

Web 2.0

Lecture 9: Cloud Architecture

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Overview

- **Introduction**
- Cloud Architecture
- Docker Containers

What is a Cloud?

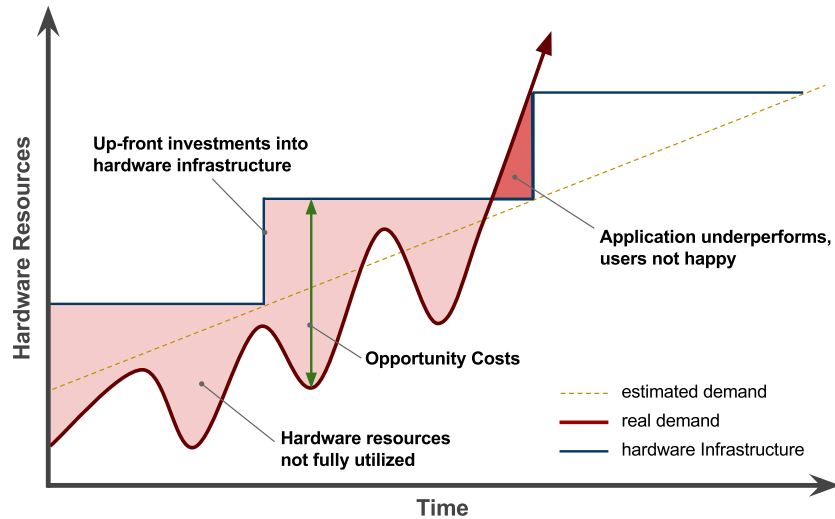
- A different way of thinking
 - *Got your grand mum's savings under your pillow?*
 - *probably not, you better have them in your bank*
 - *Data is your major asset*
 - *you better have them in a "bank" too*
 - *Someone can abuse your data?*
 - *banks bankrupt too, sometimes – it is a risk you take*
 - *there is a market and a competition*
- Outsourcing of application infrastructure
 - *Reliability and availability*
 - *Low costs – pay-per-use*
 - *Elasticity – can dynamically grow with your apps*

What is a Cloud?

- Any app you access over the web?
- A datacenter?
 - *Offers virtualization*
 - *Any company having a datacenter wants to move to*
- Cloud provider should also offer services, such as:
 - *scalability, storage*
 - *Possible to configure programmatically*
 - *integration to enterprise administration processes*
 - *usually REST interface*

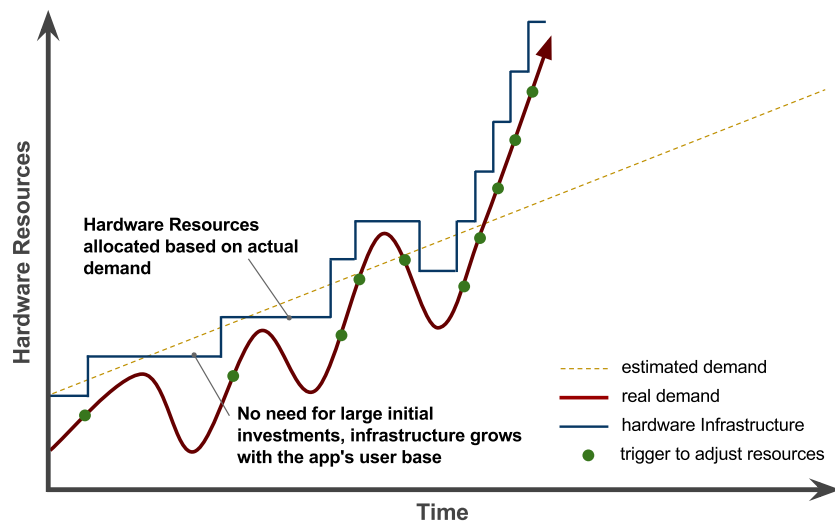
Traditional Solution to Infrastructure

- Traditional hardware model
 - *Up-front hardware investments*
 - *Hardware not optimally utilized*



Good Performance – Cloud Solution

- Cloud Computing model
 - *No up-front hardware investments*
 - *Hardware optimally utilized*



Cloud Computing Concepts

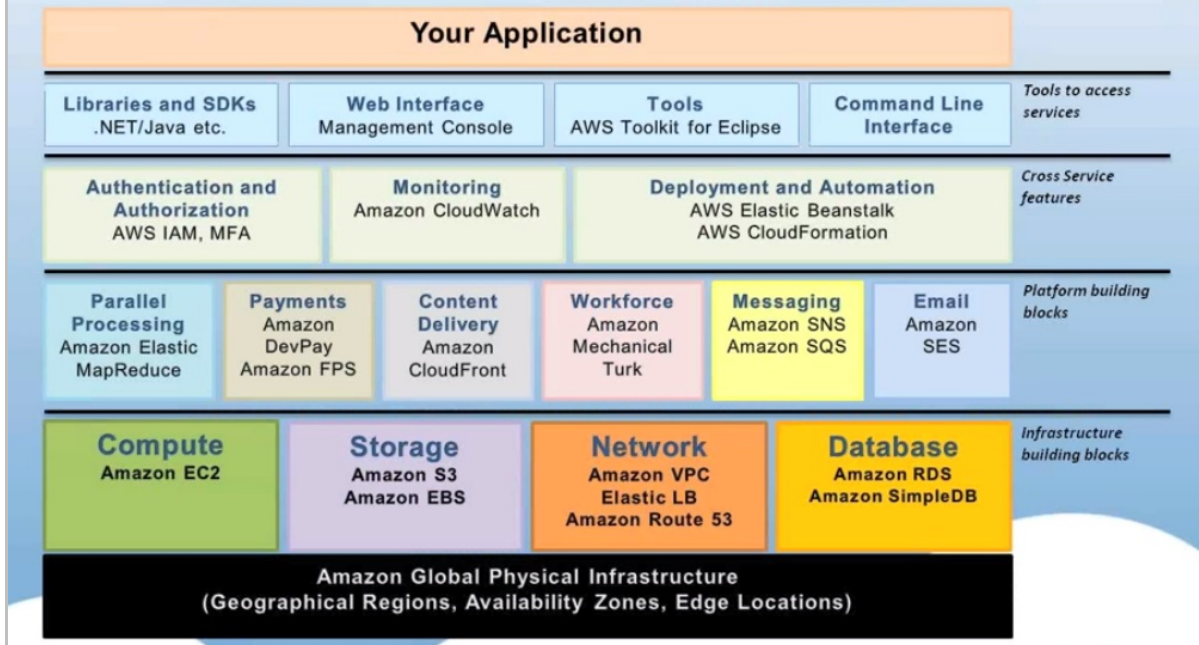
- **Resource Pooling**
 - *Resources reused by multiple tenants (multitenancy)*
 - *Resources: CPU, memory, storage, network*
- **On-demand and Self-service**
 - *Resources are provisioned as they are requested and when they are required*
 - *No human interaction, automatic*
- **Scalability and Elasticity**
 - *Infrastructure may grow and shrink according to needs*
 - *Automatic or manual*
- **Pay-per-use**
 - *Consumers only pay for resources when they use them*

Cloud Computing Concepts (Cont.)

- **Service Models (aka Cloud Layers)**
 - *IaaS – Infrastructure as a Service*
 - *PaaS – Platform as a Service*
 - *MWaaS, DBaaS, ...*
 - *SaaS – Software as a Service*
- **Deployment Models**
 - *Public Cloud*
 - *Private Cloud*
 - *Hybrid Cloud*

Cloud Provider Example – Amazon AWS

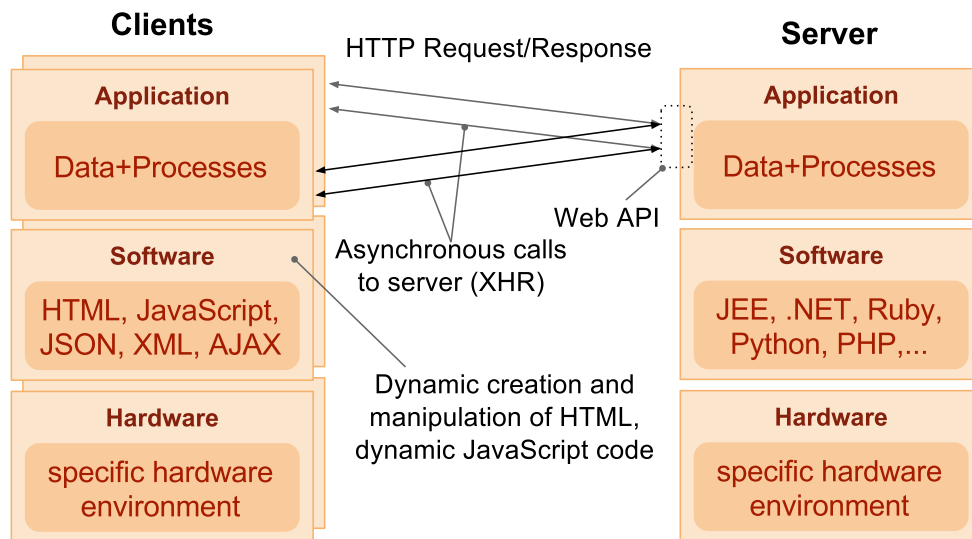
The “Living and Evolving” AWS Cloud



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- Cloud Architecture
 - *Service Models*
 - *Multitenancy*
- Docker Containers

Web 2.0 Web Architecture

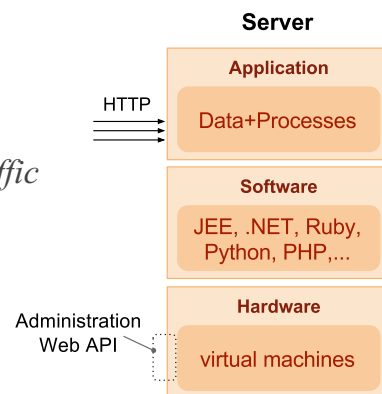


IaaS: Infrastructure as a Service

- Provides basic computing resources and services for application providers
 - *Services for application providers*
 - *A consumer is able to deploy and run arbitrary software*
- Infrastructure implications
 - *Exposing of infrastructure resources through abstraction*
 - *Support for infrastructure resources – compute (hardware/OS/VM), storage, network, etc.*
 - *Supports isolation for multitenant environments*

IaaS: Infrastructure as a Service

- Usage
 - Predefined machine instances (micro, small, large, extra-large)
 - Linux OS, 613 MB of memory, 30 GB of Storage, Load Balancer, etc.
 - Pay-per-use – pay for resources you use (time or amount); no up-front costs
- IaaS Services Examples
 - Elastic Storage
 - Monitoring resources
 - Amazon CloudWatch)
 - Auto Scalling of running instances
 - Load Balancing – distributing incoming traffic across multiple instances
- IaaS providers
 - Amazon EC2, GoGrid, Rackspace, OpenNebula, ...

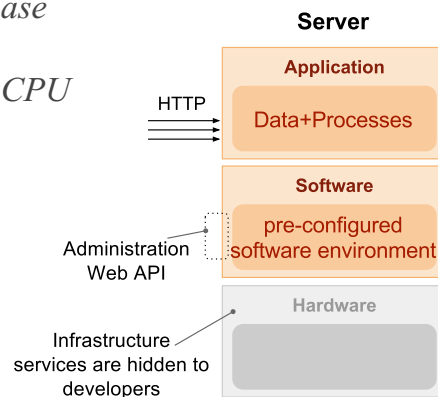


PaaS: Platform as a Service

- Provides scalable platform for applications
 - Services for application providers
 - No costs of buying and managing underlying infrastructure
 - hardware and software
- Infrastructure implications
 - Scalable platform, deploy on-demand
 - Self service interface to deploy applications and services
 - Support for monitoring and measuring platform usage
 - Model supporting isolation in multi-tenant environments

PaaS: Platform as a Service

- Usage
 - Choose software platform, e.g., JEE, .NET, Python, etc.
 - Pay-per-use – pay for the resources you use; no up-front costs
- PaaS features
 - Auto Scalling and Load Balancing of applications
 - Persistent Storage - usually NoSQL database
 - Local development environment
 - Backends – for app instances with higher CPU and memory demands
 - Administration APIs for its services
- PaaS providers
 - Google App Engine, Heroku, Windows Azure, etc.
- Limitations
 - HTTP request limit (30 - 60 sec)
 - No writes to file system, no thread support



SaaS: Software as a Service

- Software delivery model for applications hosted in the cloud
 - typically software for end-users
 - services accessed using a web browser
 - provides API for programmatic access
- SaaS characteristics
 - Typically build on top of IaaS or PaaS
 - Configurable and customizable modern Web applications
 - Usually basic version for free, need to pay for pro version
 - Global availability - any computer, any device
 - Easy management - automatic and fast updates
 - Pay-per-use – pay for the time you use
- SaaS providers
 - Google Apps, Salesforce, iCloud, Flickr, Picasa, ...

Overview

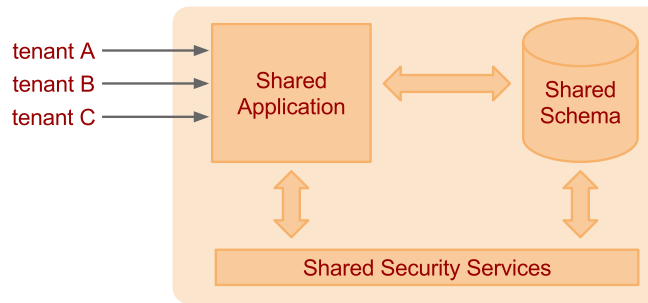
- Introduction
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 - *Multitenancy*
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Multitenancy

- Architectural approach where resources are shared between multiple tenants or consumers
- Implications
 - *Centralization of infrastructure in locations with lower costs*
 - *Peak-load capacity increases*
 - *Utilisation and efficiency improvements for systems that are not well utilised*
- Sharing options
 - *Shared Everything*
 - *Shared Infrastructure*
 - *Virtual Machines*
 - *O/S virtualization*

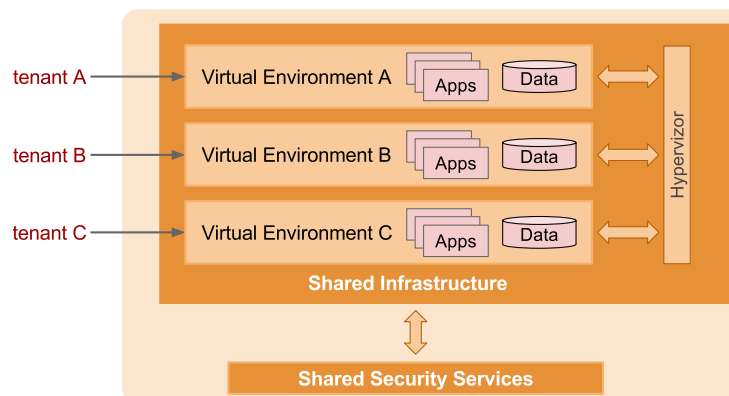
Shared Everything

- Resources are shared between all tenants or consumers
 - *tenant: a service consumer*
- Common for the SaaS model
- The application should provide tenant isolation
- Data for multiple tenants is stored in the same database tables



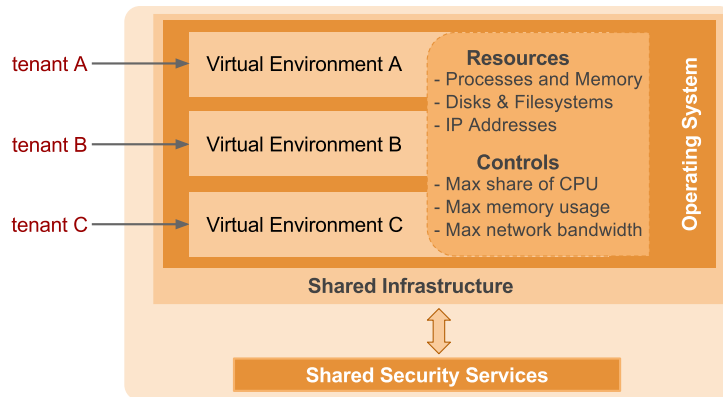
Shared Infrastructure: Virtual Machines

- Infrastructure shared via virtual machines
 - *each tenant has its own virtual environment*
 - *Isolation provided by hypervisor*
 - *hypervisor: virtual machine manager, runs virtual machines*
 - *Resource contention depends on VM capability and configuration*
 - *Adds an additional layer and processes to run and manage*



Shared Infrastructure: OS Virtualization

- Infrastructure shared via OS Virtualization
 - *Each tenant has its own processing zone*
 - *Isolation provided by the operating system*
 - *Resource contention depends on zone configuration*
 - *No VMs to run and manage, no abstraction layer between app & OS*



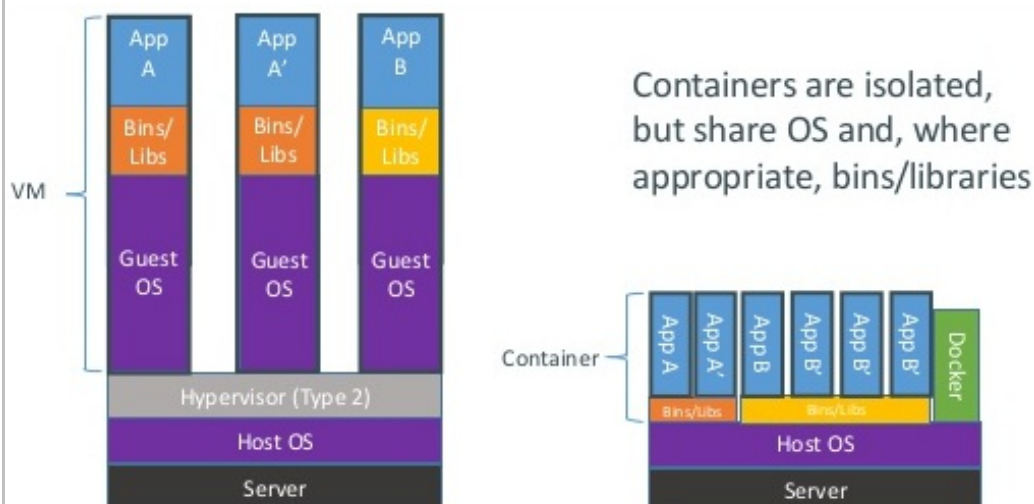
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- Docker Containers
 - *Overview*
 - *Image Layering*
 - *Working with Docker*
 - *Swarm*

Overview

- Linux Containers
 - Introduced in 2008
 - Allow to run a single process in a isolated system-level files and network "virtualization"
 - Use much less resources and disk space than traditional virtualization
- Implementations
 - LXC – default implementation in Linux
 - **Docker Containers**
 - Builds on new Kernel features: control groups (cgroups), kernel namespaces, union-capable file system (OverlayFS, AUFS, etc.)
 - A way to build, commit and share images
 - Build images using a description file called Dockerfile
 - Large number of available base and re-usable images

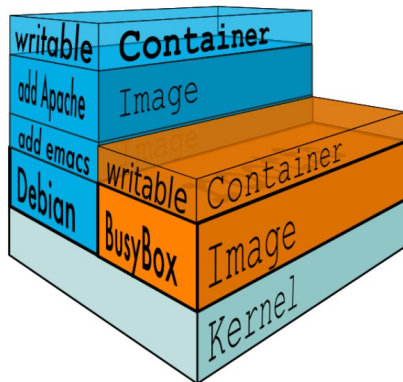
VM vs. Docker Containers



Docker Basic Terms

- Image
 - Basis for containers.
 - An image contains a union of layered filesystems stacked on top of each other.
 - An image does not have state and it never changes.
- Container
 - A runtime instance of a Docker image, a standard to "ship software".
- Docker Engine
 - The core process providing the Docker capabilities on a host.
- Docker Client
 - Interface that integrates with docker engine.
- Registry
 - A hosted service containing repository of images.
 - A registry provides a registry API to search, pull and push images.
 - Docker Hub is the default Docker registry.
- Swarm
 - A cluster of one or more docker engines.

Docker Images



- Containers are made up of R/O layers via a storage driver (OverlayFS, AUFS, etc.)
- Containers are designed to support a single application
- Instances are ephemeral, persistent data is stored in bind mounts or data volume containers.

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Image Layering with OverlayFS

- OverlayFS
 - A filesystem service implementing a **union mount** for other file systems.
 - Docker uses **overlay** and **overlay2** storage drivers to build and manage on-disk structures of images and containers.
- Image Layering
 - OverlayFS takes two directories on a single Linux host, layers one on top of the other, and provides a single unified view.
 - Only works for two layers, in multi-layered images hard links are used to reference data shared with lower layers.



Image Layers Example

- Pulling out the image from the registry

```
$ sudo docker pull ubuntu
```

```
Using default tag: latest
```

```
latest: Pulling from library/ubuntu
```

```
5ba4f30e5bea: Pull complete
```

```
9d7d19c9dc56: Pull complete
```

```
ac6ad7efd0f9: Pull complete
```

```
e7491a747824: Pull complete
```

```
a3ed95cae02: Pull complete
```

```
Digest: sha256:46fb5d001b88ad904c5c732b086b596b92cfb4a4840a3abd0e35dbb6870585e4
```

```
Status: Downloaded newer image for ubuntu:latest
```

- *Each image layer has its own directory under `/var/lib/docker/overlay/`.*
- *This is where the contents of each image layer are stored.*

- Directories on the file system

```
$ ls -l /var/lib/docker/overlay/
```

```
total 20
```

```
drwx----- 3 root root 4096 Jun 20 16:11 38f3ed2eac129654acef11c32670b534670c3a06e483fce313d72e3e
```

```
drwx----- 3 root root 4096 Jun 20 16:11 55f1e14c361b90570df46371b20ce6d480c434981cbda5fd68c6ff61
```

```
drwx----- 3 root root 4096 Jun 20 16:11 824c8a961a4f5e8fe4f4243dab57c5be798e7fd195f6d88ab06aea92
```

```
drwx----- 3 root root 4096 Jun 20 16:11 ad0fe55125ebf599da124da175174a4b8c1878afe6907bf7c7857034
```

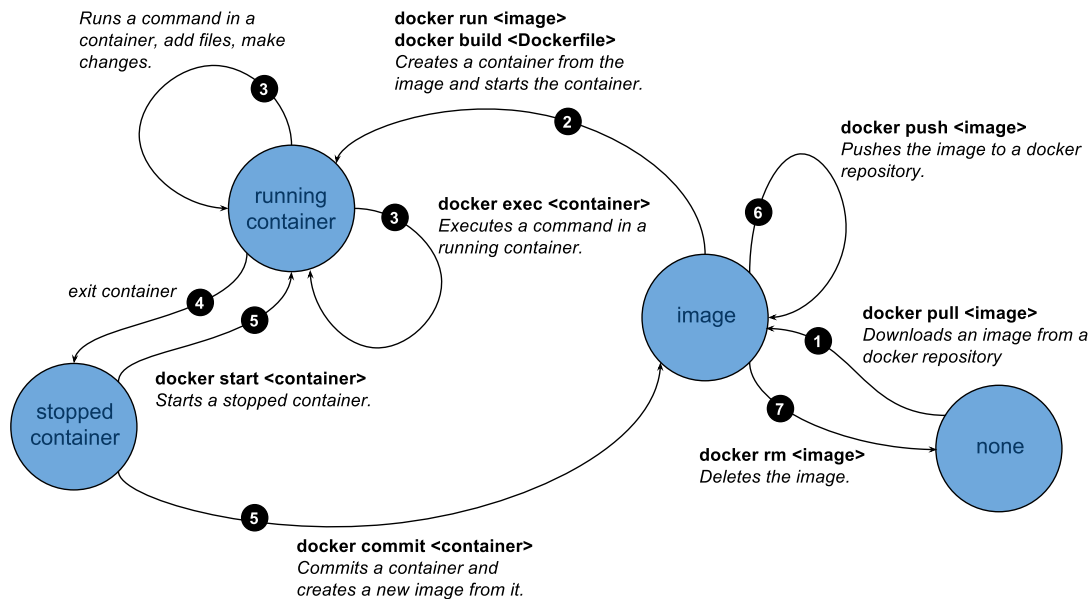
```
drwx----- 3 root root 4096 Jun 20 16:11 edab9b5e5bf73f2997524eebeac1de4cf9c8b904fa8ad3ec43b35041
```

- *The organization of files allows for efficient use of disk space.*
- *There are **files unique to every layer** and **hard links to the data** that is shared with lower layers*

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Docker Container Lifecycle State Diagram



Commands (1)

docker version

list current version of docker engine and client

docker search <image>

search for an image in the registry

docker pull <image[:version]>

*download an image of a specific from the registry
if the version is not provided, the latest version will be downloaded*

docker images

list all local images

docker run -it <image[:version]> <command>

*start the image and run the command inside the image
if the image is not found locally, it will be downloaded from the registry
option -i starts the container in interactive mode
option -t allocates a pseudo TTY*

docker ps [-as]

*list all running containers
option -a will list all containers including the stopped ones.
option -s will list the container's size.*

Commands (2)

docker rm <container>

remove the container

docker rmi <image>

remove the image

docker commit <container> <name[:version]>

create an image from the container with the name and the version

docker history <image>

display the image history

Networking and Linking

- There are 3 docker networks by default
 - **bridge** – container can access host's network (default)
 - Docker creates subnet **172.17.0.0/16** and gateway to the network
 - When a container is started, it is automatically added to this network
 - All containers in this network can communicate each other
 - **host** – all host's network interfaces will be available in the container.
 - **none** – container will be placed on its own network and no network interfaces will be configured.
- Custom Network configuration
 - You can create a new network and add containers to it
 - Containers in the new network can communicate with each other but the network will be isolated from the host network
- Linking containers (legacy)

```
$ docker run -d --name redmine-db postgres
$ docker run -it --link redmine-db:db postgres /bin/bash
root@c4b12143ebe8:/# psql -h db -U postgres
psql (9.6.1)
Type "help" for help.
postgres=# SELECT inet_server_addr();
postgres=# SELECT * FROM pg_stat_activity \x\g\x
```

- The container sees the provided name as a DNS address

Networking Commands

`docker network ls`

lists all available networks

`docker network inspect <network-id>`

Returns the details of specific network

`docker network create --driver bridge isolated_nw`

creates a new isolated network

`docker run -it --network=isolated_nw ubuntu bin/bash`

starts the container ubuntu and attaches it to the isolated network

Data Volumes

- Data Volume

- A directory that bypass the union file system
- Data volumes can be shared and reused among containers
- Data volume persists even if the container is deleted
- It is possible to mount a shared storage volume as a data volume by using a volume plugin to mount e.g. NFS

- Adding a data volume

`docker run -d -v /webapp training/webapp python app.py`

will create a new volume with name webapp,

the location of the volume can be determined by using `docker inspect`.

- Mount a host directory as a data volume

`docker run -d -v /src/webapp:/webapp training/webapp python app.py`

if the path exists in the container, it will be overlayed (not removed),

if the host directory does not exist, the docker engine creates it.

- Data volume container

- Persistent data to be shared among two or more containers

`docker create -v /dbdata --name dbstore training/postgres /bin/true`

`docker run -d --volumes-from dbstore --name db1 training/postgres`

`docker run -d --volumes-from dbstore --name db2 training/postgres`

Dockerfile

- Dockerfile is a script that creates a new image

```
# This is a comment
FROM oraclelinux:7
MAINTAINER Tomas Vitvar <tomas@vitvar.com>
RUN yum install -q -y httpd
EXPOSE 80
CMD httpd -X
```

- A line in the Dockerfile will create an intermediary layer

```
$ docker build -t tomvit/httpd:v1 .
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM oraclelinux:7
----> 4c357c6e421e
Step 2 : MAINTAINER Tomas Vitvar <tomas@vitvar.com>
----> Running in 35feebb2ffab
----> 95b35d5d793e
Removing intermediate container 35feebb2ffab
Step 3 : RUN yum install -q -y httpd
----> Running in 3b9aee3c3ef1
----> 888c49141af9
Removing intermediate container 3b9aee3c3ef1
Step 4 : EXPOSE 80
----> Running in 03e1ef9bf875
----> c28545e3580c
Removing intermediate container 03e1ef9bf875
Step 5 : CMD httpd -X
----> Running in 3c1c0273a1ef
```

– *If the processing fails at some point, all preceding points will be loaded from the cache on the next run.*

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Swarm

