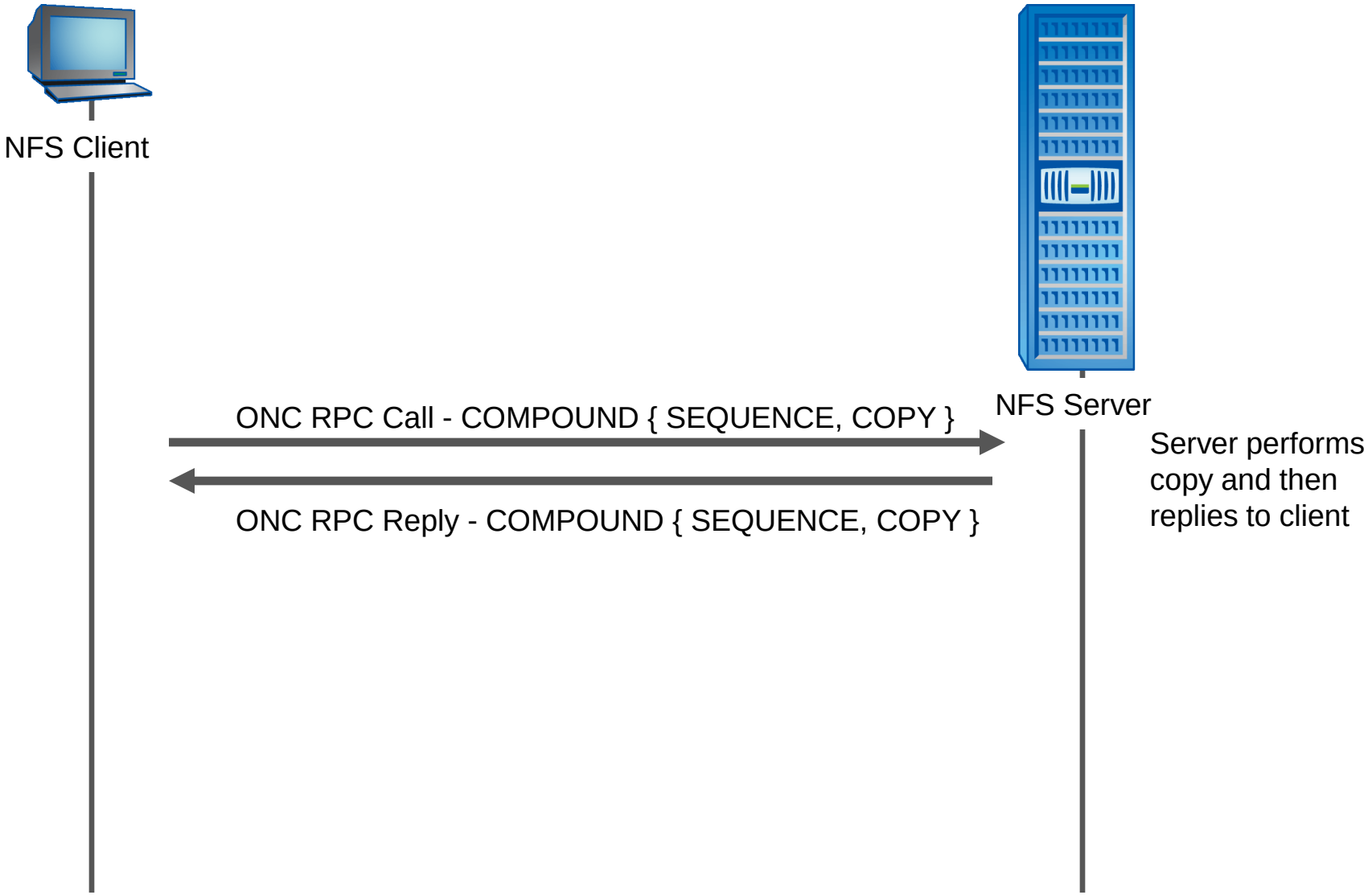
- **COPY_NOTIFY**: For inter-server copies, the client sends this operation to the source server to notify it of a future file copy from a given destination server for the given user.
- **COPY_REVOKE**: Also for inter-server copies, the client sends this operation to the source server to revoke permission to copy a file for the given user.

- **COPY**: Used by the client to request a file copy.

asynchronous

- **COPY_ABORT**: Used by the client to abort an asynchronous file copy.
- **COPY_STATUS**: Used by the client to poll the status of an asynchronous file copy.
- **CB_COPY**: Used by the destination server to report the results of an asynchronous file copy to the client.

Synchronous Intra-server Copy

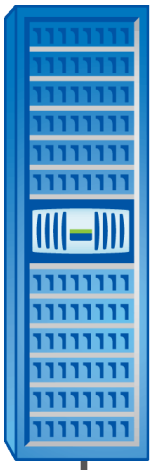


Asynchronous Intra-server Copy

NFS Client

ONC RPC Call - COMPOUND { SEQUENCE, COPY }

ONC RPC Reply - COMPOUND { SEQUENCE, COPY }



Server starts the copy and replies to client.

ONC RPC Call - COMPOUND { SEQUENCE, COPY_STAUS }

ONC RPC Reply - COMPOUND { SEQUENCE, COPY_STATUS } NFS Server

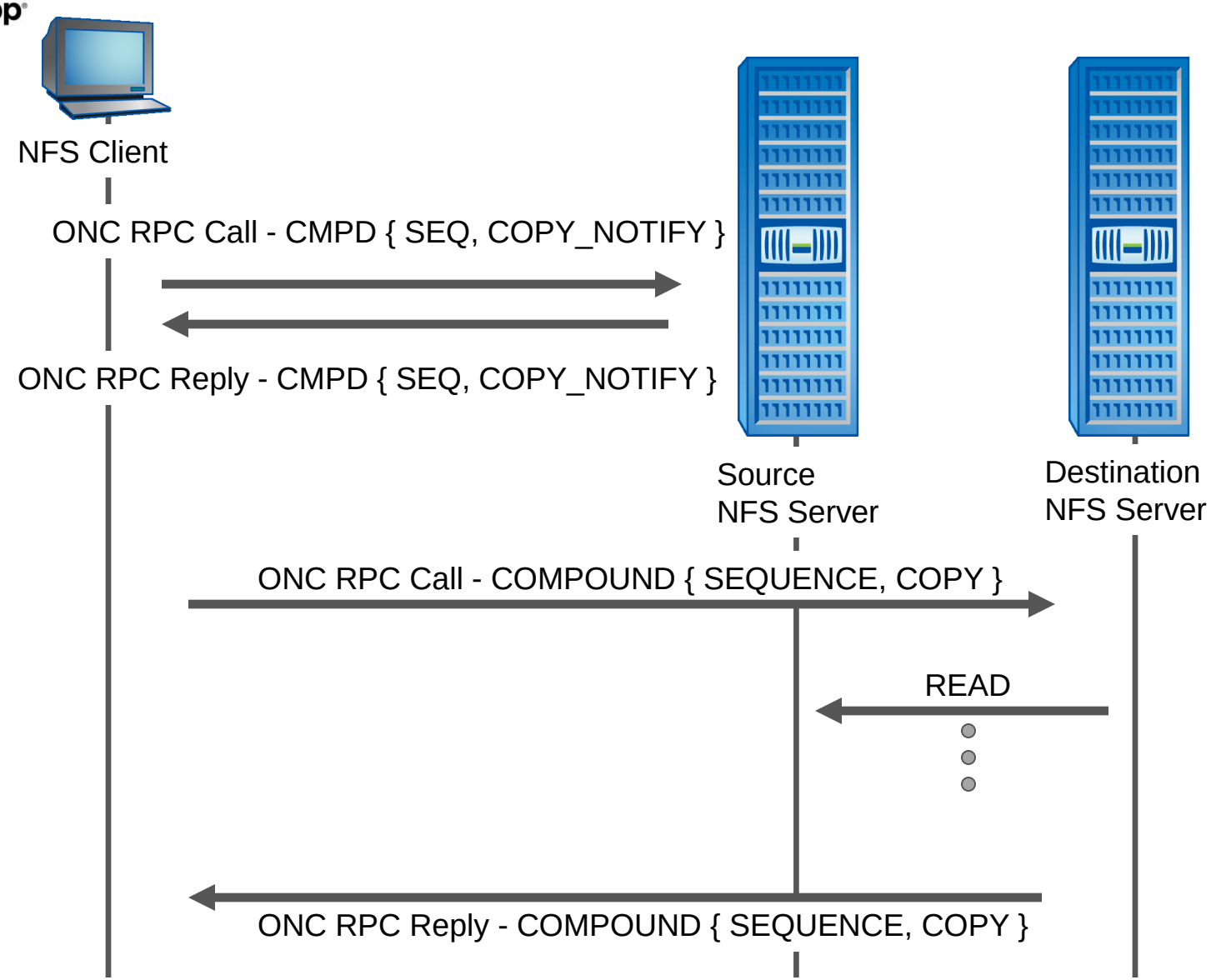
Client polls for status. Client can also cancel copy with COPY_ABORT.

ONC RPC Call – CB_COMPOUND { CB_SEQUENCE, CB_COPY }

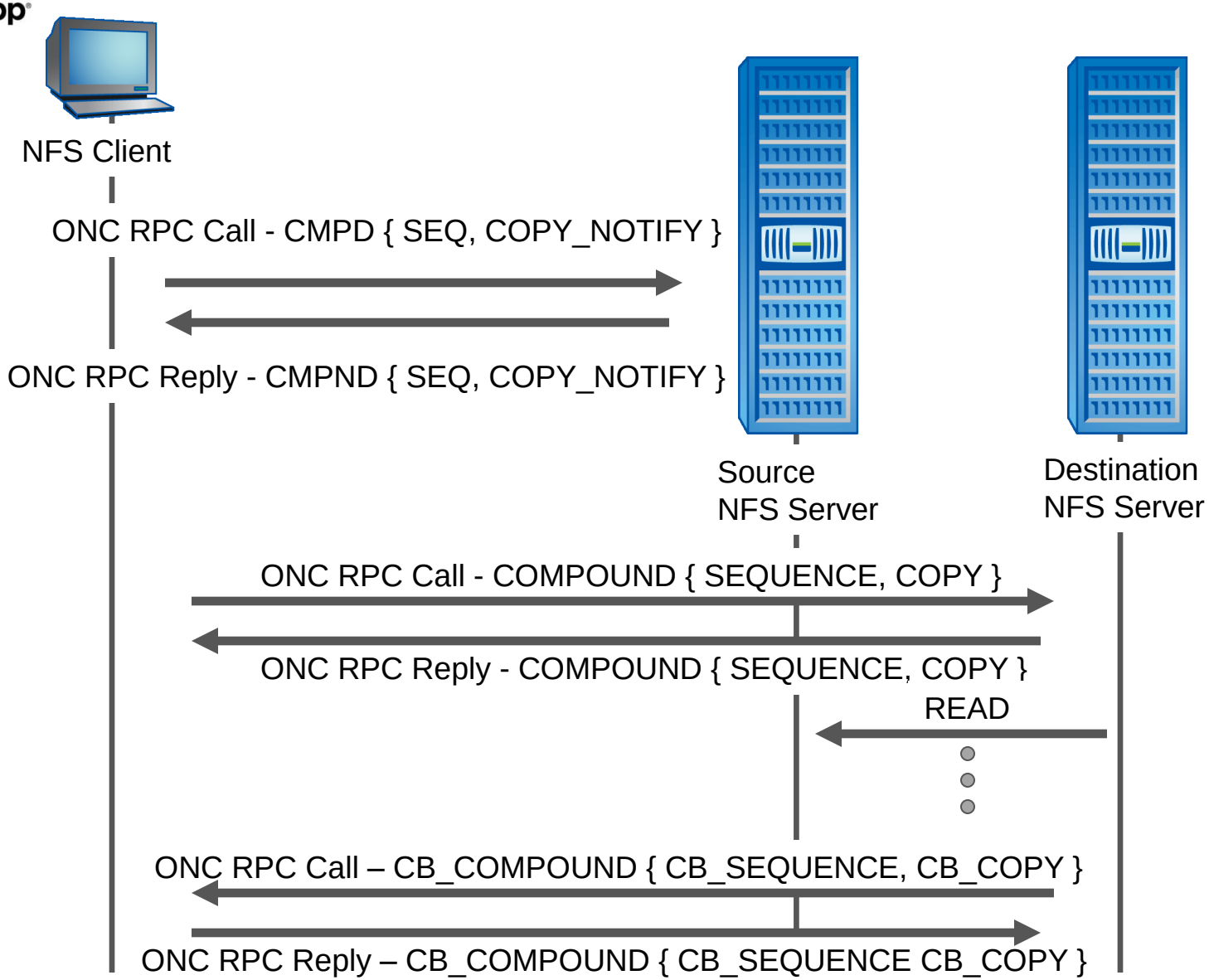
ONC RPC Reply – CB_COMPOUND { CB_SEQUENCE, CB_COPY }

Server issues callback with final results of the copy

Synchronous Inter-server Copy



Asynchronous Inter-server Copy

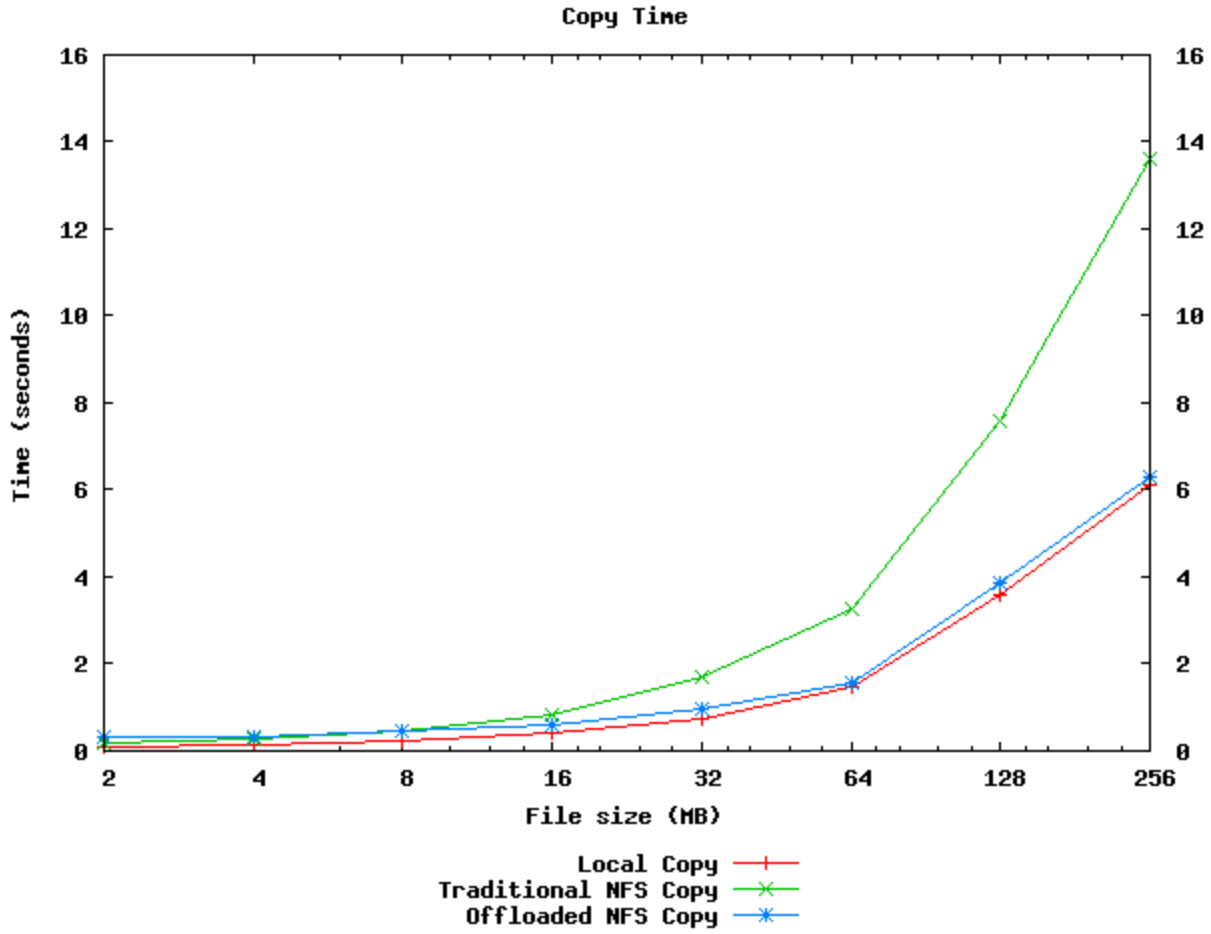


Implementation and Standardization Status

Linux Prototype

- Developed by Anshul Madan (intern) with help from Trond Myklebust and James Lentini.
- Modified Linux 2.6.34:
  - system call interface
  - NFS Client
  - NFS Server
- Implemented synchronous copy.
  - Plan to implementation asynchronous copy.
- Presented system call changes at the Linux Storage and Filesystem Summit (LSF'10).

Results



Client and Server configuration: dedicated, p2p 1 Gbps network; EXT4 export; dual core, 1.8 Ghz CPUs; 4 GB RAM

Standardization Status

- IETF Individual I-D by James Lentini, Mike Eisler, Deepak Kenchamanna, Anshul Madan, and Rahul Iyer
- Extensive feedback and comments on the NFSv4 WG mailing list starting in April, 209.
- A possible feature for NFSv4.2.
- See draft-lentini-nfsv4-server-side-copy

  http://tools.ietf.org/html/draft-lentini-nfsv4-server-side-copy

Planned Draft Updates

- Metadata copy
  - Lists which attributes MUST or SHOULD be copied
  - Only applicable to whole file copies.
- Remove COPY4_SPACE_RESERVED flag
  - space_reserve attribute in draft-iyer-nfsv4-space-reservation-ops.
- Explains how client can guard against concurrent modifications (e.g. OPEN4_SHARE_DENY_WRITE).
- Clarify that a successful copy must result in identical data in the NFS client's view of the source and destination file, but the on disk representation may be different due to backend encryption/compression/deduplication/etc.

Thank You

Questions?

Design

Design Choice: Supported Object Types

- What types of objects will the copy operations support?
  - Files?
  - Directories?
  - Namespace junctions?
- Proposal is to support copies of regular files.
- Simplifies the protocol
- Directory copies can by synthesized using multiple file copies and directory creates.
- Namespace junctions can be copied using the FedFS ONC RPC Admin protocol.

Design Choice: Synch vs. Asynch

- Does the NFS server perform the copy synchronously or asynchronously?
- Large files could require significant time to copy.
  - Problematic for a synchronous model.
- Proposal allows for both synchronous and asynchronous copies
  - Server decides what type to use

Design Choice: Server-to-server Protocol

- The protocol supports intra- and inter- server copies
  - intra-server copy: source and destination file on the same fileserver
  - inter-server copy: source and destination file on different fileservers
- The proposal doesn't require a particular server-to-server copy protocol.
- NFSv4.1 is a good candidate for heterogeneous environments.
  - Standard protocols (FTP, HTTP, …) in addition to NFS are also supported.
- Proprietary protocols are possible in homogeneous environments.
  - The source and destination server may be using a clustered file system, no data may actually need to be copied or may have the same file system format allowing physical block-level replication.

Security

Security

- Requirements:
  - flexible enough to allow for different server-to-server copy protocols.
  - compatible with using NFSv4.x as the server-to-server copy protocol.
  - no pre-configuration between the source and destination.
  - support mutual authentication between the participants (client, source server, and destination server).
- Supported mechanism:
  - RPCSEC_GSSv3 (IETF draft) for strong security
  - host-based security (e.g. AUTH_SYS)

RPCSEC_GSSv3 Security (1)

- Three new RPCSEC_GSSv3 privileges:
  - copy_from_auth_priv: established by the client on the source server to allow a copy operation from the specified destination server on behalf of the given user.
  - copy_to_auth_priv: established by the client on the destination server to allow a copy operation from the specified source server on behalf of the given user.
  - copy_confirm_auth_priv: for ONC RPC server-to-server copy protocols, established by the destination server on the source server to allow a copy operation on behalf of the given user.

RPCSEC_GSSv3 Security (2)

- Client establishes copy_from_auth_priv, source server creates <"copy_from_auth", user id, destination> record. Client sends COPY_NOTIFY using the copy_from_auth RPCSEC_GSSv3 handle. Source server annotates record with source filehandle.
- Client establishes copy_to_auth_priv, destination server creates <"copy_to_auth", user id, source> record. Client sends a COPY using the copy_to_auth RPCSEC_GSSv3 handle.
- The destination establishes a copy_confirm_auth_priv on the source. Subsequent ONC RPC requests from the destination of the source use the copy_confirm_auth_priv handle.

Host-based Security

- Without real security, only a minimal level of protection is possible.
- Unique URLs used to encode the destination's copy privilege and identify a specific copy.
- Source server returns URLs in COPY_NOTIFY reply:

  nfs://10.11.78.18//_COPY/10.11.78.56/_FH/0x12345

  nfs://192.168.33.18//_COPY/10.11.78.56/_FH/0x12345
- Destination server will identify itself by performing these operations:

  COMPOUND { PUTROOTFH, LOOKUP "_COPY" ; LOOKUP "10.11.78.56"; LOOKUP "_FH" ; OPEN "0x12345" ; GETFH }

Additional Information

Copy Offload Stateids

- Copy Offload Stateids: a new type of stateid to identify asynchronous copies.
- Valid until either:
  - the client or server restart.
  - the client issues a COPY_ABORT operation.
  - the client replies to a CB_COPY operation.
- A copy offload stateid's seqid MUST NOT be 0 (which would indicate the most recent offloaded copy). No use case for this.

NFS Client Support

- When does an NFS client use the server-side copy offload operations?
  - Changes may be needed to the OS's user/kernel interface.
    - In Linux, reflink(2) (work in progress) looks promising. reflink(2) being proposed by OCFS2 developers for use by Oracle VM, see http://blogs.oracle.com/wim/2009/05/ocfs2_reflink.html
  - Some environments may be ready to take advantage of these operations right away (e.g. a hypervisor).

Proposed Linux System Call – copyfile(2)

COPYFILE_ATTRS	0x0001
COPYFILE_PRIV_ATTRS	0x0002
COPYFILE_PERMISSIONS	0x0004

```
long sys_copyfileat(int olddfd,
                    const char __user *oldname,
                    int newdfd,
                    const char __user *newname,
                    int flags,
                    loff_t __user *result);
```

- Based on Joel Becker's reflink(2) proposal
- Available at:
  ftp://ftp.netapp.com/frm-ntap/opensource/linux_copyfileat/v1/linux_copyfileat_v1.tgz

Additional Features

- Partial file copies
  - Source file offset, destination file offset, and length
- Guarded copies
  - The copy will fail if the destination file exists
- Metadata copy
  - The destination file will duplicate all required and recommended NFS attributes