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USING HBASE

9/23/12 Strangeloop 2012

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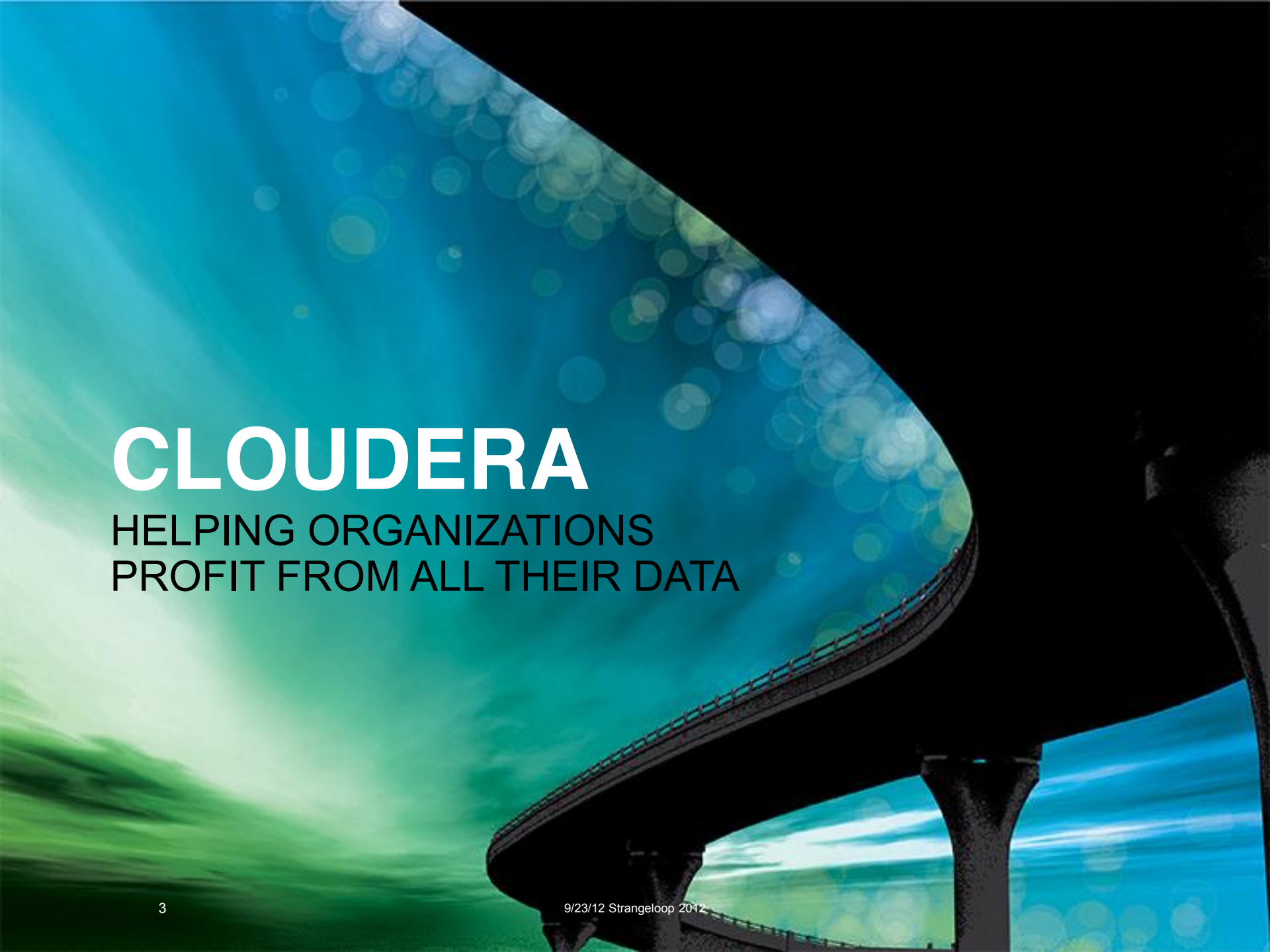
Who Am I?

- **Cloudera:**
  - Software Engineer on the Platform Team
  - **Apache HBase** committer / PMC
  - **Apache Flume** founder / committer / PMC
  - **Apache Sqoop** committer / PMC
- **U of Washington:**
  - Research in Distributed Systems


CLOUDERA
HELPING ORGANIZATIONS
PROFIT FROM ALL THEIR DATA

“The future is already here — it's just not very evenly distributed.”

William Gibson

Inspiration: Google BigTable (2006)

- OSDI 2006 paper

Bigtable: A Distributed Storage System for Structured Data

Fay Chang, Jeffrey Dean, Sanjay Ghemawat, Wilson C. Hsieh, Deborah A. Wallach
Mike Burrows, Tushar Chandra, Andrew Fikes, Robert E. Gruber
{fay,jeff,sanjay,wilsonh,kerr,m3b,tushar,fikes,gruber}@google.com
Google, Inc.

- **Goal**: **Low latency**, **Consistent**, **random read/write** access to massive amounts of **structured data**.
  - It was the data store for Google's crawler web table, gmail, analytics, earth, blogger, …

Implementation: Apache HBase (2012)

- Web Application Backend
  - Inboxes
  - Catalogs
  - Search index server
  - Web cache
  - Social Media storage
- Monitoring Real-time Analytics
  - OpenTSDB
- A data storage layer for higher level platforms

Outline

- **Enter Apache HBase**
- The HBase Data Model
- System Architecture
- Real-World Applications
- Deployment and Operations
- Conclusions

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ENTER APACHE HBASE

Low-latency, consistent, random read/write big data access

What is Apache HBase?

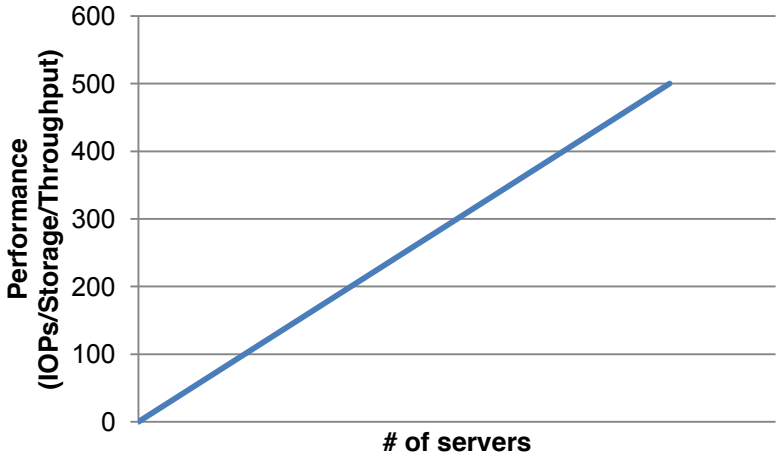
Apache HBase is an **open source**, **horizontally scalable**, **consistent, low latency, random access** data store built on top of **Apache Hadoop**

HBase is Open Source

- **Apache 2.0 License**
- A Community project with committers and contributors from diverse organizations
  - Facebook, Cloudera, StumbleUpon, Salesforce.com, Huawei, TrendMicro, eBay, HortonWorks, …
- Code license means anyone can modify and use the code.

HBase is Horizontally Scalable

- Adding more servers **linearly increases** performance and capacity
  - Storage capacity
  - Input/output operations



- Store and access data on 1-1000's **commodity servers**

- **Largest cluster**: ~1000 nodes, ~1PB
- **Most clusters**: 10-40 nodes, 100GB-4TB

Commodity Servers (circa 2012)

- 12x 1TB hard disks in a **JBOD** (Just a Bunch Of Disks) configuration
- 2 quad core CPUs, 2+GHz
- 24-96GBs of RAM (96GBs if you're considering HBase w/ MR)
- 2x 1Gigabit Ethernet
- $5k-10k / machine

What is Apache HBase?

Apache HBase is an **open source**, **horizontally scalable**, **consistent, low latency, random access** big-data store built on top of **Apache Hadoop**

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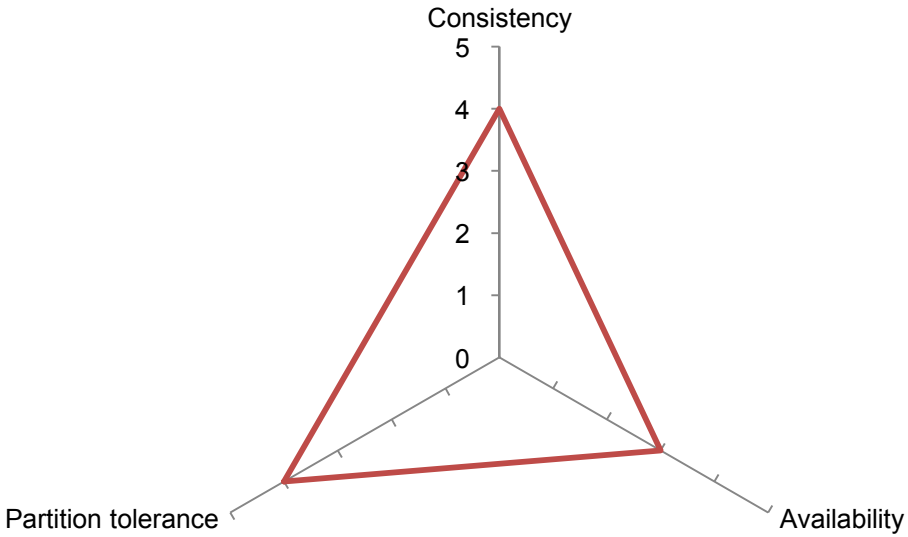
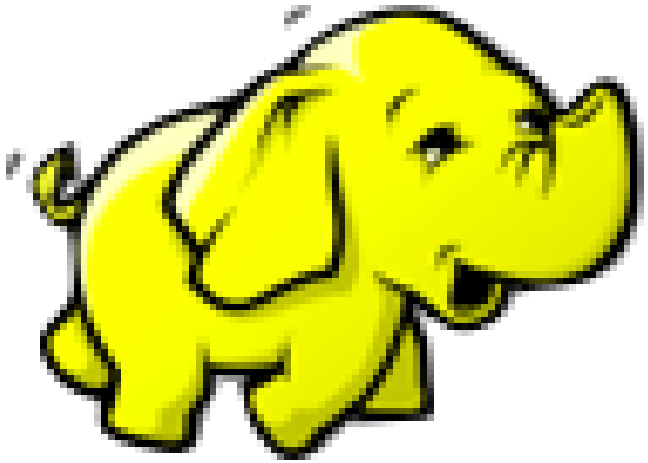
HBase is Consistent

- Brewer's CAP theorem
- **Consistency:**
  - DB-style ACID guarantees on **rows**
- **Availability:**
  - Favor recovering from faults over returning stale data
- **Partition Tolerance:**
  - If a node goes down, the system continues.



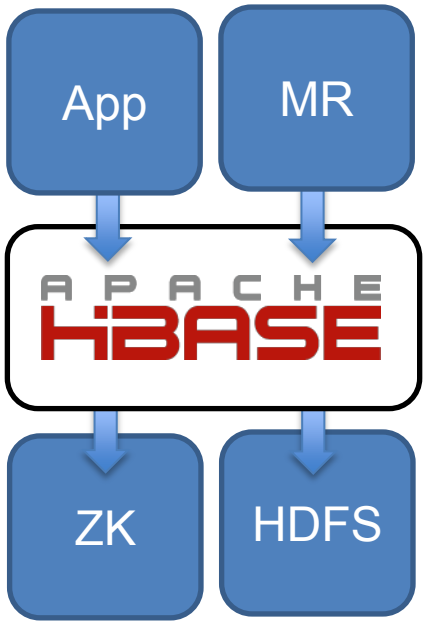
HBase depends on Apache Hadoop



Apache Hadoop is an **open source**, **horizontally scalable** system for **reliably storing** and **processing massive amounts** of data across many **commodity servers**.

HBase Depedencies

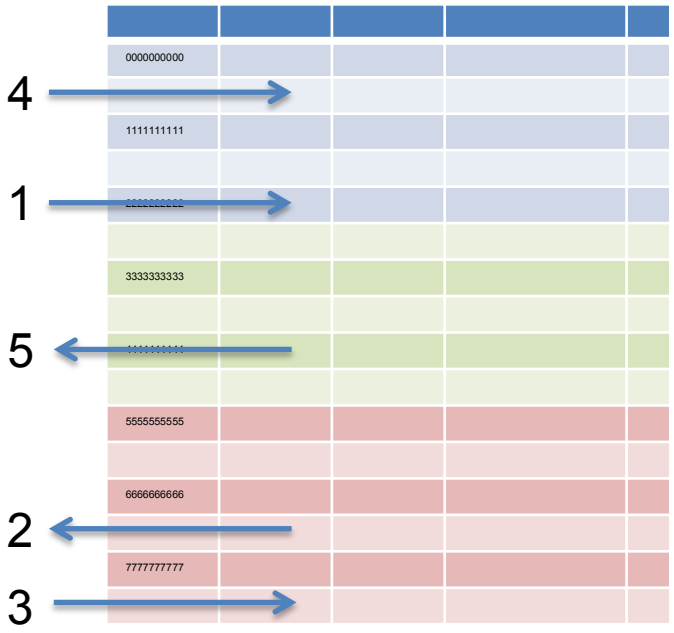
- **Apache Hadoop HDFS** for data **durability** and **reliability** (Write-Ahead Log)
- **Apache ZooKeeper** for distributed coordination
- **Apache Hadoop MapReduce** support built-in support for running MapReduce jobs



HBase does Low-latency Random Access

- **Writes**: 1-3ms, 1k-10k writes/sec per node
- **Reads:** 0-3ms cached, 10-30ms disk
  - 10-40k reads / second / node from cache
- **Cell size:** 0-3MB preferred

- Read, write and insert data anywhere in the table
  - No sequential write limitations



Do I need an HBase or some other “NoSQL” data store?

Did you try scaling your RDBMS vertically?

=>

- Upgrading to a beefier machines could be quick
  - (upgrade that m1.large to a m2.4xlarge)
- This is a good idea.

- What if this isn't enough?

Changed your RDBMS schema and queries?

- Remove text search queries (LIKE)
- Remove joins
  - Joins due to Normalization require expensive seeks
- Remove foreign keys and encode your own relations
  - Avoid constraint checks
- Just put all parts of a query in a single table.

- Lots of Full table scans?
  - Good time for Hadoop.
- Time to consider HBase

Need to scale RDBMS reads?

- Using DB replication to make more copies to read from
- Use Memcached

- Assumes 80/20 read to write ratio, this works reasonably well if can tolerate replication lag.

- Unfortunately, eventually you may need more writes.
  - Replication has diminishing returns with more writes.

Need to scale RDBMS writes?

- Let's shard and federate the DB
  - Loses consistency, order of operations.
- HA introduces operational complexity
- This is definitely a good time to consider HBase

We “optimized the DB” by discarding some fundamental SQL/relational databases features.

Outline

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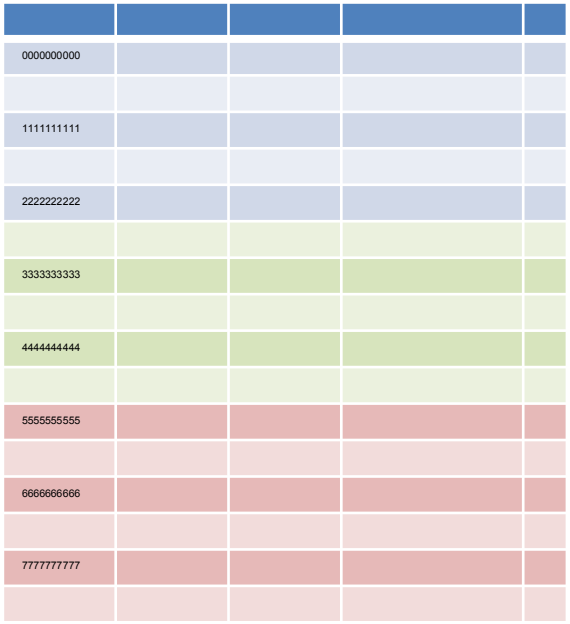
THE HBASE DATA MODEL

Rows and columns, gets and puts.

Sorted Map Datastore



- It is a big table
- Tables consist of **rows**, each of which has a primary **row key**
- Each row has a set of **columns**
- Rows are stored in **sorted** order

Sorted Map Datastore
(logical view as “records”)

Row key	info: height	info:state	roles:hadoop	roles:hbase
cutting	‘9ft’	‘CA’	‘Founder’	
tlipcon	‘5ft7’	‘CA’	‘PMC’ @ts=2011 ‘Committer’ @ts=2010	‘Committer’

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Implicit PRIMARY KEY in RDBMS terms

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A single cell might have different values at different timestamps

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

A single cell might have different values at different timestamps

Sorted Map Datastore

(logical view as "records")

Implicit PRIMARY KEY in RDBMS terms

Column format family:qualifier

Data is all `byte[]` in HBase

Row key	info: height	info:state	roles:hadoop	roles:hbase
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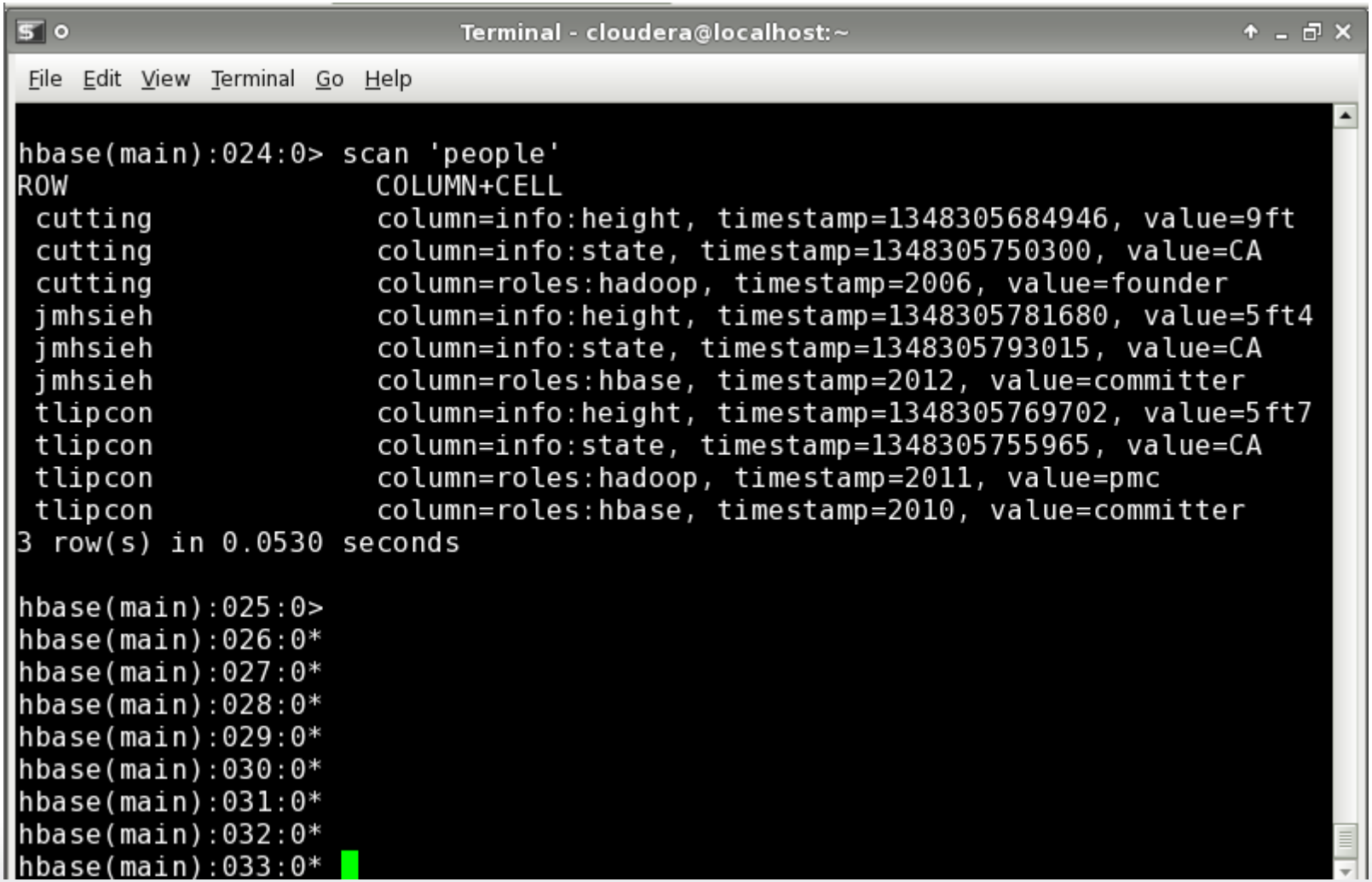
Different rows may have different sets of columns(table is *sparse*)

A single cell might have different values at different timestamps

Anatomy of a Row

- Each row has a **primary key**
  - Lexicographically sorted byte[]
  - Timestamp associated for keeping **multiple versions of data** (MVCC for consistency)
- Row is made up of columns.
- Each (row,column) referred to as a **Cell**
  - Contents of a cell are all byte[]'s.
  - Apps must "know" types and handle them.
- Rows are **Strongly consistent**

Example in Hbase Shell

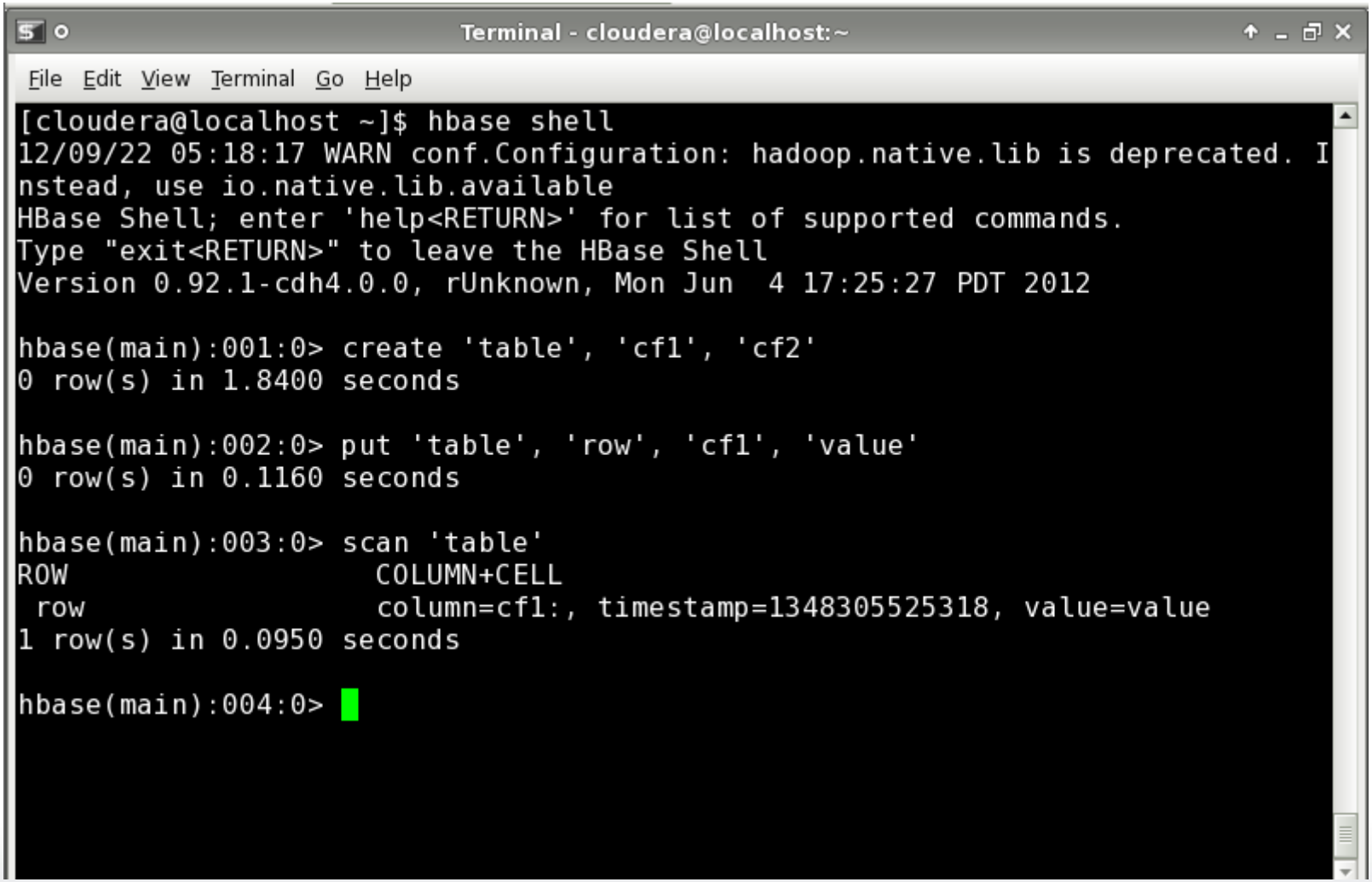


Access HBase data via an API

- Data operations
  - Get
  - Put
  - Scan
  - Increment
  - CheckAndPut
  - Delete

- Access via HBase shell, Java API, REST proxy

Shell: Create a table, add, and read a row



Java API

```
byte[] row = Bytes.toBytes(“row”);
byte[] col = Bytes.toBytes(“cf1”);
byte[] putVal = Bytes.toBytes(“your boat”);
Configuration config = HBaseConfiguration.create();

HTable table = new HTable(config, “table”);
Put p = new Put(row);
p.add(col, putVal)
table.put(p);

Get g = new Get(row);
Result r = table.get(g);
byte[] getVal = r.getValue(col);
assertEquals(putVal, getVal);
```

REST Server

- bin/hbase rest start –p 8070

- Browse:
- curl –H “Accept: application/json/” http://localhost:8070/...
  - http://localhost:8070/ tables
  - http://localhost:8070/people/schema schema
  - http://localhost:8070/people/tlipcon row

- More info here
  - http://wiki.apache.org/hadoop/Hbase/Stargate

Simple API. What is the catch?

With great power comes great responsibility.

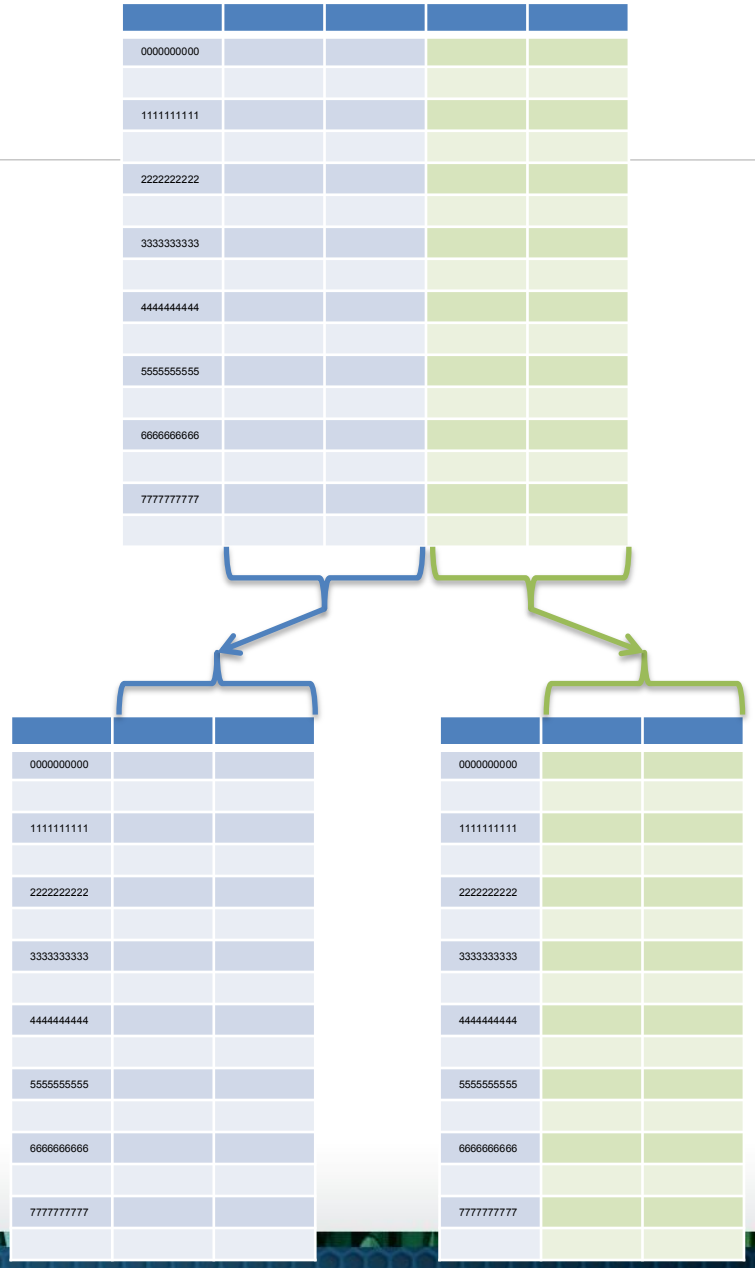
Cost Transparency

- Goal: Predictable latency of random read and write operations.
  - Now you have to understand some of the physical layout of your datastore.

- Efficiencies are based on **Locality** and your **schema.**
- Need to understand some physical concepts:
  - Column Families
  - Sparse Columns
  - Regions
- Your schema needs to consider these.

Column Families

- A **Column family** is a set of related columns.
- Group sets of columns that have similar access patterns
- Select parameters to tune read performance per column family



Physical Storage of Columns Families

Each column family is contained in its own file.

`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

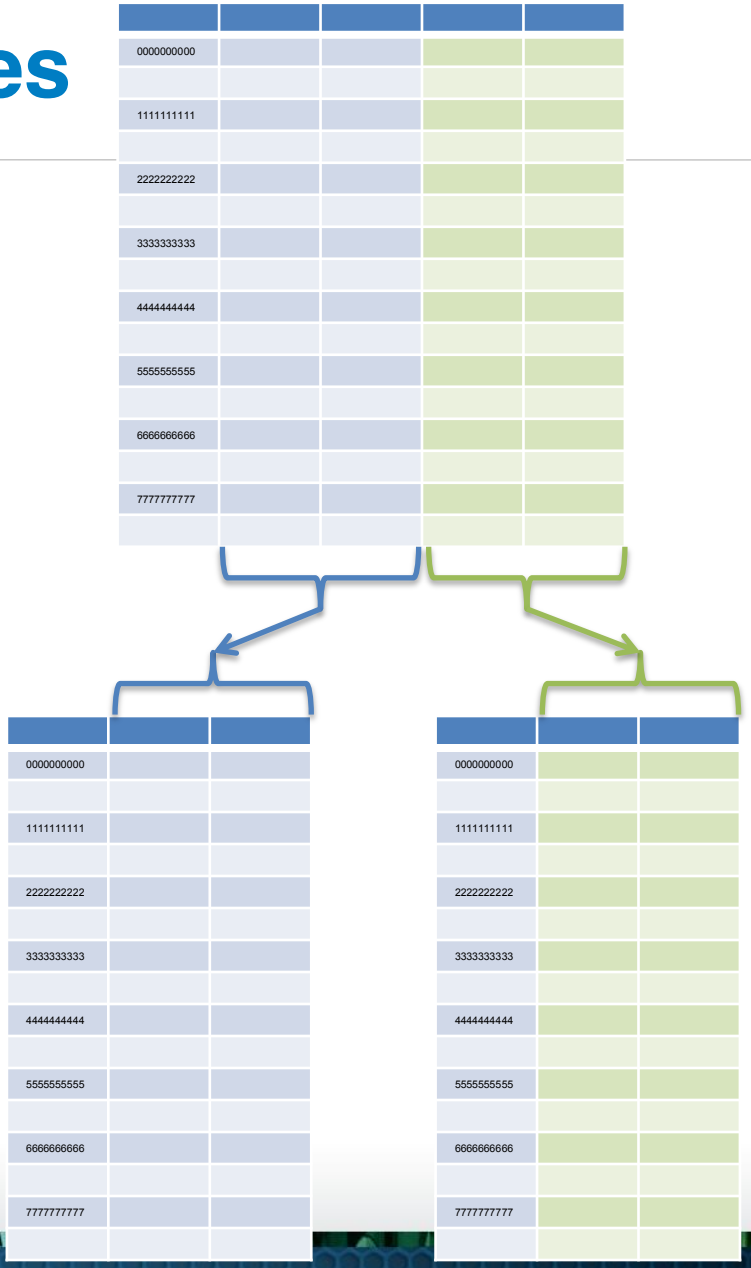
Row key	Column key	Timestamp	Cell value
cutting	roles:ASF	1273871823022	Director
cutting	roles:Hadoop	1183746289103	Founder
tlipcon	roles:Hadoop	1300062064923	PMC
tlipcon	roles:Hadoop	1293388212294	Committer
tlipcon	roles:Hive	1273616297446	Contributor

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

Milliseconds since unix epoch

Tuning Column Families

- Good for tuning **read performance**
  - Store related data together for better compression
  - Avoid polluting cache from another.
  - Derived data can have different retention policies
- Column family parameters
  - Block Compression (none, gzip, LZO, Snappy)
  - Version retention policies
  - Cache priority



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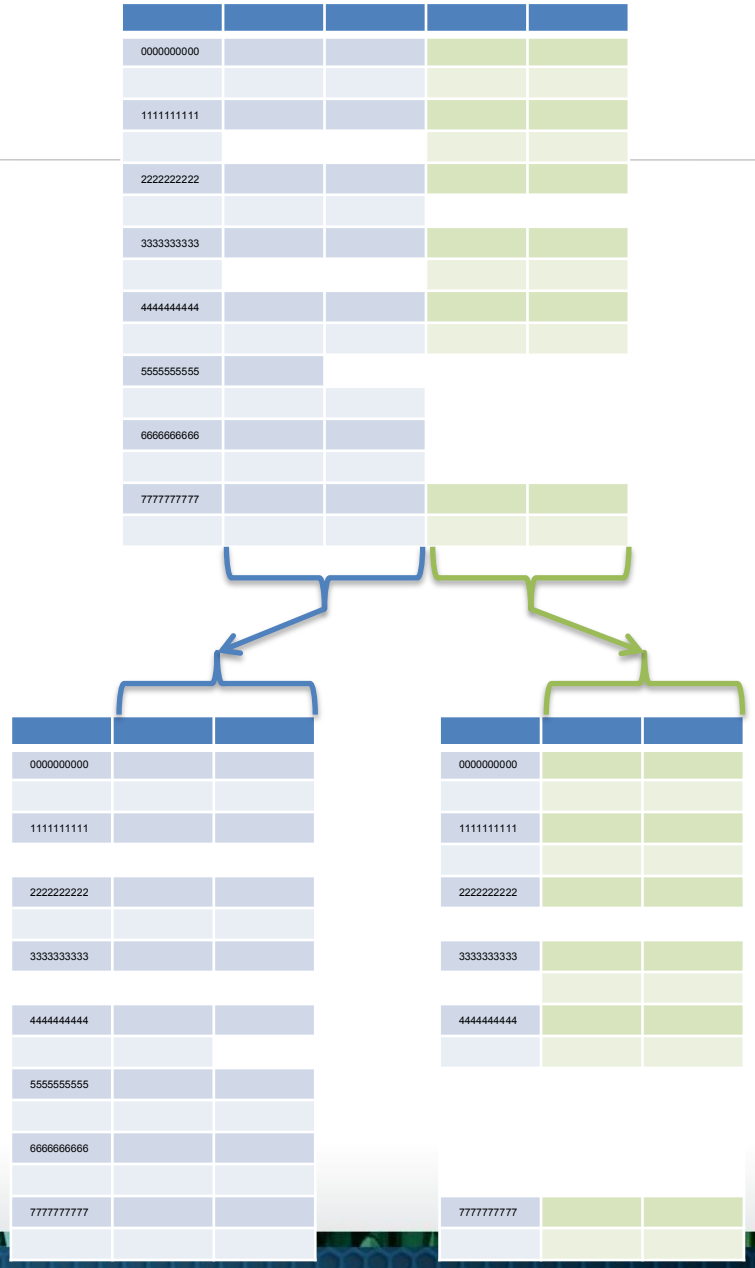
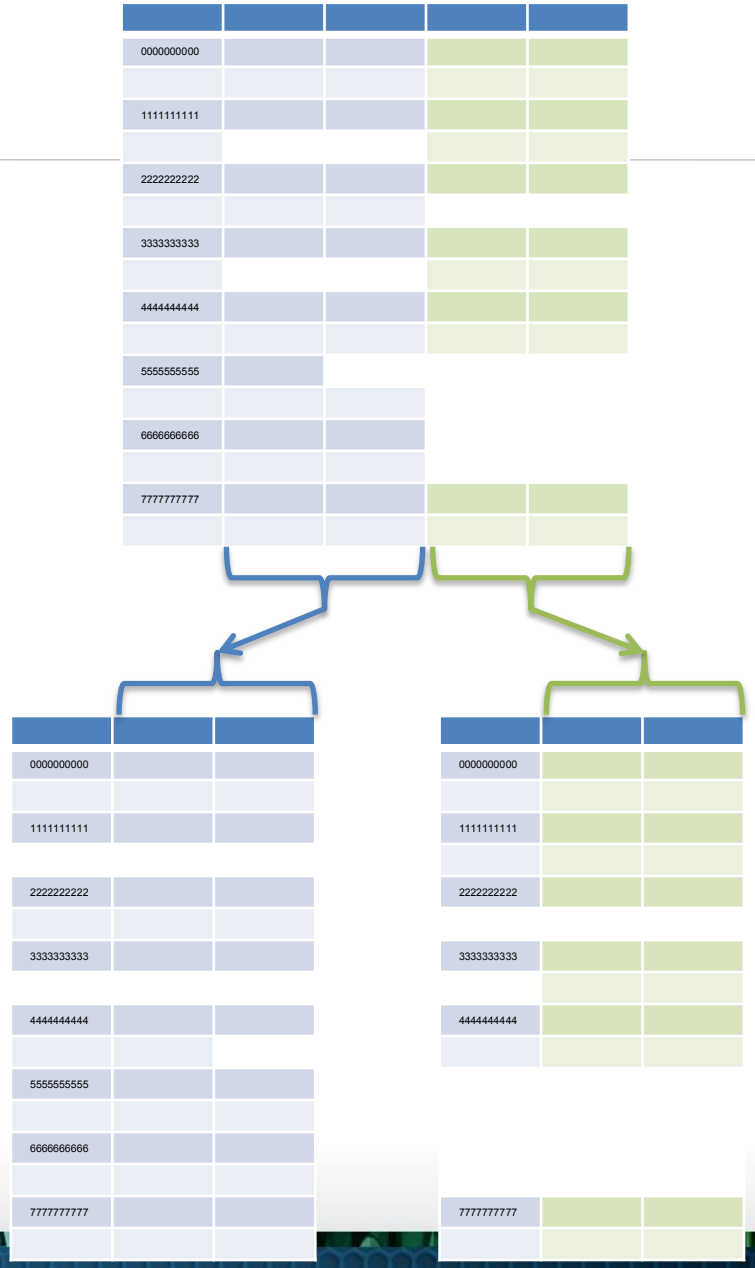
Sparse Columns

- Sparseness provides **schema flexibility**
  - Add columns later, no need to transform entire schema
  - If you find yourself adding columns to your db, HBase is a good model.



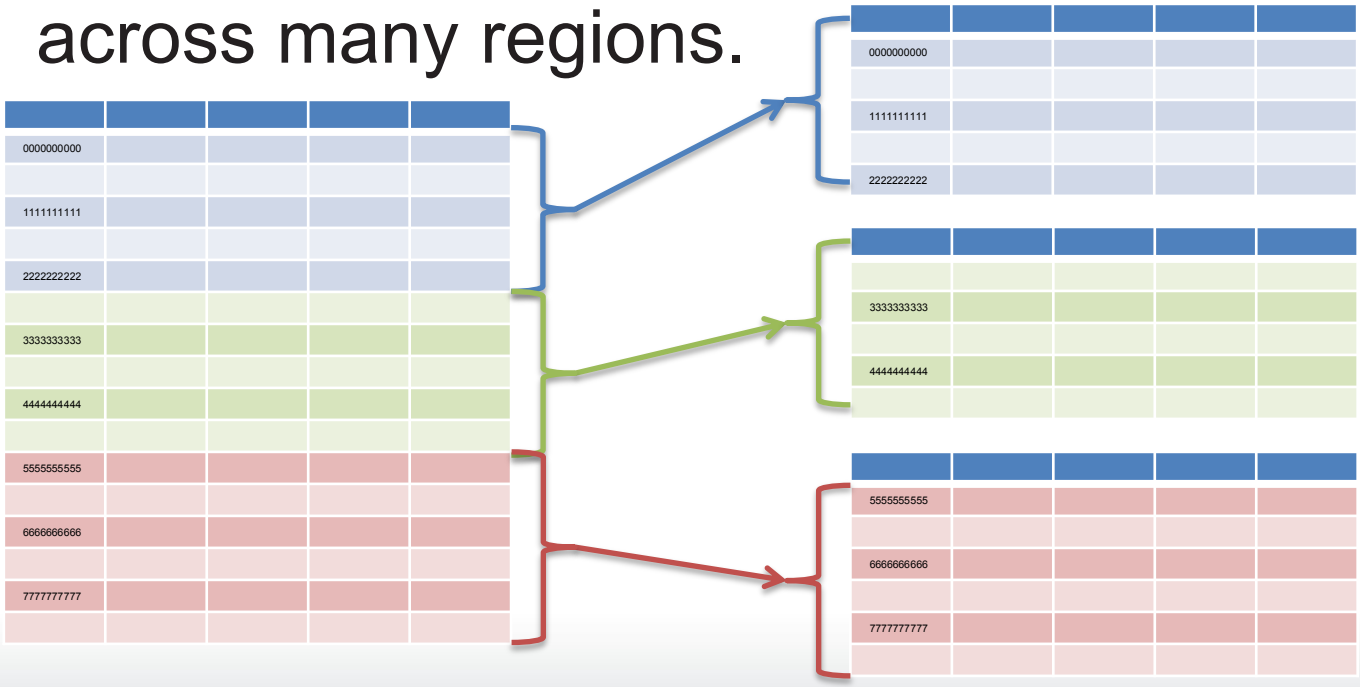
Sparse Columns

- Sparseness can improve performance
  - Null columns don't take space. You don't need to read what is not there.
  - If you have a traditional db table with lots of nulls, you data will probably fit well



Horizontal Scaling - Regions

- Tables are divided into sets of rows called **regions**
- **Scale read and write capacity** by spreading across many regions.



Regions: Tradeoffs

- Easier to scale cluster capacity
  - Auto sharding and load balancing capability
- Greater throughput and storage capacity
  - Horizontal scalability of writes and reads and storage
- Enough consistency for many applications
  - Per row ACID guarantees

- No built-in atomic multi-row operations
- No built-in consistent secondary indices
- No built-in global time ordering

SQL + HBase

- No built-in SQL query language and query optimizer
- There is work on integration Apache Hive (SQL-like query language)
  - Currently not the optimal, x5 slower than normal Hive+HDFS
- Apache Sqoop and HBase Integration
  - Copy RDMS tables from database to Hbase
  - Copy HBase Tables into RDMS
  - (there is some impedance mismatch)

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	Column family level Authentication / Authorization
Indexes	On arbitrary columns	Row-key only*
Max data size	TBs	~1PB
Read/write throughput limits	1000s queries/second	Millions of “queries”/second

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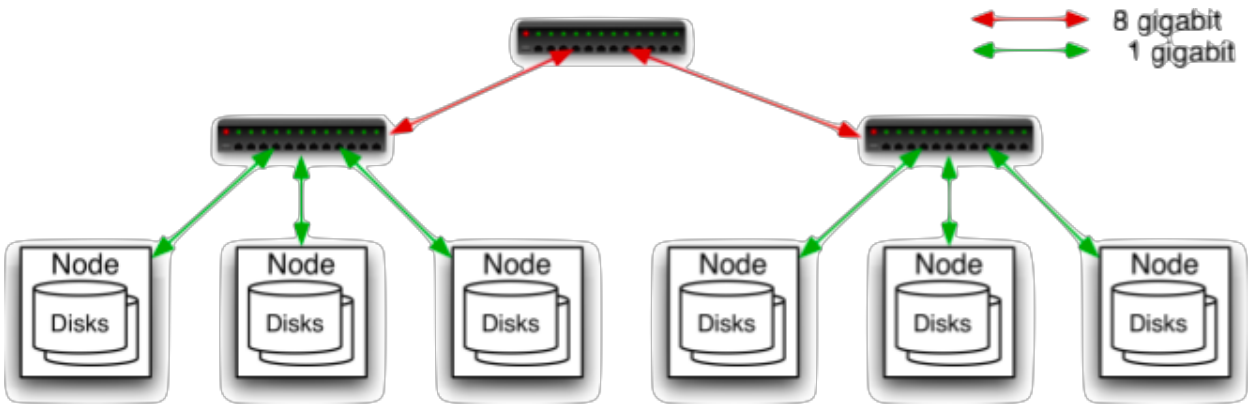
SYSTEM ARCHITECTURE

Clusters, Nodes, and Dependencies

A Typical Look...

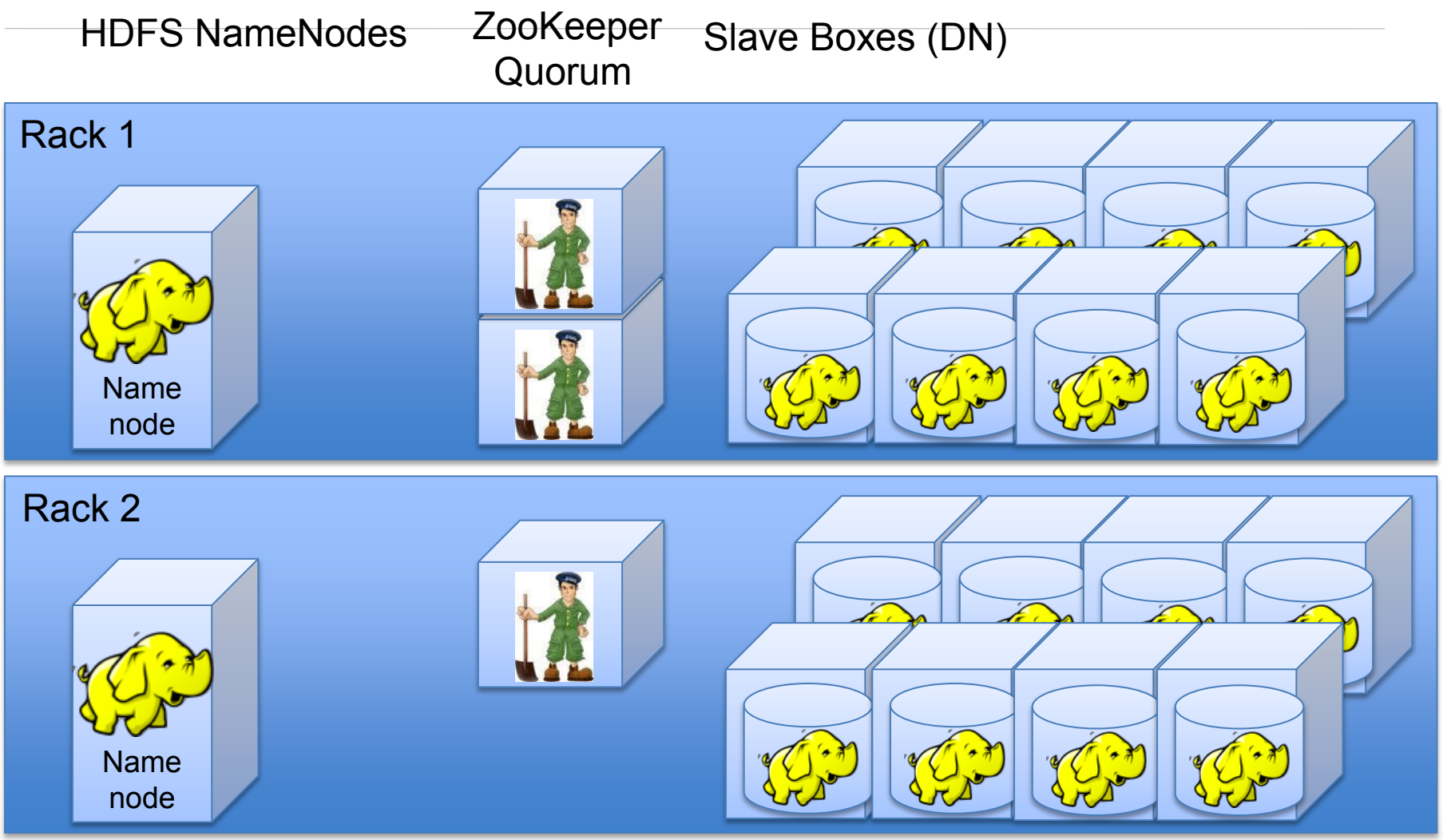
- 5-4000 commodity servers (8-core, 48 GB RAM, 12-24 TB, gig-E)
- 2-level network architecture
  - 20-40 nodes per rack



HBase Processes

- HDFS
  - Name node
  - Data node
- ZooKeeper
  - Quorum Peer
- HBase
  - Master
  - Region Server

HDFS Nodes (physically)



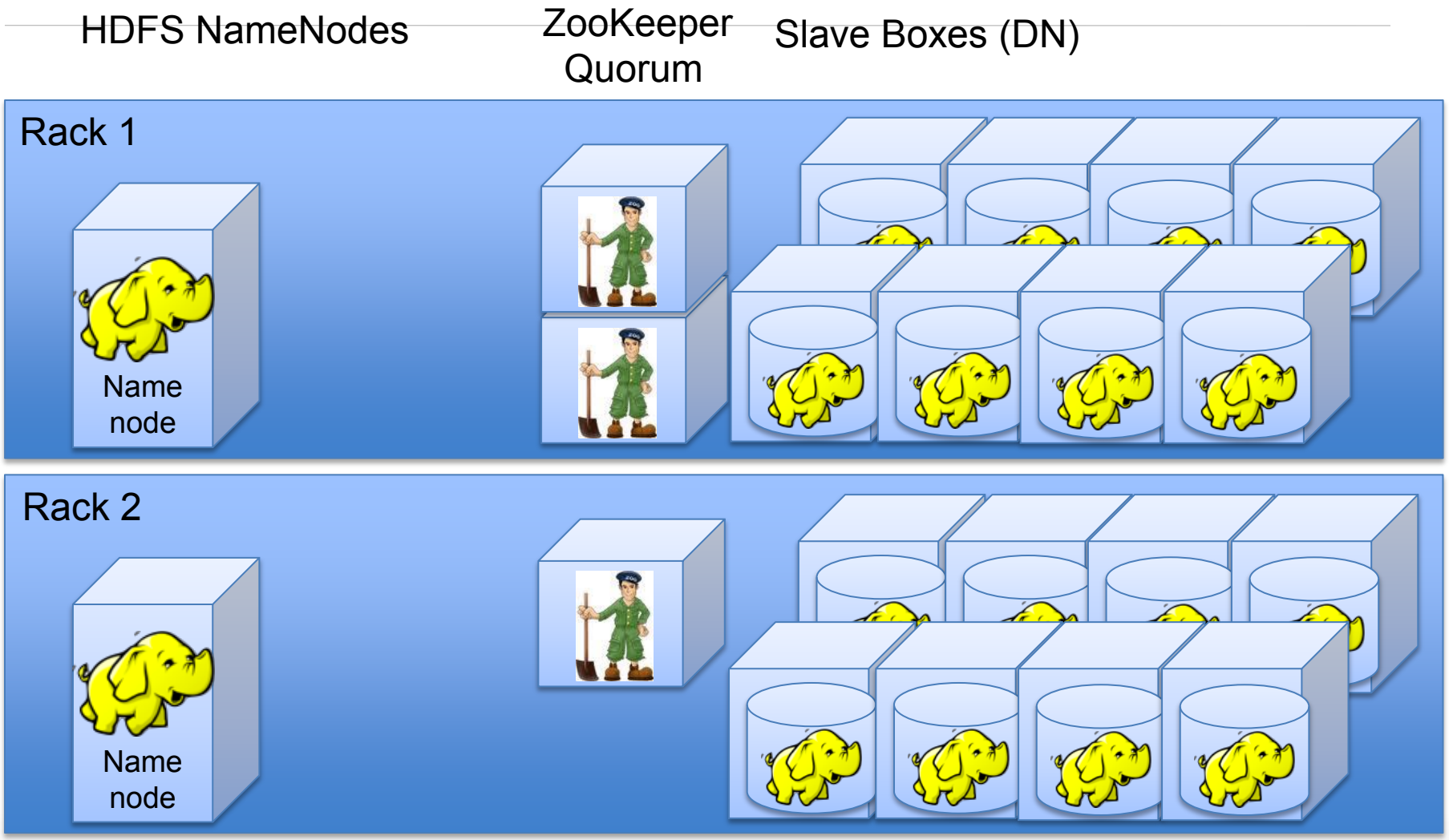
HDFS Name Node

- Stores file system metadata on disk and in memory
  - Directory structures, permissions
  - Modifications stored as an edit log
- Fault tolerant and Highly Available

HDFS Data nodes

- HDFS splits the files into 128MB (or 256MB) blocks
- **Data nodes** store and serve these Blocks
  - By default, pipeline writes to 3 different machines.
  - By default, local machine, machines on other racks.
  - Locality helps significantly on subsequent reads and computation scheduling.

HDFS Nodes (physically)

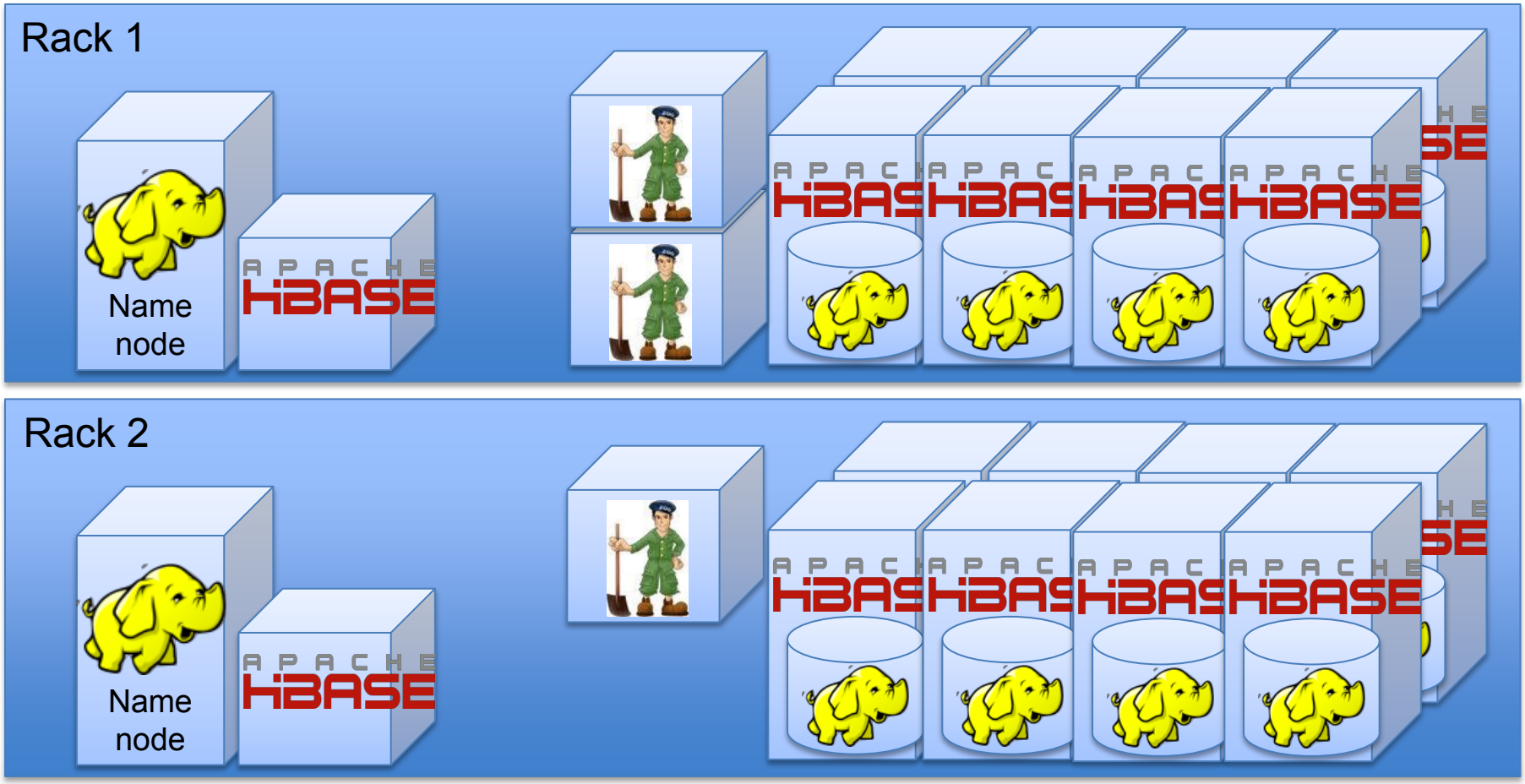


HBase + HDFS Nodes (physically)

HDFS NameNodes
HBase Masters

ZooKeeper Quorum

Slave Boxes (DN + RS)



HMaster and ZooKeeper

- HMaster
  - Controls which Regions are served by which Region Servers.
  - Assigns regions to new region servers when they arrive or fail.
  - Can have a hot standby master if active master goes down.
  - Metadata state kept in ZooKeeper
- Apache ZooKeeper
  - Highly Available System for coordination.
  - Generally 3 or 5 machines (always an odd number)
  - Uses consensus to guarantee common shared state.
  - Writes are considered expensive

Region Server

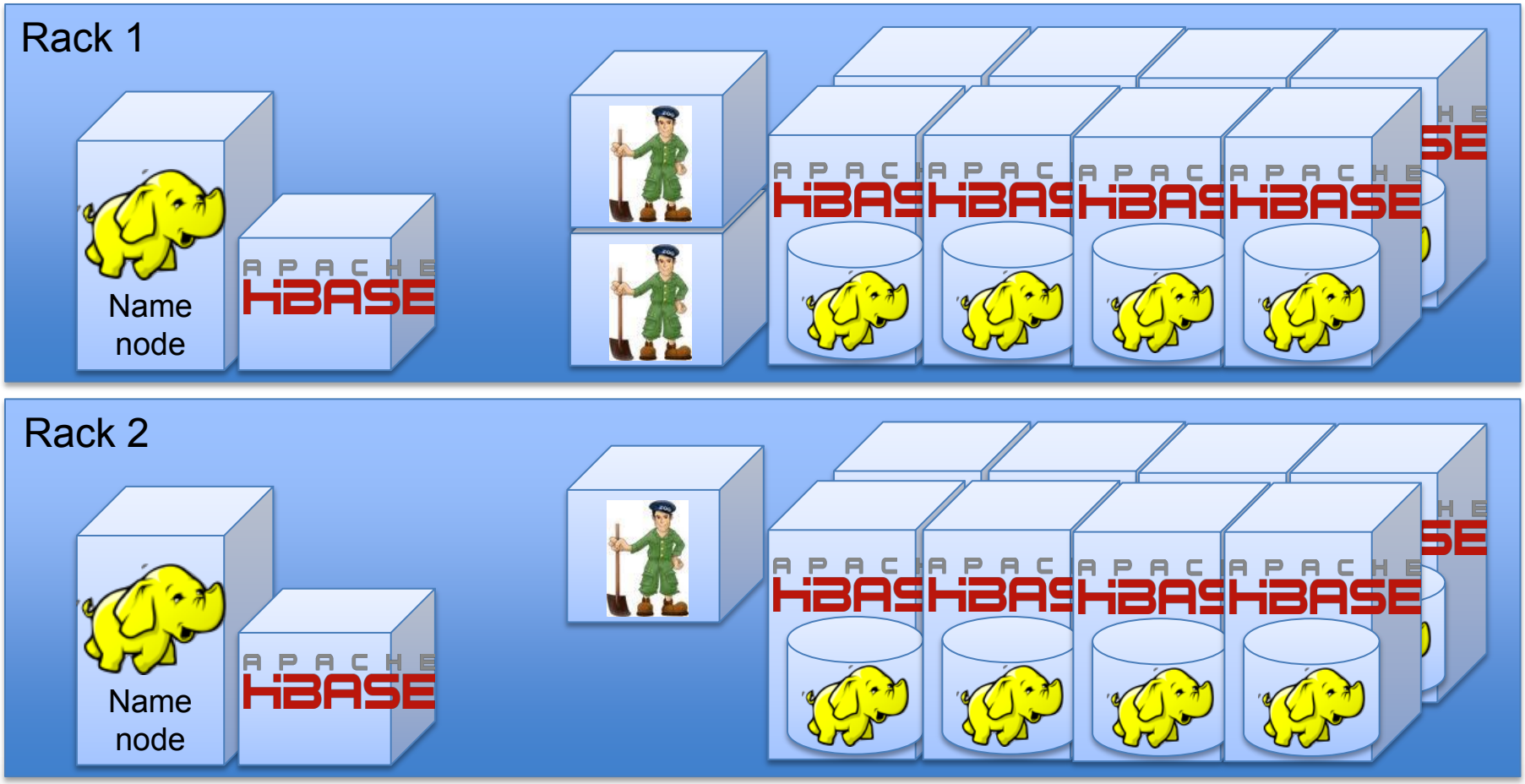
- Tables are chopped up into regions
- A region is only served by a single “region server” at a time.
- Region Server can serve multiple regions
  - Automatic load balancing if region server goes down.
- Co-locate region servers with data nodes.
  - Takes advantage of HDFS file locality
- Important that clocks are in reasonable sync. Use NTP!

HBase + HDFS Nodes (physically)

HDFS NameNodes
HBase Masters

ZooKeeper Quorum

Slave Boxes (DN + RS)

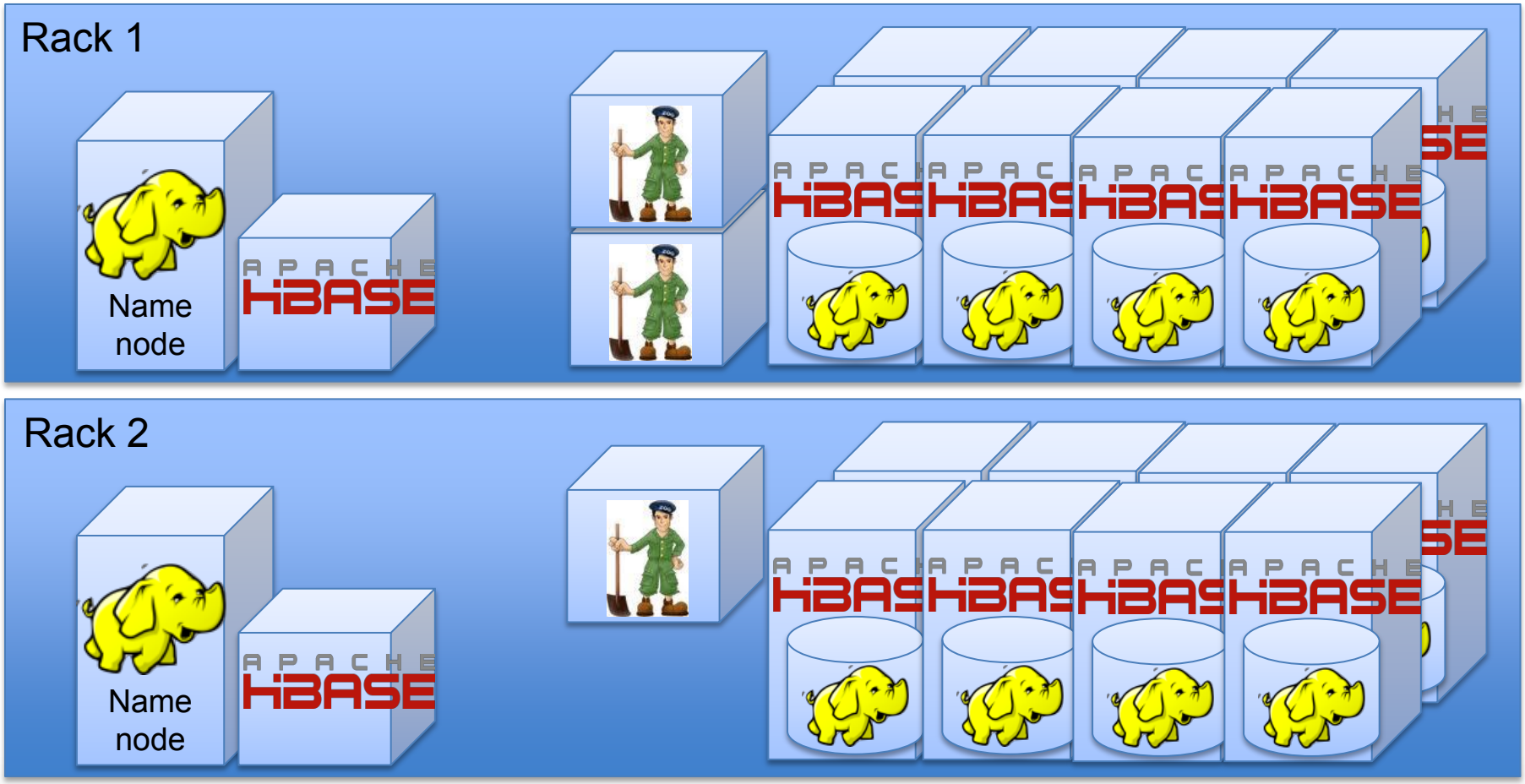


HBase + HDFS: No SPOF

HDFS NameNodes
HBase Masters

ZooKeeper Quorum

Slave Boxes (DN + RS)



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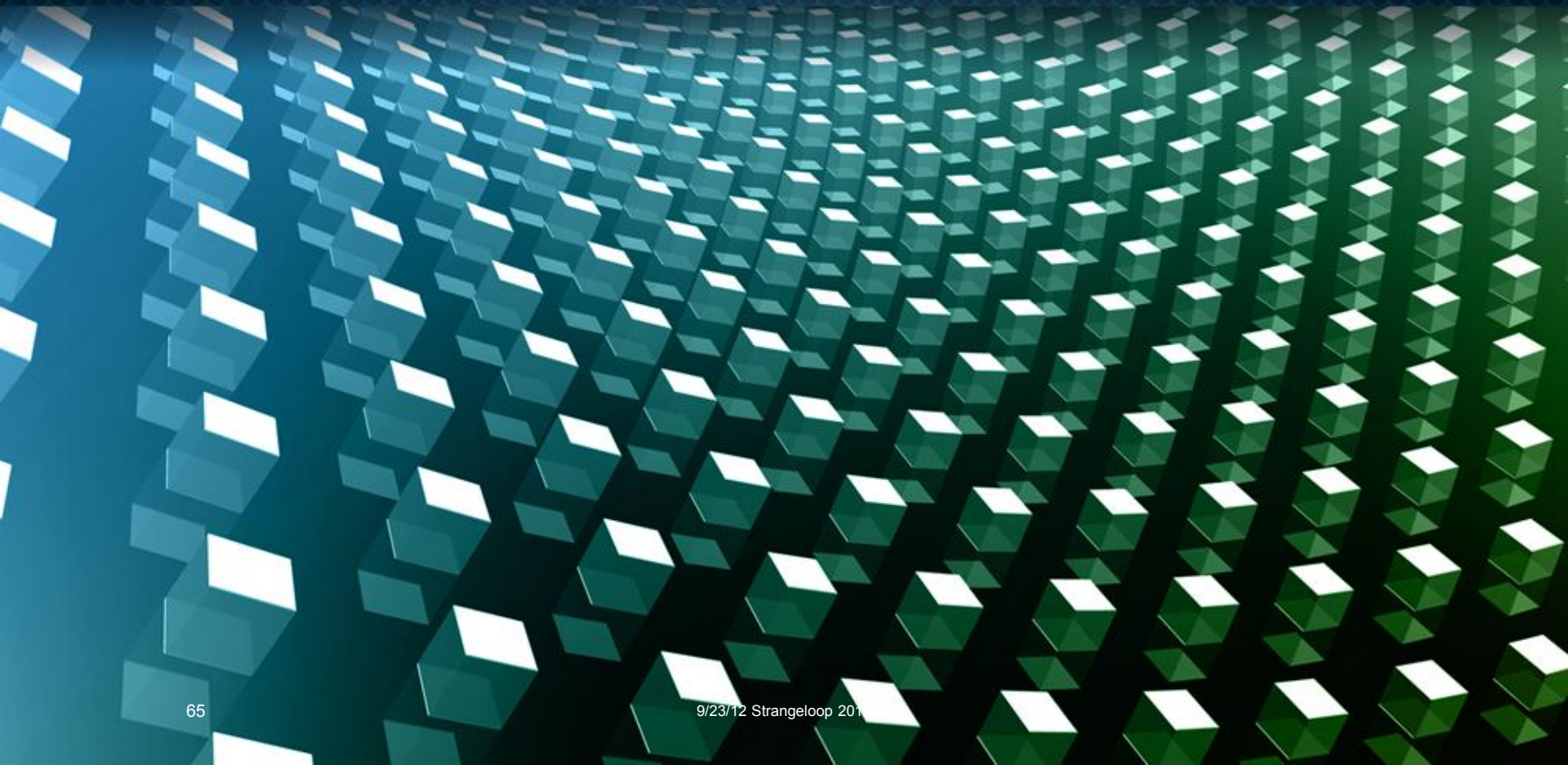
REAL WORLD APPLICATIONS

How and where is this infrastructure being used



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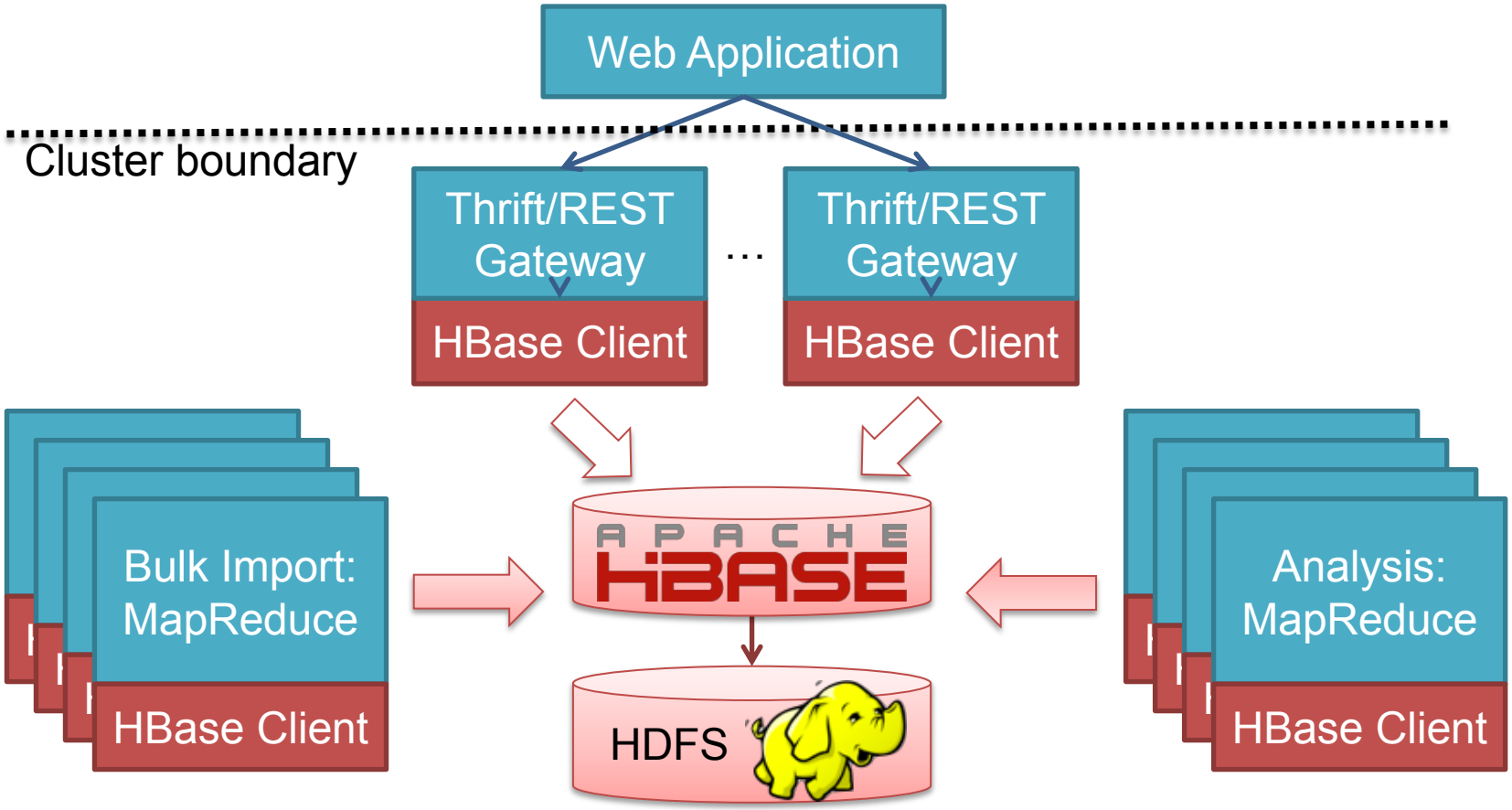
“YOU CAN’T SOLVE 21ST CENTURY PROBLEMS WITH 20TH CENTURY TECHNOLOGIES”

HBase Application Architecture

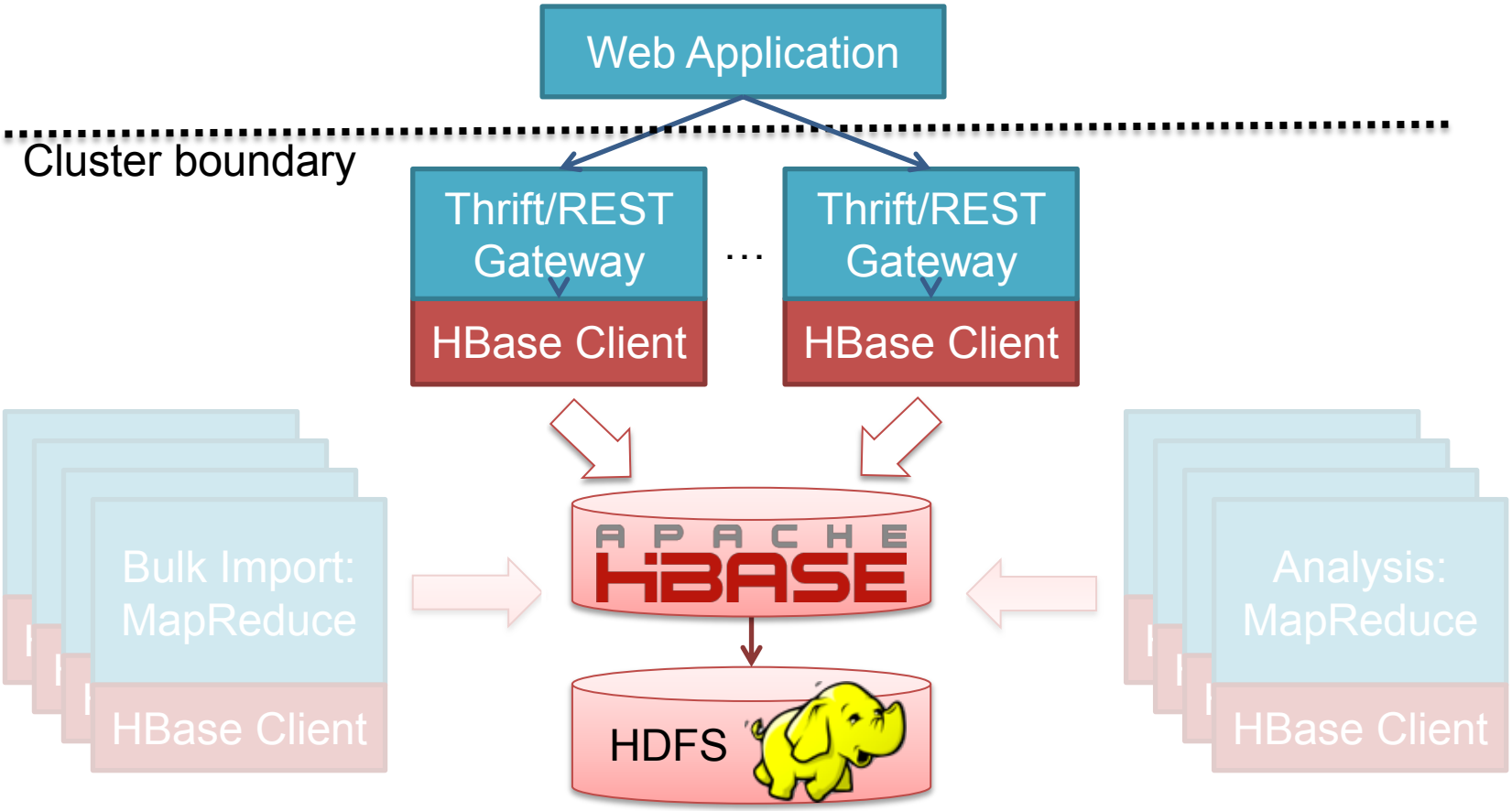


Example Apache HBase Applications

- Web Application Backends
  - Inboxes: **Facebook Messages**, Tumblr
  - Catalogs: Intuit Mint Merchant DB, Gap Inc. Clothing Database, OLCL (world library catalog)
  - URL Shortener: StumbleUpon http://su.pr,
  - Search Index: **eBay Cassini**, PhotoBucket, YapMap
- Massive datastore for Analysis
  - **Mozilla Socorro** (crash report DB), Yahoo! Web Crawl Cache
  - Mignify / Internet Memory project
- Monitoring Real-time Analytics
  - **OpenTSDB**, Sproxil, Sematext

More Info at http://www.hbasecon.com/agenda/

HBase Web Application



RDBMS: Data-centric schema design

- Entity relational model.
  - Design schema in “Normalized form”
  - Figure out your queries
  - DBA to sets primary secondary keys once query is known
- Issues:
  - Join latency and cost can be difficult to predict
  - Difficult/Expensive to change schema / add columns

HBase: Query-centric schema design

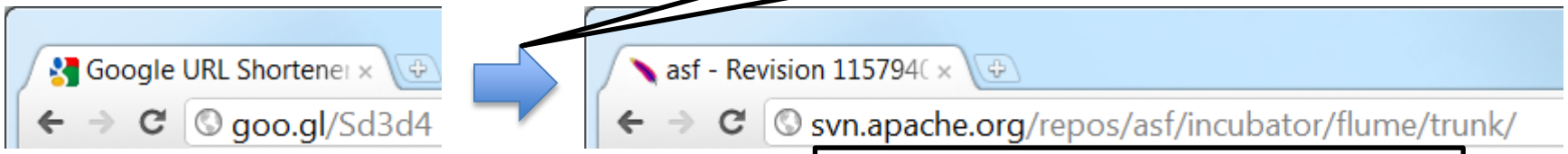
- Know your queries then design your schema
- Column-family oriented
  - Create these by knowing fields needed by queries
  - Its better to have a fewer than many
- App developers optimize the queries, not DBAs
- If you've done the relational DB query optimizations, you are mostly there already!

Schema design exercise

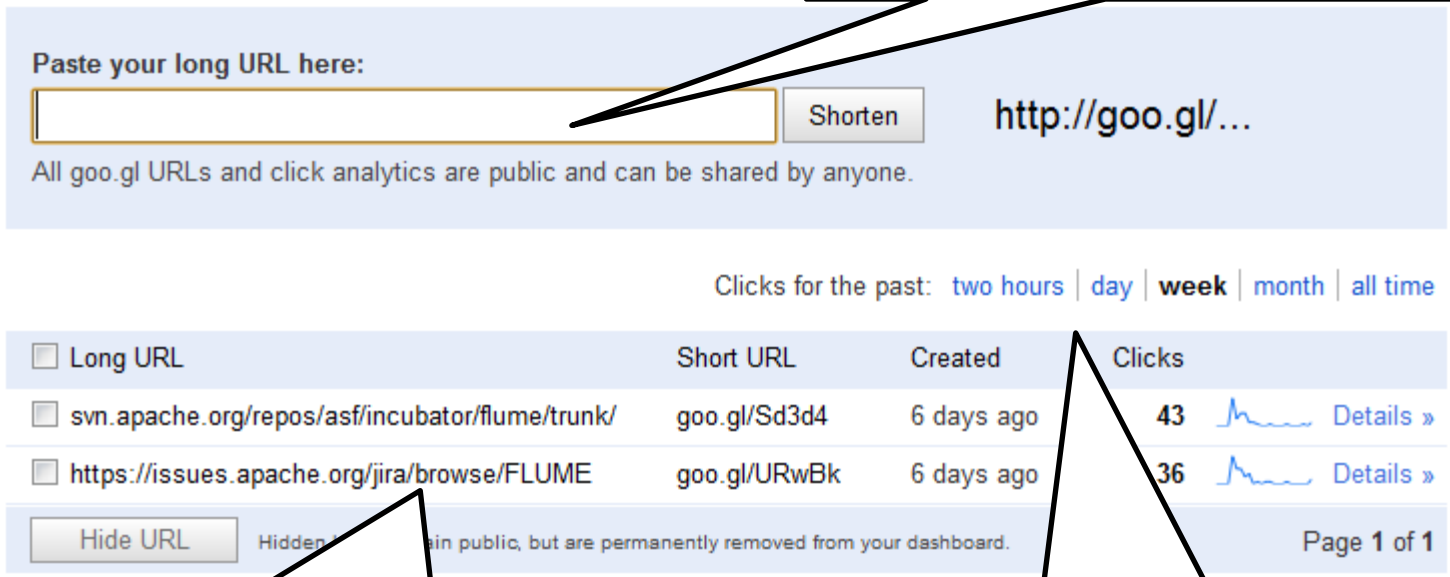
- URL Shortener
  - Bit.ly, goo.gl, su.pr etc.

Url Shortener Servic

Lookup hash, track click, and forward to full url



Enter new long url, generate store to users' mapping to short url



Look up all of a users shortened urls and display

Track historical click counts over time

Url Shortener schema

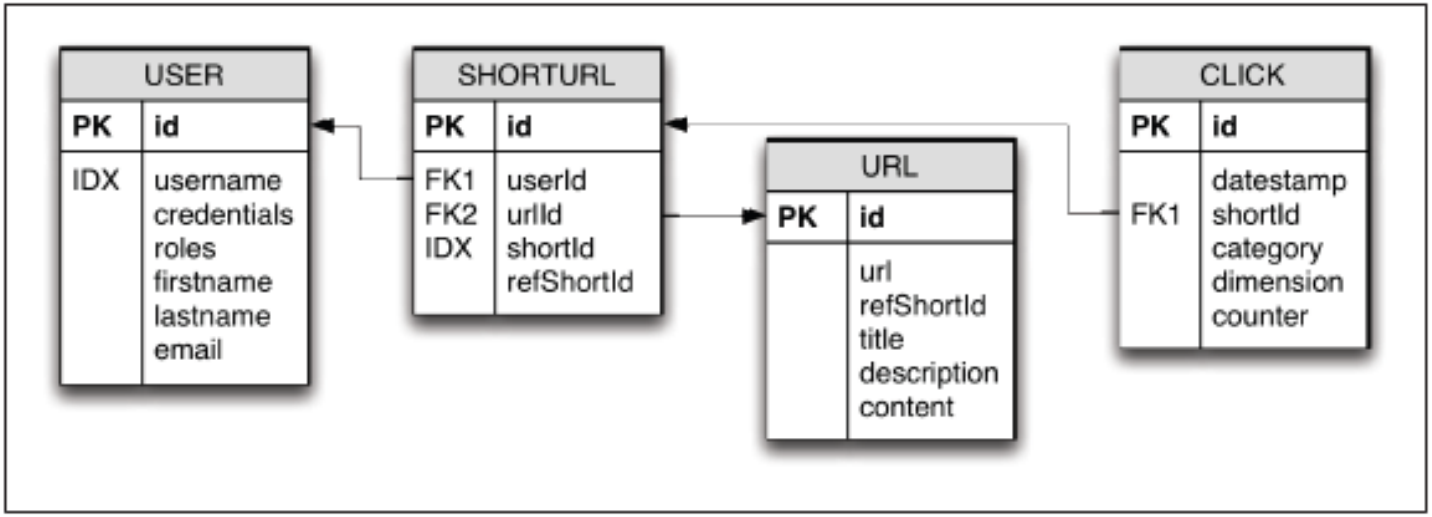


Figure 1-2. The Hush schema expressed as an ERD

- All queries have at least one join
- Constraints when adding new urls, and short urls.
- How do we delete users?

Url Shortener schema

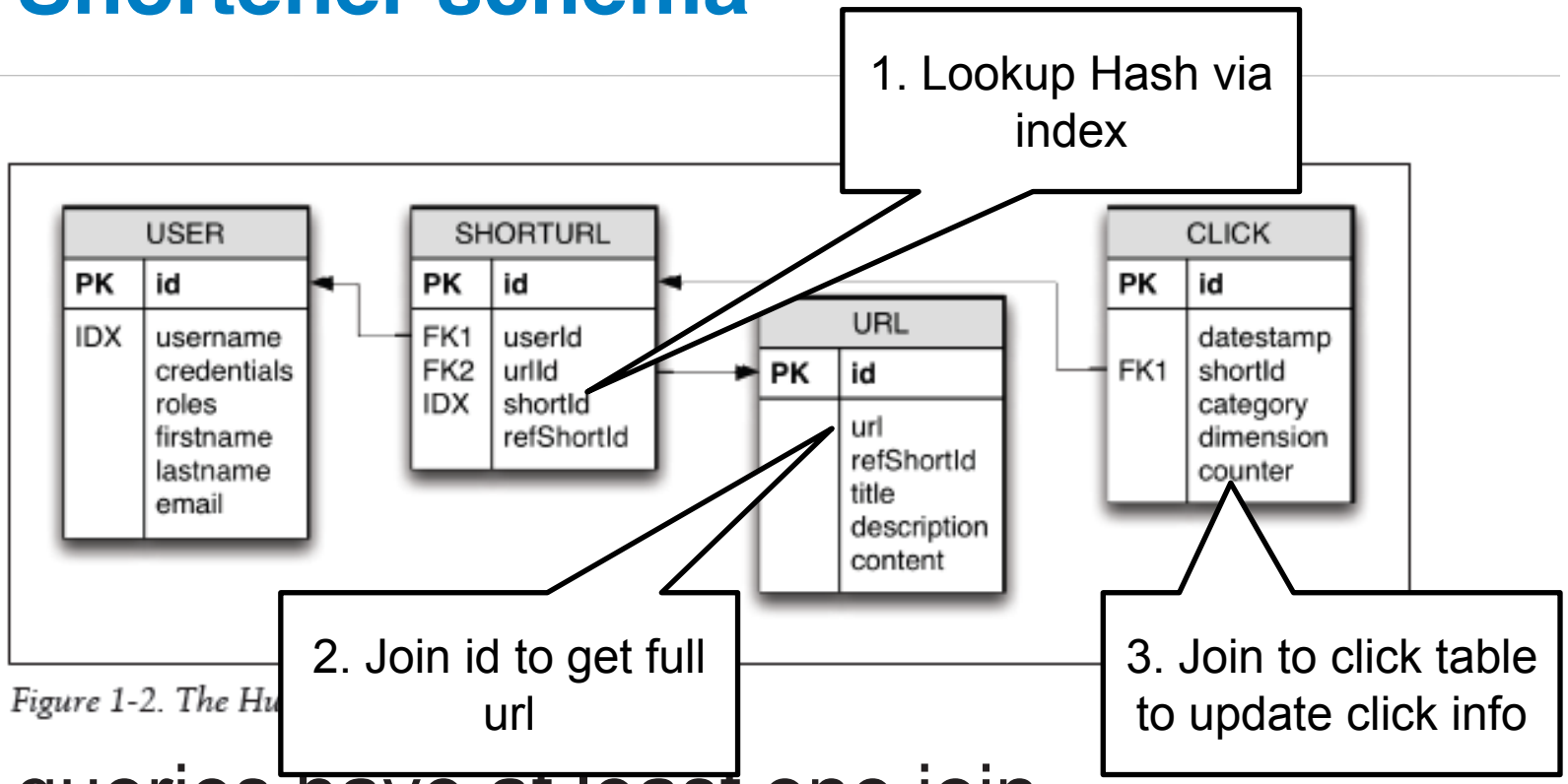


Figure 1-2. The Hu

- All queries have at least one join
- Constraints when adding new urls, and short urls.
- How do we delete users?

Url Shortener HBase schema

- All single queries
- Use c
  settin
  content column families.
- Using rowkey to group all of a user's shortened urls
- Consistency not guaranteed between tables.

1. Get url from url hash

2. Put to update click metrics

Table: shorturl		
Row Key:	shortId	
Family:	data:	Columns: [illegible], refShortId, userId, clicks
	stats-daily: **[ttl: 7days]**	Columns: YYYYMMDD, YYYYMMDD\x00<country-code>
	stats-weekly: **[ttl: 4weeks]**	Columns: YYYYWW, YYYYWW\x00<country-code>
	stats-monthly: **[ttl: 12months]**	Columns: YYYYMN, YYYYMM\x00<country-code>

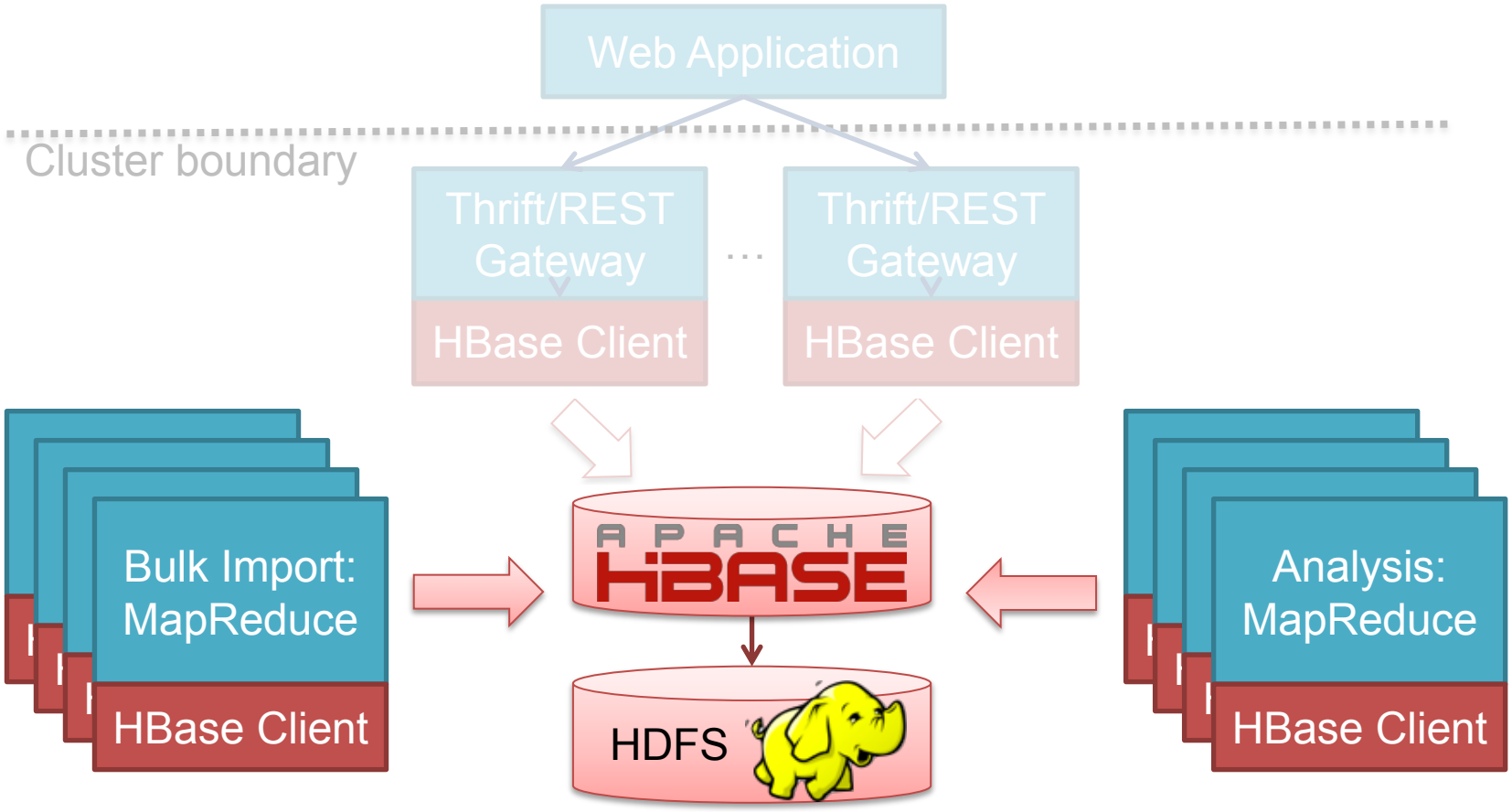
Table: url		
Row Key:	MD5(url)	
Family:	data: **[compressed]**	Columns: refShortId, title, description
	content: **[compressed]**	Columns: raw

Table: user-shorturl		
Row Key:	username\x00shortId	
Family:	data:	Columns: timestamp

Table: user		
Row Key:	username	
Family:	data:	Columns: credentials, roles, firstname, lastname, email

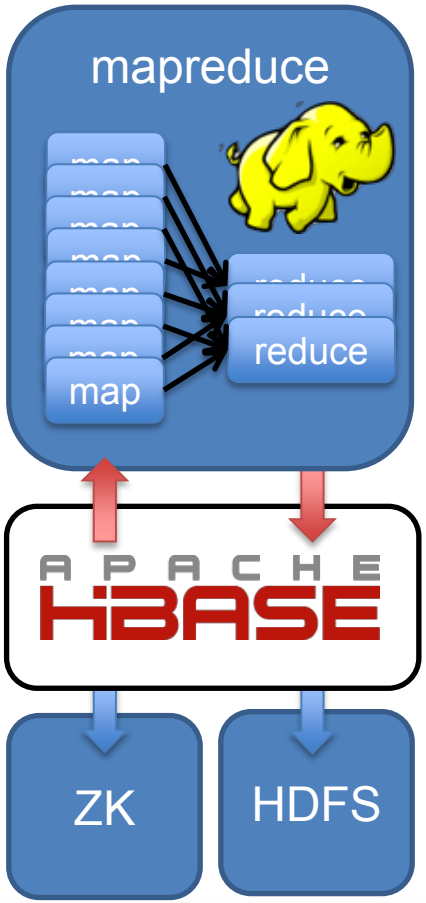
Figure 1-3. The Hush schema in HBase

HBase Analysis Application Architecture



Hadoop MapReduce and HBase

- Use to scalably **process** data into HBase
- Create new data sets from raw data.
  - ETL into DBs/HBase
- High throughput batch processing
  - You would not serve live traffic from MR query or directly from HDFS.
- Users just write a “map” function and a “reduce” function.



MapReduce Processes

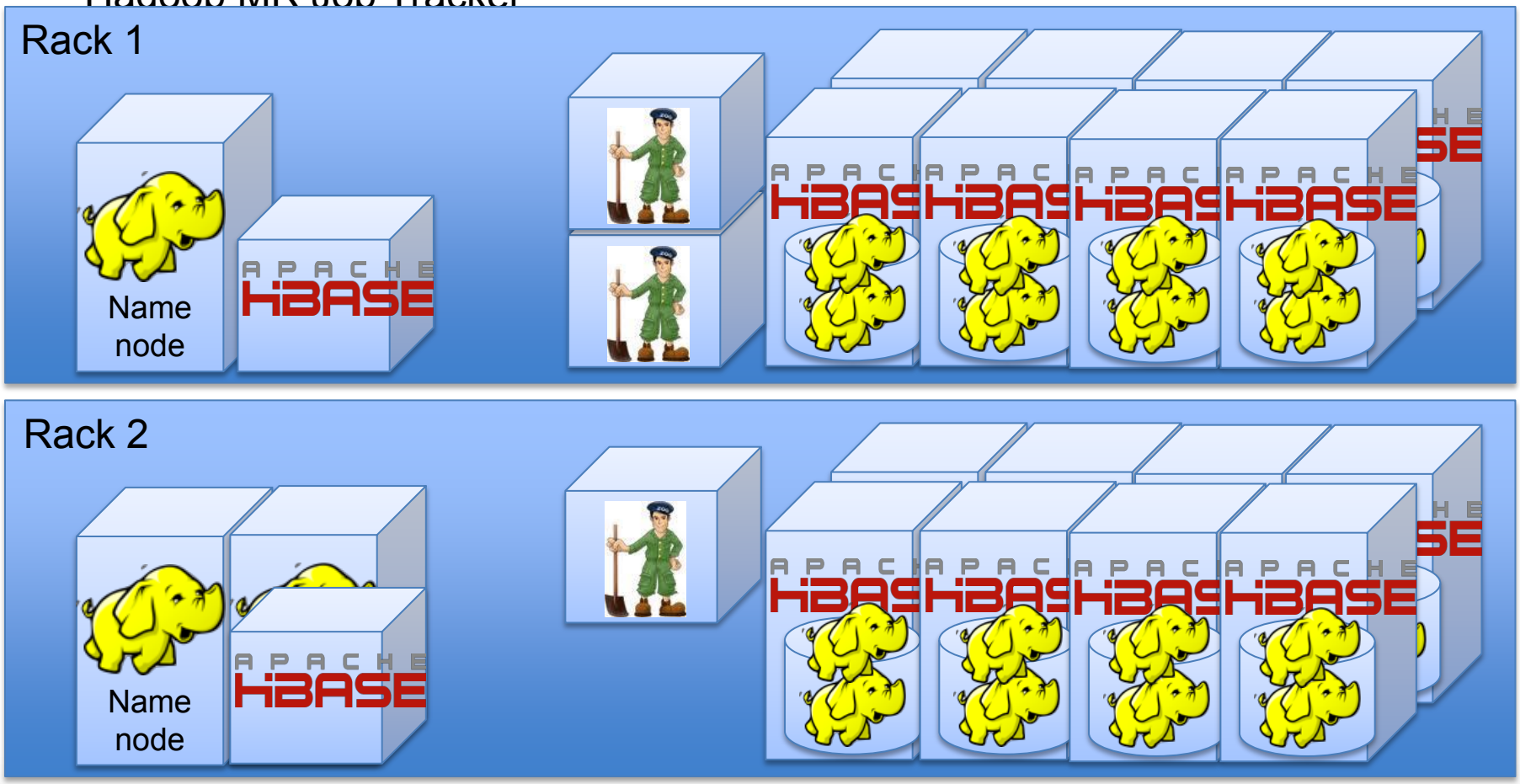
- Job Tracker
  - Schedules work and resource usage through out the cluster
  - Makes sure work gets done
    - Controls retry, speculative execution, etc.
- Task Trackers
  - These slaves do the “map” and “reduce” work
  - Co-located with data nodes

HBase + HDFS + MR Nodes (physically)

HDFS NameNodes
HBase Masters
Hadoop MR Job Tracker

ZooKeeper Quorum

Slave Boxes (DN + RS + TT)



Data Loading Patterns

- Random Writes
  - Uses Put API
  - Simple
  - Low latency
  - Less throughput (more HBase overhead)
- Use Case:
  - Real-time Web apps
  - Real-time serving of data
- Example:
  - Inbox, url shortener

- Bulk import
  - Use MapReduce to generate HBase native files, atomically add metadata.
  - High Latency
  - High Throughput
- Use Case:
  - Large scale analysis
  - Generating derived data
  - ETL
- Examples:
  - Delayed Secondary indexes
  - Building search index
  - Exploring HBase Schemas

Schema Design Exploration

- Applications optimized by designing the structure of data in HBase
  - MR, HDFS and HBase complement each other.
- Exploration Steps:
  - Save raw data to HDFS/HBase.
  - MR for data transformation and ETL-like jobs from raw data.
  - Use bulk import from MR to HBase.
  - Serve data from HBase

HBase vs just 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**
Structured storage	**Do-it-yourself / TSV / SequenceFile / Avro / ?**	**Sparse column-family data model**
Max data size	**30+ PB**	**~1PB**

If you have neither random write nor random read, stick to HDFS!

Rules for Applications

- HBase isn't really worth the effort until you have 5-10 machines.
- No Performance Isolation guarantees in HBase (yet)
  - Start conservative
  - Isolate applications and workloads by having more clusters.
    - If scale warrants, separate real-time applications into separate HBases.
    - Separate your Batch MR workloads from your realtime workloads if possible.

Examples

- Facebook
  - Many clusters, one application (Facebook Message)
  - Pods of 100-200 HBase Region servers
  - Easier for maintenance, and standardized hardware deploy in many data centers.

Outline

- Enter Apache HBase
- The HBase Data Model
- System Architecture
- Real-World Applications
- **Deployment and Operations**
- Conclusions

cloudera

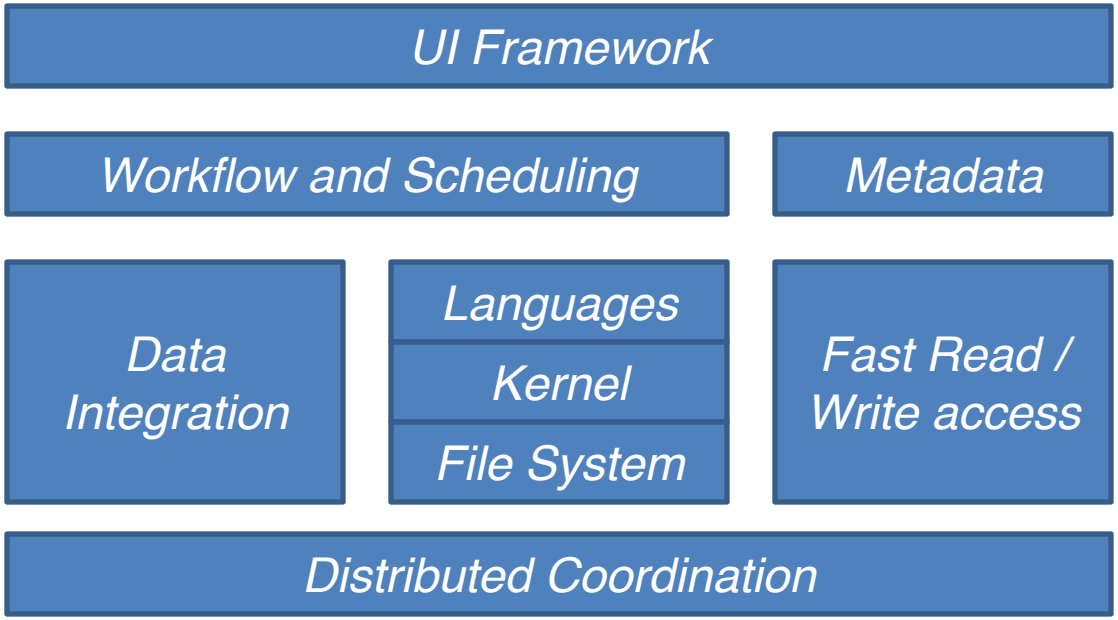
Monitoring, Benchmarking, Tuning, and Troubleshooting

DEPLOYMENT AND OPERATIONS

HBase Operations

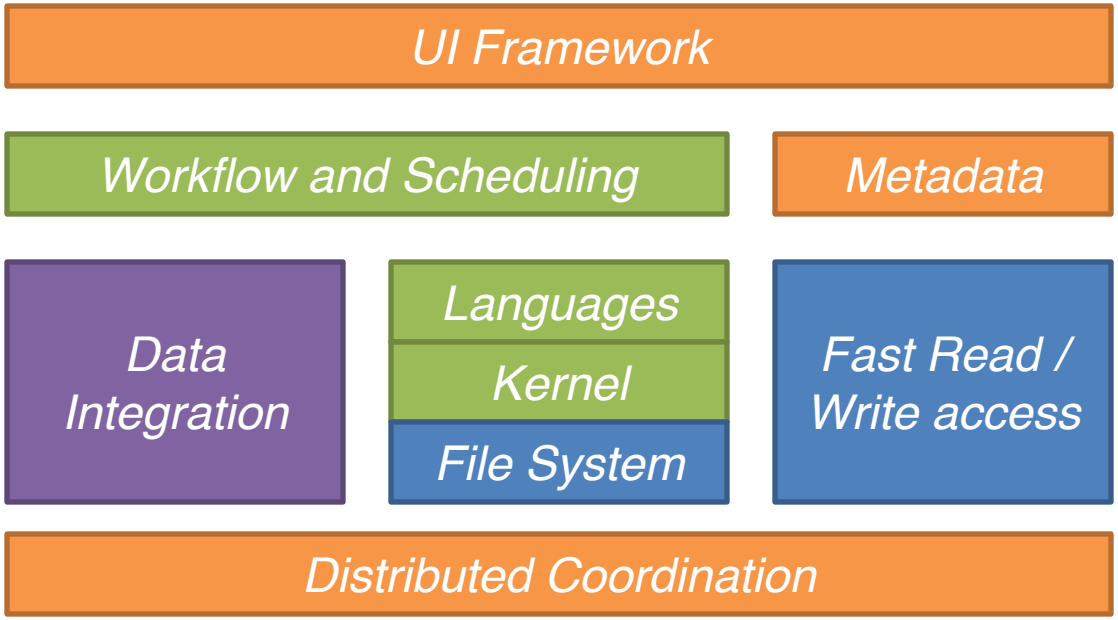
- Choosing a distribution
- Monitoring
- Performance and tuning
- Troubleshooting
- Backups and Disaster recovery

The Hadoop Big Data Stack



- Hadoop is the core of the Stack.
  - The kernel of a cluster operating system
- Each “friend” is a distributed service that has a similar workstation tool.

CDH4's Hadoop stack



- Storage : HDFS, HBASE
- Processing : MR, MR2, Pig, Hive, Mahout, Oozie
- Data Integration: Flume, Sqoop
- Coordination : ZooKeeper, Avro, Bigtop, (Hive), Hue

Distribution Options

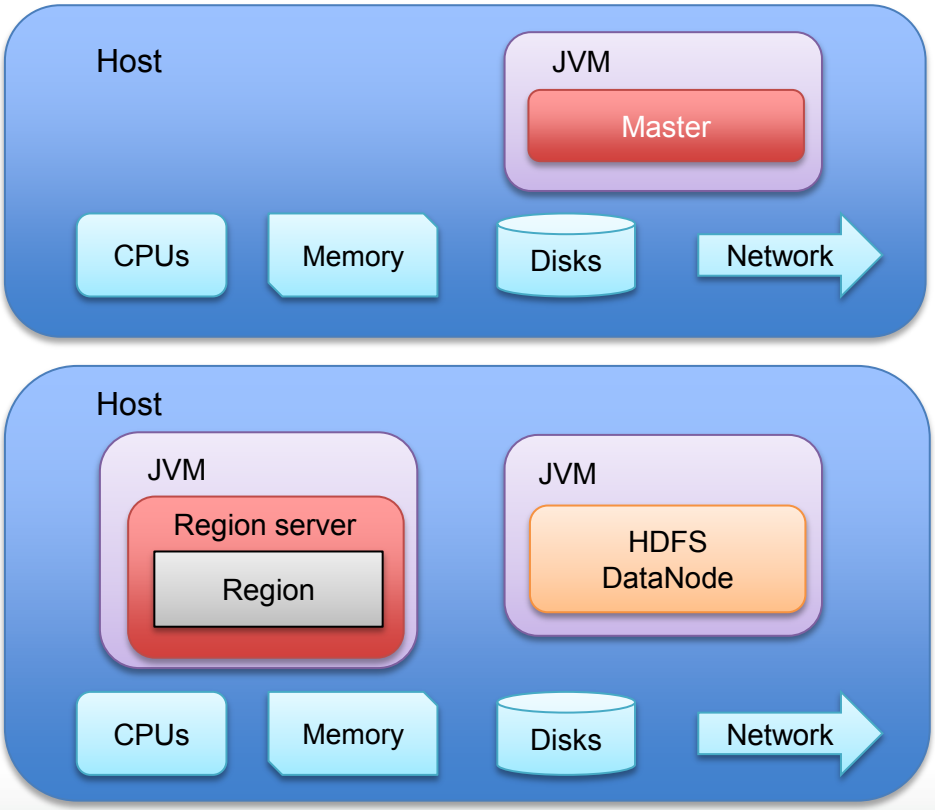
- Use Tarballs
  - Build your own deployment or use puppet/chef
  - Apache Whirr for EC2
- Use Packages (RPMs/Debs)
  - Apache Bigtop (Hadoop stack integration and packaging)
- Use Vendor Packages
  - Cloudera's Distribution including Apache Hadoop (CDH)
  - Cloudera Manager Free Edition
  - HortonWorks Data Platform

Monitoring + Metrics

- "If you cannot measure it, you cannot improve it"

- System Metrics
  - SAR
  - JVM GC
- HBase Metrics
  - Get / put latencies
  - Operations / sec
  - Hbase Health – hbck
  - HBase's Web UI

- Integrate with existing tools
  - Ganglia / Nagios
  - JMX / JConsole
  - Cloudera Manager



Ganglia .sourceforge.net

bolt Cluster Report for Sat, 22 Sep 2012 06:48:34 -0700

Get Fresh Data

Metric load_one | Last day | Sorted descending | Physical View

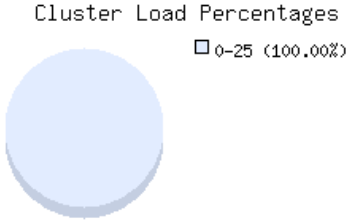
Grid > bolt > --Choose a Node

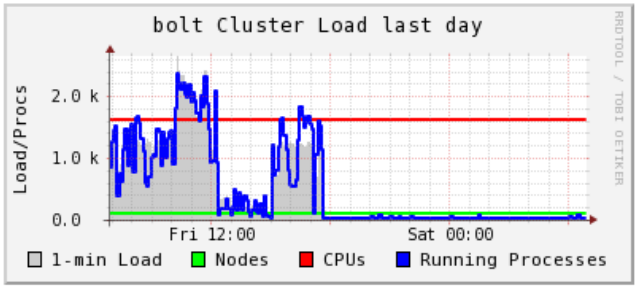
Overview of bolt

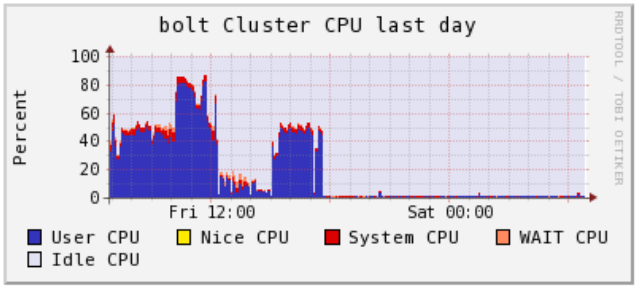
CPUs Total: **1616**
Hosts up: **102**
Hosts down: **0**

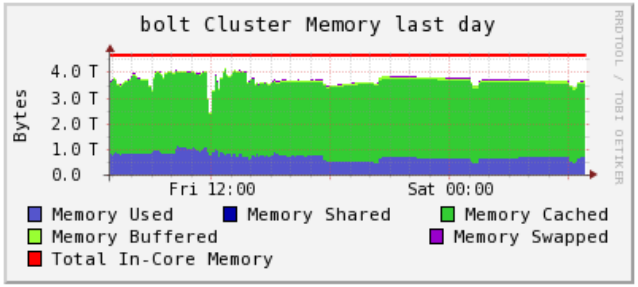
Avg Load (15, 5, 1m):
1%, 1%, 1%
Localtime:
2012-09-22 06:48

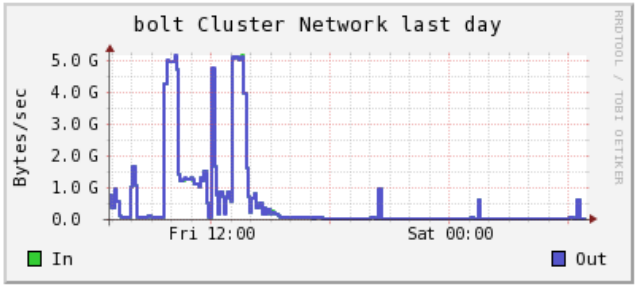
Cluster Load Percentages



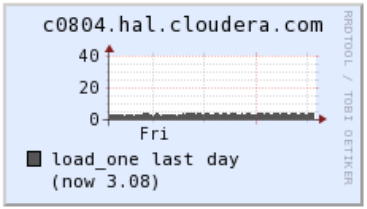


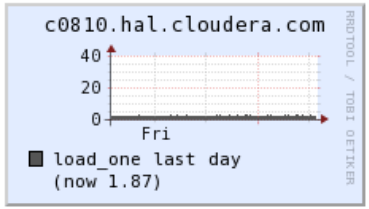


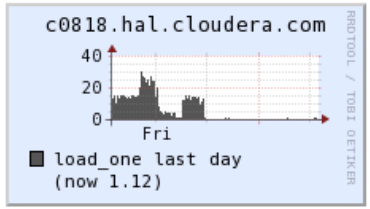


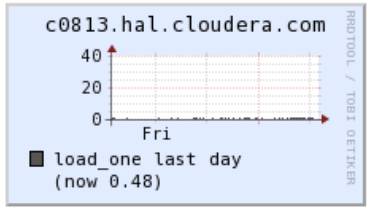


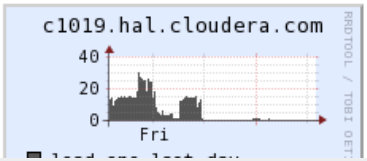
Show Hosts: yes ◉ no ○ | bolt **load_one** last **day** sorted **descending** | Columns 4 | Size small

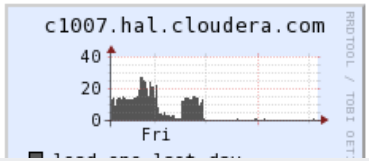


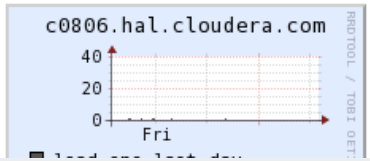


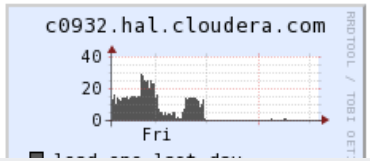












Ganglia .sourceforge.net

bfd-a Cluster Report for Sat, 22 Sep 2012 10:08:47 -0700

Get Fresh Data

Metric load_one ▾ Last month ▾ Sorted descending ▾ Physical View

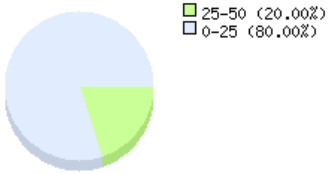
Grid > bfd-a > --Choose a Node ▾

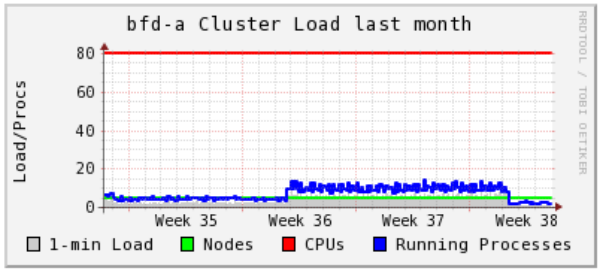
Overview of bfd-a

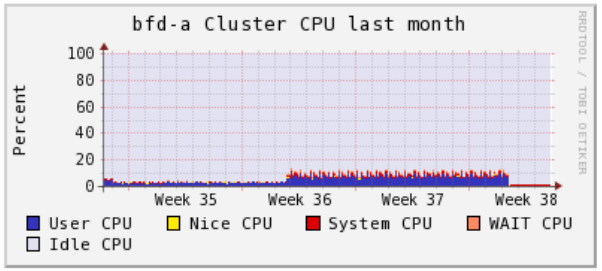
CPUs Total: **80**
Hosts up: **5**
Hosts down: **0**

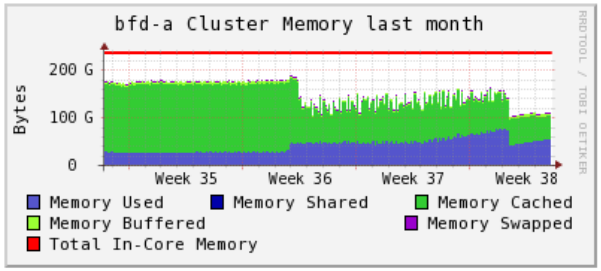
Avg Load (15, 5, 1m):
10%, 11%, 6%
Localtime:
2012-09-22 10:08

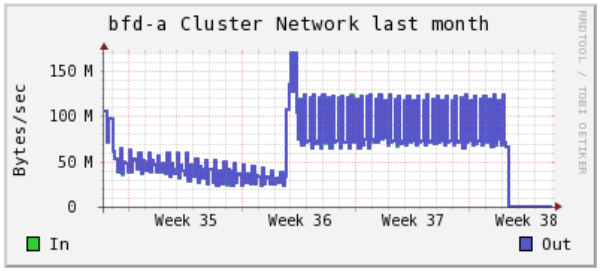
Cluster Load Percentages

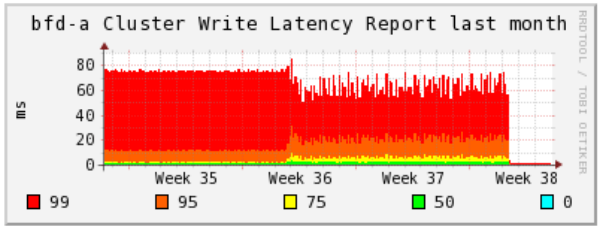


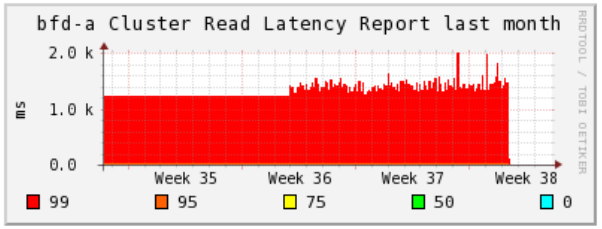




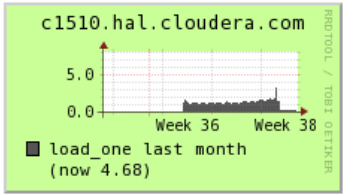


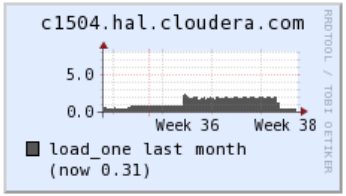


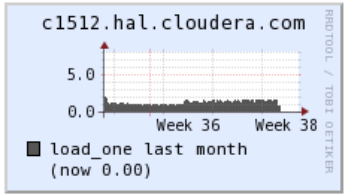


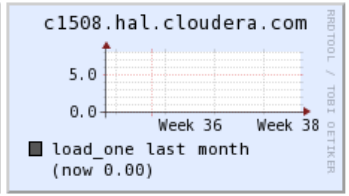


Show Hosts: yes ◉ no ○ | bfd-a **load_one** last **month** sorted **descending** | Columns 4 ▾ Size small ▾









HBase Performance Benchmarking

- Kinds of workloads:
  - Writes / Reads / Mixed workloads
  - Sequential vs Random
  - Query Distribution (Caching)
  - MR workload
- MR based benchmarks can be biased by MR overhead.

Performance benchmarks suites

- HBase:Performance Evaluation
  - Micro benchmarks (but uses MR)
  - Test some basic hbase workloads (random/sequential reads/writes)

```
hbase org.apache.hadoop.hbase.PerformanceEvaluation
```

- Yahoo!'s Cloud Serving Benchmark (YCSB)
  - http://research.yahoo.com/Web_Information_Management/YCSB
  - One harness many workloads, many Datastores.
  - Different query and write distributions: Uniform and Zipf
  - Records latencies and throughput.
  - Make sure to get updated versions that presplit HBase tables!

```
java -classpath `hbase classpath` com.yahoo.ycsb.Client  -db
   com.yahoo.ycsb.db.HBaseClient
```

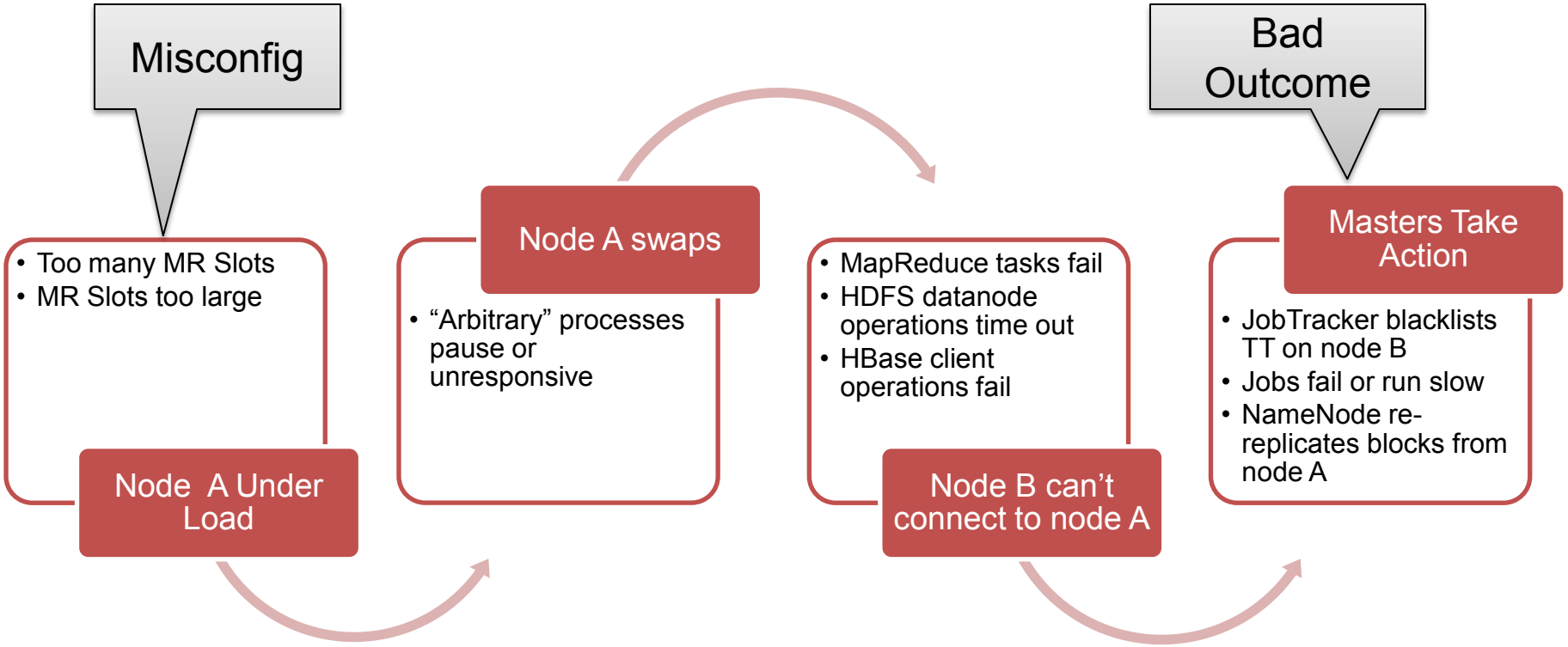
- HDFS: DFSIO
  - An aggregate HDFS IO throughput test. (uses MR)

```
hadoop jar $HADOOP_HOME/hadoop-*-test.jar TestDFSIO
```

Configuring HBase

- HBase depends on other systems so you need to understand enough of each.
- hdfs-site.xml, hbase-site.xml, zoo.cfg, hbase-env.sh
- System settings
  - Don’t Over provisioning host memory
    - 1GB / DN, 1-2GB/MR Task, 8-16 GB/RS
  - Bump up ulimit to 32k+
  - Bump up ZK max connections to 100+

Troubleshooting: Memory Over-subscription

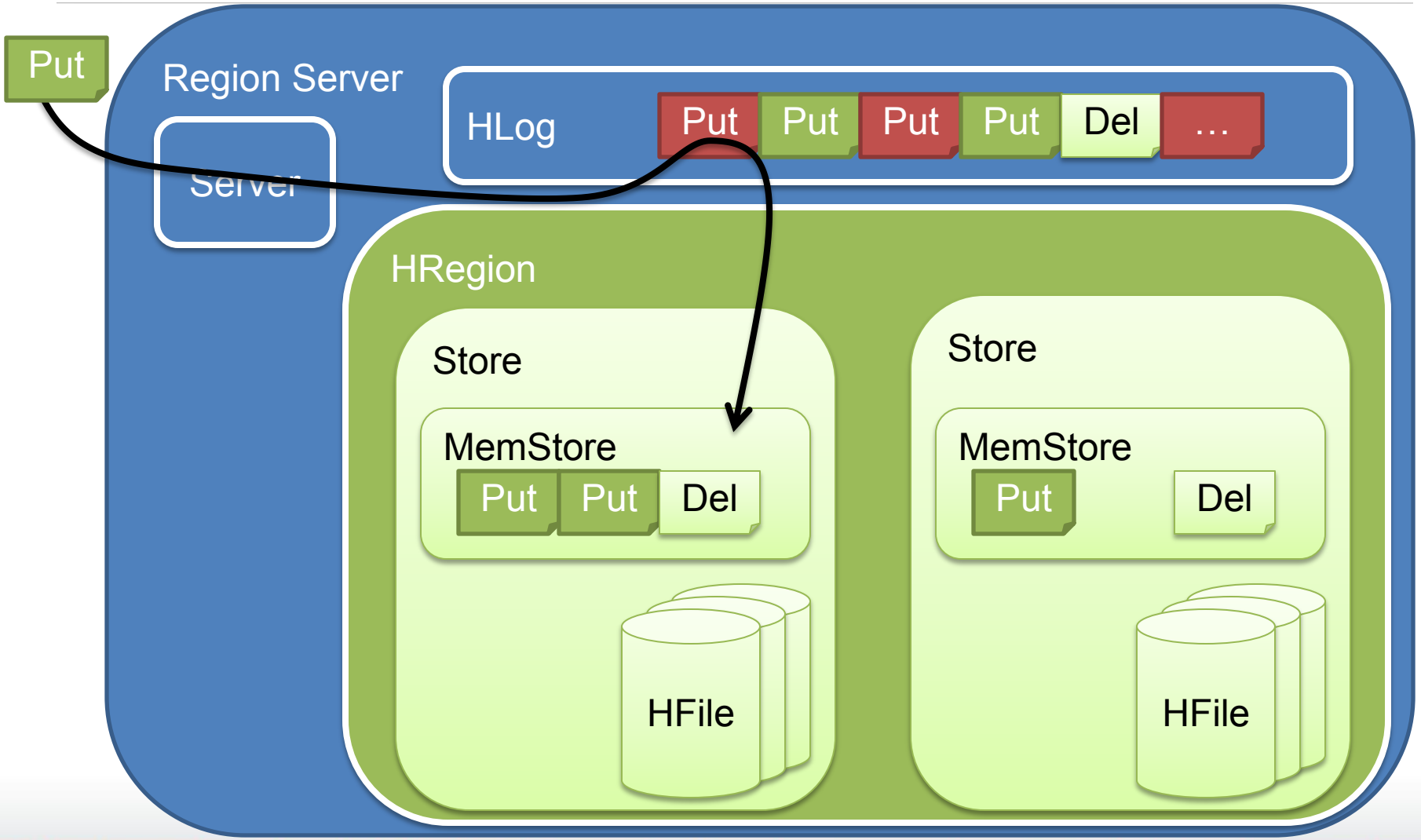


Isolate the problem, pull the thread, fix the problem.

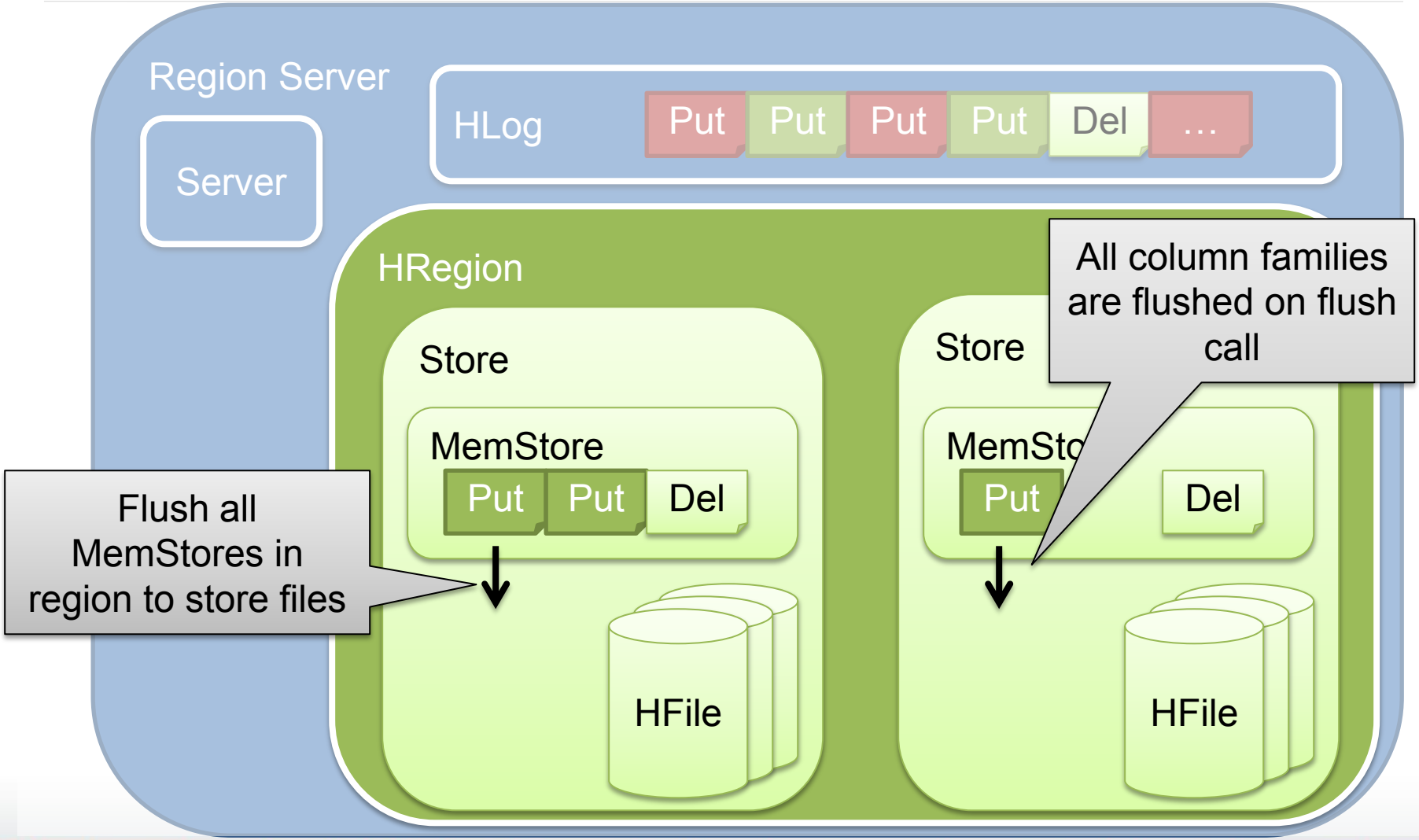
Tuning HBase for writes

- Scaling writes requires a bit of architecture understanding
  - Puts
  - Flushes
  - Compactions
  - Splits (sharding, triggers compaction)

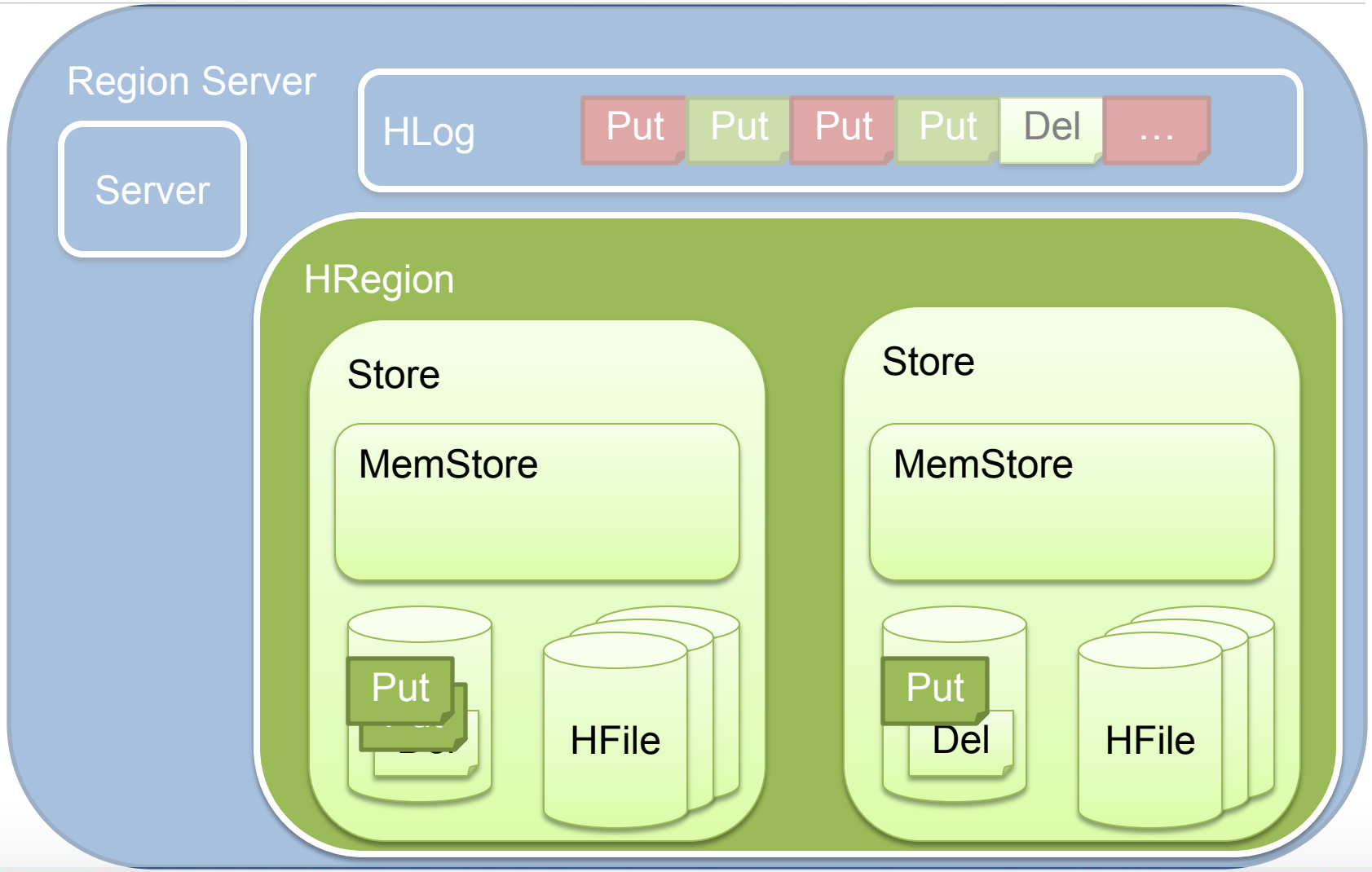
HBase Write Path



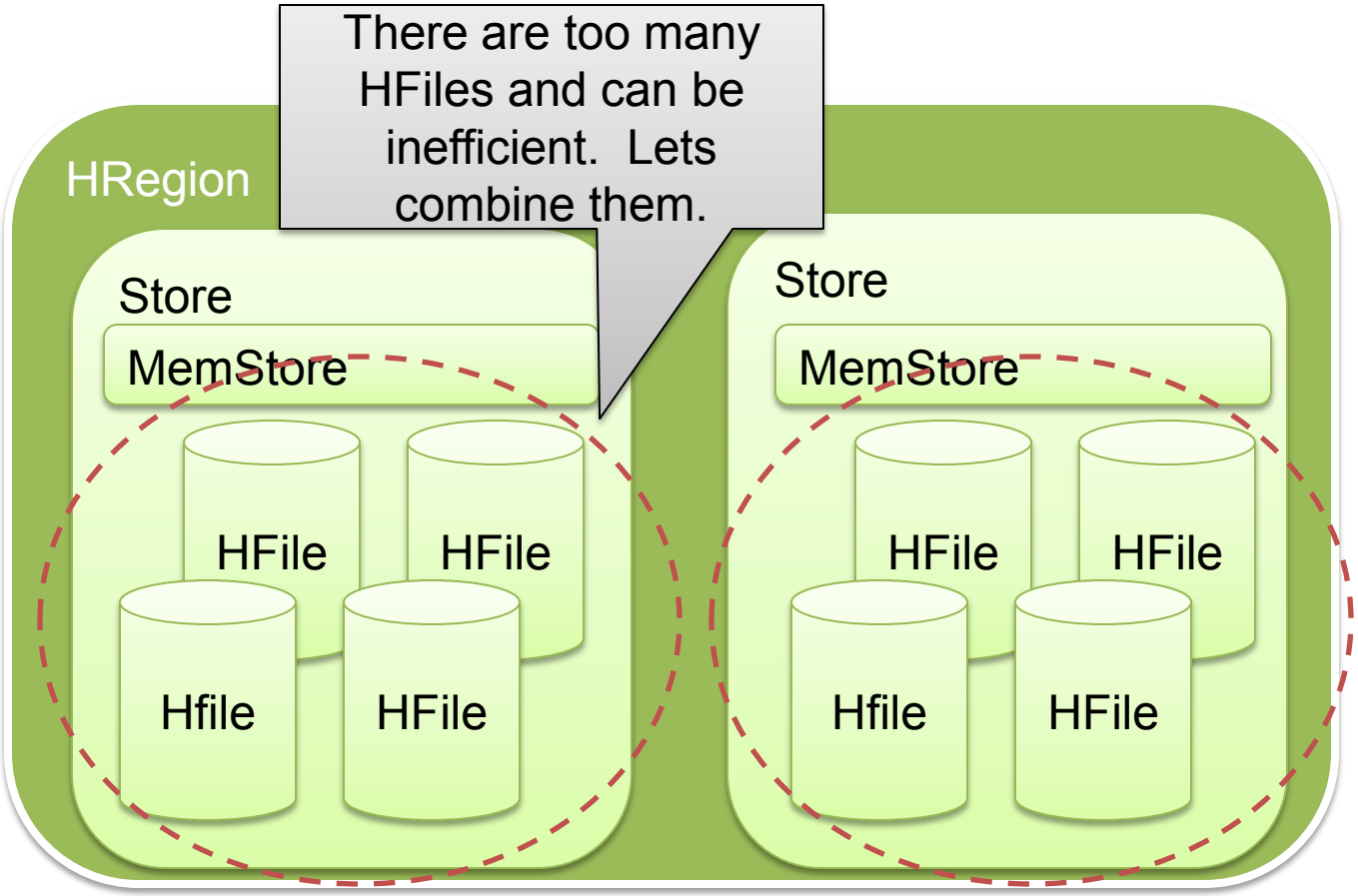
HBase Write Path: Flush



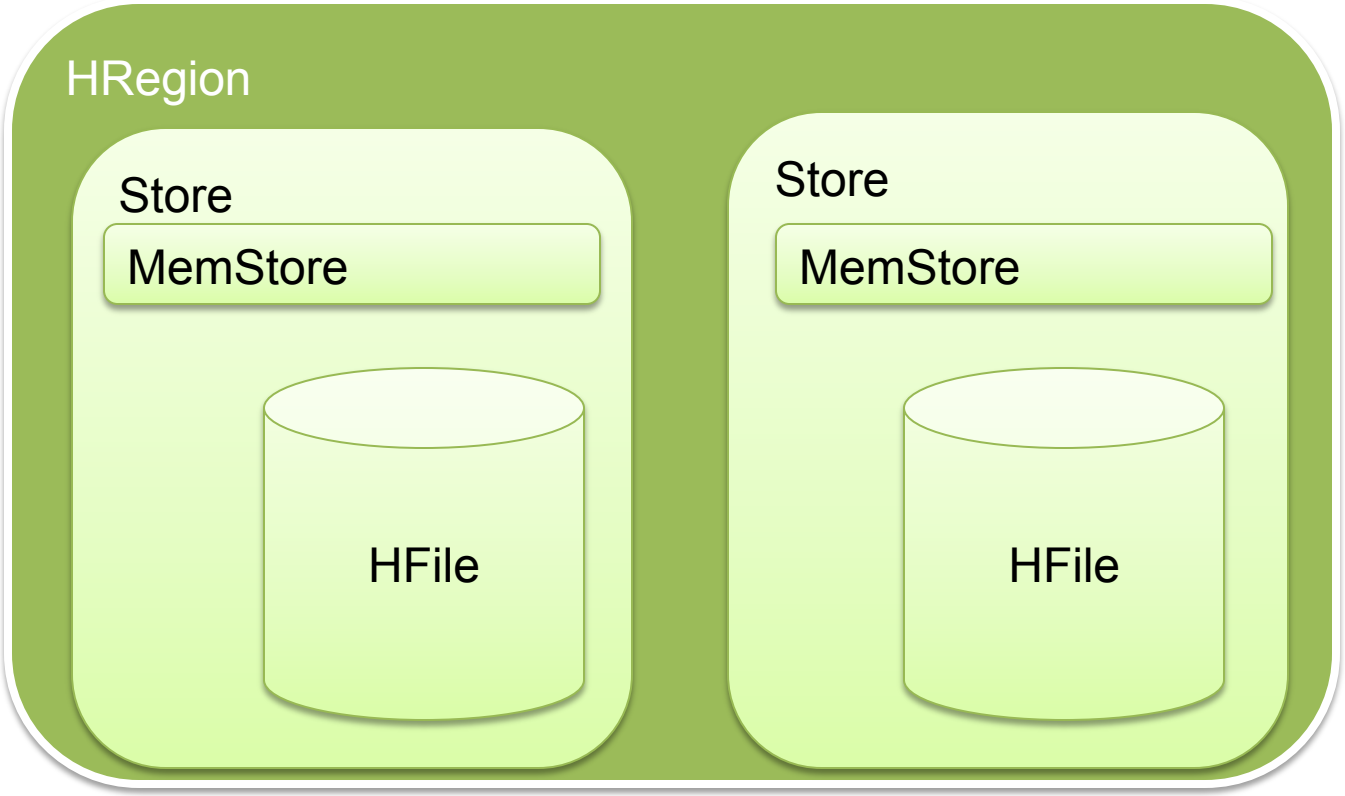
HBase Write Path: Flush



HBase Compaction



HBase Compaction



HBase Regions: operational advice

- Pre-split your regions
  - Creating a table by default creates one region that splits.
  - If you know your key distribution presplit so that writes and reads can be load balanced.
- Compaction Storms
  - GC during compaction == long pause / unavailbility
  - Schedule Major compactions at off times
  - Schedule splits at off times (Triggers major compact)
  - Tune the size of memstores / max files before majore compact
- JVM GC tuning
  - Overly large HBase heaps
    - Stop-the-world GC's @ 8-10s/GB
  - MSLAB mitigation (Avoid fragmentation old gen)
  - Debugging GC:
    - `-verbose:gc -XX:+PrintGCDetails -XX:+PrintGCDateStamps`
- Favor more machines over beefier machines (More IO)

Outline

- Enter Apache HBase
- The HBase Data Model
- System Architecture
- Real-World Applications
- Deployment and Operations
- **Conclusions**

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CONCLUSIONS

Key takeaways

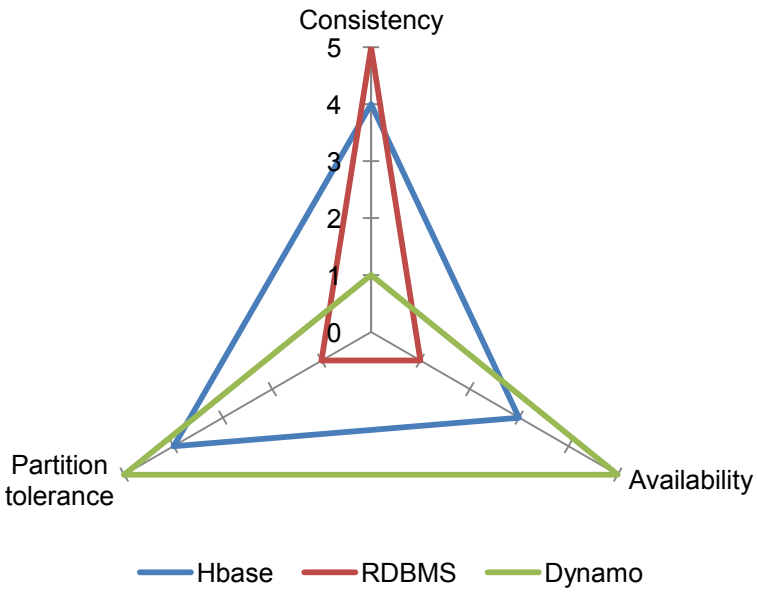
- Apache HBase is not a RDBMS! There are other scalable databases.
- Query-centric schema design, not data-centric schema design.
- In production at 100's of TB scale at several large enterprises.
- If you are restructuring your SQL DB to optimize it, you may be a candidate for HBase.
- HBase complements and depends upon Hadoop.
- New features focused for enterprise needs.

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

HBase vs other “NoSQL”

- Favors **Strong Consistency** over **Availability** (but availability is good in practice!)
- **Great Hadoop integration** (very efficient bulk loads, MapReduce analysis)
- **Ordered range partitions** (not hash)
- **Automatically shards/scales** (just turn on more servers, really proven at petabyte scale)
- **Sparse column storage** (not key-value)



HBase vs just 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**
Structured storage	**Do-it-yourself / TSV / SequenceFile / Avro / ?**	**Sparse column-family data model**
Max data size	**30+ PB**	**~1PB**

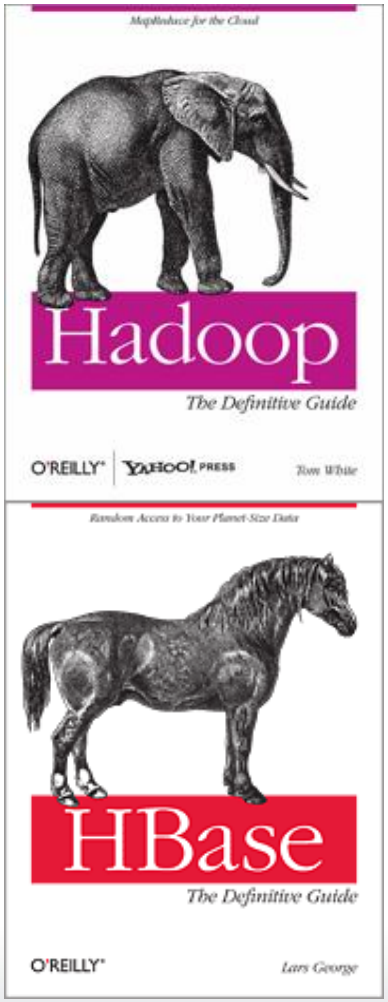
If you have neither random write nor random read, stick to HDFS!

Deployment and Operations

- HBase interacts with many systems.
  - This is powerful –
    - Each component excels at a particular function
    - Live and in production at top 100 websites
  - This can be challenging–
    - Many knobs to tune
  - Isolated instances to make managing easier
- Monitor monitor monitor

More resources?

- Download Hadoop and HBase!
  - CDH - Cloudera's Distribution including Apache Hadoop http://cloudera.com/
  - http://hadoop.apache.org/
- Try it out! (Locally, VM, or EC2)



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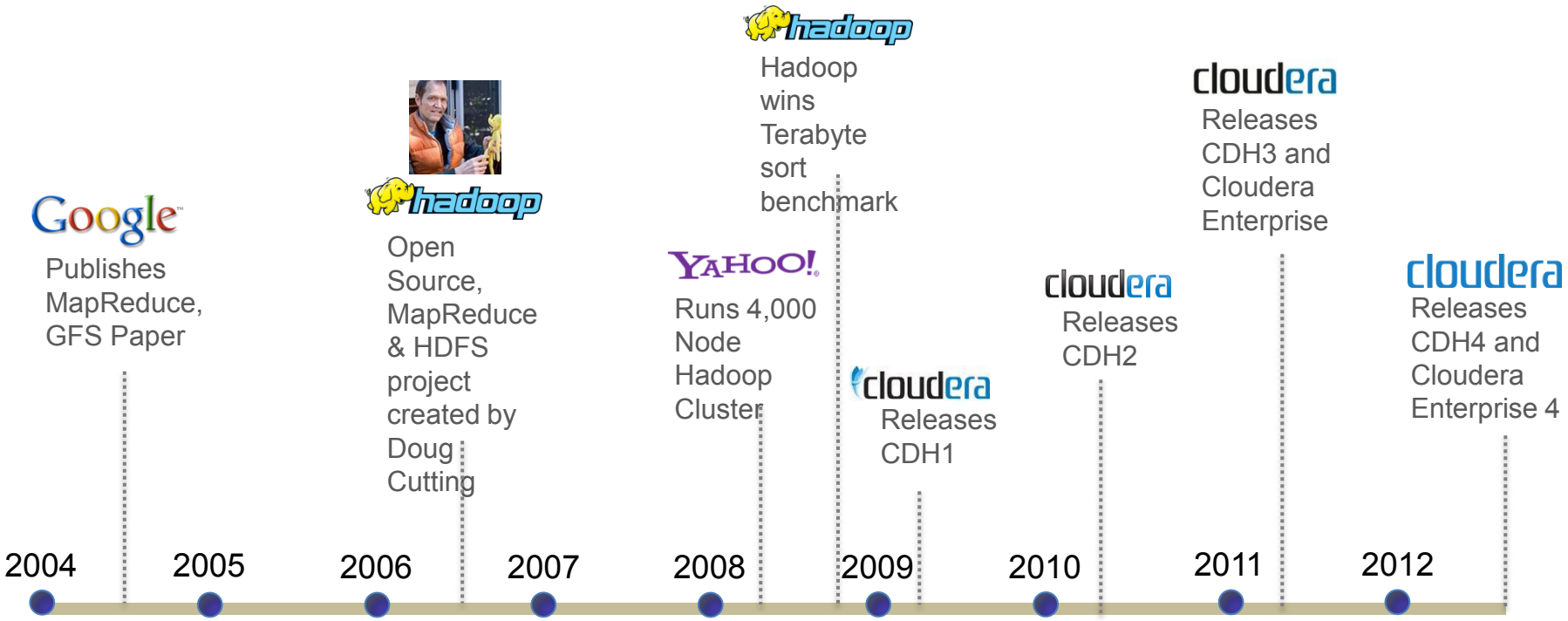
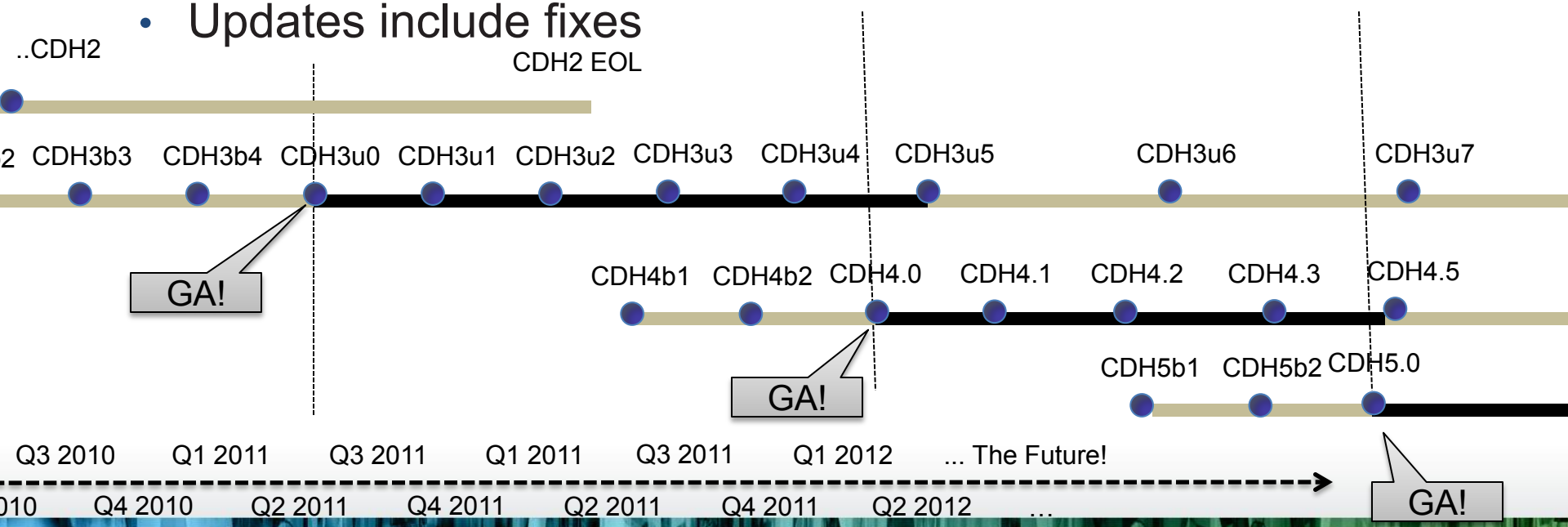
QUESTIONS?

Origin of Apache Hadoop and CDH



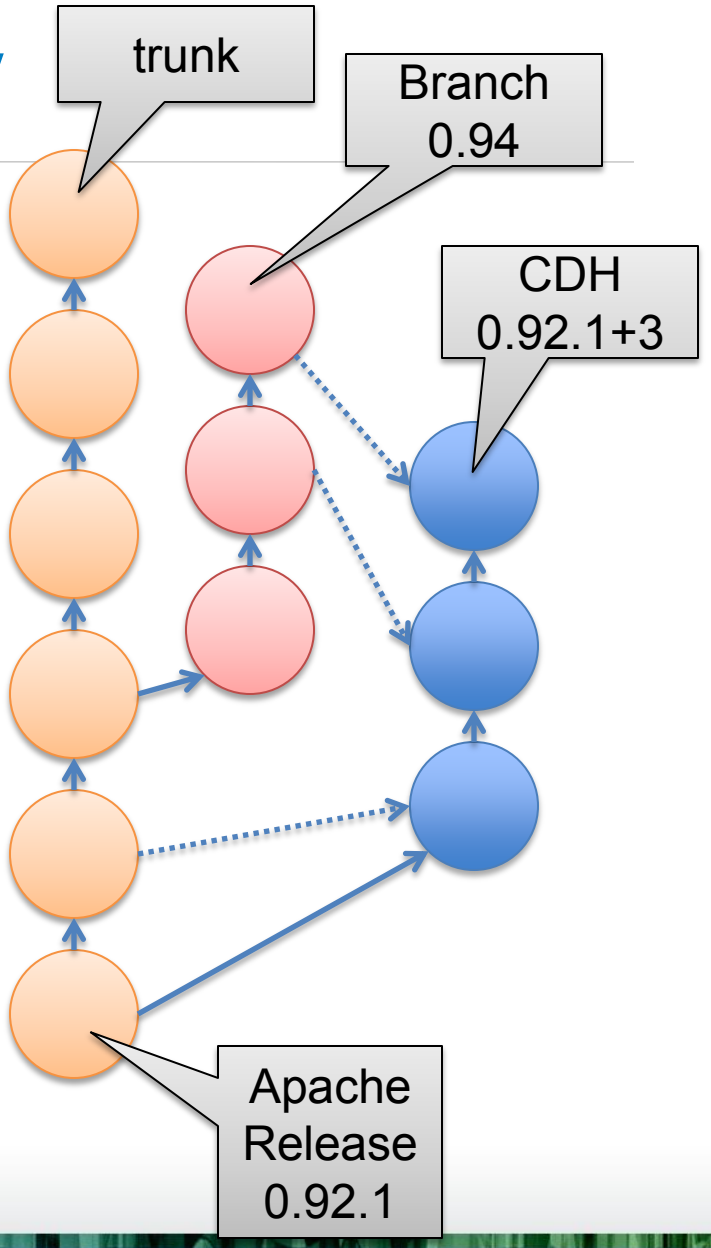
Predictable Release Schedule

- Regular release and updates
  - Skip updates without penalty
- Compatibility policy
  - Only major releases break compatibility
  - Updates can include new features
  - Updates include fixes



Open source methodology

- What's different from Apache?
- All components have code committed **upstream** first then backports code to CDH on top of a "pristine apache release"
- All patches available in tarballs

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CHANGING
THE WORLD
ONE PETABYTE
AT A TIME

Install HBase on your laptop

- Download and untar

```
wget
  http://apache.osuosl.org/hbase/hbase-
  0.92.2/hbase-0.92.2.tar.gz
tar xvfz hbase-0.92.2.tar.gz
cd hbase-0.92.2
bin/start-hbase.sh
```

- Verify:

```
bin/hbase shell
```

Browse `http://localhost:60010`