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CSE6242/CX4242: Data & Visual Analytics

Scaling Up

HBase

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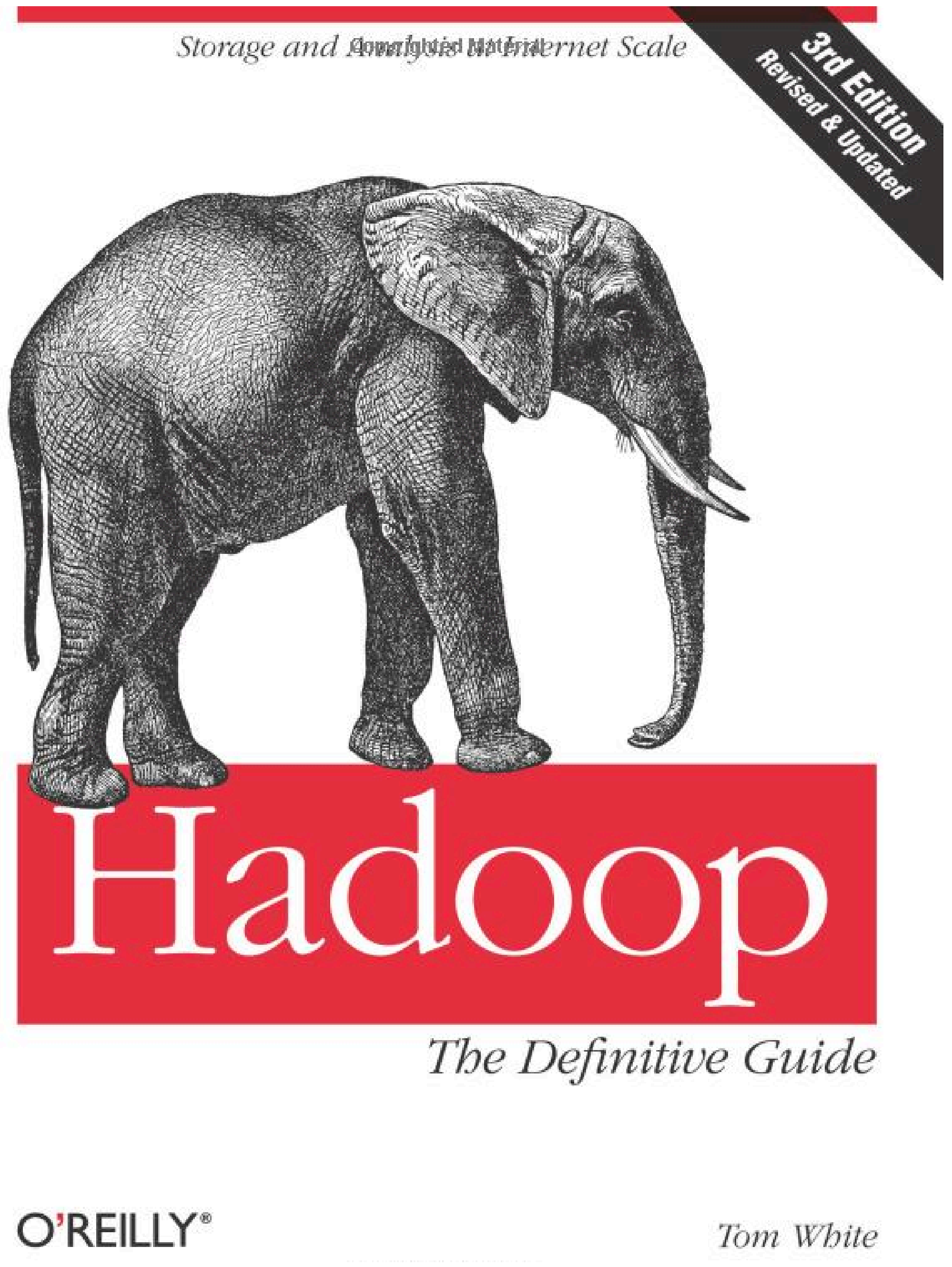
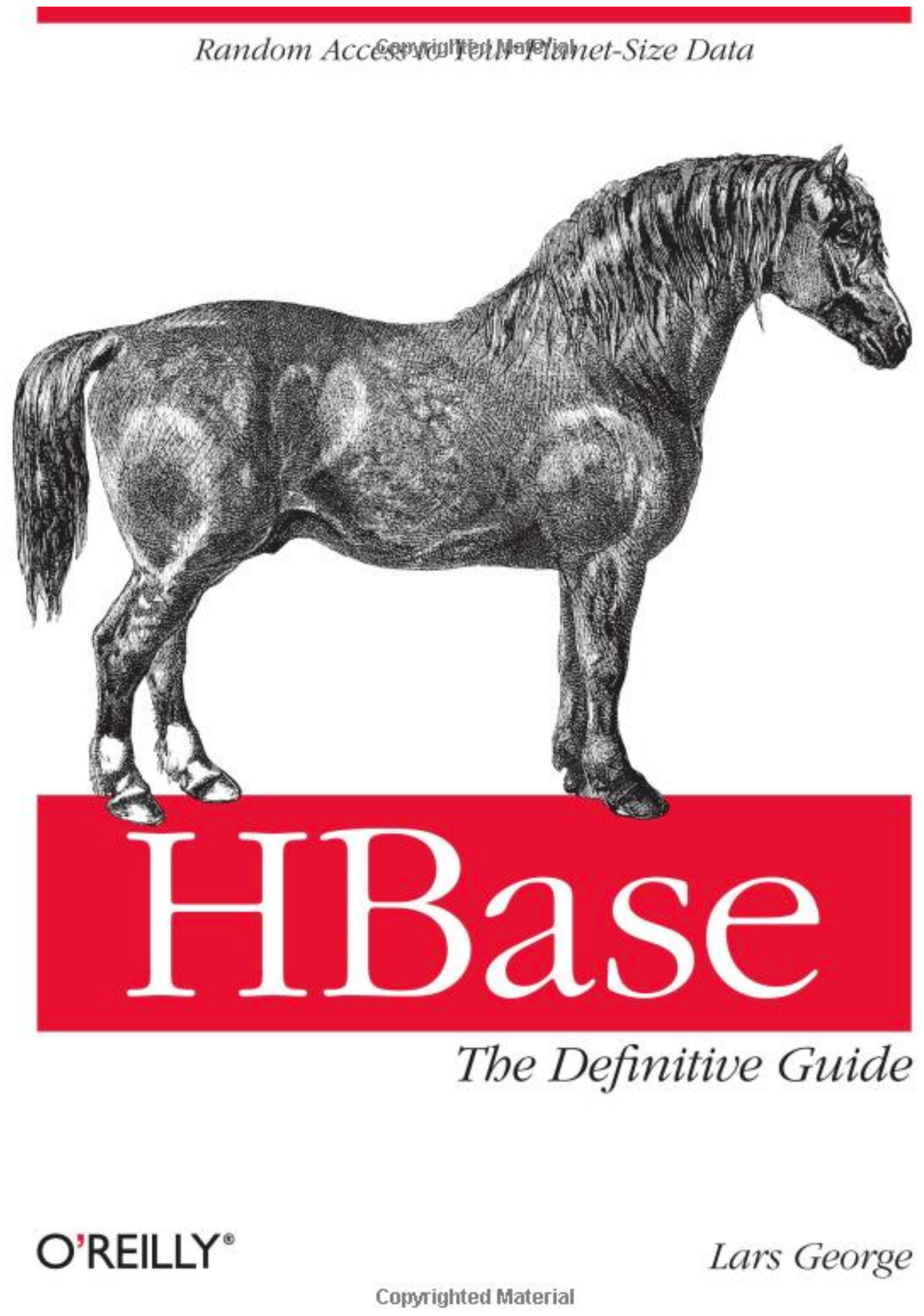
Slides adopted from Matei Zaharia (Stanford) and Oliver Vagner (NCR)

What if you need **real-time** read/write for large datasets?

Lecture based on these two books.





APACHE HBASE http://hbase.apache.org

Built on top of HDFS

Supports real-time read/write random access

Scale to very large datasets, many machines

Not relational, does NOT support SQL
("NoSQL" = "not only SQL") http://en.wikipedia.org/wiki/NoSQL

Supports billions of rows, millions of columns
(e.g., serving Facebook's Messaging Platform)

Written in Java; works with other APIs/languages
(REST, Thrift, Scala)

Where does HBase come from?

http://radar.oreilly.com/2014/04/5-fun-facts-about-hbase-that-you-didnt-know.html
http://wiki.apache.org/hadoop/Hbase/PoweredBy

HBase's "history"

Designed for batch processing

Hadoop & **HDFS** based on...

- 2003 *Google File System* (GFS) paper
  http://cracking8hacking.com/cracking-hacking/Ebooks/Misc/pdf/The%20Google%20filesystem.pdf
- 2004 Google *MapReduce* paper
  http://static.googleusercontent.com/media/research.google.com/en/us/archive/mapreduce-osdi04.pdf

HBase based on ...

- 2006 Google *Bigtable* paper

  http://static.googleusercontent.com/media/research.google.com/en/us/archive/bigtable-osdi06.pdf

Designed for random access

How does HBase work?

Column-oriented

Column is a basic unit (instead of row)

- Multiple columns form a row
- A column can have **multiple versions**, each version stored in a cell

Rows form a table

- **Row key** locates a row
- Rows **sorted** by row key lexicographically (~= alphabetically)

Row key is unique

Think of row key as the “index” of an HBase table

- **You look up a row using its row key**

Only one “index” per table (via row key)

HBase does not have built-in support for multiple indices; support enabled via extensions

Rows sorted lexicographically

(=alphabetically)

```
hbase(main):001:0> scan 'table1'
ROW     COLUMN+CELL
row-1   column=cf1:, timestamp=1297073325971 ...
row-10  column=cf1:, timestamp=1297073337383 ...
row-11  column=cf1:, timestamp=1297073340493 ...
row-2   column=cf1:, timestamp=1297073329851 ...
row-22  column=cf1:, timestamp=1297073344482 ...
row-3   column=cf1:, timestamp=1297073333504 ...
row-abc column=cf1:, timestamp=1297073349875 ...
7 row(s) in 0.1100 seconds
```

"**row-10**" comes before "**row-2**".
How to fix?

Rows sorted lexicographically
(=alphabetically)

```
hbase(main):001:0> scan 'table1'
ROW       COLUMN+CELL
row-1     column=cf1:, timestamp=1297073325971 ...
row-10    column=cf1:, timestamp=1297073337383 ...
row-11    column=cf1:, timestamp=1297073340493 ...
row-2     column=cf1:, timestamp=1297073329851 ...
row-22    column=cf1:, timestamp=1297073344482 ...
row-3     column=cf1:, timestamp=1297073333504 ...
row-abc   column=cf1:, timestamp=1297073349875 ...
7 row(s) in 0.1100 seconds
```

“**row-10**” comes before “**row-2**”.
How to fix?

Pad “row-2” with a “0”.
i.e., “row-02”

Columns grouped into **column families**

- Why?
  - Helps with organization, understanding, optimization, etc.
- In details...
  - Columns in the same family stored in same *file* called *HFile*
  - Apply compression on the whole family
  - inspired by Google's **SSTable**
  - ...

More on **column family, column**

Column family

- An HBase table supports only **few** families (e.g., <10)
  - Due to limitations in implementation
- Family name must be **printable**
- Should be defined when table is created
  - Should not be changed often

Each **column** referenced as “**family**:**qualifier**”

- Can have **millions** of columns
- Values can be **anything** that’s **arbitrarily long**

Cell Value

Timestamped

- Implicitly by system
- Or set explicitly by user

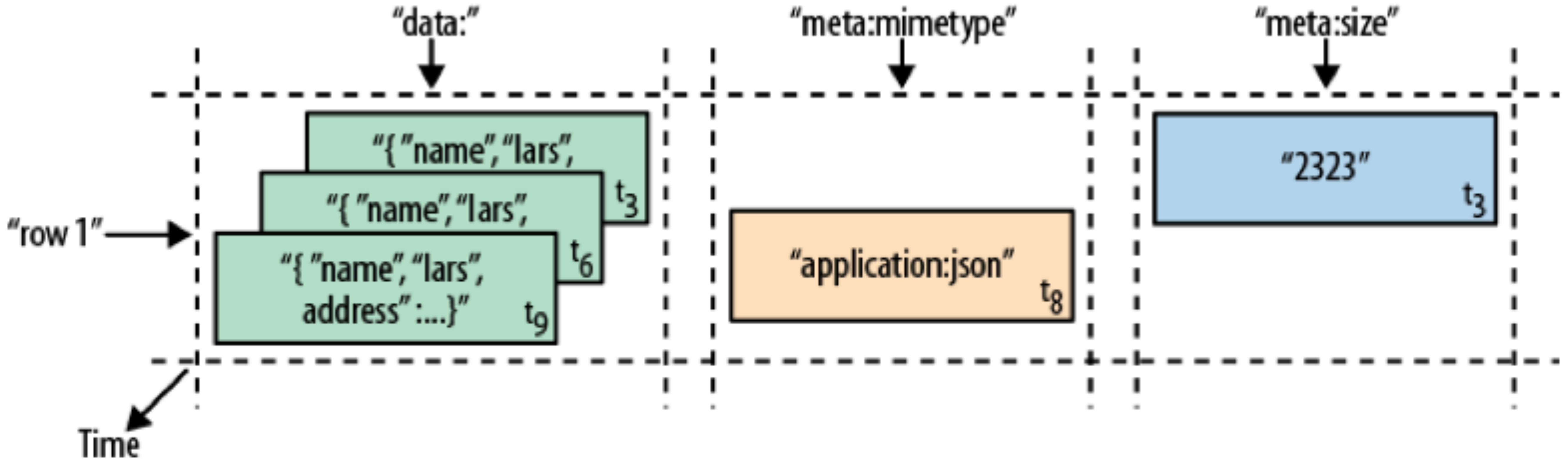
Let you store **multiple versions** of a value

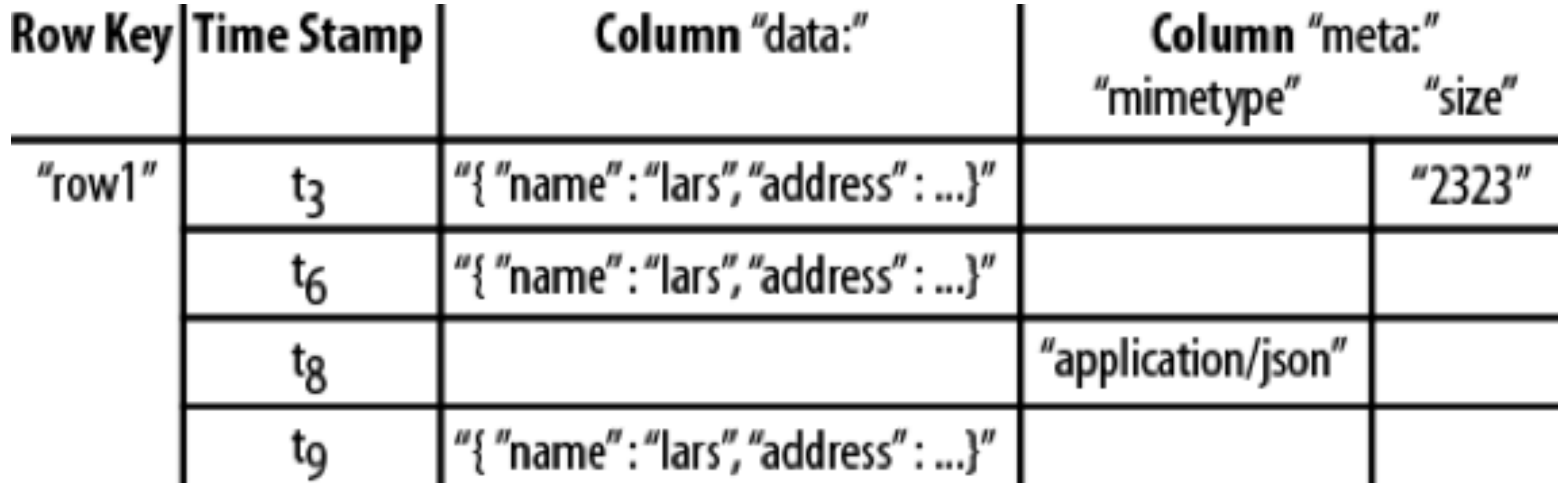
- = values over time

Values stored in **decreasing** time order

- **Most recent value** can be read first

Time-oriented view of a row





Row Key	Time Stamp	Column "data:"	Column "meta:" "mimetype"	"size"
"row1"	t_3	"{ "name" : "lars", "address" : ...}"		"2323"
	t_6	"{ "name" : "lars", "address" : ...}"		
	t_8		"application/json"	
	t_9	"{ "name" : "lars", "address" : ...}"		

Concise way to describe all these?

HBase data model (= Bigtable's model)

- Sparse, distributed, persistent, **multidimensional map**
- Indexed by row key + column key + timestamp

```
(Table, RowKey, Family, Column, Timestamp) → Value
```

$$(\texttt{Table},\ \underline{\texttt{RowKey}},\ \underline{\texttt{Family, Column}},\ \underline{\texttt{Timestamp}}) \rightarrow \texttt{Value}$$

An exercise

How would you use HBase to create a *webtable* store **snapshots** of every **webpage** on the planet, **over time**?

Details: How does HBase **scale up storage** & **balance load**?

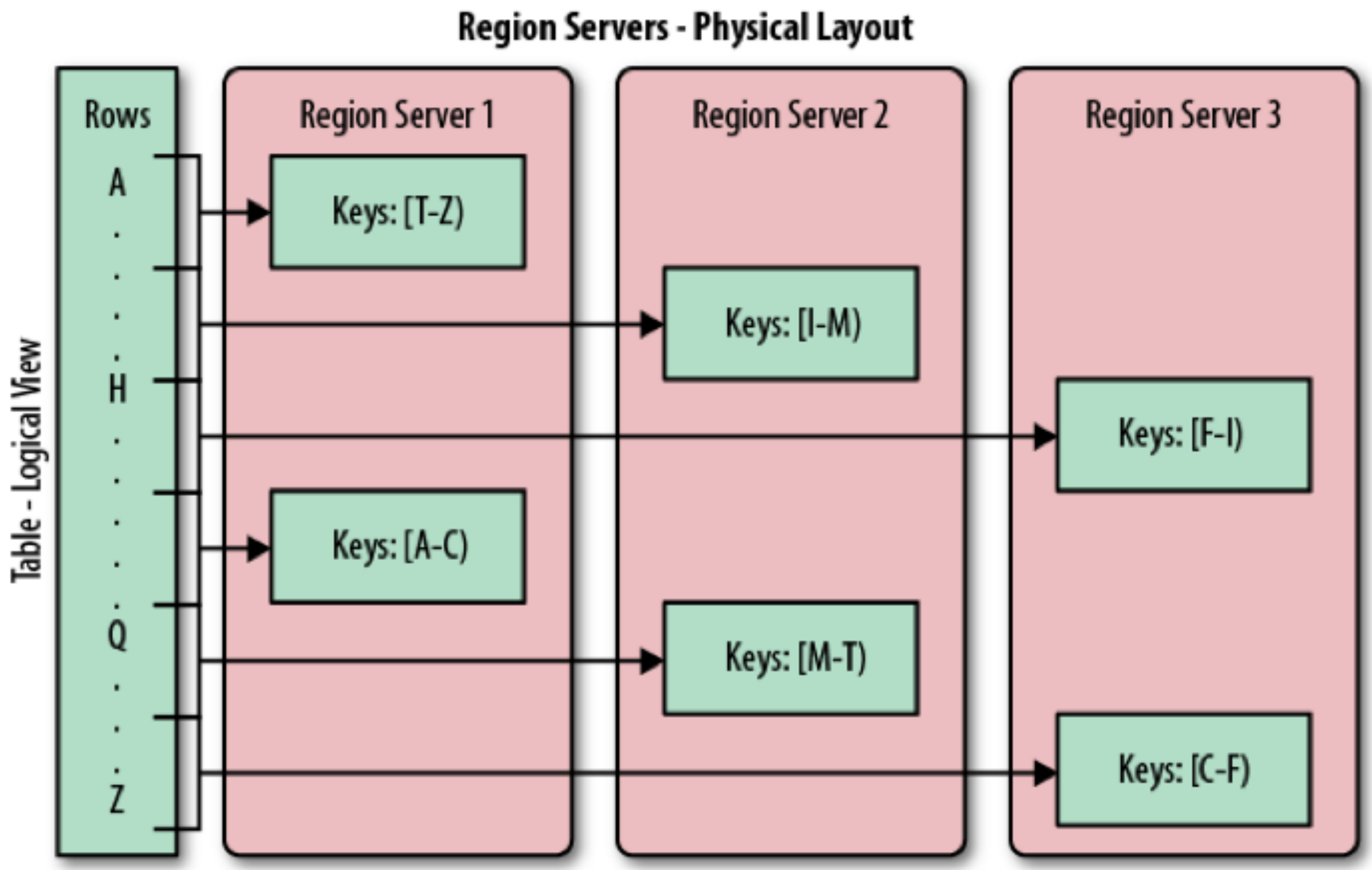
Automatically **divide contiguous ranges of rows** into **regions**

Start with one region, split into two when getting too large, and so on.

Details: How does HBase **scale up storage** & **balance load**?

Excellent Summary:

http://blog.cloudera.com/blog/2013/04/how-scaling-really-works-in-apache-hbase/



How to use HBase

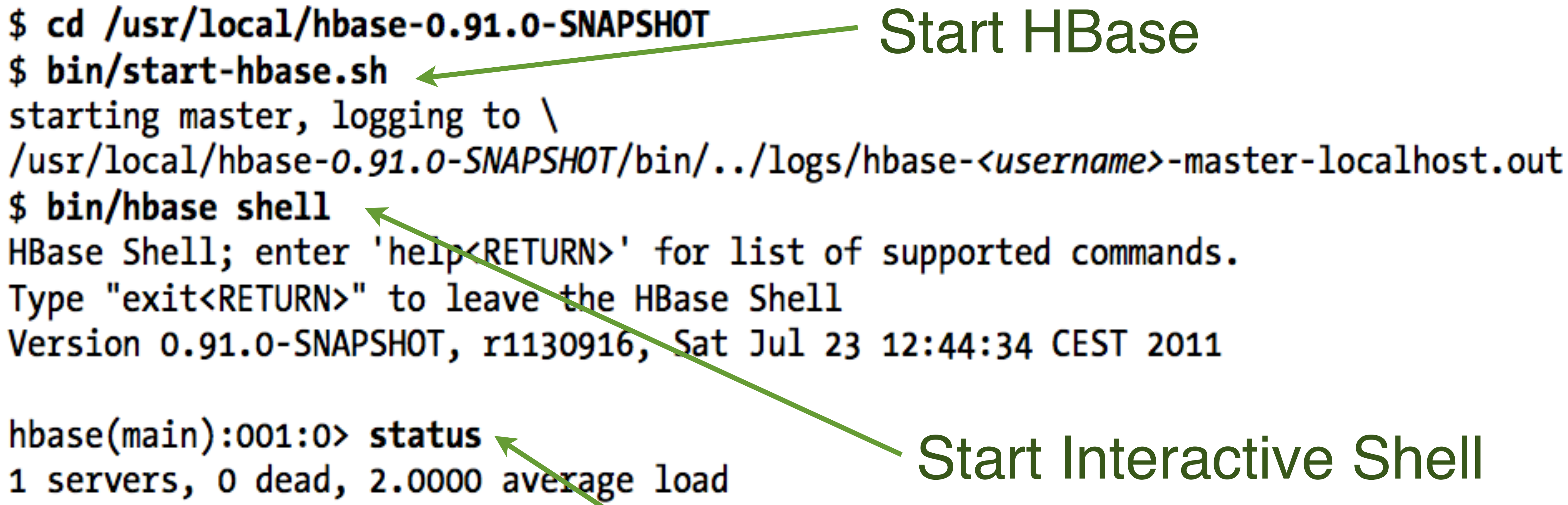
Interactive shell

- Will show you an example, locally (on your computer, without using HDFS)

Programmatically

- e.g., via Java, Python, etc.

Example, using interactive shell



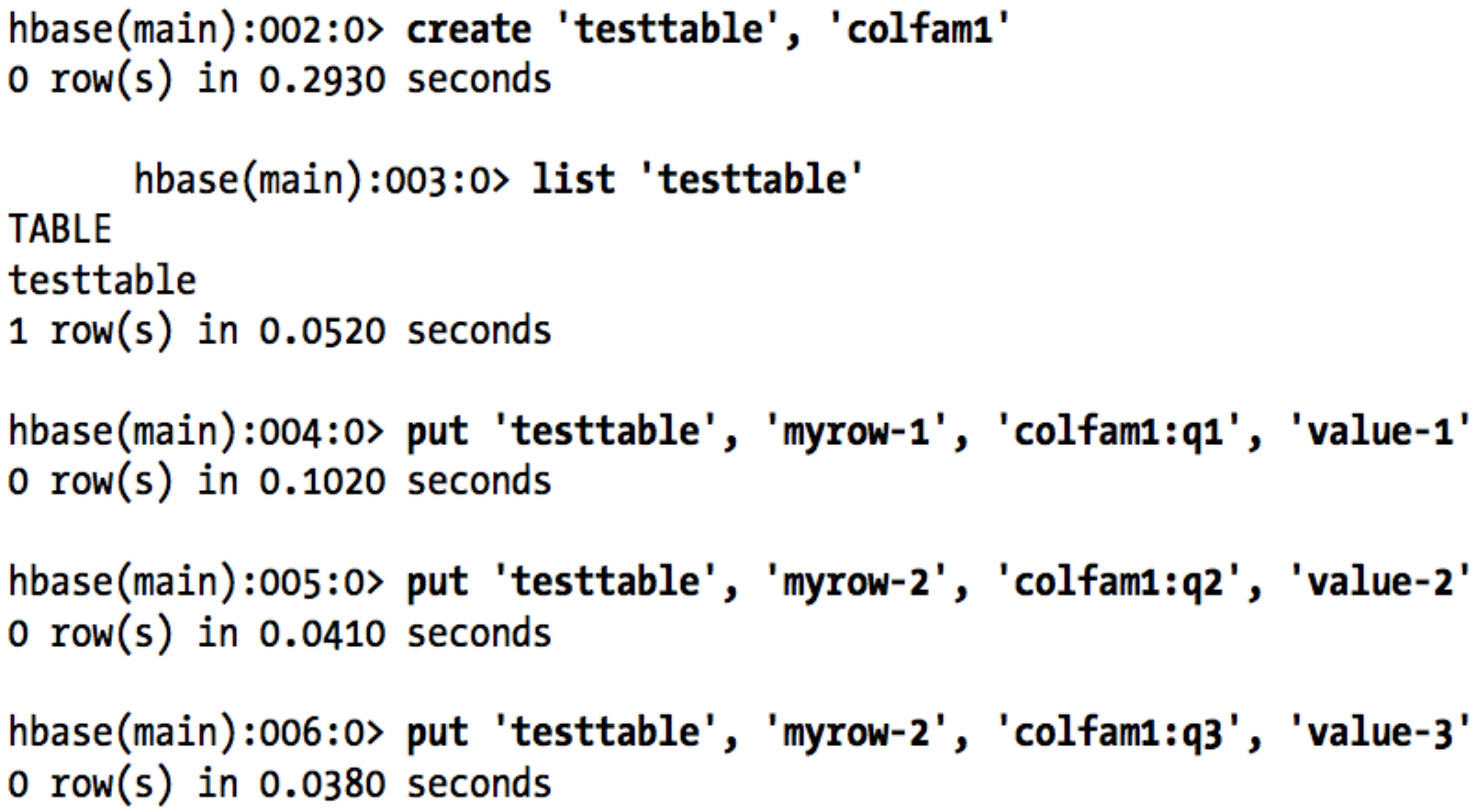
```
$ cd /usr/local/hbase-0.91.0-SNAPSHOT
$ bin/start-hbase.sh
starting master, logging to \
/usr/local/hbase-0.91.0-SNAPSHOT/bin/../logs/hbase-<username>-master-localhost.out
$ bin/hbase shell
HBase Shell; enter 'help<RETURN>' for list of supported commands.
Type "exit<RETURN>" to leave the HBase Shell
Version 0.91.0-SNAPSHOT, r1130916, Sat Jul 23 12:44:34 CEST 2011

hbase(main):001:0> status
1 servers, 0 dead, 2.0000 average load
```

Start HBase

Start Interactive Shell

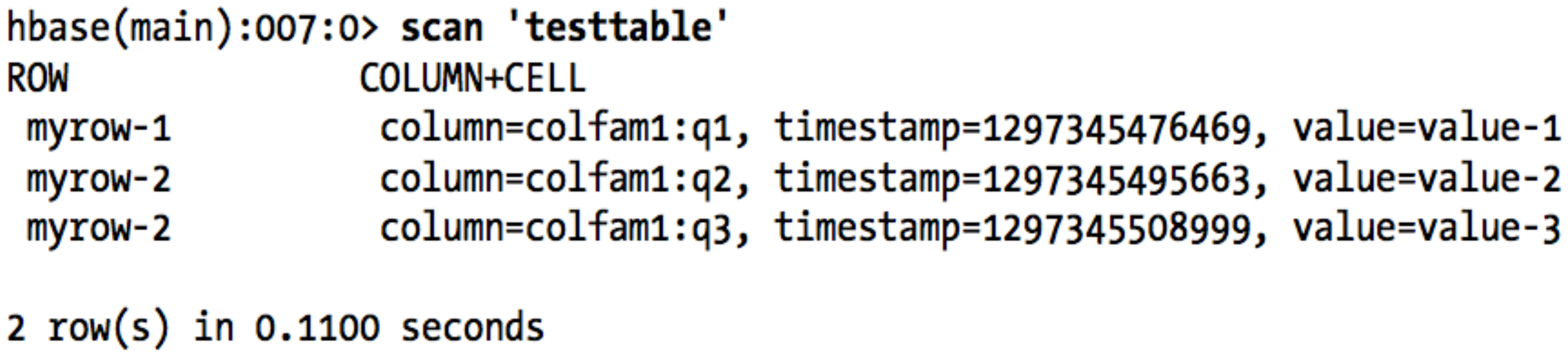
Check HBase is running

Example: Create table, add values



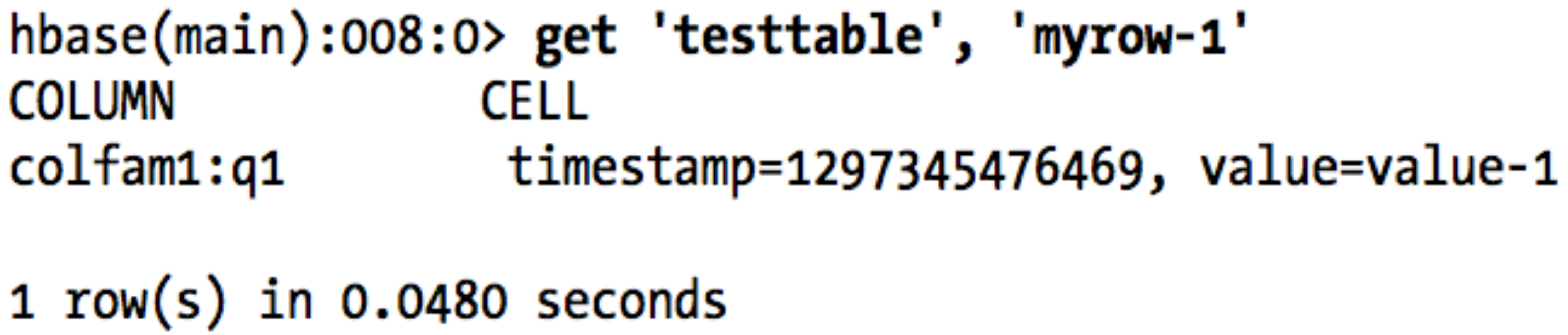
```
hbase(main):002:0> create 'testtable', 'colfam1'
0 row(s) in 0.2930 seconds

      hbase(main):003:0> list 'testtable'
TABLE
testtable
1 row(s) in 0.0520 seconds

hbase(main):004:0> put 'testtable', 'myrow-1', 'colfam1:q1', 'value-1'
0 row(s) in 0.1020 seconds

hbase(main):005:0> put 'testtable', 'myrow-2', 'colfam1:q2', 'value-2'
0 row(s) in 0.0410 seconds

hbase(main):006:0> put 'testtable', 'myrow-2', 'colfam1:q3', 'value-3'
0 row(s) in 0.0380 seconds
```

Example: Scan (show all cell values)



```
hbase(main):007:0> scan 'testtable'
ROW                  COLUMN+CELL
 myrow-1              column=colfam1:q1, timestamp=1297345476469, value=value-1
 myrow-2              column=colfam1:q2, timestamp=1297345495663, value=value-2
 myrow-2              column=colfam1:q3, timestamp=1297345508999, value=value-3

2 row(s) in 0.1100 seconds
```

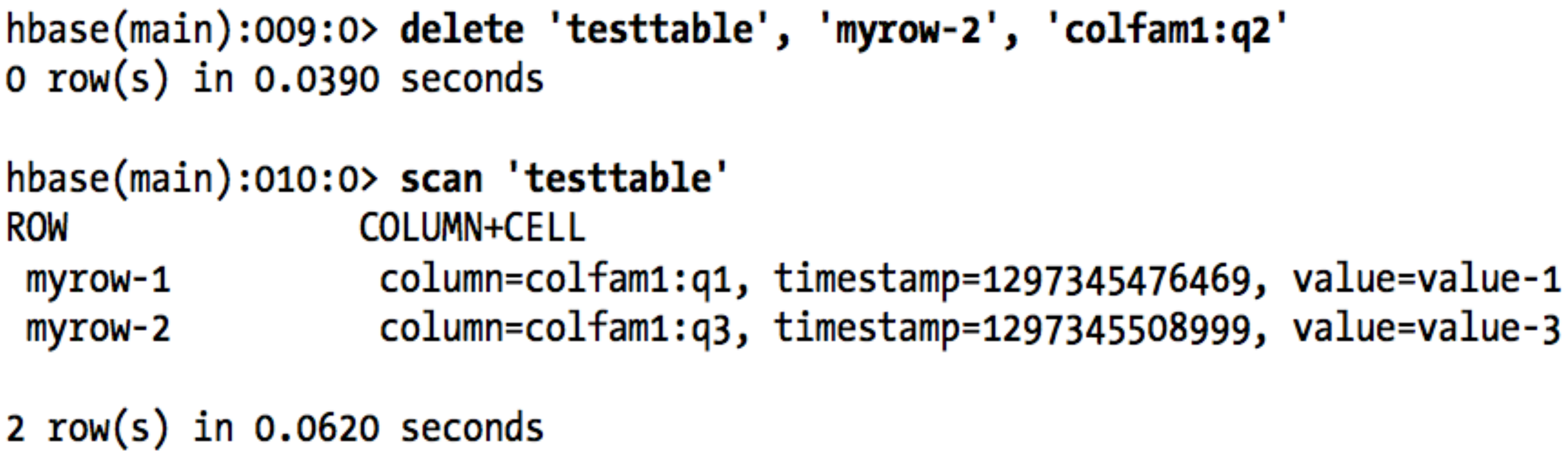
Example: Get (look up a row)



```
hbase(main):008:0> get 'testtable', 'myrow-1'
COLUMN                CELL
colfam1:q1             timestamp=1297345476469, value=value-1

1 row(s) in 0.0480 seconds
```

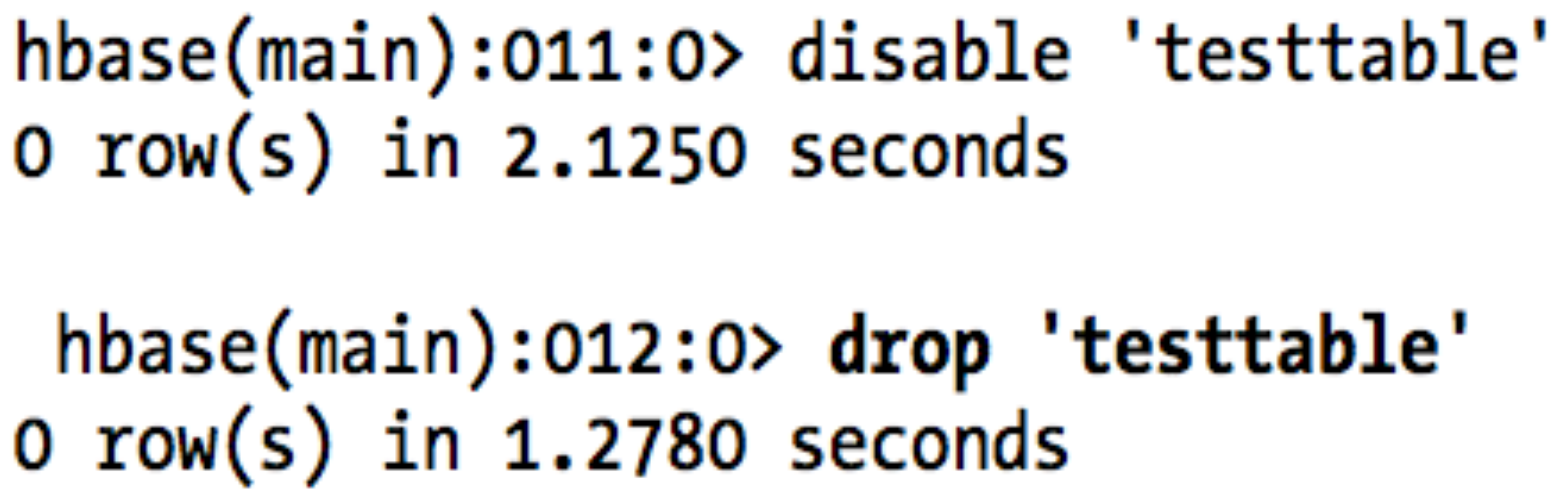
Can also look up a particular cell value with a certain timestamp, etc.

Example: Delete a value



```
hbase(main):009:0> delete 'testtable', 'myrow-2', 'colfam1:q2'
0 row(s) in 0.0390 seconds

hbase(main):010:0> scan 'testtable'
ROW                COLUMN+CELL
 myrow-1            column=colfam1:q1, timestamp=1297345476469, value=value-1
 myrow-2            column=colfam1:q3, timestamp=1297345508999, value=value-3

2 row(s) in 0.0620 seconds
```

Example: Deleting a table



```
hbase(main):011:0> disable 'testtable'
0 row(s) in 2.1250 seconds

 hbase(main):012:0> drop 'testtable'
0 row(s) in 1.2780 seconds
```

Why need to disable a table before dropping it?

http://stackoverflow.com/questions/35441342/hbase-why-do-i-need-to-disable-a-table-before-dropping-it

RDBMS vs HBase

RDBMS (=Relational Database Management System)

- MySQL, Oracle, SQLite, Teradata, etc.
- Really great for many applications
  - Ensure strong data consistency, integrity
  - Supports transactions (ACID guarantees)
  - ...

RDBMS vs HBase

How are they different?

- Hbase when you don’t know the structure/schema
- HBase supports sparse data
  - many columns, values can be absent
- Relational databases good for getting “whole” rows
- HBase: keeps multiple versions of data
- RDBMS support multiple indices, minimize duplications
- Generally a lot cheaper to deploy HBase, for same size of data (petabytes)

More topics to learn about

Other ways to get, put, delete... (e.g., **programmatically** via Java)

- Doing them in **batch**

A lot more to read about cluster adminstration

- **Configurations, specs** for master (name node) and workers (region servers)
- Monitoring cluster's health

"Bad key" design (http://hbase.apache.org/book/rowkey.design.html)

- **monotonically increasing keys** can decrease performance

Integrating with MapReduce

Cassandra, MongoDB, etc.

http://db-engines.com/en/system/Cassandra%3BHBase%3BMongoDB
http://kkovacs.eu/cassandra-vs-mongodb-vs-couchdb-vs-redis