HadoopDB: An architectural hybrid of MapReduce and DBMS technologies

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Major Trends

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   - Automation of business processes, proliferation of digital devices.
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   - Best price/performance $\longrightarrow$ data partitioned across 100-1000s of cheap, commodity, shared-nothing machines.
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Bottom line

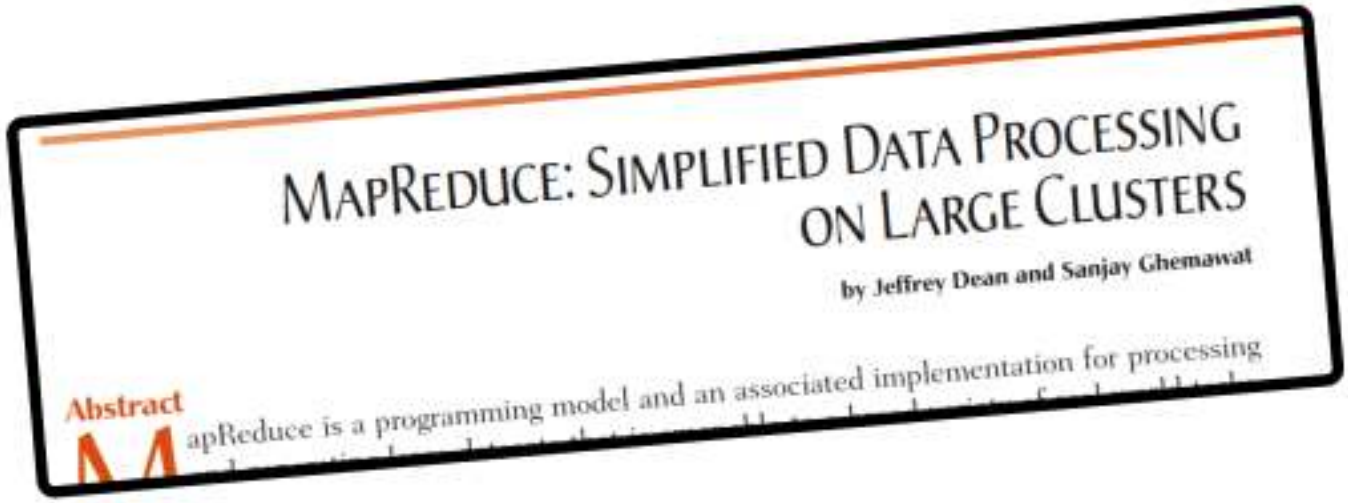
Processing massive structured data on 1000s of shared-nothing nodes.

The Candidates

	Scalability*	High Performance**
MapReduce	✓	✗
Parallel Databases	✗	✓
What we need	✓	✓

** 1000s of nodes*
*** Queries on structured data*

A bit of history ...



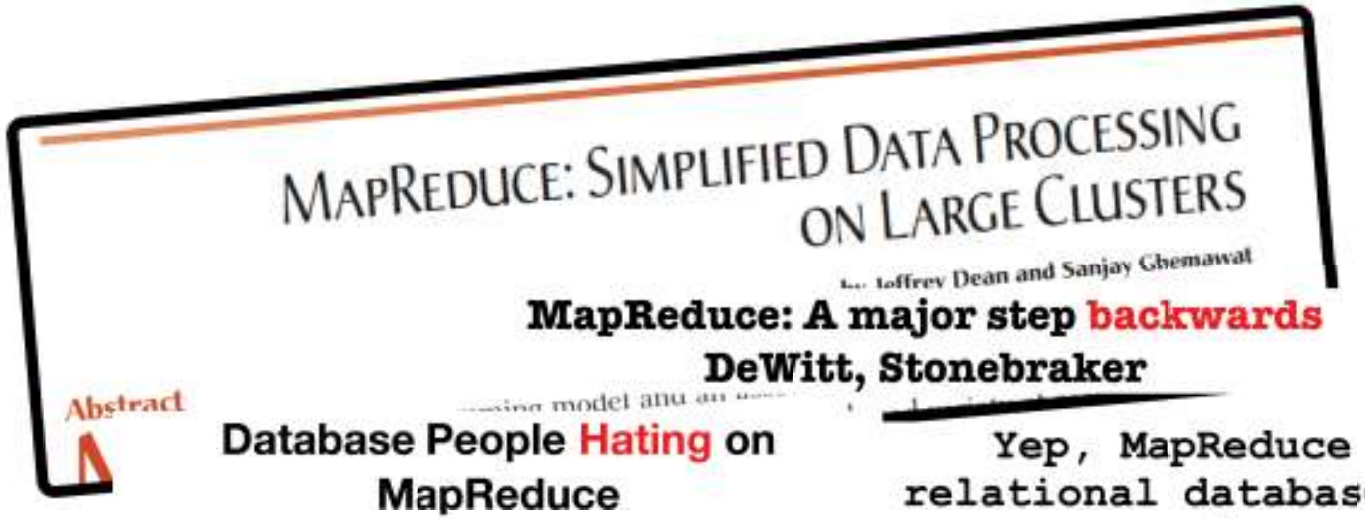
MapReduce: Simplified Data Processing on Large Clusters

by Jeffrey Dean and Sanjay Ghemawat

Abstract

MapReduce is a programming model and an associated implementation for processing

A bit of history ...



MapReduce: A major step backwards
DeWitt, Stonebraker

Database People Hating on MapReduce
Hoff

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

DATABASES ARE HAMMERS; MAPREDUCE IS A SCREWDRIVER
CHU-CAROLL

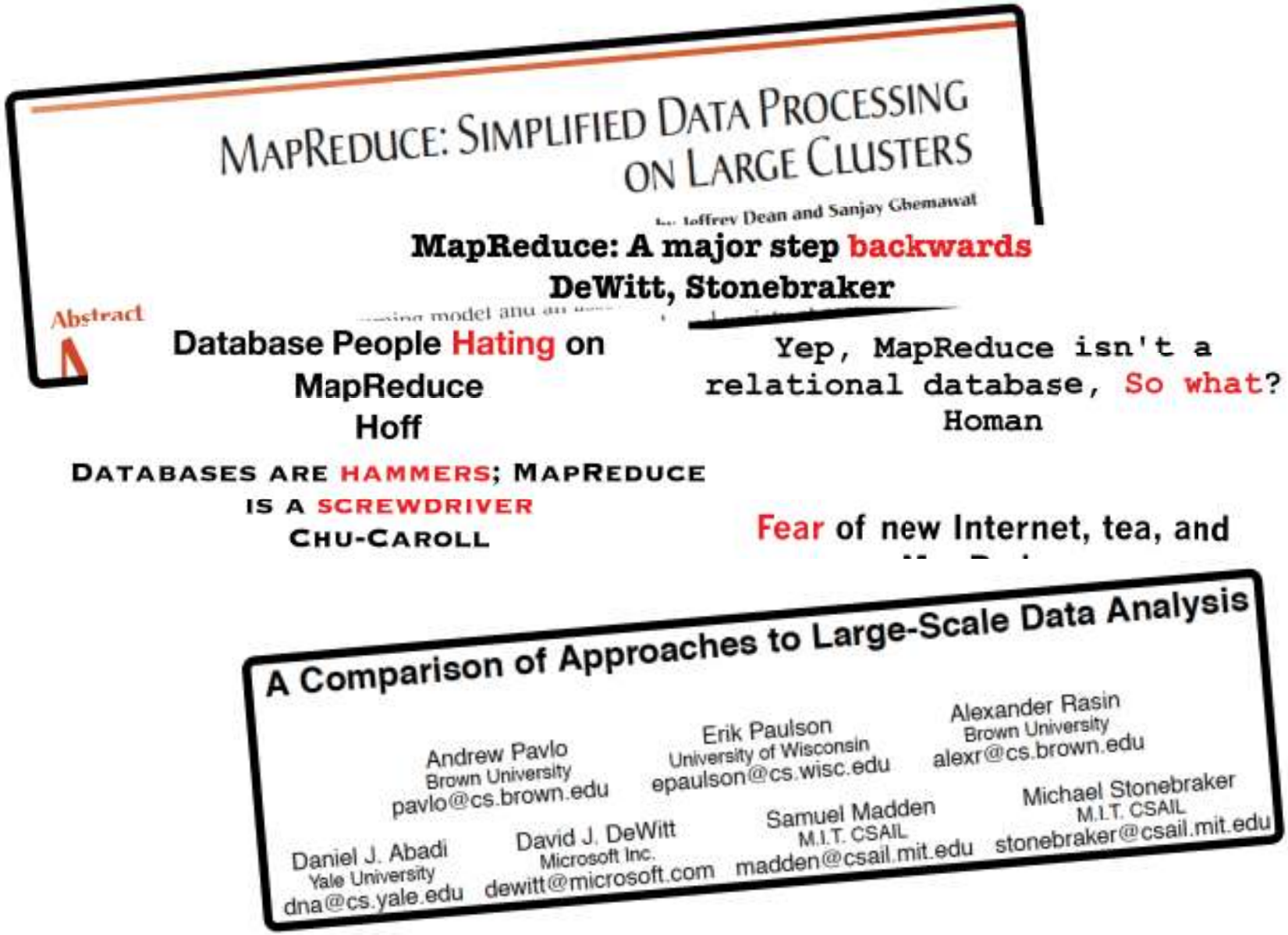
Fear of new Internet, tea, and MapReduce
Marks

Relational Database Experts Jump The MapReduce Shark
Jorgensen

Winning in the Cloud: We lose!
Hellerestein

Endless Blogging!

A bit of history ...



At Yale, we looked deeper ...

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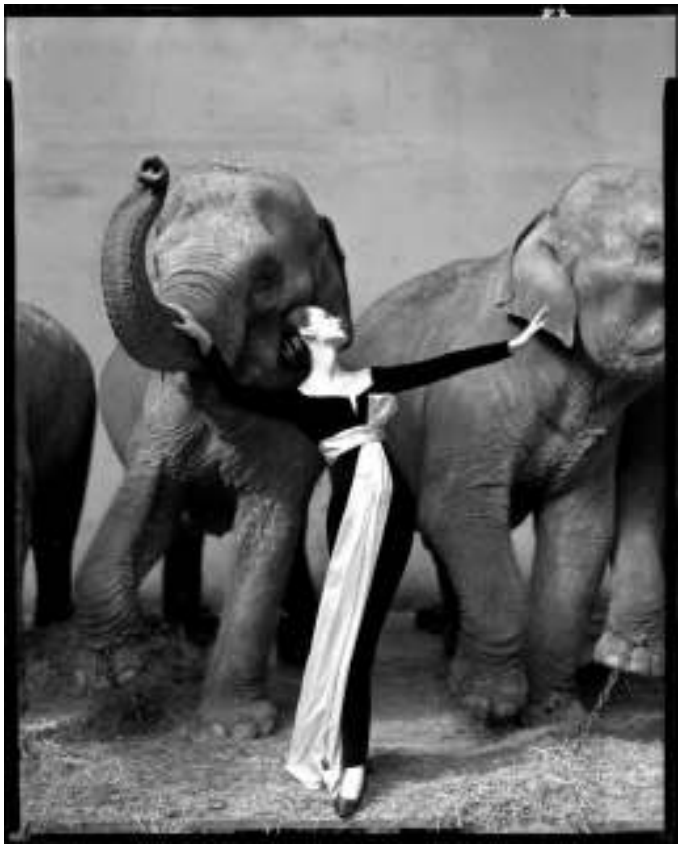
Parallel Databases

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

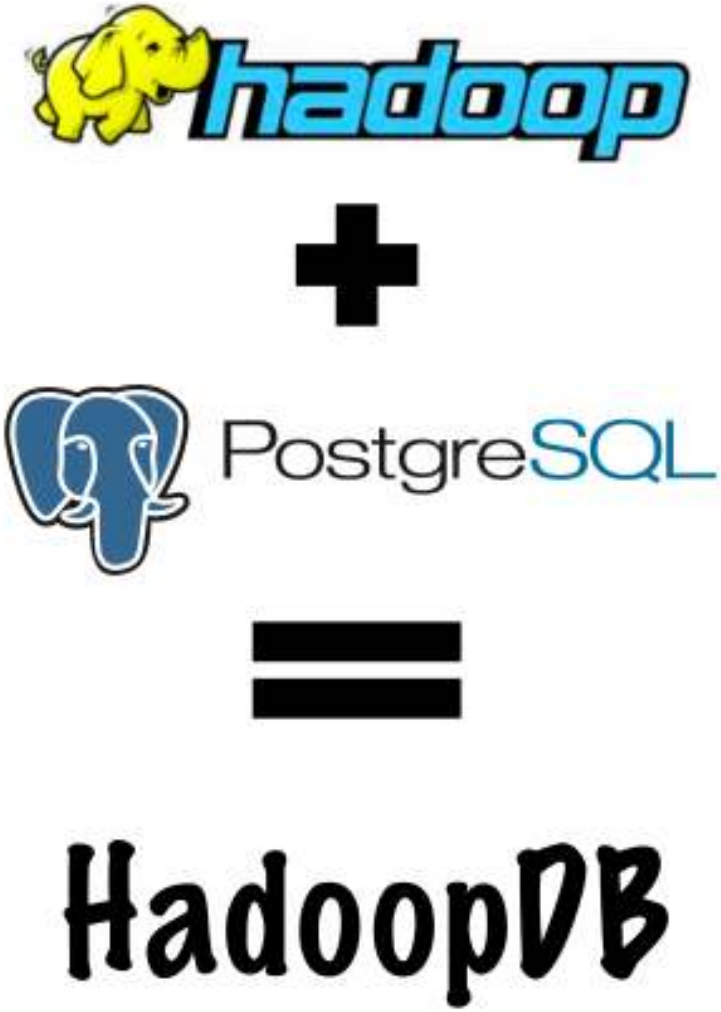
But ...

1. 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/albums/cc19/brittanybutton/elephants.jpg

HadoopDB's Design

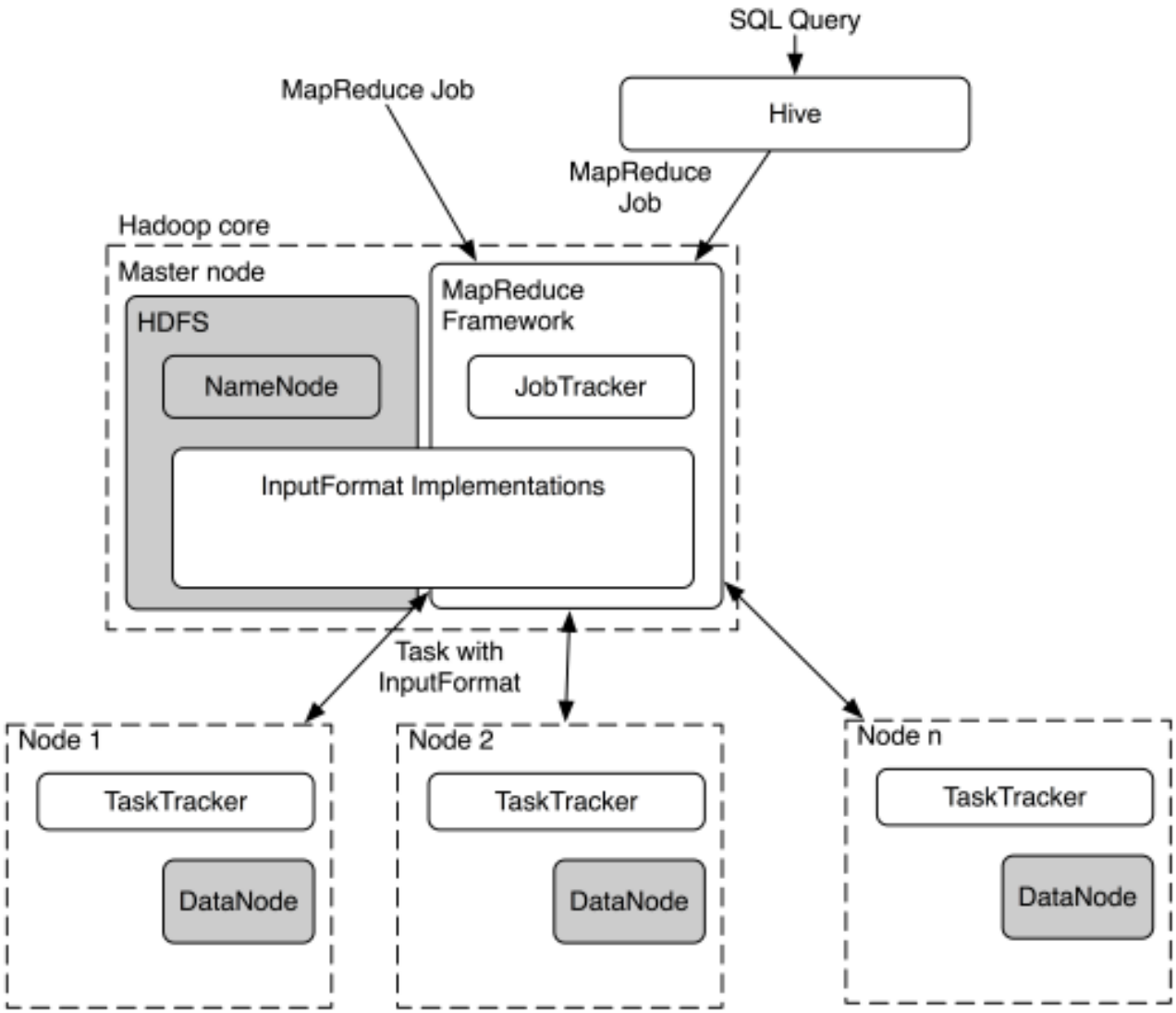
Goals:

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

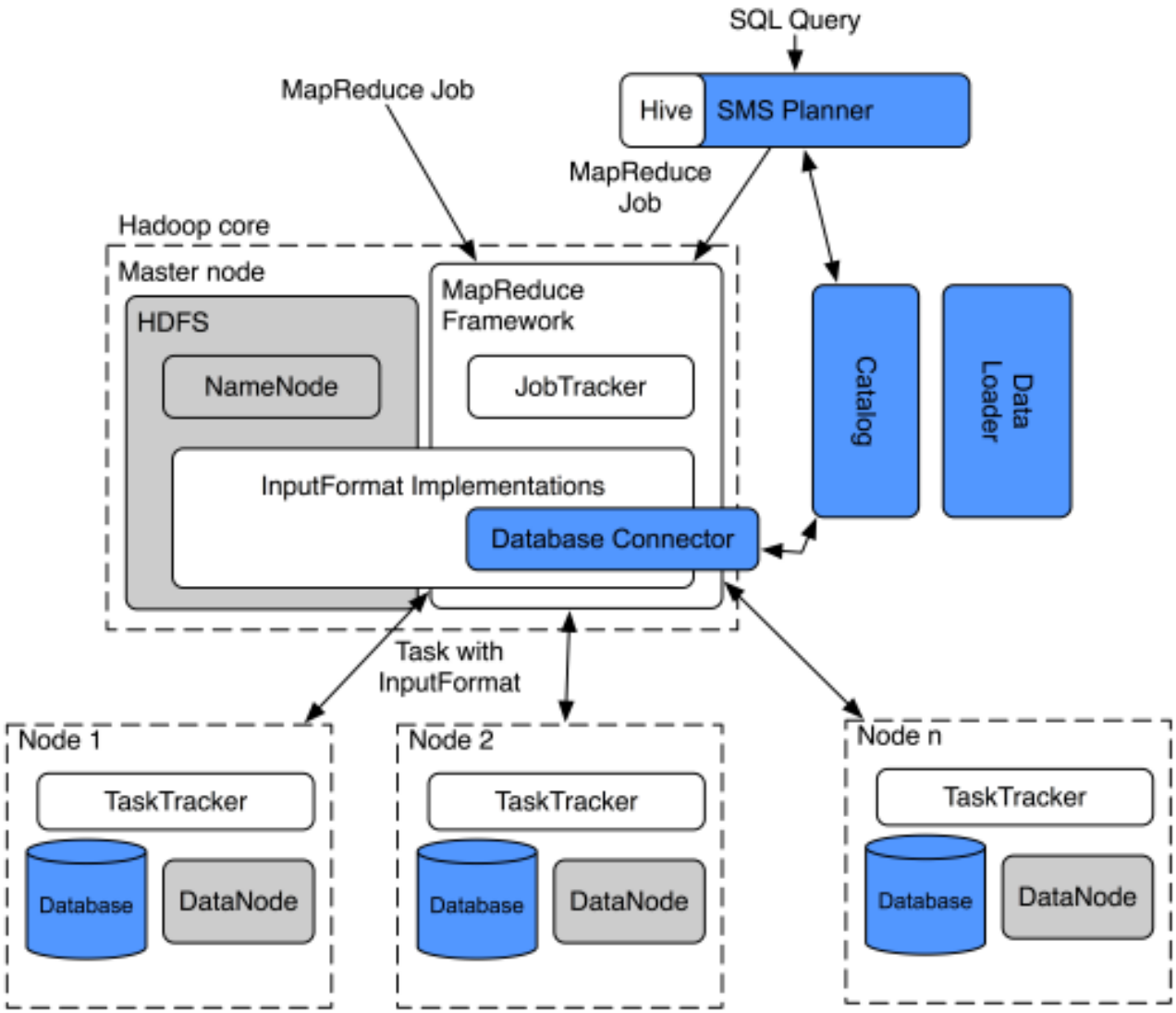
Basic design idea

Multiple, independent, single-node databases coordinated by Hadoop.

Hadoop Basics



Architecture

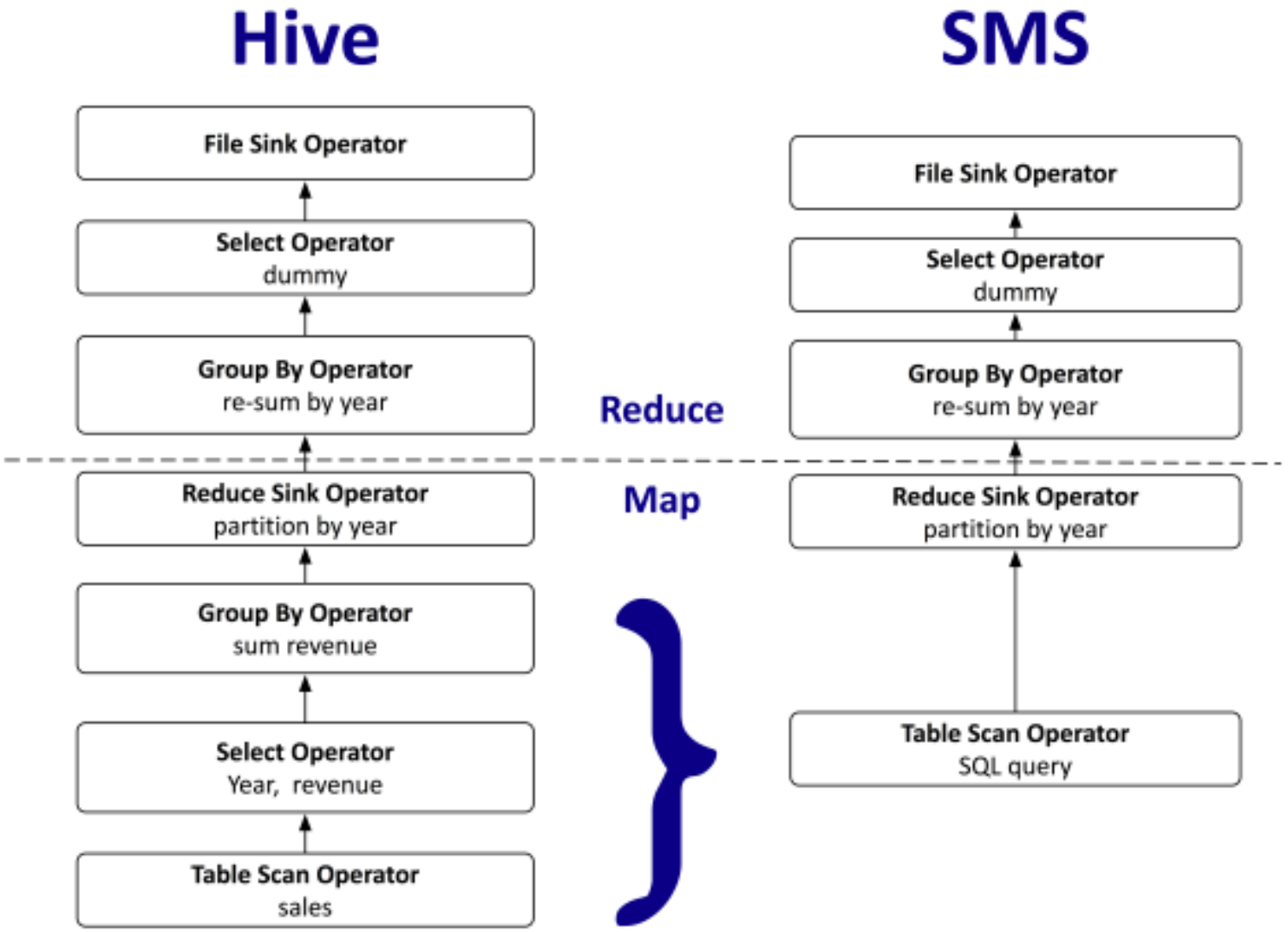


SQL-MR-SQL (SMS): Hive Basics

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

SQL-MR-SQL



SELECT YEAR(saleDate), SUM(revenue) FROM sales GROUP BY YEAR(saleDate);

Evaluating HadoopDB

Compare HadoopDB to Hadoop and Parallel databases:

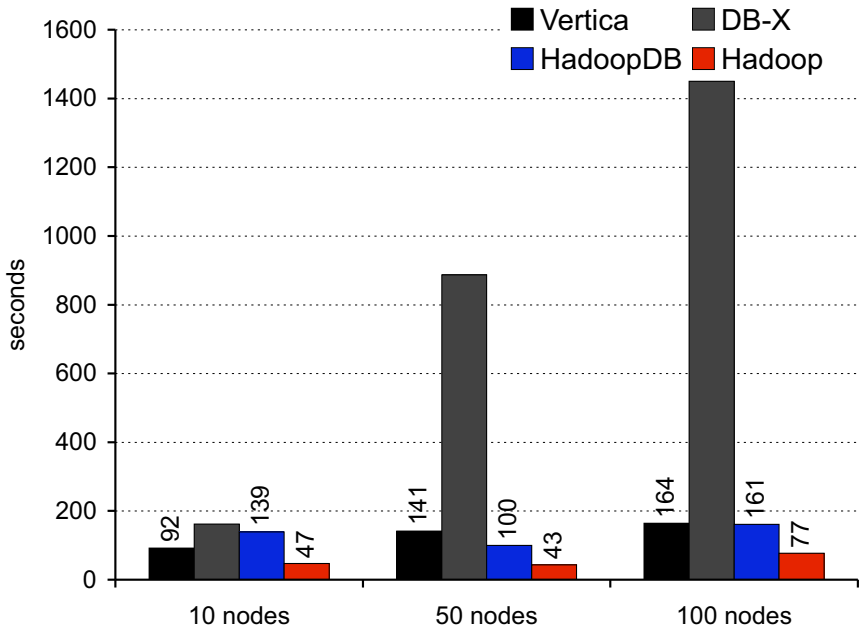
1. Performance:
   - *We expected HadoopDB to approach the performance of parallel databases*
   - Load times vs. performance trade-offs
2. Scalability:
   - *We expected HadoopDB to scale as well as Hadoop*
   - Fault- and fluctuation- tolerance

Experimental Setup

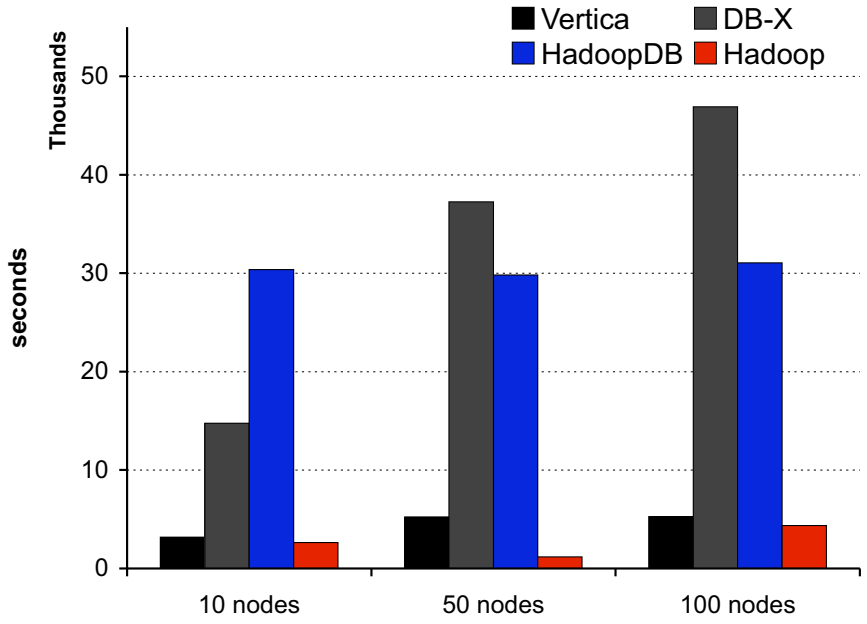
1. Stage
   - Amazon EC2 cloud, clusters of 10, 50, 100 machines
2. Characters
   - Hadoop
   - HadoopDB
   - Vertica
   - DB-X*
3. Plot
   - Pavlo et al. SIGMOD benchmark of large-scale analytical queries derived from processing web-data
   - 20+ GB/node

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

Load

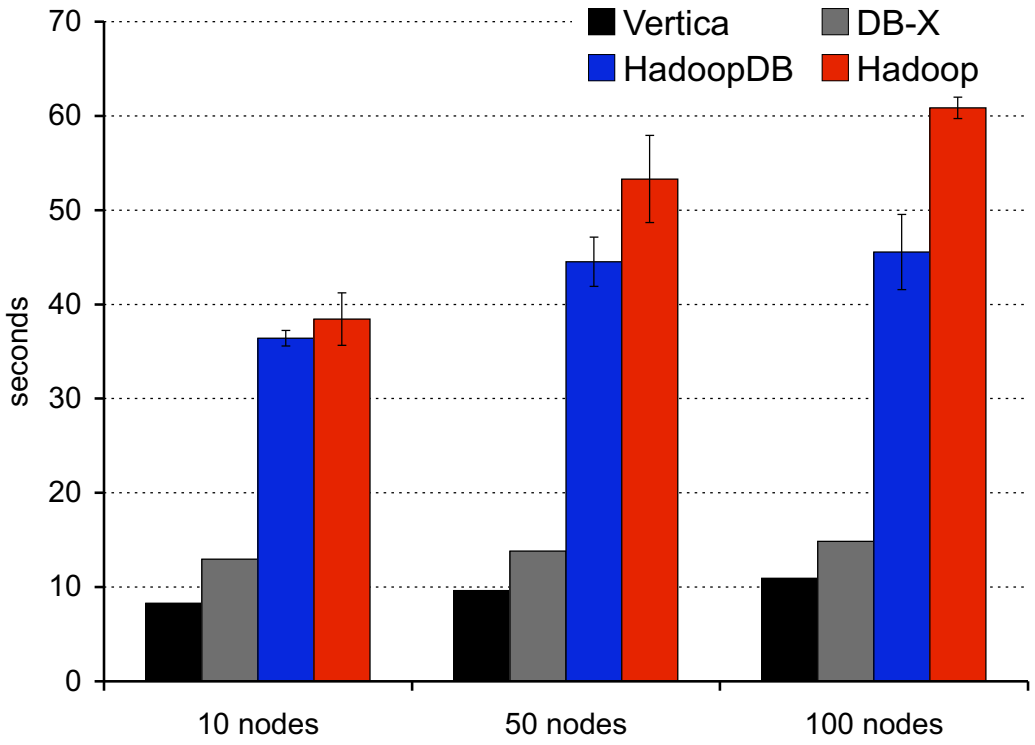


Grep Data (535MB/node):
No pre-processing, data randomly generated



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

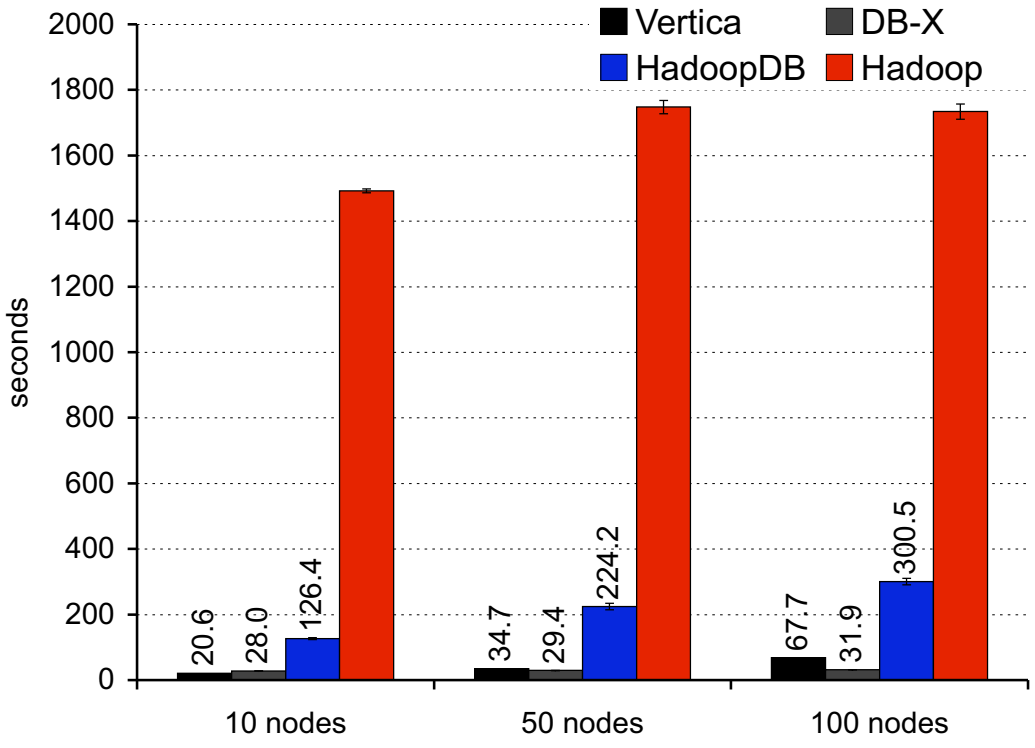
Performance: Grep Task



SELECT * FROM grep WHERE field LIKE '%xyz%';

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

Performance: Join Task




```
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;
```

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

Performance: Bottom Line

1. Unstructured data
   - HadoopDB's performance matches Hadoop
2. Structured data
   - HadoopDB's performance is close to parallel databases

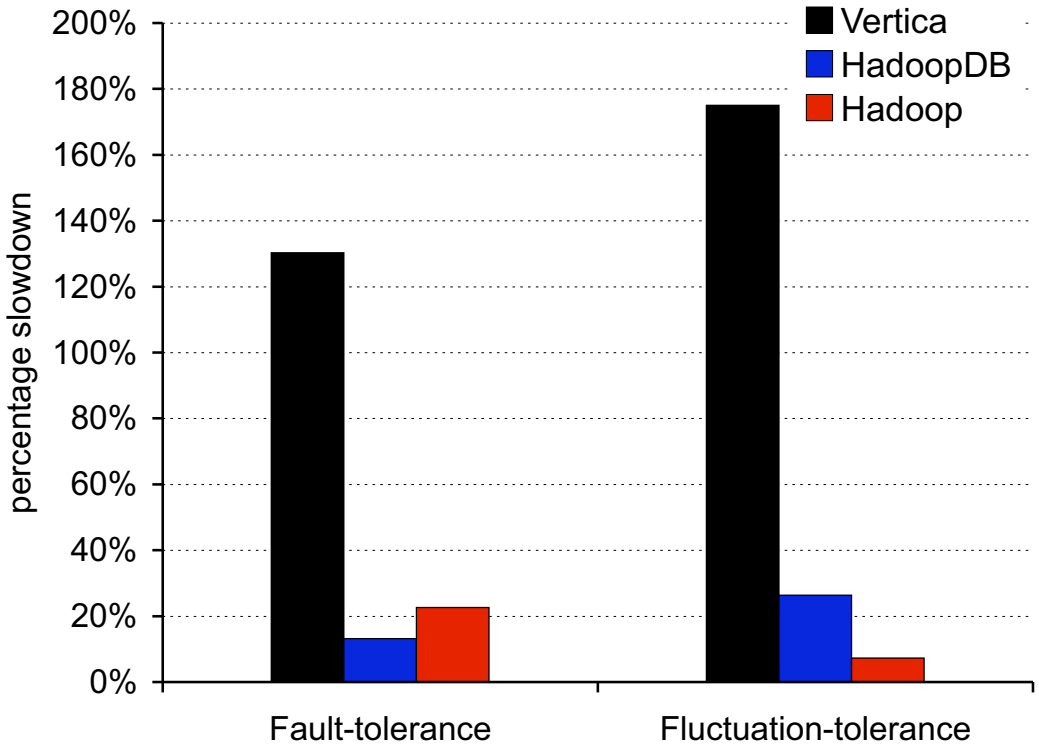
Scalability: Setup

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

Backup: Teradata Fault-tolerance

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