



# **Cross-organizational distributed systems and Clouds**

Solution for Exercise 5

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## Answers to questions

### Lesson 1: Concept of Containers

#### Question: Containers, LXC and Docker

*What architectural implications are required for an application to run in containers?*

- Service-oriented: Containerized applications work best when implementing a service-oriented design. Service-oriented applications break the functionality of a system into discrete components that communicate with each other over well-defined interfaces. One container ideally represents a single service only.
- Application state: The containers should be stateless and store the application state somewhere outside the containers (e.g. in mounted volumes). Having stateless containers allow to horizontally scale by design, and enable a fast error fail over by re-creating failed containers.
- Configuration: Containers should ideally get their configuration at run time. Hence, the configuration should not be part of the container image but should be mapped (e.g. via environment variables) into the container at creation time.

*What are pros/cons of containers compared to virtual machines?*

Containers build on top of the host operating system and reuse its kernel as a run time environment for applications or operating systems inside the container. Virtual machines are virtualized or (partially) emulated by a hypervisor. The host operating system (or bare metal hypervisor) is fully abstracted from the guest operating system inside a virtual machine.

Since virtual machines don't share software of the host, the encapsulation of virtual machines is rather strong. Stronger encapsulation affects the security/privacy aspect. Sharing on the other side allow to reuse existing software, to reduce the run time overhead and speed up the creation process.

- Pro containers: lower overhead, faster and less disk space
- Contra containers: container cannot choose operating system / kernel
- Pro virtual machines: very secure due to encapsulation, flexibly choose guest operating system
- Contra virtual machines: overhead at runtime (two operating systems), waste of disk/memory space

#### Question: LXC Containers

*Where are more processes running: on the vm operating system or inside the container? And why?*

The vm operating system has much more processes, since the container is technically a "jail" for at least one process. If the micro-service approach is used with containers, only a single (parent) process should be running inside the container.

*How does the networking look like? Why is it a good idea to have a private IP for each containers?*

Containers typically have their own “virtualized” network. This network can be either bridged or tunneled through the host network of the operating system. The virtualized network is necessary to address containers, and to control which services of a container are accessible from the outside.

*What resources can be limited via `lxc config set [container] limits.*` command?*

Lxc uses *cgroups* to limit the resources. *cgroups* can limit all available resources by setting a soft and a hard limit. Resources may be: cpu cores, cpu usage (percent), memory usage, disk usage, disk i/o usage, network i/o usage.

### **Question: Docker and Docker Hub**

Docker:

*What are the differences between a Dockerfile and a Docker image? Can you imagine pros/cons?*

A Dockerfile is a declarative definition of how to derive a Docker image. A Docker image is a binary snapshot of the container file system. While virtual machine images contain the full file system, Docker images have layers for each command defined in the Dockerfile. Docker images hence reuse identical layers from other Docker images.

Dockerfiles are text files, and hence very simple to share and archive. Docker images can be huge BLOBs, which makes it more challenging to share and archive. While Docker images contain all necessary software already, Dockerfiles may download and install software from third party sources. Images are hence more reliably and deterministic.

*How does a typical workflow for deploying a new application component look like?*

A DevOps writes software for a new application service, and writes a Dockerfile for it. Since he is smart, he works with git. When he pushed to git, the automated continuous delivery pipeline automatically compiles a Docker image from the Dockerfile and his software. The Docker image is then pushed to an image registry.

Next, a container can be started, using the image from the image registry.

Another option would be to apply changes to a container and then using the `docker commit` command to create the image. Since this is manual work, the previous path should be preferred.

Docker Hub:

*Do you think it was useful to create an image for Apache by ourselves?*

No. Try to reuse (at least the official) images. It was just useful for educational purposes :-). Of course, take care about the origin of the image. Everybody can upload to Docker Hub, there's no guarantee for security.

*How are images in Docker Hub created and maintained?*

Images can be created either by Dockerfiles or the `docker commit` command. Most if the images are generated and updated automatically from Dockerfiles. For example the official Apache image on Docker Hub [1] is stored on Github [2] and is build with Travis [3].

[1] [https://hub.docker.com/\\_/httpd/](https://hub.docker.com/_/httpd/)

[2] <https://github.com/docker-library/httpd>

[3] <https://travis-ci.org/docker-library/httpd>

## Lesson 2: Mediawiki with Docker

### Questions: Experiences with Docker

*Practically, where do you see benefits and drawbacks in the use of virtual machines versus Docker containers?*

Docker containers are rather application component centric, virtual machines are operating system centric. Virtual machines are more flexible, when the purpose is unclear (e.g. not specified in a script or Dockerfile). Docker containers on the other hand are very lightweight and fast. While creating a new virtual machine can take up to some minutes, a Docker container is up within seconds.

*Why are the two layers "Cloud Platform" and "Virtual Resources" still necessary although we have containers? Or why are both layers not necessary when working with containers?*

A strong isolation between virtual machines is necessary to share the physical hardware with multiple users. While containers can limit resources as well, the encapsulation in virtualization is much stronger. Anyway Containers can be provided as a replacement of virtual machines in cloud middleware like OpenStack [1].

But: if the need for a simpler cloud stack arises, *Infrastructure as a Service* was probably the wrong choice. *Platform as a Service* may be better - where application components are deployed directly without thinking about the underlying infrastructure.

[1] <https://wiki.openstack.org/wiki/HypervisorSupportMatrix>

### Question: Docker distributed

*Can you find a solution to distribute Docker containers on multiple hosts?*

So called *Orchestrators* are needed. Some examples are: *Docker Swarm*, Google's *Kubernetes*, *Apache Mesos*, *Rancher*

These orchestrators schedule the containers in available resources - virtual machines or bare metal servers.

## Solution for practical part

### Mediawiki with Docker

You should have the following Docker images:

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
clouds/loadbalancer	latest	...	2 hours ago	109 MB
clouds/mediawiki	latest	...	2 hours ago	412 MB
clouds/database	latest	...	3 hours ago	280 MB
telegraf	latest	...	3 days ago	239 MB
ubuntu	14.04	...	3 days ago	188 MB
nginx	latest	...	6 days ago	109 MB
chronograf	latest	...	2 weeks ago	112 MB
influxdb	latest	...	2 weeks ago	224 MB
mariadb	5.5	...	3 weeks ago	280 MB

And you should have the following Docker containers:

ID	IMAGE	...	STATUS	PORTS	NAMES
...	telegraf	...	Up 7 seconds	...	telegraf
...	chronograf	...	Up 8 seconds	0.0.0.0:8888->8888/tcp	chronograf
...	influxdb	...	Up 9 seconds	8086/tcp	influxdb
...	clouds/loadbalancer	...	Up 19 seconds	0.0.0.0:80->80/tcp	loadbalancer
...	clouds/mediawiki	...	Up 20 seconds		web2
...	clouds/mediawiki	...	Up 20 seconds		web1
...	clouds/database	...	Up 21 seconds	3306/tcp	database

### Mediawiki with Docker Compose

To install docker compose, download the binary and make it executable:

```
sudo -s
curl -L \
  https://github.com/docker/compose/releases/download/1.13.0/docker-
compose-`uname -s`-`uname -m` \
  > /usr/local/bin/docker-compose
chmod +x /usr/local/bin/docker-compose
```

The working docker-compose.yml:

```
version: '2'
services:
  web1:
    build: Mediawiki
    image: clouds/mediawiki
  web2:
    build: Mediawiki
    image: clouds/mediawiki
  database:
    build: Database
    image: clouds/database
  loadbalancer:
    build: Loadbalancer
    image: clouds/loadbalancer
    ports:
      - 80:80
  influxdb:
    image: influxdb
  chronograf:
    image: chronograf
    ports:
      - 8888:8888
  telegraf:
    image: telegraf
    volumes:
      - /var/run/docker.sock:/var/run/docker.sock:ro
      - /sys:/rootfs/sys:ro
      - /proc:/rootfs/proc:ro
      - /etc:/rootfs/etc:ro
      - ./Monitoring/telegraf.conf:/etc/telegraf/telegraf.conf:ro
    environment:
      - HOST_PROC=/rootfs/proc
      - HOST_SYS=/rootfs/sys
      - HOST_ETC=/rootfs/etc
```

To build the containers and start the services, run those commands:

```
docker-compose build
docker-compose up
```