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Weighing a Cloud:

Measuring Your Kubernetes Clusters

Han Kang, Google & Elana Hashman, Red Hat

Who are we?

Google Cloud

Han Kang

Senior Software Engineer

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Red Hat

Elana Hashman

Principal Site Reliability Engineer

- Tech Lead on Azure Red Hat OpenShift Team
- SIG Instrumentation Member
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- GitHub: **@ehashman**

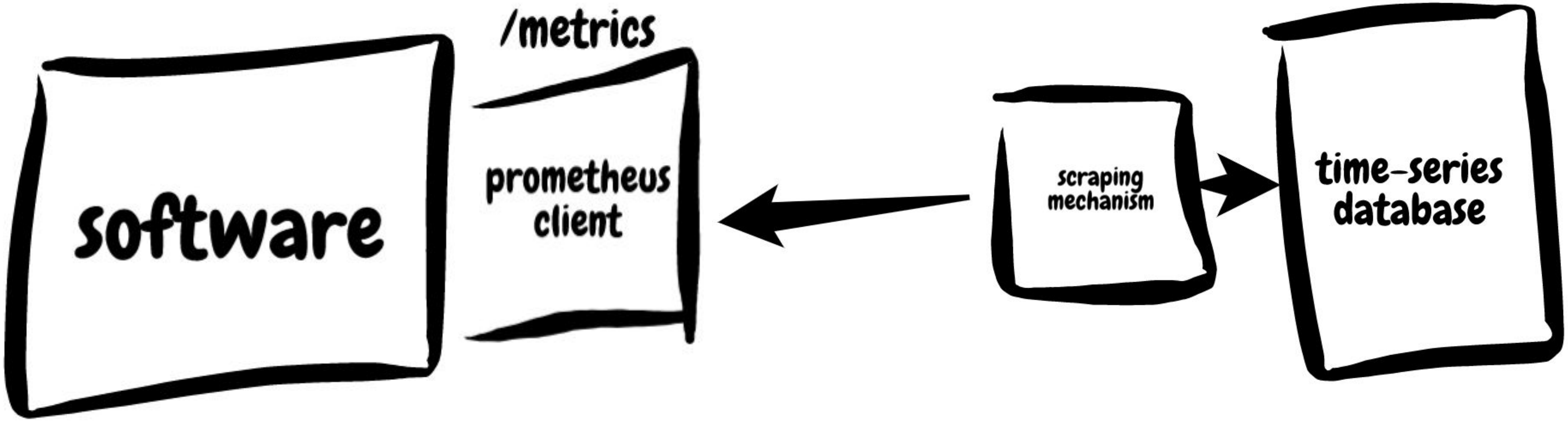
What we are going to cover

- How instrumentation works in Kubernetes
- Kubernetes control plane instrumentation
- Real-world debugging!
- Metric usability and SIG Instrumentation roadmap

How Kubernetes Instrumentation Works

Prometheus

Kubernetes components integrate with Prometheus, a time-series based monitoring and alerting toolkit.



Prometheus Data Model

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

Types of metric values:

- Counters
- Gauges
- Summaries
- Histograms

Dimensions of Measurement

1. Availability
   - `up{job="kubernetes-apiservers"}`
2. Latency
   - `apiserver_request_latency_seconds`
3. Capacity
   - `apiserver_request_total`
4. Errors
   - `apiserver_dropped_requests_total`

Using Prometheus Metrics

Prometheus query language (PromQL) powers metrics analysis and aggregation

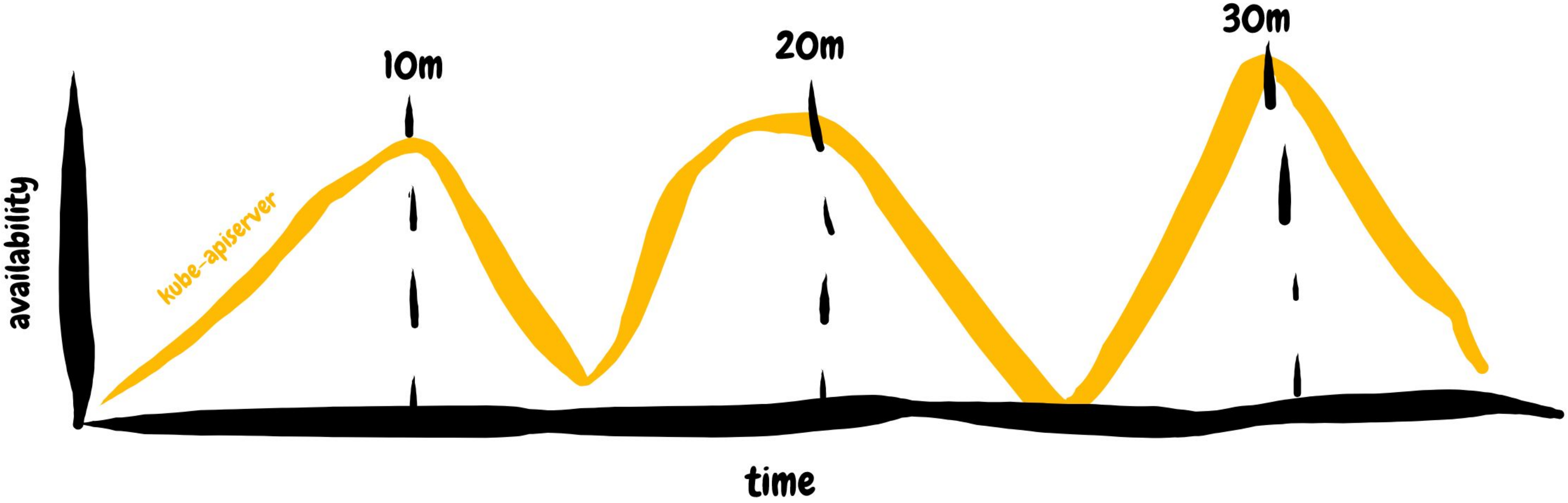
- **For prototyping and exploration:** use the Prometheus UI
- **For permanent dashboards:** attach a Prometheus data source to Grafana
- **For alerting:** set up the Prometheus Alert Manager
- **For arbitrary queries and processing:** query the Prometheus API

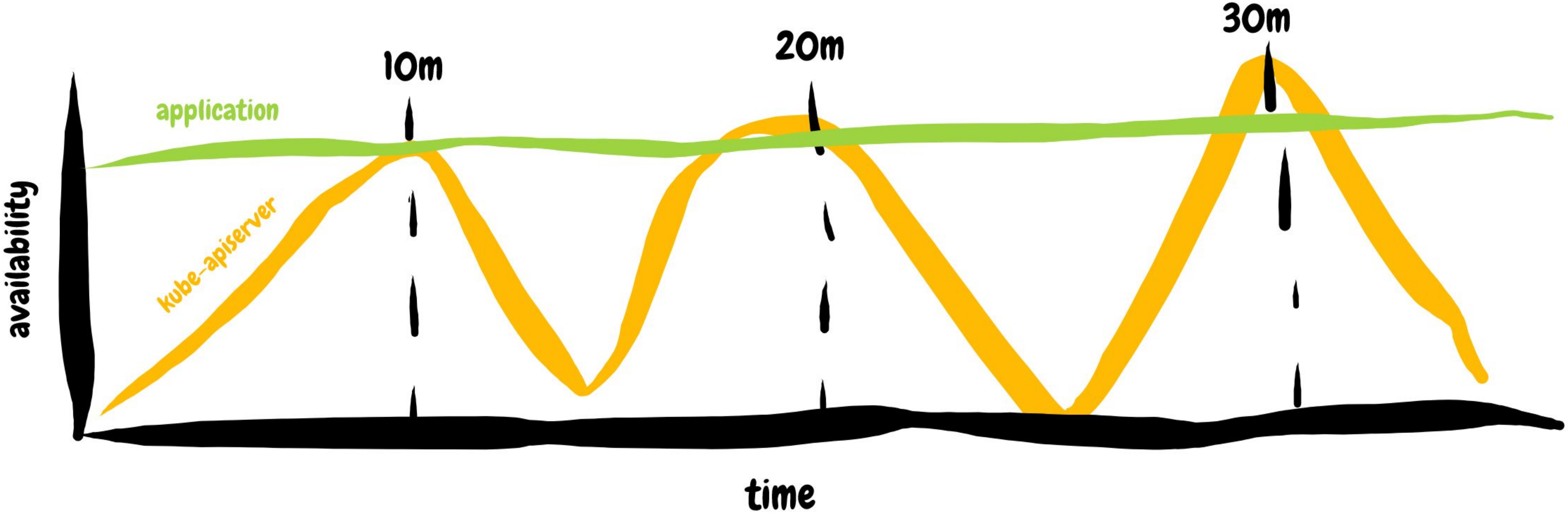
Differential Diagnoses

- Lots of very different issues might manifest the same way
    - e.g. “a node is offline” -- but why?
- A single symptom is not sufficient to form a diagnosis
- Metrics can show **how** something is failing, but not **why**
- We must track down root causes with multiple data sources

Full-Stack Debugging

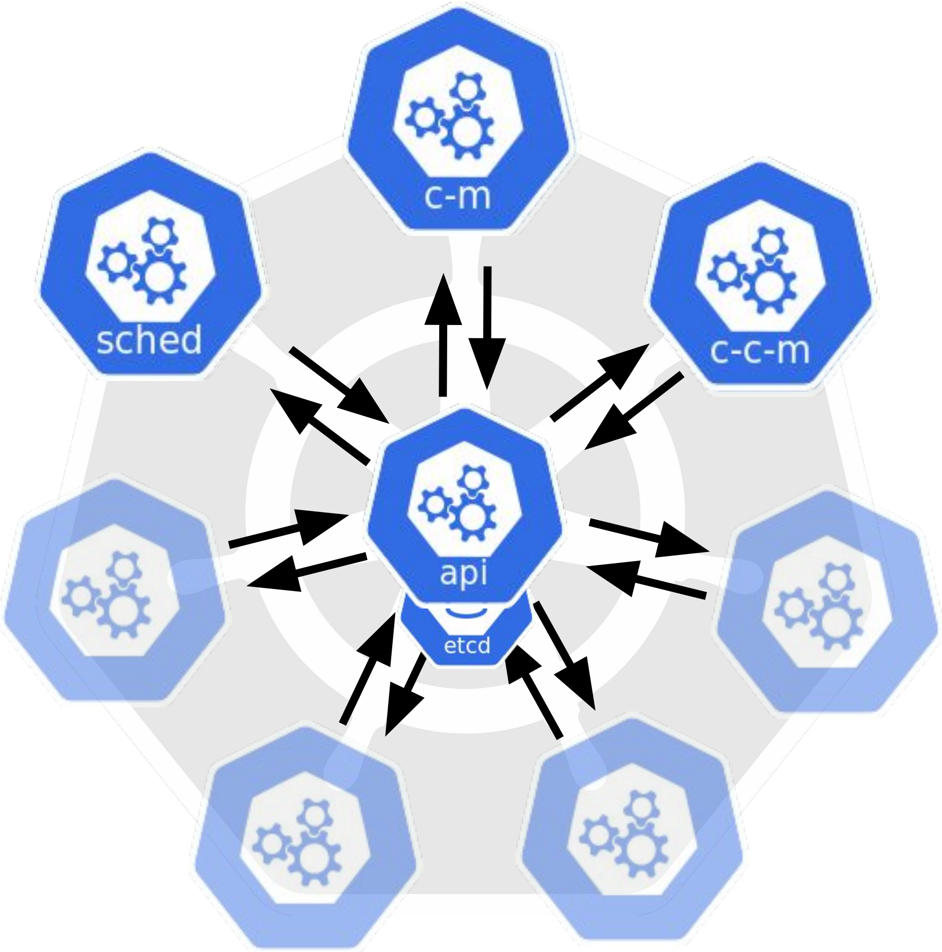
- Metrics can guide you to what you should look at next
- Not just metrics!
  - log files
  - audit logs
  - events
  - etcd (cluster database) dumps
- Metrics are most effective when you understand the context in which they were produced.


10m
20m
30m
kube-apiserver
availability
time

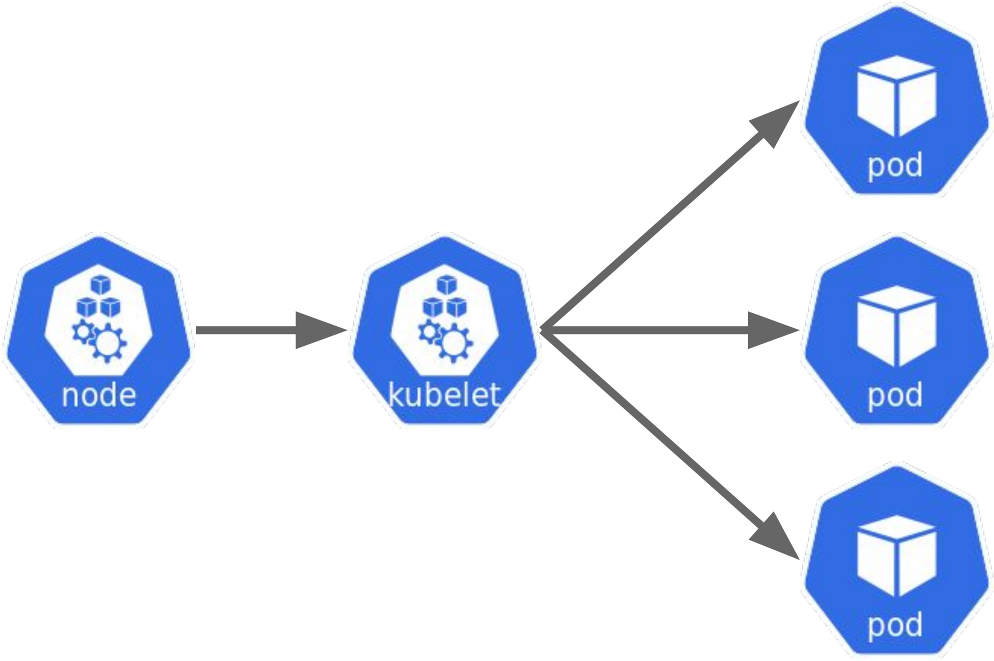

10m
20m
30m
application
kube-apiserver
availability
time

Kubernetes Control Plane Instrumentation

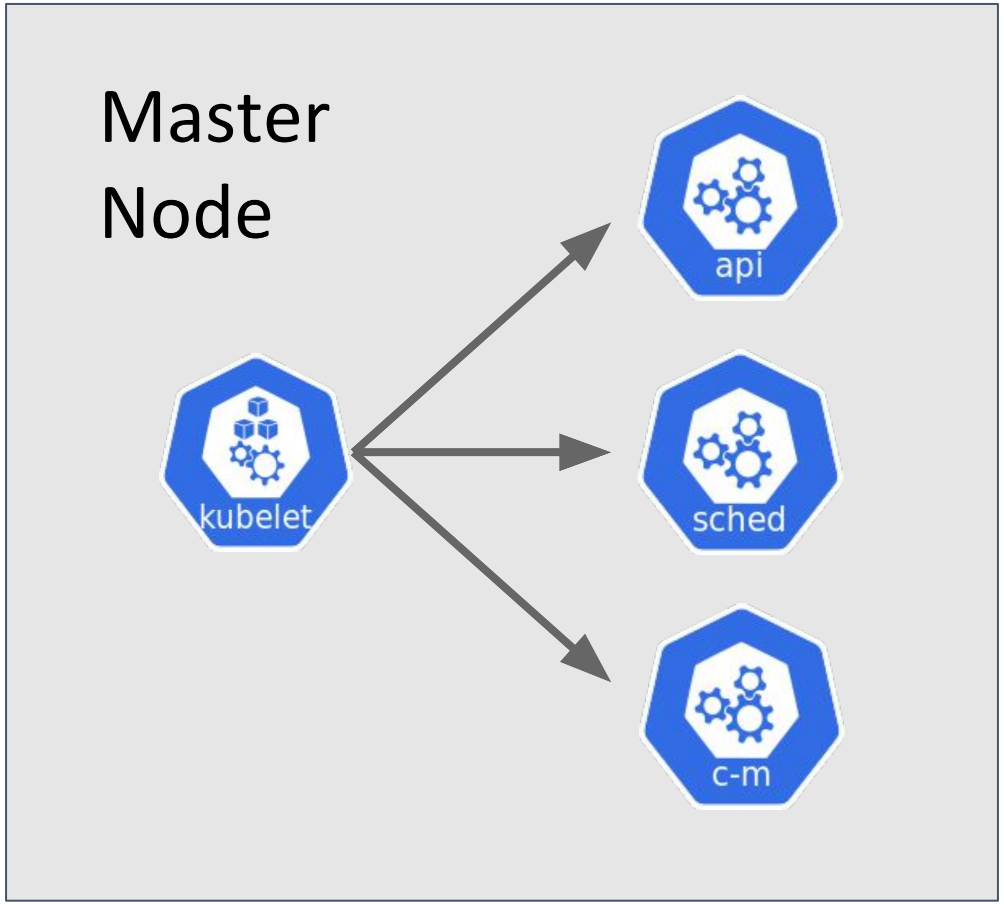
Control Plane



Kubelet



Master Kubelet

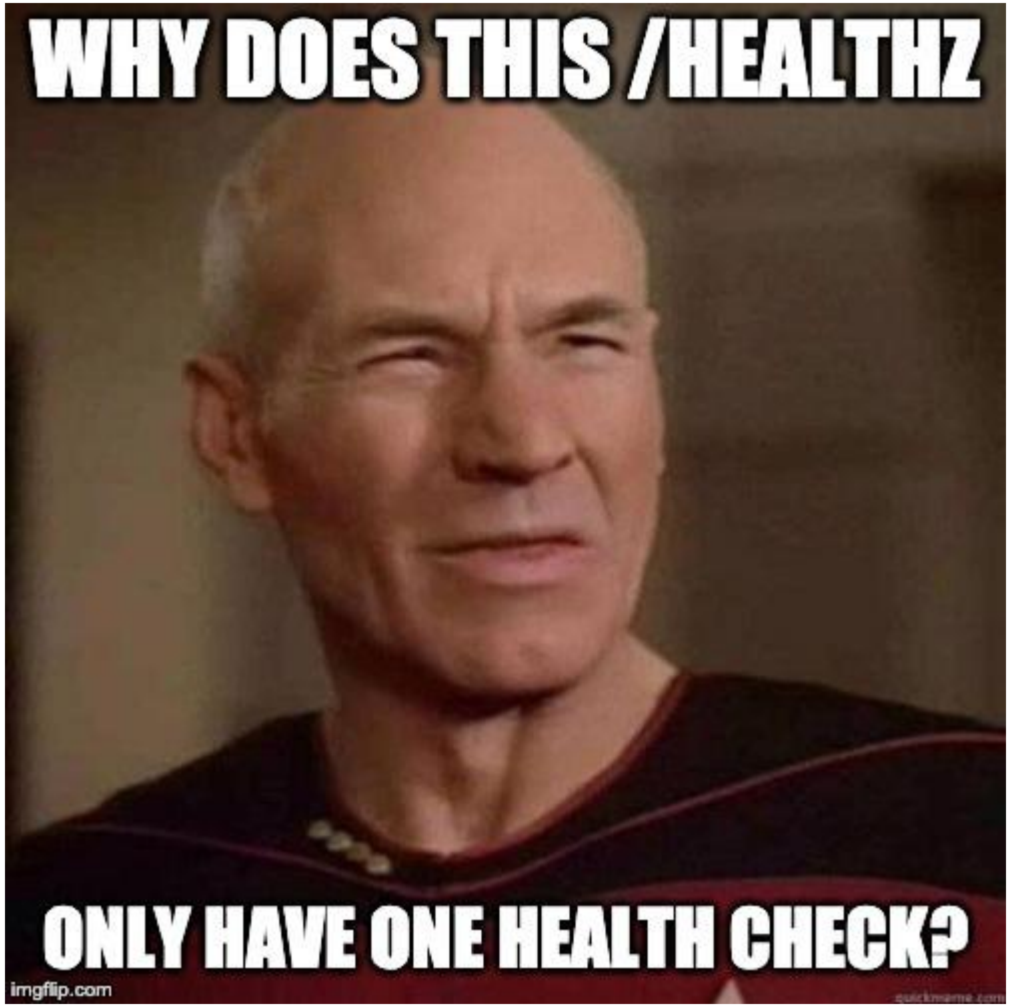


Introspecting Components

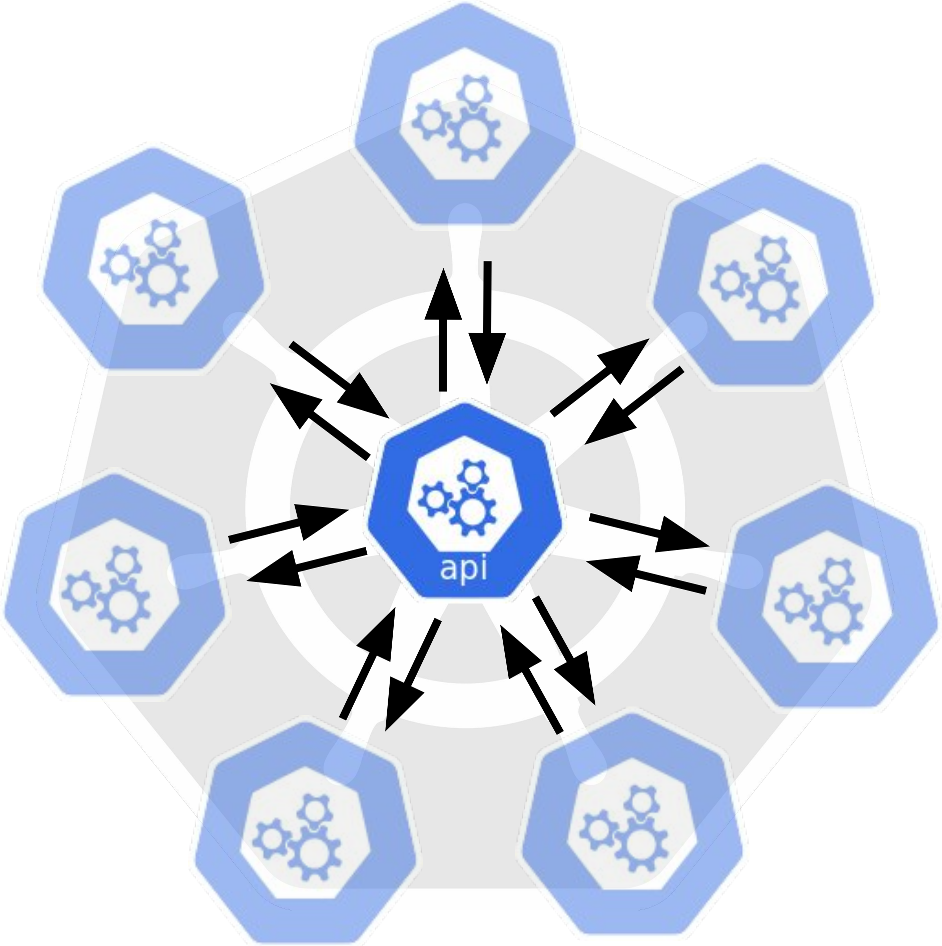
1. health check endpoint(s)
2. metrics
3. logs

Introspecting Components

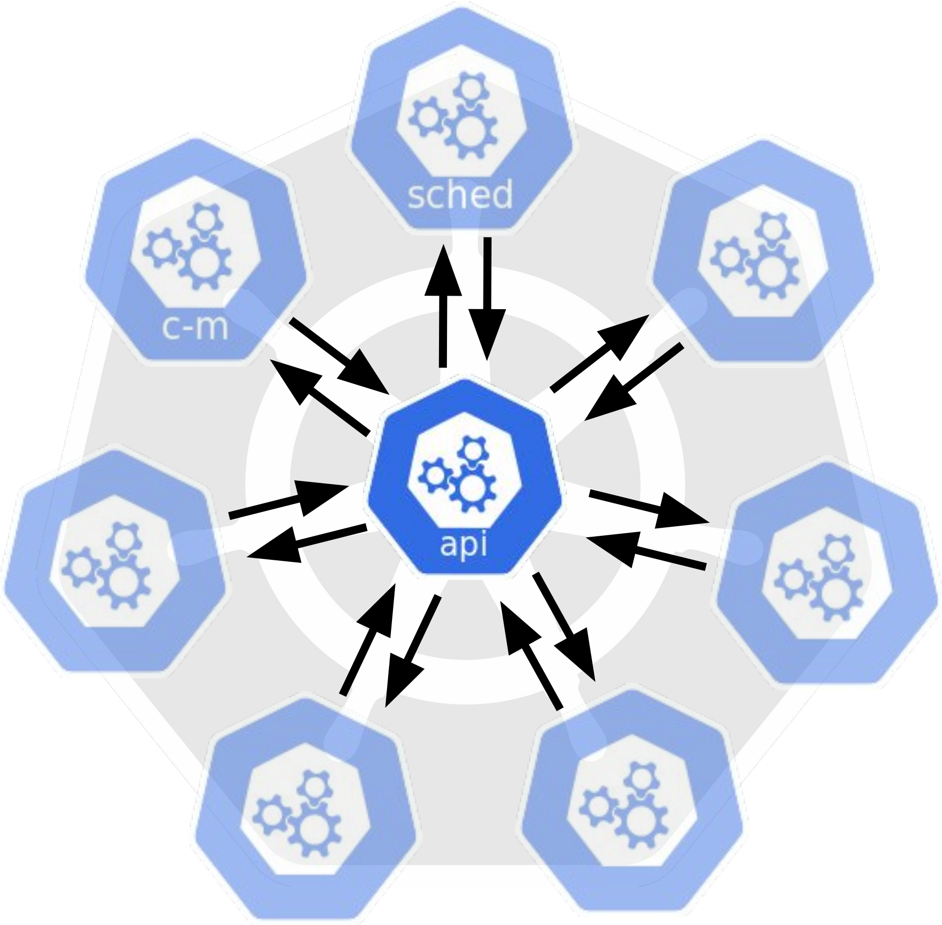
```
$ curl localhost:10251/healthz?verbose
[+]leaderElection ok
healthz check passed
```



KAS (Kube-apiserver)



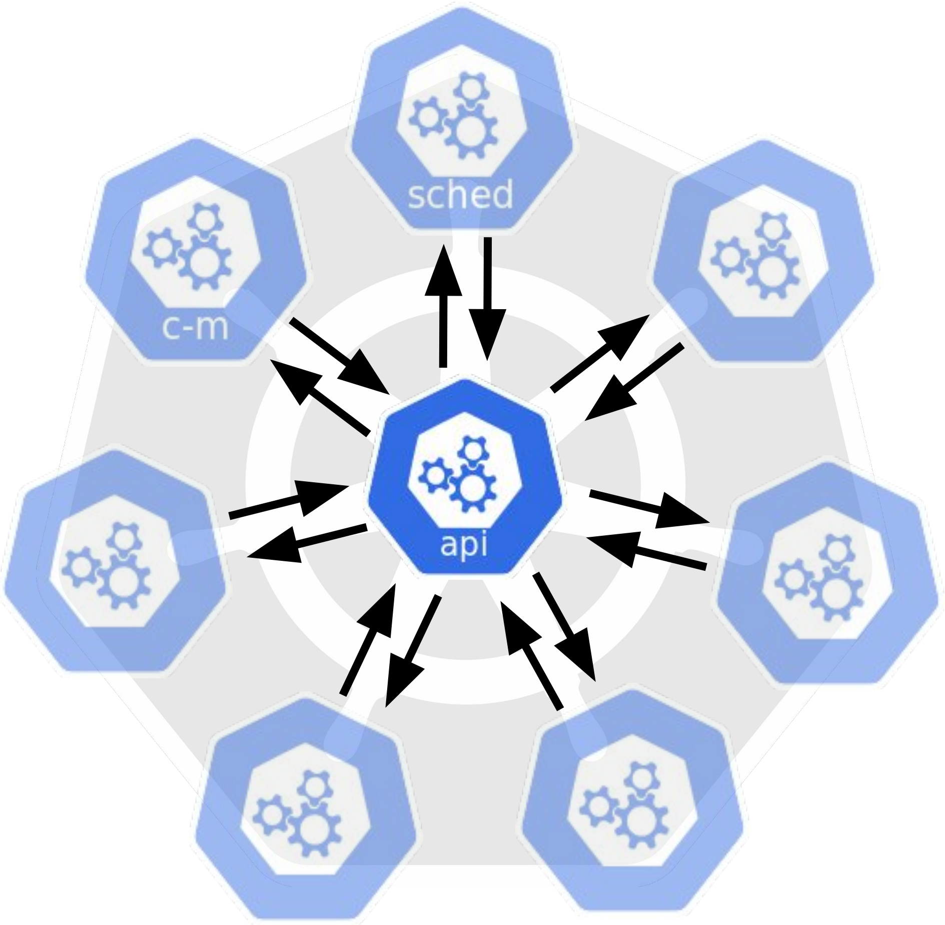
Kube-apiserver



- kubectl <command> -v=9

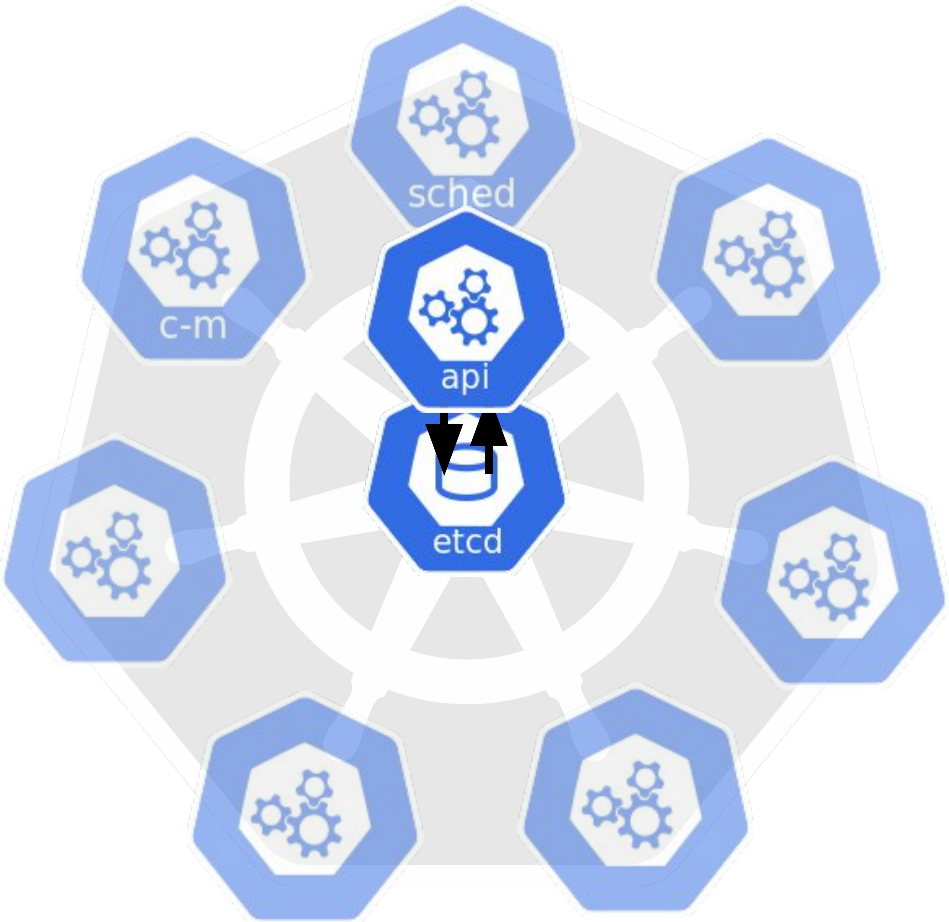
```
...
round_trippers.go:386] curl <some
headers>
'https://masterip/api/v1/components
tatuses?limit=500'
```

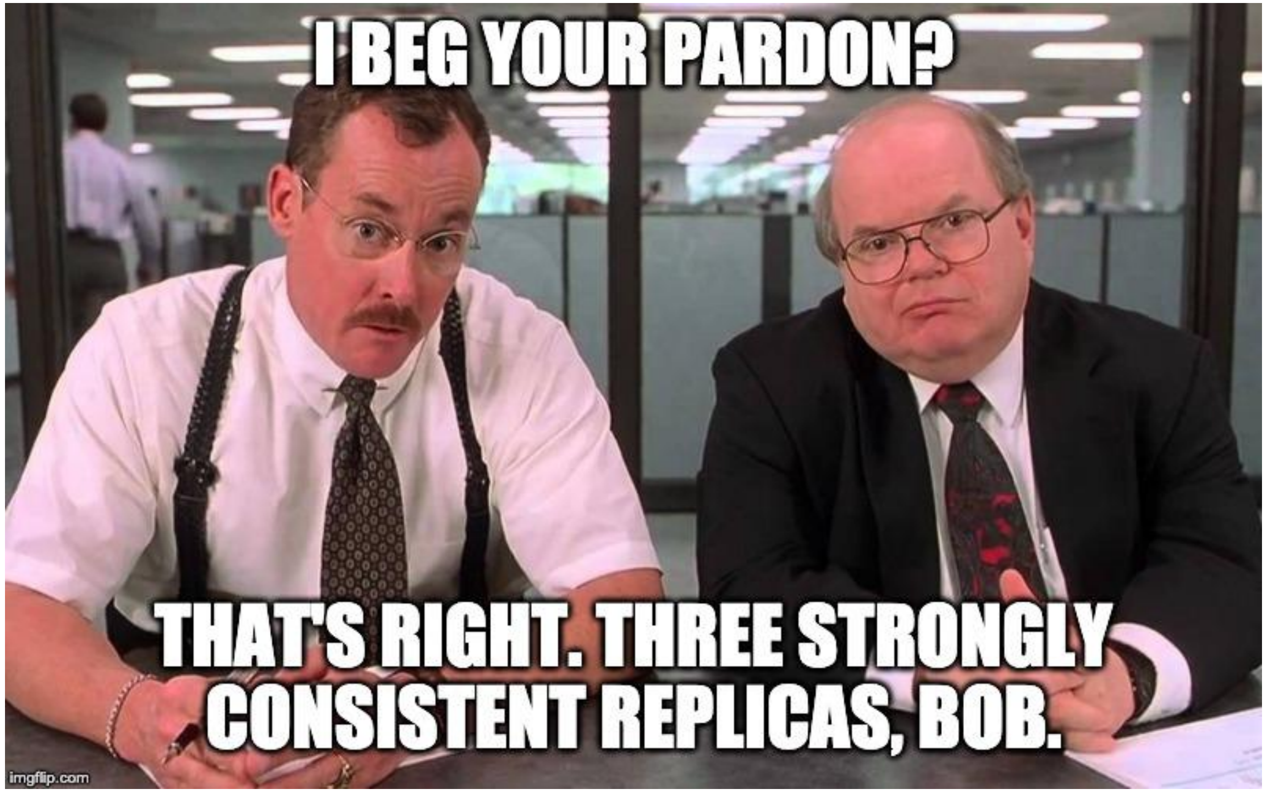
Kube-apiserver



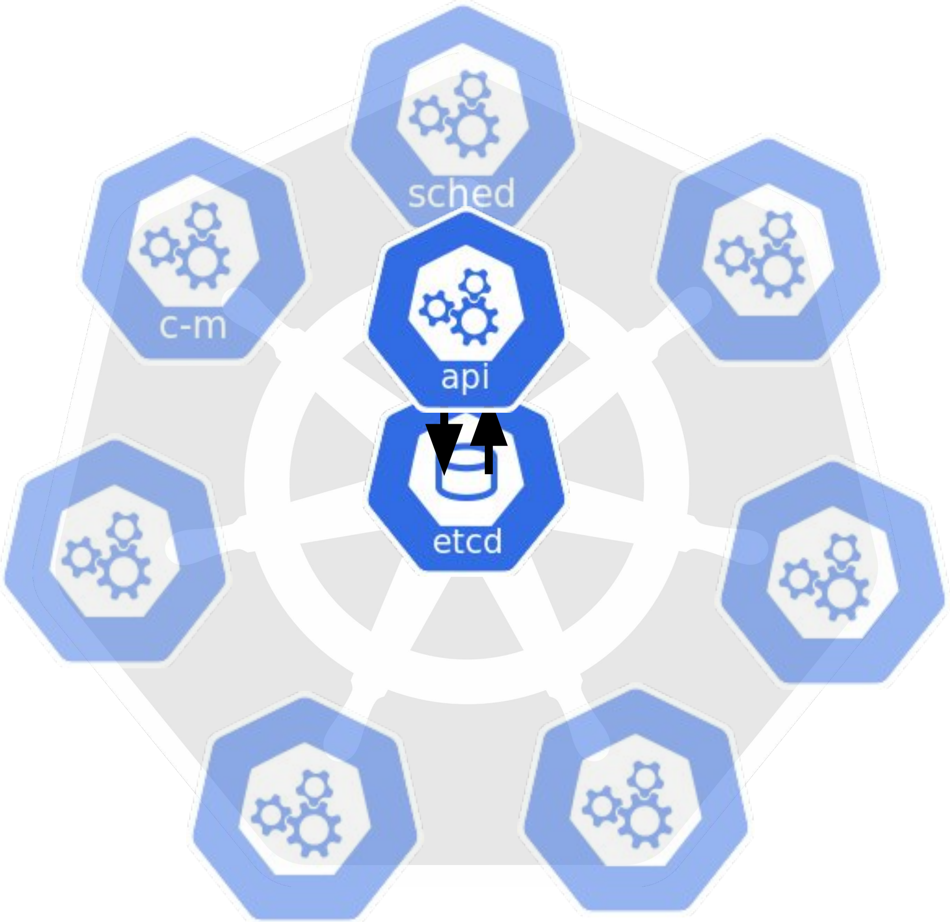
- `kubectl <command> -v=9`
- `kube-apiserver.log`
- `/metrics`
- health endpoints
  - `localhost:8080/healthz?verbose`
  - `localhost:8080/livez (v1.16+)`
  - `localhost:8080/readyz (v1.16+)`
- `audit-logs`

Etcd


sched
c-m
api
etcd


I BEG YOUR PARDON?
THAT'S RIGHT. THREE STRONGLY CONSISTENT REPLICAS, BOB.
imgflip.com

Etcd



- etcdctl
- auger
- /metrics
- /health
- etcd.log

Real-world Debugging

Kubelet Example

Problem:
Node is down

Kubelet Example

- 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
```

Kube-apiserver Example

Problem:
Crash-looping kube-apiserver

Kube-apiserver Example

Detection Strategies:

1. Directly monitor kube-apiserver health endpoints
2. Alerting based off master kubelets ‘metrics/probes’

Kube-apiserver Example

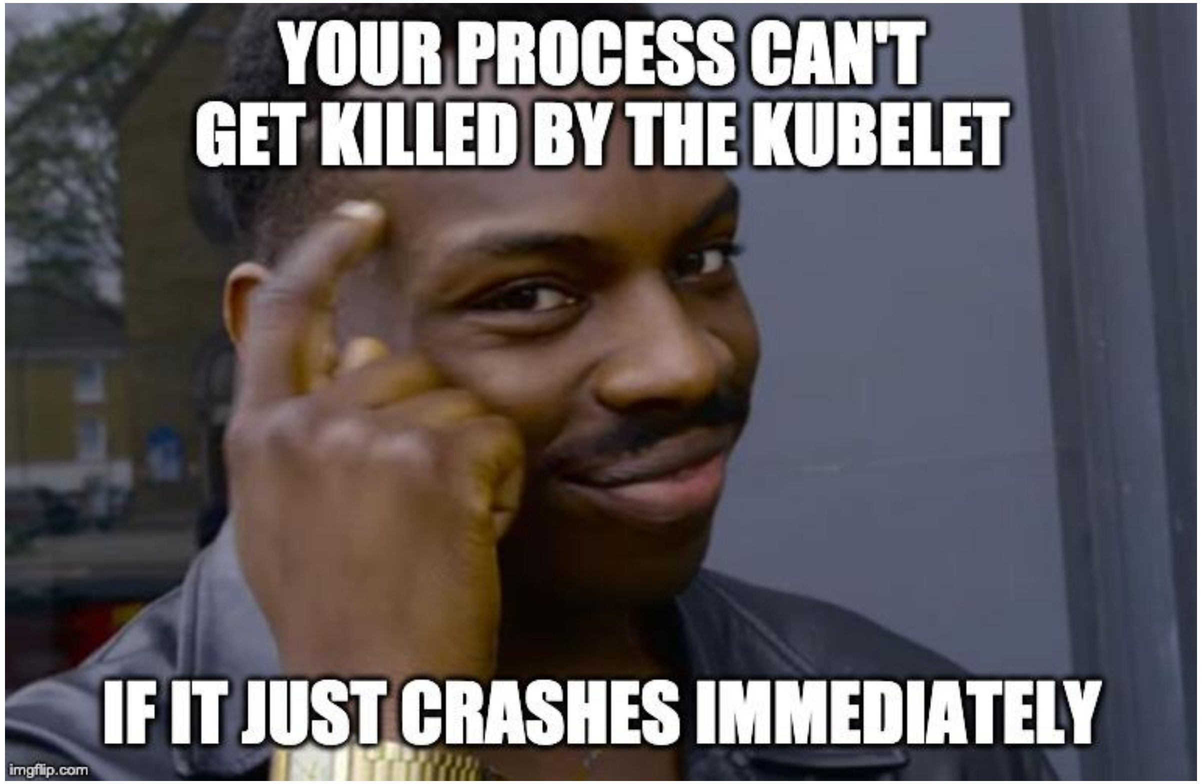
```
# output of kubelet’s metrics/probes

# HELP prober_probe_total Cumulative number of a liveness or readiness probe for a container by result.
# TYPE prober_probe_total counter
prober_probe_total{container="kube-apiserver",probe_type="Liveness",result="failed"} 10
prober_probe_total{container="kube-apiserver",probe_type="Liveness",result="successful"} 26457
prober_probe_total{container="kube-apiserver",probe_type="Readiness",result="failed"} 16
prober_probe_total{container="kube-apiserver",probe_type="Readiness",result="successful"} 26458
```

Kube-apiserver Example

Possible reasons:

a. kubelet in repair mode
b. kubelet initiated crashloops

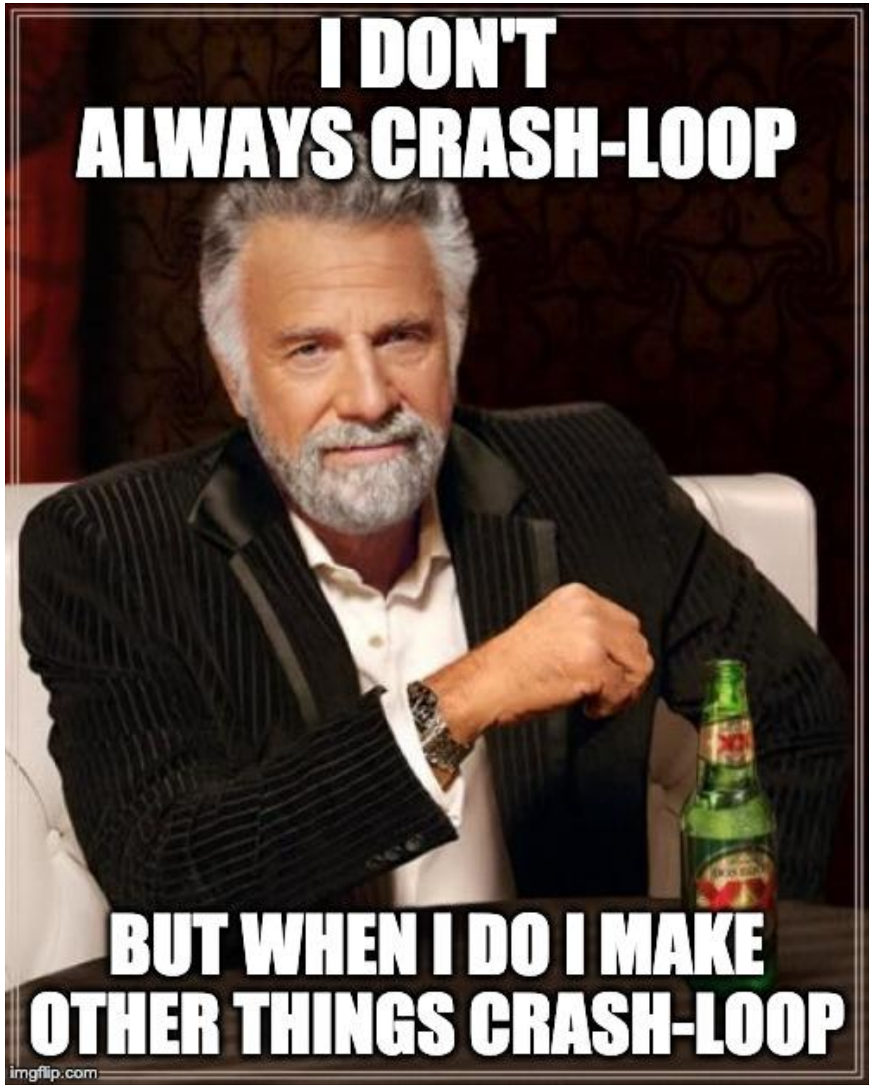

YOUR PROCESS CAN'T GET KILLED BY THE KUBELET
IF IT JUST CRASHES IMMEDIATELY
imgflip.com

Kube-apiserver Example

kube-apiserver /healthz

```
$ curl localhost:8080/healthz?verbose

[+]ping ok
[+]log ok
[-]etcd failed: reason withheld
..... ok
[+]autoregister-completion ok
healthz check failed
```



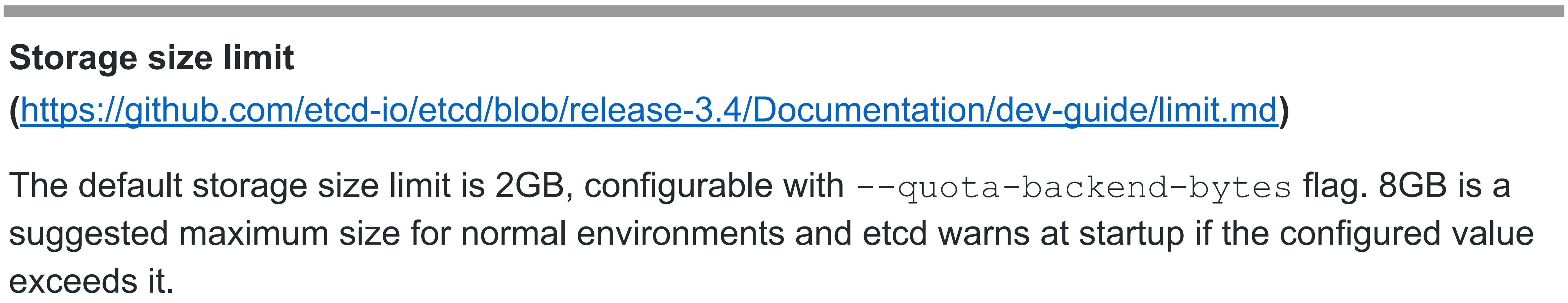
Etcd Example

Detection Strategies:

1. ~~Directly monitor etcd health endpoints~~
2. ~~Directly monitor kube-apiserver health endpoints~~
3. Alerting based off master kubelets ‘metrics/probes’

Etcd Example

```
# HELP etcd_object_counts Number of stored objects at the time of last check split by kind.
# TYPE etcd_object_counts gauge
etcd_object_counts{resource="somecrd"} 1000000
```



Storage size limit

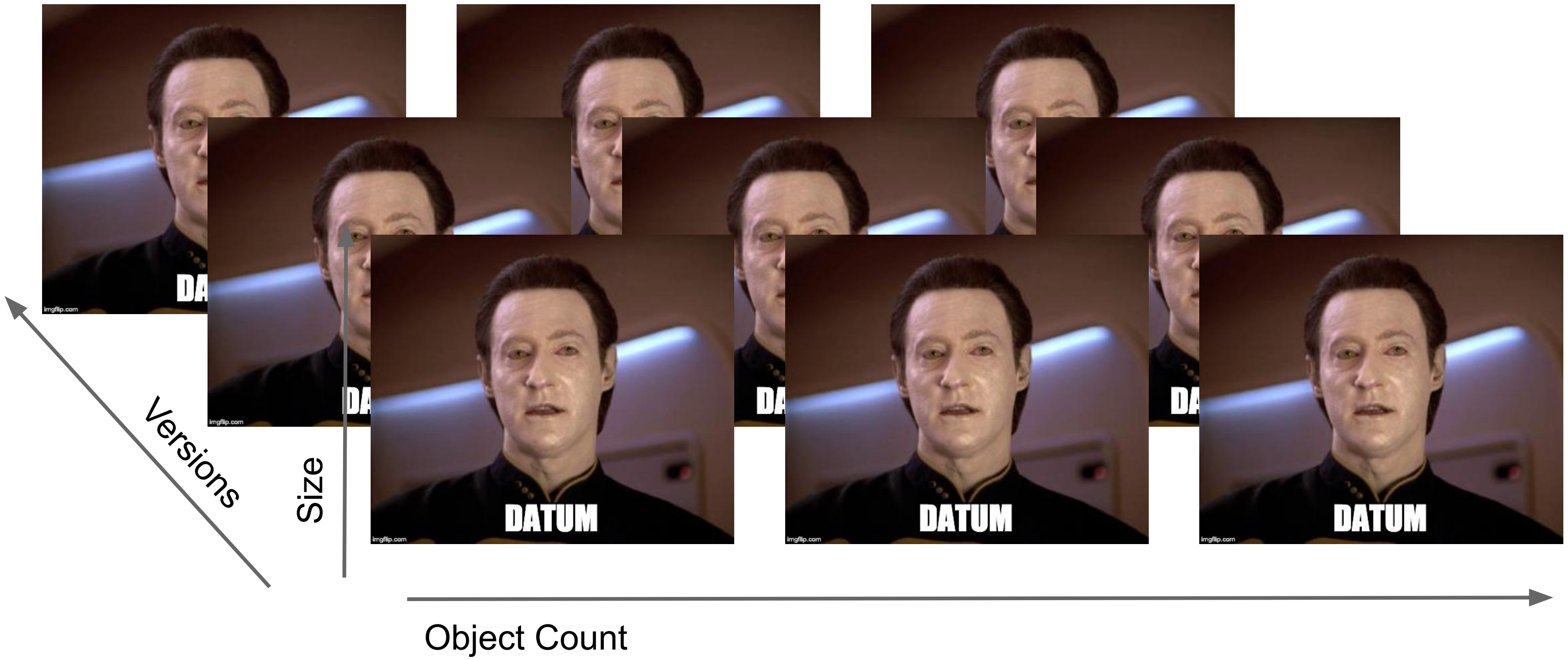
(https://github.com/etcd-io/etcd/blob/release-3.4/Documentation/dev-guide/limit.md)

The default storage size limit is 2GB, configurable with `--quota-backend-bytes` flag. 8GB is a suggested maximum size for normal environments and etcd warns at startup if the configured value exceeds it.

Etcd Example

```
etcd_object_counts{resource=”somecrd”} 1
apiserver_request_count{resource=”somecrd”, verb=”UPDATE”} 1200
```

Etcd Example



```
   # (Revisited):
   etcd_object_counts{resource=”somecrd.io”} 1
   apiserver_request_count{resource=”somecrd.io”, verb=”UPDATE”}
1200
```

Etcd Example

```
$ kubectl get -ojson somecrd.io datum | wc -c
```

```
$ auger extract -f <dbfile> -k <key> | wc -c
```

Kube-apiserver Example

Problem:
API-servers are slow.

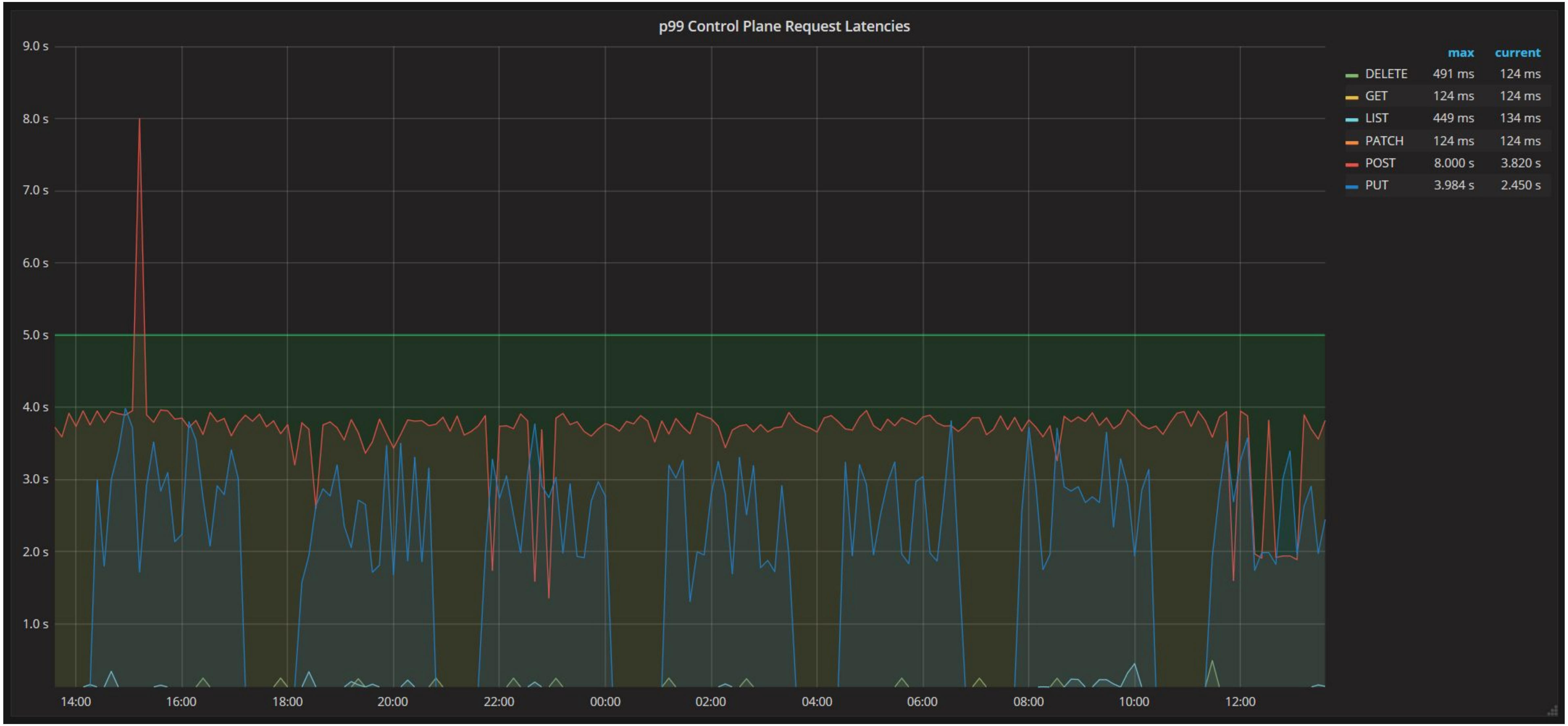
Another kube-apiserver example

Problem: API servers are slow

- Obvious: p99 request latency is high

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

Another kube-apiserver example



p99 Control Plane Request Latencies

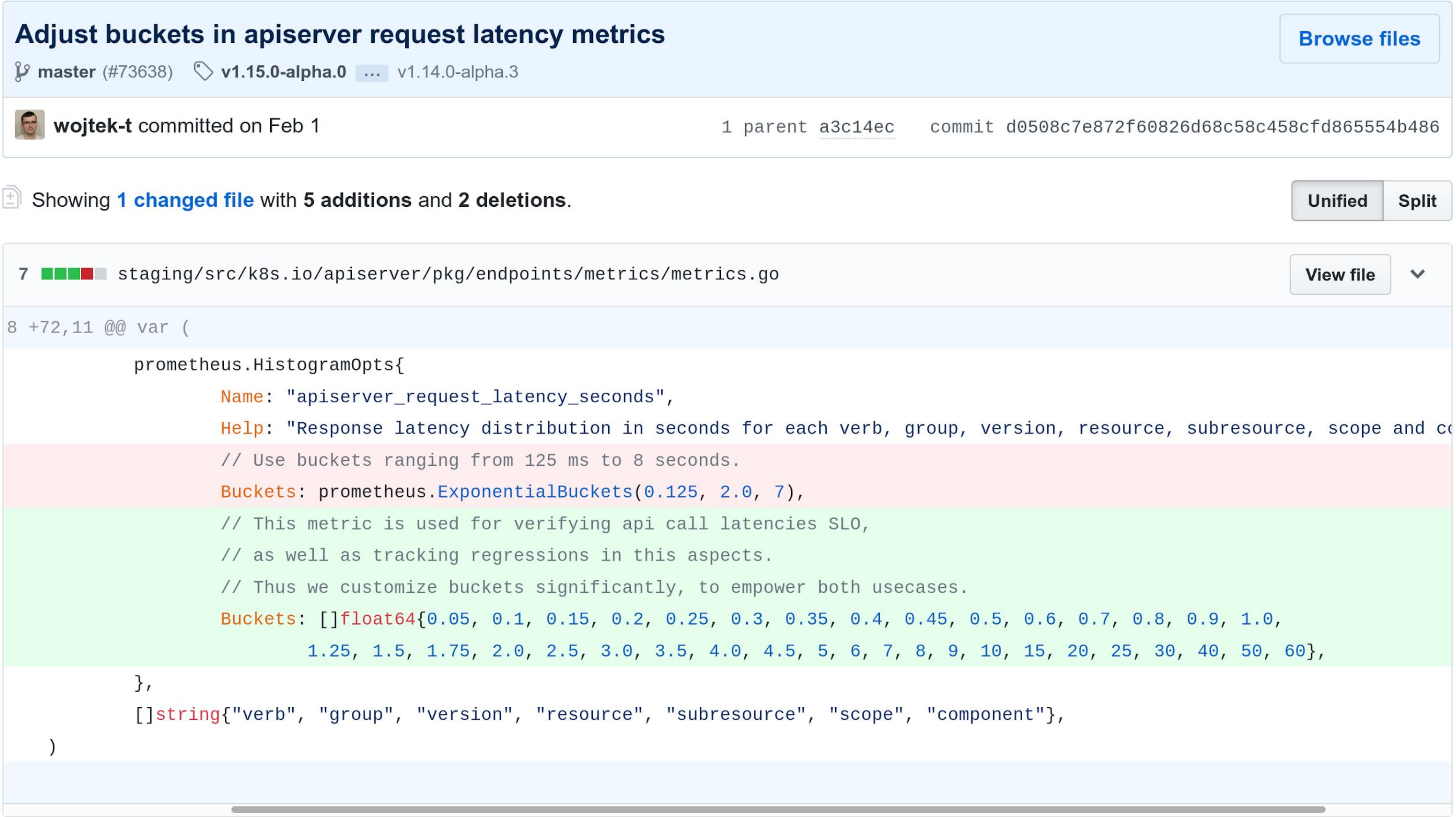
	max	current
DELETE	491 ms	124 ms
GET	124 ms	124 ms
LIST	449 ms	134 ms
PATCH	124 ms	124 ms
POST	8.000 s	3.820 s
PUT	3.984 s	2.450 s

Another kube-apiserver example

Problem: API servers are slow

- Less obvious: API server metrics prior to 1.14 release are limited to buckets between 125ms and 8s

Another kube-apiserver example



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"},
)
```

Metric Usability &
SIG Instrumentation

Handling metric issues

- SIG Instrumentation needs to be able to fix metric bugs and issues
- Updating metrics between releases could break monitoring stacks
- Bad metrics can’t be disabled, requiring a full upgrade to address
- How can we coordinate developers to address this and responsibly communicate to end users?

Metrics Overhaul (1.14)

- Many **broken metrics** were identified
    - Labels did not match instrumentation guidelines, couldn’t be joined
    - Wrong data types prevented aggregation
    - Units were not standardized
- **Fixes rolled out** in the 1.14 release
- SIG Instrumentation KEP: “Kubernetes Metrics Overhaul”

Metric Stability Framework

- SIG Instrumentation KEP: “Kubernetes Control Plane Metrics Stability”
- **Treat metrics as a proper API:** multi-release notice period for changes to stable metrics
- **Deprecation lifecycle:** slowly phase out obsolete metrics across releases before deletion
- **Enforcing Stability:** metrics migration, static analysis for stability validation, beta enforcements

Stability Metadata

```
var rpcDurations = metrics.NewSummary(
     metrics.SummaryOpts{
       Name:       "rpc_durations_seconds",
       Help:       "RPC latency distributions.",
       StabilityLevel: metrics.STABLE,
       DeprecatedVersion: "1.15",
     },
  )
)
```

More to come

- Stable metric criteria and promotion
- Distributed tracing
- Structured logs
- More metric improvements!

Questions?

Image Citations

- Slide 16 : Title*: LIveness Probe Meme;* Site: Meme Generator; *URL:* https://imgflip.com/memegenerator; Date: 11/15/19; Publisher: imgflip
- Slide 18 : Title:*Count on me Meme;* Site: Meme Generator; *URL:* https://imgflip.com/memegenerator; Date: 11/15/19; Publisher: imgflip
- Slide 19 : Title*: Only one health check Meme;* Site: Meme Generator; *URL:* https://imgflip.com/memegenerator; Date: 11/15/19; Publisher: imgflip
- Slide 20 : Title*: Talk to the hand Meme;* Site: Meme Generator; *URL:* https://imgflip.com/memegenerator; Date: 11/15/19; Publisher: imgflip
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- Slide 26 : Title*: Bambi Meme;* Site: Meme Generator; *URL:* https://imgflip.com/memegenerator; Date: 11/15/19; Publisher: imgflip
- Slide 28: Title*: Oh nos Meme;* Site: Meme Generator; *URL:* https://imgflip.com/memegenerator; Date: 11/15/19; Publisher: imgflip
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- Slide 32: Title*: Causes other crashloops Meme;* Site: Meme Generator; *URL:* https://imgflip.com/memegenerator; Date: 11/15/19; Publisher: imgflip
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