Beyond Line Charts

Why some diversity in telemetry visualization is long overdue.

Yao Yue, CEO @ IOP Systems

An online version of these slides with interactive charts can be found here.

About Me

Builder / Operator / Researcher

15+ years of large-scale systems experience;

7+ years as a pager-carrying oncall for a tier-1 service

Usually curious about *why*

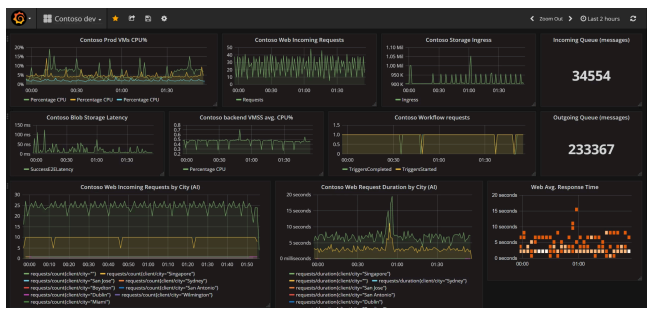
professional viz-charts starer

Reliability Engineer (2025 Edition)

What I think I do

What society thinks I do

What my boss thinks I do

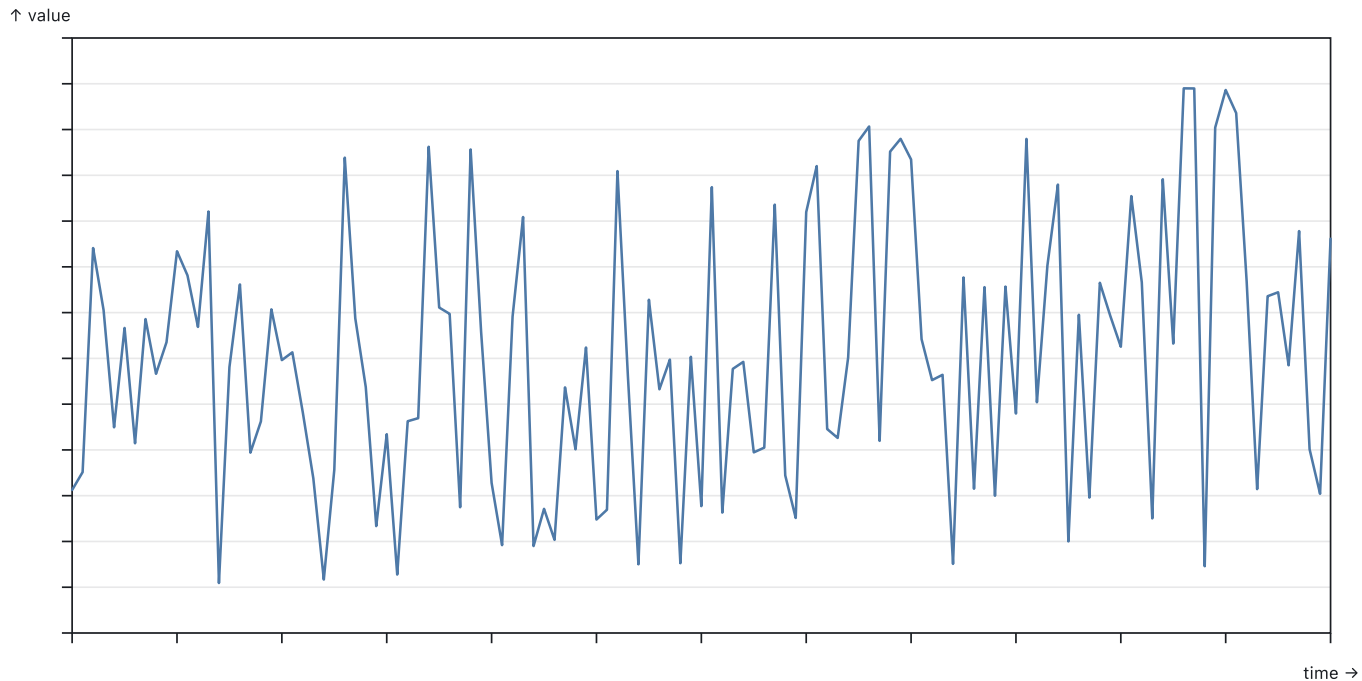


What I actually do

“The most dangerous phrase in the language is ‘we’ve always done it this way.’”

— Grace Hopper

Value-over-time As A Line Chart

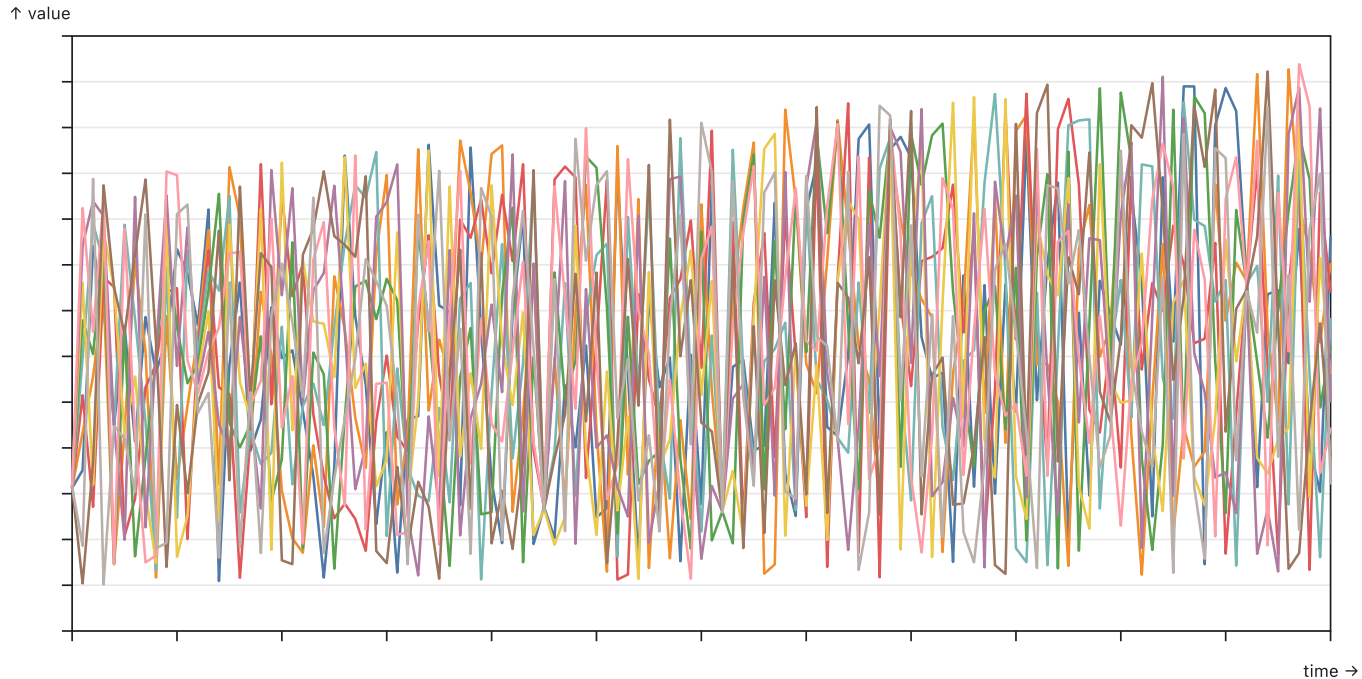


What's A Line Chart?

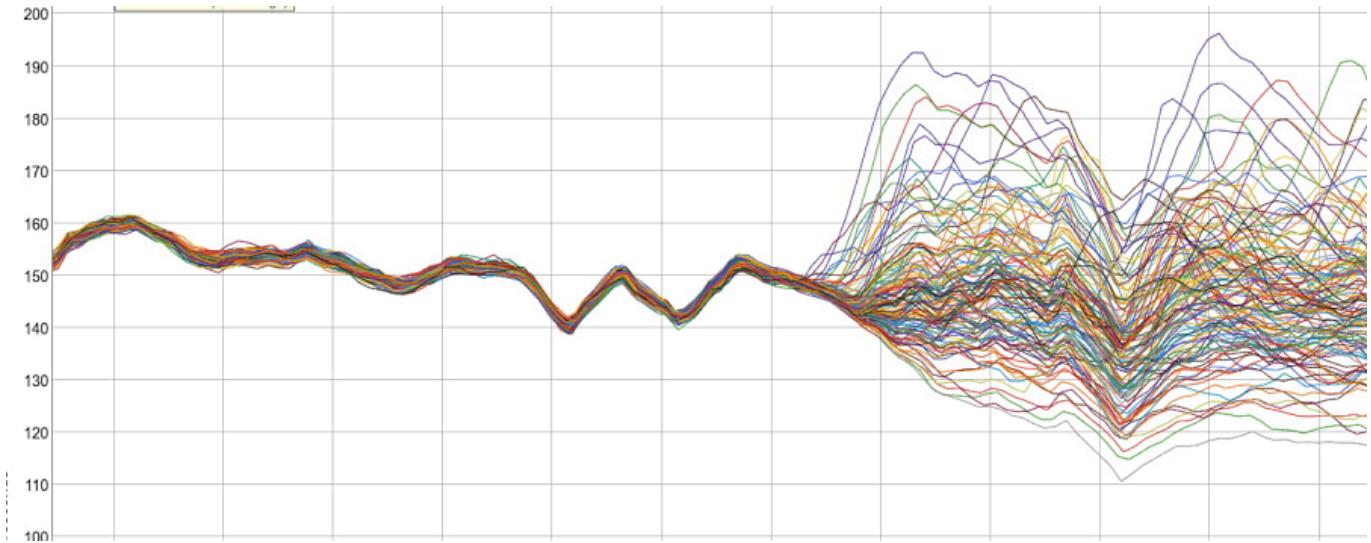
A type of chart that displays information as a series of data points connected by straight line segments.

The line segments, in particular, are a form of *interpolation*.

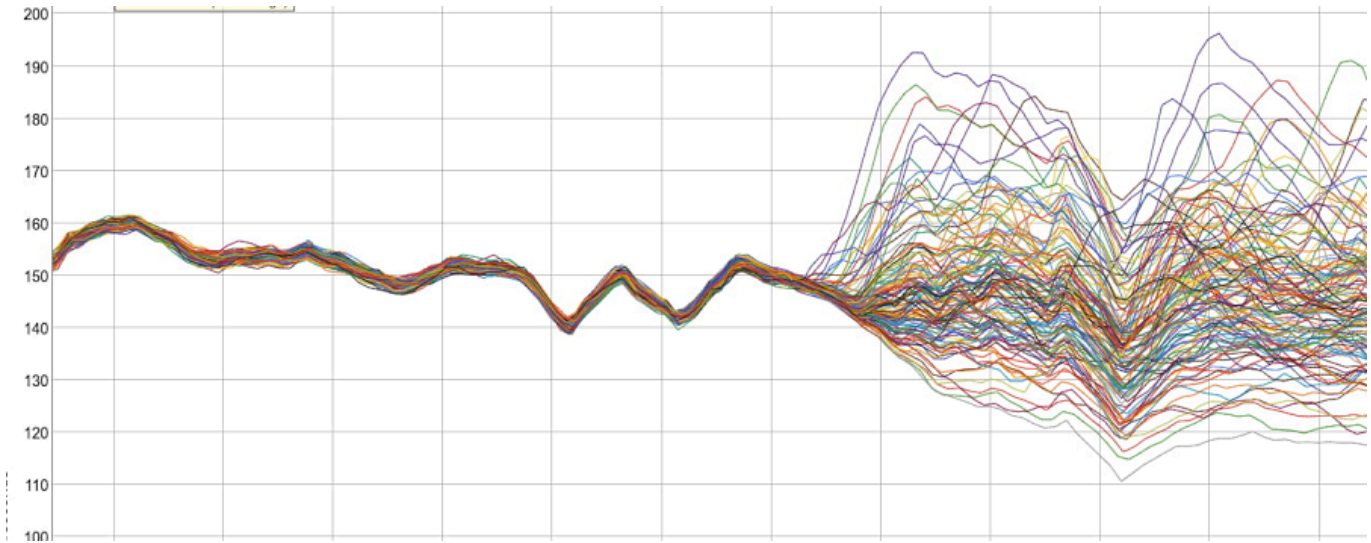
Multi-line Madness



Multi-line Madness



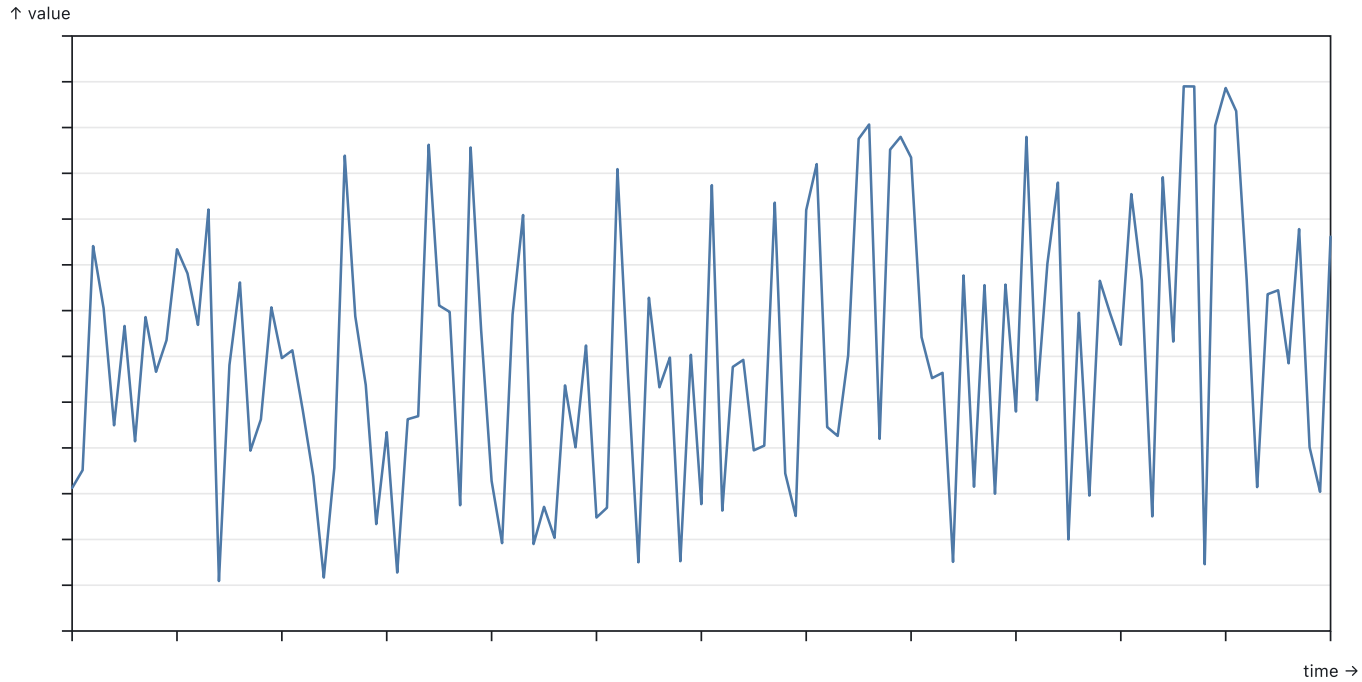
Multi-line ~~Madness~~ Art



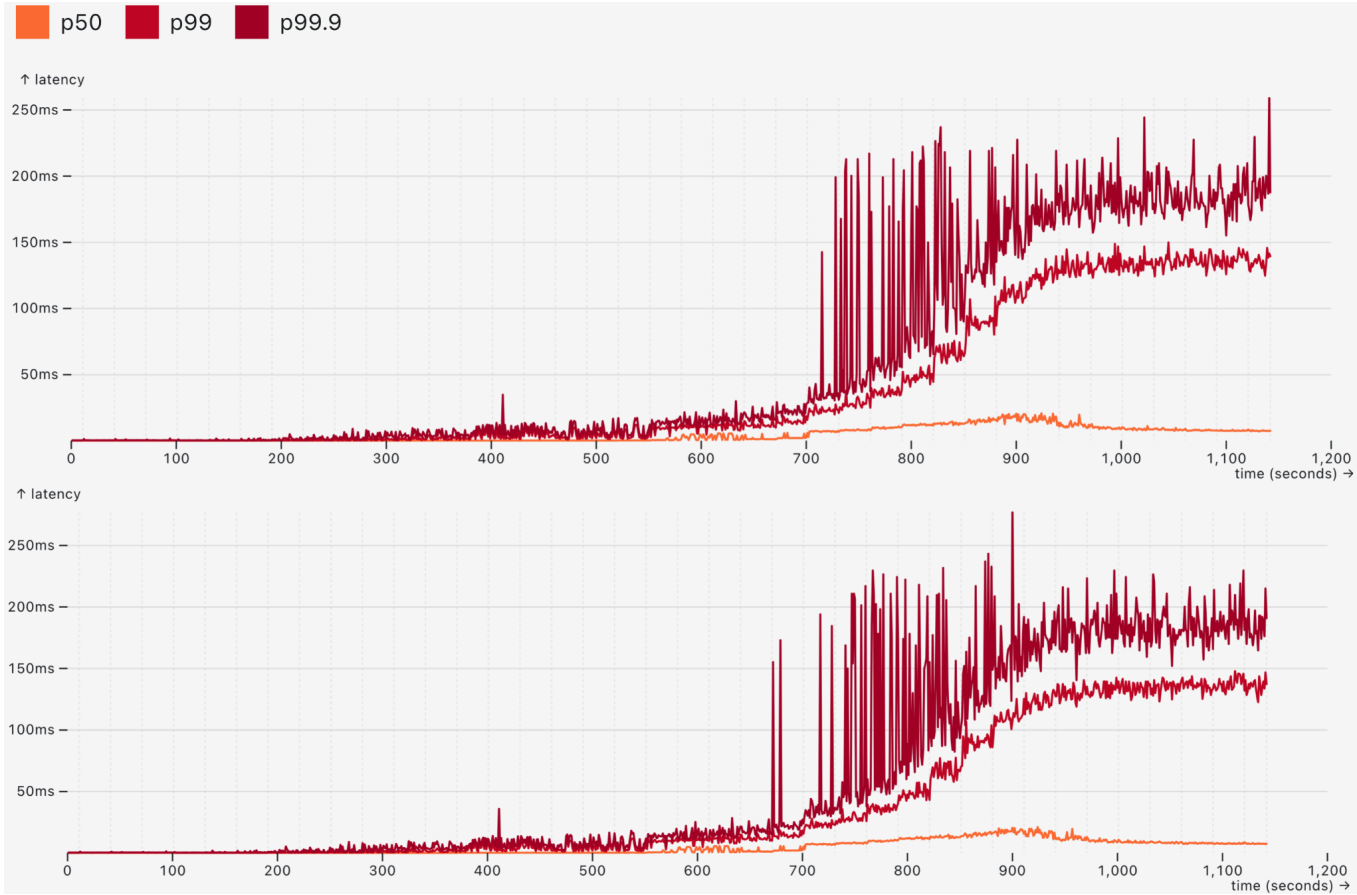
Museum of modern Borgman art

Good data visualization makes the insight obvious

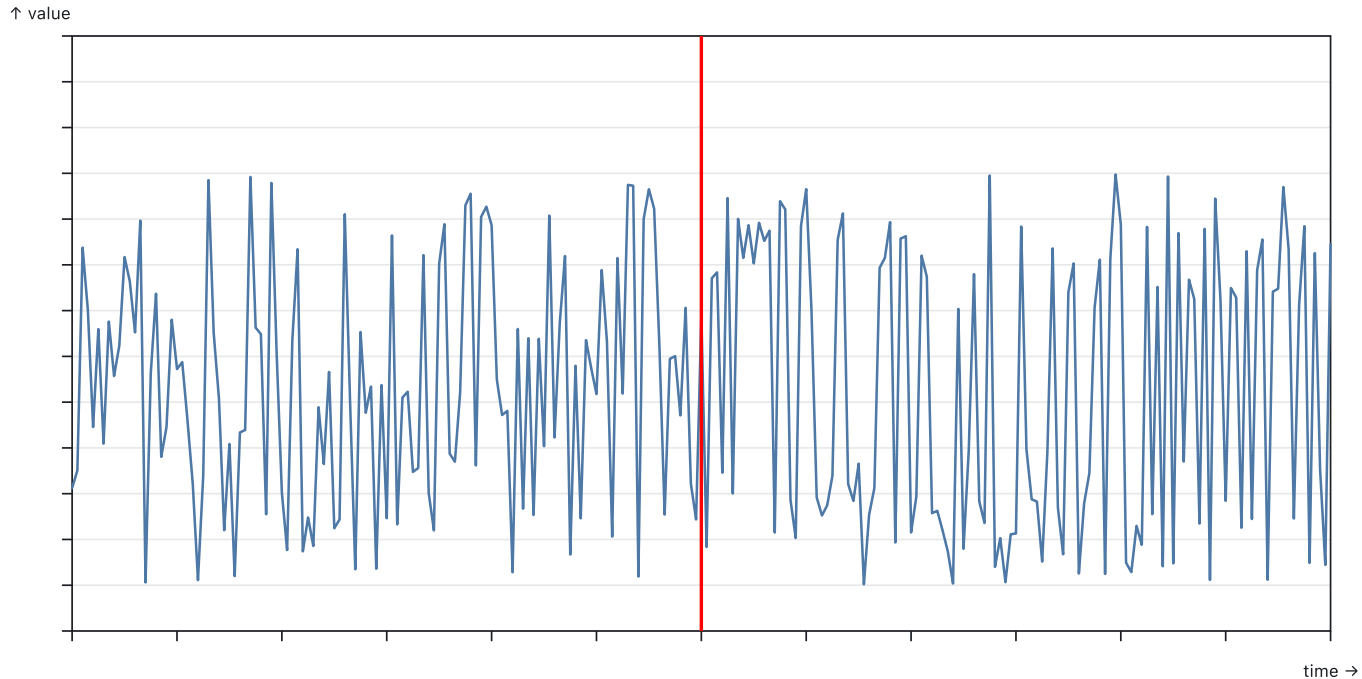
“IS THROUGHPUT CHANGING?”



"ARE THESE TWO LATENCY DISTRIBUTIONS MEANINGFULLY DIFFERENT?"



“HAS P99 CHANGED AFTER THE DEPLOY?”



“Squinting-based Analysis”

What's *My* Problem with Line Charts?

1. They can be distracting, because there are a lot of pixels—real, or interpolated.

2. They always imply "time".

Why are line charts synonymous with telemetry?

"Metrics must flow"—*writes* dominate TSDB

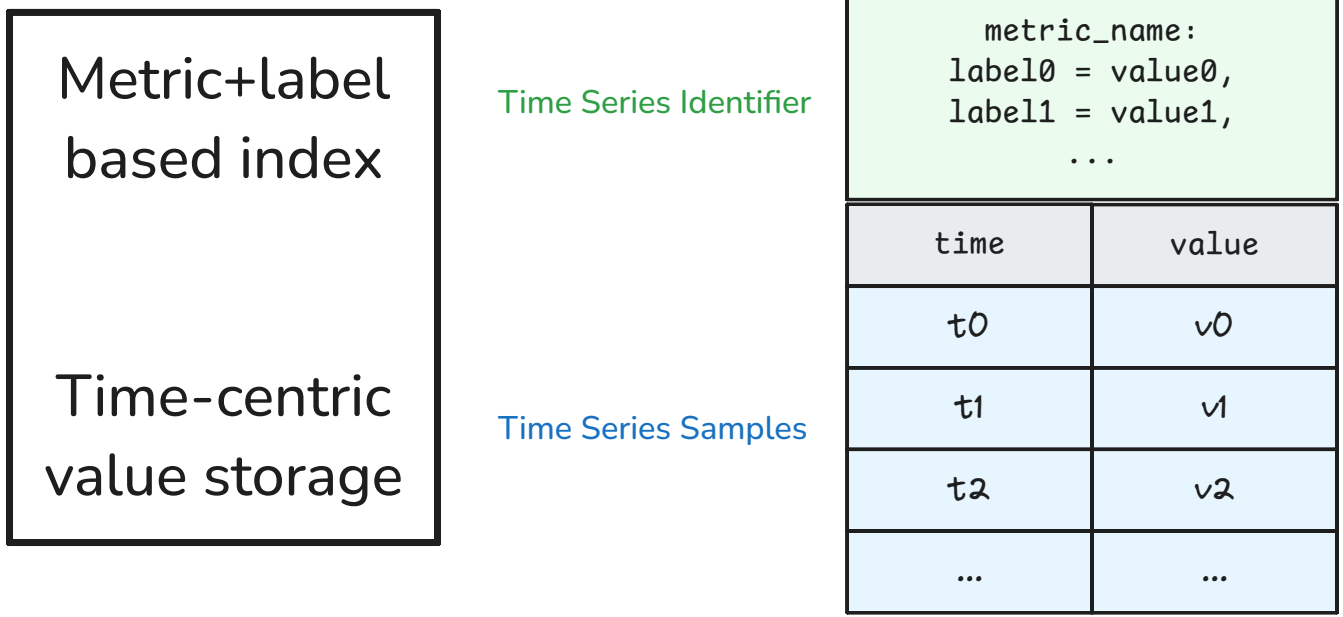
Telemetry data as time series

- Most common operation is (real-time) append
- New time series creations are less common
- Reads are range based, but far sparser than writes

Solidified over 30 years of database evolution

- Dedicated TSDB for the monitoring need of distributed services
- Append-friendly DBMSes such as DynamoDB, Cassandra are also designed for writes

Time Series Storage Format



Visualizing Time Series Values

Use Lines To Guide Flow of Time

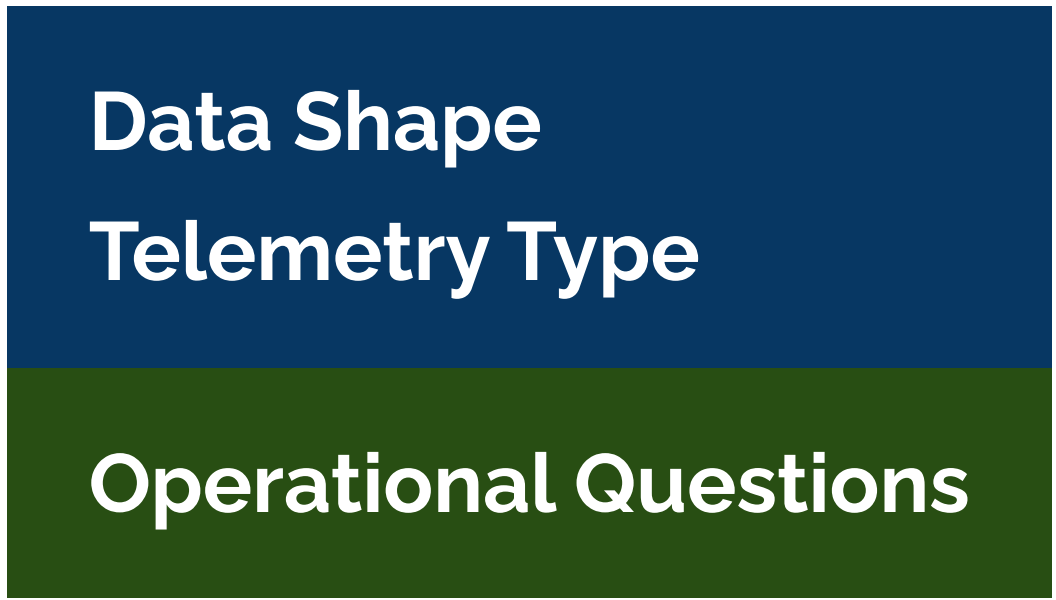
Only Keep the Line Marker

What is *better*?

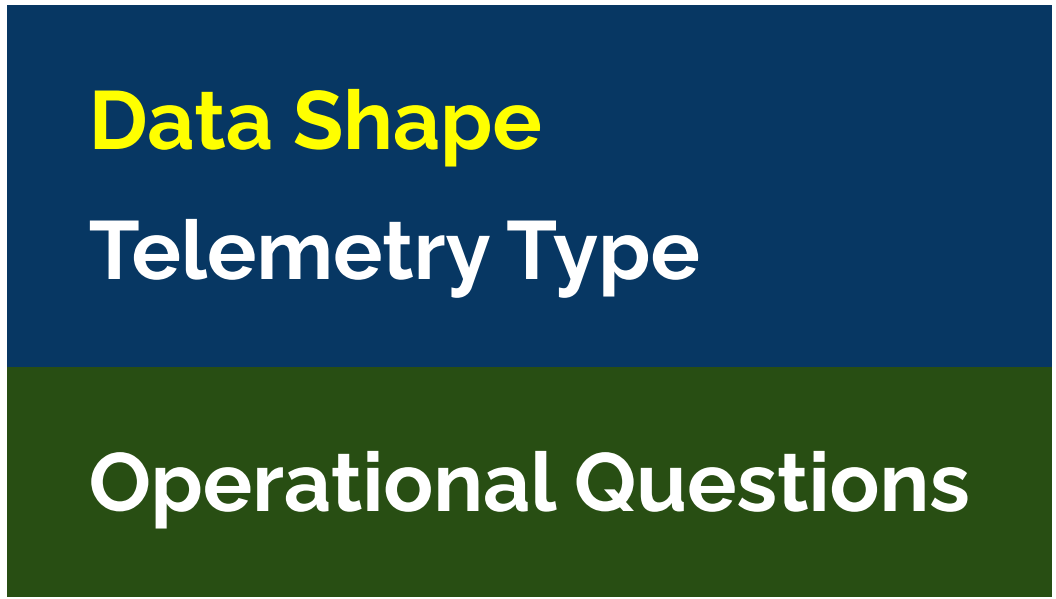
“Form follows function.”

— Louis Sullivan, architect

Telemetry

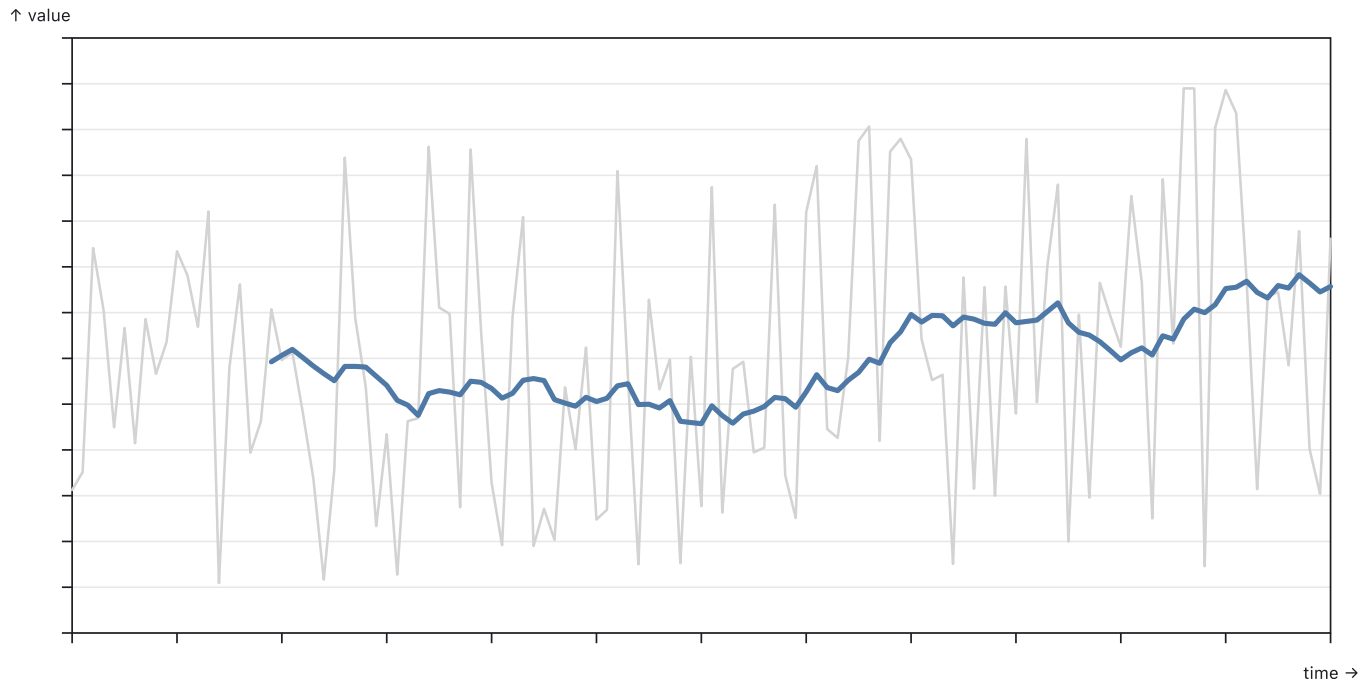


Telemetry



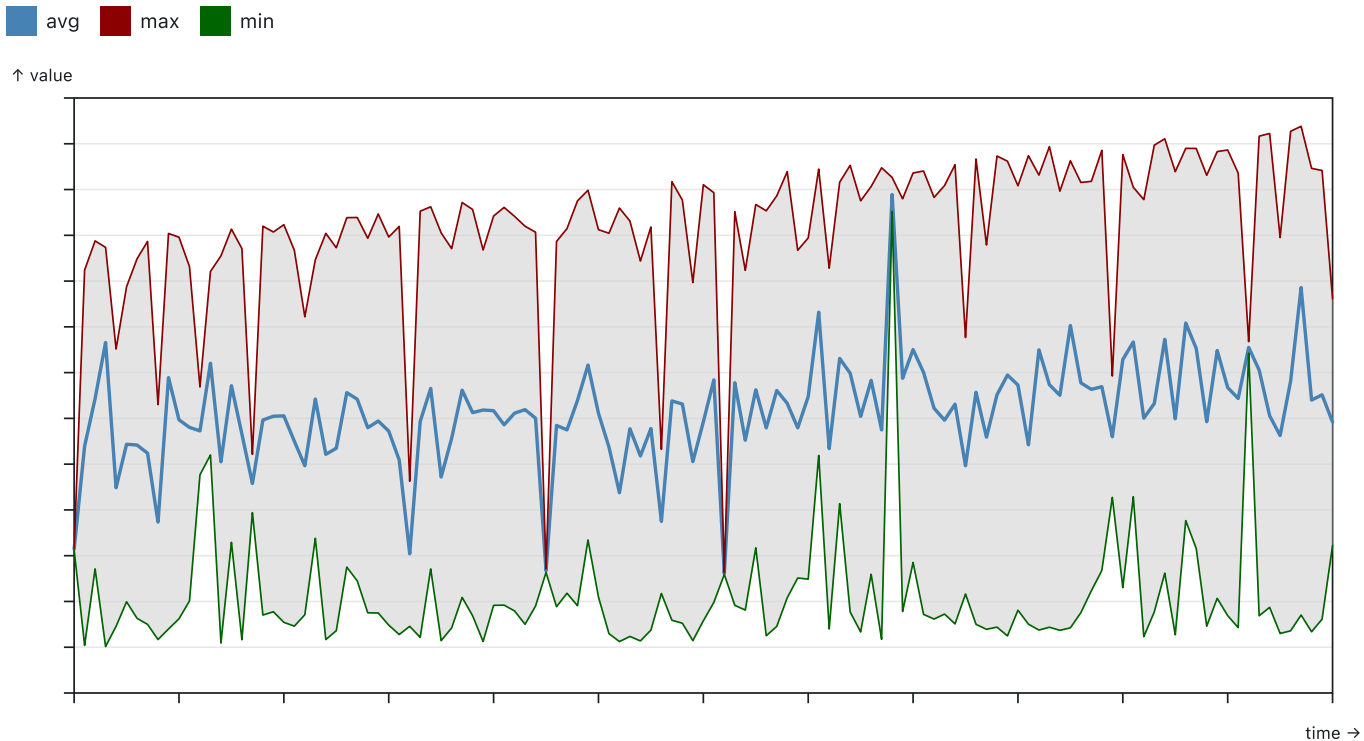
Line charts are bad for busy data.

“IS THROUGHPUT CHANGING?”



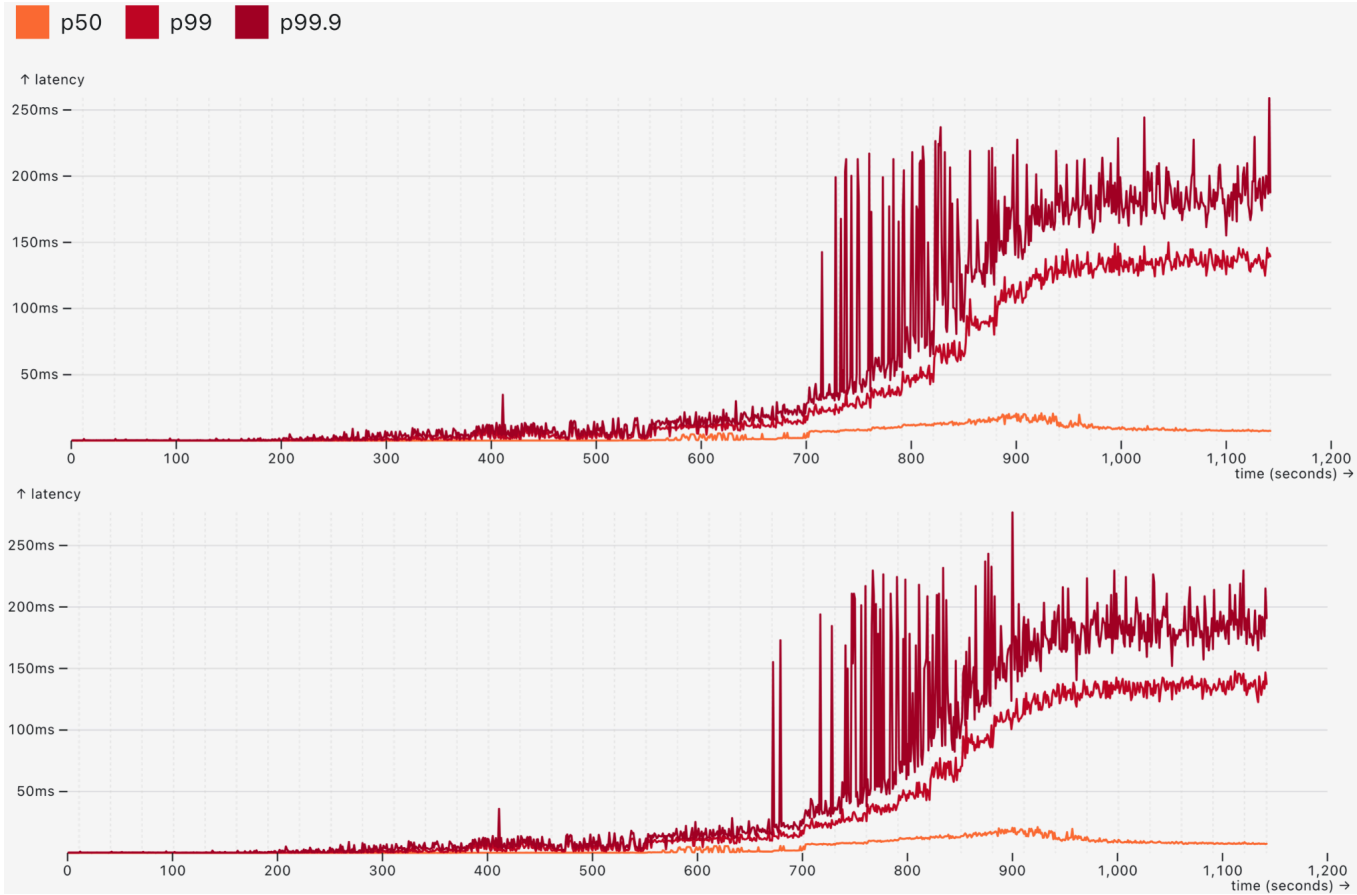
☑ Show window average

“IS CLUSTER THROUGHPUT CHANGING?”

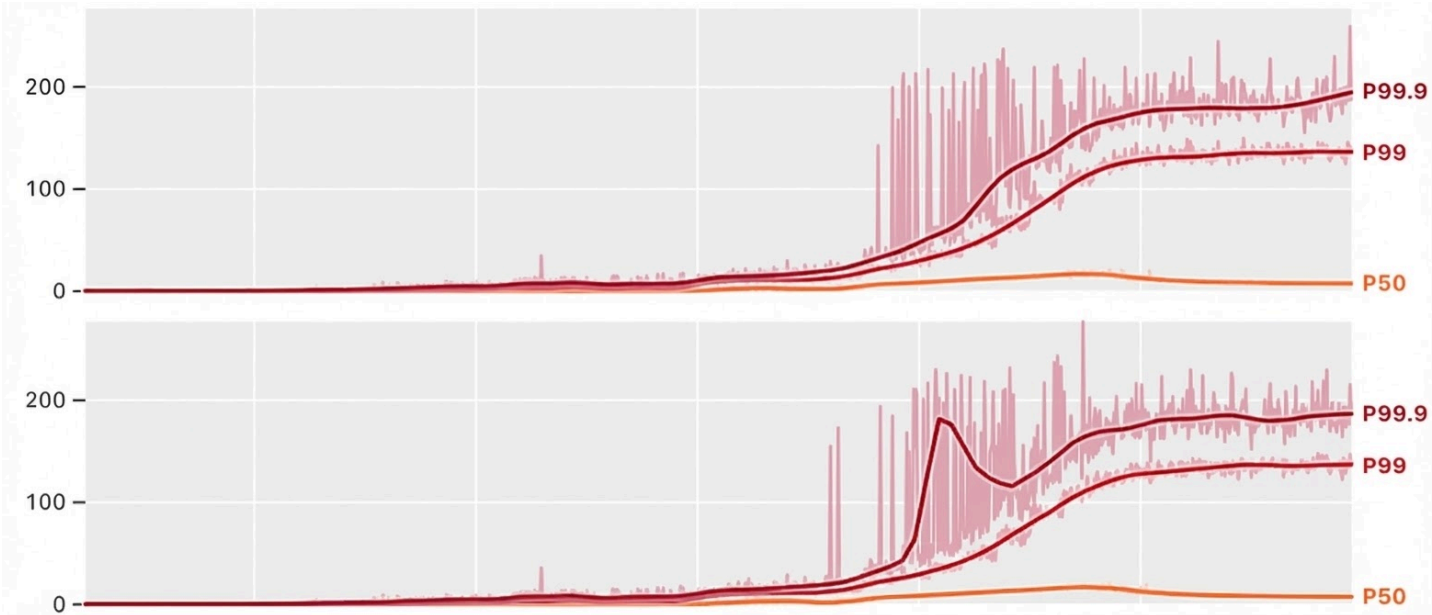


☑ Show summary

"ARE THESE TWO LATENCY DISTRIBUTIONS MEANINGFULLY DIFFERENT?"

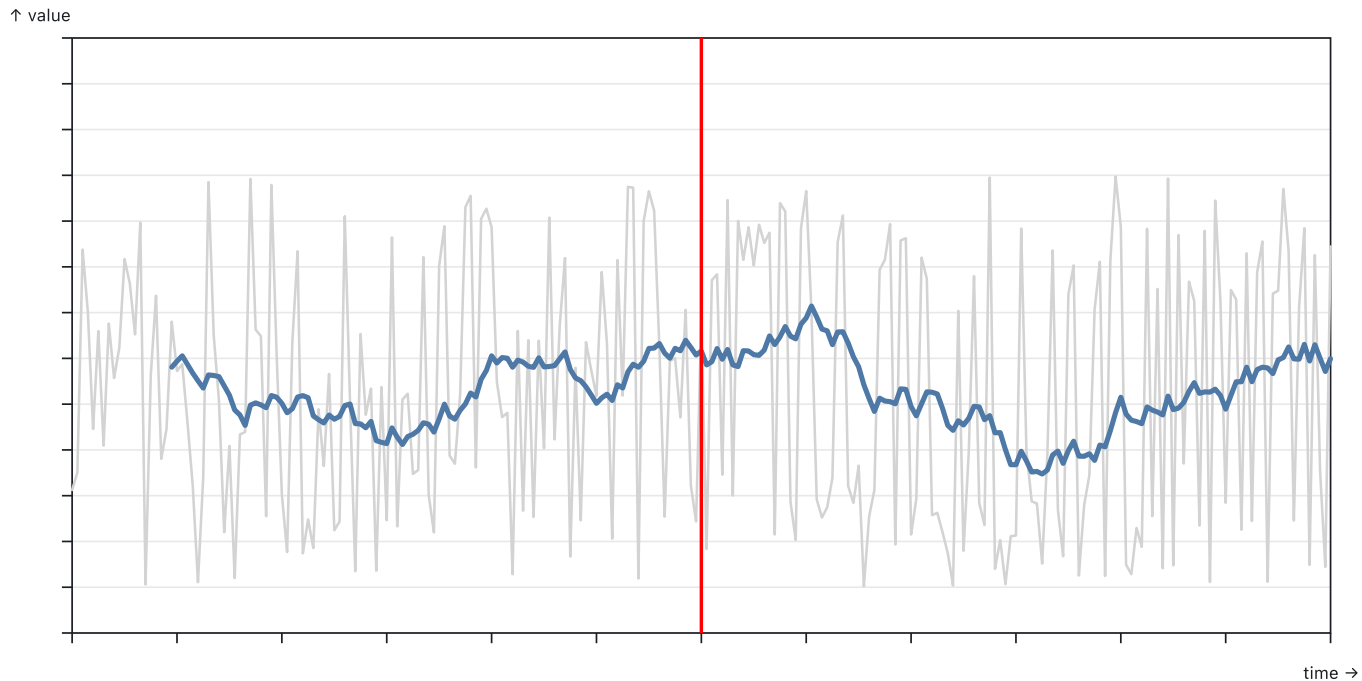


"ARE THESE TWO LATENCY DISTRIBUTIONS MEANINGFULLY DIFFERENT?"



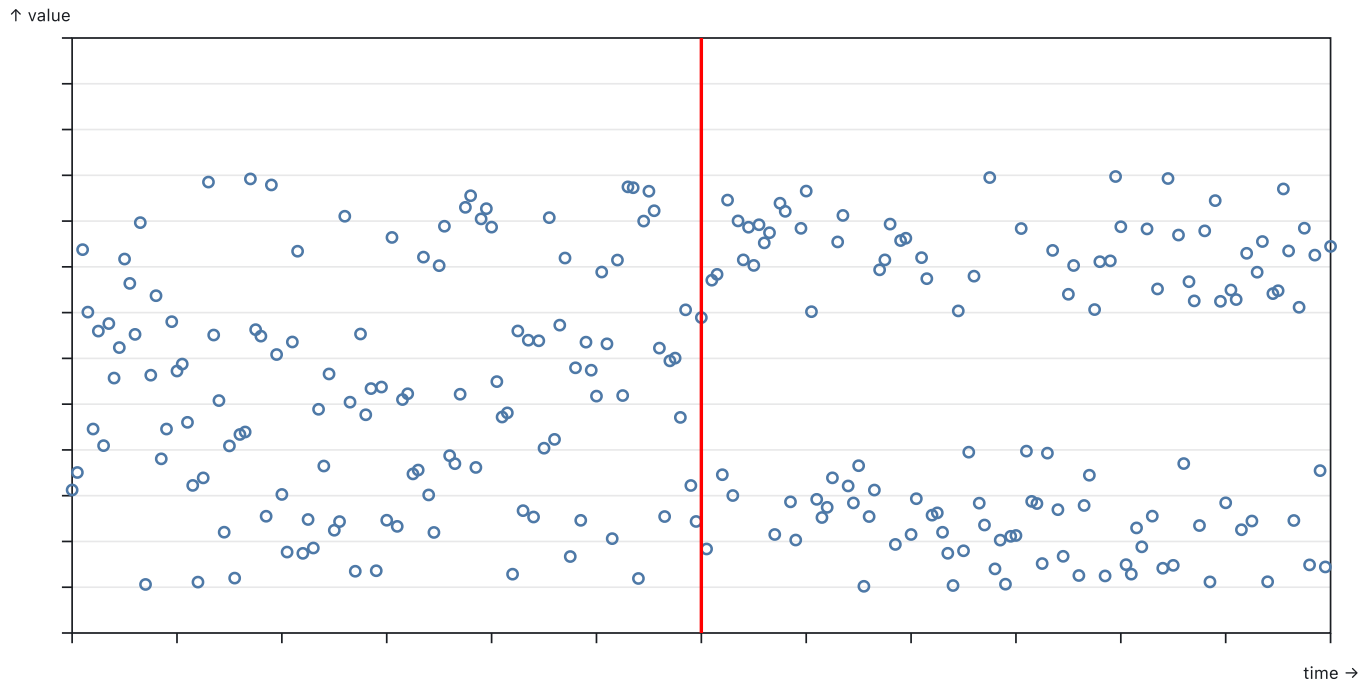
Smoothed with LOWESS: an algorithm on local regression that's 50+ years old.

“HAS P99 CHANGED AFTER THE DEPLOY?”



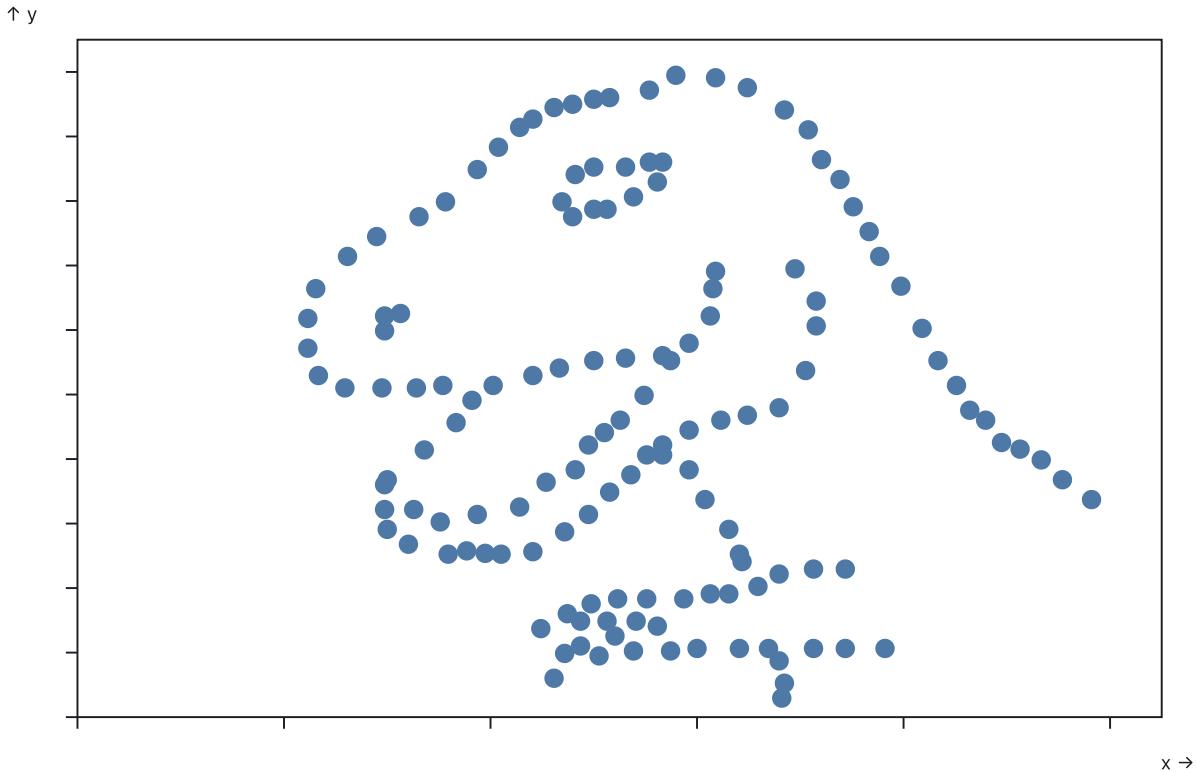
☑ Show window average

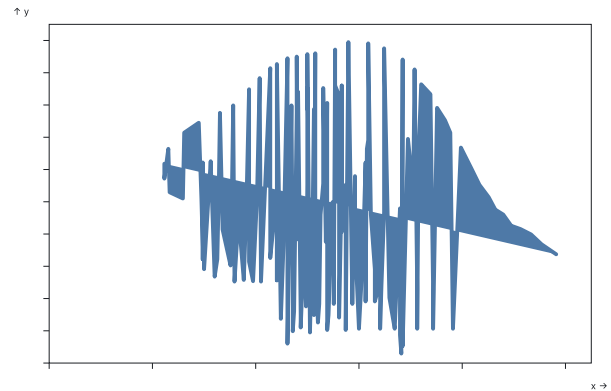
“HAS P99 CHANGED AFTER THE DEPLOY?”



☑ Show dot plot

The Power of Raw Data: See "Datasaurus"

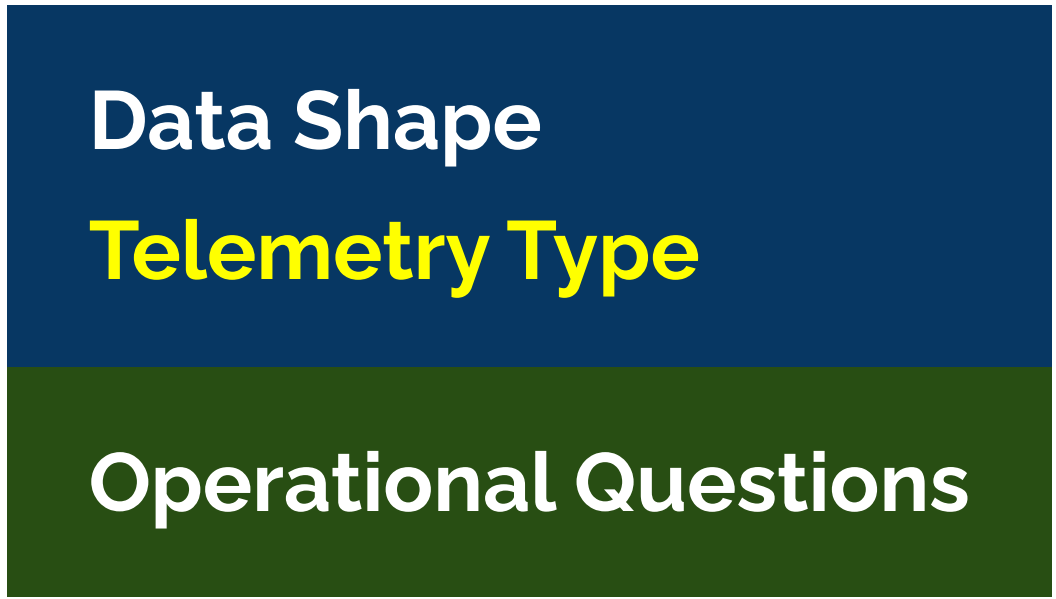




The right visualization depends on the shape of data.

You have to *try*.

Telemetry



Telemetry Type

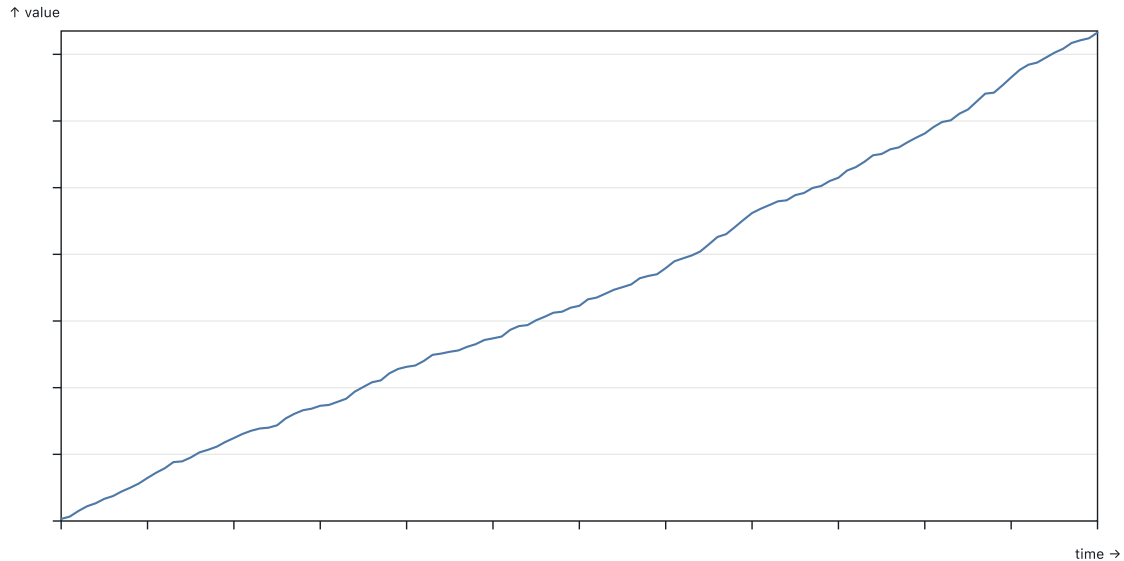
Counter: a cumulative measurement

Gauge: a spot measurement

Histogram: a distribution measurement

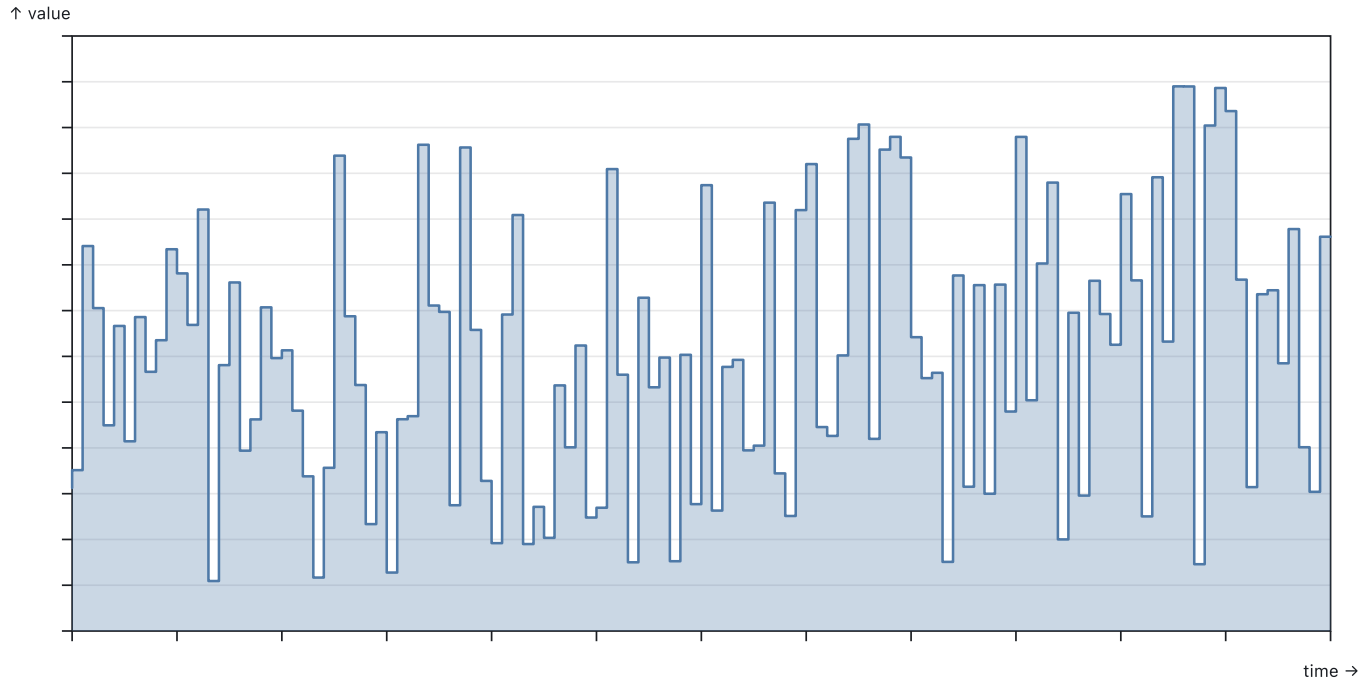
Counters

Interpolation between monotonic values with line segments? 👍



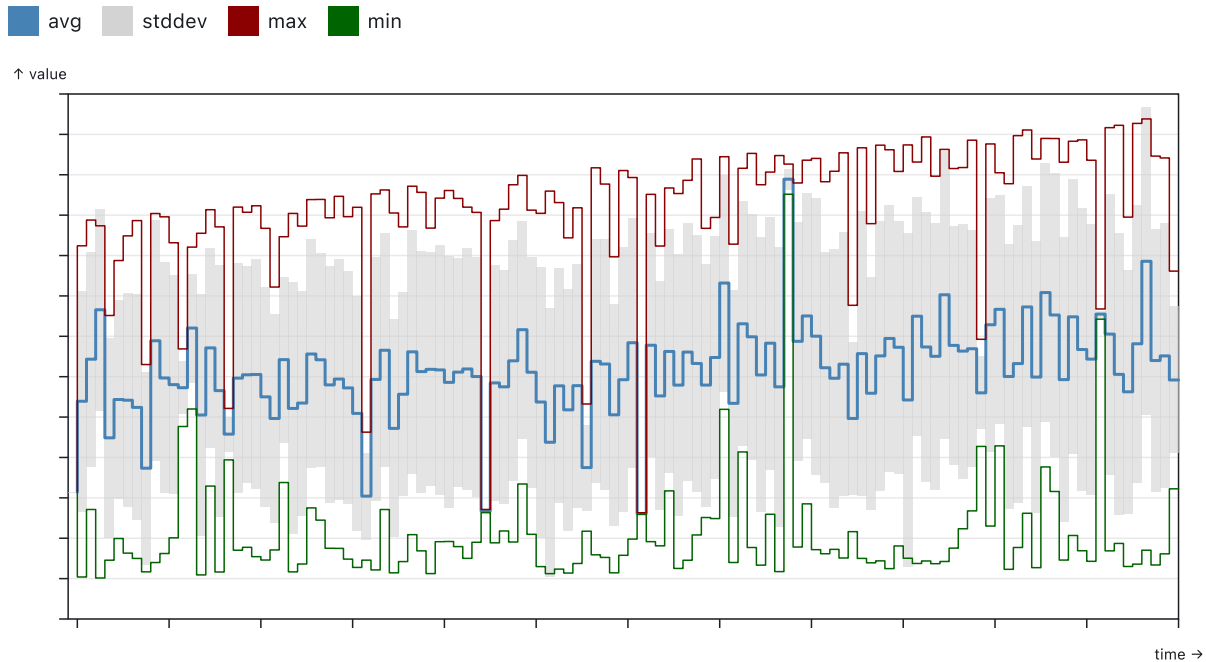
But! Almost always converted to delta counters for the slopes. 🤔

Delta Counters



☑ Counter style

Multi-line Summary



- [x] Counter style
- [x] Show stddev

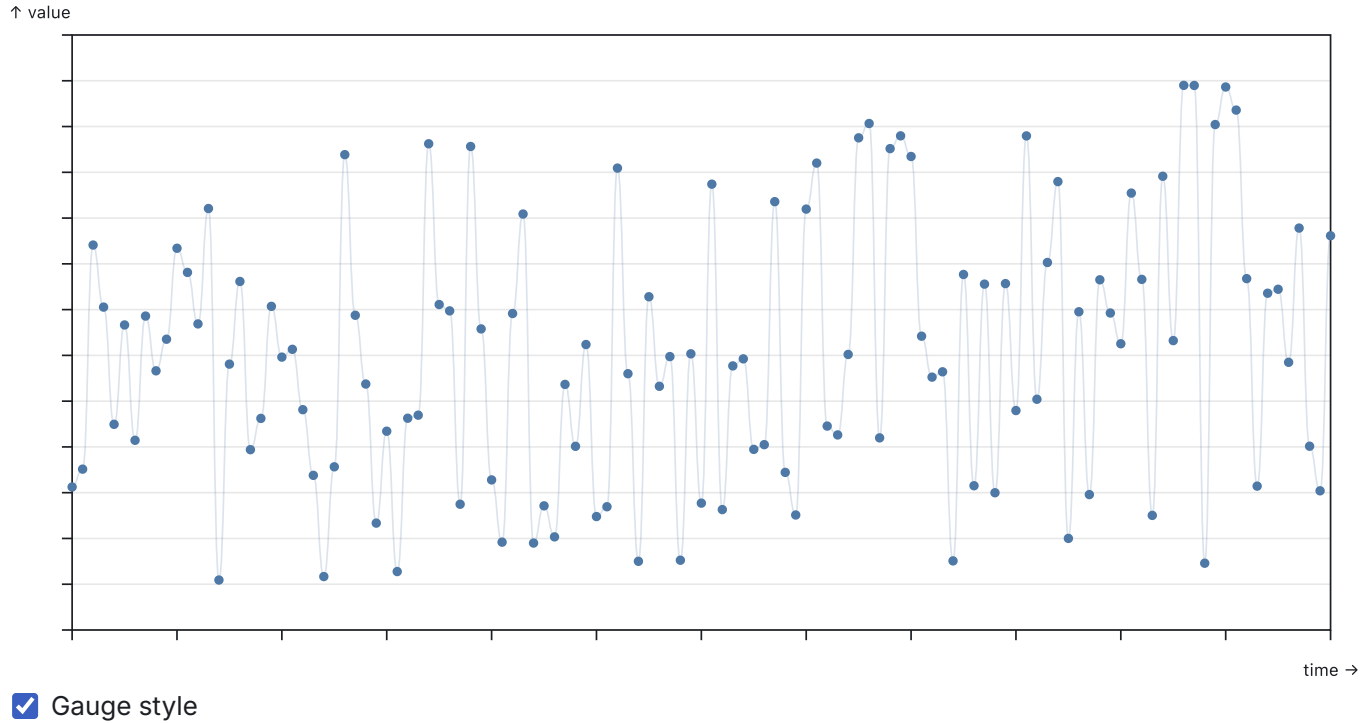
Telemetry Type

Counter: a cumulative measurement

Gauge: a spot measurement

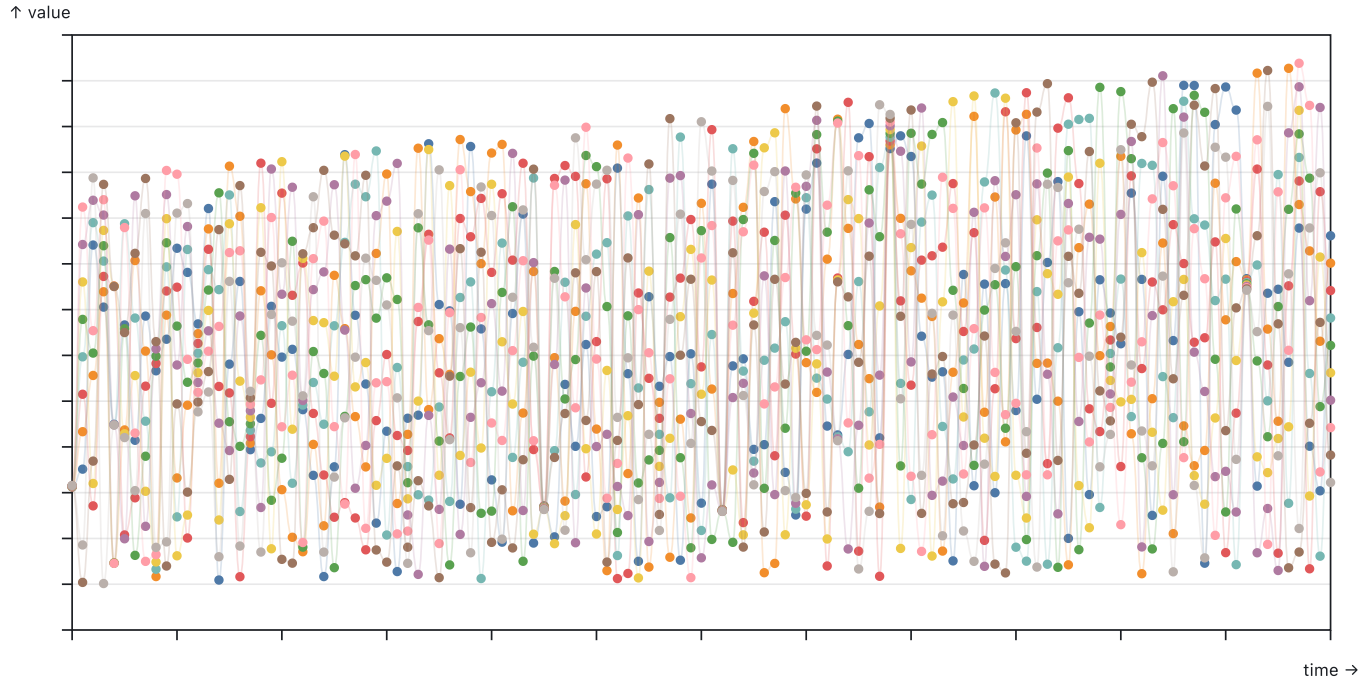
Histogram: a distribution measurement

Gauges: Points >>> Lines



☑ Gauge style

Gauges: Points >>> Lines



☑ Gauge style

Telemetry Type

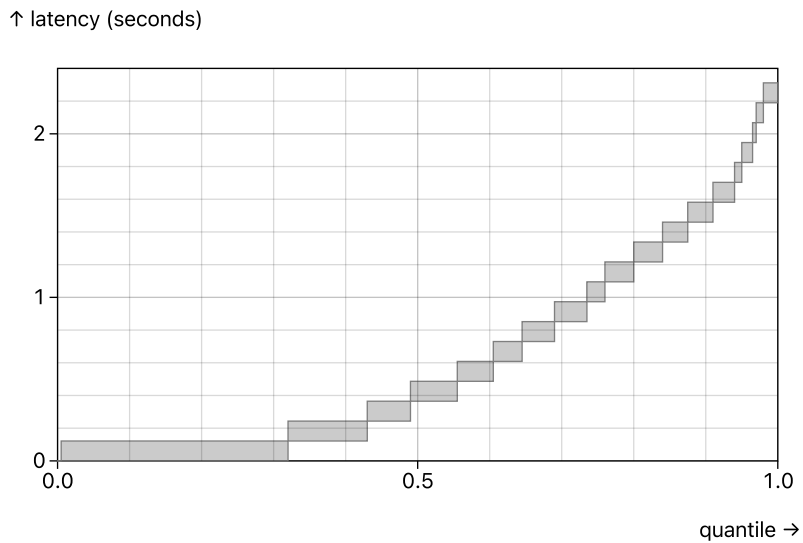
Counter: a cumulative measurement

Gauge: a spot measurement

Histogram: a distribution measurement

Latency ❤️ histogram

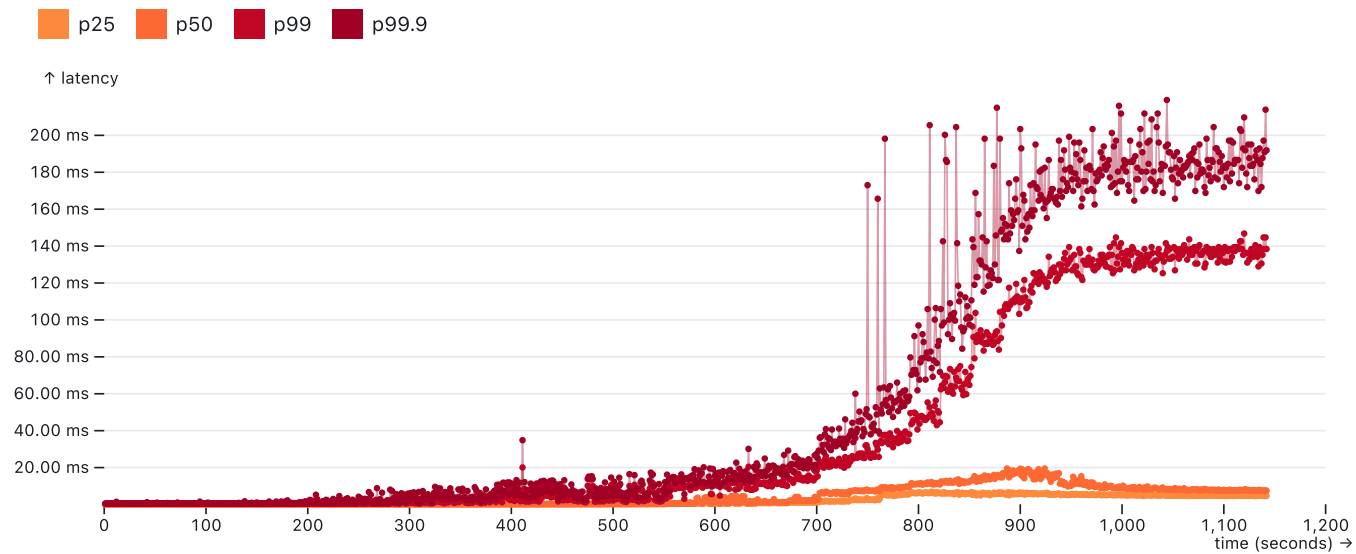
- A distribution: many quantiles, (approximate) values
- High dynamic range, high variance at tail



Not just one number!

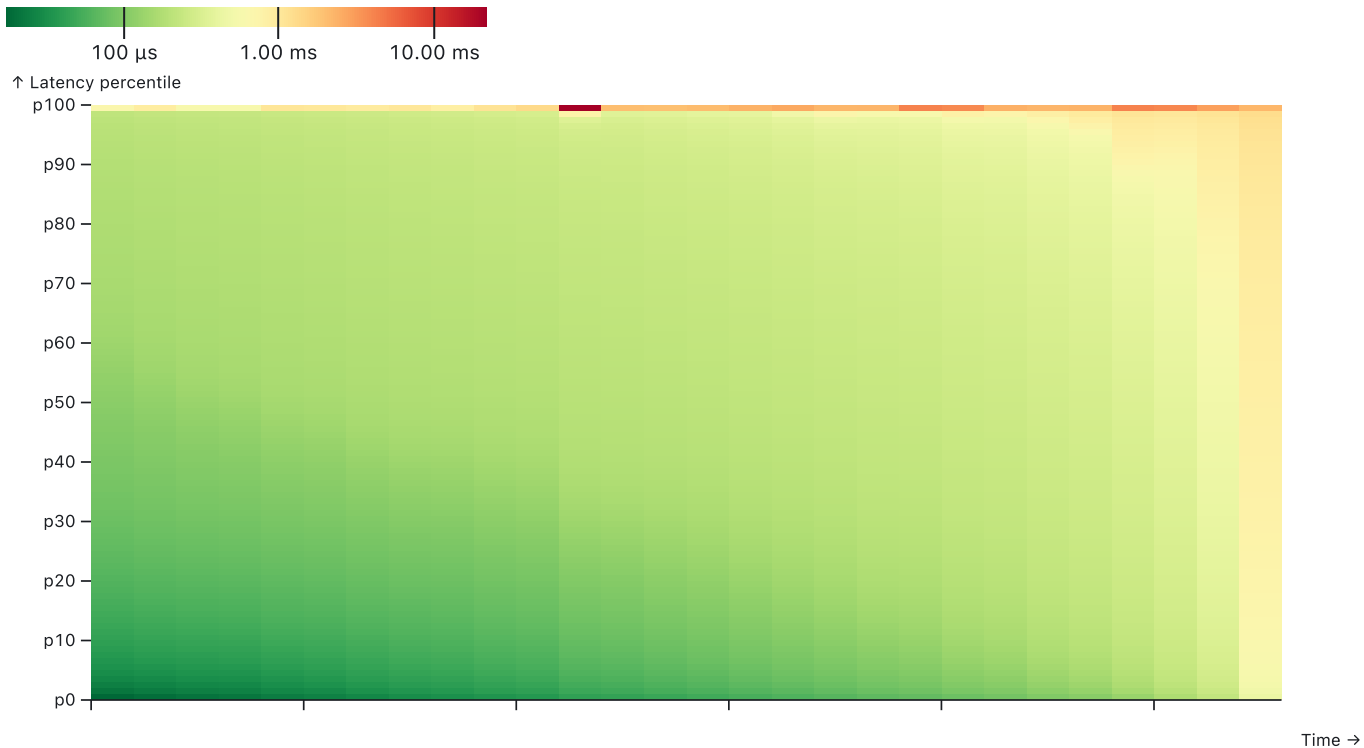
Histogram `[(quantile→"color", value→"Y")]`

p25
p50
p75
p90
p95
p99
p99.9
p99.99



☑ Gauge style

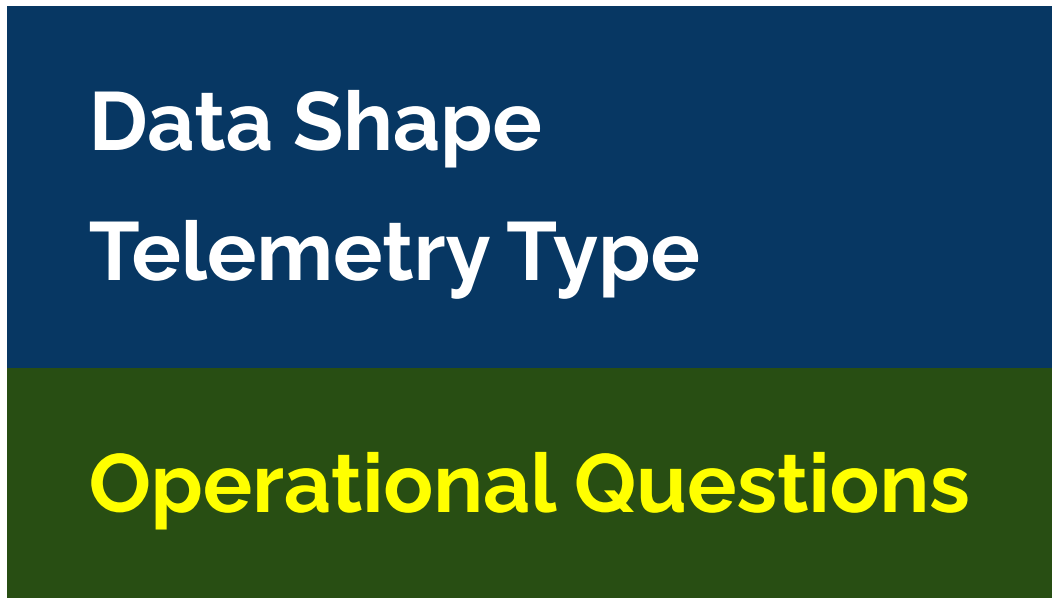
Histogram `[(quantile→“Y”, value→“color”)]`



The metric type offers strong hints on good visualization styles.

Make them the *default*.

Telemetry



Some Common Questions

"What happens to SLO if load goes up?"

"Has the new version regressed on throughput?"

"Which cloud SKU has the best ROI?"

Some Common Questions

*"What happens to SLO if **load** goes up?"*

*"Has the **new version** regressed on throughput?"*

*"Which **cloud SKU** has the best ROI?"*

TSDB Storage Implication On Read

Group values by time ✅

Group values by labels ✅

Group values by other values ❌

```
metric_name:
label0 = value0,
label1 = value1,
...
```

time	value
t0	v0
t1	v1
t2	v2
...	...

Some Common Questions

*"What happens to SLO if **load** goes up?"*

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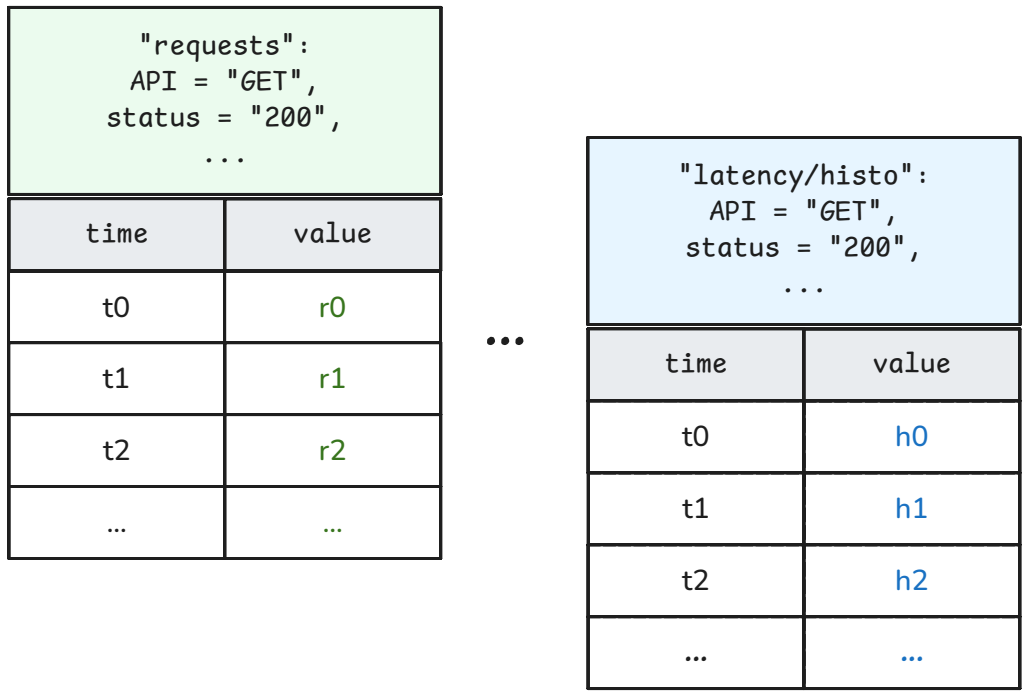
Latency by Load: Gather Metrics

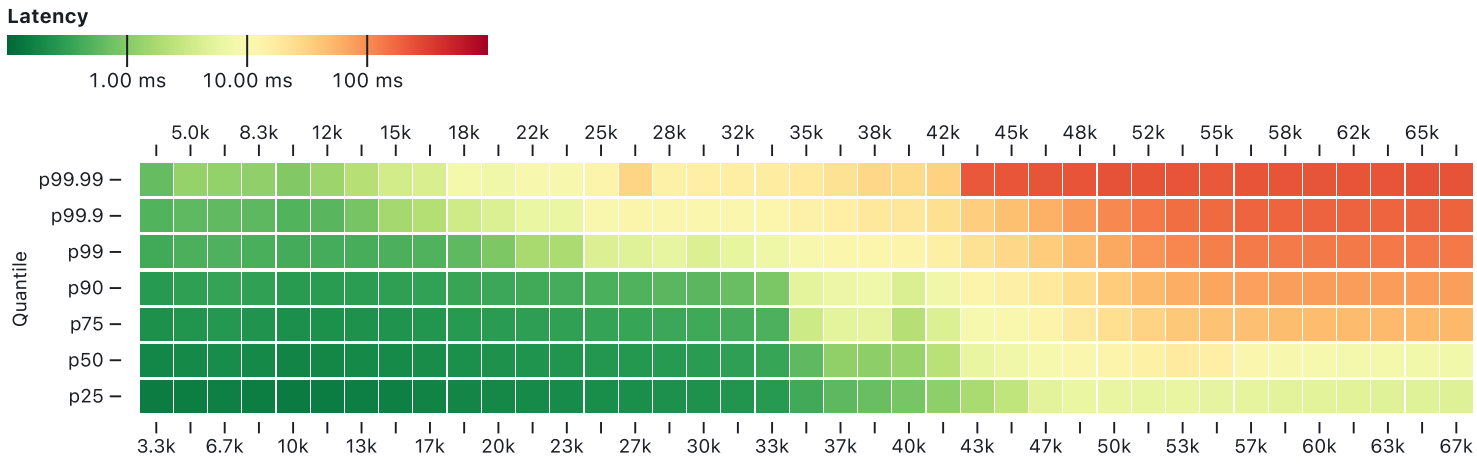


Latency by Load: Transform

time	"requests"	"latency"
t0	r0 ≈ a	h0
t1	r1 ≈ b	h1
t2	r2 ≈ c	h2
t3	r3 ≈ b	h3
t4	r4 ≈ a	h4
t5	r5 ≈ a	h5

"requests"	"latency"
≈ a	h0⊕h4⊕h5
≈ b	h1⊕h3
≈ c	h2

Load v.s. Latencies



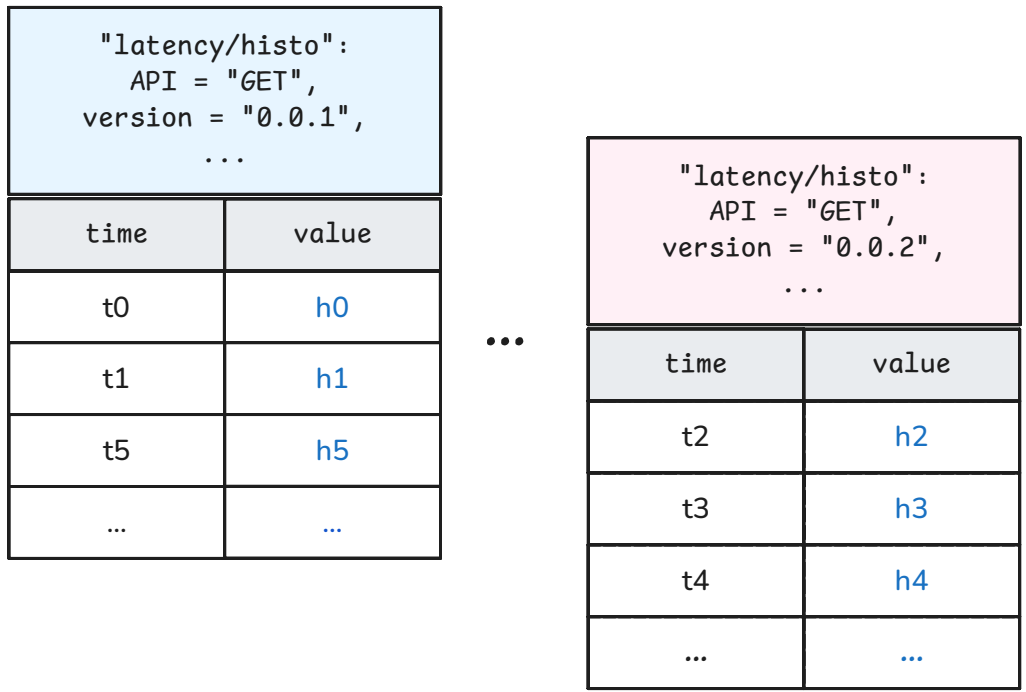
Some Common Questions

"What happens to SLO if load goes up?"

*"Has the **new version** regressed on throughput?"*

"Which cloud SKU has the best ROI?"

Regression: Metrics & Attribute

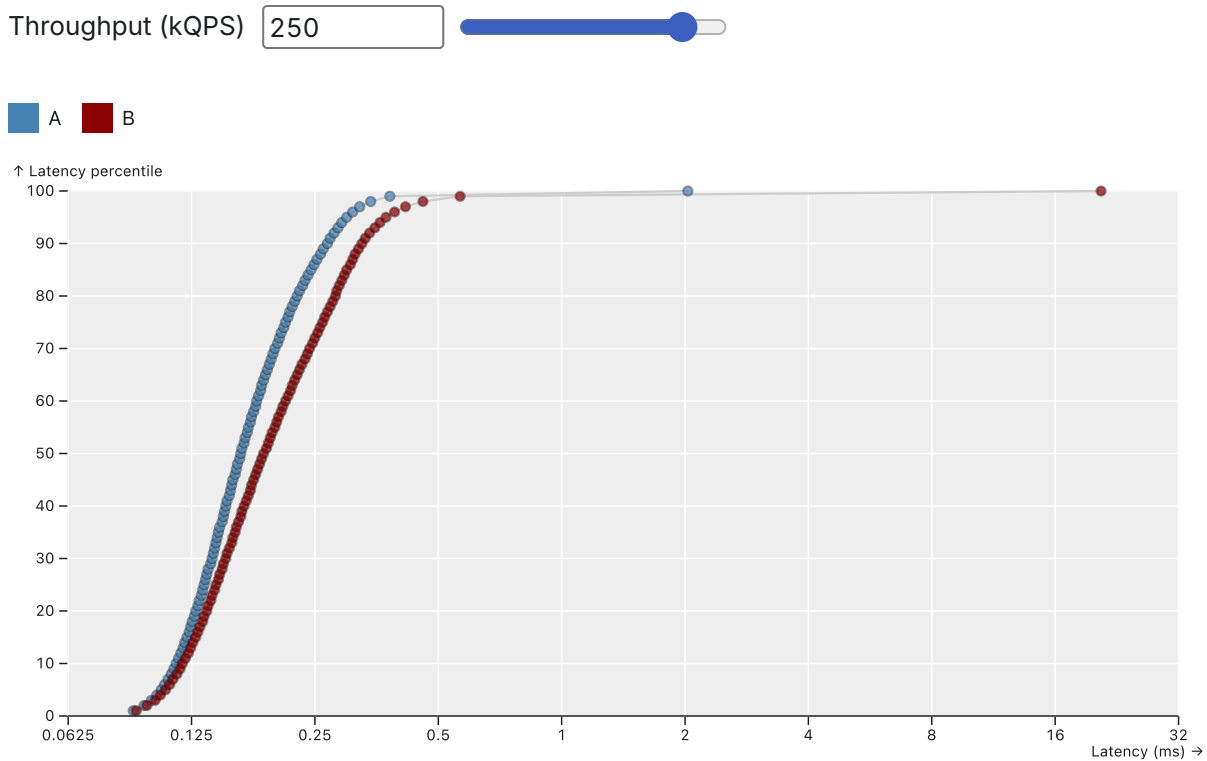


Regression: Transform

time	"version"	"latency"
t0	"0.0.1"	h0
t1	"0.0.1"	h1
t2	"0.0.2"	h2
t3	"0.0.2"	h3
t4	"0.0.2"	h4
t5	"0.0.1"	h5

"version"	"latency"
"0.0.1"	h0⊕h1⊕h5
"0.0.2"	h2⊕h3⊕h4

Regression A/B Analysis



Some Common Questions

"What happens to SLO if load goes up?"

"Has the new version regressed on throughput?"

*"Which **cloud SKU** has the best ROI?"*

SKU ROI: Gather Metrics & Prices

External Data

SKU	Instance Type	Hourly Price
g6e.xlarge	L40S GPU (NVIDIA Ada)	$0.6840
g5g.xlarge	ARM + T4G GPU	$0.1243
g5.xlarge	A10G GPU (NVIDIA Ampere)	$0.5213
c7i.xlarge	Intel (Gen 7)	$0.0823
c6i.xlarge	Intel (Gen 6)	$0.0876
c7a.xlarge	AMD (Gen 7)	$0.1066
c6a.xlarge	AMD (Gen 6)	$0.0572
c8g.xlarge	ARM Graviton4	$0.0731
c7g.xlarge	ARM Graviton3E	$0.0801
c6g.xlarge	ARM Graviton3	$0.0652

"tokens":
sku="c8g.xlarge"
...

time	value
t0	r0
t1	r1
t2	r2
...	...

...

"tokens":
sku="g5g.xlarge"
...

time	value
t0	r0
t1	r1
t2	r2
...	...

SKU ROI: Transform

time	"sku"	"tokens"
t0	"g5g.xlarge"	r0
t0	"g6e.xlarge"	r0
t0	"g5.xlarge"	r0
		r0
		r0
		r0

"sku"	"price"
"g5g.xlarge"	$0.1243
"g6e.xlarge"	$0.6840
"g5.xlarge"	$0.5213
"c8g.xlarge"	$0.0731
"c7a.xlarge"	$0.1066
"c7i.xlarge"	$0.0823

"tokens"	"sku"	"price"
r0	"g5g.xlarge"	$0.1243
r0	"g6e.xlarge"	$0.6840
r0	"g5.xlarge"	$0.5213
r0	"c8g.xlarge"	$0.0731
r0	"c7a.xlarge"	$0.1066
r0	"c7i.xlarge"	$0.0823

LLM Inference Cost per Token

Cost per 1M tokens ($)

	135M SmolLM	360M SmolLM	1B Llama 3.2	1.7B SmolLM	2B Gemma 2	3B Llama 3.2
g6e.xlarge	1.0	1.2	1.0	1.3	2.1	2.0
g5g.xlarge	0.4	0.5	0.7	0.8	1.5	1.5
c7i.xlarge	0.4	1.0	2.2	2.8	4.7	5.3
c6i.xlarge	0.4	0.8	1.8	2.5	4.2	4.4
c6a.xlarge	0.2	0.5	1.2	1.6	2.8	2.8
c7a.xlarge	0.2	0.4	1.0	1.2	2.3	2.3
c6g.xlarge	0.2	0.3	0.9	1.1	2.2	2.1
c8g.xlarge	0.1	0.2	0.7	0.8	1.7	1.6
c7g.xlarge	0.1	0.2	0.7	0.8	1.6	1.6
g5.xlarge	0.8	0.9	0.7	1.0	1.6	1.5

Telemetry As Panel Data

time	"throughput"	"p99"		"source"	"version"
t0	10	127		"hostA"	"0.0.1"
t1	6	88		"hostA"	"0.0.1"
t2	25	385		"hostA"	"0.0.1"
t3	14	101		"hostA"	"0.0.2"
t4	18	76	...	"hostA"	"0.0.2"
t5	3	92		"hostA"	"0.0.2"
t0	7	64		"hostB"	"0.0.1"
t1	19	123		"hostB"	"0.0.1"
t2	12	256		"hostB"	"0.0.1"

Does **Pandas** *ring a bell?*

Telemetry As Panel Data

time	"throughput"	"p99"	"source"	"version"
t0	10	127	"hostA"	"0.0.1"
t1	6	88	"hostA"	"0.0.1"
t2	25	385	"hostA"	"0.0.1"
t3	14	101	"hostA"	"0.0.2"
t4	18	76	"hostA"	"0.0.2"
t5	3	92	"hostA"	"0.0.2"
t0	7	64	"hostB"	"0.0.1"
t1	19	123	"hostB"	"0.0.1"
t2	12	256	"hostB"	"0.0.1"

…

Timeless questions deserve timeless schemas.

Call for Action

To Practitioners

Telemetry data have life beyond your TSDB!

1. Pay attention to data type, shape
2. Learn about viz “classics” and general statistics
3. Transform data to give direct answers

To Observability Providers

1. Better design defaults by telemetry type;
2. Enable basic statistical summary via UI;
3. Design for alternative data schema; and connect with broader analytical tools

Questions?

Meanwhile, enjoy

a viz gallery by

IOP Systems—