Docker

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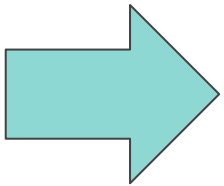
Training Objectives

At the end of training,

participants should be able to



- ❏ Know Docker & swim with them
- ❏ Build and run containers
- ❏ Bundle applications in Docker images
- ❏ Setup Docker Swarm cluster
- ❏ Run applications in Docker swarm cluster

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Module 1: Docker Concept & Terms

- Container vs Virtual Machine
- Linux Containers & Docker
- Terminologies in Docker world
- Docker Architecture
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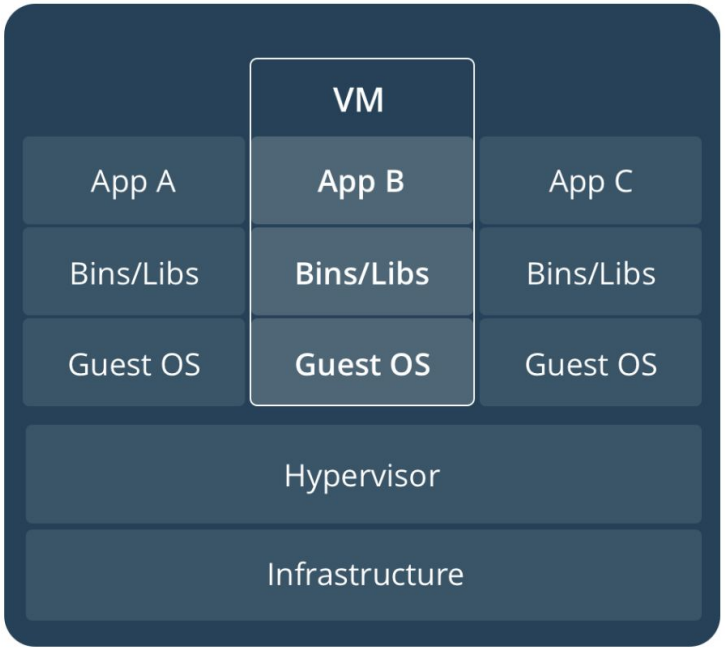
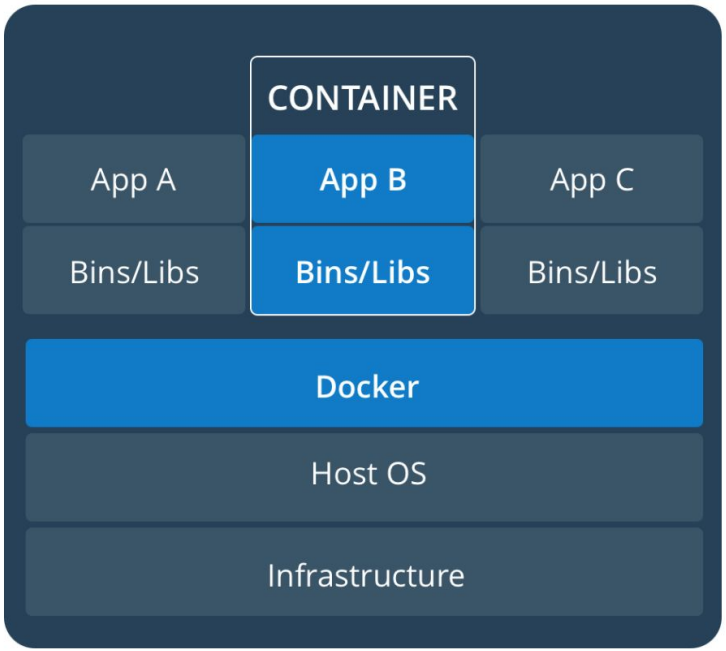
- Lab Exercises

Virtual Machines and Containers

Virtual Machine diagram



Container diagram



Containers - Brief

Linux Containers (LXC)

OS level virtualization to provide isolation to a set of processes from rest of the system.

Docker Containers

Uses LXC to develop, deploy & run apps with containers

Containerization

Use of linux containers to deploy application is called containerization

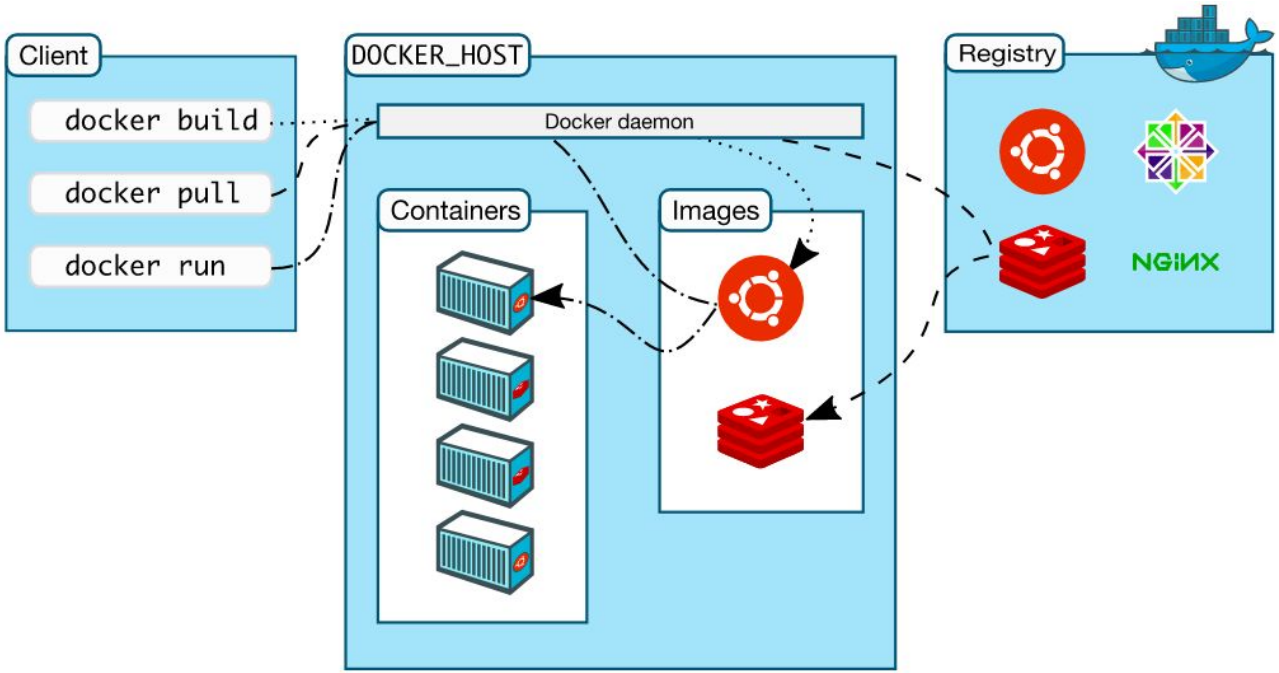
Containers - Benefits

- Flexible: Even the most complex applications can be containerized.
- Lightweight: Containers leverage and share the host kernel.
- Interchangeable: You can deploy updates and upgrades on-the-fly.
- Portable: You can build locally, deploy to the cloud, and run anywhere.
- Scalable: You can increase and automatically distribute container replicas.
- Stackable: You can stack services vertically and on-the-fly
- Running more workload on the same hardware

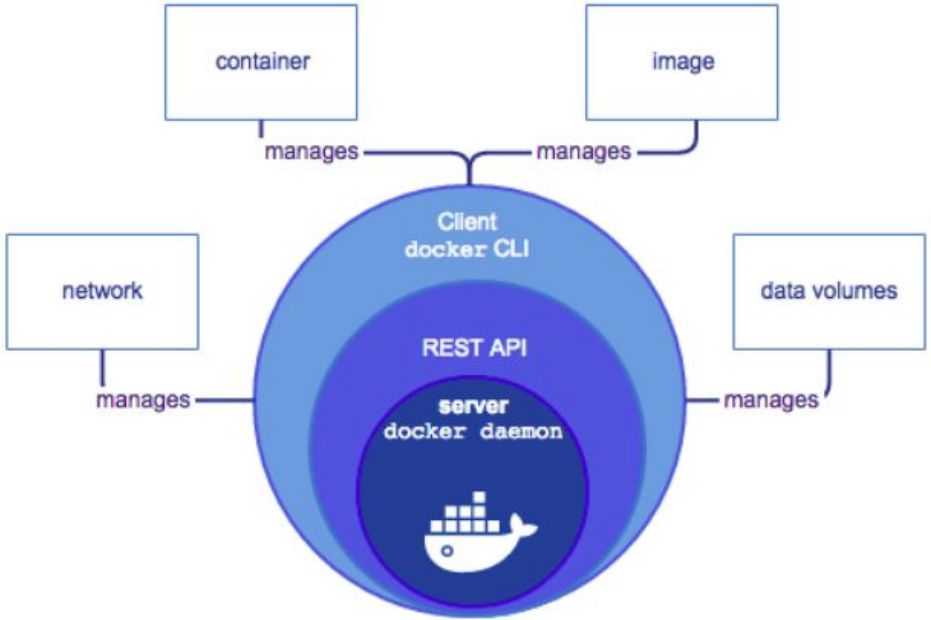
Terminologies

- **Image** - Executable package that includes everything needed to run an application – the code, a runtime, libraries, environment variables, and configuration files
- **Container** -
  - Runtime instance of an image–what the image becomes in memory when executed
- **Service** -
  - a container but service codifies the way image runs -replicas, port, name etc
- **Swarm** -
  - cluster of machines running docker containers
- **Stack** -
  - group of interrelated services that can be orchestrated and scaled together
- **Registry** -
  - storage and content delivery system, holding named Docker images, available in different tagged versions
- **Server Daemon** -
  - creates and manages docker objects - images, containers, network, volumes, swarm etc
- **Docker Client** -
  - CLI to communicate with server using Docker API
- **Docker REST API** -
  - Communication contract between docker component (servers & clients)
- **Network** -
  - Docker object holding the networking meta-data
- **Node** -
  - machine participating in Swarm
- **Volume** -
  - Storage of persistence data generated by managed by Docker containers

Docker Architecture



Docker Architecture

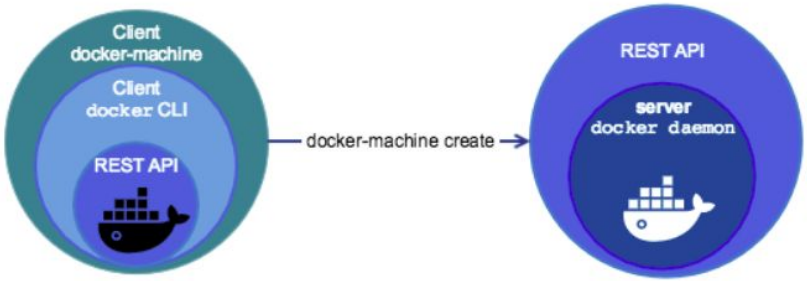


Docker - Underlying Tech

- Namespace
  - Pid, net, ipc, mnt, uts
- Control Groups
- Union File System
- Container format
  - libcontainer

Docker Machine

A tool to create and manage virtual docker hosts locally or remotely



Installation on Windows with Git BASH

```
$ if [[ ! -d "$HOME/bin" ]]; then mkdir -p
"$HOME/bin"; fi && \
curl -L
https://github.com/docker/machine/releases/dow
nload/v0.13.0/docker-machine-Windows-x86_64.ex
e > "$HOME/bin/docker-machine.exe" && \
chmod +x "$HOME/bin/docker-machine.exe"
```

Docker Setup (Ubuntu)

```
sudo apt-get update
```

```
sudo apt-get remove docker docker-engine docker.io
```

```
sudo apt install docker.io
```

```
sudo systemctl start docker
```

```
sudo systemctl enable docker
```

Docker Setup - Configuring Engine

Daemon startup params

```
$ dockerd -D --tls=true --tlscert=/var/docker/server.pem --tlskey=/var/docker/serverkey.pem
-H tcp://192.168.59.3:2376
```

Daemon config file

```
{
  "debug": true,
  "tls": true,
  "tlscert": "/var/docker/server.pem",
  "tlskey": "/var/docker/serverkey.pem",
  "hosts": ["tcp://192.168.59.3:2376"]
}
```

Lab Exercises

- Q & A
  - Why Docker?
  - Why Docker Machine?
  - What is Swarm?
  - Docker is a virtualization technology similar to VMWare. True or False?

- Verify Docker installation by running below command and expect no errors

  docker --version

  docker --help

  docker container --help

- Verify Docker Machine installation by running below command

  docker-machine --version

  docker-machine --help

Docker Containers

- Creating containers
- Running containers
- Docker Images
- Connecting containers
- Local development workflow
- Lab Exercises

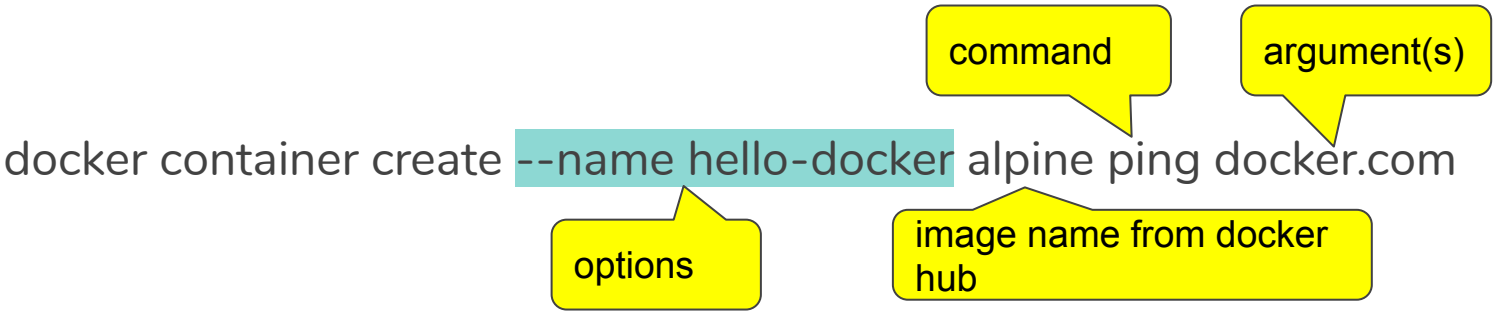
Creating containers

docker container create [OPTIONS] IMAGE [COMMAND] [ARG...]

Options:

--name string name of the container
--cpus decimal number of CPUs
--label list set metadata on a container
--memory bytes memory limit
--network string connect container to a network (default “default”)
--publish list publish container’s port to the host
--rm remove container when it exits

Creating containers - Examples



docker container create -it alpine sh

docker container create -it --name tutum-hello-world -p 80:80 tutum/hello-world

To run: docker container start tutum-hello-world

Running containers

docker container run [OPTIONS] IMAGE [COMMAND] [ARG...]

Options:

--name string name of the container
--cpus decimal number of CPUs
--label list set metadata on a container
--memory bytes memory limit
--network string connect container to a network (default “default”)
--publish list publish container’s port to the host
--rm remove container when it exits
-i interactive mode
-t allocates a pseudo-TTY

Running containers - Examples

docker container run -d -p 80:80 tutum/hello-world (creates container with random name)

docker container run -p 81:80 nginx (connects to tty, Ctrl+C to exit)

docker container run -p 81:80 -it nginx /bin/bash (interactive terminal, Ctrl+PQ to leave it running)

docker container run -d -p 81:80 --name nginx nginx (name it & run in the background)

```
docker run --name demo-mysql -e MYSQL_ROOT_PASSWORD=password -e
MYSQL_DATABASE=demo -e MYSQL_USER=demo_user -e MYSQL_PASSWORD=demo_pass -d
mysql:5.6
```

Running containers - Examples...

docker run -ti --rm r-base

docker run -ti --rm -v /home/rajesh/git/dockers/training-aug0506/hello-r/:/tmp/ r-base Rscript /tmp/main.R

docker run --log-opt max-size=20m --log-opt max-file=5 --link mysql:mysql -itd -p 8082:80 --name ui --restart always -v /tmp/unigps:/tmp/unigps/ -e JAVA_OPTS='-Xms1g' -e java.security.egd=file:/dev/./urandom -e spring.profiles.active=dev -e spring.datasource.url=jdbc:mysql://mysql:3306/db -e java.security.egd=file:/dev/./urandom -e jasypt.encryptor.password=pwd -e security.oauth2.client.clientId=clientid -e security.oauth2.client.clientSecret=auth -e aws.accessKeyId=aa -e aws.secretKey=aa -e server.port=80 unigps/track.unigps.in:2019.05.001.RELEASE

Docker Images

- **Image** - Executable package that includes everything needed to run an application – the code, a runtime, libraries, environment variables, and configuration files

- **docker images**
- **docker images nginx**
- **docker images java:8**
- **docker images --filter "dangling=true"** (untagged images)
- **docker rmi $(docker images -f "dangling=true" -q)**
- **docker search oracle (searches docker hub images having mention of oracle in it)**

Connecting Containers

Two ways:

- Networking feature (/ network port)
- Docker legacy feature --link (will be deprecated in future)
  - `--link <name or id>:alias`

Example:

```
docker run -p 8080:8080 --name demo-app --link demo-mysql:mysql -d jiwhiz/spring-boot-docker-mysql
```

Local Development Workflow

Dev Environment: Mysql, Spring MVC

```
docker run --name demo-mysql -e MYSQL_ROOT_PASSWORD=password -e MYSQL_DATABASE=demo -e MYSQL_USER=demo_user -e MYSQL_PASSWORD=demo_pass -d mysql:5.6
```

Verify using: `docker logs demo-mysql`

```
docker run -p 8080:8080 --name demo-app --link demo-mysql:mysql -d jiwhiz/spring-boot-docker-mysql
```

Lab Exercises

- Create lightweight linux container (use alpine image)
- Start the container created in above step
- Create nginx container & start it
- Check logs of nginx container
- Run mysql container in the background
- Run Spring boot app by linking to mysql docker container

Module 3: Provisioning Docker Images

- Introducing the Dockerfile
- Creating a Dockerfile
- Building images manually
- Storing and retrieving Docker Images from Docker Hub
- Building images using Continuous Integration tools
- Inspecting a Dockerfile from DockerHub
- Lab Exercises

Introducing the Dockerfile

A `Dockerfile` is a text document that contains all the commands a user could call on the command line to assemble an image.

Example
$ cat /git/dockers/training-aug0506/02-containers/python/Dockerfile

```
FROM python:2.7-slim
WORKDIR /app
ADD app.py /app
ADD requirements.txt /app
RUN pip install --trusted-host pypi.python.org -r requirements.txt
EXPOSE 80
ENV name world
CMD ["python","app.py"]
```

Usage

```
$ docker build .
Sending build context to Docker daemon  6.51 MB
...
```

Introducing the Dockerfile

- ENV - to set environment variables
- EXPOSE - to expose ports
- FROM - base image
- LABEL - to add metadata to image
- HEALTHCHECK - to check if container is running
- USER - to set user and group
- VOLUME - to specify mount point from external host
- WORKDIR - workdir to run any of the commands

Introducing the Dockerfile

- ARG - variable used during build time
- CMD - to provide defaults to executing container
- RUN - to execute commands in new layer
- COPY - Copy file,dir or remote url to image
- ADD - Copy file,dir or remote url to image
- ENTRYPOINT - to configure container as executable
- MAINTAINER - the image maintainer

RUN COPY ADD instructions create new layers in the image stack - refer layering section

Creating Dockerfile (s)

```
FROM bitnami/minideb-extras:jessie-r23
LABEL maintainer "Bitnami <containers@bitnami.com>"

# Install required system packages and dependencies
RUN install_packages libapr1 libaprutil1 libc6 libexpat1 libffi6 libgmp10 libgnutls-deb0-28 libhogweed2 libldap-2.4-2 libnettle4
libp11-kit0 libpcre3 libsasl2-2 libssl1.0.0 libtasn1-6 libuuid1 zlib1g
RUN bitnami-pkg unpack apache-2.4.29-1 --checksum
42114e87aafb1d519ab33451b6836873bca125d78ce7423c5f7f1de4a7198596
RUN ln -sf /opt/bitnami/apache/htdocs /app

COPY rootfs /

ENV APACHE_HTTPS_PORT_NUMBER="443" \
    APACHE_HTTP_PORT_NUMBER="80" \
    BITNAMI_APP_NAME="apache" \
    BITNAMI_IMAGE_VERSION="2.4.29-r1" \
    PATH="/opt/bitnami/apache/bin:$PATH"

EXPOSE 80 443

WORKDIR /app
ENTRYPOINT ["/app-entrypoint.sh"]
CMD ["nami","start","--foreground","apache"]
```

Dockerfile - Example

```
FROM jenkinsci/jenkins:latest
LABEL maintainer "r1co@post-box.cc"

USER root

# install docker cli
RUN mkdir -p /tmp/_install && cd /tmp/_install && wget https://get.docker.com/builds/Linux/x86_64/docker-latest.tgz  && tar -xvzf docker-latest.tgz && cd docker && cp docker /usr/bin/docker && rm -rf  /tmp/_install
RUN chmod +x /usr/bin/docker
# add jenkins to docker group
RUN groupadd -g 999 docker
RUN usermod -a -G docker jenkins
# install docker-compose
RUN curl -L https://github.com/docker/compose/releases/download/1.7.1/docker-compose-`uname -s`-`uname -m` > /usr/local/bin/docker-compose
RUN chmod +x /usr/local/bin/docker-compose
USER jenkins
```

Dockerfile - Example

```
FROM openjdk:8-jre-alpine

MAINTAINER rajesh@unigps.in

COPY target/track.unigps.in.jar app.jar

ENTRYPOINT ["/usr/bin/java", "-Djava.security.egd=file:/dev/./urandom", "-Djasypt.encryptor.password=",
"-Dsecurity.oauth2.client.clientId=", "-Dsecurity.oauth2.client.clientSecret=", "-Daws.accessKeyId=",
"-Daws.secretKey=",  "-jar","app.jar"]
```

```
docker run --log-opt max-size=20m --log-opt max-file=5 --link mysql:mysql -itd -p 8082:80 --name ui --restart always  -v /tmp/unigps:/tmp/unigps/
-e JAVA_OPTS='-Xms1g' -e java.security.egd=file:/dev/./urandom  -e spring.profiles.active=dev  -e
spring.datasource.url=jdbc:mysql://mysql:3306/gts  -e java.security.egd=file:/dev/./urandom  -e server.port=80
unigps/track.unigps.in:2019.05.001.RELEASE
```

Build Image manually

Build an image from a Dockerfile

Usage

```
docker build [OPTIONS] PATH | URL | -
```

Options

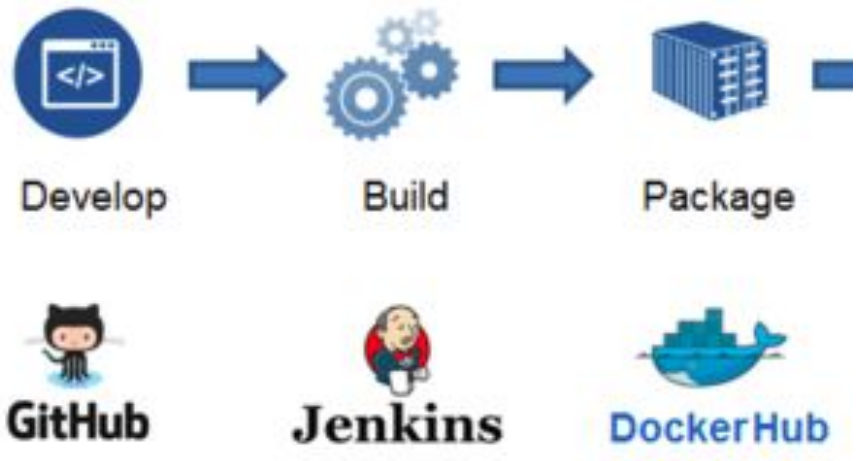
```
--build-arg set build variables
--compress compress the build context using gzip
--file name of the Dockerfile
--label set metadata for image
--rm remove intermediate containers post build
--tag name and optionally tag in the name:tag format
--ulimit options
...
```

Docker Hub - store & retrieve

https://hub.docker.com (register and create login)

- docker tag alpine rajeshgheware/alpine:rajesh
- docker push rajeshgheware/alpine:rajesh
- docker pull rajeshgheware/alpine:rajesh

Build Image using CI / Jenkins




```
docker run -d -v jenkins_home:/var/jenkins_home -p 8080:8080 -p 50000:50000 jenkins/jenkins:lts
```

Build Image - CI (Maven)

```
<profile>
	<id>docker</id>
	<build>
		<plugins>
			<plugin>
				<groupId>com.spotify</groupId>
				<artifactId>dockerfile-maven-plugin</artifactId>
				<version>1.3.6</version>
				<executions>
					<execution>
						<id>default</id>
						<goals>
							<goal>build</goal>
							<goal>push</goal>
						</goals>
					</execution>
				</executions>
				<configuration>
					<repository>${docker.image.prefix}/${project.artifactId}</repository>
					<tag>${project.version}</tag>
					<buildArgs>
						<JAR_FILE>target/${project.build.finalName}.jar</JAR_FILE>
					</buildArgs>
				</configuration>
			</plugin>
		</plugins>
	</build>
</profile>
```

Dockerfile - Docker Hub

https://hub.docker.com/u/bitnami/

https://hub.docker.com/u/springio/

https://hub.docker.com/r/sebp/elk/~/dockerfile/

Lab Exercises

Node JS App

- Create simple nodejs app to print caller address and node hostname
- Create Dockerfile by tagging the image to match your docker ID
- Run the container & verify that app is working
- Push the image to your docker hub repo having image name and tag properly
- Build this nodejs app using containerized CI - Jenkins (r1co/jenkins-docker, Use jenkins file)
- Verify CI deploys docker images to you docker hub repo
- Modify nodejs app treating the change as version 2 changes
- Verify that CI picks up the change creates next version of docker image and deploys to docker hub
- Tag the code as v3.0 and push the tag to github and observe the docker hub repo for the image corresponding to this tag

SSH Server

- Create Dockerfile to build ssh server image based on Ubuntu

Module 4: Diving deeper - Dockerfile

- Dockerfile and Layers
- The Build cache
- The ENTRYPOINT Instruction
- The CMD Instruction Docker
- The ENV Instruction
- Volumes and the VOLUME Instruction
- Building a Web Server Container
- Lab Exercises

Dockerfile & Layers

```
ubuntu@ip-172-31-31-236:~$ docker images springio/*
REPOSITORY                      TAG                 IMAGE ID            CREATED             SIZE
springio/gs-spring-boot-docker  latest              3a7a85f42b64        6 months ago        181MB

ubuntu@ip-172-31-31-236:~$ docker history 3a7a85f42b64
IMAGE               CREATED             CREATED BY                                      SIZE                COMMENT
3a7a85f42b64        6 months ago        /bin/sh -c #(nop)  ENTRYPOINT ["sh" "-c" "...   0B
<missing>           6 months ago        /bin/sh -c #(nop)  ENV JAVA_OPTS=               0B
<missing>           6 months ago        /bin/sh -c #(nop) ADD file:2f6c6463d5fd2c4...   14.4MB
<missing>           6 months ago        /bin/sh -c #(nop)  VOLUME [/tmp]                0B
<missing>           6 months ago        /bin/sh -c apk add --no-cache --virtual=bu...   156MB
<missing>           6 months ago        /bin/sh -c #(nop)  ENV JAVA_VERSION=8 JAVA...   0B
<missing>           7 months ago        /bin/sh -c #(nop)  ENV LANG=C.UTF-8             0B
<missing>           7 months ago        /bin/sh -c ALPINE_GLIBC_BASE_URL="https://...   6.7MB
<missing>           7 months ago        /bin/sh -c #(nop)  CMD ["/bin/sh"]              0B
<missing>           7 months ago        /bin/sh -c #(nop) ADD file:4583e12bf5caec4...   3.97MB
```

Dockerfile & Layers

```
FROM openjdk:8-jdk-alpine
VOLUME /tmp
ARG JAR_FILE
ADD ${JAR_FILE} app.jar
ENTRYPOINT ["java","-Djava.security.egd=file:/dev/./urandom","-jar","/app.jar"]
```

Dockerfile & Layers

```
deepti@deepti-Gazelle:~/git/dockers/test$ docker images bankmonitor/*
REPOSITORY                TAG                 IMAGE ID            CREATED             SIZE
bankmonitor/spring-boot   latest              3d89dd22e68b        10 hours ago        739MB

deepti@deepti-Gazelle:~/git/dockers/test$ docker history 3d89dd22e68b
IMAGE               CREATED             CREATED BY                                      SIZE                COMMENT
3d89dd22e68b        10 hours ago        /bin/sh -c #(nop)  CMD ["/bin/sh" "-c" "java…   0B
<missing>           10 hours ago        /bin/sh -c #(nop)  ONBUILD COPY app.jar /app…   0B
<missing>           10 hours ago        /bin/sh -c #(nop)  EXPOSE 8080/tcp              0B
<missing>           10 hours ago        /bin/sh -c #(nop) WORKDIR /app                  0B
<missing>           10 hours ago        /bin/sh -c dpkg-reconfigure -f noninteractiv…   1.83MB
<missing>           10 hours ago        /bin/sh -c ln -snf /usr/share/zoneinfo/$TZ /…   51B
<missing>           10 hours ago        /bin/sh -c #(nop)  ENV TZ=Europe/Budapest       0B
<missing>           10 hours ago        /bin/sh -c #(nop)  ENV SPRING_PROFILES_ACTIV…   0B
<missing>           10 hours ago        /bin/sh -c #(nop)  ENV TIME_ZONE=Europe/Buda…   0B
<missing>           10 hours ago        /bin/sh -c #(nop)  ENV PATH=/usr/local/sbin:…   0B
<missing>           10 hours ago        /bin/sh -c #(nop)  ENV JAVA_OPTS=               0B
<missing>           10 hours ago        /bin/sh -c #(nop)  ENV JAVA_HOME=/usr/lib/jv…   0B
<missing>           10 hours ago        /bin/sh -c #(nop)  MAINTAINER István Földház…   0B
<missing>           7 weeks ago         /bin/sh -c /var/lib/dpkg/info/ca-certificate…   394kB
<missing>           7 weeks ago         /bin/sh -c set -ex;   if [ ! -d /usr/share/m…   461MB
<missing>           7 weeks ago         /bin/sh -c #(nop)  ENV CA_CERTIFICATES_JAVA_…   0B
<missing>           7 weeks ago         /bin/sh -c #(nop)  ENV JAVA_DEBIAN_VERSION=8…   0B
<missing>           7 weeks ago         /bin/sh -c #(nop)  ENV JAVA_VERSION=8u151       0B
<missing>           7 weeks ago         /bin/sh -c #(nop)  ENV JAVA_HOME=/docker-jav…   0B
<missing>           7 weeks ago         /bin/sh -c ln -svT "/usr/lib/jvm/java-8-open…   33B
<missing>           7 weeks ago         /bin/sh -c {   echo '#!/bin/sh';   echo 'set…   87B
<missing>           7 weeks ago         /bin/sh -c #(nop)  ENV LANG=C.UTF-8             0B
<missing>           7 weeks ago         /bin/sh -c apt-get update && apt-get install…   2.21MB
<missing>           7 weeks ago         /bin/sh -c apt-get update && apt-get install…   142MB
<missing>           7 weeks ago         /bin/sh -c set -ex;  if ! command -v gpg > /…   7.8MB
<missing>           7 weeks ago         /bin/sh -c apt-get update && apt-get install…   23.8MB
<missing>           7 weeks ago         /bin/sh -c #(nop)  CMD ["bash"]                 0B
<missing>           7 weeks ago         /bin/sh -c #(nop) ADD file:eb2519421c9794ccc…   100MB
```

Dockerfile & Layers

```
FROM openjdk:8-jdk
MAINTAINER István Földházi <istvan.foldhazi@gmail.com>

ENV JAVA_HOME             /usr/lib/jvm/java-8-openjdk-amd64
ENV JAVA_OPTS             ""
ENV PATH                  $PATH:$JAVA_HOME/bin

ENV TIME_ZONE             Europe/Budapest
ENV SPRING_PROFILES_ACTIVE test

ENV TZ=$TIME_ZONE
RUN ln -snf /usr/share/zoneinfo/$TZ /etc/localtime && echo $TZ > /etc/timezone
RUN dpkg-reconfigure -f noninteractive tzdata

WORKDIR /app

EXPOSE 8080

ONBUILD COPY app.war /app/app.war

CMD ["/bin/sh", "-c", "java $JAVA_OPTS -jar /app/app.war --spring.profiles.active=$SPRING_PROFILES_ACTIVE"]
```

/bin/sh -c set -ex; if [! -d /usr/share/man/man1]; then mkdir -p /usr/share/man/man1; fi; apt-get update; apt-get install -y openjdk-8-jdk="$JAVA_DEBIAN_VERSION" ca-certificates-java="$CA_CERTIFICATES_JAVA_VERSION" ; rm -rf /var/lib/apt/lists/*; ["$(readlink -f "$JAVA_HOME")" = "$(docker-java-home)"]; update-alternatives --get-selections | awk -v home="$(readlink -f "$JAVA_HOME")" 'index($3, home) == 1 { $2 = "manual"; print | "update-alternatives --set-selections" }'; update-alternatives --query java | grep -q 'Status: manual' 461MB

Build Cache

Why Layers & Cache?

- To identify similar portions of content by componentizing image
- To avoid downloading similar content thus reduce network traffic
- To build images faster by reusing parts which were created earlier

The ENTRYPOINT instruction

To configure a container that will run as an executable

Two forms:

- `ENTRYPOINT ["executable", "param1", "param2"]` (*exec* form, preferred)
- `ENTRYPOINT command param1 param2` (*shell* form)

Notes:

- Container run arguments will be appended to the above
- Override using docker run --entrypoint flag
- Last ENTRYPOINT will have effect
- CMD / Container run arguments will make executable NOT receive UNIX signal like SIGTERM (when run in shell form)
- Shell form ignores CMD / docker run arguments

Examples:

- `ENTRYPOINT ["top", "-b"]`
- `ENTRYPOINT ["/usr/sbin/apache2ctl", "-D", "FOREGROUND"]`
- `ENTRYPOINT [ "sh", "-c", "echo $HOME" ]`
- `ENTRYPOINT exec top -b`

The CMD instruction

To provide defaults for an executing container

Three forms:

- `CMD ["executable","param1","param2"]` (*exec* form, this is the preferred form)
- `CMD ["param1","param2"]` (as *default parameters to ENTRYPOINT*)
- `CMD command param1 param2` (*shell* form)

Notes:

- Only the last CMD taken into account per Dockerfile
- If executable not specified, then ENTRYPOINT must
- Differs from RUN as RUN is executed at container build time and results committed to image
- No shell is used for non-shell form so do not use env variable in non-shell form
- Container run arguments override CMD arguments

Examples:

- CMD ["python", "manage.py", "runserver", "0.0.0.0:8000"]
- CMD ["rails", "server"]
- CMD npm start
- CMD ["mvn", "clean", "install", "-D skip.unit.tests=true"]
- CMD /usr/sbin/sshd -D
- CMD ["bash", "-c", "(while true; do echo '.'; sleep 60; done) & tox"]
- CMD ["java", "Main"]
- CMD [`"sh", "-c", "echo $HOME"`]

ENTRYPOINT & CMD

	No ENTRYPOINT	ENTRYPOINT exec_entry p1_entry	ENTRYPOINT ["exec_entry", "p1_entry"]
No CMD	*error, not allowed*	/bin/sh -c exec_entry p1_entry	exec_entry p1_entry
CMD ["exec_cmd", "p1_cmd"]	exec_cmd p1_cmd	/bin/sh -c exec_entry p1_entry	exec_entry p1_entry exec_cmd p1_cmd
CMD ["p1_cmd", "p2_cmd"]	p1_cmd p2_cmd	/bin/sh -c exec_entry p1_entry	exec_entry p1_entry p1_cmd p2_cmd
CMD exec_cmd p1_cmd	/bin/sh -c exec_cmd p1_cmd	/bin/sh -c exec_entry p1_entry	exec_entry p1_entry /bin/sh -c exec_cmd p1_cmd

The ENV instruction

To set environment variable <key> to the <value>

Two forms:

- `ENV key value`
- `ENV key=value`

Notes:

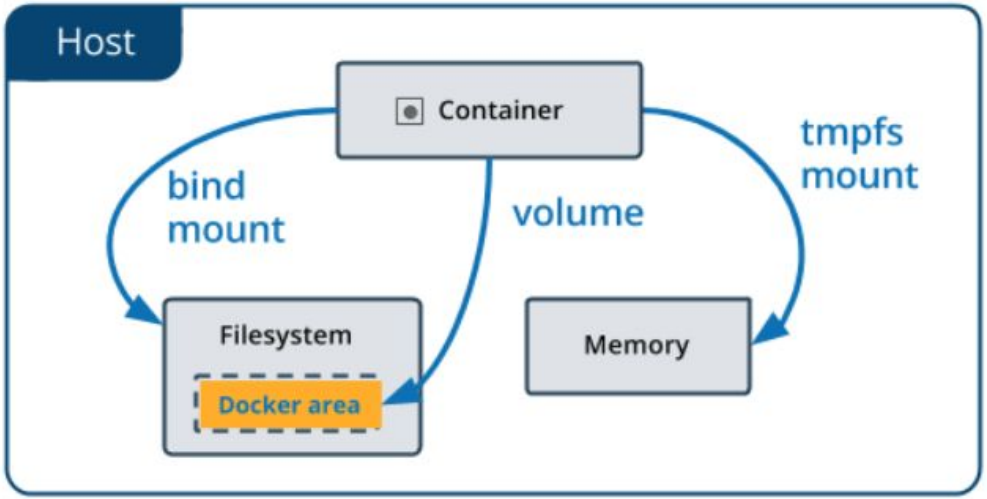
- Override using docker run --env flag
- Extremely useful in planning & executing deployments

Examples:

- `ENV myName=rajesh g`
- `ENV org unigps`
- `ENV CN IN`
- `ENV environment dev uat`
- `ENV myName="rajesh g" org=unigps CN=IN`
- `ENV REST_ARCHIVE=rust-1.21.0-x86_64-unknown-linux-gnu.tar.gz`
- `ENV REST_DOWNLOAD_URL=https://static.rust-lang.org/dist/$RUST_ARCHIVE`
- `ENV PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/root/.cargo/bin"`
- `JENKINS_HOME="/data/jenkins"`

The VOLUME - Data Persistence

Storage of persistence data generated by managed by Docker containers



Commands:

- `docker volume create my-vol`
- `docker volume ls`
- `docker volume inspect my-vol`
- `docker volume rm my-vol`

VOLUME - Examples

Examples (volume): Persist data in a container's writeable layer

- `docker run -d --name devtest --mount source=/app,target=/app nginx:latest`
- `docker service create -d --replicas 4 --mount source=/app,target=/app nginx:latest`

Examples (bind volume): a file or directory on the *host machine* is mounted into a container. Performant but not-reliable

- `docker run -d -it --name devtest --mount type=bind,source="$(pwd)"/target,target=/app \`
  `Nginx:latest`
- `docker run -d -it --name devtest --mount type=bind,source="$(pwd)"/target,target=/app,readonly \`
  `nginx:latest`

Examples (tmfs volume): For temporary sensitive data to be kept only in memory

- `docker run -d -it --name tmptest --mount type=tmpfs,destination=/app nginx:latest`

VOLUME - preferred way

- Volumes are easier to back up or migrate than bind mounts.
- You can manage volumes using Docker CLI commands or the Docker API.
- Volumes work on both Linux and Windows containers.
- Volumes can be more safely shared among multiple containers.
- Volume drivers allow you to store volumes on remote hosts or cloud providers, to encrypt the contents of volumes, or to add other functionality.
- A new volume’s contents can be pre-populated by a container.

Building a web server container

Steps

- Find lightweight tomcat image
- Create spring MVC project
- Build project to obtain the WAR artifact
- Write Dockerfile
- Build dockerfile
- Run docker container (tomcat container)

Lab Exercises

WAR App Image build

- Build dockerfile to run tomcat container
- Build simple web app and create WAR artifact
- Update Dockerfile to include WAR
- Build image for the web war app
- Run container and verify its output
- Use Dockerized CI Jenkins to build image and deploy it on docker hub

Optimize Image

- Write optimized Dockerfile to reduce image size to run node app
- Ref: https://hub.docker.com/r/training/webapp/~/dockerfile/ (138MB to less than half size)

Module 5: Working with Registry

- Overview
- Creating a Public repo on Docker Hub
- Using our Public repo on Docker Hub
- Using a Private Registry
- Docker Enterprise
- Lab Exercises

Overview - Registry

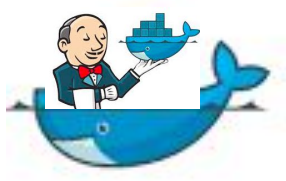
Registry

Stateless, highly scalable server side application that stores and lets you distribute Docker images.

When to use

- tightly control where your images are being stored
- fully own your images distribution pipeline
- integrate image storage and distribution tightly into your in-house development workflow

Dockerizing dev workflow




```
docker run -d -p 5002:8080 -e REG1=http://localhost:5000/v2/  atcol/docker-registry-ui
docker run -d -v jenkins_home:/var/jenkins_home -p 8080:8080 -p 50000:50000 jenkins/jenkins:lts
```

Registry Server

- With no docker volume (uses default volume for container)
  - `docker run -d -p 5000:5000 --name registry registry:2`
  - `docker push localhost:5000/rajeshgheware/alpine:registry`
  - `Docker pull localhost:5000/rajeshgheware/alpine:registry`
- With docker volume
  - `docker volume create docker_registry`
  - `docker run -d -p 5000:5000 -v docker_registry:/var/lib/registry --name registry registry:2`
  - `docker container stop registry && docker container rm -v registry`
- With Volume Mount on Host
  - `docker run -d -p 5000:5000 -v /media/deepti/Ubuntu/home/docker_registry:/var/lib/registry --name registry registry:2`

Mount host FS

Case One

```
docker container run -ti -v /tmp:/data alpine sh
```

Case Two

```
docker container run -d -p 80:80 -v /home/deepti/indiagovsite:/usr/share/nginx/html nginx
```

Docker Enterprise

Capabilities	Community Edition	Enterprise Edition Basic	Enterprise Edition Standard	Enterprise Edition Advanced
Container engine and built in orchestration, networking, security	✓	✓	✓	✓
Certified infrastructure, plugins and ISV containers		✓	✓	✓
Image management			✓	✓
Container app management			✓	✓
Image security scanning				✓

Lab Exercises

- Create local registry server
- Create registry server and bind it docker volume
- Create registry server and bind it to volume pointing to host location
- Tag and push an image to registry server created in last step
- Stop & remove registry server and check if the image content are found in host mount
- Create Spring Boot Rest App (https://github.com/rajeshgheware/rest-service)
- Build docker using Dockerized Jenkins and deploy docker image to local registry server

Module 6: Docker Networking

- Overview
- The docker0 Bridge
- User Defined Network
- Exposing Ports
- Viewing Exposed Ports
- Linking Containers
- Lab Exercises

Overview - Networking

Defines how containers communicate with external world, amongst cluster members etc

Two types of networks:

- Default
- Custom Defined

Default:

- Bridge - docker0 (docker created default network) Configurable
- Host - container on host network stack Not configurable
- None - container specific network stack (no network interface) Not configurable

Custom Defined Network: User specific network rules using underlying iptables

Notes:

- Change container network(s) on the fly
- First non internal network is the main external connectivity interface

The docker0 bridge

- Containers default network is docker0
- Container inter-connectivity using IP addresses (no name resolution)
- For name resolution, legacy --link feature available for limited period
- Change default bridge to none using --network flag or daemon.json server config

User Defined Network

To control which containers can communicate with each other

Automatic DNS resolution of container names to IP addresses (DNS 127.0.0.11)

Create unlimited networks

Types

- Bridge Network
- Overlay Network
- MACVLAN Network

User Defined Network - bridge

bridge

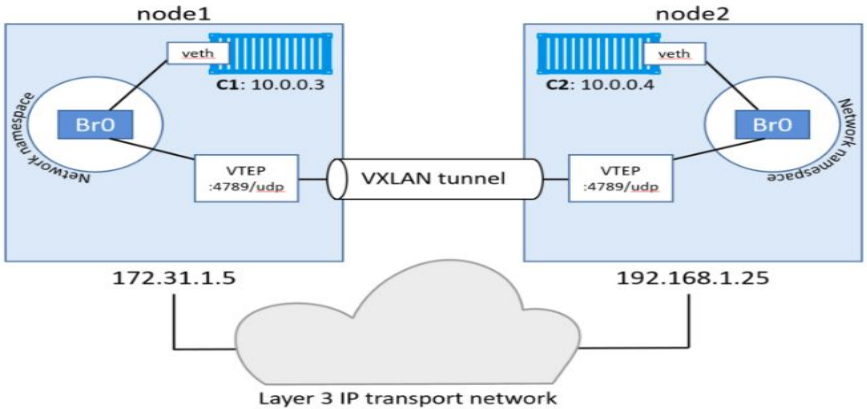
- Most common type of network in Docker world
- No linking feature
- Good for small network

docker_gwbridge

- Docker created network for communication among swarm nodes
- Provides external connectivity when none of the networks provide

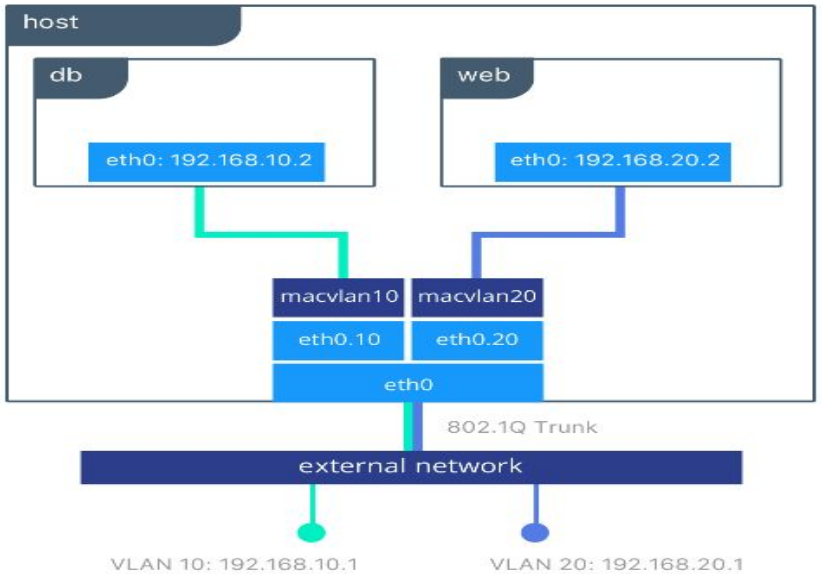
Overlay Network

- Scope is swarm mode
- Provided to service tasks in swarm cluster
- Only for swarm nodes and not for standalone containers else require key-value store (Zookeeper, Consul etc)
- Uses NAT and port mapping (iptables)



MACVLAN Network

- Provides better control over IPv4 and IPv6 addressing
- Extremely lightweight & highly performant
- Attached to Docker Host directly
- Stricter dependency between localhost and external network
- Does not use linux bridge or port mapping
- Scope is outside swarm



Test Setup - 1

Test Setup:

Create custom network n1

- docker network create n1

Create two busybox containers attached to n1

- docker run -itd --name c1 --network n1 busybox
- docker run -itd --name c2 --network n1 busybox

Tests

- Log into c1 and ping c2 (should succeed)
  - docker exec -it c1 sh
  - ping -c3 c2
- Log into c2 and ping c1 (should succeed)
  - docker exec -it c2 sh
  - ping -c3 c1

Test Setup - 2

Prerequisites: Test Setup -1

Test Setup:
Remove network from both containers c1 & c2

- docker network disconnect n1 c1
- docker network disconnect n1 c2

Tests:

- Login into c1 and ping c2 (should fail)
  - docker exec -it c1 sh
  - ping -c3 c2
- Login into c1 and ping google.com (should fail)
  - docker exec -it c1 sh
  - ping -c3 google.com
- Run ifconfig on c1 to see interfaces (should see only loopback interface)
  - docker exec -it c1 sh
  - ifconfig
- Do the same on c2 (results should be similar)

Test Setup - 3

Test Setup:

- Create four networks n1, n2, n3, n4
  - docker network n1
  - docker network n2
  - docker network n3
  - docker network n4
- Create four containers c1 (n1), c2 (n2), c3 (n3), c4 (n4) associated with denoted network
  - docker run -itd --name c1 --network n1 busybox
  - docker run -itd --name c2 --network n2 busybox
  - docker run -itd --name c3 --network n3 busybox
  - docker run -itd --name c4 --network n4 busybox
- Create n23 network and connect c2 and c3 with it
- docker network n23
- docker network connect n23 c2
- docker network connect n23 c3

Tests:

- Login into c2 and ping c3 (should succeed)
  - docker exec -it c2 sh
  - ping c3
- Login into c3 and ping c4 (should fail)
  - docker exec -it c3 sh
  - ping c4

Test Setup - 4

Test Setup:

- Create container c5 with host network
  docker run -itd --name c5 --network host busybox

Tests:

- Run ifconfig on c5 as well as docker host (networks listed should be same)
  - docker run exec -it c5 sh
  - ifconfig
- Disconnect c5 from host (operation should fail)
  - docker network disconnect host c5

Test Setup - 5 (Overlay)

- docker swarm init (aws ec2)
- docker swarm join …. (current laptop)
- docker network create -d overlay laboverlay (ec2)
- docker service create --name test --network laboverlay --replicas 2 ubuntu sleep infinity (inspect network on ec2)
- docker exec -it 396c8b142a85 bash
- (ec2 and install iputils-ping - apt-get update && apt-get install iputils-ping and ping / traceroute vm2)
    - apt-get install openssh-server net-tools && service restart ssh

Lab Exercises

- Create a docker container (busybox)
- Inspect the network connected
- Create custom network of type bridge
- Without stopping container, change the network to custom network bridge
- Create two custom networks (isolated_nw and isolated_nw2) of type bridge
- Create two containers (busybox) - one having network_nw and another having isolated_nw2 and verify if they can communicate among themselves

Module 7 - Troubleshooting

- Docker Daemon Logging
- Container Logging
- Planning Image Builds
- Intermediate Images
- The docker0 Bridge
- Lab Exercises

Logging

- docker logs <container name>
- daemon.json

```
{
  "log-driver": "json-file",
  "log-opts": {
    "labels": "production_status",
    "env": "os,customer"
  }
}
```

- docker inspect <container>
- docker run -it --log-opt mode=non-blocking --log-opt max-buffer-size=4m alpine ping 127.0.0.1
- Log Drivers: syslog, json-file, journald, fluentd, splunk, gcplogs etc (docker logs command)

Troubleshooting - Common issues

Error checking TLS connection: Error checking and/or regenerating the certs: There was an error validating certificates for host "192.168.99.100:2376": dial tcp 192.168.99.100:2376: i/o timeout

`Fix: docker-machine regenerate-certs default`

Network timed out while trying to connect to https://index.docker.io/v1/repositories/library/hello-world/images. You may want to check your internet connection or if you are behind a proxy.

`FIX: Configure HTTPS_PROXY`

General Commands: docker inspect <docker object>

Lab Exercises

Problem to Solve:

http://localhost:9000 should show the nginx web server output

Setup:

Run docker container nginx using custom network

Module 9 Deploying applications

- Spring Boot App
- Angular / NodeJS App
- Automated builds (Jenkins CI / CD)
- Deploy JMS server
- Cassandra cluster
- Lab Exercises

Deployment

Objective: To set up various app services

- Create spring boot app, build docker and run it
- Setup local docker hub on docker
- Setup CI on docker and build boot and deploy on docker hub OR use maven to build and deploy docker
- Setup & run dockerized Cassandra (Optional)

Dockerization steps

- docker run --name demo-mysql -e MYSQL_ROOT_PASSWORD=password -e MYSQL_DATABASE=demo -e MYSQL_USER=demo_user -e MYSQL_PASSWORD=demo_pass -d mysql:5.6

- docker run -p 8080:8080 -e spring.profiles.active=prod -e spring.datasource.url=jdbc:mysql://mysql:3306/demo -e spring.datasource.username=demo_user -e spring.datasource.password=demo_pass --link demo-mysql:mysql --name spa -itd -v logs:/logs rajeshgheware/spa-sboot-docker:1.3.0

- docker run -p 5601:5601 -p 9200:9200 -p 5044:5044 -e ES_HEAP_SIZE="2g" -e LS_HEAP_SIZE="1g" --name elk -v /tmp/elastic_search:/var/lib/elasticsearch/nodes -v /tmp/elastic_search/logs:/logs -itd sebp/elk (requires to set sudo sysctl -w vm.max_map_count=262144)

Logstash config for java

```
root@0c415fec6fb4:/etc/logstash/conf.d# cat logstash-spring.conf
input {
  stdin {}
  file {
    path =>  [ "/logs/spa-boot-docker/server-rolling.log" ]
  }
}
filter {
   multiline {
      pattern => "^(%{TIMESTAMP_ISO8601})"
      negate => true
      what => "previous"
   }
   grok {
      # Do multiline matching with (?m) as the above mutliline filter may add newlines to the log messages.
      match => [ "message", "(?m)^%{TIMESTAMP_ISO8601:logtime}%{SPACE}%{LOGLEVEL:loglevel}
%{SPACE}%{NUMBER:pid}%{SPACE}%{SYSLOG5424SD:threadname}%{SPACE}---%{SPACE}%{JAVACLASSSHORT:classname}%{SPACE}:%{SPA
CE}%{GREEDYDATA:logmessage}" ]
   }
}
output {
  elasticsearch { host => "localhost" }
```

Restart logstash agent:

Lab Exercise

Objective: To set up various app services

- Create spring boot app & run it
- Setup local docker hub on docker
- Setup CI on docker and build boot and deploy on docker hub OR use maven docker
- Setup & run dockerized Cassandra (Optional)

Module 10: Docker Swarm

- Intro
- Architecture
- Features & Use Cases Example
- Lab Exercises

Intro

Swarm - a group of machines that are running docker and joined a cluster.

Swarm Manager - Executes docker commands onto a cluster

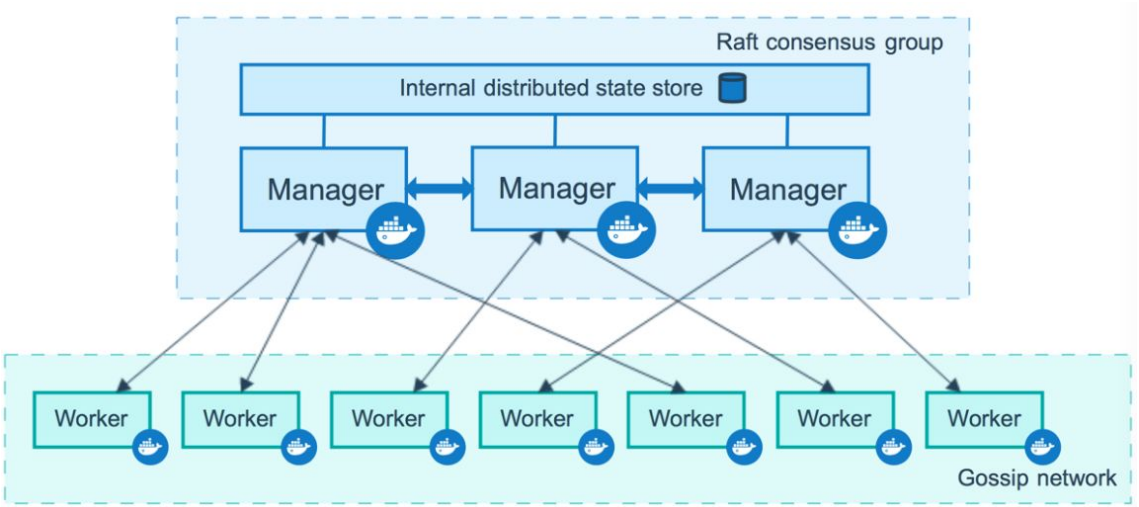
Swarm worker - provide execution capacity by letting docker containers run on it

NOTES:

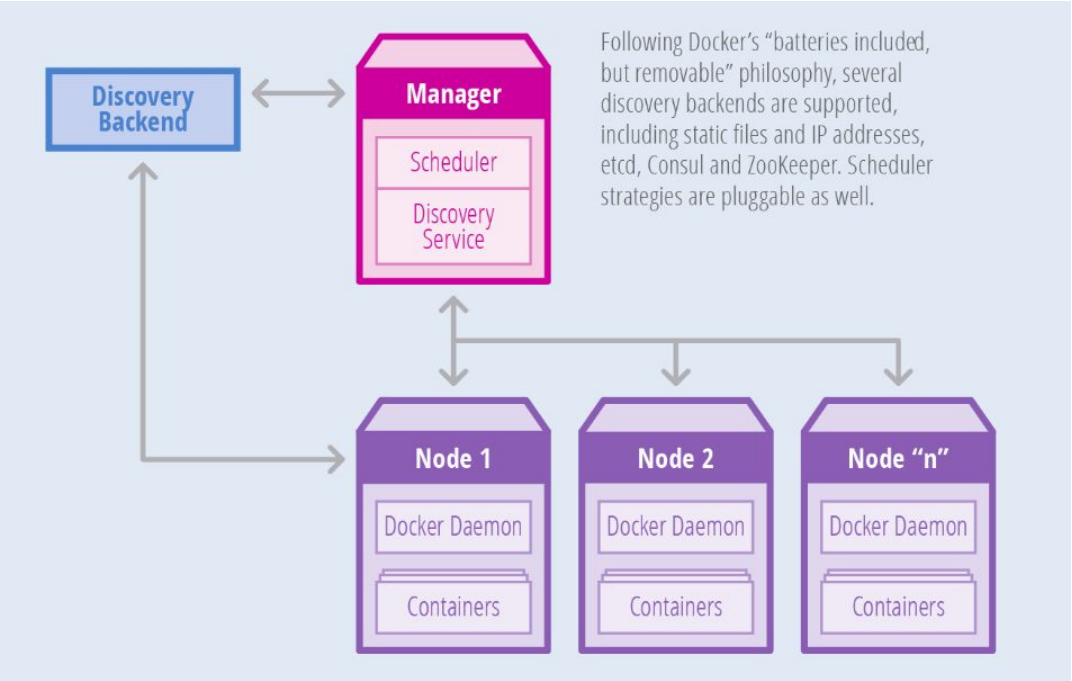
- Machines can be virtual / physical
- Machines also known as nodes

Deployment Strategy: Global or Least utilized node

Swarm Architecture

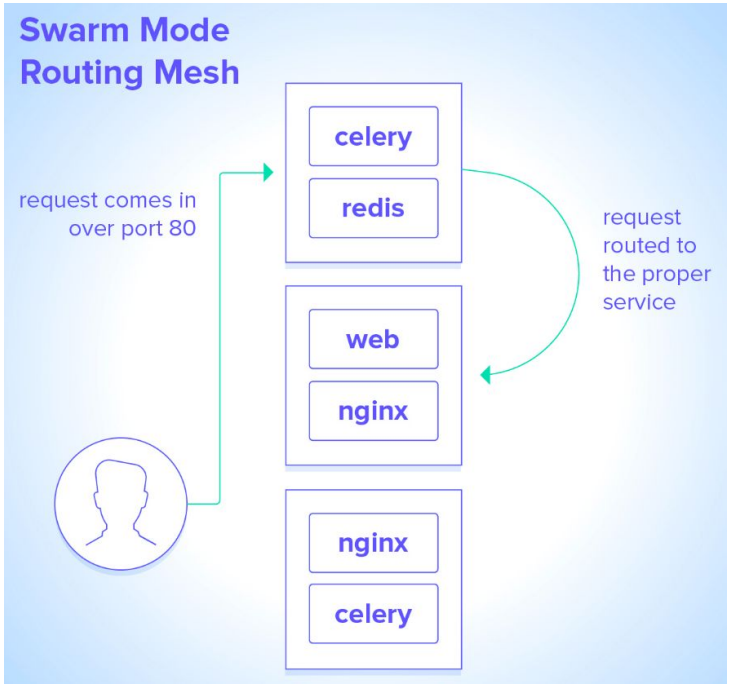


Manager & Node

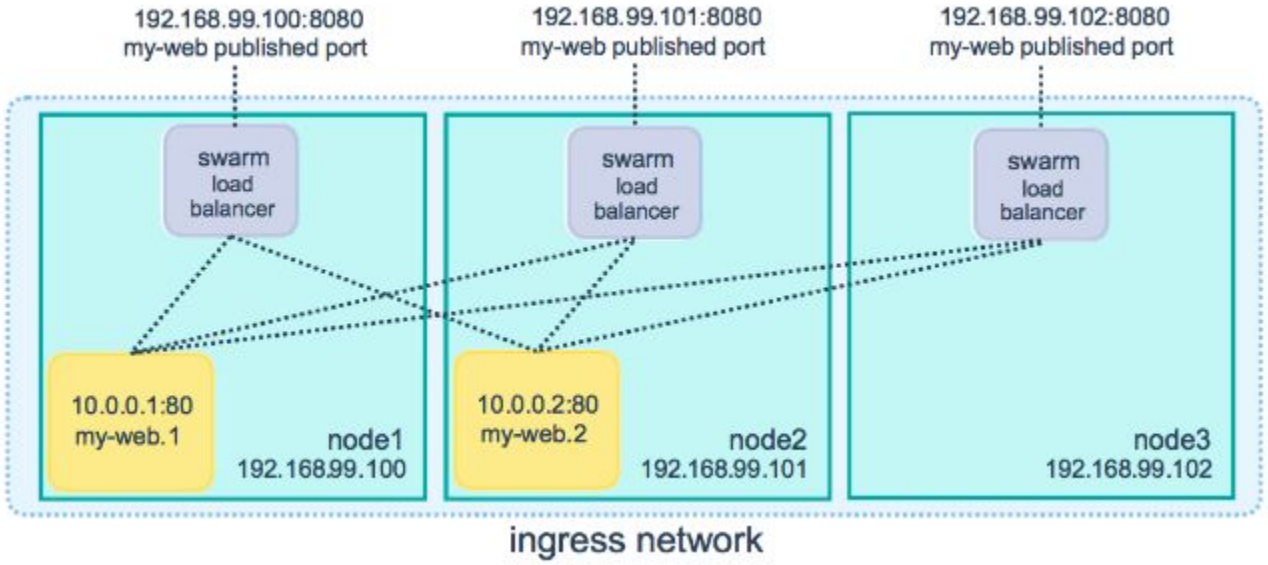


Docker Stack

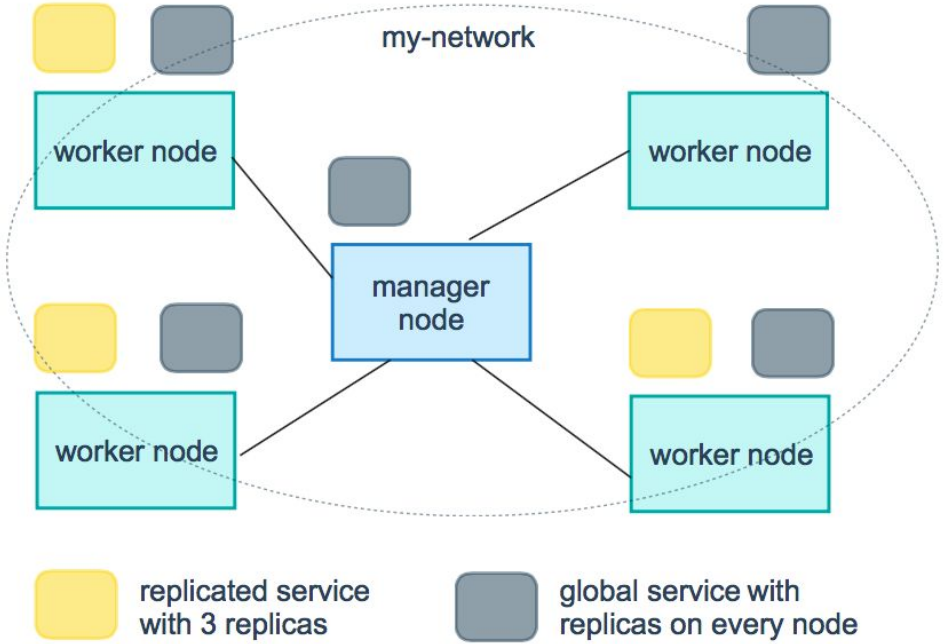
Docker Stack - Mesh Routing



Docker Stack - Routing



Swarm - Replication



Swarm #1 simple web app

docker-compose.yml

```yaml
version: "3"
services:
  web:
    # replace username/repo:tag with your name and image details
    image: tutum/hello-world:latest
    deploy:
      replicas: 5
      resources:
        limits:
          cpus: "0.1"
          memory: 50M
      restart_policy:
        condition: on-failure
    ports:
      - "80:80"
    networks:
      - webnet
networks:
  webnet:
```

```
docker stack deploy -c docker-compose.yml www
```

Getting started with Swarm

Create Virtual machines (vm1, vm2, vm3) and run below on vm1

```
docker@vm1:~$ docker swarm init --advertise-addr 10.0.2.15
Swarm initialized: current node (ilm7z6h3hv0r6d78yta6h5qgw) is now a manager.

To add a worker to this swarm, run the following command:

    docker swarm join --token SWMTKN-1-504fkskwcd4j06zkuxkj1ht8yoyrjgxvzxqeokg3fugz77w0f1-1fc2o737voph6bkaphfzlw4bx
10.0.2.15:2377

To add a manager to this swarm, run 'docker swarm join-token manager' and follow the instructions.
```

On vm2, run below

```
docker swarm join --token SWMTKN-1-54qhvaba3wf8dyvqswucwnvger1j9skyolbxehoitb7gara94k-czg4trgwfz9ap7gbx0t16k2j8
192.168.99.100:2377
```

On vm3, run below

```
docker swarm join --token SWMTKN-1-54qhvaba3wf8dyvqswucwnvger1j9skyolbxehoitb7gara94k-czg4trgwfz9ap7gbx0t16k2j8
192.168.99.100:2377
```

On vm1, run below

```
docker node ls
ID                            HOSTNAME            STATUS              AVAILABILITY        MANAGER STATUS
o2z5738o02aw5d4xe9xu628ag *   vm1                 Ready               Active              Leader
szd0o96rkcfrpczci1clqju46     vm2                 Ready               Active
x459ato12y2tfpdookk3sq806     vm3                 Ready               Active
```

Some commands

```
docker stack ls                                            # List stacks or apps
docker stack deploy -c <composefile> <appname>  # Run the specified Compose file
docker service ls                 # List running services associated with an app
docker service ps <service>                  # List tasks associated with an app
docker inspect <task or container>                   # Inspect task or container
docker container ls -q                                      # List container IDs
docker stack rm <appname>                             # Tear down an application
docker swarm leave --force      # Take down a single node swarm from the manager
```

```
eval $(docker-machine env myvm1)
```

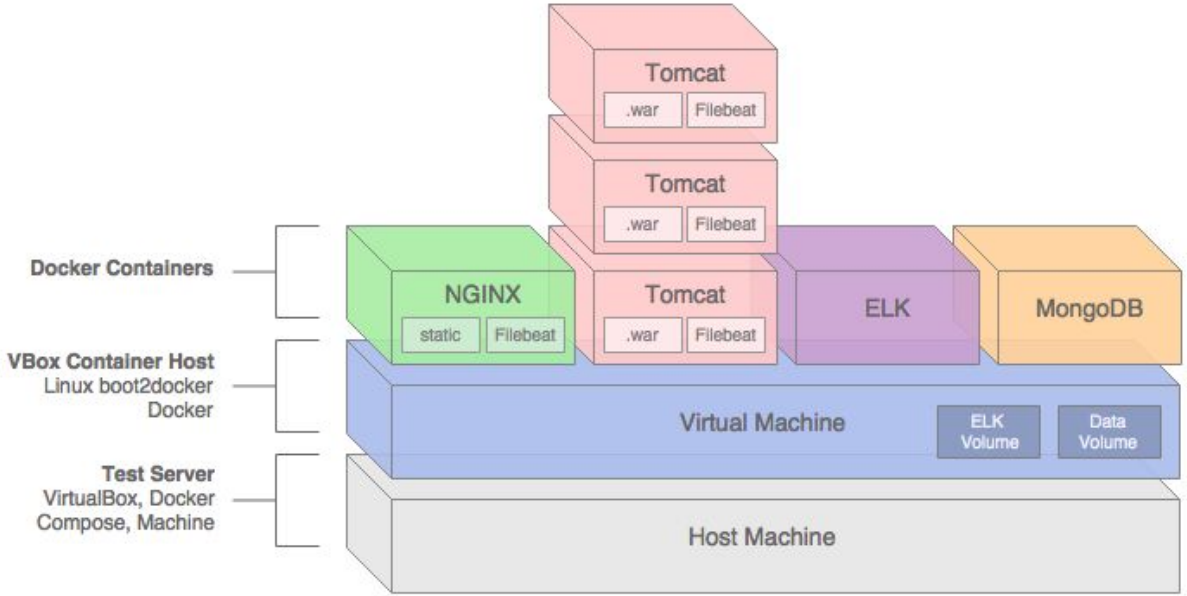
Swarm #2 CMS (wordpress & mysql)

```
version: '3'

services:
   db:
     image: mysql:5.7
     volumes:
       - db_data:/var/lib/mysql
     restart: always
     environment:
       MYSQL_ROOT_PASSWORD: somewordpress
       MYSQL_DATABASE: wordpress
       MYSQL_USER: wordpress
       MYSQL_PASSWORD: wordpress

   wordpress:
     depends_on:
       - db
     image: wordpress:latest
     ports:
       - "8000:80"
     restart: always
     environment:
       WORDPRESS_DB_HOST: db:3306
       WORDPRESS_DB_USER: wordpress
       WORDPRESS_DB_PASSWORD: wordpress
volumes:
    db_data:
```

Swarm #3 ELK stack

```
version: '2'
services:
 app:
   build: .
   ports:
     - "8080:8080"
   links:
     - logstash
 elasticsearch:
   build: elk/elasticsearch/
   container_name: elasticsearch
   ports:
     - "9200:9200"
     - "9300:9300"
   environment:
     ES_JAVA_OPTS: "-Xms1g -Xmx1g"
 logstash:
   build: elk/logstash/
   container_name: logstash
   command: -f /etc/logstash/conf.d/
   volumes:
     - ./elk/logstash/config:/etc/logstash/conf.d
   ports:
     - "9999:9999"
   links:
     - elasticsearch
 kibana:
   build: elk/kibana/
   container_name: kibana
   volumes:
     - ./elk/kibana/config/:/opt/kibana/config/
   ports:
     - "5601:5601"
   links:
     - elasticsearch
```

Example - Spring Music App



Example - Spring Music App

```
version: '2'
services:
 proxy:
   build: nginx/
   ports:
   - 80:80
   networks:
   - net
   depends_on:
   - app
   hostname: proxy
   container_name: proxy
 app:
   build: tomcat/
   ports:
   - 8080
   networks:
   - net
   depends_on:
   - mongodb
   hostname: app
 mongodb:
   build: mongodb/
   ports:
   - 27017:27017
   networks:
   - net
   depends_on:
   - elk
   hostname: mongodb
   container_name: mongodb
   volumes:
   - music_data:/data/db
   - music_data:/data/configdb
 elk:
   image: sebp/elk:latest
   ports:
   - 5601:5601
   - 9200:9200
   - 5044:5044
   - 5000:5000
   networks:
   - net
   volumes:
   - music_elk:/var/lib/elasticsearch
   hostname: elk
   container_name: elk


volumes:
 music_data:
   external: true
 music_elk:
   external: true


networks:
 net:
   driver: bridge
```

Example - Voting app stack

```
version: "3"
services:
 redis:
   image: redis:alpine
   ports:
     - "6379"
   networks:
     - frontend
   deploy:
     replicas: 1
     update_config:
       parallelism: 2
       delay: 10s
     restart_policy:
       condition: on-failure
 db:
   image: postgres:9.4
   volumes:
     - db-data:/var/lib/postgresql/data
   networks:
     - backend
   deploy:
     placement:
       constraints: [node.role == manager]
```

```
vote:
  image: dockersamples/examplevotingapp_vote:before
  ports:
    - 5000:80
  networks:
    - frontend
  depends_on:
    - redis
  deploy:
    replicas: 2
    update_config:
      parallelism: 2
    restart_policy:
      condition: on-failure
result:
  image: dockersamples/examplevotingapp_result:before
  ports:
    - 5001:80
  networks:
    - backend
  depends_on:
    - db
  deploy:
    replicas: 1
    update_config:
      parallelism: 2
      delay: 10s
    restart_policy:
      condition: on-failure
```

```
 worker:
   image: dockersamples/examplevotingapp_worker
   networks:
     - frontend
     - backend
   deploy:
     mode: replicated
     replicas: 1
     labels: [APP=VOTING]
     restart_policy:
       condition: on-failure
       delay: 10s
       max_attempts: 3
       window: 120s
     placement:
       constraints: [node.role == manager]
 visualizer:
   image: dockersamples/visualizer:stable
   ports:
     - "8080:8080"
   stop_grace_period: 1m30s
   volumes:
     - "/var/run/docker.sock:/var/run/docker.sock"
   deploy:
     placement:
       constraints: [node.role == manager]
networks:
 frontend:
 backend:
volumes:
 db-data:
```

Example - Multi Managers (Visualize node)

```
version: "3"
services:
  web:
    image: username/repo:tag
    deploy:
      replicas: 5
      restart_policy:
        condition: on-failure
      resources:
        limits:
          cpus: "0.1"
          memory: 50M
    ports:
      - "80:80"
    networks:
      - webnet
  visualizer:
    image: dockersamples/visualizer:stable
    ports:
      - "8080:8080"
    volumes:
      -
"/var/run/docker.sock:/var/run/docker.sock"
    deploy:
      placement:
        constraints: [node.role == manager]
    networks:
      - webnet
networks:
  webnet:
```

Lab Exercise

EX 01: **Web cluster**

- Create a cluster of 3 nodes
- Launch cluster of web app (use tutum/hello-world)
- Set replica to 5
- Verify that web app is seen on all nodes
- Change replica to 2 in compose file and redeploy
- docker stack deploy --prune -c docker-compose.yml
- Verify that web app is running on two nodes only
- Verify that you can access the web app on remaining node (though app is not running on that node)

EX 02: App Cluster

App Components:

- Spring boot
- MySQL
- ELK

Write docker-compose.yml for the app comprising of above elements and launch the cluster

K8S - Docker - VMWare

	Docker	Kubernetes
Scheduling Unit	Container	Pod
Scaling	Service	ReplicaSet
Rolling Updates	Service	Deployment
Load Balancer, DNS	Service	Service
Cluster Manager	Swarm	Deployment

Thank You for your active participation!

Please join gheWARE cluster

(community of brainlets sharing brainware to help upgrade each other)

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