IBM

Kubernetes

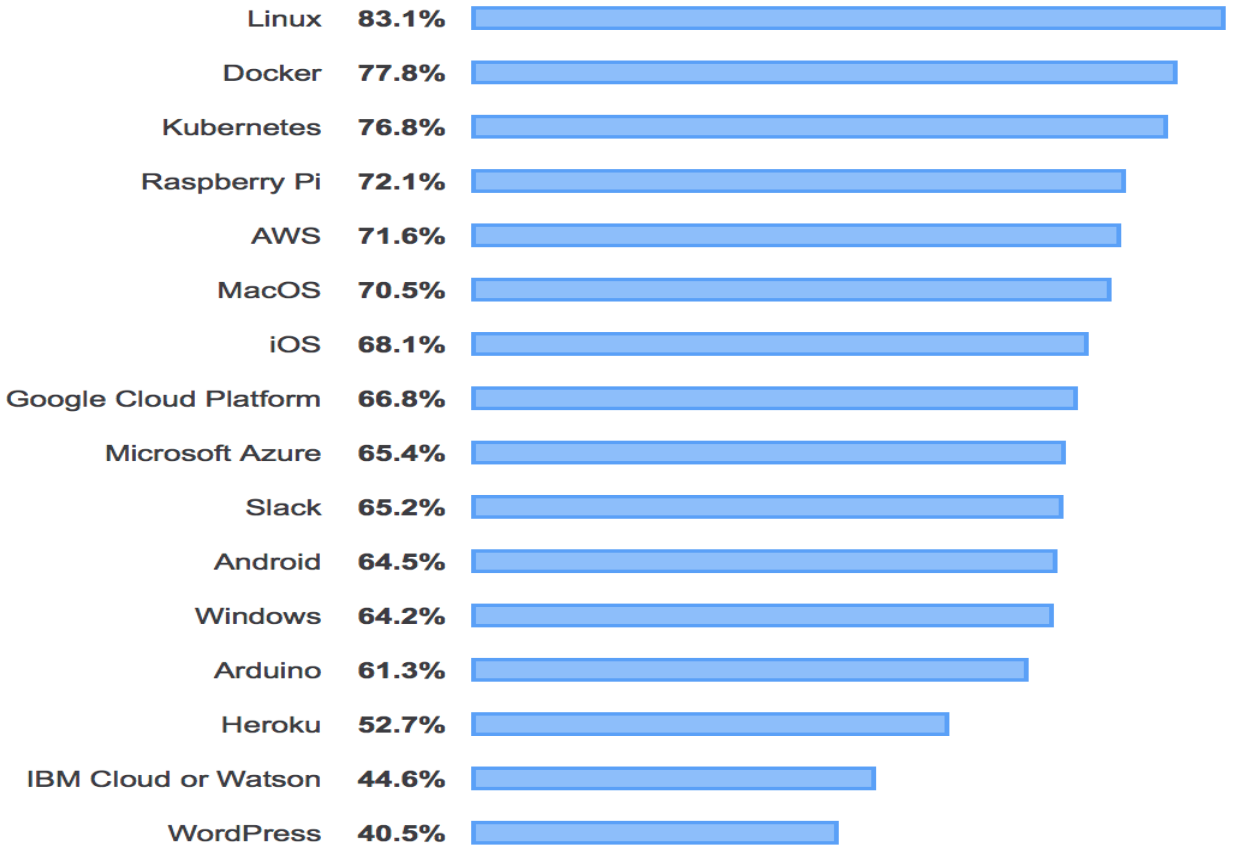
Basics

Saif ur Rehman

IBM Cloud

Most Loved, Dreaded, and Wanted Platforms

Loved | Dreaded | Wanted



stackoverflow Developer Survey Results 2019

Why do you want to run your application inside containers?

HelloWorld (~/javastarter) - gedit

Open Save Undo

HelloWorld

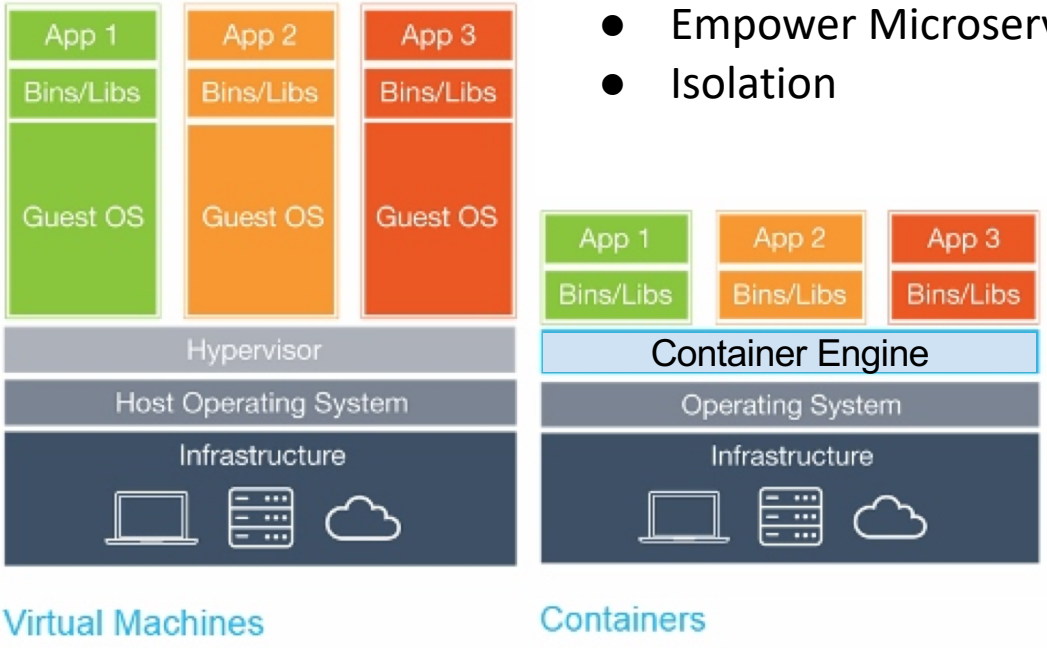
```
// A small Java program
public class HelloWorld {
        public static void main(String[] args) {
                System.out.println("Hello World");
        }
}
```

C Tab Width: 8 Ln 6, Col 2


BREAKS IN PRODUCTION
- SAY THE LINE BART!
- BUT IT WORKS ON MY MACHINE

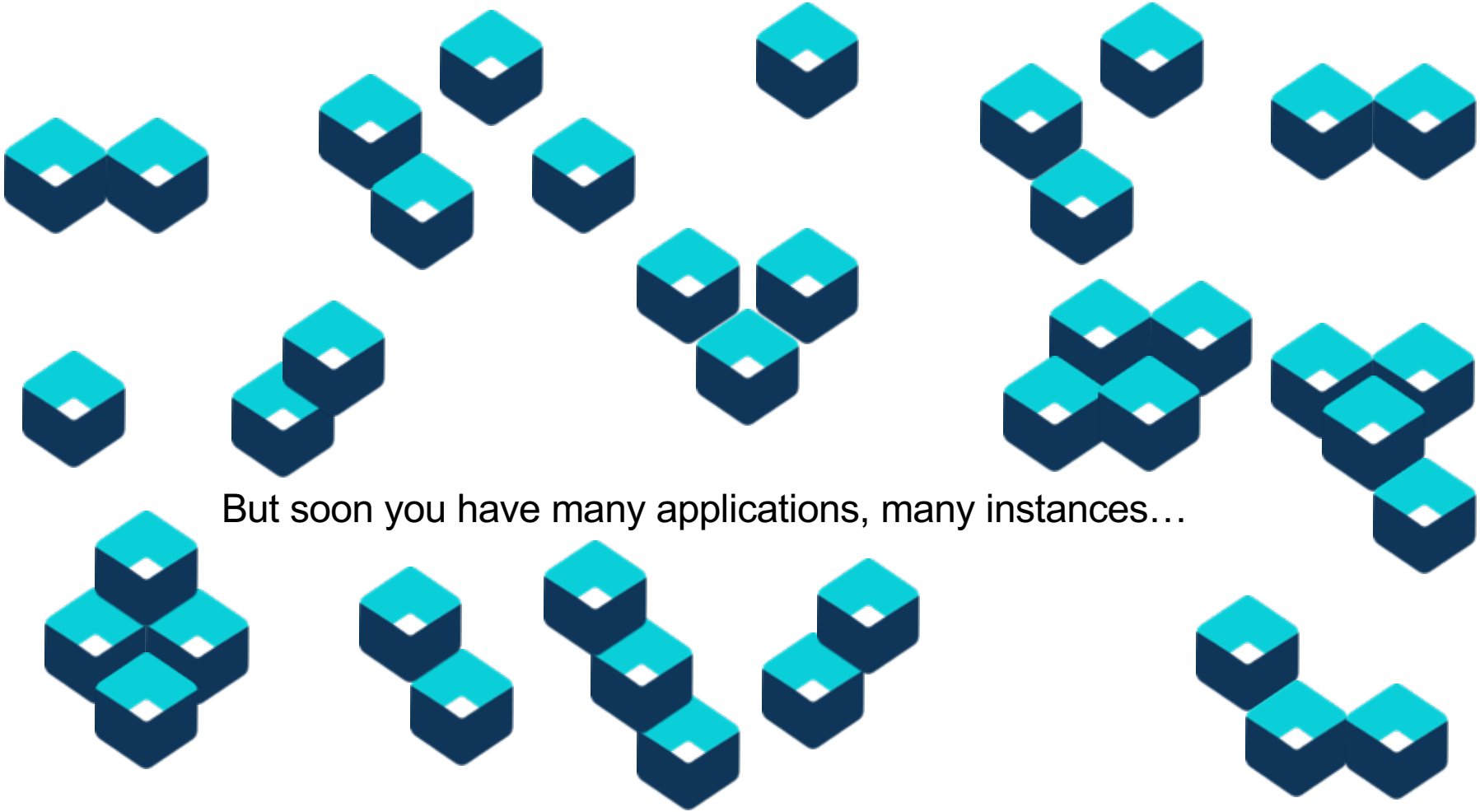
Container Advantages

- Lightweight footprint and minimal overhead,
- Portability across machines,
- Simplify DevOps practices,
- Speeds up Continuous Integration,
- Empower Microservices Architectures.
- Isolation



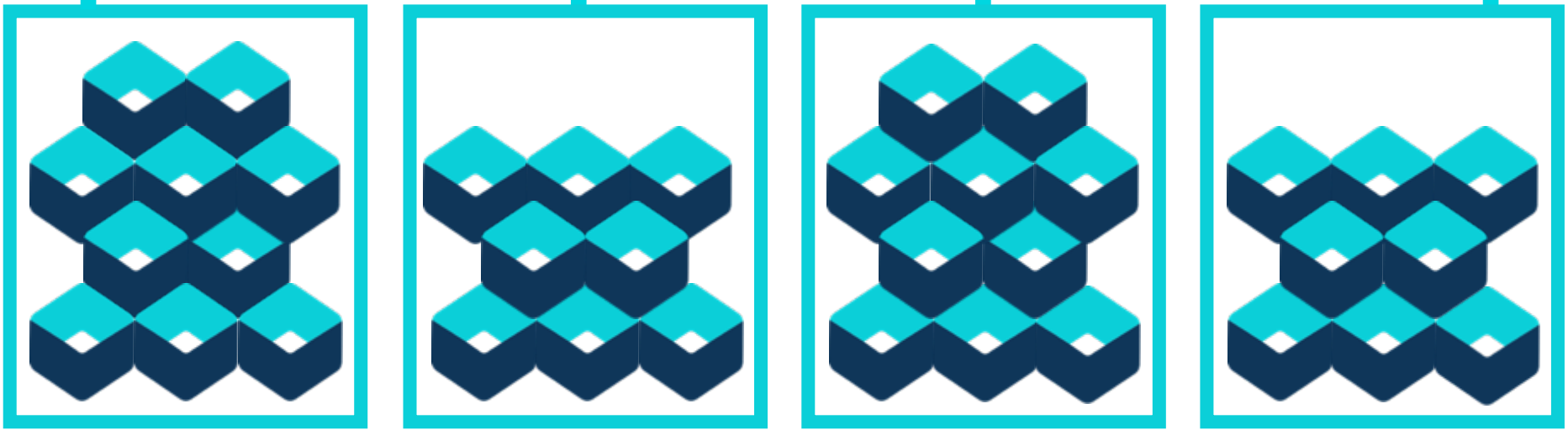
Everyone’s container journey starts with one container….

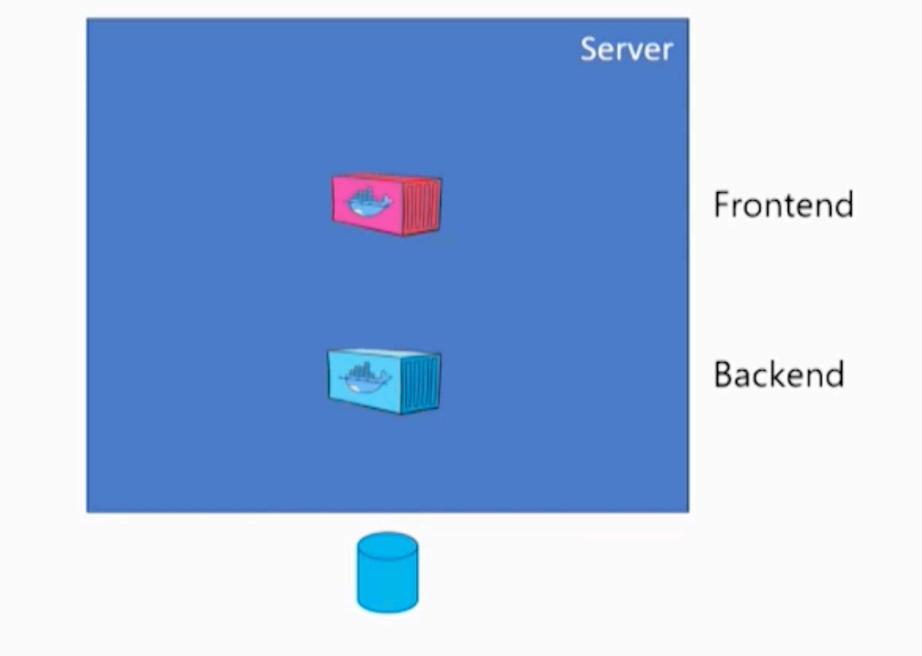
At first the growth is easy to handle….

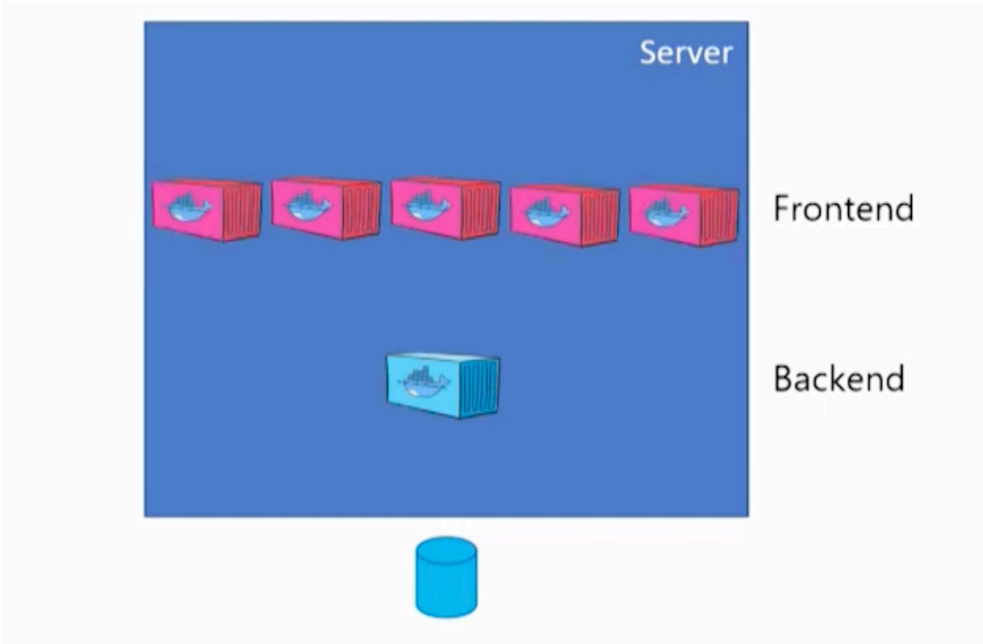


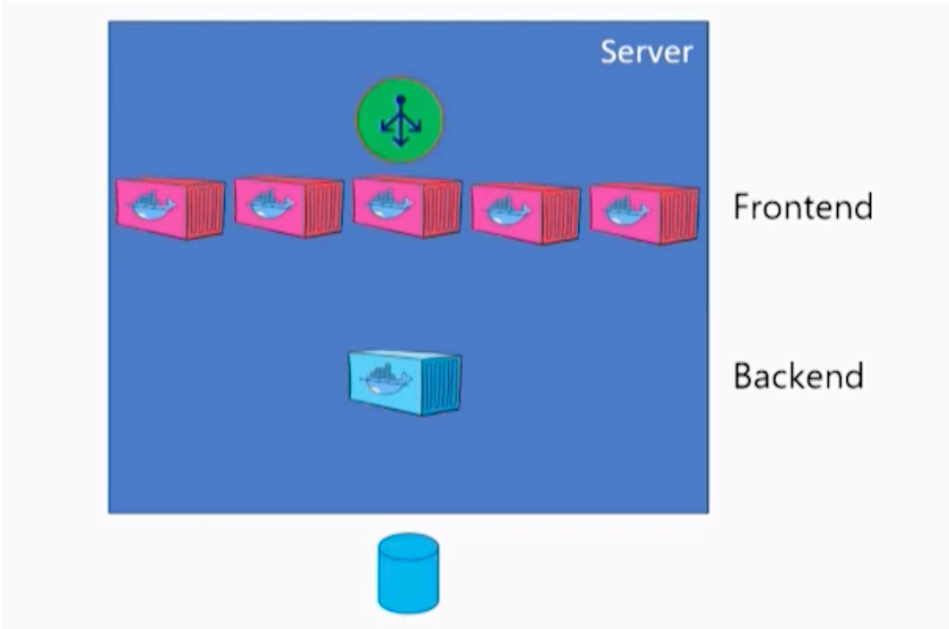
But soon you have many applications, many instances…

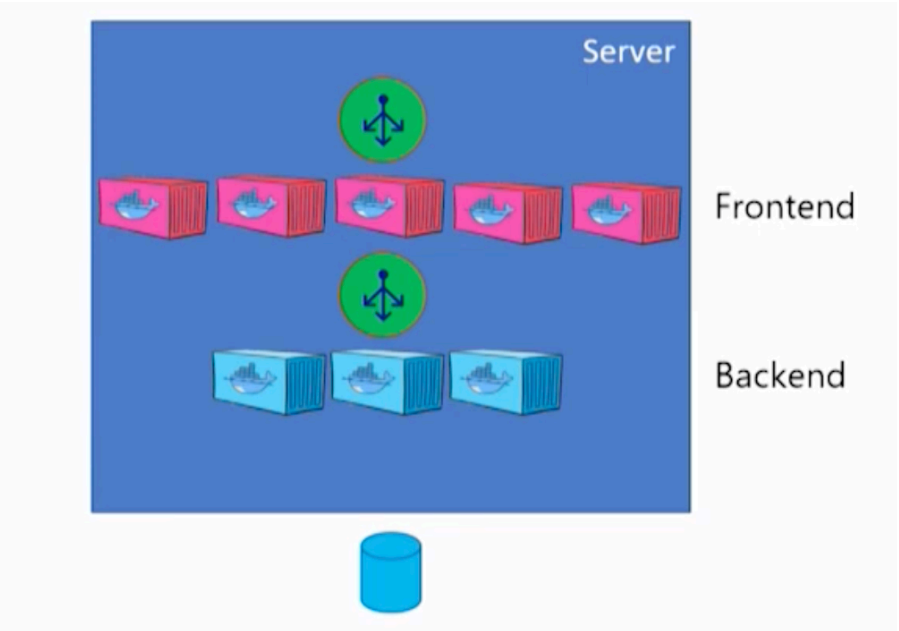
And that is why there is container orchestration

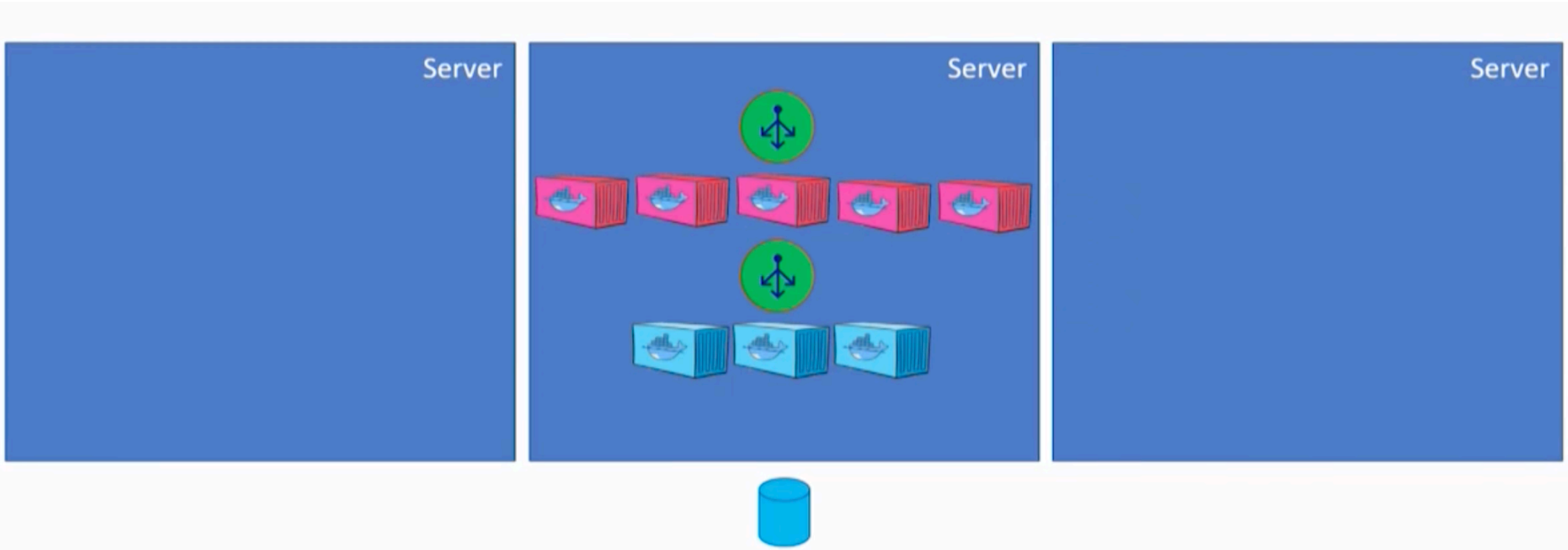


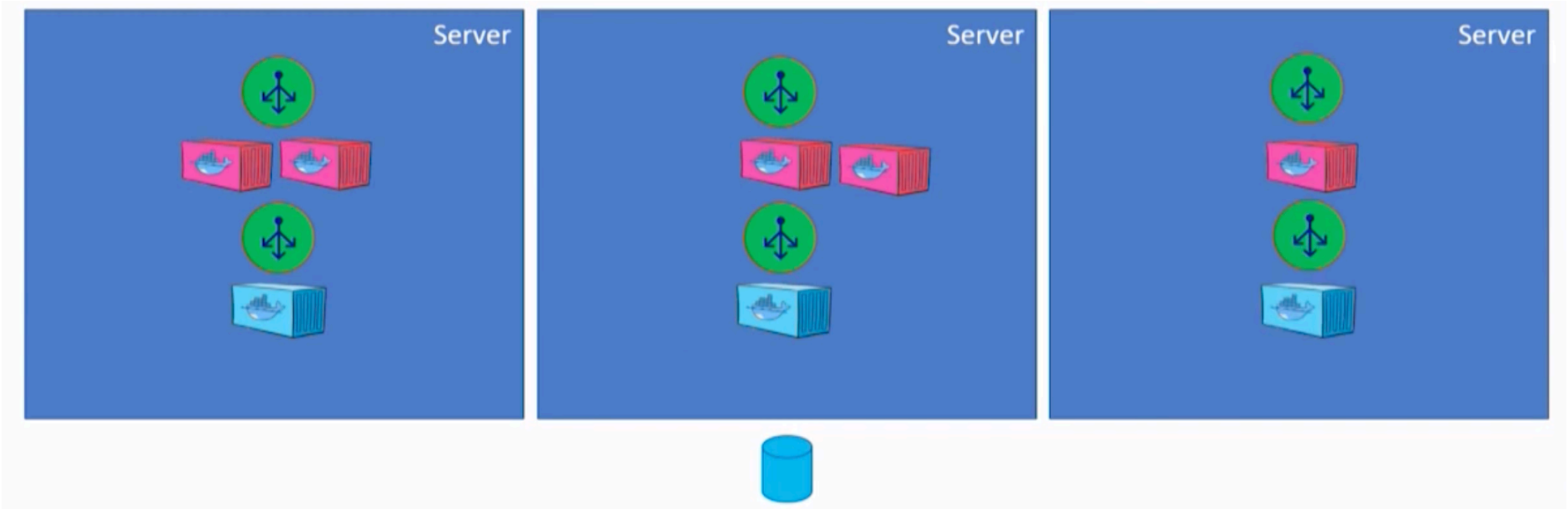

Server
Frontend
Backend

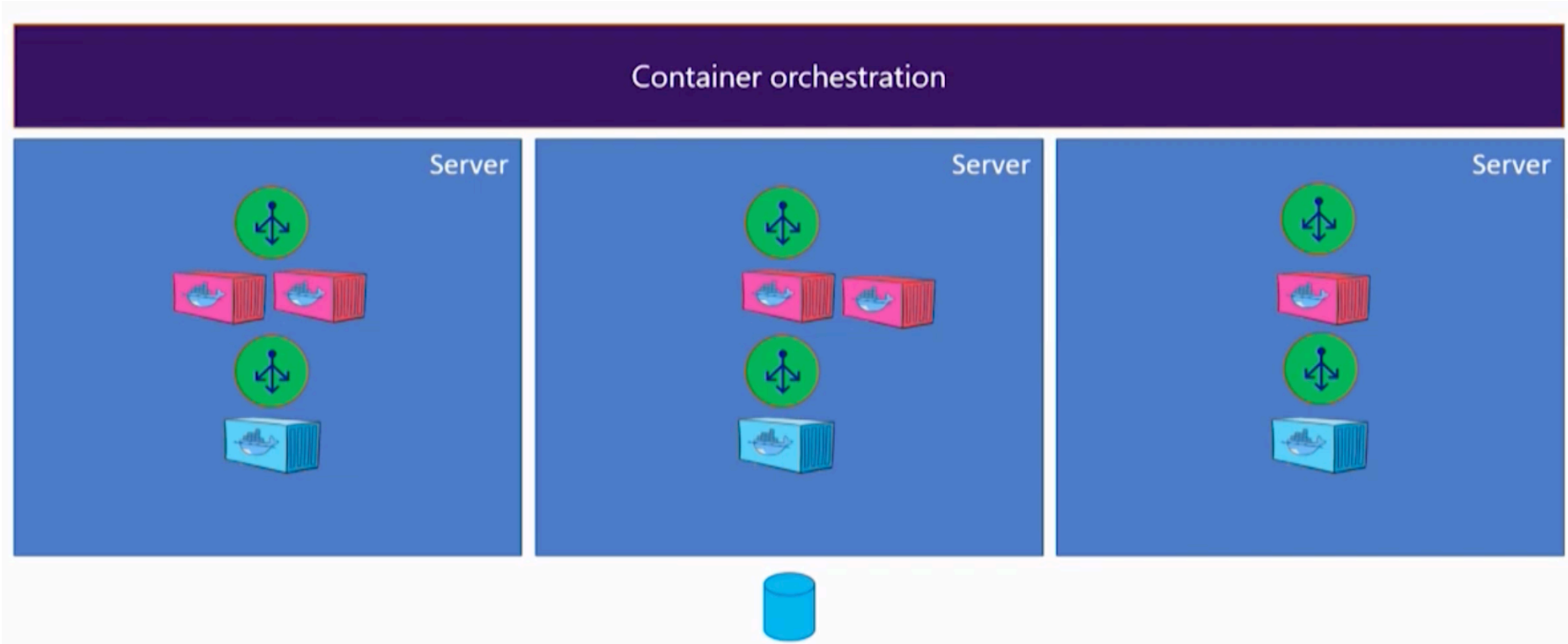

Server
Frontend
Backend

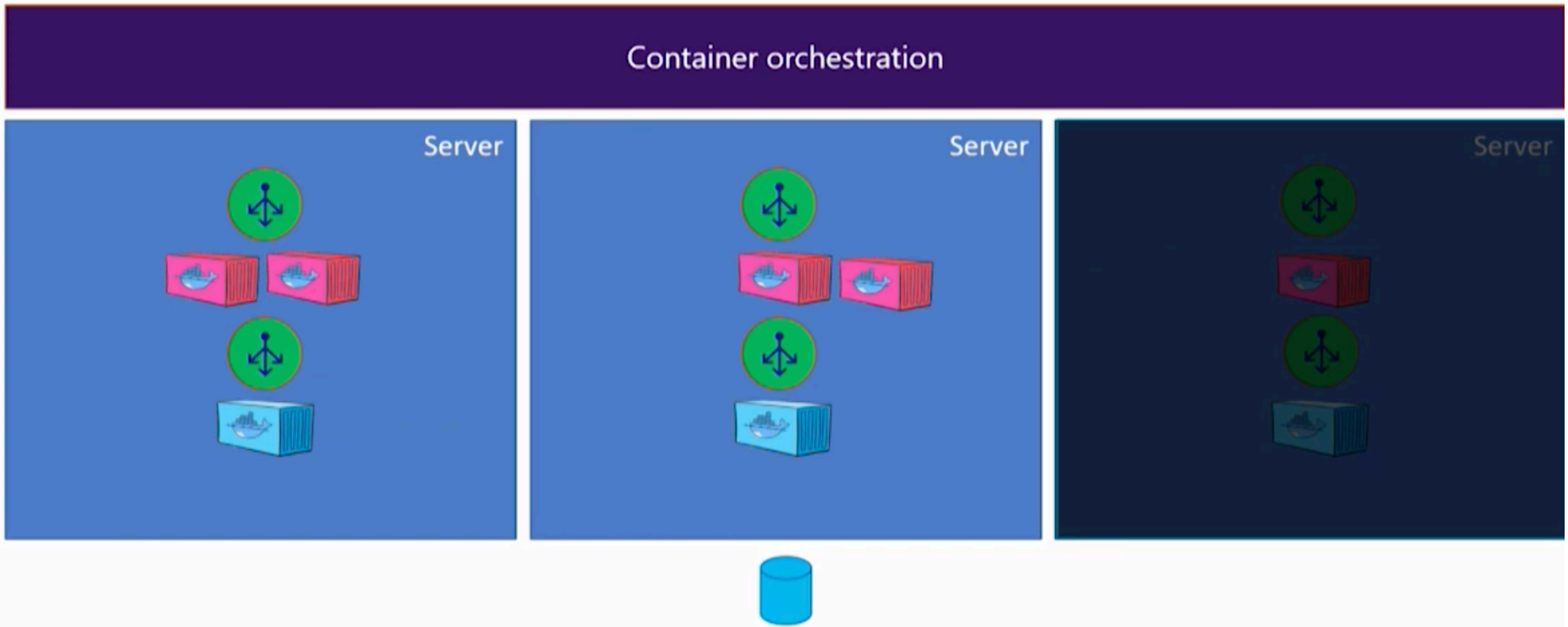

Server
Frontend
Backend

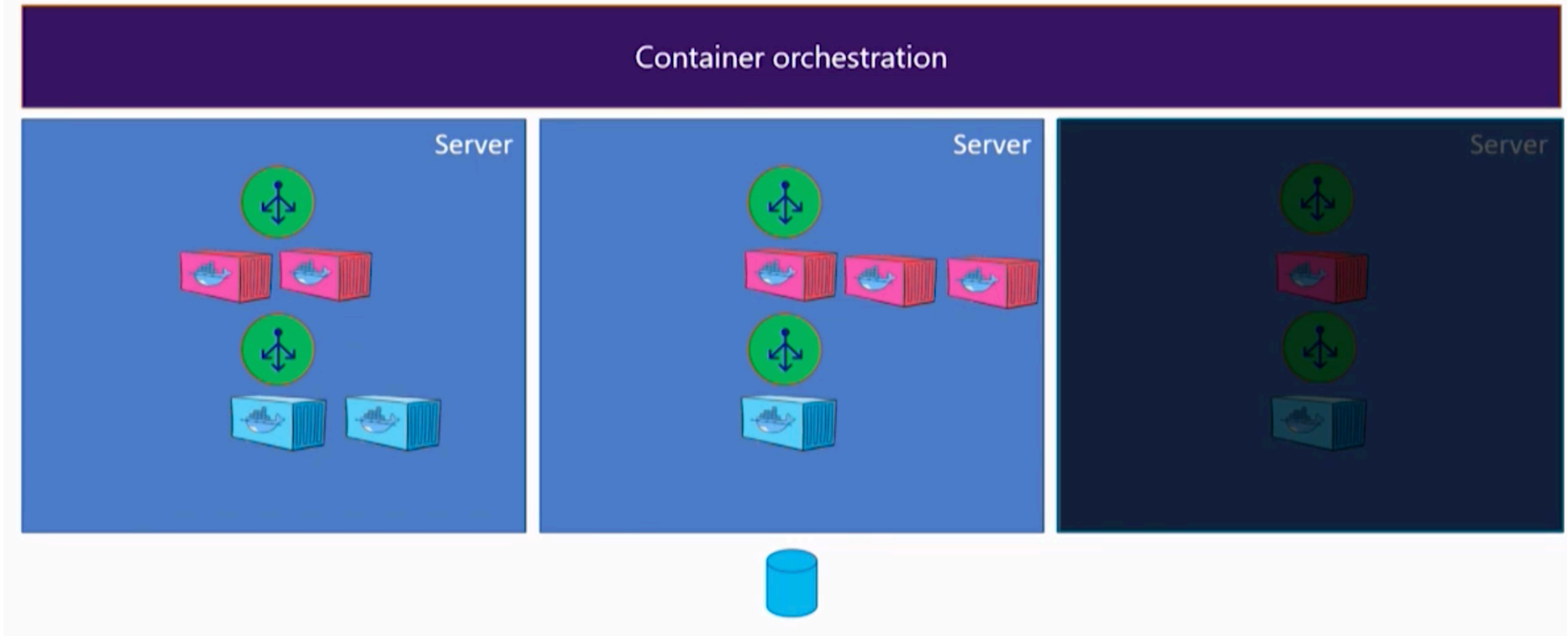

Server
Frontend
Backend


Server
Server
Server


Server
Server
Server


Container orchestration
Server
Server
Server


Container orchestration
Server
Server
Server


Container orchestration
Server
Server
Server

Challenges for multiple containers

- How to scale?
- How to avoid port conflicts?
- How to manage them in multiple hosts?
- How to keep them running?
- How to update them?
- Where are my containers?
- How to handle fail over and self healing?
- How do I isolate between different containers ?
- How do I communicate between containers?

What is Kubernetes?

Fully open source container orchestrator inspired and informed by Google's experiences and internal systems

Unified API for deploying web applications, batch jobs, and databases maintaining and tracking the global view of the cluster

Supports multiple cloud and bare-metal environments

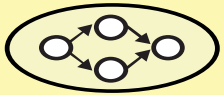
Manage applications, not machines providing a better framework to support rolling updates, canary deploys, and blue-green deployments

Designed for extensibility

Rich ecosystem of plug-ins for scheduling, storage, and networking

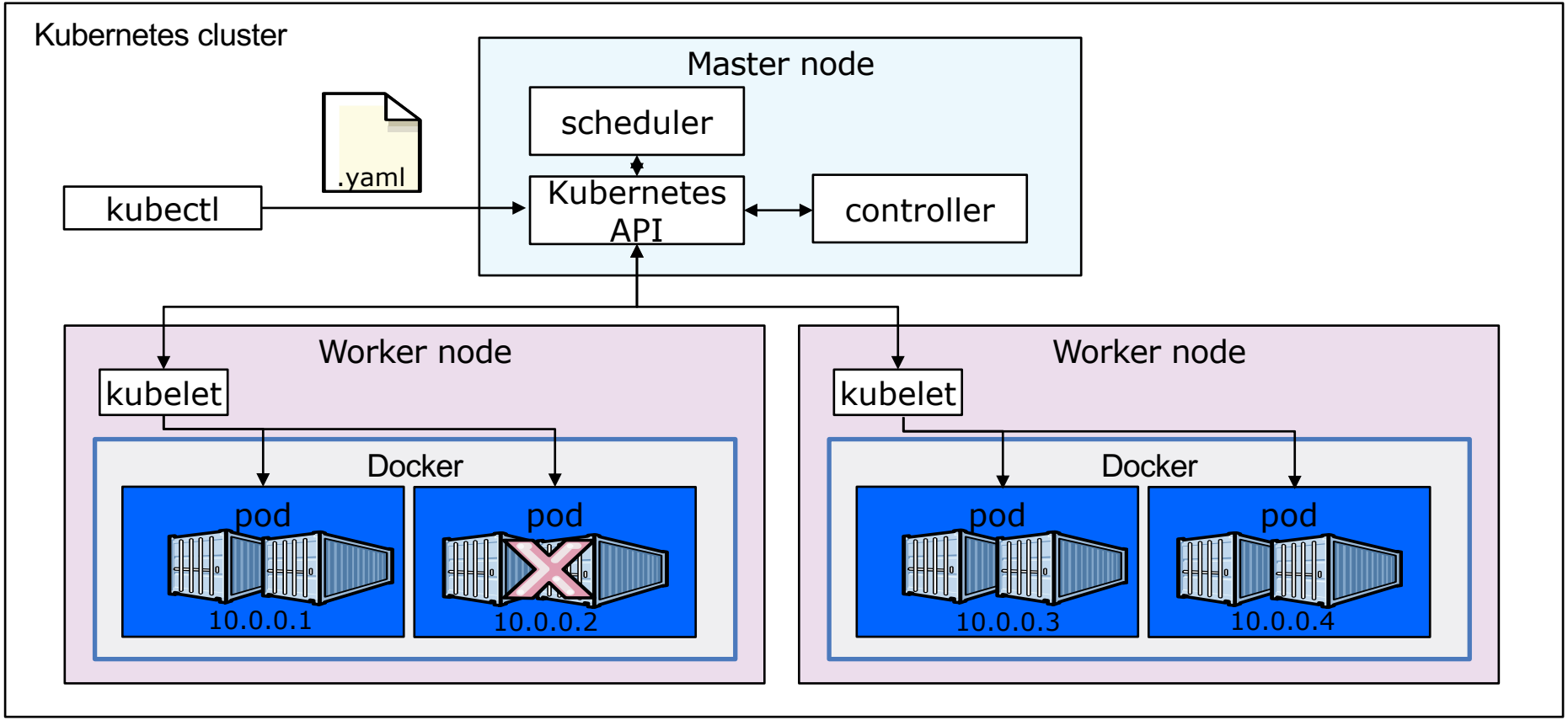
Open source project managed by the Linux Foundation

Container ecosystem

7		Application workflow	
6		Container orchestration	Kubernetes, Docker Swarm, Apache Mesos
5		Container scheduling	
4		Container engine	Docker
3		Operating system	Ubuntu, RedHat, CoreOS
2		Virtual infrastructure	VMWare, AWS
1		Physical infrastructure	

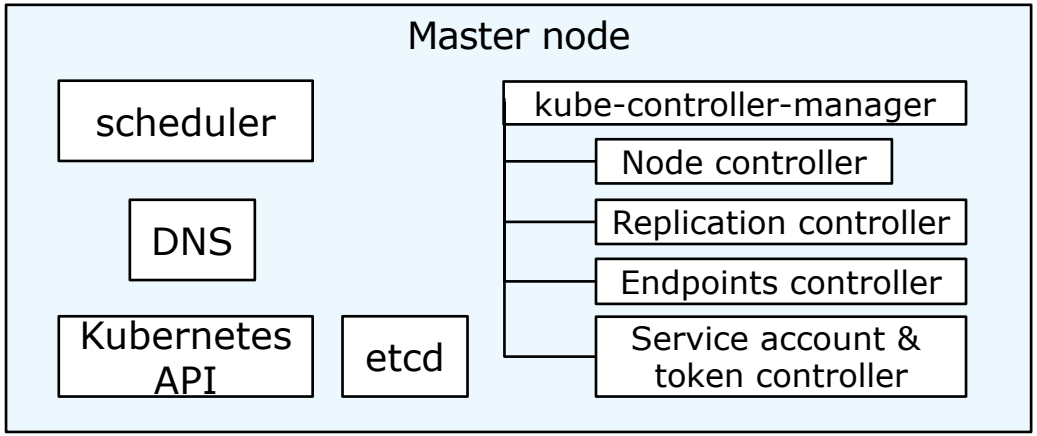
© Copyright IBM Corporation 2017

Kubernetes cluster architecture



Master Node components

- Make scheduling decisions for the cluster, and respond to cluster events, like a node failure
- Can run on any node in the cluster, but typically all master components run on the same virtual machine (vm), and do not run any container apps on that vm



Master Node Components

Etcd

- A highly-available key value store
- Stores all cluster data

API Server

- Exposes API for managing Kubernetes
- Used by kubectl CLI

Scheduler

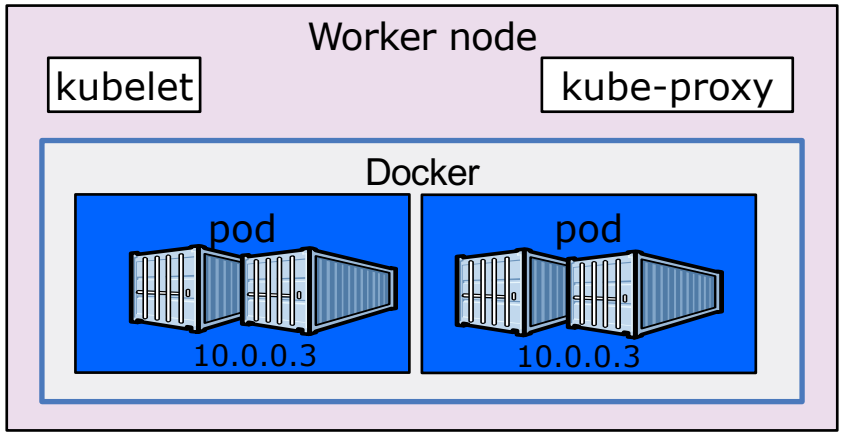
- Selects the worker node for each pods runs

Controller manager

- Daemon that runs controllers (background threads that handle routine tasks in the cluster)
- Node Controller – Responsible for noticing and responding when nodes go down
- Endpoints Controller – Populates the Endpoints object (joins services and pods)
- Service Account and Token Controllers – Create default accounts and API access tokens for new namespaces

Worker Node Components

- Provide the Kubernetes runtime environment; run on every node
- Maintain running pods



Naming in Kubernetes

Name

– Each resource object by type has a unique name

Namespace

– Resource isolation: Each namespace is a virtual cluster within the physical cluster

  - Resource objects are scoped within namespaces
  - Low-level resources are not in namespaces: nodes, persistent volumes, and namespaces themselves
  - Names of resources need to be unique within a namespace, but not across namespaces

– Resource quotas: Namespaces can divide cluster resources

– Initial namespaces

  - `default` – The default namespace for objects with no other namespace
  - `kube-system` – The namespace for objects created by the Kubernetes system

Kubernetes strengths

Clear governance model

- Managed by the Linux Foundation.
- Google is driving the product features and roadmap, while allowing the rest of the ecosystem to participate.

Growing and vibrant ecosystem

- IBM, Huawei, Intel, and Red Hat are among the companies making prominent contributions to the project.

Avoid dependency and vendor lock-in

- Active community participation and ecosystem support.

Support for a wide range of deployment options

- Customers can choose between bare metal, virtualization, private, public, and hybrid cloud deployments
- Wide range of delivery models across on-premises and cloud-based services.

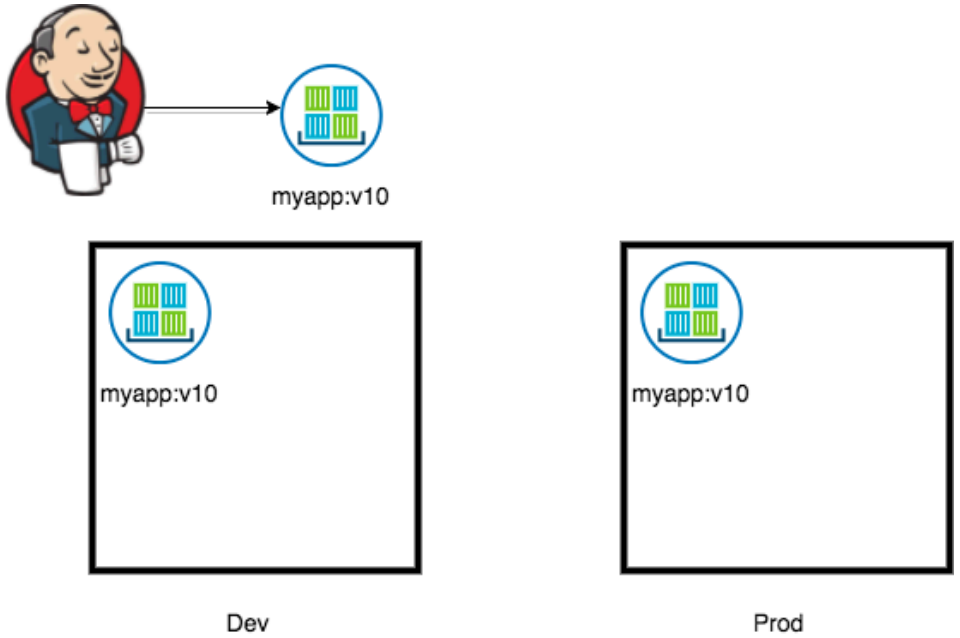
Design is more operations-centric

- First choice of DevOps teams.

Immutability

Build Once - Deploy Everywhere

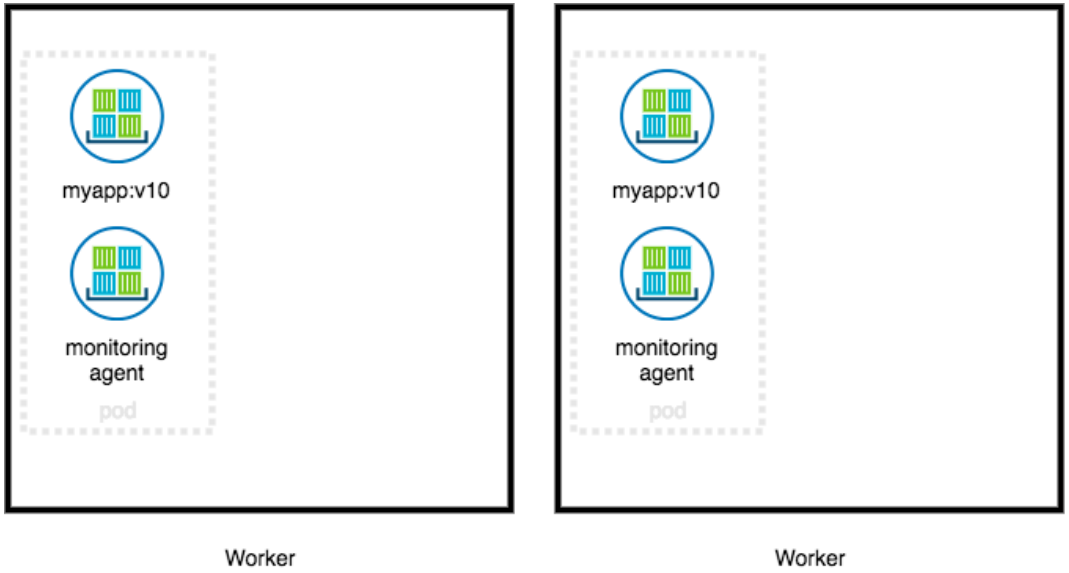
The same container image is built once and is moved between environments



Pod

A single unit of work in Kubernetes, which may consist of one or more containers

All containers in a pod are co-located and co-scheduled, and share the kernel namespace (process, storage, network, etc.)



pets

vs

cattle

Pod Health Checking

Pods are automatically kept alive by “process check” checking the basic status of the main process for the application

To go beyond this Kubernetes allows you to create a liveness probe to provide additional means for identifying health.

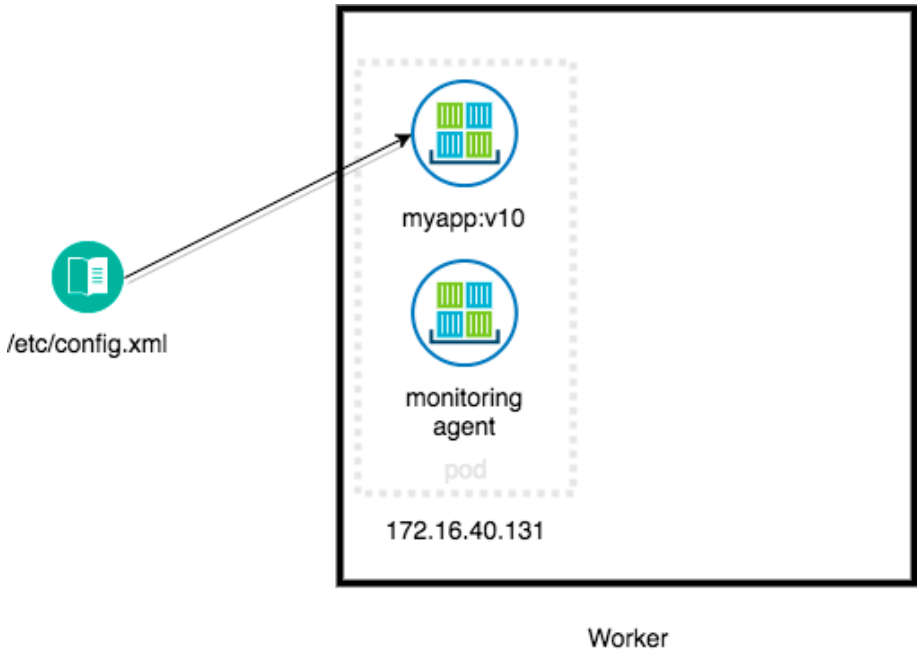
```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-with-http-healthcheck
spec:
  containers:
  - name: nginx
    image: nginx
    # defines the health checking
    livenessProbe:
      # an http probe
      httpGet:
        path: /_status/healthz
        port: 80
      # length of time to wait for a pod to initialize
      # after pod startup, before applying health checking
      initialDelaySeconds: 30
      timeoutSeconds: 1
    ports:
    - containerPort: 80
```

Config Maps & Secrets

Share and store configurations, credentials and more

Store the configurations and secrets (credentials, certificates) in the K8s environment and mount them to the local filesystem within container(s)

The container image can move un-changed between environments (i.e. container immutability)

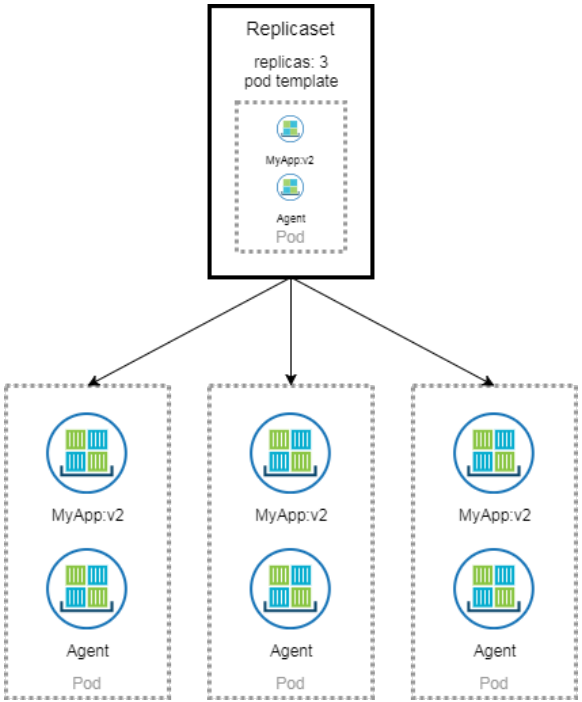


Replicaset

Scale pods horizontally and provide resiliency

Replicasets run one-to-many instances of the desired pod

When possible the replica pod should be stateless or near-stateless



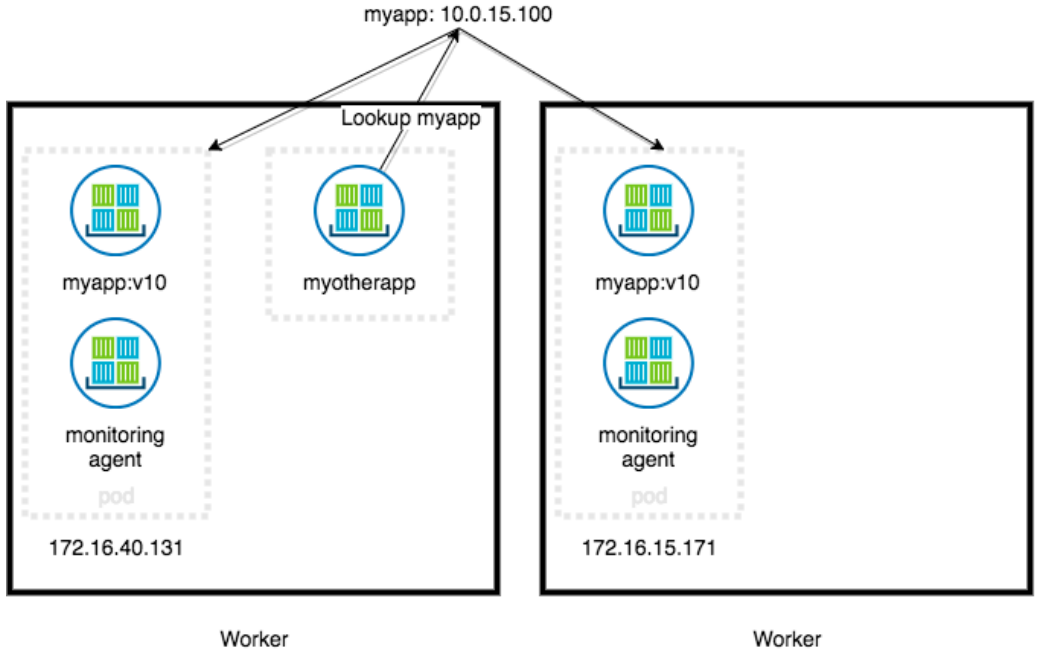

```yaml
apiVersion: apps/v1beta2 # for versions before 1.8.0 use apps/v1beta1
kind: ReplicaSet
metadata:
  name: frontend
  labels:
    app: guestbook
    tier: frontend
spec:
  # this replicas value is default
  # modify it according to your case
  replicas: 3
  selector:
    matchLabels:
      tier: frontend
    matchExpressions:
      - {key: tier, operator: In, values: [frontend]}
  template:
    metadata:
      labels:
        app: guestbook
        tier: frontend
    spec:
      containers:
      - name: php-redis
        image: gcr.io/google_samples/gb-frontend:v3
        resources:
          requests:
            cpu: 100m
            memory: 100Mi
        env:
        - name: GET_HOSTS_FROM
          value: dns
          # If your cluster config does not include a dns service, then to
          # instead access environment variables to find service host
          # info, comment out the 'value: dns' line above, and uncomment the
          # line below.
          # value: env
        ports:
        - containerPort: 80
```

Service Discovery

Kubernetes has an internal DNS that is used as a Service Registry.

A Service resource in Kubernetes results in an entry in the internal DNS

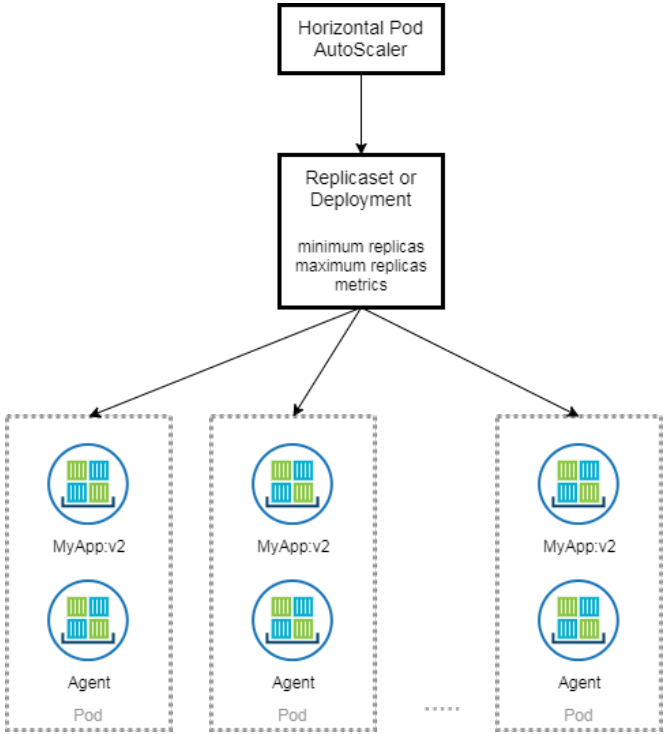
By default, a Service points to an internal Cluster IP that load balances between a set of healthy running pods



More on Scaling

Horizontal Pod Auto-scaling (HPA)

Allows you to scale the number of running pods in a replicaset based upon resource (or application custom) metrics




```yaml
apiVersion: autoscaling/v2beta1
kind: HorizontalPodAutoscaler
metadata:
  name: php-apache
  namespace: default
spec:
  scaleTargetRef:
    apiVersion: apps/v1beta1
    kind: Deployment
    name: php-apache
  minReplicas: 1
  maxReplicas: 10
  metrics:
  - type: Resource
    resource:
      name: cpu
      targetAverageUtilization: 50
status:
  observedGeneration: 1
  lastScaleTime: <some-time>
  currentReplicas: 1
  desiredReplicas: 1
  currentMetrics:
  - type: Resource
    resource:
      name: cpu
      currentAverageUtilization: 0
      currentAverageValue: 0
```

Statefulsets

Similar to replicaset for the purpose of scale or redundancy and/or, statefulsets run one-to-many instances of the desired pod

Unlike replicasets, statefulsets are intended for applications requiring state.

Valuable for applications that require:

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

```yaml
apiVersion: v1
kind: Service
metadata:
  name: nginx
  labels:
    app: nginx
spec:
  ports:
  - port: 80
    name: web
  clusterIP: None
  selector:
    app: nginx
---
apiVersion: apps/v1beta2
kind: StatefulSet
metadata:
  name: web
spec:
  selector:
    matchLabels:
      app: nginx # has to match .spec.template.metadata.labels
  serviceName: "nginx"
  replicas: 3 # by default is 1
  template:
    metadata:
      labels:
        app: nginx # has to match .spec.selector.matchLabels
    spec:
      terminationGracePeriodSeconds: 10
      containers:
      - name: nginx
        image: gcr.io/google_containers/nginx-slim:0.8
        ports:
        - containerPort: 80
          name: web
        volumeMounts:
        - name: www
          mountPath: /usr/share/nginx/html
  volumeClaimTemplates:
  - metadata:
      name: www
    spec:
      accessModes: [ "ReadWriteOnce" ]
      storageClassName: my-storage-class
      resources:
        requests:
          storage: 1Gi
```

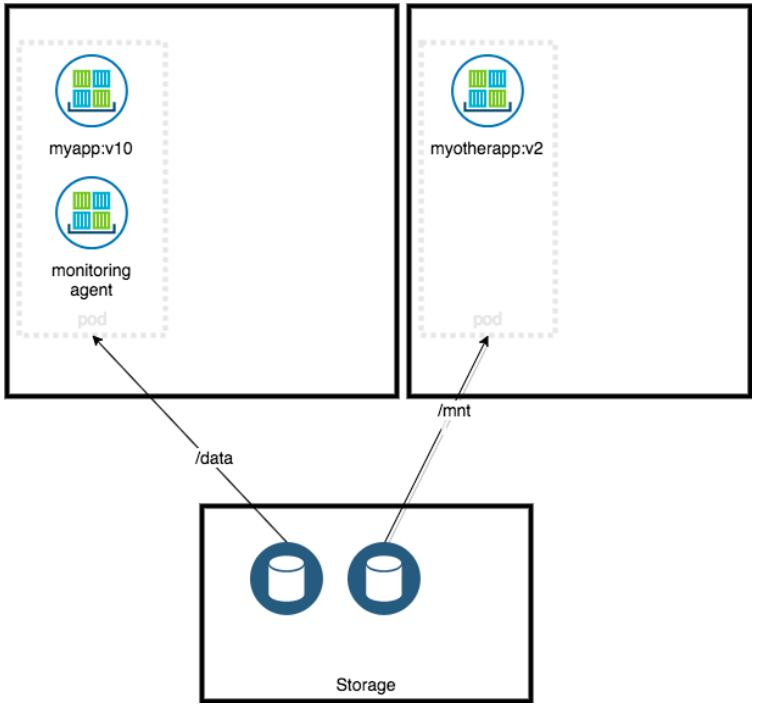
Persistence & Storage

There are many types of persistent storage and many provider options

Some pods must be able to persist data so that if Kubernetes restarts them on the same or another node data loss is avoided

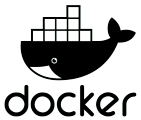
Kubernetes will re-attach the shared storage when the pod (re)starts

Storage providers support different retention and recycling policies and the definitions of these are not universal



Persistent Storage Overview

Storage that persists beyond the lifecycle of the container allows workload to achieve state



Docker, containers and persistence

Kubernetes, pods and persistence

Terminology and the persistent lexicon

Value of the persistence solution

IBM Cloud / © 2018 IBM Corporation

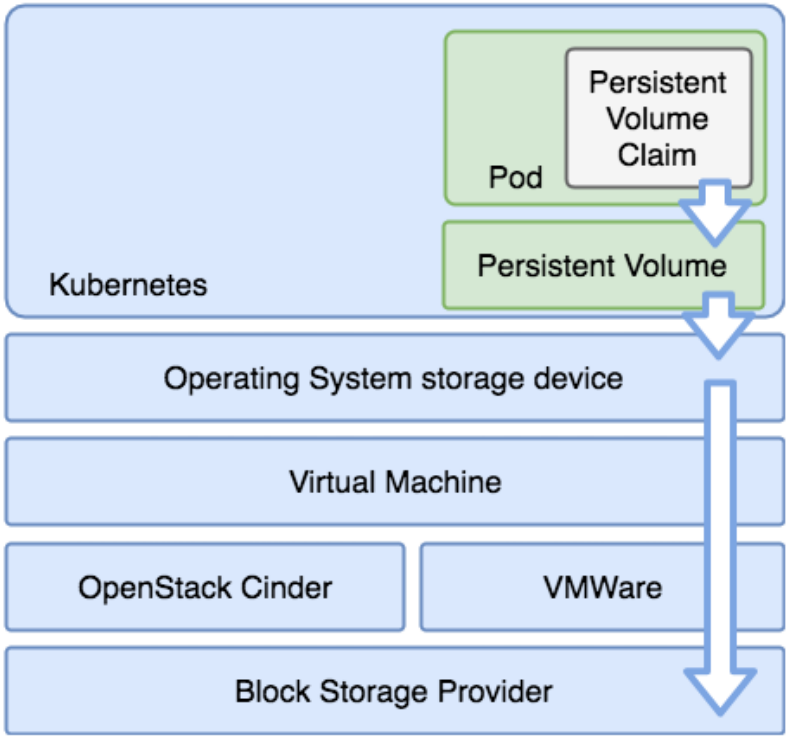
Persistent Storage

Solution components

Persistent Volume is a storage resource within the cluster. PVs have a lifecycle independent of any individual pod that uses it. This API object encapsulates the details of the storage implementation or cloud-provider-specific storage system.

A **Persistent Volume Claim** is a storage request, or claim, made by the developer. Claims request specific sizes of storage, as well as other aspects such as access modes.

A **StorageClass** describes an offering of storage and allow for the dynamically provisioning of PVs and PVCs based upon these controlled definitions.

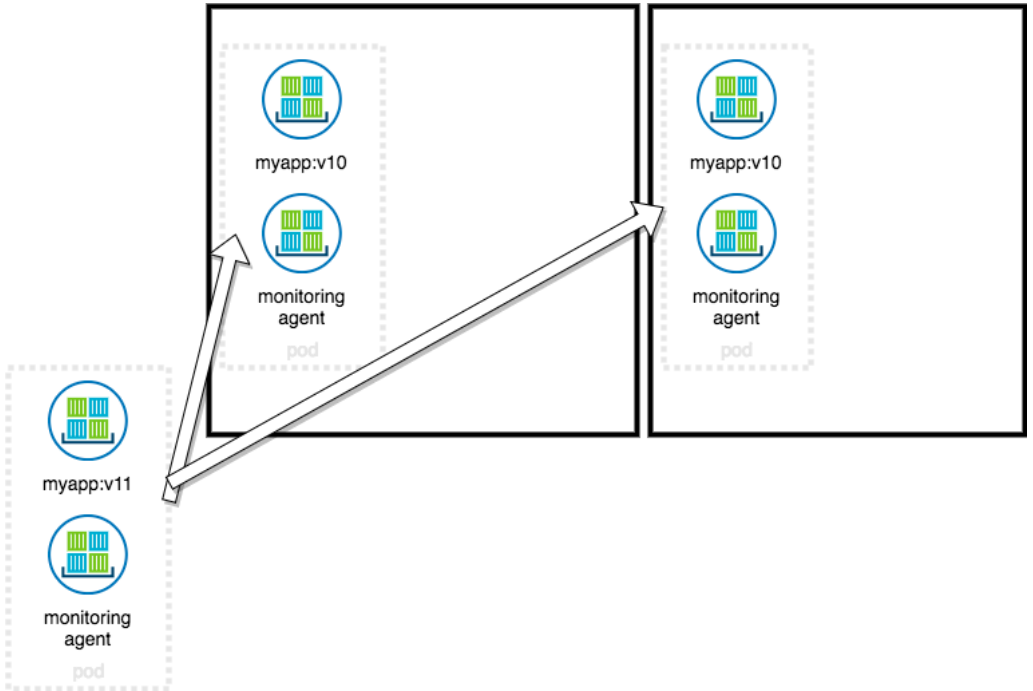


Deployments

Deployments manage rolling updates to ReplicaSets and StatefulSets

When a new version of the application is available, the Deployment provides the ability to scale down the previous version of the application and scale up the new version in a controlled fashion with zero downtime

Enables rollback in the case of failure



Kubernetes configuring Containers and Resources

Label

- Metadata assigned to Kubernetes resources (pods, services, etc.)
- Key-value pairs for identification
- Critical to Kubernetes

Selector

- An expression that matches labels to identify related resources

Kubectl commands

Support different approaches to working with Kubernetes objects:

- Imperative commands on live objects.
- Individual configuration files or directories of files.

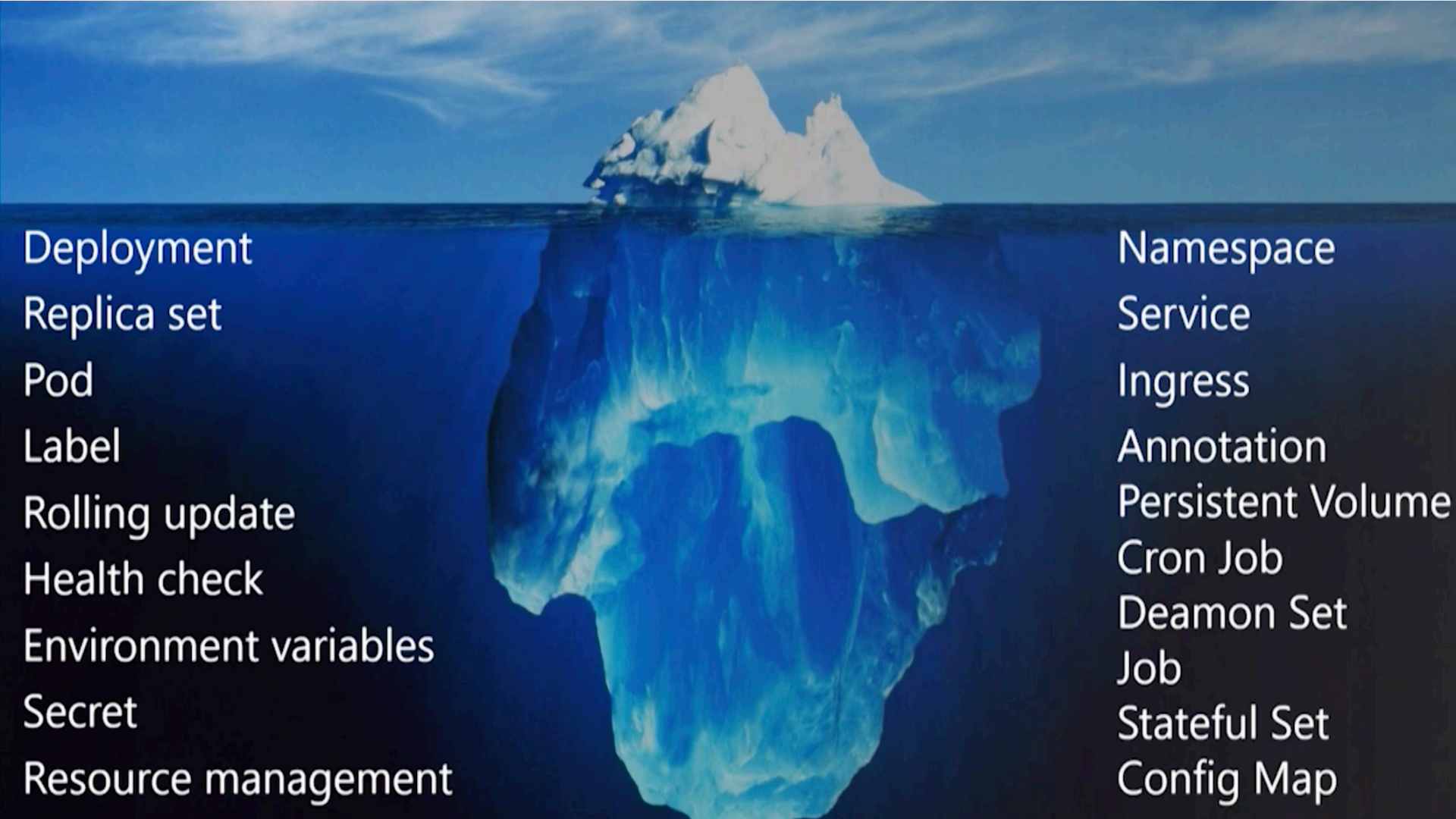
Important: maintain a consistent approach when working with the same object; do not mix approaches.

Basic syntax:

```
<verb> <objecttype> [<subtype>] <instancename>
```

- Where the `<verb>` is an action such as: **`create`**, **`run`**, **`expose`**, **`autoscale`**.
- `<objecttype>` is the object type, such as a **`service`**.
- Some objects have subtypes. For example, a service has **`ClusterIP`**, **`LoadBalancer`**, **`NodePort`**.
- Use the **-h** flag to find the arguments and flags supported by a subtype
- `<instancename>` specifies the name of the object

© Copyright IBM Corporation 2018


Deployment
Replica set
Pod
Label
Rolling update
Health check
Environment variables
Secret
Resource management
Namespace
Service
Ingress
Annotation
Persistent Volume
Cron Job
Deamon Set
Job
Stateful Set
Config Map

Kubectl command useful examples

Get the state of a cluster

```
$ kubectl cluster-info
```

Get all the nodes of a cluster

```
$ kubectl get nodes -o wide
```

Get info about the pods of a cluster

```
$ kubectl get pods -o wide
```

Get info about the replication controllers of a cluster

```
$ kubectl get rc -o wide
```

Get info about the services of a cluster

```
$ kubectl get services
```

Get full config info about a Service

```
$ kubectl get service NAME_OF_SERVICE -o json
```

Get the IP of a Pod

```
$ kubectl get pod NAME_OF_POD -template={{.status.podIP}}
```

Delete a Pod

```
$ kubectl delete pod NAME
```

Delete a Service

```
$ kubectl delete service NAME_OF_SERVICE
```

Resources

Kubernetes tutorial

- https://kubernetes.io/docs/tutorials/kubernetes-basics/

Introduction to container orchestration

- https://www.exoscale.ch/syslog/2016/07/26/container-orch/

TNS Research: The Present State of Container Orchestration

- https://thenewstack.io/tns-research-present-state-container-orchestration/

Large-scale cluster management at Google with Borg

- https://research.google.com/pubs/pub43438.html