Cassandra in Response Time Sensitive Environments

Gil Tene, CTO & co-Founder, Azul Systems
@giltene

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About me: Gil Tene

- co-founder, CTO @Azul Systems
- Have been working on "think different" GC approaches since 2002
- A Long history building Virtual & Physical Machines, Operating Systems, Enterprise apps, etc...
- I also depress people by demonstrating how terribly wrong their latency measurements are...

* working on real-world trash compaction issues, circa 2004

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- We build Java Virtual Machines
- Powering mission-critical Java applications for Global 2000+
- Deep expertise with latency-sensitive applications
  - from human sensitivity to application responsiveness (fractions of a second)
  - to low latency trading systems (fractions of a msec)
- Cassandra is one of our common deployment scenarios

Zing Overview

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Zing 

- A JVM for Linux/x86 servers
- Delivers a continuously responsive execution platform
- ELIMINATES Garbage Collection as a concern for enterprise applications
- Very wide operating range:
  - Used in everything from low latency to huge in-memory apps
  - 1GB to 1TB Heaps. 10MB/sec to 20GB/sec allocation rates.
- Combats Execution inconsistencies of all types
  - Not just GC: Anything that makes a JVM glitch or slow down
  - "Not just Fast. Always Fast."

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What is Zing good for?

- If you have a server-based Java application
- And you are running on Linux (x86)
- And you use using more than ~300MB of memory
- Then Zing will likely deliver superior behavior metrics

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Where Zing shines

- Low latency
  - Eliminate behavior blips down to the sub-millisecond-units level
- Machine-to-machine "stuff"
  - Support higher *sustainable* throughput (the one that meets SLAs)
- Human response times
  - Eliminate user-annoying response time blips. Multi-second and even fraction-of-a-second blips will be completely gone.
  - Support larger memory JVMs *if needed* (e.g. larger virtual user counts, or larger cache, in-memory state, or consolidating multiple instances)
- "Large" data and in-memory analytics
  - Make batch stuff "business real time". Gain super-efficiencies.

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Why Zing?

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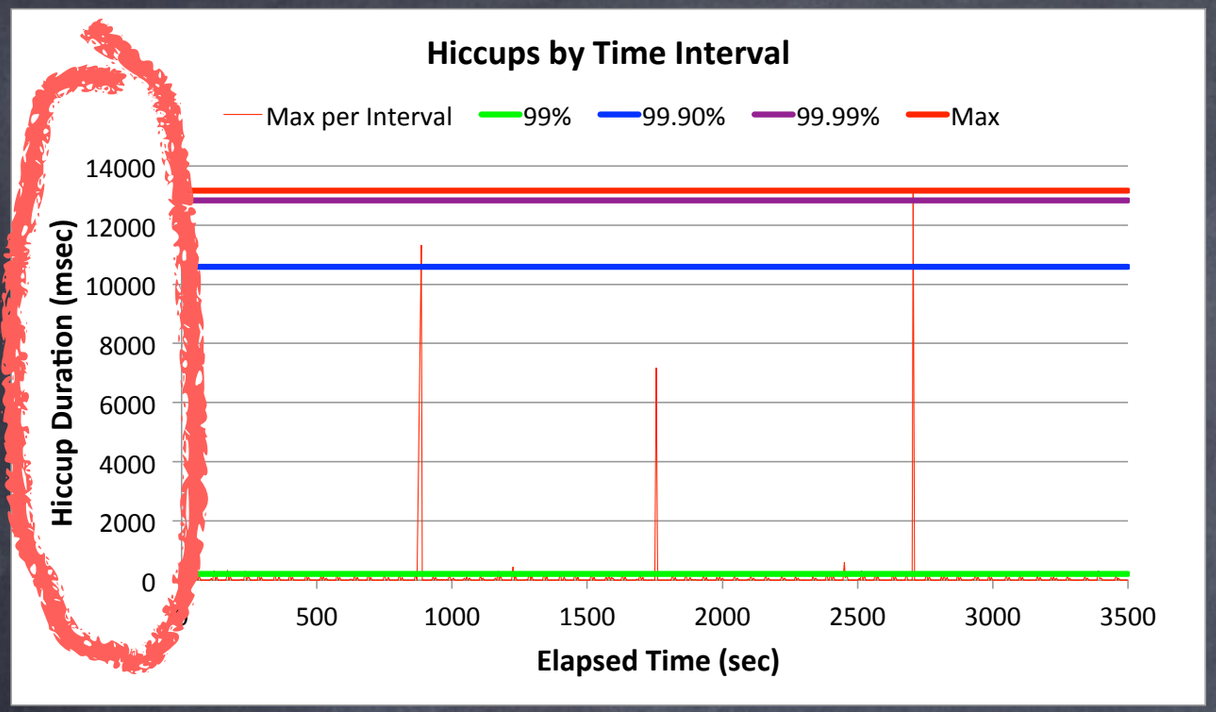
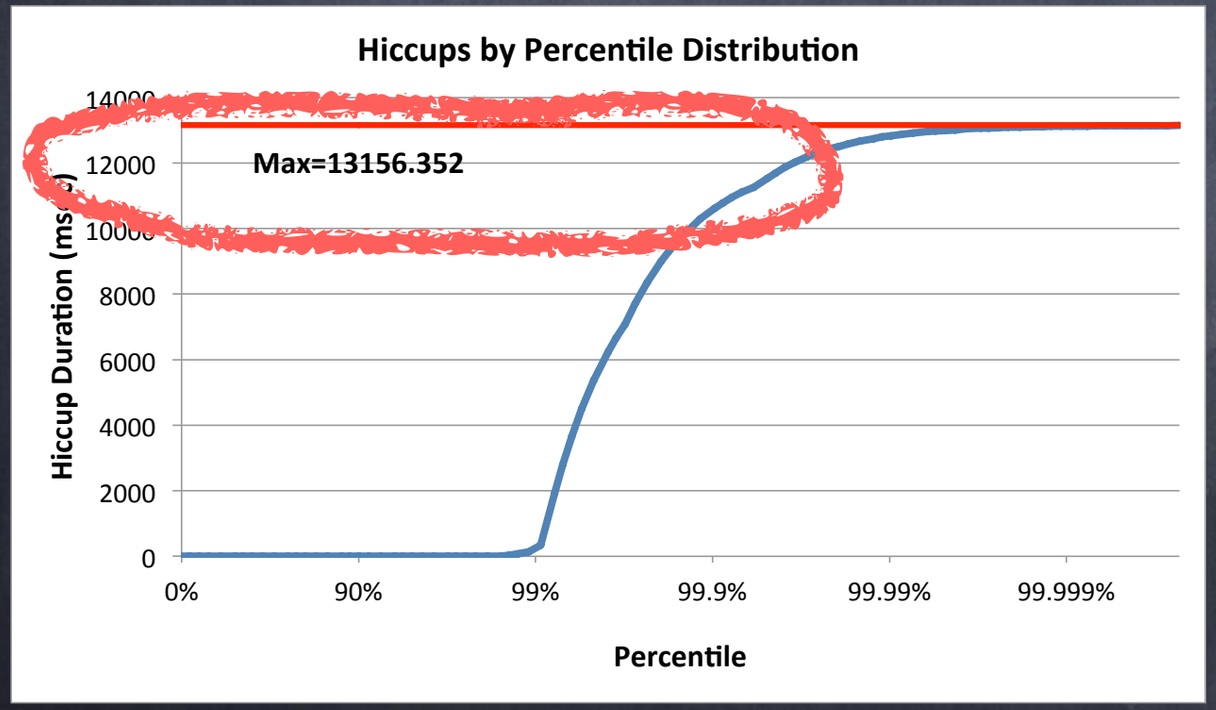
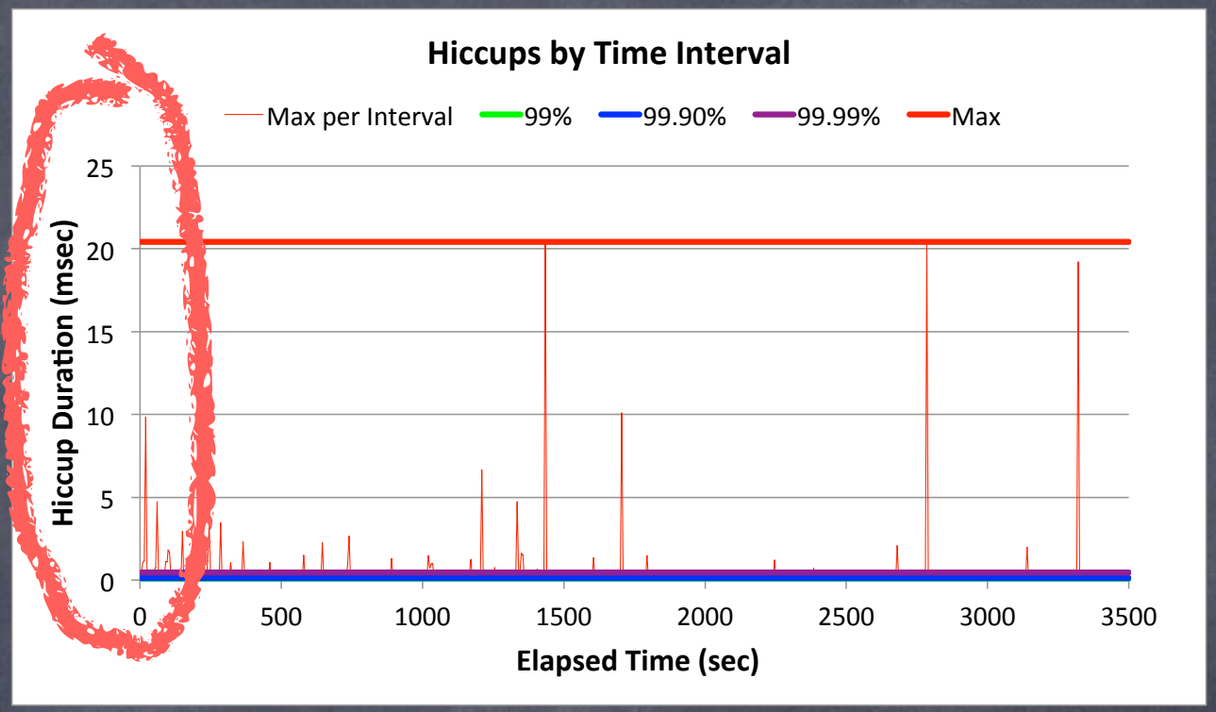
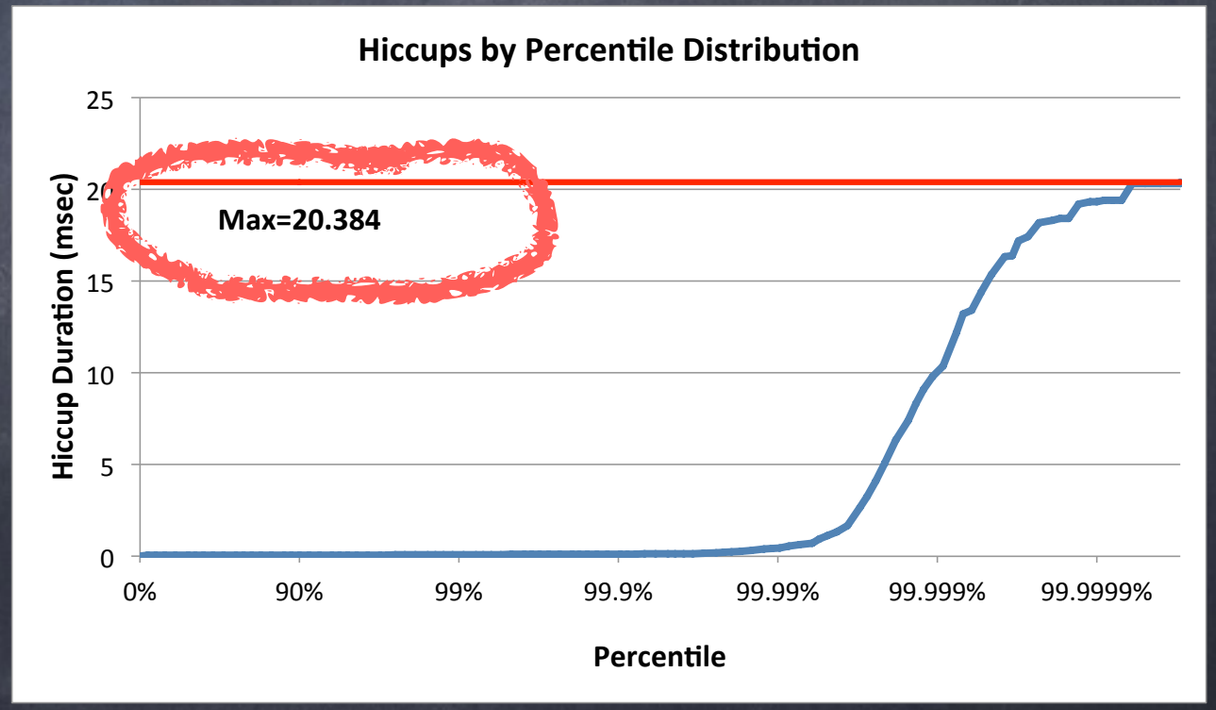
Oracle HotSpot CMS, 1GB in an 8GB heap





Zing 5, 1GB in an 8GB heap





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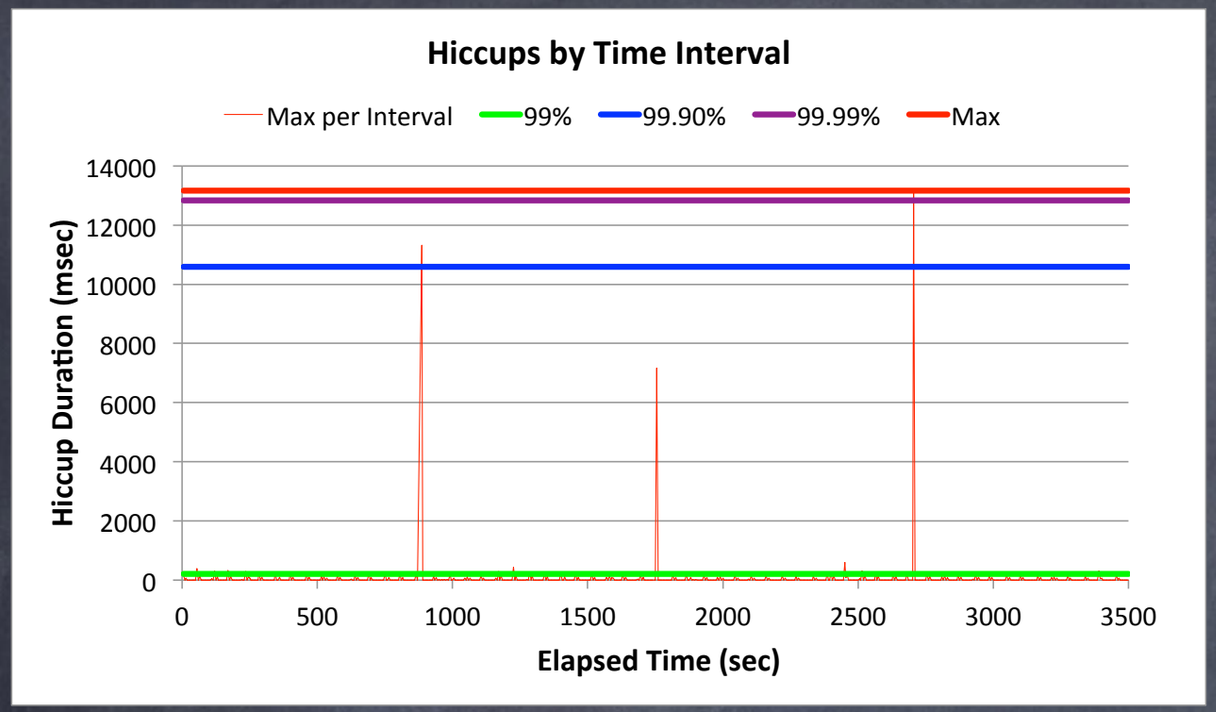
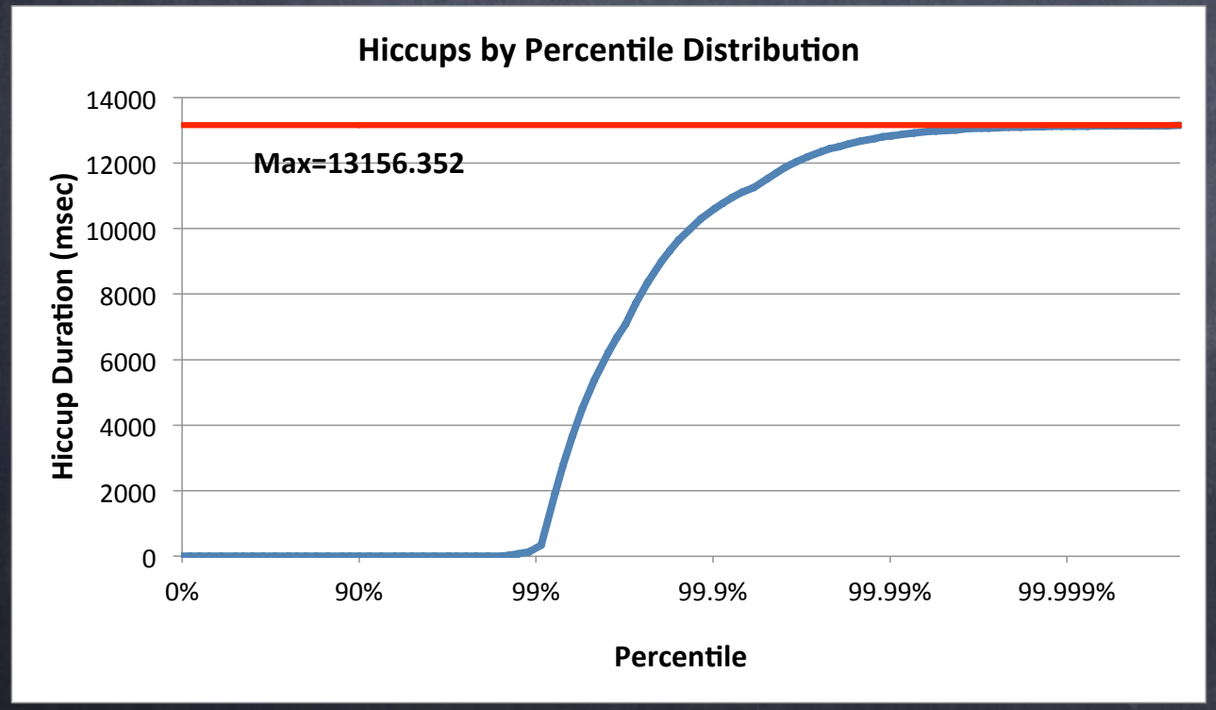
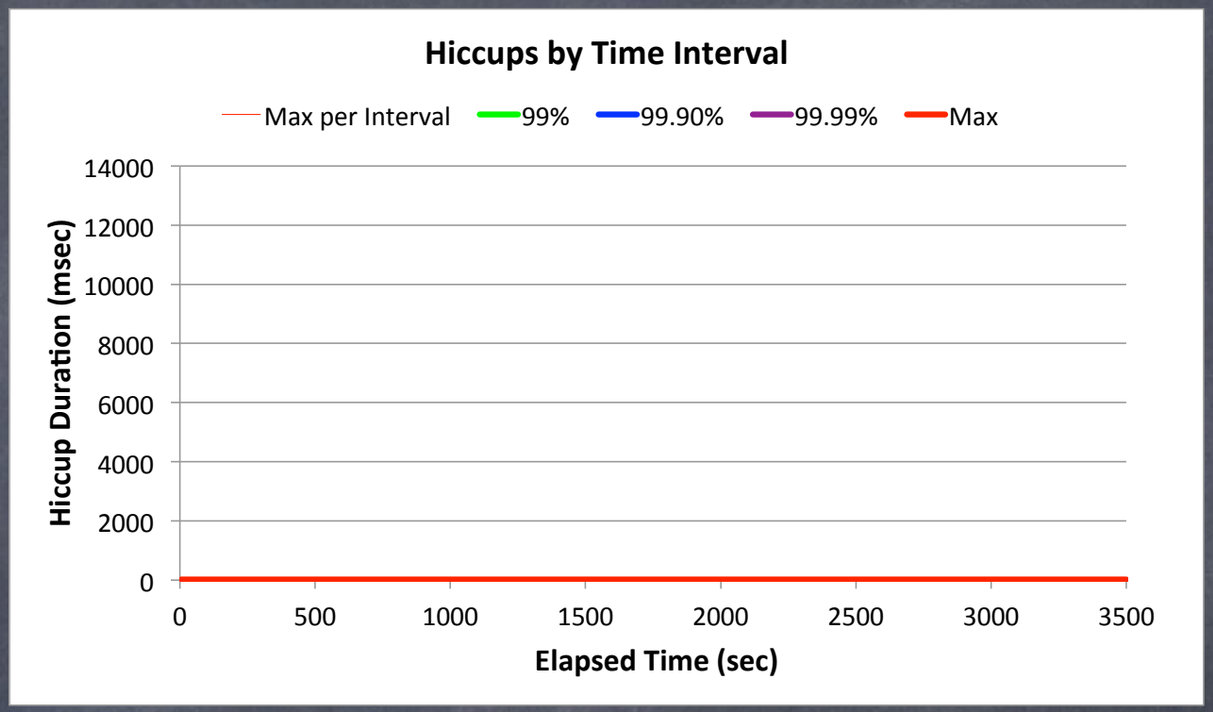
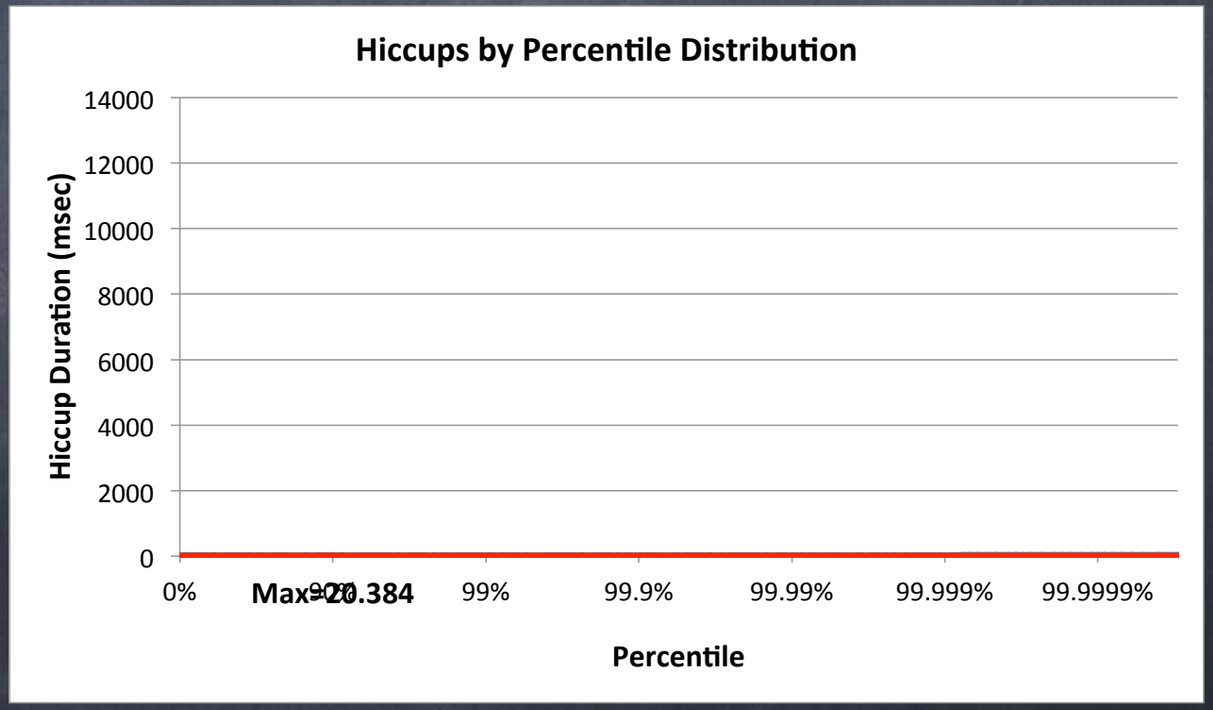




Zing 5, 1GB in an 8GB heap





Drawn to scale

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Sustainable Throughput:
The throughput achieved while safely maintaining service levels

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Percentiles Matter

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Is the 99%'ile "rare"?

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Cumulative probability…

What are the chances of a single web page view experiencing the 99%'ile latency of:

- A single search engine node?

- A single Key/Value store node?

- A single Database node?

- A single CDN request?

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Site	# of requests	page loads that would experience the 99%'lie [(1 - (.99 ^ N)) * 100%]
amazon.com	190	85.2%
kohls.com	204	87.1%
jcrew.com	112	67.6%
saksfifthavenue.com	109	66.5%
--	--	--
nytimes.com	173	82.4%
cnn.com	279	93.9%
--	--	--
twitter.com	87	58.3%
pinterest.com	84	57.0%
facebook.com	178	83.3%
--	--	--
google.com (yes, that simple noise-free page)	31	26.7%
google.com search for "http requests per page"	76	53.4%

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Which HTTP response time metric is more "representative" of user experience?

The 95%'lie or the 99.9%'lie

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Gauging user experience

Example: A typical user session involves 5 page loads, averaging 40 resources per page.

- How many of our users will NOT experience something worse than the 95%'lie?

Answer: ~0.003%

- How may of our users will experience at least one response that is longer than the 99.9%'lie?

Answer: ~18%

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Response Time vs. Service Time

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Service Time vs. Response Time

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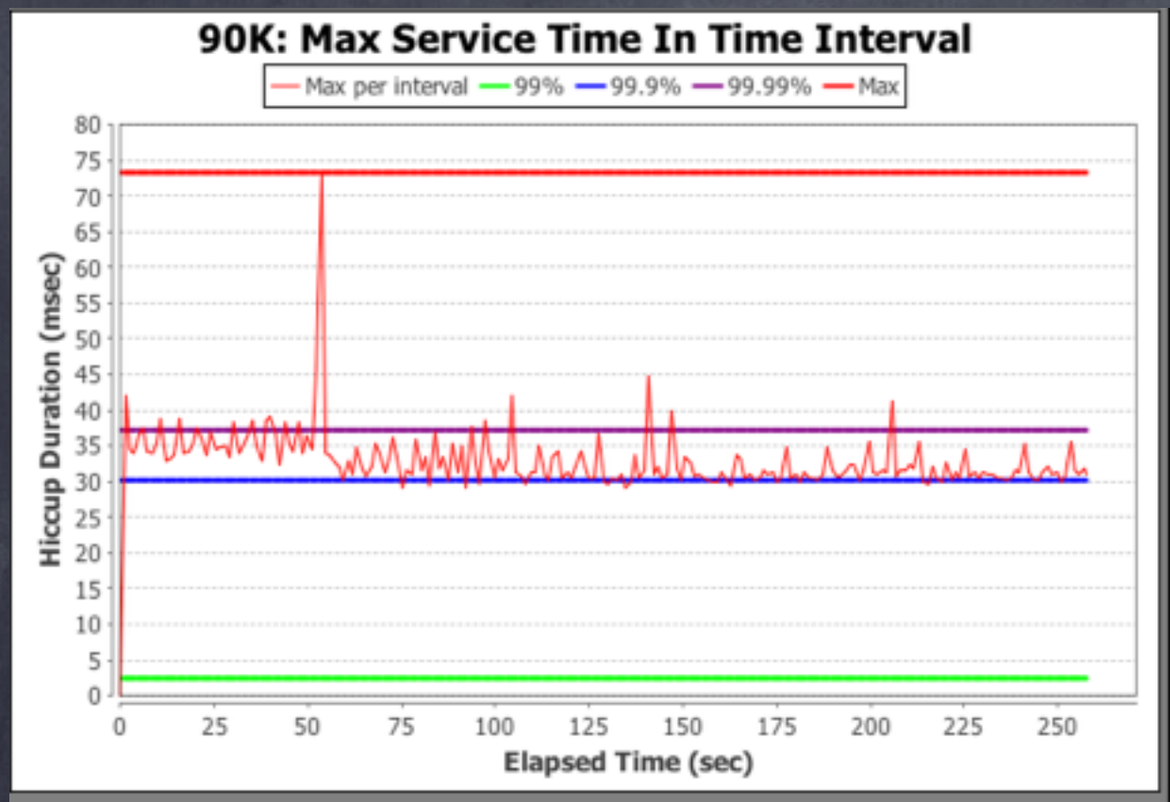
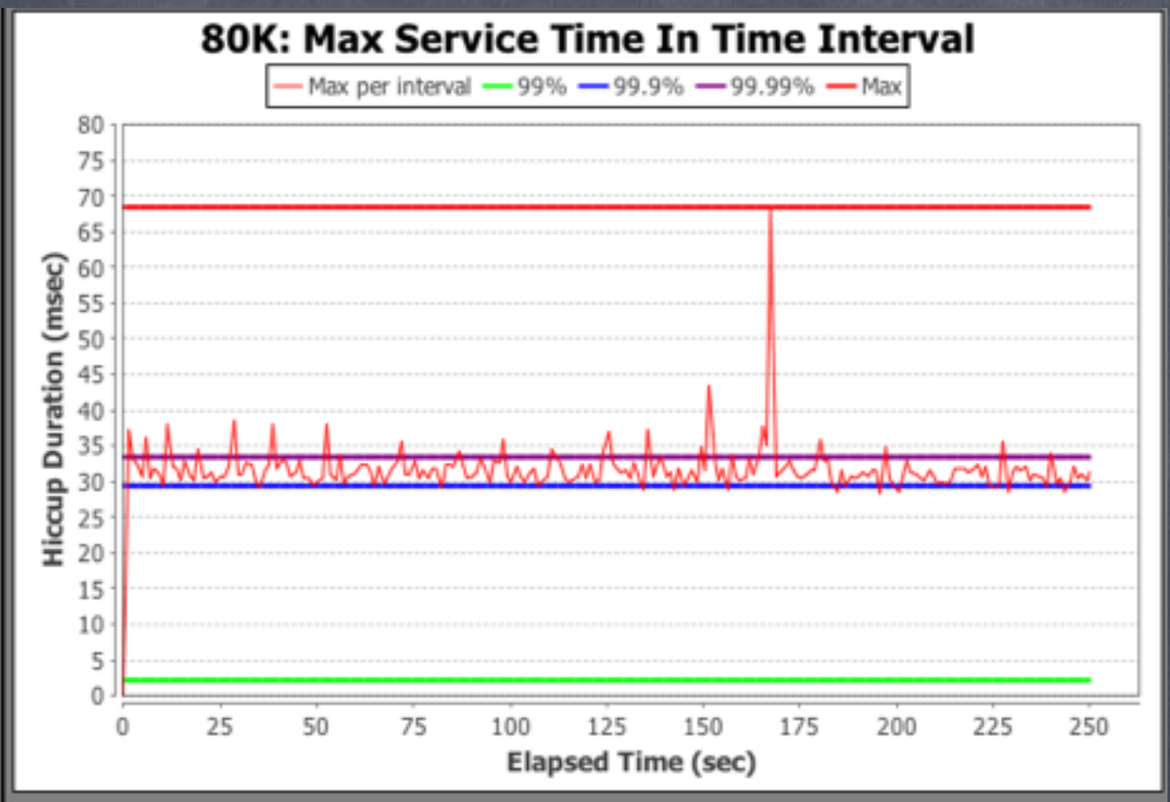
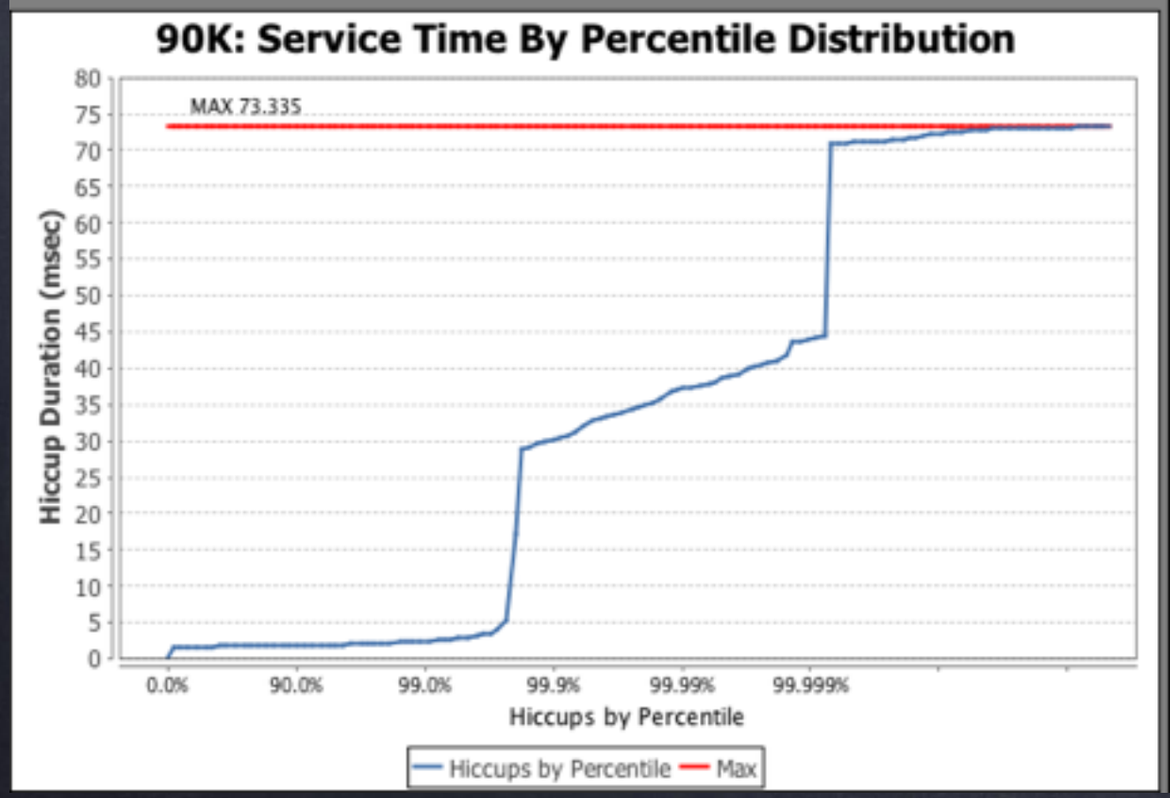
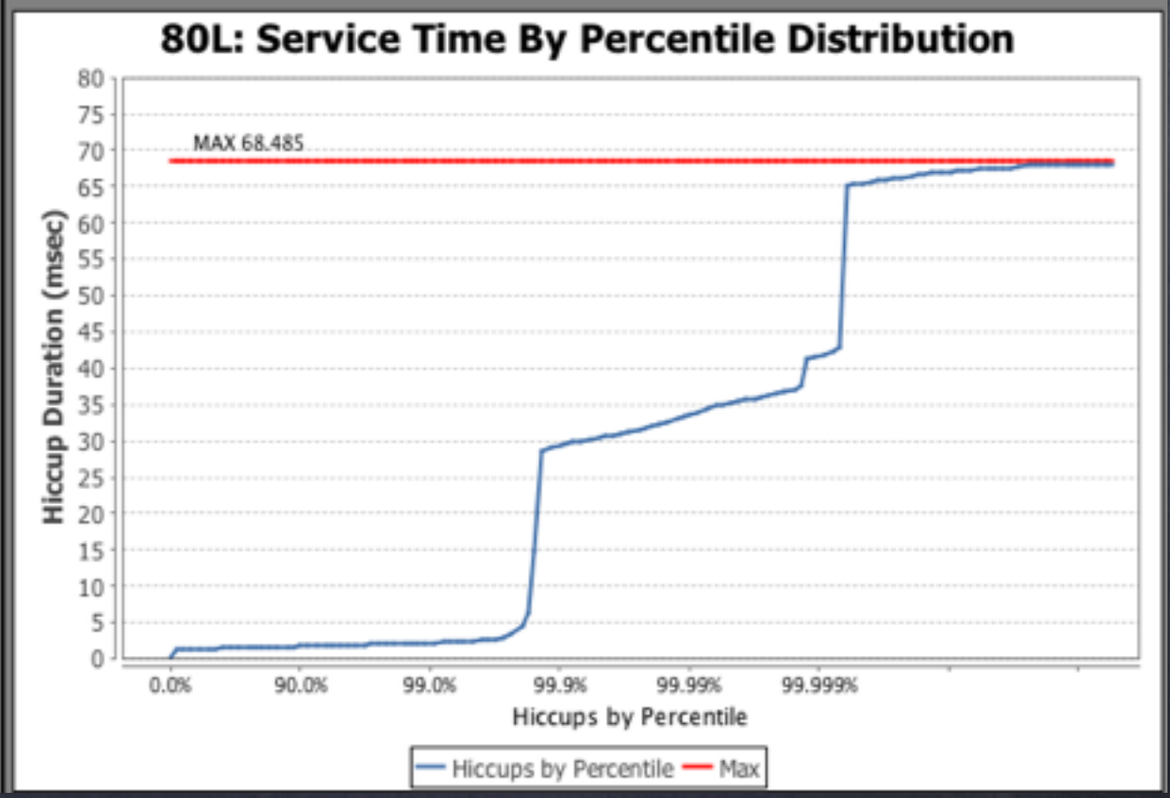
Service Time, 90K/s vs 80K/s









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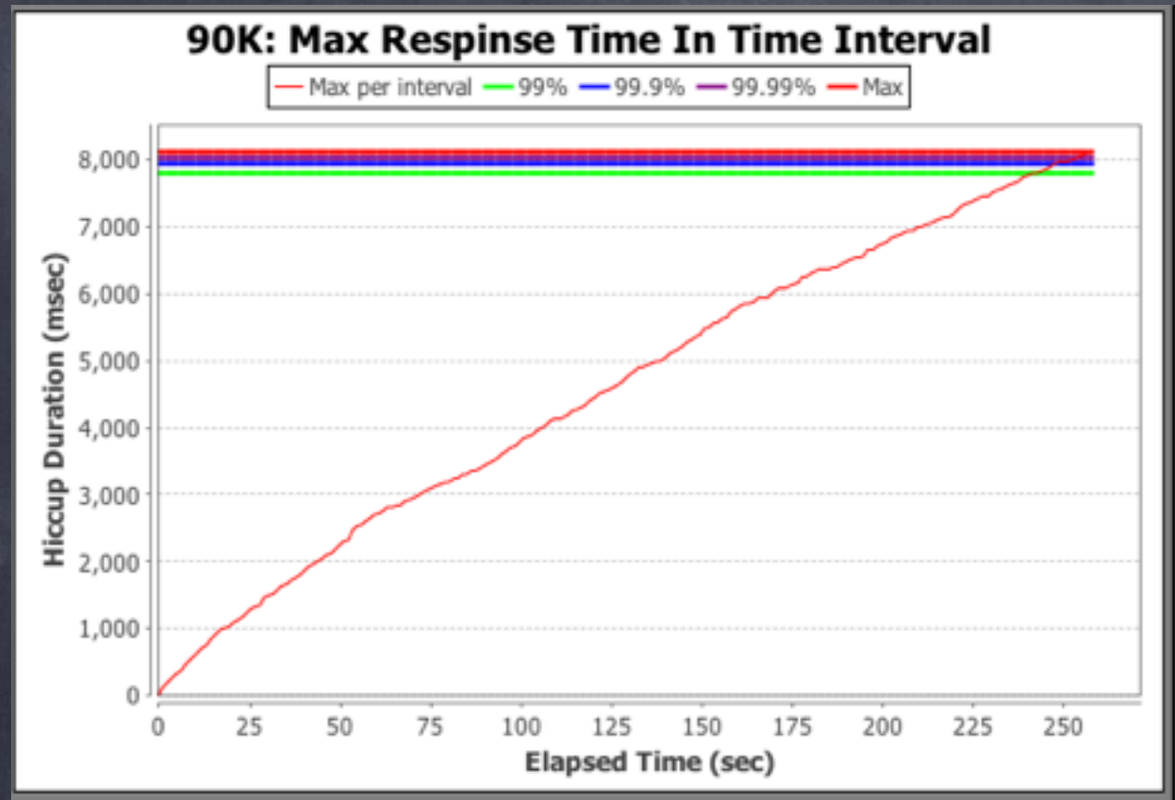
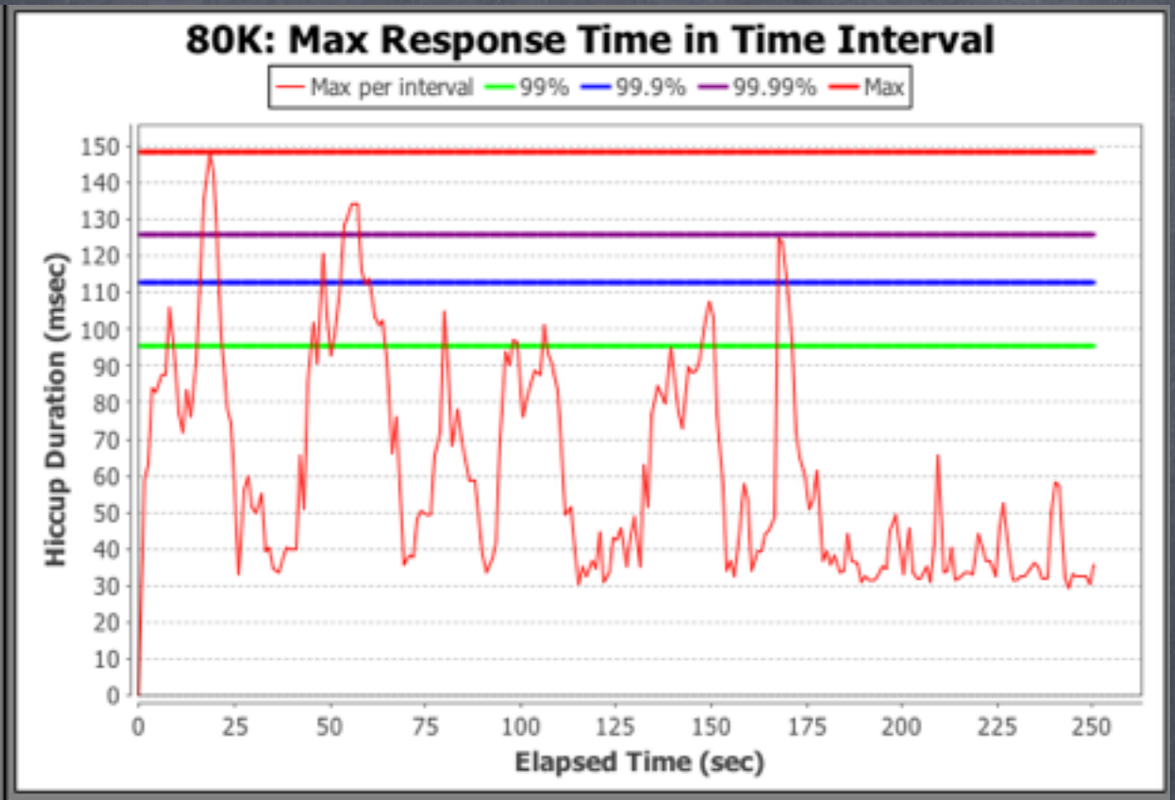
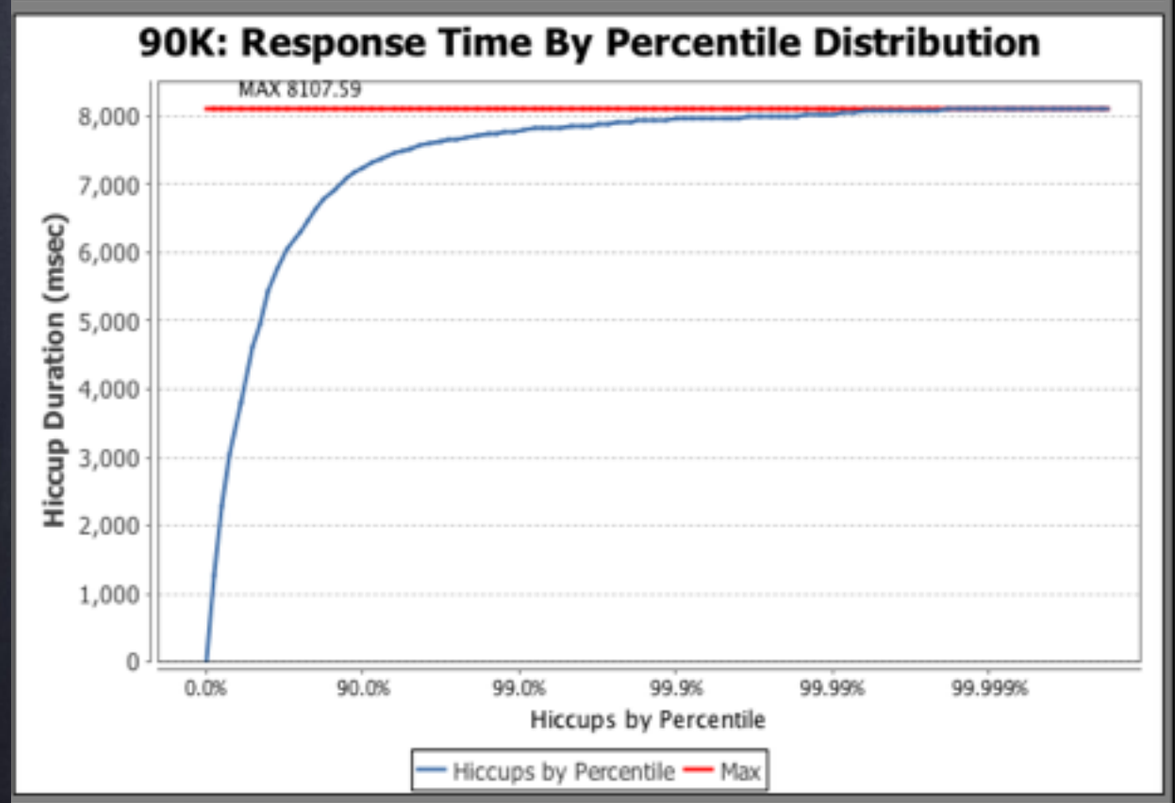
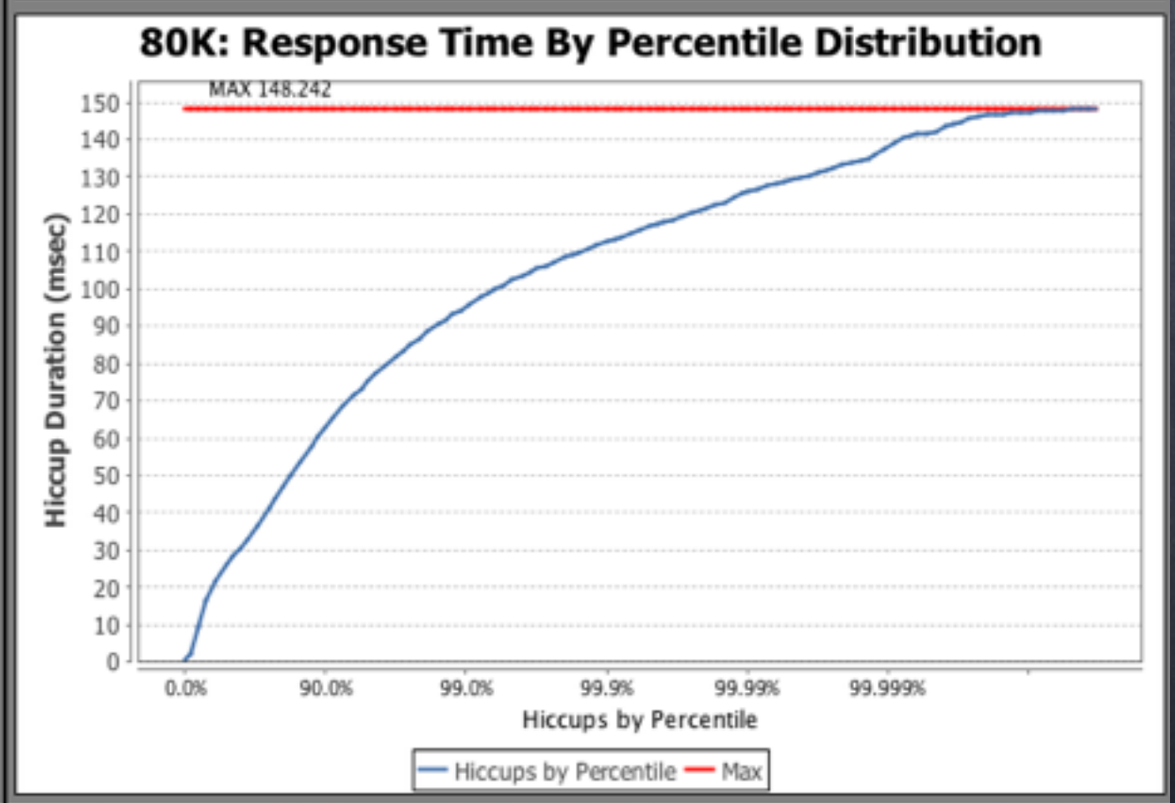
Response Time, 90K/s vs 80K/s









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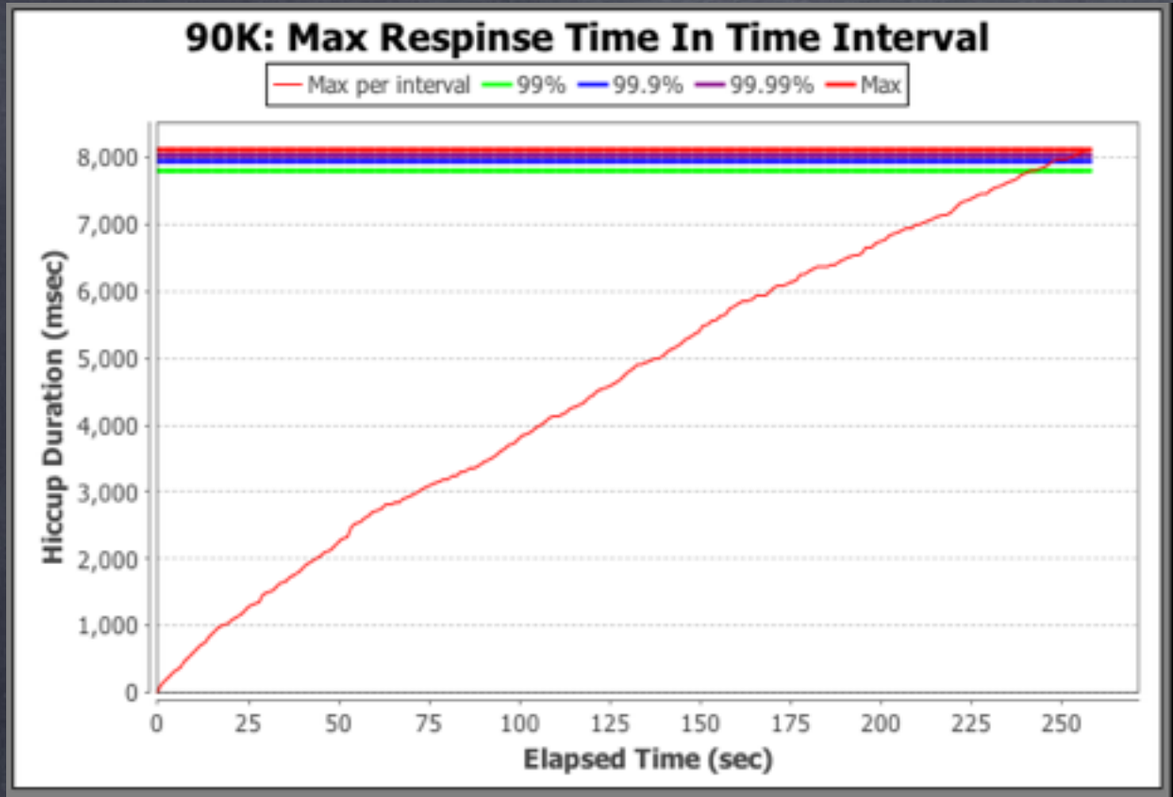
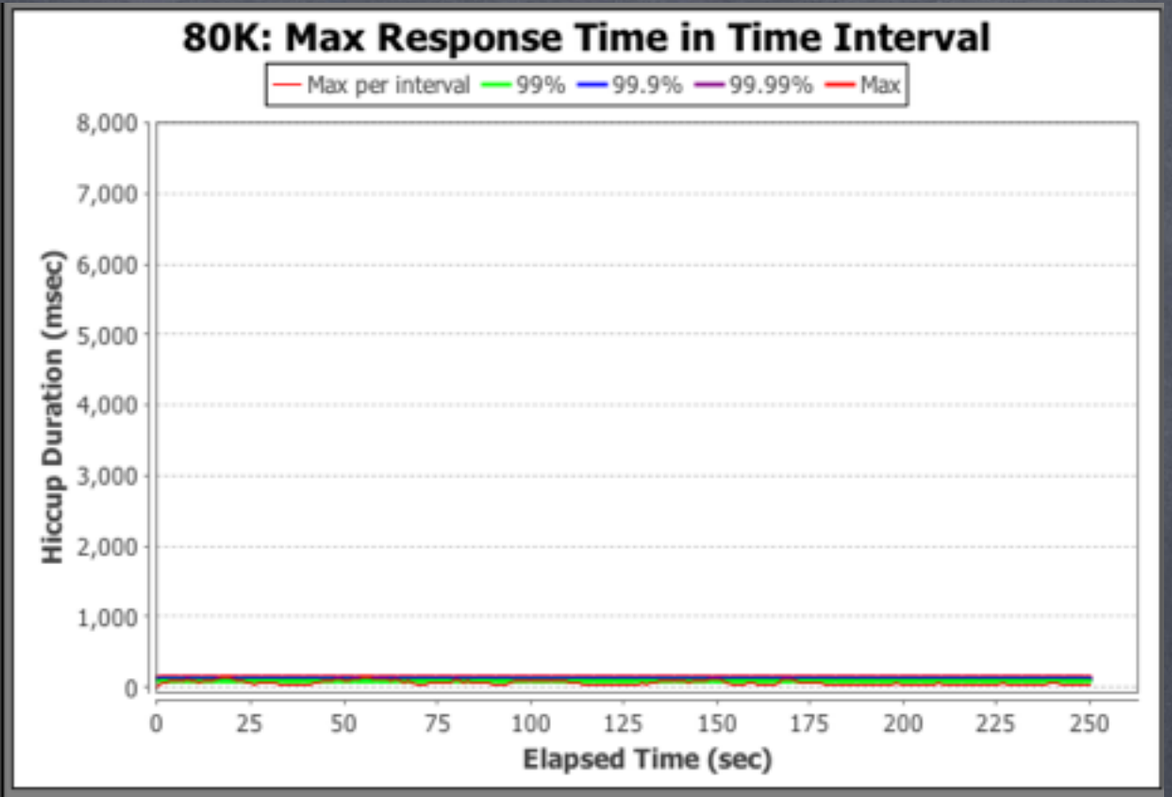
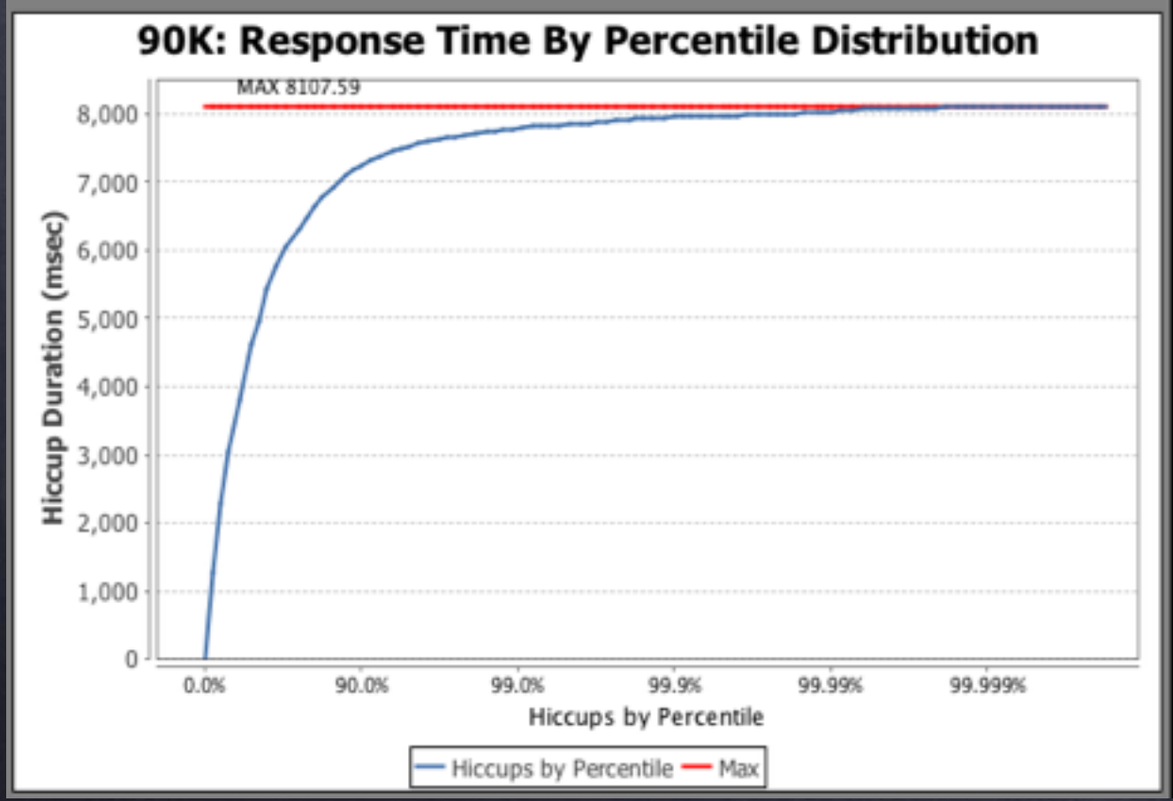
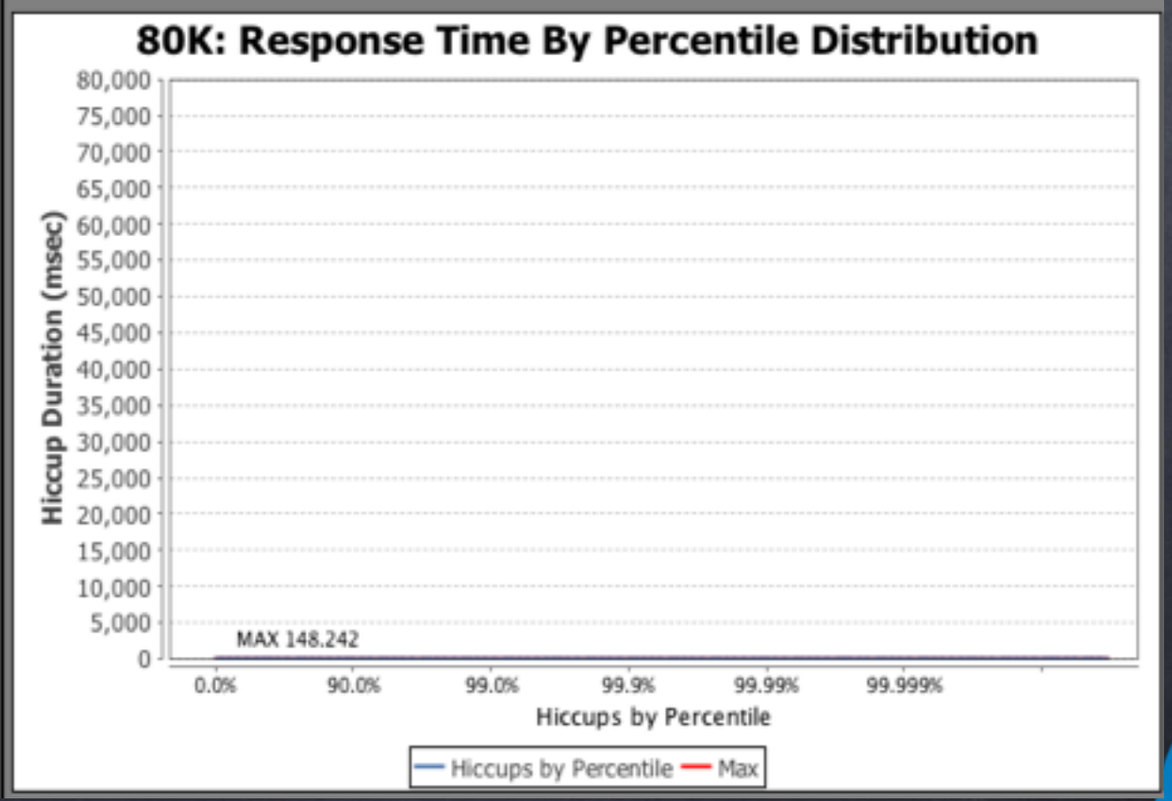
Response Time, 90K/s vs 80K/s : Boom!









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"coordinator as savior" latency myth

"But with Cassandra's Coordinator and Quorum Consistency levels..."

Theory: If one node pauses, other nodes are not likely to pause at the same time

... so a quorum will be reached without observing any one node's pause

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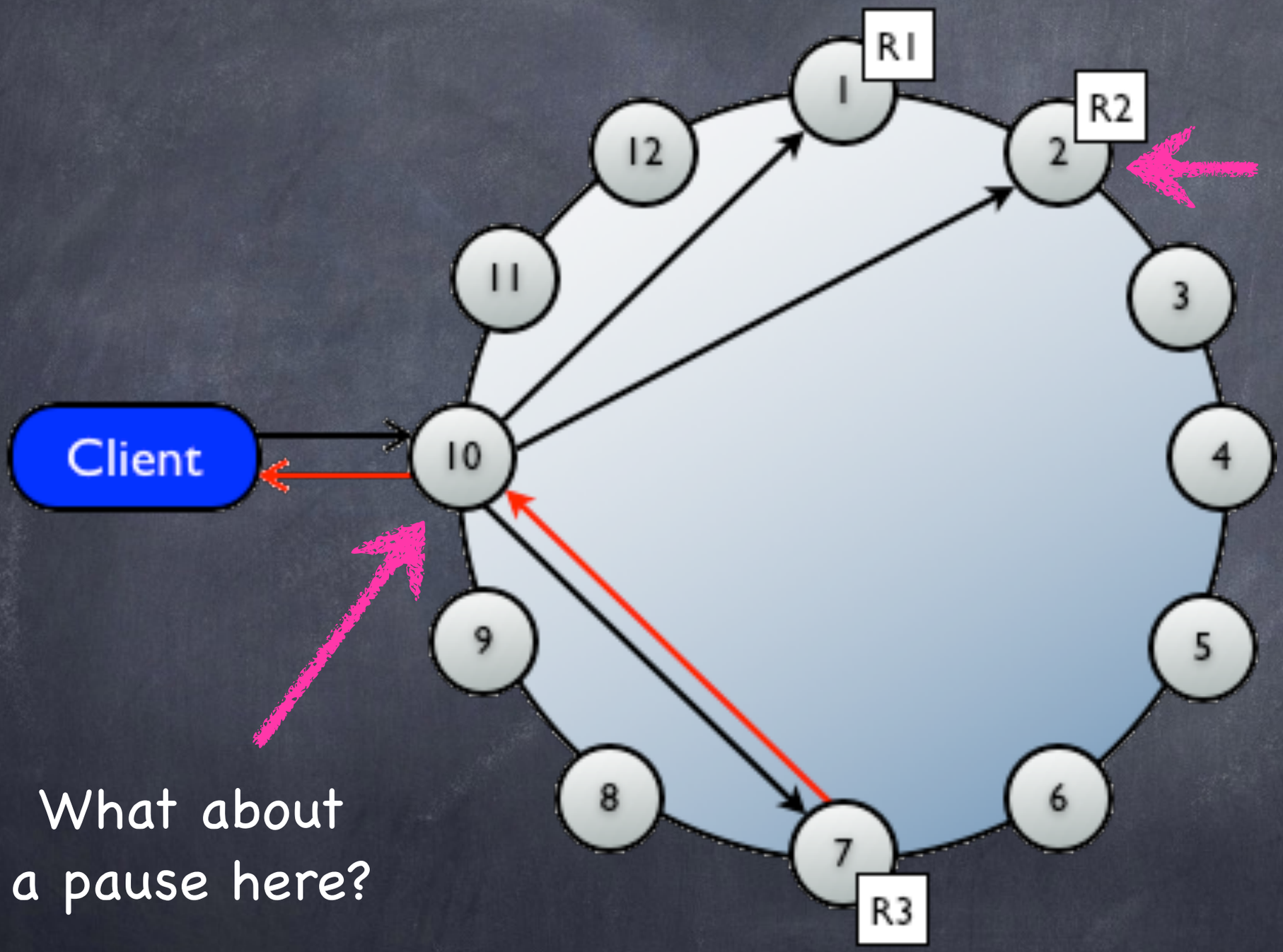
Anatomy of a quorum read…



A pause here won't be noticed by client…

What about a pause here?

And since every node is also a coordinator…

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Cassandra behavior on Zing

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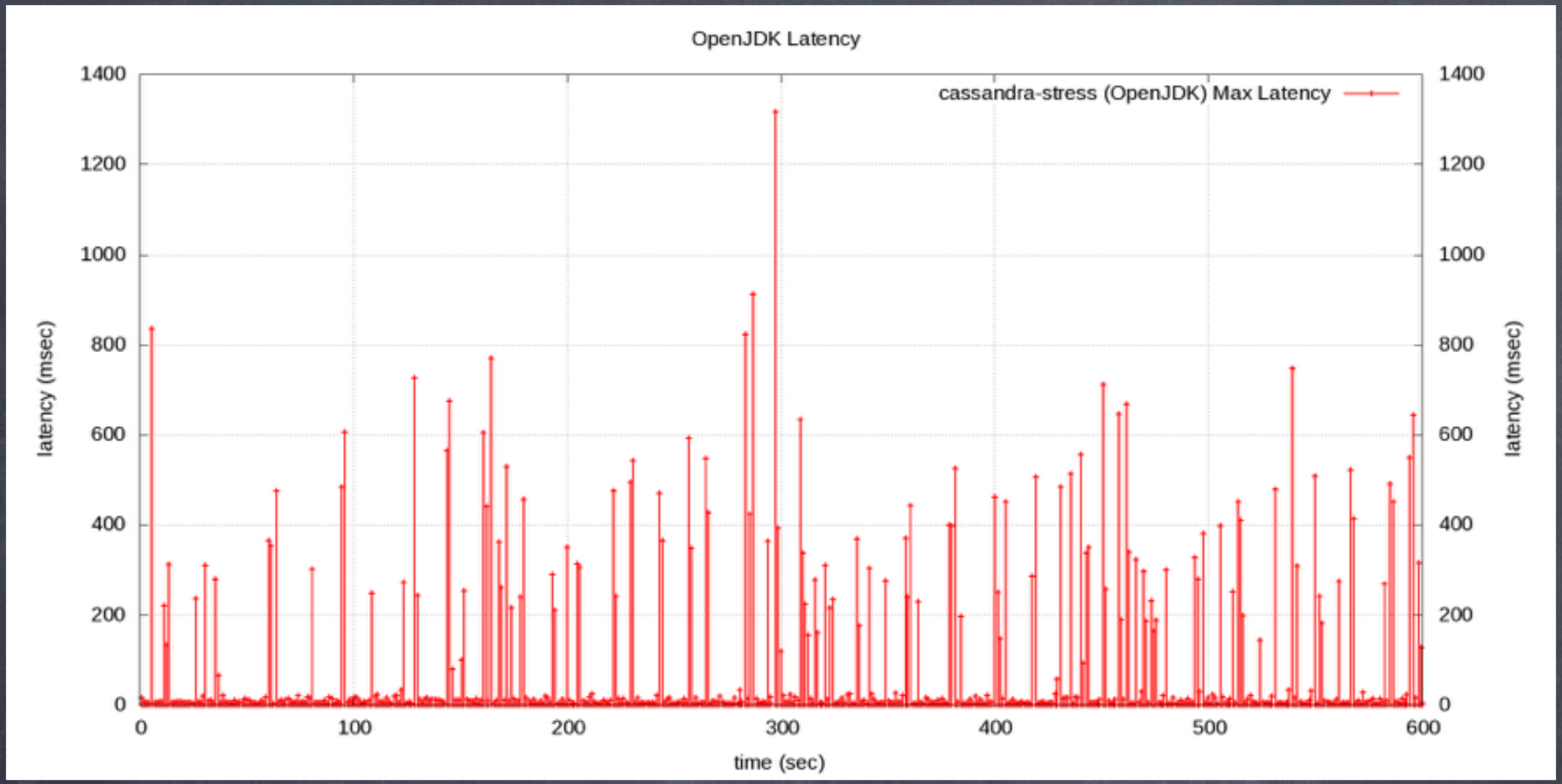


```
op rate                   : 40001
partition rate            : 26996
row rate                  : 26996
latency mean              : 30.6 (0.7)
latency median            : 0.5 (0.5)
latency 95th percentile   : 244.4 (1.1)
latency 99th percentile   : 537.4 (2.0)
latency 99.9th percentile : 1052.2 (8.4)
latency max               : 1314.9 (1312.8)
```

Response Time

Service time

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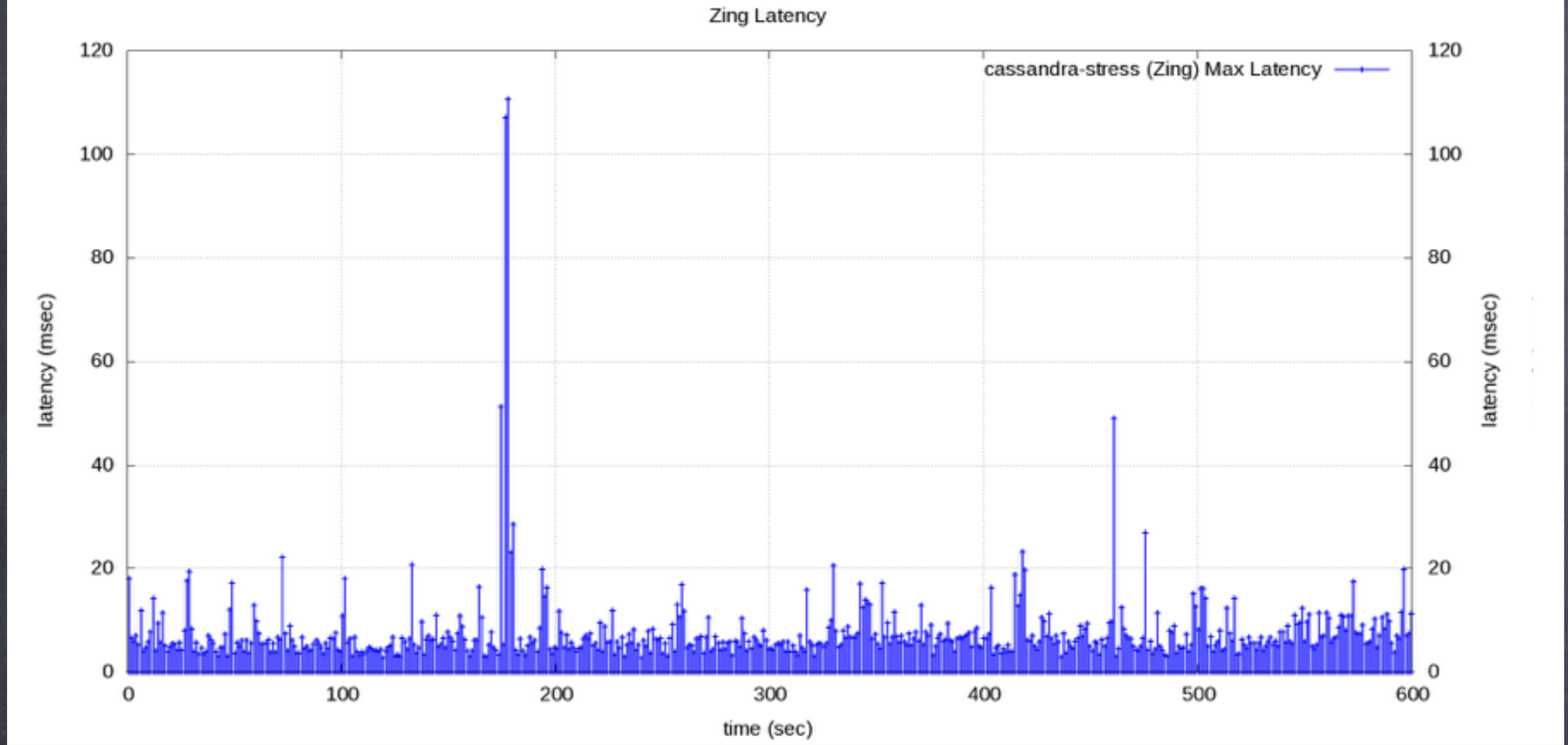


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latency 99th percentile   : 2.7 (1.9)
latency 99.9th percentile : 13.3 (3.8)
latency max               : 110.6 (28.2)
```

Response Time

Service time

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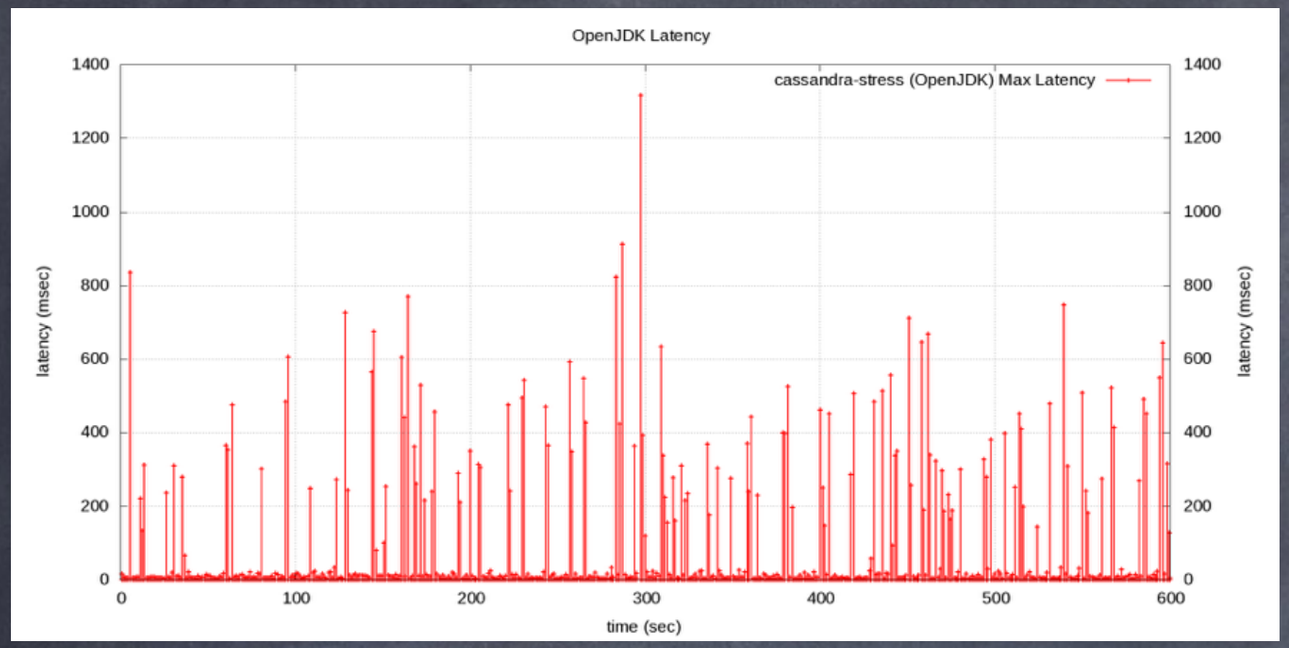
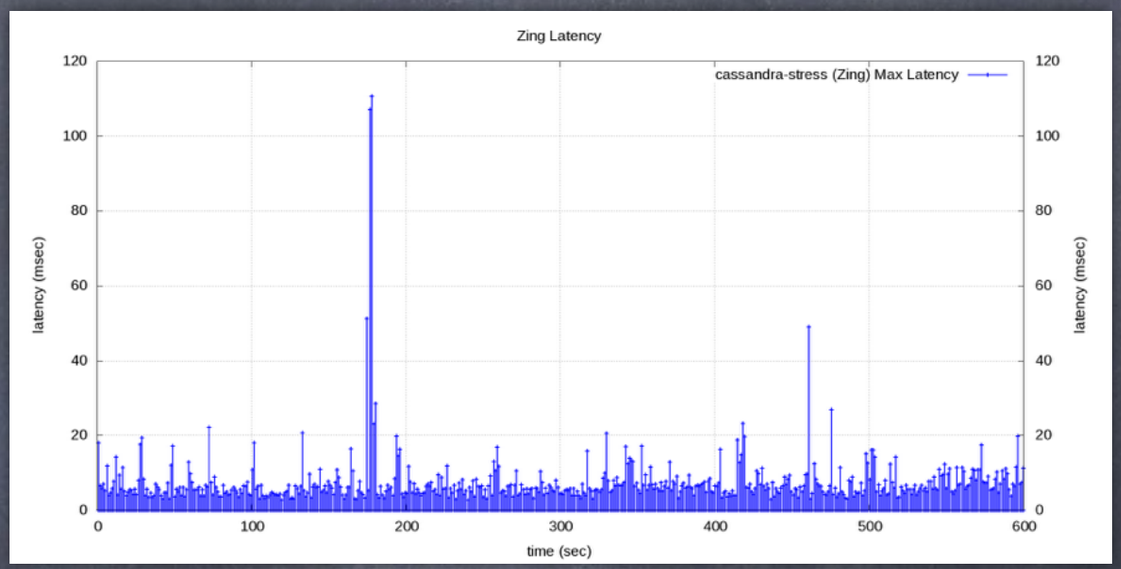
OpenJDK: 200-1400 msec stalls



Zing

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Response Time Service time

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Response Time Service time

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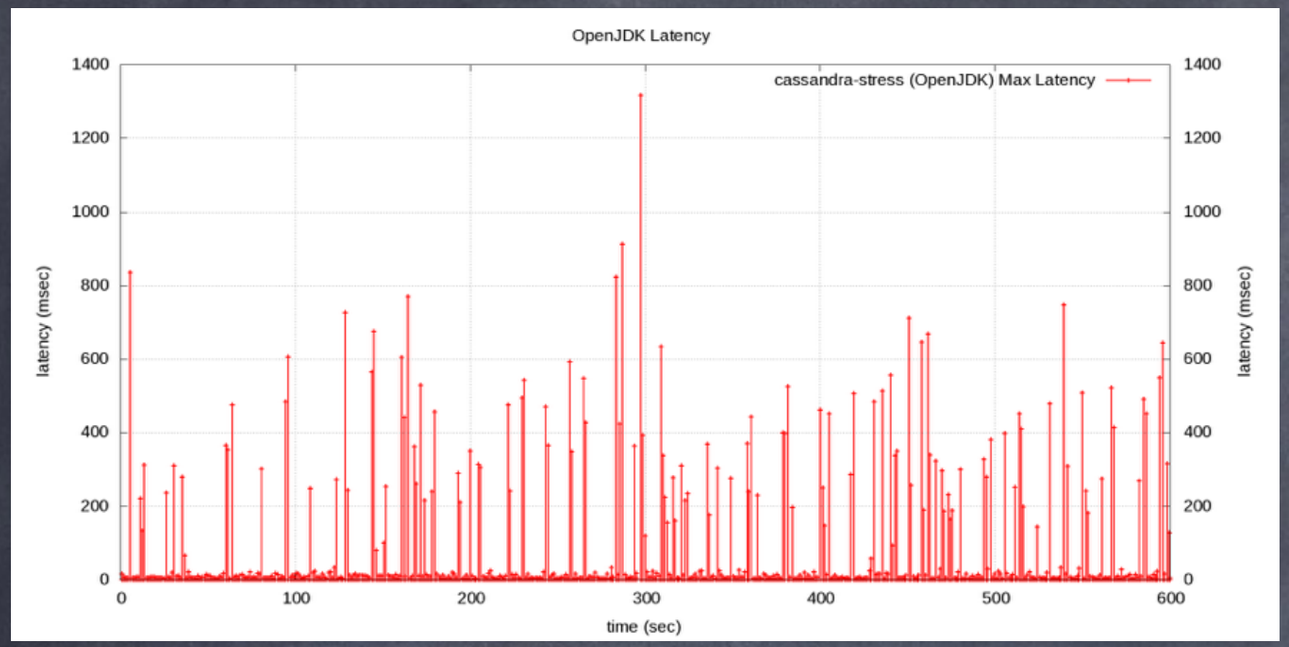
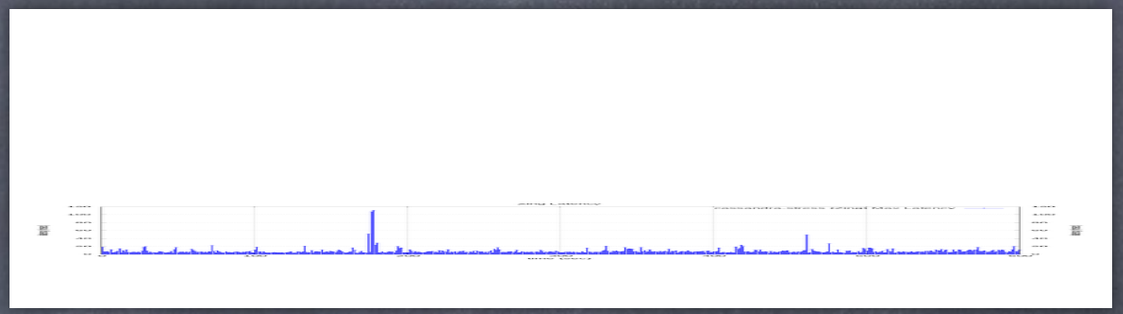


Zing (drawn to scale)



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Response Time Service time

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Response Time Service time

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What if we focused on "already low latency" setups?

"I know really bad GC pauses may happen once in a while, but I'm interested in the common behavior between those…"

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A set of pure read experiments…

aimed at highly repeatable results

(focused on frequent blips, not the hard to reliably repeat huge pauses)

* Same AWS r3.8xlarge instance (underutilized)
** single node cluster, pre-primed with 5M entries
*** stressed via (enhanced) cassandra-stress, pure read test

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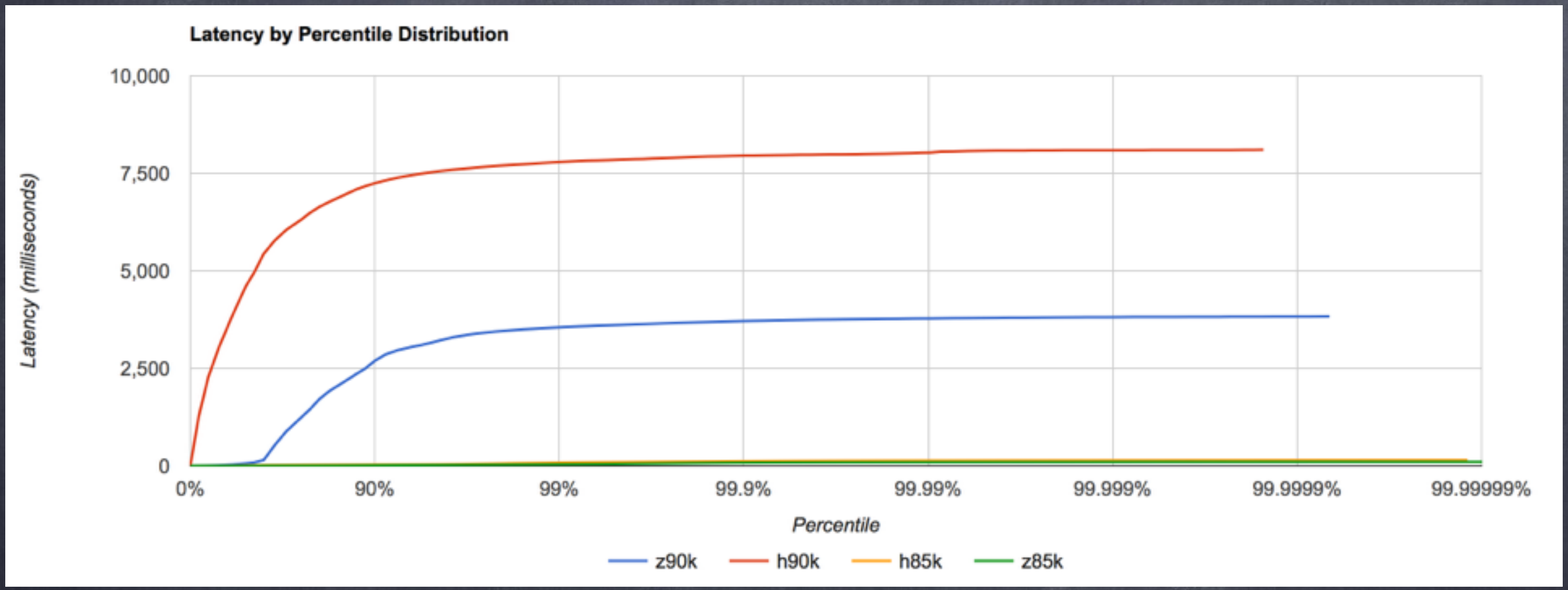
HotSpot @90K/s & 85K/s vs. Zing @90K/s & 85K/s



Wrong Place to Look: They both “suck” at >85K/sec

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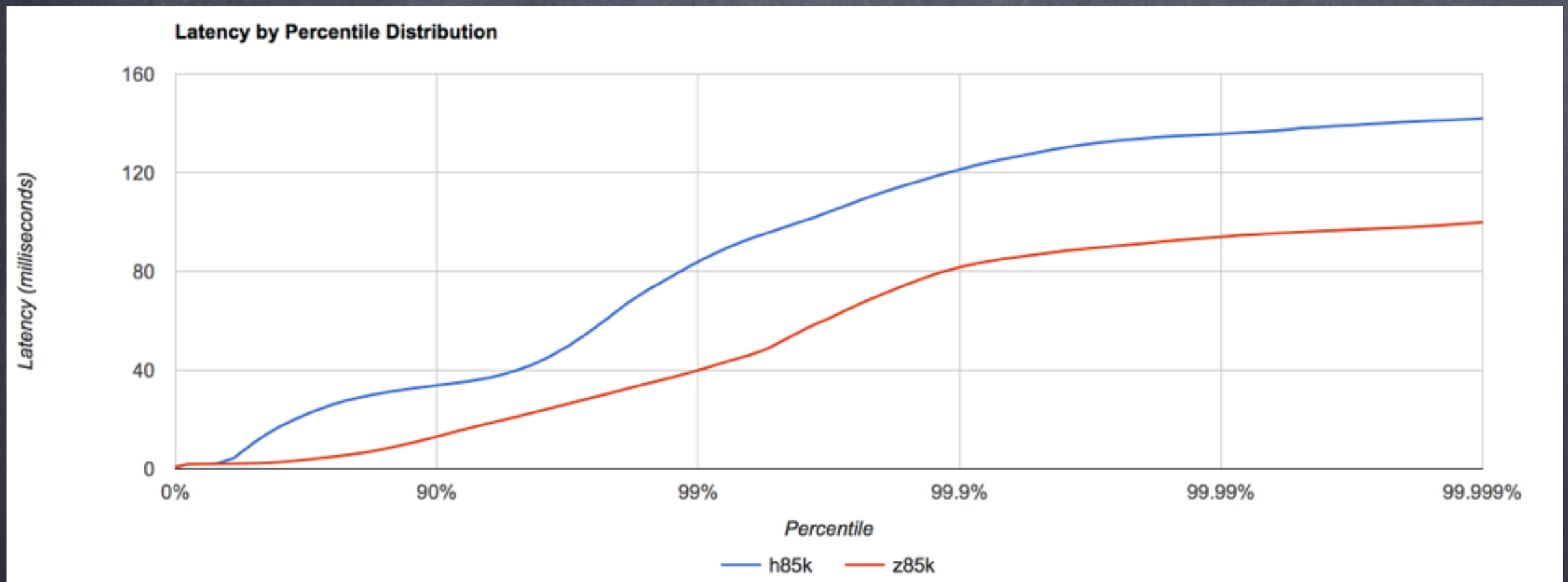
HotSpot 85K/s vs. Zing 85K/s



Looks good, but still
the wrong place to look

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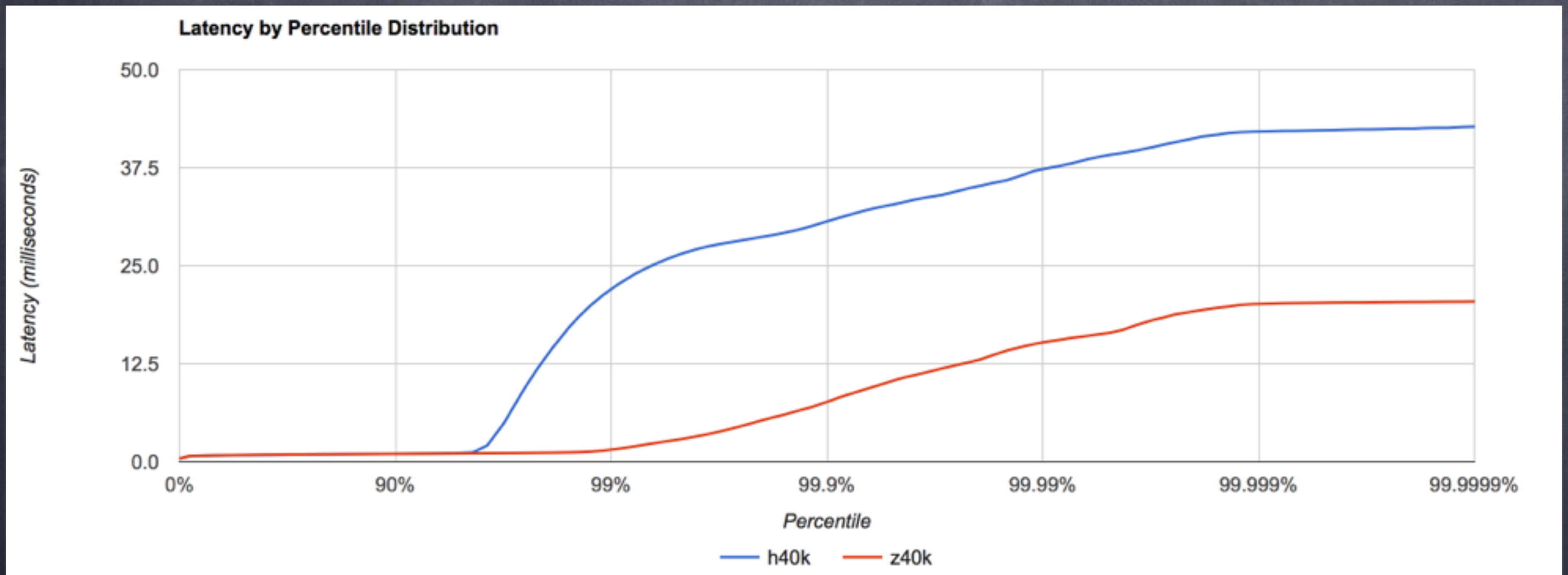
HotSpot @40K/s vs. Zing @40K/s



More interesting…
What can we do with this?

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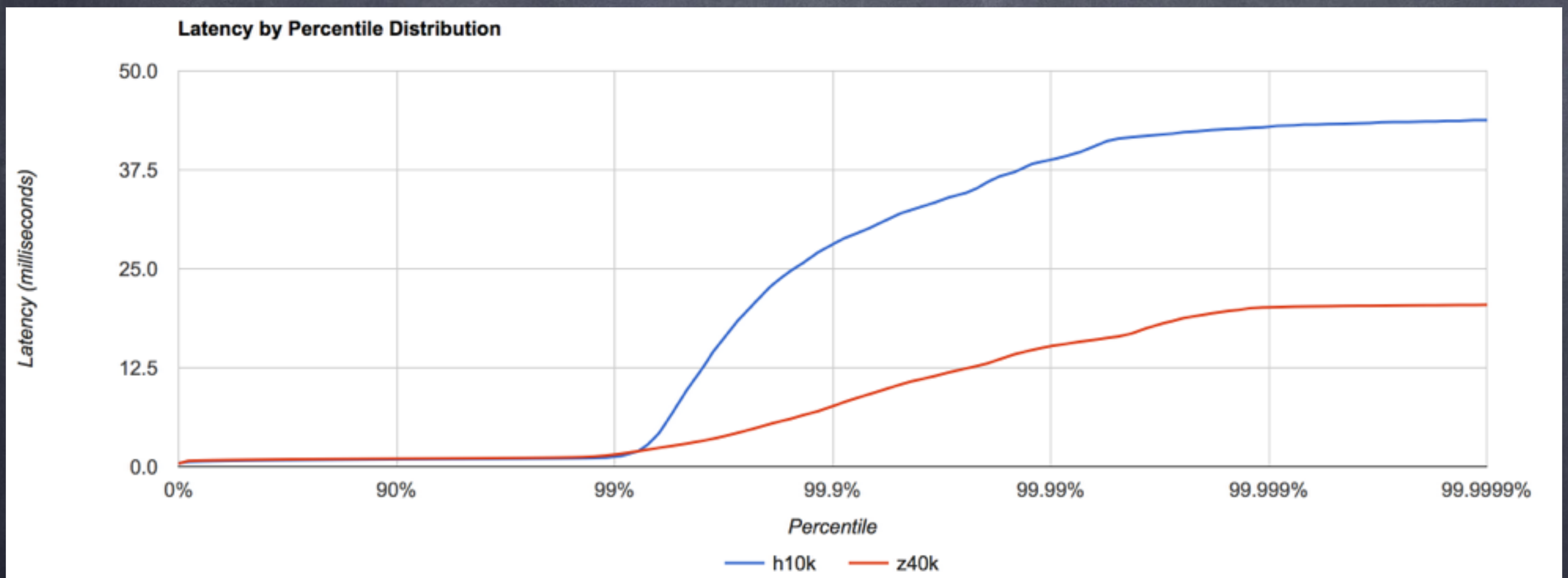
HotSpot @10K/s vs. Zing @40K/s



E.g. if “99%’ile < 5msec” was a goal:
Zing delivers similar 99%’ile and superior 99.9%’ile+
while carrying 4x the throughput

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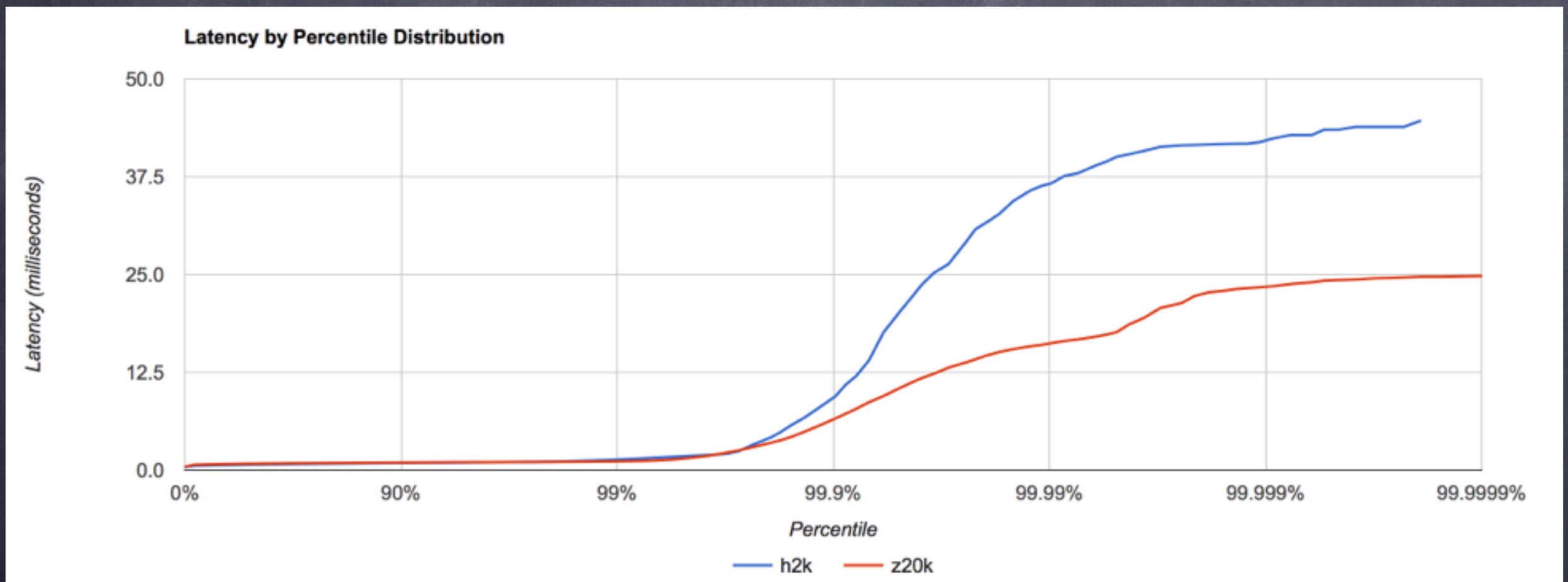
HotSpot @2K/s vs. Zing @20K/s



E.g. if "99.9%'ile < 10msec" was a goal:
Zing delivers similar 99%'ile and 99.9%'ile
while carrying 10x the throughput

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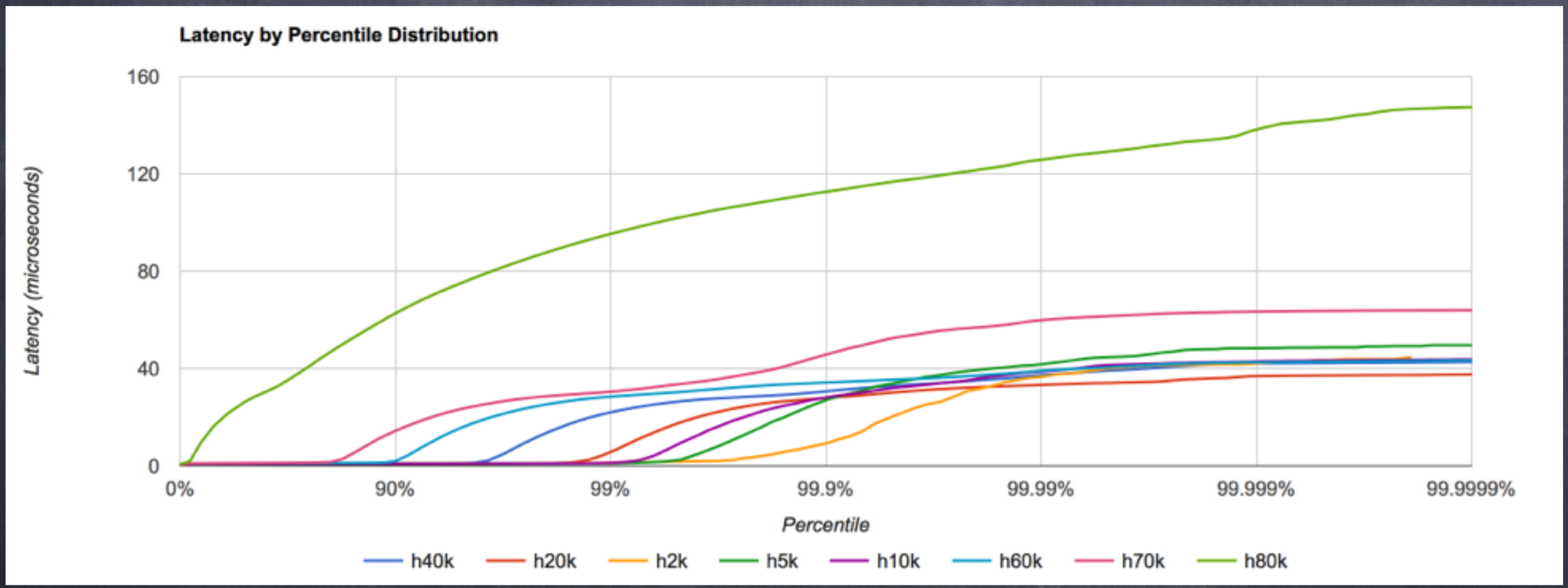
HotSpot @2k thru 80k



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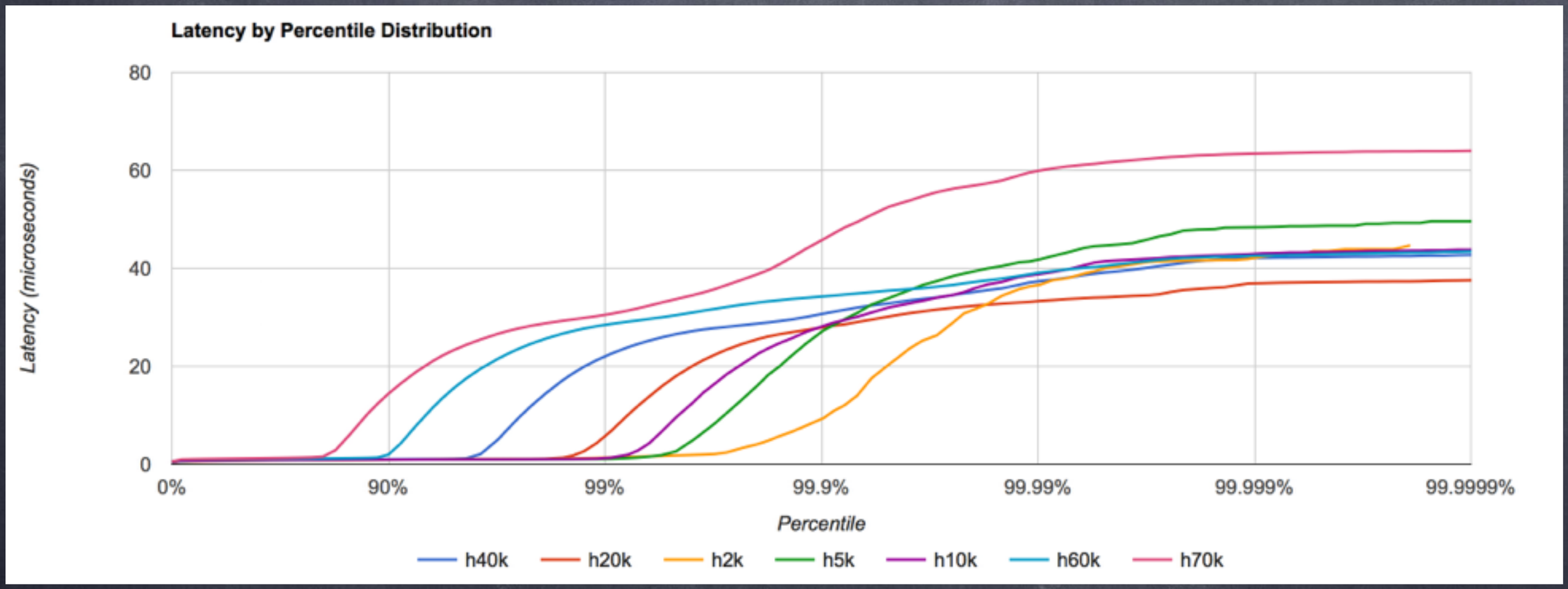
HotSpot @2k thru 70k



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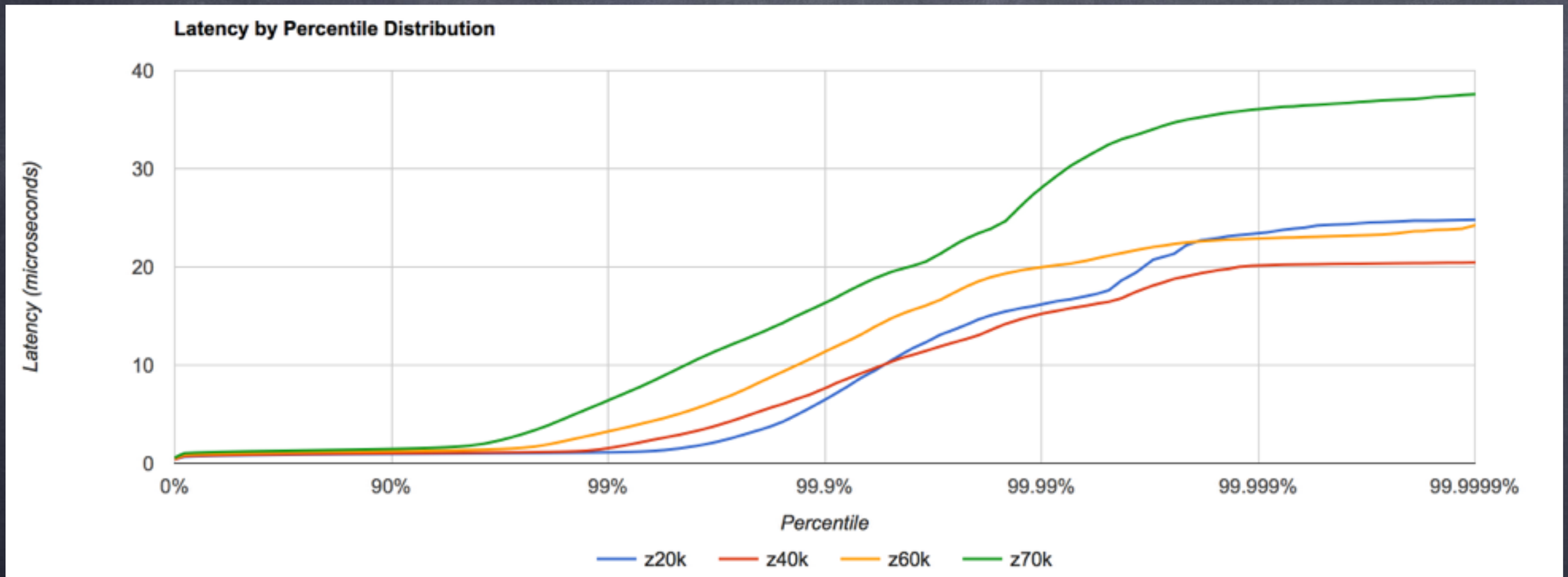
Zing @20k thru 70k



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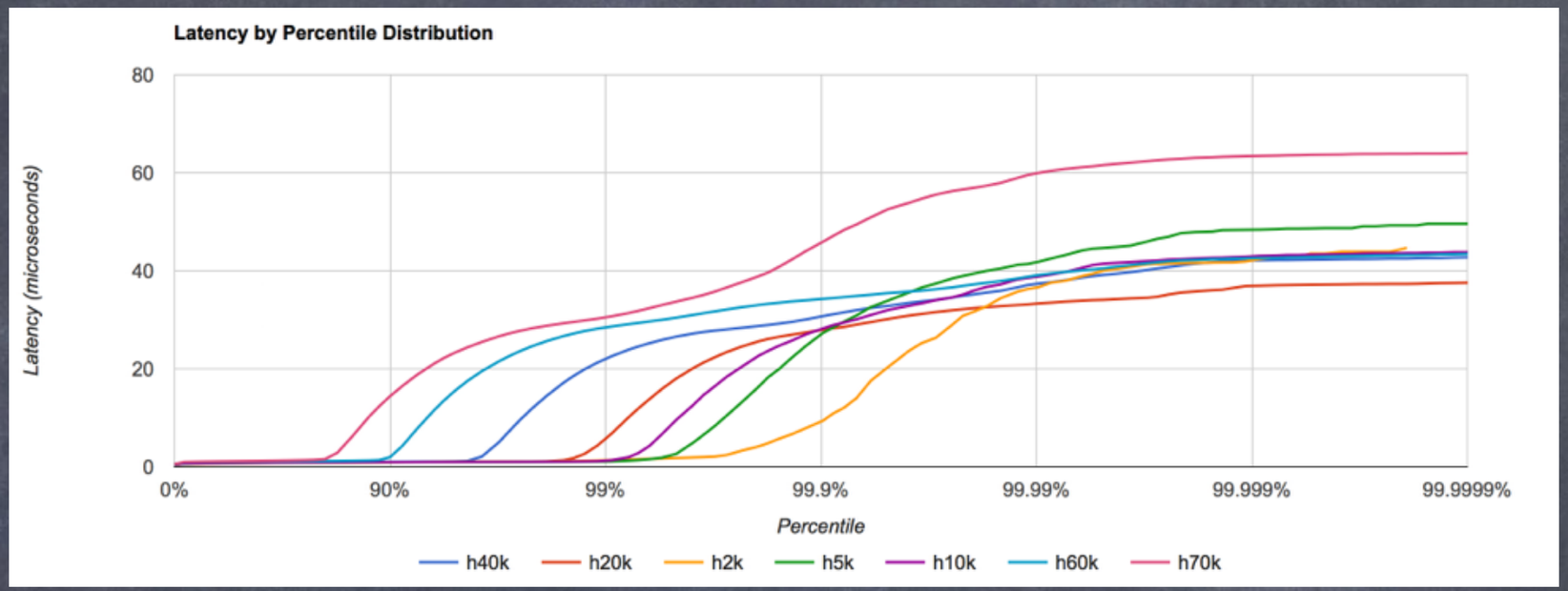
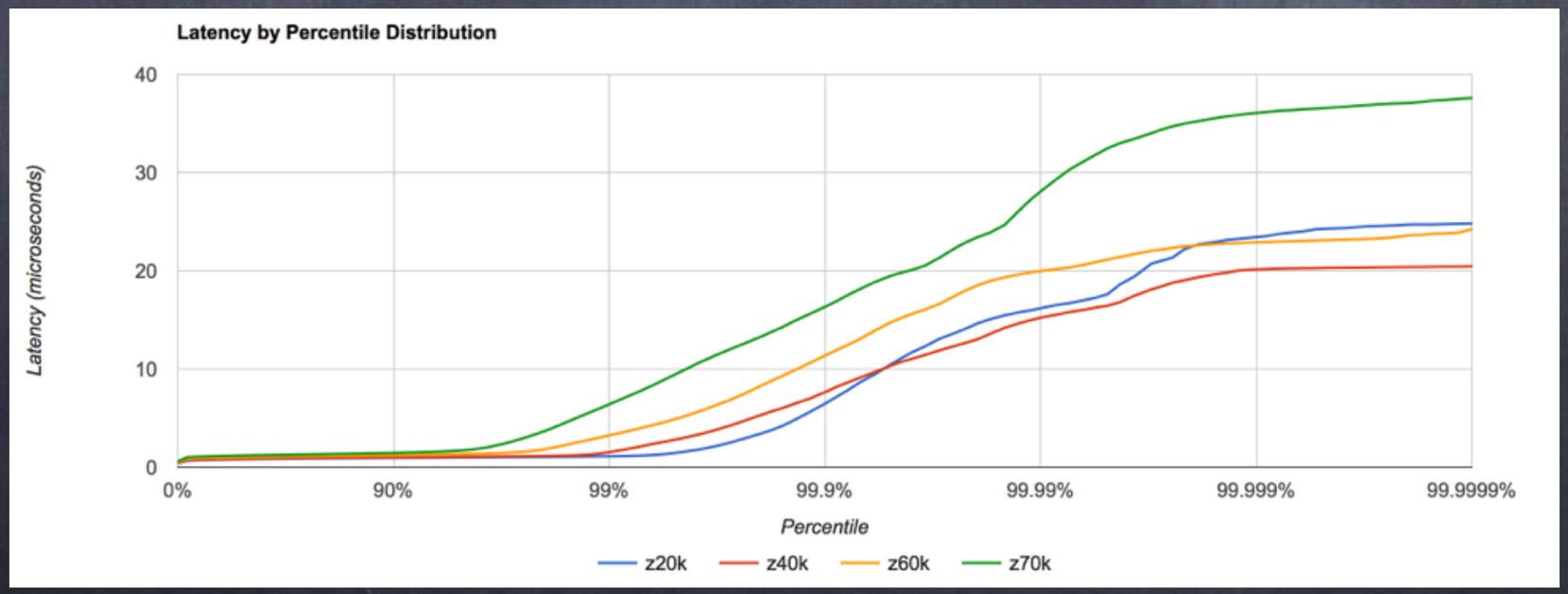
Zing & HotSpot @2k thru 70k





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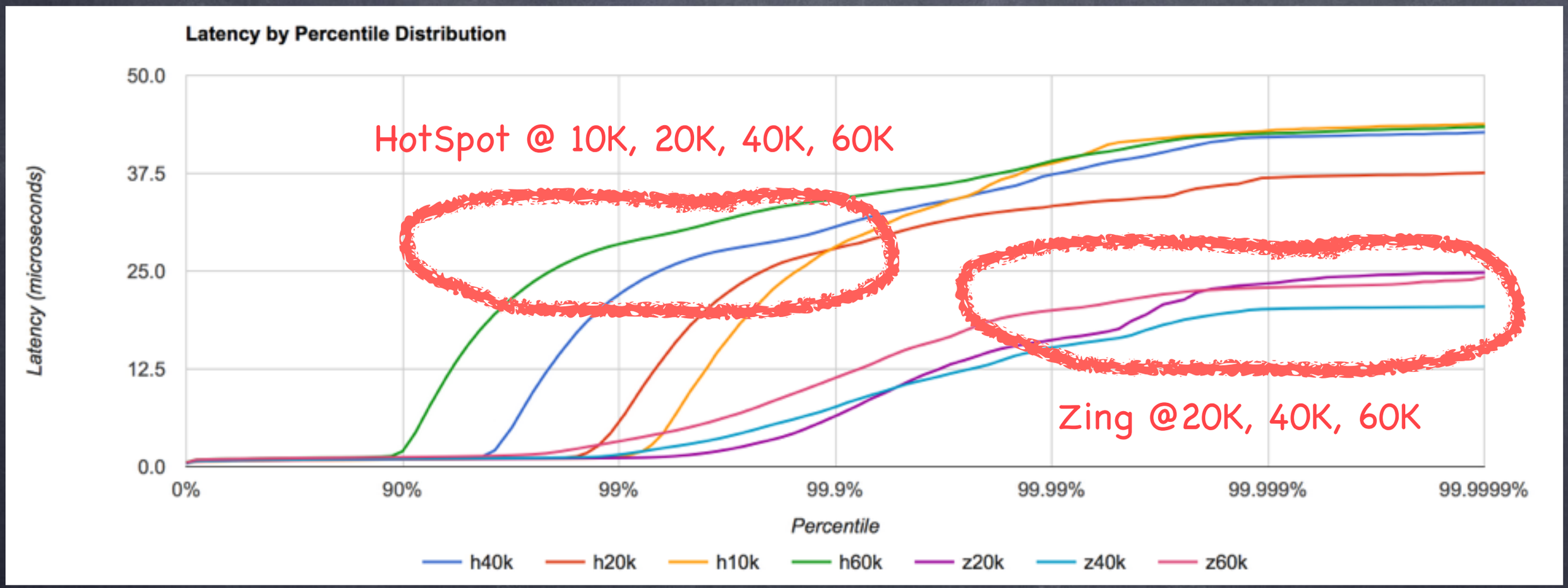
Zing & HotSpot, 10K/s thru 60K/s



Lots of conclusions can be drawn from the above…
E.g. Zing delivers a consistent 100x reduction in the rate of occurrence of >20msec response times

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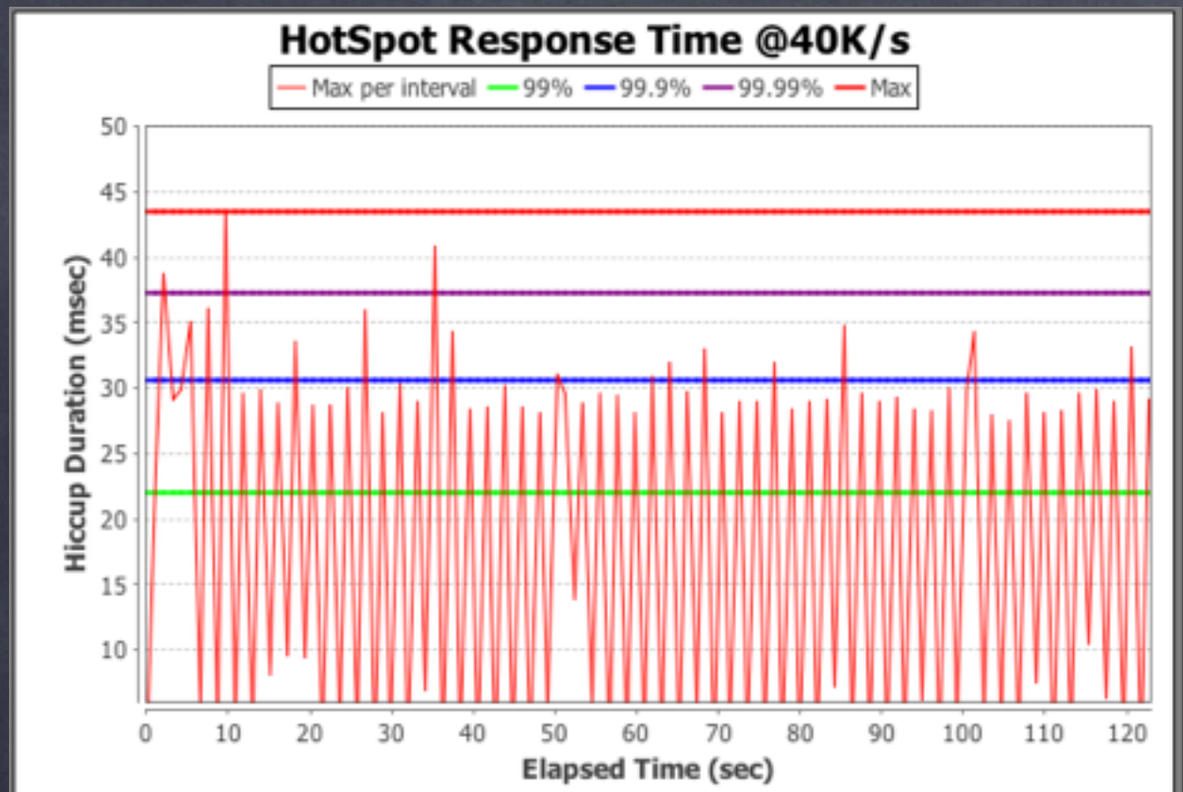

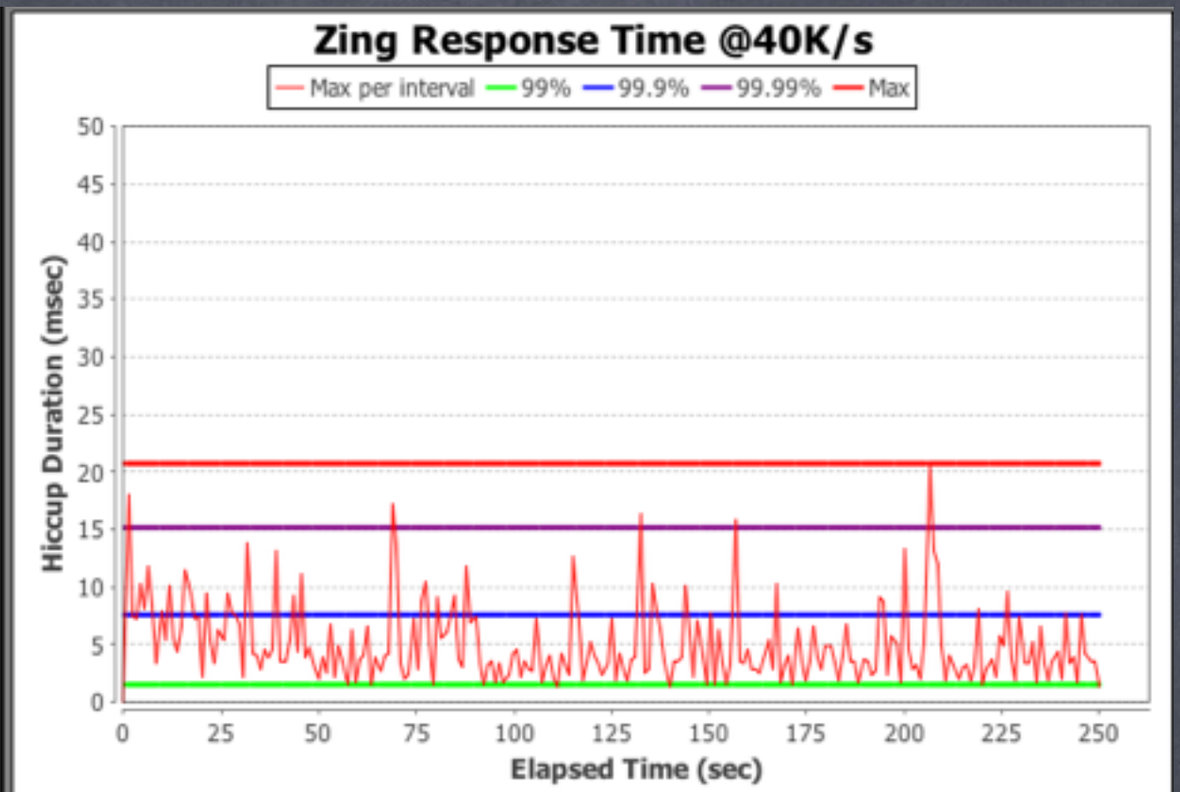

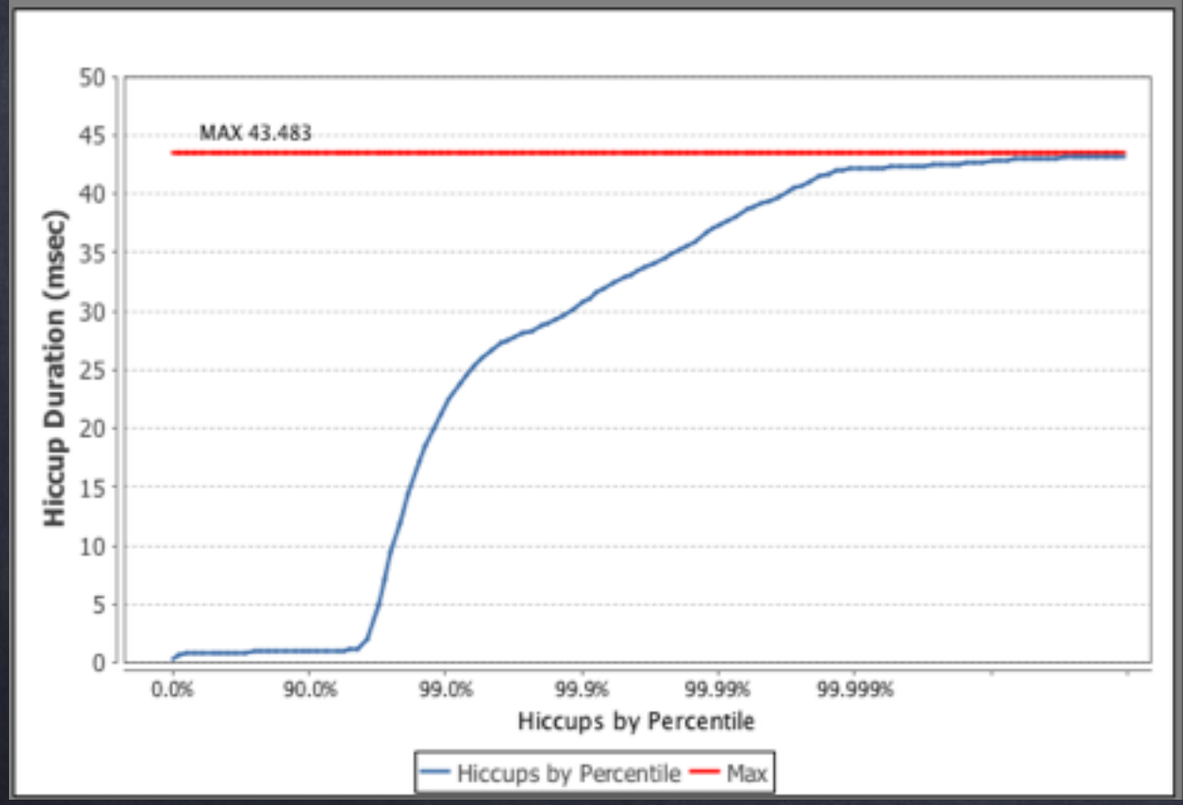

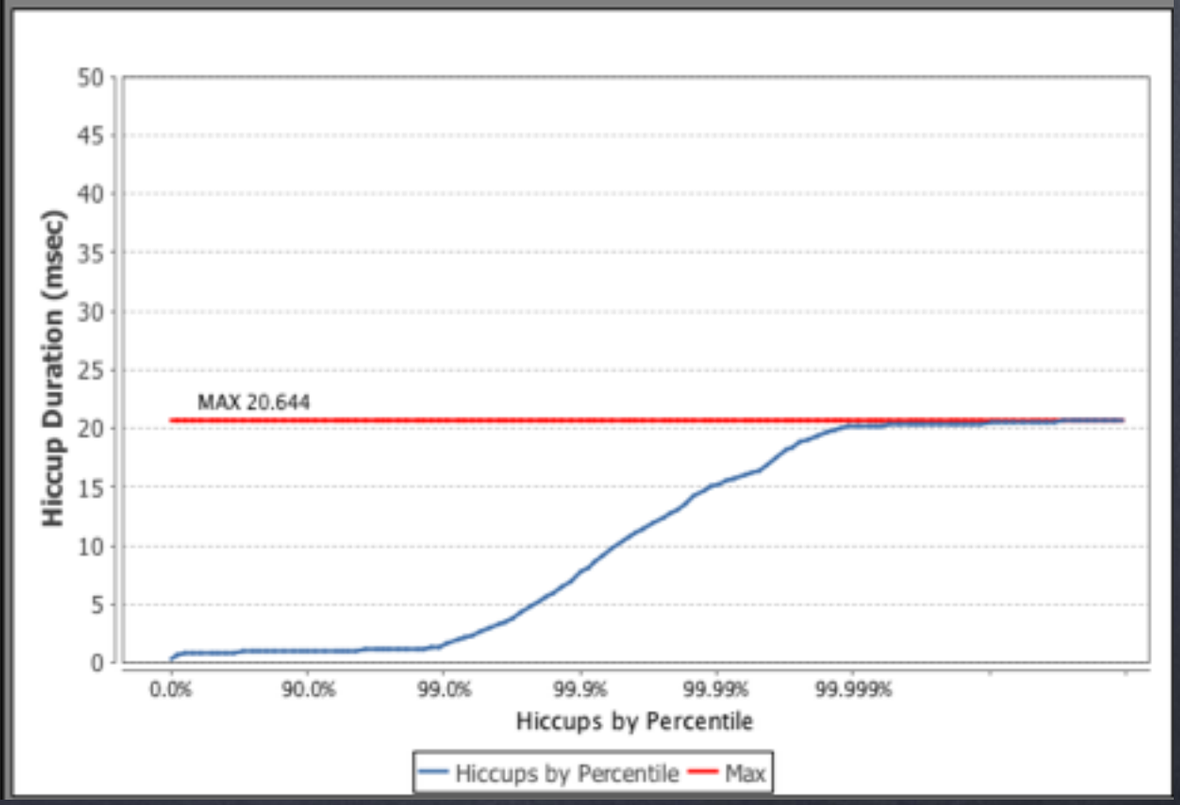

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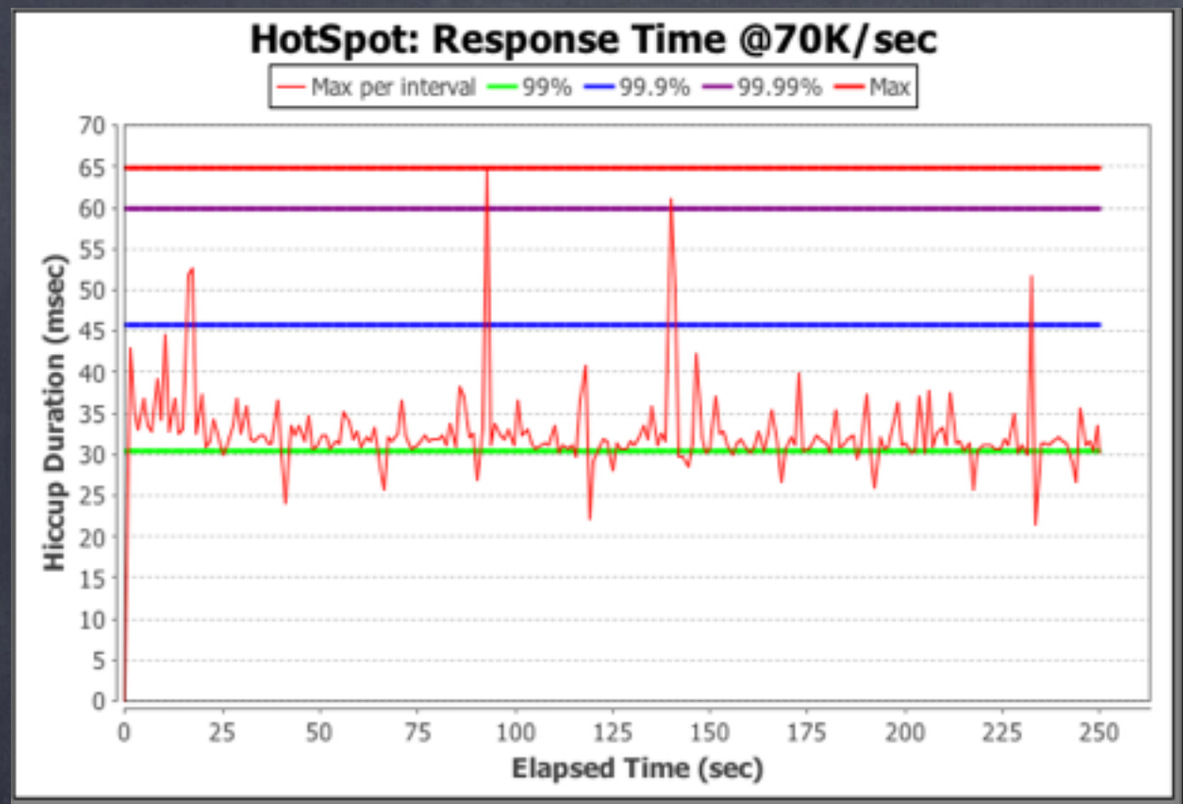

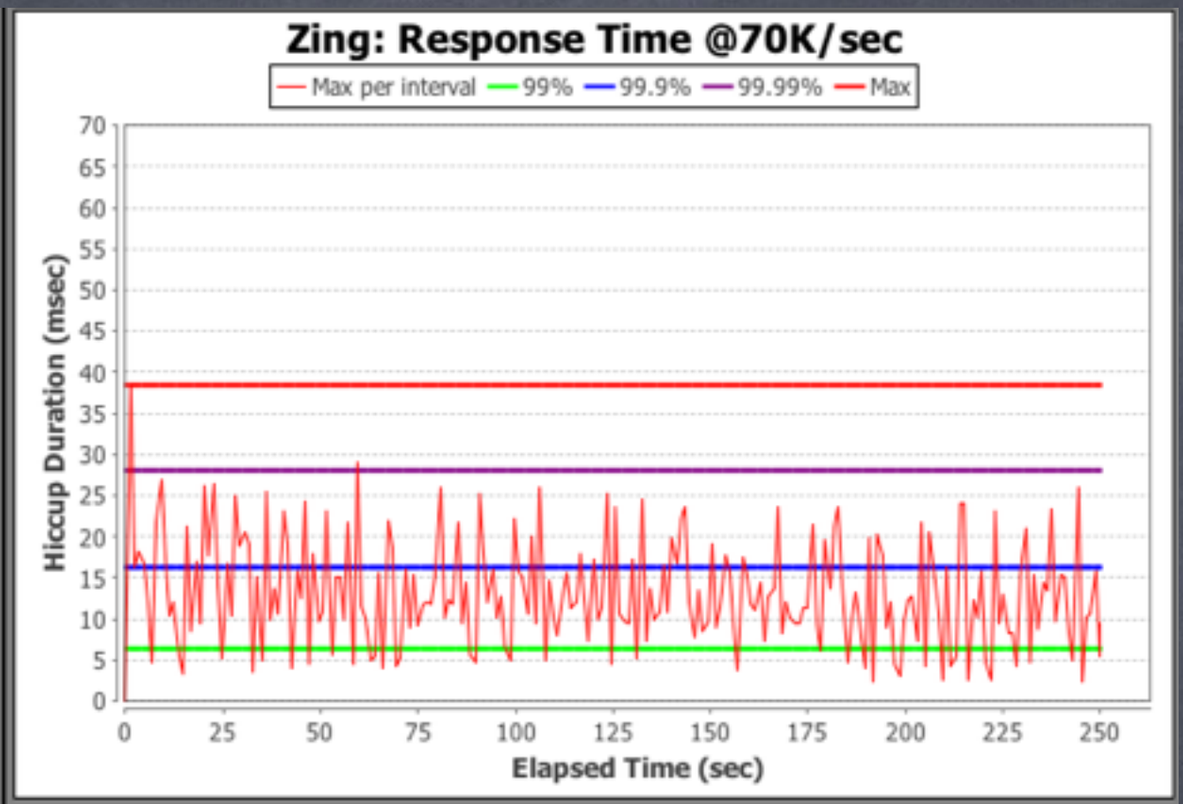

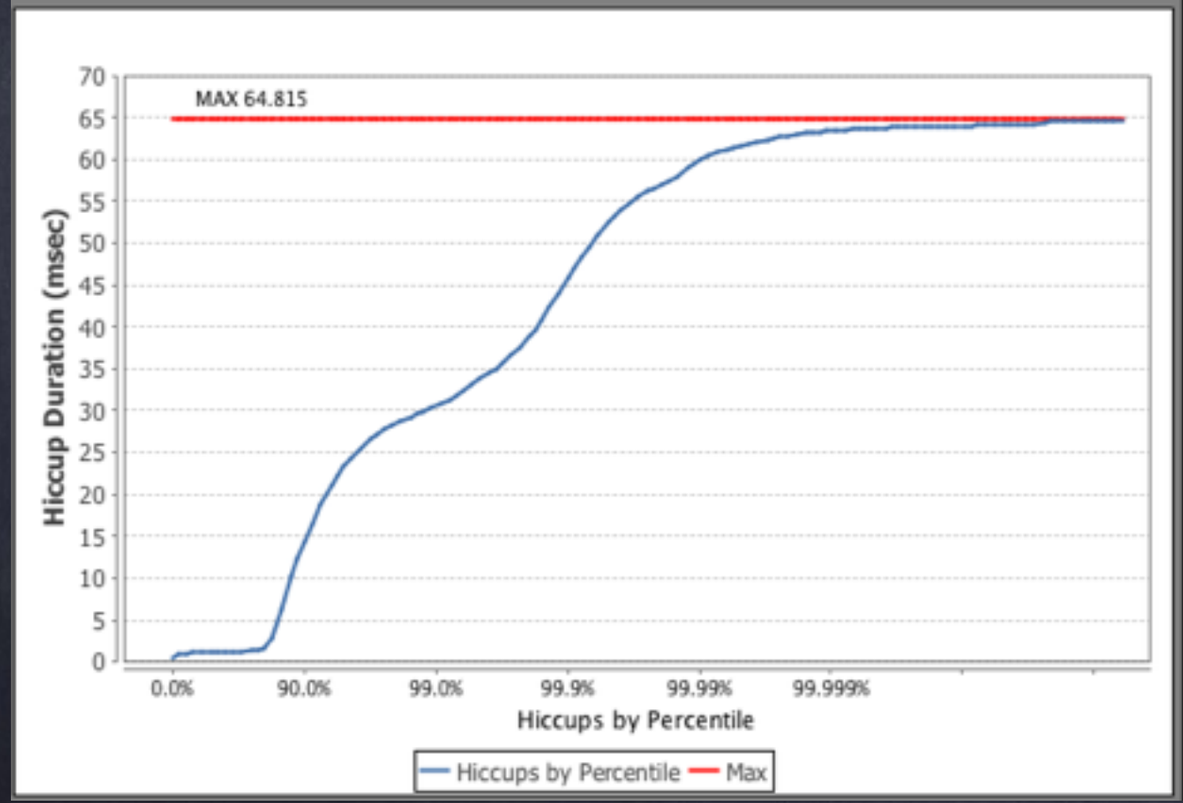

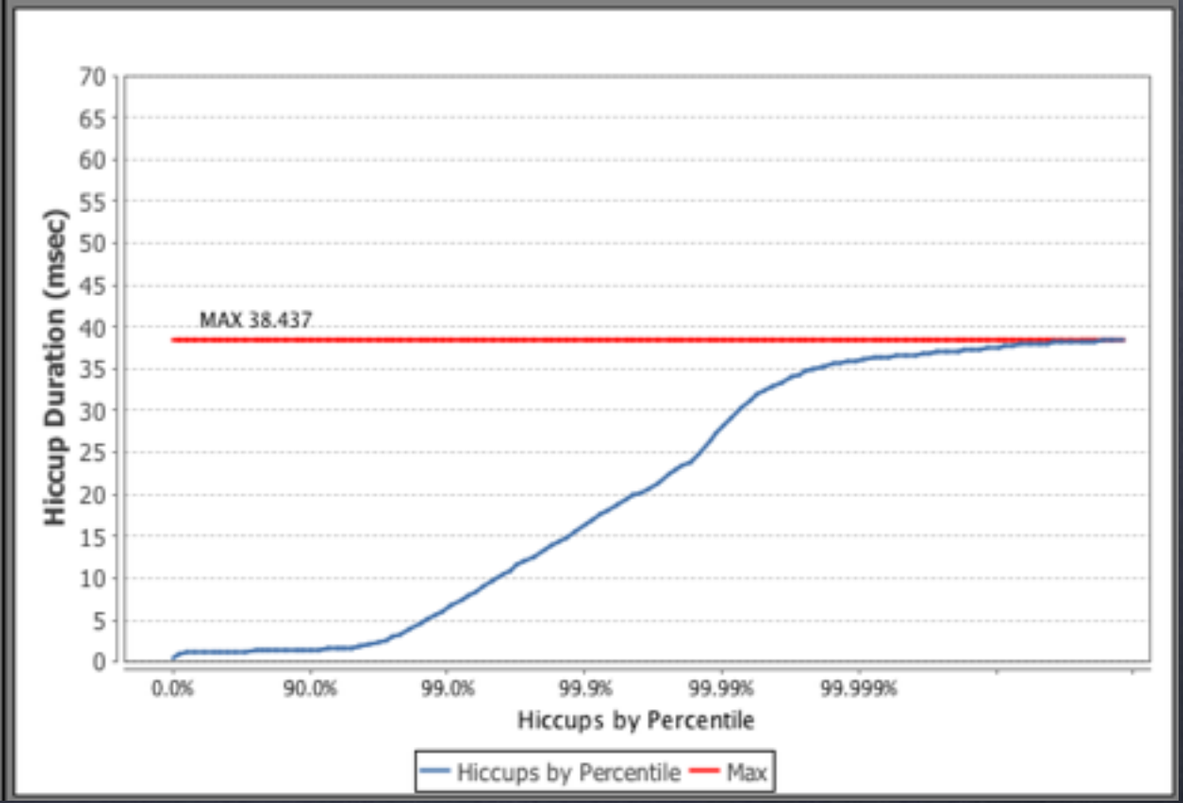

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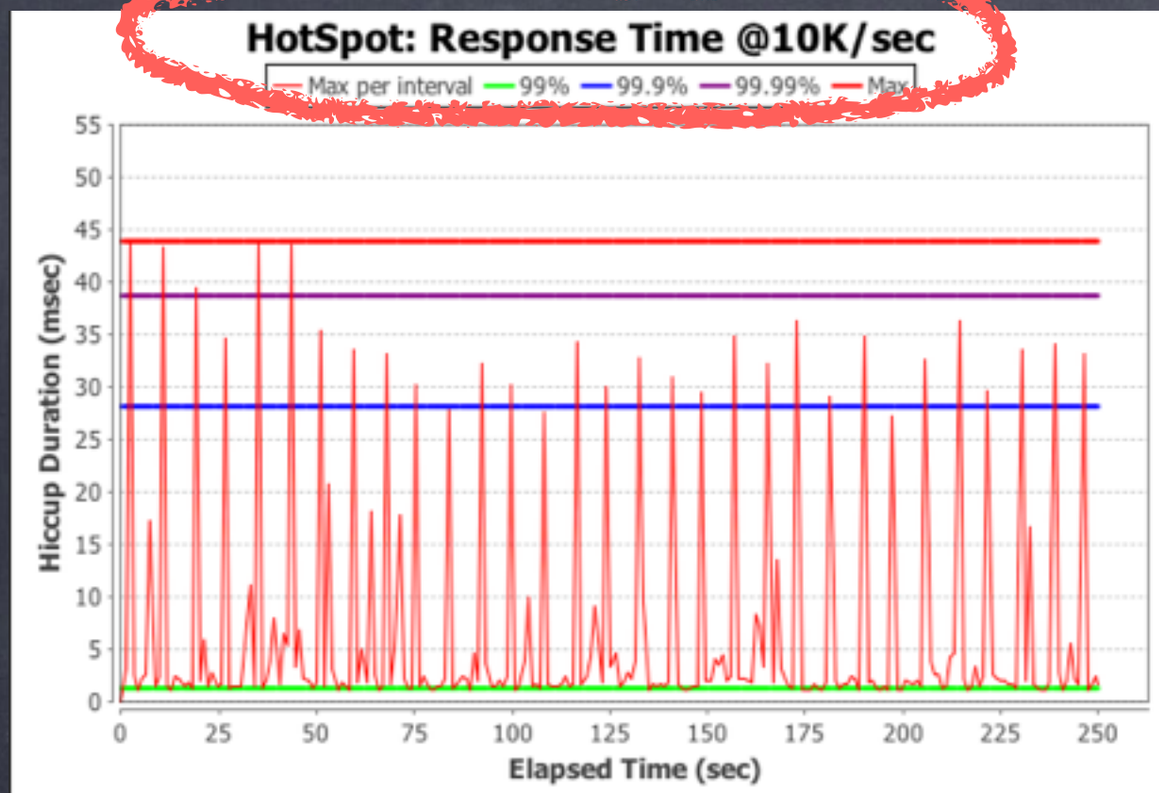

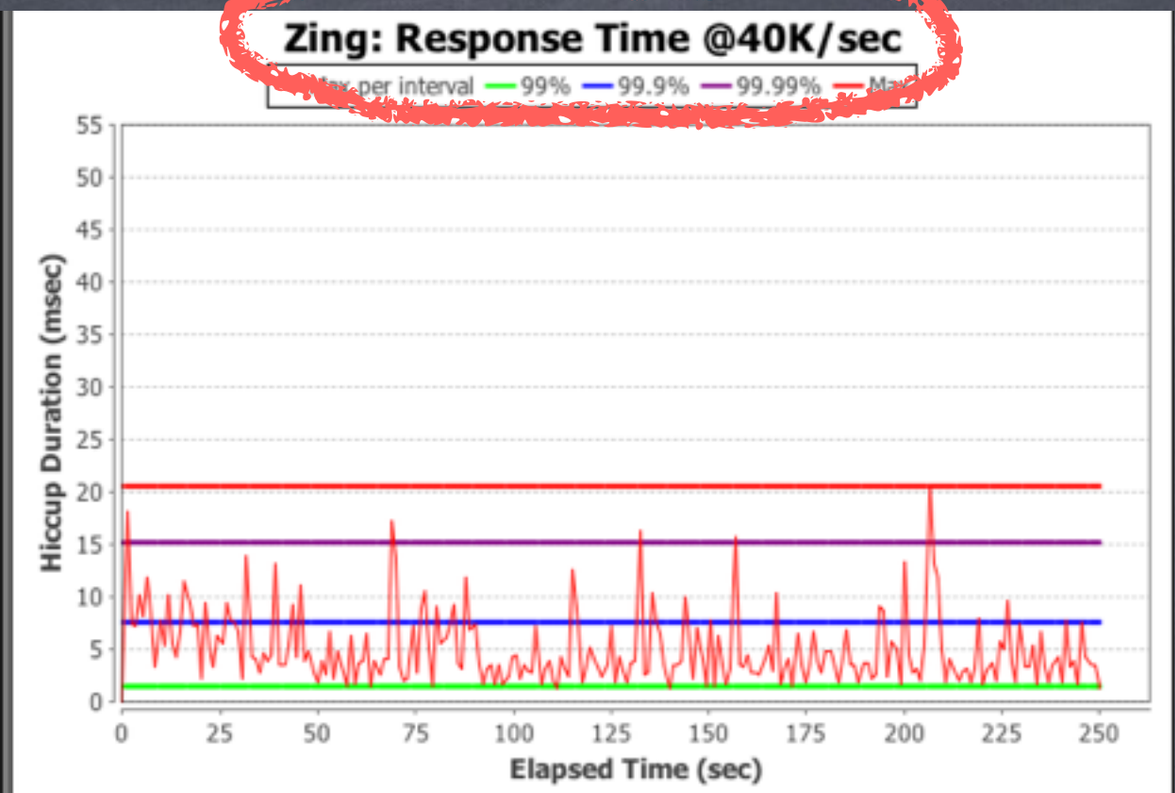

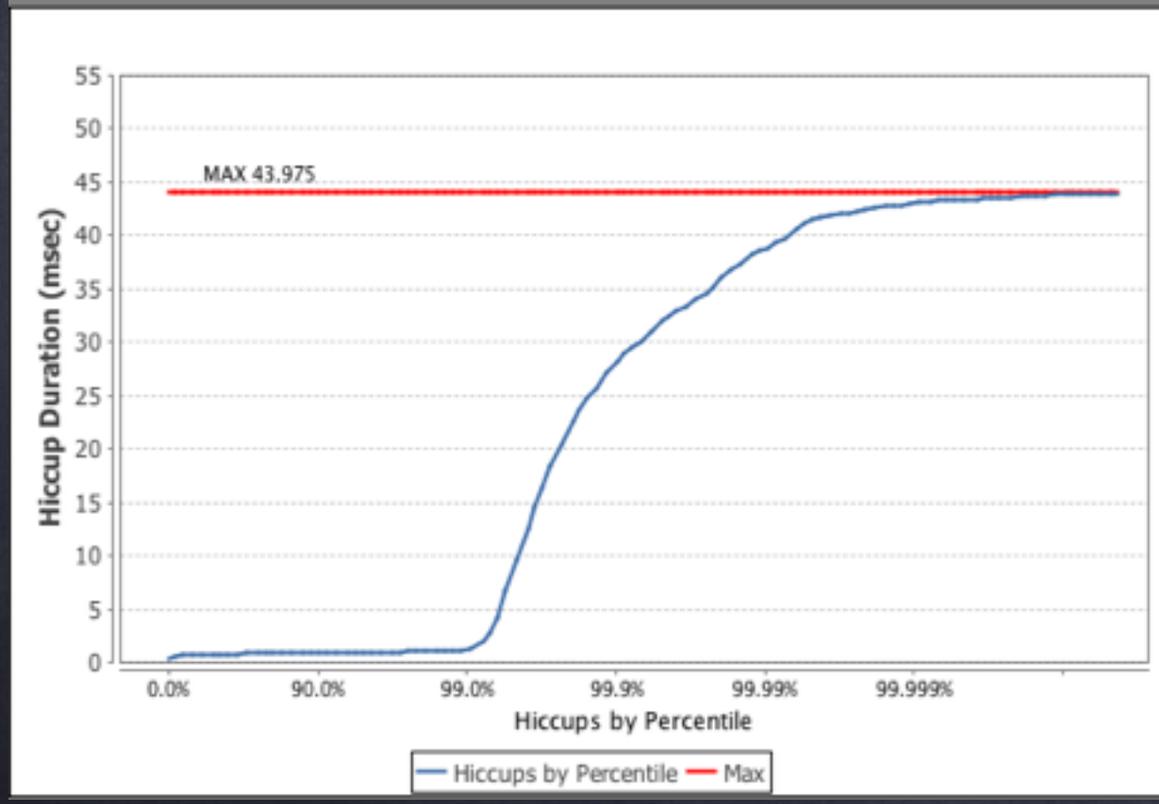

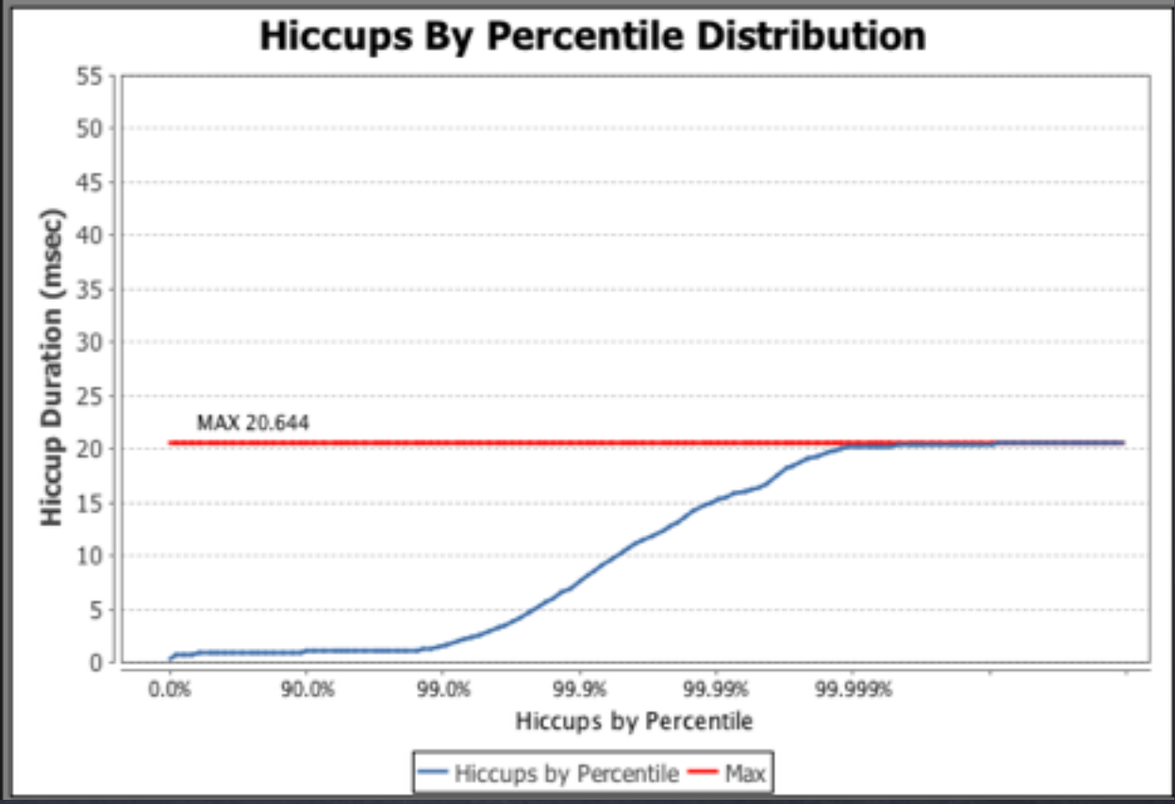

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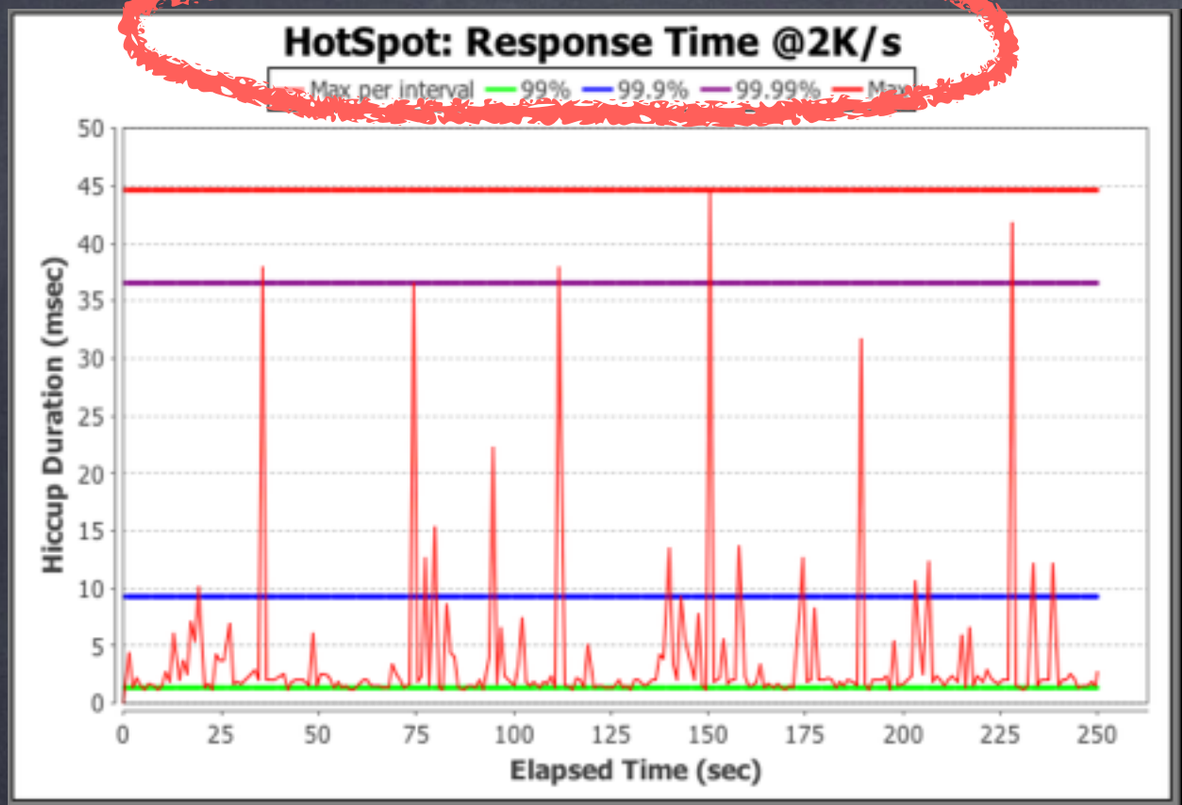

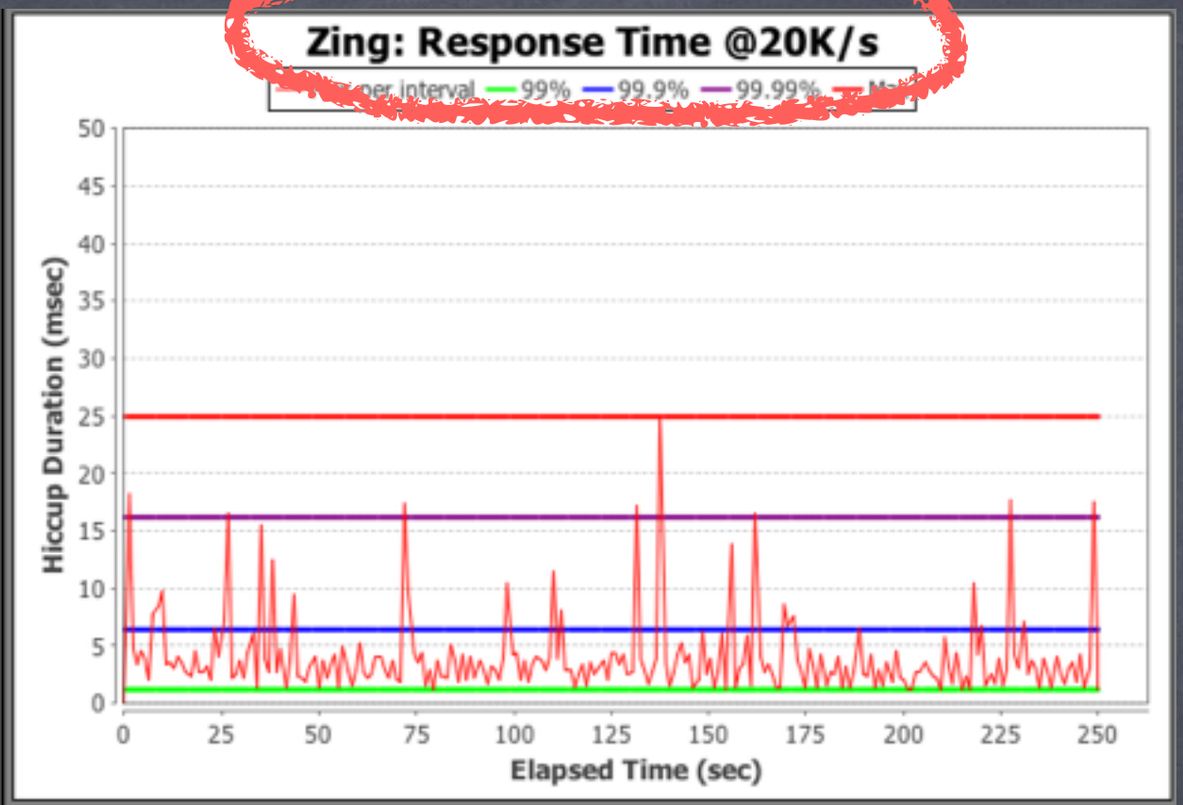

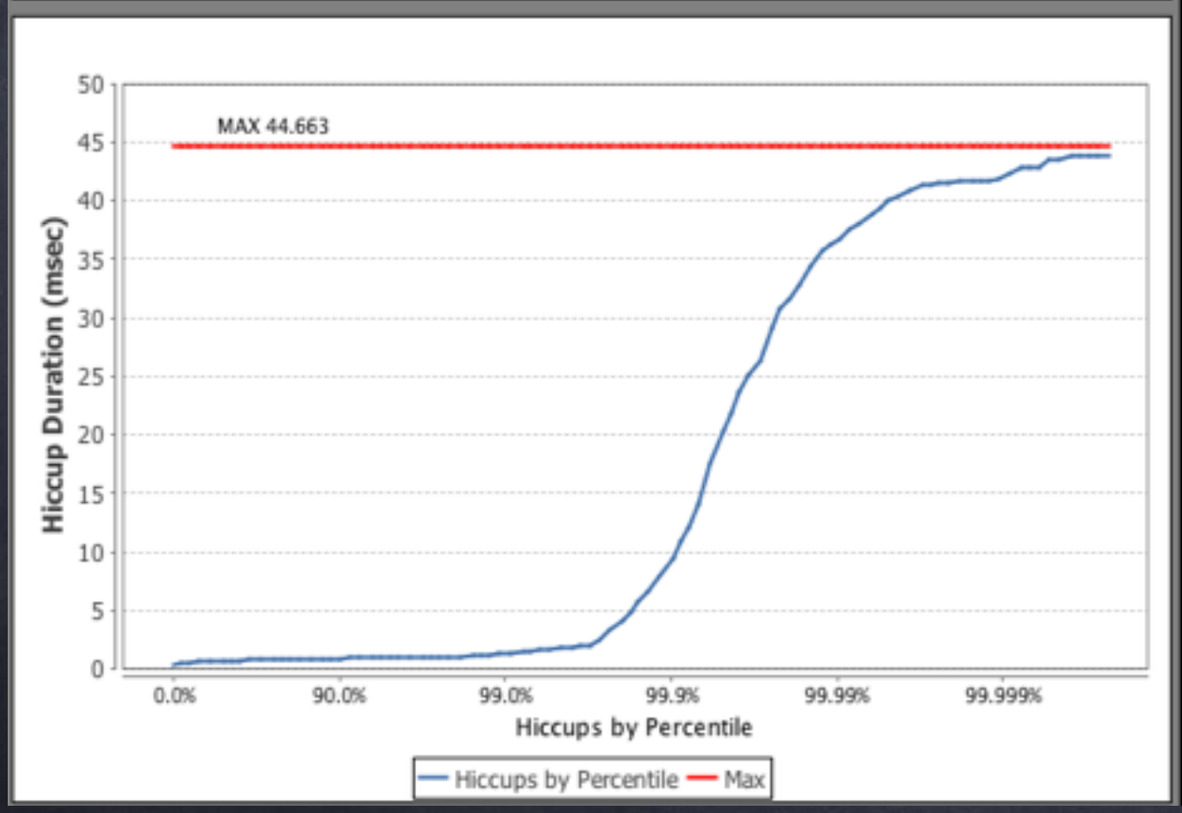

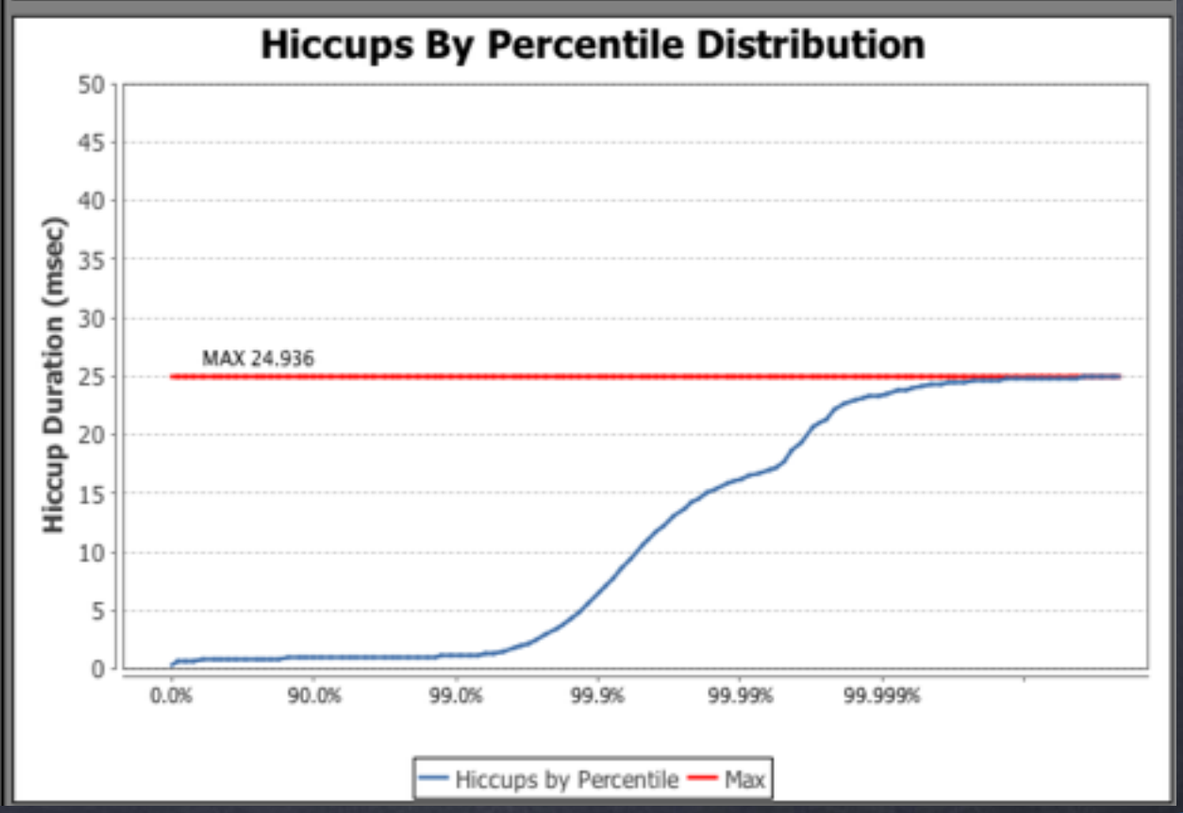

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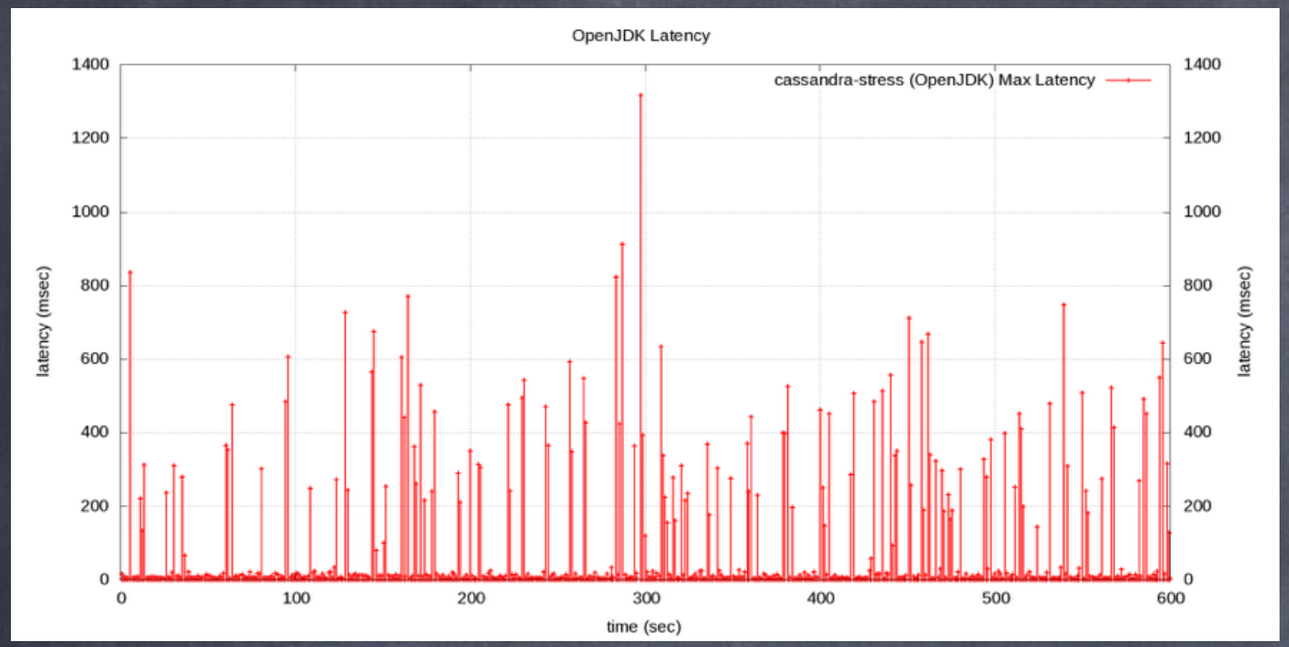
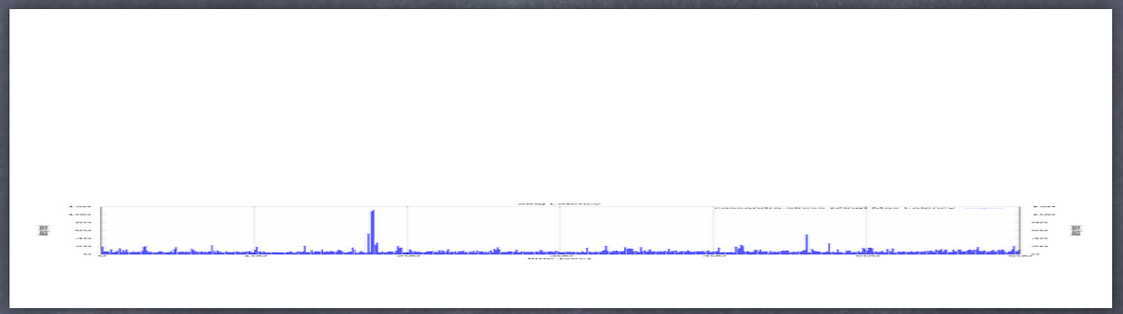
OpenJDK: 200-1400 msec stalls



Zing (drawn to scale)



```
op rate                   : 40001
partition rate            : 26996
row rate                  : 26996
latency mean              : 30.6 (0.7)
latency median            : 0.5 (0.5)
latency 95th percentile   : 244.4 (1.1)
latency 99th percentile   : 537.4 (2.0)
latency 99.9th percentile : 1052.2 (8.4)
latency max               : 1314.9 (1312.8)
```

Response Time Service time

```
op rate                   : 40001
partition rate            : 26961
row rate                  : 26961
latency mean              : 0.6 (0.5)
latency median            : 0.5 (0.5)
latency 95th percentile   : 1.0 (0.9)
latency 99th percentile   : 2.7 (1.9)
latency 99.9th percentile : 13.3 (3.8)
latency max               : 110.6 (28.2)
```

Response Time Service time

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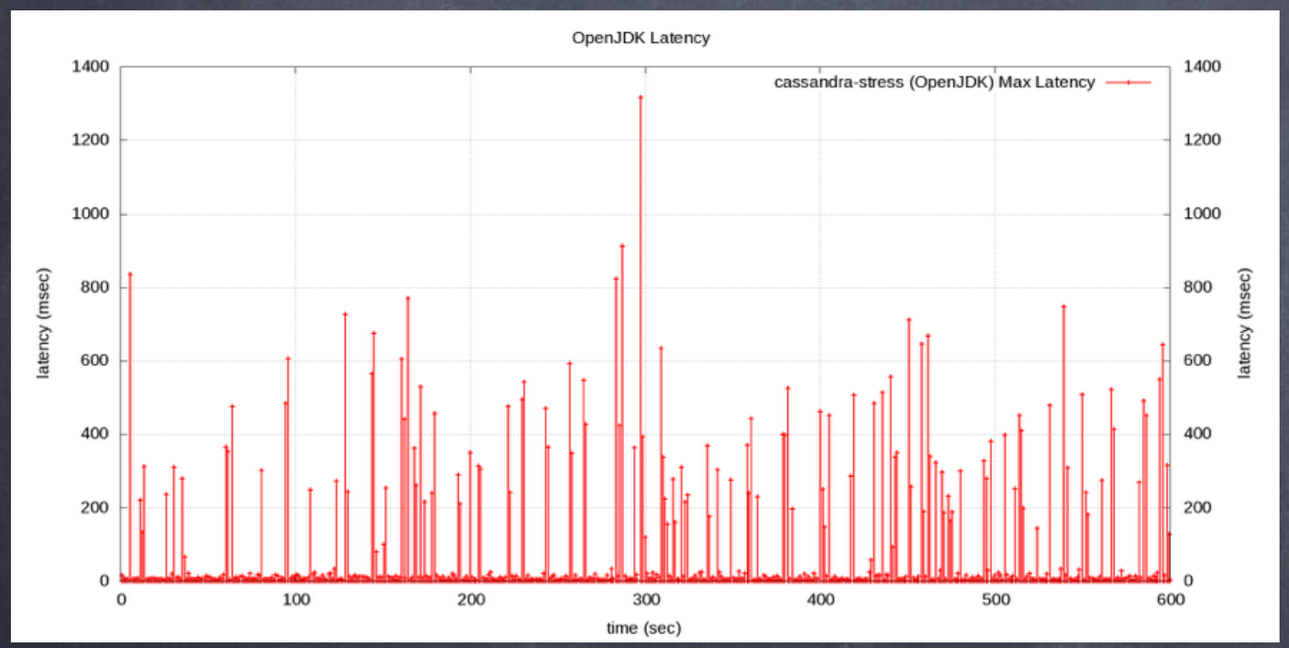
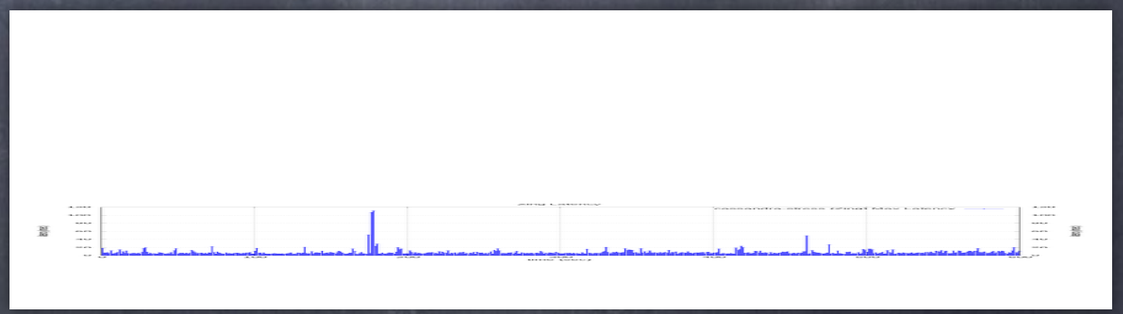
A simple visual summary

This is Cassandra on HotSpot



This is Cassandra on Zing



Any Questions?

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