Introduction to Kubernetes

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What is container orchestration?

History of Kubernetes

source: https://kubernetes.io/blog/2018/07/20/the-history-of-kubernetes-the-community-behind-it/

Kubernetes (“K8s” or “Kube”, κυβερνήτης > Gr. "helmsman" or "pilot"), originally designed by Google,
now maintained by the Cloud Native Computing Foundation (CNCF).

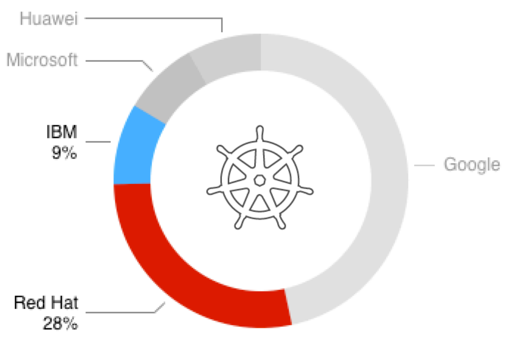
2003-2004, Borg System, Google’s proprietary specific cluster management system,
In 2013... container orchestration existed... but not in cloud and not in the enterprise. Docker changed all of that by popularizing a lightweight container runtime and providing a simple way to package, distribute and deploy applications.

The basic feature set for an orchestrator MVP was:

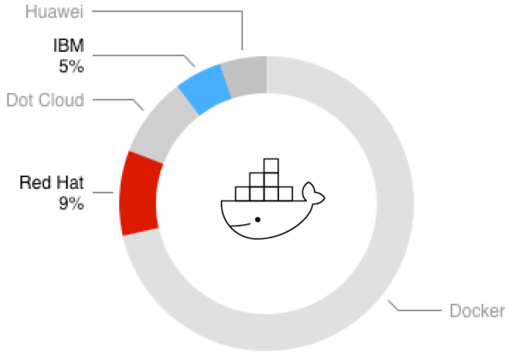
- Replication to deploy multiple instances of an application
- Load balancing and service discovery to route traffic to these replicated containers
- Basic health checking and repair to ensure a self-healing system
- Scheduling to group many machines into a single pool and distribute work to them

June of 2014 , Google open-sourced Kubernetes, as a generic cluster management system. The OpenShift team at Red Hat had joined even prior to launch.
July 21, 2015 , Kubernetes v1.0, Google partnered with the Linux Foundation to form the CNCF.
December 2016, Kubernetes v1.5 introduced Container Runtime Interface (CRI).
June 2017, Kubernetes v1.7 introduced Custom Resource Definitions (CRD)
Current contributors: (1) Google, (2) VMWare, (3) IBM & RedHat, (4) Microsoft, (5) Independent.

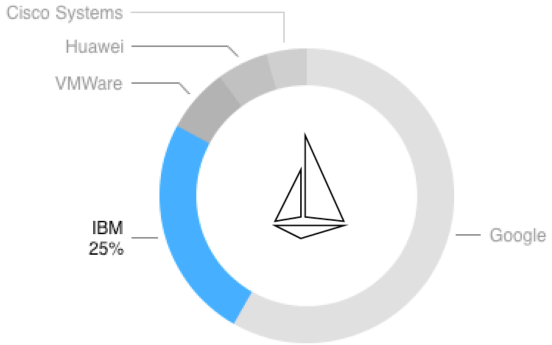
IBM and RedHat contributions to Kubernetes, Docker and Istio projects (top 5 orgs, apart from independent developers)



Top 5 organizations (apart from independent developers) who contribute to **Kubernetes** Open Source Projects



Top 5 organizations (apart from independent developers) who contribute to **Docker** Open Source Projects



Top 5 organizations (apart from independent developers) who contribute to **Istio** Open Source Projects

Container Orchestration

- Provision, manage, scale containers
- Manage resources
  - Volumes
  - Networks
  - Secrets
  - Environment Variables
- Replication
- Service discovery
- Health management
- Cluster management
- Scheduling
- Declarative state management

Benefits:

- Automated scheduling and scaling
- Zero downtime deployments
- High availability and fault tolerance
- A/B deployments

Kubernetes Architecture

- At its core, Kubernetes is a database (etcd) with "watchers" and "controllers" that react to changes in etcd,
- The kube-api-server is an API server that exposes the Kubernetes API,
- The kube-scheduler watches for new Pods not assigned to a node and selects a node to run the Pod on,
- The kube-controller-manager runs the controller loops that make Kubernetes,
- The cloud-controller-manager interacts with the underlying cloud provider,
- The etcd key-value store represents the user defined desired state of the objects,
- The kubelet makes sure that containers are running in a Pod,
- The kube-proxy is a network proxy that maintains network rules on nodes,

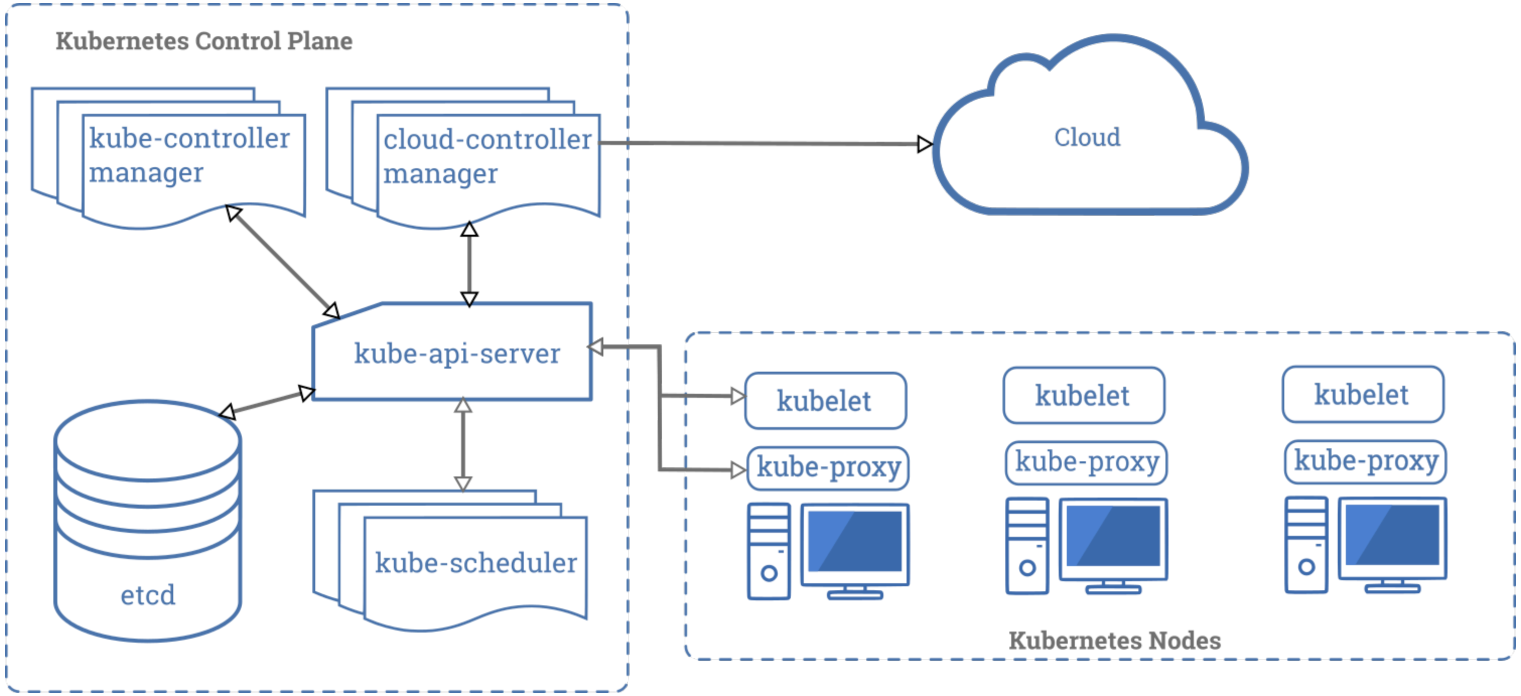


image source: https://kubernetes.io/docs/concepts/overview/components/

Kubernetes Objects

Kubernetes objects are persistent entities in the Kubernetes system. Kubernetes uses these entities to represent the state of your cluster.

Each Kubernetes object includes metadata and two nested object fields:

- the object ”spec” describes the desired state, provided in a .yaml file when you create an object,
- the object ”status” describes the current state.

All Kubernetes objects are considered an API resource and have a corresponding endpoint in the Kubernetes API.

```yaml
kind: Deployment
apiVersion: apps/v1
metadata:
  name: guestbook-v1
  namespace: default
  labels:
    app: guestbook
    version: ‘1.0’
spec:
  replicas: 3
  selector:
    matchLabels:
      app: guestbook
  template:
    metadata:
      labels:
        app: guestbook
    spec:
      containers:
      - name: guestbook
        image: ibmcom/guestbook:v1
        ports:
          - name: http-port
            containerPort: 80
status:
  replicas: 3
  readyReplicas: 3
  availableReplicas: 3
  conditions:
    - type: Available
…
```

API Groups

All Kubernetes objects are considered an API resource and have a corresponding endpoint in the Kubernetes API.

The Kubernetes API is divided into API Groups to make it easier to extend the API, disabling APIs, supporting different versions, support API Plugin.

API groups:

- core,
- apps,
- extensions,
- batch,
- autoscaling,
- storage.k8s.io,
- admissionregistration.k8s.io,
- apiextensions.k8s.io,
- policy,
- scheduling.k8s.io,
- settings.k8s.io,
- apiregistration.k8s.io,
- certificates.k8s.io,
- rbac.authorization.k8s.io,
- authorization.k8s.io,
- networking.k8s.io,
- auditregistration.k8s.io

Kubernetes API - *core*

source: https://kubernetes.io/docs/reference/#api-reference

- Workloads APIs
  - Pod
  - Container
  - ReplicationController
- Service APIs
  - Endpoints
  - Service
- Config and Storage APIs
  - ConfigMap
  - Volume
  - PersistentVolumeClaim
- MetaData APIs
  - Event
  - LimitRange
  - PodTemplate
- Cluster APIs
  - Binding
  - ComponentStatus
  - Namespace
  - Node
  - PersistentVolume
  - ResourceQuota
  - ServiceAccount

apps API Group: deployment.yaml

```yaml
apiVersion: apps/v1beta2
kind: Deployment
metadata:
  name: my-app-deployment
  namespace: my-ns
  labels:
    app: my-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: my-app
  template:
    metadata:
      labels:
        app: my-app
    spec:
      containers:
      -  name: my-app
        image: remkohdev/my-app:latest
        ports:
        -  name: main
          protocol: TCP
          containerPort: 6661
        envFrom:
        - configMapRef:
            name: my-app-configmap
        resources:
          requests:
             memory: "120M"
             cpu: "500m"
```

Kubernetes API – *apps,rbac.authorization.k8s.io*

apps

- Workloads APIs
  - DaemonSet
  - Deployment
  - ReplicaSet
  - StatefulSet
- MetaData APIs
  - ControllerRevision

rbac.authorization.k8s.io

- Cluster
  - ClusterRole
  - ClusterRoleBinding
  - Role
  - RoleBinding

apiextensions

- MetaData APIs
  - CustomResourceDefinition

autoscaling

- MetaData APIs
  - HorizontalPodAutoscaler

Extending Kubernetes

Customization can be divided into:

- configuration,
- Extensions.

You can extend the Kubernetes by using the Controller pattern or the webhook model.
Controllers read a “spec”, do work, and then update the “status”.
When Kubernetes is the client that calls out to a remote service, it is called a Webhook and the remote service is the Webhook Backend.

Extension points:

1. Kubectl, kubectl plugins,
2. Extensions in the apiserver allow authenticating or blocking requests, editing content and handling deletion,
3. Custom Resources (CR) using CustomResourceDefinition API and Operators,
4. Scheduler Extensions,
5. Controllers are often used with CR,
6. Node-level Network Plugins, CNI Plugins or Kubenet plugins,
7. Storage Plugins,

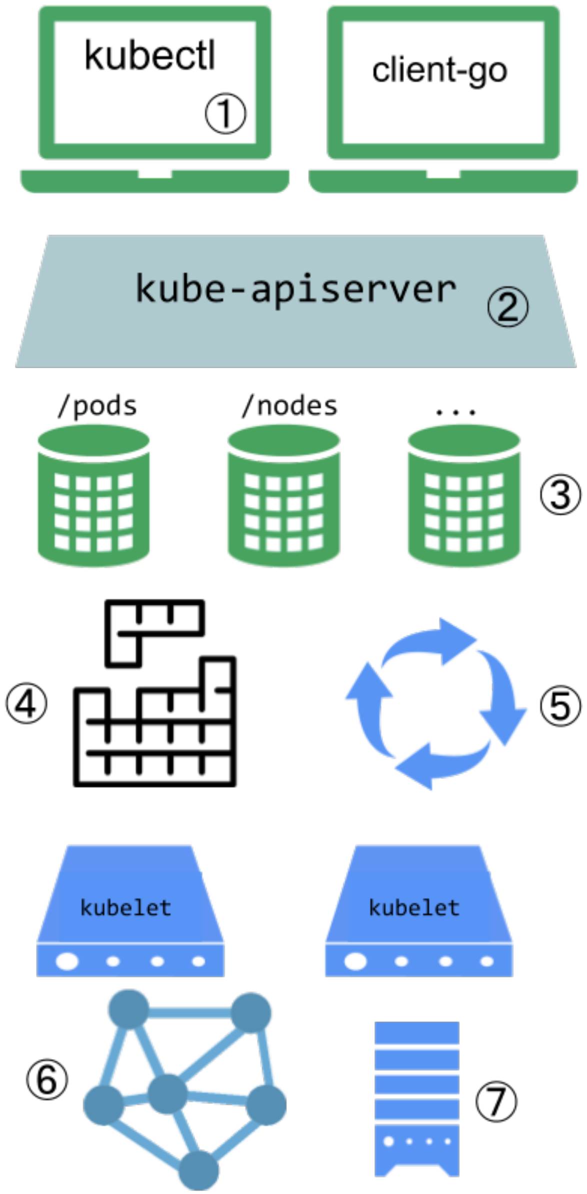


image source: https://kubernetes.io/docs/concepts/extend-kubernetes/extend-cluster/

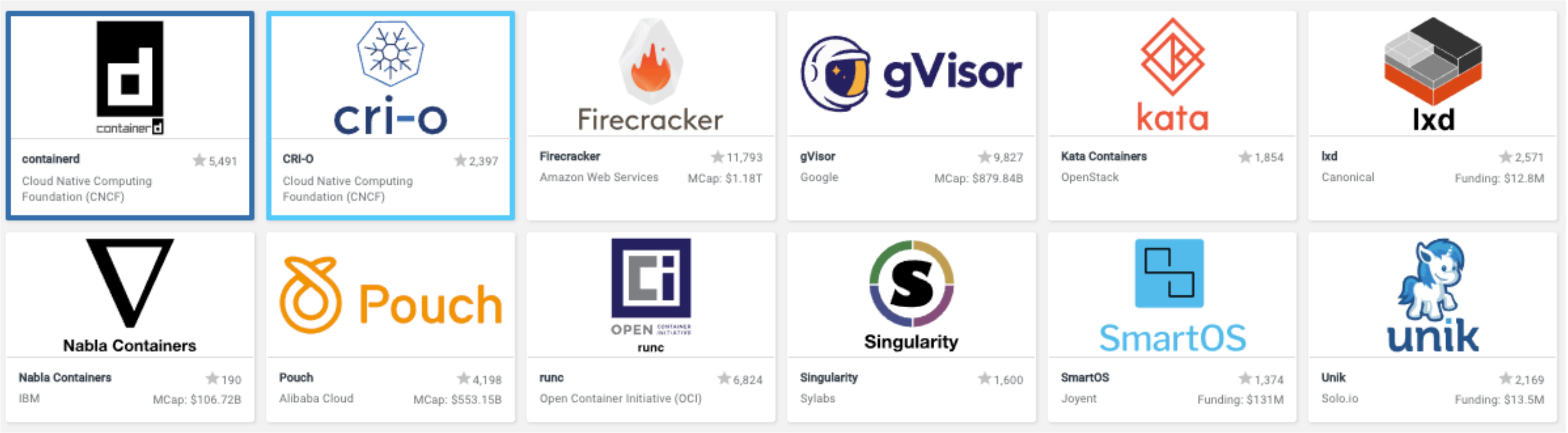
Kubernetes Container Runtime

Kubernetes supports several container runtimes: Docker, containerd, CRI-O, and any implementation of the Kubernetes CRI (Container Runtime Interface), like dockerd, containerd, runc, Kata, Firecracker, singularity.

Kubernetes originally levered Docker for running containers. In December 2014, CoreOS (now RedHat) released “rkt” as an alternative to Docker and initiated *app container* (appc) and *application container image* (ACI) as independent committee-steered specifications, developed into OCI. Kubernetes 1.3 introduced rktnetes that enabled rkt.

On June 22, 2015 the Open Container Initiative (OCI) was announced, formed under the Linux Foundation and launched by Docker, CoreOS and others. The OCI currently contains a Runtime Specification (runtime-spec) and an Image Specification (image-spec).

In December 2016, Kubernetes v1.5 introduced Container Runtime Interface (CRI). Interaction between Kubernetes and any given runtime must use the CRI API. CRI-O was the first container runtime created for the Kubernetes CRI interface.



Kubernetes Client

CLI tool to interact with Kubernetes cluster

Platform specific binary available to download

- https://kubernetes.io/docs/tasks/tools/install-kubectl

The user directly manipulates resources via json/yaml

```
$ kubectl (create|get|apply|delete) -f myResource.yaml
```

Deploy

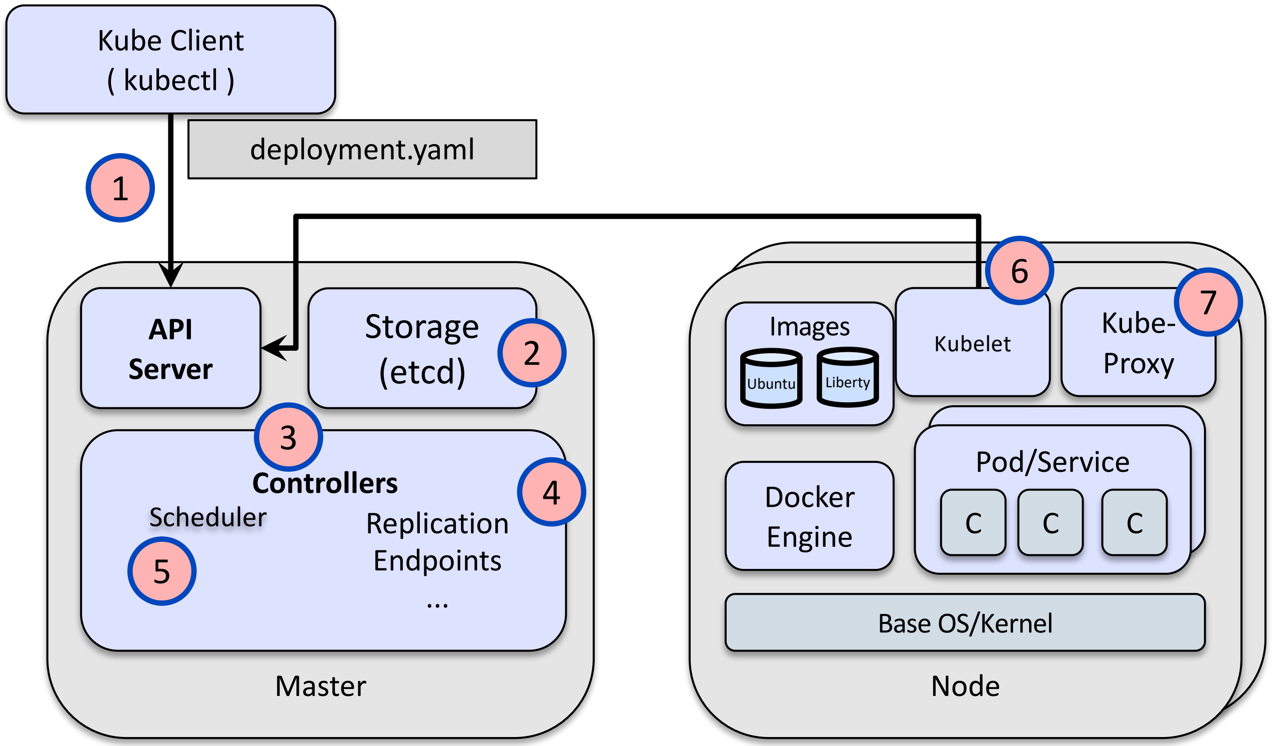
```
# configmap
kubectl delete configmap -n my-ns my-app-configmap
kubectl create -f ./helm/templates/configmap.yaml

# deployment
kubectl delete deployment -n my-ns my-app-deployment
kubectl create -f ./helm/templates/deployment.yaml

# service
kubectl delete svc -n my-ns my-app-svc
kubectl create -f ./helm/templates/svc.yaml
```

Kubernetes in Action

1. User via "kubectl" deploys a new application
2. API server receives the request and stores it in the DB (etcd)
3. Watchers/controllers detect the resource changes and act upon it
4. ReplicaSet watcher/controller detects the new app and creates new pods to match the desired # of instances
5. Scheduler assigns new pods to a kubelet
6. Kubelet detects pods and deploys them via the container runing (e.g. Docker)
7. Kubeproxy manages network traffic for the pods – including service discovery and load-balancing



Demo - IBM Kubernetes Service

Thank You