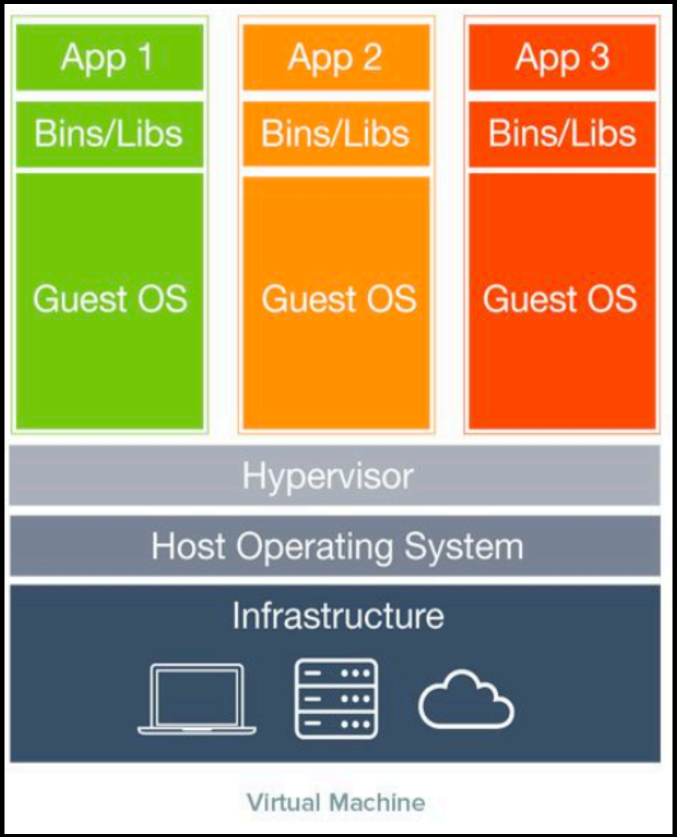
Containerization

Simplifying *Application Deploymen***t with Containers**

Background - Virtualization.

- **Virtualization is a process of creating an abstraction layer over hardware, allowing a single computer to be divided into multiple virtual computers. Each of those virtual computers (“guests”) uses part of the hardware resources of the main computer (a host)**
- **The software used to achieve this is a hypervisor. It run on the host OS and enable multiple guest Oss to run on top of it, sharing the same physical resources managed by the host OS.**



Advantages of Virtualization

- Minimize hardware costs (Capital Expenditure)
  - Multiple virtual servers on one hardware.
- Easily move VMs to other data centres.
  - Provide disaster recovery. Facilitate Hardware maintenance.
  - Follow the sun (active users) or follow the moon (cheap power).

Advantages of Virtualization

- Easier automation (Lower Operating Expenditure)
  - Simplified provisioning/administration of hardware and software.
- Scalability and Flexibility: Multiple operating systems.

- Consolidate idle workloads. Usage is bursty and asynchronous. Increase device utilization
- Conserve power
  - Free up unused physical resources

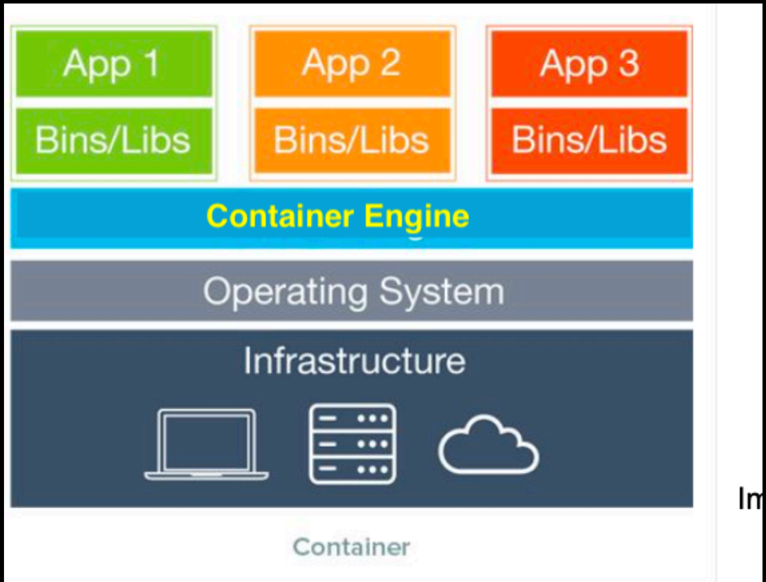
Problems of Virtualization

- Each VM requires a full operating system (OS). Each OS:
  - Requires a license ⇒ Capital Expenditure.
  - Has its own compute and storage overhead.
  - Needs maintenance, updates ⇒ Operating Expenditure.

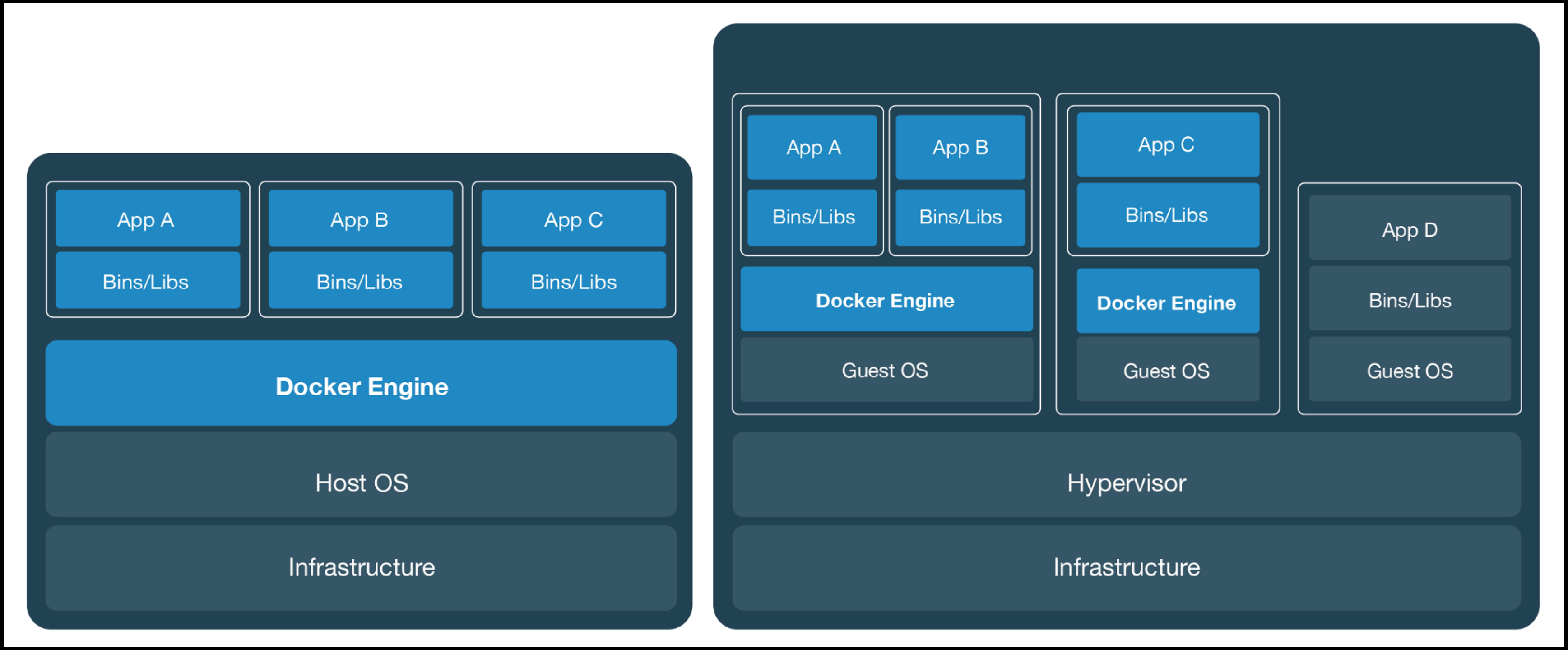
- VM Tax = added Capital Expenditure + Operating Expenditure.

Solution : Containers

- Containers:
  - Isolated environments to run apps/services (OS process isolation).
  - Portable, easy to build, quick to deploy.
  - Share the resources of an OS kernel.
  - Disposable / Ephemeral.



Containers Versus VMs - They’re different, not mutually exclusive.



The Problem Containers Solve.

- Developers often face issues when working in different environments with varying configurations.
  - Development, test, production
  - But it works on my computer!

- Containers provide a consistent and isolated environment, ensuring that your application runs the same way across different machines.

Benefits of Containerization

- Containerization offers several benefits for application development and deployment:
  - Portability: Applications and environments packaged in containers can run on any machine or cloud platform that supports containerization.
  - Scalability: you to scale your applications easily by running multiple containers across multiple machines.
  - Cost-effective – Containers are lightweight and use far less system respouces the VMs.
  - Reproducibility: you can replicate and share your application’s environment to ensure consistent results.

Containers.

- Containers have all the good properties of VMs:
  - Self-contained – Come complete with all files and data an appp needs to run.
  - Scalable – Multiple copies can be run on the same machine or different machine.
  - Flexible, Portable – Same image can run on a PC, in a data center or in the cloud.
  - Isolation – For example, “Show Process” (ps on Linux) command in a container will show only the processes in the container.

VMs versus Containers.

- Criteria: Performance, Scalability, Security ….

Criteria	VM	Containers
Image Size	3X	X
Boot Time	>10s	~1s
Computer Overhead	>10%	<5%
Disk I/O Overhead	>50%	Negligible
Isolation	Good	Good
Security	Low-Medium	Medium-High

Containerization – Key terms.

- Image: a standalone, executable <u>package</u> that includes everything needed to run a piece of software (application code, dependencies, system tools and libraries, configuration files).
  - The entire <u>filesystem</u> and metadata (e.g. environment variables) for an app at runtime.
  - An <u>immutable</u> <u>template</u> for a containers
- Container: The <u>runtime instance</u> of an image.
  - What the image becomes in memory when it's executed.
  - An OS process isolated from the rest of the system through abstractions created by the OS.
  - A container's filesystem comes from an image.

Introduction to Docker

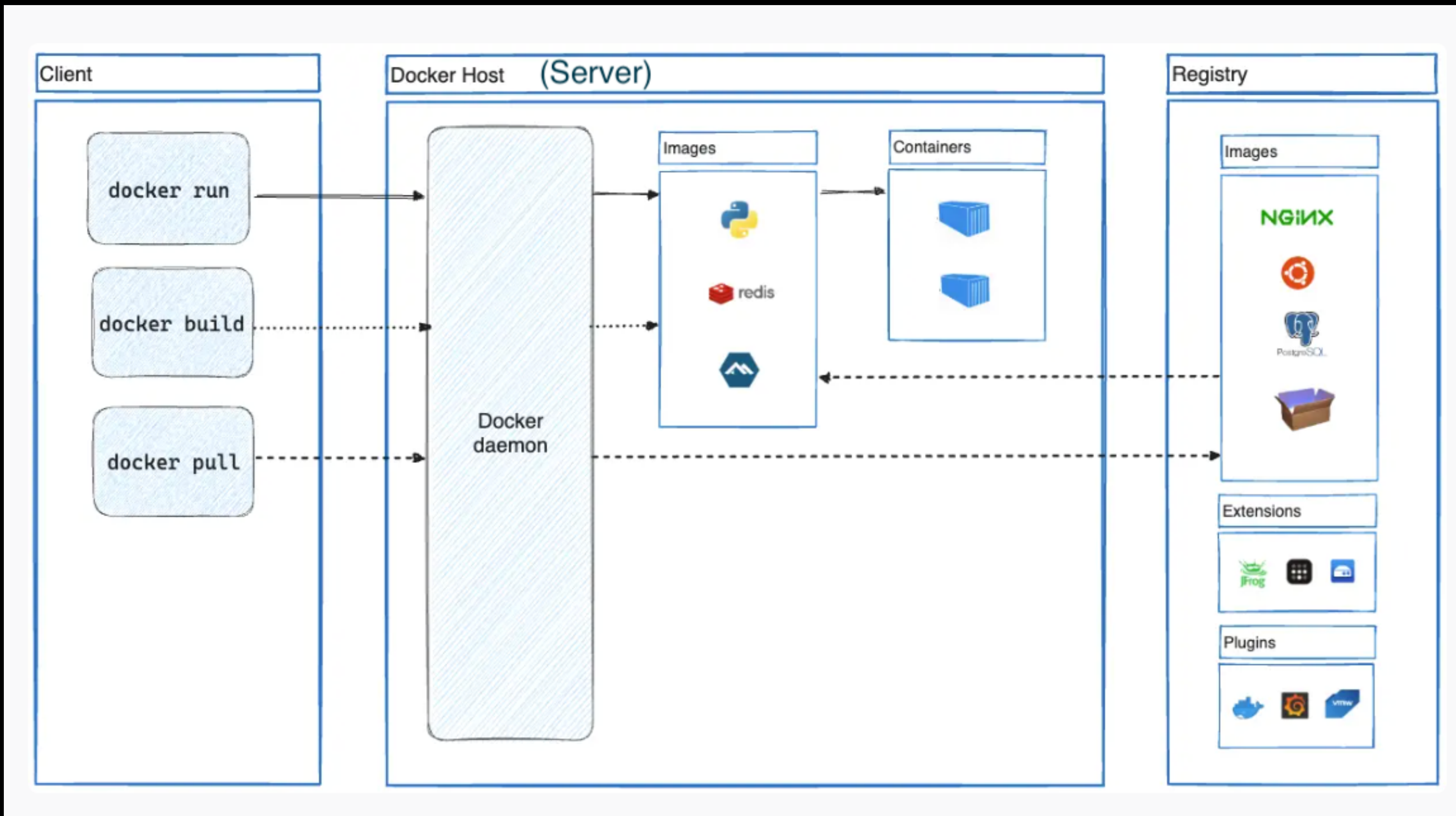
Docker.

- Docker is an open-source platform for creating and managing container-based environments.

- Docker simplifies the development and deployment process by providing a consistent environment across different machines.
- Facilitates share and distribute your applications with others.

- Written in Go language.
- Released in 2013.
- Linux-based, but solutions that work on Windows and Mac OS X now available, via virtualization.

Docker Architecture.



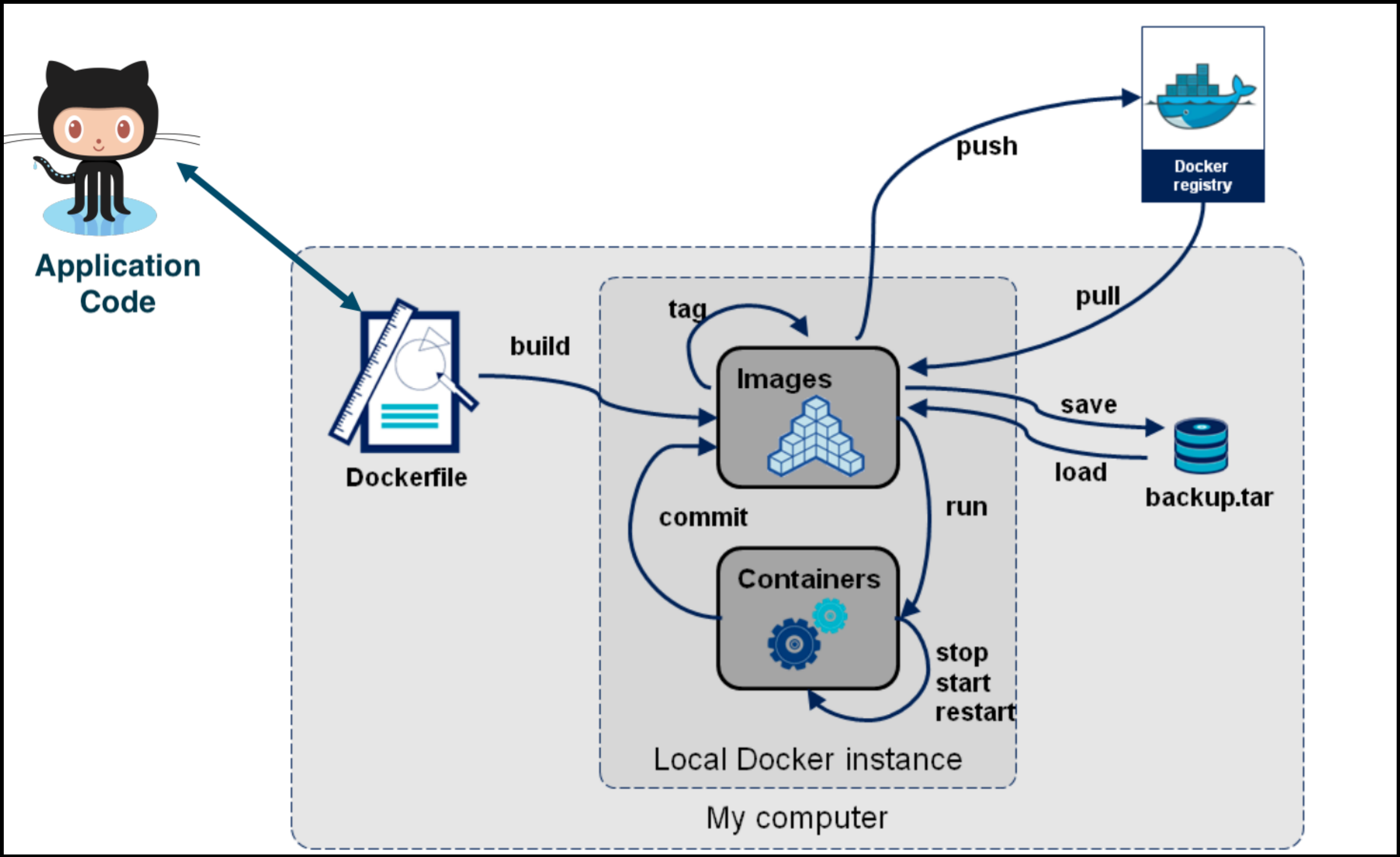
Docker Architecture.

- Docker Daemon.
  - Creates, ships and runs Docker containers deployable on a physical or virtual machine, hosted locally, in a datacentre or cloud service provider.
  - aka Docker Engine, Docker Runtime.
  - Provides an API for user interaction.
- Docker Client – the primary way a user interacts with the deamon.
- Registry.
  - Cloud or server based storage and distribution service for Docker images.
  - Docker Hub (default), AWS ECR, GitHub, GitLab.

Docker – Basics.

- Basic workflow:
  1. Create an image locally from a Dockerfile (set of instructions/directives).
  2. Instantiate container from the image
  3. Push (i.e. upload) the image to a remote registry, e.g. Docker Hub.
  4. Pull (i.e. download) the image on a target machine and run a container from the image.
- Basic commands:
  - docker build – create image
  - docker push – upload
  - docker pull – download
  - docker run –create container instance from image.
  - docker ps – list running containers
  - Docker stop/start – stop/start container

Docker – Basics.



Docker – Command line Interface (CLI).

`$ docker run httpd      (Apache Web Server image)`

- What happens?
  1. Check if httpd image is available locally? No
  2. Download httpd image from Docker Hub registry and store in the local registry.
  3. Create a new container from the image
     - Allocate system resources – CPU, memory, storage
     - Assign IP address to container from the subnet of Docker’s default virtual network.
  4. Container executes the image’s start-up command, i.e. start the Apache web server.

Docker CLI – Image handling.

- Download an image from the registry:
  `$ docker pull <image>`
- Upload an image to the registry:
  `$ docker push <image>`

- Image names have the form:
  `[registry/][user/]name[:tag]`
  - Default registry is registry-1.docker.io (Docker Hub)
  - Default user is library (Official images)
  - default tag is latest.

  ```
  $ docker pull
        registry-1.docker.io/library/httpd:latest
  ```

Docker CLI – Image handling..

- List images in local registry:

  $ docker images

- Tagging – Give an image an alternative name (alias):

  $ docker tag <oldname> <newname>

  e.g.

  ```
  $ docker tag
      registry-1.docker.io/library/httpd:latest
      mywebserver:1.0
  $ docker run  mywebserver:1.0 ls /
  ```

- Delete an image locally:

  $ docker rmi <image>

  – Stop and delete its containers first, if any

Docker CLI – Run.

- Start a new container

  $ docker run <imagename>
- Most used options
  - --name Give the container a symbolic name
  - -d Run container in background mode
  - -p Publish a container's port(s) to the host
  - -e Set environment variables in the container
  - -v Bind/mount a host volume to the container
  - --restart="no" Restart policy (no, on-failure[:max-retry], always)
  - --rm Automatically remove the container when it exits. Useful when experimenting.
  - -t Allocate a pseudo-TTY

Docker CLI – Run.

- The run command (contd.)
  - Publish port 80 from container as port 8080 on host: -p 8080:80
  - Mount local directory /html as directory /usr/share/nginx/html in the container:

    -v /html:/usr/share/nginx/html
  - “Mount” just means “make available”.
  - /usr/share/nginx/html is where nginx web server expects HTML files.
- Example

```
$ docker run -d -p 8080:80
      --name nginx-server nginx:1.15.8-alpine
```

[NGINX is another popular web server and load balancer]

Docker CLI – Container handling.

- List containers

  $ docker ps   # The running containers
  ¢ docker ps –a   # All containers(lncludes exited ones)
- Stop running containers:

  $ docker stop <container..>
- Start stopped containers:
- $ docker
- Remove containers:

  $ docker rm <container..>

Docker CLI – Interaction and Debugging.

- The exec command:
  - Run a command in an existing container,

    $ docker exec <containername/ID> <command>

    e.g start a shell inside a container

    $ docker exec -it <container> /bin/bash

    - Some images only support /bin/sh

- See the logs (stdout) of a container.
  $ docker logs -f <container>

- Show Metadata of a container

  $ docker inspect <container-name/ID>