Nottingham Trent University

Department of Computer Science

Department of Computer Science

Use of docker for teaching Computer Sciences subjects in HE

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Outline

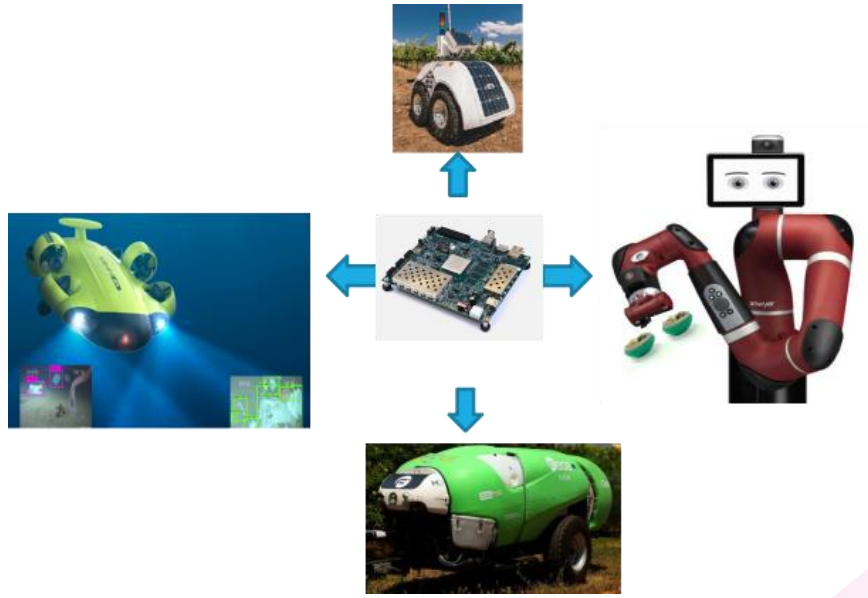
- Research interests
- Introduction to Docker
- Docker demo
- Conclusions

Research Interests

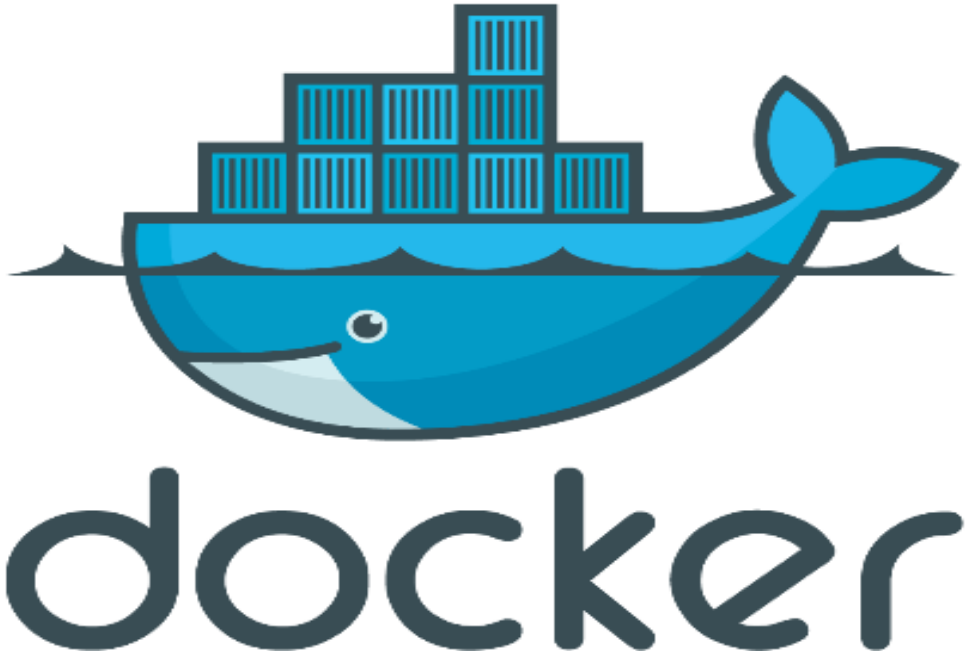
- Edge Computing
- Neuromorphic Engineering
- Robotics
- Intelligent Sensors
- Spiking Neural Networks

UPD project

IoW project



Introduction to Docker



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What is Docker ?!!!

- Open platform for developers and sysadmins to build, ship and run distributed applications
- Can run on popular 64-bit Linux distributions with kernel 3.8 or later
- Supported by several cloud platforms including Amazon EC2, Google Compute Engine, Microsoft Azure and Rackspace.

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Features….

- Light-Weight
- Minimal overhead (cpu/io/network)
- Based on Linux containers
- Uses layered filesystem to save space (AUFS/LVM)
- Uses a copy-on-write filesystem to track changes
- Portable
- Can run on any Linux system, Windows or MacOS.
- Edge devices support.
- A Docker container contains everything it needs to run
- Minimal Base OS
- Libraries and frameworks
- Application code
- A docker container can run anywhere that Docker can run.

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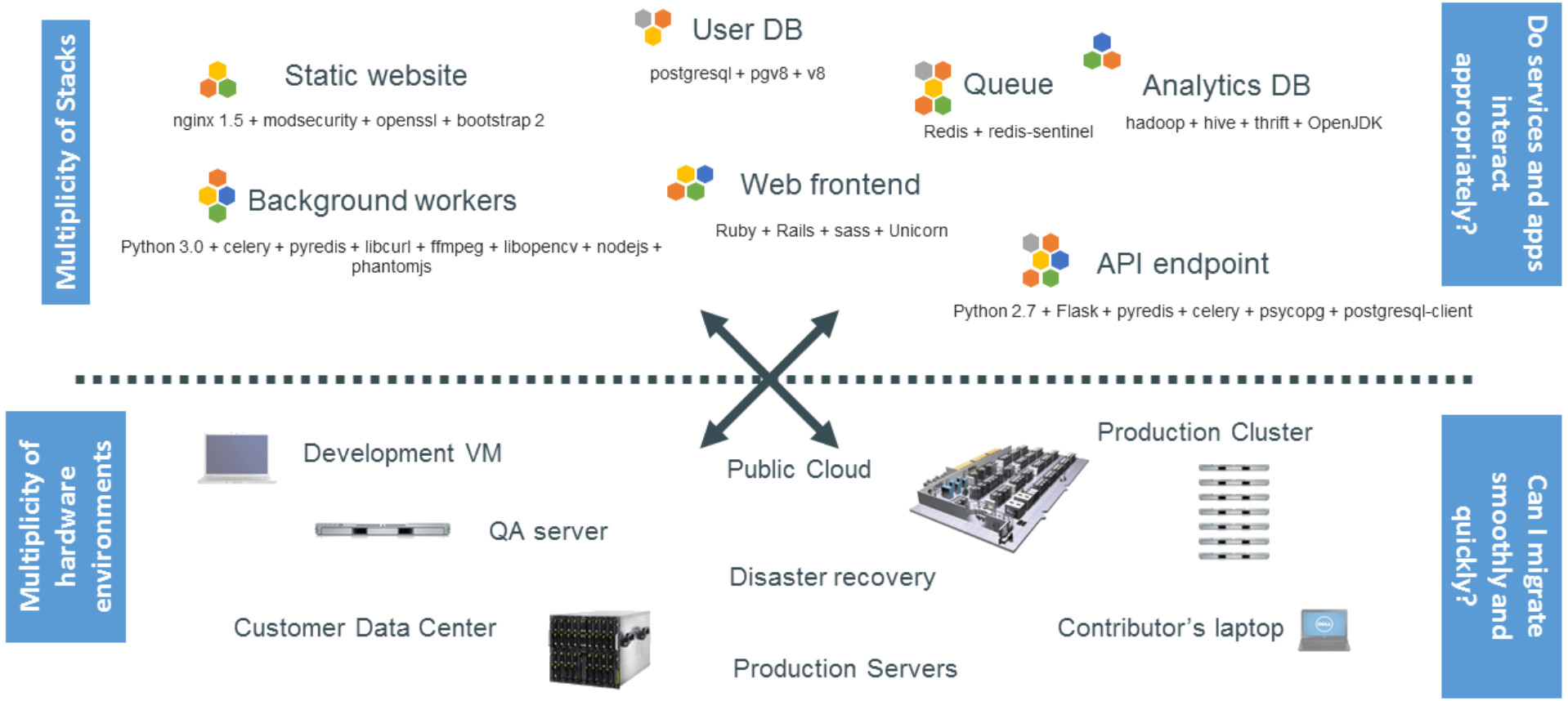
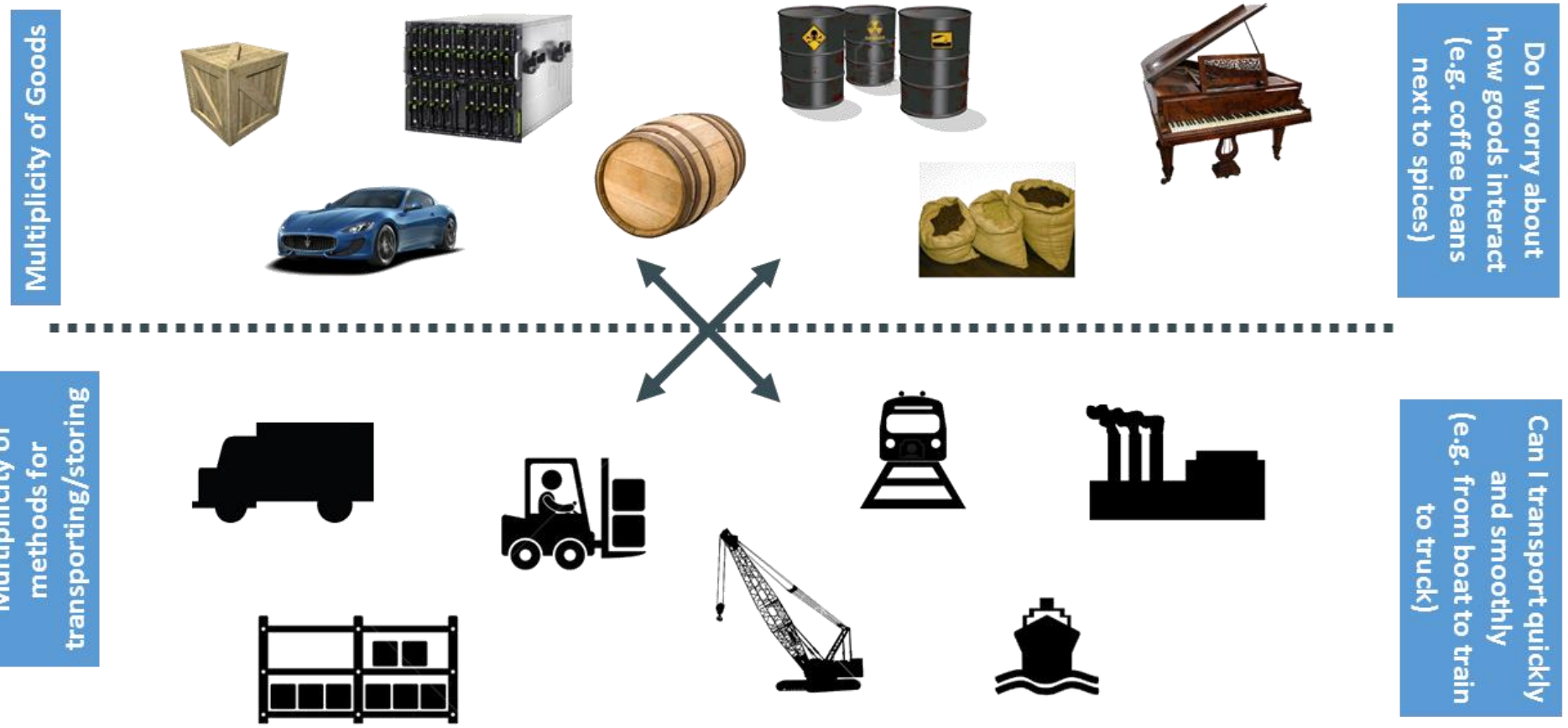
The Challenge……



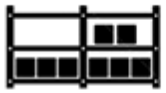
What and Where?

	Development VM	QA Server	Single Prod Server	Onsite Cluster	Public Cloud	Contributor's laptop	Customer Servers
Static website	?	?	?	?	?	?	?
Web frontend	?	?	?	?	?	?	?
Background workers	?	?	?	?	?	?	?
User DB	?	?	?	?	?	?	?
Analytics DB	?	?	?	?	?	?	?
Queue	?	?	?	?	?	?	?

Cargo Transport Pre-1960……

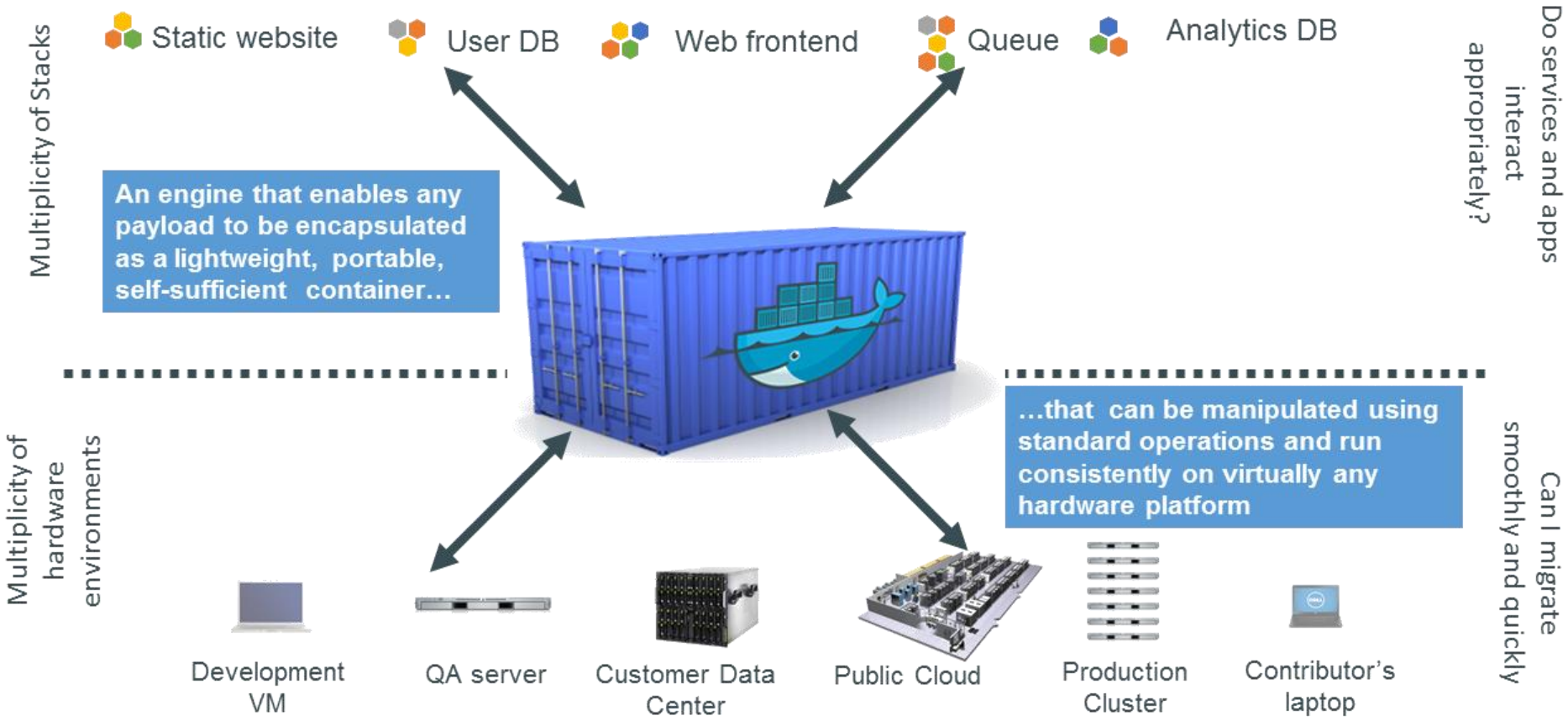


What and where?

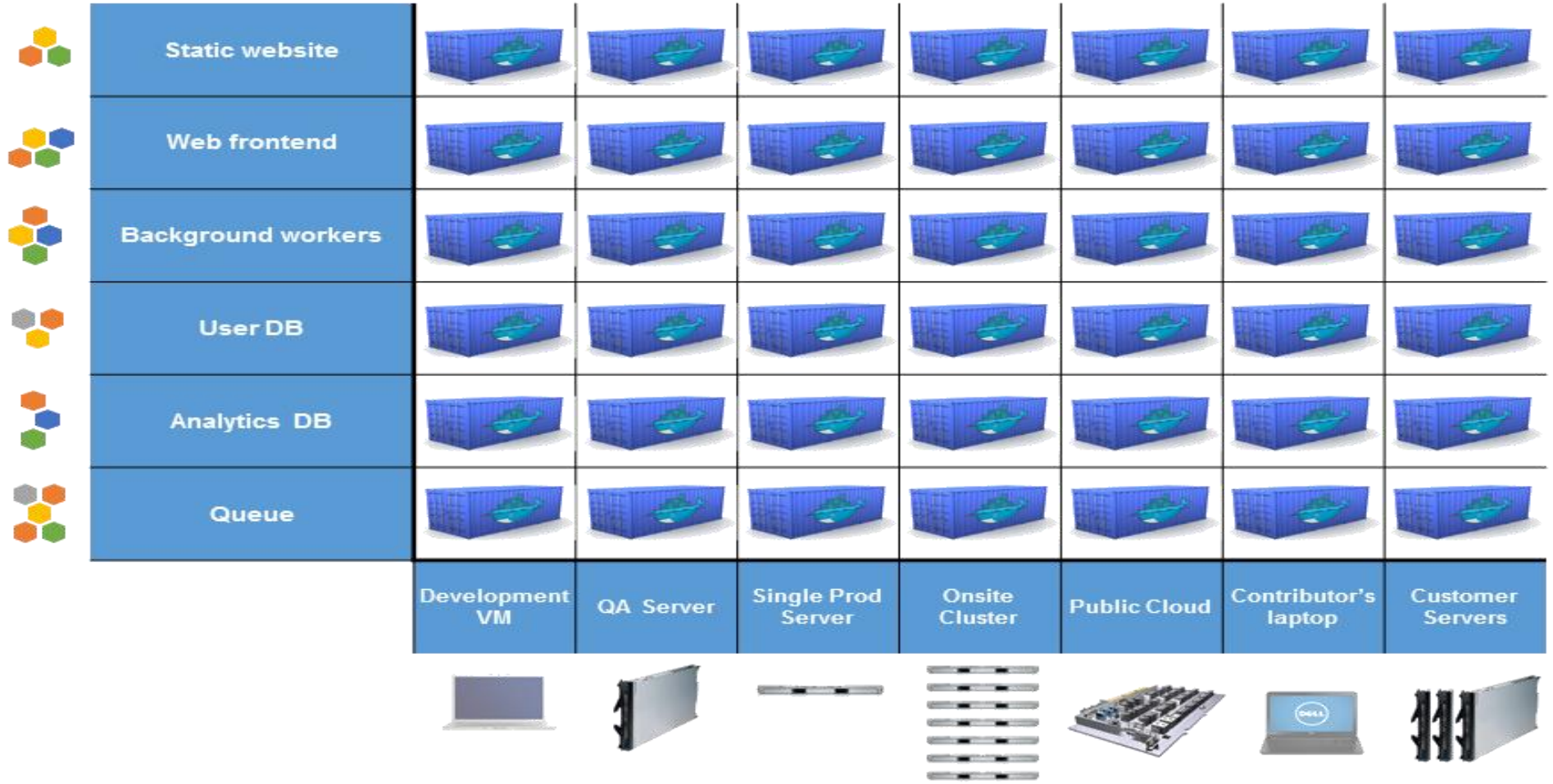
	?	?	?	?	?	?	?
	?	?	?	?	?	?	?
	?	?	?	?	?	?	?
	?	?	?	?	?	?	?
	?	?	?	?	?	?	?
	?	?	?	?	?	?	?
							

Solution: Intermodal Shipping Container

Docker is a Container System for Code……

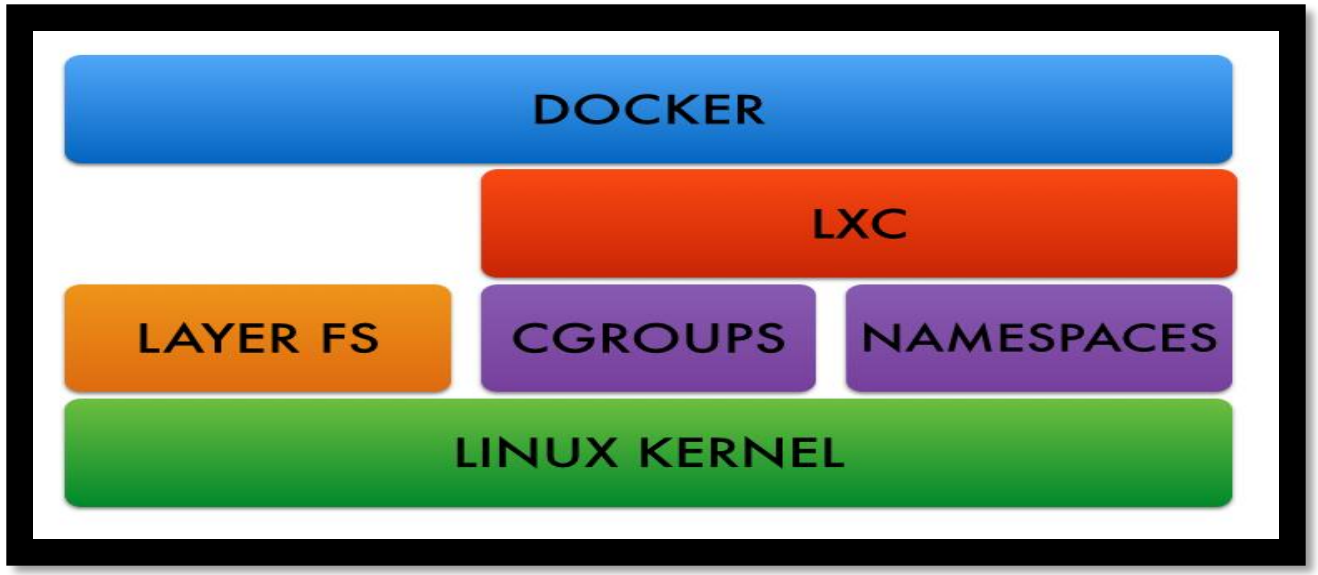


Docker provides the answer to what and where



Docker Architecture

- Docker Engine
  - CLI
  - Docker Daemon
  - Docker Registry
- Docker Hub
  - Cloud service
    - Share Applications
    - Automate workflows
    - Assemble apps from components
- Docker images
- Docker containers



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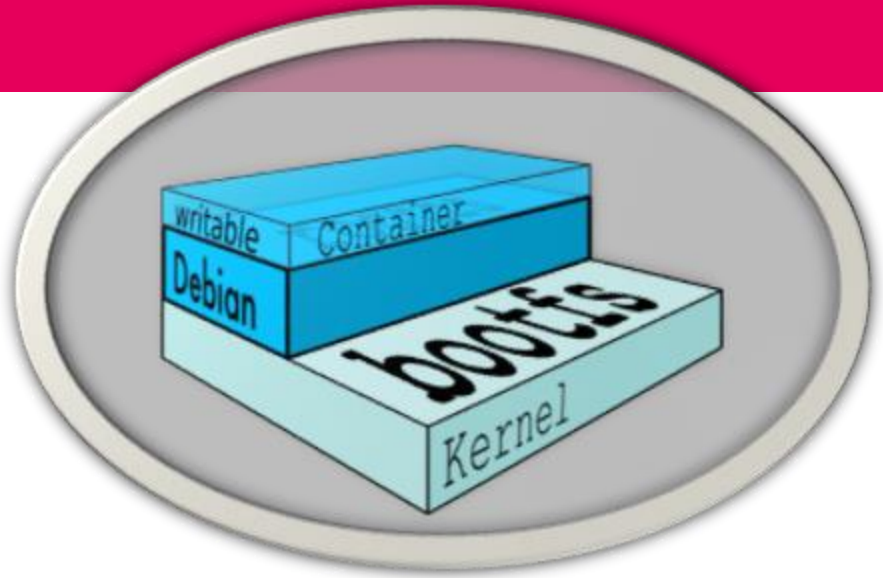
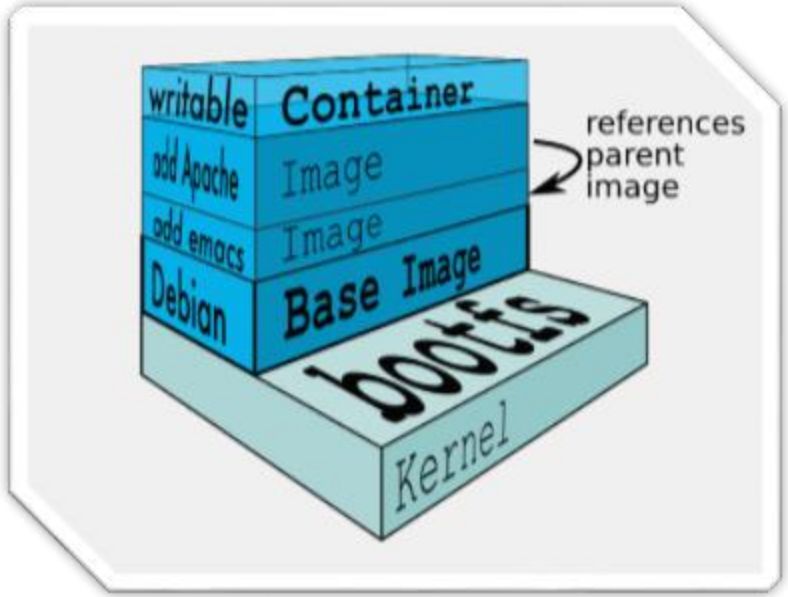
Docker images

- NOT A VHD
- NOT A FILESYSTEM
- uses a *Union File System*
- a read-only *Layer*
- do not have state
- Basically a tar file
- Has a hierarchy
    - Arbitrary depth
- Fits into the Docker Registry





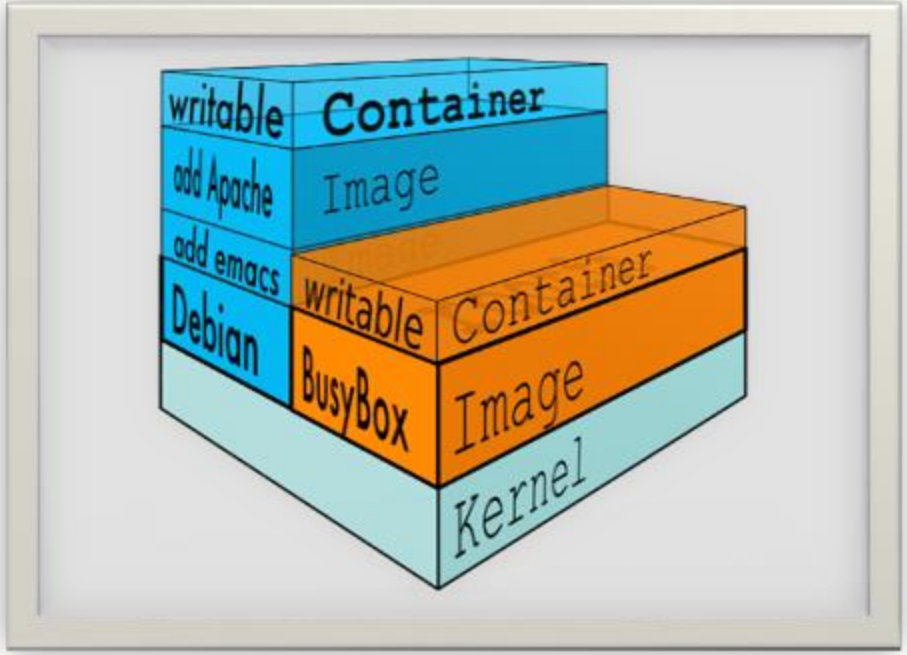
Docker Containers...

Units of software delivery (ship it!)

- run everywhere
  - regardless of kernel version
  - regardless of host distro
  - (but container and host architecture must match*)

- run anything
  - if it can run on the host, it can run in the container
  - i.e., if it can run on a Linux kernel, it can run

*Unless you emulate CPU with qemu and binfmt



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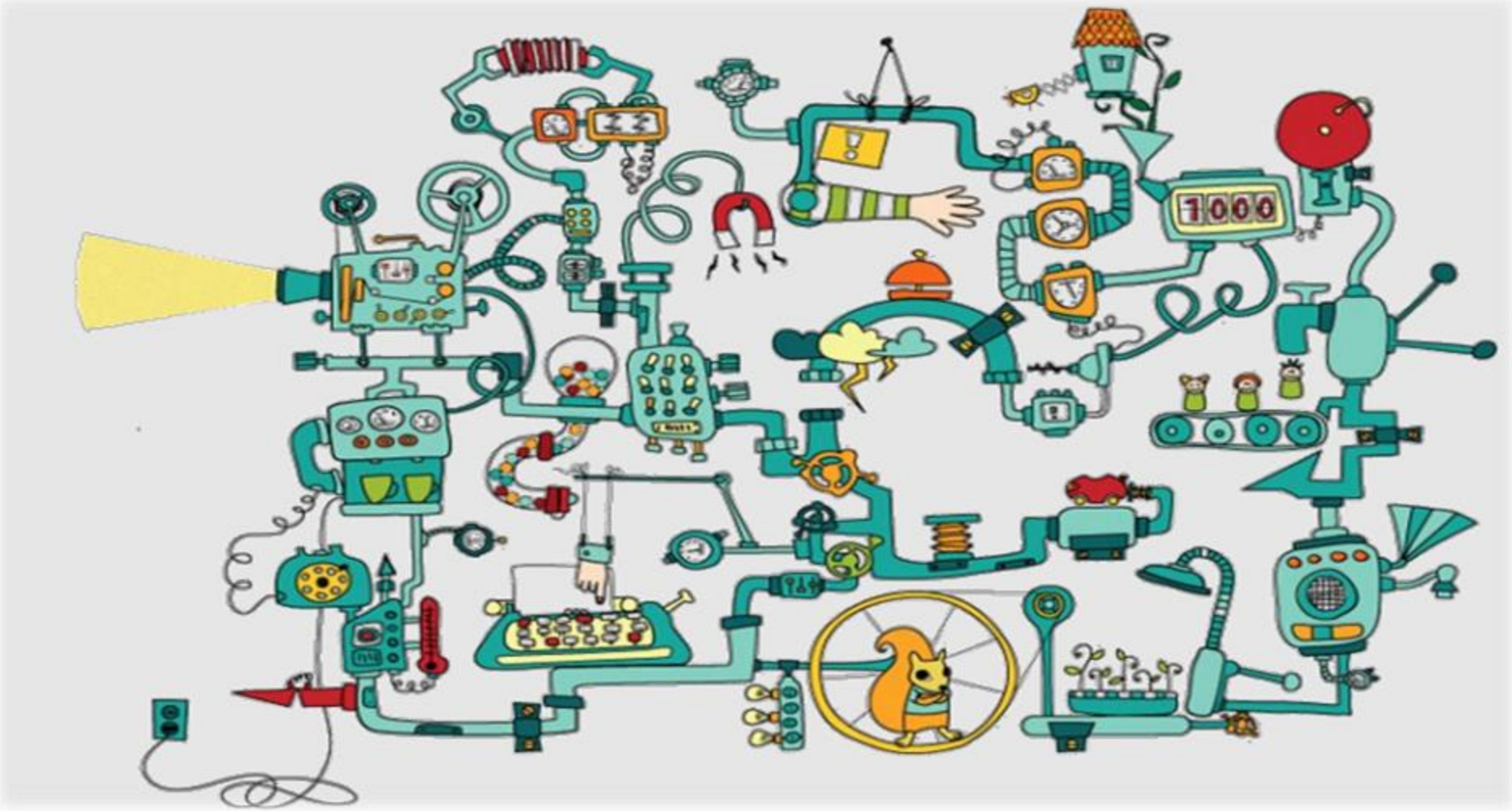
Containers before Docker



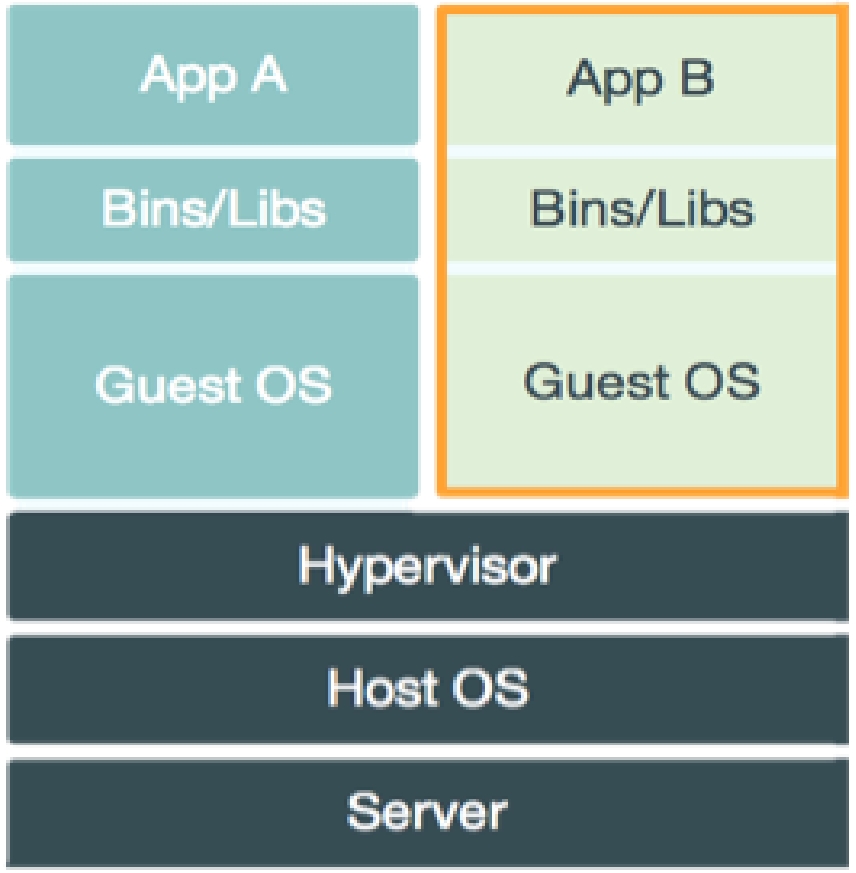

Containers after Docker

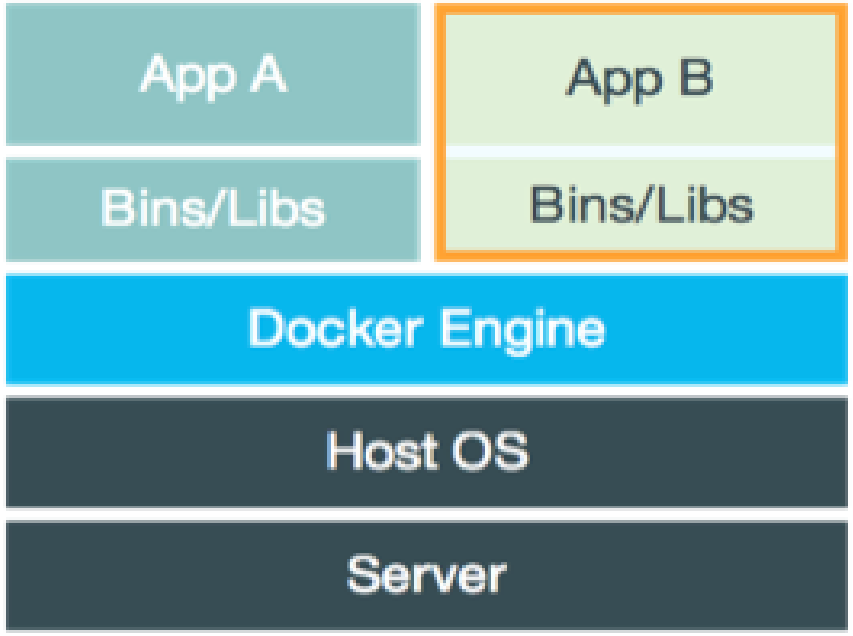
How does Docker work ?

- You can build Docker images that hold your applications
- You can create Docker containers from those Docker images to run your applications.
- You can share those Docker images via Docker Hub or your own registry

https://hub.docker.com/repository/docker/pedrombmachado/ntu_lubuntu

Virtual Machine Versus Container……





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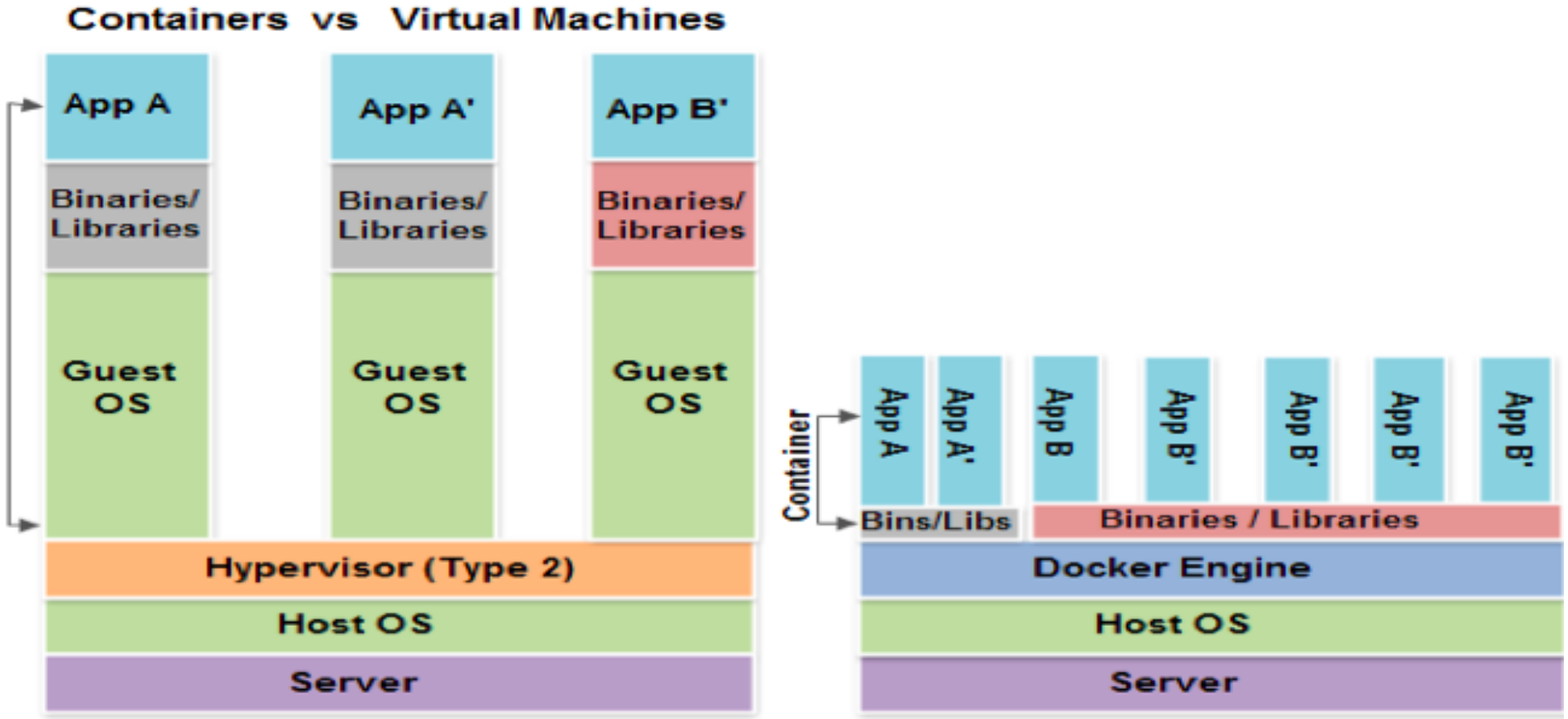
Virtual Machine Versus Container



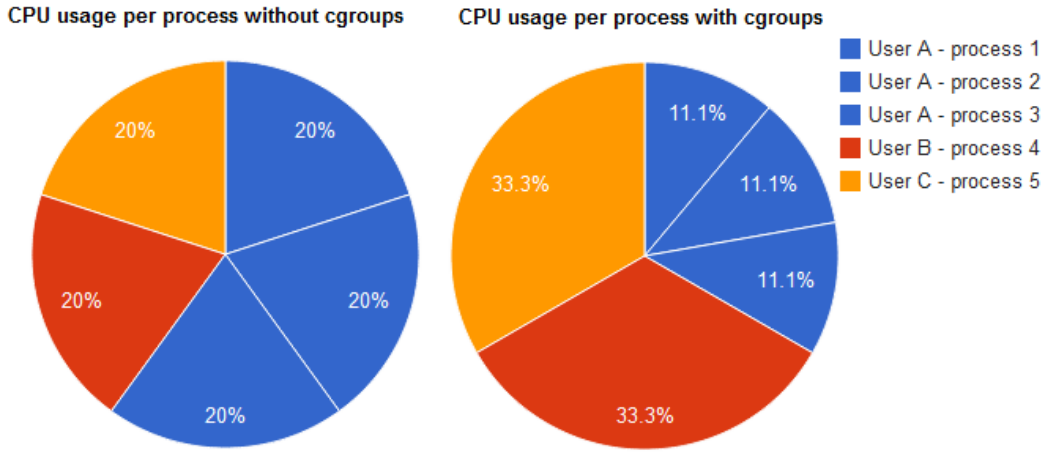
Docker Container Lifecycle

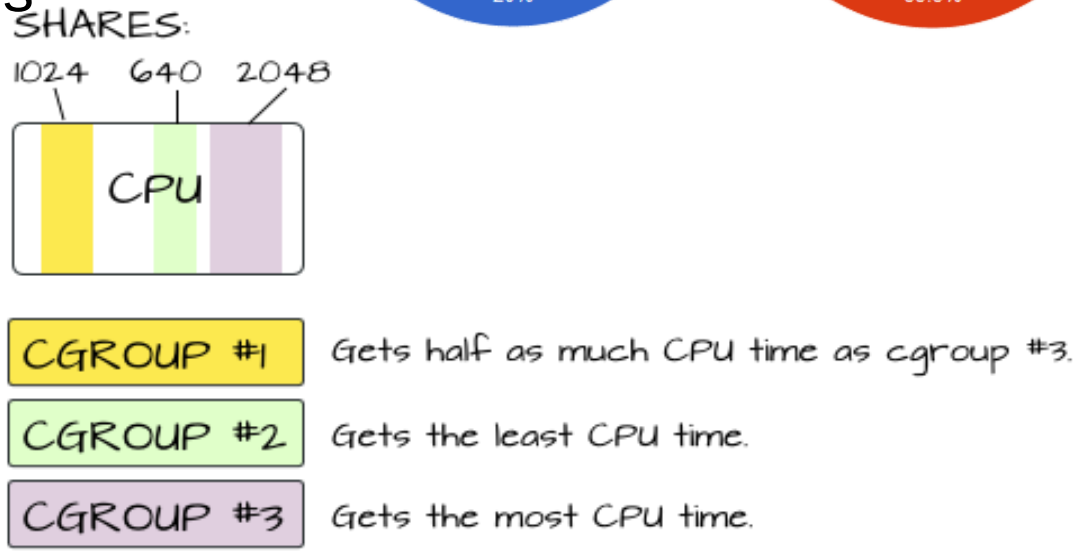
- Conception
  - **BUILD** an Image from a Dockerfile
- Birth
  - **RUN** (create+start) a container
- Reproduction
  - **COMMIT** (persist) a container to a new image
  - **RUN** a new container from an image
- Sleep
  - **KILL** a running container
- Wake
  - **START** a stopped container
- Death
  - **RM** (delete) a stopped container

- Extinction
  - **RMI** a container image (delete image)

Linux Cgroups

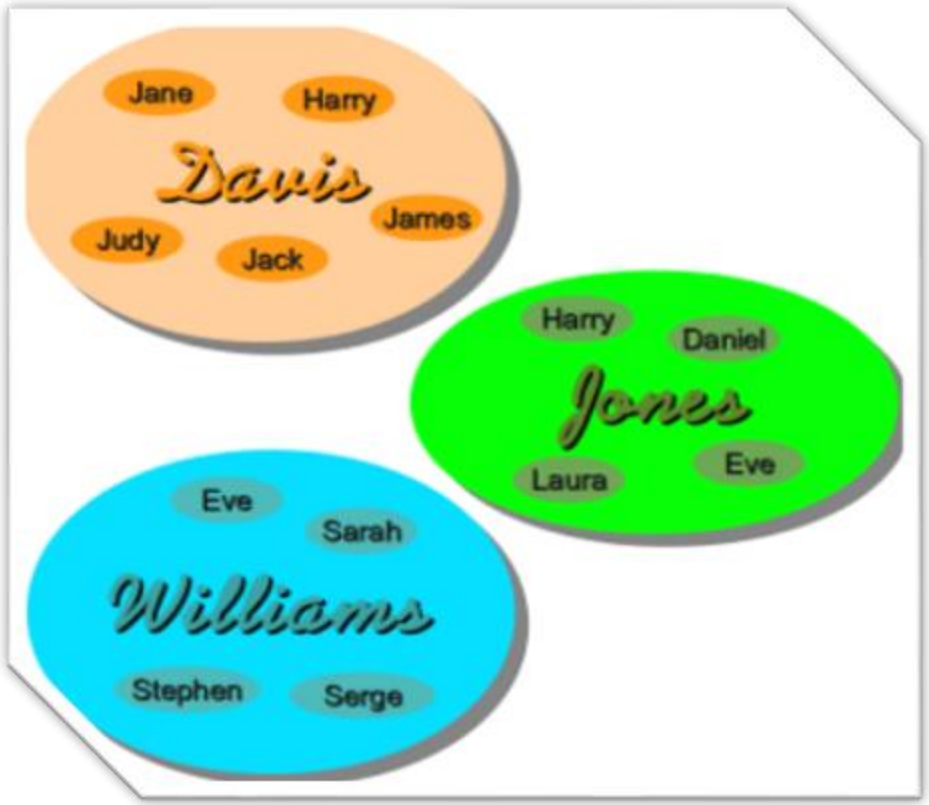
- Kernel Feature
- Groups of processes
- Control resource allocations
  - CPU
  - Memory
  - Disk
  - I/O
- May be nested





Linux Kernel Namespaces

- Kernel Feature
- Restrict your view of the system
  - Mounts (CLONE_NEWNS)
  - UTS (CLONE_NEWUTS)
    - uname() output
  - IPC (CLONE_NEWIPC)
  - PID (CLONE_NEWPID)
  - Networks (CLONE_NEWNET)
  - User (CLONE_NEWUSER)
    - Not supported in Docker yet
    - Has privileged/unprivileged modes today
- May be nested



Dockerfile

- Like a Makefile (shell script with keywords)
- Extends from a Base Image
- Results in a new Docker Image
- Imperative, not Declarative
- A Docker file lists the steps needed to build an images
- docker build is used to run a Docker file
- Can define default command for docker run, ports to expose, etc

```
# syntax=docker/dockerfile:1
FROM ubuntu:18.04
COPY . /app
RUN make /app
CMD python /app/app.py
```

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```
exec        Run a command in a running container
export      Export a container's filesystem as a tar archive
history     Show the history of an image
images      List images
import      Import the contents from a tarball to create a filesystem image
info        Display system-wide information
inspect     Return low-level information on Docker objects
kill        Kill one or more running containers
load        Load an image from a tar archive or STDIN
login       Log in to a Docker registry
logout      Log out from a Docker registry
logs        Fetch the logs of a container
pause       Pause all processes within one or more containers
port        List port mappings or a specific mapping for the container
ps          List containers
pull        Pull an image or a repository from a registry
push        Push an image or a repository to a registry
rename      Rename a container
restart     Restart one or more containers
rm          Remove one or more containers
rmi         Remove one or more images
run         Run a command in a new container
save        Save one or more images to a tar archive (streamed to STDOUT by default)
search      Search the Docker Hub for images
start       Start one or more stopped containers
stats       Display a live stream of container(s) resource usage statistics
stop        Stop one or more running containers
tag         Create a tag TARGET_IMAGE that refers to SOURCE_IMAGE
top         Display the running processes of a container
unpause     Unpause all processes within one or more containers
```

Docker CLI Commands

Docker in Higher Education

- How do we train our students?
- How do we reduce installation and configuration times?
- How do we offer the same Dev environment to all our students?

Run the docker container

Only for personal laptops: ensure that the steps described in Install Docker Desktop on Windows machines have been completed successfully.

1. Start docker desktop
2. Start PowerShell (Windows) or Terminal (Linux/Mac OS) and run the following commands and **DO NOT copy the $ sign**:
3. Load the container (**ONLY FOR LAB PCs**). **DO NOT copy the $ sign**:

```
$ docker load --input 'C:\Users\Public\Documents\Shared Virtual Machines\Docker
\comp20081.docker'

$ docker create volume docker_comp20081

$ docker run -it --rm -p "3390:3389/tcp" --name="ntu-vm-scomp20081" -v docker_comp20081:/home
/ntu-user/NetBeansProjects pedrombmachado/ntu_lubuntu:comp20081
```

Docker demo

Get docker desktop from https://docs.docker.com/get-docker/

Instructions

On AMD64/Intel64 (your laptop). DO NOT copy the $ sign:

```
$ docker volume create docker_comp20081
$ docker run -it --rm -p "3390:3389/tcp" --name="ntu-vm-comp20081" -v
docker_comp20081:/home/ntu-user/NetBeansProjects
pedrombmachado/ntu_lubuntu:comp20081
```

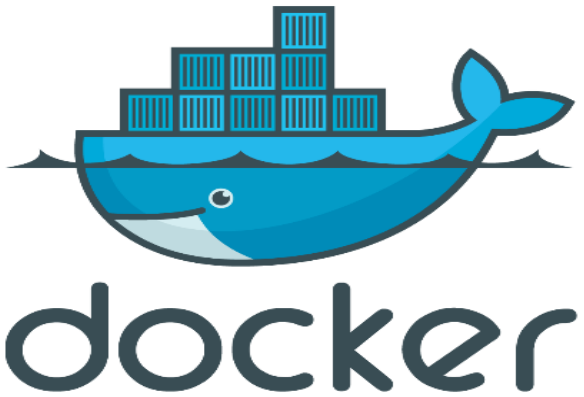
On ARM64 architecture (Mac M1/M2, Chrome book, etc.). DO NOT copy the $ sign:

```
$ docker volume create docker_soft40051
$ docker run -it --rm -p "3390:3389/tcp" --name="ntu-vm-comp20081" -v
docker_comp20081:/home/ntu-user/NetBeansProjects
pedrombmachado/ntu_lubuntu:arm64v8_comp20081
```

Docker Hub repo

Docker demo

Conclusions



- Easy to build, run & share containers
- Rapidly expanding ecosystem
- Better performance vs. VMs
- Layered file system gives us git-like control of images
- Reduces complexity of system builds
- Can be used in higher education to train students and abstract students from installing complex packages.

https://www.docker.com/

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