

HBase A Comprehensive Introduction

James Chin, Zikai Wang Monday, March 14, 2011 CS 227 (Topics in Database Management) CIT 367





Overview



- Began as project by Powerset to process massive amounts of data for natural language search
- Open-source implementation of Google's BigTable
 - Lots of semi-structured data
 - Commodity Hardware
 - Horizontal Scalability
 - Tight integration with MapReduce
- Developed as part of Apache's Hadoop project and runs on top of HDFS (Hadoop Distributed Filesystem)
 - Provides fault-tolerant way of storing large quantities of sparse data.



- Non-relational, distributed database
- Column-Oriented
- Multi-Dimensional
- High Availability
- High Performance



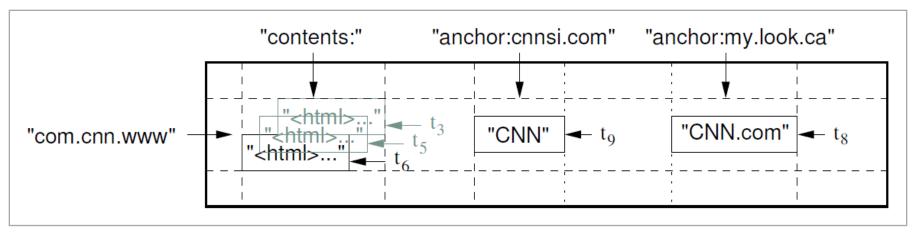
Data Model & Operators



A sparse, multi-dimensional, sorted map

{row, column, timestamp} -> cell

Column = Column Family : Column Qualifier



- Rows are sorted lexicographically based on row key
- Region: contiguous set of sorted rows
- HBase: a large number of columns, a low number of column families (2-3)





Operations are based on row keys

Single-row operations:

- Put
- Get
- Scan

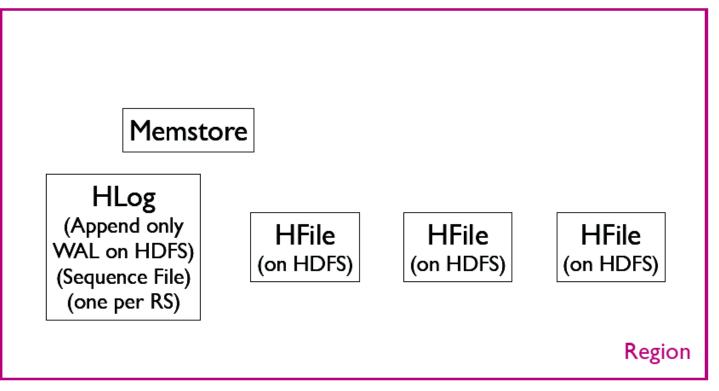
Multi-row operations:

- Scan
- MultiPut
- No built-in joins (use MapReduce)



Physical Structures

Physical Structures: Data Organization



BROWN

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- Region: unit of distribution and availability
- Regions are split when grown too large
- Max region size is a tuning parameter
 - Too low: prevents parallel scalability
 - Too high: makes things slow



- HBase has no built-in support for secondary indexes
- API only exposes operations by row key

Row Key	Name	Position	Nationality
"1"	Nowitzki, Dirk	PF	Germany
"2"	Kaman, Chris	С	Germany
"3"	Gasol, Paul	PF	Spain
"4"	Fernandez, Rudy	SG	Spain

Find all players from Spain?

- With built-in API, scan the entire table
- Manually build a secondary index table
- Exploit the fact that rows are sorted lexicographically by row key based on byte order



Data Table:

Row Key	Name	Position	Nationality
"1"	Nowitzki, Dirk	PF	Germany
"2"	Kaman, Chris	С	Germany
"3"	Gasol, Paul	PF	Spain
"4"	Fernandez, Rudy	SG	Spain

Index table on nationality column

- a scan operation
- start row = "Spain"
- stop scanning: set a RowFilter with a BinaryPrefixComparator on the end value("Spain")
- range queries are also supported

Row Key	Dummy
"Germany 1"	Germany 1
"Germany 2"	Germany 2
"Spain 3"	Spain 3
"Spain 4"	Spain 4

Find all power forwards from Spain?

- A composite index
- Row keys are plain byte arrays
 - Byte order = your desired order?
 - Convert strings, integers, floats, decimals carefully to bytes
 - Default sorting is ascending; if descending indexes are needed, reverse bit order



Lily's HBase Indexing Library

- Aids in building and querying indexes in HBase
- Hides the details of playing with byte[] row keys

• HBase + full text indexing and searching systems

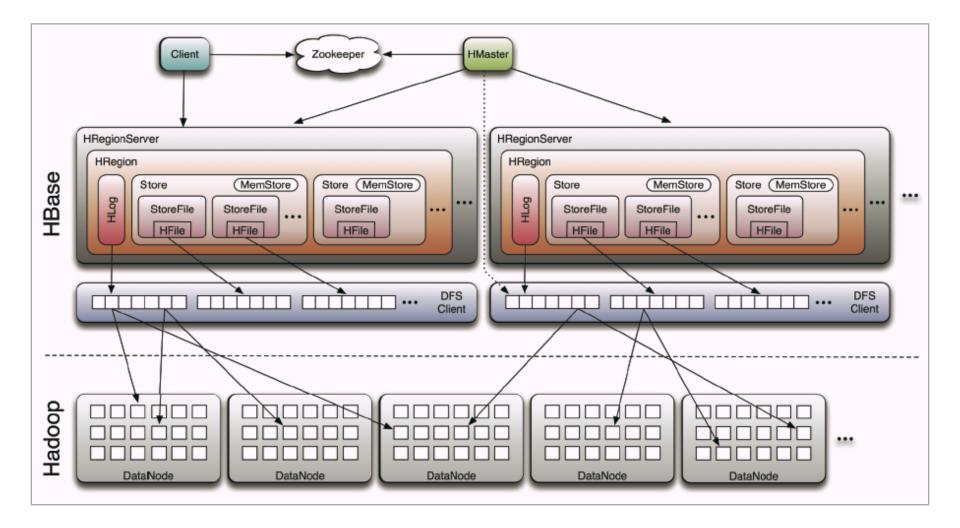
- Apache Lucene (Apache Solr, elasticsearch)
- Lily, HAvroBase (HBase + Solr), HBasene (HBase + Lucene)



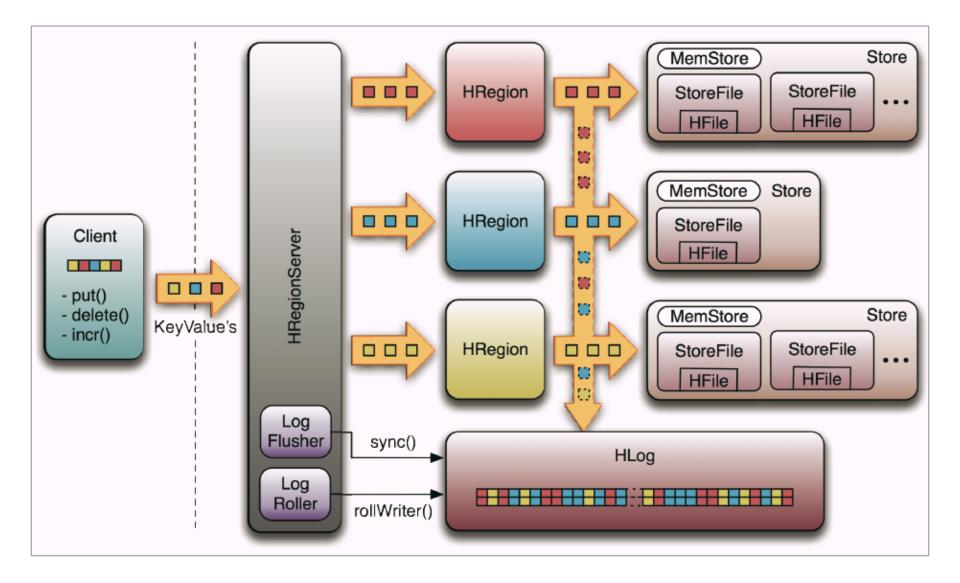
System Architecture

System Architecture: Overview



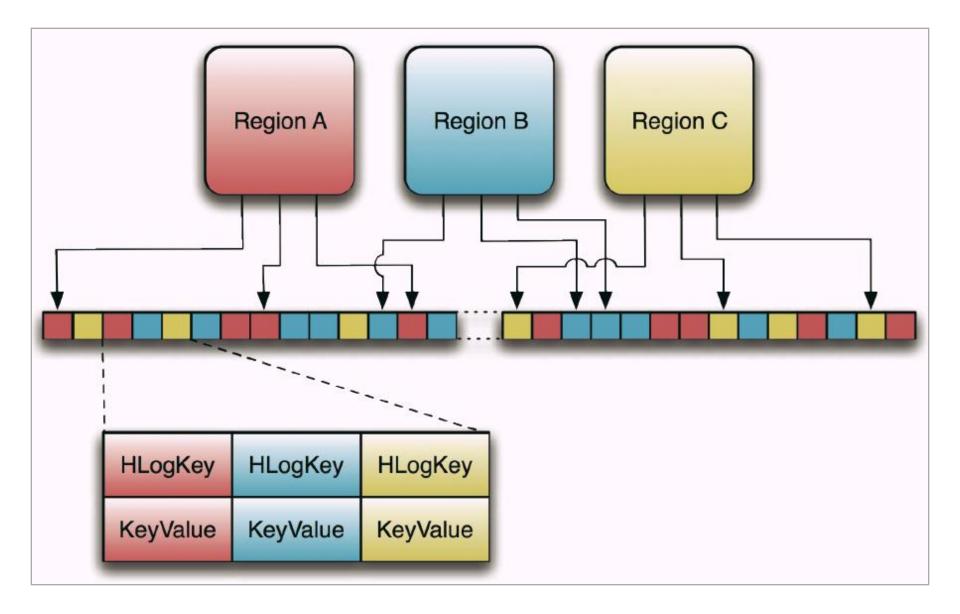


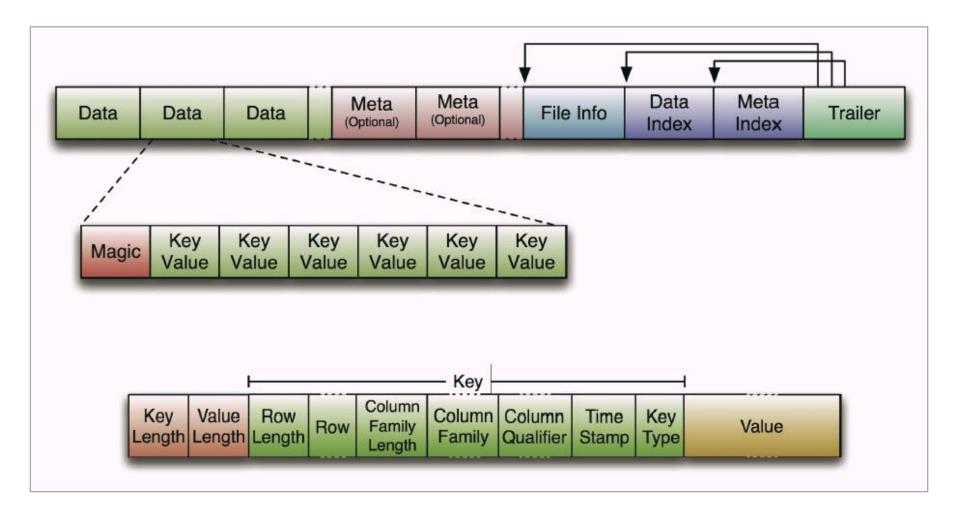
System Architecture: Write-Ahead-Log Flow



System Architecture: WAL (cont.)











APIs

APIs: Overview



Java

- Get, Put, Delete, Scan
- IncrementColumnValue
- TableInputFormat MapReduce Source
- TableOutputFormat MapReduce Sink
- Rest
- Thrift
- Scala
- Jython
- Groovy DSL
- Ruby shell
- Java MR, Cascading, Pig, Hive



ACID Properties



 HBase not ACID-compliant, but does guarantee certain specific properties

Atomicity

- All mutations are atomic within a row. Any put will either wholely succeed or wholely fail.
- APIs that mutate several rows will *not* be atomic across the multiple rows.
- The order of mutations is seen to happen in a well-defined order for each row, with no interleaving.

Consistency and Isolation

 All rows returned via any access API will consist of a complete row that existed at some point in the table's history.

Consistency of Scans

- A scan is not a consistent view of a table. Scans do not exhibit snapshot isolation.
- Those familiar with relational databases will recognize this isolation level as "read committed".

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Durability

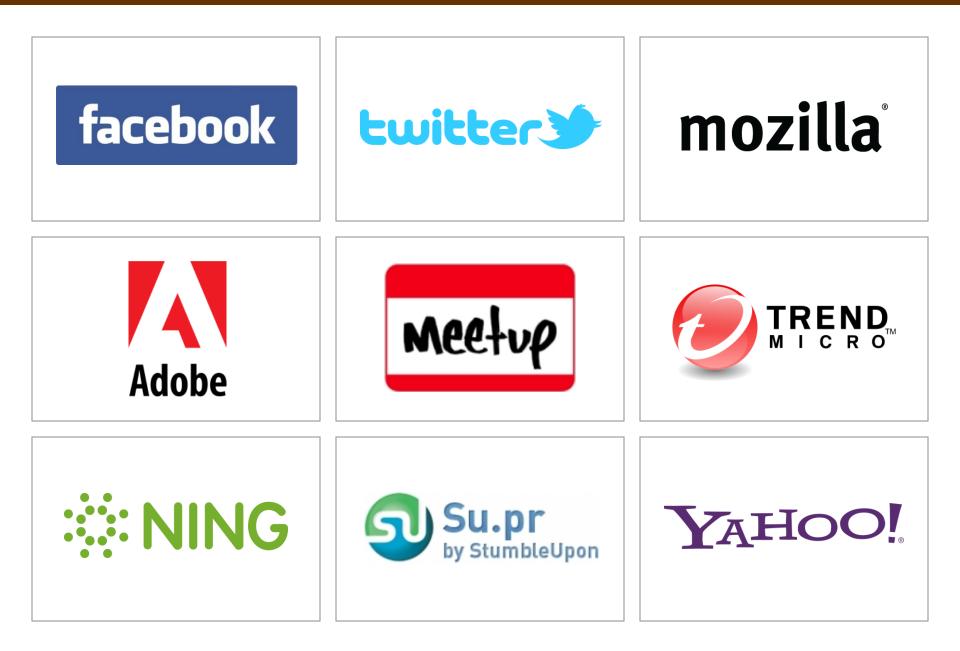
- All visible data is also durable data. That is to say, a read will never return data that has not been made durable on disk.
- Any operation that returns a "success" code (e.g. does not throw an exception) will be made durable.
- Any operation that returns a "failure" code will not be made durable (subject to the Atomicity guarantees above).
- All reasonable failure scenarios will not affect any of the listed ACID guarantees.



Users

Users: Just to name a few...









The New Messages

Texts, chat and email together in one simple conversation.

All your messages together



Get Facebook messages, chats and texts all in the same place.

- Include email by activating your optional Facebook email address
- Control who can send you messages through your privacy settings

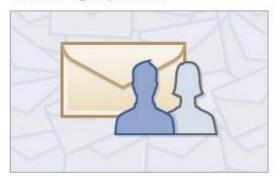
Full conversation history



See everything you've ever discussed with each friend as a single conversation.

- No need for subject lines or other formalities
- Easily leave large conversations that no longer interest you

The messages you want



Focus on messages from your friends.

- Messages from unknown senders and bulk email go into the Other folder
- Spam is hidden from view automatically

For more information, read the top questions about the new Messages.

Request an Invitation

- Previous Solution: Cassandra
- Current Solution: HBase
- Why? Cassandra's replication behavior

Cassanc	Ira Replication
Client writes a single record	Replica 1 Replica 2 Replica 3
Hadoop	/HBase Replication
Client writes a single record	Replica 1 Replica 2 Replica 3

Users: Twitter - People Search



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- Customer Indexing
- Previous Solution: offline process at a single node

Current Solution:

- Import user data into HBase
- Periodically MapReduce job reading from HBase
- Hits FlockDB and other internal services in mapper
- Write data to sharded, replicated, horizontally scalable, in-memory, low-latency Scala service

• Vs. Others:

- HDFS: Data is mutable
- Cassandra: OLTP vs. OLAP?

Users: Mozilla - Socorro



mozilla crash reports					Q Find Crash ID or Signature
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- Socorro, Mozilla's crash reporting system (https://crashstats.mozilla.com/products)
 - Catches, processes, and presents crash data for Firefox, Thunderbird, Fennec, Camino, and Seamonkey.
- 2.5 million crash reports per week, 320GB per day
- Previous Solution: NFS (raw data), PostgreSQL (analyze results)
 - 15% of crash reports are processed
- Current Solution: Hadoop (processing) + HBase (storage)



HBase vs. RDBMS



HBase	RDBMS
Column-oriented	Row oriented (mostly)
Flexible schema, add columns on the fly	Fixed schema
Good with sparse tables	Not optimized for sparse tables
No query language	SQL
Wide tables	Narrow tables
Joins using MR – not optimized	Optimized for joins (small, fast ones too!)
Tight integration with MR	Not really



HBase	RDBMS
De-normalize your data	Normalize as you can
Horizontal scalability – just add hardware	Hard to shard and scale
Consistent	Consistent
No transactions	Transactional
Good for semi-structured data as well as structured data	Good for structured data



Questions?



Thanks!