Venti: a new approach to archival storage[1]

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[1] powered by pandoc and XƎLaTeX

Outline

1. Overview
   - Abstract
   - Background
   - Venti
2. Data Organization
3. Application Example
4. Implementation
5. Performance
6. Conclusion

Abstract

- Venti: A network storage system intended for archival data
- A building block for a variety of storage applications
  1. logical backup
  2. physical backup
  3. snapshot file systems
- A block is identified by a unique hash of it's contents
- Enforce a write-once policy
- Duplicate copies of a block can be coalesced

Archival Storage

- Purpose
  - Store data for long periods of time (forever)
  - Data may not be needed frequently, but when it is needed it is often crucial

Prevalent Form

- Tape backup
  - Backup data to magnetic tape
  - (tar, ufsdump...)
  - Full backup vs Incremental backup
  - To provide backup as a central service for a number of client machines

Prevalent Form

- Snapshot
  - A snapshot is a consistent read-only view of the file system at some point in the past.
  - Each snapshot is a complete file system tree, much like a full backup.
  - A snapshot only requires additional storage for the blocks that have changed, like a incremental backup.
  - Always available and easy to access
  - Plan 9, WAFL, AFS...

Venti Archival Storage

- Goal: To provide a write-once archival reponository than can be shared by mutiple client machines and applications.
- Block level network storage system
  - Actually a backend storage for client apps
- Blocks addressed by hash of their contents
  - Use SHA-1 algorithm
  - Use hash value as its unique ‘fingerprint’
- Write-Once policy
  - Block once written, never modified
  - Modified blocks will have new address

Venti

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Why SHA-1?

- SHA-1 hash function is developed by NIST
- Output 160 bit hash values(20 bytes)
- Probability that there will be one or more collisions:

$$p \leq \frac{n(n-1)}{2} \times \frac{1}{2^b}$$

- Consider a large storage system contains 10^{18} byte of data stored as 8 Kbyte blocks($\sim 10^{14}$ blocks), the probability is less then 10^{-20}.
- Variants of SHA-1 can produce 256, 384 and 512 bit results for future use.

Venti Archival Storage

- Multiple clients can Share a Venti server
  - Hash function gives an unversal namespace
  - Duplication increases the utility rate of space
- Inherent integrity checking for data
- Caching is simplified
- Uses magnetic disk as storage technology
  - Access time comparable to non-archival data

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Data Organization

- Data is divided into blocks and written to the server
- Pack the fingerprints into additional blocks, called pointer blocks, that are also written to the server
- Until a single fingerprint is obtained
- Applications can use such a structure to store a single file or to mimic the behavior of a physical device such as a tape or a disk drive

Data Organization

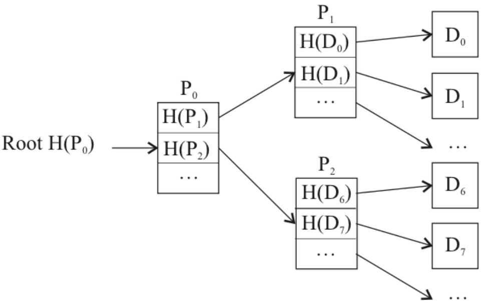

Figure 1. A tree structure for storing a linear sequence of blocks

Data Organization

- Venti does not allow such a tree to be modified
- But new versions of the tree can be generated efficiently by storing the new or modified data blocks and reusing the unchanged sections
- By mixing data and fingerprints in a block, more complex data structures can be constructed.
- For example, a structure for storing a file system may include three types of blocks:
  - Directory
  - Pointer
  - Data.

Data Organization

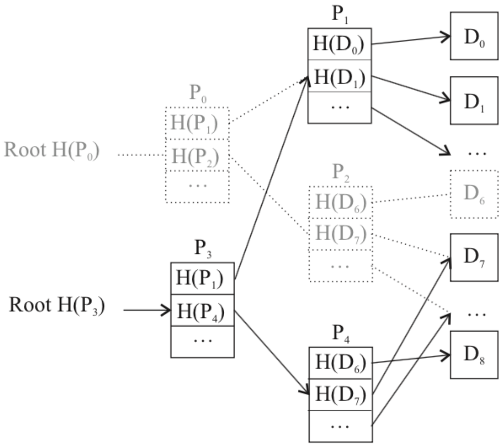

Figure 2. Build a new version of the tree.

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Vac

- Vac is an application similar to tar and zip
  - With vac, Selected files will be stored as a tree of blocks on Venti server.
  - The output is always 45 bytes long, included a 20 byte root fingerprint.
  - ‘unvac’ enables user to estore files from a vac archive.
- Vac writes each file as a seperated collection of Venti blocks, which can coalesce duplicate copies of a file
- Incremental backups options can improve performance

Physical Backup

- Vac archive data at the file or logical level
- Alternative approach: block-level or physical backup
- Copy the raw contents of disk drives to Venti
- Coalescing duplicate blocks is the main advantage
- Can even mount a backup file system image from Venti
- Full restore can be done in a lazy fashing

Plan 9 File System

- When combined with a small amount of read/write storage, Venti can be used as the primary location for data
- Plan 9 file system store snapshot on optical jukebox
- magnetic disks act as a cache for the jukebox
- New version of the Plan 9 file system uses Venti instead of an optical jukebox as its storage device

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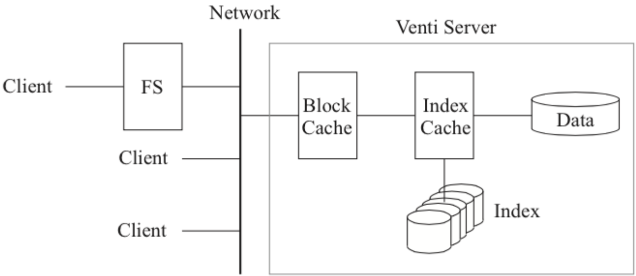
Implementation



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Implementation

- For data block
  - Use Append-only log
  - Blocks store on a RAID — 5 array of IDE disk drives
- For Index
  - Using a disk-resident hash table
  - Index is diveided into fixed-size buckets
  - Index store on 8 SCSI drives
- Additional work
  - caching, striping, write buffering

Format of Data Log

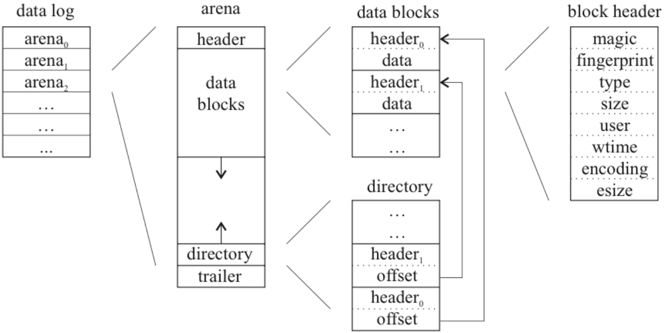

Figure 4. The format of the data log.

Format of Index

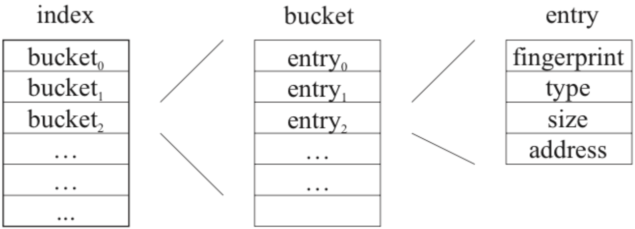

Figure 5. Format of the index.

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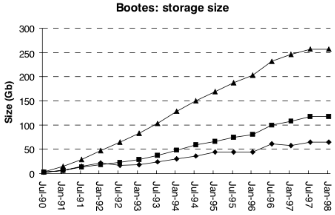
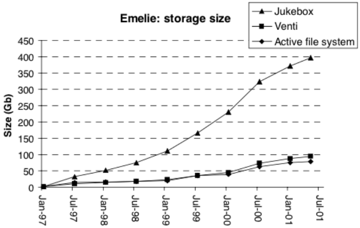
Performance

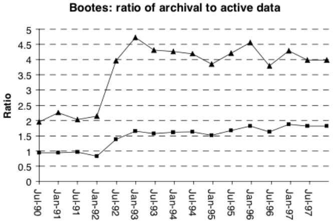
The performance of read and write in Mbytes/s :

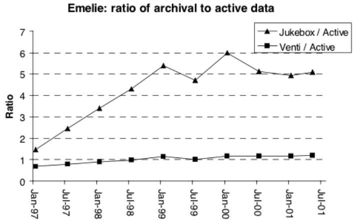
	sequential reads	random reads	virgin writes	duplicate writes
uncached	0.9	0.4	3.7	5.6
index cache	4.2	0.7	-	6.2
block cache	6.8	-	-	6.5
raw raid	14.8	1.0	12.4	12.4

Performance


Bootes: storage size


Emelie: storage size


Bootes: ratio of archival to active data


Emelie: ratio of archival to active data

Performance

The percentage reduction in the size of data stored on Venti :

	bootes	emelie
Elimination of duplicates	27.8%	31.3%
Elimination of fragments	10.2%	25.4%
Data Compression	33.8%	54.1%
Total Reduction	59.7%	76.5%

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Conclusion

- Approach of identifying a block by SHA-1 hash is a well suited to archival storage
- Write-once policy of a block and ability to coalesce duplicate copies of a block makes Venti a useful building block for many interesting storage application
- By rapid groth in capacity of magnetic disks, it seems unlikely that archival data will be deleted to reclaim space

$$\Downarrow$$

Venti provides an attractive approach to archive data

Q&A

Any Questions?

End

Thanks For Attention!