

# Introduction to the Network File System (NFS)

☞ What was life like before NFS?



# Introduction to the Network File System (NFS)

☞ NFS is built on top of:

☞→ UDP - User Datagram Protocol (unreliable delivery)

☞→ XDR - eXternal Data Representation (machine independent data format)

☞→ RPC - Remote Procedure Call



# NFS overview

- 👉 Two protocols, mount and nfs: “mount” protocol establishes initial link between client and server machines



# NFS overview

- ☞ NFS protocols provide a set of RPCs for remote file operations
  - ☞ Searching a directory
  - ☞ Reading a set of directory entries
  - ☞ Manipulating links and directories



# NFS overview

- Accessing file attributes
- Read and writing files
- Notably missing are `open()` and `close()`



# NFS overview

➤ There was no equivalent to traditional UNIX file table on the server side (NFS was designed to be stateless on the server side). However, this stateless wasn't all that practical and we soon ended up with caching and file handles



# NFS problems

## ☞ Performance

- ☞ Modified data may be cached locally on the client
- ☞ Once the cache flushes to the server, the data must be written to disk before results are returned to the client and the cache is flushed



# NFS problems

## ☞ File write operation semantics

### ☞ UNIX semantics (without NFS)

- ☞ Writes to an open file are visible immediately to other users who have the file open at the same time
- ☞ The file is viewed as a single resource





# NFS problems

## ⇒ Session semantics

- ⇒ Writes to an open file are not visible to others having it open at the same time
- ⇒ Once a file is closed the changes are visible only in the sessions opened later



# NFS problems

- NFS is close to UNIX semantics, but...
  - there are two client caches: file blocks and file attributes
  - cached attributes are validated with server on an open()
  - the old biod/nfsiod process implemented read-ahead and delayed-write techniques on the client-side, but is not seen much (if at all) these days



# NFS problems

- ➡ newly created files may not be visible to other sites for up to 30 seconds
- ➡ it is indeterminant whether writes to a file will be immediately seen by other clients who have the file open for reading
- ➡ If a single NFS `stat()` request hangs, it can hang up UNIX commands, like “df” !



# NFS problems

- ➡ “magic cookies” (random numbers) used to short-cut future validations. Given to client from server, client can use it to re-connect whenever a server comes back up after a crash.



# NFS problems

Network File System, FSINFO Call DH:0x75867c04

Program Version: 3

V3 Procedure: FSINFO (19)

object

length: 12

hash: 0x75867c04

type: Linux knfsd (new)

version: 1

encoding: 0 0 0

auth\_type: no authentication (0)

fsid\_type: major/minor/inode (0)

fileid\_type: root (0)

authentication: none

file system ID: 3,2 (inode 4112441)

major: 3

minor: 2



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inode: 4112441  
file ID: root inode



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# NFS problems

- The original NFS protocol can be spoofed (no encryption nor authentication). The first attempts to add authentication were not all that good (see USAH p 492).
- Note that “stale cookies” can make a client hang (solution: remount the filesystem on the client to make it get a new, fresh cookie).
- RPCSEC is supposed to cure all manner of security problems, but depends on kerberos infrastructure.



# What are the differences in v2 and v3?

See RFC1813 <http://www.ietf.org/rfc/rfc1813.txt> for a full description of v3. There is a good summary at [nfs.sourceforge.net](http://nfs.sourceforge.net) of the differences in v2 and v3:

- ☞ In v2, clients can access only 2 gigabytes of a file. In v3, much larger (64 bit)
- ☞ v3 supports larger reads and writes





# What are the differences in v2 and v3?

- ☞ Idea of “Weak Cache Consistency” introduced in v3 to help detect if modifications are happening to an object (file or directory).
- ☞ Server-based access checks



# What are the differences in v2 and v3?

- ☞ v3 supports “safe asynchronous writes”, where a server is permitted to reply before it has synced data to the drive.



# Starting NFS on Linux

```
[root@sophie root]# more /etc/exports
```

```
#
```

```
/home/exports    monet.cs.fsu.edu(ro,no_root_squash,insecure)
```

```
[root@sophie root]# /etc/init.d/nfs start
```

```
Starting NFS services: [ OK ]
```

```
Starting NFS quotas: [ OK ]
```

```
Starting NFS daemon: [ OK ]
```

```
Starting NFS mountd: [ OK ]
```

```
[root@sophie root]# /etc/init.d/iptables stop
```

```
Flushing firewall rules: [ OK ]
```

```
Setting chains to policy ACCEPT: filter [ OK ]
```

```
Unloading iptables modules: [ OK ]
```



# Starting NFS on Linux

On the client side:

```
mount sophie:/etc/exports /mnt-tmp
```



# Starting NFS on Linux

What is actually done when on a Linux machine when you run `/etc/init.d/nfs`

```
exportfs    # /etc/exports  
rpc.rquotad  
rpc.nfsd  
rpc.mountd
```



# Starting NFS on Solaris

```
shareall # /etc/dfs/dfstab, not /etc/dfs/sharetab  
mountd  
nfsd
```



# NFS Security

- ☞ Don't export to hosts for which non-trusted users have root access.
- ☞ If you don't control root on the machine then don't export the file system.
- ☞ Block NFS traffic at your router/firewall, if possible.



# Tuning NFS

- ☞ You can adjust the number of `nfsd`
- ☞ Use `nfsstat -c` to see client-side NFS traffic
- ☞ Use `nfsstat -s` to see server-side NFS traffic





# Tuning NFS

```
/usr/sbin/nfsstat -s
```

```
Server rpc stats:
```

| calls | badcalls | badauth | badclnt | xdr call |
|-------|----------|---------|---------|----------|
| 28    | 0        | 0       | 0       | 0        |

```
Server nfs v3:
```

| calls | badcalls | badauth | badclnt | xdr call | calls | badcalls | badauth | badclnt | xdr call |   |    |
|-------|----------|---------|---------|----------|-------|----------|---------|---------|----------|---|----|
| 2     | 7%       | 10      | 35%     | 0        | 0%    | 2        | 7%      | 3       | 10%      | 0 | 0% |
| 8     | 28%      | 0       | 0%      | 0        | 0%    | 0        | 0%      | 0       | 0%       | 0 | 0% |
| 0     | 0%       | 0       | 0%      | 0        | 0%    | 0        | 0%      | 0       | 0%       | 1 | 3% |
| 0     | 0%       | 2       | 7%      | 0        | 0%    | 0        | 0%      | 0       | 0%       |   |    |



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# Tuning NFS

☞ Tuning with mount command:

☞→ `rsize=n` → Set the read buffer size to `n` bytes.

☞→ `wsize=n` → Set the write buffer size to `n` bytes.

☞→ `timeo=n` → Set the NFS timeout to `n` tenths of a second.

☞→ `retrans=n` → The number of NFS retransmissions.



# Tuning NFS

☞ Tuning with `sysctl` command:

☞→ Do `sysctl -a | egrep '(r|w)mem'`

☞→ Increasing both `net.core` and `net.ipv4` memory settings seems to help



# Automounting

- ❏ Original implementations were buggy, and some (Ultrix) required reboots to straighten out problems.
- ❏ For most production environments, the reasons for automounting are less of an issue from server-to-server since this is not done a great deal in practice and almost never to random hosts as auto-mounting assumes; for server-to-client, this would be only a benefit where a number of distinct NFS servers needed to be accessed



on an irregular basis by a given client — not all common these days.



# Beyond NFS

- 👉 NFS v4 (RFC3530 – <http://www.ietf.org/rfc/rfc3530.txt>)
  1. adds state (NFS was originally stateless)



# Beyond NFS

2. file delegation – the client can work on a local copy of a file until another client requests the same file
3. multiple RPCs in a single request
4. better security with RPCSEC/GSS





# Beyond NFS

5. improved ACL support
6. consolidates disparate parts into a single NFS mechanism (no longer lock, mount, stat, nfs)



# Beyond NFS

## ☞ AFS – Andrew File System

1. was in development since the late 1980s
2. better security than NFS, but never saw the success that NFS did and seems to be on the retreat



## Beyond NFS

3. AFS has been used in global configurations; Morgan Stanley, for instance, has a global AFS network (25,000+ hosts over 6 continents (good slide presentation at <http://www-conf.slac.stanford.edu/AFSBestPractices/Sl>
4. OpenAFS – IBM released a branch for open source development, but has dropped all commercial support



## More references

A very good reference for NFS operations can be found  
<http://nfs.sourceforge.net/nfs-howto/>

