

# Kubernetes (k8s)

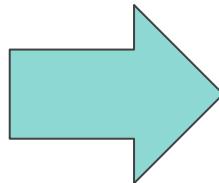
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# Training Objectives

At the end of training,  
participants should be able to



- Know Kubernetes and Be a Helmsman
- Create and run PODs
- Bundle applications & Deploy
- Service apps using Load Balancers
- Troubleshoot

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Practicals	Practicals		
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Practicals			



# Docker

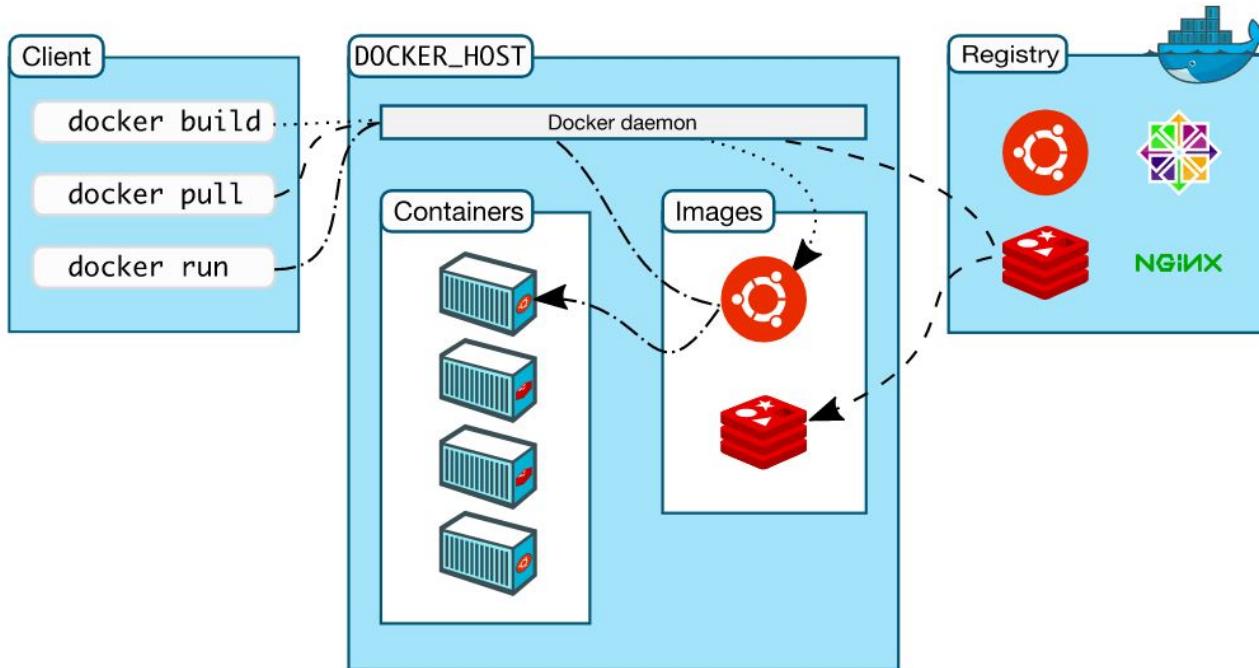
- Overview
- Dockerfile
- Images & Containers
- Registry
- Jenkins / CI
- Demo



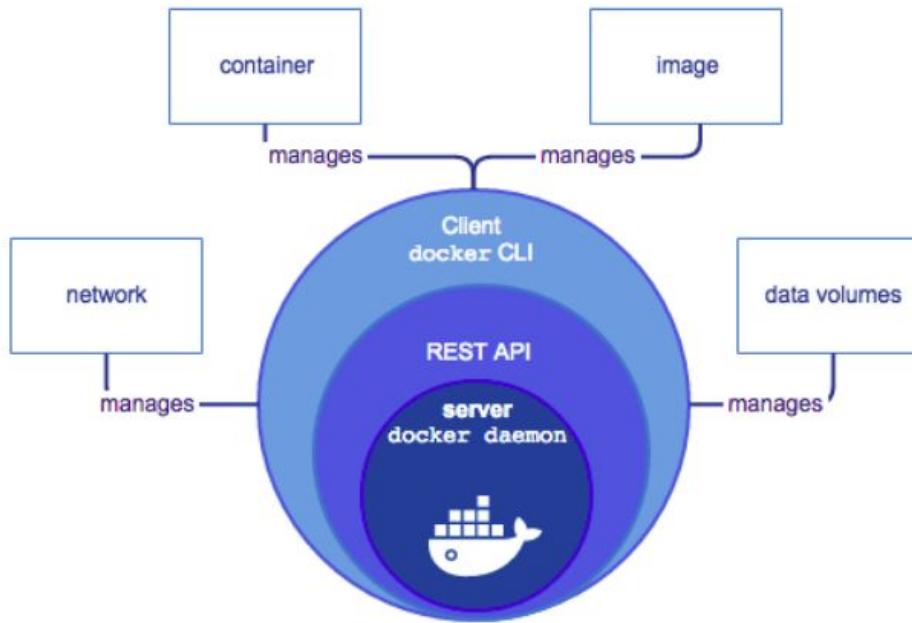
# Containers - Benefits

- Flexible: Even the most complex applications can be containerized.
- Lightweight: Containers leverage and share the host kernel.
- Interchangeable: You can deploy updates and upgrades on-the-fly.
- Portable: You can build locally, deploy to the cloud, and run anywhere.
- Scalable: You can increase and automatically distribute container replicas.
- Stackable: You can stack services vertically and on-the-fly
- Running more workload on the same hardware

# Docker Architecture



# Docker Architecture



# Introducing the Dockerfile

A Dockerfile is a text document that contains

- a set of instructions required to assemble the app (image) and/ run it

**Usage:**

```
docker build [OPTIONS] PATH | URL | -
```

Options:

--add-host list	Add a custom host-to-IP mapping (host:ip)
--compress	Compress the build context using gzip
--cpu-quota int	Limit the CPU CFS (Completely Fair Scheduler) quota
-f, --file string	Name of the Dockerfile (Default is 'PATH/Dockerfile')
--force-rm	Always remove intermediate containers
--label list	Set metadata for an image
-m, --memory bytes	Memory limit
--pull	Always attempt to pull a newer version of the image
--rm	Remove intermediate containers after a successful build (default true)
-t, --tag list	Name and optionally a tag in the 'name:tag' format



# Introducing the Dockerfile

Example:

- docker build -f Dockerfile .

```
rajesh@rajesh-Gazelle:~/git/dockers/trainora-aug/images/simple$ cat Dockerfile
FROM alpine:latest

MAINTAINER rajesh@unigps.in
```



# Introducing the Dockerfile

Few more variations:

- docker build -t myfirstimage -f Dockerfile .
- docker build -f /home/rajesh/git/dockers/trainora-aug/images/simple/Dockerfile-myfirstimage .
- docker build -t myfirstimage -f ./simple/Dockerfile ./simple/
- docker build -t myimage -t rajesh/myimage:1.0.0 -t localhost:5000/rajesh/myimage:1.0.0 .



# Introducing the Dockerfile

- ENV - to set environment variables
- EXPOSE - to expose ports
- FROM - base image
- LABEL - to add metadata to image
- HEALTHCHECK - to check if container is running
- USER - to set user and group
- VOLUME - to specify mount point from external host
- WORKDIR - workdir to run any of the commands



# Introducing the Dockerfile

- ARG - variable used during build time
- CMD - to provide defaults to executing container
- RUN - to execute commands in new layer
- COPY - Copy file, dir or remote url to image
- ADD - Copy file, dir or remote url to image
- ENTRYPOINT - to configure container as executable
- MAINTAINER - the image maintainer

RUN COPY ADD instructions create new layers in the image stack - refer layering section



# Building Images (Python)

```
rajesh@rajesh-Gazelle:~/git/dockers/trainora-aug/images/python$ cat Dockerfile
```

```
FROM python:2.7-slim
WORKDIR /app
ADD app.py /app
ADD requirements.txt /app
RUN pip install --trusted-host pypi.python.org -r requirements.txt
EXPOSE 80
ENV name world
CMD ["python","app.py"]
```

## Build

- docker build -t mypython .

## Run

- docker run -p 80:80 mypython



# Dockerfile - Example (Apache)

```
FROM bitnami/minideb-extras:jessie-r23
LABEL maintainer "Bitnami <containers@bitnami.com>

# Install required system packages and dependencies
RUN install_packages libapr1 libaprutil1 libc6 libexpat1 libffi6 libgmp10 libgnutls-deb0-28 libhogweed2 libldap-2.4-2 libnettle4
libp11-kit0 libpcre3 libsasl2-2 libssl1.0.0 libtasn1-6 libuuid1 zlib1g
RUN bitnami-pkg unpack apache-2.4.29-1 --checksum
42114e87aafb1d519ab33451b6836873bca125d78ce7423c5f7f1de4a7198596
RUN ln -sf /opt/bitnami/apache/htdocs /app

COPY rootfs /

ENV APACHE__HTTPS_PORT_NUMBER="443" \
    APACHE__HTTP_PORT_NUMBER="80" \
    BITNAMI_APP_NAME="apache" \
    BITNAMI_IMAGE_VERSION="2.4.29-r1" \
    PATH="/opt/bitnami/apache/bin:$PATH"

EXPOSE 80 443

WORKDIR /app
ENTRYPOINT ["/app-entrypoint.sh"]
CMD ["nami","start","--foreground","apache"]
```



# Dockerfile - Example (Jenkins CI)

```
FROM jenkinsci/jenkins:latest
LABEL maintainer "r1co@post-box.cc"

USER root

# install docker cli
RUN mkdir -p /tmp/_install && cd /tmp/_install && wget https://get.docker.com/builds/Linux/x86_64/docker-latest.tgz && tar -xvzf docker-latest.tgz && cd docker && cp docker /usr/bin/docker && rm -rf /tmp/_install
RUN chmod +x /usr/bin/docker
# add jenkins to docker group
RUN groupadd -g 999 docker
RUN usermod -a -G docker jenkins
# install docker-compose
RUN curl -L https://github.com/docker/compose/releases/download/1.7.1/docker-compose-`uname -s`-`uname -m` >
/usr/local/bin/docker-compose
RUN chmod +x /usr/local/bin/docker-compose
USER jenkins
```



# Dockerfile - Example (Multi stage)

```
FROM golang:1.7.3 AS builder
WORKDIR /go/src/github.com/alexellis(href-counter/
RUN go get -d -v golang.org/x/net/html
COPY app.go .
RUN CGO_ENABLED=0 GOOS=linux go build -a -installsuffix cgo -o app .

FROM alpine:latest
RUN apk --no-cache add ca-certificates
WORKDIR /root/
COPY --from=builder /go/src/github.com/alexellis(href-counter/app .
CMD ["../app"]
```



# Docker Hub - store & retrieve

<https://hub.docker.com> (register and create login)

- docker tag alpine rajeshgheware/alpine:rajesh
- docker push rajeshgheware/alpine:rajesh
- docker pull rajeshgheware/alpine:rajesh



# Registry Server

- With no docker volume (uses default volume for container)
  - `docker run -d -p 5000:5000 --name registry registry:2`
  - `docker push localhost:5000/rajesh/alpine:test`
  - `Docker pull localhost:5000/rajesh/alpine:test`
- With docker volume
  - `docker volume create docker_registry`
  - `docker run -d -p 5000:5000 -v docker_registry:/var/lib/registry --name registry registry:2`
  - `docker container stop registry && docker container rm -v registry`
- With Volume Mount on Host
  - `docker run -d -p 5000:5000 -v /media/deepti/Ubuntu/home/docker_registry:/var/lib/registry --name registry registry:2`



# Build Image using CI / Jenkins



Develop

Build

Package



**GitHub**



**Jenkins**



**DockerHub**

```
docker run -p 8080:8080 -p 50000:50000 -v /var/run/docker.sock:/var/run/docker.sock r1co/jenkins-docker
```

<https://jenkins.io/doc/tutorials/build-a-node-js-and-react-app-with-npm/> (ci for node reactjs build with pipeline)

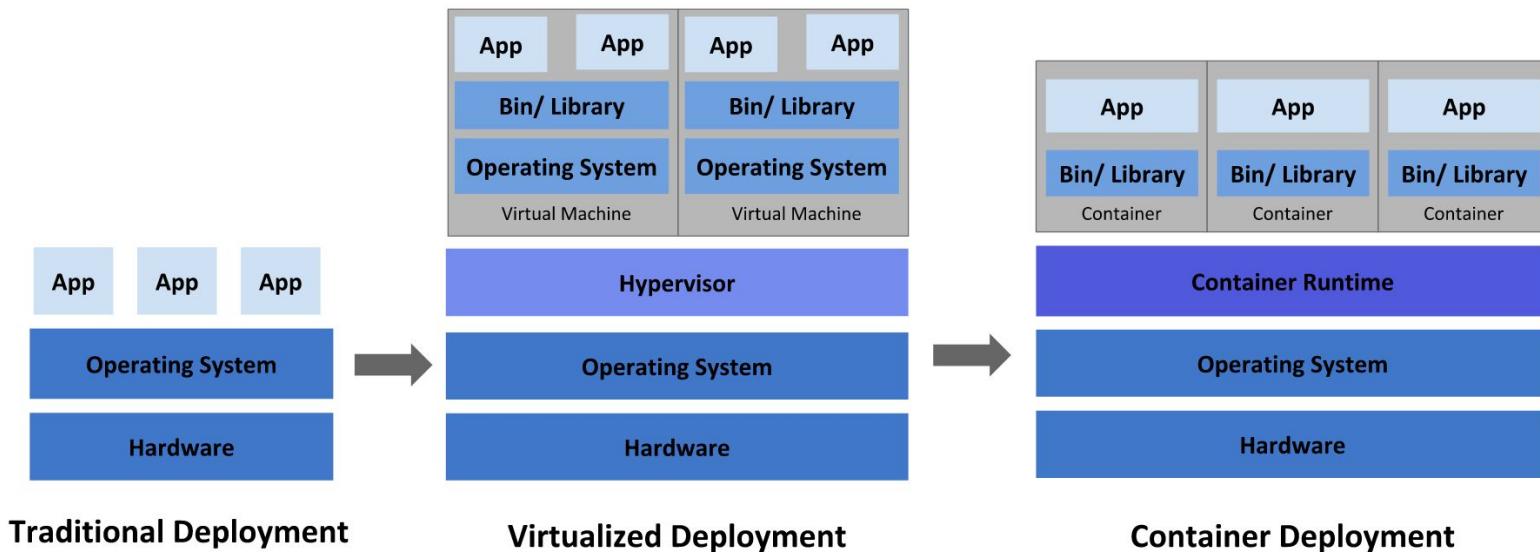


# Kubernetes Core

- Architecture
- Components
  - Master Components
  - Node Components
  - Add ons
- API Primitives
- Kubectl
- Demo
- Practicals



# Deployment - Journey





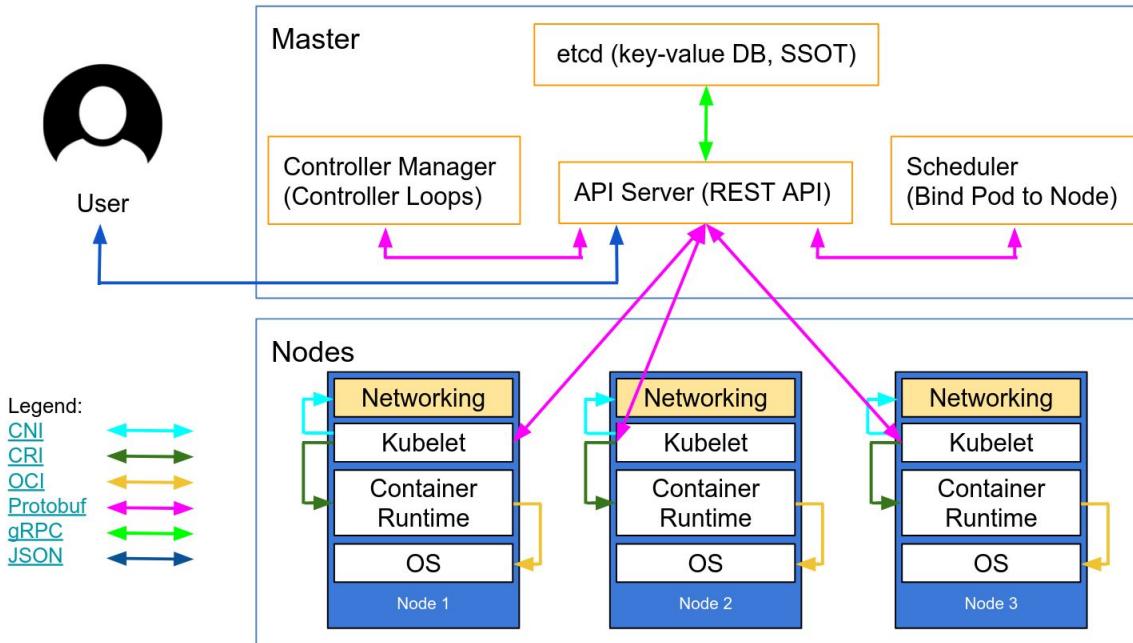
# What is / why Kubernetes

**Kubernetes** - Helmsman (in ancient greek): Guy who steers ship / boat

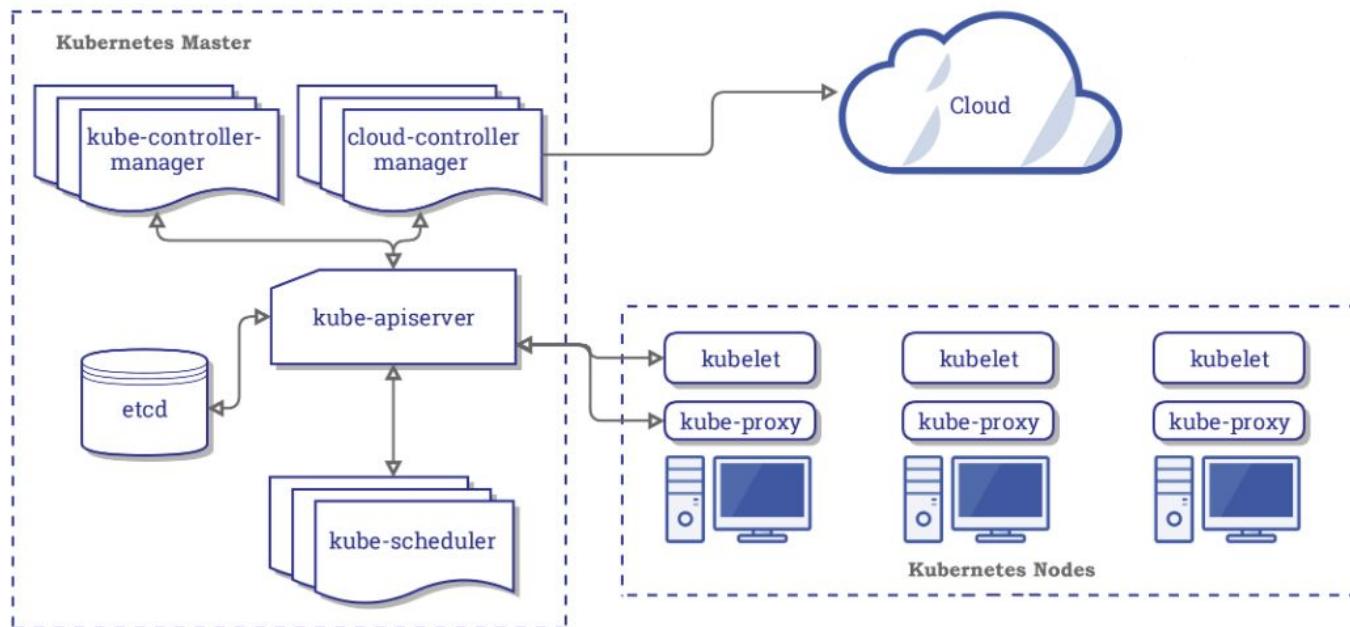
## Why Kubernetes?

- Service Discovery & Load Balancing
- Storage Orchestration
- Automated rollouts & rollbacks
- Automatic bin packing
- Self-healing
- Secret and configuration Management

# Architecture - Overview



# Architecture (view 2)





# Master Components - ETCD

- Distributed reliable key-value store that is simple, secure & fast
- Uses RAFT based consensus algorithm to work in distributed environment
- Key value store distributed database
- Runs on port 2379



# Master Components - API Server

- The central management entity
- Only component that connects to ETCD
- Designed for horizontal scaling

Connectivity:

- External: kubectl
- Internal: kubelet
- Persistent Storage: ETCD



# Master Components - Scheduler

Schedules pods on appropriate Node(s)

Watches for newly created PODs that have no nodes assigned

Decision Parameters:

- Resource requirements (memory, cpu, disk type say SSD)
- Hardware, Software, Policy requirements
- Affinity, Anti-affinity
- Data locality
- Inter workload interference
- Deadlines



# Master Components - Kube Controller

- Node Controller
  - Responsible for noticing and responding 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 (that is, joins Services & Pods)
- Service Account & token Controller
  - Create default accounts and API access tokens for new namespaces



# Master Components - Cloud Controller

- Route Controller
  - For checking the cloud provider to determine if a node has been deleted in the cloud after it stops responding
- Service Controller
  - For setting up routes in the underlying cloud infrastructure
- Service Controller
  - For creating, updating and deleting cloud provider load balancers
- Volume Controller
  - For creating, attaching, and mounting volumes, and interacting with the cloud provider to orchestrate volumes



# Node Components - kube-proxy

- Network proxy that runs on every node in cluster
- Maintains network rules on nodes
- Uses OS packet filtering layer else forwards traffic itself



# Node Components - Container RT

- Docker
- Containerd
- cri-o
- rktlet

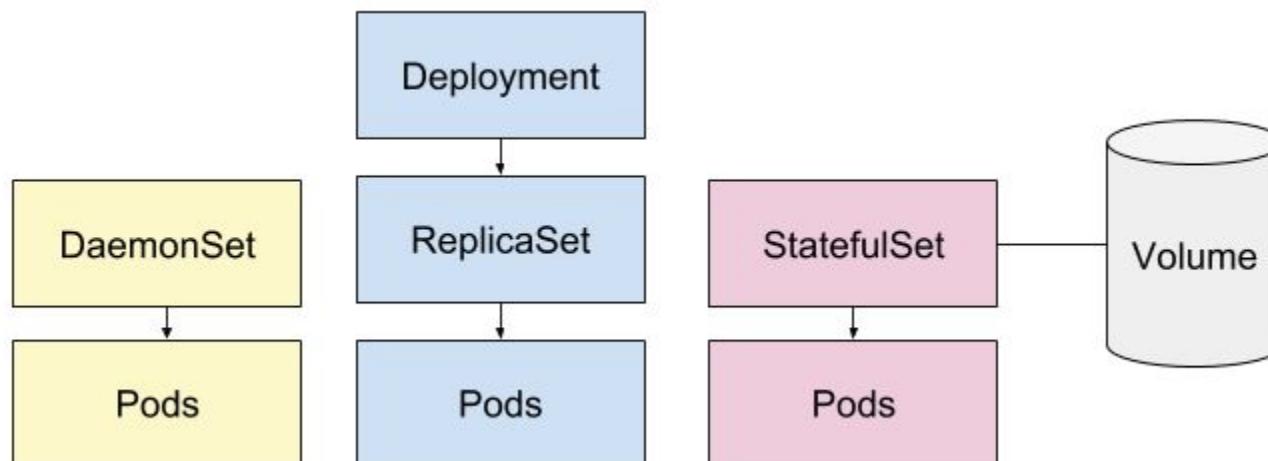


# Addon Components

- Cluster DNS
  - Cluster DNS is a DNS server, in addition to the other DNS server(s) in your environment, which serves DNS records for Kubernetes services
- Web UI
  - General purpose, web-based UI for Kubernetes clusters to view and manager cluster
- Container Resource Monitoring
  - Generic time-series metrics about containers in a central database, and provides a UI for browsing that data
- Cluster level Logging
  - Mechanism responsible for saving container logs to a central log store with search/browsing interface

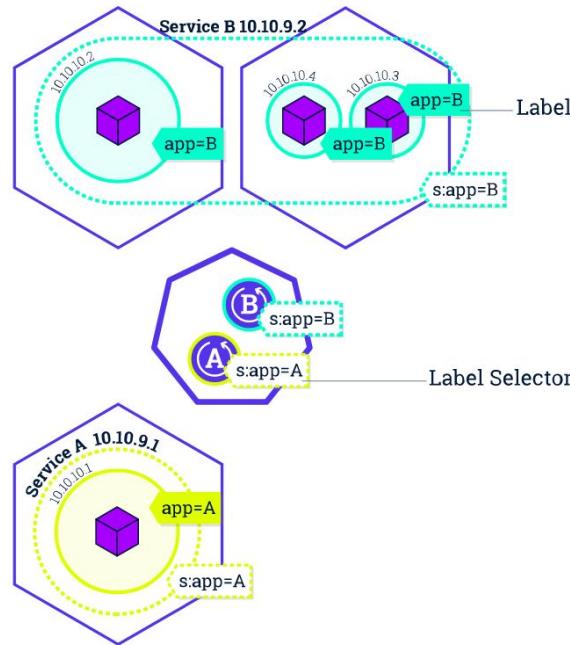


# Objects





# Objects





# Node Components - kubelet

- Runs on every node
- Ensures containers are running & healthy in PODs
- Doesn't manage container not created by K8S



# Kubectl

**Command line tool to control kubernetes cluster**

- Imperative commands to manage objects (basic & intermediate)
- Deploy commands
- Cluster Management commands
- Troubleshooting and Debugging
- Advanced, Settings and Other



# kubectl - commands

- kubectl get pods
- kubectl describe pod hello-world
- kubectl describe pod/nginx
- kubectl delete pod nginx
- kubectl cluster-info
- kubectl get pods -o yaml
- kubectl get services -o json
- kubectl get pods --sort-by=.metadata.name
- kubectl get rs,deployments,service
- kubectl describe pods
- kubectl get pod/<pod-name> svc/<svc-name>
- kubectl get pod -l name=<label-name>
- kubectl delete pods --all
- kubectl get nodes -o json | jq '.items[] | {name:.metadata.name, cap:.status.capacity}'
- kubectl get nodes -o yaml | egrep '\sname:|cpu:|memory:'
- kubectl get all
- kubectl run hello --image=tutum/hello-world --port=80
- kubectl run -it busybox --image=busybox --restart=Never
- kubectl run nginx --image=nginx



# Exercises (30 mins)

Run Hello World POD using tutum/hello-world image (kubectl run...) & then

- Get POD summary (kubectl get ...)
- Get POD details (kubectl describe ...)
- Get POD IP (kubectl describe pod... -o yaml | egrep....podIP:)
- Delete the POD created above (kubectl delete ...)
- Verify using kubectl get all
- View cluster info



# POD

- Overview
- Lifecycle
- Init Containers
- Preset
- Topology Spread
- Ephemeral Containers



# POD - Overview

- ❖ Smallest deployable unit
- ❖ Supports multiple cooperating processes (containers) that form cohesive unit of service
- ❖ Ephemeral Entity

Encapsulates

- application container(s)
- Storage resources
- Unique network IP

Shared Resources:

- Networking
- Storage



# Example

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   creationTimestamp: null
5   labels:
6     run: nginx
7   name: nginx
8 spec:
9   containers:
10    - image: nginx
11      name: nginx
12      resources: {}
13   dnsPolicy: ClusterFirst
14   restartPolicy: Always
15 status: {}
```

# Example

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   labels:
5     run: pod-busybox
6   name: pod-busybox
7 spec:
8   containers:
9     - command:
10       - sh
11       - -c
12       - echo App is running! && sleep 30
13     image: busybox
14     name: pod-busybox
15     resources: {}
16   restartPolicy: Never
```



# POD - Lifecycle

- Phase
  - Pending (waiting to be scheduled, image downloading)
  - Running (all containers started and ready to serve)
  - Succeeded (all containers exited with success)
  - Failed (all containers exited but at least one with failure)
  - Unknown (unable to fetch status as node is unreachable)
- Container States
  - Waiting, Running, Terminated
- Restart Policy (**Always**, Never, OnFailure)
- Conditions
  - Type: PodScheduled, ContainersReady, Initialized, Ready  
(lastProbeTime, lastTransitionTime, Message, reason, status)
- Probes
  - Startup, Readiness, Liveness
- Lifecycle hooks



# Phase - Pending

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   creationTimestamp: null
5   labels:
6     run: nginx
7   name: nginx
8 spec:
9   containers:
10    - image: nginx
11      name: nginx
12      resources:
13        requests:
14          cpu: "1000m"
15          memory: "1Gi"
16      dnsPolicy: ClusterFirst
17      restartPolicy: Never
18 status: {}
```



# Phase - Running

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   creationTimestamp: null
5   labels:
6     run: busybox
7   name: busybox
8 spec:
9   containers:
10    - command:
11      - ping
12      - google.com
13    image: busybox
14    name: busybox
15    resources: {}
16  dnsPolicy: ClusterFirst
17  restartPolicy: Always
18 status: {}
```

# Phase - Succeeded

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   creationTimestamp: null
5   labels:
6     run: busybox
7   name: busybox
8 spec:
9   containers:
10    - image: busybox
11      name: busybox
12      resources: {}
13   dnsPolicy: ClusterFirst
14   restartPolicy: Never
15 status: {}
```



# Probes

- Types
  - Startup
  - Readiness
  - Liveness
- Methods
  - Http
  - Tcp
  - Command
- Settings
  - initialDelaySeconds
  - periodSeconds
  - timeoutSeconds
  - successThreshold
  - failureThreshold
- Http
  - Host
  - Scheme
  - Path
  - Port
  - Headers

# Probe - Liveness - Exec

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: probe-liveness-exec
5 spec:
6   containers:
7     - name: probe-liveness-exec
8       image: k8s.gcr.io/busybox
9       args:
10      - /bin/sh
11      - -c
12      - touch /tmp/healthy; sleep 30; rm -rf /tmp/healthy; sleep 600
13     livenessProbe:
14       exec:
15         command:
16           - cat
17           - /tmp/healthy
18       initialDelaySeconds: 5
19       periodSeconds: 5
```

# Probe - Liveness - http

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: probe-liveness-http
5 spec:
6   containers:
7     - name: probe-liveness-http
8       image: k8s.gcr.io/liveness
9       args:
10      - /server
11   livenessProbe:
12     httpGet:
13       path: /healthz
14       port: 8080
15     httpHeaders:
16       - name: Custom-Header
17         value: Awesome
18     initialDelaySeconds: 3
19     periodSeconds: 3
```

# Probe - Liveness - readiness - tcp

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: probe-liveness-readiness-tcp
5 spec:
6   containers:
7     - name: probe-liveness-readiness-tcp
8       image: k8s.gcr.io/goproxy:0.1
9       ports:
10      - containerPort: 8080
11      readinessProbe:
12        tcpSocket:
13          port: 8080
14        initialDelaySeconds: 5
15        periodSeconds: 10
16      livenessProbe:
17        tcpSocket:
18          port: 8080
19        initialDelaySeconds: 15
20        periodSeconds: 20
```

# Probe - Liveness - startup - http

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: probe-liveness-startup-http
5 spec:
6   containers:
7     - name: probe-liveness-startup-http
8       image: k8s.gcr.io/liveness
9       args:
10      - /server
11     livenessProbe:
12       httpGet:
13         path: /healthz
14         port: 8080
15       failureThreshold: 1
16       periodSeconds: 10
17     startupProbe:
18       httpGet:
19         path: /healthz
20         port: 8080
21       failureThreshold: 30
22       periodSeconds: 10
```



# POD Init Containers

- Always run to completion
- Must complete successfully before next one
- Readiness probes not supported
- Run(s) before application containers

Examples:

- Custom code / utilities to run before app containers
- Block / delay app container startup
- App container image building can be separate



# POD Init - Statuses

- Init:N/M
- Init:Error
- Init:CrashLoopBackOff
- Pending
- PodInitializing
- Running



# Example

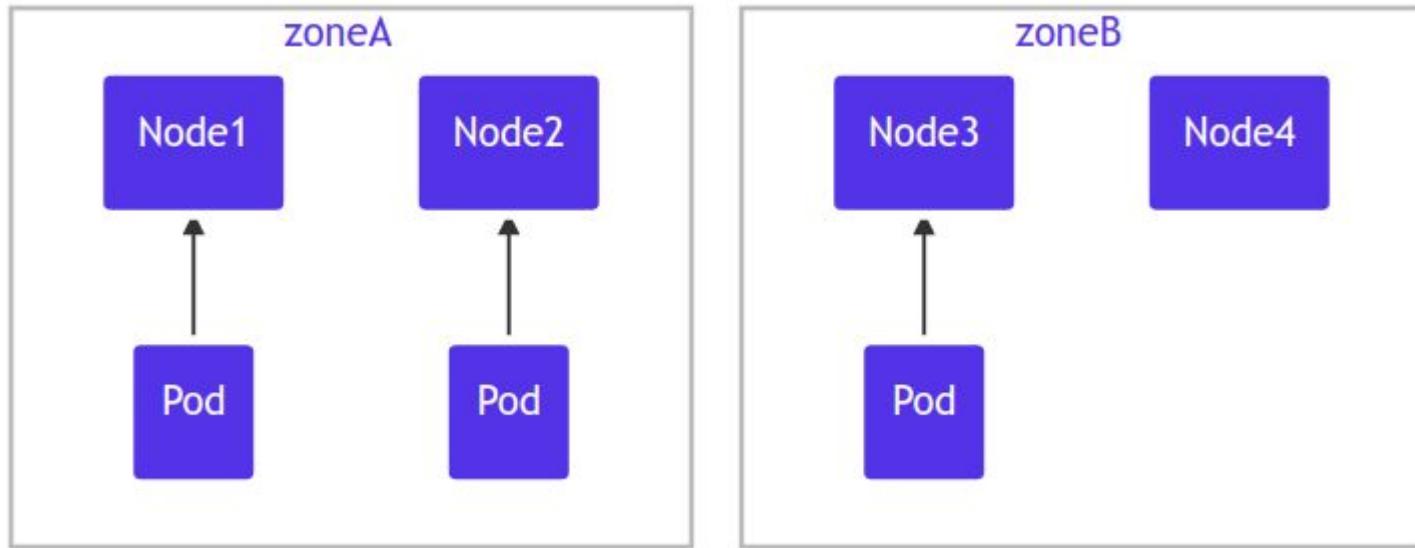
```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: init-containers
5 spec:
6   containers:
7     - name: main-container
8       image: busybox:1.28
9       command: ['sh', '-c', 'echo The app is running! && sleep 3600']
10  initContainers:
11    - name: init-service
12      image: busybox:1.28
13      command: ['sh', '-c', "until nslookup myservice.$(cat /var/run/secrets/kubernetes.io/serviceaccount/namespace).svc.cluster.local; do echo waiting for myservice; sleep 2; done"]
14    - name: init-mydb
15      image: busybox:1.28
16      command: ["sh", "-c", "until nslookup mydb.$(cat /var/run/secrets/kubernetes.io/serviceaccount/namespace).svc.cluster.local; do echo waiting for mydb; sleep 2; done"]
```



# POD - Topology Spread

- Objectives
  - To control how Pods are spreads across **regions**, zones, nodes and other user defined topology domains
  - To achieve high availability
  - To achieve efficient resource utilization
- Spread Constraints
  - maxSkew
  - topologyKey
  - whenUnsatisfiable (DoNotSchedule / ScheduleAnyway)
  - labelSelector

# POD - Topology Spread

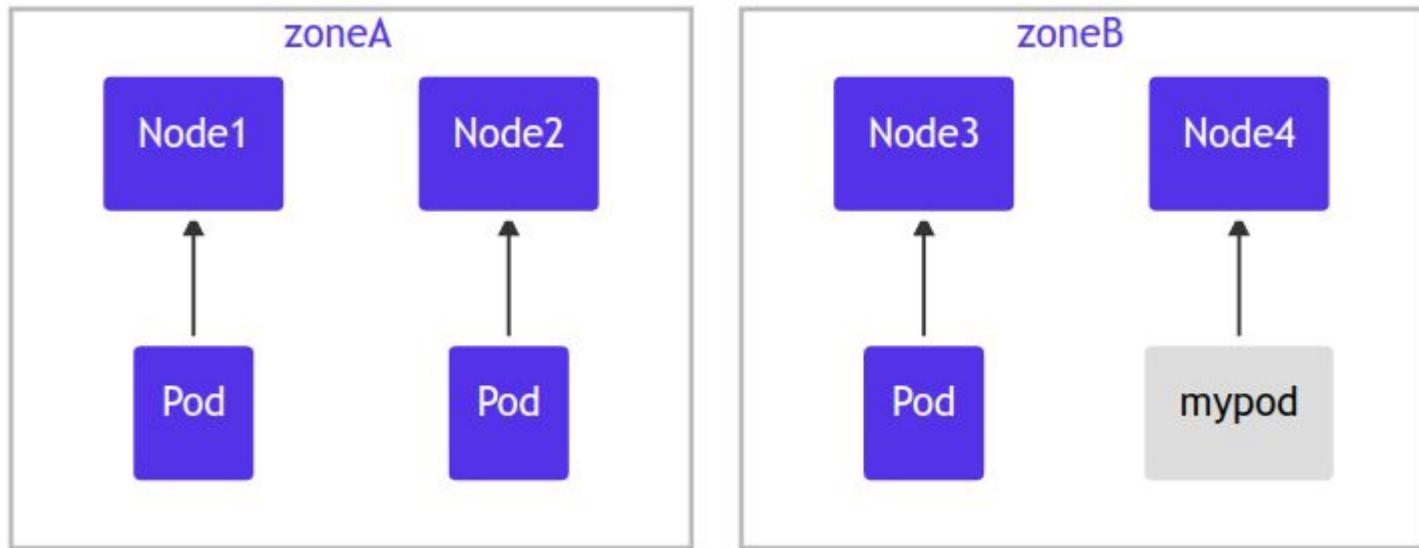




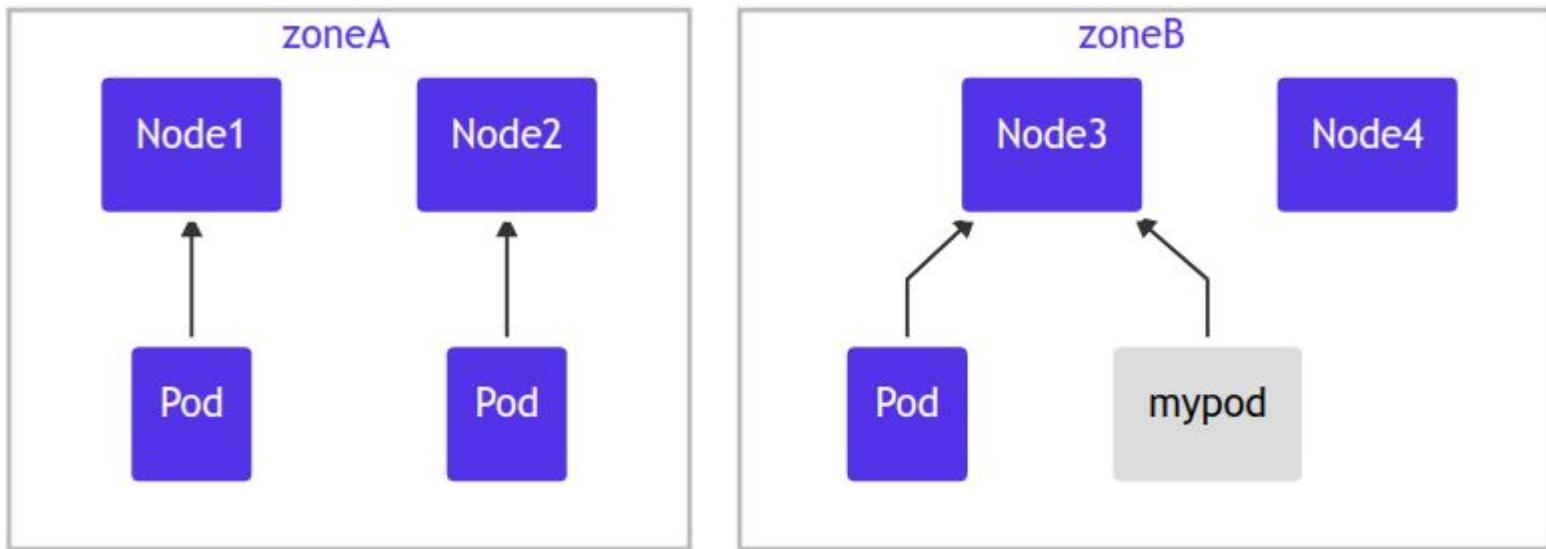
# POD - Topology Spread

```
1 kind: Pod
2 apiVersion: v1
3 metadata:
4   name: topology-zone-constraint-1
5   labels:
6     foo: bar
7 spec:
8   topologySpreadConstraints:
9     - maxSkew: 1
10    topologyKey: failure-domain.beta.kubernetes.io/zone
11    whenUnsatisfiable: DoNotSchedule
12    labelSelector:
13      matchLabels:
14        foo: bar
15 containers:
16   - name: pause
17     image: k8s.gcr.io/pause:3.1
```

# POD - Topology Spread



# POD - Topology Spread





# Topology - Multiple Constraints

```
1 kind: Pod
2 apiVersion: v1
3 metadata:
4   name: topology-constraints-two
5   labels:
6     foo: bar
7 spec:
8   topologySpreadConstraints:
9     - maxSkew: 1
10    topologyKey: topology.kubernetes.io/zone
11    whenUnsatisfiable: DoNotSchedule
12    labelSelector:
13      matchLabels:
14        foo: bar
15    - maxSkew: 1
16      topologyKey: kubernetes.io/hostname
17      whenUnsatisfiable: DoNotSchedule
18      labelSelector:
19        matchLabels:
20          foo: bar
21 containers:
22 - name: pause
23   image: k8s.gcr.io/pause:3.1
```



# Topology - Constraint & Node Affinity

```
1 kind: Pod
2 apiVersion: v1
3 metadata:
4   name: topology-constraint-nodeaffinity
5   labels:
6     foo: bar
7 spec:
8   topologySpreadConstraints:
9     - maxSkew: 1
10    topologyKey: zone
11    whenUnsatisfiable: DoNotSchedule
12    labelSelector:
13      matchLabels:
14        foo: bar
15 affinity:
16   nodeAffinity:
17     requiredDuringSchedulingIgnoredDuringExecution:
18       nodeSelectorTerms:
19         - matchExpressions:
20           - key: zone
21             operator: NotIn
22             values:
23               - zoneC
24 containers:
25   - name: pause
26     image: k8s.gcr.io/pause:3.1
```



# POD Preset

- To inject certain info at creation time
- Can include secrets, volume, volume mounts, environment variables

```
1 apiVersion: settings.k8s.io/v1alpha1
2 kind: PodPreset
3 metadata:
4   name: pod-present-db-config
5 spec:
6   selector:
7     matchLabels:
8       role: frontend
9   env:
10    - name: DB_PORT
11      value: "6379"
12    - name: duplicate_key
13      value: FROM_ENV
14    - name: expansion
15      value: ${REPLACE_ME}
16   envFrom:
17    - configMapRef:
18      name: etcd-env-config
19   volumeMounts:
20    - mountPath: /cache
21      name: cache-volume
22   volumes:
23    - name: cache-volume
24      emptyDir: {}
```

```
1 apiVersion: v1
2 kind: ConfigMap
3 metadata:
4   name: pod-preset-config
5 data:
6   number_of_members: "1"
7   initial_cluster_state: new
8   initial_cluster_token: DUMMY_ETCD_INITIAL_CLUSTER_TOKEN
9   discovery_token: DUMMY_ETCD_DISCOVERY_TOKEN
10  discovery_url: http://etcd_discovery:2379
11  etcdctl_peers: http://etcd:2379
12  duplicate_key: FROM_CONFIG_MAP
13  REPLACE_ME: "a value"
```

# POD - Ephemeral

- Meant for interactive troubleshooting inside POD
- No resource guarantees
- Never restart automatically
- Process Namespace sharing

```
kubectl replace --raw /api/v1/namespaces/default/pods/example-pod/ephemeralcontainers -f ec.json
```

```
apiVersion: "v1",
kind: "EphemeralContainers",
metadata: {
    name: "example-pod"
},
ephemeralContainers: [
    command: [
        "sh"
    ],
    image: "busybox",
    imagePullPolicy: "IfNotPresent",
    name: "debugger",
    stdin: true,
    tty: true,
    terminationMessagePolicy: "File"
]
```



# Exercises (30 mins)

- Create POD with init containers
  - Main app container from tutum/hello-world
  - Init container using busybox to fetch google.com/index.html and save to /www/google.html
- Create POD to keep in different state (Pending, Running, Succeeded)
- Create POD with readiness probe for container readiness requiring 60 seconds
- Create POD and restart if not live after 30 seconds having 10 s interval
- Create POD that requires 90 s to start but restart every 30 s if not live
- Create two PODs and make sure they are not deployed on the same node
- Create two PODs and make sure they are deployed on the same node
- Create two PODs and ensure they are deployed on different zones
- Create four PODs and ensure no more than one is deployed on same zone



# Multi Container Pods

- Ambassador
- Sidecar
- Adapter
- Demo
- Practicals



# Patterns - POD

- To extend the functionality of the existing container
- To have helper process enhancing work of the existing container
- To send logs to external server
- Types
  - Sidecar - To export logs
  - Ambassador - To proxy connection
  - Adapter - To standardise and normalize output

# Pattern - Sidecar

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: sidecar
5 spec:
6   volumes:
7     - name: shared-logs
8       emptyDir: {}
9   containers:
10    - name: main-container
11      image: alpine
12      command: ["/bin/sh"]
13      args: ["-c", "while true; do date >> /var/log/index.html; sleep 10;done"]
14      volumeMounts:
15        - name: shared-logs
16          mountPath: /var/log
17    - name: sidecar-container
18      image: nginx
19      ports:
20        - containerPort: 80
21      volumeMounts:
22        - name: shared-logs
23          mountPath: /usr/share/nginx/html
```



# Pattern - Adapter

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: adapter
5 spec:
6   volumes:
7     - name: shared-logs
8       emptyDir: {}
9   containers:
10    - name: main-container
11      image: alpine
12      command: ["/bin/sh"]
13      args: ["-c", "while true; do date > /var/log/top.txt && top -n 1 -b >> /var/log/top.txt; sleep 10;done"]
14      volumeMounts:
15        - name: shared-logs
16          mountPath: /var/log
17    - name: adapter-container
18      image: alpine
19      command: ["/bin/sh"]
20      args: ["-c", "while true; do (cat /var/log/top.txt | head -1 > /var/log/status.txt) && (cat /var/log/top.txt | head -2 | tail -1 | grep
21      -o -E '\\\\d+\\\\w' | head -1 >> /var/log/status.txt) && (cat /var/log/top.txt | head -3 | tail -1 | grep
22      -o -E '\\\\d+' | head -1 >> /var/log/status.txt); sleep 5; done"]
23      volumeMounts:
24        - name: shared-logs
25          mountPath: /var/log
```

# Pattern - Ambassador

```
1 apiVersion: v1
2 kind: ConfigMap
3 metadata:
4   name: ambassador-nginx-config
5 data:
6   nginx.conf: |
7     worker_processes 1;
8     worker_rlimit_nofile 4096;
9     events {
10       worker_connections 512;
11     }
12     http {
13       proxy_set_header HOST $host;
14       proxy_set_header X-Forwarded-Proto $scheme;
15       proxy_set_header X-Real-IP $remote_addr;
16       proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
17       upstream backend {
18         server msn.com:80;
19       }
20       server {
21         listen 80;
22         location / {
23           proxy_pass http://backend;
24         }
25       }
26     }
27 ...
28 apiVersion: v1
29 kind: Pod
30 metadata:
31   name: multi-pod-ambassador
32 spec:
33   containers:
34     - name: main-app
35       image: busybox
36       imagePullPolicy: IfNotPresent
37       command: ["/bin/sh"]
38       args: ["-c", "while true; do wget -O /tmp/app.txt localhost ; sleep 30; done"]
39     - name: ambassador
40       image: nginx
41       imagePullPolicy: IfNotPresent
42       ports:
43         - containerPort: 80
44       volumeMounts:
45         - name: nginx-config
46           mountPath: /etc/nginx/nginx.conf
47           subPath: nginx.conf
48     volumes:
49       - name: nginx-config
50         configMap:
51           name: ambassador-nginx-config
```



# Exercises

- Create POD having below
  - Main container: busybox
    - Appending ping outputs to /tmp/index-input.html
  - Sidecar container: busybox
    - Copy the index.html to /tmp/index-output.html
- Create POD having below
  - Main container: alpine
    - Print date to /tmp/index.html
  - Adapter container: busybox
    - Copy the index.html to /tmp/index-output.html
- Create POD having below
  - Main container: busybox
    - Storing localhost ping outputs to /tmp/index-input.html
  - Ambassador container: nginx
    - Proxying localhost:80 to https://www.brainupgrade.in



# Pod Design

- Deployments
- Rolling Updates & Rollbacks
- Auto scaling pods
- Jobs, Cron Jobs
- Labels, Selectors, Annotations
- Demo
- Practicals



# Deployments

## Use Cases

- To rollout a set of PODs
- To declare a new set of PODs
- To rollback to an earlier version of deployment
- To scale up deployment to facilitate more load
- To pause the deployment / rollout
- To autoscale deployment when cpu usage threshold reached

# Deployment - Example

```
1 apiVersion: apps/v1
2 kind: Deployment
3 metadata:
4   name: test-app
5 spec:
6   replicas: 1
7   selector:
8     matchLabels:
9       component: test-app
10  template:
11    metadata:
12      labels:
13        component: test-app
14  spec:
15    containers:
16      - name: test-app
17        image: brainupgrade/test-app:all-tiers-in-one
18        imagePullPolicy: IfNotPresent
19        ports:
20          - containerPort: 8080
21        resources:
22          requests:
23            cpu: "100m"
24            memory: "250Mi"
```



# Deployment - Commands

- kubectl create deployment nginx --image=nginx:1.15 --replicas=5
- kubectl get deployment/nginx
- kubectl describe deployment/nginx
- kubectl rollout history deployment/nginx
- kubectl set image deployment/nginx nginx=nginx:1.16
- kubectl rollout history deployment/nginx
- kubectl rollout undo deployment/nginx
- kubectl rollout undo deployment/nginx --to-revision=2
- kubectl scale --replicas=50 deployment/nginx
- kubectl rollout pause deployment/nginx
- kubectl rollout status deployment/nginx
- kubectl rollout resume deployment/nginx
- kubectl autoscale deployment/nginx --min=2 --max=10



# Job

- To provide reliable parallel execution of tasks
- Examples:
  - Send emails, transcode files, Scan database for a set of rows,
- Patterns
  - Non parallel job
  - Fixed completion count job
  - Work queue job



# Job

```
1 apiVersion: batch/v1
2 kind: Job
3 metadata:
4   name: job
5 spec:
6   template:
7     spec:
8       containers:
9         - name: perl
10           image: perl
11             command: ["perl", "-Mbignum=bpi", "-wle", "print bpi(2000)"]
12           restartPolicy: Never
13         backoffLimit: 4
```



# Job - Timeout

```
1 apiVersion: batch/v1
2 kind: Job
3 metadata:
4   name: job-timeout
5 spec:
6   backoffLimit: 5
7   activeDeadlineSeconds: 100
8   template:
9     spec:
10       containers:
11         - name: perl
12           image: perl
13             command: ["perl", "-Mbignum=bpi", "-wle", "print bpi(2000)"]
14       restartPolicy: Never
```



# CronJob

- Creates jobs on a repeating schedule
- Schedule times are based on kube-controller-manager
- Useful for tasks like migrating data to reporting server, sending emails, creating backups etc
- Schedule tasks at specific time (like when cluster is idle)

## Key Configurations:

- startingDeadlineSeconds - Missed occurrences in last X seconds will be counted
- concurrencyPolicy
  - If Allow, then job will run at least once
  - If Forbid, will be missed if previous instance is still running



# CronJob - Expression

```
# └───────── minute (0 - 59)
#   └──────── hour (0 - 23)
#     └───────── day of the month (1 - 31)
#       └──────── month (1 - 12)
#         └───────── day of the week (0 - 6) (Sunday to Saturday;
#           7 is also Sunday on some systems)
#
#
# * * * * * <command to execute>
```

## Examples:

- \*/15 0,8,16 \* \* \* echo running backup (every 15 minutes of 0,8 & 16th hour)
- 30 0 \* \* 6 /home/oracle/scripts/export\_dump.sh (last day of week at 00:30)
- 1 0 \* \* \* printf "" > /var/log/apache/error\_log (everyday at 00:01 )

# CronJob - Expression

```
1 apiVersion: batch/v1beta1
2 kind: CronJob
3 metadata:
4   name: cron-job
5 spec:
6   schedule: "*/1 * * * *"
7   jobTemplate:
8     spec:
9       template:
10      spec:
11        containers:
12          - name: cron-job
13            image: busybox
14            args:
15              - /bin/sh
16              - -C
17              - date; echo Migrating data to reporting server...
18        restartPolicy: OnFailure
19
```



# Labels

- Labels
  - Key value pairs attached to objects
  - To specify identifying attributes of objects
  - To organize and select subset of objects
  - To query objects efficiently (cli as well gui monitoring tools)
  - Attached at creation time and can be added / modified at any time
  - Label key must be unique per object
- Example labels:
  - "release" : "stable", "release" : "canary"
  - "environment" : "dev", "environment" : "qa", "environment" : "production"
  - "tier" : "frontend", "tier" : "backend", "tier" : "cache"
  - "partition" : "customerA", "partition" : "customerB"
  - "track" : "daily", "track" : "weekly"



# Labels

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: pod-labels
5   labels:
6     environment: production
7     app: nginx
8 spec:
9   containers:
10  - name: nginx
11    image: nginx
12    ports:
13      - containerPort: 80
~
```



# Selectors

- Equality Based

- `environment = production`
- `tier != frontend`

- Set Based

- `environment in (production, qa)`
- `tier notin (frontend, backend)`
- `partition`
- `!partition`

# Selectors - Examples

- `kubectl get pods -l environment=production,tier=frontend`
- `kubectl get pods -l 'environment in (production),tier in (frontend)'`
- `kubectl get pods -l 'environment in (production, qa)'`
- `kubectl get pods -l 'environment,environment notin (frontend)'`

Jobs, Deployments, ReplicaSet, Daemonset

```
selector:  
  matchLabels:  
    component: redis  
  matchExpressions:  
    - {key: tier, operator: In, values: [cache]}  
    - {key: environment, operator: NotIn, values: [dev]}
```



# Selectors - Examples

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: selector-pod-node
5 spec:
6   containers:
7     - name: cuda-test
8       image: "k8s.gcr.io/cuda-vector-add:v0.1"
9       resources:
10         limits:
11           nvidia.com/gpu: 1
12   nodeSelector:
13     accelerator: nvidia-tesla-p100
```



# Annotations

- To attach non-identifying arbitrary metadata to objects
- Usage
  - Pointers for debugging purposes
  - Build, release, image hashes etc
  - Author info, contact details
  - Metadata to help tools for deployment, management, introspection

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: annotations-pod
5   annotations:
6     imageregistry: "https://hub.docker.com/"
7 spec:
8   containers:
9     - name: nginx
10    image: nginx
11    ports:
12      - containerPort: 80
```



# Exercises (30 mins)

- Create a deployment to run 3 replicas of nginx container
- Scale down the replicas to 1
- Scale up replicas to 10
- View the roll out history
- Switch to rollout version 2
- View deployments, rc, pod using kubectl
- Scale down replicas to 5
- Update image to nginx:1.18 and immediately try another rollout with nginx:1.17
- Observe if rollout with nginx:1.17 was completed or not
- Autoscale pod to max 5 min 1



# Persistence

- Persistence Volume
- Persistence Volume Claim
- Statefulset
- Daemonset



# Overview - PV / PVC

- Ephemeral
  - Tightly coupled with POD lifetime
  - Deleted when POD is removed
  - Example: emptydir
- Persistent
  - Survives POD reboots
  - Meant for long term and independent of POD / Node lifecycle
  - Examples: hostpath, NFS, Cloud storage (EBS etc)
- The access modes are:
  - ReadWriteOnce – the volume can be mounted as read-write by a single node
  - ReadOnlyMany – the volume can be mounted read-only by many nodes
  - ReadWriteMany -- the volume can be mounted as read-write by many nodes



# Examples - emptyDir

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: volume-emptydir
5 spec:
6   containers:
7     - image: nginx
8       name: test-container
9       volumeMounts:
10      - mountPath: /cache
11        name: cache-volume
12   volumes:
13     - name: cache-volume
14       emptyDir: {}
```



# Examples - hostpath (file/dir)

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: hostpath-volume
5 spec:
6   containers:
7     - image: nginx
8       name: test-container
9       volumeMounts:
10      - mountPath: /data-mounted-as
11        name: hostpath-volume
12   volumes:
13     - name: hostpath-volume
14       hostPath:
15         # directory location on host
16         path: /data
17         # this field is optional
18         type: DirectoryOrCreate
```

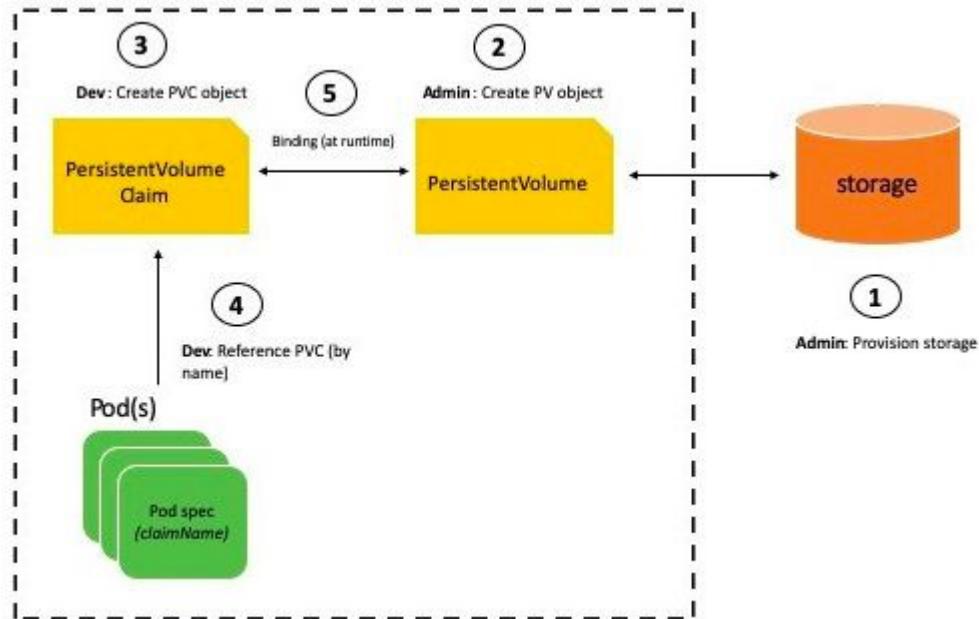
# Persistent Volume - local & node

```
1 apiVersion: v1
2 kind: PersistentVolume
3 metadata:
4   name: pv-local-node-affinity
5 spec:
6   capacity:
7     storage: 10Gi
8   # volumeMode field requires BlockVolume Alpha feature gate to be enabled.
9   volumeMode: Filesystem
10  accessModes:
11    - ReadWriteMany
12  persistentVolumeReclaimPolicy: Delete
13  storageClassName: local-storage
14  local:
15    path: /mnt/disks/ssd1
16  nodeAffinity:
17    required:
18      nodeSelectorTerms:
19        - matchExpressions:
20          - key: kubernetes.io/hostname
21            operator: In
22            values:
23              - ip-172-31-87-231.ec2.internal
~
```

# Persistent Volume - EBS

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: volume-ebs
5 spec:
6   containers:
7     - image: k8s.gcr.io/test-webserver
8       name: test-container
9       volumeMounts:
10      - mountPath: /test-ebs
11        name: ebs-volume
12   volumes:
13     - name: ebs-volume
14       # This AWS EBS volume must already exist.
15       awsElasticBlockStore:
16         volumeID: <volume-id>
17         fsType: ext4
```

# Persistent Volume - static





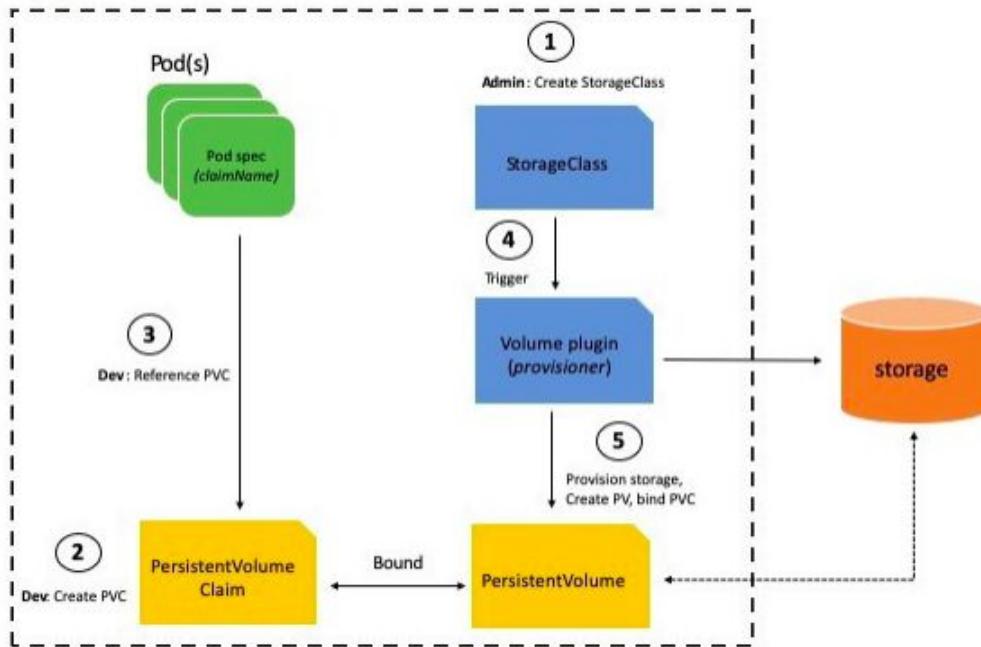
# Example

```
1 apiVersion: v1
2 kind: PersistentVolume
3 metadata:
4   name: pv-hostpath
5   annotations:
6     pv.beta.kubernetes.io/gid: "1234"
7   labels:
8     type: local
9 spec:
10  storageClassName: manual
11  capacity:
12    storage: 10Gi
13  accessModes:
14    - ReadWriteOnce
15  hostPath:
16    path: "/mnt/data"
```

```
1 apiVersion: v1
2 kind: PersistentVolumeClaim
3 metadata:
4   name: pvc-test
5 spec:
6   storageClassName: manual
7   accessModes:
8     - ReadWriteOnce
9   resources:
10  requests:
11    storage: 3Gi
```

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: pod-pv-pvc
5 spec:
6   volumes:
7     - name: pv-storage
8       persistentVolumeClaim:
9         claimName: pvc-test
10    containers:
11      - name: task-pv-container
12        image: nginx
13        ports:
14          - containerPort: 80
15            name: "http-server"
16        volumeMounts:
17          - mountPath: "/usr/share/nginx/html"
18            name: pv-storage
```

# Persistent Volume - Dynamic





# Example

```
1 kind: StorageClass
2 apiVersion: storage.k8s.io/v1
3 metadata:
4   name: storageclass-generic
5 provisioner: kubernetes.io/aws-ebs
6 parameters:
7   type: gp2
8   zones: us-east-1a,us-east-1b,us-east-1c
9   iopsPerGB: "10"
10  fsType: ext4
```

```
1 apiVersion: v1
2 kind: PersistentVolumeClaim
3 metadata:
4   name: pvc-dynamic
5   labels:
6     app: nginx
7 spec:
8   storageClassName: storageclass-generic
9   accessModes:
10    - ReadWriteOnce
11   resources:
12     requests:
13       storage: 1Gi
```

```
1 kind: Pod
2 apiVersion: v1
3 metadata:
4   name: pod-volume-dynamic
5   labels:
6     app: nginx
7 spec:
8   containers:
9     - name: nginx
10    image: nginx
11   volumeMounts:
12    - mountPath: "/var/www/html"
13      name: external
14 volumes:
15  - name: external
16    persistentVolumeClaim:
17      claimName: pvc-dynamic
```



# Persistent Volumes

- GCEPersistentDisk
- AWSElasticBlockStore
- AzureFile
- AzureDisk
- CSI
- FC (Fibre Channel)
- FlexVolume
- Flocker
- NFS
- iSCSI
- RBD (Ceph Block Device)
- CephFS
- Cinder (OpenStack block storage)
- Glusterfs
- VsphereVolume
- Quobyte Volumes
- HostPath (Single node testing only – local storage is not supported in any way and WILL NOT WORK in a multi-node cluster)
- Portworx Volumes
- ScaleIO Volumes
- StorageOS



# StatefulSet

## Use Cases

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

## Limitations

- No automatic deletion of referenced volumes
- No PODs deletion guarantee when StatefulSet is deleted
- Rolling Updates not consistent always

# StatefulSet - Example

```
1 apiVersion: apps/v1
2 kind: StatefulSet
3 metadata:
4   name: sts-web
5 spec:
6   serviceName: "nginx"
7   replicas: 2
8   selector:
9     matchLabels:
10    app: nginx
11 template:
12   metadata:
13     labels:
14       app: nginx
15   spec:
16     containers:
17       - name: nginx
18         image: k8s.gcr.io/nginx-slim:0.8
19         ports:
20           - containerPort: 80
21             name: web
22         volumeMounts:
23           - name: www
24             mountPath: /usr/share/nginx/html
25   volumeClaimTemplates:
26     - metadata:
27       name: www
28     spec:
29       accessModes: [ "ReadWriteOnce" ]
30       resources:
31         requests:
32           storage: 1Gi
```

- Scale Up
- Scale Up
- Update (image)



# StatefulSet - Example

- Scale Up
- Scale down
- kubectl set image sts/sts-web nginx=nginx:1.18
- Staged Update
  - kubectl patch statefulset sts-web -p '{"spec":{"updateStrategy":{"type":"RollingUpdate","rollingUpdate":{"partition":3}}}}'
  - kubectl patch statefulset sts-web --type='json' -p='[{"op": "replace", "path": "/spec/template/spec/containers/0/image", "value":"nginx:1.17"}]'
  - kubectl get pod sts-web-1 --template '{{range \$i, \$c := .spec.containers}}{{\$.c.image}}{{end}}'



# Controllers - DaemonSet

## Purpose

- To run a copy of a POD on all / some node(s)

## Use Cases

- Storage cluster daemon (gluster, ceph)
- Log Collectors (fluentd, logstash)
- Node Monitoring daemons (Prometheus, Dynatrace, collectd)

# DaemonSet - Example

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: fluentd-elasticsearch
  namespace: kube-system
  labels:
    k8s-app: fluentd-logging
spec:
  selector:
    matchLabels:
      name: fluentd-elasticsearch
  template:
    metadata:
      labels:
        name: fluentd-elasticsearch
    spec:
      tolerations:
        - key: node-role.kubernetes.io/master
          effect: NoSchedule
      containers:
        - name: fluentd-elasticsearch
          image: quay.io/fluentd_elasticsearch/fluentd:v2.5.2
          resources:
            limits:
              memory: 200Mi
            requests:
              cpu: 100m
              memory: 200Mi
          volumeMounts:
            - name: varlog
              mountPath: /var/log
            - name: varlibdockercontainers
              mountPath: /var/lib/docker/containers
              readOnly: true
      terminationGracePeriodSeconds: 30
  volumes:
    - name: varlog
      hostPath:
        path: /var/log
    - name: varlibdockercontainers
      hostPath:
        path: /var/lib/docker/containers
```



# Exercises (15 mins)

- Create POD (nginx / redis) to use volume emptyDir
- Launch POD and login into POD
- Create test file
- Kill the container process (nginx / redis)
- Observe POD status and login into POD again
- Verify if test file exists

NOTE:

POD has restartPolicy as Always

Ephemeral storage is associated till POD is deleted



# Exercises (15 mins)

- Create nginx POD that uses pvc for serving web files
- Define pvc that uses pv
- Define pv that refers to host path /mnt/data
- Create index.html echoing ‘hello k8s’ under host path
- Verify that nginx serves the index.html contents that you saved



# Exercises (15 mins)

- Create StatefulSet having image=nginx:1.16 and replicas 5
- Scale replicas to 5
- Change image to nginx:1.17
- Set the rolling update partition to 3
- Change the image to nginx:1.17
- Watch the pods scaling up / down using
  - `kubectl get -w pods`



# Configuration

- Config Maps, Environment
- Secrets
- Security Contexts
- Service Accounts
- Demo
- Practicals

# ConfigMap

- To store non-confidential key-value pairs
- Can be consumed as env variables, command line args or config files in volume
- To decouple env specific config from images for portability
- Max data 1MB

```
1 apiVersion: v1
2 kind: ConfigMap
3 metadata:
4   name: cm-game-demo
5 data:
6   # property-like keys; each key maps to a simple value
7   player_initial_lives: "3"
8   ui_properties_file_name: "user-interface.properties"
9   # file-like keys
10  game.properties: |
11    enemy.types=aliens,monsters
12    player.maximum-lives=5
13  user-interface.properties: |
14    color.good=purple
15    color.bad=yellow
16    allow.textmode=true
```

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: pod-configmap
5 spec:
6   containers:
7     - name: demo
8       image: alpine
9       command: ["sleep", "3600"]
10      env:
11        # Define the environment variable
12        - name: PLAYER_INITIAL_LIVES # Notice that the case is different here
13          valueFrom:
14            configMapKeyRef:
15              name: cm-game-demo # The ConfigMap this value comes from.
16              key: player_initial_lives # The key to fetch.
17        - name: UI_PROPERTIES_FILE_NAME
18          valueFrom:
19            configMapKeyRef:
20              name: cm-game-demo
21              key: ui_properties_file_name
22      volumeMounts:
23        - name: config
24          mountPath: "/config"
25          readOnly: true
26 volumes:
27   # You set volumes at the Pod level, then mount them into containers inside that Pod
28   - name: config
29     configMap:
30       # Provide the name of the ConfigMap you want to mount.
31       name: cm-game-demo
32       # An array of keys from the ConfigMap to create as files
33       items:
34         - key: "game.properties"
35           path: "game.properties"
36         - key: "user-interface.properties"
37           path: "user-interface.properties"
```



# Secret

- To manage sensitive info like password, oauthkeys, docker login, ssh keys, tls etc
- Examples

```
kubectl create secret docker-registry secret-tiger-docker \
    --docker-username=tiger \
    --docker-password=pass113 \
    --docker-email=tiger@acme.com
```

```
kubectl create secret tls my-tls-secret \
    --cert=path/to/cert/file \
    --key=path/to/key/file
```

# Secret

```
1 apiVersion: v1
2 data:
3   username: YWRtaW4=
4   password: MWYyZDFlMmU2N2Rm
5 kind: Secret
6 metadata:
7   name: pod-secret
8   namespace: default
9   resourceVersion: "164619"
10  uid: cfee02d6-c137-11e5-8d73-42010af00002
11 type: Opaque
```

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: pod-secret
5 spec:
6   containers:
7     - name: mypod
8       image: redis
9       env:
10         - name: SECRET_USERNAME
11           valueFrom:
12             secretKeyRef:
13               name: mysecret
14               key: username
15         - name: SECRET_PASSWORD
16           valueFrom:
17             secretKeyRef:
18               name: mysecret
19               key: password
20   volumeMounts:
21     - name: foo
22       mountPath: "/etc/foo"
23       readOnly: true
24   volumes:
25     - name: foo
26       secret:
27         secretName: pod-secret
28         items:
29           - key: username
30             path: my-group/my-username
=
```



# Security Context

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   name: security-context-demo
5 spec:
6   securityContext:
7     runAsUser: 1000
8     runAsGroup: 3000
9     fsGroup: 2000
10  volumes:
11    - name: sec-ctx-vol
12      emptyDir: {}
13  containers:
14    - name: sec-ctx-demo
15      image: busybox
16      command: [ "sh", "-c", "sleep 1h" ]
17      volumeMounts:
18        - name: sec-ctx-vol
19          mountPath: /data/demo
20      securityContext:
21        allowPrivilegeEscalation: false
22        capabilities:
23          add: ["NET_ADMIN", "SYS_TIME"]
24
```



# User Accounts & Service Accounts

- User Accounts
  - User accounts are for humans.
  - User accounts are intended to be global. Names must be unique across all namespaces of a cluster.
- Service Accounts
  - Service accounts are for processes, which run in pods.
  - Service accounts are namespaced.
  - Service account creation is intended to be more lightweight



# Scheduling

- Node Name
- Node Selector
- Affinity (Pod, Node)
- Taints & Tolerations
- Demo
- Practicals

# Node Name

```
1 apiVersion: apps/v1
2 kind: Deployment
3 metadata:
4   name: schedule-node
5 spec:
6   replicas: 1
7   selector:
8     matchLabels:
9       component: schedule-node
10  template:
11    metadata:
12      labels:
13        component: schedule-node
14    spec:
15      nodeName: ip-172-31-102-18.ec2.internal
16      containers:
17        - name: test-app
18          image: brainupgrade/test-app:all-tiers-in-one
19          imagePullPolicy: IfNotPresent
20        ports:
21          - containerPort: 8080
22        resources:
23          requests:
24            cpu: "100m"
25            memory: "250Mi"
```

# Node Selector

```
1 apiVersion: apps/v1
2 kind: Deployment
3 metadata:
4   name: schedule-nodeselector
5 spec:
6   replicas: 1
7   selector:
8     matchLabels:
9       component: schedule-nodeselector
10  template:
11    metadata:
12      labels:
13        component: schedule-nodeselector
14  spec:
15    nodeSelector:
16      node-role.kubernetes.io/spot-worker: "true"
17    containers:
18      - name: test-app
19        image: nginx
20        imagePullPolicy: IfNotPresent
21        ports:
22          - containerPort: 80
```

# POD - Affinity & Anti Affinity (example 1)

```
14   spec:
15     affinity:
16       podAffinity:
17         requiredDuringSchedulingIgnoredDuringExecution:
18           - labelSelector:
19             matchExpressions:
20               - key: tier
21                 operator: In # NotIn, Exists, NotExists
22                 values:
23                   - cache
24         topologyKey: topology.kubernetes.io/zone
25     podAntiAffinity:
26       preferredDuringSchedulingIgnoredDuringExecution:
27         - weight: 100
28           podAffinityTerm:
29             labelSelector:
30               matchExpressions:
31                 - key: tier
32                   operator: In
33                   values:
34                     - messaging
35         topologyKey: topology.kubernetes.io/hostname
36     containers:
37       - name: pod-affinity-middle-tier
38         image: nginx
39         imagePullPolicy: IfNotPresent
40         ports:
41           - containerPort: 80
```

# POD - Affinity & Anti Affinity (example 2)

```
1 apiVersion: apps/v1
2 kind: Deployment
3 metadata:
4   name: app-cache-store
5 spec:
6   selector:
7     matchLabels:
8       app: cache-store
9   replicas: 2
10  template:
11    metadata:
12      labels:
13        app: cache-store
14    spec:
15      affinity:
16        podAntiAffinity:
17          requiredDuringSchedulingIgnoredDuringExecution:
18            - labelSelector:
19              matchExpressions:
20                - key: app
21                  operator: In
22                  values:
23                    - cache-store
24          topologyKey: "kubernetes.io/hostname"
25    containers:
26      - name: redis-server
27        image: redis:3.2-alpine
```

```
1 apiVersion: apps/v1
2 kind: Deployment
3 metadata:
4   name: app-web-server
5 spec:
6   selector:
7     matchLabels:
8       app: web-server
9   replicas: 2
10  template:
11    metadata:
12      labels:
13        app: web-server
14    spec:
15      affinity:
16        podAntiAffinity:
17          requiredDuringSchedulingIgnoredDuringExecution:
18            - labelSelector:
19              matchExpressions:
20                - key: app
21                  operator: In
22                  values:
23                    - web-server
24          topologyKey: "kubernetes.io/hostname"
25    podAffinity:
26      requiredDuringSchedulingIgnoredDuringExecution:
27        - labelSelector:
28          matchExpressions:
29            - key: app
30              operator: In
31              values:
32                - cache-store
33          topologyKey: "kubernetes.io/hostname"
34    containers:
35      - name: web-app
36        image: nginx:1.16-alpine
```

# Node - Affinity

```
1 apiVersion: apps/v1
2 kind: Deployment
3 metadata:
4   name: node-affinity
5 spec:
6   replicas: 1
7   selector:
8     matchLabels:
9       tier: middle-tier
10  template:
11    metadata:
12      labels:
13        tier: middle-tier
14    spec:
15      affinity:
16        nodeAffinity:
17          requiredDuringSchedulingIgnoredDuringExecution:
18            nodeSelectorTerms:
19              - matchExpressions:
20                - key: topology.kubernetes.io/zone
21                  operator: In #In, NotIn, Exists, DoesNotExist, Gt, Lt
22                  values:
23                    - us-east-1b
24                    - us-east-1c
25          preferredDuringSchedulingIgnoredDuringExecution:
26            - weight: 1
27              preference:
28                matchExpressions:
29                  - key: kops.k8s.io/instancegroup
30                      operator: In #NotIn, DoesNotExist for AntiAffinity
31                      values:
32                        - spotnodes
33 containers:
34   - name: nginx
35     image: nginx
36     imagePullPolicy: IfNotPresent
37     ports:
38       - containerPort: 80
```



# Taints & Tolerations

- Objective

To steer pods away from nodes or evict pods that should not be running on particular nodes

- Use Cases

- Dedicated Nodes
- Nodes with special hardware

- Notes

- Taints - Node (to reject pods that don't tolerate taints)
- Tolerations - Pod (to allow pods to schedule onto nodes matching taints)



# Taints

```
lab@rajesh-Gazelle:~$ kubectl get nodes -o json | jq ".items[]|{name:.metadata.name, taints:.spec.taints}"  
{  
  "name": "ip-172-31-102-18.ec2.internal",  
  "taints": null  
}  
{  
  "name": "ip-172-31-34-27.ec2.internal",  
  "taints": [  
    {  
      "effect": "NoSchedule",  
      "key": "node-role.kubernetes.io/master"  
    }  
  ]  
}  
{  
  "name": "ip-172-31-87-231.ec2.internal",  
  "taints": null  
}
```



# Taints

- Examples (Taints)

- To apply

```
kubectl taint nodes qanode release=qa:NoSchedule
```

```
kubectl taint nodes devnode release=dev:PreferNoSchedule
```

```
kubectl taint nodes prodnode release=prod:NoExecute
```

- To remove

```
kubectl taint nodes node-name key=value:Effect-
```



# Tolerations

```
1 apiVersion: v1
2 kind: Pod
3 metadata:
4   labels:
5     release: qa
6   name: tolerations-release-qa
7 spec:
8   containers:
9     - image: nginx
10    name: tolerations-unreachable
11   dnsPolicy: ClusterFirst
12   restartPolicy: Always
13   tolerations:
14     - key: "release"
15       operator: "Exists"
16       value: "qa"
17       effect: "NoSchedule"
```



# Services

- Cluster IP
- Node Port
- Load Balancer
- Demo
- Practicals



# Service Types

- Cluster IP
  - Service exposed on cluster internal IP
  - Reachable only within cluster
- Node Port
  - Exposed on each Node IP at static port
- Load Balancer
  - Exposed through external cloud load balancer
- External Name
  - Exposed through the contents of external field via CNAME record

# Service

- An abstract way to expose an application running on pod as network service.
- Frontends and backends of application can connect without worrying about POD IPs
- Uses session affinity while connecting to backend PODs

```
1 apiVersion: v1
2 kind: Service
3 metadata:
4   labels:
5     app: nginx
6   name: nginx
7 spec:
8   ports:
9     - port: 80
10    protocol: TCP
11    targetPort: 80
12 selector:
13   app: nginx
```



# Service - External IP

```
apiVersion: v1
kind: Service
metadata:
  name: my-service
spec:
  selector:
    app: MyApp
  ports:
    - name: http
      protocol: TCP
      port: 80
      targetPort: 9376
  externalIPs:
    - 80.11.12.10
```

## Use Cases:

- External DB Cluster in production
- To point a service in another namespace / cluster



# Ingress & Networking

- Ingress Controller
- Ingress Resources
- Multi domain frontends with service
- Demo
- Practicals



# Ingress

- Provides load balancing, SSL Termination and Name based virtual hosting
- Provides externally reachable URLs to Services
- Used for HTTP / HTTPS protocols

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: test-ingress
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /
spec:
  rules:
  - http:
      paths:
      - path: /testpath
        backend:
          serviceName: test
          servicePort: 80
```



# Examples

- API Services rollout
- Wordpress with mysql
- Spring Boot with DB



# Rollout Strategies

- Rolling Updates
- Recreate
- Blue/Green
- Canary



# Exercises (15 mins)

- Create deployment based on nginx image with 3 replicas
- View service URL and access it using browser
- Create another service of type Ingress
- View service URL and Access the service outside cluster
- Create one more service of type ClusterIP
- View service URL and find a way to access it



# Exercise - Scenario

**Assume that based on your recently acquired K8S expertise, you are tasked by your firm to develop real time video based facility monitoring service with below high level Objectives:**

- New video service should be independent of any other earlier services (/API) developed
- Deployment should be as easy as possible
- New service should be provided to end customers via <existing-url>/video
- You are expected to use current k8s setup and extend on it

**Outcome expected:**

- Yaml based definitions of deployment, service and domain based routing and load balancing.
- Service deployment should have at least 5 instances of replica



# Monitoring

- Liveness Probes
- Readiness Probes
- Container Logging
- Monitoring & Debugging
  - Debug - live debugging with Telepresence
  - Shell to running container
- Demo
- Practicals



# Monitoring Dashboard

```
kubectl apply -f  
https://raw.githubusercontent.com/kubernetes/dashboard/v2.0.0-beta8/aio/deploy/re  
commended.yaml
```

```
kubectl proxy
```

<http://localhost:8001/api/v1/namespaces/kubernetes-dashboard/services/https:kubernetes-dashboard:/proxy/>



# Cluster Access

To view cluster configuration

```
kubectl config view
```

Reverse proxy to API server

```
kubectl proxy --port=8080
```



# Port Forwarding

```
kubectl port-forward <pod> 7000:6379
```

```
kubectl port-forward <deployment> 7000:6379
```

```
kubectl port-forward <svc> 7000:6379
```

To access LoadBalancer service on localhost

```
minikube tunnel
```



# Introspection & debugging

```
kubectl get pods  
kubectl get pod <pod-name> -o yaml  
kubectl describe <pod-name>  
kubectl describe <pod-name> -o yaml  
kubectl get events  
kubectl get events --namespace=my-namespace  (--all-namespaces)  
kubectl get nodes  
kubectl get node <node-name>  
kubectl get node <node-name> -o yaml  
kubectl describe node <node-name>  
kubectl describe node <node-name> -o yaml
```

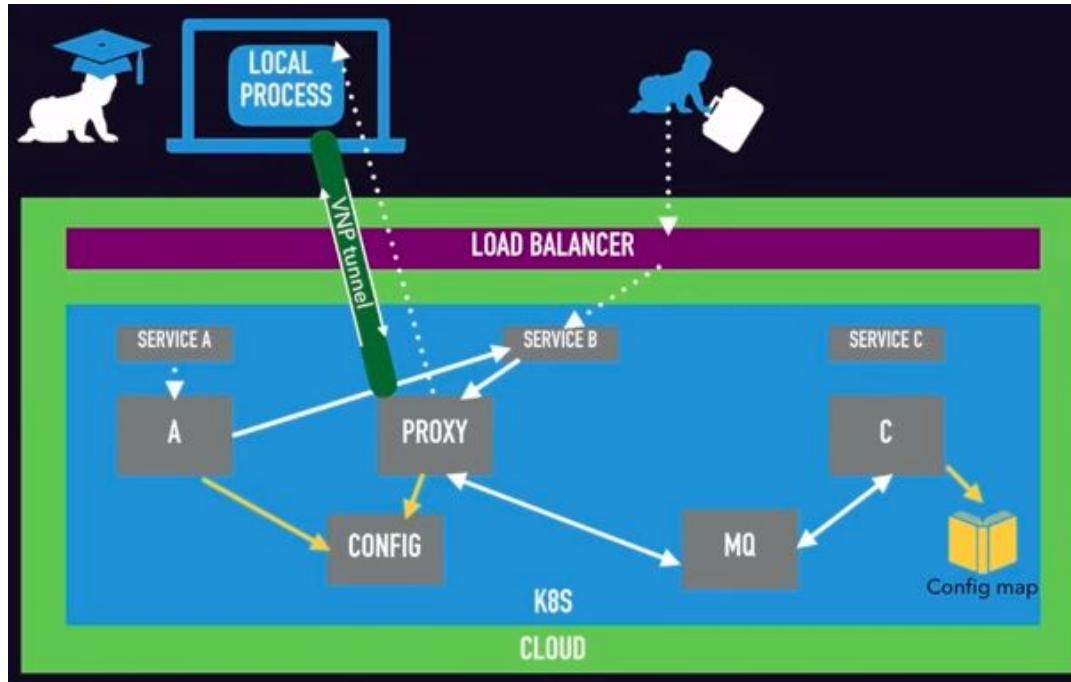


# Live debugging using IDE

```
telepresence --swap-deployment hostnames --namespace default --run mvn spring-boot:run  
-Dspring-boot.run.jvmArguments="-Xdebug  
-Xrunjdwp:transport=dt_socket,server=y,suspend=y,address=5005"
```

Project: git/rest-service

# Telepresence - Live debugging





# Shell to running container

```
rajesh@rajesh-Gazelle:~/git/kubernetes/debugging/shell$ kubectl apply -f shell-demo.yaml
```

```
kubectl get pod shell-demo
```

```
kubectl exec -it shell-demo -- /bin/bash
```

```
root@shell-demo:/# ls /
```

```
root@shell-demo:/# echo Hello shell demo > /usr/share/nginx/html/index.html
```

```
root@shell-demo:/# apt-get update
```

```
root@shell-demo:/# apt-get install curl
```

```
root@shell-demo:/# curl localhost
```

```
kubectl exec shell-demo env
```

```
kubectl exec -it my-pod --container main-app -- /bin/bash
```



# Best Practices

- Configuration - specify latest stable API version
- Keep config files in version control before pushing to cluster
- Prefer YAML over JSON
- Group related objects into one file whenever it makes more sense
- Don't specify default values unnecessarily
- Put Object descriptions as part of annotations
- Don't use naked PODs
- Create service before deployments
- Avoid using hostPort for POD
- Use labels effectively
- Use image tag instead of using latest as the default
- Use kubectl run and expose to launch single container deployments & services



# Best Practices- Security

## 4 Cs of Cloud Native Security

- Code
- Container
- Cluster
- Cloud

## Areas of caution / concern:

- API Server: Avoid exposing Master Nodes / API server publicly
- Nodes Access: Should allow only master nodes to communicate on specified ports
- Access to Cloud API: Based on principle of least privilege, Cloud API access to K8S should be provided
- ETCD: Master only should have access and data should be encrypted



# Recap

- Review
- Q & A



# Misc: Spring boot app monitoring

```
- name: management.endpoints.web.exposure.include
  value: "*"
- name: spring.application.name
  value: fleetLytics
- name: management.server.port
  value: "8888"
- name: management.metrics.web.server.request.autotime.enabled
  value: "true"
- name: management.metrics.tags.application
  value: fleetLytics
```

```
annotations:
  prometheus.io/scrape: "true"
  prometheus.io/port: "8888"
  prometheus.io/path: /actuator/prometheus
```

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-actuator</artifactId>
</dependency>
<dependency>
    <groupId>io.micrometer</groupId>
    <artifactId>micrometer-registry-prometheus</artifactId>
</dependency>
```

# **Thank You for your active participation!**

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