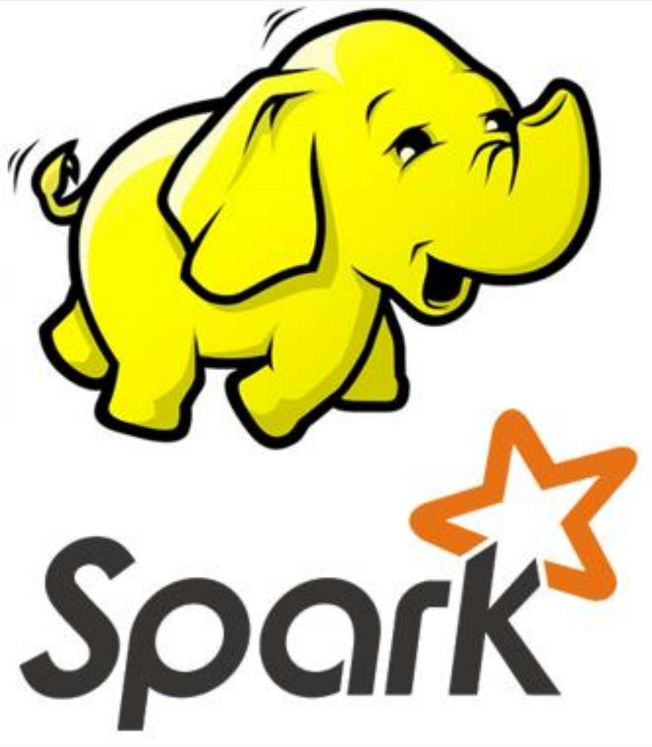
COMP9313: Big Data Management



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Course web site: http://www.cse.unsw.edu.au/~cs9313/

Chapter 8.1: NoSQL and HBase

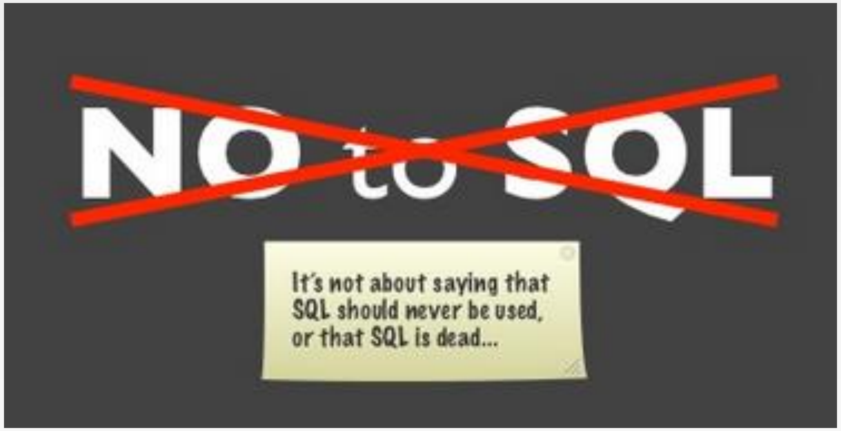
Part 1: Introduction to NoSQL

What does RDBMS provide?

- Relational model with schemas
- Powerful, flexible query language (SQL)
- Transactional semantics: ACID
- Rich ecosystem, lots of tool support (MySQL, PostgreSQL, etc.)

What is NoSQL?

- The name stands for **N**ot **O**nly **SQL**
- Does not use SQL as querying language
- Class of non-relational data storage systems
- The term NOSQL was introduced by Eric Evans when an event was organized to discuss open-source distributed databases
- It's not a replacement for a RDBMS but compliments it
- All NoSQL offerings relax one or more of the ACID properties (will talk about the CAP theorem)



It's not about saying that SQL should never be used, or that SQL is dead...

What is NoSQL?

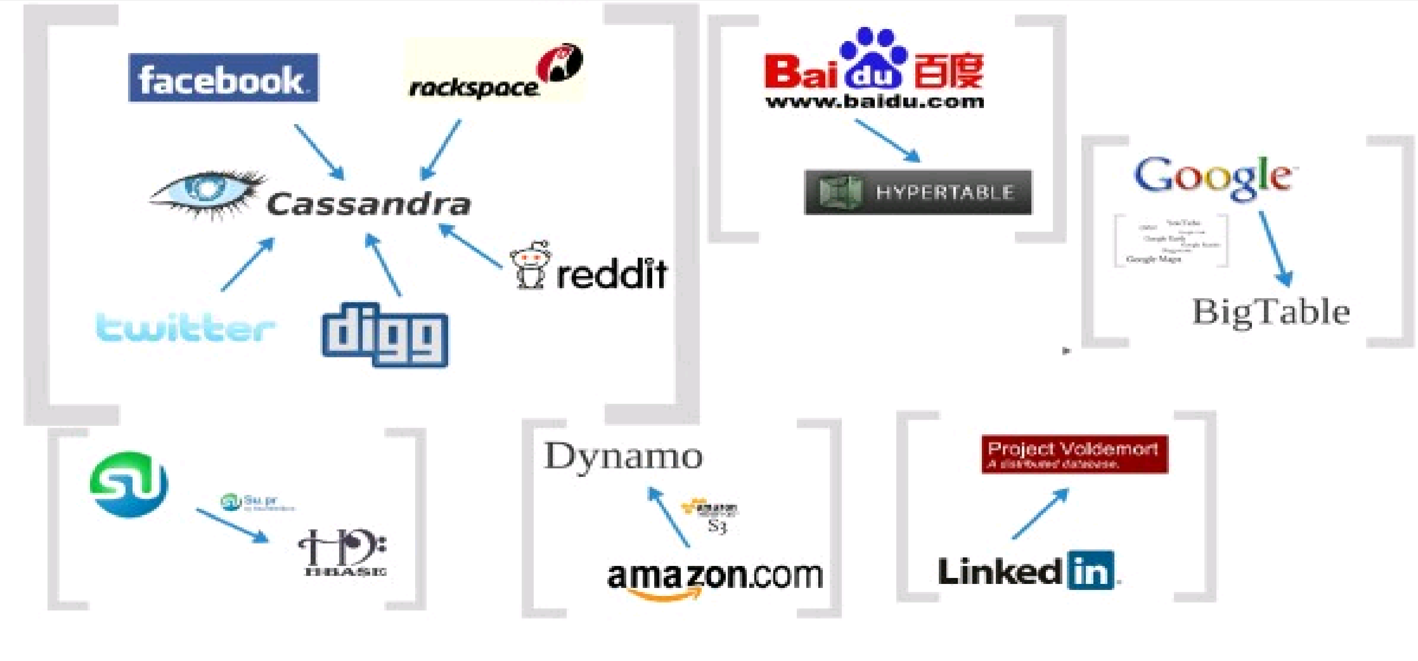
- Key features (advantages):
  - non-relational
  - don’t require strict schema
  - data are replicated to multiple nodes (so, identical & fault-tolerant) and can be partitioned:
    - down nodes easily replaced
    - no single point of failure
  - horizontal scalable
  - cheap, easy to implement (open-source)
  - massive write performance
  - fast key-value access

Why NoSQL ?

- Web apps have different needs (than the apps that RDBMS were designed for)
  - Low and predictable response time (latency)
  - Scalability & elasticity (at low cost!)
  - High availability
  - Flexible schemas / semi-structured data
  - Geographic distribution (multiple datacenters)
- Web apps can (usually) do without
  - Transactions / strong consistency / integrity
  - Complex queries

Who are Using NoSQL?

- Google (BigTable)
- LinkedIn (Voldemort)
- Facebook (Cassandra)
- Twitter (HBase, Cassandra)
- Baidu (HyperTable)

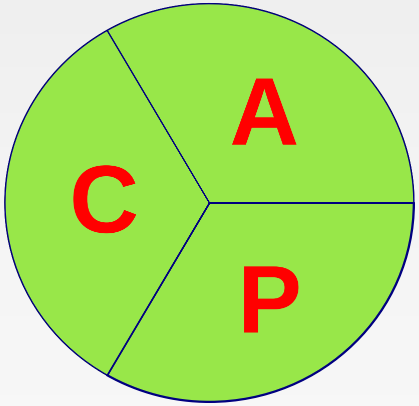


Three Major Papers for NoSQL

- Three major papers were the seeds of the NoSQL movement
  - BigTable (Google)
  - Dynamo (Amazon)
    - Ring partition and replication
    - Gossip protocol (discovery and error detection)
    - Distributed key-value data store
    - Eventual consistency
  - CAP Theorem (discuss in the next few slides)

CAP Theorem

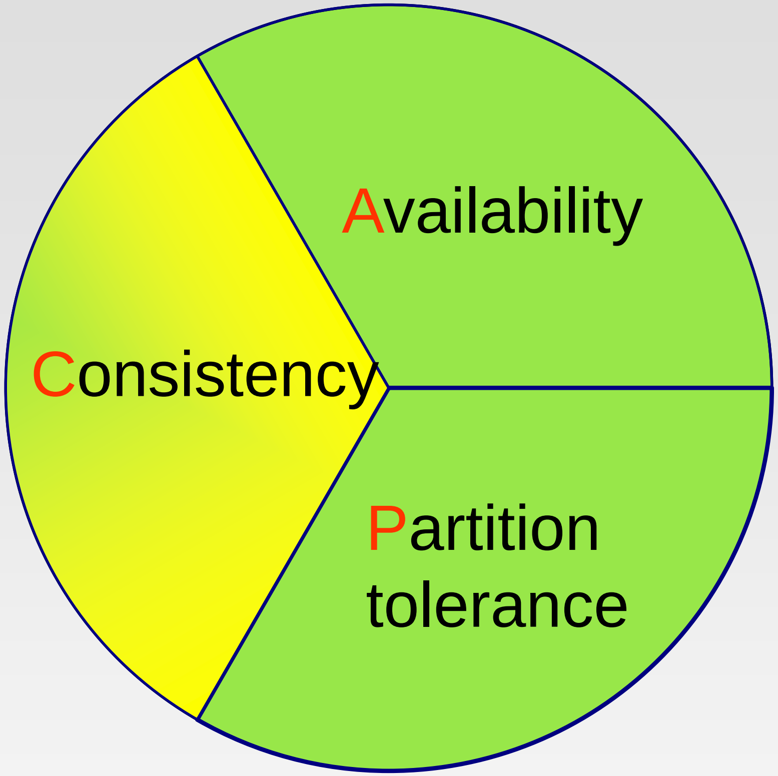
- Suppose three properties of a distributed system (sharing data)
  - **Consistency:**
    - all copies have same value
  - **Availability:**
    - reads and writes always succeed
  - **Partition-tolerance:**
    - system properties (consistency and/or availability) hold even when network failures prevent some machines from communicating with others



CAP Theorem

- Brewer's CAP Theorem:
  - *For any system sharing data, it is "impossible" to guarantee simultaneously all of these three properties*
  - You can have at most two of these three properties for any shared-data system
- Very large systems will "partition" at some point:
  - That leaves either **C** or **A** to choose from (traditional DBMS prefers **C** over **A** and **P**)
  - In almost all cases, you would choose **A** over **C** (except in specific applications such as order processing)

CAP Theorem: Consistency



All client always have the same view of the data

Once a writer has written, all readers will see that write

- Two kinds of consistency:
  - strong consistency – ACID (Atomicity Consistency Isolation Durability)
  - weak consistency – BASE (Basically Available Soft-state Eventual consistency)

ACID & CAP

- **ACID**
  - A DBMS is expected to support “ACID transactions,” processes that are:
  - **Atomicity:** either the whole process is done or none is
  - **Consistency:** only valid data are written
  - **Isolation:** one operation at a time
  - **Durability:** once committed, it stays that way

- **CAP**
  - **Consistency:** all data on cluster has the same copies
  - **Availability:** cluster always accepts reads and writes
  - **Partition tolerance:** guaranteed properties are maintained even when network failures prevent some machines from communicating with others

Consistency Model

- A consistency model determines rules for visibility and apparent order of updates
- Example:
  - Row X is replicated on nodes M and N
  - Client A writes row X to node N
  - Some period of time t elapses
  - Client B reads row X from node M
  - **Does client B see the write from client A?**
  - Consistency is a continuum with tradeoffs
  - **For NOSQL, the answer would be: “maybe”**
  - CAP theorem states: *“strong consistency can't be achieved at the same time as availability and partition-tolerance”*

Eventual Consistency

- When no updates occur for a long period of time, eventually all updates will propagate through the system and all the nodes will be consistent

- For a given accepted update and a given node, eventually either the update reaches the node or the node is removed from service

- Known as BASE (**B**asically **A**vailable, **S**oft state, **E**ventual consistency), as opposed to ACID

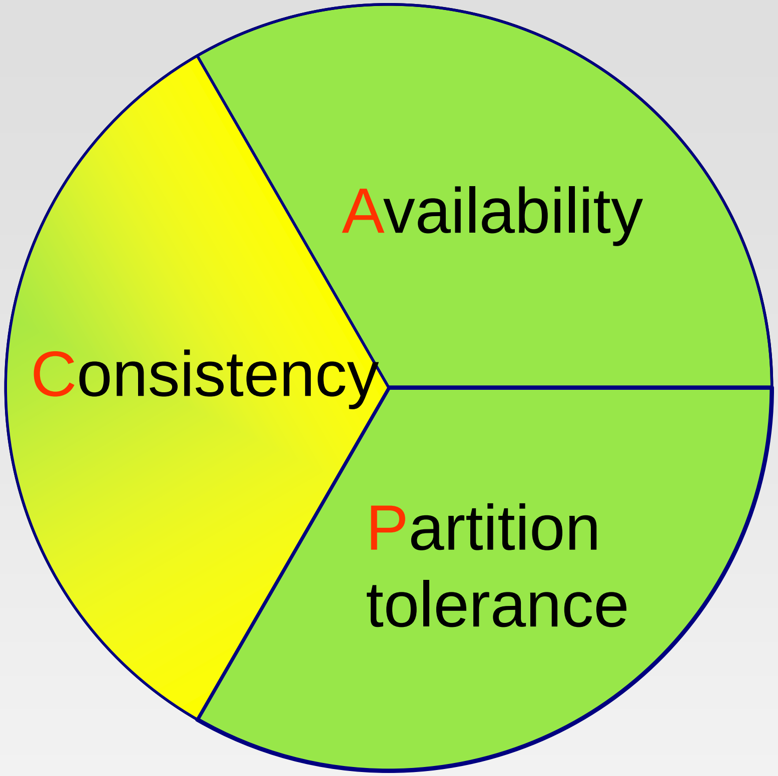
- http://en.wikipedia.org/wiki/Eventual_consistency

Eventual Consistency

- The types of large systems based on CAP aren't ACID they are BASE (http://queue.acm.org/detail.cfm?id=1394128):
  - Basically Available - system seems to work all the time
  - Soft State - it doesn't have to be consistent all the time
  - Eventually Consistent - becomes consistent at some later time

- Everyone who builds big applications builds them on CAP and BASE: Google, Yahoo, Facebook, Amazon, eBay, etc.

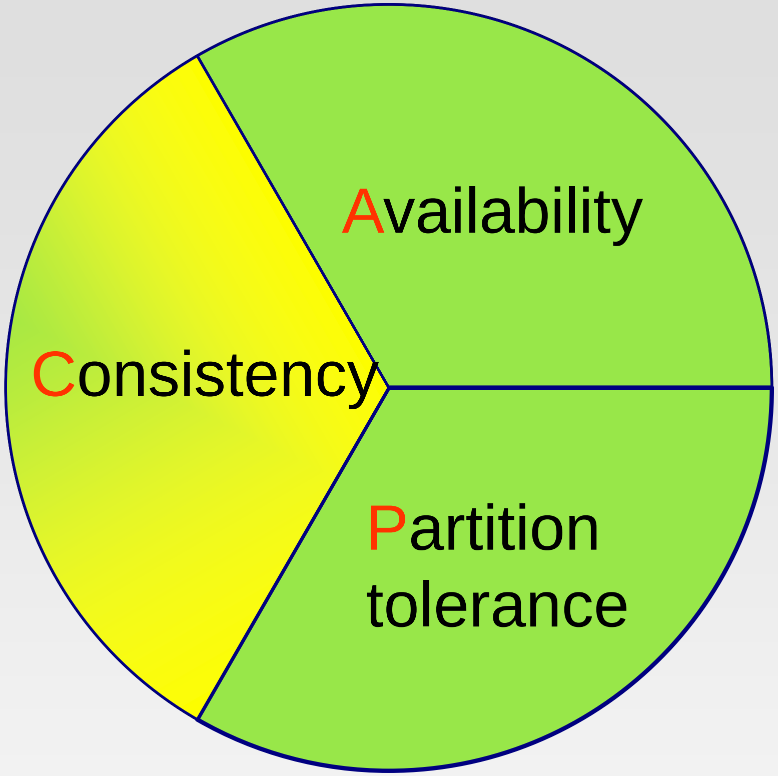
CAP Theorem: Availability



System is available during software and hardware upgrades and node failures.

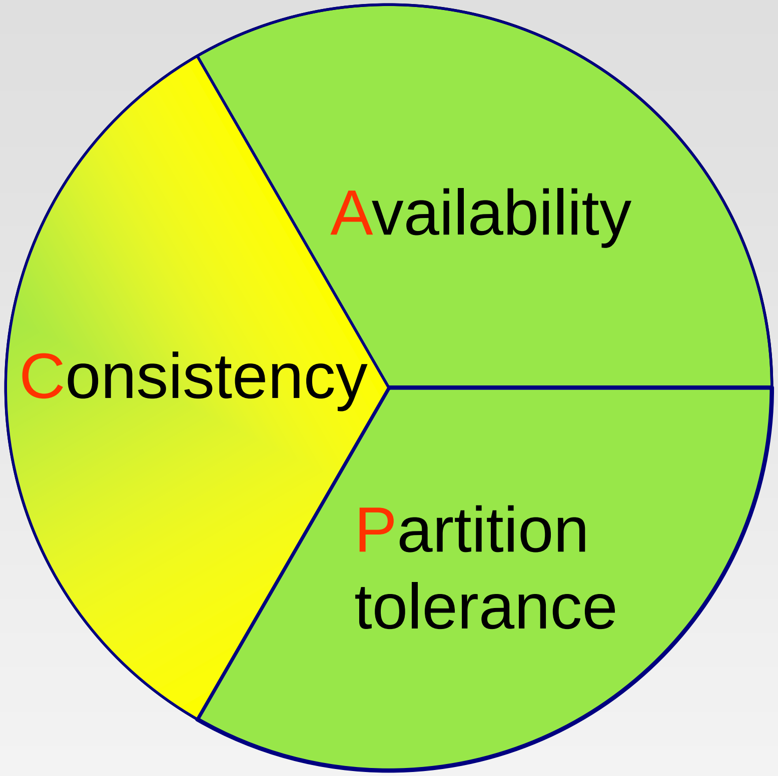
- Traditionally, thought of as the server/process available five 9's (99.999 %).
  - However, for large node system, at almost any point in time there's a good chance that a node is either down or there is a network disruption among the nodes.
  - Want a system that is resilient in the face of network disruption

CAP Theorem: Partition-Tolerance



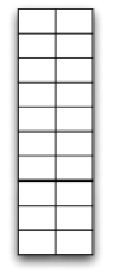
A system can continue to operate in the presence of a network partitions.

CAP Theorem

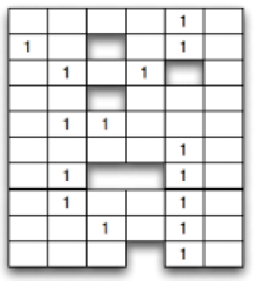


CAP Theorem: You can have at most **two** of these properties for any shared-data system

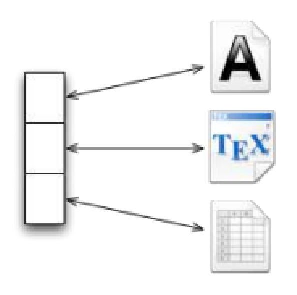
NoSQL Taxonomy



- Key-Value stores
  - Simple K/V lookups (DHT)



- Column stores
  - Each key is associated with many attributes (columns)
  - NoSQL column stores are actually hybrid row/column stores
    - Different from “pure” relational column stores!



- Document stores
  - Store semi-structured documents (JSON)

- Graph databases
  - Neo4j, etc.
  - Not exactly NoSQL
    - can’t satisfy the requirements for High Availability and Scalability/Elasticity very well

Key-value

- Focus on scaling to huge amounts of data
- Designed to handle massive load
- Based on Amazon’s dynamo paper
- Data model: (global) collection of Key-value pairs
- *Dynamo ring partitioning* and *replication*
- Example: (DynamoDB)
  - *items* having one or more attributes (name, value)
  - An *attribute* can be single-valued or multi-valued like set.
  - items are combined into a *table*

Key-value

- Basic API access:
  - get(key): extract the value given a key
  - put(key, value): create or update the value given its key
  - delete(key): remove the key and its associated value
  - execute(key, operation, parameters): invoke an operation to the value (given its key) which is a special data structure (e.g. List, Set, Map .... etc)

Key-value

- Pros:
  - very fast
  - very scalable (horizontally distributed to nodes based on key)
  - simple data model
  - eventual consistency
  - fault-tolerance

- Cons

  Can’t model more complex data structure such as objects

Key-value

Name	Producer	Data model	Querying
SimpleDB	Amazon	set of couples (key, {attribute}), where attribute is a couple (name, value)	restricted SQL; select, delete, GetAttributes, and PutAttributes operations
Redis	Salvatore Sanfilippo	set of couples (key, value), where value is simple typed value, list, ordered (according to ranking) or unordered set, hash value	primitive operations for each value type
Dynamo	Amazon	like SimpleDB	simple get operation and put in a context
Voldemort	LinkeIn	like SimpleDB	similar to Dynamo

Document-based

- Can model more complex objects
- Inspired by Lotus Notes
- Data model: collection of documents
- Document: JSON (**J**ava**S**cript **O**bject **N**otation is a data model, key-value pairs, which supports objects, records, structs, lists, array, maps, dates, Boolean with **nesting**), XML, other semi-structured formats.
- Example: (MongoDB) document
  - {Name:"Jaroslav",

    Address:"Malostranske nám. 25, 118 00 Praha 1”,

    Grandchildren: {Claire: "7", Barbara: "6", "Magda: "3", "Kirsten: "1", "Otis: "3", Richard: "1“}

    Phones: [“123-456-7890”, “234-567-8963”]

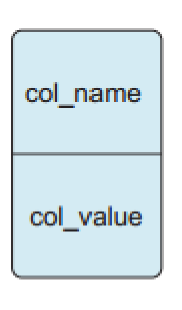
    }

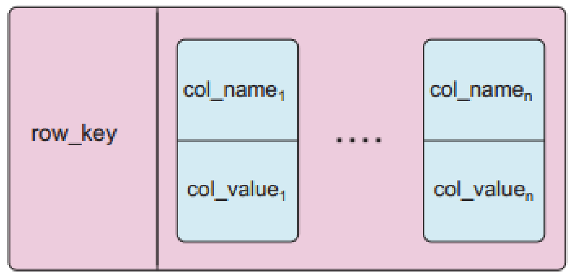
Document-based

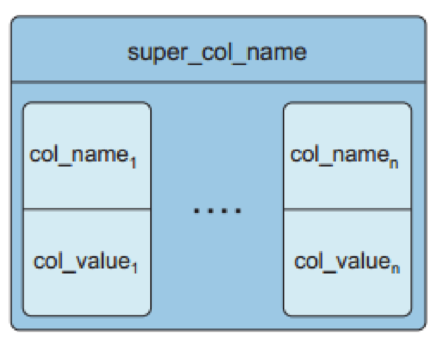
Name	Producer	Data model	Querying
MongoDB	10gen	object-structured documents stored in collections; each object has a primary key called ObjectId	manipulations with objects in collections (find object or objects via simple selections and logical expressions, delete, update,)
Couchbase	Couchbase	document as a list of named (structured) items (JSON document)	by key and key range, views via Javascript and MapReduce

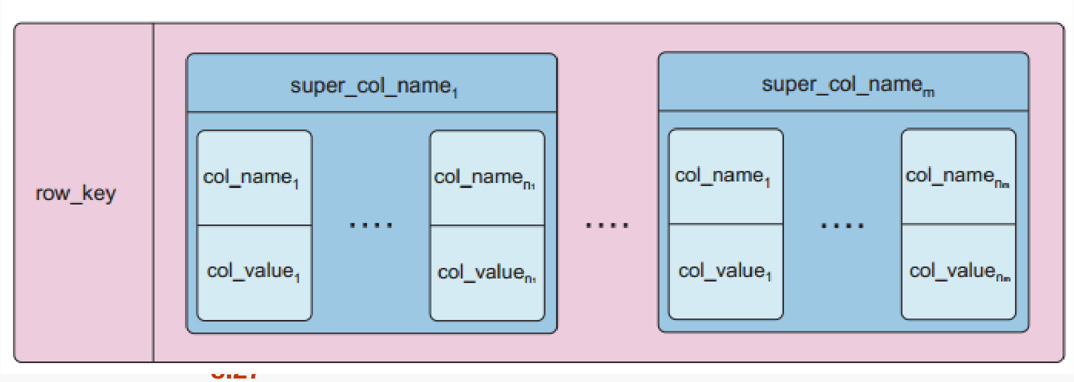
Column-based

- Based on Google’s BigTable paper
- Like column oriented relational databases (store data in column order) but with a twist
- Tables similarly to RDBMS, but handle semi-structured
- Data model:
  - Collection of Column Families
  - Column family = (key, value) where value = set of **related** columns (standard, super)
  - indexed by *row key*, *column key* and *timestamp*









Column-based

- One column family can have variable numbers of columns
- Cells within a column family are sorted “physically”
- Very sparse, most cells have null values
- Comparison: RDBMS vs column-based NoSQL
  - Query on multiple tables
    - RDBMS: must fetch data from several places on disk and glue together
    - Column-based NoSQL: only fetch column families of those columns that are required by a query (all columns in a column family are stored together on the disk, so multiple rows can be retrieved in one read operation data locality)

Column-based

Name	Producer	Data model	Querying
BigTable	Google	set of couples (key, {value})	selection (by combination of row, column, and time stamp ranges)
HBase	Apache	groups of columns (a BigTable clone)	JRUBY IRB-based shell (similar to SQL)
Hypertable	Hypertable	like BigTable	HQL (Hypertext Query Language)
CASSANDRA	Apache (originally Facebook)	columns, groups of columns corresponding to a key (supercolumns)	simple selections on key, range queries, column or columns ranges
PNUTS	Yahoo	(hashed or ordered) tables, typed arrays, flexible schema	selection and projection from a single table (retrieve an arbitrary single record by primary key, range queries, complex predicates, ordering, top-k)

Graph-based

- Focus on modeling the structure of data (*interconnectivity*)
- Scales to the complexity of data
- Inspired by mathematical Graph Theory (G=(E,V))
- Data model:
    - (Property Graph) nodes and edges
        - Nodes may have properties (including ID)
        - Edges may have labels or roles
    - Key-value pairs on both
- Interfaces and query languages vary
- *Single-step* vs *path expressions* vs *full recursion*
- Example:
    - Neo4j, FlockDB, InfoGrid …

NoSQL Pros/Cons

- Advantages
  - Massive scalability
  - High availability
  - Lower cost (than competitive solutions at that scale)
  - (usually) predictable elasticity
  - Schema flexibility, sparse & semi-structured data
- Disadvantages
  - Don’t fully support relational features
    - no join, group by, order by operations (except within partitions)
    - no referential integrity constraints across partitions
  - No declarative query language (e.g., SQL) → more programming
  - Eventual consistency is not intuitive to program for
    - Makes client applications more complicated
  - No easy integration with other applications that support SQL
  - Relaxed ACID (see CAP theorem later) → fewer guarantees

Conclusion

- NOSQL database cover only a part of data-intensive cloud applications (mainly Web applications)
- Problems with cloud computing:
  - SaaS (Software as a Service or on-demand software) applications require enterprise-level functionality, including ACID transactions, security, and other features associated with commercial RDBMS technology, i.e. NOSQL should not be the only option in the cloud
  - Hybrid solutions:
    - Voldemort with MySQL as one of storage backend
    - deal with NOSQL data as semi-structured data

      ->integrating RDBMS and NOSQL via SQL/XML

Part 2: Introduction to HBase

What is HBase?

- HBase is an **open-source**, **distributed**, **column-oriented** database built on top of HDFS based on BigTable
  - Distributed – uses HDFS for storage
  - Row/column store
  - Column-oriented - nulls are free
  - Multi-Dimensional (Versions)
  - Untyped - stores byte[]
- HBase is part of Hadoop
- HBase is the Hadoop application to use when you require real-time read/write random access to very large datasets
  - Aim to support low-latency random access

How Data is Stored in HBase ?

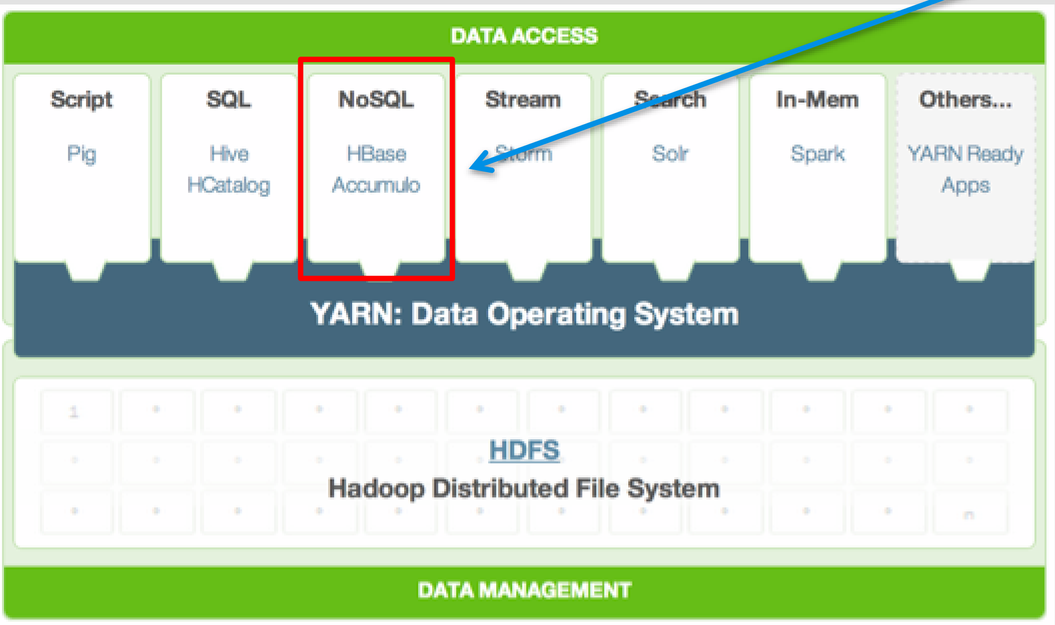
- A *sparse*, *distributed*, *persistent multi-dimensional sorted* map
- Sparse
  - Sparse data is supported with no waste of costly storage space
  - HBase can handle the fact that we don't (yet) know that information
  - HBase as a schema-less data store; that is, it's fluid — we can add to, subtract from or modify the schema as you go along
- Distributed and persistent
  - Persistent simply means that the data you store in HBase will persist or remain after our program or session ends
  - Just as HBase is an open source implementation of BigTable, HDFS is an open source implementation of GFS.
  - HBase leverages HDFS to persist its data to disk storage.
  - By storing data in HDFS, HBase offers reliability, availability, seamless scalability and high performance — all on cost effective distributed servers.

What is HBase? (Cont')

- Multi-dimensional sorted map
  - A map (also known as an associative array) is an abstract collection of key-value pairs, where the key is unique.
  - The keys are stored in HBase and sorted.
  - Each value can have multiple versions, which makes the data model multidimensional. By default, data versions are implemented with a timestamp.

HBase: Part of Hadoop's Ecosystem

HBase is built on top of YARN and HDFS

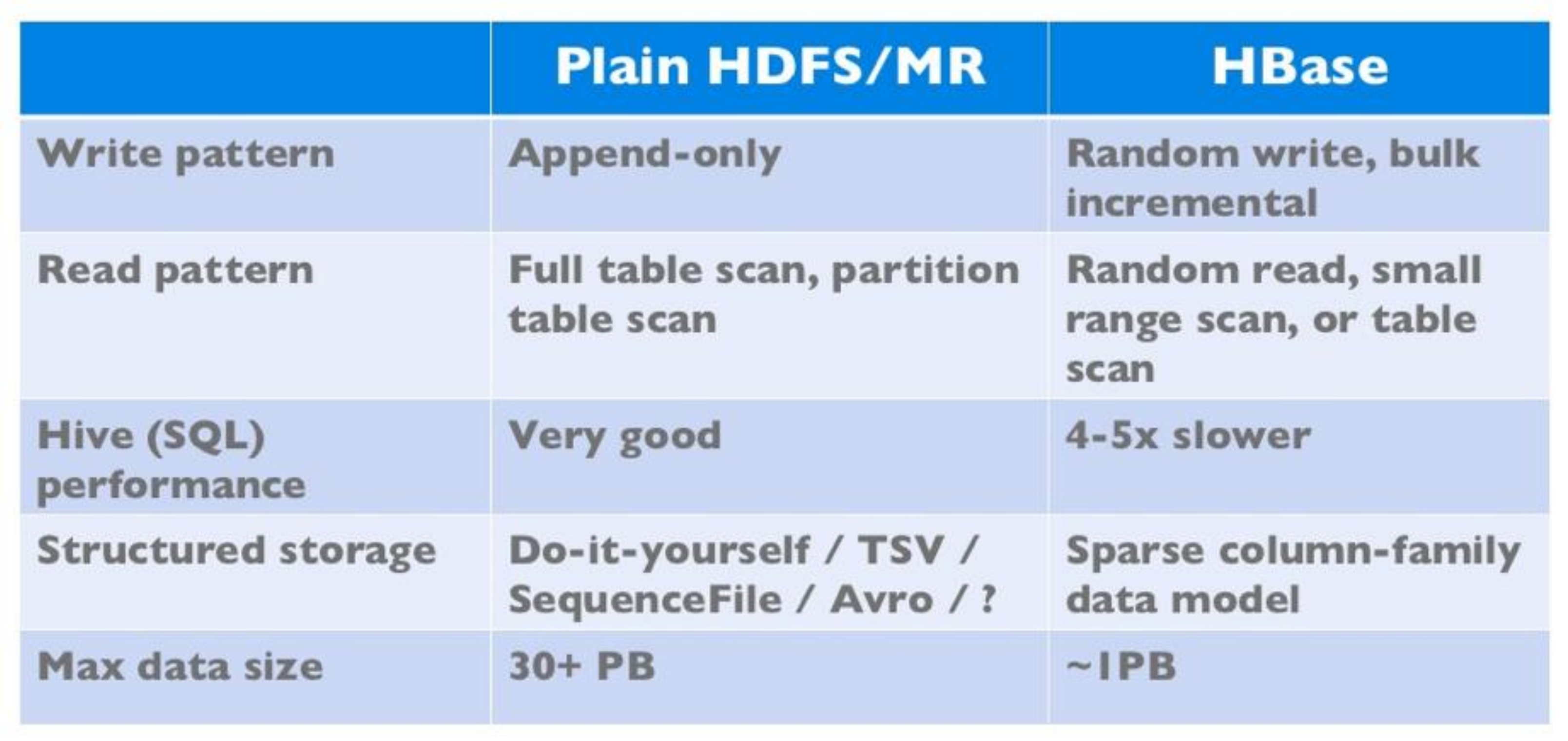


HBase files are internally stored in HDFS

HBase vs. HDFS

- Both are distributed systems that scale to hundreds or thousands of nodes
- HDFS is good for batch processing (scans over big files)
  - Not good for record lookup
  - Not good for incremental addition of small batches
  - Not good for updates
- HBase is designed to efficiently address the above points
  - Fast record lookup
  - Support for record-level insertion
  - Support for updates (not in place)
- HBase updates are done by creating new versions of values

HBase vs. HDFS



	Plain HDFS/MR	HBase
Write pattern	Append-only	Random write, bulk incremental
Read pattern	Full table scan, partition table scan	Random read, small range scan, or table scan
Hive (SQL) performance	Very good	4-5x slower
Structured storage	Do-it-yourself / TSV / SequenceFile / Avro / ?	Sparse column-family data model
Max data size	30+ PB	~1PB

If application has neither random reads or writes ➔ Stick to HDFS

HBase Characteristics

- Tables have one primary index, the *row key*.
- No join operators.
- Scans and queries can select a subset of available columns, perhaps by using a wildcard.
- There are three types of lookups:
  - Fast lookup using row key and optional timestamp.
  - Full table scan
  - Range scan from region start to end.
- Limited atomicity and transaction support.
  - HBase supports multiple batched mutations of single rows only.
  - Data is unstructured and untyped.
- No accessed or manipulated via SQL.
  - Programmatic access via Java, HBase shell, Thrift (Ruby, Python, Perl, C++, ..) etc.

Too Big, or Not Too Big

- Two types of data: two big, or not too big
- If data is not too big, a relational database should be used
  - The model is less likely to change as your business needs change. You may want to ask different questions over time, but if you got the logical model correct, you'll have the answers.
- The data is too big?
  - The relational model doesn't acknowledge scale.
  - You need to:
    - Add indexes
    - Write really complex, messy SQL
    - Denormalize
    - Cache
    - … …
  - How NoSQL/HBase can help?

HBase Data Model

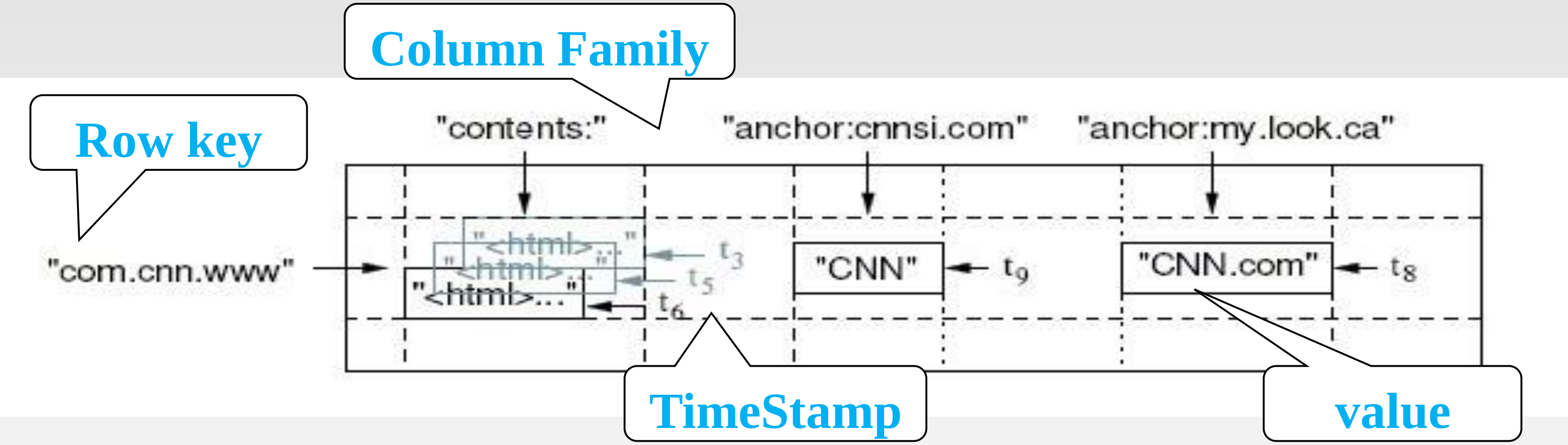
- Table: Design-time namespace, has multiple sorted rows.
- Row:
  - Atomic key/value container, with one row key
  - Rows are sorted alphabetically by the row key as they are stored
    - store data in such a way that related rows are near each other (e.g., a website domain)
- Column:
  - A column in HBase consists of a column family and a column qualifier, which are delimited by a : (colon) character.
- Table schema only define it’s Column Families
  - Column families physically co-locate a set of columns and their values
    - Column: a key in the k/v container inside a row
    - Value: a time-versioned value in the k/v container
  - Each column consists of any number of versions
  - Each column family has a set of storage properties, such as whether its values should be cached in memory etc.
  - Columns within a family are sorted and stored together

HBase Data Model (Cont')

- Column:
  - A column qualifier is added to a column family to provide the index for a given piece of data
  - Given a column family content, a column qualifier might be content:html, and another might be content:pdf
  - Column families are fixed at table creation, but column qualifiers are mutable and may differ greatly between rows.
- Timestamp: long milliseconds, sorted descending
  - A timestamp is written alongside each value, and is the identifier for a given version of a value.
  - By default, the timestamp represents the time on the RegionServer when the data was written, but you can specify a different timestamp value when you put data into the cell
- Cell:
  - A combination of row, column family, and column qualifier, and contains a value and a timestamp, which represents the value's version
- (Row, Family:<Column, Value>, Timestamp) → Value

HBase Data Model Examples

HBase is based on Google’s Bigtable model



Column Family

Row key

TimeStamp

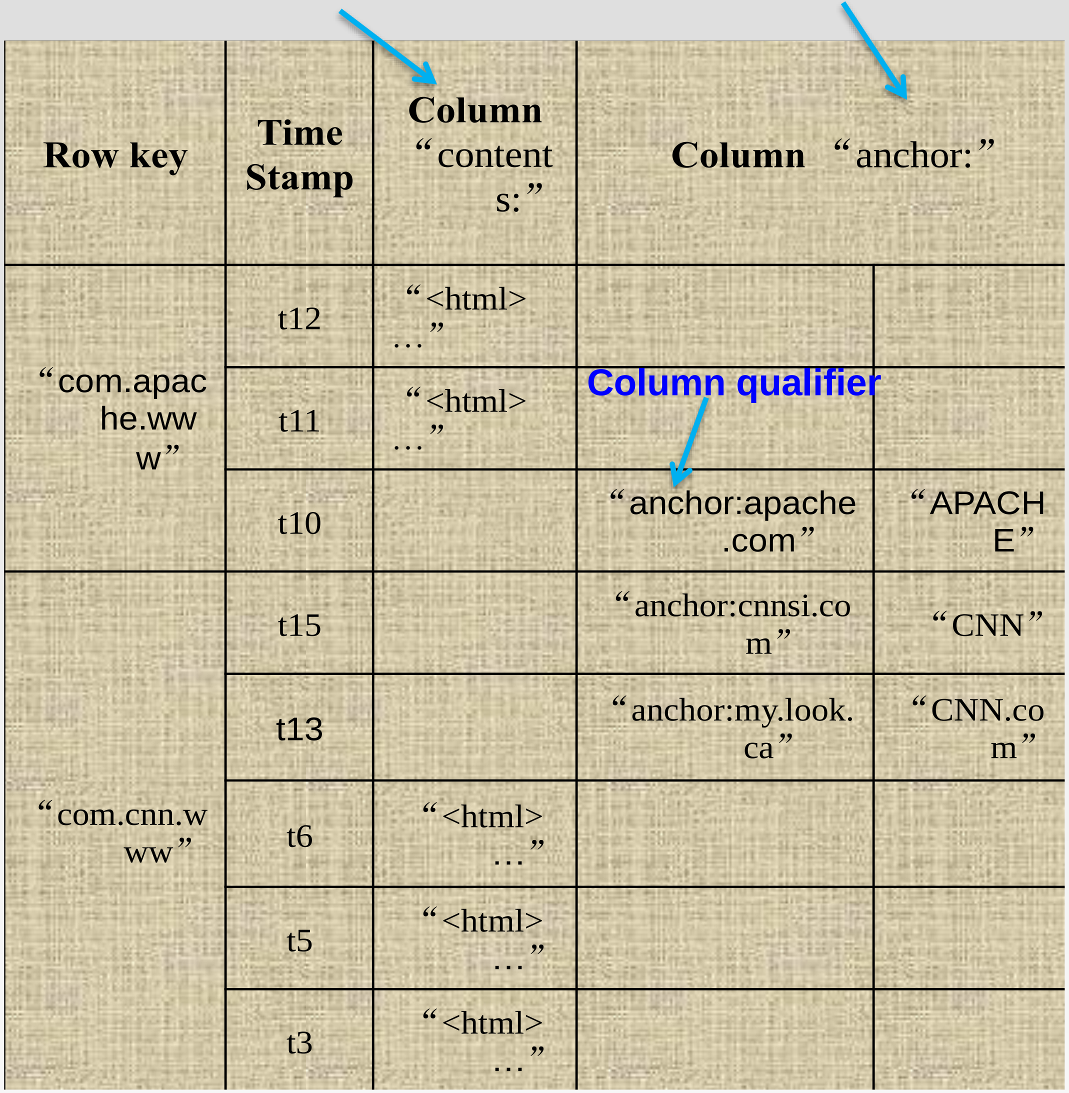
value

HBase Data Model Examples

- Key
  - Byte array
  - Serves as the primary key for the table
  - Indexed for fast lookup
- Column Family
  - Has a name (string)
  - Contains one or more related columns
- Column Qualifier
  - Belongs to one column family
  - Included inside the row
    - *familyName:columnName*

Column family named “Contents”

Column family named “anchor”



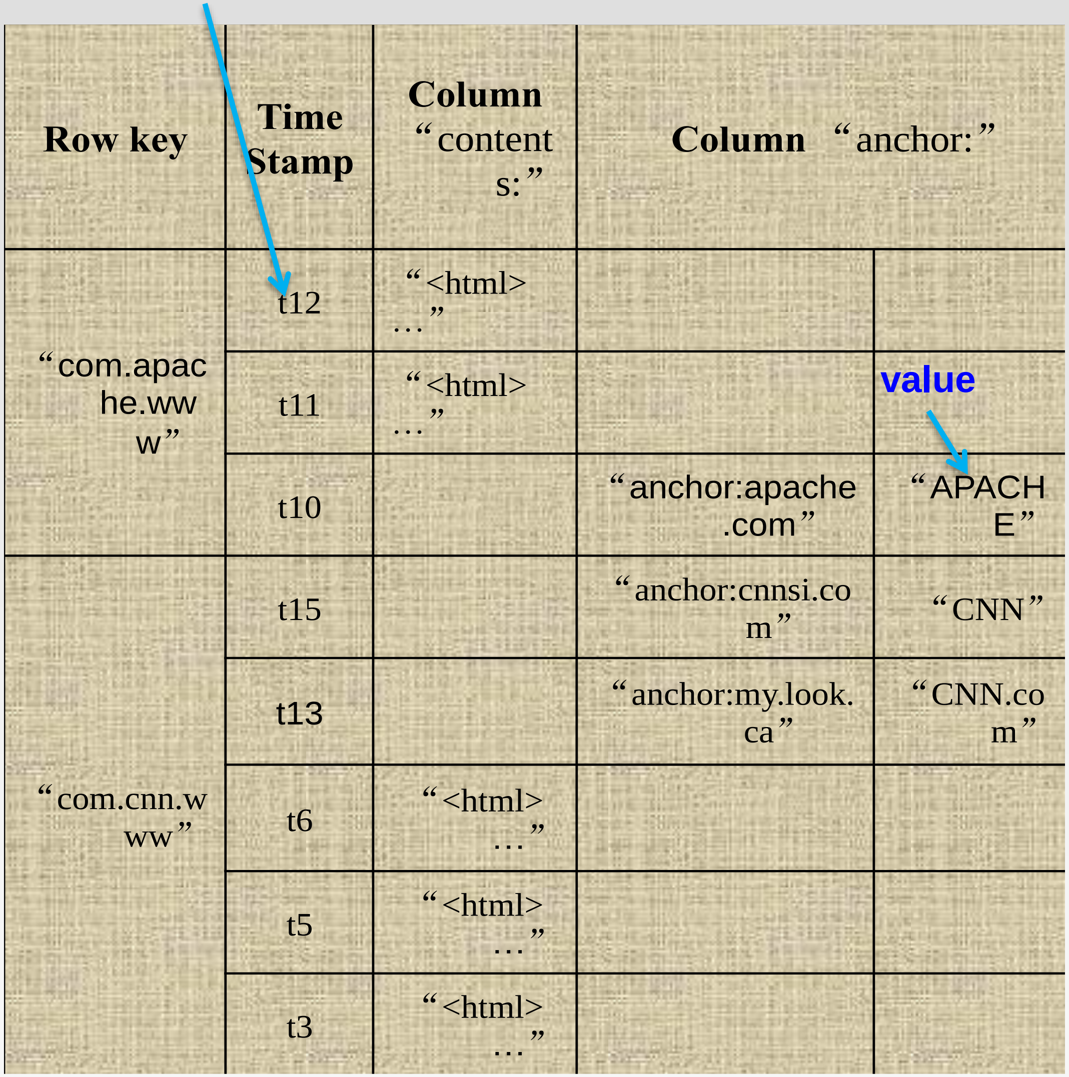
Row key	Time Stamp	Column “contents:”	Column “anchor:”	
“com.apache.www”	t12	“<html>…”		
	t11	“<html>…”		
	t10		“anchor:apache.com”	“APACHE”
“com.cnn.www”	t15		“anchor:cnnsi.com”	“CNN”
	t13		“anchor:my.look.ca”	“CNN.com”
	t6	“<html>…”		
	t5	“<html>…”		
	t3	“<html>…”		

Column qualifier

HBase Data Model Examples

- Version Number
  - Unique within each key
  - By default→ System’s timestamp
  - Data type is Long
- Value
  - Byte array

Version number for each row



Row key	Time Stamp	Column “contents:”	Column “anchor:”	
“com.apache.www”	t12	“<html>…”		
	t11	“<html>…”		
	t10		“anchor:apache.com”	“APACHE”
“com.cnn.www”	t15		“anchor:cnnsi.com”	“CNN”
	t13		“anchor:my.look.ca”	“CNN.com”
	t6	“<html>…”		
	t5	“<html>…”		
	t3	“<html>…”		

value

HBase Data Model Examples

Row	Timestamp	Column family: animal:		Column family: repairs:
		animal:type	animal:size	repairs:cost
enclosure1	t2	zebra		1000 EUR
	t1	lion	big	
enclosure2	…	…	…	…

- Storage: every "cell" (i.e. the time-versioned value of one column in one row) is stored "fully qualified" (with its full rowkey, column family, column name, etc.) on disk

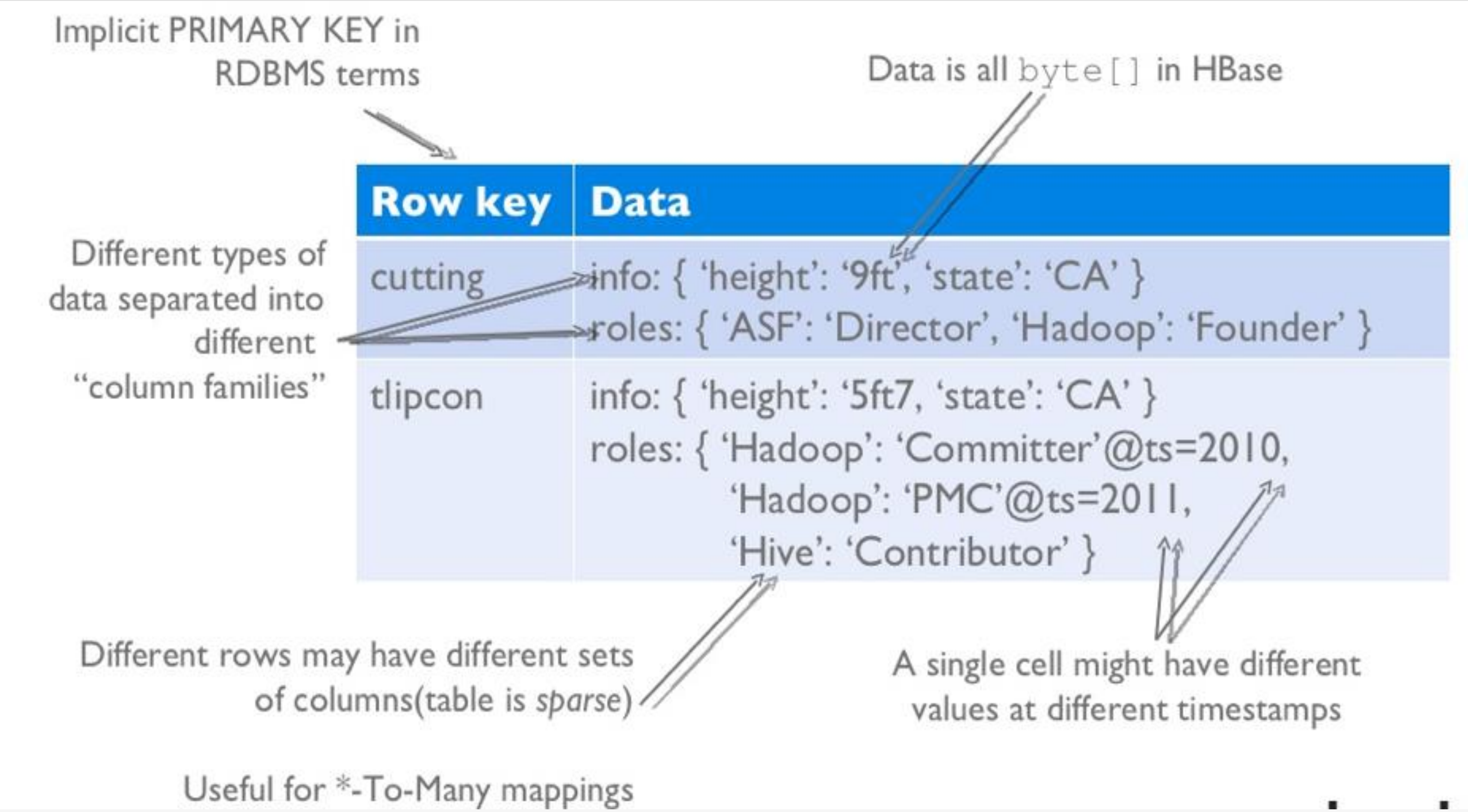
Column family animal:

(enclosure1, t2, animal:type)	zebra
(enclosure1, t1, animal:size)	big
(enclosure1, t1, animal:type)	lion

Column family repairs:

(enclosure1, t1, repairs:cost)	1000 EUR

HBase Data Model Examples



Implicit PRIMARY KEY in RDBMS terms

Data is all `byte[]` in HBase

Row key	Data

cutting	info: { 'height': '9ft', 'state': 'CA' }
	roles: { 'ASF': 'Director', 'Hadoop': 'Founder' }

tlipcon	info: { 'height': '5ft7, 'state': 'CA' }
	roles: { 'Hadoop': 'Committer'@ts=2010,
	'Hadoop': 'PMC'@ts=2011,
	'Hive': 'Contributor' }

Different types of data separated into different "column families"

Different rows may have different sets of columns(table is *sparse*)

A single cell might have different values at different timestamps

Useful for *-To-Many mappings

HBase Data Model

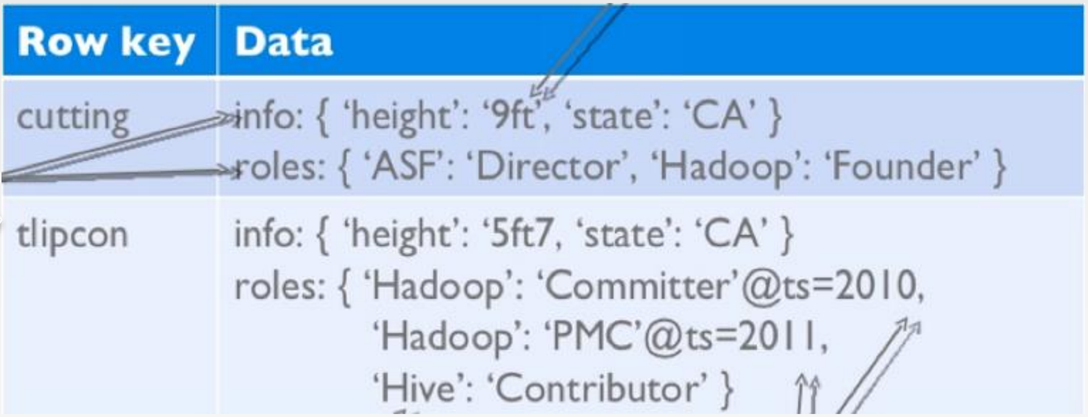
- Row:
  - The "row" is atomic, and gets flushed to disk periodically. But it doesn't have to be flushed into just a single file!
  - It can be broken up into different files with different properties, an reads can look at just a subset.
- Column Family: divide columns into physical files
  - Columns within the same family are stored together
  - Why? Table is sparse, many columns
    - No need to scan the whole row when accessing a few columns
    - Each column a file will generate too many files

- Row keys, column names, values: arbitrary bytes
- Table and column family names: printable characters
- Timestamps: long integers

Notes on Data Model

- HBase schema consists of several ***Tables***
- Each table consists of a set of ***Column Families***
  - Columns are not part of the schema
- HBase has ***Dynamic Columns***
  - Because column names are encoded inside the cells
  - Different cells can have different columns

“Roles” column family has different columns in different cells



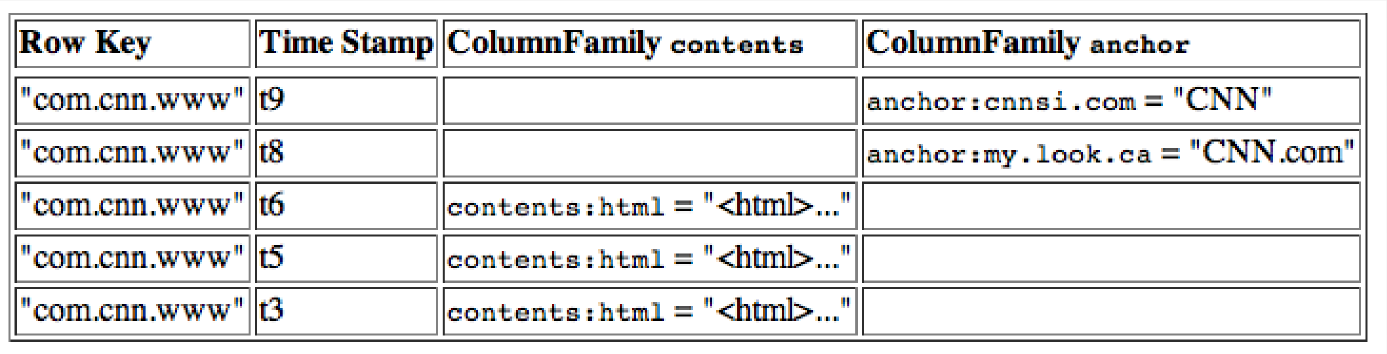
Row key	Data

cutting	info: { ‘height’: ‘9ft’, ‘state’: ‘CA’ }
	roles: { ‘ASF’: ‘Director’, ‘Hadoop’: ‘Founder’ }

tlipcon	info: { ‘height’: ‘5ft7, ‘state’: ‘CA’ }
	roles: { ‘Hadoop’: ‘Committer’@ts=2010,
	‘Hadoop’: ‘PMC’@ts=2011,
	‘Hive’: ‘Contributor’ }

Notes on Data Model (Cont'd)

- The ***version number*** can be user-supplied
  - Even does not have to be inserted in increasing order
  - Version number are unique within each key
- Table can be very sparse
  - Many cells are empty
- ***Keys*** are indexed as the primary key

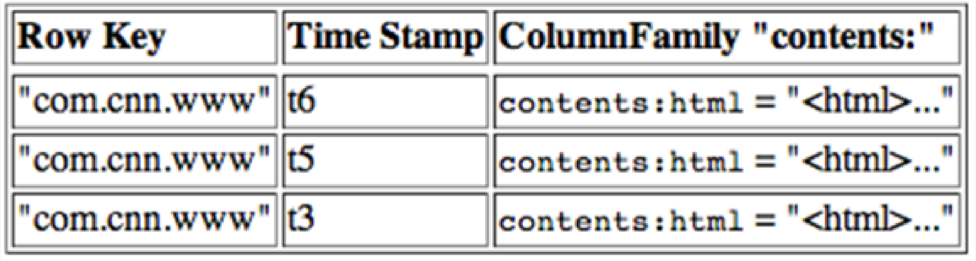


Row Key	Time Stamp	ColumnFamily `contents`	ColumnFamily `anchor`
"com.cnn.www"	t9		`anchor:cnnsi.com` = "CNN"
"com.cnn.www"	t8		`anchor:my.look.ca` = "CNN.com"
"com.cnn.www"	t6	`contents:html` = "<html>..."	
"com.cnn.www"	t5	`contents:html` = "<html>..."	
"com.cnn.www"	t3	`contents:html` = "<html>..."	

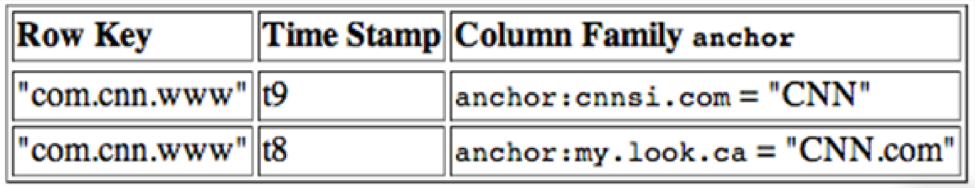
A conceptual view of HBase table

HBase Physical View

- Each column family is stored in a separate file (called ***HTables***)
- Key & Version numbers are replicated with each column family
- Empty cells are not stored

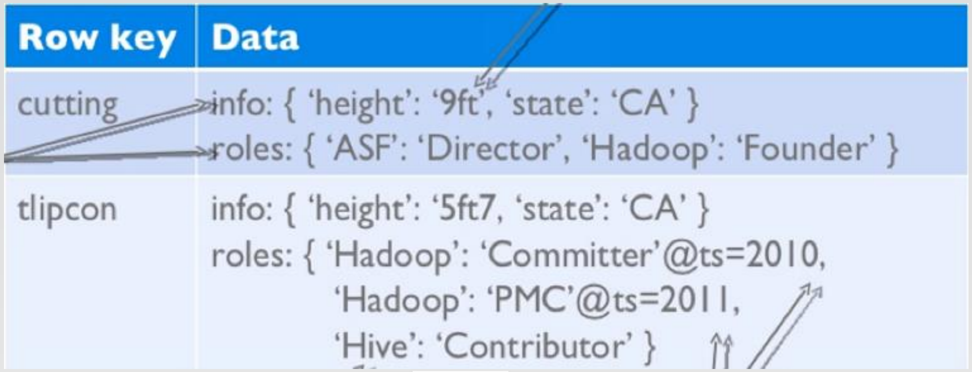


Row Key	Time Stamp	ColumnFamily "contents:"
"com.cnn.www"	t6	contents:html = "<html>..."
"com.cnn.www"	t5	contents:html = "<html>..."
"com.cnn.www"	t3	contents:html = "<html>..."



Row Key	Time Stamp	Column Family anchor
"com.cnn.www"	t9	anchor:cnnsi.com = "CNN"
"com.cnn.www"	t8	anchor:my.look.ca = "CNN.com"

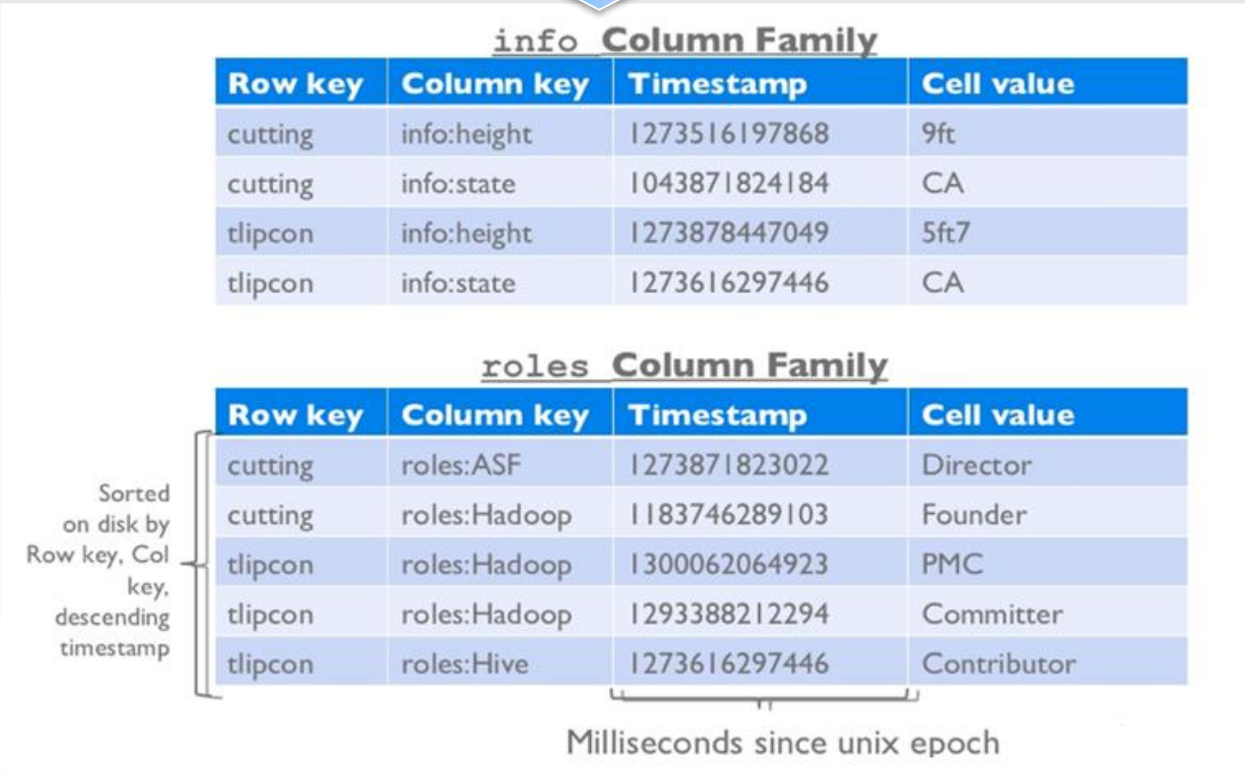
HBase Physical Model



Row key	Data

cutting	info: { 'height': '9ft', 'state': 'CA' }
	roles: { 'ASF': 'Director', 'Hadoop': 'Founder' }

tlipcon	info: { 'height': '5ft7, 'state': 'CA' }
	roles: { 'Hadoop': 'Committer'@ts=2010,
	'Hadoop': 'PMC'@ts=2011,
	'Hive': 'Contributor' }



info Column Family

Row key	Column key	Timestamp	Cell value
cutting	info:height	1273516197868	9ft
cutting	info:state	1043871824184	CA
tlipcon	info:height	1273878447049	5ft7
tlipcon	info:state	1273616297446	CA

roles Column Family

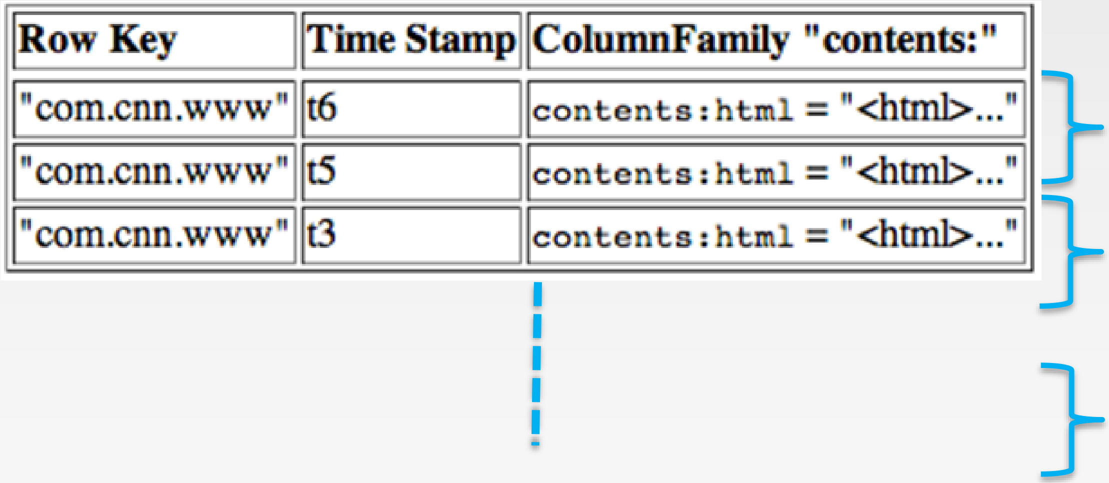
Row key	Column key	Timestamp	Cell value
cutting	roles:ASF	1273871823022	Director
cutting	roles:Hadoop	1183746289103	Founder
tlipcon	roles:Hadoop	1300062064923	PMC
tlipcon	roles:Hadoop	1293388212294	Committer
tlipcon	roles:Hive	1273616297446	Contributor

Sorted on disk by Row key, Col key, descending timestamp

Milliseconds since unix epoch

HBase Physical Model

- Column Families stored separately on disk: access one without wasting I/O on the other
- HBase Regions
  - Each HTable (column family) is partitioned horizontally into ***regions***
    - Regions are counterpart to HDFS blocks



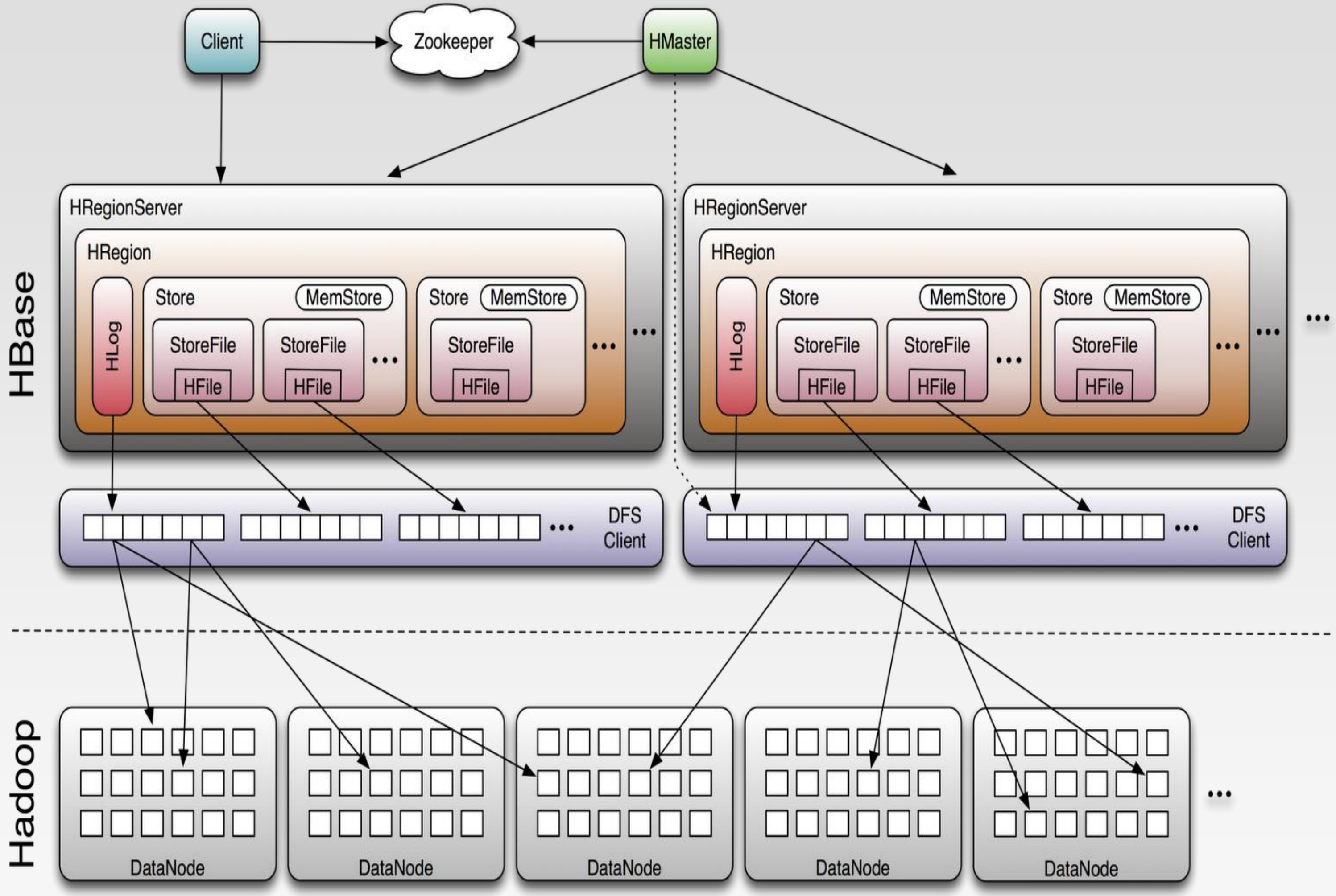
Row Key	Time Stamp	ColumnFamily "contents:"
"com.cnn.www"	t6	contents:html = "<html>..."
"com.cnn.www"	t5	contents:html = "<html>..."
"com.cnn.www"	t3	contents:html = "<html>..."

Each will be one region

HBase Architecture

- Major Components
  - The MasterServer (HMaster)
    - One master server
    - Responsible for coordinating the slaves
    - Assigns regions, detects failures
    - Admin functions
  - The RegionServer (HRegionServer)
    - Many region servers
    - Region (HRegion)
      - A subset of a table’s rows, like horizontal range partitioning
      - Automatically done
    - Manages data regions
    - Serves data for reads and writes (using a log)
  - The HBase client

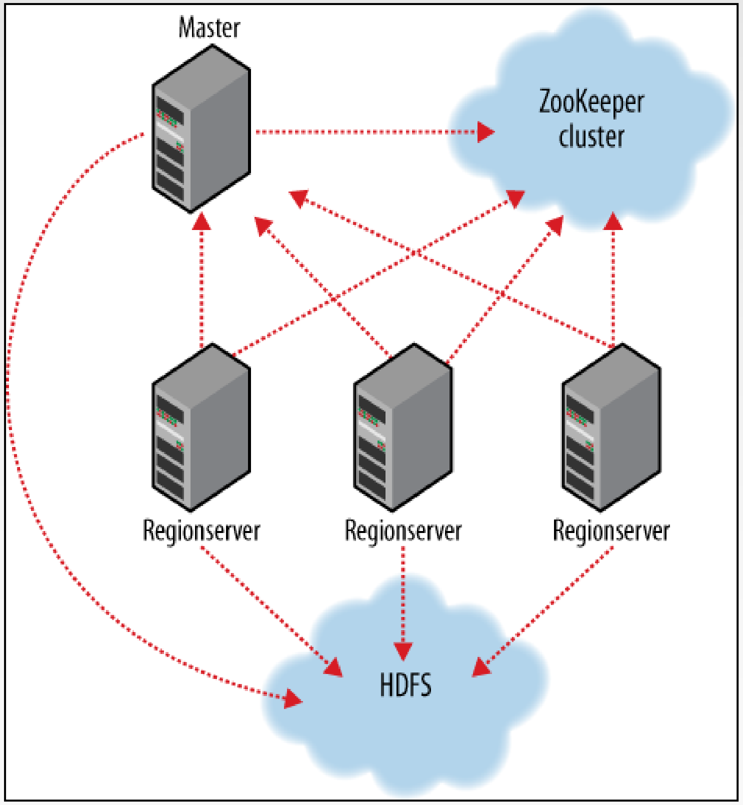
HBase Architecture



ZooKeeper

- HBase clusters can be huge and coordinating the operations of the MasterServers, RegionServers, and clients can be a daunting task, but that’s where **Zookeeper** enters the picture.
- Zookeeper is a distributed cluster of servers that collectively provides reliable coordination and synchronization services for clustered applications.

- HBase depends on ZooKeeper
- By default HBase manages the ZooKeeper instance
  - E.g., starts and stops ZooKeeper
- HMaster and HRegionServers register themselves with ZooKeeper



Install HBase

- Install Java and Hadoop first
- Download at: https://hbase.apache.org/
- The current stable version： 2.4.15
- Install:

```
$ tar xzf hbase- 2.4.15.tar.gz
$ mv hbase- 2.4.15 ~/hbase
```

- Environment variables in ~/.bashrc

```
export HBASE_HOME = ~/hbase
export PATH = $HBASE_HOME/bin:$PATH
```

- Edit hbase-env.sh: $ vim $HBASE_HOME/conf/hbase-env.sh

```
export JAVA_HOME = /usr/lib/jvm/…
export HBASE_MANAGES_ZK = true
```

  - hbase maintains its own ZooKeeper

Configure HBase as Pseudo-Distributed Mode

- Configure hbase-site.xml: $ vim $HBASE_HOME/conf/hbase-site.xml

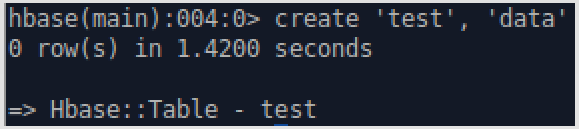
```
<configuration>
                <property>
                                <name>hbase.rootdir</name>
                                <value>hdfs://localhost:9000/hbase</value>
                </property>
                <property>
                                <name>hbase.cluster.distributed</name>
                                <value>true</value>
                </property>
</configuration>
```

  - hbase.rootdir： must be consistent with HDFS configuration
  - hbase.cluster.distributed: directs HBase to run in distributed mode, with one JVM instance per daemon
  - More configurations refer to: https://hbase.apache.org/book.html#config.files

- Start HBase: $ start-hbase.sh
- Launch the HBase Shell: $ hbase shell

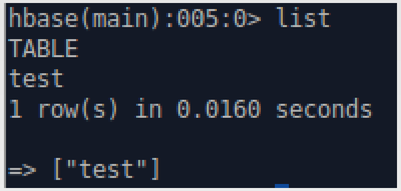
HBase Shell Commands

- Create a table



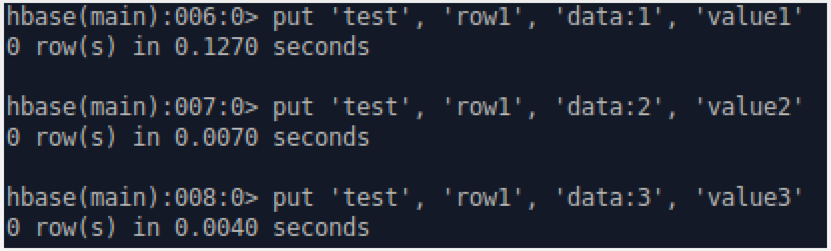
```
hbase(main):004:0> create 'test', 'data'
0 row(s) in 1.4200 seconds

=> Hbase::Table - test
```

- List Information About your Table



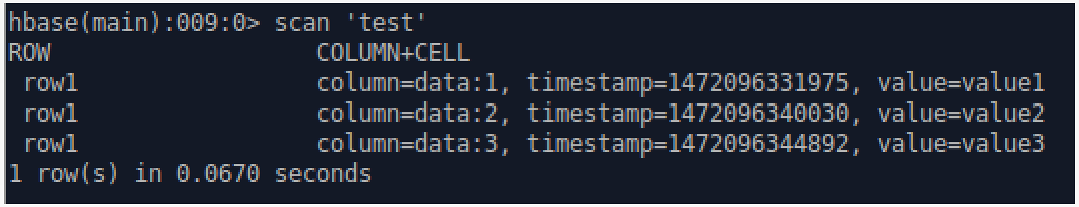
```
hbase(main):005:0> list
TABLE
test
1 row(s) in 0.0160 seconds

=> ["test"]
```

- Put data into your table



```
hbase(main):006:0> put 'test', 'row1', 'data:1', 'value1'
0 row(s) in 0.1270 seconds

hbase(main):007:0> put 'test', 'row1', 'data:2', 'value2'
0 row(s) in 0.0070 seconds

hbase(main):008:0> put 'test', 'row1', 'data:3', 'value3'
0 row(s) in 0.0040 seconds
```

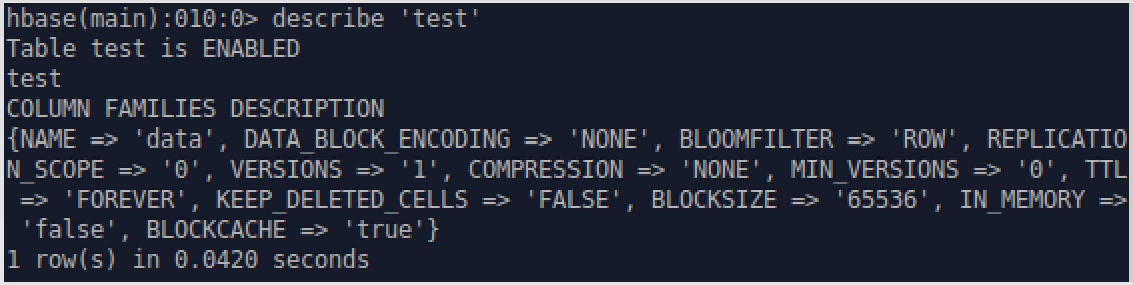
- Scan the table for all data at once



```
hbase(main):009:0> scan 'test'
ROW                   COLUMN+CELL
 row1                 column=data:1, timestamp=1472096331975, value=value1
 row1                 column=data:2, timestamp=1472096340030, value=value2
 row1                 column=data:3, timestamp=1472096344892, value=value3
1 row(s) in 0.0670 seconds
```

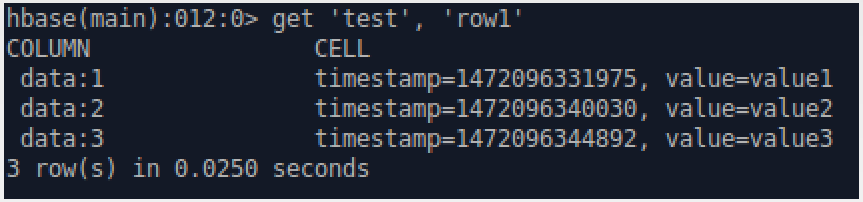
HBase Shell Commands

- Describe a table



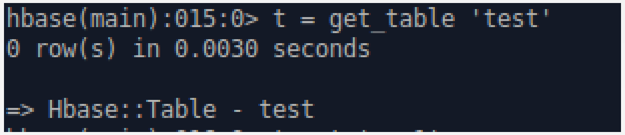
```
hbase(main):010:0> describe 'test'
Table test is ENABLED
test
COLUMN FAMILIES DESCRIPTION
{NAME => 'data', DATA_BLOCK_ENCODING => 'NONE', BLOOMFILTER => 'ROW', REPLICATIO
N_SCOPE => '0', VERSIONS => '1', COMPRESSION => 'NONE', MIN_VERSIONS => '0', TTL
 => 'FOREVER', KEEP_DELETED_CELLS => 'FALSE', BLOCKSIZE => '65536', IN_MEMORY =>
 'false', BLOCKCACHE => 'true'}
1 row(s) in 0.0420 seconds
```

- Get a single row of data

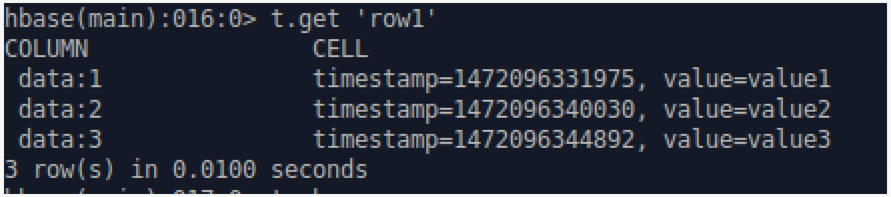


```
hbase(main):012:0> get 'test', 'row1'
COLUMN                     CELL
 data:1                    timestamp=1472096331975, value=value1
 data:2                    timestamp=1472096340030, value=value2
 data:3                    timestamp=1472096344892, value=value3
3 row(s) in 0.0250 seconds
```

- Assign a defined table to a variable; use the variable for operation



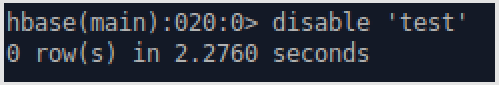
```
hbase(main):015:0> t = get_table 'test'
0 row(s) in 0.0030 seconds

=> Hbase::Table - test
```



```
hbase(main):016:0> t.get 'row1'
COLUMN                     CELL
 data:1                    timestamp=1472096331975, value=value1
 data:2                    timestamp=1472096340030, value=value2
 data:3                    timestamp=1472096344892, value=value3
3 row(s) in 0.0100 seconds
```

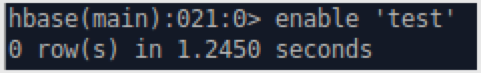
HBase Shell Commands

- Disable a table
  - If you want to delete a table or change its settings, as well as in some other situations, you need to disable the table first



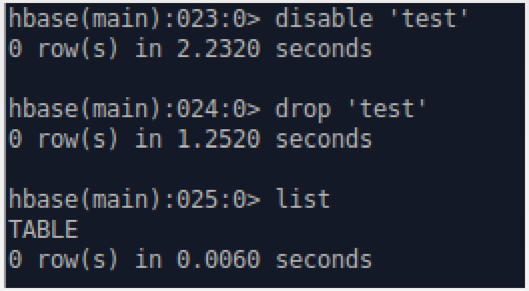
```
hbase(main):020:0> disable 'test'
0 row(s) in 2.2760 seconds
```

  - You can re-enable it using the enable command.



```
hbase(main):021:0> enable 'test'
0 row(s) in 1.2450 seconds
```

- Drop (delete) the table



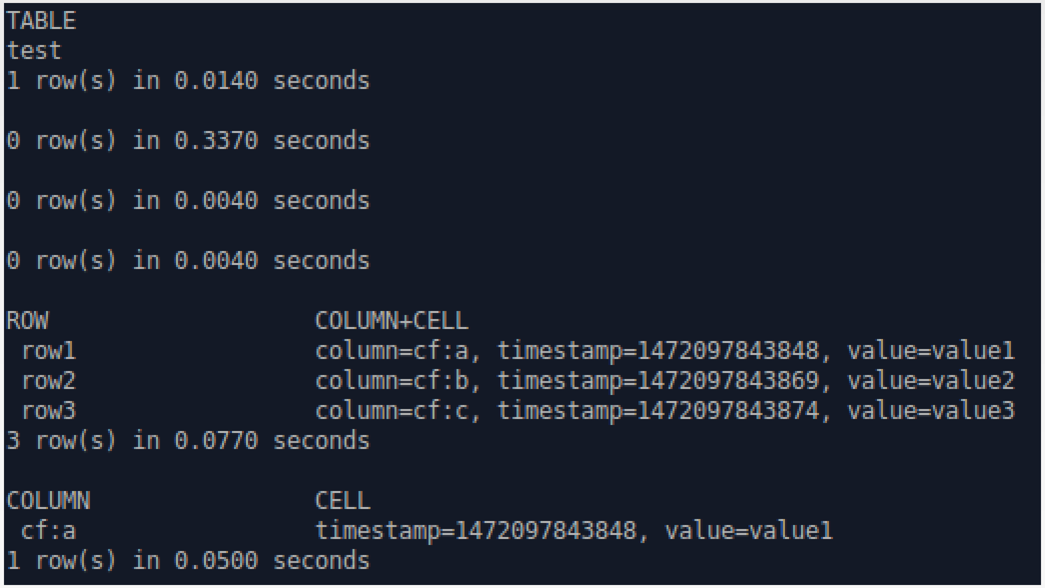
```
hbase(main):023:0> disable 'test'
0 row(s) in 2.2320 seconds

hbase(main):024:0> drop 'test'
0 row(s) in 1.2520 seconds

hbase(main):025:0> list
TABLE
0 row(s) in 0.0060 seconds
```

- Exit the HBase Shell
  - To exit the HBase Shell and disconnect from your cluster, use the quit command. HBase is still running in the background.

HBase Shell Commands

- You can also enter HBase Shell commands into a text file, one command per line, and pass that file to the HBase Shell.

```
create 'test', 'cf'
list 'test'
put 'test', 'row1', 'cf:a', 'value1'
put 'test', 'row2', 'cf:b', 'value2'
put 'test', 'row3', 'cf:c', 'value3'
scan 'test'
get 'test', 'row1'
```

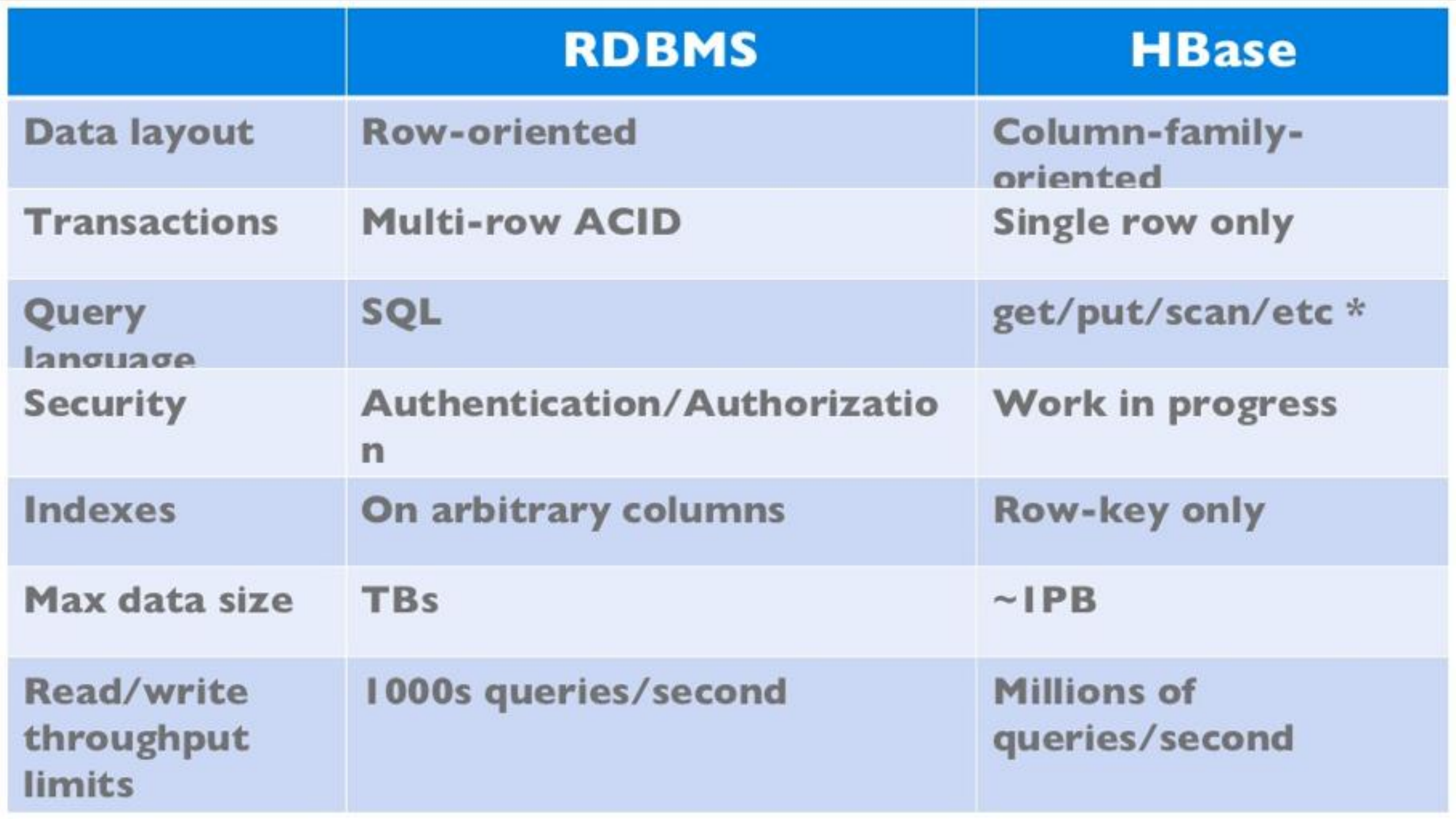


```
TABLE
test
1 row(s) in 0.0140 seconds

0 row(s) in 0.3370 seconds

0 row(s) in 0.0040 seconds

0 row(s) in 0.0040 seconds

ROW                   COLUMN+CELL
 row1                 column=cf:a, timestamp=1472097843848, value=value1
 row2                 column=cf:b, timestamp=1472097843869, value=value2
 row3                 column=cf:c, timestamp=1472097843874, value=value3
3 row(s) in 0.0770 seconds

COLUMN                CELL
 cf:a                 timestamp=1472097843848, value=value1
1 row(s) in 0.0500 seconds
```

HBase benefits than RDBMS

- *No real indexes*
- *Automatic partitioning*
- *Scale linearly and automatically with new nodes*
- *Commodity hardware*
- *Fault tolerance*
- *Batch processing*

HBase vs. RDBMS



	RDBMS	HBase
Data layout	Row-oriented	Column-family-oriented
Transactions	Multi-row ACID	Single row only
Query language	SQL	get/put/scan/etc *
Security	Authentication/Authorization	Work in progress
Indexes	On arbitrary columns	Row-key only
Max data size	TBs	~1PB
Read/write throughput limits	1000s queries/second	Millions of queries/second

When to use HBase

- You need random write, random read, or both (but not neither, otherwise stick to HDFS)

- You need to do many thousands of operations per second on multiple TB of data

- Your acces patterns are well-known and simple

References

- https://hbase.apache.org/book.html
- Hadoop The Definitive Guide. HBase Chapter
- http://www.cs.kent.edu/~jin/Cloud12Spring/HbaseHivePig.pptx

End of Chapter 8.1