**Learning**

**Docker and Kubernetes**

**Through the Lens**

**of**

**Python Development**

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# General Introduction

# IP

As an author, I will always strive to cite sources.

# Glossary

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| --- | --- | --- | --- |
|  | **Term** | **Description** | **Additional Reading** |
|  | Docker image | * 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. | <https://www.docker.com/resources/what-container>  (Description extracted from the above link) |
|  | Docker container | * A container is a standard unit of software that packages up code and all its dependencies so the application runs quickly and reliably from one computing environment to another. * A container is always derived from an image | <https://www.docker.com/resources/what-container>  (A container, in a way, is like a SandBox)  (Description extracted from the above link) |
|  | Virtualization |  |  |
|  | Hyper-V |  |  |
|  | Layer |  |  |
|  | Linux Containers |  |  |
|  | Container Orchestration |  |  |
|  | Virtual Machines |  |  |
|  | APT | Advanced Packaging Tool |  |
|  | Multi container Applications |  |  |
|  | Volumes | Volumes are directories (or files) that are outside of the default Union File System *[Docker’s own internal filesystem ]* and exist as normal directories and files on the host filesystem.  Another description –  A Volume is a a file system that lives on a host machine outside of any container.  Volumes are created and managed by Docker.  Volumes are:   * persistent * free-floating filesystems, separate from any one container * sharable with other containers * efficient for input and output * able to be hosted on remote cloud providers * encryptable * nameable * able to have their content pre-populated by a container * handy for testing | <https://docs.docker.com/storage/volumes/>  <https://blog.container-solutions.com/understanding-volumes-docker>  <https://towardsdatascience.com/pump-up-the-volumes-data-in-docker-a21950a8cd8>  (Description extracted from multiple sources, links given above) |
|  | Docker Compose |  |  |
|  | Running Container |  |  |
|  | Image Developer |  |  |
|  | Dockerfile |  |  |
|  | Union File System |  |  |
|  | Mountpoint |  |  |
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# Docker

## Introduction

This document aims to introduce the reader to the use of Docker and Kubernetes (“DANK”) in modern software development. Generally speaking, people discuss DANK in the context of CI/CD, but the use is not just restricted to that, project teams can leverage the power of DANK for a variety of purposes.

Important Point to always remember - Docker is built to deploy applications, not machines

Source – Docker web site

## Use Cases that illustrate the importance of using Docker

|  |  |  |
| --- | --- | --- |
| **#** | **Use Case** |  |
| 1 | A set of development machines need to access Postgresql database, but can’t install it |  |
| 2 | Windows environment – Need to use a software that runs only on LINUX |  |
| 3 | Need to provide a testing environment to multiple testers |  |
| 4 | Your application runs on Python 3.7 but the production environment uses Python 2 and this can’t be changed |  |
|  |  |  |
|  |  |  |

## Does Docker help us dispense with VMs , Docker versus VMs ?

A more appropriate response is “Can Docker work with VMs ?”. Don’t debate on which is a better choice. Focus on co-existence.

An interesting article to read is <https://www.docker.com/blog/containers-and-vms-together/>

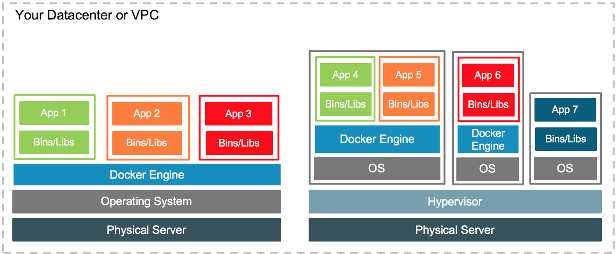


Figure – Source - <https://www.docker.com/blog/containers-and-vms-together/>

Note – In the above diagram, the Docker Engine can be substituted by “Containerization Engine”

## Alternatives to Docker

# Kubernetes

## Introduction

Kubernetes is all about Container Orchestration. Well, “Orchestration” is a word that is extensively used / over-used in the industry to explain certain tasks/activities in a posh way.

In the context of Kubernetes, the platform delivers true orchestration. Please note that Kubernetes is not a Docker replacement.

Docker is designed to create all kinds of applications that can be deployed as containers. The focus is on the creation of containerized apps.

Kubernetes, on the other hand, has been created for the following

* Enable the deployments of containers (Docker, non-Docker) on clusters
* Scale the deployments
* Update the containers
* Troubleshoot issues

To know more, from which the above information is based upon, visit - <https://kubernetes.io/docs/concepts/overview/what-is-kubernetes/>

Another nice link is - <https://docs.bitnami.com/kubernetes/get-started-kubernetes/>

## Why is Kubernetes so useful, important and in the news these days ?.

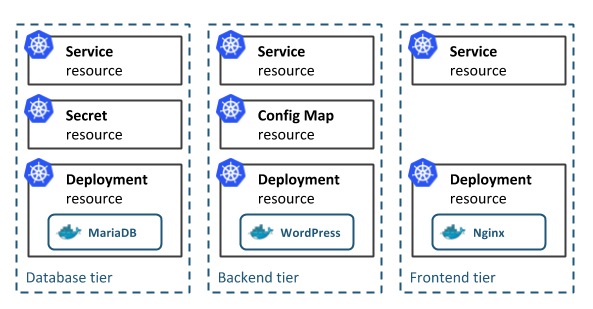
Not only are we in the era of containerized apps, but also in that of Cloud Native based solutions/platforms.

With the rapid adoption of cloud, businesses are moving their entire infrastructure to providers like AWS, Azure, GCP, Alibaba and others.

Deploying a single container on the cloud may not need Kubernetes, but as the complexity grows, a platform like Kubernetes is required to solve these problems.

Given the history of Kubernetes, first developed by Google and then open sourced, the tool is feature rich, battle hardened, tested for all kinds of “weather”.

Just as businesses have adopted the cloud, the cloud has adopted Kubernetes for Container Orchestration. Vendors have built add-ons that work with Kubernetes to take this platform to the next level.



Source - <https://docs.bitnami.com/kubernetes/get-started-kubernetes/> [Nice read]

The above is a typical Cloud Native application architecture. [GKE](https://docs.bitnami.com/google/get-started-gke), AKS, EKS, [ACK](https://www.alibabacloud.com/product/kubernetes)– all support this

### Use Cases that illustrate the importance of using Kubernetes

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## Tools that help you to learn about Kubernetes

### MiniKube

### KIND (K in D)

### Microk8s (<https://microk8s.io/>)

# Docker and Kubernetes together

Docker and Kubernetes are frequently used together. In fact, these two platforms dominate the landscape in today’s Container Era.

# Why Docker and Kubernetes with Python development

# A complete CI/CD example using Docker, Kubernetes and Python

# Docker Hands on Tutorial

| **MAIN TOPIC** | **SUB TOPIC** | **DETAILS**  **/**  **(LINKS FOR FURTHER STUDY)**  **/**  **(FEEDBACK)**  **/**  **(SAMPLE PROGRAMS)** | **(CLASSROOM EXERCISES)**  **/**  **(ASSIGNMENTS)** | **TRACKING DATA** |
| --- | --- | --- | --- | --- |
| **OVERALL CONTEXT** | WHAT ARE YOU EXPECTING ? | <Update after feedback from the students> | **N/A** | DAY 1  (<=15 mins) |
|  | MY EXPECTATIONS FROM THE STUDENTS/YOU | * Be aware of the course content (*Have all of you gone through the course details [separate doc] ?)* * Do the class room exercises * Complete your assignments * Make notes *(I do it and it helps me)* * Don’t just nod your head to what I say. Digest it slowly. Stop me if I am going too fast | **N/A** | DAY 1  (<= 15 mins) |
|  | An overview of commonly used Docker commands | *#*  *# Docker Images, Containers, docker files,* layers , docker build  #  *# Use this command to search the repository*  docker search <>  *##*  *## Launch a container*  docker **run** -t -i ubuntu /bin/bash  *## get the container IDs*  docker **ps -all**  *##*  docker ps  *##*  1. docker ps -all (use this to get the container id)  2. docker **start** <container ID>  3. docker **attach** <container id>  *## Listing all containers running or otherwise*  docker container ls -a  *## Removing a container*  docker container rm  ## Run a command in a running container  docker exec  *## Attach local standard input, output, and error streams to a running container*  docker attach  ## Docker inspect  *## Listing all images*  docker image ls  *## pruning the system*  docker system prune |  |  |
|  | Going deeper into Docker container commands | <https://docs.docker.com/engine/reference/commandline/container/>  The main ones :-  *# start an existing docker container*  docker start [container id]  *# stop an existing docker container*  docker stop [container id]  *# Use docker attach to attach your terminal’s*  *# standard input, output, and error (or any*  *# combination of the three) to a running*  *# container using the container’s ID or name.*  *# This allows you to view its ongoing output or*  *# to control it interactively, as though the*  *# commands were running directly in your*  *# terminal*  docker **attach** <container id>  *# Kill an existing container*  docker kill [container id]  *# pause an existing docker container*  docker pause [container id]  *# Run a shell command inside a container*  docker exec {-ti} [container id] {command}  *# restart an existing docker container*  docker restart [container id]  *# Inspect an existing docker container*  docker container inspect [container id]  Note – There are many more commands. Please refer to the docker documentation |  |  |
|  |  |  |  |  |
|  | Persisting data – setting the stage for Volumes | There are two ways to persist data beyond the life of the container. One way is to *bind mount* a file system to the container.  With a bind mount, processes outside Docker also can modify the data.  <https://docs.docker.com/storage/bind-mounts/>  <https://docs.docker.com/storage/volumes/>  Volumes rather than bind mounts should be used for persisting data. |  |  |
|  |  |  |  |  |
|  | Understanding Docker Volumes | * Preferred way to save data over restarts of a docker container * Volumes can be visualized as directories (or files) that are outside of the default UFS and exist as normal directories and files on the host system * There are different types of Docker Volumes * Volume drivers allow volumes to be stored on remote hosts or cloud providers |  |  |
|  |  |  |  |  |
|  | Volume related commands | Key commands   * docker volume create * docker volume ls * docker volume inspect * docker volume rm * docker volume prune |  |  |
|  |  |  |  |  |
|  | Run multiple containers of the same image | This is an exercise that you can try out. The Hello World image can be used | **Why would you launch multiple containers of the same image ?**  **Create a volume that is used by the different containers of the same image** |  |
|  |  |  |  |  |
|  | For a single container, persisting data | This is achieved through the use of Volumes |  |  |
|  |  |  |  |  |
|  | Sharing data across multiple containers | This is achieved through the use of Volumes |  |  |
|  |  |  |  |  |
|  | Networking concepts in Docker | * Docker networking is used to establish communication between docker containers and the outside world via the host machine * This is an important topic in container architecture * This is of importance to network administrators * It is no longer a physical world, but one of VMs and Containers | **[**<https://www.ostechnix.com/explaining-docker-networking-concepts/>]  **Q? Why are Docker networks important ?** |  |
|  |  |  |  |  |
|  | Docker Application Development | * <https://docs.docker.com/engine/reference/commandline/image_build/> * <https://www.scalyr.com/blog/create-docker-image/> * <https://www.youtube.com/watch?v=YFl2mCHdv24> |  |  |
|  |  |  |  |  |
|  | **Docker build**  **(Critical command)** | * A **Dockerfile** is a script that contains collections of commands and instructions that will be automatically executed in sequence in the docker environment for building a new docker image | **(Taken from Docker documentation)** |  |
|  |  |  |  |  |
|  | Key DockerFile commands | **FROM**  **MAINTAINER**  **RUN**  **ADD** |  |  |
|  |  |  |  |  |
|  | Design considerations | * Slim, medium sized and fat builds * Layer caching * Multi-stage builds |  |  |
|  |  |  |  |  |
|  | Managing Application Data |  |  |  |
|  |  |  |  |  |
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|  | **Docker-compose**  **(Critical feature)** | <https://docs.docker.com/compose/>  <https://www.baeldung.com/docker-compose>  <https://www.youtube.com/watch?v=Qw9zlE3t8Ko>  Using Compose is basically a three-step process:   * Define your app’s environment with a Dockerfile so it can be reproduced anywhere. * Define the services that make up your app in docker-compose.yml so they can be run together in an isolated environment. * Run docker-compose up and Compose starts and runs your entire app. | **>> To the audience – Do you understand the Docker build process, Volumes, networking in Docker ?**  **These are pre-requisites for using docker compose which is much more difficult to understand and implement** |  |
|  |  |  |  |  |
|  | Run multiple containers (from different images) / Multi-container docker applications | This is achieved using Docker compose.  A thorough understanding of Docker compose is required to operate a multi container docker environment |  |  |
|  |  |  |  |  |
|  | Deploying a Docker image to another environment | * Manual approach * Using Kubernetes |  |  |

## Using Docker to run stuff on Windows

### Postgresql

|  |  |
| --- | --- |
| docker run -d -p 5432:5432 -v postgres-data:/var/lib/postgresql/data `  --name postgres1 postgres  docker exec -it postgres1 sh  createdb -U postgres mydb  psql -U postgres mydb | **Credit -** <https://markheath.net/post/exploring-postgresql-with-docker> |

### Redis

|  |  |
| --- | --- |
| docker run -d -p 6379:6379 --name redis1 redis    docker ps  docker logs redis1  docker exec -it redis1 sh  redis-cli  # combining the above 2 cmds  **docker exec -it redis1 redis-cli** | **Credit –**  <https://markheath.net/post/exploring-redis-with-docker> |

### Apache SOLR

### Apache Kafka

#### Bitnami

|  |  |
| --- | --- |
| docker pull bitnami/kafka:latest  docker pull bitnami/kafka:[TAG]  >> Build the image yourself (learn more about this)  docker build -t bitnami/kafka:latest 'https://github.com/bitnami/bitnami-docker-kafka.git#master:2/debian-10' | **Credit –**  <https://github.com/bitnami/bitnami-docker-kafka> |
| Step 1: Create a network  $ docker network create app-tier --driver bridge | **Credit –**  <https://github.com/bitnami/bitnami-docker-kafka> |
| Step 2-a : Launch the Zookeeper server instance  Use the --network app-tier argument to the docker run command to attach the Zookeeper container to the app-tier network.  $ docker run -d --name zookeeper-server \  --network app-tier \  -e ALLOW\_ANONYMOUS\_LOGIN=yes \  bitnami/zookeeper:latest | **Credit –**  <https://github.com/bitnami/bitnami-docker-kafka>  **bitnami/zookeeper:latest – This is a separate docker image** |
| Step 2-b : Launch the Kafka server instance  Use the --network app-tier argument to the docker run command to attach the Kafka container to the app-tier network.  $ docker run -d --name kafka-server \  --network app-tier \  -e ALLOW\_PLAINTEXT\_LISTENER=yes \  -e KAFKA\_CFG\_ZOOKEEPER\_CONNECT=zookeeper-server:2181 \  bitnami/kafka:latest | **Credit –**  <https://github.com/bitnami/bitnami-docker-kafka> |
| Step 3: Launch your Kafka client instance  Finally we create a new container instance to launch the Kafka client and connect to the server created in the previous step:  $ docker run -it --rm \  --network app-tier \  -e KAFKA\_CFG\_ZOOKEEPER\_CONNECT=zookeeper-server:2181 \  bitnami/kafka:latest kafka-topics.sh --list --zookeeper zookeeper-server:2181 | **Credit –**  <https://github.com/bitnami/bitnami-docker-kafka> |
| **<< Are these the complete steps ?. Re-check.** |  |
|  |  |

#### Official Confluent Docker Image for Kafka (Community Version)

|  |  |
| --- | --- |
| **docker pull confluentinc/cp-kafka** |  |
|  |  |

### NGINX

### Flask apps on Gunicorn

# Kubernetes Hands On Tutorials

These tutorials are based on Minikube and Microk8s

## Using Minikube

| **MAIN TOPIC** | **SUB TOPIC** | **DETAILS**  **/**  **(LINKS FOR FURTHER STUDY)**  **/**  **(FEEDBACK)**  **/**  **(SAMPLE PROGRAMS)** | **(CLASSROOM EXERCISES)**  **/**  **(ASSIGNMENTS)** | **TRACKING DATA** |
| --- | --- | --- | --- | --- |
| **OVERALL CONTEXT** | WHAT ARE YOU EXPECTING ? | <Update after feedback from the students> | **N/A** | DAY 1  (<=15 mins) |
|  | MY EXPECTATIONS FROM THE STUDENTS/YOU | * Be aware of the course content (*Have all of you gone through the course details [separate doc] ?)* * Do the class room exercises * Complete your assignments * Make notes *(I do it and it helps me)* * Don’t just nod your head to what I say. Digest it slowly. Stop me if I am going too fast | **N/A** | DAY 1  (<= 15 mins) |
|  |  |  |  |  |
| **Deployments** | Deploy a Kubernetes cluster on a local machine | * Minikube is a tool that makes it easy to run Kubernetes locally. * Minikube runs a single-node Kubernetes cluster inside a Virtual Machine (VM) on your laptop for users looking to try out Kubernetes or develop with it day-to-day. |  |  |
|  | Using Minikube on Windows | NOTE – Minikube will allow you to start a cluster     * Minikube start * Minikube status * Minikube stop * Minikube delete * minikube dashboard | **Have you encountered “unable to resolve docker endpoint: default orchestrator is kubernetes but unable to resolve kubernetes endpoint: invalid configuration: no configuration has been provided” ?**  **What did you do to resolve it ?** |  |
|  | Kubectl commands | Kubectl is used to execute commands against a Kubernetes cluster  Sample commands   * kubectl version --client |  |  |
|  |  |  |  |  |
|  |  | Tools for managing resources in a Kubernetes cluster: |  |  |
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|  |  | Helm Charts |  |  |
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|  | On the cloud |  |  |  |
|  | On-prem datacenter |  |  |  |
|  | Managed Kubernetes cluster |  |  |  |
|  |  |  |  |  |

## Using Microk8s (<https://microk8s.io/>)

# Ubuntu using Docker hands on Tutorial

|  |
| --- |
| docker container run --interactive --tty --rm ubuntu bash |
|  |
| (sudo) apt-get update |
| (sudo) apt-get install apt-utils |
| (sudo) apt-get install python3.7 |
| apt install python3-pip |
| # difference between apt-get and apt  # apt list –upgradable  #  # dpkg -l | grep systemd  #  # |
| python3/3.7 -m pip install --upgrade pip |
| # for virtual environments  apt-get install python3.7-venv |
|  |
| python3.7 -m venv /home/workspaces/my-python-sandpit/muttli  / |
| Source activate  Deactivate  From the bin folder that resides within your virtual environment |
|  |
| Apt install nginx |
|  |
| apt install docker.io  systemctl start docker  systemctl enable docker |
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