HaCeph: Scalable Metadata Management for Hadoop using Ceph

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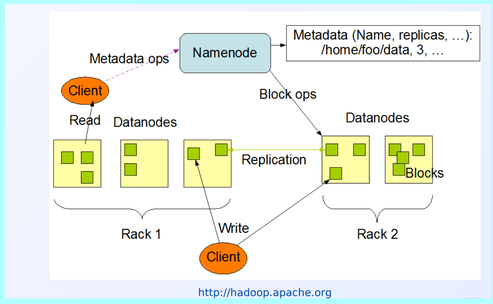
Motivation

- Hadoop is popular for large-scale data analysis
- Hadoop filesystems need to manage huge datasets with large numbers of files
- Scalability problem Hadoop's HDFS filesystem uses only one *namenode* for metadata
- Ceph filesystem: uses multiple metadata servers with dynamic subtree partitioning
- Goal: make Ceph available for use by Hadoop, with similar or better performance

HDFS scalability limitations

- Single NameNode must keep namespace and location of all data blocks in memory (about 150 bytes per file, directory, and data block)
- Adding nodes requires explicit rebalancing, with NameNode's cooperation
- NameNode must receive heartbeats from each DataNode
- NameNode must run re-replication on DataNode failure
- Slow create calls
- Current workaround: Hadoop Archive, a packed file format to reduce number of files in HDFS



Running Hadoop on Ceph

We have two ways of running Hadoop on Ceph.

Method 1: Mount Ceph with its kernel client, and run Hadoop on the "local" filesystem

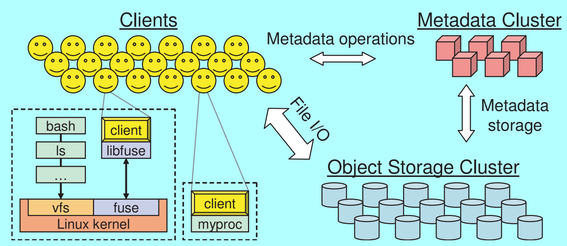
- Can be run without special support in Hadoop
- Accesses must go through the kernel
- Hadoop cannot exploit locality this way (yet)

Method 2: Use a JNI interface to add Ceph support (in development)

- Ceph patch exists for Hadoop trunk (submitted by Gregory Farnum)
- Must use JNI code, but runs entirely in userspace

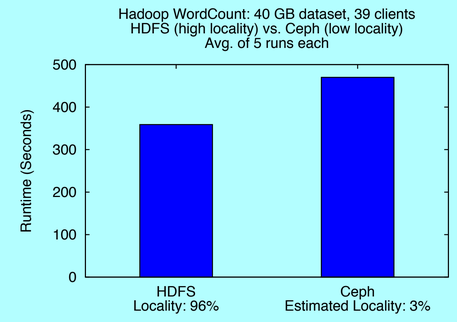
Ceph scalability advantages

- Ceph's metadata server is dynamically distributed over many nodes
- Ceph's *reliable object store* handles replication, rebalancing, and failure recovery in a peer-to-peer fashion
- Metadata server does not store block locations
- Data placement is computed, not stored; cluster state is compact
- Each file can specify its own striping strategy



Preliminary results

WordCount comparison: MapReduce WordCount job on 40 GB input file, across 39 storage/client nodes.



Ceph runs using kernel client, with no locality information. Any locality was coincidental.

- HDFS: only 4% of input data read over network
- Ceph: estimated 97% of input data read over network
- Task takes 31% longer on Ceph
- Prediction: adding locality information will close performance gap

Conclusions and Future Work

- Preliminary results show somewhat slower Ceph performance; expected, as we are not yet exploiting locality
- Allow Hadoop to exploit locality in Ceph
- Compare kernel client and JNI code performance
- Run benchmarks with huge numbers of files, to compare HDFS and Ceph namespace scalability

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