Compute Services

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Goals

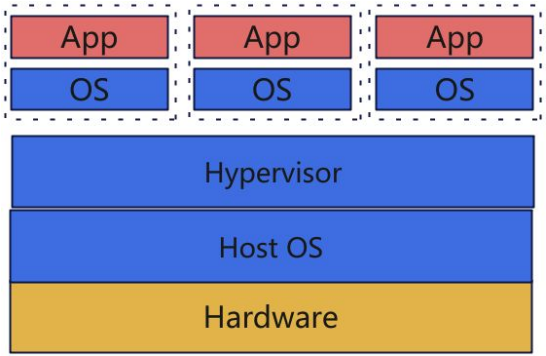
1. Bare Metals
2. Virtualization
3. **Containers**
4. Unikernels/MicroVM

Containers

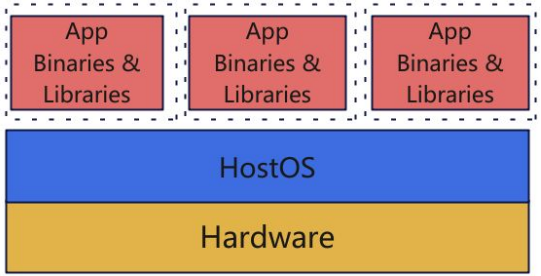
- Lightweight Virtualization
  - Represent virtualization solutions aiming at providing, vs. traditional virtual machines:
    - Lower memory footprint: 0 to a few MB per virtualized instance
    - Lower disk footprint: in the order of KBs/MBs
    - Faster boot times: in the order of micro/milliseconds
  - **Simple examples are containers and unikernels**

Containers

- **Containers: process-level sandboxing technologies**
  - Enforced by the operating system
  - **Called OS-level virtualization**



Traditionnal virtualization



Containers

Containers

- The OS restricts the visibility on system resources for a process or a set of processes
- The OS also controls hardware resource allocation/usage between such isolated processes
  - CPU cores, memory, disk/network bandwidth, etc.
- A container is much lighter than a VM
  - Per-container system memory/disk footprint close to 0
  - Boot time is that of spawning a process, i.e micro seconds
- Still containers are not an ideal form of virtualization
  - **Security issues**

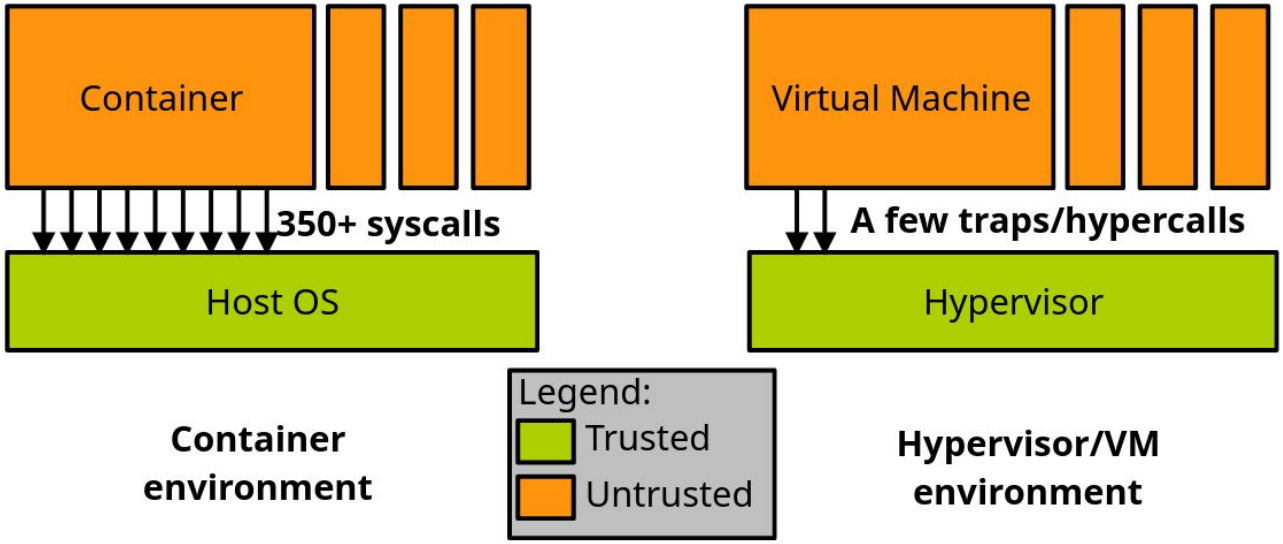
Containers

- **Uses cases**
- **Software development/testing/deployment**
  - Develop, build and test in a controlled, identical environment
  - Deploy in the same environment as the development one (repeatability)
    - Can be deployed on any server/cloud supporting containers independently of the host configuration
- **Lightweight (low cost) & elastic virtualization**
  - Containers consume few resources and can be brought up/destroyed very fast
  - Cloud services such as Gmail and Facebook make extensive use of containers
  - Function as a Service (e.g. AWS Lambda)

Containers

- **Software Development with Containers**
- **Package application programs and dependencies**
  - One of the main benefits: ease of development/testing/deployment
    - “Shipping containers”
- **Developing and running application X requires a complex set of dependencies**
  - Libraries sources and/or binaries (ex: glibc, etc.)
  - Build tools (ex: cmake, autotools, etc.)
  - System tools (ex: perl, grep, etc.)
  - All of these with sometimes very specific versions that may not be compatible with that of application Y that we also want to build & run
- **One solution would be to build and run application X and Y each in their own VM**
  - Too heavy, does not scale to a high number of apps
  - **Containers can help!**

Containers and security

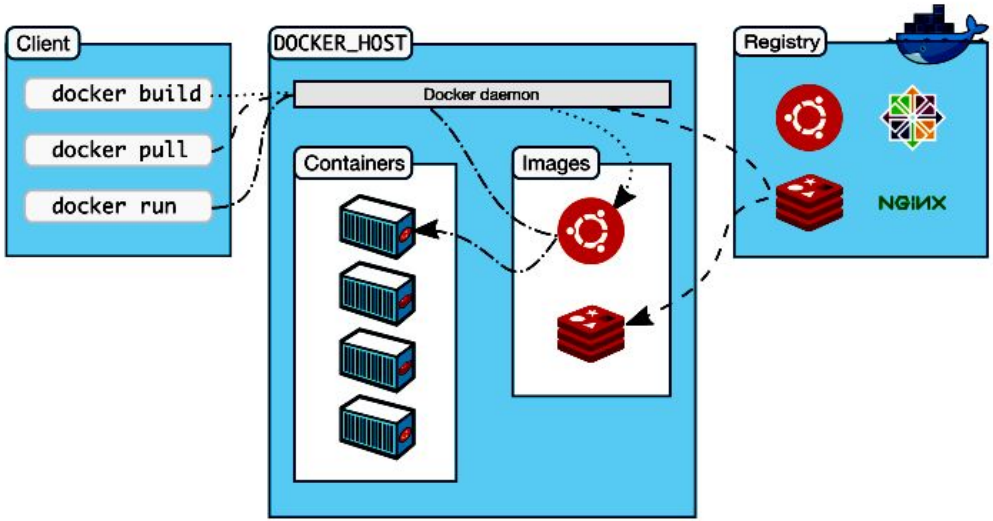


Containers and security

- The isolation enforced by a host OS between containers is not trusted to be as strong as that enforced between VMs by a hypervisor
  - Due to the size and complexity of the interface between a container and the host OS: **the system call interface**
- Attempts at securing containers:
  - Run containers within virtual machines...

Docker

- Virtualization system Allow building very light VMs (containers)
- Set of user-friendly tools for managing containers
- Client-server architecture



Docker

- **The image of a VM**
  - Docker relies on Union File System for the representation of images
  - An image is represented as a set of layers
  - Each layer describes a modification of the file system (like diff)
- **Advantages of this representation**
  - Allows building a file system
  - From a standard image
  - With small additional data (tens of Mb instead of hundreds of Mb)
  - Efficiently
- **The same set of standard images can be reused**
- **The modification of a file system does not generate a full file system (only a layer)**
  - Only diffs are saved
- **Docker allows sharing images**
  - https://hub.docker.com

Docker

- **Some basic commands**
- Installation under Linux
  - *wget -qO- https://get.docker.com/ | sh*
- Starting a container
  - *docker run -it ubuntu bash*
- Lookup the image
  - If the image is not in the local registry, download from the hub
  - Ubuntu: pre-existing image in the hub
- Build the Linux file system
- Start the container
- Configure the IP address of the container
  - Also communication between outside and the container

Docker

- List local images
- docker images

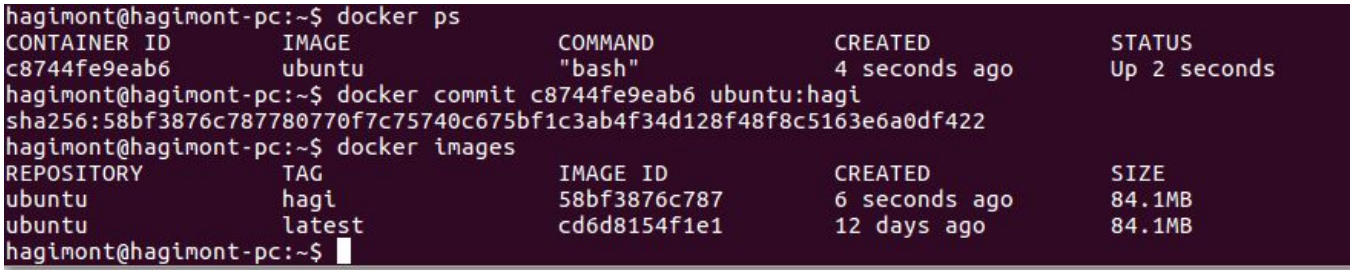
```
hagimont@hagimont-pc:~$ docker images
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
ubuntu              latest              cd6d8154f1e1        12 days ago
84.1MB
hagimont@hagimont-pc:~$
```

- Log in the hub
  - docker login/logout
- Lookup an image in the hub
  - docker search hagimont

```
hagimont@hagimont-pc:~$ docker search hagimont
NAME                      DESCRIPTION               STARS               OFFICIAL
        AUTOMATED
hagimont/docker-whale                               0

hagimont/hagi             my repo                   0

lwapet/projet_docker      ENSP - hagimont Daniel    0

hagimont@hagimont-pc:~$
```

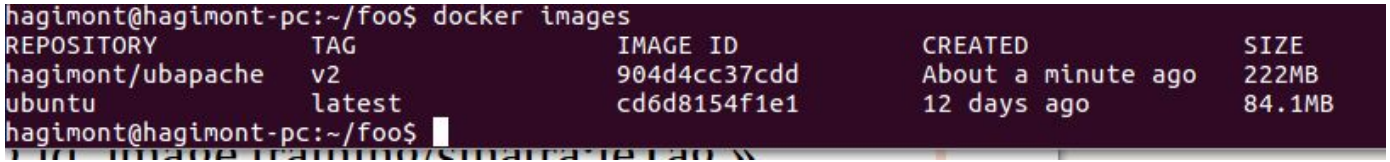
Docker

- Creation of an image
- From a container instance
  - Start the container (from an initial standard image)
  - Modify the file system (apt-get install ...)
  - Commit the instance with a new image name
    - docker commit c8744fe9eab6 ubuntu:hagi



Docker

- **Creation of an image**
- **From a Dockerfile**
  - mkdir foo
  - cd foo
  - Create a file Dockerfile
    - # This is a comment
    - FROM ubuntu
    - RUN apt-get update && apt-get install -y apache2
- *docker build -t hagimont/ubapache:v2 .*



Docker

- **Management of images in the hub**
  - You must be logged in
  - Save the image in the hub
  - *docker push hagimont/ubapache:v2*
- **Download an image from the hub**
  - *docker pull hagimont/ubapache:v2*
- **Tag an image (versioning)**
  - *docker tag id_image training/sinatra:thetag*

Docker

- **Goal of data volumes**
  - make visible in one or more containers a directory or file from the host file system
  - Allows file sharing between several containers
- **Persistent even after container destruction**
- Any modification is immediately effective
- **Command**:
  - *docker run -it -v /tmp/host_file:/tmp/container_f*
- Port redirection
- Example of link: host → container
  - *docker run -d -p 80:5000 hagimont/apache*
- Any connection on port 80 of the host is forwarded to port 5000 of the container