CONTAINERS, KUBERNETES AND OPENSHIFT

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Objectives

- OpenShift Foundations
- Containers
- Container Orchestration
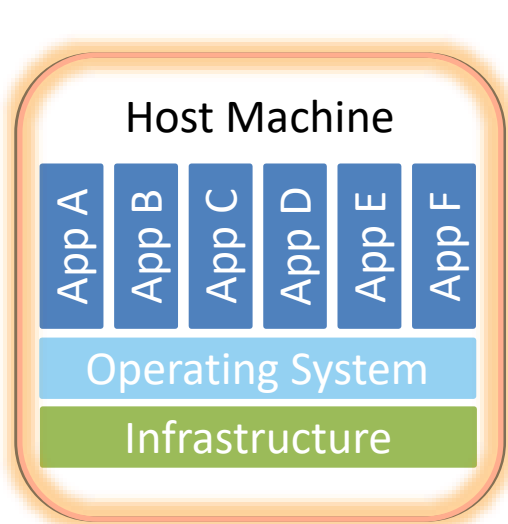- Kubernetes
- What OpenShift adds to Kubernetes

OpenShift Foundations

- OpenShift is built on two open-source technologies, which we briefly introduce here:
  - Containers
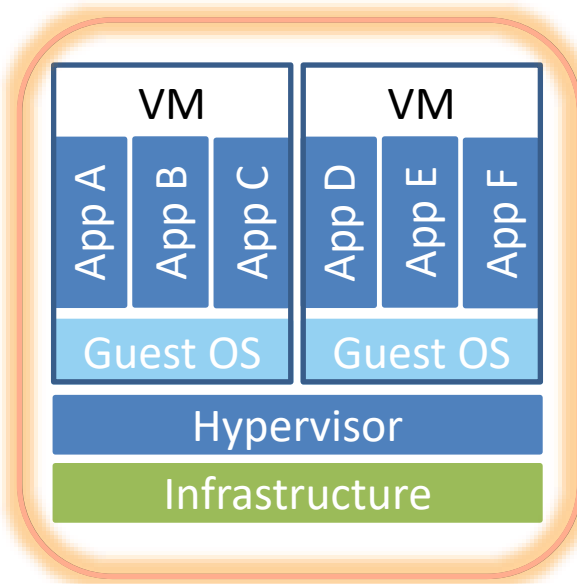 - Kubernetes container orchestration

Extending Hardware Usage

- Common requirements:
  - Users - Run app transparently, with all dependencies etc in place
  - SysAdmin - Run multiple workloads with appropriate resource allocation and isolation.
- Two approaches:
  - Virtual Machines: Multiple self-contained computers on one piece of hardware
  - Containers: Self-contained file systems running on a container service on one piece of hardware.
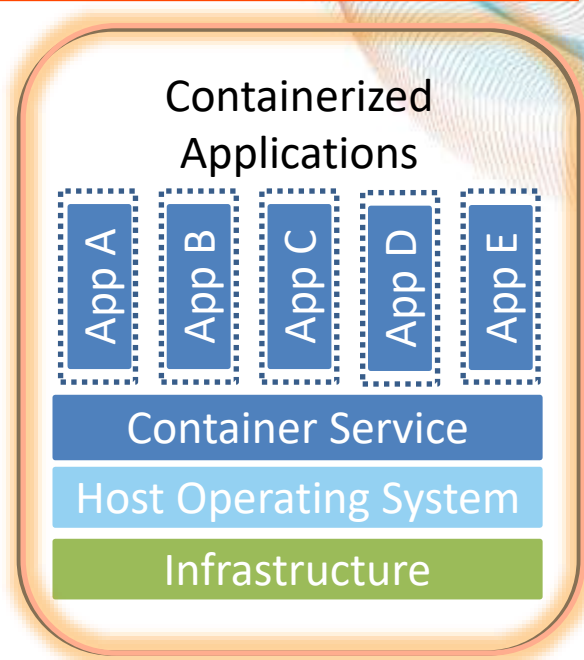
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Containers

Host Machine					
App A	App B	App C	App D	App E	App F
Operating System					
Infrastructure					

VM			VM		
App A	App B	App C	App D	App E	App F
Guest OS			Guest OS		
Hypervisor					
Infrastructure					

Containerized Applications

App A	App B	App C	App D	App E
Container Service				
Host Operating System				
Infrastructure				

Single machine architecture   Virtual machine architecture   Container architecture

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Containers vs VMs

- The biggest advantage is size!
- Containers are much smaller than VMs, so they can be moved around much more simply.
- Containers deploy quickly as they don't have to boot up an OS.
- Containers still benefit from isolation (supplied by the Linux kernel).
- Containers have a defined share of the resources, and their own file system.

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Docker Containers

- Docker spearheaded the use of Linux containers using Linux namespacing to isolate one container from another.
- Docker opensourced three things that allows their containers to be widely used:
  - A standard container format
  - Tools for developers to build containers
  - Tools for operators to run containers

Docker Containers

- The standard box docker packs a program together with all the libraries and other resources it needs is called a container image
- Once built, images are immutable.
- When a container runtime runs a container image it is called a container.
  - A program running inside a container sees no other program running on the machine.
  - The container has its own filesystem, network and storage interfaces, processes and even memory.

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Dockerfiles

- Docker provides a simple filespec - which is instantiated in a Dockerfile, from which a container image can be built.

```
# Start from an image that already contains Python 3.8.
FROM python:3.8

# Install dependencies; be explicit about versions.
RUN pip install flask==1.1

# Copy the application's source code into the image.
COPY src/ /code

# Add useful information for operators.
EXPOSE 80/tcp

# Specify how to start the application.
ENTRYPOINT python /code/main.py
```

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Example: Wordpress & MySQL

- Docker provides a CLI, `docker-compose` which allows you to run a deployment of multiple containers with a single command.
- This docker-compose.yml file deploys a MySQL database in a container, then deploys the Wordpress install process using the MySQL db as a backend.

```yaml
version: "3.9"

services:
  db:
    image: mysql:5.7
    volumes:
      - db_data:/var/lib/mysql
    restart: always
    environment:
      MYSQL_ROOT_PASSWORD: somewordpress
      MYSQL_DATABASE: wordpress
      MYSQL_USER: wordpress
      MYSQL_PASSWORD: wordpress

  wordpress:
    depends_on:
      - db
    image: wordpress:latest
    volumes:
      - wordpress_data:/var/www/html
    ports:
      - "8000:80"
    restart: always
    environment:
      WORDPRESS_DB_HOST: db
      WORDPRESS_DB_USER: wordpress
      WORDPRESS_DB_PASSWORD: wordpress
      WORDPRESS_DB_NAME: wordpress
volumes:
  db_data: {}
  wordpress_data: {}
```

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Example: Wordpress & MySQL

- The whole thing is deployed with
  `$ docker-compose up -d`
- The Wordpress install can be accessed on localhost:8000
- The whole thing is taken down with
  `$ docker-compose down --volumes`
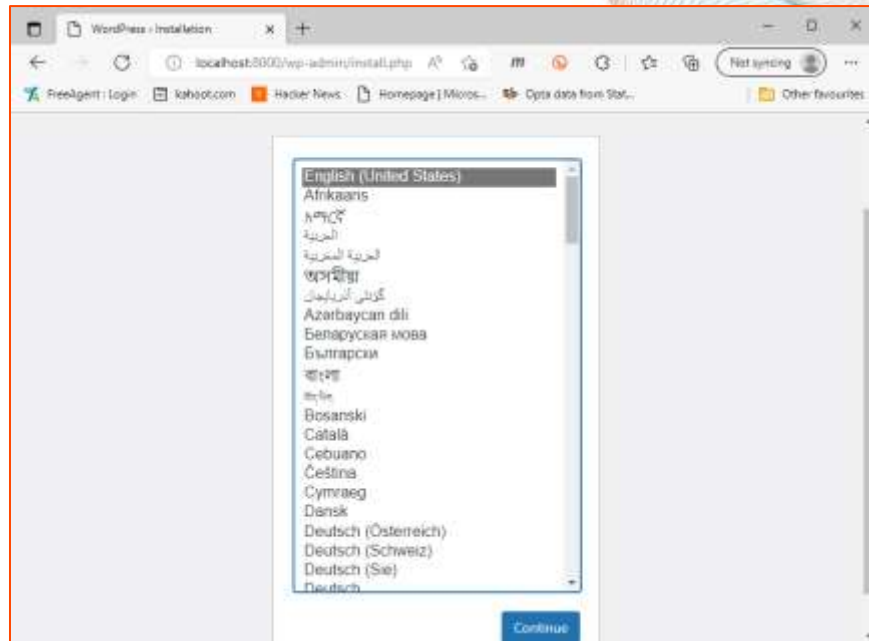
The Open Container Initiative (OCI)

- An open governance structure to create open industry standards around container image formats and container runtimes.
- Docker donated their `runc` runtime to OCI.
- Docker's original image format has become the OCI Image Specification
- There are a variety of open-source build tools supporting it
  - **BuildKit**: an optimized build engine
  - **Podman**: a command-line tool
  - **Buildah**: a command line alternative to writing Dockerfiles

The Need for Container Orchestration

- Platforms like Docker handle containers running on a single host well.
- Applications often require more resources than can be available on a single host
- So … deploy multiple containers on multiple hosts!
- The extra complexity (network, security, service discovery) requires a **Container Orchestrator** to manage.

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Kubernetes

- According to their website:
  "Kubernetes is an open-source system for automating deployment, scaling, and management of containerized applications."
- Comes from Greek **κυβερνήτης**: helmsman or ship pilot. Can also be referred to as k8s (pronounced Kate's)
- Started by Google and donated to CNCF in July 2015.

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Kubernetes Features

- Automatic container scheduling to maximize utilization without affecting availability
- Self-healing and automatic traffic re-routing from failed nodes
- Manually or automatically scale your cluster
- Service discovery and load balancing within the cluster
- Automated rollouts and rollbacks
- Secrets management and configuration details management

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Kubernetes Architecture
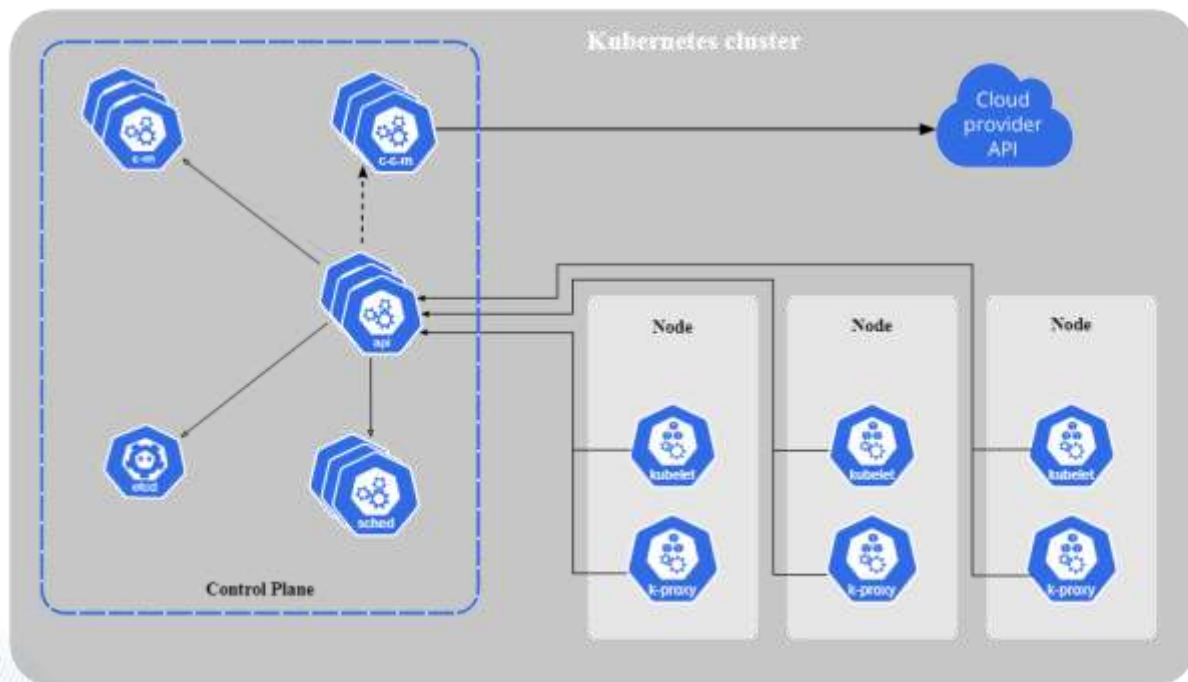
Kubernetes Architecture: Control Plane

- This runs on the master node
- Responsible for managing cluster state - needs to be kept running!
- It consists of the following
  - Distributed key-value store for the most critical system data
  - API server that coordinates all the administrative tasks
  - Scheduler that assigns workloads to worker nodes
  - Controller manager running controllers to regulate cluster state.

Kubernetes Cluster: Worker Nodes

- Provide running environment for client applications.
- Applications are run in containers, encapsulated in Pods, controlled by the control plane on the master node.
- They run the following components:
  - Container runtime
  - Node agent to interface with the API server
  - Proxy for communication between pods

`kubectl` **command line manager**

- Kubernetes provides a command line tool - `kubectl` - for communicating with a cluster's control plane.
- The following is the standard syntax for kubectl commands:

`kubectl [command][TYPE][NAME][flags]`

|	
`command:`	the operation you want to perform, e.g. create, get, describe
TYPE:	the resource type
NAME:	the name of the resource (if required)
flags:	optional flags

What Does Kubernetes Do?

- Kubernetes is like an operating system for a distributed platform.
- It defines a set of common resources, and an API for utilizing them.
- Kubernetes is *declarative,* which means you declare what you would like your system to look like, then Kubernetes works to match your desired state.
  - This is called the *reconcile loop* of the cluster.

What Kubernetes Doesn't Do

- To really use a Kubernetes cluster you need to add some extra components on top of Plain Old Kubernetes.
- In a fully DevOps system these include
  - Tools to build, compile and run apps.
  - Tools to manage workloads on the cluster and deploy updates
  - Networking, monitoring and security.

OpenShift is Kubernetes++

- OpenShift builds on Kubernetes and containers to add features and the components that support them.

OPENSHIFT 4

istio   knative   node   php   kiali   KEDA   jaeger
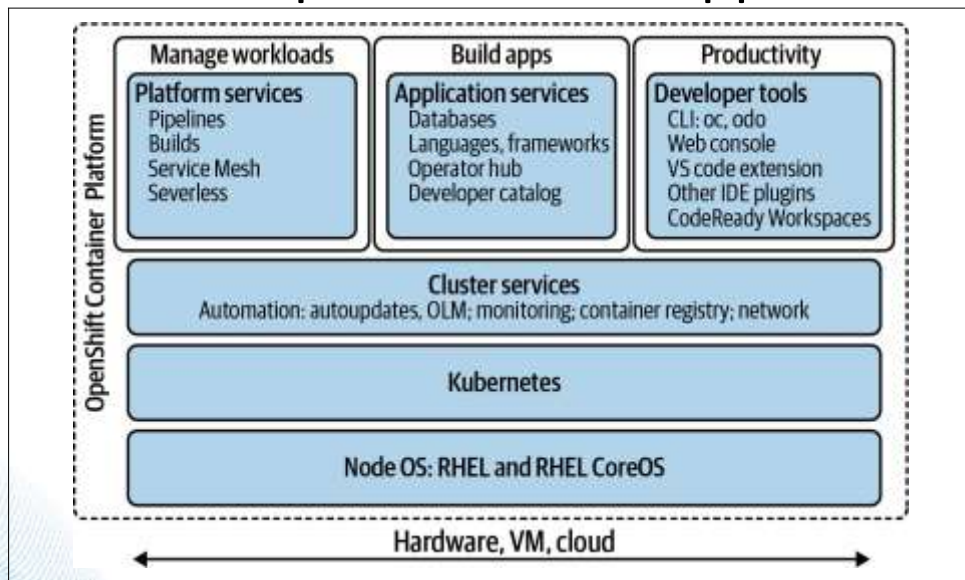
Best IT ops experience

CaaS ⟷ PaaS | FaaS

Best developer experience

prometheus
Grafana
ElasticSearch
fluentd   Kibana

Cluster services	Application services	Developer services
Monitoring, showback, registry, logging	Middleware, functions, ISV	Dev tools, automated builds, CI/CD, IDE
	Service mesh	

jenkins
TEKTON
RED HAT CODEREADY

OPERATOR LIFECYCLE MANAGER

Automated operations

kubernetes

Red Hat Enterprise Linux CoreOS

cri-o   skopeo
podman   buildah

Any infrastructure

Physical   Virtual   Private   Public

Red Hat

OpenShift Components: Containers

- OpenShift adds some key container management components to the Kubernetes standard:
    - **CRI-O** - container runtime (lightweight alternative to Docker)
    - **Podman** - container engine for developing, managing and running OCI containers on Linux
    - **Skopeo** - tool for moving container images between different types of storage (e.g. docker to internal registry)
    - **Buildah** - tool to build OCI container images.
    - **Quay** - container registry

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The OpenShift Web Console

- A key addition OpenShift makes to Kubernetes is its **Web Console**
  - o Kubernetes has a web console, but it currently has very limited functionality.
- This is a full featured UI to your cluster, networking and CI/CD capabilities.

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OpenShift CLI tools

- The main CLI tool OpenShift offers is the oc tool. **We will focus on this**
- This is a souped up version of `kubectl`
    - It uses the `kubectl` syntax and can be used with all kubectl subcommands
    - It also adds a suite of commands only available on OpenShift.
- The `odo` command line tool is a tool for developing, testing, debugging and deploying microservices-based applications on a k8s cluster without having to understand the platform deeply.
- There are also CLI tools for Tekton pipelines (`tkn`), serverless (`kn`), and Operator development and management (Operator SDK and `opm`).

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The OpenShift App Store

- The Web Console aggregates software catalogues
  - Application templates to simplify standard deployments
  - Kubernetes Operators for full lifecycle management of backend services
- Find and deploy databases, message queues, etc

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CI/CD Pipelines

- OpenShift sets itself to add full CI/CD capabilities to Kubernetes.
- **OpenShift pipelines** based on Tekton sets you up to automatically
  - o Build
  - o Test
  - o Package
  - o Release
- OpenShift also hooks in easily to Jenkins build pipelines.

Networking and Service Mesh

- In k8s setting up connections within your cluster and to the outside world can be pretty cumbersome.
- OpenShift addresses this with
  - OpenShift Routes: A layer 7 reverse proxy for external HTTP connections to internal, load-balanced cluster Services.
  - Istio: A bolt on service mesh that measures and controls how services connect with each other and the outside world.

Metrics, Monitoring and Alerts

- OpenShift also bolts on a number of monitoring resources based around Prometheus.
  - Prometheus is an open-source systems monitoring and alerting toolkit originally from SoundCloud.
- This gives accurate resource monitoring for all levels of granularity right down to a running container.

Summary

- OpenShift Foundations
- Containers
- Container Orchestration
- Kubernetes
- What OpenShift adds to Kubernetes

Questions and Comments?