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?

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Why are we even here?

To operate systems that make users happy.
When something goes wrong

Observability 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??

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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

\[
\text{up\{job="kube-apiserver",instance="api-1"\}} \quad 1
\]
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

- **master node**
  - etcd
  - api-server

- **worker node**
  - etcd
  - api-server

- pods
  - kubectl
  - cadvisor

- container runtime
  - Prom
  - KSM
A minimal monitoring stack for Kubernetes

- **etcd**
- **api-server**
- **kubelet**
- **cadvisor**
- **Prom**
- **KSM**

**Scrape targets:**
- worker node
- container runtime
- pods

**Master node:**
- etcd
- api-server

**Worker node:**
- etcd
- api-server
- kubelet
- cadvisor
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"}
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
  \[
  \text{up\{job="kube-nodes"\} != 1}
  \]

- **Less obvious:** Grey failure indicated by unusually slow scrape time
  \[
  \text{scrape\_duration\_seconds\{job="kube-nodes"\} > 2}
  \]
Service Degradation: Customer can’t launch Pods

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

  \[
  \frac{\text{sum}(\text{kube_resourcequota}\{\text{namespace}="\text{foo}",\text{resource}="\text{cpu}",\text{type}="\text{used}"\})}{\text{kube_resourcequota}\{\text{namespace}="\text{foo}",\text{resource}="\text{cpu}",\text{type}="\text{hard}"\}} > 0.95
  \]

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

  \[
  \frac{\text{sum}(\text{container_cpu_usage_seconds_total}:\text{rate1m}\{\text{namespace}="\text{foo}"\})}{\text{kube_resourcequota}\{\text{namespace}="\text{foo}",\text{resource}="\text{cpu}",\text{type}="\text{hard}"\}} < 0.35
  \]
Service Degradation: API Server is slow

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

  
  \[
  \text{histogram\_quantile} (0.99, \sum \text{rate}(\text{apiserver\_request\_latencies\_bucket}[1m])) \text{ by (le, verb)}
  \]

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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

wojtek-t committed on Feb 1

1 changed file with 5 additions and 2 deletions.

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

8  @ prometheus.HistogramOpts{

   Name: "apiserver_request_latency_seconds",
   Help: "Response latency distribution in seconds for each verb, group, version, resource, subresource, scope and component",

   // 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 SL0,
   // as well as tracking regressions in this aspects.
   // Thus we customize buckets significantly, to empower both use cases.
   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:

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Talk resources: https://hashman.ca/srecon-2019