# How the *Global File System* uses Dlock


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# Outline

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# What is GFS?

- GFS is a Shared-Disk filesystem for Fibre Channel

- GFS is Symmetric (No File Manager)

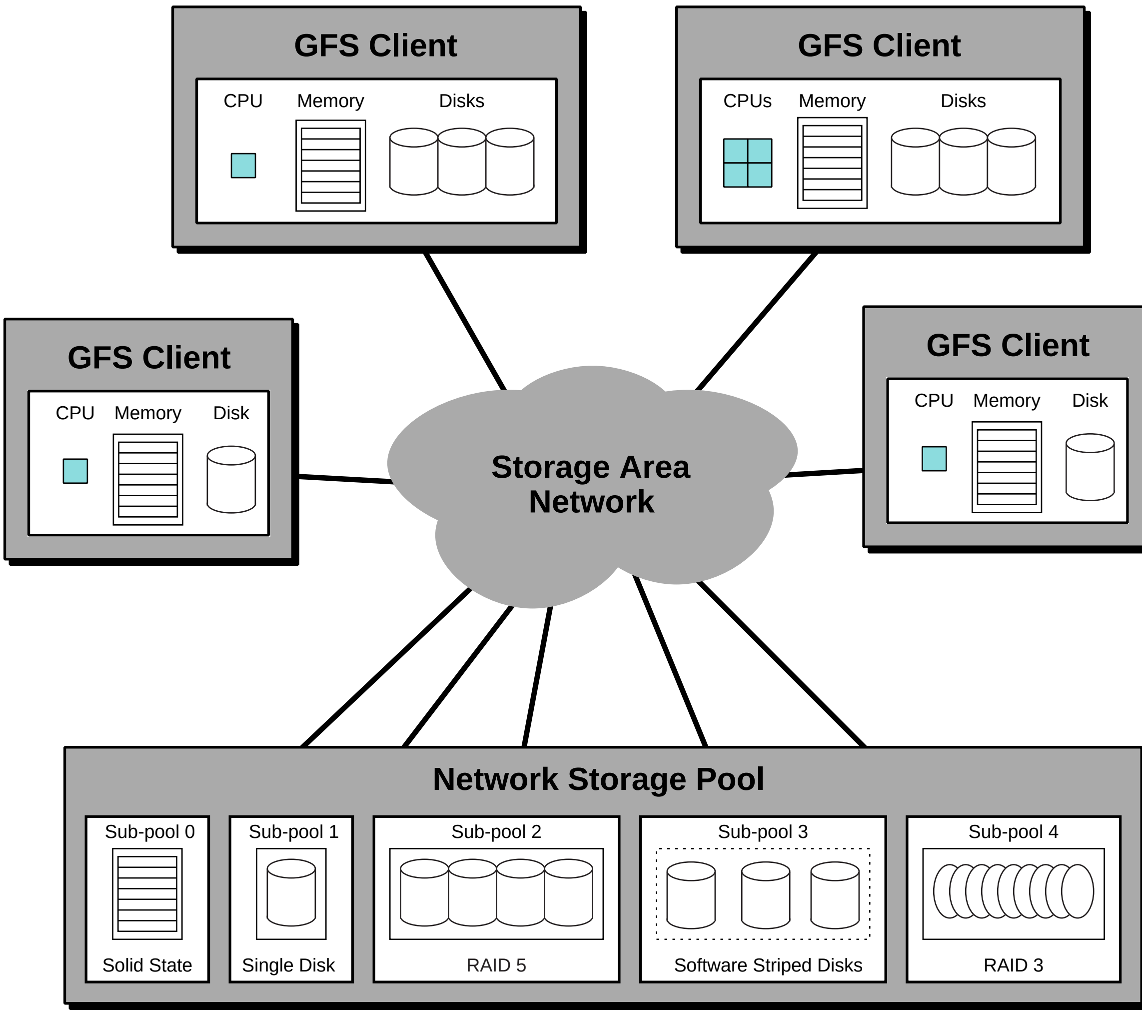
- Currently implemented on Irix and Linux

- Two parts

  1. The Network Storage Pool Driver

  2. The File System

- Uses an earlier implementation of Dlock on Seagate drives


GFS Client
CPU
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Storage Area
Network
Network Storage Pool
Sub-pool 0
Solid State
Sub-pool 1
Single Disk
Sub-pool 2
RAID 5
Sub-pool 3
Software Striped Disks
Sub-pool 4
RAID 3

# Pool

- Provides an uniform address space of data blocks and Dlocks to the FS.

- Takes lock and unlock commands from the FS and translates them into SCSI Dlock commands.

- Handles retries if the lock is busy, lock time-outs, and lock resets

# The File System

- Very similar to a local filesystem, but with locks for consistency

- Each client is in charge of keeping the meta-data consistent as it writes data

- Handles deadlock avoidance, caching, crash recovery

# Why Dlocks?

- SCSI devices are more reliable than most hosts

- Locks can be distributed across many disks without the complexity of DLMs

- Dlocks are faster in the firmware of a drive than on a general purpose computer

- Dlocks aren't connected to any particular part of the medium. A Dlock on one device can be used to lock data blocks on another device. What each lock represents it totally up to the initiators using it.

# Current GFS

- Uses a early version of the Dlock Spec – no shared locks, lock timeout, or World Wide Names

- Implemented on Irix and Linux

- GNU GPL source on http://gfs.lcse.umn.edu

# Locking

- Dlocks are used to perform mutual exclusion when metadata is updated.

- One Lock for the Superblock, Root Inode, and Rename Lock

- One Lock for each *Resource Group* (bitmaps)

- Each Inode hashes to a Dlock – Many to one mapping

- Dlocks are only held for short read-modify-write operations.

# Caching

- Dlocks provide a means of validating client-held caches of data

- Two types of Unlock actions

  1. Unlock – Regular unlock

  2. Unlock Increment – Increment the lock's *Version Number*

- Operations that change metadata on disk use Unlock Increment

- Read-only operations use Unlock

# Caching

- Each Lock action returns the version number for that lock.

- Clients compare the version number returned from a lock action with the version number from when they last held the lock.

- If the two version numbers match, the cache is valid.

# Caching – Example

| | **Machine A** | | **Lock** | **Machine B** | |
|---|---|---|---|---|---|
| | Action | Valid | | Action | Valid |
| 0 | | | U,0 | | |
| 1 | Lock Shared | No | S,0 | | |
| 2 | No Modify | | S,0 | | |
| 3 | Unlock | | U,0 | | |
| 4 | | | S,0 | Lock Shared | No |
| 5 | | | S,0 | No Modify | |
| 6 | | | U,0 | Unlock | |
| 7 | | | E,0 | Lock Exclusive | Yes |
| 8 | | | E,0 | Modify | |
| 9 | | | U,1 | Unlock Incr | |
| 10 | Lock Shared | No | S,1 | | |
| 11 | Modify | | S,1 | | |
| 12 | Unlock Incr | | U,2 | | |
| 13 | | | S,2 | Lock Shared | No |
| 14 | | | S,2 | No Modify | |
| 15 | | | U,2 | Unlock | |
| 16 | Lock Exclusive | Yes | E,2 | | |
| 17 | No Modify | | E,2 | | |
| 18 | Unlock | | U,2 | | |

# Crash Recovery

- We want to be able to detect when a client holding a lock crashes
- Currently, GFS does this by repeatedly polling the lock
- If the version number doesn't change for a set amount of time, it is assumed that a client has crashed.
- The lock is then reset and the FS can invoke a recovery routine.

# Areas of improvement for GFS

- The current GFS implementation works, but there are areas for improvements

- GFS currently doesn't do any write caching.

- Some locks (like the root inode lock) are read a lot, but not written.

- Online recovery is hard

# Dlocks are held longer

- Instead of a Dlock being acquired and released each operation, it is held for a long period of time.

- While the lock is held, write-caching is possible.

- Write-caching makes a journal-ed or log-structured file system efficient.

- The effect of the latency involved in getting a Dlock is lessened.

- But, this breaks our recovery scheme. A Dlock isn't constantly being locked an unlocked, how do we know when it is held by a failed initiator?

- But, if some other client has a lock and is holding it for a long time, how do we get it?

# Dlock Timeouts

- Dlocks time out (and become unlocked) if they are left idle for too long

- All that is required to recover from a failed client is to keep retrying the lock until it succeeds.

- When a lock action succeeds, a flag is passed back letting the client know whether or not the lock was expired.

- A *touch lock* command exists that lets a client reset the timeout on one of its locks.

- A client failure on a infrequently used Dlock is automatically detected

# World Wide Names

- When a lock command fails, a list of World Wide Names is returned to the client.

- Each WWN belongs to a client that is currently holding the lock

- Allows a client who wants a lock to ask other clients to release it.

- Allows arbitrary crash detection algorithms.

# Reader/Writer Locks

- Locks are acquired in one of two modes: Shared or Exclusive.

- A shared lock can be held by multiple clients that all want to read – but not write data.

- An exclusive lock is held by a client that wants to write.

- Locks that are read a lot, but seldom changed (like the root directory) can be held as shared locks to reduce congestion

# Summary

- GFS has been implemented using a early Dlock Specification

- GFS shows that it is possible to implement a shared-disk filesystem without having to rely on a centralized file manager.

- Future version will efficiently scale from a multiple machine cluster down to a single client.

- Dlocks provide a robust, distributed locking mechanism.