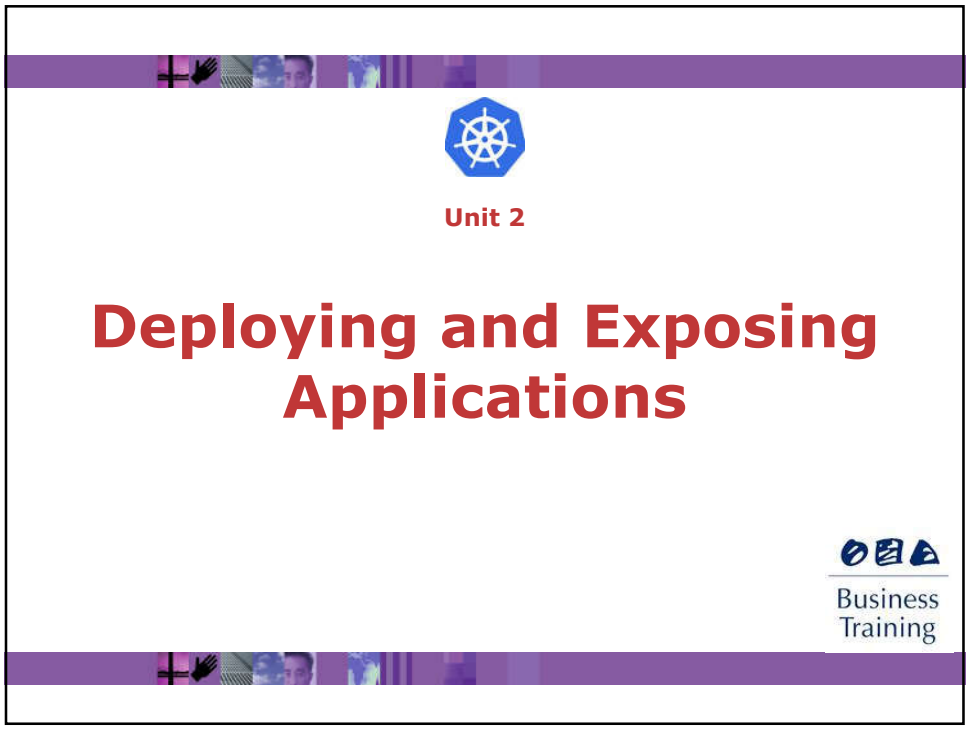

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Outline

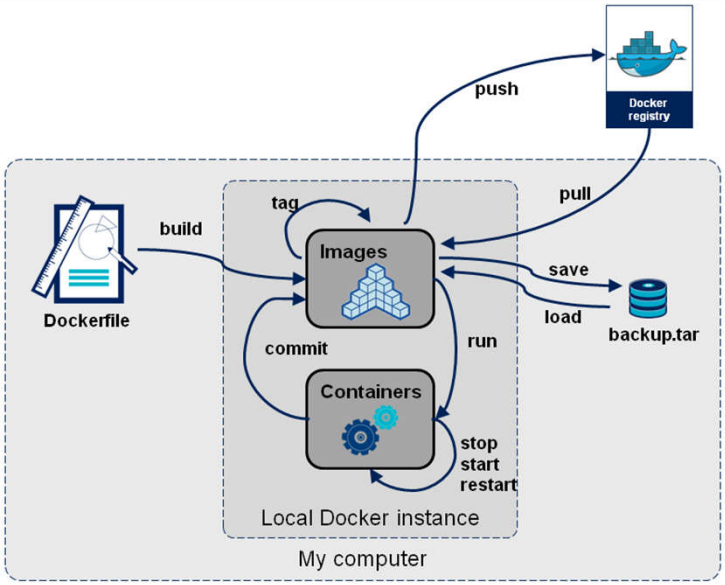
- Building and Shipping Docker Images
- Authoring manifests for deployment
- Exposing Applications with Services
- Accessing internal services

2

Building and Shipping Docker Images

3

Docker containers & images



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docker build example

- **This Dockerfile for creating a simple Java application:**

```
FROM maven:3.5.2-jdk-9
COPY src /usr/src/app/src
COPY pom.xml /usr/src/app
RUN mvn -f /usr/src/app/pom.xml clean package

EXPOSE 8080
ENTRYPOINT ["java","-jar","/usr/src/app/target/myapp-1.0.0-SNAPSHOT.jar"]
```

- **The image can be built with the following command:**

```
$ docker build -t my-app .
```

- **Notes:**
  - The build has the current directory as context
  - Each command in the Dockerfile creates a new (temporary container)
  - Every creation step generates a layer that is is cached, so repeated builds are fast

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Dockerfile instructions

Instruction	Description
FROM	Parent image
ARG	Parameters for contructing the image
ENV	Specify Environnement variables
LABEL	Specify Label meta-data
VOLUME	Mount volumes
RUN	Run a command
COPY	Copy files to the image
ADD	Add files to the image
WORKDIR	Specify the working directory
EXPOSE	Expose ports to be accessed
USER	User name or UID to be used
ONBUILD	Instructions to execute when constructing child images
CMD	Command to execute when starting a container
ENTRYPOINT	The default entry point of the container

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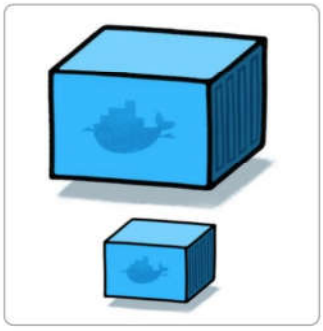
Deploying and exposing applications

What are multi stage builds ?

- **Multi-stage builds are a method of organizing a Dockerfile to minimize the size of the final container.**
  - This is made possible by the image building process into multiple stages
  - Each stage is a separate image, and can copy files from previous stages.

```
# Dockerfile
# build stage
FROM buildbase as build
...
...
...

# production ready stage
FROM runbase
...
COPY --from=build
/artifact /app
```



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Deploying and exposing applications

Multi-stage builds in practice

- **Building a Java Spring Boot Application in a single image**

```
FROM maven:3.5.2-jdk-9
COPY src /usr/src/app/src
COPY pom.xml /usr/src/app
RUN mvn -f /usr/src/app/pom.xml clean package

EXPOSE 8080
ENTRYPOINT ["java","-jar","/usr/src/app/target/myapp-1.0.0-SNAPSHOT.jar"]
```

- **Building the Java Spring Boot Application using a multi-stage build**

```
FROM maven:3.5.2-jdk-9 AS build
COPY src /usr/src/app/src
COPY pom.xml /usr/src/app
RUN mvn -f /usr/src/app/pom.xml clean package

FROM openjdk:9-jre-alpine
COPY --from=build /usr/src/app/target/ myapp-1.0.0-SNAPSHOT.jar
/usr/app/myapp-1.0.0-SNAPSHOT.jar
EXPOSE 8080
ENTRYPOINT ["java","-jar","/usr/app/myapp-1.0.0-SNAPSHOT.jar"]
```


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Useful Docker Commands

- **docker ps** list running containers.
- **docker ps -a** list all container including stopped container
- **docker pull** download a image from Docker Hub registry.
- **docker build** . to build a container based on the Dockerfile in the current directory (the dot). docker build -t "myimage:latest" . creates a container and stores the image under the given name
- **docker images** or docker image ls shows all local storage images
- **docker run** to run a container using the image given in parameter
- **docker logs** display the logs of a container, you specified. To continue showing log updates just use docker logs -f mycontainer
- **docker volume ls** lists the volumes, which are commonly used for persisting data of Docker containers.
- **docker network ls** - list all networks available for docker container
- **docker network** connect adds the container to the given container network. That enables container communication by simple container name instead of IP.
- **docker rm** removes one or more containers. docker rm mycontainer, but make sure the container is not running
- **docker rmi** removes one or more images. docker rmi myimage, but make sure no running container is based on that image
- **docker stop** stops one or more containers.

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Shipping an Image to a registry

- **An account is required to push images to Dockerhub**
- **Ship an image to DockerHub.com**

```
> docker push myrepo/myimage:1.0
```

- **DockerHub has a limit of the number of Pulls, since 11/2020**
  - 100 pulls in 6 Hours /Anonymous
  - 200 pulls in 6 Hours/Logged in user
- **Alternatives to DockerHub**
  - RedHat Quay.io
  - Amazon Elastic Container Registry (ECR)
  - JFrog Artifactory.
  - Azure Container Registry.
  - Google Container Registry.
  - VMWare Harbor

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Dockerfile best practices

- Use official base images
- Prefer COPY over ADD
- Group RUN instructions in one line
- ADD a .dockerignore file
- Use Multi-stage builds

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Authoring manifests for deployment

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Yaml manfiest structure

- **Required fields**
  - **apiVersion** - Which version of the Kubernetes API you're using to create this object
  - **kind** - What kind of object you want to create
  - **metadata** - Data that helps uniquely identify the object, including a name string, UID, and optional namespace
  - **spec** - What state you desire for the object. The precise format of the object spec is different for every Kubernetes object
- **The status field**
  - While spec describes the desired state, the status describes the current state. It is added and updated continuously by K8s control plane.

```
kubectl get deploy mydepl -o yaml
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  selector:
    matchLabels:
      app: nginx
  replicas: 2
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.14.2
        ports:
        - containerPort: 80
```


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kubectl apply vs create

- **`kubectl create -f whatever.yaml`**
  - creates resources if they don't exist
  - if resources already exist, don't alter them (and display error message)
- **`kubectl apply -f whatever.yaml`**
  - creates resources if they don't exist
  - if resources already exist, update them (to match the definition provided by the YAML file)
  - stores the manifest as an annotation in the resource

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Simple Pod Deployment

- **Deployement steps**
  1. Describe the app using Kubernets YAML (**my-ngnix-pod.yaml**)
  2. Run the deployment Command **`kubectl apply -f my-ngnix-pod.yaml`**
  3. Make sure the pod has been created **`kubectl get pods`**
  4. Tear down your app **`kubectl apply -f my-ngnix-pod.yaml`**

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: mynginxapp
  labels:
    name: mynginxapp
spec:
  containers:
    - name: mynginxapp
      image: nginx
      ports:
        - containerPort: 80
```


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Simple Pod with namespace and labels

- **Additional information**
  - **Namespace**: Namespaces provide a scope for Kubernetes resources, splitting the cluster in smaller units.
  - **Labels**: Labels are intended to be used to specify identifying attributes of objects that are meaningful and relevant to users, but do not directly imply semantics to the core system.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: mynginxapp
  namespace: default
  labels:
    name: mynginxapp
    profile: dev
spec:
  containers:
  - name: mynginxapp
    image: nginx
    ports:
      - containerPort: 80
```


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A Multi container Pod: Main Container with Side Car Container

- Main Container and the Side Car Container share a Volume

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-with-sidecar
spec:
  # Create a volume called 'shared-logs' that the pp and sidecar share.
  volumes:
  - name: shared-logs
    emptyDir: {}
  containers:
  - name: app-container # Main application container
    # Simple application: write the current date  to the log file every 5 seconds
    image: alpine
    command: ["/bin/sh"]
    args: ["-c", "while true; do date >> /var/log/app.txt; sleep 5;done"]
    volumeMounts: # Mount the pod's shared log file into the app container
    - name: shared-logs
      mountPath: /var/log

  - name: sidecar-container # Sidecar container
    image: nginx:1.7.9
    ports:
      - containerPort: 80
    volumeMounts: # Mount the pod's shared log file into the sidecar
    - name: shared-logs
      mountPath: /usr/share/nginx/html # nginx-specific mount path
```


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Using Deployments

- **Saving this manifest into `nginxdeploy.yaml` and submitting it to a Kubernetes cluster will create the defined Deployment, ReplicaSet and the Pods**
  - You can then get the current Deployments deployed:

    `kubectl get deployments`
  - You can then get the current ReplicaSets deployed:

    `kubectl get rs`
  - You can then get the current pods deployed:

    `kubectl get pods`

```yaml
# for versions before 1.9.0 use apps/v1beta2
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  selector:
    matchLabels:
      app: nginx
  replicas: 2 # tells deployment to run 2 pods
  template:                    Pod Template
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.14.2
        ports:
        - containerPort: 80
```


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Updating the deployment

- You can update the deployment by applying a new YAML file. This YAML file specifies that the deployment should be updated to use nginx 1.16.1

```yaml
# for versions before 1.9.0 use apps/v1beta2
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  selector:
    matchLabels:
      app: nginx
  replicas: 2 # tells deployment to run 2 pods
  template:                          Pod Template
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.16.1
        ports:
        - containerPort: 80
```


Scaling the application by increasing the replica count

- You can increase the number of pods in your Deployment by applying a new YAML file. This YAML file sets replicas to 4, which specifies that the Deployment should have four pods:

```yaml
# for versions before 1.9.0 use apps/v1beta2
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  selector:
    matchLabels:
      app: nginx
  replicas: 4 # Update the replicas from 2 to 4
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.16.1
        ports:
        - containerPort: 80
```

Exposing Applications with Services

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Services

- **Services give us a stable endpoint to connect to a pod or a group of pods**
  - Durable resource (unlike Pods)
    - static cluster-unique IP
  - Target Pods using equality based selectors
  - kube-proxy provides simple load-balancing.
- **A Kubernetes Service can select the pods it is supposed to abstract through a label selector**
- **We can create a service either using the command `kubectl expose` or using a Yaml manifest**
    - Services are automatically added to an internal DNS zone
- **A service has a number of "endpoints"**

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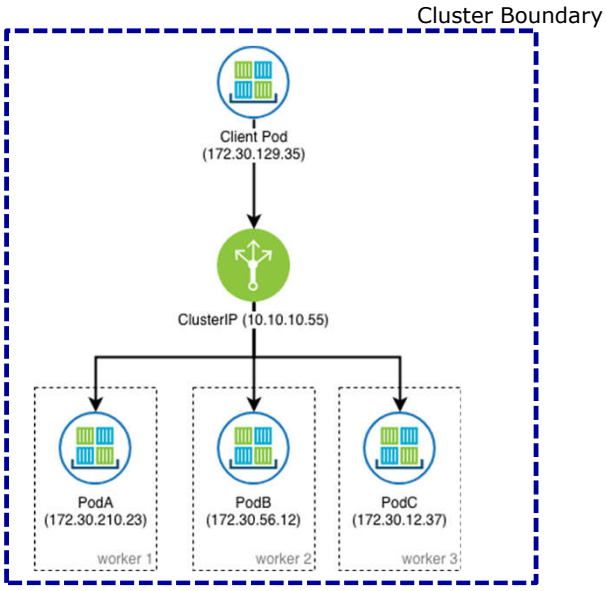
Service Types

- There are 3 major service types:
  1. ClusterIP (default)
  2. NodePort
  3. LoadBalancer
- There is also another type of services: ExternalName. They do does not have selectorsnot have selectors and uses DNS names instead. They serve as a way to return an alias to an external service residing outside the cluster.

ClusterIP Services



ClusterIP Services

- It is the default service type
- A virtual IP address is allocated for the service
- This IP address is reachable only from within the cluster (nodes and pods)
- Perfect for internal communication, within the cluster

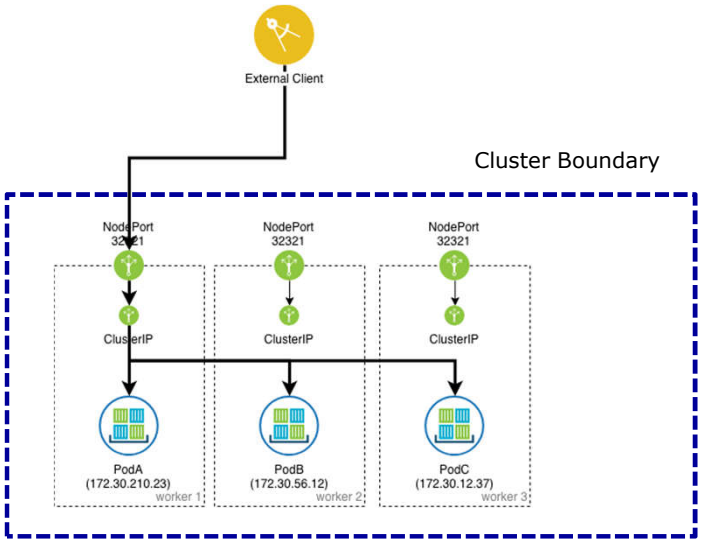
```yaml
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  type: ClusterIP
  selector:
    app: nginx
    env: prod
  ports:
  - protocol: TCP
    port: 8080
    targetPort: 80 # should meet the
                Container port
```


NodePort Services

- NodePort services extend the ClusterIP service.
  - Exposes a port on every node's IP.
- Port can either be statically defined, or dynamically taken from a range between 30000-32767.

```yaml
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  type: NodePort
  selector:
    app: nginx
    env: prod
  ports:
  - nodePort:30008
    port: 80
    targetPort: 80
```

NodePort Services



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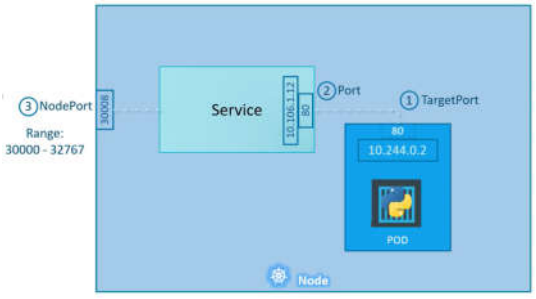
nodePort, port, targetPort



service-definition.yml

```
apiVersion: v1
kind: Service
metadata:
    name: myapp-service

spec:
    type: NodePort
    ports:
      - targetPort: 80
        port: 80
        nodePort: 30008
```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Deploying and exposing applications

LoadBalancer Services

- LoadBalancer services extend NodePort.
- Works in conjunction with an external system to map a cluster external IP to the exposed service (typically a cloud load balancer, e.g. ELB on AWS, GLB on GCE ...)

```
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  type: LoadBalancer
  selector:
    app: nginx
    env: prod
  ports:
    protocol: TCP
    port: 80
    targetPort: 80
```


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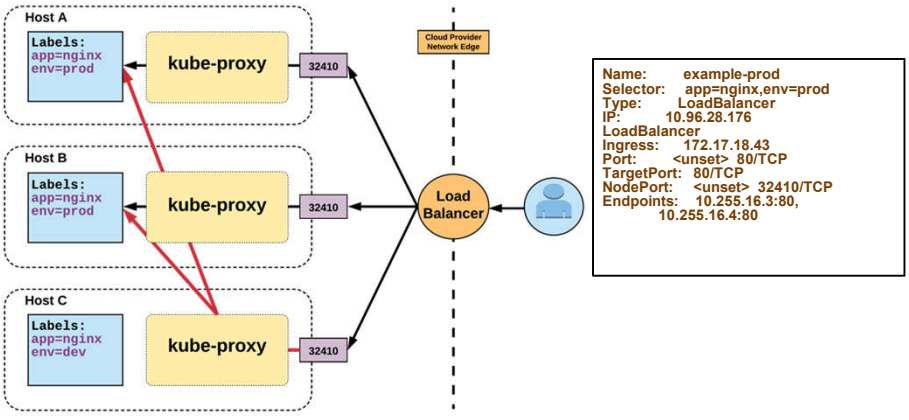
Deploying and exposing applications

LoadBalancer Services



- Gets external IP from provider

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Accessing Internal Services

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Accessing internal services

- **When we are logged in on a cluster node, we can access internal services**
  - As per the Kubernetes network model: all nodes can reach all pods and services)
- **When we are accessing a remote cluster, our local machine won't have access to the cluster's internal subnet. To overcome this:**
  - **kubectl proxy**: gives us access to the API, which includes a proxy for HTTP resources
  - **kubectl port-forward**: allows forwarding of TCP ports to arbitrary pods, services, ...

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kubectl proxy

- **Running `kubectl proxy` gives us access to the entire Kubernetes API**
  - The API includes routes to proxy HTTP traffic
  - By default, the proxy listens on port 8001
- **These routes look like the following:**
  - `/api/v1/namespaces/<namespace>/services/<service>/proxy`
- **We just add the URI to the end of the request, for instance:**
  - `/api/v1/namespaces/<namespace>/services/<service>/proxy/index.html`
- **We can access services and pods this way !**
- ***Security considerations : kubectl proxy is intended for local use***
  - Running kubectl proxy openly is a huge security risk
  - It is slightly better to run the proxy where you need it (and copy credentials, e.g. ~/.kube/config, to that place)
  - It is even better to use a limited account with reduced permissions

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kubectl port-forward

- **What if we want to access a TCP service?**
  - We can use **kubectl port-forward** instead
  - It will create a TCP relay to forward connections to a specific port (of a pod, service, deployment...)
- **The syntax is:**

```
kubectl port-forward service/name_of_service local_port:remote_port
```

  - If only one port number is specified, it is used for both local and remote ports

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Additional Deployment Objects

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DaemonSets

- **A DaemonSet ensures that all (or some) Nodes run a copy of a Pod.**
  - As nodes are added to the cluster, Pods are added to them.
  - As nodes are removed from the cluster, those Pods are garbage collected. Deleting a DaemonSet will clean up the Pods it created.
  - Typical uses of a DaemonSet are:
    - 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

```yaml
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: my-daemonset
  namespace: my-namespace
  Labels:
    key: value
spec:
  template:
    metadata:
      labels:
        name: my-daemonsetcontainer
    ...
  selector:
    matchLabels:
      name: my-daemonsetcontainer
```


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StatefulSets

- **StatefulSet is the workload API object used to manage stateful applications.**
  - StatefulSets represent a set of Pods with unique, persistent identities and stable hostnames that are maintained regardless of where they are scheduled.
  - StatefulSets use an ordinal index for the identity and ordering of their Pods.
    - By default, StatefulSet Pods are deployed in sequential order and are terminated in reverse ordinal order.
    - For example, a StatefulSet named web has its Pods named web-0, web-1, and web-2. When the web Pod specification is changed, its Pods are gracefully stopped and recreated in an ordered way; in this example, web-2 is terminated first, then web-1, and so on.
  - StatefulSets are suitable for deploying Kafka, MySQL, Redis, ZooKeeper, and other applications needing unique, persistent identities and stable hostnames.

```yaml
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: web
spec:
  serviceName: "nginx"
  replicas: 2
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: k8s.gcr.io/nginx
        ports:
        - containerPort: 80
          name: web
        volumeMounts:
        - name: www
          mountPath: /usr/share/nginx/html
```