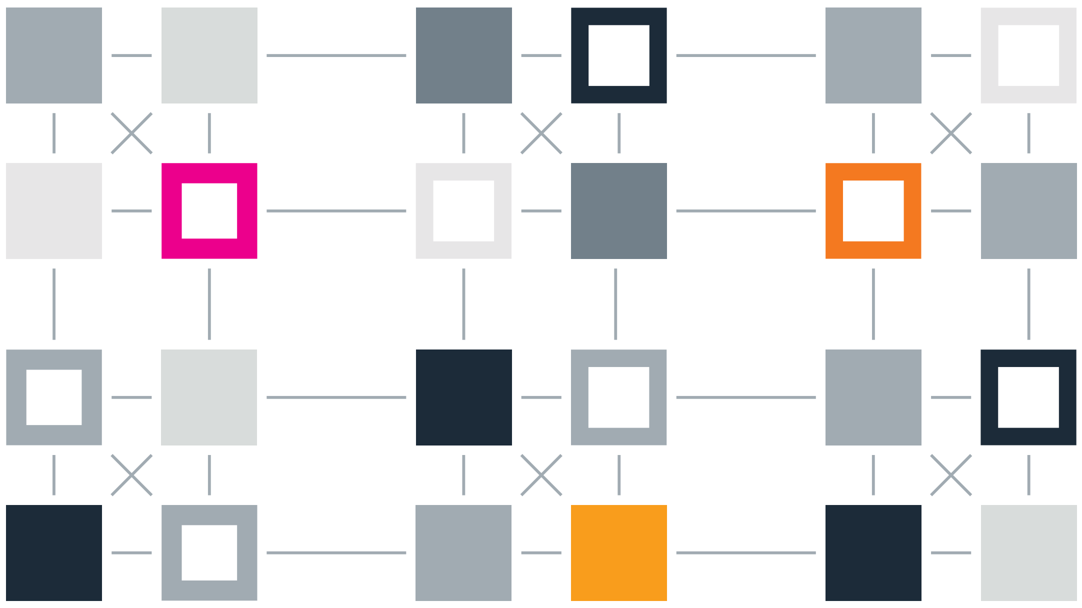
WHITE PAPER

Monitoring Microservices on Kubernetes



According to the latest bi-annual survey from CNCF, monitoring is one of the top challenges for organizations adopting Kubernetes.

This White Paper provides insights into how to best monitor both Kubernetes clusters and microservices deployed on Kubernetes in order to pinpoint performance issues, minimizing mean time-to-resolution (MTTR).

Managing performance issues in real-time is a controllable way to enable a flawless end-user experience. Enterprises need to develop best practices for operating Kubernetes clusters as well as for understanding performance across the entire stack, including distributed traces across all microservices.

The Brain Behind the Orchestration of Containerized Applications

Kubernetes is a leading container orchestration solution for deploying containerized applications. Enterprises across every industry are adopting containerized microservices in order to gain:

- **Speed** — to accelerate the pace of innovation
- **Scale** — to deliver optimized application experiences across different geographies and cloud providers
- **Efficiency** — to provide more value at a lower cost by optimizing resource consumption

Kubernetes has several logical layers to support various use cases and manage the lifecycle of containerized microservices.

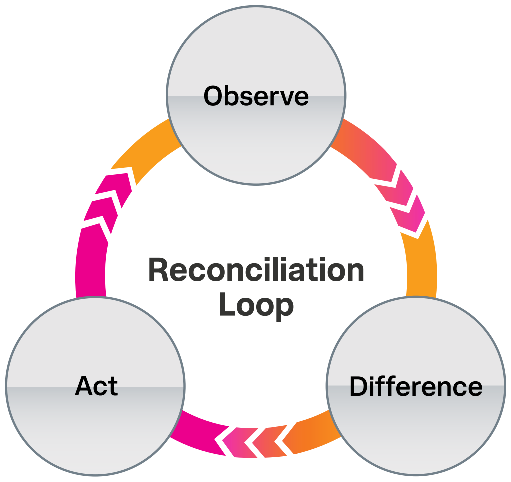
There are three foundational pillars of the Kubernetes deployment philosophy

Infrastructure Abstraction	Declarative Configuration	Immutability
Application orchestration from the infrastructure resources such as compute servers, storage volumes, and networks	Kubernetes continuously monitors the state of the applications deployed and Kubernetes objects; It also implements the desired state of the system as expressed by the operators such as how many replicas of a service should be running	Continuing the immutability requirements set forth by Docker where container images are immutable, Kubernetes objects are also immutable e.g. different versions of Kubernetes Services are completely separate and are not interchangeable

Why Use Kubernetes?

In addition to the benefits that containerization provides for application developers, Kubernetes makes the life of operations easier in many different ways:

Automated Application Lifecycle Management	Cloud Interoperability	Self-Healing System
Kubernetes automates application lifecycle management as an end-to-end solution including application provisioning, autoscaling, and replication management as well as CI/CD	Kubernetes provides abstraction over the infrastructure so that applications become truly portable across Amazon Web Services (AWS) environments	Kubernetes guards applications against any failures or unreliable behavior that destabilizes the system. It continuously takes actions to ensure the state of the system conforms to the desired state, as expressed in the declarative configuration

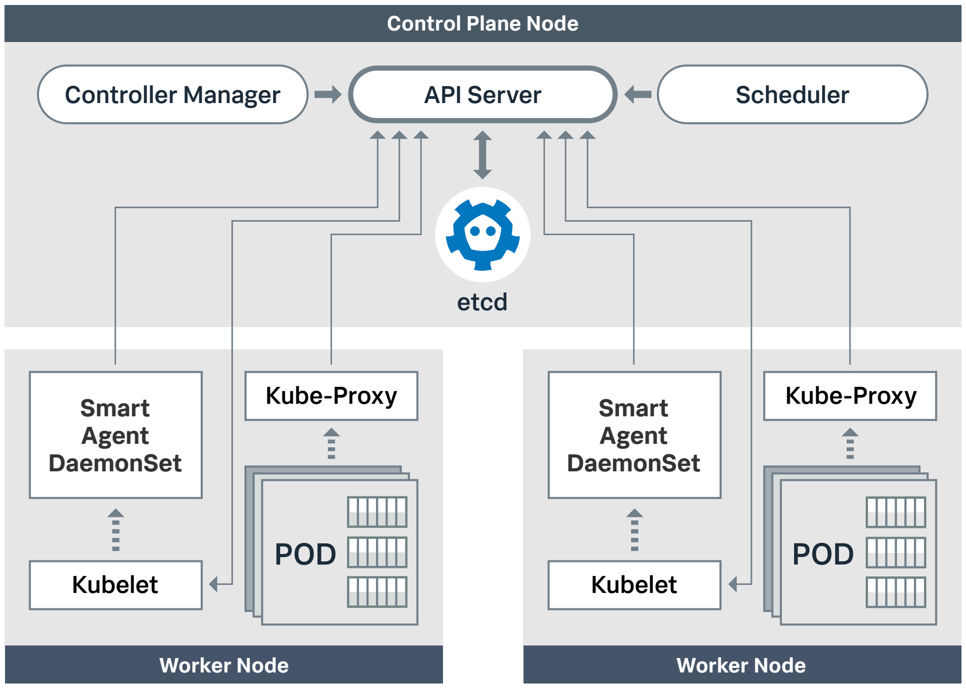


Kubernetes Controller Manager continuously compares the desired state with the actual state, evaluates the differences between them, and reconciles the differences by taking appropriate actions.

Understanding Kubernetes Components

Kubernetes is a system that assembles a group of machines into a single unit that can be consumed via an API. Kubernetes further segments the compute resources into two groups:

Worker Nodes and Control Plane Nodes



Here are the main components running on control plane and worker nodes:

Control Plane Nodes
API Server • Gateway to the Kubernetes cluster • Mediates all the requests from clients and API objects stored in etcd • Performs authentication and role-based access control RBAC • Requests validation and admission control • More information: http://bit.ly/k8s-apiserver
Control Manager • Daemon process that implements the control loops built into Kubernetes — rolling deployments, replica sets, number of worker nodes, etc. • More information: http://bit.ly/k8s-ctrl-mgr
Scheduler • Decides where pods should run based on multiple factors — affinity, available resources, labels, QoS, etc. • More: http://bit.ly/k8s-scheduler
etcd • Heart of the Kubernetes cluster; persists key-value information on all Kubernetes objects More: https://etcd.io/

Worker Nodes
Kubelet — Agent On Every Worker • Initiates pods (a group of one or more containers) using PodSpec and ensures all pods are running and healthy • Interacts with containers — e.g. Docker • More: http://bit.ly/k8s-kubelet
Kube Proxy — Agent On Every Worker • Network proxy and load balancer for Kubernetes Services • More: http://bit.ly/k8s-proxy

These are the Kubernetes add-ons that are required for the most applications:

kube-dns	kubectl
• Provisioned as a pod and a service on Kubernetes • Every service gets a DNS entry in Kubernetes • kube-dns resolves DNS of all services in the cluster	• The official command line for Kubernetes • Behind the scenes uses REST-based API calls to Kubernetes API server

Key Kubernetes Constructs and Objects:

Namespaces	Pods
Virtual segmentation of single clusters	A logical grouping of one or more containers that are managed by Kubernetes
Nodes	**Replicaset**
Infrastructure fabric of Kubernetes (host of worker and control plane components)	Continuous loop that ensures given number of pods are running
Roles	**Ingresses**
Role-based access controls for Kubernetes cluster	Manages external HTTP traffic to hosted service
Deployments	**Services**
Manages a ReplicaSet, pod definitions, updates and other concepts	A logical layer that provides IP, DNS, etc. persistence to dynamic pods

Monitoring Challenges in Kubernetes Environments

According to the latest survey from CNCF, complexity, monitoring, and security are amongst the top challenges for organizations adopting Kubernetes. Monitoring strategies of yore do not work in the cloud-native era primarily because:

- There are many more components to monitor
- Containers are ephemeral and dynamic
- Kubernetes automatically schedules pods based on the best resource utilization. While it does increase efficiency, it also adds unpredictability on where the pods get deployed and run unless specific intent is expressed using affinity or taints

This results in the following set of conditions for Kubernetes environments:

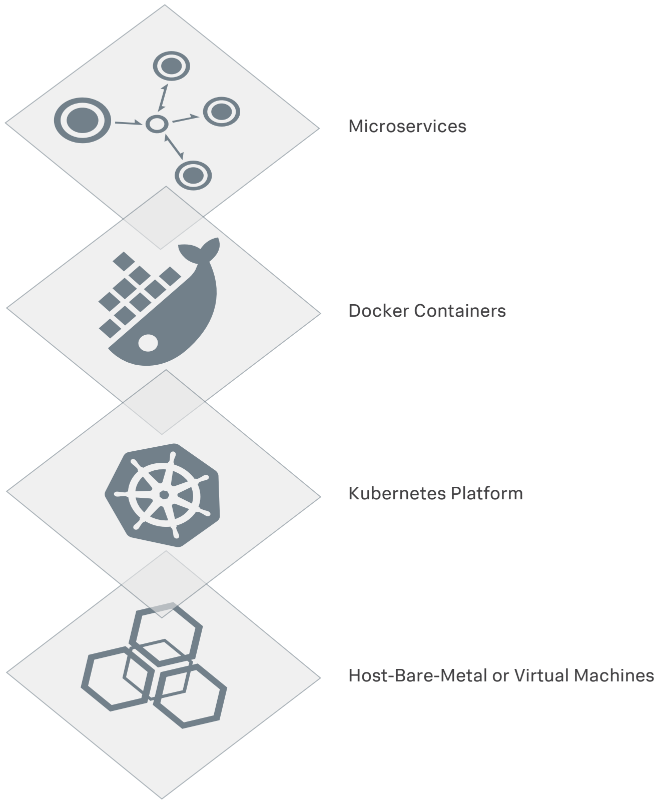
- There are many more components to monitor
- Containers are ephemeral and have unpredictable pod placement
- Containerized microservices require different protocol to monitor

More Components to Monitor

In the monolithic world, there are only two components to monitor — applications and the hosts on which the applications were deployed.

In the cloud-native world, containerized applications orchestrated by Kubernetes have multiple components that require monitoring:

- Hosts
- The Kubernetes platform itself
- Docker containers
- Containerized Microservices



Container Ephemerality and Unpredictable Placement

Unlike the traditional long-running host model, modern microservices-based applications are typically deployed on containers that are dynamic and ephemeral. Kubernetes makes sure the desired number of application replicas are running. Kubernetes will place the pods on the nodes that it deems fit unless specifically instructed not to do so via node affinity or taints. In fact, letting Kubernetes schedule pods is the key design goal for this self-adjusting system.

Traditional monitoring approaches do not work in these highly dynamic environments because they tend to follow long-running hosts by using hostnames or IP addresses. For containerized environments, monitoring tools must provide immediate service discovery and automatically detect the lifecycle events of containers, while also adjusting metric collection when containers are spun up or restarted in seconds.

Monitoring the Performance of Microservices

Pinpointing issues in a microservices environment is more challenging than with a monolithic one, as requests traverse both between different layers of the stack and across multiple services. Modern monitoring tools must monitor these interrelated layers while also efficiently correlating application and infrastructure behavior to streamline troubleshooting.

Key Performance Metrics to Monitor

POD Metrics

It's essential to monitor all Kubernetes objects in order to ensure each cluster is healthy and resource utilization is optimized. Monitoring Kubernetes pod metrics as well as Deployments and Services will help determine whether Kubernetes is working as intended in your environment.

PODS	Number of Desired Pods
	Number of Available Pods
	Pods by Phase (failed, pending, running)
	Desired Pods per Deployment
	Desired Pods per Service
	Available Pods by Deployment
	Available Pods by Service
	Pods Desired by ReplicaSet
	Running Pods Per Node

Resource Utilization Metrics

It's important to also keep track of resource utilization to ensure that your applications and Kubernetes clusters remain healthy.

- Docker Socket provides container metrics and node-level resource utilization metrics, such as CPU and memory usage. Kubernetes provides collectd metrics as well as metrics emitted by Kubernetes.
- Correlating CPU, memory, Disk IO, and network performance metrics with application performance and Kubernetes events help to get to the root cause of a performance issue quicker.
- Monitoring Docker and Kubernetes events, such as container or pod lifecycle events, helps to pinpoint misconfigurations or resource starvation.

Monitoring Kubernetes with Splunk

Kubernetes provides detailed information about its components and application resource usage at the cluster, pod, and service level that can easily be collected by a vast array of monitoring solutions, but the task of making this data actionable is left to end users.

Splunk enables you to monitor Kubernetes with flexible, open instrumentation and pre-built dashboards that provide immediate visibility into the various layers of their environment. By combining streaming analytics with distributed tracing, Splunk users can go beyond basic data collection — leveraging real-time alerting and performance analysis to find and resolve issues in seconds.

Collect AWS Cloud Metrics

For basic monitoring of a managed Kubernetes service like Amazon Elastic Container Service for Kubernetes (EKS), the simplest way to collect metrics is by integrating Splunk with services such as Amazon CloudWatch.

This approach is the most straightforward, and enables Splunk to collect Kubernetes metrics without having to install an agent or modify application code. However, these services are configured by default to aggregate and report metrics at relatively infrequent intervals (Amazon CloudWatch updates every 5 minutes by default) and do not provide insight into the specific services deployed on your Kubernetes clusters.

Fully Automated Kubernetes Monitoring

For greater insight into services and finer-grained monitoring of container metrics, we recommend installing the Smart Agent throughout your Kubernetes clusters.

An open-source metrics collection agent built on top of collectd, the Smart Agent provides automatic service discovery and configuration for monitoring content. One advantage with this approach is the Smart Agent's ability to submit metrics to Splunk at 1-second resolution, making it especially well-suited for the ephemeral nature of Kubernetes pods.

The Smart Agent runs as a DaemonSet in Kubernetes to ensure that it is installed on every node in the cluster. It collects data from Kubernetes and uses cAdvisor to get resource and performance characteristics from running Docker containers. Zero-touch configuration with automatic discovery of Kubernetes components and containerized services instantly monitors the entire stack. The Smart Agent is installed with one simple step:

```
helm install splunk --set splunkAccessToken=<
YOUR_ACCESS_TOKEN> --set
clusterName=<YOUR_CLUSTER_NAME> splunk/
splunk-agent
```

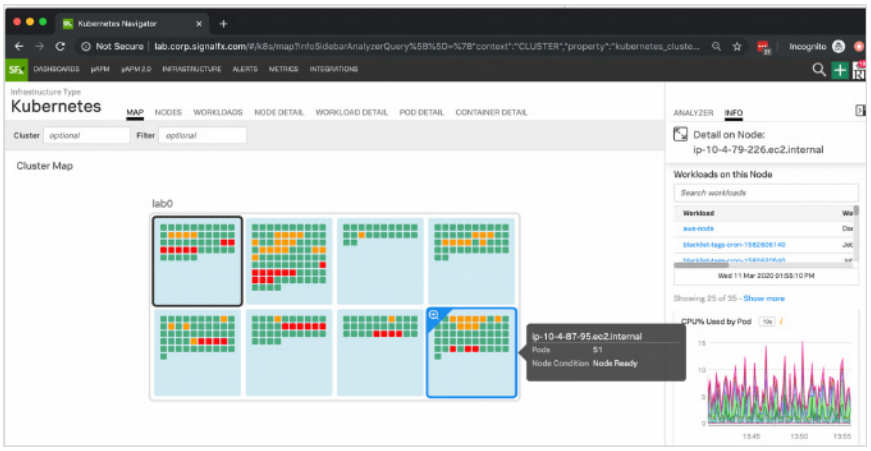
Not only can the Smart Agent monitor upstream Kubernetes, it is also capable of collecting metrics from managed Kubernetes services like Amazon EKS, as well as platforms like Openshift.

The Smart Agent also provides monitors that can collect data from other metrics protocols like Prometheus and StatsD, so that teams with existing metrics pipelines can easily take advantage of Splunk.

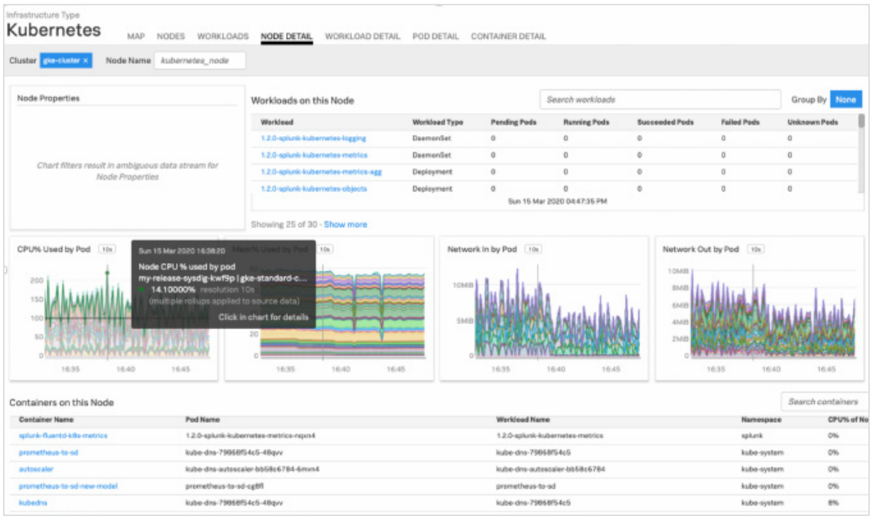
Navigating Through Your Kubernetes Environment

Pre-Built Kubernetes Dashboards

Starting with the bird's eye view, Kubernetes Navigator enables teams to quickly understand the performance of the entire Kubernetes environment with intuitive and hierarchical navigation. Select, filter, or search for any Kubernetes entity and drill-down for detailed analysis, e.g., node, pod, and container level within seconds. Understand relationships between dynamic Kubernetes components and quickly fix interdependent performance issues arising from noisy neighbors.



Drilling down to an individual node will display system metrics for that particular node, as well as dashboards for the specific services running on that node.



Workloads on this Node

Workload	Workload Type	Pending Pods	Running Pods	Succeeded Pods	Failed Pods	Unknown Pods
1.2.0-splunk-kubernetes-logging	DaemonSet	0	0	0	0	0
1.2.0-splunk-kubernetes-metrics	DaemonSet	0	0	0	0	0
1.2.0-splunk-kubernetes-metrics-agg	Deployment	0	0	0	0	0
1.2.0-splunk-kubernetes-objects	Deployment	0	0	0	0	0

Sun 15 Mar 2020 04:47:35 PM

Showing 25 of 30 - Show more

Sun 15 Mar 2020 16:38:20
Node CPU % used by pod
my-release-sysdig-kwf9p | gke-standard-c...
14.10000% resolution 10s
(multiple rollups applied to source data)

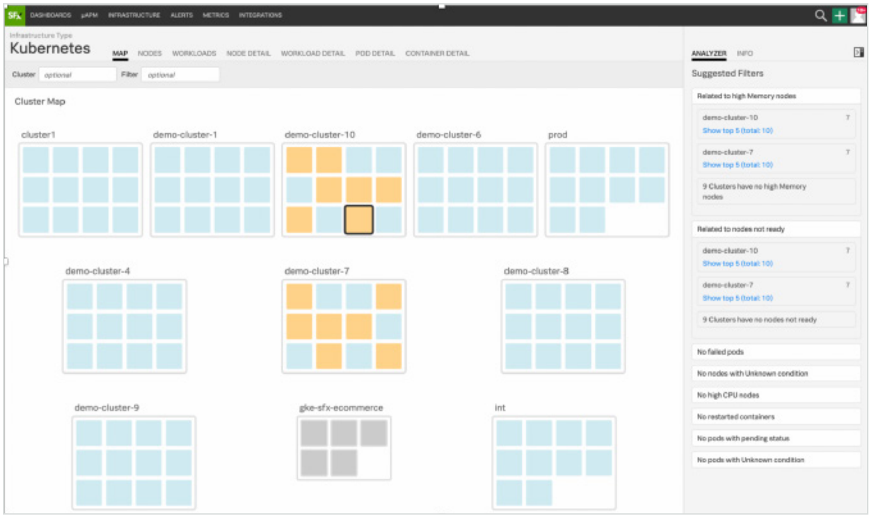
Containers on this Node

Container Name	Pod Name	Workload Name	Namespace	CPU% of No
splunk-fluentd-k8s-metrics	1.2.0-splunk-kubernetes-metrics-nqxn4	1.2.0-splunk-kubernetes-metrics	splunk	0%
prometheus-to-sd	kube-dns-79868f54c5-48qvv	kube-dns-79868f54c5	kube-system	0%
autoscaler	kube-dns-autoscaler-bb58c6784-6mvn4	kube-dns-autoscaler-bb58c6784	kube-system	0%
prometheus-to-sd-new-model	prometheus-to-sd-cg8fl	prometheus-to-sd	kube-system	0%
kubedns	kube-dns-79868f54c5-48qvv	kube-dns-79868f54c5	kube-system	8%

You can also view all of the pods running in your Kubernetes cluster, and track activity across a particular pod or across all the pods in your cluster. From here, it's possible to drill down to individual Docker containers in each pod.

Kubernetes Analyzer

AI-driven analytics automatically surfaces insights and recommendations to precisely answer, in real-time, what is causing anomalies across the entire Kubernetes cluster — nodes, containers, and workloads. Sophisticated algorithms, including Historical Performance Baselines and Sudden Change, detect system-level issues such as a sudden increase in Goroutines or container restarts and alert within seconds.



Suggested Filters

Related to high Memory nodes
- demo-cluster-10 — Show top 5 (total: 10)
- demo-cluster-7 — Show top 5 (total: 10)
- 9 Clusters have no high Memory nodes

Related to nodes not ready
- demo-cluster-10 — Show top 5 (total: 10)
- demo-cluster-7 — Show top 5 (total: 10)
- 9 Clusters have no nodes not ready

No failed pods

No nodes with Unknown condition

No high CPU nodes

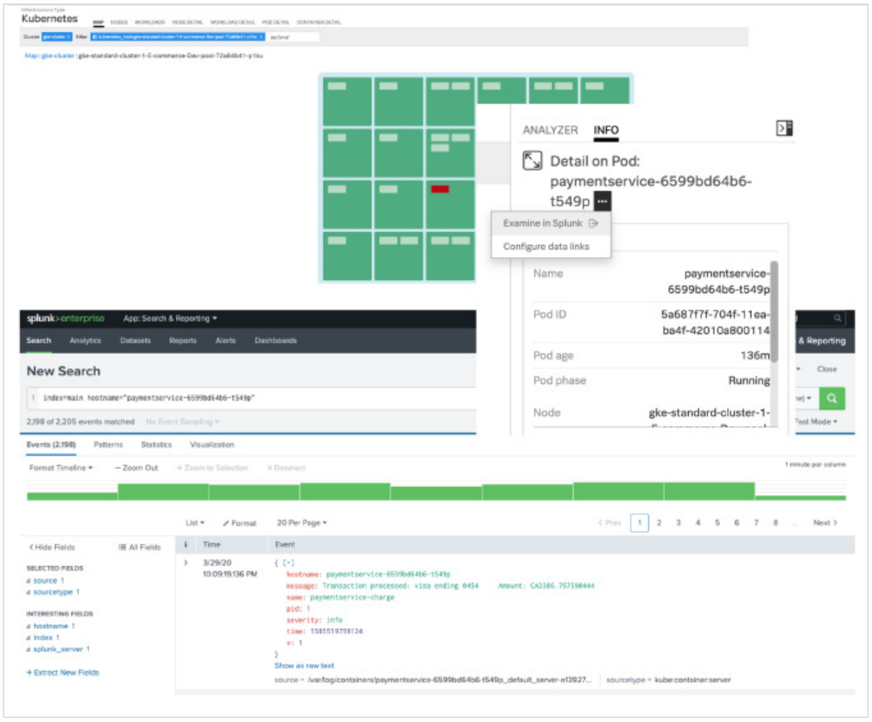
No restarted containers

No pods with pending status

No pods with Unknown condition

Logs in Context

Seamlessly pivot to logs and get granular visibility into application, Kubernetes, and container logs to correlate performance across the entire stack without any context switching. Visibility into lifecycle events of Kubernetes and API Server Audit logs help you understand and maintain your security and compliance postures.



Detail on Pod: paymentservice-6599bd64b6-t549p

Name	paymentservice-6599bd64b6-t549p
Pod ID	5a687f7f-704f-11ea-ba4f-42010a800114
Pod age	136m
Pod phase	Running
Node	gke-standard-cluster-1-

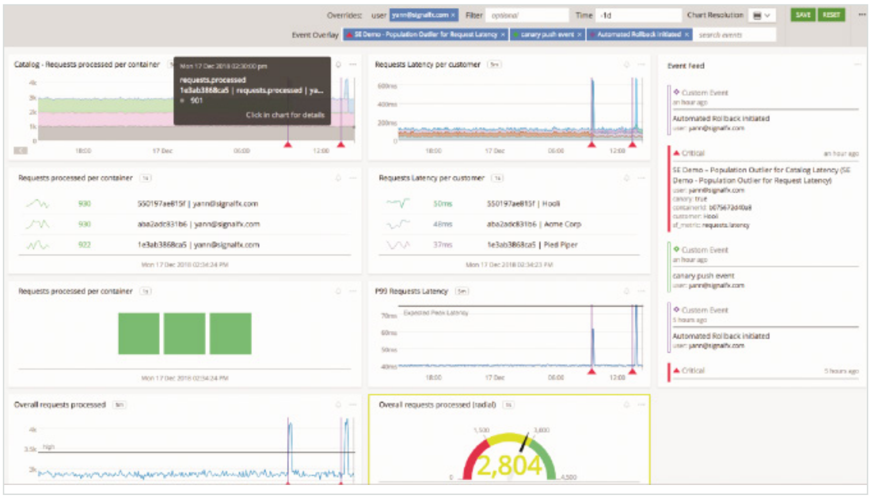
```
1  index=main hostname="paymentservice-6599bd64b6-t549p"
```

2,198 of 2,205 events matched

```
3/29/20
10:09:19.136 PM
{ [-]
   hostname: paymentservice-6599bd64b6-t549p
   message: Transaction processed: visa ending 0454    Amount: CA3386.757590444
   name: paymentservice-charge
   pid: 1
   severity: info
   time: 1585519759124
   v: 1
}
Show as raw text
source = /var/log/containers/paymentservice-6599bd64b6-t549p_default_server-e13927...  sourcetype = kube:container:server
```

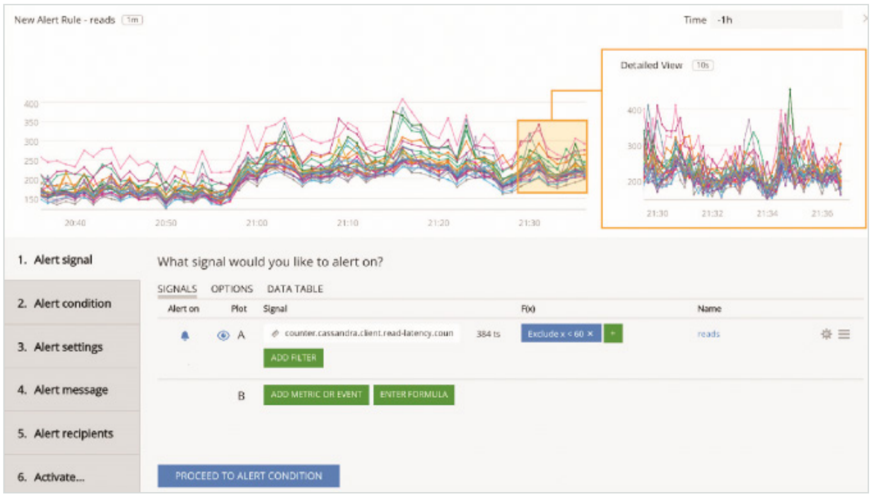
Creating Custom Service Dashboards

Splunk lets you view container metrics alongside other performance indicators to provide visibility across every layer of your environment. For example, a service owner who wants to monitor canary deployments might create the following dashboard, with container metrics displayed next to charts measuring request latency and an event feed that tracks code pushes, alerts, and any remediation actions are taken.


Overrides
Filter
Time -1d
Chart Resolution
SAVE
RESET
Event Overlay
Catalog - Requests processed per container
Requests Latency per customer
Event Feed
Custom Event
Automated Rollback initiated
Critical
canary push event
Requests processed per container
Requests Latency per customer
P99 Requests Latency
Overall requests processed
Overall requests processed (radial)
2,804

Detect Problems in Real-Time

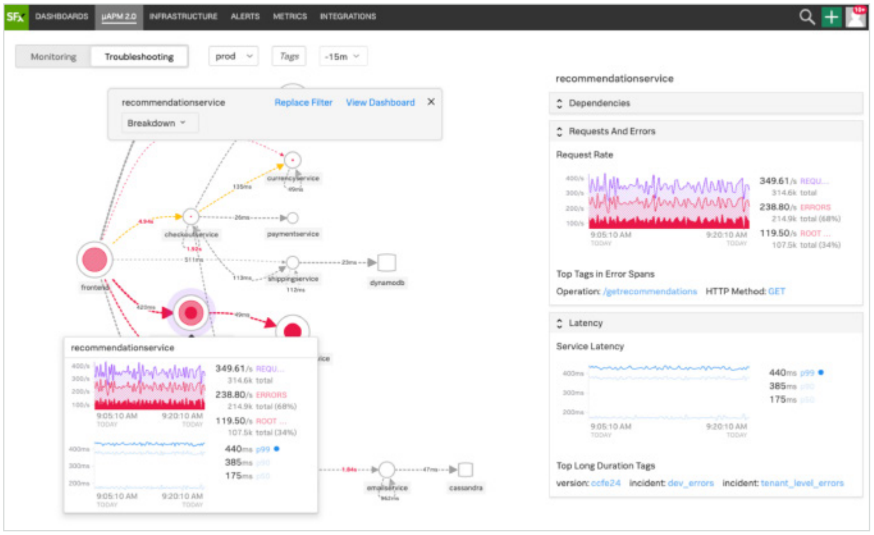
With Splunk, setting up alerts doesn't have to be a compromise between accuracy and timeliness. Proactively alert on issues by combining high-resolution metrics from your Kubernetes clusters with a library of statistical functions and algorithms in Splunk. Preview alerts against historical data to tune them before deployment, and apply data science to alerting to avoid the false positives and alert storms common in highly ephemeral environments.


New Alert Rule - reads 1m
Time -1h
Detailed View 10s
1. Alert signal
2. Alert condition
3. Alert settings
4. Alert message
5. Alert recipients
6. Activate...
What signal would you like to alert on?
SIGNALS OPTIONS DATA TABLE
Alert on Plot Signal F(x) Name
A counter.cassandra.client.read-latency.coun 384 ts Exclude x < 60 × reads
ADD FILTER
B ADD METRIC OR EVENT ENTER FORMULA
PROCEED TO ALERT CONDITION

Leverage Distributed Tracing for Directed Troubleshooting

Splunk APM provides users with distributed tracing capabilities to dig deep when a performance-impacting event occurs. No matter where an issue arises in your Kubernetes environment, you can navigate from real-time alerts directly to application traces and correlate performance trends between infrastructure, Kubernetes, and your microservices. Splunk APM is built on a **NoSample™** Full-Fidelity architecture that ingests and analyzes all traces so outliers and anomalies never go undetected.

Outlier Analyzer™ provides directed troubleshooting by surfacing most commonly represented patterns in outlier traces enabling you to quickly narrow down to anomalous Kubernetes nodes, cluster, cloud region or application specific labels or tags.



Increase DevOps Velocity

Once data from Kubernetes is flowing into Splunk, DevOps teams can more easily leverage monitoring best practices and solutions to common problems across the entire organization. Splunk provides out of the box, instant visibility into hosts, containers, pods, and Kubernetes objects with zero-touch, built-in dashboards, while also allowing teams to customize dashboards, alerts, and notifications for their specific needs.

Central teams can deliver monitoring as code by using the Splunk API to programmatically create monitoring content and define analytics, and leverage Service Bureau to control usage, access, and editing permissions for users and teams.

```
curl \  --request post \ --header “x-sf-token: your_access_
token” \ --header “content-type: application/json” \ --data \‘{
“name”: “cpu load”, “programtext”: “data(‘cpu.load’).publish()”
}’ \ https://api.splunk.com/v2/chart
```

Splunk is Trusted by Leading Organizations

Enterprises from every industry and across the globe are leveraging Splunk to accelerate their journey to cloud-native and adopt Kubernetes in their organizations with confidence. Following is a list of just a few customers.

More information: **https://www.splunk.com/en_us/customers.html**

Get Started Today with Splunk Infrastructure Monitoring

Ready to learn how Splunk can accelerate Kubernetes adoption in your organization?

Our customer success managers and solutions engineers will work with your teams to accelerate your Kubernetes adoption, and to monitor Kubernetes in real-time. Get started with a 14-day free trial: **https://www.observability.splunk.com**

Sign up for a free trial

Get Started

Deploy Smart Agent

Learn More

Start monitoring Kubernetes environments

Learn More

About Splunk and AWS

AWS and Splunk are uniquely positioned to help organizations achieve digital transformation success with their highly integrated data-driven cloud adoption and modernization offerings. With industry-leading cloud infrastructure from AWS, combined with the Splunk® Data-to-Everything™ Platform, companies can innovate with confidence, migrate and modernize existing environments, and scale without limits, with data at the center of every business outcome.

To learn more about Kubernetes Navigator for real-time monitoring and troubleshooting Kubernetes environments, at any scale, download the free **Kubernetes Navigator Data Sheet**.

Learn more: www.splunk.com/asksales

www.splunk.com