Kubernetes for Newbies

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Overview

- Linux Containers
  - Quick intro / recap
  - System Containers vs. Application Containers
- Kubernetes - What is it?
- Kubernetes Pod
- Kubernetes Deployment
- Kubernetes Service
- Summary
- Future Topics

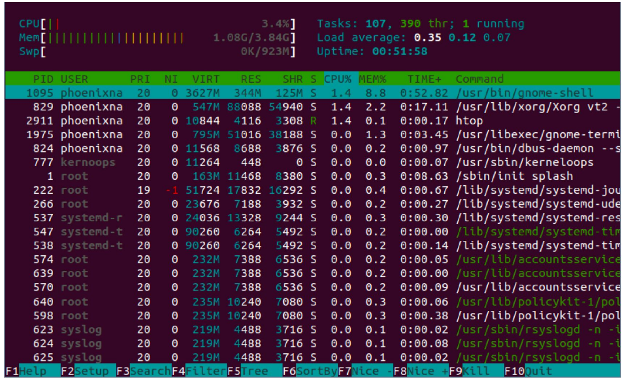
Linux Containers - Quick Intro / Recap

- A lightweight method for running multiple isolated applications under one Linux host
- **Feature - Portability**
  - Each container encapsulates its dependencies
  - Ensures consistent behavior across environments
- **Feature - Efficiency**
  - Containers share the host's kernel
  - Lower overhead compared to traditional virtualization
- **Feature - Scalability**
  - Containers can be spun up or shut down quickly
  - Enables rapid deployment and scaling of applications
- **Feature - Versioning / Rollback**
  - Containers support versioning
  - Facilitates easy (automatable) rollbacks

System Containers vs. Application Containers

System Containers:

- Running system-level processes and services
    - Like a mini virtual machine
- A lightweight environment for system-level tasks
- Designed to encapsulate and deploy components of the operating system
    - System daemons - systemd, cron, rsyslog, etc.
- No goal to decouple services any more than a traditional VM or bare-metal host
- Examples
    - LXC / LXD



```
  CPU[||                           3.4%]   Tasks: 107, 390 thr; 1 running
  Mem[||||||||||||||||||||   1.08G/3.84G]   Load average: 0.35 0.12 0.07
  Swp[                          0K/923M]   Uptime: 00:51:58

    PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
   1095 phoenixna  20   0 3627M  344M  125M S  1.4  8.8  0:52.82 /usr/bin/gnome-shell
    829 phoenixna  20   0  547M 88088 54940 S  1.4  2.2  0:17.11 /usr/lib/xorg/Xorg vt2 -
   2911 phoenixna  20   0 10844  4116  3308 R  1.4  0.1  0:00.17 htop
   1975 phoenixna  20   0  795M 51016 38188 S  0.0  1.3  0:03.45 /usr/libexec/gnome-termi
    824 phoenixna  20   0 11568  8688  3876 S  0.0  0.2  0:00.97 /usr/bin/dbus-daemon --s
    777 kernoops   20   0 11264   448     0 S  0.0  0.0  0:00.07 /usr/sbin/kerneloops
      1 root       20   0  163M 11468  8380 S  0.0  0.3  0:08.63 /sbin/init splash
    222 root       19  -1 51724 17832 16292 S  0.0  0.4  0:00.67 /lib/systemd/systemd-jou
    266 root       20   0 23676  7188  3932 S  0.0  0.2  0:00.27 /lib/systemd/systemd-ude
    537 systemd-r  20   0 24036 13328  9244 S  0.0  0.3  0:00.30 /lib/systemd/systemd-res
    547 systemd-t  20   0 90260  6264  5492 S  0.0  0.2  0:00.00 /lib/systemd/systemd-tim
    538 systemd-t  20   0 90260  6264  5492 S  0.0  0.2  0:00.14 /lib/systemd/systemd-tim
    574 root       20   0  232M  7388  6536 S  0.0  0.2  0:00.05 /usr/lib/accountsservice
    639 root       20   0  232M  7388  6536 S  0.0  0.2  0:00.00 /usr/lib/accountsservice
    570 root       20   0  232M  7388  6536 S  0.0  0.2  0:00.09 /usr/lib/accountsservice
    640 root       20   0  235M 10240  7080 S  0.0  0.3  0:00.06 /usr/lib/policykit-1/pol
    598 root       20   0  235M 10240  7080 S  0.0  0.3  0:00.38 /usr/lib/policykit-1/pol
    623 syslog     20   0  219M  4488  3716 S  0.0  0.1  0:00.02 /usr/sbin/rsyslogd -n -i
    624 syslog     20   0  219M  4488  3716 S  0.0  0.1  0:00.08 /usr/sbin/rsyslogd -n -i
    625 syslog     20   0  219M  4488  3716 S  0.0  0.1  0:00.02 /usr/sbin/rsyslogd -n -i
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

System Containers vs. Application Containers

Application Containers:

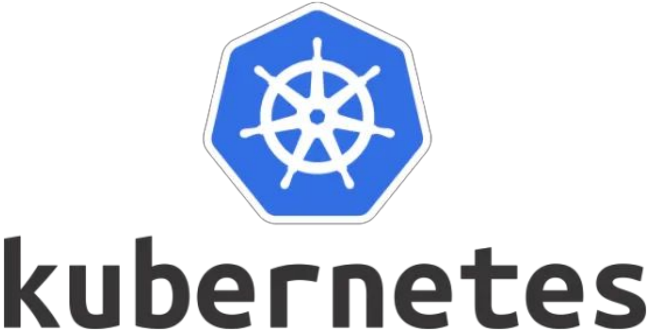
- Designed to encapsulate individual applications and their dependencies
  - Fosters portability across different environments
  - Enables a microservices architecture
- Optimizes performance and scalability for the application itself
  - Avoids oversubscribing resources for more efficient use of host resources
- Examples
  - Docker
  - Containerd
  - Podman
  - CRI-O
  - Kubernetes

Containers - The Challenges

- Container runtime provides an a single host where an application can run
- Moving containerized applications from single hosts to production-worthy services requires some "extras"
- Challenges to consider:
  - Shared file systems, configurations, secrets
  - Networking across redundant hosts
  - Load balancing across instances of a service
  - Scheduling - i.e. where to provision container workload
  - Distribution - i.e how to deploy the container workload
  - etc.

Kubernetes - What is it?

- K8s = Kubernetes
- K8s is an open-source container orchestration platform
- Automates the deployment, scaling, and management of containerized applications across a set of hosts (cluster)
- Supports load balancing, rolling updates, and application monitoring / scheduling



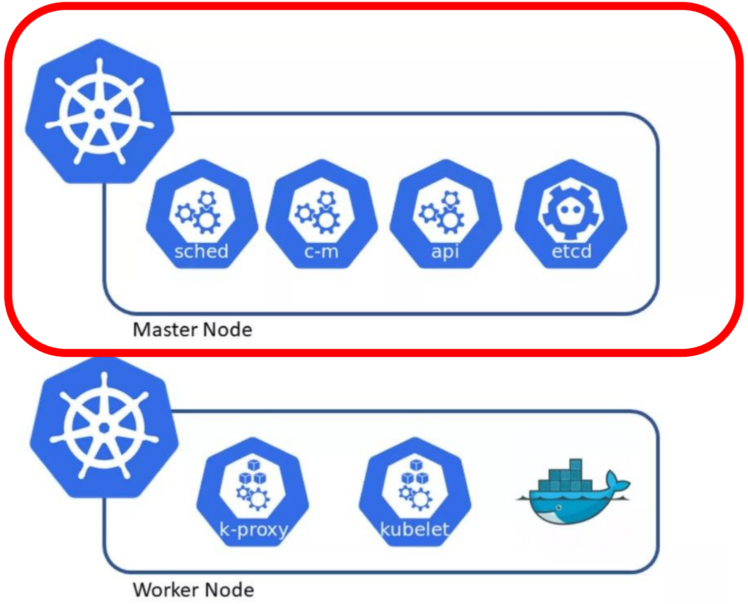
Kubernetes - History

- **2003-2004 - Borg**
  - Progenitor container orchestration platform built at Google to manage many applications
- **2014 - Kubernetes open-sourced**
  - Google engineers build a new open source orchestrator based on Borg
    - Written in the Go programming language
- **2015 - Kubernetes 1.0 released**
  - In conjunction, Google partners with the Linux Foundation
    - Forms the Cloud Native Computing Foundation (CNCF)
  - CNCF goes on to host many open source projects - containerd, prometheus, etcd, etc.
- **2017 - Winner of the container wars**
  - Industry rallies around K8S - Docker, Microsoft AKS, Amazon EKS, etc.
- **Today**
  - Continues to evolve with a strong community contributing to its future

Kubernetes - Architecture

Control plane (master) nodes

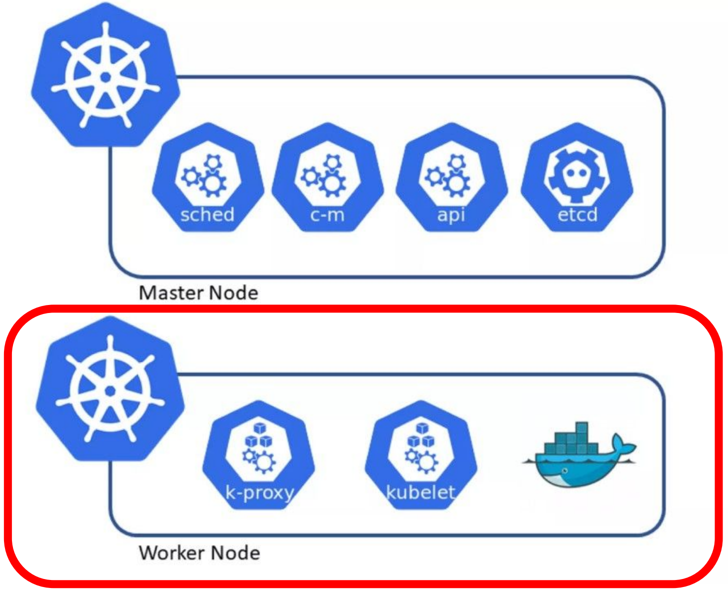
- **kube-apiserver** - Exposes Kubernetes API for cluster management.
- **kube-controller-manager** - Manages desired cluster state via controllers.
- **kube-scheduler** - Assigns Pods to nodes based on resources.
- **etcd** - Distributed key-value store for cluster data.
- … and many more depending on your environment.



Kubernetes - Architecture

Worker nodes

- **kubelet** - Agent running on workers, executing instructions from the control plane.
- **container runtime** - Software responsible for running containers (e.g. containerd).
- **kube-proxy** - Maintains network rules and enables communication across the cluster.
- **CNI (Container Network Interface)** - Plugin enabling Pod networking across nodes.



Minikube Prep

Note - Assumes container runtime installed (e.g. Docker)

Install minikube

```
$ curl -LO \
https://storage.googleapis.com/minikube/releases/latest/minikube-linux-amd64

$ sudo install minikube-linux-amd64 /usr/local/bin/minikube
```

Install kubectl

```
$ curl -LO "https://dl.k8s.io/release/$(curl -L -s
https://dl.k8s.io/release/stable.txt)/bin/linux/amd64/kubectl"

$ sudo install kubectl /usr/local/bin/kubectl
```

Minikube Init

Start Cluster

```
$ minikube start --nodes 2 -p newbie-demo

$ minikube status -p newbie-demo

$ minikube ssh -p newbie-demo -n newbie-demo # control plan

$ minikube ssh -p newbie-demo -n newbie-demo-m02 # worker
```

Nodes Provisioned

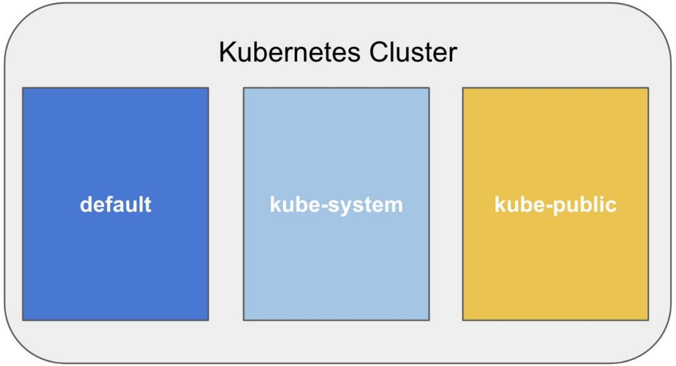
```
$ kubectl get nodes

$ kubectl describe nodes
```

Namespaces

- **Resource Partitioning** - Divides cluster resources into logical groups.
- **Isolation** - Securely share cluster with multiple teams.

Create a namespace:

```
$ kubectl create namespace newbie-ns

$ kubectl get namespace

$ kubectl describe namespace
```



Namespace: kube-system

- **System Components** - Dedicated namespace for essential system components and infrastructure services.
- **Critical Operations** - Hosts management components (schedulers, controllers, network plugins, etc.) essential for cluster operations.
- **Isolation** - Helps isolate critical system components from user workloads, enhancing security and maintainability.

```
$ kubectl get namespace kube-system
```

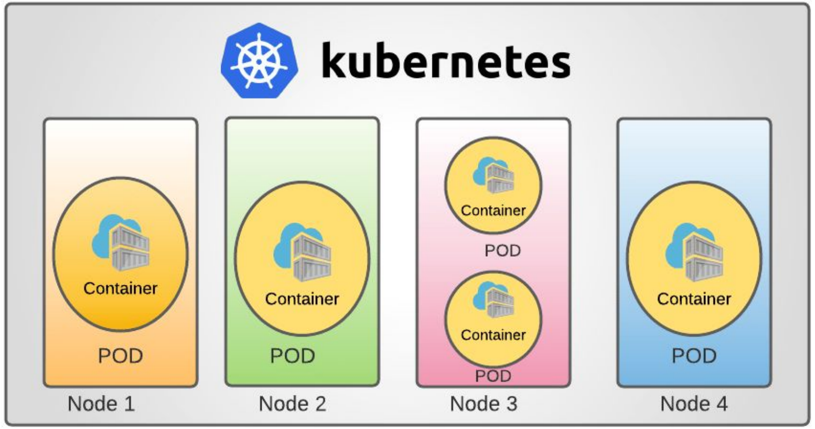
```
$ kubectl describe namespace kube-system
```

Run a K8S Pod

```
# Create a Pod imperatively

$ kubectl run nginx-pod --image=nginx:latest --restart=Never

$ kubectl delete pod nginx-pod

# Create a Pod declaratively

$ kubectl apply -f k8s/nginx-pod.yaml
```

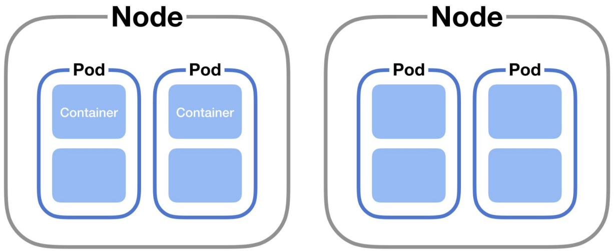
Take a Look at the Pod

```
$ kubectl get pod nginx-pod [-o wide] [-o yaml]

$ kubectl describe pod nginx-pod

$ kubectl logs nginx-pod

$ kubectl exec -it nginx-pod - /bin/bash

    $ curl inside the container

$ docker ps  # check the containers

$ kubectl port-forward nginx-pod 8080:80
```



K8S Pod

- **Basic Unit** -The smallest unit in the Kubernetes object model
- **Isolation** - Pod processes and resource allocations are segregated
  - Helps secure Pod interactions with the rest of the cluster
  - Caps resources at the Pod level to protect other workloads in the cluster
- **Shared Resources** - Containers within a Pod share the same IP and ports
  - Enables easy communication over the localhost
- **Lifespan** - Pods can have a short lifespan
  - Easily created, terminated, and replaced based on the application's requirements.



Run a K8S Deployment

```
# Create a deployment imperatively

kubectl create deployment nginx-deployment --image=nginx:latest

kubectl scale deployment  nginx-deployment –replicas=3

kubectl delete deployment nginx-deployment

# Create a deployment declaratively

kubectl apply -f k8s/nginx-deployment.yaml
```

Take a Look at the Deployment

```
$ kubectl get pod nginx-deployment [-o wide] [-o yaml]

$ kubectl describe pod nginx-deployment

$ kubectl get pods

$ kubectl logs … # using pod names discovered

$ docker ps  # check the containers
```

K8S Deployment

- Scalability -: Scale applications up or down by adjusting replica counts.
- Automated Load Balancing - Built-in load balancing for even distribution of traffic.
- Self-healing - Health checks and automatic replacement of unhealthy pods for high reliability.
- Rolling Updates - Updates without downtime, with quick rollback options.

- … this is where K8S value starts to show

Run a K8S Service

```
# Expose the deployment imperatively

kubectl expose deployment nginx-deployment \

  –name=nginx-service --port=80 --type=NodePort

kubectl delete service nginx-service

# Expose the deployment declaratively

kubectl apply -f k8s/nginx-service.yaml
```

Take a Look at the Service

```
kubectl get service nginx-service

kubectl describe service nginx-service

kubectl get endpoints nginx-service

NODE_IP=$(kubectl get nodes -o jsonpath='{.items[0].status.addresses[0].address}')

NODE_PORT=$(kubectl get service nginx-service -o jsonpath='{.spec.ports[0].nodePort}')

curl $NODE_IP:$NODE_PORT

kubectl logs <pod-name>
```

K8S Service

- Load Balancing - Efficiently distributes incoming traffic among pods.
- Service Discovery - Provides a stable endpoint for communicating with pods.
- Dynamic Management - Organizes and manages pods dynamically using labels for scalability and updates.
- Communication Flexibility - Facilitates both internal cluster communication and external requests.

Clean-up

```
$ minikube delete -p newbie-demo

$ minikube status -p newbie-demo
```

Summary

Possible Future Discussions

- Orchestration
  - Hashicorp Nomad
  - K8S ConfigMaps, Secrets, Persistent Volumes
  - K8S Ingress, Gateway
- Monitoring
  - Prometheus / Grafana
  - ELK / EFK
- Messaging
  - RabbitMQ / ActiveMQ
- Data Pipelines
  - Airflow / Dagster
- Other ideas welcome!

Backup Slides

Exercise 1 - ...

Setup:

```
$
```

Try:

```
$
```