# Docker & Kubernetes

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# Docker

- Docker is an open platform for developing, shipping, and running applications.
- Docker enables you to separate your applications from your infrastructure so you can deliver software quickly.
- Docker provides the ability to package and run an application in a loosely isolated environment called a container.
- Containers are lightweight and contain everything needed to run the application, so you do not need to rely on what is currently installed on the host.

# CONTAINER

- Container is a software package that consists of all the dependencies required to run an application.

- A Docker container image is a lightweight, standalone, executable package of software that includes everything needed to run an application: code, runtime, system tools, system libraries and settings.

- Containerization is simply a way of packaging software applications into containers.

# VIRTUALIZATION

- Virtualization is the process of creating a simulated computing environment that's abstracted from the physical computing hardware.

- Virtualization allows you to create multiple, virtual computing instances from the hardware and software components of a single machine.

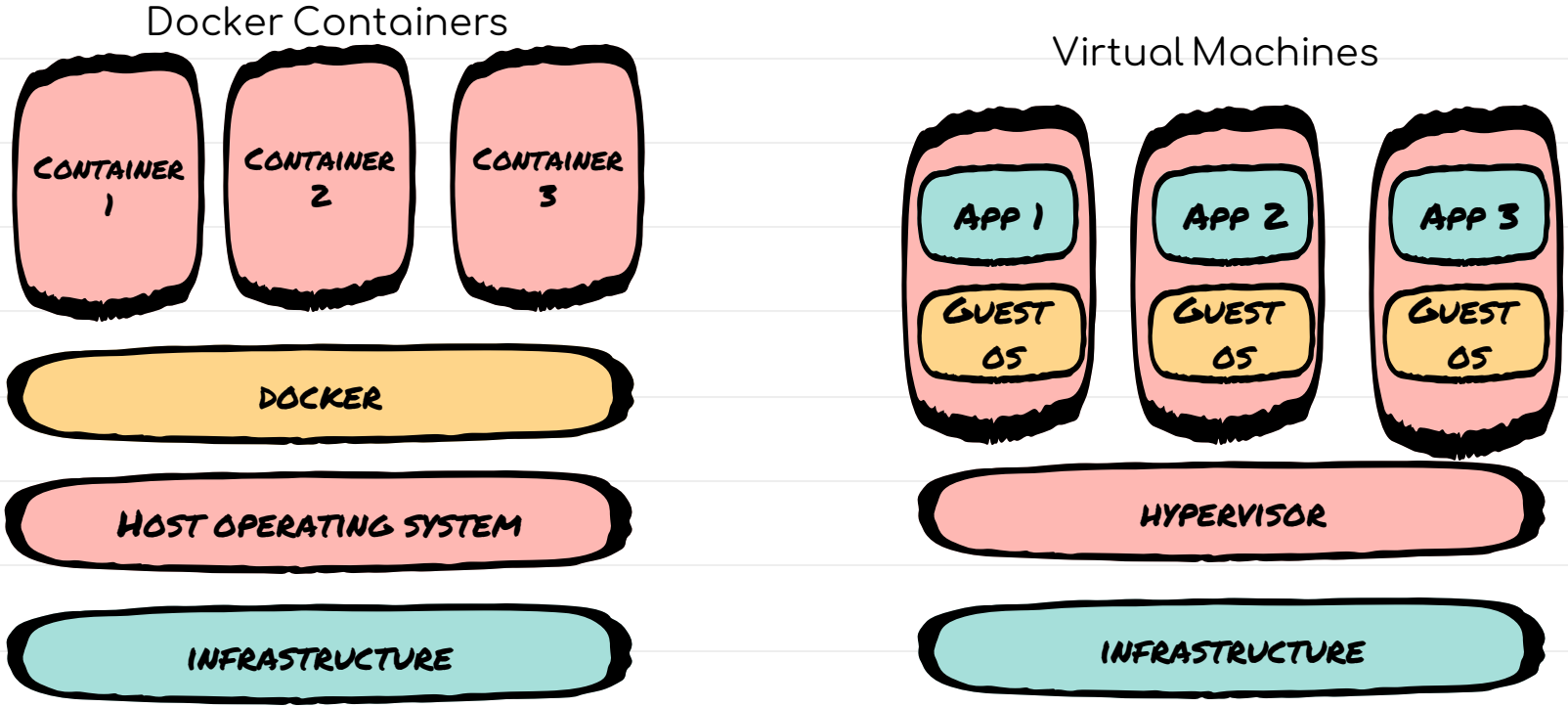
# Hypervisor

- The software that enables virtualization is called a hypervisor.
- It's a lightweight software layer that sits between the physical hardware and the virtualized environments and allows multiple operating systems (OS) to run in tandem on the same hardware.
- The hypervisor is the middleman that pulls resources from the raw materials of your infrastructure and directs them to the various computing instances.

# Virtual machines

- Separate computers running on hardware that is contained in one physical computer.
- Each VM requires its own OS.
- The OS and any applications running on an individual VM share hardware resources from a single host server, or from a pool of host servers.

# Docker vs Virtualization



# Building Docker images

- Docker image is built using a Docker file.
- A docker image contains all the project's code, whereas a Dockerfile is a text file which contains commands for building a Docker image.
- With docker images containers can be built.
- From Docker Hub users can pull any Docker Image and build new containers.

# Docker Hub

- Docker Hub is a hosted repository service provided by Docker for finding and sharing container images.

- Users get access to free public repositories for storing and sharing images or can choose subscription plan for private repos.

# Docker compose

- Docker Compose is used for running multiple containers as a single service.
- Compose is a tool for defining and running multi-container Docker applications.
- With Compose, you use a YAML file to configure your application's services.

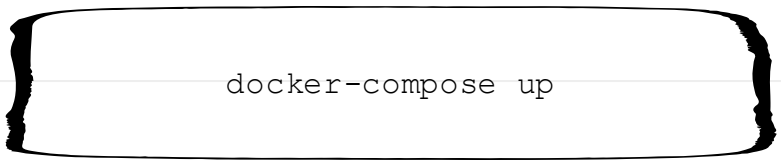
# Docker compose

- Then, with a single command, you create and start all the services from your configuration.

- Docker Compose works by applying many rules declared within a single docker-compose.yml configuration file.

# DOCKER-COMPOSE.YML

- Contains
  - services
  - volumes (optional)
  - networks



# Volumes + networks

- Volume
  - is a shared directory in the host, visible from a container.

- Network
  - define the communication rules between containers, and between a container and the host.
  - Common network zones will make containers' services discoverable by each other, while private zones will segregate them in virtual sandboxes.

# SERVICES

- Refers to containers' configuration.
- Let's dockerize an app consisting of frontend-app, backend-app, database and app-umur.

```
services:
  frontend-app:
    image: my-frontend-app
    ports:
      - "8080:2000"
  backend-app:
    image: my-backend-app
  db:
    image: postgres
  umur-app:
    image: awesome-app
```

Port 2000 will be available in 8080 on the host.

# SERVICES

```yaml
services:
  frontend-app:
    image: my-frontend-app
    ports:
      - "8080:2000"
    networks:
      - network1
  backend-app:
    image: my-backend-app
    networks:
      - network1
  db:
    image: postgres
  umur-app:
    image: awesome-app
    networks:
      - network2
```

```yaml
networks:
  network1: {}
  network2: {}
```

my-backend-app can reach frontend-app whereas it cannot reach umur-app.

# VOLUMES

```
services:
  frontend-app:
    image: my-frontend-app
    ports:
      - "8080:2000"
    networks:
      - network1
    volumes:
      - /tmp:/volume1/from-host
  backend-app:
    image: my-backend-app
    networks:
      - network1
  db:
    image: postgres
  umur-app:
    image: awesome-app
    networks:
      - network2
networks:
  network1: {}
  network2: {}
```

The /tmp folder of the host is mapped to /volume1/from-host folder of the container.

# Docker compose commands

- `docker compose up`
  - Creates and start containers.
- `docker compose down`
  - Stops and removes containers.
- `docker compose create`
  - Creates containers for a service.
- `docker compose ls`
  - Lists running compose projects.

# Docker commands

- `docker ps`
  - Lists the running containers.
- `docker ps -a`
  - Lists all the running and exited containers.
- `docker stop <container id>`
  - Stops a running container
- `docker images`
  - Lists all the locally stored docker images.

# Docker commands

- `docker rm <container id>`
  - Deletes a stopped container.
- `docker build <path to docker file>`
  - Builds an image from a specified docker file.
- `docker run –pHOST:CONTAINER -d –-name custom-name –net network-name name-of-image`

# Docker commands

- `docker logs container-id`
- `docker pull name-of-image`
- `docker exec –it container-id /bin/bash`
- `docker start name-of-image`

# Docker commands

- `docker network ls`
- `docker network create name-of-network`
- `docker exec –it container-id /bin/bash`
- `docker start name-of-image`

# Dockerfile

- Each Dockerfile is a script, composed of various commands (instructions) and arguments listed successively to automatically perform actions on a base image in order to create (or form) a new one.

- Dockerfiles begin with defining an image FROM which the build process starts. Followed by various other methods, commands, and arguments (or conditions), in return, provide a new image which is to be used for creating docker containers.

```
docker build
```

# Dockerfile commands

- `MAINTAINER`
  - Sets the author.
  - `MAINTAINER umur_inan`
- `ADD`
  - Takes 2 arguments, a source and a destination.
  - It copies files from source on the host machine into the container.
  - The source can also be a URL.
  - `ADD /from/host /to/container`

# Dockerfile commands

- `CMD`
  - Executes a specific command.
  - It is not executed during build but when the container is created/started.
  - `CMD “echo” “Hello World”`
- `RUN`
  - It is executed during build unlike CMD command.

# Dockerfile commands

- `FROM`
  - Specifies the base image to use to create the container.
  - It can be default images from docker hub or your own custom image.
  - `FROM <image>`
  - `FROM <image>:<tag>`
  - Tag is `latest` by default.

# Dockerfile commands

- `WORKDIR`
  - Sets the current path or the path where `CMD`, `RUN`, `COPY`, `ADD` commands going to be executed.
  - `WORKDIR /source`
- `VOLUME`
  - Creates a mount point with the specified name and marks it as holding externally mounted volumes from native host or other containers.

# Dockerfile commands

- `EXPOSE`
  - EXPOSE is used as documentation for the port. This is just a communication between the person who builds the image and the person who runs the container.
  - `EXPOSE 8080`

# Dockerfile commands

- `docker images`
  - List all images.

- `docker run -it -d image-name`
  - Run the image.

- `docker build -t image-name:tag-name .`
  - Builds a docker image.

# Dockerfile

```
# Comment Line
FROM ubuntu
MAINTAINER uinan@miu.edu

WORKDIR /home/umurinan

RUN apt-get update
RUN apt-get install –y nginx

CMD [“echo”, ”Hello World”]

COPY from-my-computer to-container
```

# Spring Boot -- Docker

```
FROM openjdk

WORKDIR /path/to/jar/file
COPY app.jar app.jar
EXPOSE 8080
CMD ["java", "-jar", "app.jar"]
```

# KUBERNETES

- Kubernetes, also known as K8s, is an open-source system for
  - automating deployment,
  - scaling,
  - management of
- containerized applications.

- It groups containers that make up an application into logical units for easy management and discovery.

# CONTAINER ORCHESTRATOR

- Container orchestrators are designed to run complex applications with large numbers of scalable components.

- They work by inspecting the underlying infrastructure and determining the best server to run each container.

# KUBERNETES

- Open-source
  - You can download and use it without paying any fee.
- Battle-tested
  - There're plenty of examples of companies running it in production.
- Well-looked-after
  - Redhat, Google, Microsoft, IBM, Cisco are only a few of the companies that have heavily invested in the future of Kubernetes by creating managed services, contributing to upstream development and offering training and consulting.

# Kubernetes features

- Service Discovery and Load Balancing
- Storage Orchestration
- Automated Rollouts and Rollbacks
- Automatic Bin Packing
- Self-Healing
- Secret and Configuration Management

# Service discovery and load balancing

- Kubernetes can expose a container using the DNS name or using their own IP address.
- If traffic to a container is high, Kubernetes is able to load balance and distribute the network traffic so that the deployment is stable.

# Storage orchestration

- Kubernetes allows you to automatically mount a storage system of your choice, such as local storages, public cloud providers, and more.

# Automated rollouts and rollbacks

- Kubernetes allows you to automatically mount a storage system of your choice, such as local storages, public cloud providers, and more.

# Automatic bin packing

- You provide Kubernetes with a cluster of nodes that it can use to run containerized tasks.
- You tell Kubernetes how much CPU and memory (RAM) each container needs.
- Kubernetes can fit containers onto your nodes to make the best use of your resources.

# Self-healing

- Kubernetes restarts containers that fail, replaces containers, kills containers that don't respond to your user-defined health check, and doesn't advertise them to clients until they are ready to serve.

# Secret and configuration management

- Kubernetes lets you store and manage sensitive information, such as passwords, OAuth tokens, and SSH keys.

- You can deploy and update secrets and application configuration without rebuilding your container images, and without exposing secrets in your stack configuration.

# TERMINOLOGY

- Namespaces
  - In Kubernetes, the namespaces is effectively your working area. It's like a project in GCP or a similar thing in AWS.

# TERMINOLOGY

- Pods
  - Abstraction for Containers.
  - Pod is a group of containers and is the smallest unit that Kubernetes administers.
  - Pods have a single IP address that is applied to every container within the pod.
  - Containers in a pod share the same resources such as memory and storage.
  - It's quite common to have a pod with only a single container, when the application or service is a single process that needs to run.

# TERMINOLOGY

- Service
  - A service is an abstraction over the pods, and essentially, the only interface the various application consumers interact with.
  - As pods are replaced, their internal names and IPs might change.
  - A service exposes a single machine name or IP address mapped to pods whose underlying names and numbers are unreliable.
  - A service ensures that, to the outside network, everything appears to be unchanged.

# TERMINOLOGY

- Service
    - Has permanent IP address.
    - Is also a load balancer.

# TERMINOLOGY

- Deployment
    - Blueprint for pods.
        - Specify how many replicas you want to have
    - Abstraction of Pods.
    - For stateLESS applications.
        - Use statefulset for stateful applications or databases.

# TERMINOLOGY

- Ingress
  - This works with the service to make sure everything ends up in the right place. Ingress can also provide load balancing.
- Node
  - A Kubernetes node manages and runs pods; it's the machine (whether virtualized or physical) that performs the given work.
  - Just as pods collect individual containers that operate together, a node collects entire pods that function together.

# TERMINOLOGY

- API Server
  - The API server exposes a REST interface to the Kubernetes cluster.
  - All operations against pods, services, and so forth, are executed programmatically by communicating with the endpoints provided by it.

# TERMINOLOGY

- Scheduler
  - The scheduler is responsible for assigning work to the various nodes.
  - It keeps watch over the resource capacity and ensures that a worker node's performance is within an appropriate threshold.
- Controller Manager
  - The controller-manager is responsible for making sure that the shared state of the cluster is operating as expected.
  - More accurately, the controller manager oversees various controllers which respond to events

# TERMINOLOGY

- Kubelet
  - A Kubelet tracks the state of a pod to ensure that all the containers are running.
  - It provides a heartbeat message every few seconds to the control plane.
  - If a replication controller does not receive that message, the node is marked as unhealthy.

# TERMINOLOGY

- Kube Proxy
  - The Kube proxy routes traffic coming into a node from the service.
  - It forwards requests for work to the correct containers.
- Etcd
  - Holds the current status of any K8s component.
  - is a distributed key-value store that Kubernetes uses to share information about the overall state of a cluster.

# Configuration Files

- Each config file has 3 parts.
  - Metadata
  - Specification
    - Attributes of spec are specific to the kind.
    - Kind: Deployment, Service
  - Status
    - Auto-generated by Kubernetes.
    - Desired state ?= Actual State
    - It comes from etcd.

# Commands

- `kubectl get node`
- `kubectl apply -f config_file_path`
- `kubectl get all`
- `kubectl describe service name-of-the-service`
- `kubectl describe pod name-of-the-pod`
- `minikube ip`
- `kubectl port-forward svc/webapp-service 8080:8080`

# Kubernetes Architecture