FS-Cache aware CIFS

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Overview

- Why Network filesystem caching?
- Some use-cases/scenarios
- Caching data flow
- FS-Cache
- Cache back-ends
- CIFS current implementation
- Q &A

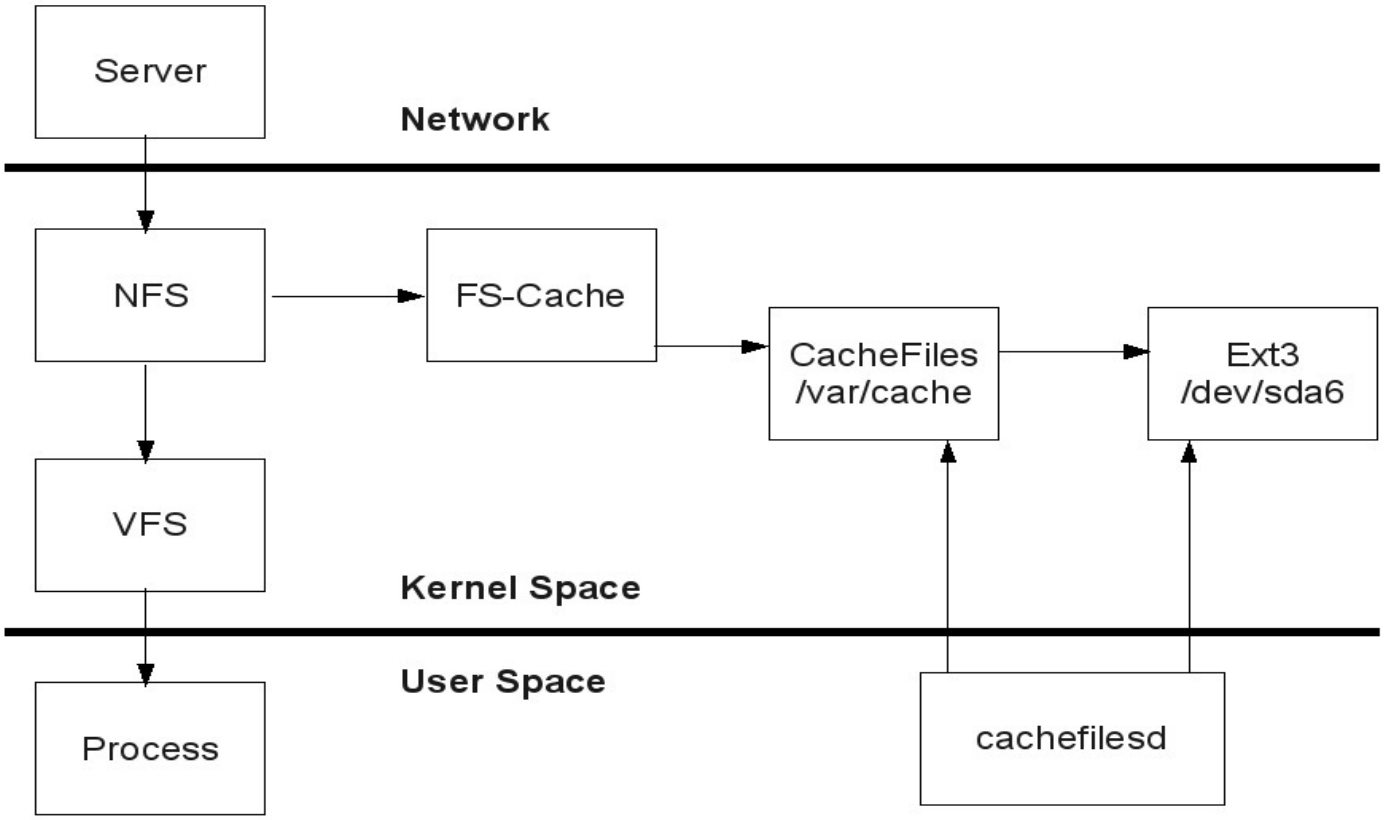
Why Network filesystem caching?

- Network based filesystems over slow network
  - Re-reading over loaded Network/Server can be slow
  - Local caching can help
    - Reduce Network traffic and Network latency
    - Reduce Server load
    - Improve Performance and Scalability
- First step towards making disconnected operations a reality!
  - Still lot needed from Network filesystem
- Not for every workload or I/O pattern
  - Trade offs

Some use-cases/scenarios

- Render farms in Entertainment industry
  - Use to distribute textures to individual rendering units
- Read only multimedia workloads
- Accelerate distributed web-servers
  - Web server cluster nodes serve content from the cache
- /usr distributed by a network file system
  - Avoid spamming Servers when there is a power outage
- Caching Server with SSDs reexporting netfs data
- Persistent cache remains across reboots

Caching data flow



Source: http://www.linux-mag.com

FS-Cache

FS-Cache (1)

- Terminology - FS-Cache, CacheFS
- Caching facility for network filesystems, slow media
  - Mediates between netfs and cache back-end
  - Allows persistent local storage for caching data and metadata
  - Cache is transparent
  - Serves out pages, does not load file entirely
  - Hides cache I/O errors from the netfs
  - Allows netfs to decide on index hierarchy
  - Index hierarchy used to locate file objects/discard subset of files cached
- Written by David Howells, upstream since 2.6.30

FS-Cache (2)

- Deals with Objects
- Objects have certain attributes
  - Type
    - Index, Data storage and special
    - Non-index object can store pages of data
  - Key
    - Supplied by Netfs, blob of binary data
    - Used to lookup an object in its parent index
    - Must be unique in its index's key-space (e.g. share)
  - Auxiliary data (used to validate objects on lookup)
- Filesystem has to be modified to use FS-Cache
- AFS, NFS, Plan 9 (9p) are FS-Cache capable

Cache back-ends

Cache back-ends

- CacheFs (caching filesystem)
  - uses a block device directly rather than a directory under fs
  - can perform its own journaling more efficiently
  - Development stalled due to design issues
- CacheFiles (fs/cachefiles)
  - uses directory on already mounted local filesystem (e.g. ext3)
  - Integrity guarantees only as good as underlying fs
  - /dev/cachefiles as communication channel

CacheFiles

- Cache started by cachedfilesd
- Uses dnotify to monitor and discard inactive objects
- Uses userspace daemon to do reaping of stale nodes and culling
  - Maintains x% of free space (configurable), shrinks
  - Cache culling discards objects on LRU basis
- Configuration file - /etc/cachefilesd.conf
- Don't create, rename, unlink while cache is active

CacheFiles: Cache structure (1)

/var/cache/fscache/cache/

@a9/l04cifs/@92/J80w004gL0zap_300/@18/l05share/@99/E80gkHk1000000000

@a9/l04cifs/@92/J80w004gL0zap_300/@18/l05share/@97/E80MjHk1000000000

@4a/l03nfs/@e3/Jc000000000000gWoci40/@05/J0100000000000000000000000000000000000M0000000010000400Kb000wFe000jt000oG30000000400000000000/@2b/Eg0g004g000000kRFe0gEfo8S

@4a/l03nfs/@e3/Jc000000000000gWoci40/@05/J0100000000000000000000000000000000000M0000000010000400Kb000wFe000jt000oG30000000400000000000/@0a/Eg0g004g000000USFe0gpjAMk

CacheFiles: Cache structure (2)

/var/cache/fscache

/ \

cache/ graveyard/

- Active cache objects in cache/
- Retired objects (but not yet unlinked) graveyard/
- Cachefilesd uses dnotify to delete files from graveyard
- Index objects starts with “I...” or “J...”
  - printable Vs encoded
- Data objects starts with “D..” or “E..”
- Special objects starts with “S...” or “T...”

CacheFiles: Cache structure (3)

/var/cache/fscache/cache/

@a9/l04cifs/@92/J80w004gL0zap_300/@18/l05share/@99/E80gkHk1000000000

@a9/l04cifs/@92/J80w004gL0zap_300/@18/l05share/@97/E80MjHk1000000000

@4a/l03nfs/@e3/Jc000000000000gWoci40/@05/J0100000000000000000000000000000000000M0000000010000400Kb000wFe000jt000oG30000000400000000000/@2b/Eg0g004g000000kRFe0gEfo8S

@4a/l03nfs/@e3/Jc000000000000gWoci40/@05/J0100000000000000000000000000000000000M0000000010000400Kb000wFe000jt000oG30000000400000000000/@0a/Eg0g004g000000USFe0gpjAMk

- *Child objects keys prepended with '@'*
- *Child objects are present inside that directory*
- *Printable Vs Encoded object representation*
  - *Base64 encode if it is not printable (e.g. contains characters such as '/')*
- *Objects having children represented as a directory*

Making a filesystem FS-Cache aware (1)

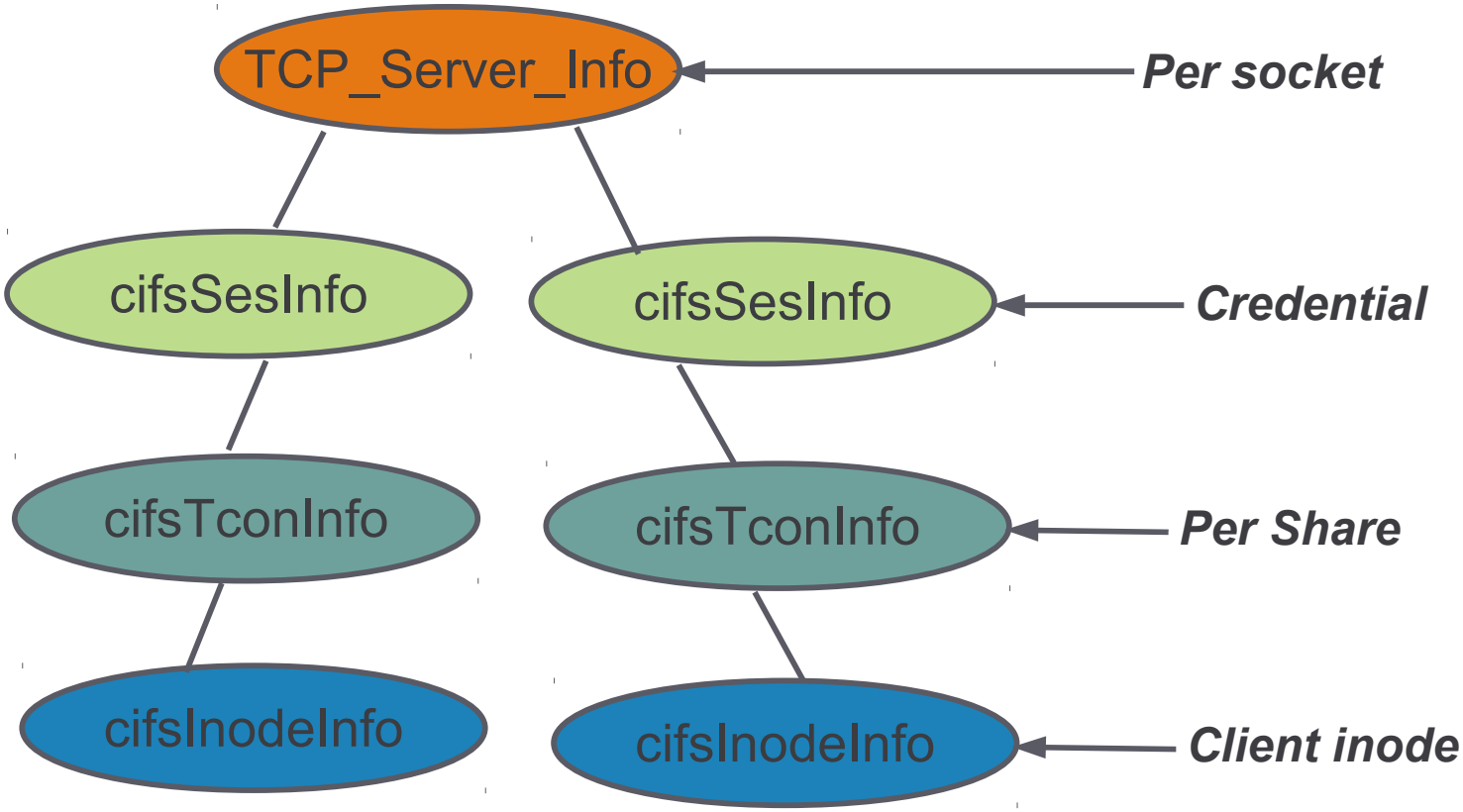
- Define netfs for FS-Cache and register
- Decide on the Index hierarchy
  - Not too deep
  - Index objects can only be children of index objects
- Define objects and methods associated
  - struct fscache_cookie_def
  - Name, type
  - get_key, select_cache, get_aux, check_aux, now_uncached etc.
- All the indices in the index hierarchy and the data file need to be registered

Making filesystem FS-Cache aware (2)

- Functions to store and retrieve pages in the cache
- Cache validation
- Function to release any in-memory representation for the network filesystem page.
- Way to invalidate a data file or index subtree and relinquish cookies.
- Root directory validation (optional)

CIFS current Implementation

CIFS Object hierarchy



CIFS Index hierarchy

- Three level hierarchy
- Server
  - Keyed with Ipaddress, family, port sequence
- Share
  - Superblock keyed with name of the share
- File
  - Keyed with UniqueId
    - Inode number for Unix filesystems
    - IndexNumber for FAT-like filesystems

Server Resource validation

- Superblock object keyed by sharename
- Ensure that the exported SMB resource didn't change without client's knowledge
- For e.g.
  - Server exports /vol1/foo
  - Client mounts and access files (persistently cached)
  - Client unmounts
  - Server exports /vol2/foo
  - Client assumes it already has data in cache and provides wrong data
- UniqueId/IndexNumber

Cache validation

- Inodes validation considers
  - LastWriteTime
  - ctime
  - EOF reported by Server
- CreateTime ?

Current status

- RFC posted last month
  - Used Servername/IP as key
  - No way to validate root directory of Server resource (share)
  - Needed an rsize of 4k to work properly
  - Support caching on files opened Read-only
  - Enabled with mount option 'fsc'
- Revised, improved version posted on 05 July
  - Number of Fixes
  - Server key uses Ipaddress, family, port sequence
  - Root dir validation added
  - Better cache validation checks

Open issues

- 'noserverino' mount option
  - Client generates uniqueid (a.k.a inode numbers)
  - will vary after unmount or reboot
  - Used when all server filesystems support does not support unique inode numbers
  - Possible cache aliasing, cache not used
- Cache coherency check
  - When client sets LastWriteTime (tar), some CIFS servers are known not to update mtime until the client closes the filehandle
  - Not a major issue in practice as concurrent access using such application by other machines is uncommon

How to use

- Cachefilesd package (openSUSE repository)
  - Configure /etc/cachefilesd.conf
- Grab the patches from

  http://www.kernel.org/pub/linux/kernel/people/jays/patches/
- Kernel Configuration
  - CONFIG_FSCACHE, CONFIG_CACHEFILES
  - CONFIG_CIFS_FSCACHE
- Mount the cifs share
- Try copying a huge file from mount point to local filesystem
  - cache will be initialized the first time
  - it should be read from the local cache the second time

Debugging

- CONFIG_FSCACHE_DEBUG
  - /sys/module/fscache/parameters/debug
  - Bitmask (Cache mgmt, Page handling, operation mgmt etc.)
- CONFIG_CACHEFILES_DEBUG
  - /sys/module/cachefiles/parameters/debug
  - Bitmask (entry, exit, general)

Questions?

References

http://people.redhat.com/dhowells/fscache/FS-Cache.pdf

http://people.redhat.com/steved/fscache/slides/cachefs-new.odp.bz2

Documentation/filesystems/caching/

Performance

- Reading a 150 MB file
- time cat /mnt/amuse.zip > /dev/zero (cache init)

  real 0m14.019s

  user 0m0.008s

  sys 0m1.728s
- time cat /mnt/egm.zip > /dev/zero (cache hot)

  real 0m5.265s

  user 0m0.008s

  sys 0m0.320s

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