Web 2.0

Lecture 9: Cloud Architecture

doc. Ing. Tomáš Vitvar, Ph.D.
tomas@vitvar.com • @TomasVitvar • http://vitvar.com

Czech Technical University in Prague
Faculty of Information Technologies • Software and Web Engineering • http://vitvar.com/courses/w20

Modified: Wed Mar 22 2017, 19:38:47
Humla v0.3

Overview

- Introduction
- Cloud Architecture
- Docker Containers

What is a Cloud?

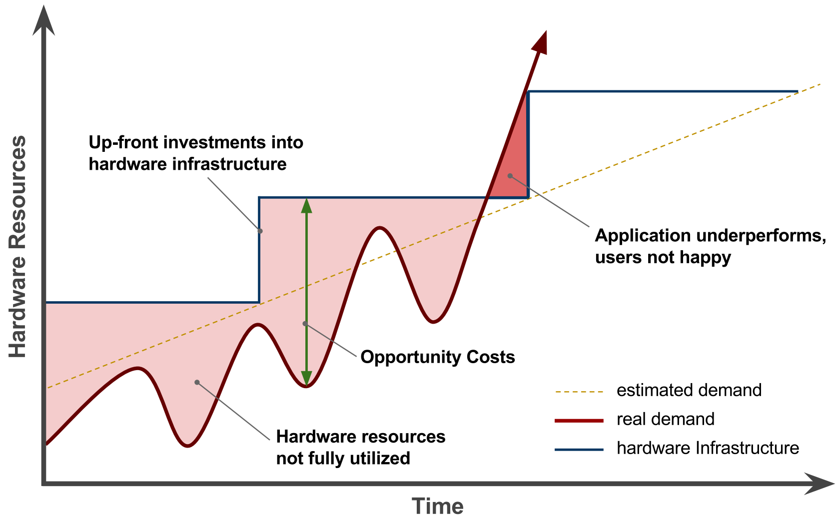
- A different way of thinking
  - *Got your grand mum's savings under your pillow?*
    → probably not, you better have them in your bank
  - *Data is your major asset*
  - *you better have them in a "bank" too*
  - *Someone can abuse your data?*
  - *banks bankrupt too, sometimes – it is a risk you 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

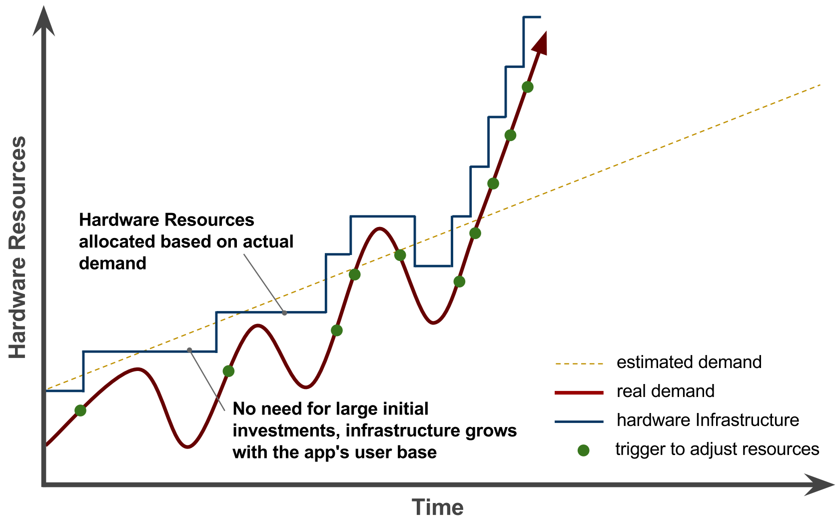
Traditional Solution to Infrastructure

- 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*



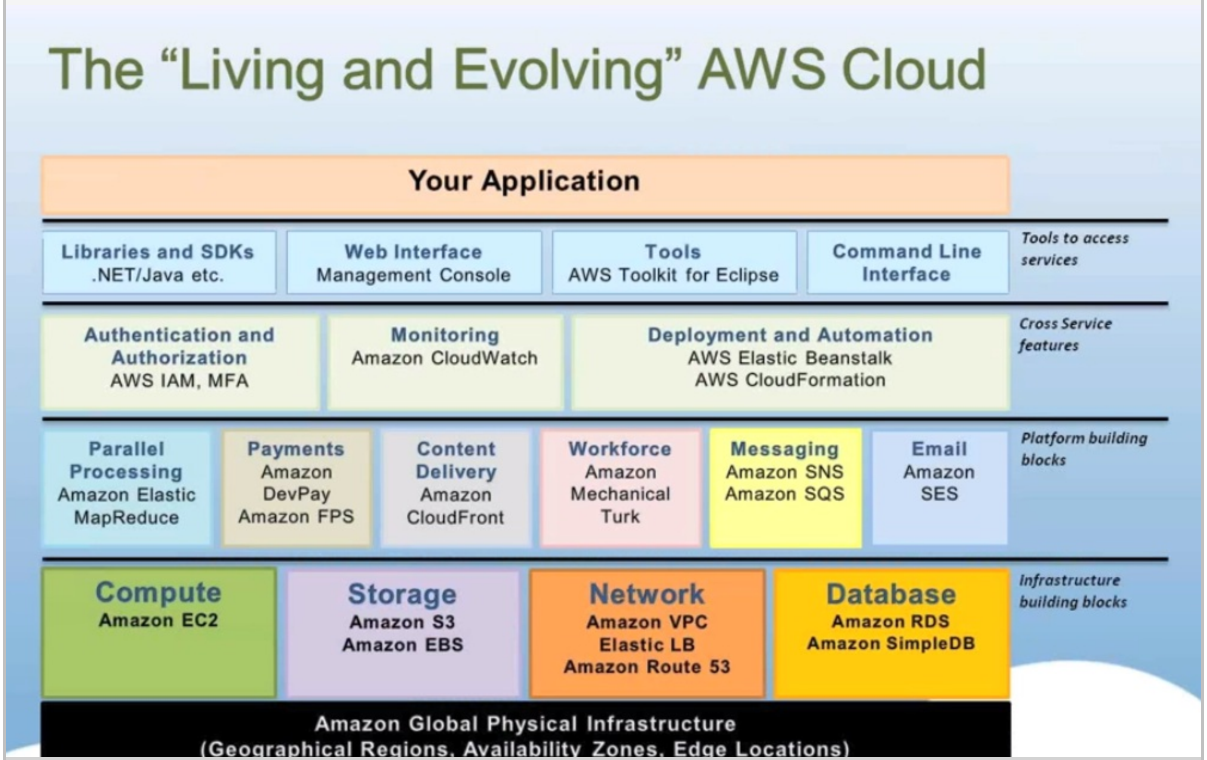
Cloud Computing Concepts

- **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*

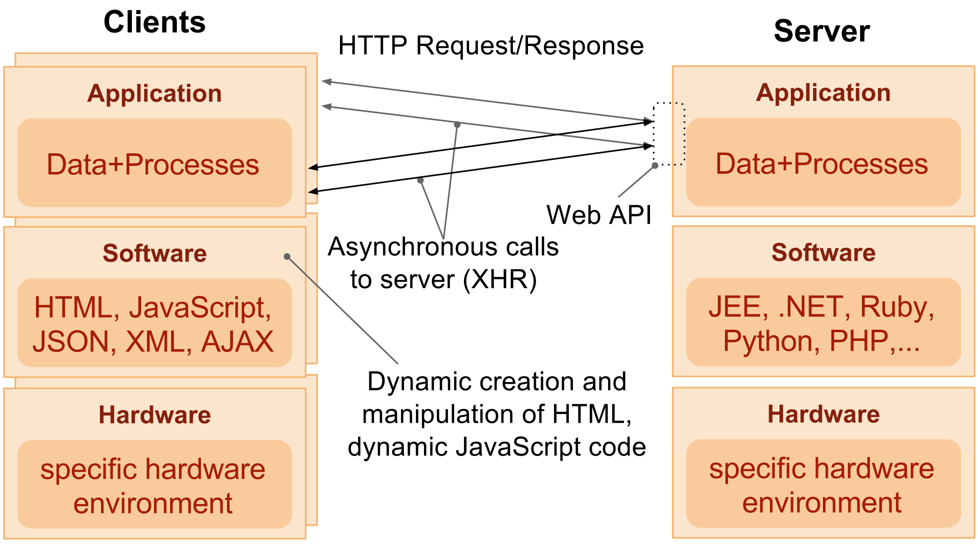
Cloud Provider Example – Amazon AWS



Overview

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

Web 2.0 Web Architecture

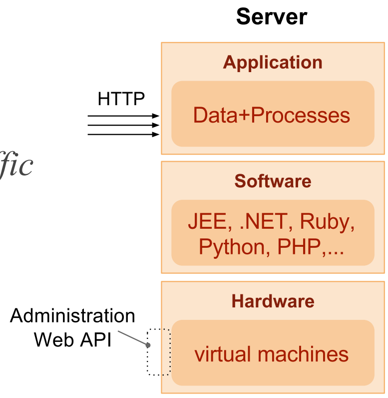


IaaS: Infrastructure as a Service

- 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, ...*

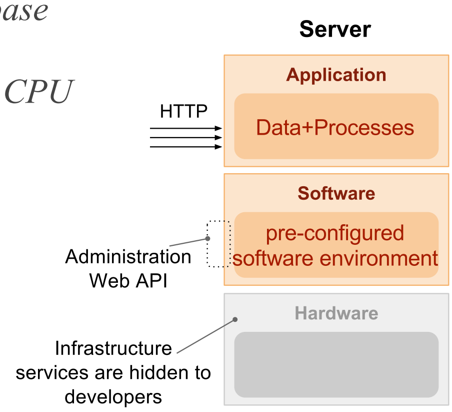


PaaS: Platform as a Service

- 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

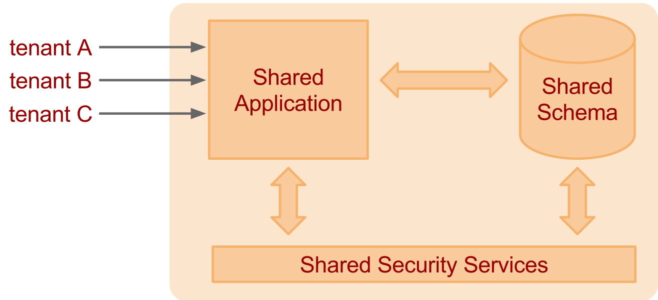
- Introduction
- Cloud Architecture
  – *Service Models*
  – *Multitenancy*
- Docker Containers

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*

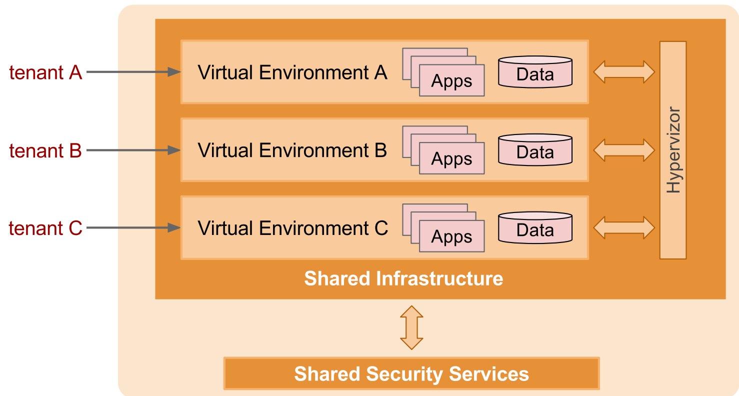
Shared Everything

- 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



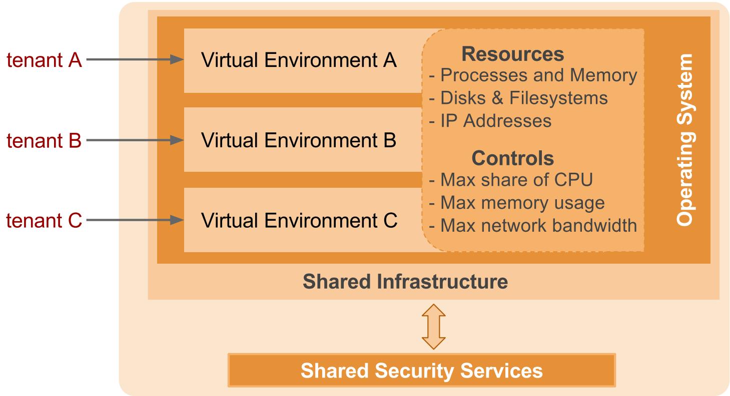
Shared Infrastructure: Virtual Machines

- 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*



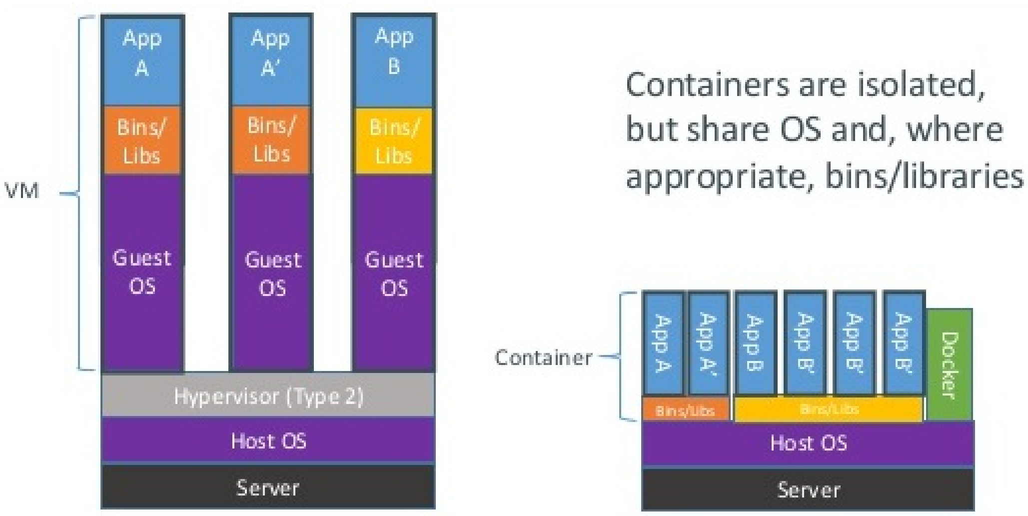
Overview

- Introduction
- Cloud Architecture
- Docker Containers
  – *Overview*
  – *Image Layering*
  – *Working with Docker*
  – *Swarm*

Overview

- Linux Containers
  - *Introduced in 2008*
  - *Allow to run a process tree in a isolated system-level "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*

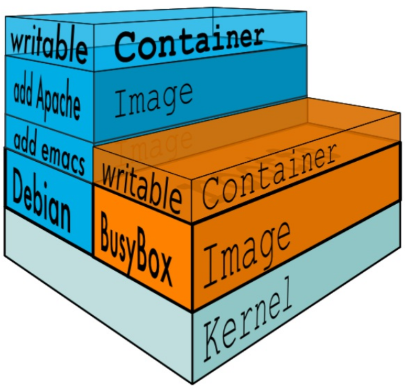
VM vs. Docker Containers



Docker Basic Terms

- Image
  - *Bssis 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.*

Overview

- Introduction
- Cloud Architecture
- Docker Containers
  – *Overview*
  – *Image Layering*
  – *Working with Docker*
  – *Swarm*

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.*

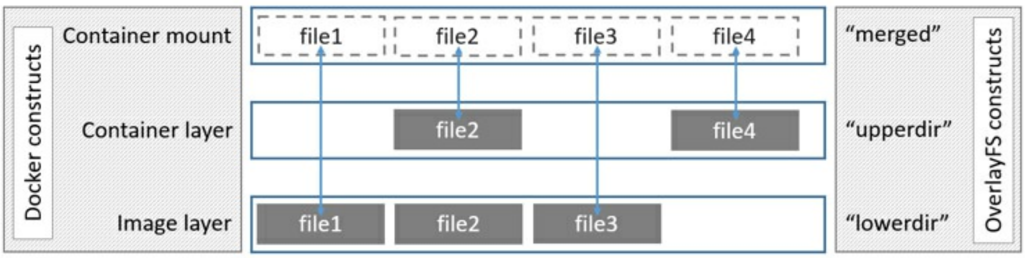


Image Layers Example

- 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
a3ed95caeb02: 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

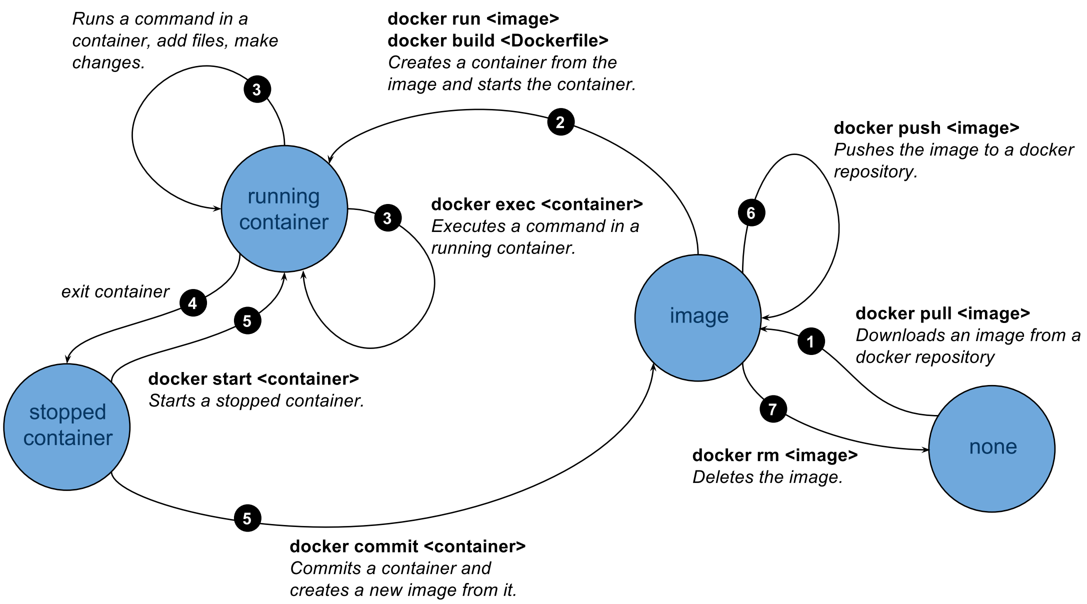
```
$ ls -l /var/lib/docker/overlay/

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*

Overview

- Introduction
- Cloud Architecture
- Docker Containers
  – *Overview*
  – *Image Layering*
  – *Working with Docker*
  – *Swarm*

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
```

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 sotrage volume as a data volue 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 value 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

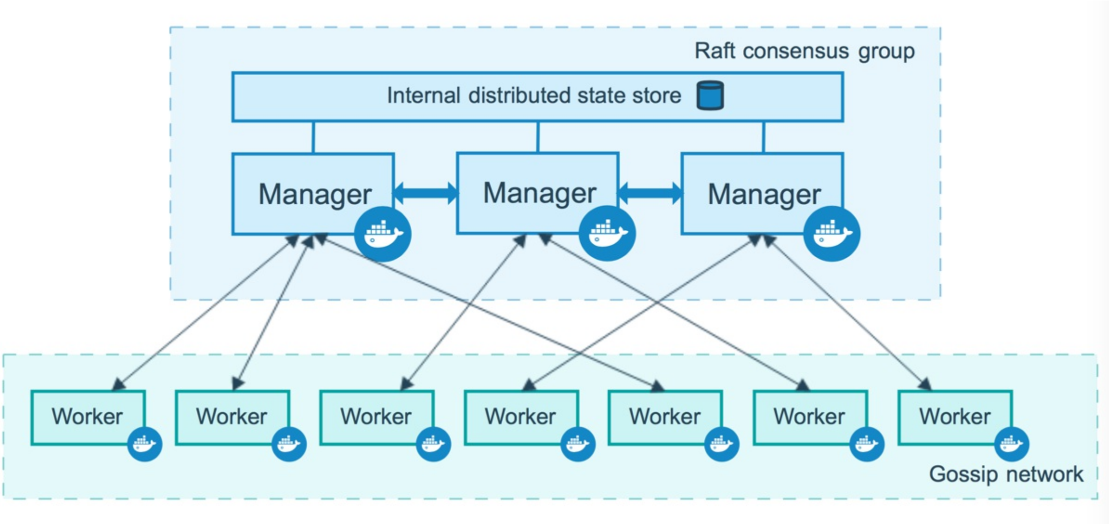
```
$ docker build -t tomvit/httpd:v1 .
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM oraclelinux:7
 ---> 4c357c6e421e
Step 2 : MAINTAINER Tomas Vitvar <tomas@vitvar.com>
 ---> Running in 35feebb2ffab
 ---> 95b35d5d793e
Removing intermediate container 35feebb2ffab
Step 3 : RUN yum install -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*

Overview

- Introduction
- Cloud Architecture
- Docker Containers
  – *Overview*
  – *Image Layering*
  – *Working with Docker*
  – *Swarm*

Swarm


Raft consensus group
Internal distributed state store
Manager
Manager
Manager
Worker
Worker
Worker
Worker
Worker
Worker
Worker
Gossip network