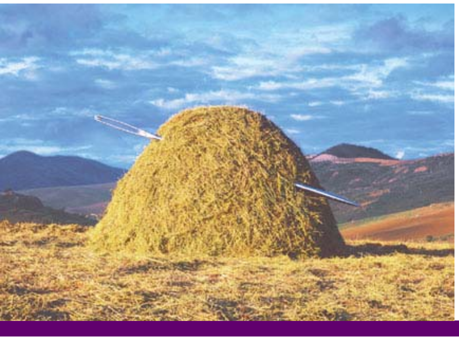


Finding the Needle in the Haystack: Metadata-Indexed Cluster Filesystems

Milo Polte and Garth Gibson
CS Department, CMU

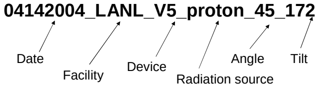
John Bent
HPC-5, LANL

Motivating Multidimensional Datasets

Effects of Radiation on Field Programmable Gate Arrays

- Studies effects of radiation on bit flip errors
- Dataset is thousands of files, millions of samples
- Groups samples into many single files whose names are a concatenation of sample attributes:

04142004_LANL_V5_proton_45_172



Work by Heather M. Quinn and Sarah Michalak at LANL

Purging a Petascale Cluster Filesystem

- Recursively walks entire file system tree to find old, large files
  - Old serial version ran for 20 hours
  - Many programmer hours later, new parallel version runs for 45 minutes

Work by Ben McClelland at LANL

Why Not a Pure Database System

- Many applications are based on the POSIX API
  - Many tools are scripts or compiled programs that might be difficult to modify to use a database
- Databases have a lot of extra things (e.g. transactions), that we don't need
- Distributed filesystems already used in large scale clusters
  - PVFS, PanFS, LUSTRE, etc.
- Our goal: Database-style search on a cluster filesystem for performance and expressiveness
- Our approach: Leverage database technology within a cluster filesystem

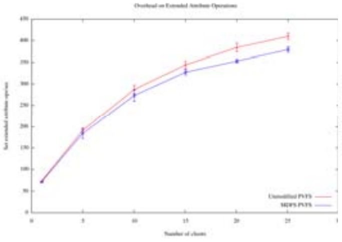
Operations: Replicating Attributes

- Client behavior remains unchanged
- Cluster filesystem asynchronously replicates attributes and extended attributes into internal database

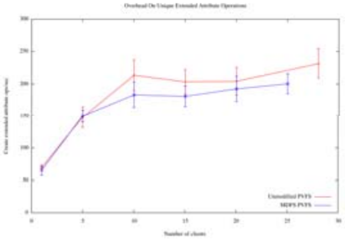
- Clients can set (and search) additional application specific tags using *setxattr*
  - Already an existing operation within some cluster filesystems

Overhead

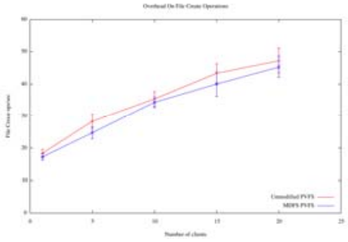
Updating Tags



Adding Application Tags



File Creation



Current File Systems and MDDS's

- Often users need to filter or search very large datasets
  - "Show me all proton results from LANL"
  - "Remove all large files created more than a year ago and not accessed within the last month"
  - "View all satellite images containing super-novas"
  - "Find all songs by a particular artist"
- Existing search is slow and non-parallel
- Adding a new tag is slow - may need to update (i.e. rename all files)
- Data volumes growing larger, size of data sets increasing, existing solutions becoming decreasingly tractable

"I'll be late for dinner, Dear. I'm up to my neck in paperwork."

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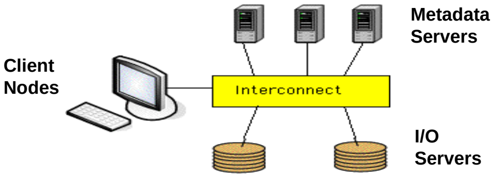
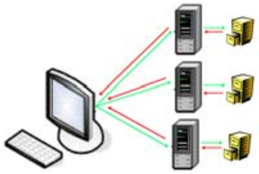
Prototype Design

- Built by extending open source Parallel Virtual File System (PVFS) distributed cluster filesystem



- Each metadata server augmented with an sqlite3 database
- Indexes both standard and extended attributes

Operations: Queries



- Querying linked to *mkdir* operation
  - On a *mkdir,* the client
    - Makes the directory normally
    - Checks if its path is of the form mkdir /mdfs/query/"<sql query>"
    - If so, issues the query to all metadata servers in parallel
      - Found files are symbolically linked into the directory
    - If not, return normally
  - Applications can use *readdir to process result of a query*

Summary

- Filename+Path is a poor way to organize large, multidimensional datasets
- Users need database style querying in cluster filesystems
- One solution is to integrate databases within filesystems
  - Retain POSIX interface as the primary application API
  - Integration results in tighter coherence, less maintenance
- Low overhead prototype demonstrates feasibility of this approach

PARALLEL DATA LABORATORY
CARNEGIE MELLON UNIVERSITY

Los Alamos
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