Operating Within Normal Parameters: Monitoring Kubernetes

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Outline

- A brief introduction to “observability”
- Service Level Objectives (SLOs), a measure of “normal”
- Collecting Kubernetes metrics: what’s available?
- **How-to:** A minimal FOSS monitoring stack for Kubernetes
- Debug some common problems using our metrics!

What is “observability?”

A fancy name to make monitoring more marketable?

Why are we even here?

To operate systems that
make users happy.

When **something goes wrong**

O*bservability* lets you answer
what, where, how, and ***why***

How do you agree on
something gone wrong?

Service Level Objectives, perhaps

Defining Service Level Objectives

- **Service Level Objectives (SLOs)** are a formal specification of what your team considers **normal** for a service
- SLOs cover areas (**availability**, **latency**, **capacity**, etc.) and specific targets for quality of service
- Areas and targets differ depending on circumstances
  - e.g. development vs. production

Defining Service Level Objectives

- Who are your users and how do they interact with your cluster?
  - Do you have an intermediary platform?
  - What are their performance expectations?
- What capacity and load are you expecting?
  - How many nodes per cluster and what size?
  - How many users? What is their average workload size?

Defining Service Level Objectives

- SLOs communicate your service expectations with users
- Some Kubernetes-specific examples:
  - **Availability:** Control plane has 99% monthly uptime
  - **Latency:** Valid Pods should start within 5s for p99
  - **Capacity:** Cluster accommodates 50 running Pods per user

Defining Service Level Objectives

- ▪ SLOs are flexible and context-dependent

✔ SLOs set customer expectations through a commitment to quality of service

✘ SLOs are not a measure of your team's ability to deliver 9's

Defining Service Level Objectives

- Can't commit to quality of service targets if you have no idea what your quality of service is
- Sample workloads provide data for performance tuning and iteration on SLOs
- Must include a monitoring stack *in every cluster* at launch
  - But how??

Case study: instrumenting Kubernetes

Collecting Kubernetes metrics

- What sources of metrics are available?
- How can metrics be analyzed, aggregated, and visualized?

What sources of metrics are available?

Timeseries	Value
`up{job="kube-apiserver",instance="api-1"}`	1

What sources of metrics are available?

Out-of-the-box metrics

- Most Kubernetes components export Prometheus metrics
  - etcd (`/metrics`)
  - API servers (`/metrics`)
  - Kubelets (`/api/v1/nodes/<node>/proxy/metrics`)
  - cadvisor (`/api/v1/nodes/<node>/proxy/metrics/cadvisor`)
  - Service endpoints (`/metrics` via cluster service discovery)

What sources of metrics are available?

Official Kubernetes metric exporters

- kubernetes/**kube-state-metrics** (stable)
  - Prometheus adapter for cluster state
- kubernetes-incubator/**metrics-server** (alpha)
  - Aggregates metrics from kubelets (**not** Prometheus format)
  - Provides programmatic access for autoscalers, `kubectl top`, etc.
- kubernetes-retired/**heapster** (deprecated)
  - Similar to metrics-server, used InfluxDB backend storage

What sources of metrics are available?

Even more metrics from Prometheus exporters!

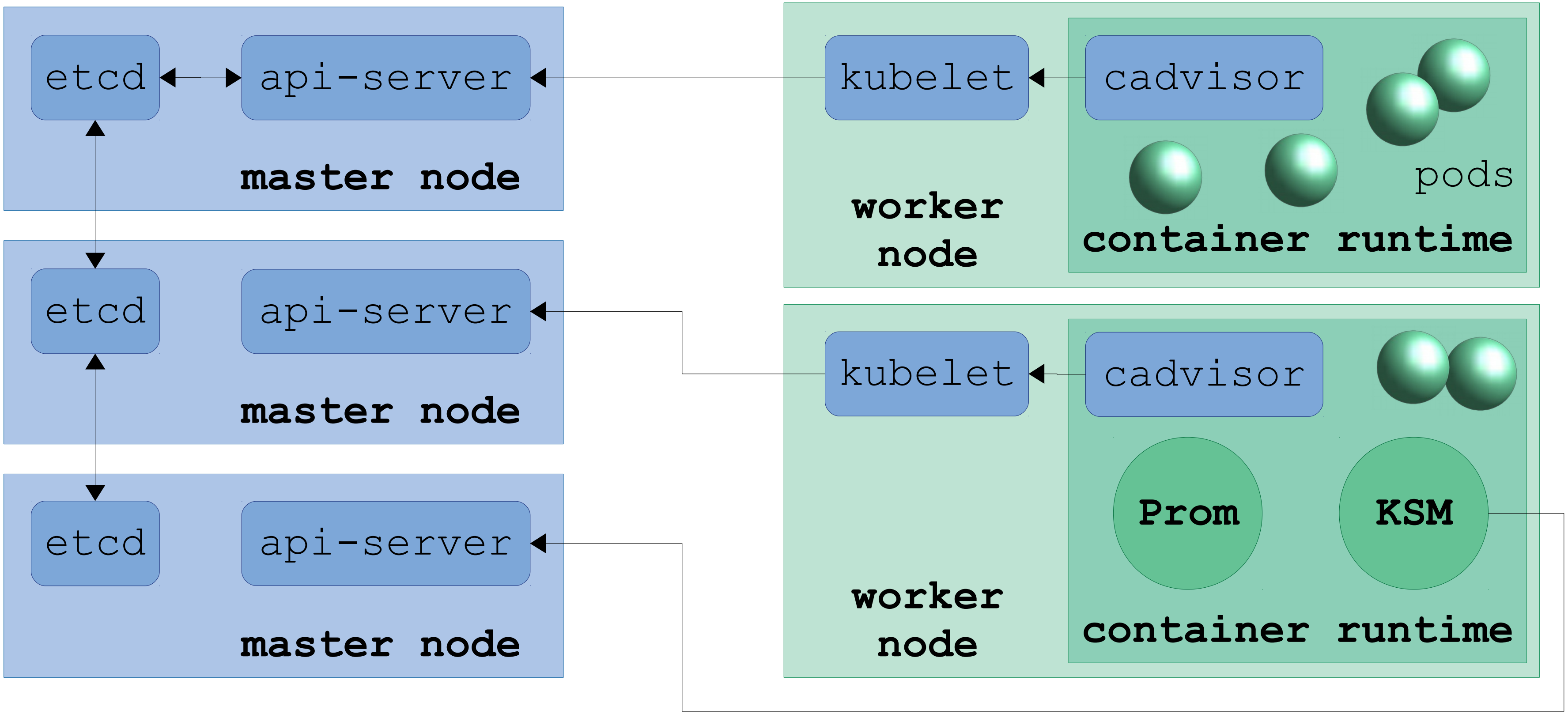
- prometheus/**node_exporter**
  - System metrics for your Kubernetes Nodes
- prometheus/**blackbox_exporter**
  - Probes arbitrary endpoints via HTTP, HTTPS, DNS, TCP, or ICMP
- Write your own
- Many other open source options

What types of metrics are available?

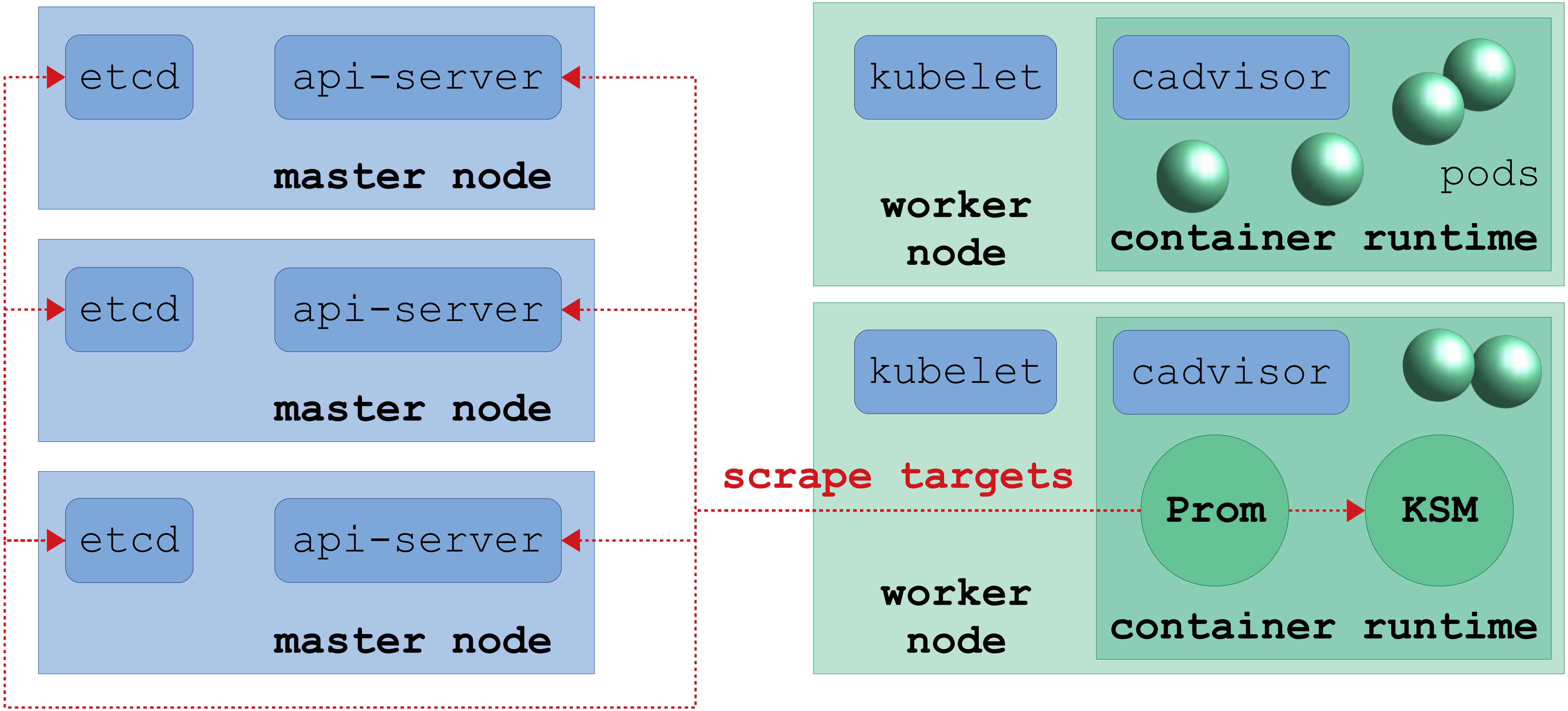
- Container CPU, memory, network utilization: **cadvisor**
- General Pod info: **kube-state-metrics**
- Node performance info: **node_exporter**
- General cluster info: **many sources**
- Control plane info: **etcd, API servers**
  - Sample metric queries → *see talk resources*

How-to: Let's deploy this!

A minimal monitoring stack for Kubernetes

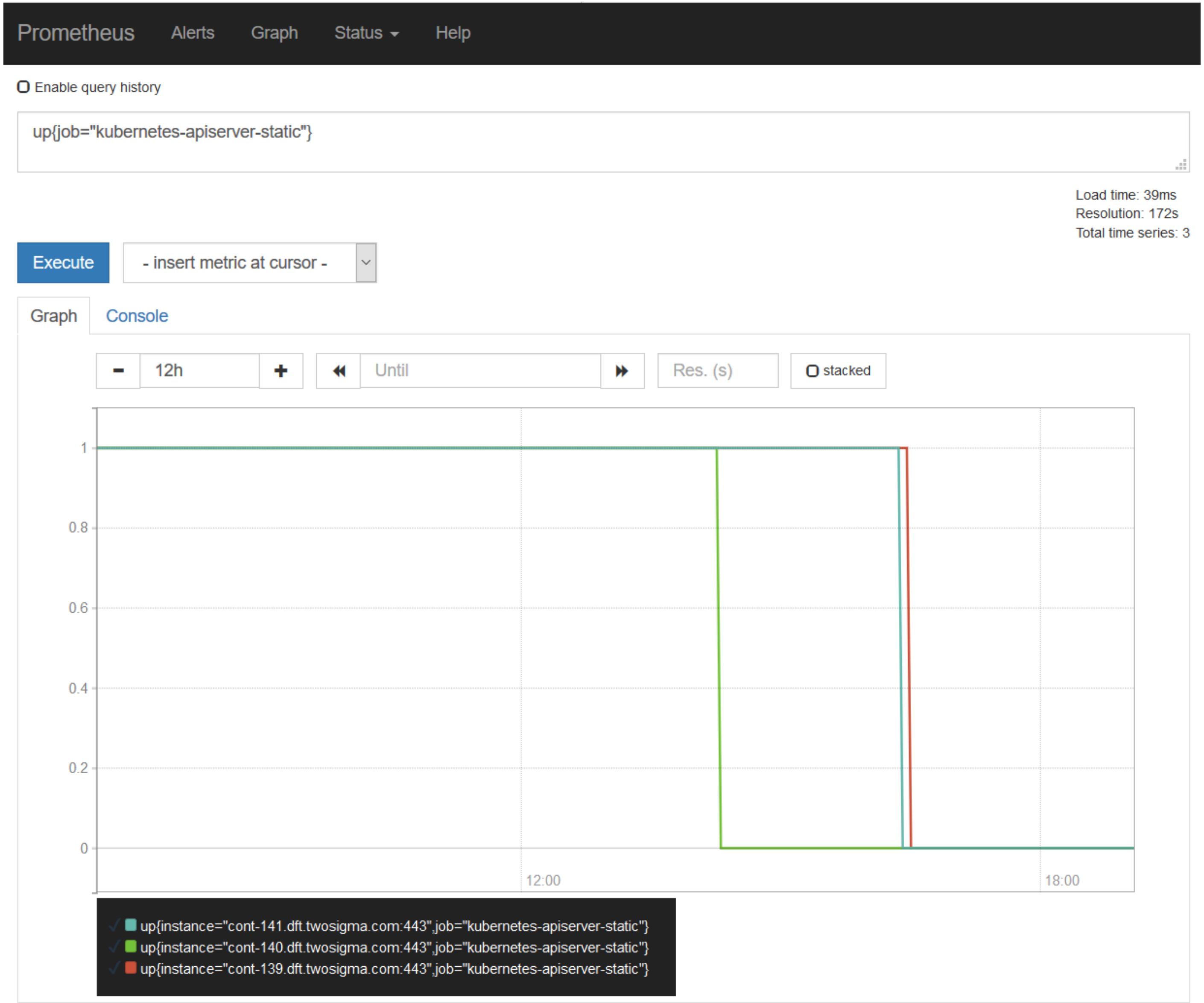


A minimal monitoring stack for Kubernetes



Run your monitoring stack on Kubernetes!

- Credentials for scraping are way easier to manage
  - Grant a ServiceAccount granular permissions!
  - ServiceAccount tokens get automatically rotated!
- Kubernetes abstractions and architecture are powerful
  - Built-in service discovery for scraping!
  - Kubernetes Deployments keep your Pods alive!
  - Data plane is resilient to control plane failures!



```
up{job="kubernetes-apiserver-static"}
```

Load time: 39ms
Resolution: 172s
Total time series: 3

✓ 🟦 up{instance="cont-141.dft.twosigma.com:443",job="kubernetes-apiserver-static"}
✓ 🟩 up{instance="cont-140.dft.twosigma.com:443",job="kubernetes-apiserver-static"}
✓ 🟥 up{instance="cont-139.dft.twosigma.com:443",job="kubernetes-apiserver-static"}

Let’s not worry about high availability!

- High availability is not as simple as “run two replicas”
  - Two Prometheus replicas doubles (high) scrape load
  - Prometheus replicas are stateful, with subtly different state
- kube-state-metrics is stateless, so why not?
  - Prometheus counters monotonically increase but differ between replicas
  - You could scrape all of them simultaneously and deduplicate client-side?
- >:(

It’s okay for Prometheus to not be a panacea

- Set up backup monitoring jobs
  - Run them off-cluster
  - Kubernetes’ scheduling gives us 99% uptime for ~free
  - Alert when Prometheus or KSM has extended downtime
- This architecture avoids data integrity issues and deployment complexity, for way less work

Metric analysis, aggregation, visualization

- **Prometheus** query language (PromQL) powers metric analysis and aggregation; Prometheus UI for visualizations
- **Grafana** accepts Prometheus data sources for dashboards
- Can perform arbitrary processing on metrics in **JSON format**
  - *Prometheus format JSON:* use Prometheus query API
  - *Metrics API format JSON or gRPC:* use Metrics Server API

How can we use this data for debugging?

Service Degradation: Node is down

- **Obvious:** Prometheus scrape job is down

```
up{job="kube-nodes"} != 1
```

- **Less obvious:** Grey failure indicated by unusually slow scrape time

```
scrape_duration_seconds{job="kube-nodes"} > 2
```

Service Degradation: Customer can’t launch Pods

- **Obvious:** Customer has hit their quota limit

```
sum(kube_resourcequota{namespace="foo",resource="cpu",type="used"})
 /  kube_resourcequota{namespace="foo",resource="cpu",type="hard"}
 > 0.95
```

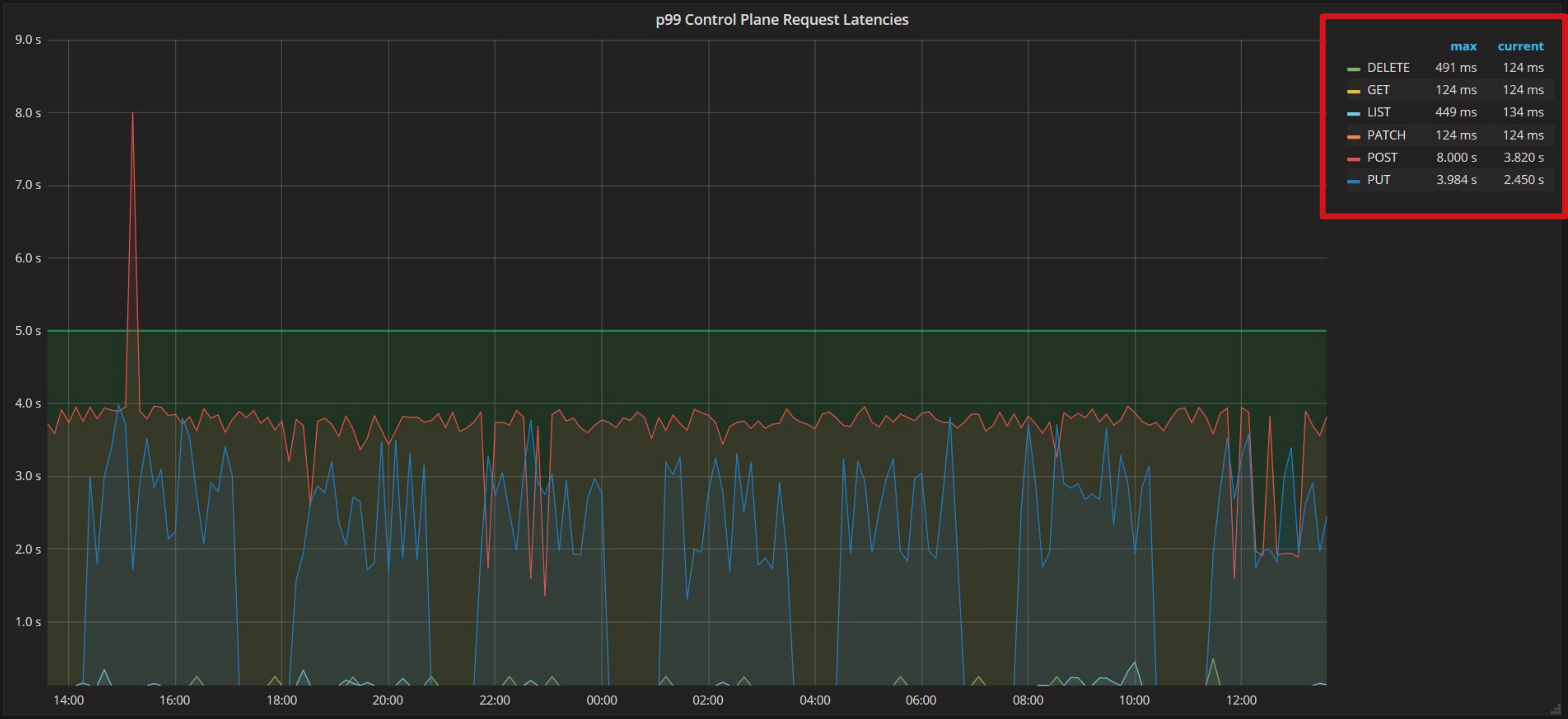
- **Less obvious:** Customer has overprovisioned their workloads

```
sum(container_cpu_usage_seconds_total:rate1m{namespace="foo"})
 /  kube_resourcequota{namespace="foo",resource="cpu",type="hard"}
 < 0.35
```

Service Degradation: API Server is slow

- **Obvious:** API server calls are slow

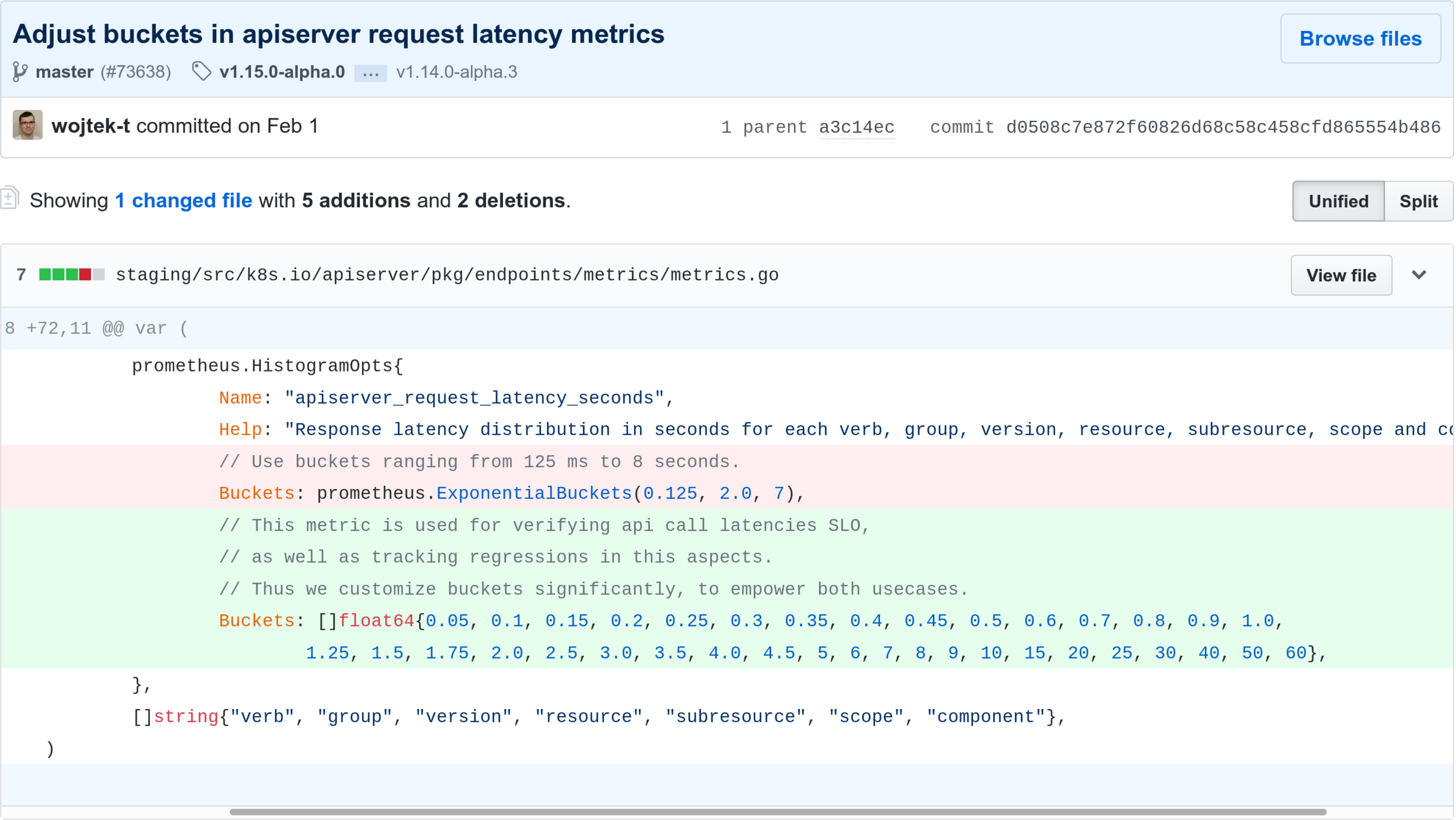
```
histogram_quantile(
  0.99,
  sum(rate(apiserver_request_latencies_bucket[1m]))
    by (le, verb)
)
```



	max	current
🟩 DELETE	491 ms	124 ms
🟨 GET	124 ms	124 ms
🟦 LIST	449 ms	134 ms
🟧 PATCH	124 ms	124 ms
🟥 POST	8.000 s	3.820 s
🟦 PUT	3.984 s	2.450 s

Service Degradation: API Server is slow

- **Less obvious:** API server metrics cap out between 125ms–8s because of default bucketing???



Adjust buckets in apiserver request latency metrics

master (#73638) v1.15.0-alpha.0 ... v1.14.0-alpha.3

wojtek-t committed on Feb 1

1 parent a3c14ec commit d0508c7e872f60826d68c58c458cfd865554b486

Showing **1 changed file** with **5 additions** and **2 deletions**.

7 🟩🟩🟩🟥⬜ staging/src/k8s.io/apiserver/pkg/endpoints/metrics/metrics.go

```
8 +72,11 @@ var (
		prometheus.HistogramOpts{
			Name: "apiserver_request_latency_seconds",
			Help: "Response latency distribution in seconds for each verb, group, version, resource, subresource, scope and co
			// Use buckets ranging from 125 ms to 8 seconds.
			Buckets: prometheus.ExponentialBuckets(0.125, 2.0, 7),
			// This metric is used for verifying api call latencies SLO,
			// as well as tracking regressions in this aspects.
			// Thus we customize buckets significantly, to empower both usecases.
			Buckets: []float64{0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0,
				1.25, 1.5, 1.75, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 40, 50, 60},
		},
		[]string{"verb", "group", "version", "resource", "subresource", "scope", "component"},
	)
```

Recap

- We learned how to select Service Level Objectives
- We explored FOSS monitoring solutions for Kubernetes
- We built a minimal monitoring stack
- We used it to debug some production issues
- **Try it for yourself:** check out the sample code on GitHub

Questions?

Thanks to:

Two Sigma Investments, LP
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Talk resources: https://hashman.ca/srecon-2019