DataStax

Apache Cassandra in Action

Jonathan Ellis

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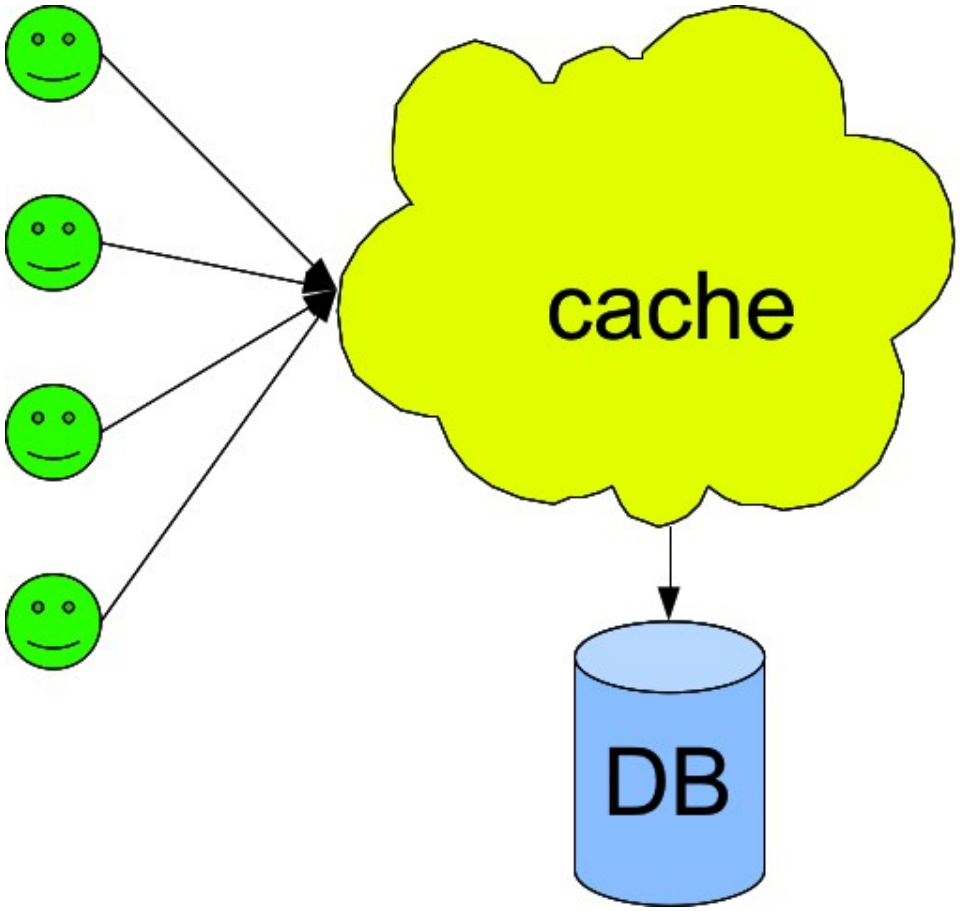
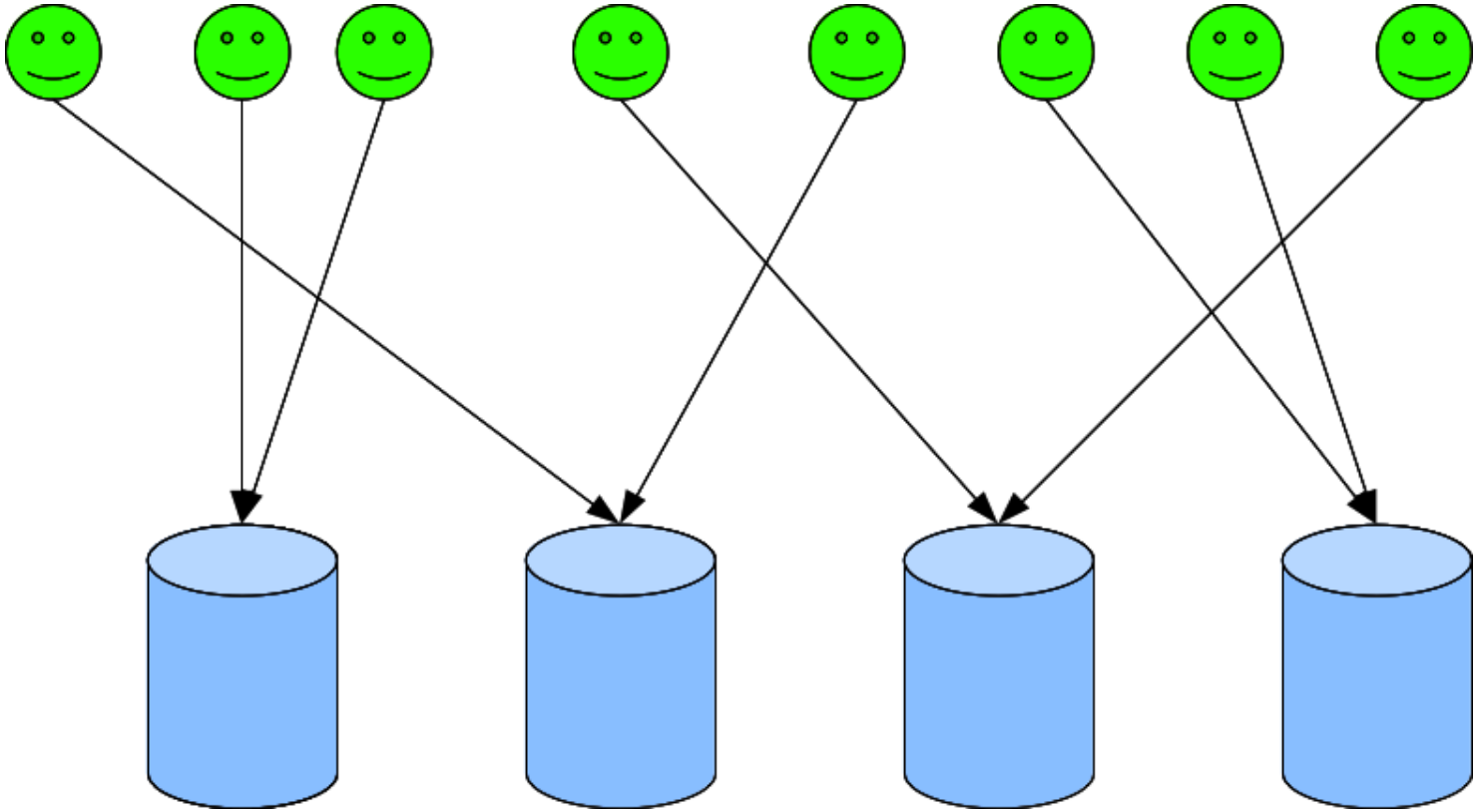
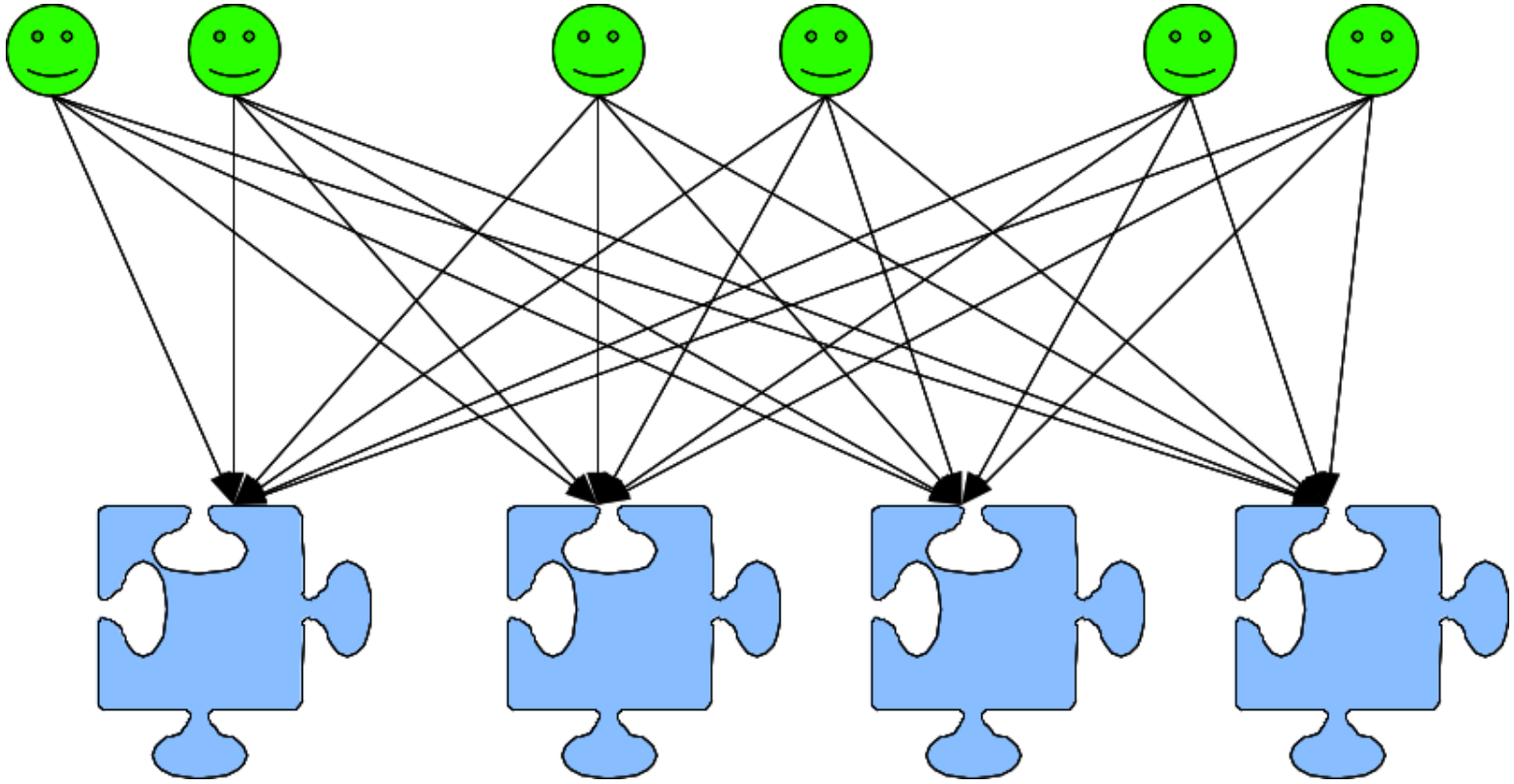
Why Cassandra?

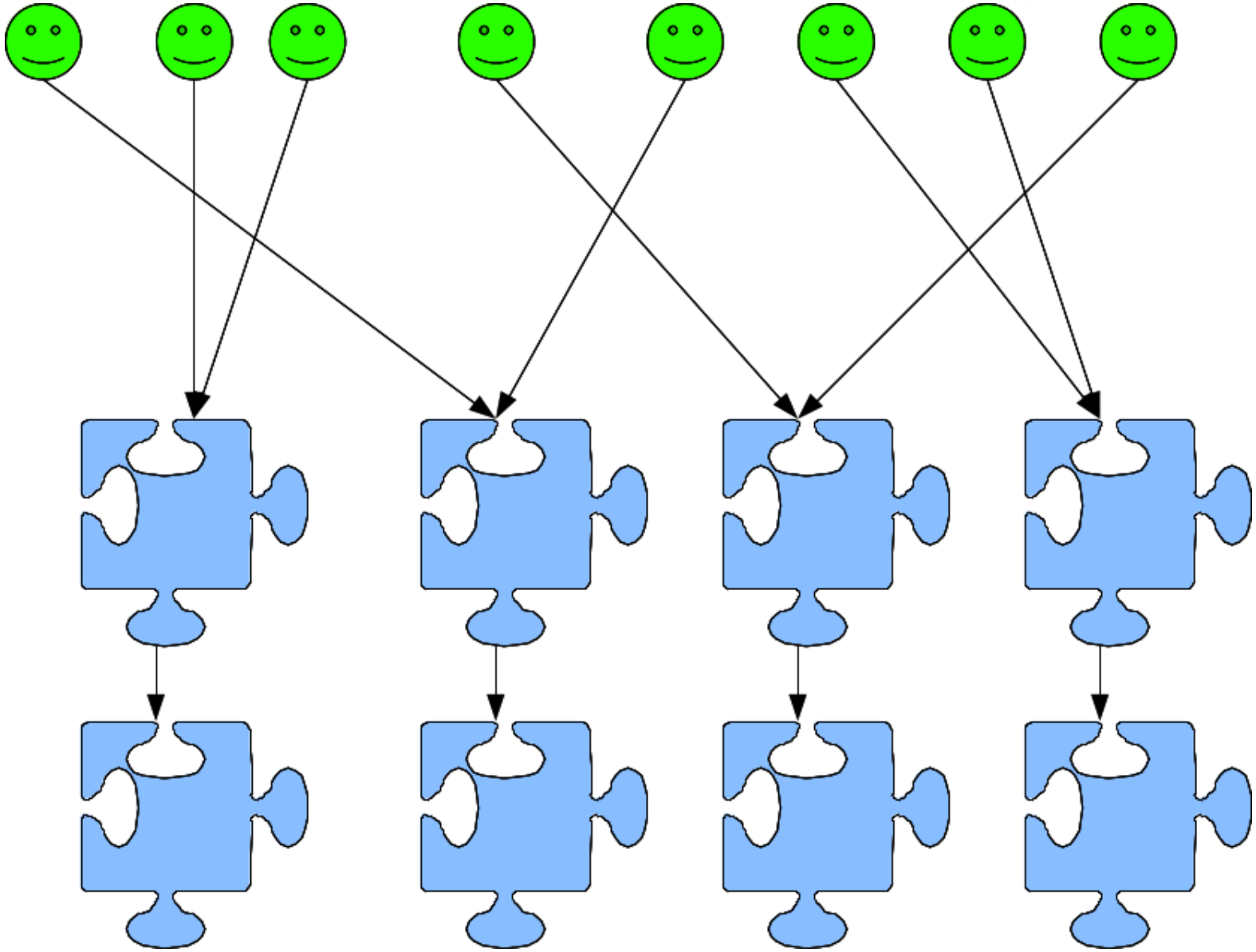
- **Relational databases are not designed to scale**
- **B-trees are slow**
  - and require read-before-write

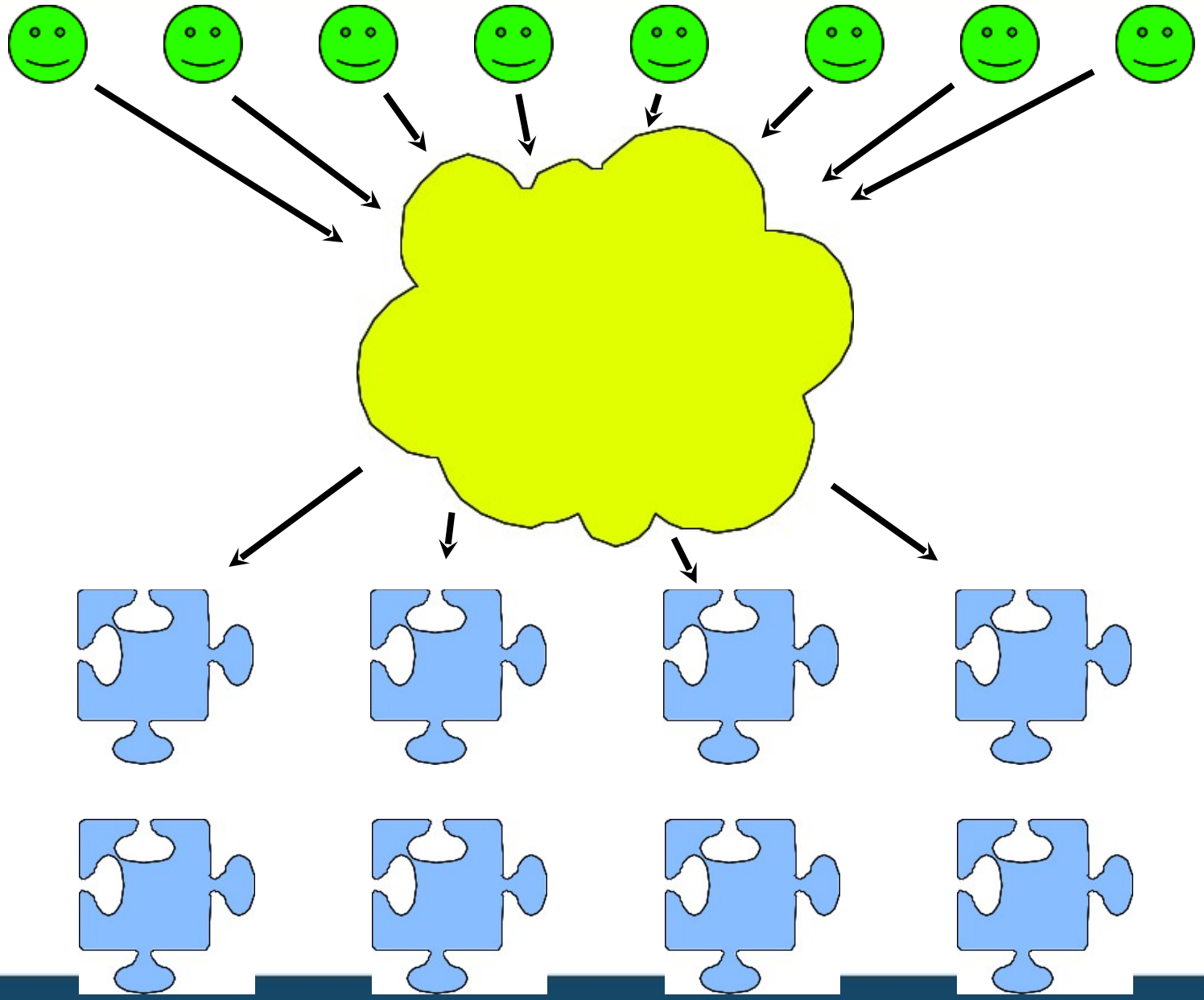

Sun
microsystems
Sun
microsystems

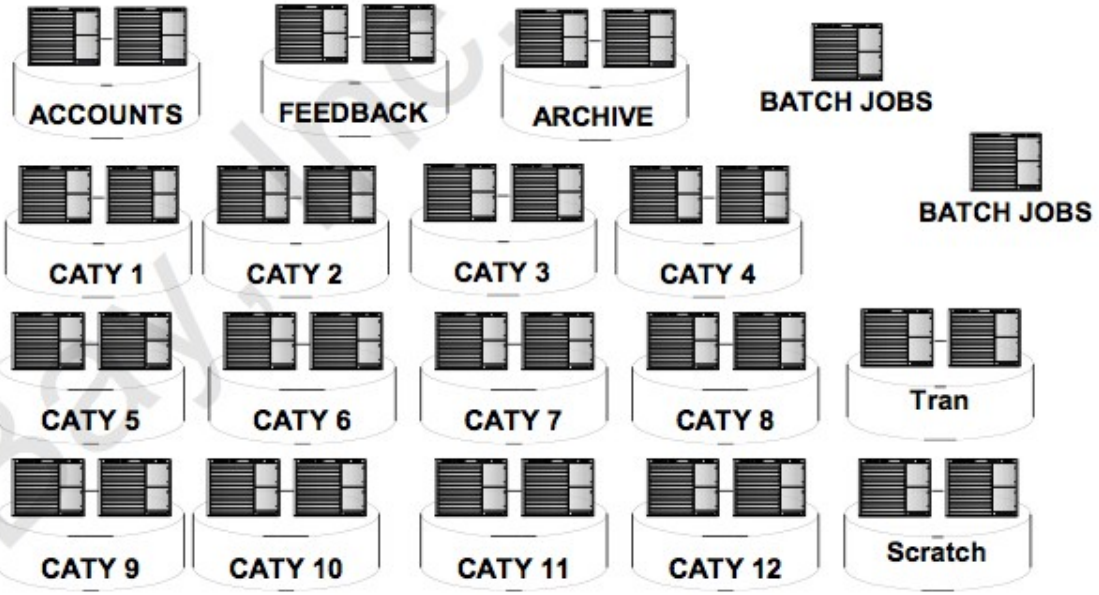

cache
DB







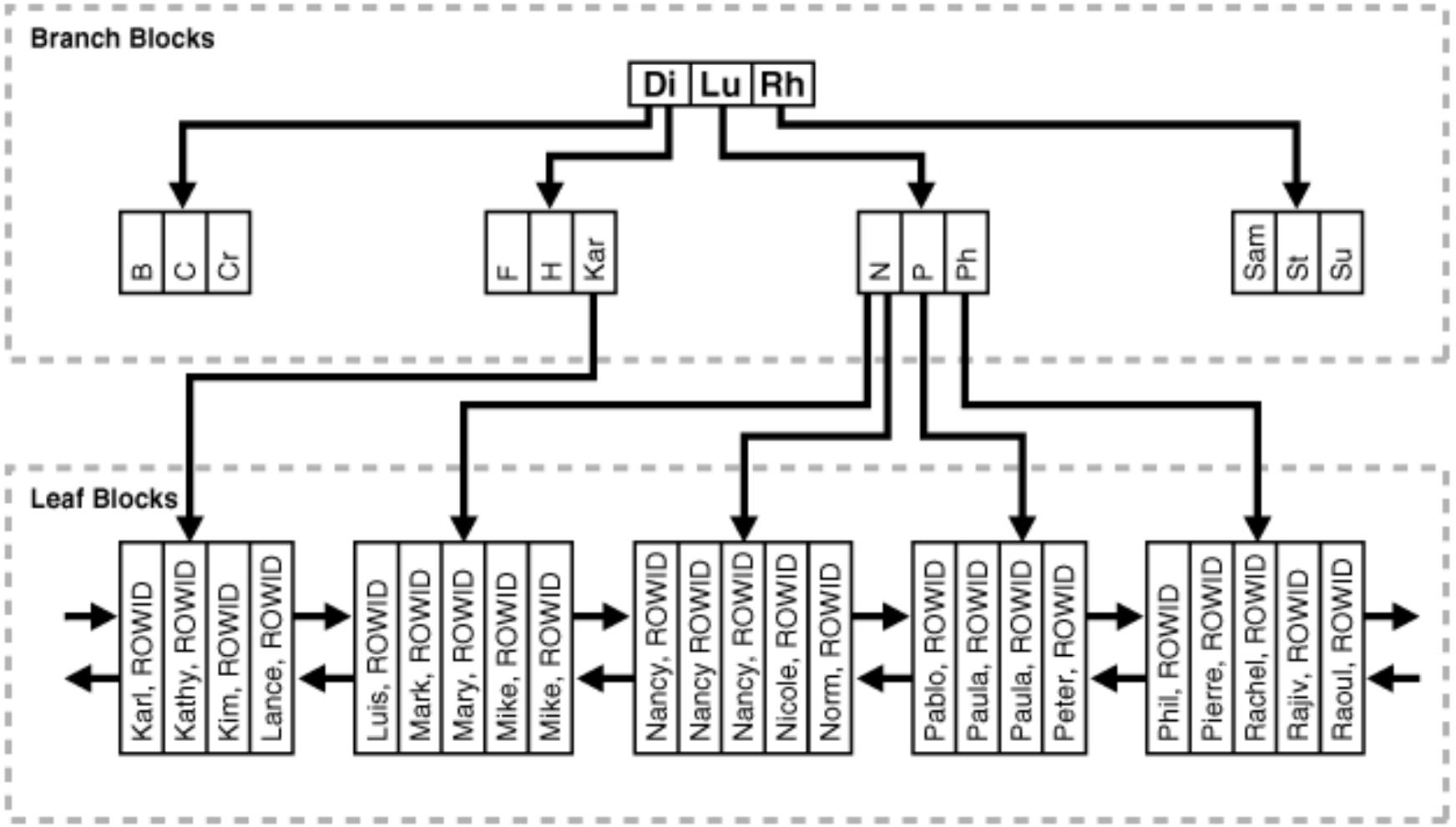




December, 2002

("The eBay Architecture," Randy Shoup and Dan Pritchett)


JENGA
Your turn
motifake.com


Branch Blocks
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P
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Sam
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Su
Leaf Blocks
Karl, ROWID
Kathy, ROWID
Kim, ROWID
Lance, ROWID
Luis, ROWID
Mark, ROWID
Mary, ROWID
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Mike, ROWID
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Norm, ROWID
Pablo, ROWID
Paula, ROWID
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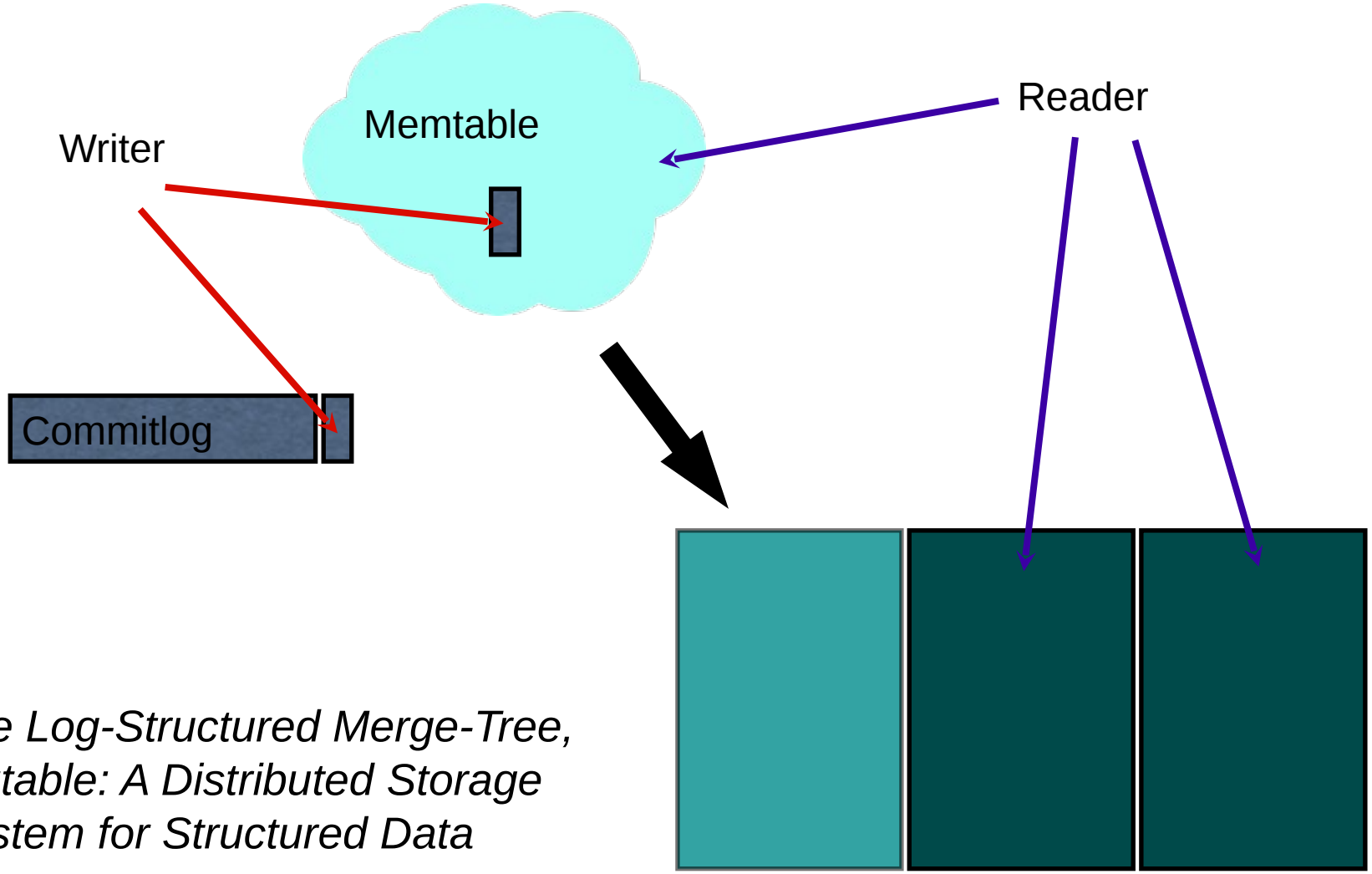
Phil, ROWID
Pierre, ROWID
Rachel, ROWID
Rajiv, ROWID
Raoul, ROWID



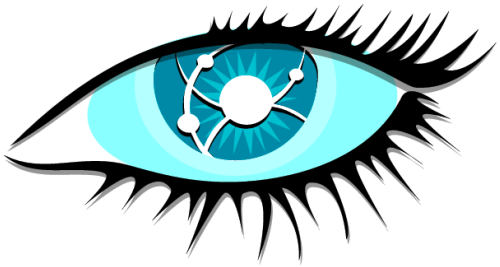
The Log-Structured Merge-Tree, Bigtable: A Distributed Storage System for Structured Data

Bigtable, 2006

Dynamo, 2007

OSS, 2008

Incubator, 2009



TLP, 2010

Cassandra in production

- Digital Reasoning: NLP + entity analytics
- OpenWave: enterprise messaging
- OpenX: largest publisher-side ad network in the world
- Cloudkick: performance data & aggregation
- SimpleGEO: location-as-API
- Ooyala: video analytics and business intelligence
- ngmoco: massively multiplayer game worlds

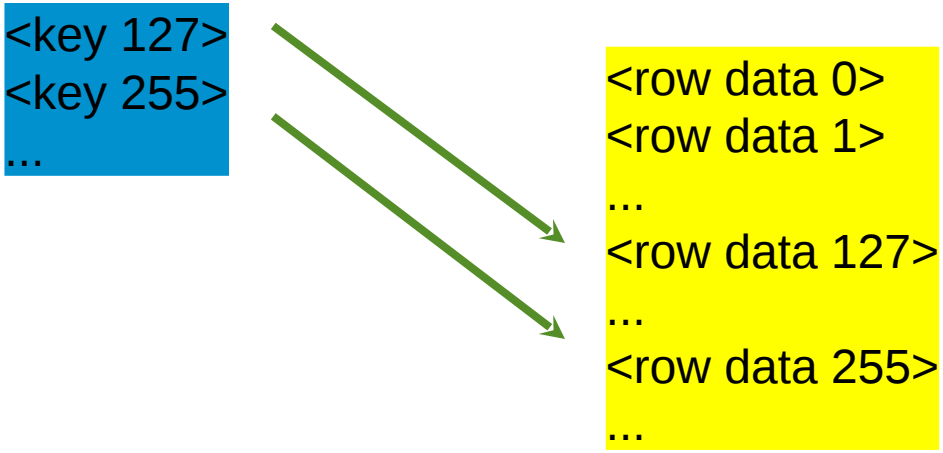
FUD?

- **“Cassandra is only appropriate for unimportant data.”**

Durabilty

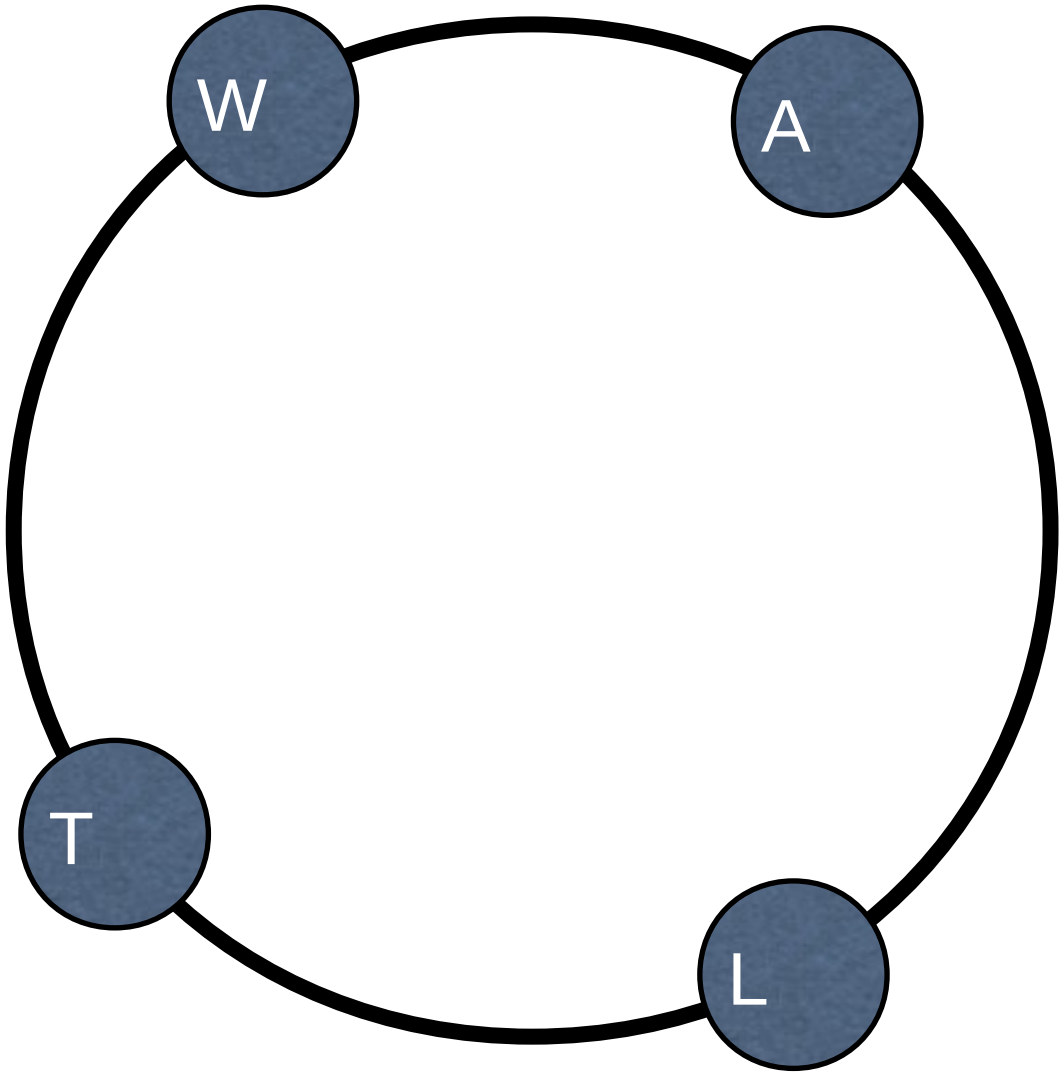
- **Write to commitlog**
  - fsync is cheap since it's append-only
- **Write to memtable**
- **[amortized] flush memtable to sstable**

SSTable format, briefly



Sorted [clustered] by row key

Scaling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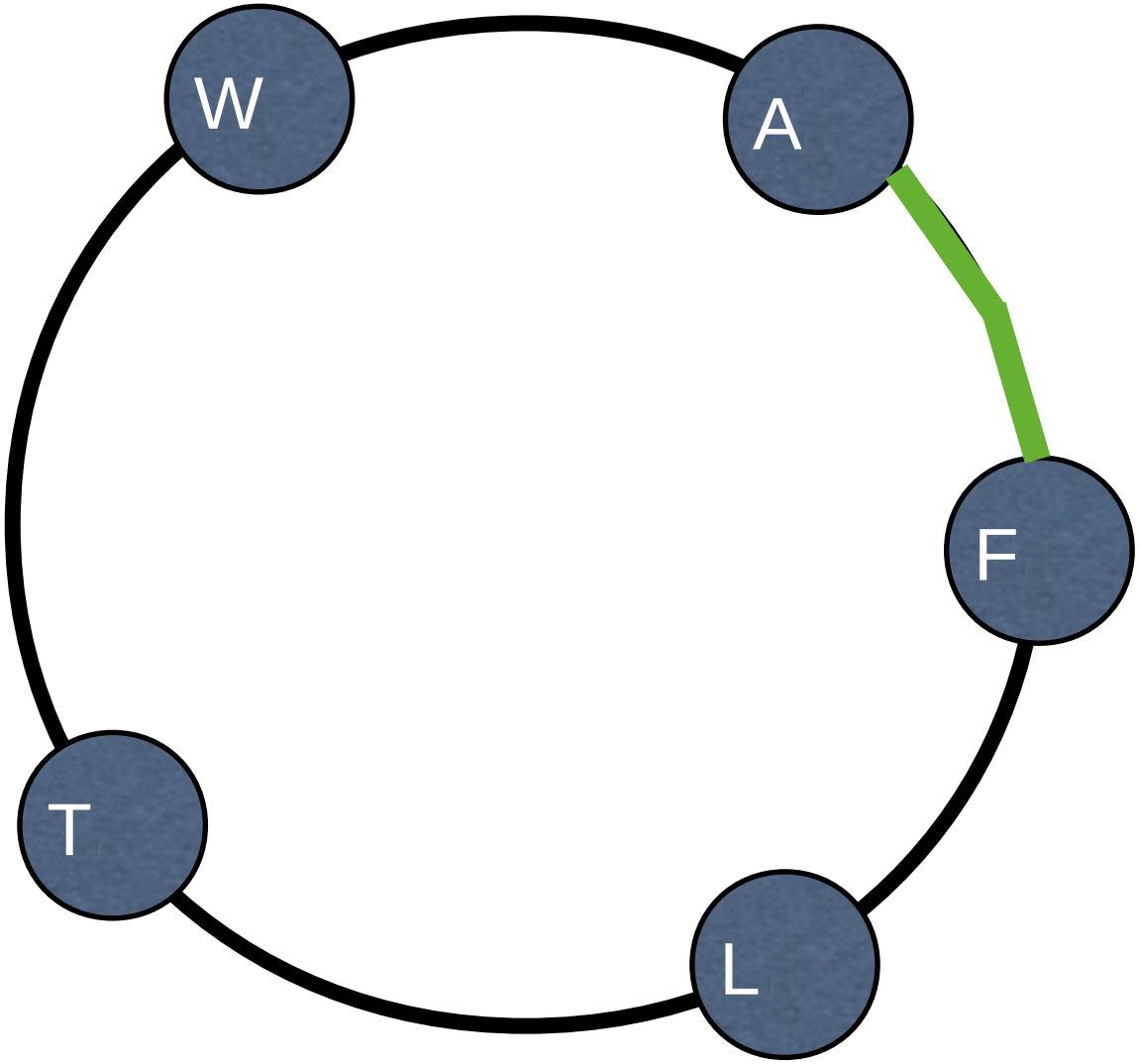
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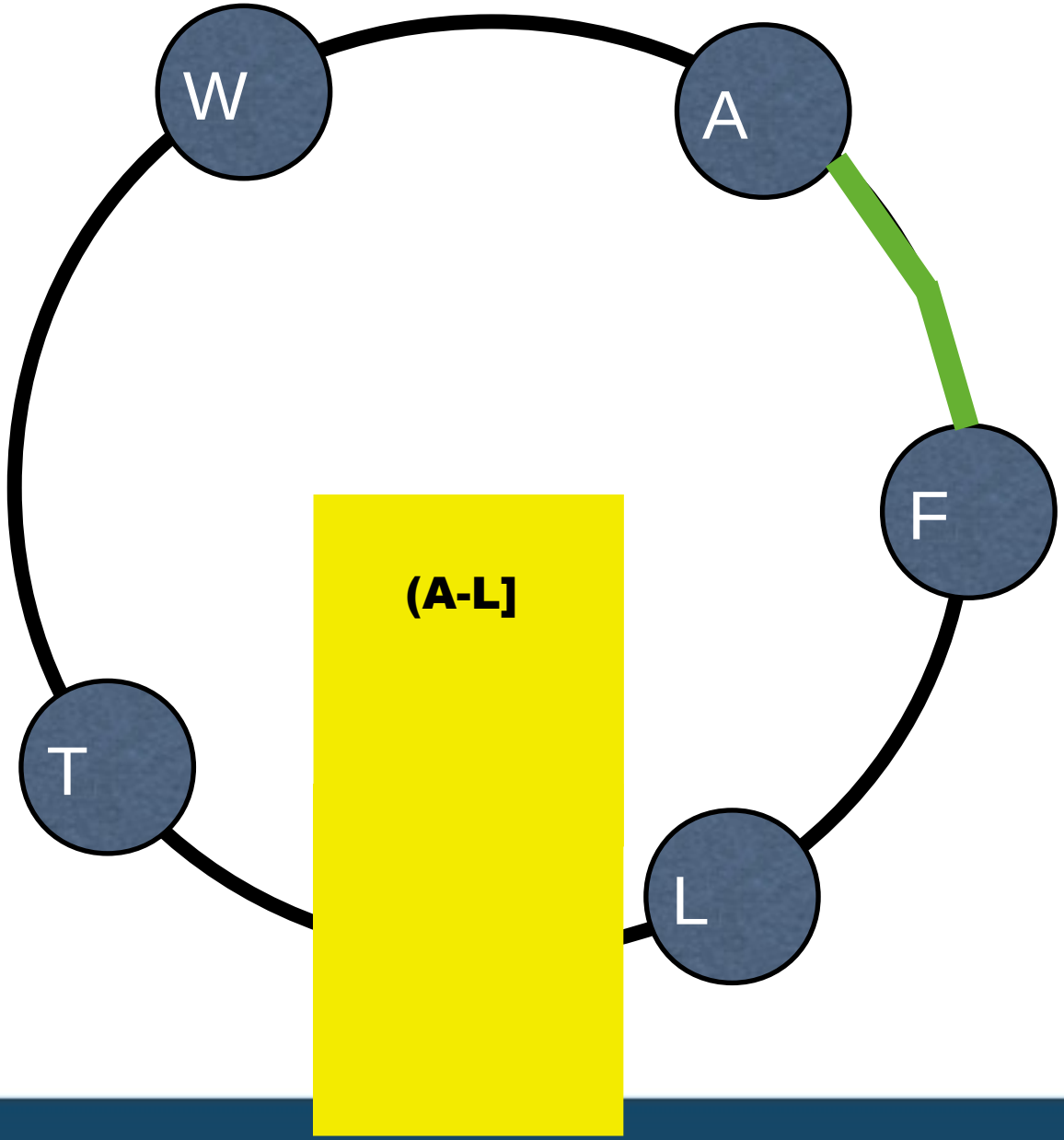
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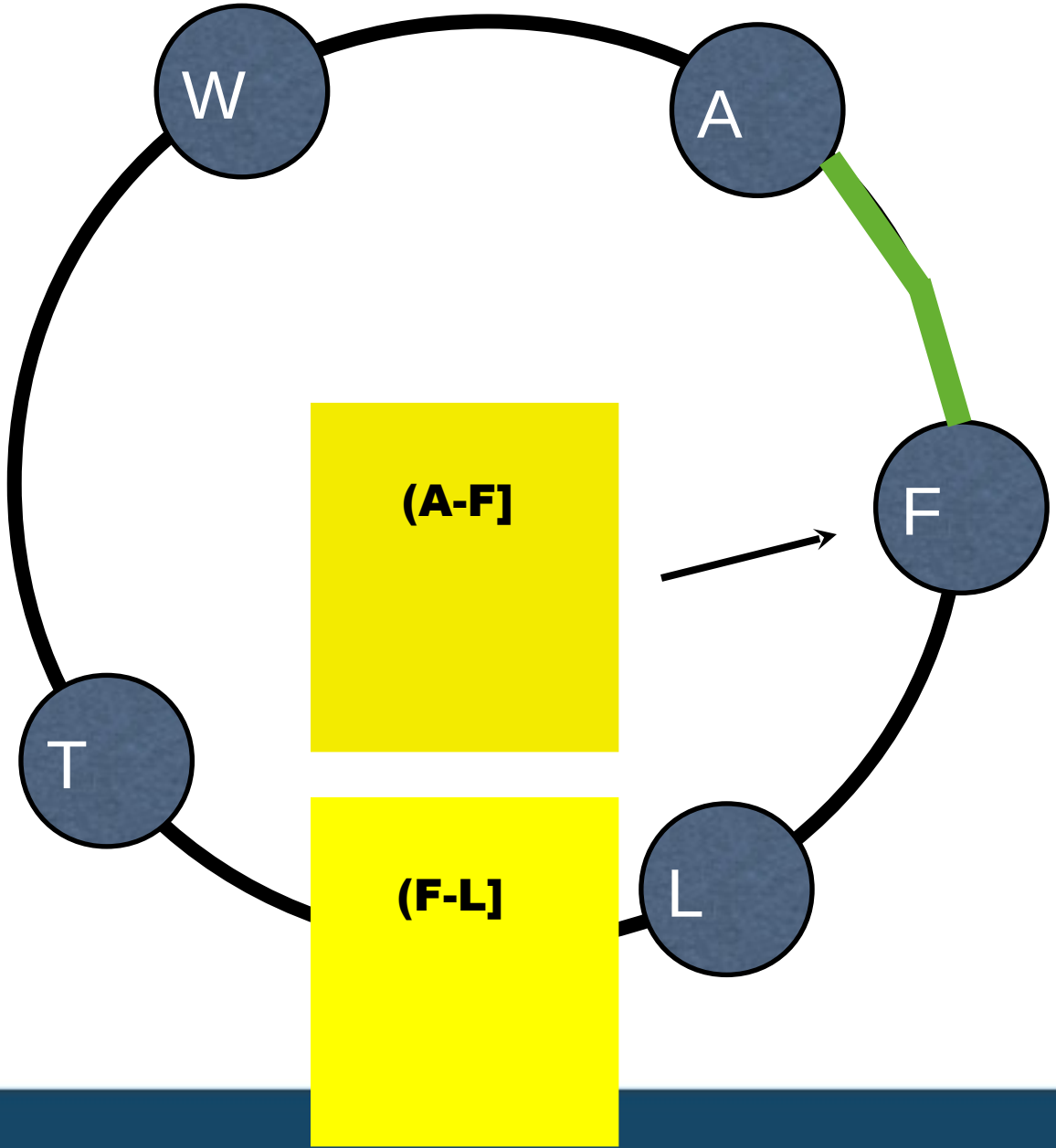
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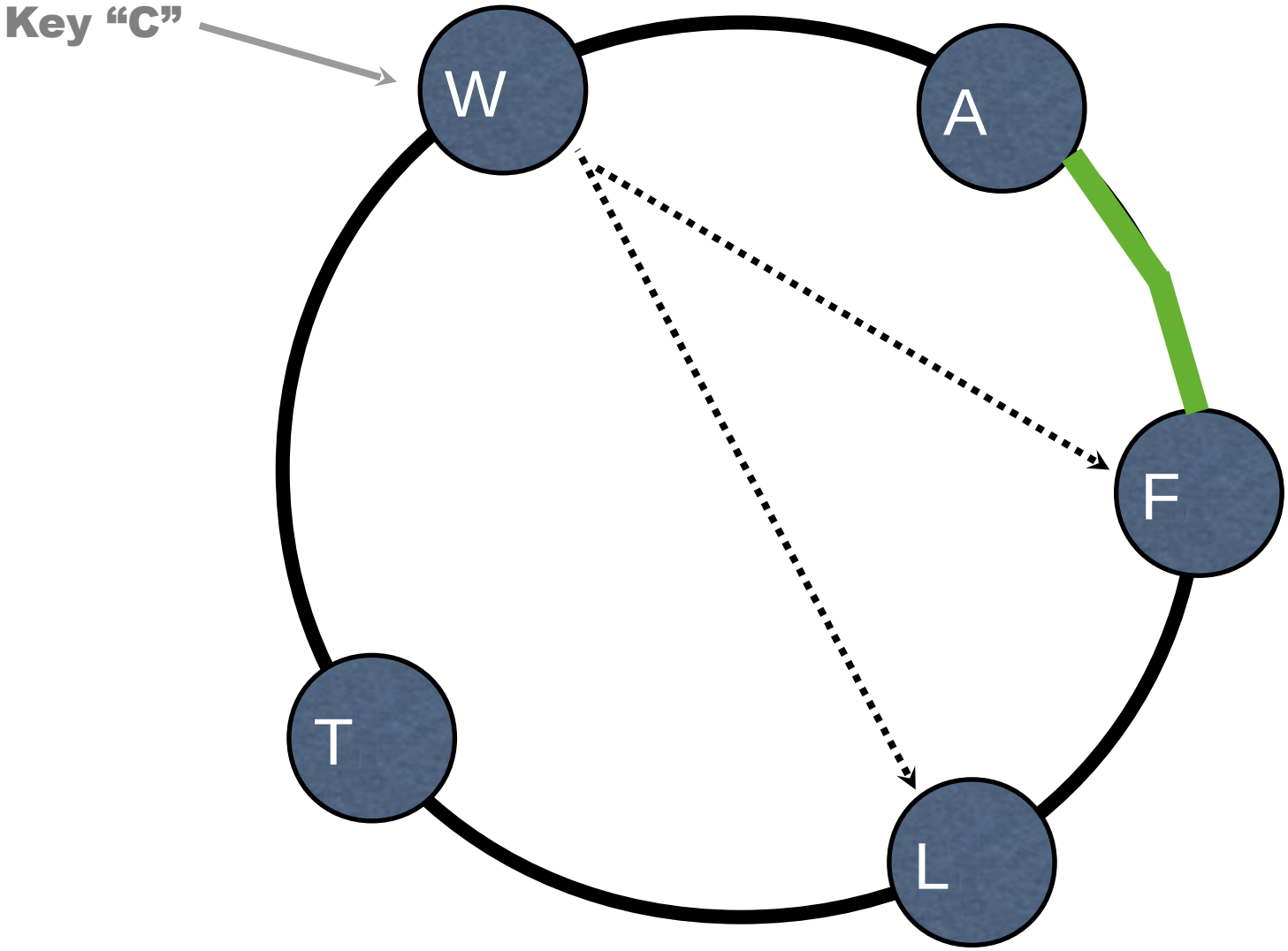
Key “C”
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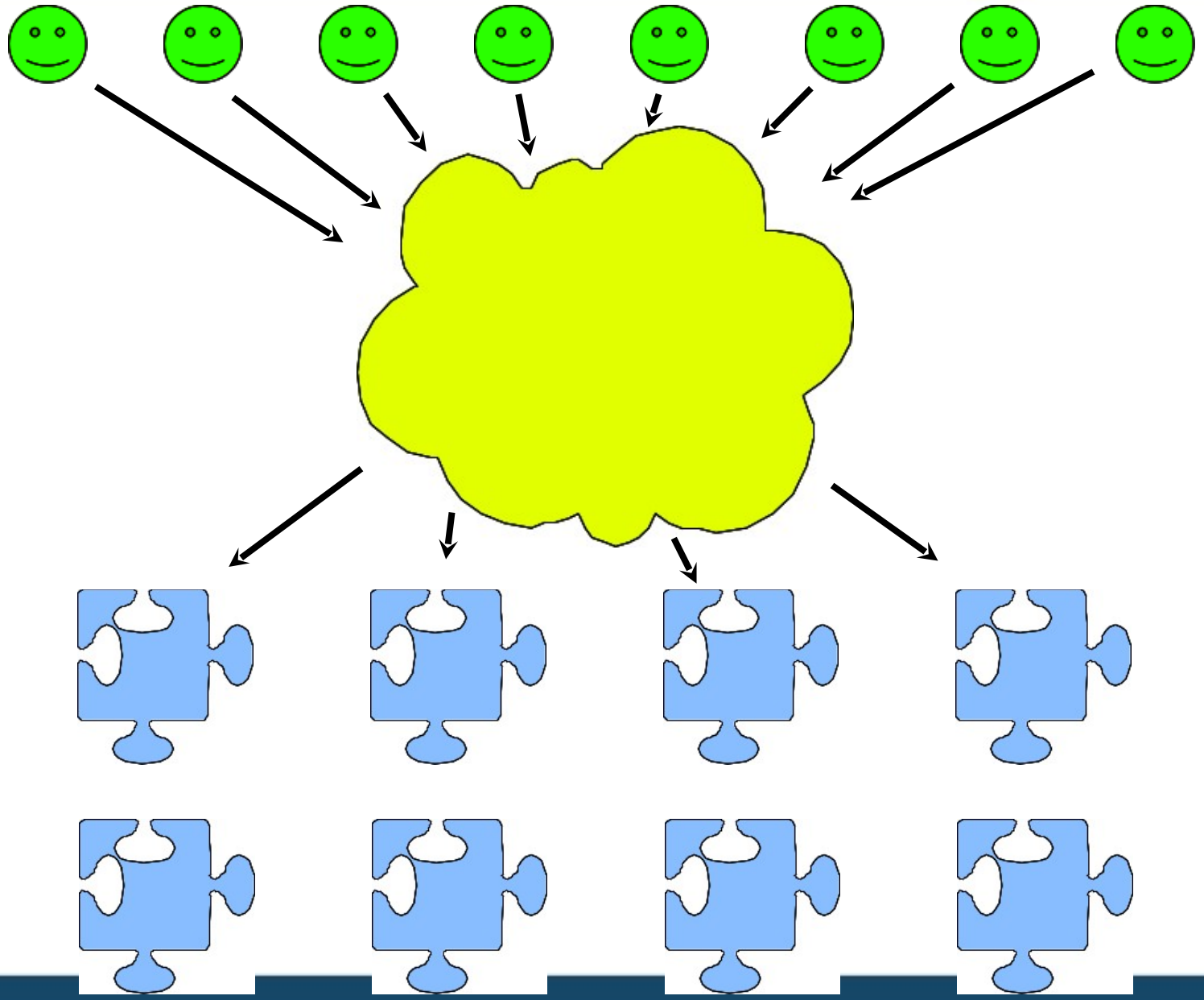
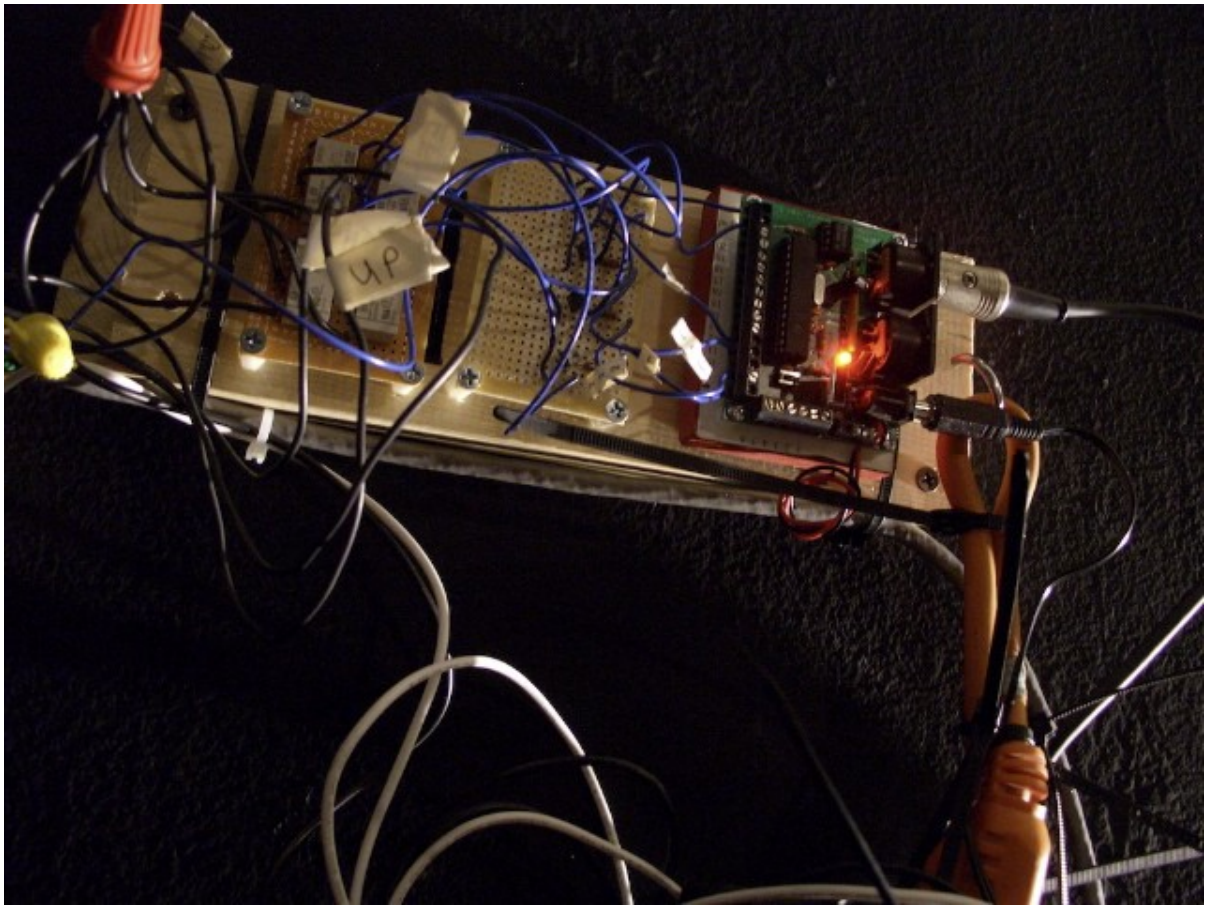
Reliability

- No single points of failure
- Multiple datacenters
- Monitorable

Some headlines

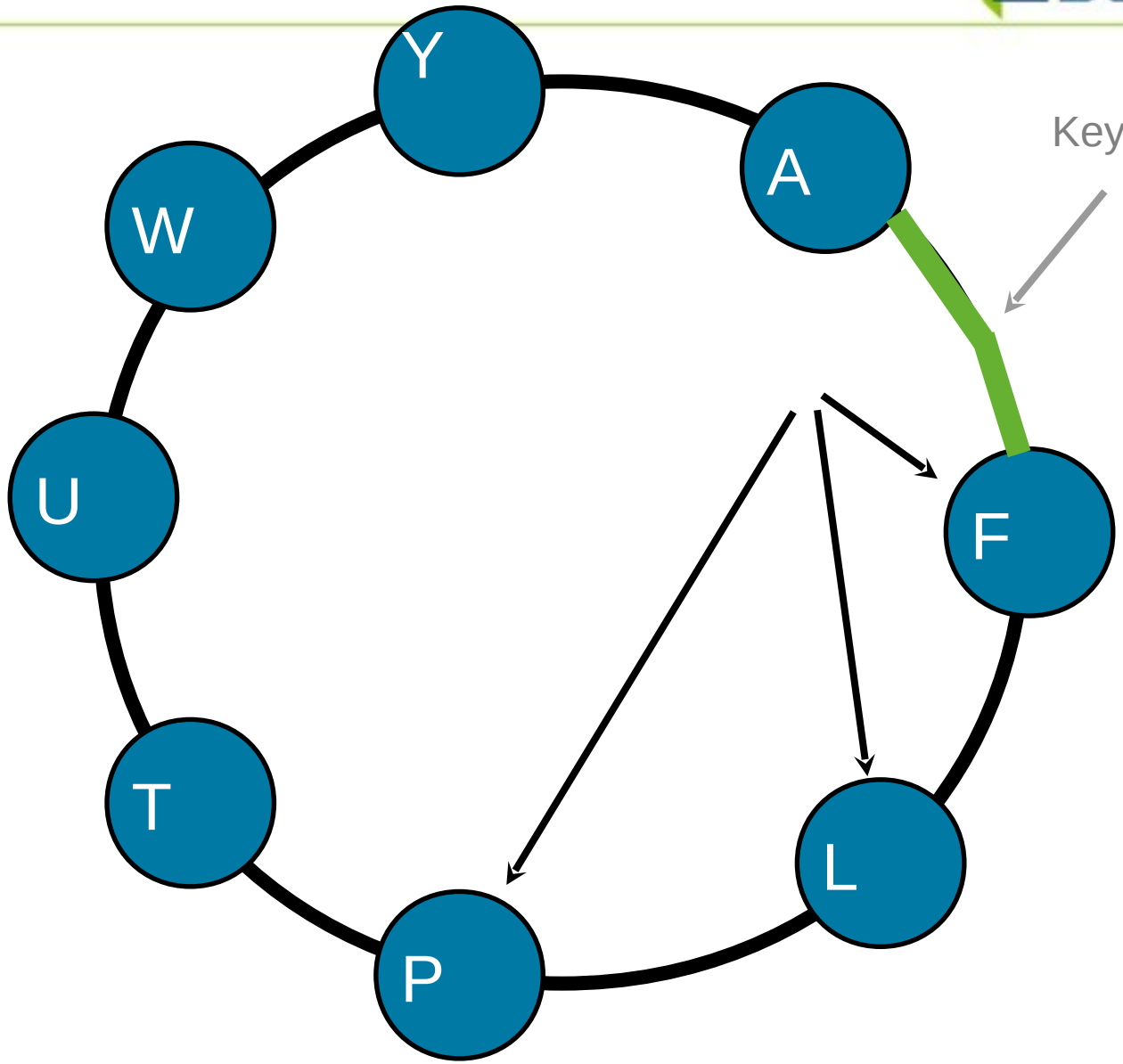
- “Resyncing Broken MySQL Replication”
- “How To Repair MySQL Replication”
- “Fixing Broken MySQL Database Replication”
- “Replication on Linux broken after db restore”
- “MySQL :: Repairing broken replication”




UP

Good architecture solves multiple problems at once

- **Availability in single datacenter**
- **Availability in multiple datacenters**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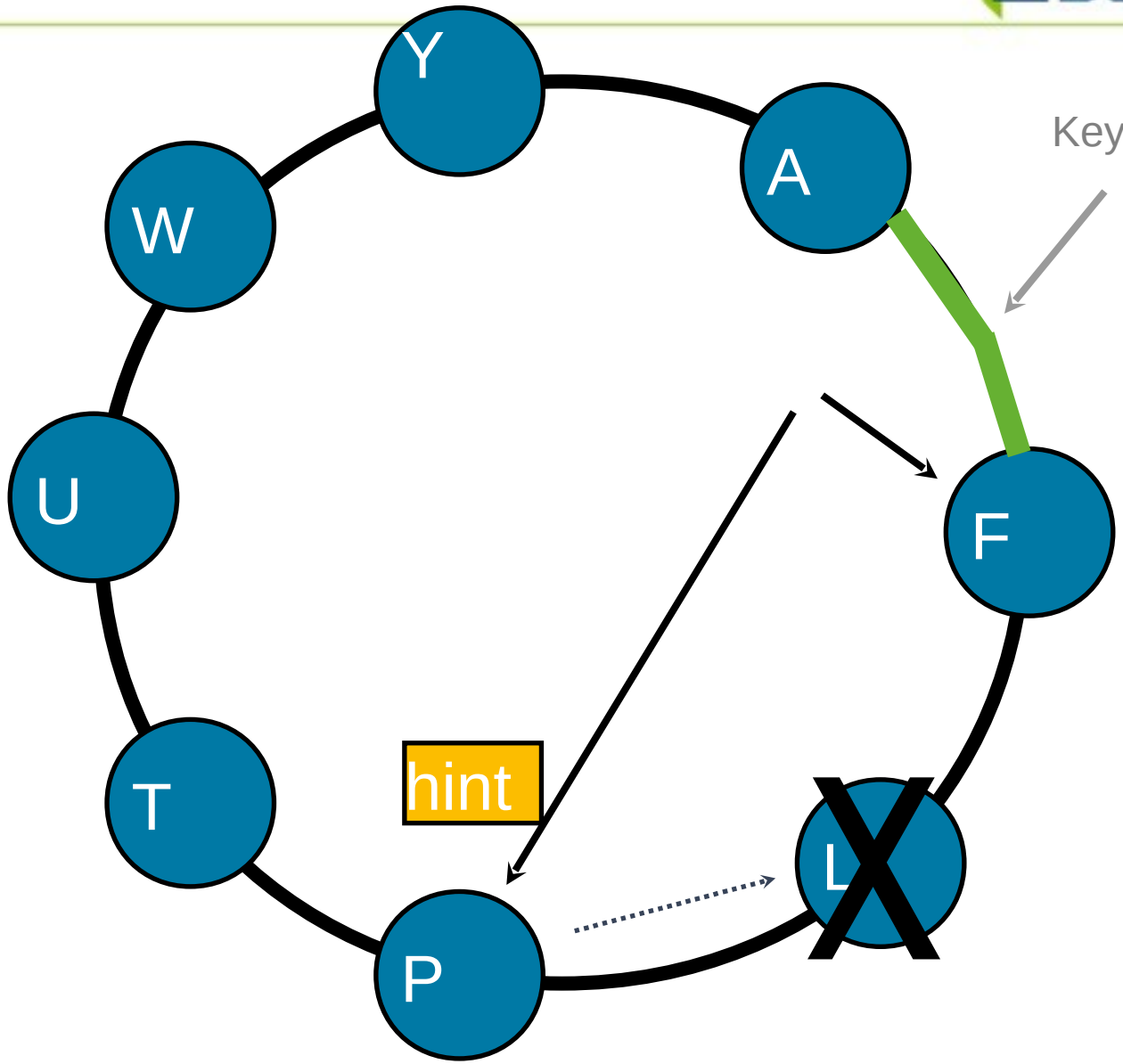
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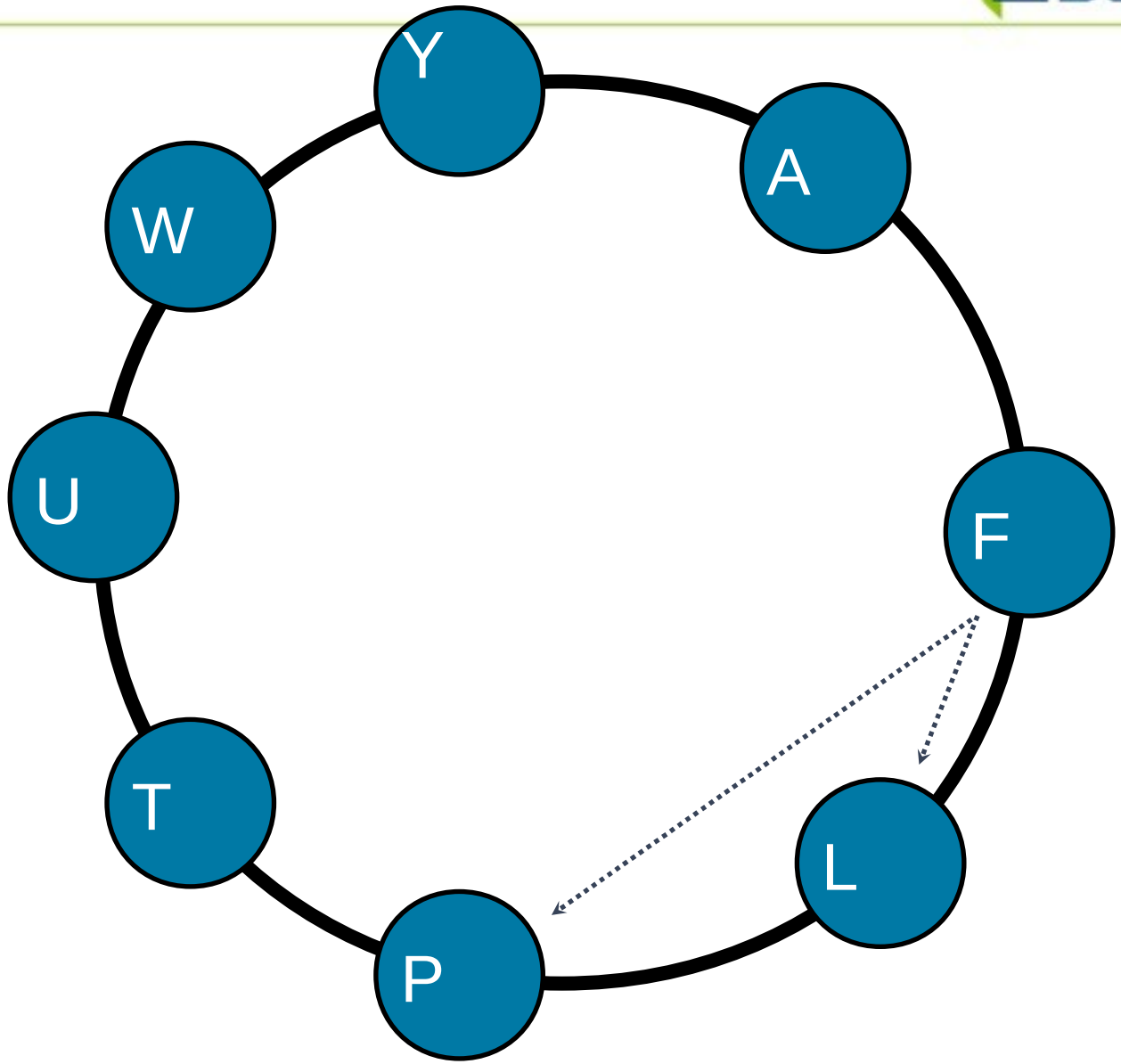
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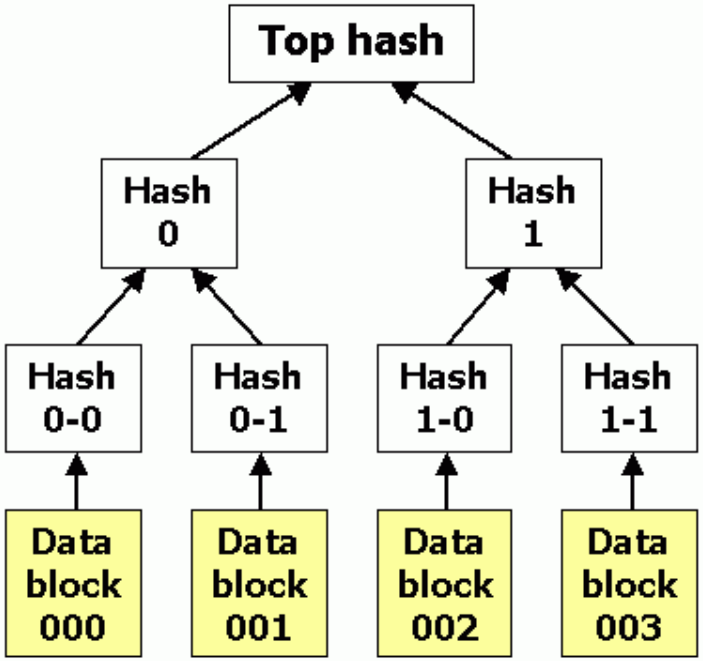
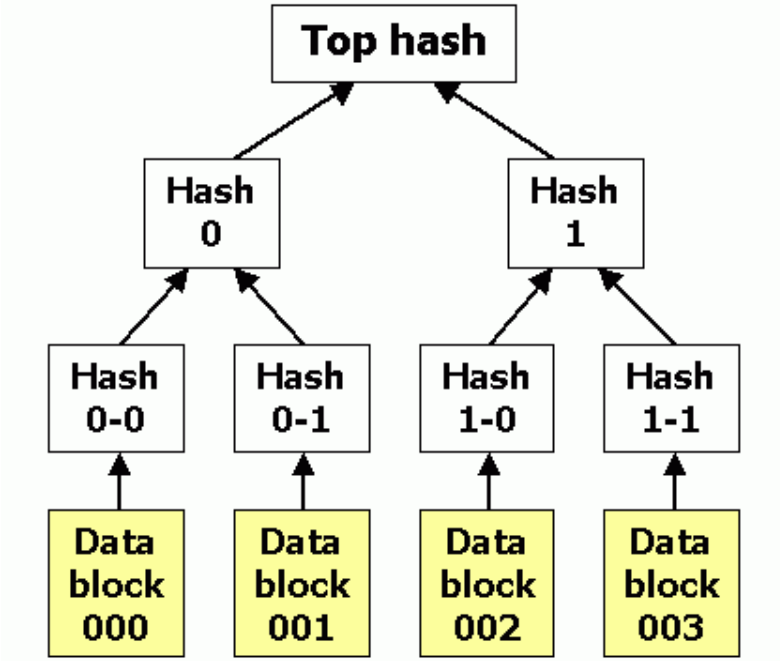
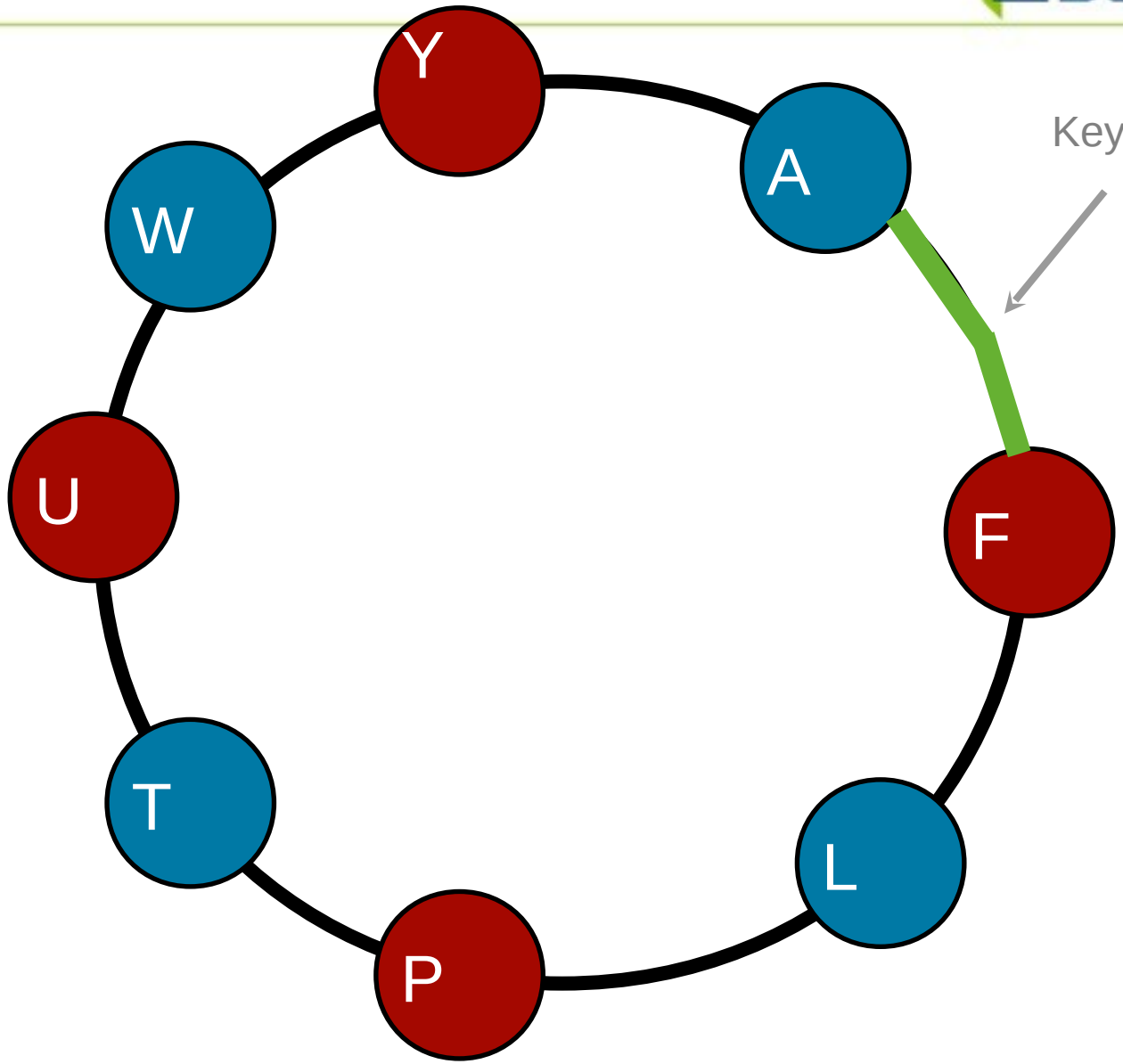

Top hash
Hash 0
Hash 1
Hash 0-0
Hash 0-1
Hash 1-0
Hash 1-1
Data block 000
Data block 001
Data block 002
Data block 003


Top hash
Hash 0
Hash 1
Hash 0-0
Hash 0-1
Hash 1-0
Hash 1-1
Data block 000
Data block 001
Data block 002
Data block 003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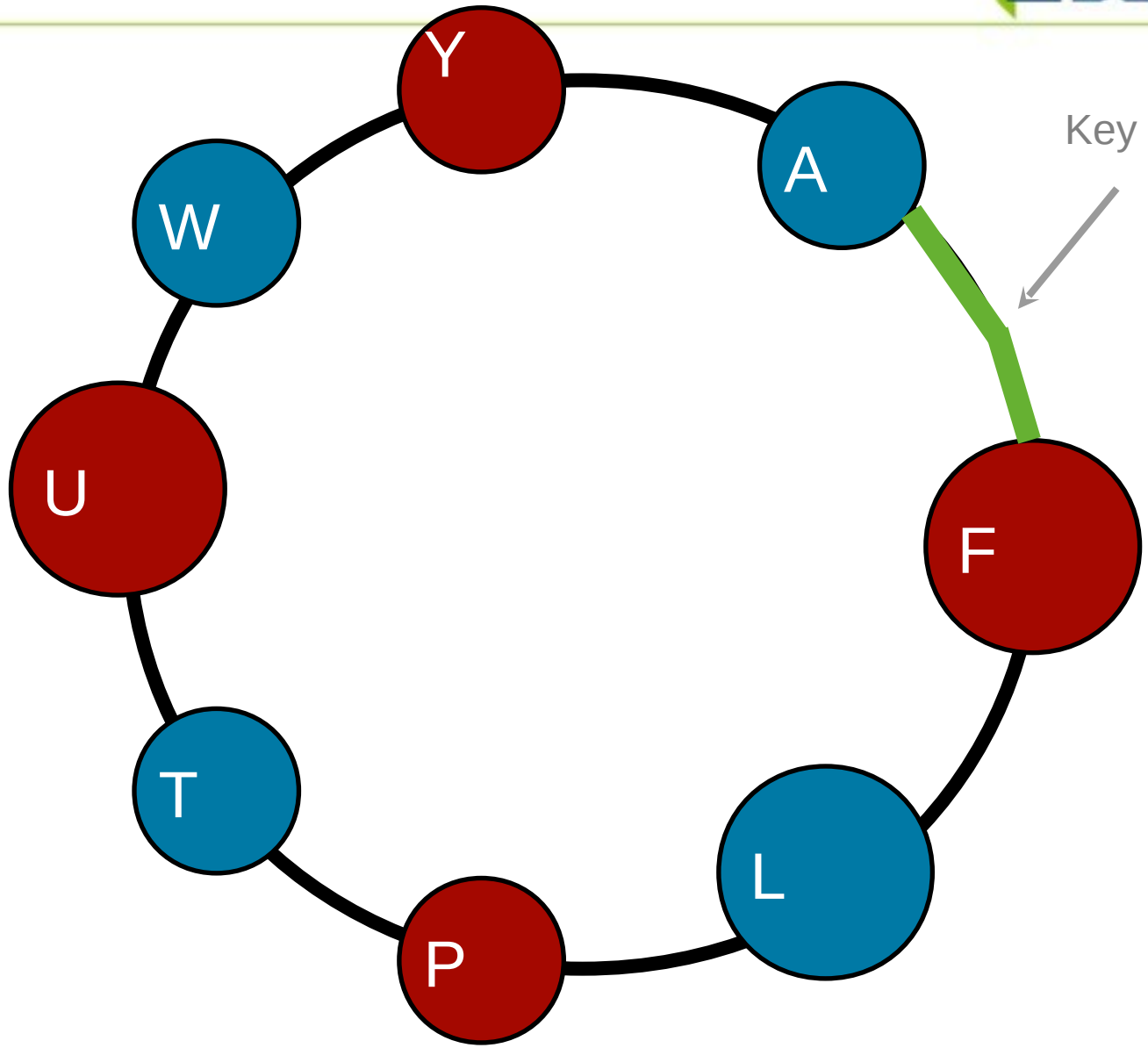
Y
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Key “C”
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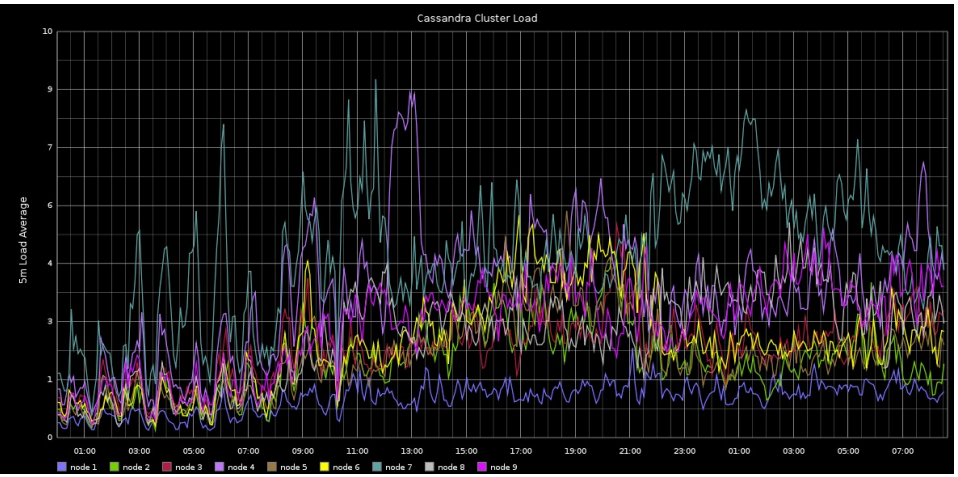
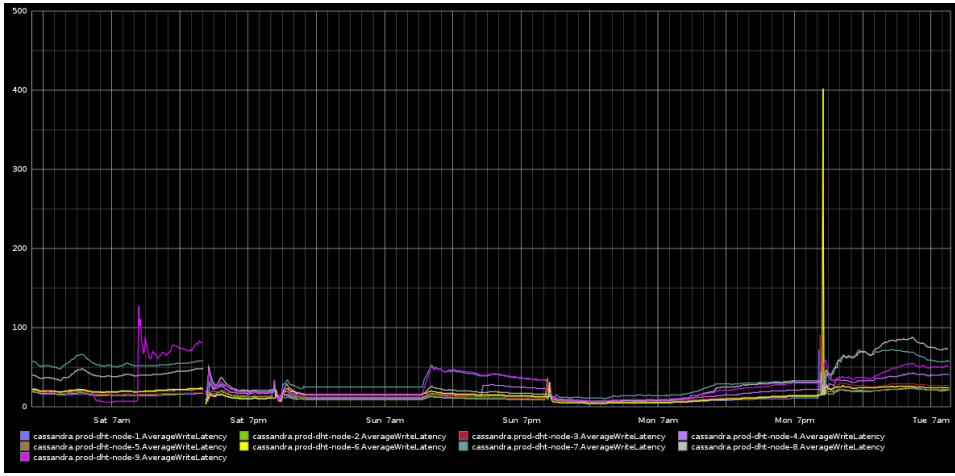
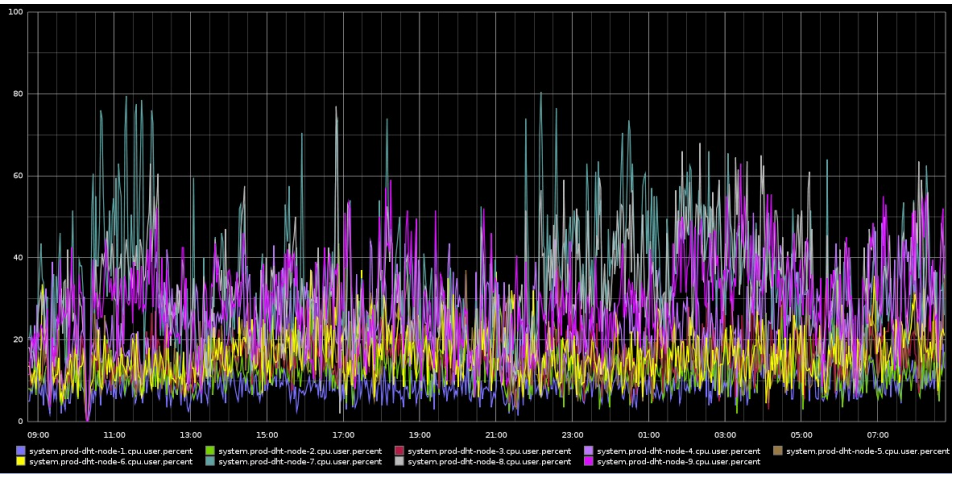
Tuneable consistency

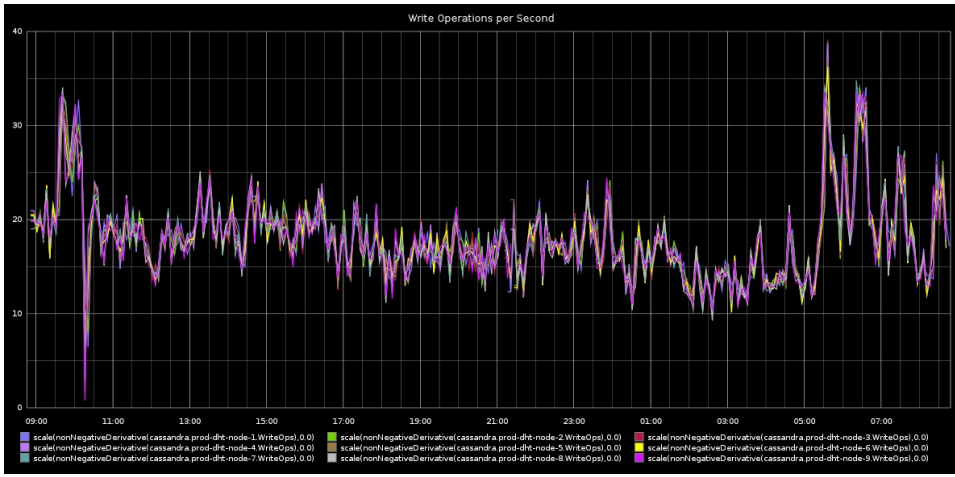
- ONE, QUORUM, ALL
- R + W > N
- Choose availability vs consistency (and latency)

Monitorable

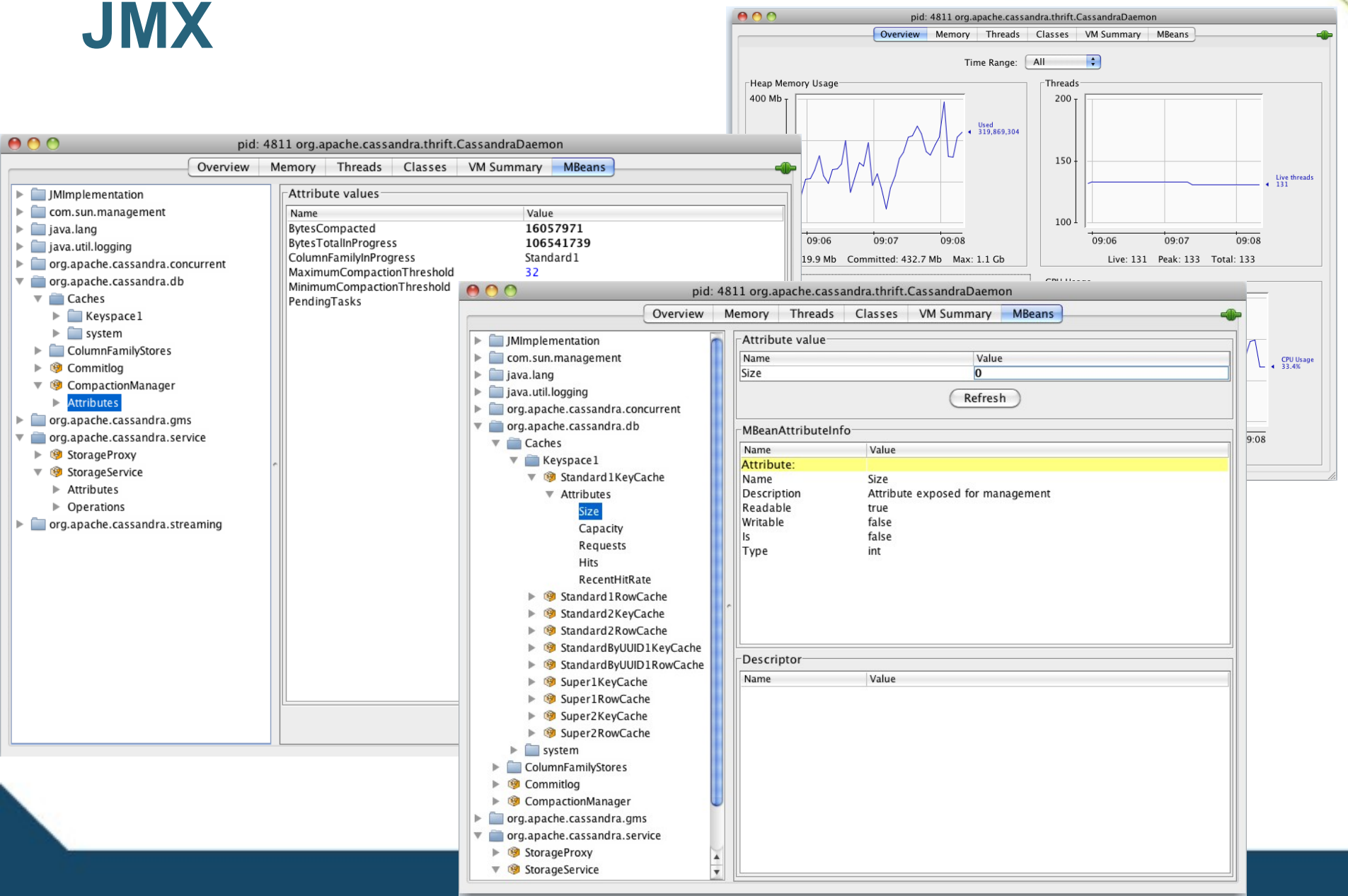




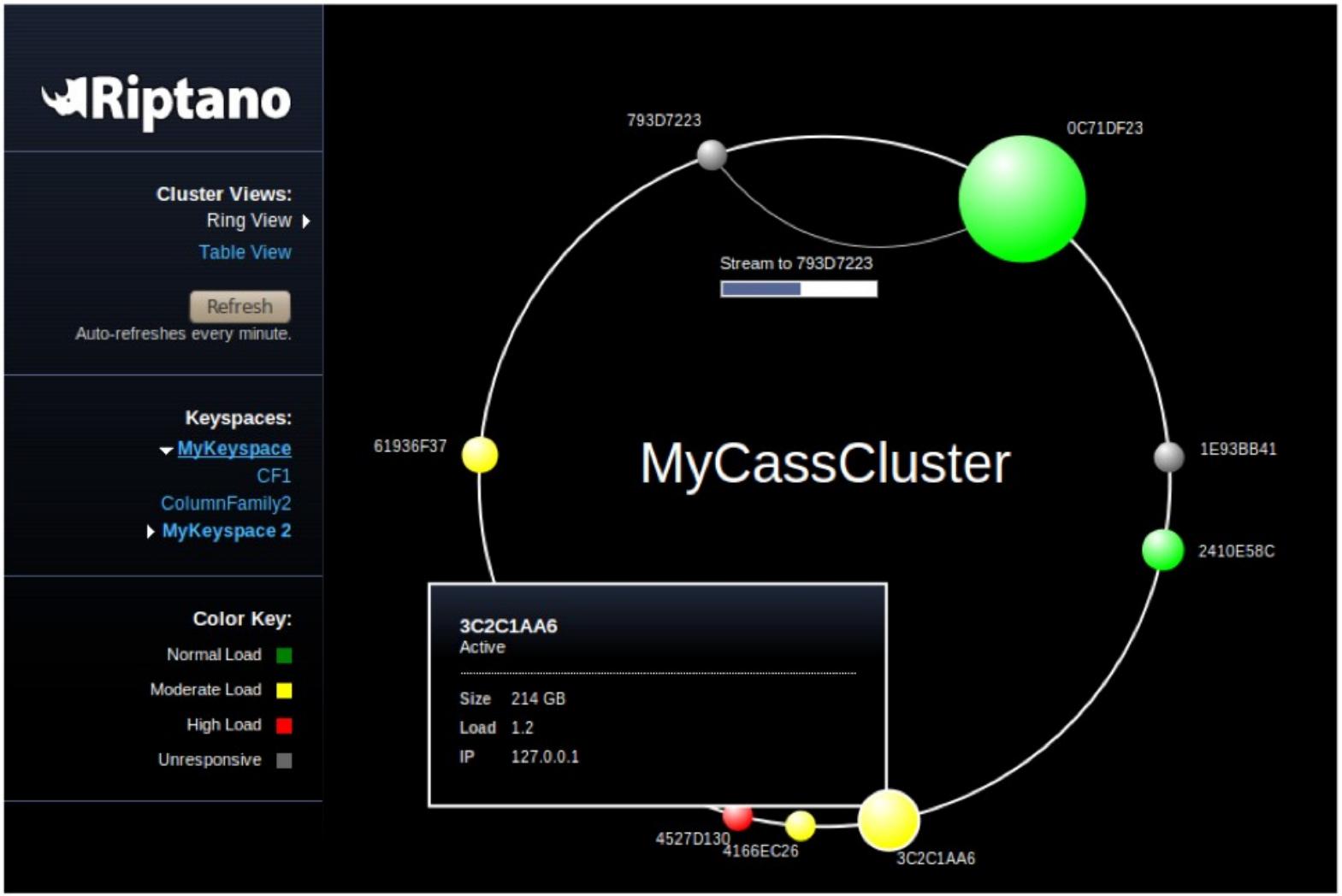




JMX


pid: 4811 org.apache.cassandra.thrift.CassandraDaemon
Overview
Memory
Threads
Classes
VM Summary
MBeans
Time Range:
All
Heap Memory Usage
400 Mb
Used
319,869,304
09:06
09:07
09:08
19.9 Mb
Committed: 432.7 Mb
Max: 1.1 Gb
Threads
200
150
100
Live threads
131
Live: 131
Peak: 133
Total: 133
CPU Usage
33.4%
JMImplementation
com.sun.management
java.lang
java.util.logging
org.apache.cassandra.concurrent
org.apache.cassandra.db
Caches
Keyspace1
system
ColumnFamilyStores
Commitlog
CompactionManager
Attributes
org.apache.cassandra.gms
org.apache.cassandra.service
StorageProxy
StorageService
Attributes
Operations
org.apache.cassandra.streaming
Attribute values
Name
Value
BytesCompacted
16057971
BytesTotalInProgress
106541739
ColumnFamilyInProgress
Standard1
MaximumCompactionThreshold
32
MinimumCompactionThreshold
PendingTasks
Attribute value
Name
Value
Size
0
Refresh
MBeanAttributeInfo
Name
Value
Attribute:
Name
Size
Description
Attribute exposed for management
Readable
true
Writable
false
Is
false
Type
int
Descriptor
Name
Value
Standard1KeyCache
Attributes
Size
Capacity
Requests
Hits
RecentHitRate
Standard1RowCache
Standard2KeyCache
Standard2RowCache
StandardByUUID1KeyCache
StandardByUUID1RowCache
Super1KeyCache
Super1RowCache
Super2KeyCache
Super2RowCache

OpsCenter


Riptano
Cluster Views:
Ring View
Table View
Refresh
Auto-refreshes every minute.
Keyspaces:
MyKeyspace
CF1
ColumnFamily2
MyKeyspace 2
Color Key:
Normal Load
Moderate Load
High Load
Unresponsive
793D7223
0C71DF23
Stream to 793D7223
61936F37
MyCassCluster
1E93BB41
2410E58C
3C2C1AA6
Active
Size 214 GB
Load 1.2
IP 127.0.0.1
4527D130
4166EC26
3C2C1AA6

When do you need Cassandra?

- Ian Eure: “If you’re deploying memcache on top of your database, you’re inventing your own ad-hoc, difficult to maintain NoSQL data store”

Not Only SQL

- Curt Monash: "**ACID-compliant transaction integrity** commonly costs more in terms of DBMS licenses and many other components of TCO (Total Cost of Ownership) than [scalable NoSQL]. Worse, it **can actually hurt application uptime**, by forcing your system to pull in its horns and stop functioning in the face of failures that a non-transactional system might smoothly work around. Other flavors of "complexity can be a bad thing" apply as well. Thus, **transaction integrity can be more trouble than it's worth**." [Curt's emphasis]

Keyspaces & ColumnFamilies

- **Conceptually, like “schemas” and “tables”**

Inside CFs, columns are dynamic

- **Twitter: “Fifteen months ago, it took two weeks to perform ALTER TABLE on the statuses [tweets] table.”**

ColumnFamilies

- **Static**
  - Object data
- **Dynamic**
  - Precalculated query results

“static” columnfamilies

Users

zznate	Password: *	Name: Nate	
driftx	Password: *	Name: Brandon	
thobbs	Password: *	Name: Tyler	
jbellis	Password: *	Name: Jonathan	Site: riptano.com

“dynamic” columnfamilies

Following

zznate	driftx:	thobbs:				
driftx						
thobbs	zznate:					
jbellis	driftx:	mdennis:	pcmanus	thobbs:	xedin:	zznate

Inserting

- Really “insert or update”
- Not a key/value store – update as much of the row as you want

Example: twissandra

- http://twissandra.com

```
CREATE TABLE users (
    id INTEGER PRIMARY KEY,
    username VARCHAR(64),
    password VARCHAR(64)
);
```

```
CREATE TABLE following (
    user INTEGER REFERENCES user(id),
    followed INTEGER REFERENCES user(id)
);
```

```
CREATE TABLE tweets (
    id INTEGER,
    user INTEGER REFERENCES user(id),
    body VARCHAR(140),
    timestamp TIMESTAMP
);
```

Cassandrified

```
create column family users with comparator = UTF8Type
and column_metadata = [{column_name: password,
validation_class: UTF8Type}]

create column family tweets with comparator = UTF8Type
and column_metadata = [{column_name: body, validation_class:
UTF8Type}, {column_name: username, validation_class:
UTF8Type}]

create column family friends with comparator = UTF8Type
create column family followers with comparator = UTF8Type

create column family userline with comparator = LongType and
default_validation_class = UUIDType
create column family timeline with comparator = LongType and
default_validation_class = UUIDType
```

Connecting

```
CLIENT = pycassa.connect_thread_local('Twissandra')

USER = pycassa.ColumnFamily(CLIENT, 'User')
```

User

```
RowKey: ericflo
=> (column=password, value=****,
timestamp=1289446382541473)

-------------------
RowKey: jbellis
=> (column=password, value=****,
timestamp=1289446438490709)
```

```
uname = 'jericevans'
password = '**********'

columns = {'password': password}

USER.insert(uname, columns)
```

Natural keys vs surrogate

DataStax

Friends and Followers

```
RowKey: ericflo

=> (column=jbellis, value=1289446467611029,
timestamp=1289446467611064)

=> (column=b6n, value=1289446467611031,
timestamp=1289446467611080)
```

```
to_uname = 'ericflo'

FRIENDS.insert(uname, {to_uname: time.time()})
FOLLOWERS.insert(to_uname, {uname: time.time()})
```

zznate	driftx:	thobbs:					
driftx							
thobbs	zznate:						
jbellis	driftx:	mdennis:	pcmanus:	thobbs:	xedin:	zznate:	

Tweets

```
RowKey: 92dbeb50-ed45-11df-a6d0-000c29864c4f

=> (column=body, value=Four score and seven years ago,
timestamp=1289446891681799)

=> (column=username, value=alincoln,
timestamp=1289446891681799)

--------------------
RowKey: d418a66e-edc5-11df-ae6c-000c29864c4f

=> (column=body, value=Do geese see God?,
timestamp=1289501976713199)

=> (column=username, value=pdrome,
timestamp=1289501976713199)
```

Userline

```
RowKey: ericflo

=> (column=1289446393708810, value=6a0b4834-ed44-11df-
bc31-000c29864c4f, timestamp=1289446393710212)

=> (column=1289446397693831, value=6c6b5916-ed44-11df-
bc31-000c29864c4f, timestamp=1289446397694646)

=> (column=1289446891681780, value=92dbeb50-ed45-11df-
a6d0-000c29864c4f, timestamp=1289446891685065)

=> (column=1289446897315887, value=96379f92-ed45-11df-
a6d0-000c29864c4f, timestamp=1289446897317676)
```

Userline

zznate	1289847840615: 3f19757a-c89d...	1289847887086: a20fcf52-595c...
driftx		
thobbs	1289847887086: a20fcf52-595c...	
jbellis	1289847840615: 3f19757a-c89d...	128984784425: 844e75e2-b546...

twitter Home P

spyced

That's you!

@davefauth you read NEWS.txt yes?

about 10 hours ago via web in reply to davefauth

zzzeek SQLAlchemy 0.6.0 is released. http://bit.ly/cLot6o #sqlalchemy
7:03 PM Apr 18th via Tweetie
Retweeted by you and 13 others

standardsociety cf-cassandra (Active): A CFX wrapper that allows Coldfusion to interact with Apache Cassandra http://bit.ly/bLBvjD
12:28 PM Apr 16th via twitterfeed
Retweeted by you

dberlind John Quinn (VP Eng, Digg) @ #UTR: If you want a database that really scales, don't use Oracle, PostgreSQL. Use Cassandra
11:31 AM Apr 16th via TweetDeck
Retweeted by you and 6 others

rk slides from my #cassandra presentation yesterday: http://www.slideshare.net/ryansking/scaling-twitter-with-cassandra #chirp
3:31 PM Apr 16th via Tweetie
Retweeted by you and 8 others

twitter Hom

What's happening?

Latest: @davefauth you read NEWS.txt yes? about 10 hours ago

Home

tlesher Verity Stob applies her usual laser-like insights SQL, to great effect: http://bit.ly/c4pQNX
5 minutes ago via TweetDeck

argv0 RT @monkchips: a 1 hour talk, 40 mins in and Bry [ed: @hobbyist] is only just getting to RIAK features. #no #nosales awesome.
about 2 hours ago via TweetDeck

tjake Hacksaw Jim Duggin
about 2 hours ago via Tweetie

wootshirt $10.00 : @-@ : LAST CALL http://shirt.woot.c
about 2 hours ago via web

klein_stephane Est-ce qu'il est possible de lancer des requêtes SPARQL sur Amazon ? exemple, avoir les titres tous les livres de l'auteur "foobar"
about 2 hours ago via web

nitot Superbe : Quand Socrate nous aide à mieux comprendre le logiciel libre: http://tinyurl.com/y6ehhqe
about 2 hours ago via Identica
Retweeted by klein_stephane and 9 others

Timeline

```
RowKey: ericflo

=> (column=1289446393708810, value=6a0b4834-ed44-11df-
bc31-000c29864c4f, timestamp=1289446393710212)

=> (column=1289446397693831, value=6c6b5916-ed44-11df-
bc31-000c29864c4f, timestamp=1289446397694646)

=> (column=1289446891681780, value=92dbeb50-ed45-11df-
a6d0-000c29864c4f, timestamp=1289446891685065)

=> (column=1289446897315887, value=96379f92-ed45-11df-
a6d0-000c29864c4f, timestamp=1289446897317676)
```

Adding a tweet

```
tweet_id = str(uuid())
body = '@ericflo thanks for Twissandra, it helps!'
timestamp = long(time.time() * 1e6)

columns = {'uname': useruuid, 'body': body}
TWEET.insert(tweet_id, columns)

columns = {ts: tweet_id}
USERLINE.insert(uname, columns)

TIMELINE.insert(uname, columns)
for follower_uname in FOLLOWERS.get(uname, 5000):
    TIMELINE.insert(follower_uname, columns)
```

Reads

```
timeline = USERLINE.get(uname, column_reversed=True)
tweets = TWEET.multiget(timeline.values())
```

```
start = request.GET.get('start')
limit = NUM_PER_PAGE

timeline = TIMELINE.get(uname, column_start=start,
column_count=limit, column_reversed=True)
tweets = TWEET.multiget(timeline.values())
```

Programatically

- **Don't use thrift directly**
- **Higher level clients have a lot of features you want**
  - Knowledge about data types
  - Connection pooling
  - Automatic retries
  - Logging

Raw thrift API: Connecting

```
def get_client(host='127.0.0.1', port=9170):
    socket = TSocket.TSocket(host, port)
    transport = TTransport.TBufferedTransport(socket)
    transport.open()
    protocol =
TBinaryProtocol.TBinaryProtocolAccelerated(transport)
    client = Cassandra.Client(protocol)
    return client
```

Raw thrift API: Inserting

```
data = {'id': useruuid, ...}
columns = [Column(k, v, time.time())
           for (k, v) in data.items()]
mutations = [Mutation(ColumnOrSuperColumn(column=c))
             for c in columns]
rows = {useruuid: {'User': mutations}}

client.batch_mutate('Twissandra', rows,
ConsistencyLevel.ONE)
```

API layers

- libpq
- JDBC
- JPA
- Thrift
- Hector
- Hector object-mapper

Running twissandra

- **Login: notroot/notroot**
  - (root/riptano)

- **cd twissandra**
- **python manage.py runserver &**
- **Navigate to http://127.0.0.1:8000**
- **Login as jim/jim, tom/tom, or create your own**

One more thing

- **!PUBLIC! userline**

Exercise 1

- **$ cassandra-cli --host localhost**
- **] use twissandra;**
  ] help;
  ] help list;
  ] help get;
  ] help del;
- **Delete the most recent tweet**
  - How would you find this w/o looking at the UI?

Exercise 2

- User jim is following user tom, but twissandra doesn't populate Timeline with tweets from before the follow action.
- Insert a tweet from tom before the follow action into jim's timeline

Secondary (column) indexes

Exercise 3

- **Add a state column to the Tweet column family definition, with an index (index_type KEYS).**
  - Hint: a no-op update column family on Tweet would be update column family Tweet with column_metadata=[{column_name:body, validation_class:UTF8Type}, {column_name:username, validation_class:UTF8Type}]
- **Set the state column on several tweets to TX. Select them using get … where.**

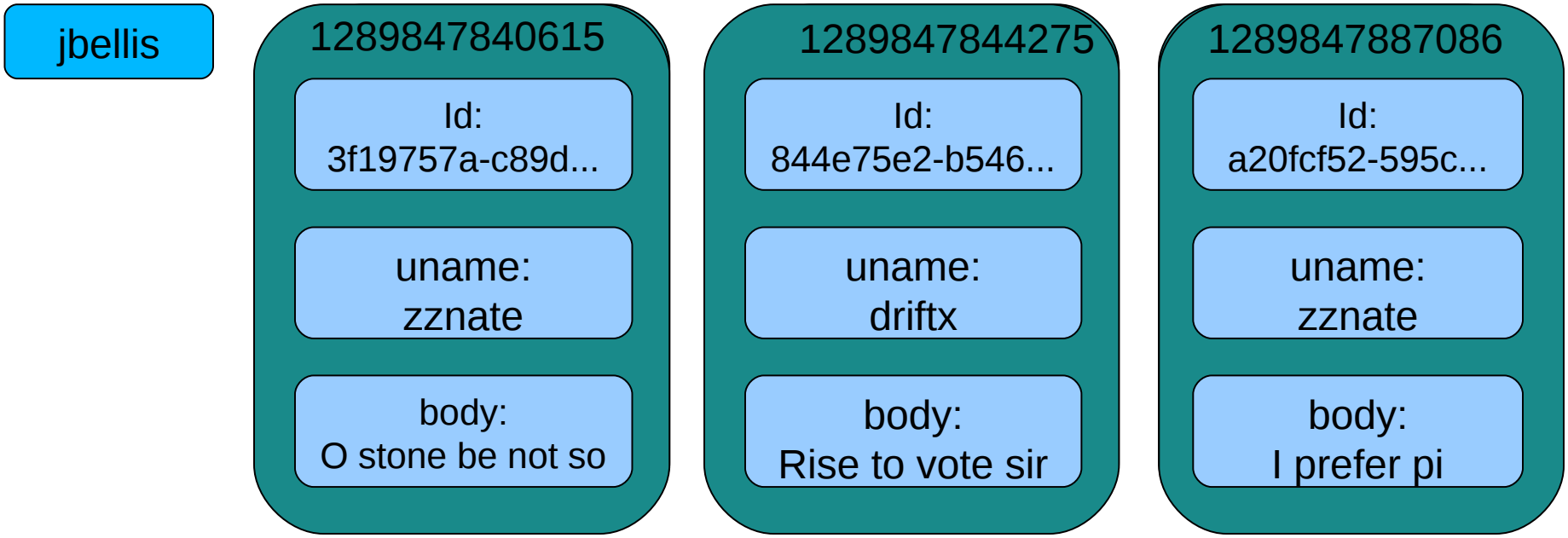
Language support

- **Python**
  - pycassa
  - telephus
- **Ruby**
  - Speed is a negative
- **Java**
  - Hector
- **PHP**
  - phpcassa

Done yet?

- **Still doing 1+N queries per page**
- **Solution: Supercolumns**

Applying SuperColumns to Twissandra



Supercolumns: limitations

- **Requires reading an entire SC (not the entire row) from disk even if you just want one subcolumn**

UUIDs

- **Column names should be uuids, not longs, to avoid collisions**
- **Version 1 UUIDs can be sorted by time ("TimeUUID")**
- **Any UUID can be sorted by its raw bytes ("LexicalUUID")**
  - Usually Version 4
  - Slightly less overhead

Lucandra

- **What documents contain term X?**
  - … and term Y?
  - … or start with Z?

Fields and Terms

```
<doc>
  <field name="title">apache talk</field>
  <field name="date">20110201</field>
</doc>
```

field	term	freq	position
title	apache	1	0
title	talk	1	1
date	20110201	1	0

Lucandra ColumnFamilies

```
create column family documents with comparator = BytesType;

Create column family terminfo with column_type = Super and
comparator = BytesType and subcomparator = BytesType;
```

Lucandra data

```
Document Key        col name          value
"documentId" => { fieldName , value }

Term Key            col name          value
"field/term" => { documentId , position vector }
```

Lucandra queries

- get_slice
- get_range_slices
- No silver bullet

FAQ: counting

- UUIDs + batch process
- column-per-app-server
- counter API (after 1.0 is out)

Locking

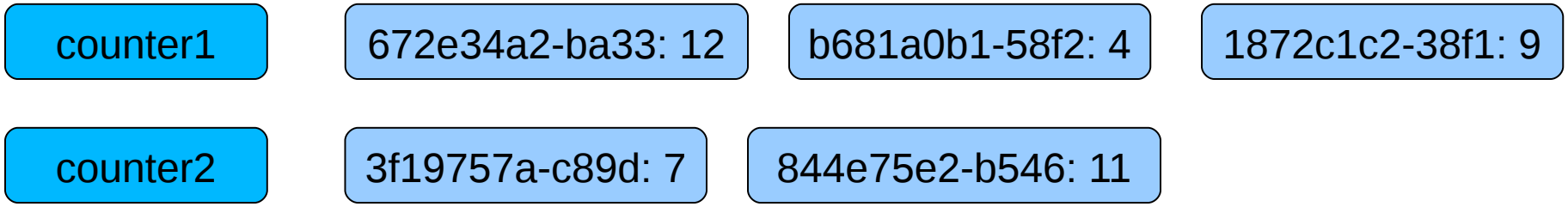
- Zookeeper
- Cages: http://code.google.com/p/cages/
- Not suitable for multi-DC

UUIDs

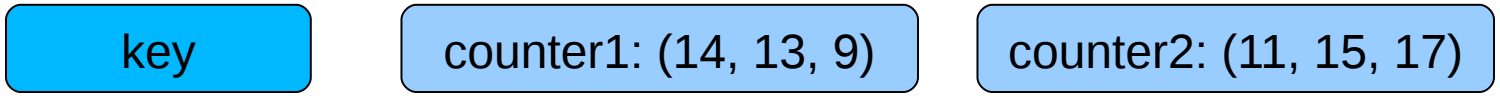
counter1	672e34a2-ba33...	b681a0b1-58f2...	
counter2	3f19757a-c89d...	844e75e2-b546...	a20fcf52-595c...

counter1	aggregated: 27
counter2	aggregated: 42

Column per appserver



Counter API



General Tips

- Start with queries, work backwards
- Avoid storing extra “timestamp” columns
- Insert instead of check-then-insert
- Use client-side clock to your advantage
- use TTL
- Learn to love wide rows


DataStax