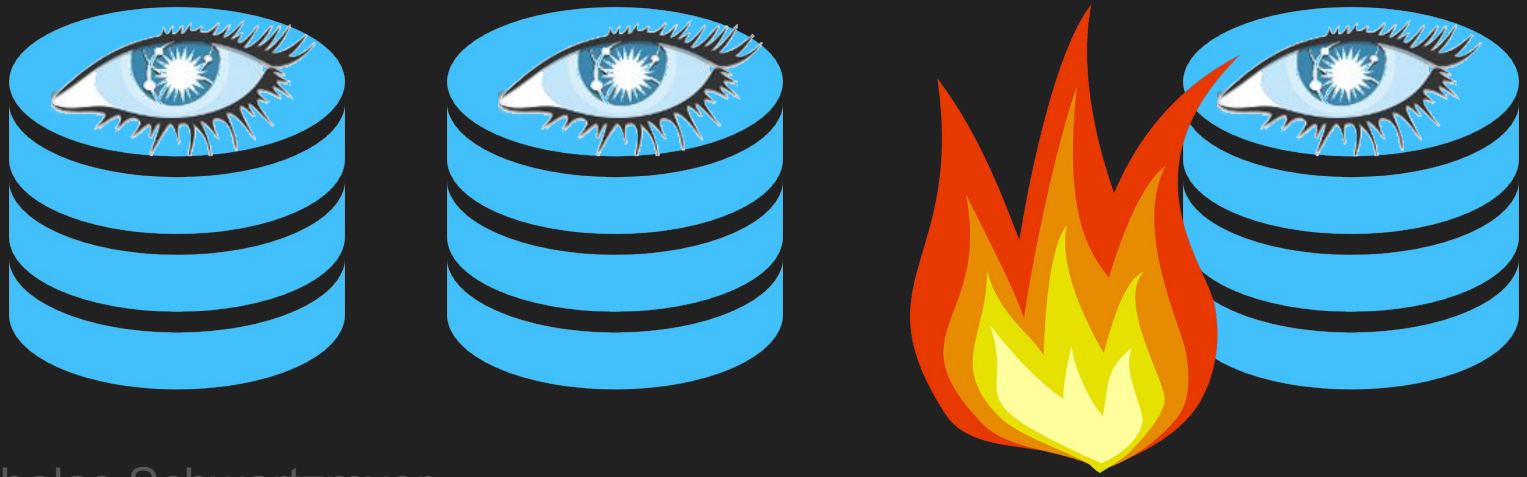
Store it, maybe?

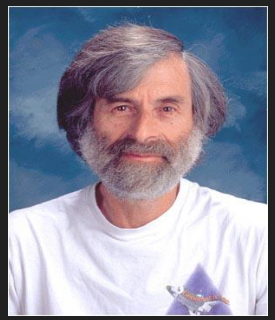
Partition testing Cassandra with Jepsen



Nicholas Schwartzmyer
Insight Data Engineering Fellowship
New York

What’s the value of this project?

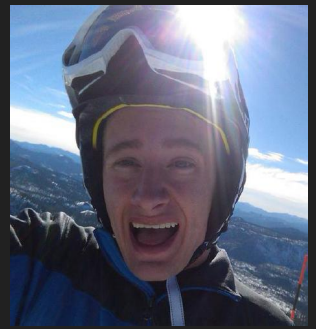
- Understanding system failure is vital to becoming a good engineer.
- Distributed systems are notoriously hard to reason about, even for seasoned engineers behind industry-standard distributed databases.
- Reason better while diving deep into an industry-standard data-store



Try to Think like a Distributed boss!

<-- Leslie Lamport

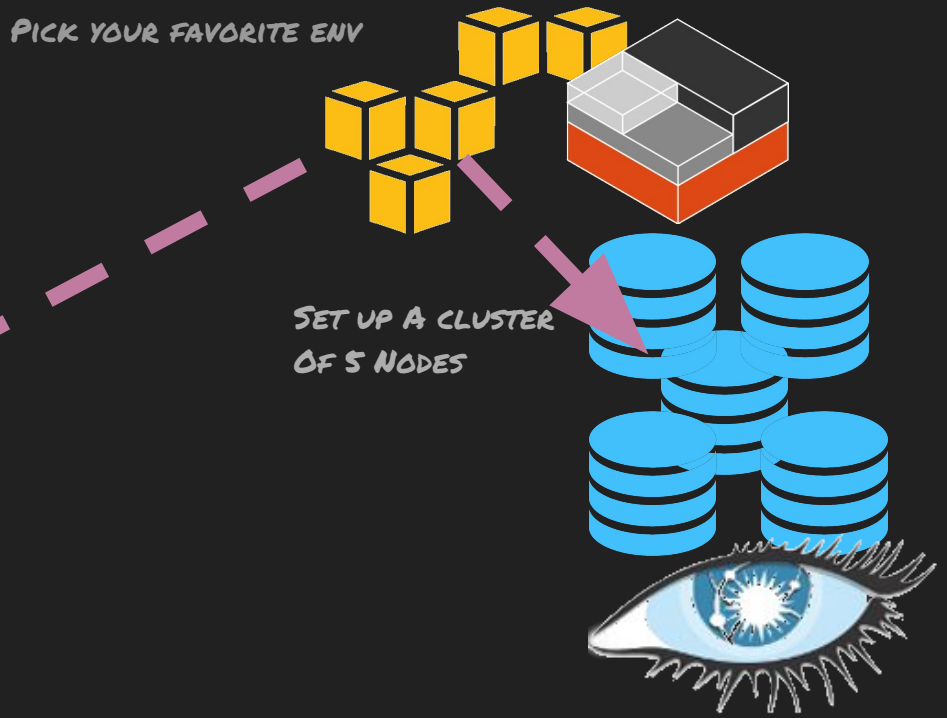
Kyle Kingsbury/Aphyr -->



Also...

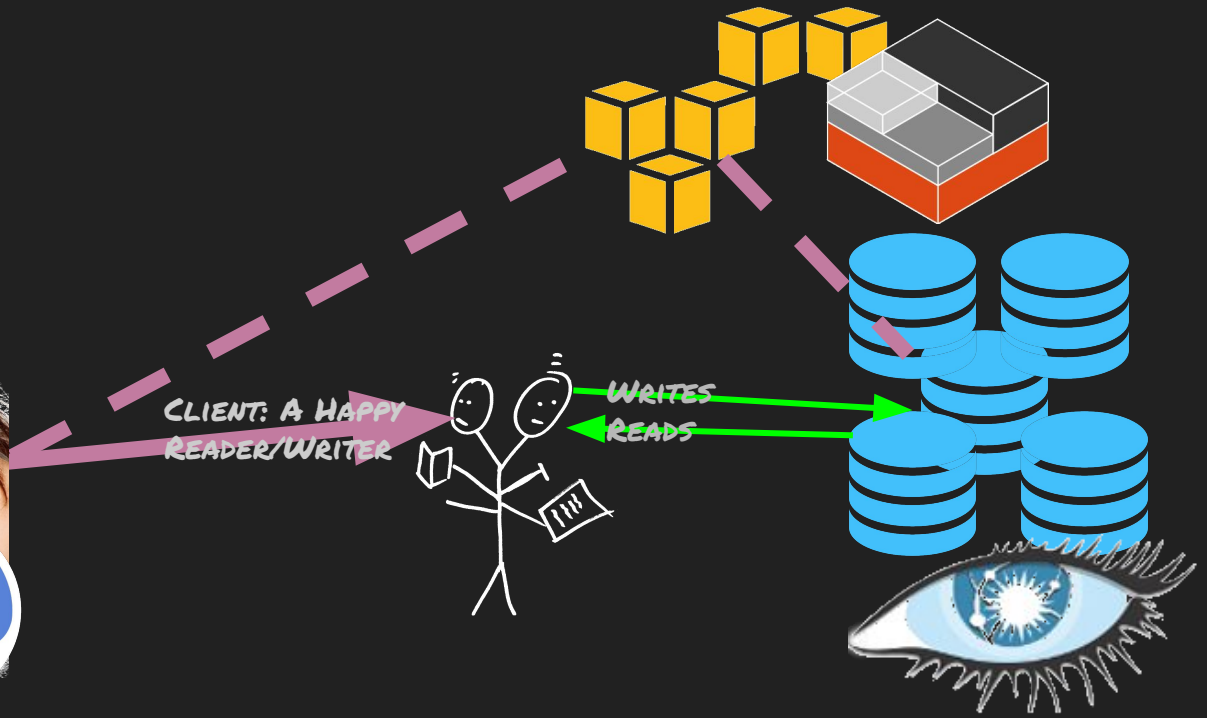
Data drives our companies. Losing or corrupting it is BAD!

Jepsen



Jepsen was written by Kyle Kingbury (Aphyr)
(https://github.com/aphyr/jepsen)

Jepsen



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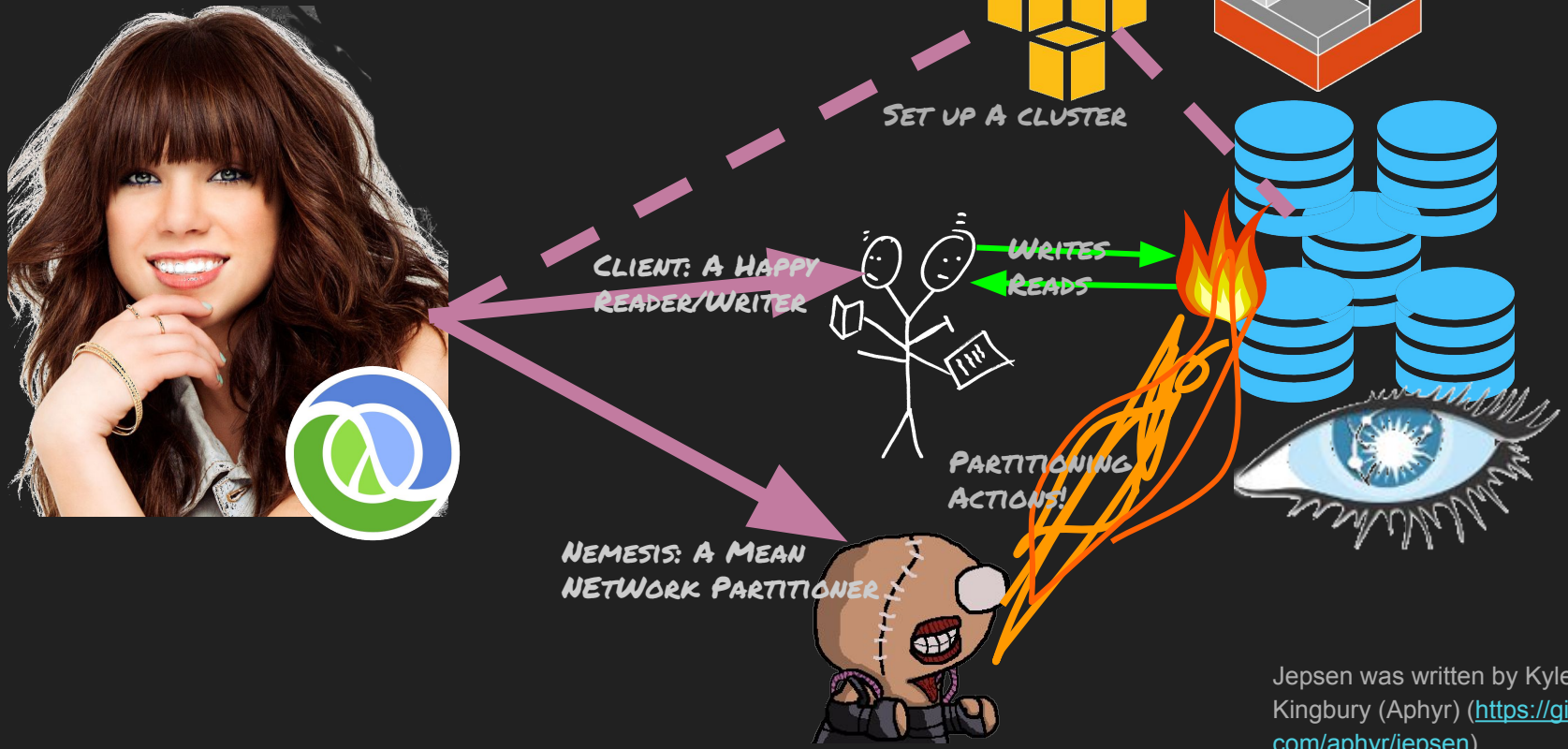
Jepsen



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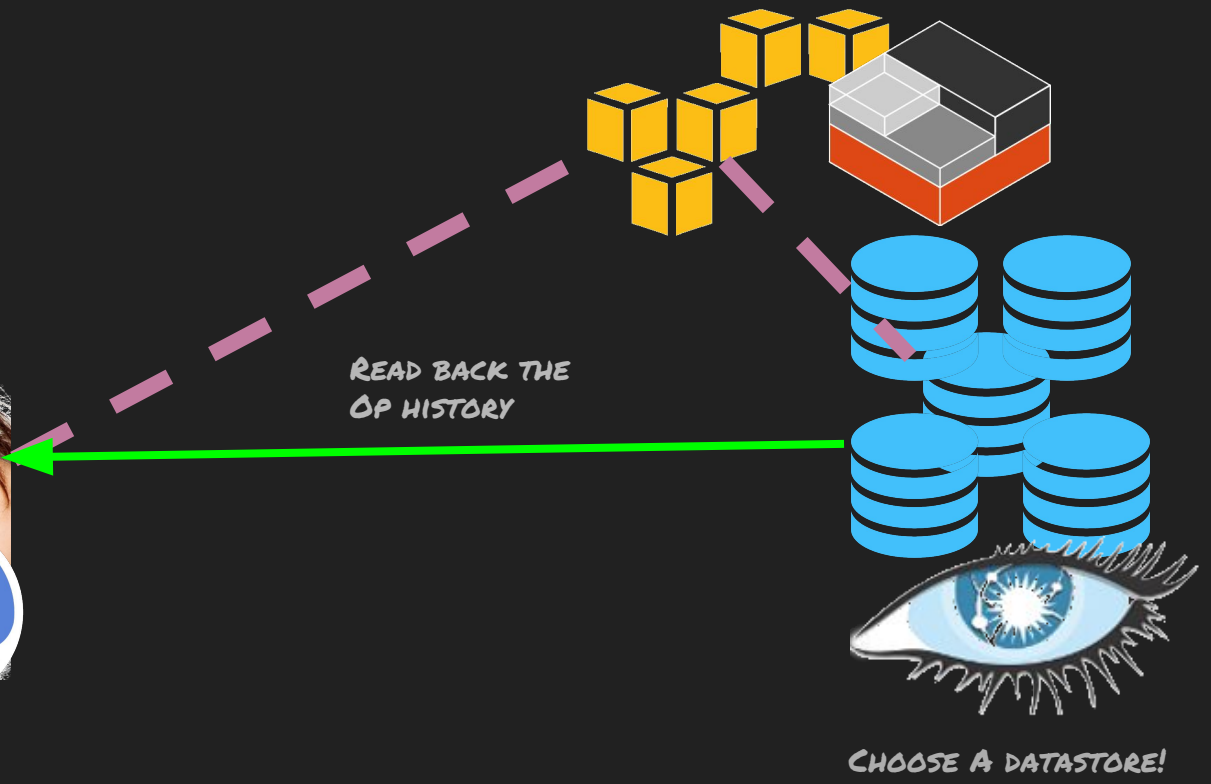
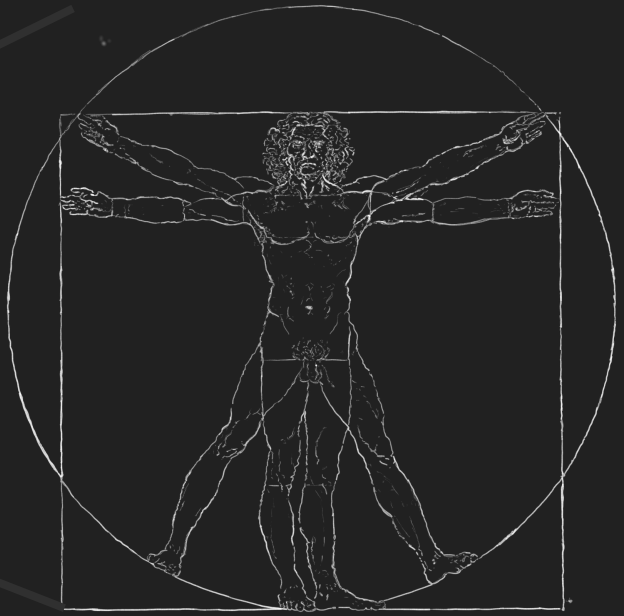
Jepsen



Jepsen was written by Kyle Kingbury (Aphyr) (https://github.com/aphyr/jepsen)

Jepsen

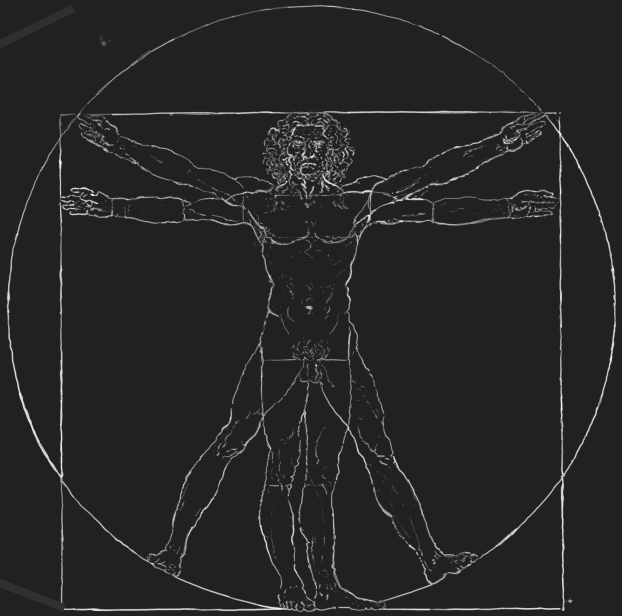
Model: The Ideal sequence of ops



Jepsen was written by Kyle Kingbury (Aphyr) (https://github.com/aphyr/jepsen)

Jepsen

Check Model Against History



Jepsen was written by Kyle Kingbury (Aphyr) (https://github.com/aphyr/jepsen)

Why test Cassandra?

- Most popular wide-column datastore*
- Emphasis on availability ⇝ *eventual consistency*
- EC ⇝ error-prone ordering decisions
- Existing tests ⇝ verifiable, incorrect
  (https://aphyr.com/posts/294-jepsen-cassandra)

*http://db-engines.com/en/ranking/wide+column+store

Test Plan

Used DataStax's existing tests
(http://www.datastax.com/dev/blog/testing-apache-cassandra-with-jepsen)

Cassandra 2.1.14 & 2.26

- Tests for 3.6 had compatibility issues
- Changelogs did not indicate work that would *weaken* fundamental data persistence
- 3.x important when EPaxos is released (https://issues.apache.org/jira/browse/CASSANDRA-6246)

Focus on stable state tests

- Lightweight transactions
- Batch inserts
- Counters
- Set & Map operations

Test Plan

Parameter tweaks:

- add/read/write consistency level
  ALL->QUORUM->TWO, SERIAL
- hinted_handoff: (true|false)
- batch only: ATOMIC (default)/UNLOGGED
  *UNLOGGED *not* tested by DataStax
- Keep replication factor = 3

Results

All Results found here:
https://github.com/nps/jepsen/tree/master/cassandra/analysis

Let’s focus on the more interesting cases for now:

- Lightweight Transactions (LWT)
- Batch inserts (Atomic & Unlogged)

Results: Atomic Batch

W=Q,R=ALL,+/-hinted_handoff:

```
INFO  jepsen.core - Everything looks good! ヽ(‘ー`)ノ
```

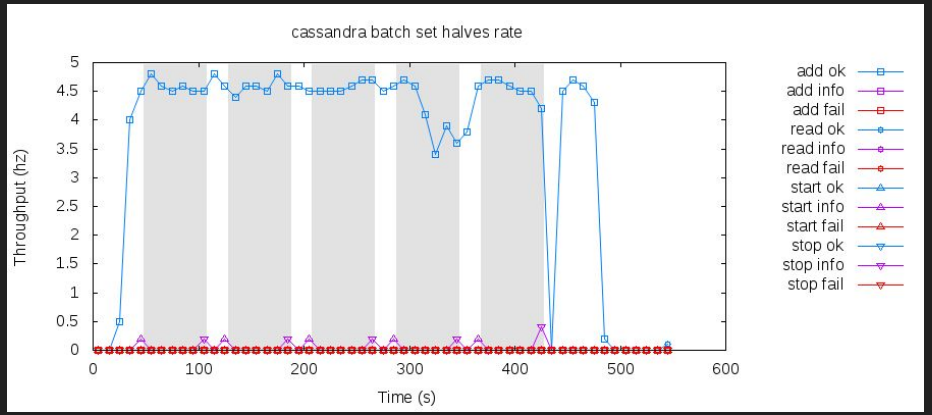
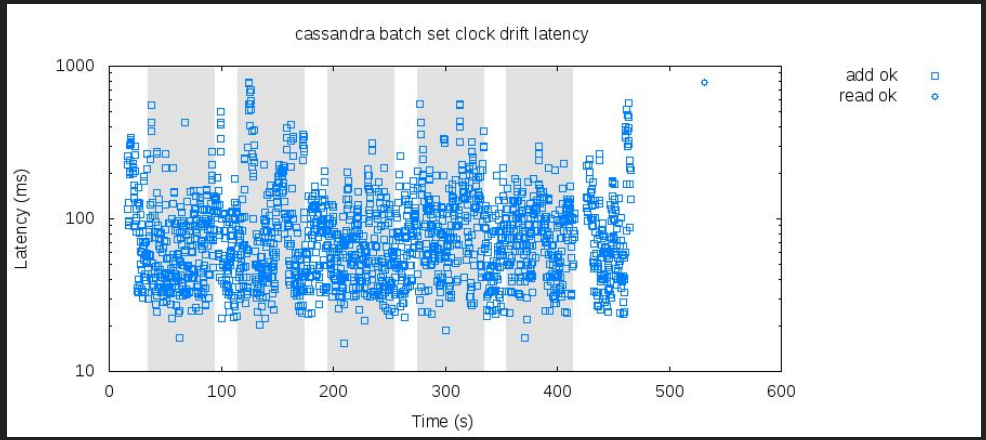


Fig1: qa, +hh



W=Q,R=Q,+/-hinted_handoff:

```
INFO  jepsen.core - Everything looks good! ヽ(‘ー`)ノ
```

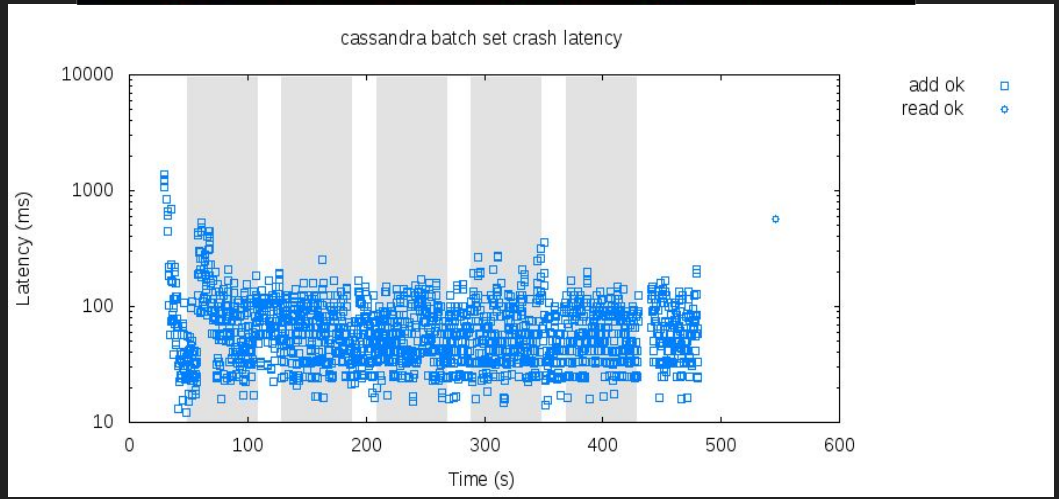
Fig2: qq, -hh

Results: Unlogged Batch

Inconsistencies are possible if client & coordinator both suffer failures.

W=Q,R=Q,-hinted_handoff:

```
INFO  jepsen.core - Everything looks good! ヽ(‘ー`)ノ
```



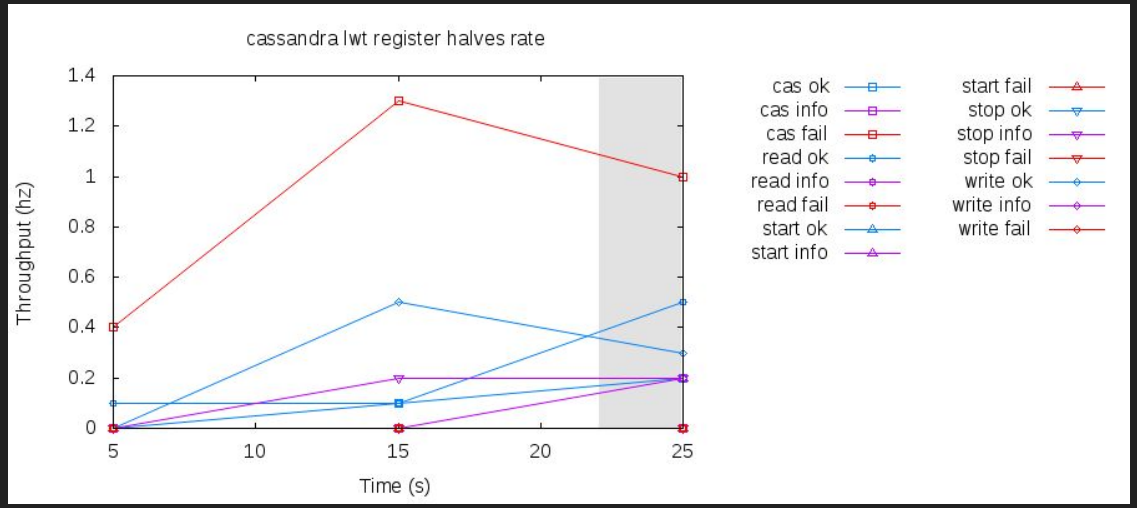
Results: Lightweight Transactions

Docs* promise
linearizable consistency.
That's a juicy claim…

R=ALL/Q, +/-hinted_handoff

Oh, FAILED CAS!

but not so fast...



*http://www.datastax.com/dev/blog/lightweight-transactions-in-cassandra-2-0

Results: Lightweight Transactions

These aren't failures *per se*
https://issues.apache.org/jira/browse/CASSANDRA-9328

> Not sure where that hypothesis comes from. CAS is atomic: either all of it will be applied or none of it will. It just happens that there is some situation where you, the client, won't know which one that is.

and mapped in the DataStax test

```
40    ; A failure; fill in either value.
41    :fail
42    (let [i           (get index (:process op))
43          _           (assert i)
44          invocation  (nth history i)
45          value       (or (:value invocation) (:value op))
46          [invocation' op'] (if (and (= :cas (:f op)) (number? (:value op)))
47                              [(assoc invocation :f :read :value (:value op))
48                               (assoc op :f :read :type :ok)]
49                              [(assoc invocation :value value) (assoc op :value value)])]
```

So..is that legit?

Aphyr: "looks like for CAS they replace :fail results with an actually read value, which is why the number? check is there--it ensures that they only insert a read op if they actually read something. It's a little odd, but I think it's legal."

In Summary

The original Jepsen tests
succeeded in making the
C* folks better at designing for failure

Testing makes our systems better

But finding nothing wrong is also kind of sad.

About Me

Nick Schwartzmyer

- MS, Computational Linguistics
- 8 years professional experience

Command line geek

I Like Hunting bugs!

Getting interested in Software Correctness

Intentionally blank

Test Plan

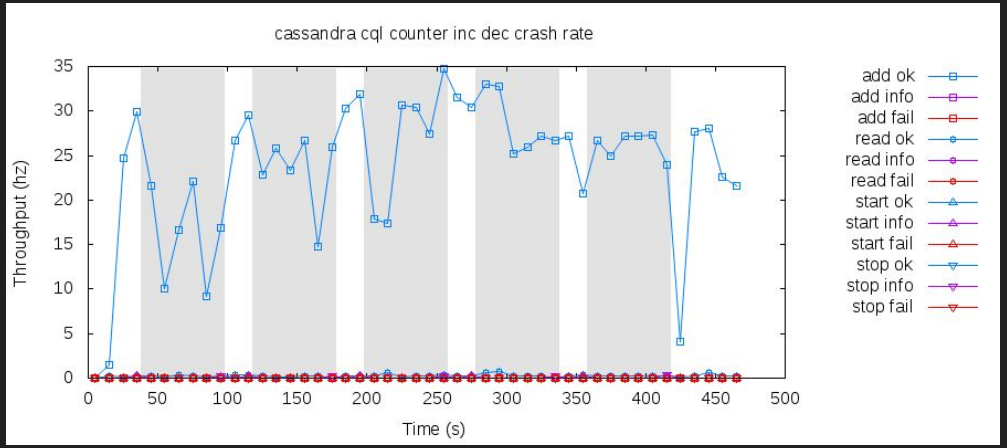
Nemesis types:

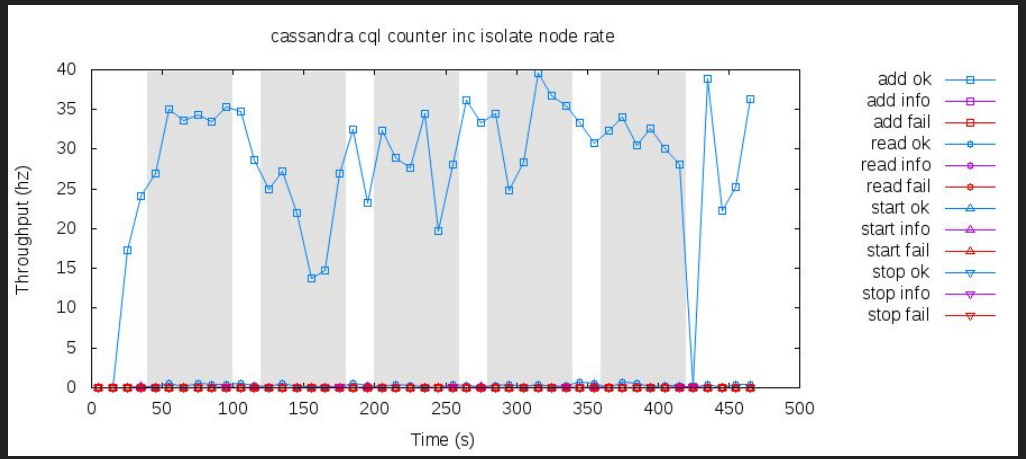
- Bridge partitions
- Random node isolations
- Clock skew
- Kill a node

Results: Counters

Monotonic INC & INC/DEC tests:

```
INFO  jepsen.core - Everything looks good! ヽ(‘ー`)ノ
```

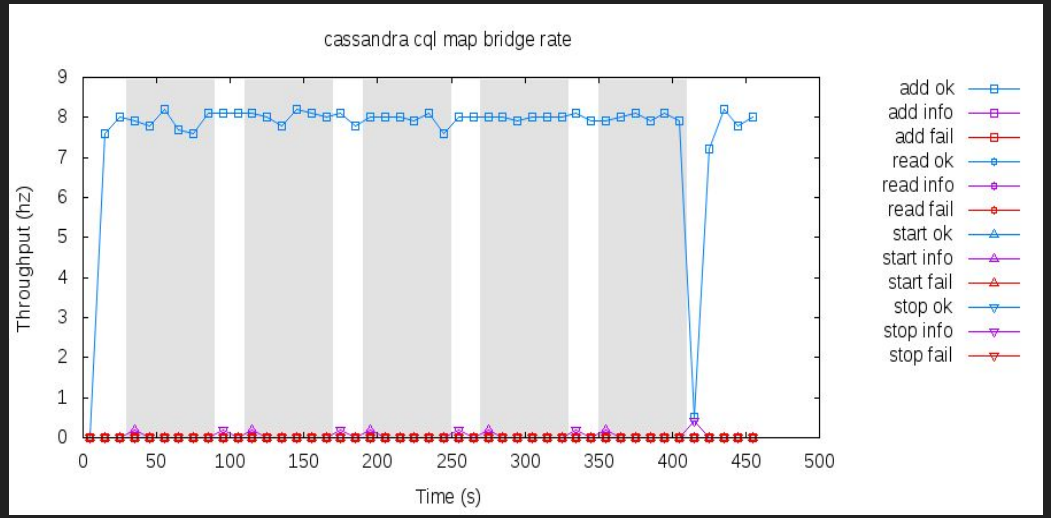




Results: Map & Set tests

```
INFO  jepsen.core - Everything looks good! ヽ(‘ー`)ノ
```

```
{:set
 {:valid? true,
  :lost "#{}",
  :recovered "#{}",
  :ok "#{0..3525}",
  :recovered-frac 0,
  :unexpected-frac 0,
  :unexpected "#{}",
  :lost-frac 0,
  :ok-frac 1},
 :perf
 {:latency-graph {:valid? true},
  :rate-graph {:valid? true},
  :valid? true},
 :valid? true}
results.edn (END)
```



Future directions

Get tests working for C* 3.6

Compare with Riak

- Also Dynamo-based, old Jepsen test exist
- Richer CRDTs; what's the performance hit when partitioned?

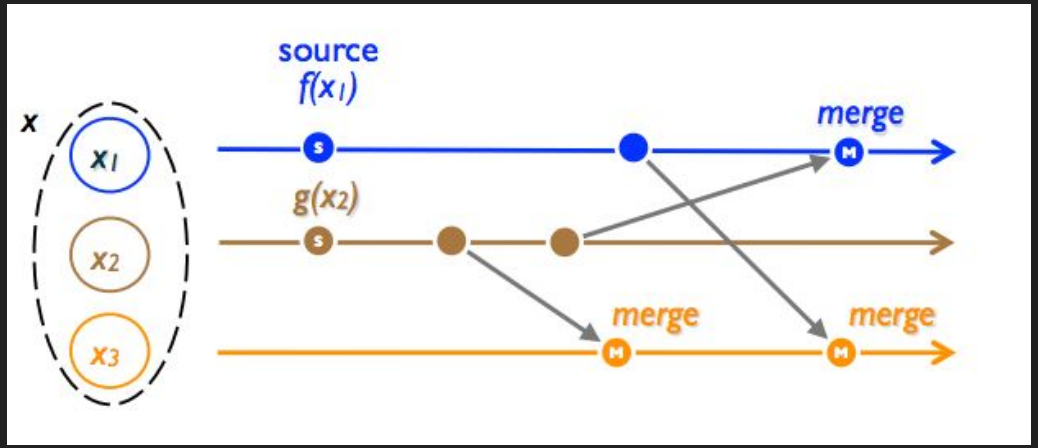
Write my own tests!

- HBase: Aphyr: "I wouldn't be at all surprised if HBase is terrible haha."
- Accumulo: Growing in popularity, NSA backed

(These are backed by Zookeeper, so already have known minimum constraints, though…)

In an even more distant future...

For fun, Implement a class of CRDT atop a datastore

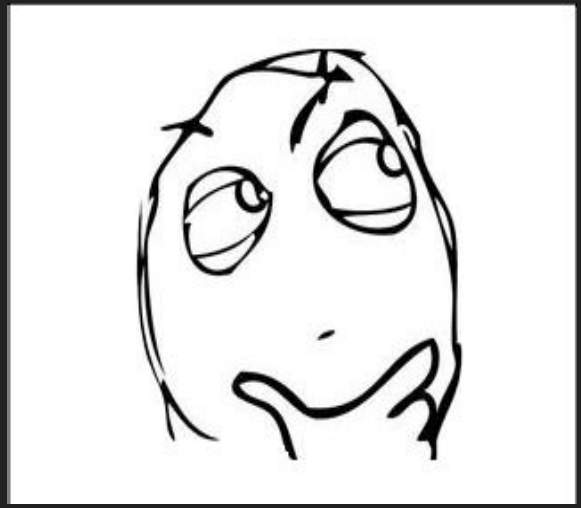


Analyze how they impact with Jepsen tests

Challenges!

The (sort of) glamorous

- Understanding Jepsen mechanics by reading through the code
- Picking up some Clojure to do so!
- Crash course in Cassandra fault tolerance model
- Researching distributed data structures and state models



Challenges!

The realities-of-working-with-software kind

- Getting Jepsen up-and-running
- Significant code rot in the tests