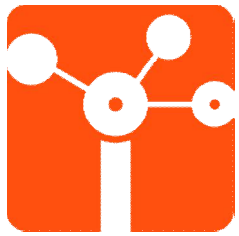
Department of Computer Engineering and Industrial Automation (DCA)
Faculty of Electrical and Computer Engineering (FEEC)
University of Campinas (UNICAMP)



Docker: Introdução e experiências iniciais com uma tecnologia de virtualização leve e ágil

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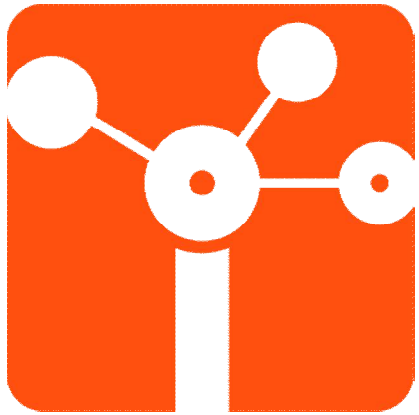
Agenda

- Introduction to Linux Containers
- Docker: Basics (theory and examples)
- Experiences at the INTRIG Lab @ FEEC/UNICAMP
- Hands-on examples
  - Docker and Networking

    Docker & OVS, tunneling, etc.

Credits

- http://docker.io/
- http://docker.com/
- https://github.com/docker/docker
- @docker
- @jpetazzo – OSCON 2014



Intro

CONTAINERS

What's the problem?

django web frontend	?	?	?	?	?	?
node.js async API	?	?	?	?	?	?
background workers	?	?	?	?	?	?
SQL database	?	?	?	?	?	?
distributed DB, big data	?	?	?	?	?	?
message queue	?	?	?	?	?	?
	my laptop	your laptop	QA	staging	prod on cloud VM	prod on bare metal

A Similar Matrix...

Solution:
the *intermodal shipping container*

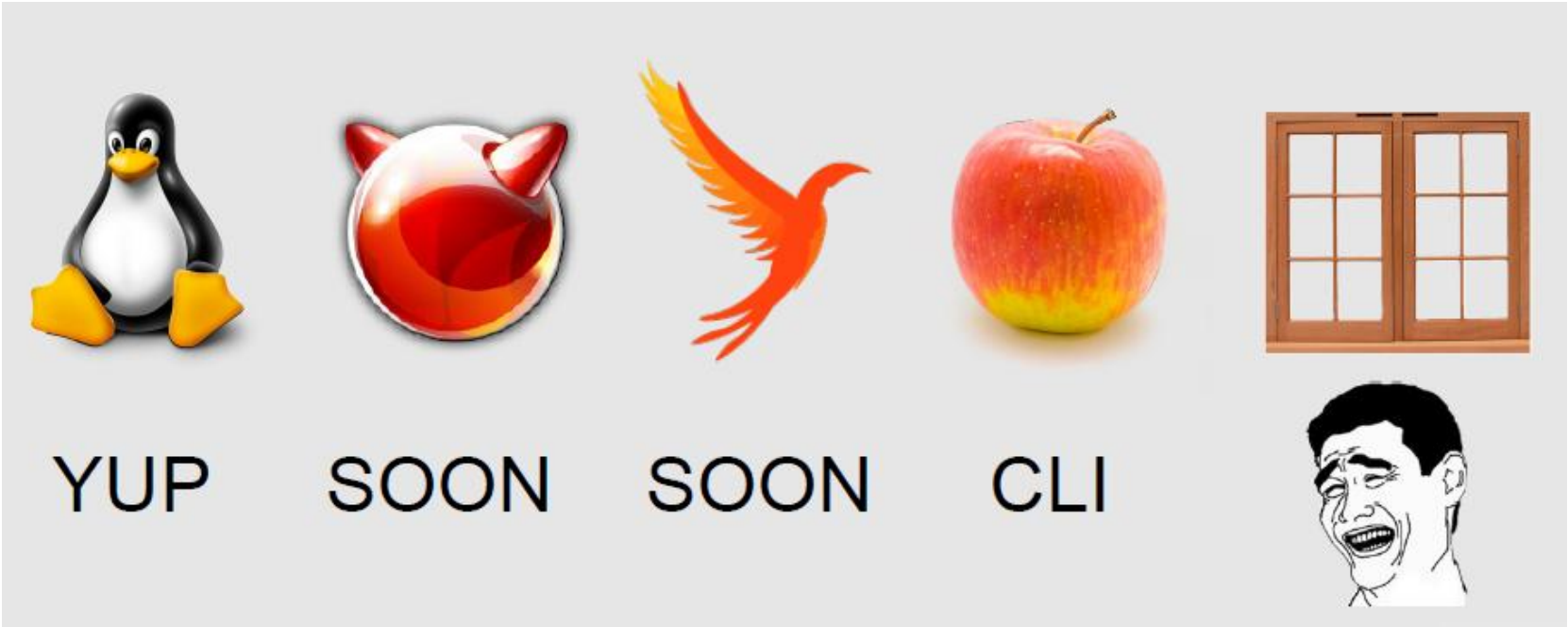
Solution:
the *intermodal shipping container*

Solution to the deployment problem: the *Linux* container

- Units of software delivery (**ship it!**)
- 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

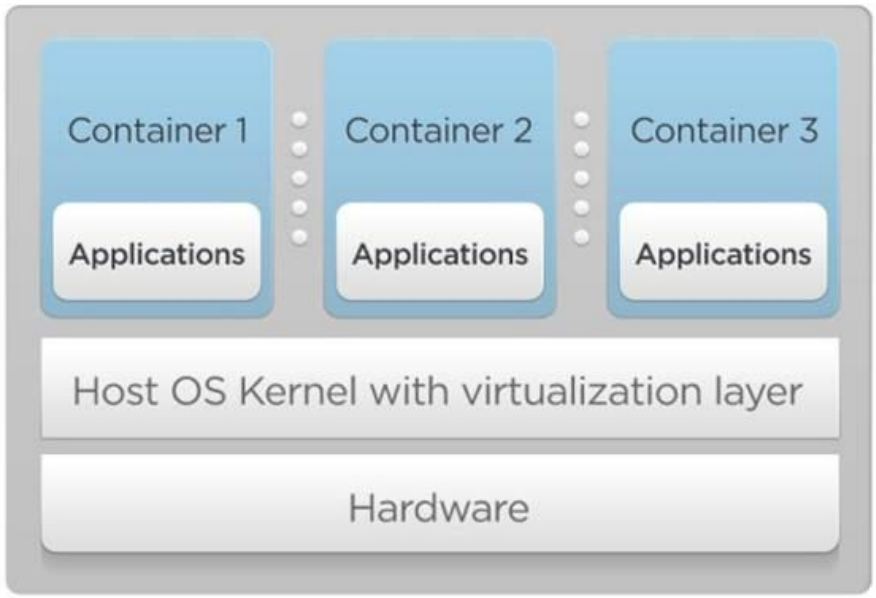
Deploy (almost) everywhere

- Linux servers
- VMs or bare metal
- Any distro
- Kernel 3.8 (or RHEL 2.6.32)



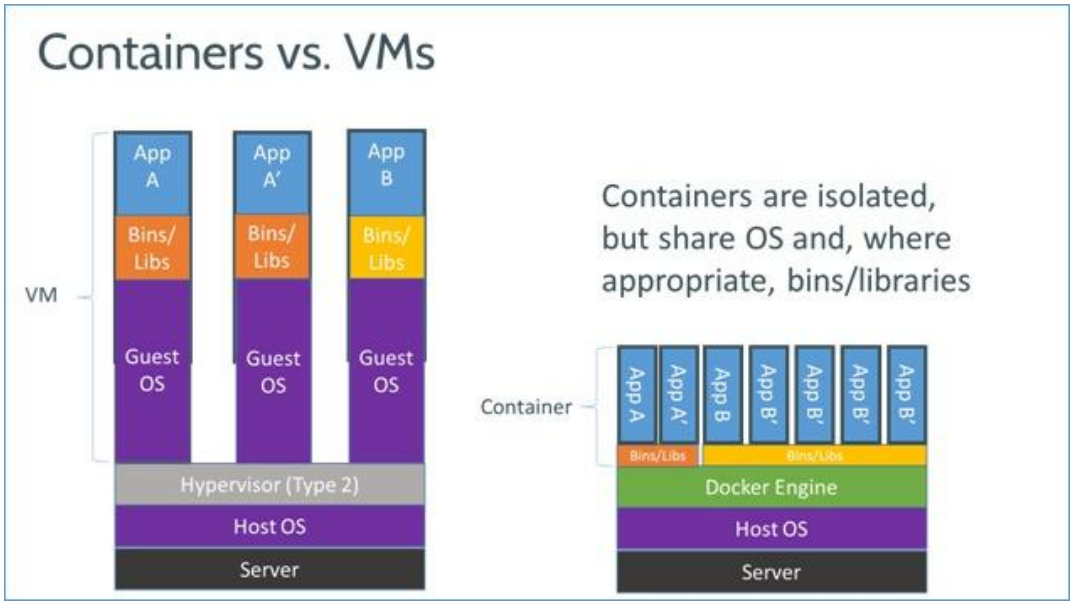
What's a Container?

- High level approach: it's a lightweight VM
  - own process space
  - own network interface
  - can run stuff as root
  - can have its own /sbin/init
    - (different from the host)



What's a Container?

- Low level approach: it's chroot on steroids
  - can also *not* have its own /sbin/init
  - container = isolated process(es)
  - share kernel with host
  - no device emulation (neither HVM nor PV)



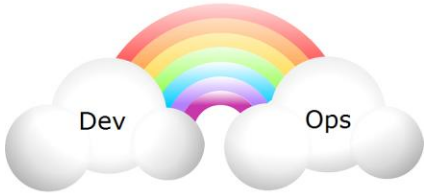
Separation of Concerns

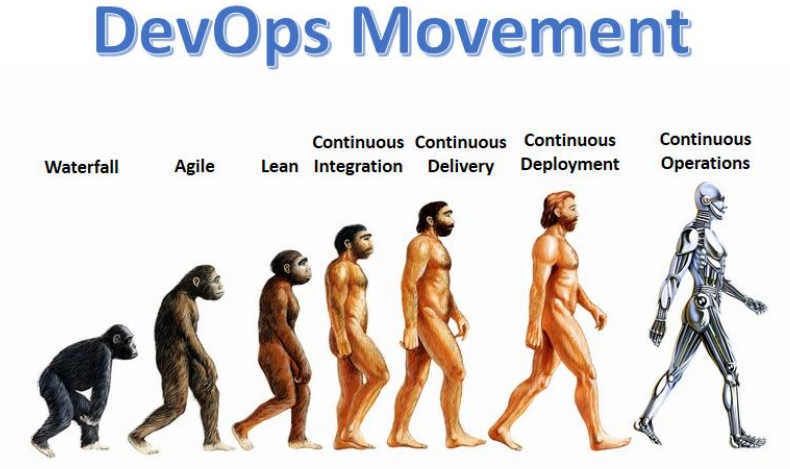
Developer

- inside my container:
  - my code
  - my libraries
  - my package manager
  - my app
  - my data

Operations

- outside the container:
  - logging
  - remote access
  - network configuration
  - monitoring

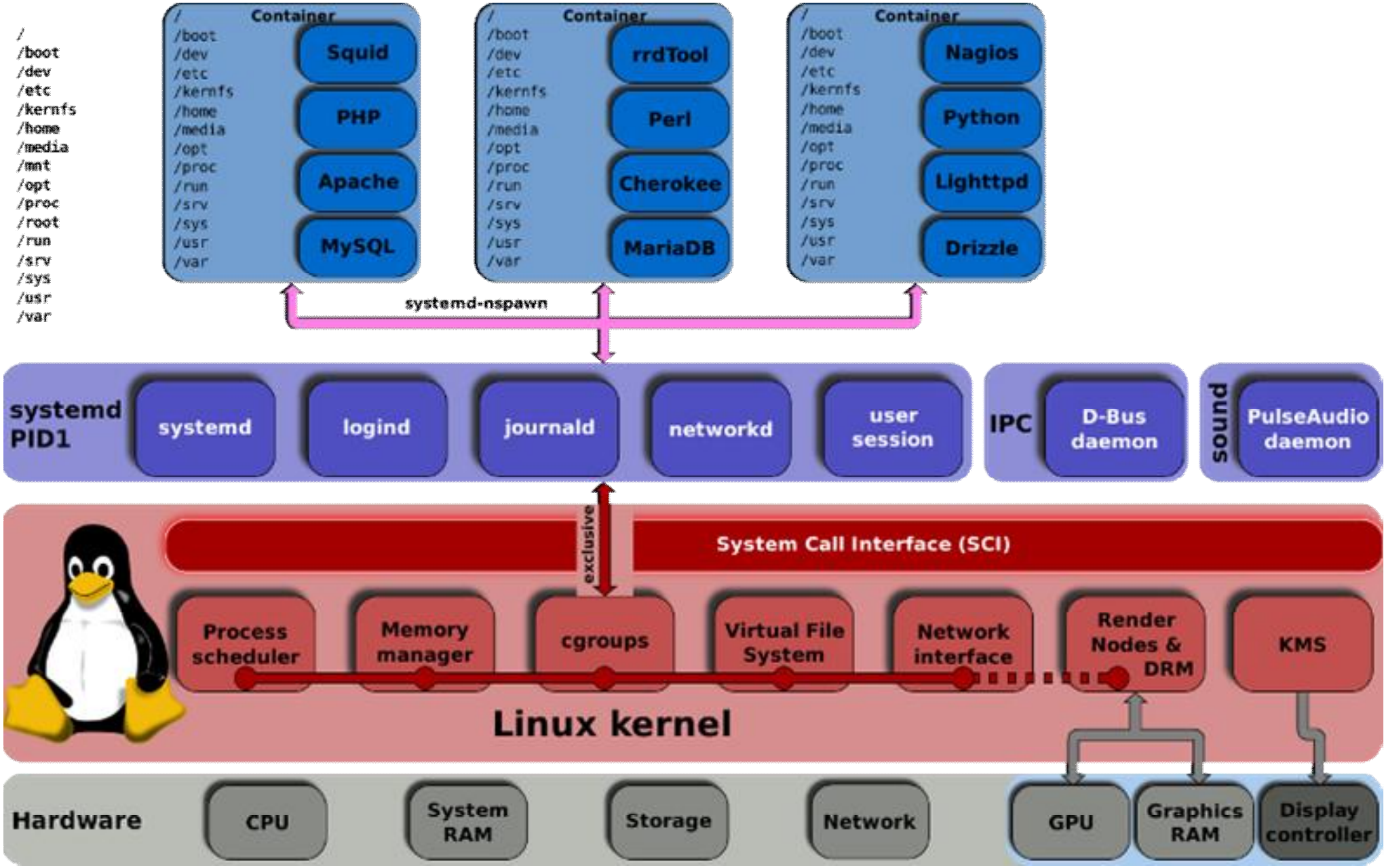




How does it work?

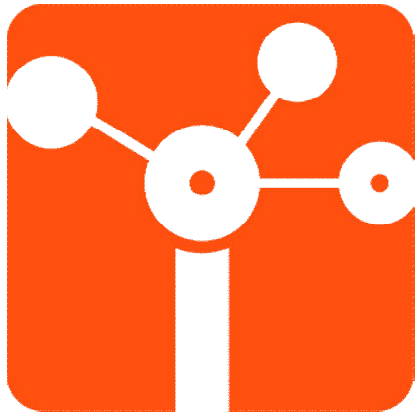
- Isolation with **namespaces**
  - pid
  - mnt
  - net
  - uts
  - ipc
  - user
- Isolation with **cgroups**
  - memory
  - cpu
  - blkio
  - devices

Linux Containers



Containers: Why is this a hot topic?

- LXC (Linux Containers) have been around for *years*
- Lightweight, fast, disposable... virtual environments
  - boot in milliseconds
  - just a few MB of intrinsic disk/memory usage
  - bare metal performance is possible
- The new way to build, ship, deploy, run your apps!
- Everybody* wants to deploy containers now
- Tools like Docker made containers very easy to use



And now...

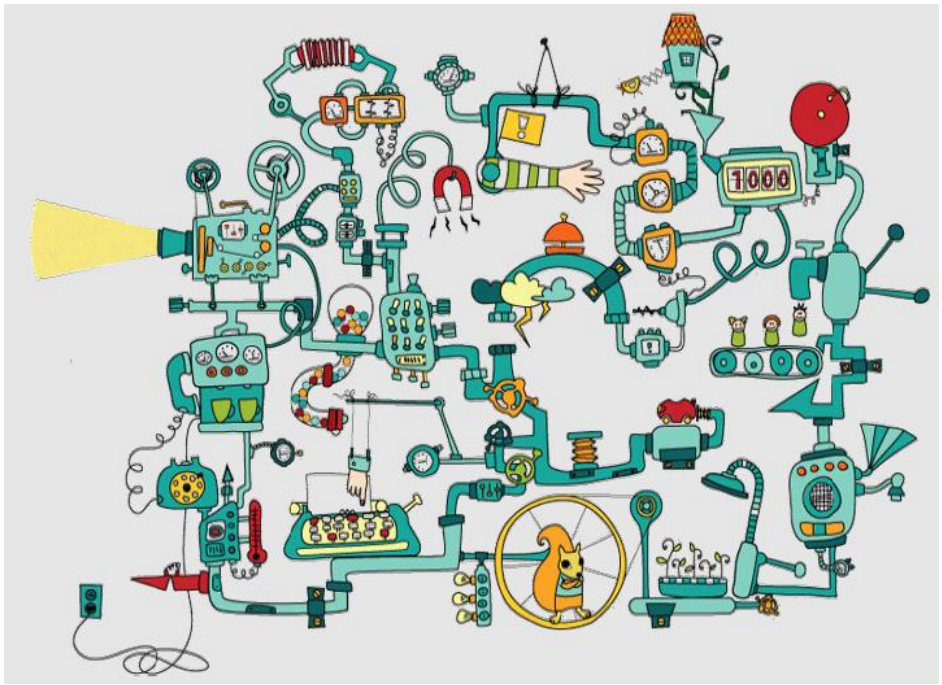
DOCKER

Docker

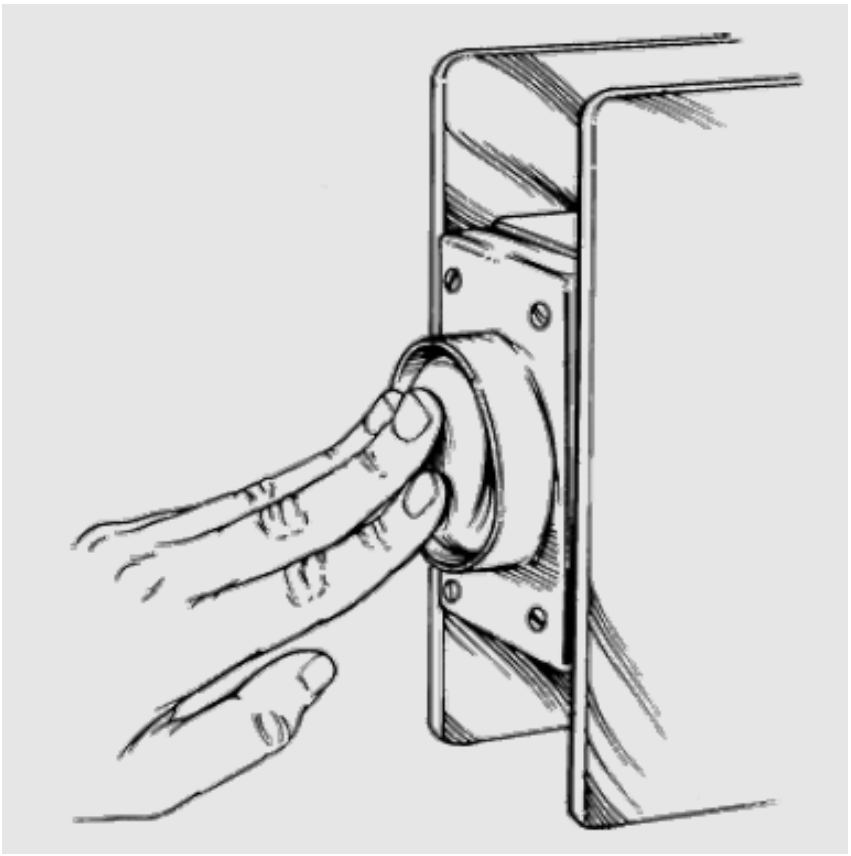
- Open Source engine to **commoditize** LXC
  - the whole point is to **commoditize**,
  - i.e. make it ridiculously easy to use

Containers

Before Docker



After Docker



Docker-what?

The Big Picture

- Open Source engine to commoditize LXC
- using copy-on-write for quick provisioning
- allowing to **create and share** *images*
- **standard format** for containers
- (stack of layers; 1 layer = tarball+metadata)
- standard, *reproducible* way to *easily* build
- *trusted* images (Dockerfile, Stackbrew...)

Docker-what?

Under the hood

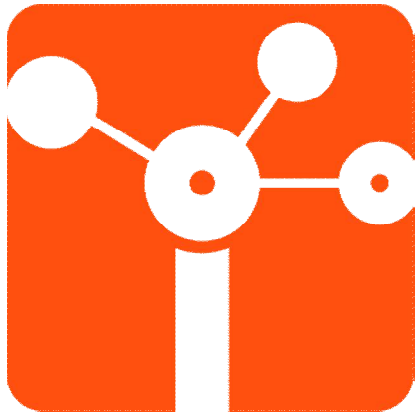
- rewrite of dotCloud internal container engine
  - original version: Python, tied to dotCloud's internal stuff
  - released version: Go, legacy-free
- the Docker daemon runs in the background
  - manages containers, images, and builds
  - HTTP API (over UNIX or TCP socket)
  - embedded CLI talking to the API
- Open Source (GitHub public repository + issue tracking)
- user and dev mailing lists
- FreeNode IRC channels #docker, #docker-dev

Docker-what?
The Ecosystem

- Docker Inc. (formerly dotCloud Inc.)
  - ~30 employees, VC-backed
  - SaaS and support offering around Docker
- Docker, the community
  - more than 300 contributors, 1500 forks on GitHub
  - dozens of projects around/on top of Docker
  - x100k trained developers

Working with Docker

- On your servers (Linux)
  - Packages (Ubuntu, Debian, Fedora, Gentoo…)
  - Single binary install (Golang)
  - Easy provisioning on Rackspace, Digital Ocean, EC2…
- On your dev env (Linux, OS X, Windows)
  - Vagrantfile (describe machine config reqs)
  - boot2docker (25 MB VM image)
  - Natively (if you run Linux)



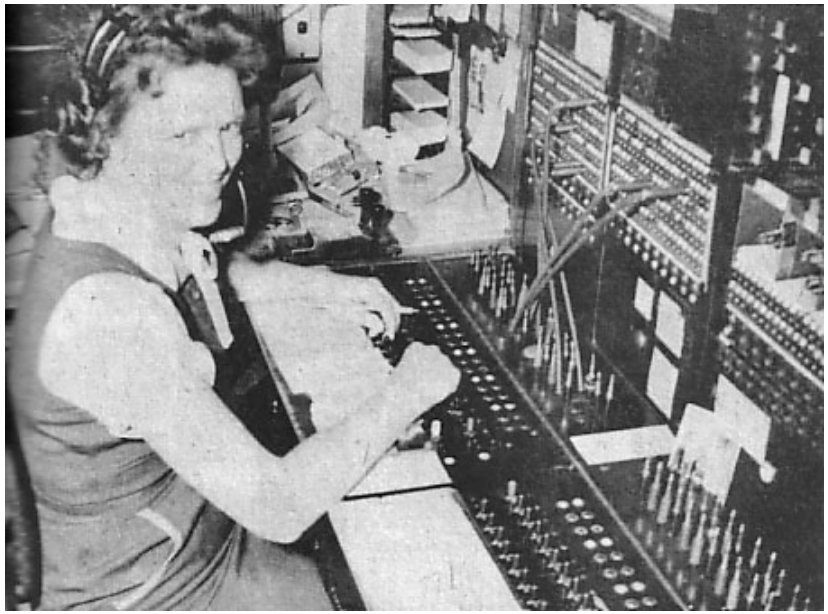
Why not?! Let’s try it...

HANDS-ON

Get in Touch

- First Contact
  - https://www.docker.com/tryit/

- All useful information
  - https://docs.docker.com/



Install

- On Ubuntu 14.04
  - $ sudo apt-get install docker.io
- Other distros
  - https://docs.docker.com/installation/#installation
- *windows / OSX: boot2docker

Dockerizing Applications: A "Hello world"

$ sudo docker run ubuntu:14.04 /bin/echo 'Hello world‘

- First App

$ sudo docker run –t –i ubuntu:14.04 /bin/bash

- Inside a container (Comparison with outside world)

$ sudo docker run -d ubuntu:14.04 /bin/sh -c "while true; do echo hello world; sleep 1; done“

- Something about id/name, logs, stop

Working with Containers

$ sudo docker .... [version]

- What docker client can do
- More: https://docs.docker.com/reference/commandline/cli/

$ sudo docker run -d -P training/webapp python app.py

- Let's inspect, stop, rm, top, ps, …

Working with Images

$ sudo docker images

- Repo, tag, id, ...

$ sudo docker search ...

- Or https://hub.docker.com/

Creating your images:

$ sudo docker pull training/sinatra

$ sudo docker run -t -i training/sinatra /bin/bash

gem install json

$ sudo docker commit -m="Added json gem" -a="Kate Smith" **ID** ouruser/sinatra:v2

Working with Images

Dockerfiles:

"# This is a comment

FROM ubuntu:14.04

MAINTAINER Kate Smith <ksmith@example.com>

RUN apt-get update && apt-get install -y ruby ruby-dev

RUN gem install sinatra"

$ sudo docker build -t="ouruser/sinatra:v2" .

- More: https://docs.docker.com/reference/builder

Tagging:

$ sudo docker tag **ID** ouruser/sinatra:devel

Managing Data in Containers

- A simple mount:

  $ sudo docker run -d -P --name web -v /webapp training/webapp python app.py

- Or

  $ sudo docker run -d -P --name web -v /src/webapp:/opt/webapp training/webapp python app.py

- And then:

  $ sudo docker run -d --volumes-from web --name db training/postgres

- Removing volumes

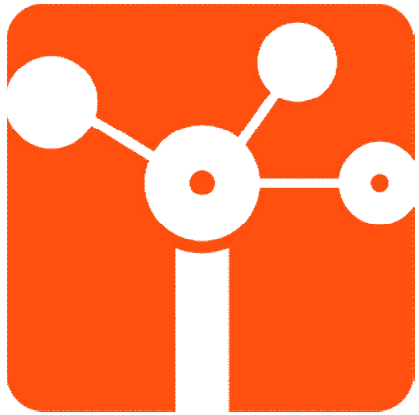
  $ sudo docker rm -v /src/webapp

Linking Containers

- Links:
  - Env Variables
  - /etc/hosts updates

```
$ sudo docker run -d --name db training/postgres
```

```
$ sudo docker run -d -P --name web --link db:db training/webapp
/bin/bash
```



Docker in Production...

DEVOPS

The Docker Workflow 1/2

- Work in dev environment

  (local machine or container)
- Other services (databases etc.) in containers

  (and behave just like the real thing!)
- Whenever you want to test ≪ for real ≫:
  - Build in *seconds*
  - Run *instantly*

The Docker Workflow 2/2

- Satisfied with your local build?
  - Push it to a *registry* (public or private)
  - Run it (automatically!) in CI/CD
  - Run it in production
  - Happiness!
- Something goes wrong? Rollback painlessly!

DevOps

Authoring images with run/commit

1) docker run ubuntu bash
2) apt-get install this and that
3) docker commit <containerid> <imagename>
4) docker run <imagename> bash
5) git clone git://.../mycode
6) pip install -r requirements.txt
7) docker commit <containerid> <imagename>
8) repeat steps 4-7 as necessary
9) docker tag <imagename> <user/image>
10) docker push <user/image>

Authoring images with run/commit

- Pros
  - Convenient, nothing to learn
  - Can roll back/forward if needed
- Cons
  - Manual process
  - Iterative changes stack up
  - Full rebuilds are boring, error-prone

Authoring images with a Dockerfile

```
FROM ubuntu
RUN apt-get -y update
RUN apt-get install -y g++
RUN apt-get install -y make wget
EXPOSE 80
CMD ["/bin/ping"]
```

docker build -t AUTHOR/DOCKER-NAME .

Authoring images with a Dockerfile

- Minimal learning curve
- Rebuilds are easy
- Caching system makes rebuilds faster
- Single file to define the whole environment!

Sysadmin chores

- Backups
- Logging
- Remote access

File-level Backups

- Use volumes

  $ docker run --name mysqldata -v /var/lib/mysql busybox true

  $ docker run --name mysql --volumes-from mysqldata mysql

  $ docker run --rm --volumes-from mysqldata mysqlbackup \ tar -cJf- /var/lib/mysql | stream-it-to-the-cloud.py

- Of course, you can use anything fancier than tar (e.g. rsync, tarsnap...)

Data-level backups

- Use links

```
$ docker run --name mysql mysql
$ docker run --rm --link mysql:db mysqlbackup \
$ mysqldump --all-databases | stream-it-to-the-cloud.py
```

- Can be combined with volumes
  - put the SQL dump on a volume
  - then backup that volume with file-level tools (previous slide)

Logging for legacy apps

- Legacy = let me write to eleventy jillion arbitrary files in /var/lib/tomcat/logs!

- Solution: volumes

  $ docker run --name logs -v /var/lib/tomcat/logs busybox true

  $ docker run --name tomcat --volumes-from logs my_tomcat_image

  - Inspect logs:

    $ docker run --rm --volumes-from logs ubuntu bash

  - Ship logs to something else:

    $ docker run --name logshipper --volumes-from logs sawmill

Remote Access

- If you own the host: SSH to host + nsenter
  https://github.com/jpetazzo/nsenter
- If you don't own the host: SSH in the container
  https://github.com/phusion/baseimage-docker
- More on that topic ("do I need SSHD in containers?"):
  http://blog.docker.com/2014/06/why-you-dont-need-to-run-sshd-in-docker/
- In the future:
  - run separate SSH container
  - log into that
  - "hop" onto the target container

Orchestration

- There's more than one way to do it (again!)
  - describe your stack in files
    (Fig, Maestro-NG, Ansible and other CMs)
  - submit requests through an API
    (Mesos)
  - implement something that looks like a PAAS
    (Flynn, Deis, OpenShift)
  - the “new wave”
    (Kubernetes, Centurion, Helios...)
  - OpenStack

Do you (want to) use OpenStack?

- Yes
  - if you are building a PaaS, keep an eye on Solum
    (and consider contributing)
  - if you are moving VM workloads to containers, use Nova
    (that's probably what you already have; just enable the Docker driver)
  - otherwise, use Heat
    (and use Docker resources in your Heat templates)

- No
  - go to next slide

Are you looking for a PaaS?

- Yes
  - CloudFoundry (Ruby, but increasing % Go)
  - Deis (Python, Docker-ish, runs on top of CoreOS)
  - Dokku (A few 100s of line of Bash!)
  - Flynn (Go, bleeding edge)
  - OpenShift geard (Go)

- Choose wisely (or go to the next slide)
  - http://blog.lusis.org/blog/2014/06/14/paas-for-realists/

    "I don't think ANY of the current private PaaS solutions are a fit right now."

How many Docker hosts do you have?

- Only one per app or environment
  - Fig
- A few (up to ~10)
  - Maestro-NG
  - your favorite CM (e.g. Ansible has a nice Docker module)
- A lot
    - Mesos
  - have a look at (and contribute to) the “new wave” (Centurion, Helios, Kubernetes...)

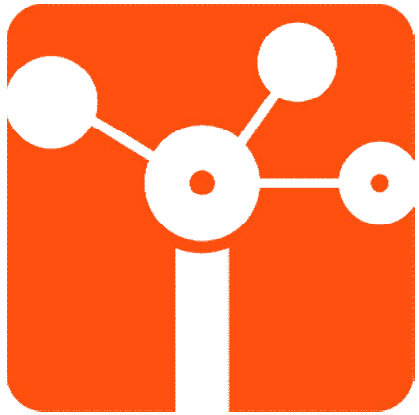
Performance: measure things

- cgroups give us per-container...
  - CPU usage
  - memory usage (fine-grained: cache and resident set size)
  - I/O usage (per device, reads vs writes, in bytes and in ops)

- cgroups don't give us...
  - network metrics (have to do tricks with network namespaces)

https://github.com/google/cadvisor

http://jpetazzo.github.io/2013/10/08/docker-containers-metrics/



Our Experience...

INTRIG LAB

Most images already available

- We can built our own dockerfiles
  - Images without being verified
  - Some of them old
  - Custom configs

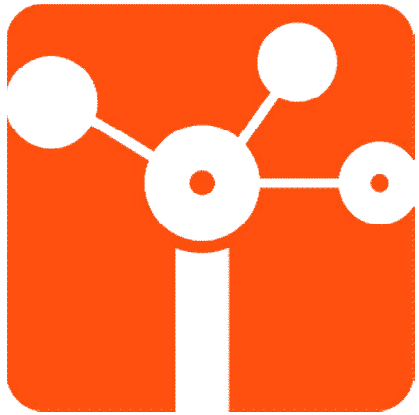
- Old x86 machines (Core 2Duo, 4GB, 250 GB)
  - Monitoring containers performance
  - Following Apps recommendations

Inside only!

- Evaluating...

Outside world: 2015

- Start deploying our private repository
- Containers configuration management
  - Documentation
- No need for CM platform right now!
- Security configs required for production
  - Under analysis!



Training...

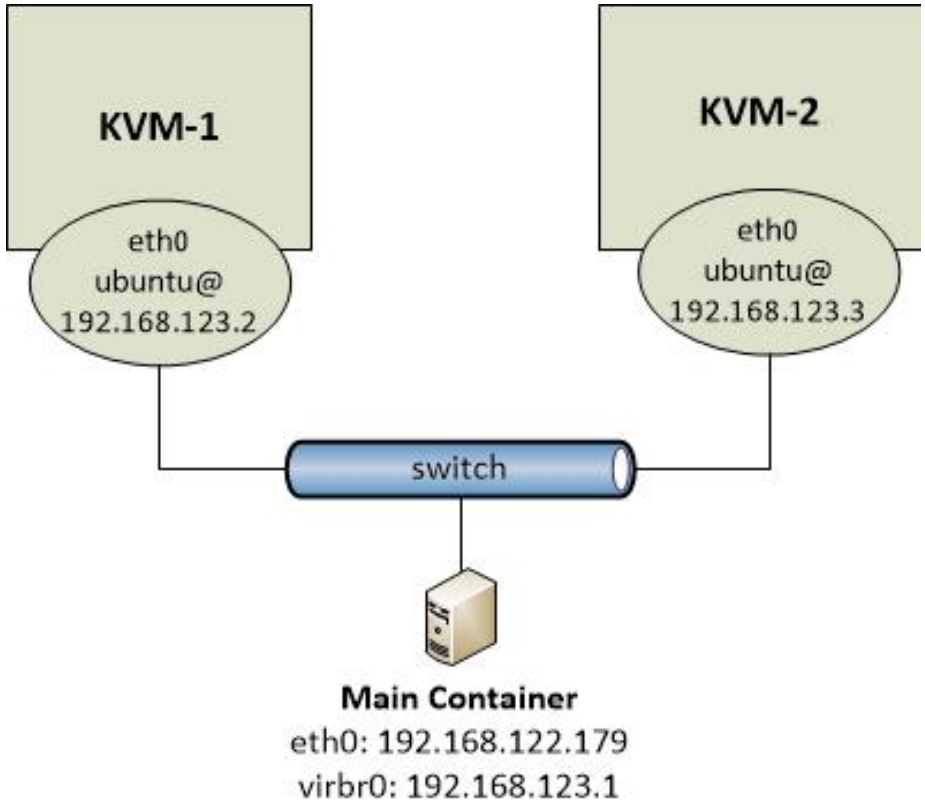
EXAMPLES

Hands-on #1

Access to the VM recently started:
$ ssh ubuntu@192.168.122.179

To start each VM remotely:
$ sudo virsh net-start default
$ sudo virsh start ubuntu1
$ sudo virsh start ubuntu2

#Use different terminals to access each VM
From terminal 1
$ ssh ubuntu@192.168.123.2
From terminal 2
$ ssh ubuntu@192.168.123.3

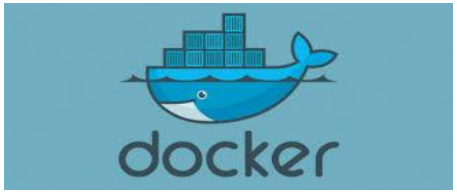


Initiating Docker

 # First, we check if docker is up
$ sudo ps aux |grep docker
root 624 0.0 1.5 328816 11536 ? Ssl 17:30 0:00 /usr/bin/docker -d

 # If docker is not up then give the below command:
service docker start

 # In each VM, search and pull the pre-configured container from docker hub
KVM-1: $ docker search intrig/tutorial
KVM-2: $ docker search intrig/tutorial
KVM-1: $ docker pull intrig/tutorial
KVM-2: $ docker pull intrig/tutorial

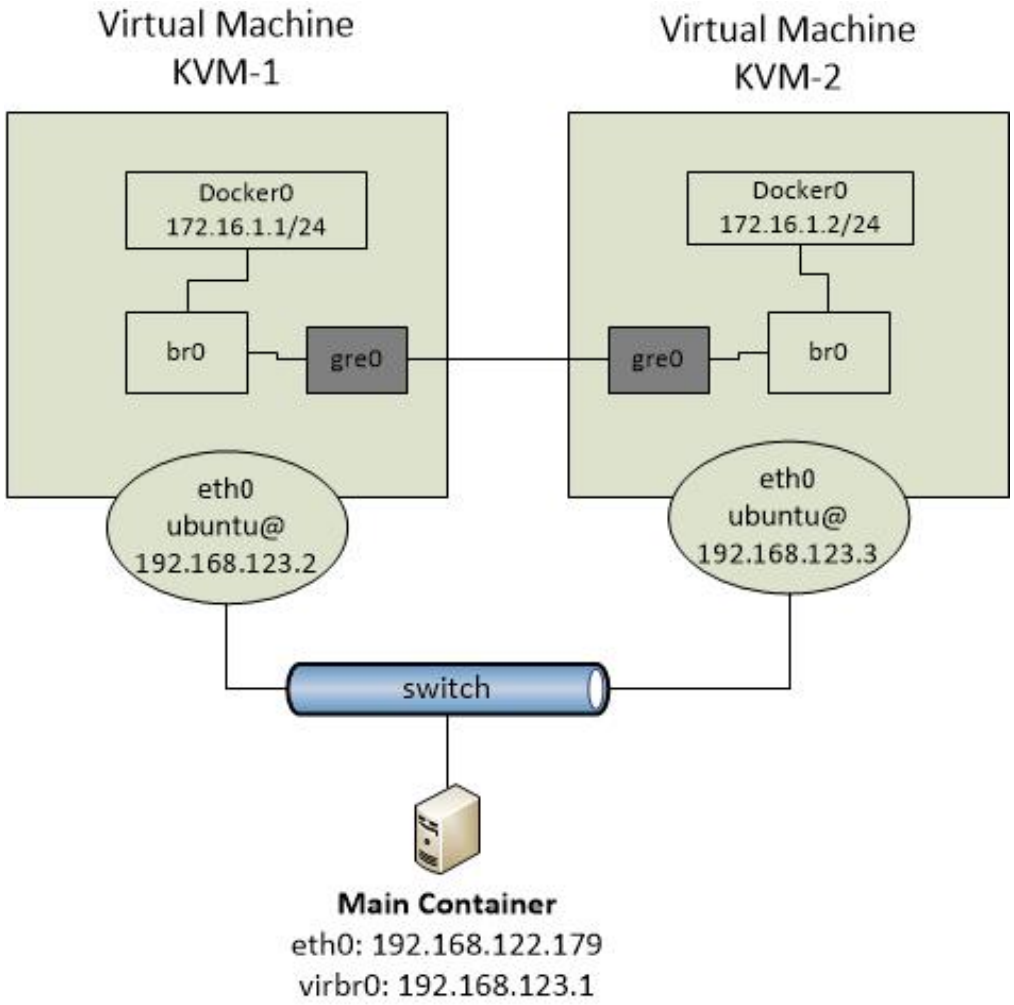


 # Check if docker was correctly downloaded from reposities Docker Hub
KVM-1: $ docker images
KVM-2: $ docker images

GRE Tunnel in Docker 1/4

 # Virtual Machine 1 (KVM-1)

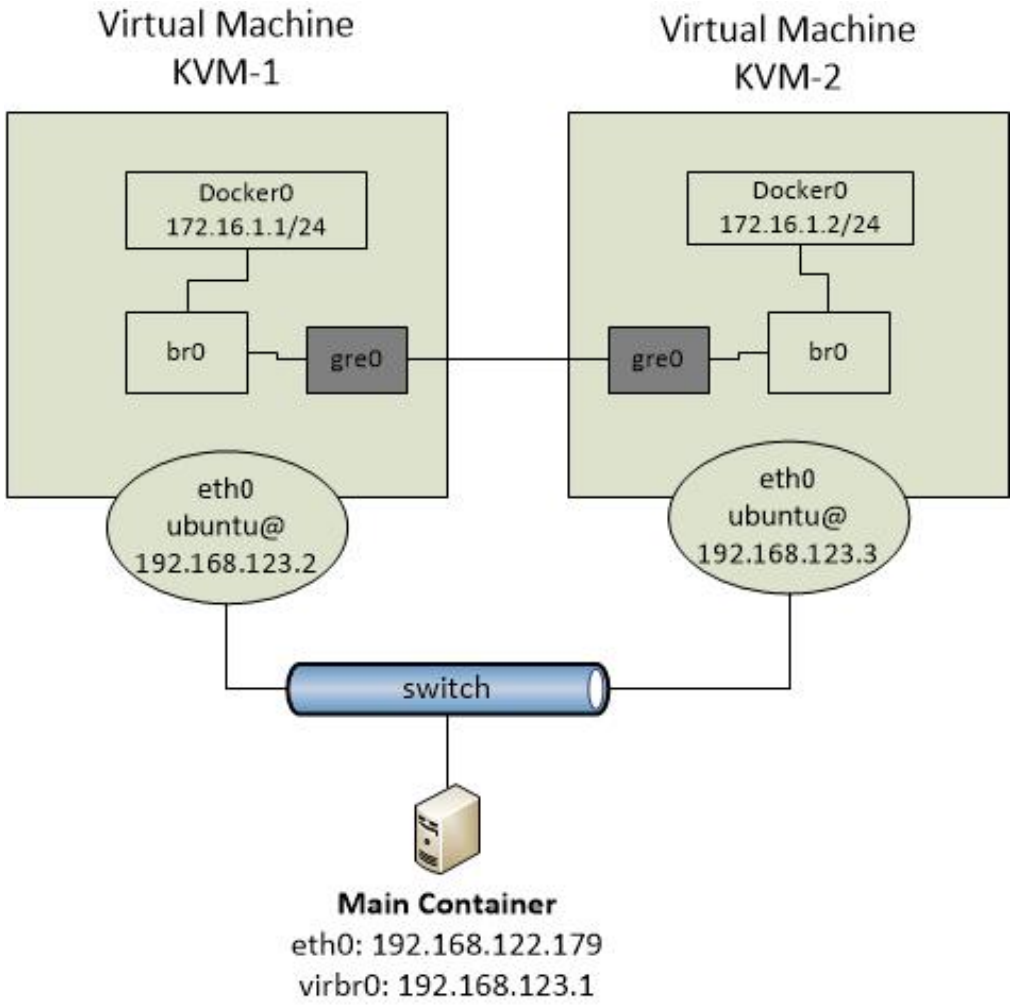
 # Resetting the docker interface
sudo ip link set docker0 down
sudo brctl delbr docker0
sudo brctl addbr docker0
 # Assigning IP to the Docker interface
sudo ip addr add 172.16.1.1/24 dev docker0
sudo ip link set docker0 up
sudo ovs-vsctl add-br br0
 # Creating a tunnel GRE
sudo ovs-vsctl add-port br0 gre0 -- set interface gre0 type=gre options:remote_ip=192.168.123.3
 # Adding the bridge 'br0' as interface to the bridge 'docker0'
sudo brctl addif docker0 br0



GRE Tunnel in Docker 2/4

 # Virtual Machine 2 (KVM-2)

 # Resetting the docker interface
sudo ip link set docker0 down
sudo brctl delbr docker0
sudo brctl addbr docker0
 # Assigning IP to the Docker interface
sudo ip addr add 172.16.1.2/24 dev docker0
sudo ip link set docker0 up
sudo ovs-vsctl add-br br0
 # Creating a tunnel GRE
sudo ovs-vsctl add-port br0 gre0 -- set interface gre0 type=gre options:remote_ip=192.168.123.2
 # Adding the bridge 'br0' as interface to the bridge 'docker0'
sudo brctl addif docker0 br0



GRE Tunnel in Docker 3/4

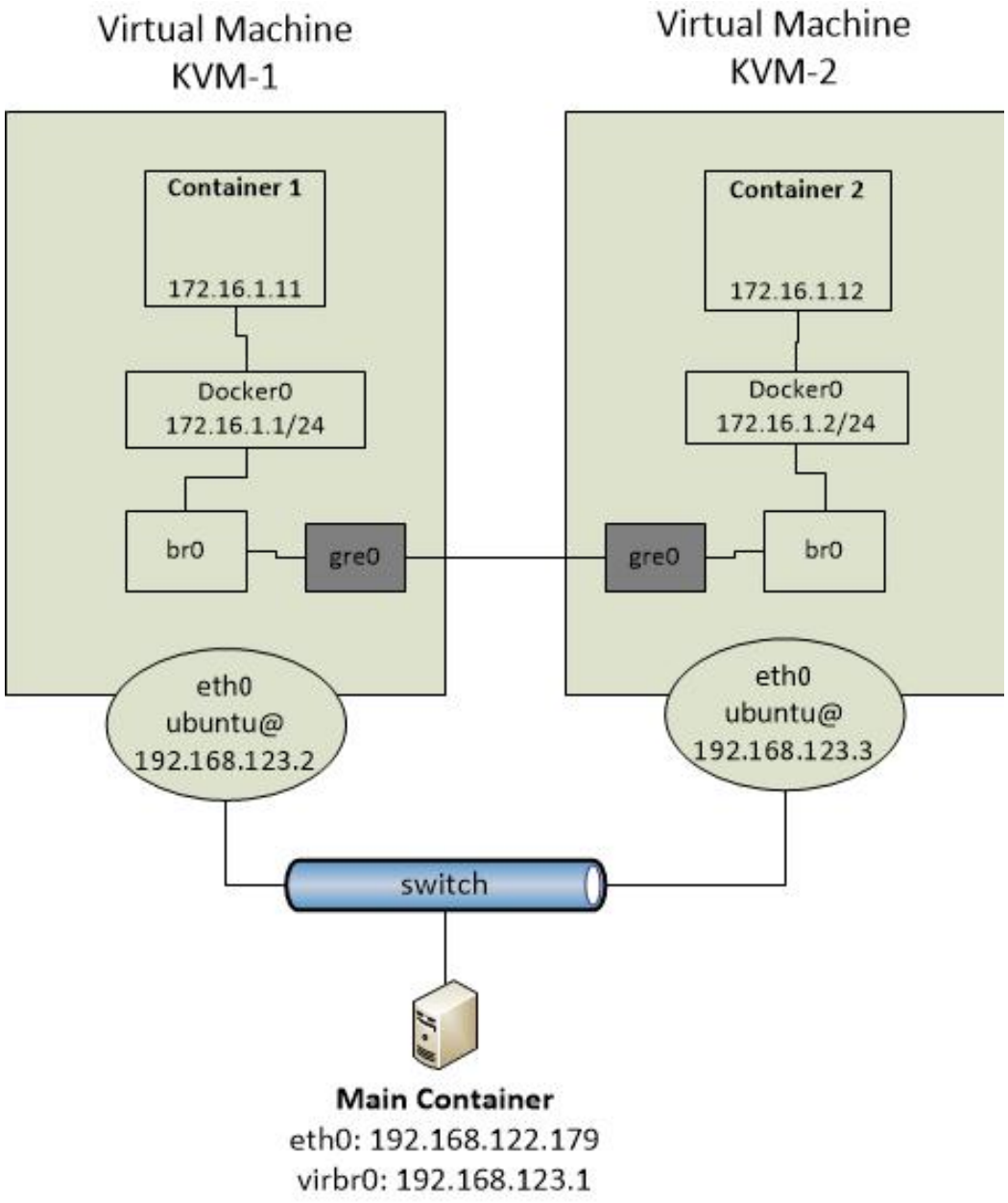
 # Virtual Machine 1 (KVM-1)

 # Activate docker for the container 1

$docker run -i -t --privileged --name=container1 --hostname=container1 --publish 127.0.0.1:2222:22 intrig/tutorial:v3 /bin/bash

 # If you get the below mentioned prompt, then configure an IP address for it. This prompt signifies that you have successfully started the container.

root@container1:/#
root@container1:/# ifconfig eth0 172.16.1.11 netmask 255.255.255.0
root@container1:/# route add default gw 172.16.1.1



GRE Tunnel in Docker 4/4

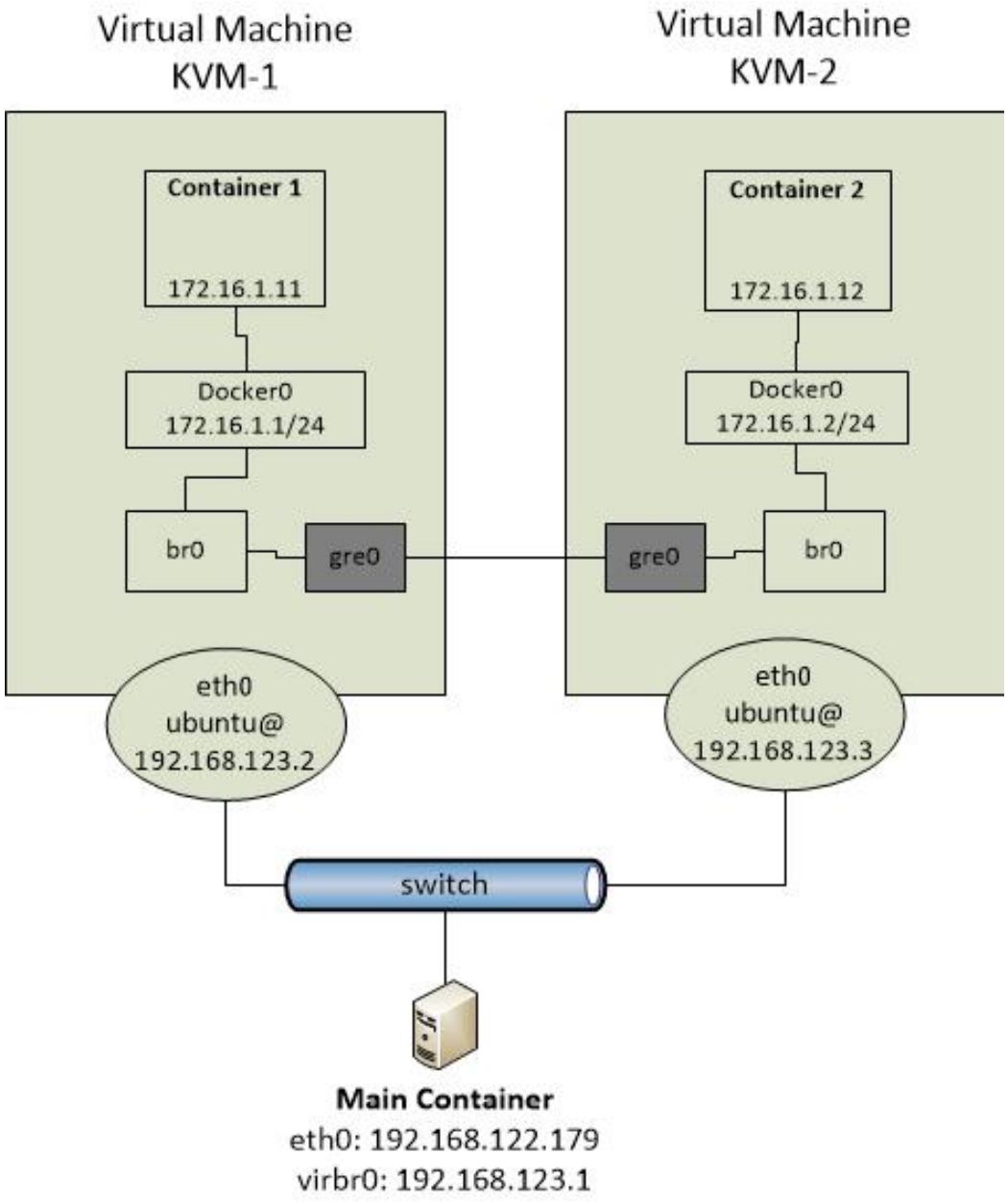
 # Virtual Machine 2 (KVM-2)

 # Activate docker for the container 2

$docker run -i -t --privileged --name=container2 --hostname=container2 --publish 127.0.0.1:2222:22 intrig/tutorial:v3 /bin/bash

 # If you get the below mentioned prompt, then configure an IP address for it. This prompt signifies that you have successfully started the container.

root@container2:/#
root@container2:/# ifconfig eth0 172.16.1.12 netmask 255.255.255.0
root@container2:/# route add default gw 172.16.1.2



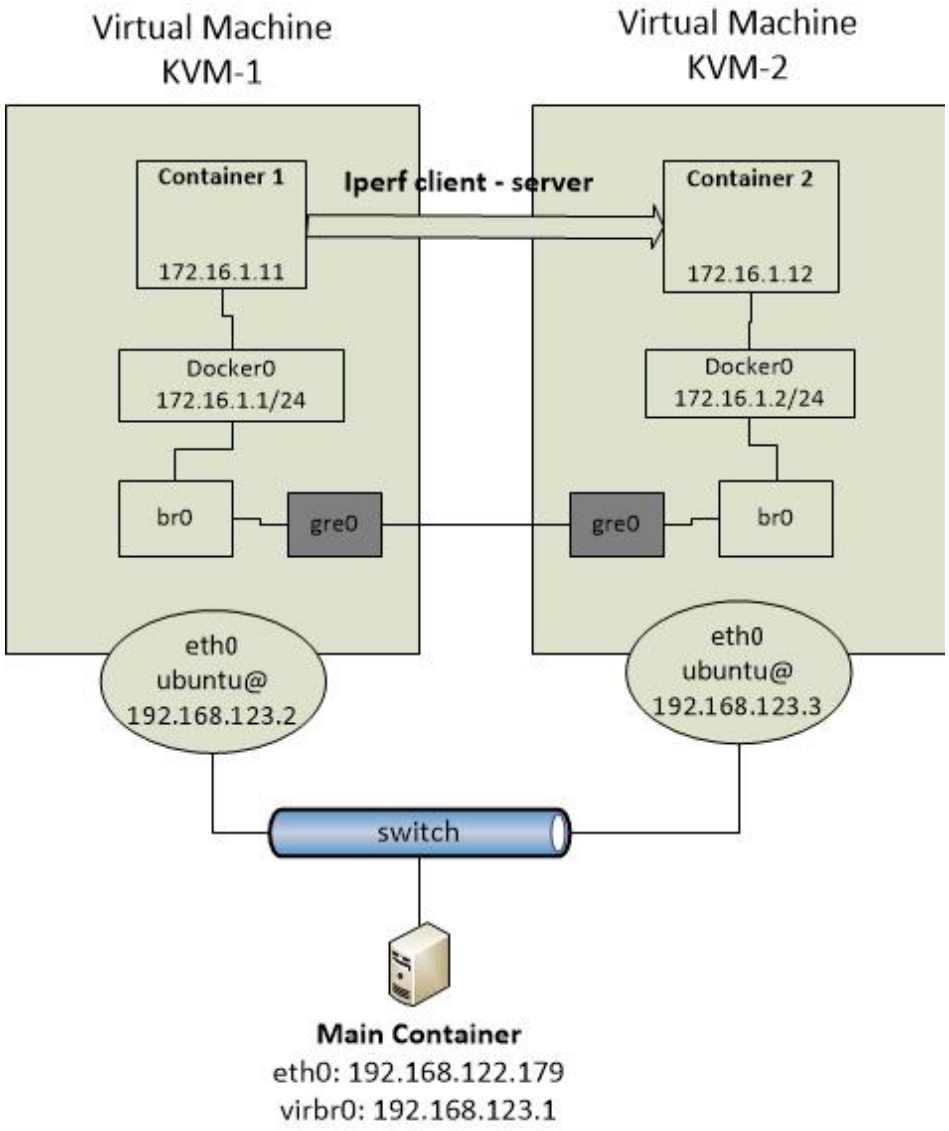
Testing GRE Tunnel

 # Testing the connectivity between dockers

-From the Container 1 to Container 2
Container1:/# ping 172.16.1.12
- From the Container 2 to Container 1
Container2:/# ping 172.16.1.11

 # Copy the binary 'iperf' from KVM1 to the container docker of KVM-1

KVM1: sudo cp /usr/bin/iperf /var/lib/docker/aufs/diff/**<ID-docker1>**/usr/bin/
KVM2: sudo cp /usr/bin/iperf /var/lib/docker/aufs/diff/<**ID-docker2**>/usr/bin/



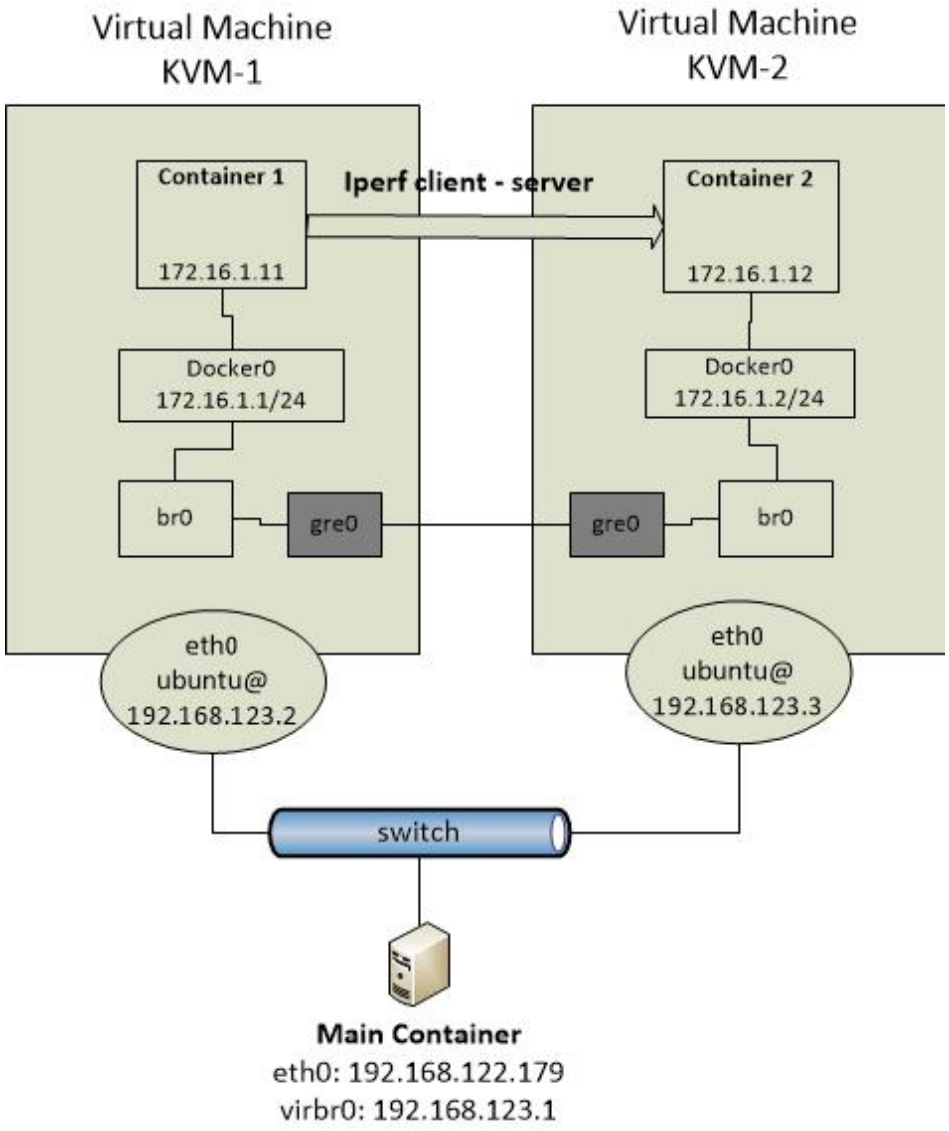
Testing GRE Tunnel

 # Verify the RTT using IPERF

From the Container Docker 172.16.1.12, we launch Iperf Server listening on TCP port 5001
$ sudo iperf -s

From the another Container Docker 172.16.1.11, we launch Iperf Client connecting to 172.16.1.12, TCP port 5001
$ sudo iperf -c 172.16.1.12

What can you say of the "Bandwith" ?



Hands-on #2

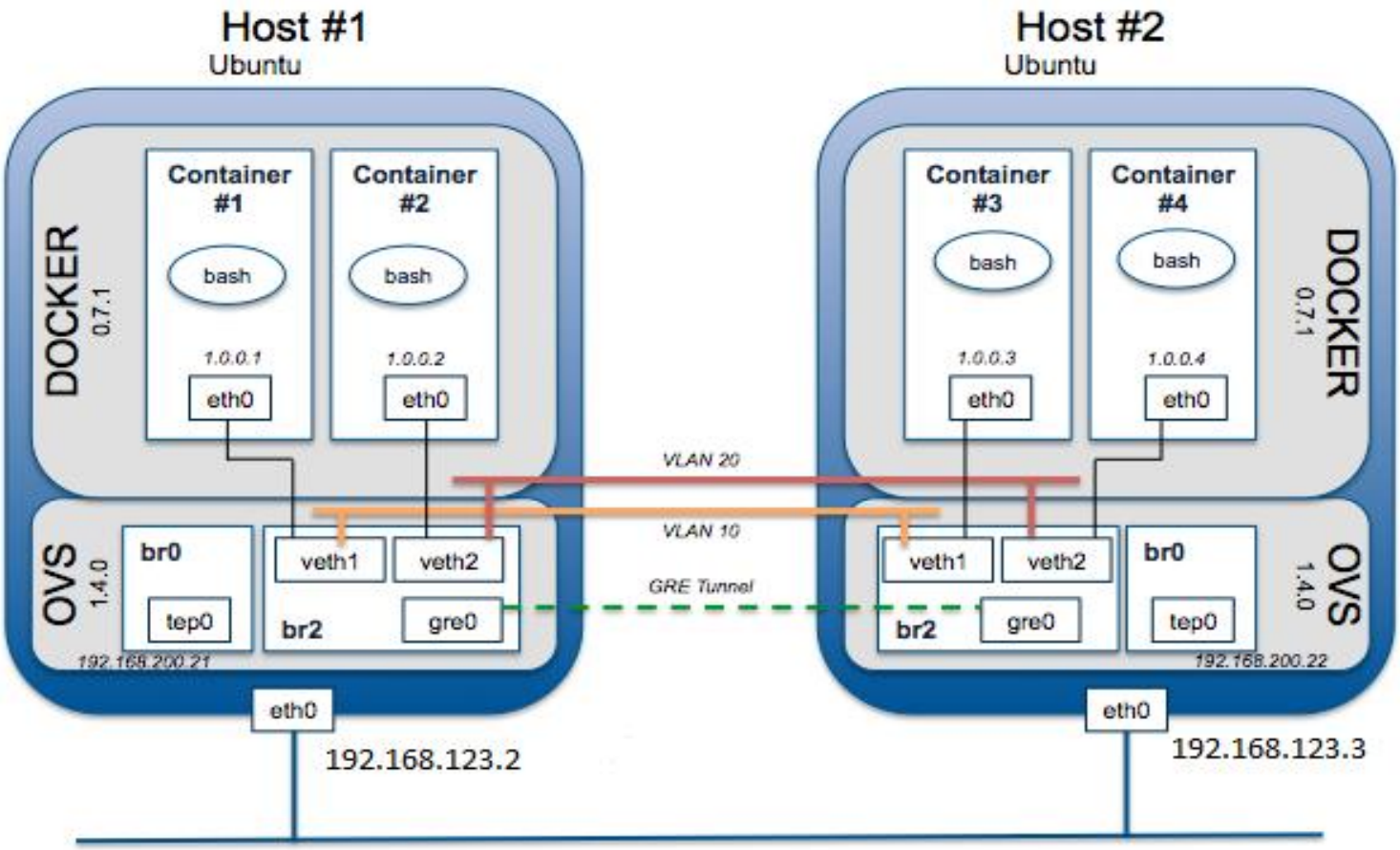


Fig: Work Environment with Docker and Open vSwitch

Docker with Open vSwitch and GRE Tunnel 1/7

Creating GRE Tunnel using OVS

 # Virtual Machine 1 (KVM-1)

```
$ sudo ovs-vsctl del-br br0
$ sudo ovs-vsctl add-br br0
$ sudo ovs-vsctl add-br br2
$ sudo ovs-vsctl add-port br0 tep0 -- set interface tep0 type=internal
$ sudo ifconfig tep0 192.168.200.21 netmask 255.255.255.0
$ sudo ovs-vsctl add-port br2 gre0 -- set interface gre0 type=gre\
options:remote_ip=192.168.123.3
```

 # Virtual Machine 2 (KVM-2)

```
$ sudo ovs-vsctl del-br br0
$ sudo ovs-vsctl add-br br0
$ sudo ovs-vsctl add-br br2
$ sudo ovs-vsctl br0 tep0 -- set interface tep0 type=internal
$ sudo ifconfig tep0 192.168.200.22 netmask 255.255.255.0
$ sudo ovs-vsctl add-port br2 gre0 -- set interface gre0 type=gre\
options:remote_ip=192.168.123.2
```

Docker with Open vSwitch and GRE Tunnel 2/7

Starting Containers

 # Virtual Machine 1 (KVM-1)

 # Delete the container docker created in the last exercise
$ docker stop container1
$ docker rm container1

 # Create two containers docker and set the network mode to none. Each containers is on a local variable.
$ C1=$(docker run -d --net=none -t -i --privileged --name=container1 --hostname=container1 intrig/tutorial:v3 /bin/bash)
$ C2=$(docker run -d --net=none -t -i --privileged --name=container2 --hostname=container2 intrig/tutorial:v3 /bin/bash)

Docker with Open vSwitch and GRE Tunnel 3/7

Starting Containers

 # Virtual Machine 2 (KVM-2)

 # Delete the container docker created in the last exercise
$ docker stop container2
$ docker rm container2

 # Create two containers docker and set the network mode to none. Each containers is on a local variable.
$ C3=$(docker run -d --net=none -t -i --privileged --name=container3 --hostname=container3 intrig/tutorial:v3 /bin/bash)
$ C4=$(docker run -d --net=none -t -i --privileged --name=container4 --hostname=container4 intrig/tutorial:v3 /bin/bash)

Docker with Open vSwitch and GRE Tunnel 4/7

Binding docker with Open Vswitch Interface

 # Virtual Machine 1 (KVM-1)

 # To know the PID value of the container created, we use the script findPID.sh

$./findPID.sh $C1

The PID value of the container created is: 6485 (for example). Same for $C2

 # Bind dockers with a Open vSwitch interface

$ sudo ./ovswork-1.sh br2 $C1 1.0.0.1/24 1.0.0.255 1.0.0.254 10
$ sudo ./ovswork-1.sh br2 $C2 1.0.0.2/24 1.0.0.255 1.0.0.254 20

 # Virtual Machine 2 (KVM-2)

 # Bind dockers with a OpenVswitch interface

$ sudo ./ovswork-1.sh br2 $C3 1.0.0.3/24 1.0.0.255 1.0.0.254 10
$ sudo ./ovswork-1.sh br2 $C4 1.0.0.4/24 1.0.0.255 1.0.0.254 20

Docker with Open vSwitch and GRE Tunnel 5/7

Initiating Docker

 # Using different terminals, start the container1, container2, container3, container4

From terminal 1:
$ docker start -a -i container1

From terminal 2:
$ docker start -a -i container2

From terminal 3:
$ docker start -a -i container3

From terminal 4:
$ docker start -a -i container4

Docker with Open vSwitch and GRE Tunnel 6/7

Testing of connectivity

 # From the Container1 (Terminal 1)

Container1$ ping 1.0.0.3 -c 2
Container1$ ping 1.0.0.4 -c 2

 # From the Container3 (Terminal 3)

Container3$ ping 1.0.0.1 -c 2
Container3$ ping 1.0.0.2 -c 2

What ping is successful? And why?

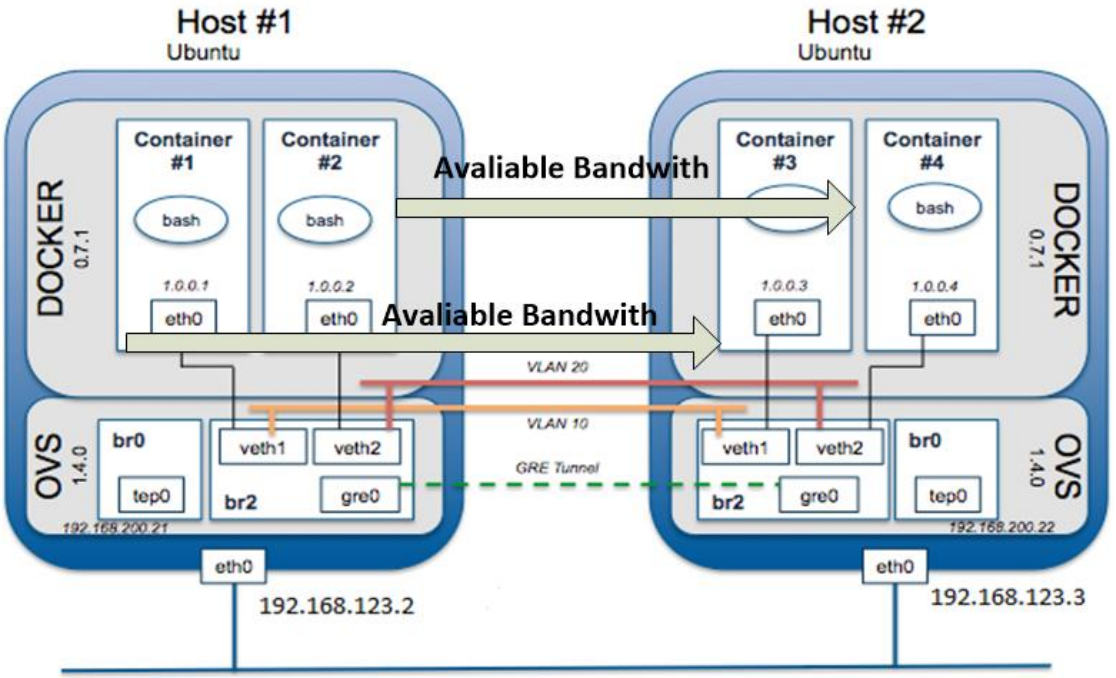
root@container1:/# ping 1.0.0.3
PING 1.0.0.3 (1.0.0.3) 56(84) bytes of data.
64 bytes from 1.0.0.3: icmp_seq=1 ttl=64 time=2.52 ms
64 bytes from 1.0.0.3: icmp_seq=2 ttl=64 time=0.651 ms

Docker with Open vSwitch and GRE Tunnel 7/7

Testing of connectivity with Iperf

Verify the RTT using IPERF
From the Container #1 1.0.0.3 launch Iperf Server listening on TCP port 5001
$ sudo iperf -s
From the another Container #3, launch Iperf Client connecting to 1.0.0.3, TCP port 5001
$ sudo iperf -c 1.0.0.3

What can you say of the "Bandwith" ?

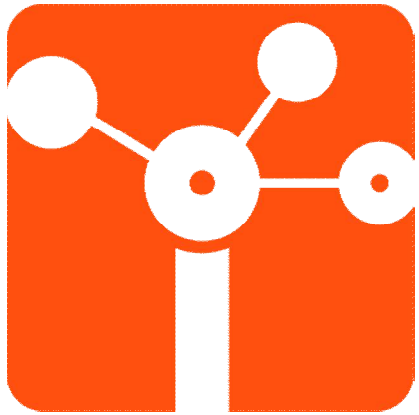


 # Virtual Machine 1 (KVM-1)

$ sudo ovs-vsctl show br2
$ sudo ovs-ofctl show br2
$ sudo ovs-ofctl dump-flows br2

 # Virtual Machine 2 (KVM-2)

$ sudo ovs-vsctl show br2
$ sudo ovs-ofctl show br2
$ sudo ovs-ofctl dump-flows br2



Questions?

THANKS

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