Firebird meets NoSQL (Apache HBase) Case Study

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The SCCH is an initiative of

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Netzwerk für Forschung, Lehre und Praxis

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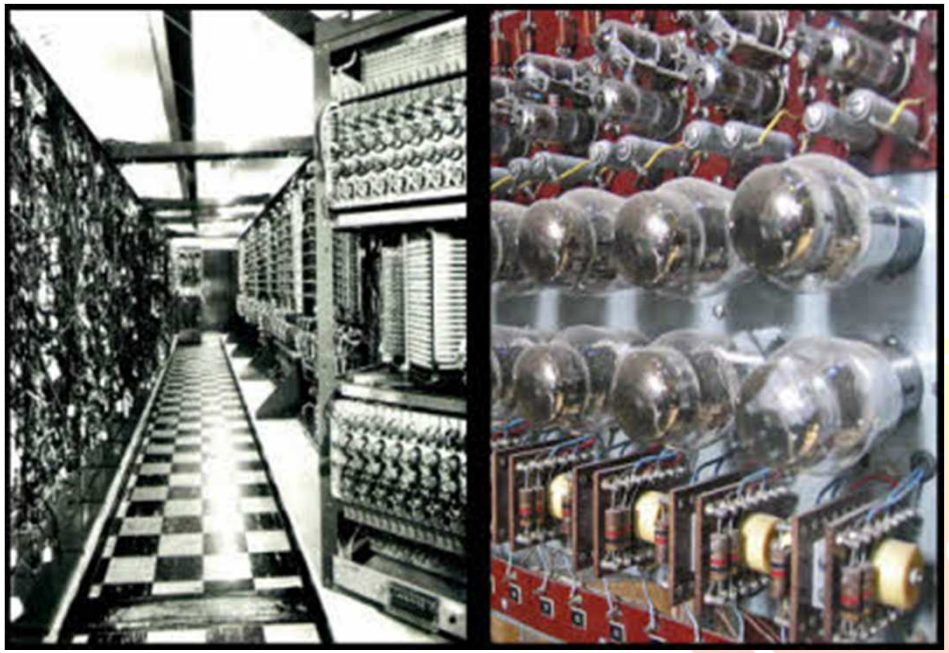
ATTENTION – Think BIG



Source: http://www.telovation.com/articles/gallery-old-computers.html

ATTENTION – Think BIGGER

Source: Google pictures search engine

Agenda

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- **Big Data Trend**
- Scalability Challenges
- Apache Hadoop/HBase
- Firebird meets NoSQL – Case study
- Q&A

Big Data Trend

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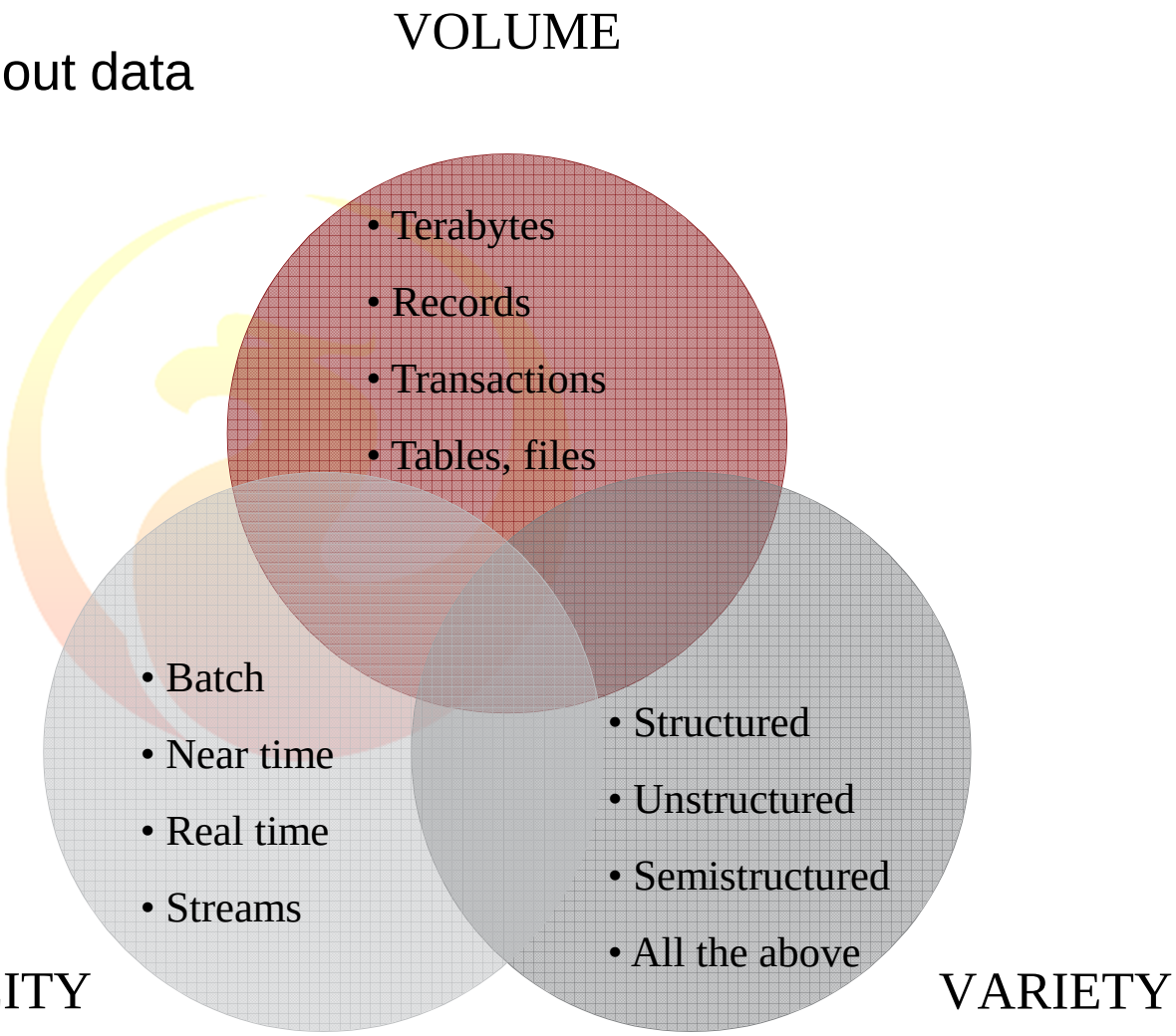
- Data volume grows dramatically
  - 40% up to 60% per year is common
- What is big?
  - Gigabyte, Terabyte, Petabyte ...?
  - It depends on your business and the technology you use to manage this data
- Google, Facebook, Yahoo etc. are all managing petabytes of data
- Most of the data is unstructured or semistructured, thus (far) away from our perfect relational/normalized world

Big Data Trend
The Three Vs

- Big Data is not just about data volume



Source: Big Data Analytics – TDWI Best Practices Report

Big Data Trend
Typical application domains

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- Sensor networks
- Social networks
- Search engines
- Health care (medical images and patient records)
- Science
- Bioinformatics
- Financial services
- Condition Monitoring systems

Agenda

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- Big Data Trend
- **Scalability Challenges**
- Apache Hadoop/HBase
- Firebird meets NoSQL – Case study

Scalability Challenges
RDBMS scalability issues

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- How do you tackle scalability issues in your RDBMS environment?
  - **Scale-Up** database server
    - Faster/more CPU, more RAM, Faster I/O
  - Create indices, optimize statements, partition data
  - Reduce network traffic
  - Pre-aggregate data
  - Denormalize data to avoid complex join statements
  - Replication for distributed workload
- Problem: This usually fails in the Big Data area due to technical or licensing issues
- Solution: Big Data Management demands **Scale-Out**

Scalability Challenges
A True Story (not happened to me)

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- A MySQL (doesn‘t matter) environment
- Started with a regular setup, a powerful database server
- Business grow, data volume increased dramatically
- The project team began to
  - Partition data on several physical disks
  - Replicate data to several machines to distribute workload
  - Denormalize data to avoid complex joins
- Removed transaction support (ISAM storage engine)
- At the end, they gave up:
  - More or less a few (or even one) denormalized table
  - Data spread across several machines and physical disks
  - Expensive and hard to administrate
- Now they are using a NoSQL solution

Scalability Challenges
How can NoSQL help

- NoSQL – **N**ot **O**nly **SQL**
- NoSQL implementations target different user bases
  - Document databases
  - Key/Value databases
  - Graph databases
- NoSQL can Scale-Out easily
- In the previous true story, they switched to a distributed key/value store implementation called HBase (NoSQL database) on top of Apache Hadoop

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- Big Data Trend
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- **Apache Hadoop/HBase**
- Firebird meets NoSQL – Case study
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Apache Hadoop/HBase
The Hadoop Universe

- Apache Hadoop is an open source software for reliable, scalable and distributed computing
- Consists of
  - Hadoop Common: Common utilities to support other Hadoop sub-projects
  - Hadoop Distributed Filesystem (HDFS): Distributed file system
  - Hadoop MapReduce: A software framework for distributed processing of large data sets on compute clusters
- Can run on commodity hardware
- Widely used
  - Amazon/A9, Facebook, Google, IBM, Joost, Last.fm, New York, Times, PowerSet, Veoh, Yahoo! ...

Apache Hadoop/HBase
The Hadoop Universe

- Other Hadoop-related Apache projects
  - Avro™: A data serialization system.
  - Cassandra™: A scalable multi-master database with no single points of failure.
  - Chukwa™: A data collection system for managing large distributed systems.
  - **HBase™: A scalable, distributed database that supports structured data storage for large tables.**
  - Hive™: A data warehouse infrastructure that provides data summarization and ad hoc querying.
  - Mahout™: A Scalable machine learning and data mining library.
  - Pig™: A high-level data-flow language and execution framework for parallel computation.
  - ZooKeeper™: A high-performance coordination service for distributed applications.

Apache Hadoop/HBase MapReduce Framework

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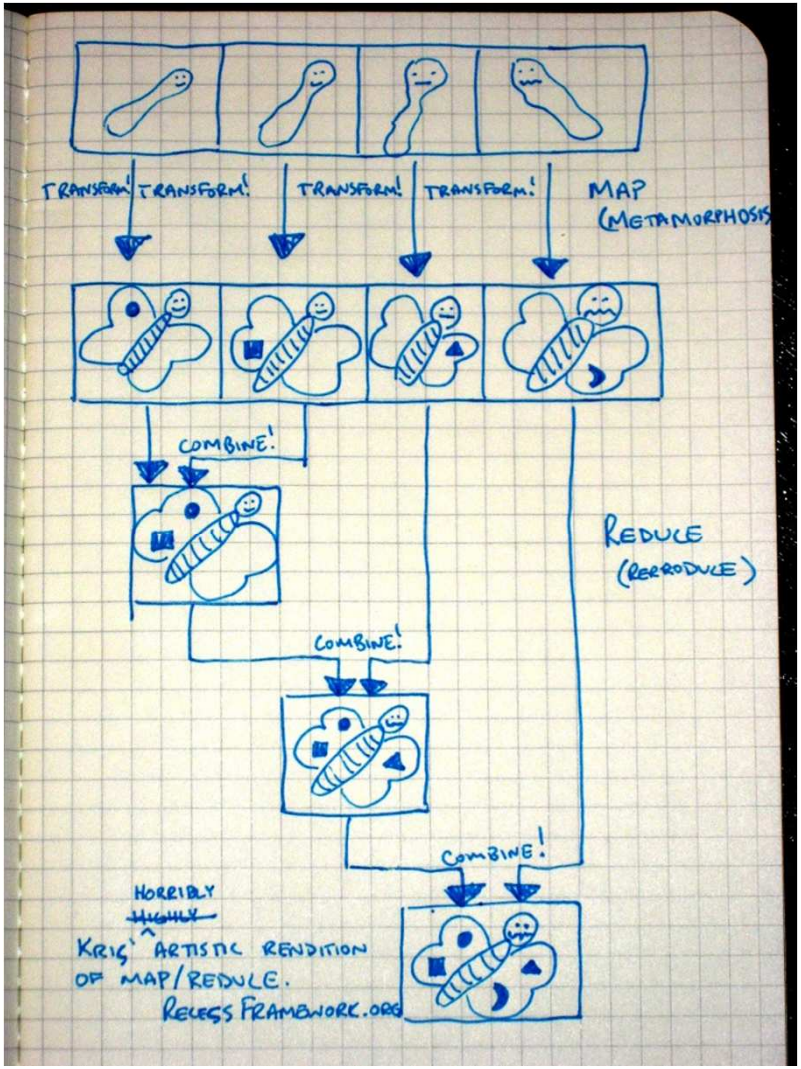
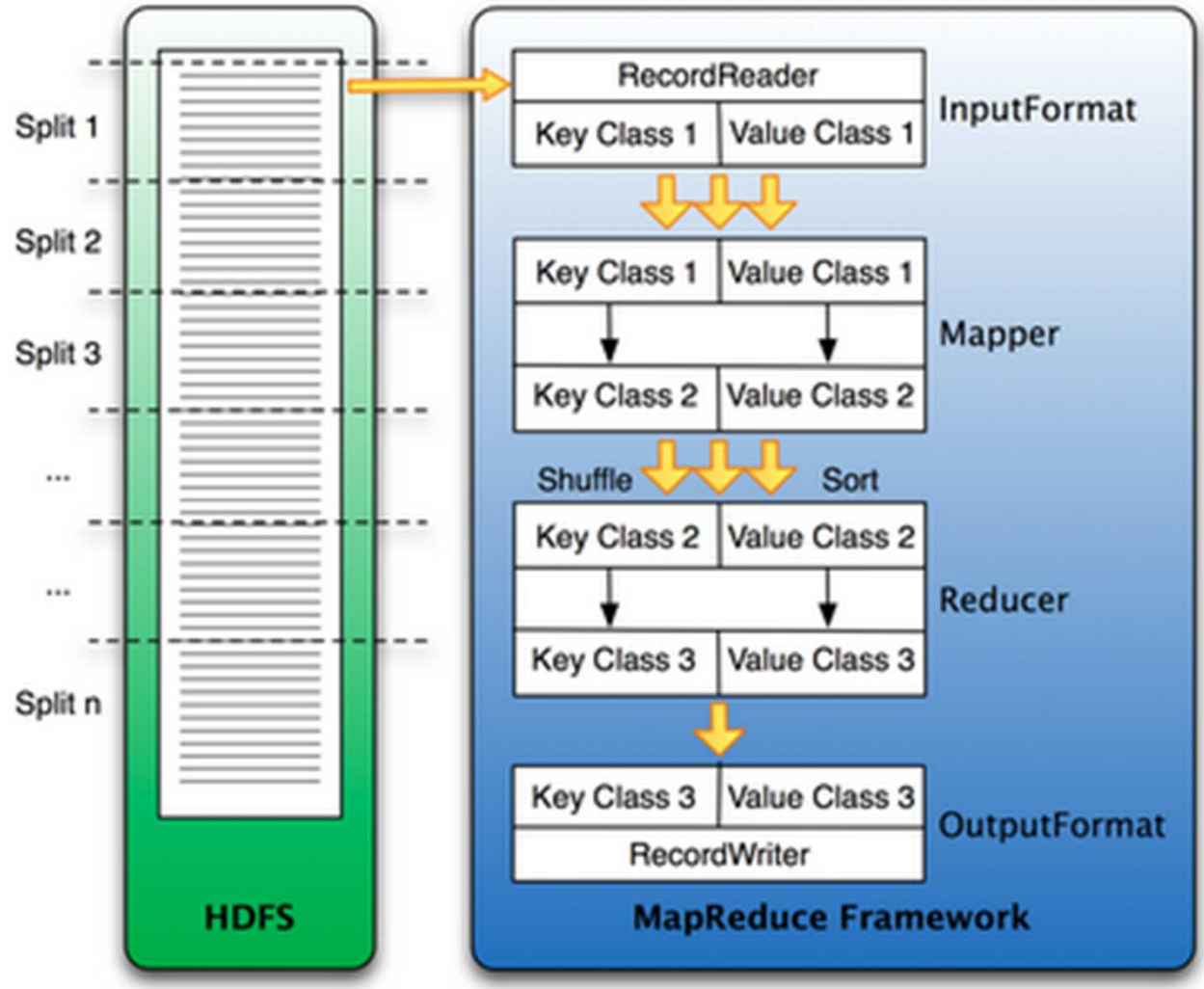


Source: http://www.recessframework.org/page/map-reduce-anonymous-functions-lambdas-php

Apache Hadoop/HBase MapReduce Framework



Source: http://www.larsgeorge.com/2009/05/hbase-mapreduce-101-part-i.html

Apache Hadoop/HBase
HBase – Overview

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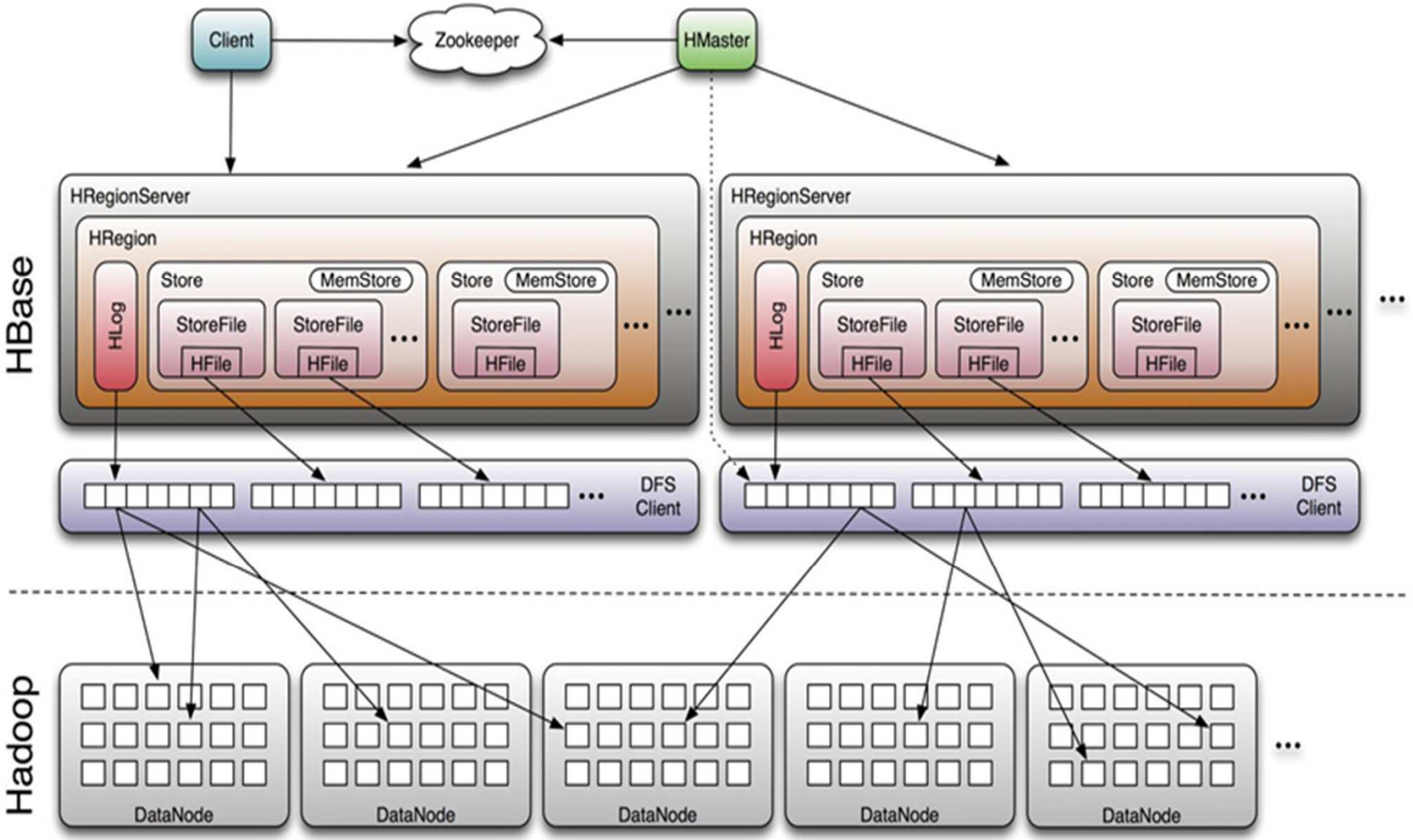
- Open source Java implementation of Google‘s **BigTable** concept
- Non-relational, distributed database
- Column-oriented storage, optimized for sparse data
- Multi-dimensional
- High Availability
- High Performance
- Runs on top of Apache Hadoop Distributed Filesystem (HDFS)
- Goals
  - Billions of rows * Million of columns * Thousands of Versions
  - Petabytes across thousands of commodity servers

Apache Hadoop/HBase
HBase – Architecture



Source: http://www.larsgeorge.com/2009/10/hbase-architecture-101-storage.html

HBase – Data Model

- A **sparse, multi-dimensional, sorted** map
  - {rowkey, column, timestamp} -> cell
- Column = <column_family>:<qualifier>
- Rows are **sorted lexicographically** based on the rowkey

	ColumnFamily1					(CF2)
	Timestamp	qualifier1	qualifier2	qualifier3	qualifier4	...
rowkey1	ts3	value	value			
	ts2		value		value	
	ts1	value			value	
rowkey2	ts5	value				
	ts4			value		
	ts3	value			value	
	ts2			value		

Apache Hadoop/HBase
HBase – API's

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- Native Java
- REST
- Thrift
- Avro
- Ruby shell
- Apache MapReduce
- Hive
- ...

Apache Hadoop/HBase
HBase – Users

- Facebook
- Twitter
- Mozilla
- Trend Micro
- Yahoo
- Adobe
- ...

Apache Hadoop/HBase
HBase vs. RDBMS

- HBase is not a drop-in replacement for a RDBMS
  - No data types just byte arrays, interpretation happens at the client
  - No query engine
  - No joins
  - No transactions
  - Secondary indexes problematic
  - Denormalized data
- HBase is bullet-proof to
  - Store key/value pairs in a distributed environment
  - Scale horizontally by adding more nodes to the cluster
  - Offer a flexible schema
  - Efficiently store sparse tables (NULL doesn‘t need any space)
  - Support semi-structured and structered data

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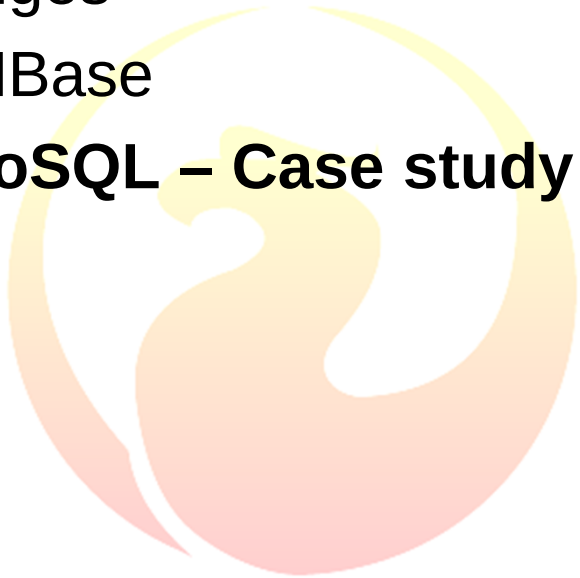

Firebird meets NoSQL – Case study
High-Level Requirements

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- Condition Monitoring System in the domain of solar collectors and inverters
- Collecting measurement values (current, voltage, temperature ...)
- Expected data volume
  - ~ 1300 billions measurement values (rows) per year
- Long-term storage solution necessary
- Web-based customer portal accesing aggregated and detailed data
- Backend data analysis, data mining, machine learning, fault detection

Firebird meets NoSQL – Case study
Prototypical implementation

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- Initial problem: You can‘t manage this data volume with a RDBMS
- Measurement values are a good example for key/value pairs
- Evaluated Apache Hadoop/HBase for storing detailed measurement values
- Virtualized Hadoop/HBase test cluster with 12 nodes
- RDBMS (Firebird/Oracle) for storing aggregated data

Firebird meets NoSQL – Case study
Prototypical implementation

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- HBase data model based on the web application object model
  - Row-Key: <DataLogger-ID>-<Device-ID>-<Timestamp>
    `0000000000000050-0000000000000001-20110815134520`
  - Column Families and Qualifiers based on classes and attributes in the object model
- Test data generator (TDG) and scanner (TDS) implementing the HBase data model for performance tests
  - TDG: ~70000 rows per second
  - TDS: <150ms response time with 400 simulated clients querying detail values for a particular DataLogger-ID/Device-ID for a given day for a HBase table with ~5 billions rows

Firebird meets NoSQL – Case study
Prototypical implementation

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- MapReduce job implementation for data aggregation and storage
  - Throughput: 600000 rows per second
  - Pre-aggregation of ~15 billions rows in ~7h, including storage in RDBMS
- Prototypical implementation based on a fraction of the expected data volume
  - Simply add more nodes to the cluster to handle more data

MapReduce Demonstration

Live Demonstration

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Q&A

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Questions and Answers

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The End

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Thanks for your attention!

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Resources

- Apache Hadoop: http://hadoop.apache.org/
- Apache HBase: http://hbase.apache.org/
- MapReduce: http://www.larsgeorge.com/2009/05/hbase-mapreduce-101-part-i.html
- Hadoop/Hbase powered by:
  http://wiki.apache.org/hadoop/PoweredBy
  http://wiki.apache.org/hadoop/Hbase/PoweredBy
- HBase goals:
  http://www.docstoc.com/docs/2996433/Hadoop-and-HBase-vs-RDBMS
- HBase architecture:
  http://www.larsgeorge.com/2009/10/hbase-architecture-101-storage.html
- Cloudera Distribution: http://www.cloudera.com/