CIRCONUS

The Problem with Percentiles

Aggregation brings Aggravation, Histograms bring Help

By Fred Moyer
Developer Evangelist @Circonus

@phredmoyer

CIRCONUS

Latency

Is it important?

CIRCONUS

Latency

For any of your services, how many requests were served within 0.55 seconds over the last month?

CIRCONUS

Latency

How would you answer that question for your services?

CIRCONUS

Latency

How accurate would your answer be?

CIRCONUS

Talk Agenda

- SLO Primer
- A Common Mistake with Percentiles
- Computing SLOs with log data
- Computing SLOs by counting requests
- Computing SLOs with histograms

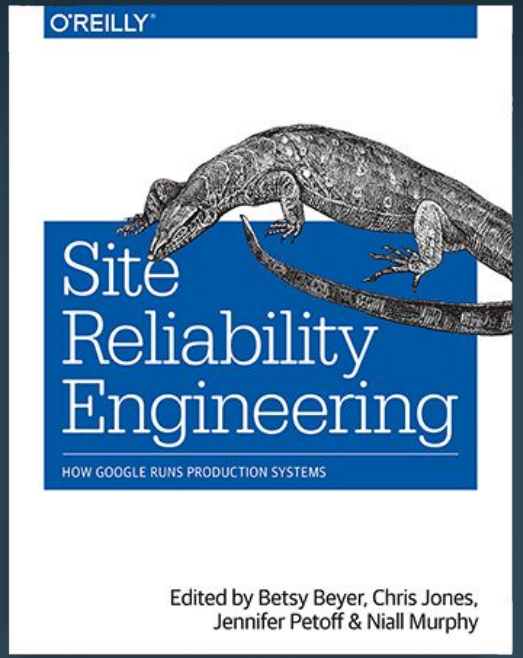
CIRCONUS

Service Level Objectives

SLI - Service Level Indicator

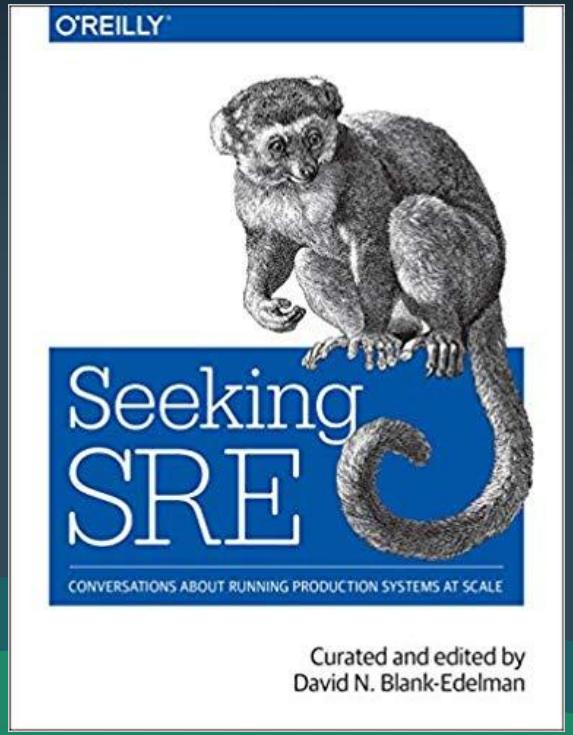
SLO - Service Level Objectives

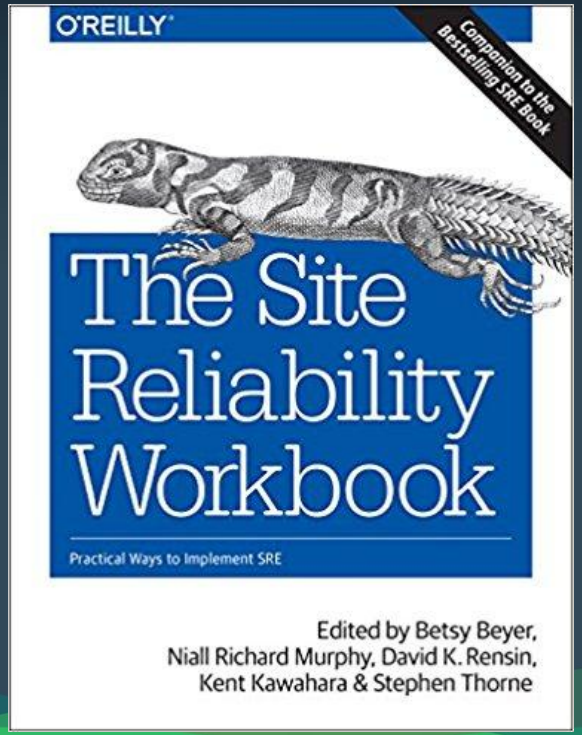
SLA - Service Level Agreement



CIRCONUS

Service Level Objectives





@phredmoyer

CIRCONUS

“SLIs drive SLOs which inform SLAs”

SLI - Service Level Indicator, a measure of the service that can be quantified

“99th percentile latency of homepage requests over the past 5 minutes < 300ms”

Excerpted from “SLIs, SLOs, SLAs, oh my!”
@sethvargo @lizthegrey

https://youtu.be/tEylFyxbDLE

CIRCONUS

“SLIs drive SLOs which inform SLAs”

SLO - Service Level Objective, a target for Service Level Indicators

“99th percentile homepage SLI will succeed 99.9% over trailing year”

Excerpted from “SLIs, SLOs, SLAs, oh my!”
@sethvargo @lizthegrey

https://youtu.be/tEylFyxbDLE

CIRCONUS

Talk Agenda

- [x] SLO Primer
- A Common Mistake with Percentiles
- Computing SLOs with log data
- Computing SLOs by counting requests
- Computing SLOs with histograms

CIRCONUS

A Common Mistake with Percentiles

Averaging Percentiles

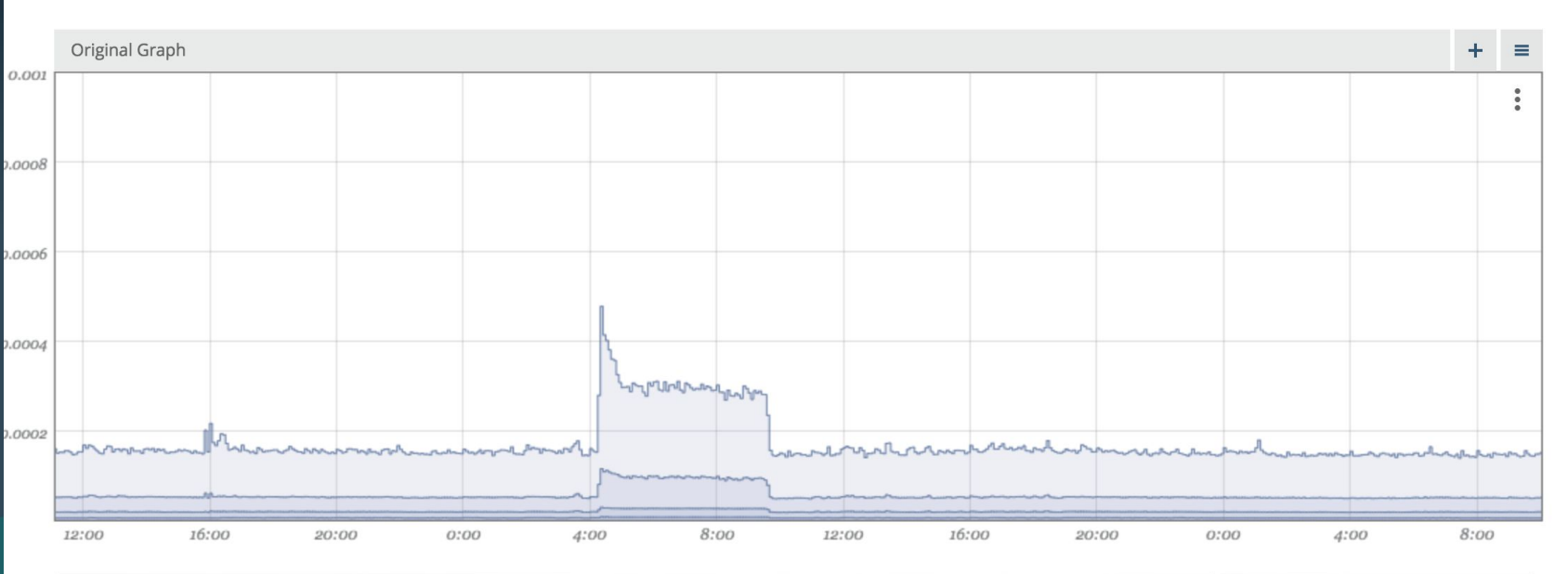
$$p95(W1 \cup W2) != (p95(W1) + p95(W2))/2$$

Works fine when node workload is symmetric

Hides problems when workloads are asymmetric

CIRCONUS

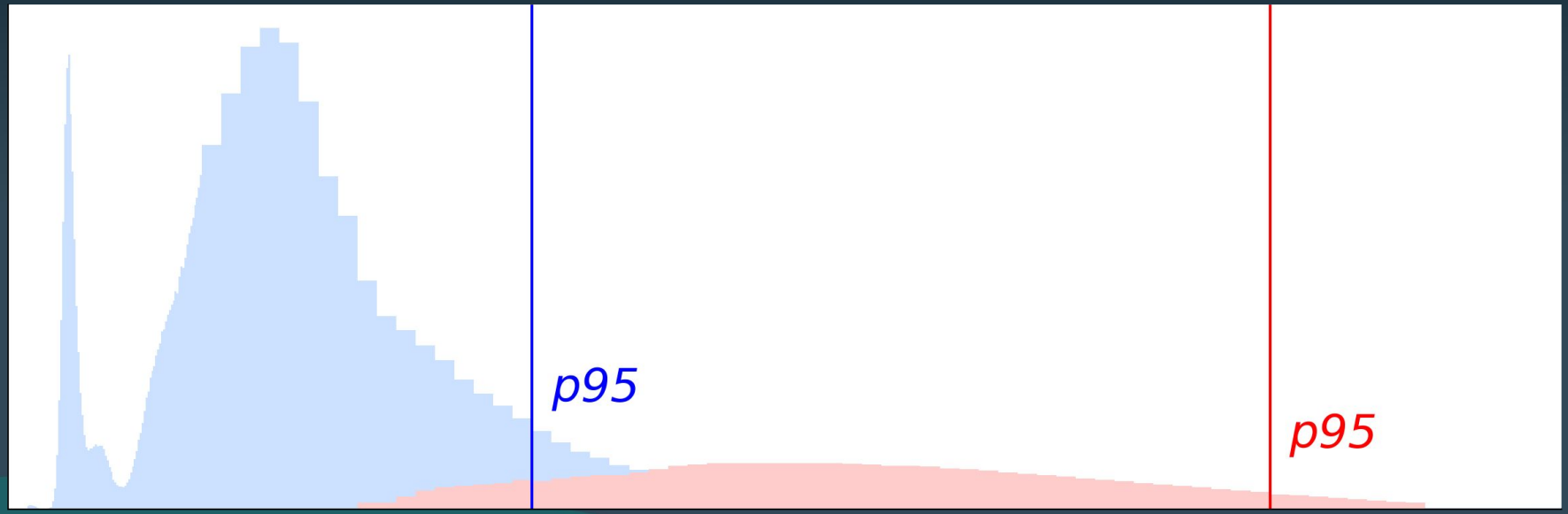
A Common Mistake with Percentiles



@phredmoyer

CIRCONUS

A Common Mistake with Percentiles



CIRCONUS

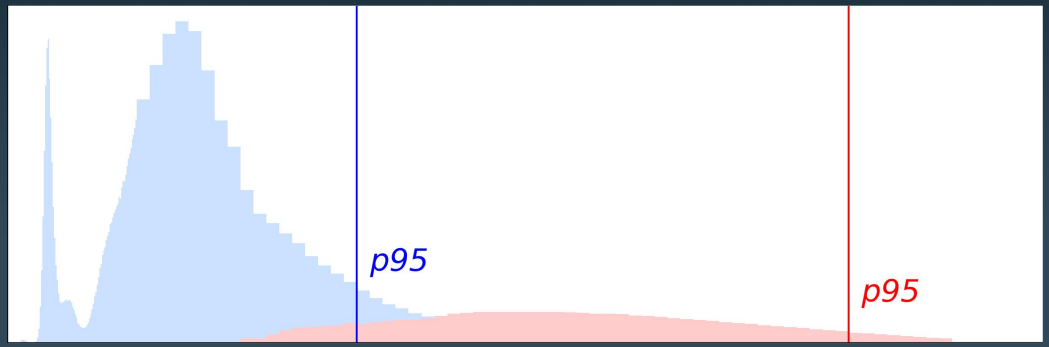
A Common Mistake with Percentiles

p95(W1) = 220ms
p95(W2) = 650ms

p95(W1 ∪ W2) = 230ms

(p95(W1)+p95(W2))/2 = 430ms

~200% difference



CIRCONUS

A Common Mistake with Percentiles

Log parser => Metrics (mtail)

What metrics are you storing?

Averages? p50, p90, p95, p99, p99.9, p99.9?

CIRCONUS

Talk Agenda

- ✔ SLO Primer
- ✔ A Common Mistake with Percentiles
- Computing SLOs with log data
- Computing SLOs by counting requests
- Computing SLOs with histograms

CIRCONUS

Computing SLOs with log data

"%{%d/%b/%Y %T}t.**%{msec_frac}t** %{%z}t"

~100 bytes per log line

~1GB for 10M requests

CIRCONUS

Computing SLOs with log data

Logs => HDFS

Logs => ElasticSearch/Splunk

ssh -- `grep ... | awk ... > 550 ... | wc -l`

Then query all the log files.

CIRCONUS

Computing SLOs with log data

Calculating p95 SLI

1. Extract samples for time window
2. Sort the samples by value
3. Find the sample 5% count from largest
4. That's your p95

CIRCONUS

Computing SLOs with log data

Calculating p95 SLO

"95th percentile SLI will succeed 99.9% trailing year"

1. Divide 1 year samples into 1,000 slices
2. For each slice, calculate SLI
3. Was p95 SLI met for 999 slices? Met SLO if so

CIRCONUS

Computing SLOs with log data

Pros:

1. Easy to configure logs to capture latency
2. Easy to roll your own processing code, some open source options out there
3. Accurate results

CIRCONUS

Computing SLOs with log data

Cons:

1. Expensive (see log analysis solution pricing)
2. Sampling possible but skews accuracy
3. Slow
4. Difficult to scale

CIRCONUS

Talk Agenda

- [x] SLO Primer
- [x] A Common Mistake with Percentiles
- [x] Computing SLOs with log data
- [ ] Computing SLOs by counting requests
- [ ] Computing SLOs with histograms

CIRCONUS

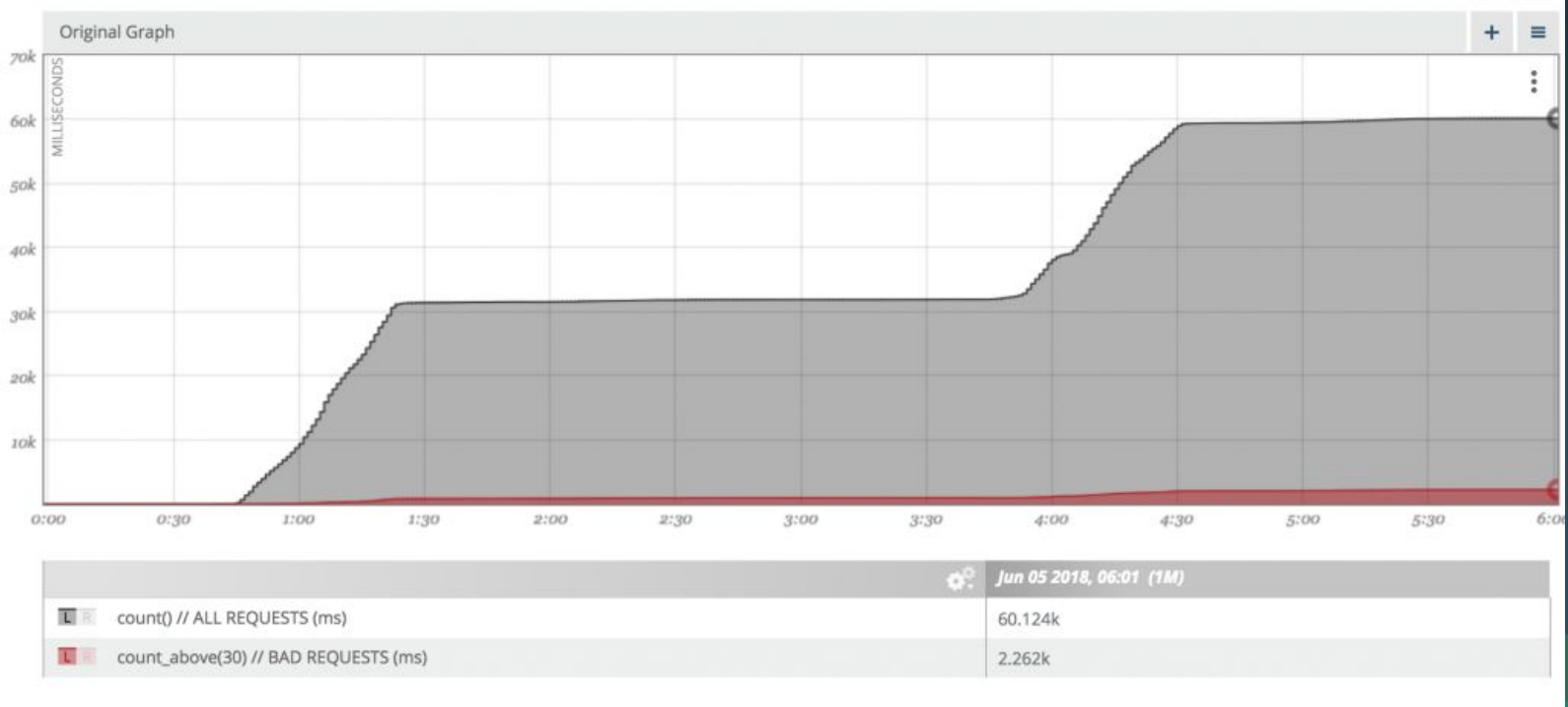
Computing SLOs by counting requests

1. Count # of requests that violate SLI threshold
2. Count total number of requests
3. % success = 100 - (#failed_reqs/#total_reqs)*100

Similar to Prometheus cumulative ‘le’ histogram

CIRCONUS

Computing SLOs by counting requests



CIRCONUS

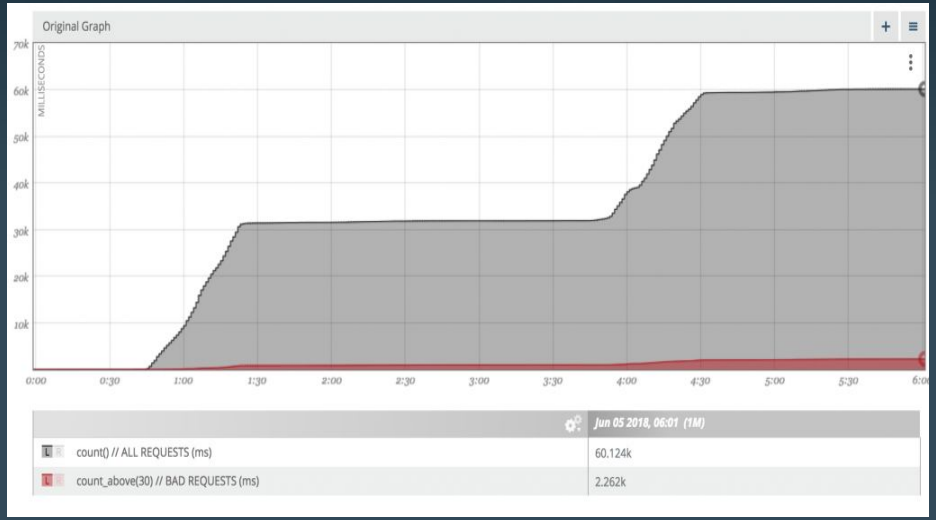
Computing SLOs by counting requests

SLO = 90% of reqs < 30ms

bad requests = 2,262
total requests = 60,124

100-(2262/60124)*100 = 96.2%

SLO was met



CIRCONUS

Computing SLOs by counting requests

Pros:

1. Simple to implement
2. Performant
3. Scalable
4. Accurate

CIRCONUS

Computing SLOs by counting requests

Cons:

1. Fixed SLO threshold - must reconfigure
2. Look back impossible for other thresholds

CIRCONUS

Talk Agenda

- [x] SLO Primer
- [x] A Common Mistake with Percentiles
- [x] Computing SLOs with log data
- [x] Computing SLOs by counting requests
- [ ] Computing SLOs with histograms

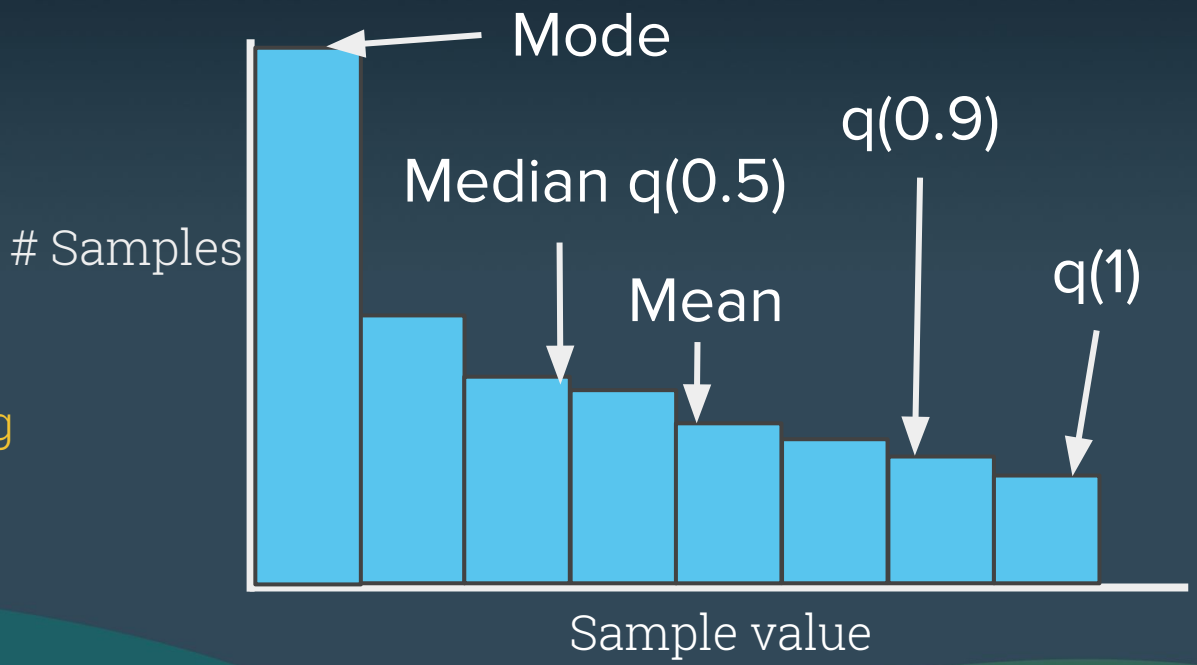
CIRCONUS

Computing SLOs with histograms

AKA distributions

Sample counts
in bins/buckets

Gil Tene's hdrhistogram.org



CIRCONUS

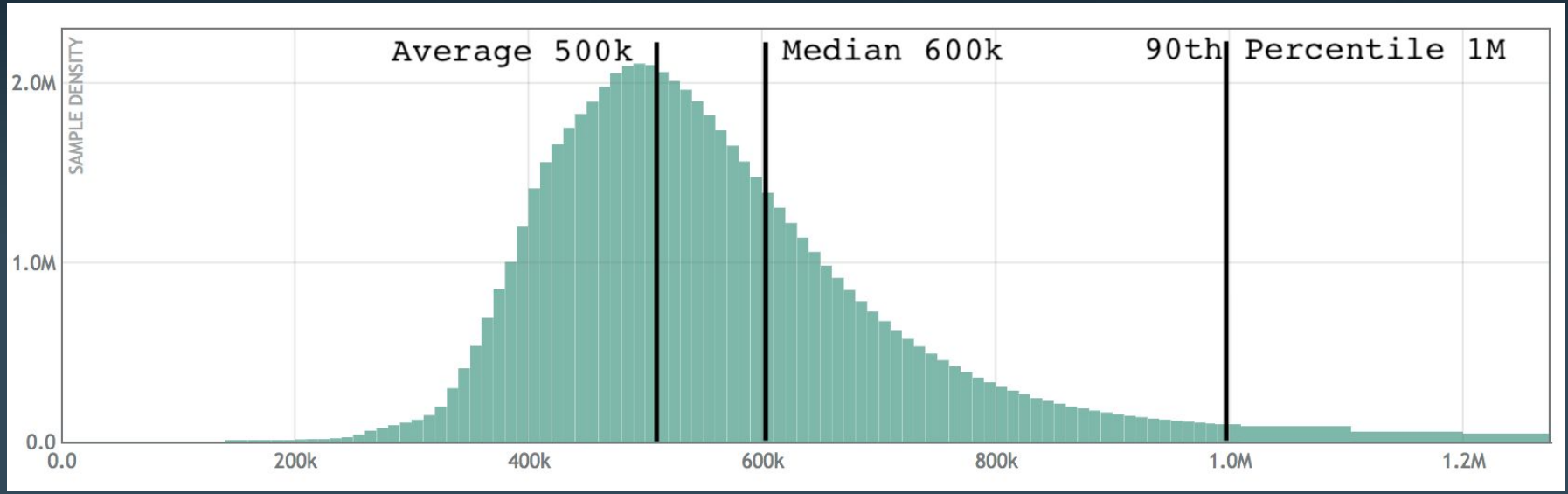
Computing SLOs by counting requests

Some histogram types:

1. Linear
2. Approximate
3. Fixed bin
4. Cumulative
5. Log Linear

CIRCONUS

Log Linear Histogram



github.com/circonus-labs/libcircllhist
github.com/circonus-labs/circonusllhist

@phredmoyer

CIRCONUS

Mergeability

$$h(A \cup B) = h(A) \cup h(B)$$

A & B must have identical bin boundaries

Can be aggregated both in space and time

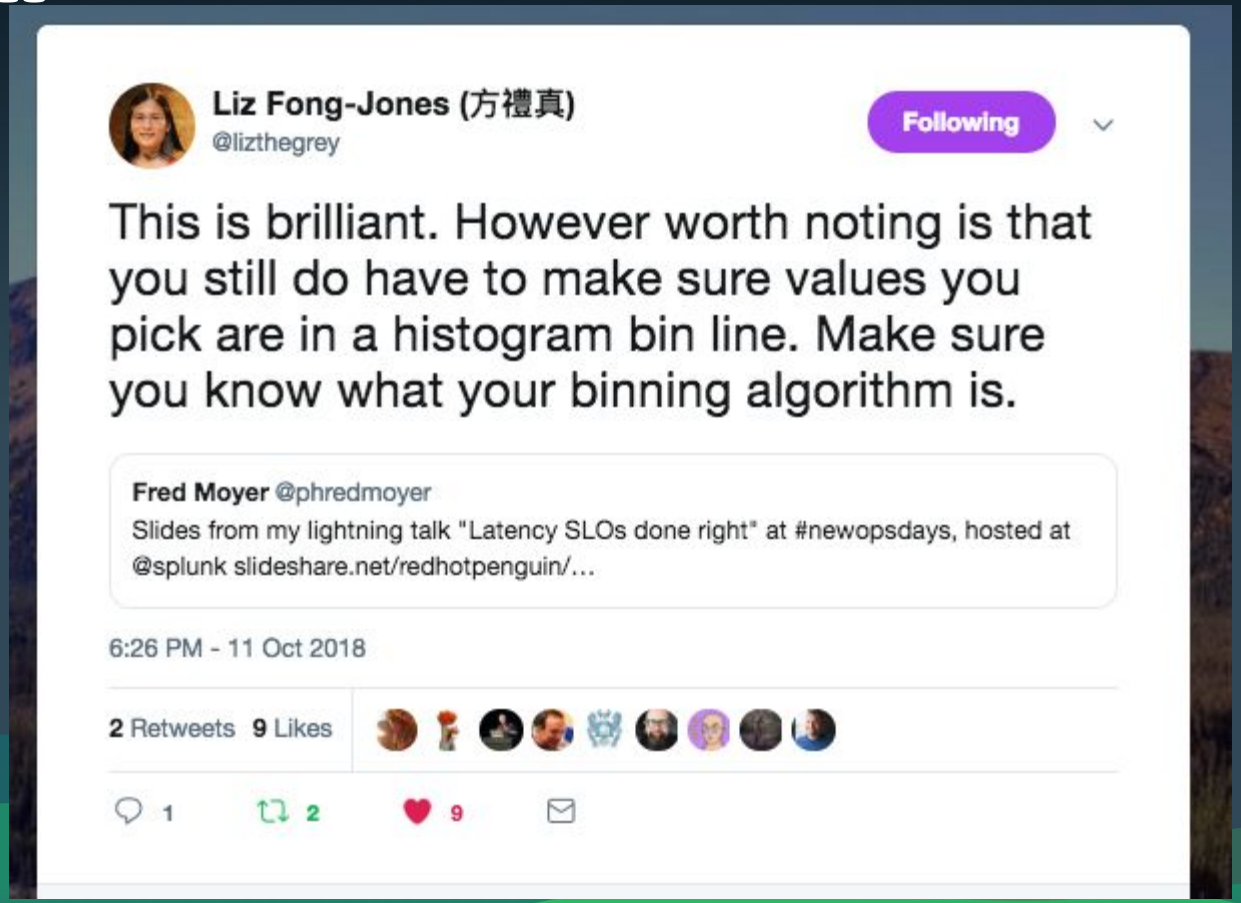
CIRCONUS

Computing SLOs with histograms

How many requests are faster than 330ms?

1. Walk the bins lowest to highest until you reach 330ms
2. Sum the counts in those bins
3. Done

CIRCONUS


Liz Fong-Jones (方禮真)
@lizthegrey
Following
This is brilliant. However worth noting is that you still do have to make sure values you pick are in a histogram bin line. Make sure you know what your binning algorithm is.
Fred Moyer @phredmoyer
Slides from my lightning talk "Latency SLOs done right" at #newopsdays, hosted at @splunk slideshare.net/redhotpenguin/...
6:26 PM - 11 Oct 2018
2 Retweets 9 Likes
1
2
9

CIRCONUS

So ... where are the bin boundaries?

For the libcircllhist implementation we have bins at:

... 320, 330, 340, ...

.... And: 10,11,12,13...

.... And: 0.0000010, 0.0000011, 0.0000012,

For every decimal floating point number, with 2 significant digits, we have a bin (within 10^{+/-128}).

CIRCONUS

Computing SLOs with histograms

Pros:

1. Space Efficient (HH: ~ 300bytes / histogram in practice, 10x more efficient than logs)
2. Full Flexibility:
   - Thresholds can be chosen as needed and analyzed
   - Many statistical methods can be applied, IQR, count_below, stddev, q(1), etc.
3. Mergability (HH: Aggregate data across nodes)
4. Performance (ns insertions, µs percentile calculations)
5. Bounded error (half the bin size)
6. Several open source libraries available

CIRCONUS

Computing SLOs with histograms

Cons:

1. Math is more complex than other methods
2. Some loss of accuracy (<<5%)

CIRCONUS

Log Linear histograms with Python

github.com/circonus-labs/libcircllhist

github.com/circonus-labs/libcircllhist/tree/master/src/python

pip install circllhist

@phredmoyer

CIRCONUS

Log Linear histograms with Python

```
h = Circllhist()
h.insert(123)    # insert value 123
h.insert(456)
h.insert(789)
print(h.count())  # prints 3
print(h.sum())    # prints 1,368
print(h.quantile(0.5)) # prints 456
```

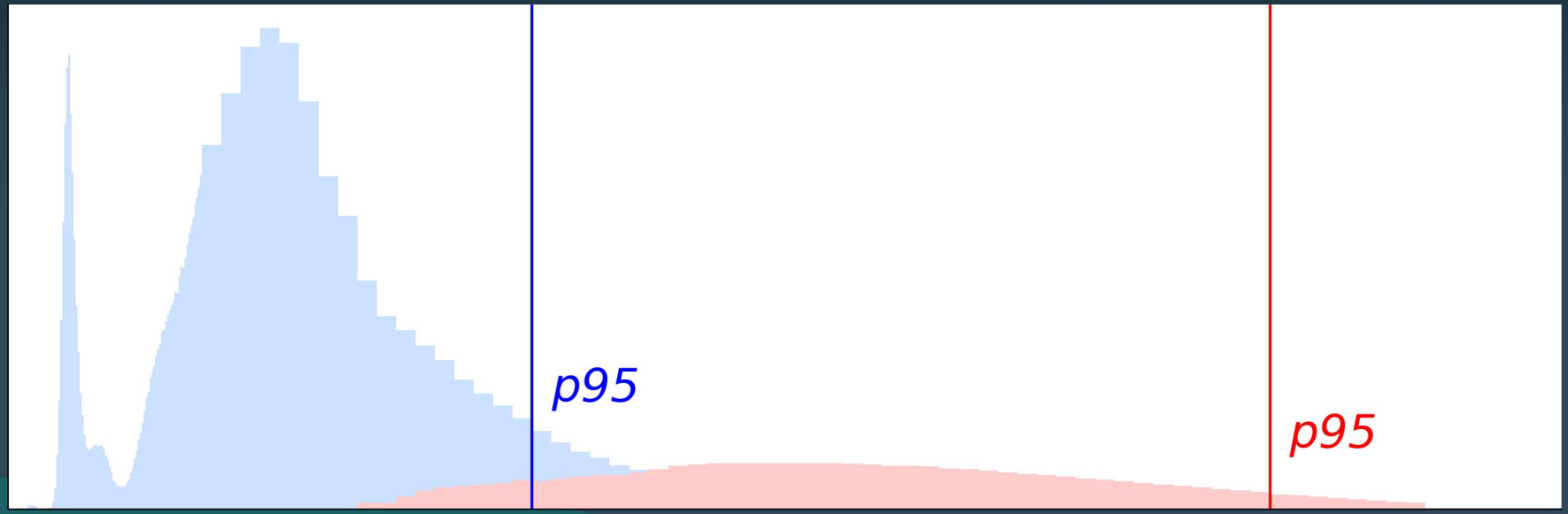
CIRCONUS

Log Linear histograms with Python

```
from matplotlib import pyplot as plt
from circllhist import Circllhist
H = Circllhist()
... # add latency data to H via insert()
H.plot()
plt.axvline(x=H.quantile(0.95), color=red)
```

CIRCONUS

Log Linear histograms with Python



CIRCONUS

Conclusions

1. Averaging Percentiles is tempting, but misleading
2. Use counters or histograms to calculate SLOs correctly
3. Histograms give the most flexibility in choosing latency thresholds, but only a couple libraries implement them (libcircllhist, hdrhistogram)
4. Full support for (sparsely encoded-, HDR-) histograms in TSDBs still lacking (except IRONdb).

CIRCONUS

Thank you!

Tweet me: @phredmoyer

AMA about histograms on: slack.s.circonus.com

More talks about histograms:

slideshare.net/redhotpenguin