DiskReduce: Making Room for More Data on DISCs

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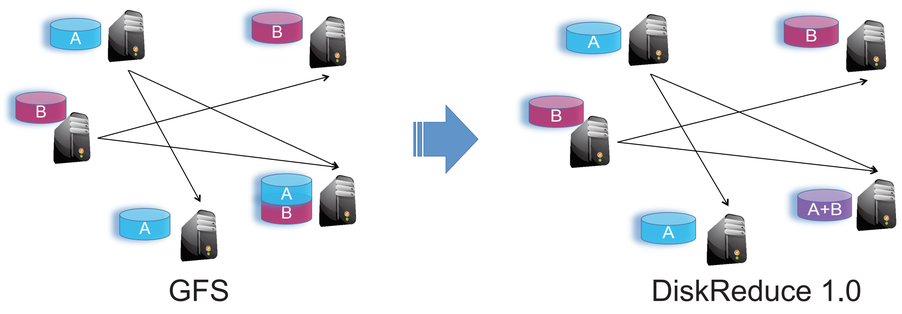
Overview

Google FS/ HDFS on Data Intensive Scalable Computers

- Triplication can recover from 2 failures but it trades 200% extra storage for this redundancy

DiskReduce

- With parity, we can use a lot less storage and still tolerate the loss of any two nodes

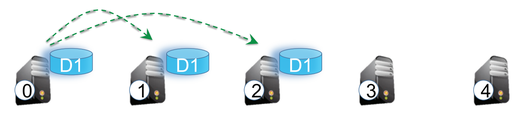


- DiskReduce 1.0 uses a background process to search for optimal blocks to replace with their parities
  - Search algorithm does not scale well to support more than one parity per data block

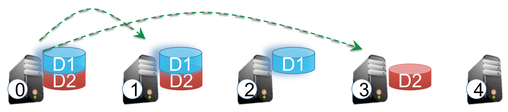
DiskReduce 2.0

- When generating blocks, the creator picks a RAID stripe pattern and sends consecutively created data blocks to corresponding nodes.
- Other nodes in the pattern picked at random
  - Parallel reconstruction and load and capacity balancing
- Method is independent of RAID code
  e.g., apply RAID-DP in 3+2 disks
  (f_1 = row parity, f_2 = diagonal parity)
- Step0: N_0 picks a pattern (N_0, N_1, N_2, N_3, N_4)

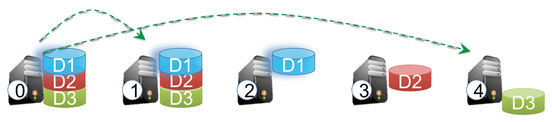
- Step1: N_0 creates D_1 and sends to N_1, N_2



- Step2: N_0 creates D_2 and sends to N_1, N_3



- Step3: N_0 creates D_3 and sends to N_1, N_4



- Step4: N_0 and N_1 compress D_1, D_2 and D_3 and replace with $P_1 = f_1(D_1,D_2,D_3)$, $P_2 = f_2(D_1,D_2,D_3)$

Challenge

Complexity: Yahoo! & Cloudera nervous of cluster RAID

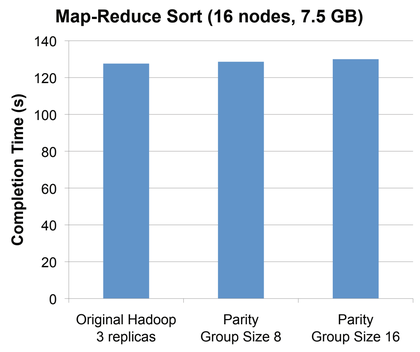
- In traditional RAID, encoding and reconstruction are inline with critical data path
- DiskReduce is based on HDFS approach
  - Triplicate data blocks initially
  - Use asynchronous background process to encode and to reconstruct
  - This approach simplifies the implementation greatly

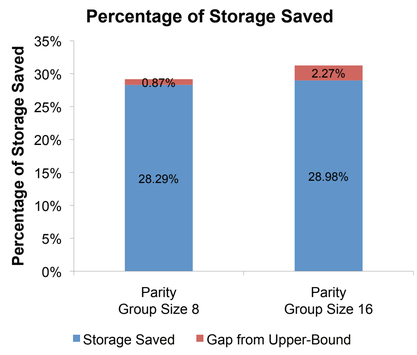
Deletion/Clean up

- Delete only one block either frees no space or needs parity to be recomputed
- Parity only internal to file (PanFS) not space effective
  - Large percentage of small files (e.g. 50% of files in M45 HDFS clusters have 5 blocks or less)
- Parity computed on consecutively created blocks at one node
  - Spatial locality: blocks of one file tend to be created together
  - Temporal locality: files created at same time tend to be deleted together

DiskReduce 1.0 Experiments

- 16 nodes (PentiumD dual-core 3.00GHz, 4GB memory, 7200 rpm SATA 160GB disk, Gigabit Ethernet)
- DiskReduce 1.0 w/ single parity





- Little degradation of performance
- Small gap between the upper bound (~33%) and the actual storage saved

Status and Plan

Status (DiskReduce version 1.0): stopped work

- A class project in Advanced Operating Systems (15-712)
- Extended HDFS to support a single parity (both encoding and recovery path)

Plan (DiskReduce version 2.0): designing now

- Retain most of components used in version 1.0
- New block-to-code scheme that can scale well to support more than one parity per data block
- Support deletion space recovery (cleaning)
- Developing analytical model of MTTDL, rate of data loss, expected amount lost per loss event

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