Towards Adaptive Replication for Hot/Cold Blocks in HDFS using MemCached

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ELVES Research Laboratory

THIS IS EXPERIMENTAL AND VIRTUALIZED SYSTEM (ELVES) RESEARCH LABORATORY

ABOUT US

Our lab conducts experimental systems research, specifically addressing high performance and enterprise applications on virtualized and distributed platforms; focusing on big data analytics systems, specific research interests include runtime adaptation, methods for online resource management, and system support solving enterprise motivated real-world problems that embody complicated data analytics; focusing on systems virtualization, research interests range from basic technologies to innovative technology application.

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Our lab targets training students towards becoming first-class systems researchers and system builders. We are looking for passionate students who are interested in big data systems, systems virtualization and distributed systems to join us!

RECENT PUBLICATIONS

- CLOUD’18: “Oases: An Online Scalable Spam Detection System for Social Networks”
- CLOUD’18: “A Toolset for Detecting Containerized Application’s Dependencies in CaaS Clouds”
- ICAC’17: “GOVERNOR: Smoother Stream Processing Through Smarter Backpressure”
Outline

- Problem Description & Challenges
  - Problem description
  - Challenges

- System Design
  - The basic workflow
  - Approach implementation

- Experimental Evaluation
  - Experiments showing functionality
  - Experiments showing improves application performance

- Conclusion & Future Works
Problem Description

- Big Data Becomes A Big Topic

Multiple industries use big data ranging from:
- Banking
- Healthcare
- Energy
- Technology
- Consumer
- Manufacturing
- etc.
Problem Description

- HDFS is the Major Player in Big Data Storage
  - Low cost per byte
  - High bandwidth to support MapReduce workloads
  - Solid data reliability
Problem Description

- Skewed Popularity of Data Access
  - A Review on Hadoop from Yahoo!
  - Scarlett from Microsoft
Problem:

Create a strategy to cater to the skewed popularity in HDFS?
Key Challenges

- Reduce resource contention.
  - Network resource contention.
  - Disk resource contention.
Key Challenges

- **Reduce response time.**
  - A typical DRAM has a transfer rate of 2-20GB/s, whereas typical SSDs have a transfer rate of 50MB-200MB/s. It's one to two orders of magnitude slower.
Key Challenges

- Increase Data Availability
  - Avoid single point of failure
Challenge:

The system needs to have the properties of reducing resource contention, reducing response time and keep the availability.
Integrate Memcached with HDFS
System Design

- Integrate Memcached with HDFS
System Design

- Vanilla Replication Algorithm
  - Set threshold access value to get in/out Memcached.

Set key := CurrentLocatedBlock.BlockID

IF (key exist in map)
  Increment counter
ELSE Set counter

IF (key counter value > threshold)
  Hot block detected!
  Set in Memcached
ELSE Normal operation
System Design

- Vanilla Replication Algorithm
  - Set threshold access value to get in/out Memcached.
Dynamic Collaborative Replacement

Algorithm 1: Dynamic collaborative replacement algorithm

Input: Label M, Label N

1. if (M == 0) // datablock is not in MemCached. then
   2. if (N == 0) // tag hit is 0 then
      3. LRU; // call LRU
      4. Replace(bottom); // replace the data at bottom
      5. MoveDown(other data); // other data move down in turn
   6. if (N == 1) // tag hit is 1 then
      7. MRU; // call MRU
      8. Replace(top); // replace the data at top
      9. MoveUp(other data); // other data move up in turn
11. if (M == 1) // datablock is in MemCached. then
12. if (N == 0) // tag hit is 0 then
   13. MRU; // call MRU
   14. minHeap.put(<hitData.id, hitData.weight++>);
   15. MoveUp(other data); // other data move up in turn
16. if (N == 1) // tag hit is 1 then
   17. LRU; // call LRU
   18. maxHeap.put(<hitData.id, hitData.weight++>);
   19. MoveDown(other data); // other data move down in turn
Functionality Evaluation

Figure 4. Job execution time for word count and grep.
Functionality Evaluation

Figure 5. I/O throughput for word count and grep.
Overhead Evaluation

(a) CPU usage comparison.

(b) Memory usage comparison.
Conclusion

The designed system integrates Memcached successfully into HDFS, with the improved performance evaluation results.

**Contributions** compared to related work

- The designed system can benefit for the skewed data access pattern.
- The designed system can dynamically adjust the hot/cold blocks.
- The designed system can keep the high availability property.
Future Work

- Evaluate and manage the distributed file system at cloud-scale.

- Explore more efficient ways to adjust the blocks such as on-line learning method.

- Explore the ways to expend the strategy to other distributed file system.
Thank You.

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