

# Kubernetes Architecture

Wednesday, March 18, 2020 3:02 PM

## What is Kubernetes?

Portable, extensible, open-source platform for managing containerized workloads and services.

## Deployment Schemes

### Traditional

- Applications ran on physical servers
- Couldn't define resource boundaries
- Large investment in hardware to run multiple applications cleanly

### Virtualized

- Multiple VMs on one physical host
- Allows application isolation between VMs
- Increased security between applications/VMs
- Full machine with all components and OS running on virtual hardware

### Containerized

- Similar to VMs but each container shares the same OS
- Run natively on the host machine
- Has own FS, CPU, memory, process space, and more
- Decoupled from the infrastructure, portable, lightweight

## Why Kubernetes

Containers are good to run applications, but you will still need to manage and monitor containers to ensure uptime. Kubernetes provides the framework for running resilient, distributed systems.

- Service discovery and load balancing
  - dns/ip routing
  - traffic load balancing
- Storage orchestration
  - automatically mount storage providers of choice (local, cloud, etc)
- Automated rollouts and rollbacks
  - declarative deployments allow kubernetes to match deployments to a desired state and resource usage
- Automatic bin packing
  - Kubernetes will deploy containers across a node cluster to best utilize the available resources
- Self-healing
  - restarts failing containers, replaces containers, kill non-responsive containers to user-defined health check, doesn't advertise until service is ready and stable
- Secret and config management
  - Kubernetes will manage sensitive information like passwords, OAuth tokens, and SSH keys. Management configuration without rebuilding container images, and w/o exposing secrets in your stack configuration.

## What Kubernetes is not?

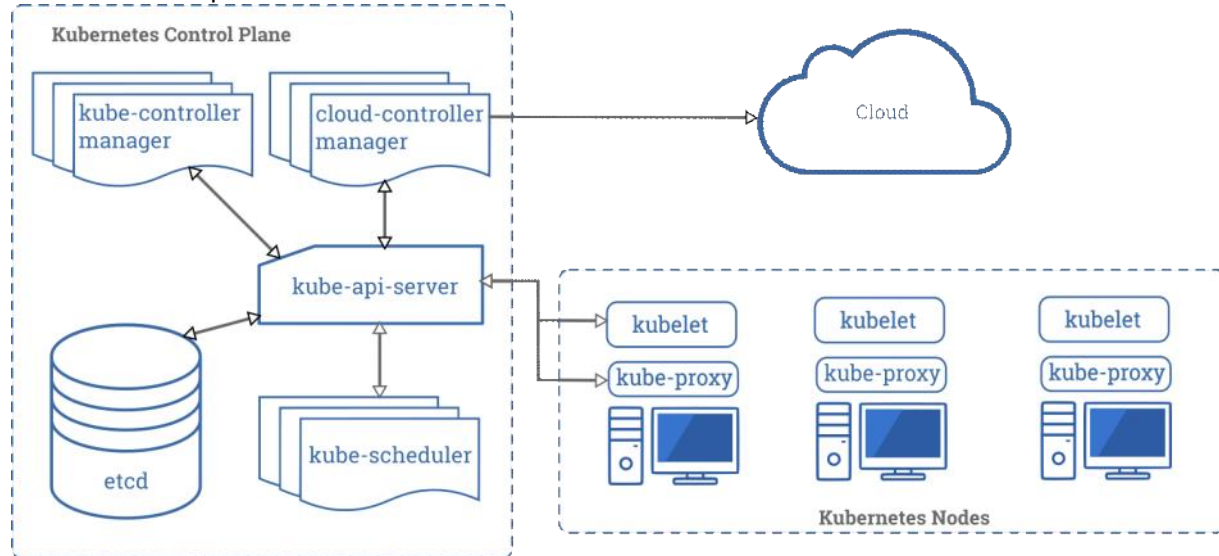
K8S is not PaaS. K8S has some features similar to PaaS (deployment, scaling, load balancing, logging, monitoring), but it operates at the container level with the default solutions being pluggable.

- Doesn't limit the type of application. If it runs in a container, it should run on K8S
- Doesn't build your application. Doesn't deploy source code
- Doesn't provide application-level services like middleware (messaging buses), data-

processing (Spark), databases (PostgreSQL), caches.

- Doesn't dictate logging, monitoring, or alerting solutions. It provides some integrations as PoC and mechanisms to collect and export metrics
- Doesn't provide or mandate a config language/system. It provides a declarative API that may be targeted by arbitrary forms of declarative specifications.
- Does not provide nor adopt any comprehensive machine configuration, maintenance, management, or self-healing systems
- Is not just orchestration. K8S doesn't impose centralized control, but rather is a set of composable control processes that continuously drive the current state towards the provided desired state.

## Kubernetes Components



## Control Plane Components

The Control Plane makes the global decisions for the cluster (scheduling), as well as detecting and responding to cluster events (starting new pods when needed). Control plane components can run on any machine in the cluster, but for simplicity sake they the components are typically run on a single master and no user containers are run on this machine.

- kube-apiserver
  - exposes the k8s api, the frontend for the control plane
- etcd
  - key/value store for all cluster data
- kube-scheduler
  - watches for newly created Pods with no assigned node and chooses the optimal node to run it on.
  - considers individual and collective resource requirements like hardware, software, policy constraints, affinity and anti-affinity specs, data locality, inter-workload interference, and deadlines
- kube-controller-manager
  - Collection of controllers that run controller processes
    - Node Controller
      - Notices and responds when nodes go down
    - Replication Controller
      - Responsible for maintaining the correct number of pods for every replication controller object in the system
    - Endpoints Controller

- Populates the Endpoints object (joins Services & Pods)
- Service Account & Token Controllers
  - create default accounts and API access tokens for new namespaces
- cloud-controller-manager
  - runs controllers that interact with the underlying cloud providers.
  - Provides abstraction between cloud provider evolution and k8s.
    - Node Controller
      - checking the cloud provider to determine if a node has been deleted in the cloud after it stops responding
    - Route Controller
      - Setting up routes in the underlying cloud infrastructure
    - Service Controller
      - creating, updating, and deleting cloud provider load balancers
    - Volume Controller
      - creating, attaching, and mounting volumes, and interacting with cloud provider to orchestrate volumes

### Node Components

Node components run on every node, maintaining pods and providing the K8S environment

- kubelet
  - agent that ensures all containers are running in a Pod
  - Handles only containers that appear in a PodSpec
  - doesn't manage containers not created by k8s
- kube-proxy
  - implements part of the k8s Service concept
    - exposes an application running on a set of Pods as a network service
    - Allow network communication between Pods from session inside or outside of your cluster
- Container Runtime
  - software that is responsible for running containers
  - Supports Docker, containerd, CRI-O and any impl of Kubernetes CRI (Container Runtime Interface)

# Objects

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Kubernetes contains a number of abstractions that represent the state of your system. The abstractions represent deployed containerized applications and workloads, their associated network and disk resources, and other information about the cluster and what it's doing. These abstractions are represented by objects in the Kubernetes API

## Basic Objects

- [Pod](#)
- [Service](#)
- [Volume](#)
- [Namespace](#)

## High level Objects

- [Deployment](#)
- [DaemonSet](#)
- [StatefulSet](#)
- ReplicaSet
- Job

The high level objects rely on controllers to build upon the basic objects.

# Pods

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## What is a Pod

Pods are the basic execution unit of Kubernetes. A pod is the simplest unit in K8S object model that you create or deploy.

Pods are encapsulations of an application's container, storage resources, unique IP, and other container options. A pod is a single instance of an application in K8S which may contain one or more running containers

- Single container pods
  - Most common pattern
  - One container per pod
- Multi-Container Pod
  - Sidecar pattern
  - Tightly coupled containers
  - Typically one container supplies the interface while the others provide support

## Working with Pods

Each Pod is meant to run a single instance of an application. Don't replicate containers in a single pod. Horizontal scaling is accomplished by replicating containers in separate pods, one for each replica. Replicated pods are usually created and managed as a group by a Controller

When Pods are created the kube-scheduler is responsible for finding a node in the cluster that has the resources needed. By their nature Pods are ephemeral, disposable entities. Pods will run on the it's assigned node until terminated, deleted, or evicted. Pods don't self-heal and any event that causes the Pod to fail or it's node to fail will result in the Pod being effected permanently.

## Pods and Controllers

Controllers can easily create and manage multiple pods, handling replication and rollout, provide self-healing.

## Examples of Controllers with one or more Pods

- [Deployment](#)
- [DaemonSet](#)
- [StatefulSet](#)

## Pod Templates

In general Controllers use pod templates to create Pod replicas. A template provides a description of the desired state. There is no entanglement between the template and the pods, any changes to the template will have no direct effect on the pods already created.

```
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
```

```
  labels:
    app: myapp
spec:
  containers:
    ○ name: myapp-container
      image: busybox
      command: ['sh', '-c', 'echo Hello Kubernetes! && sleep 3600']
```

# Deployment

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## What is a Deployment

A deployment provided declarative updates to Pods and ReplicaSets. Simply put a Deployment is a description of Pod templates that are being controlled by a ReplicaSet. Deployments are the easiest way to create and orchestrate replicas of application containers is Kubernetes.

## Creating a Deployment

controllers/nginx-deployment.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: nginx
          image: nginx:1.14.2
          ports:
            - containerPort: 80
```

This example

- Creates a deployment named 'nginx-deployment'
- Creates 3 replicated Pods
- The selector field defines how the deployment finds it's Pods
- The template field describes the Pods

- Pods are labeled 'app: nginx'
- Each Pod runs a container named 'nginx' using the image nginx:1.14.2

#### Complete Deployment

Kubernetes considers a deployment to be complete when

- All replicas have been updated
- All replicas are available
- No old replicas are running

#### Failed Deployment

Deployments can fail and never complete when"

- Insufficient quota
- Readiness probe failures
- Image pull errors
- Insufficient permissions



# Service

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## What is a Service

A service is an abstraction which defines a logical set of Pods and a policy for accessing them. Services provide the abstraction so clients don't have to memorize ephemeral IP addresses.

## Service Discovery

The API server Endpoints controller can be queried for service information. In non-native environments, Kubernetes offers ways to place a network port or load balancer between your application and backend Pods.

## Defining a Service

```
apiVersion: v1
kind: Service
metadata:
  name: my-service
spec:
  selector:
    app: MyApp
  ports:
    - protocol: TCP
      port: 80
      targetPort: 9376
```

This creates a service named my-service (must be valid DNS name). When created Kubernetes will assign it an IP address. The controller for the service continuously scans for Pods that match its selector and updates any updates to an Endpoint object also named "my-service". Traffic incoming on port 80 will be mapped to pod port 9376

## Service Types

There are several types of services used for exposing your application externally.

- **ClusterIP:** Exposes the Service on a cluster-internal IP. This makes the service reachable from inside the cluster. (Default)
- **NodePort:** Exposes the Service on each Node's IP at a static port. A ClusterIP Service to which the NodePort Service routes is automatically created. You can contact the NodePort Service from outside the cluster by contacting <NodeIP>:<NodePort>
- **LoadBalancer:** Exposes the Service externally using a cloud provider's load balancer. NodePort and ClusterIP Services, to which the external load balancer routes, are automatically created.
- **ExternalName:** Maps the Service to the contents of the externalName field (foo.bar.example.com) by returning a CNAME record with its value. No proxying of any kind is setup.

Ingress can also be used to expose a Service. Ingress is not a service type, but it acts as an entry point to the cluster. It can consolidate routing rules into one resource, it can expose multiple services under the

same IP address.

```
Type NodePort
apiVersion: v1
kind: Service
metadata:
  name: client-node-port
spec:
  type: NodePort
  ports:
    - name: serviceport
      port: 3050
      targetPort: 3000
      nodePort: 31515
      protocol: TCP
  selector:
    component: web
```

Defining a NodePort requires us to set up at least one port field. 'nodePort' is how the service will be accessed from outside the cluster. If not specified 'nodePort' will be assigned a random port in the default range of 30000-32767. 'port' is how the service is accessed internally from the clusterIP proxy. 'targetPort' is the mapped Pod port

#### Type ClusterIP

ClusterIP services are used for internal access only. Typically used for one of two reasons.

1. An Ingress and LoadBalancer will be routing external traffic to the service
2. Access will only be allowed to other internal K8S objects

```
apiVersion: v1
kind: Service
metadata:
  name: api-cluster-service
spec:
  type: ClusterIP
  selector:
    component: api
  ports:
    - port: 5000
      targetPort: 5000
```

# Namespace

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## What is a namespace

A virtual k8s cluster inside a physical cluster. K8S supports the creation and management of multiple virtual clusters in a single physical cluster.

## Using multiple namespaces

Namespaces are intended for environments with multiple teams or projects. For clusters with only a few users, namespaces aren't truly necessary.

## Working with namespaces

Kubernetes starts with 3 namespaces

- Default – the default namespace for object with no other namespace
- Kube-system – the namespace for object create by the Kubernetes system
- Kube-public – objects in this namespace are readable by all users (even not authenticated). This namespace is mostly reserved for cluster usage.

## Namespaces and DNS

When a service is created, it will create a DNS entry in the form of <service-name>.<namespace-name>.svc.cluster.local. If a container uses <service-name> the it resolves to the service which is local to that container's Pod's namespace. If you need to access service across namespaces, you need to use the FQDN.

## Creating a Namespace

apiVersion: v1

kind: Namespace

metadata:

name: <insert-namespace-name-here>

# Volume

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Containers by their nature are ephemeral. When a container crashes kubelet will restart it, but the files will be lost. If a pod is running multiple containers it is common for the containers to share file. The Volume abstraction solves the problem.

Volumes in K8S are Pod centric. This means that the volume will live as long as the Pod does providing consistent volume access to any containers running in the Pod. However, if the Pod is ever removed for any reason the Volume will be removed as well. K8S supports different types of volumes and a Pod can use any number of them simultaneously.

## Volume Types

<https://kubernetes.io/docs/concepts/storage/volumes/#types-of-volumes>

# StatefulSet

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## What is a StatefulSet

A Stateful set is similar to a Deployment, but is used to help manage a Stateful application. Unlike Deployments though StatefulSet Pods have a sticky identities. These Pods are created from the same spec, but are not interchangeable. Each of the Pods identities is maintained across any rescheduling.

## Using StatefulSets

StatefulSets are useful for

- Stable, unique network identifiers
- Stable, persistent storage
- Ordered, graceful deployment and scaling
- Ordered, automated rolling updates

## Limitations

- The storage must be pre-provisioned
- Deleting or scaling will not remove the volumes
- StatefulSet require a Headless Service to be responsible for the Pod identity. You must create the Service
- Pods may not be terminated if the StatefulSet is delete. To ensure graceful termination, scale down to 0 first
- When using OrderedReady Rolling Updates it is possible to reach a broken state that requires manual intervention to repair

## Creating a StatefulSet

```
apiVersion: v1
```

```
kind: Service
```

```
metadata:
```

```
  name: nginx
```

```
  labels:
```

```
    app: nginx
```

```
spec:
```

```
  ports:
```

- ```
    - port: 80
      name: web
      clusterIP: None
      selector:
        app: nginx
```

```
---
```

```
apiVersion: apps/v1
```

```

kind: StatefulSet
metadata:
  name: web
spec:
  selector:
    matchLabels:
      app: nginx # has to match .spec.template.metadata.labels
  serviceName: "nginx"
  replicas: 3 # by default is 1
  template:
    metadata:
      labels:
        app: nginx # has to match .spec.selector.matchLabels
    spec:
      terminationGracePeriodSeconds: 10
      containers:
        - name: nginx
          image: k8s.gcr.io/nginx-slim:0.8
          ports:
            - containerPort: 80
              name: web
          volumeMounts:
            - name: www
              mountPath /usr/share/nginx/html
      volumeClaimTemplates:
        - metadata:
            name: www
          spec:
            accessModes: [ "ReadWriteOnce" ]
            storageClassName: "my-storage-class"
            resources:
              requests:
                storage: 1Gi

```

In the above configuration

- A headless service is used to control the network domain
- A StatefulSet with 3 replicated Pods is created
- For a StatefulSet with N replicas, when Pods are being deployed, they are created sequentially, in order from {0..N-1}
- VolumeClaimTemplates will provide a stable storage using Persistent Volumes provisioned by a PersistentVolume Provisioner
- When Pods are being deleted, they are terminated in reverse order, from {N-1..0}.
- Before a scaling operation is applied to a Pod, all of its predecessors must be Running and Ready.
- Before a Pod is terminated, all of its successors must be completely shutdown.

# DaemonSet

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A DaemonSet ensure that all (or some) Nodes run a copy of a Pod. This is useful for

- running a cluster storage daemon, such as glusterd, ceph, on each node.
- running a logs collection daemon on every node, such as fluentd or filebeat.
- running a node monitoring daemon on every node, such as [Prometheus Node Exporter](#), [Flowmill](#), [Sysdig Agent](#), collectd, [Dynatrace OneAgent](#), [AppDynamics Agent](#), [Datadog agent](#), [New Relic agent](#), Ganglia gmond, [Instana Agent](#) or [Elastic Metricbeat](#).

# Ingress

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## What is an Ingress?

An Ingress exposes HTTP and HTTPS routes from outside the cluster to services within the cluster. Traffic routing is defined on the Ingress resource.

To make an effective Ingress you must

- Have created an Ingress Controller
- Don't create an Ingress Controller manually (just use one of the standard like [ingress-nginx](#))

## Creating an Ingress

```
apiVersion: networking.k8s.io/v1beta1
```

```
kind: Ingress
```

```
metadata:
```

```
  name: test-ingress
```

```
  annotations:
```

```
    nginx.ingress.kubernetes.io/rewrite-target: /
```

```
spec:
```

```
  rules:
```

```
  - http:
```

```
    TLSpaths:
```

```
    apiVersion: v1
```

```
      - path: /testpath
```

```
    kind: Secret
```

```
      backend:
```

```
    metadata:
```

```
      serviceName: test
```

```
      name: testsecret-tls
```

```
    namespace: default
```

```
data:
```

```
  tls.crt: base64 encoded cert
```

```
  tls.key: base64 encoded key
```

```
type: kubernetes.io/tls
```

```
apiVersion: networking.k8s.io/v1beta1
```

```
kind: Ingress
```



metadata:

name: tls-example-ingress

spec:

tls:

- hosts:

- sslexample.foo.com

secretName: testsecret-tls

rules:

- host: sslexample.foo.com

http:

paths:

- path: /

backend:

serviceName: service1

servicePort: 80

# Command Ref

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# Intro

Friday, March 20, 2020 1:26 PM

## What is Helm?

Helm is a package manager, similar to Homebrew, Apt, or Yum. Helm makes it easy to install and deploy complex applications in a Kubernetes cluster.

## Three Big Concepts

A Chart is a Helm package, It contains all of the resource definitions to run the workload in your cluster. A Chart is similar to a Homebrew formula, Apt dpkg, or Yum RPM file.

A Repository is the place where charts reside. Repositories make it easy to distribute charts. There are many public repositories available which you can explore at <https://hub.helm.sh>. There is also the Kubernetes public <https://kubernetes-charts.storage.googleapis.com/>.

A Release is an instance of a chart running in a K8S cluster. One chart can often be installed many times into the same cluster. Each Release can then be managed separately from each other.

# Installing Helm

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To install helm please follow the install directions of your choice at [Helm Install](#).

# Command Ref

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## Finding charts

- `helm search hub` searches [the Helm Hub](#), which comprises helm charts from dozens of different repositories.
- `helm search repo` searches the repositories that you have added to your local helm client (with `helm repo add`). This search is done over local data, and no public network connection is needed.

After adding a repo or simply using the public hub.helm.sh you can search for charts using the following syntax.

```
helm search hub wordpress
or
helm search <repo-name> <chart-name>
```

Helm using fuzzy search logic so it is not necessary to know the complete chart name. You can search for parts of the name.

## Installing charts

To install a chart use the `helm install`. The command takes in a release name and the chart name.

```
helm install <release-name> <chart-name>
helm install mischievous-mouse stable/mariadb
```

The release name can be left off and helm will generate a name, just use `--generate-name`

```
helm install stable/mariadb --generate-name
```

When installing charts Helm doesn't wait for all resources to startup. Use `helm status <release-name>` to track the install progress of a chart.

## Customizing an Install

A simple helm install will install the chart with all of its default values. It is possible to customize the install by using `helm show values <chart-name>`

```
helm show values stable/mariadb
```

## Declarative customization

Prior to an install it is possible to place your customized values in a yaml file and pass the file to the install command.

```
echo '{mariadbUser: user0, mariadbDatabase: user0database}' > config.yaml
helm install -f config.yaml stable/mariadb --generate-name
```

Either the `-f` or the `-values` option can be used to pass in a file. These options can be used multiple times in a single install command, the right most file values will have highest precedence.

## Imperative customization

Single customize values can be passed at the command line using the `--set` option. This option can be

used multiple time in a single install command and can be used with the `--values/-f` options as well. The `--set` option will take precedence over `--values/-f` options. Values overridden with `--set` are persisted in a ConfigMap and can be viewed using `helm get values <release-name>`. Those values can also be reset using `helm upgrade <release-name> --reset-values`

#### `--set` formats

The `--set` option is translated to a YAML equivalent

- `--set name=value`
  - `name: value`
- `--set a=b, c=d`
  - `a: b`
  - `c: d`
- `--set outer.inner=value`
  - `outer:`
    - `inner: value`
- `--set name={a,b,c}`
  - `name:`
    - `- a`
    - `- b`

#### Upgrade and Rollback

When a new version of a chart is released or when you want to change the configuration of a release `helm upgrade <release-name>`. Helm will upgrade only parts of the chart that have changed to reduce interference with operation.

If during upgrade a problem occurs during an upgrade use `helm rollback <release-name> <revision>`.  
`helm rollback happy-panda 1`

The previous command will rollback the release name happy-panda to its first revision. Helm will track a release's history with every upgrade. Use `helm history <release-name>` to view a release's history

#### Uninstalling a release

`helm uninstall <release-name>`