HadoopDB: An architectural hybrid of MapReduce and DBMS technologies

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Major Trends

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   - eBay has a 6.5 petabyte warehouse.
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2. Deep analysis over raw data:
   - Inefficient to push data from database into specialized analysis engines → process data in the database.
   - Best price/performance → data partitioned across 100-1000s of cheap, commodity, shared-nothing machines.
   - Clouds of processing nodes on demand, pay for what you use
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Bottom line
Processing massive structured data on 1000s of shared-nothing nodes.
The Candidates

<table>
<thead>
<tr>
<th></th>
<th>Scalability*</th>
<th>High Performance**</th>
</tr>
</thead>
<tbody>
<tr>
<td>MapReduce</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Parallel Databases</td>
<td>✗</td>
<td>✓</td>
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<tr>
<td>What we need</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
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* 1000s of nodes
** Queries on structured data
A bit of history ...
A bit of history ...

MAPREDUCE: SIMPLIFIED DATA PROCESSING ON LARGE CLUSTERS

MAPREDUCE: A major step backwards
DeWitt, Stonebraker

Database People Hating on
MapReduce
Hoff

Databases are hammers; MapReduce is a screwdriver
Chu-Carroll

Relational Database Experts
Jump The MapReduce Shark
Jorgensen

Yep, MapReduce isn't a relational database, So what?
Homan

Fear of new Internet, tea, and MapReduce
Marks

Winning in the Cloud: We lose!
Hellerstein

Endless Blogging!
A bit of history ...
At Yale, we looked deeper ...
At Yale, we looked deeper ...
Parallel Databases

1. Great performance with queries on structured data

But ...

1. “It’s okay to lose work!”
   - fault: restarts the query
     - Google reports 1.2 failures/job
   - performance fluctuations: wait for slowest node

2. No open-source parallel database!! Commercial ones are expensive $$$

“Postgres is a high-maintenance, perfectionist, fussy, city girl”

http://briansmithphoto.files.wordpress.com/2009/05/avedon-dovima-with-elephants1.jpg
MapReduce

1. Great scalability
   - Jobs broken into more granular independent tasks
   - Run-time scheduling
   - Yahoo! runs 4000+ node clusters with Hadoop

2. Free and open-source

But ...

3. Poor performance with queries on structured data
   - Ignores schema
   - Brute-force model

“Hadoop is a slow, lazy, brute, farm boy”

http://www.breedbay.co.uk/gallery//data/500/elephant-chmai-basketball.jpg
Until we discovered ...

... that they complete each other

http://i214.photobucket.com/albu
HadoopDB’s Design

Goals:
- Performance
- Flexible query interface
- Fault-tolerance
- Tolerance for fluctuations from expected performance
- Scalability

Basic design idea
Multiple, independent, single-node databases coordinated by Hadoop.
Hadoop Basics

[Diagram of Hadoop ecosystem with nodes and tasks]
Architecture
Hive Converts SQL queries into MapReduce jobs over HDFS files

1. Derives schema of files from an internal catalog
2. Parses, plans, optimizes the SQL query into a *relational* operator DAG
3. Breaks down plan into series of Map / Reduce task with interleaving re-partition operators
SELECT YEAR(saleDate), SUM(revenue) FROM sales GROUP BY YEAR(saleDate);
Evaluating HadoopDB

Compare HadoopDB to Hadoop and Parallel databases:

1. **Performance:**
   - *We expected HadoopDB to approach the performance of parallel databases*
   - Load times vs. performance trade-offs

2. **Scalability:**
   - *We expected HadoopDB to scale as well as Hadoop*
   - Fault- and fluctuation- tolerance
Experimental Setup

1. **Stage**
   - Amazon EC2 cloud, clusters of 10, 50, 100 machines

2. **Characters**
   - Hadoop
   - HadoopDB
   - Vertica
   - DB-X*

3. **Plot**
   - Pavlo et al. SIGMOD benchmark of large-scale analytical queries derived from processing web-data
   - 20+ GB/node

*DB-X results reproduced from Pavlo et al. 2009
Load

Grep Data (535MB/node): No pre-processing, data randomly generated

User Visits Log (20GB/node): Partitioning, chunking (1GB chunks), sorting and indexing
Performance: Grep Task

1. Full table scan, highly selective filter
2. Random data, no room for indexing
3. Hadoop overhead outweighs query processing time in single-node databases

SELECT * FROM grep WHERE field LIKE ‘%xyz%’;
Performance: Join Task

1. No full table scan due to clustered indexing
2. Hash partitioning and efficient join algorithm
3. Partial aggregation pushed into DB layer

```sql
SELECT sourceIP, AVG(pageRank), SUM(adRevenue)
FROM rankings, uservisits
WHERE pageURL=destURL
AND visitDate BETWEEN 2000-1-15 AND 2000-1-22
GROUP BY sourceIP
ORDER BY SUM(adRevenue) DESC LIMIT 1;
```
Performance: Bottom Line

1. Unstructured data
   - HadoopDB’s performance matches Hadoop

2. Structured data
   - HadoopDB’s performance is close to parallel databases
Scalability: Setup

1. Simple aggregation task - full table scan
2. Data replicated across 10 nodes
3. Fault-tolerance: Kill a node halfway
4. Fluctuation-tolerance: Slow down a node for the entire experiment

Key differences

- HadoopDB and Hadoop take advantage of runtime scheduling by splitting data into chunks or blocks
- Parallel databases restart wait for the slowest node
Scalability: Results

1. Run-time scheduling
   - Block-level vs. Query-level restart

2. Frequent checkpointing vs. pipelining results
To summarize

**HadoopDB ...**

1. is a hybrid of DBMS and MapReduce
2. scales better than commercial parallel databases
3. is as fault-tolerant as Hadoop
4. approaches the performance of parallel databases
5. is free and open-source

http://hadoopdb.sourceforge.net
Future work

Engineering work:

1. Full SQL support in SMS
2. Data compression
3. Integration with other open source databases
4. Full automation of the loading and replication process
5. Out-of-the-box deployment
6. We’re hiring!

Research Work:

- Incremental loading and on-the-fly repartitioning
- Dynamically adjusting fault-tolerance levels based on failure rate
Thank You

We welcome all thoughts on how to raise HadoopDB ...

http://www.jpbutler.com/thailand/images/elephant-8-days-old.jpg
What happens if a processing node fails?

“Teradata’s parallel architecture ensures that part of every request is executing on every node. When a processing node fails, all work is affected. This is an area where Teradata is fault resilient rather than fault tolerant. Our nodes are achieving such a large mean time between failures (MTBF) today that this is a rare occurrence.

If a node fails, the rest of the system is immediately notified and cycles through a recovery process. All requests are halted and rolled back. ... moves units of parallelism from the failed node to an operational one. ...”

http://www.teradata.com/td/go.aspx/?id=115417&logout_127166=1