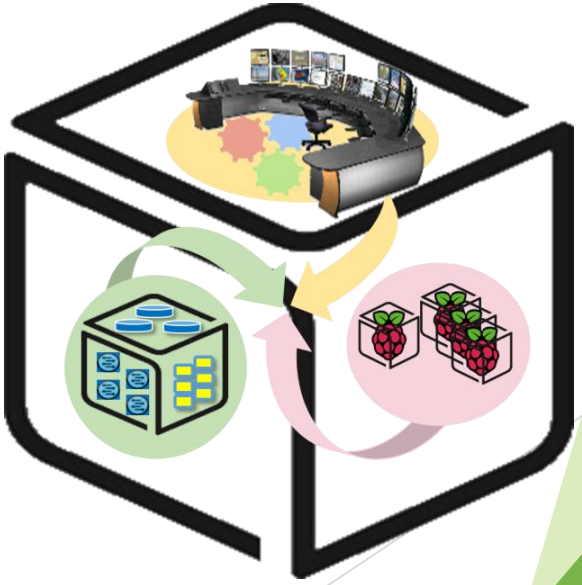
SmartX Labs
for Computer Systems

Box Lab v6

(2016, Spring)



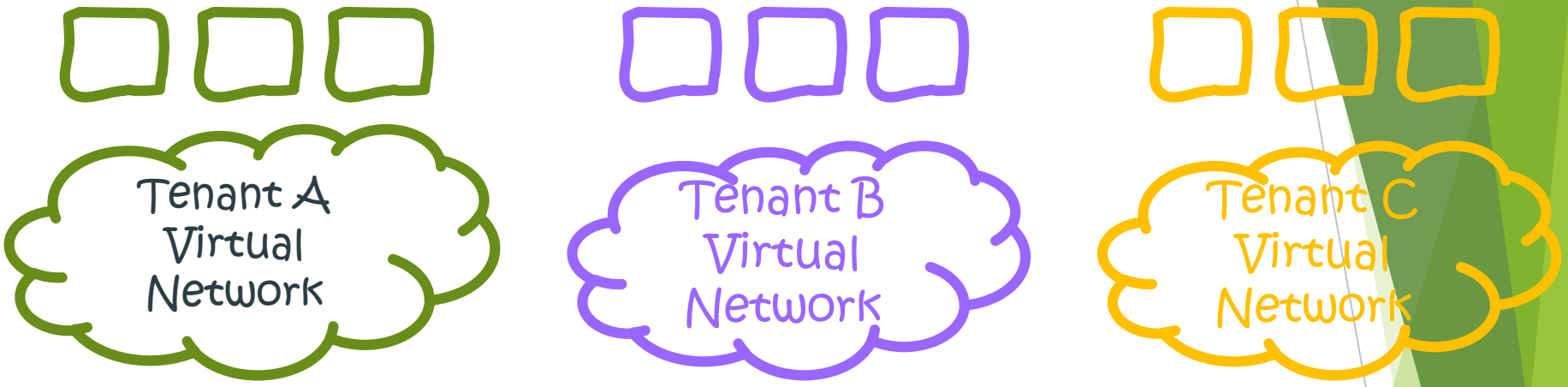
NetCS Lab

History and Contributor of Box Lab (2016. 04. 20)

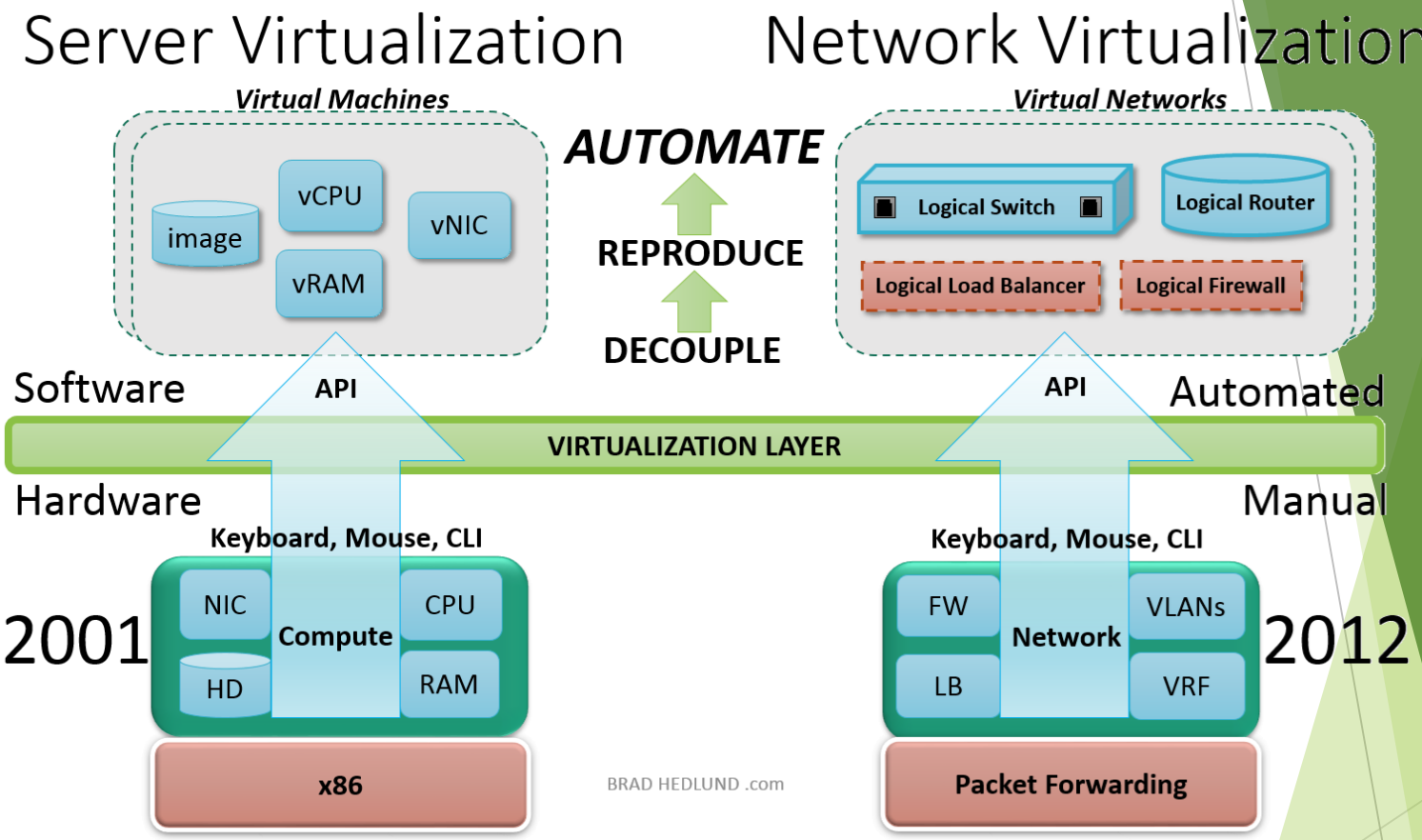
Version	Updated Date	Updated Contents	Contributor
v01	2015/09	OvS, Docker 자료 초안 작성	배 정 주
v02	2015/09	KVM 자료 초안 작성	윤 희 범
v03	2015/10	자료 취합 및 Functions Lab 초안 제작	배 정 주
v04	2015/10	Functions Lab 자료 편집 및 수정	윤 희 범
v05	2016/03	Function Lab → Box Lab 이전 작업, 세부자료 수정	남 택 호
v06	2016/04	추가 설명자료 및 단어 교정, History 작성	남 택 호

Outline / Contents 추가 예정

Virtualization: Basic Concept



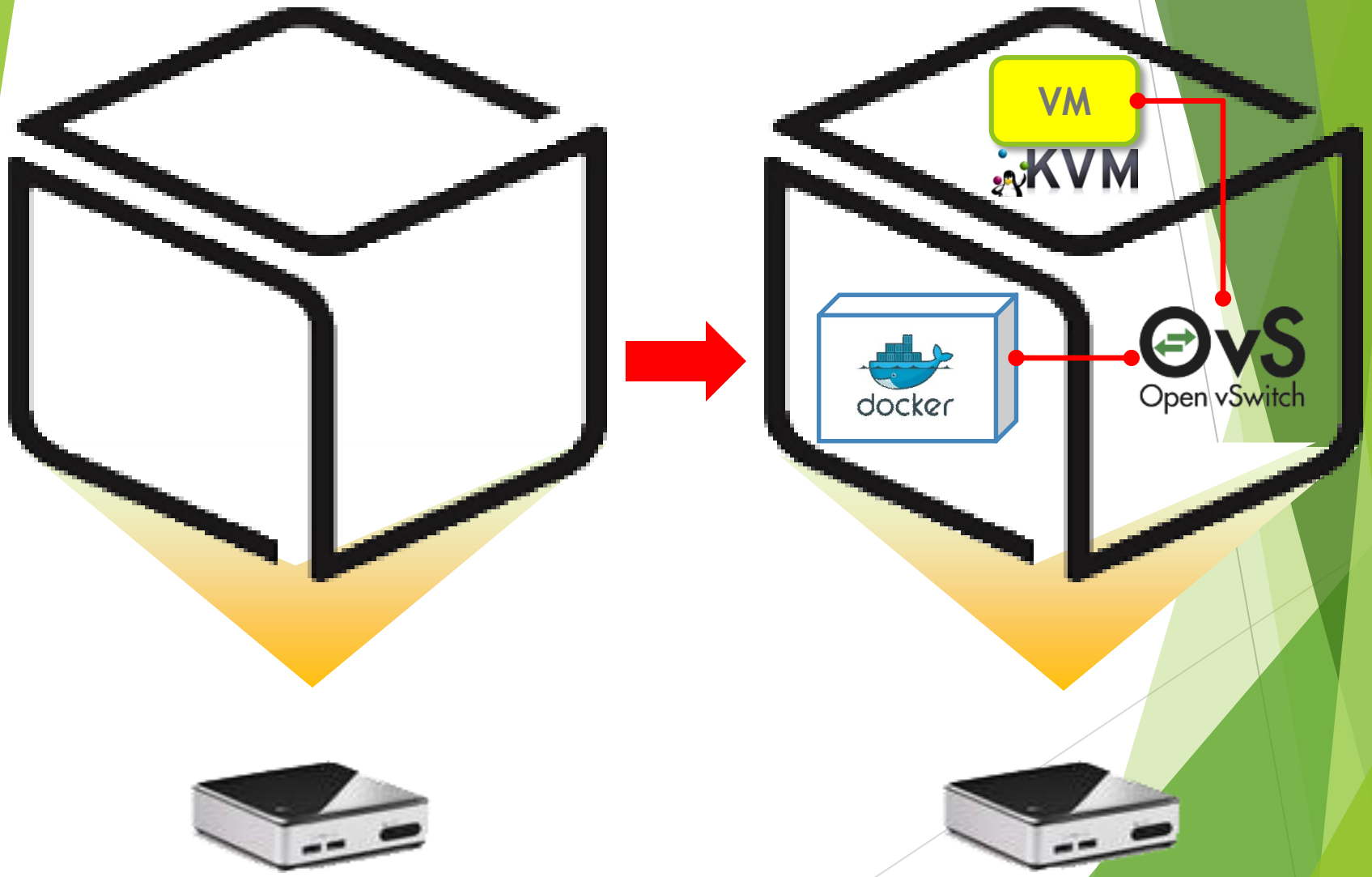
Virtualization: Basic Concept



- Virtualization is the basic act of **decoupling** an infrastructure service from the physical assets on which that service operates. With the virtual network fully decoupled, the physical network configuration is simplified to provide packet forwarding service from one hypervisor to the next

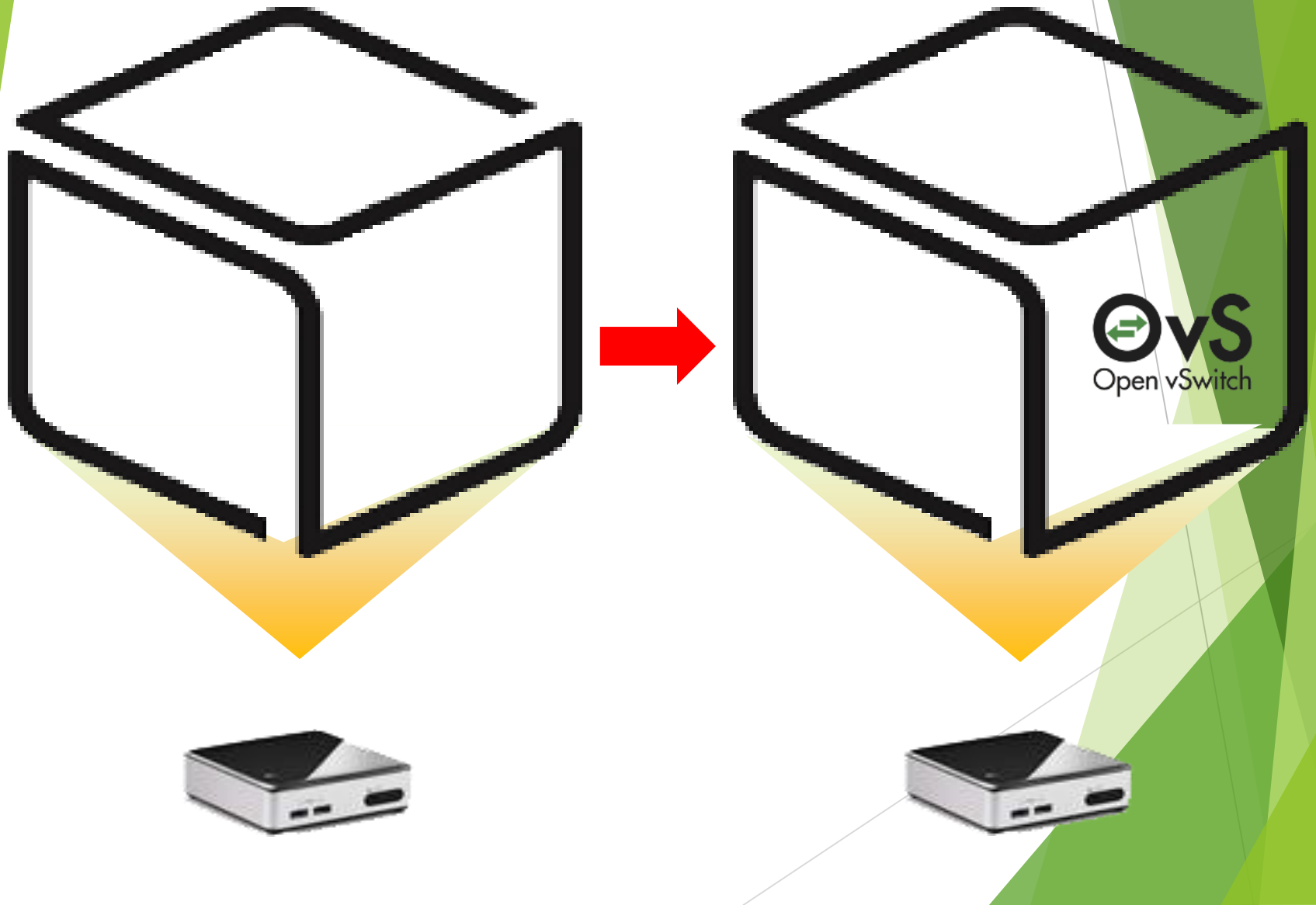
http://bradhedlund.com/2013/05/28/what-is-network-virtualization/

Box Lab: Final Goal



Open vSwitch: Goal of this part

- Update and Configuration



vSwitches: Virtual(soft) Switches

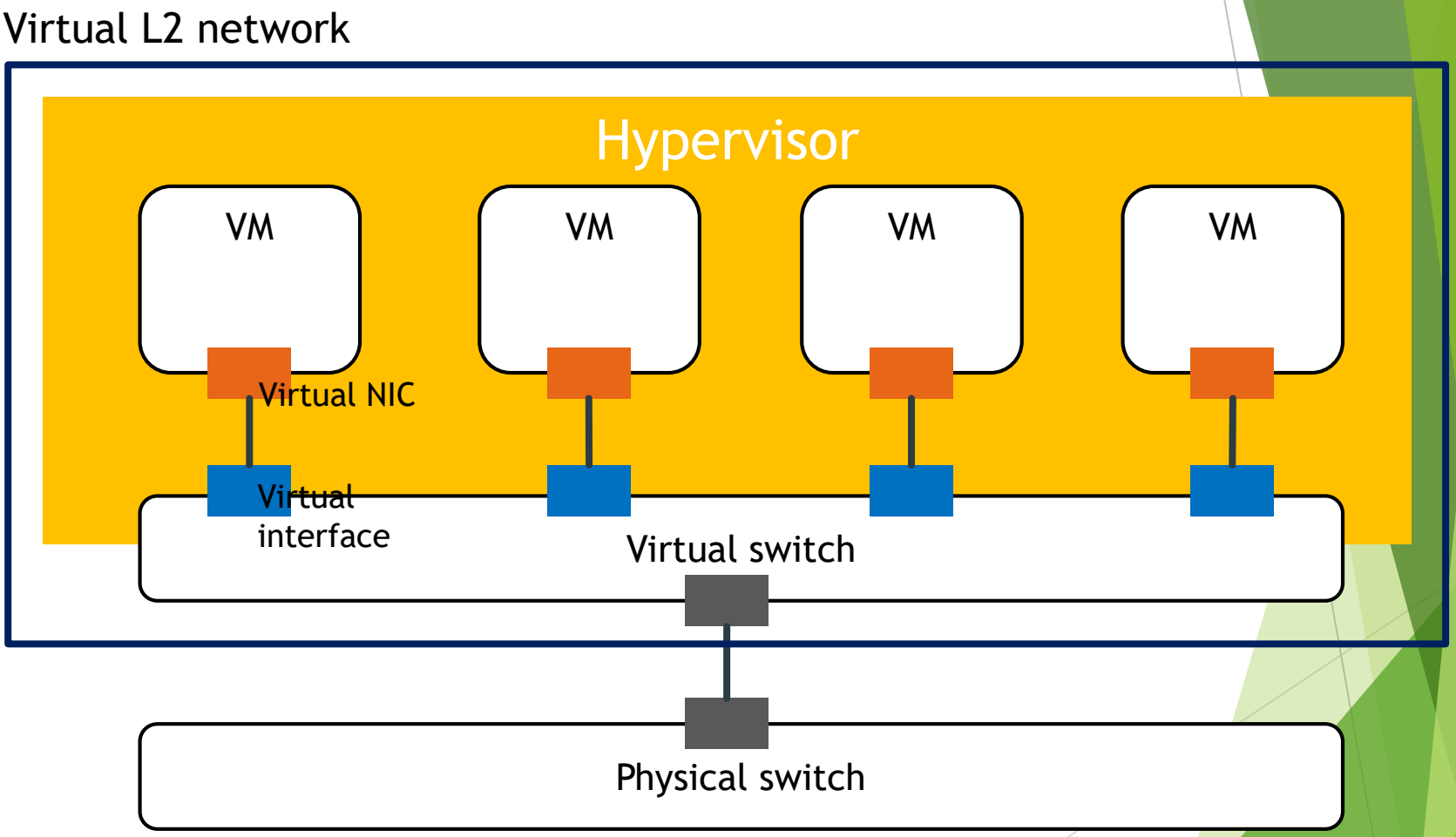
- A switch for every server means a 50:1 (virtual : physical) ratio; Approaching feature-parity with hardware switches: Visibility, ACLs, Quality of Service; Optionally leveraging hardware off-loading
- Tight integration with hypervisor ➔ Good for virtual edge (e.g., inter-VM) networking, network overlay: the leading initial NV use case
- Centralized management

- VMWare, Nicira (open & proprietary), Cisco, IBM, Microsoft
  - VMware vSwitch (vDS), Cisco Nexus 1000V, **Open vSwitch**

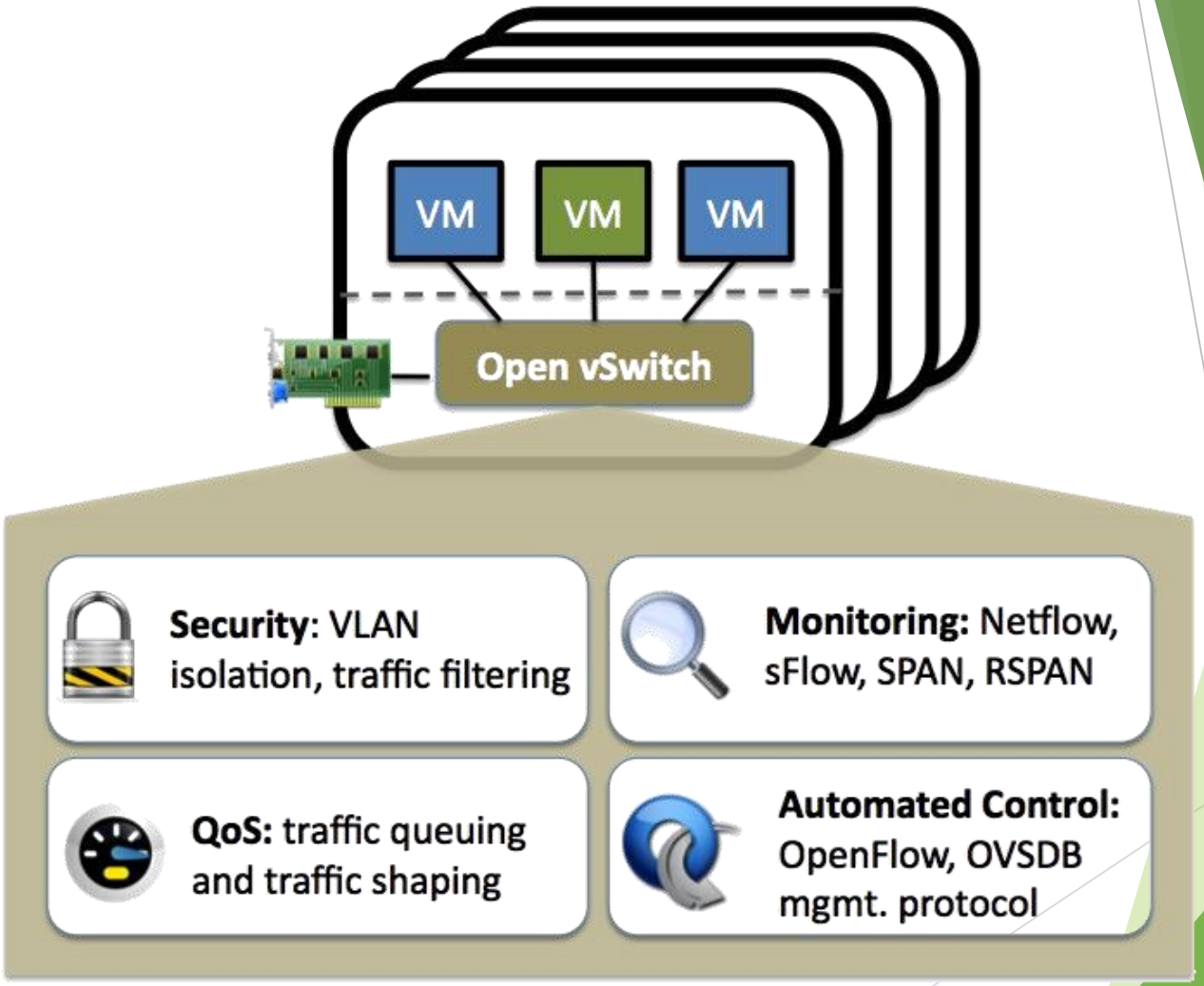
Virtual Switches: Soft vs Hardware

- H/W Switches: With an approach like pass through + tagging + switching in the NIC (with enforcement in the first hop switch); Latency is reduced to the wire speed; Packet classification noticeably outperforms x86-based software switches.
- S/W Switches: Flexibility and upgrade cycle of software + Benefits of virtualization (memory overcommit, page sharing, etc.); Simple resource efficiency
  - Can saturate a 10G link from a guest to the wire with less than a x86 CPU core (assuming MTU size packets), Can saturate a 1G link with less than 20% of a core. In the case of Open vSwitch, these numbers include full packet lookup over L2, L3 and L4 headers.

Virtual Switch: Basic Architecture

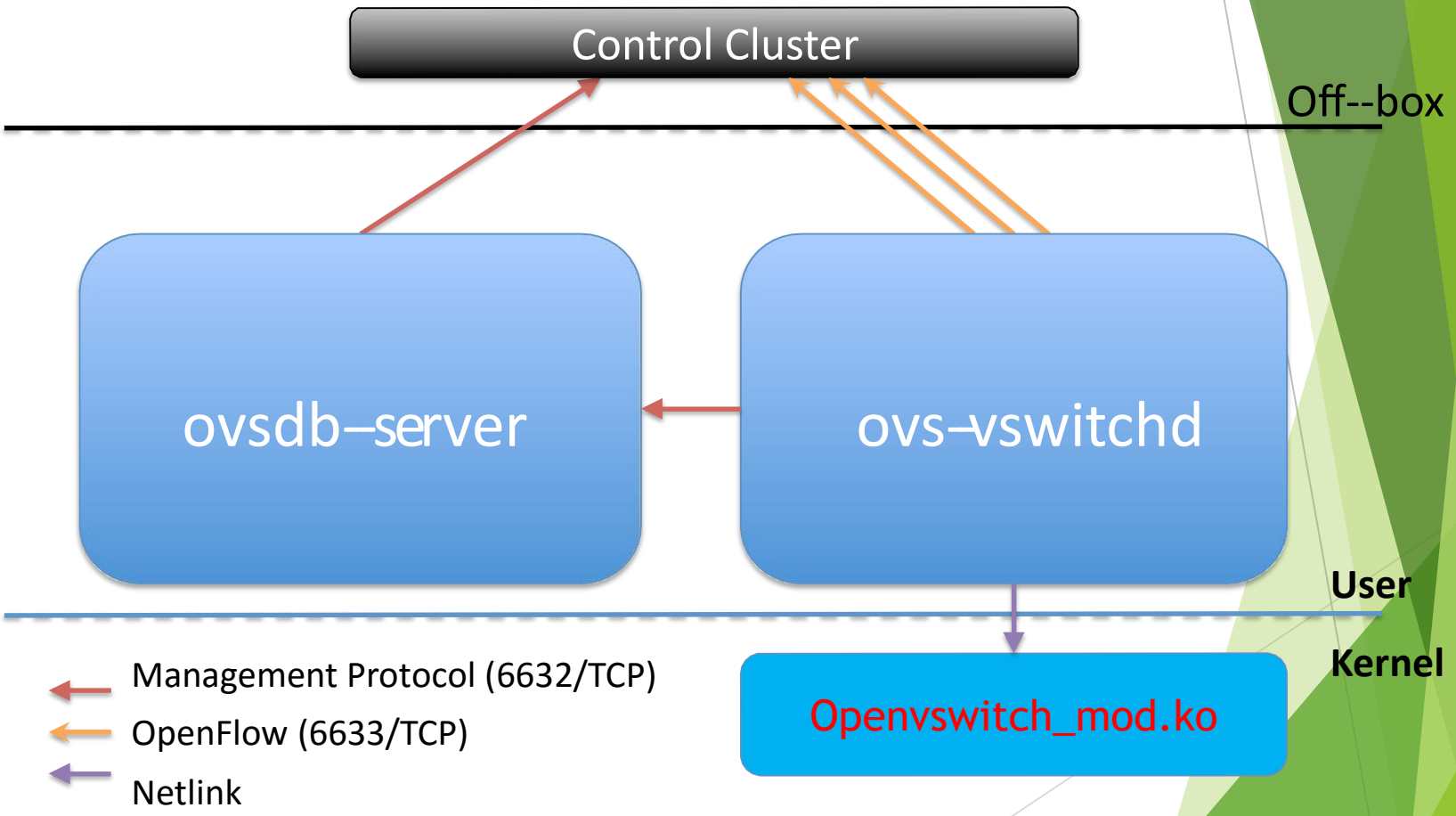


Open vSwitch: Introduction

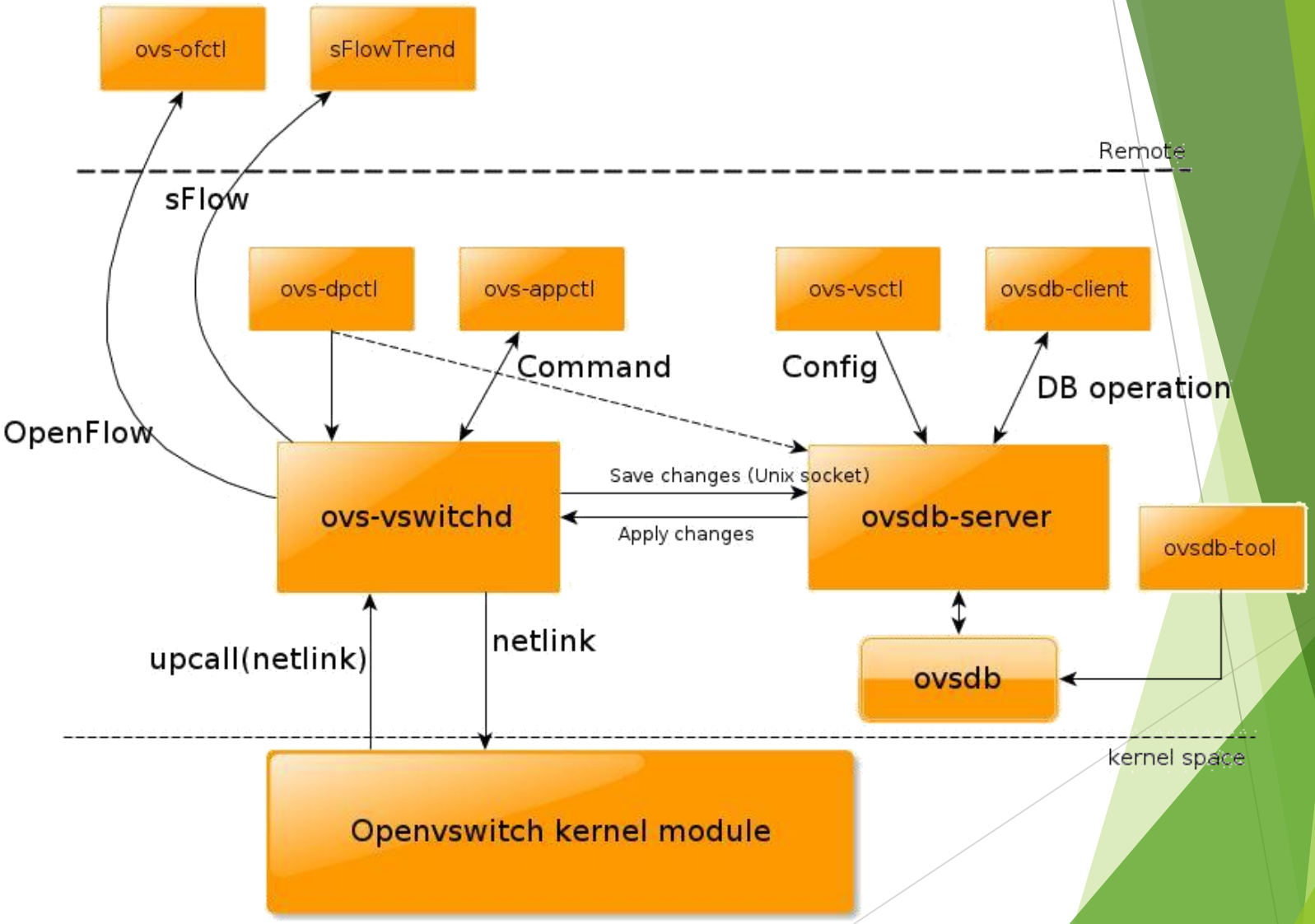


http://openvswitch.org/

Open vSwitch: Main Components



Open vSwitch: All Components



Prerequisite for Box Lab

Installed 64bit Ubuntu 14.04 LTS in Intel NUC
(We recommend to use desktop version)

OpenVswitch
- Update & Install

Update index information of Open vSwitch package.
Install a Open vSwitch package, openvswitch-switch.
Other dependencies are automatically installed.

$sudo apt-get update
$sudo apt-get install openvswitch-switch

```
tein@SmartXCIServer:~$ sudo apt-get install openvswitch-
openvswitch-common            openvswitch-ipsec
openvswitch-controller        openvswitch-pki
openvswitch-datapath-dkms     openvswitch-switch
openvswitch-datapath-source   openvswitch-test
openvswitch-dbg
```

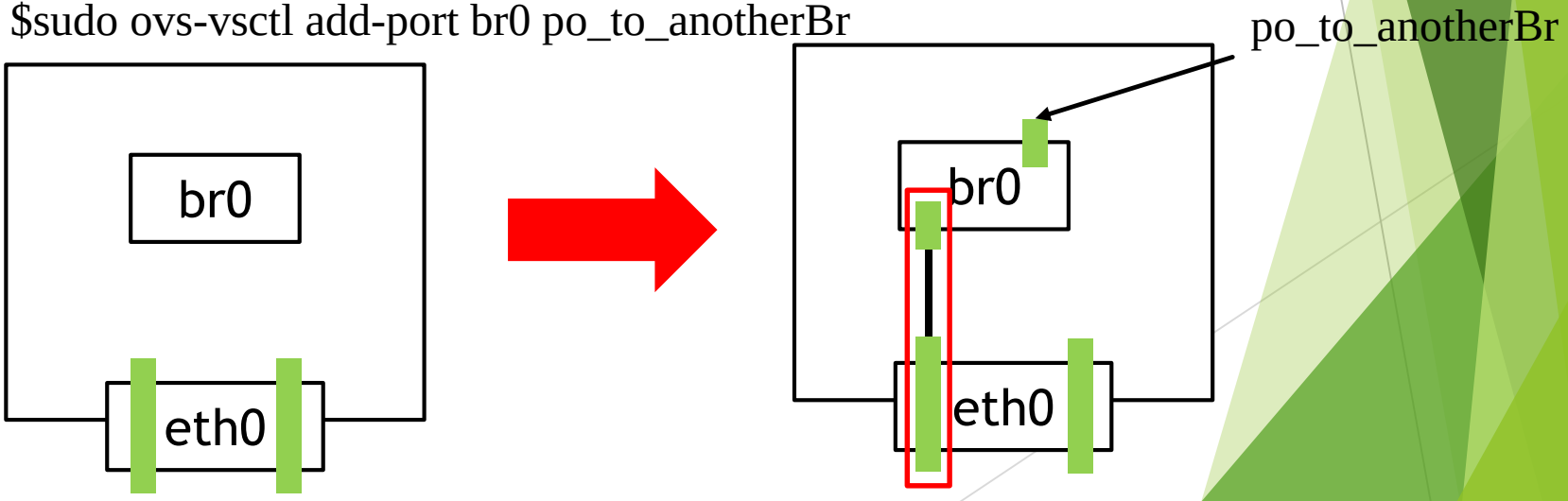
Open vSwitch
- Basic command (ovs-vsctl)

$sudo ovs-vsctl add-br <bridge_name>
$sudo ovs-vsctl add-port <bridge_name> <NIC>
$sudo ovs-vsctl add-port <bridge_name> <port_name>
$sudo ovs-vsctl del-br <bridge_name>
$sudo ovs-vsctl del-port <port_name>

Example)

※You don't need to follow below command.

$sudo ovs-vsctl add-br br0
$sudo ovs-vsctl add-port br0 eth0
$sudo ovs-vsctl add-port br0 po_to_anotherBr

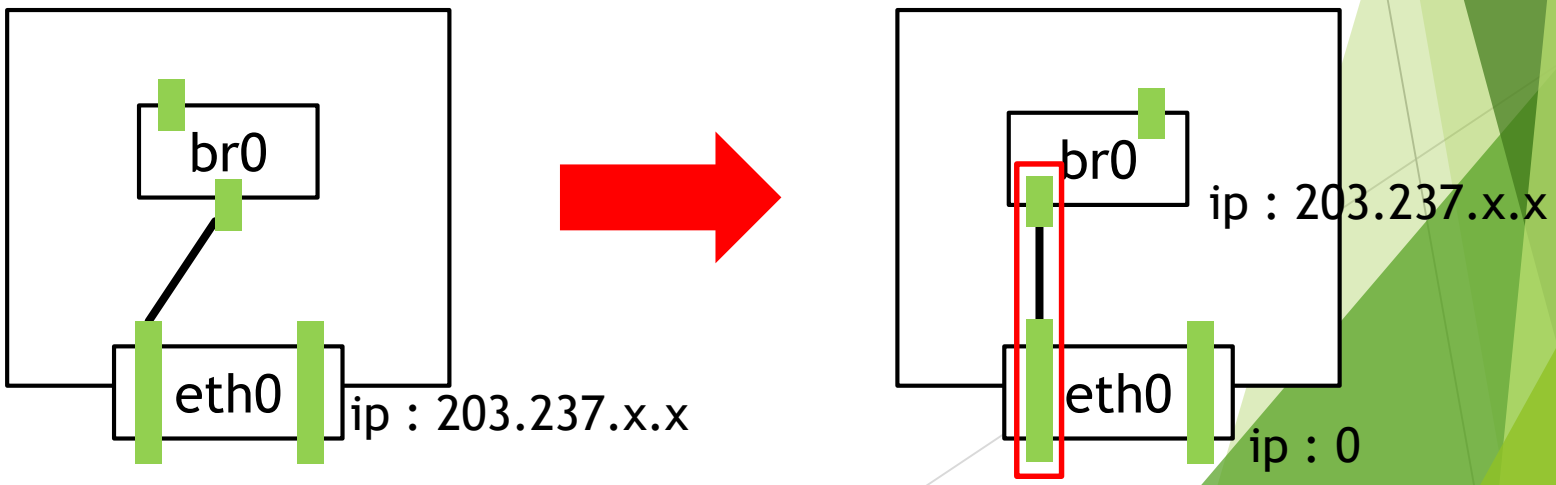


Open vSwitch
- Interface configuration setting

Example)

※You don't need to follow below command.

$sudo ifconfig eth0 0
$sudo ifconfig br0 0
$sudo ifup br0
$sudo ifconfig br0 up
$sudo ifconfig br0 203.237.x.x
$sudo ifconfig eth0 up



Open Vswitch
- Configure bridged networking

Modify network interface configuration.

$sudo vi /etc/network/interfaces

---------- /etc/network/interfaces ----------

```
# The primary network interface
auto (eth0->)br0
iface (eth0->)br0 inet static
…
```

before

```
# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
auto eth0
Iface eth0 inet static
        address 123.45.67.89
        netmask 255.255.255.0
        network 123.45.67.0
        broadcast 123.45.67.255
        gateway 123.45.67.1
        dns-nameservers 8.8.8.8
```

After

```
# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
auto br0
Iface br0 inet static
        address 123.45.67.89
        netmask 255.255.255.0
        network 123.45.67.0
        broadcast 123.45.67.255
        gateway 123.45.67.1
        dns-nameservers 8.8.8.8
```

Open Vswitch
- Configure bridged networking

$sudo ovs-vsctl add-br br0

```
nuc@nuc:~$
nuc@nuc:~$ sudo su -
[sudo] password for nuc:
root@nuc:~# ovs-vsctl show
3bb93923-3eac-420a-9da9-9143aff14209
    Bridge "br0"
        Port "br0"
            Interface "br0"
                type: internal
    ovs_version: "2.0.2"
```

Open Vswitch
- Configure bridged networking

$sudo ovs-vsctl add-port br0 eth0

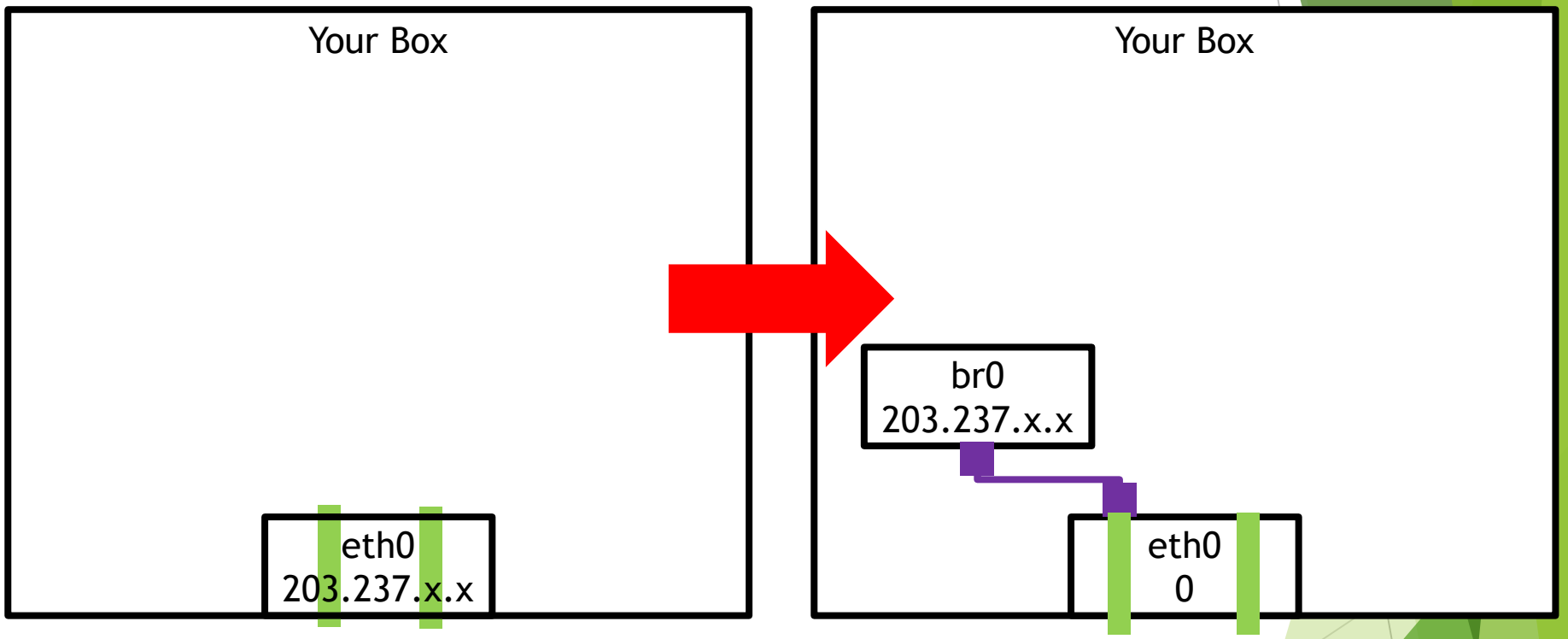
```
root@nuc:~# ifconfig
br0       Link encap:Ethernet  HWaddr 86:f9:ed:3c:74:42
          inet addr:210.125          Bcast:210.125.84.255  Mask:255.255.255.0
          inet6 addr: fe80::fccc:4fff:fe23:4e1c/64 Scope:Link
          UP BROADCAST RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:648 (648.0 B)

em1       Link encap:Ethernet  HWaddr ec:a8:6b:fb:a2:09
          inet addr:210.125          Bcast:210.125.84.255  Mask:255.255.255.0
          inet6 addr: fe80::eea8:6bff:fefb:a209/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:10899 errors:0 dropped:0 overruns:0 frame:0
          TX packets:566 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:3485825 (3.4 MB)  TX bytes:78389 (78.3 KB)
          Interrupt:20 Memory:f7c00000-f7c20000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:4 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:366 (366.0 B)  TX bytes:366 (366.0 B)
```

eth0 인터페이스가 global 영역에서 bridge 영역으로 이동하기 때문에 연결이 끊김

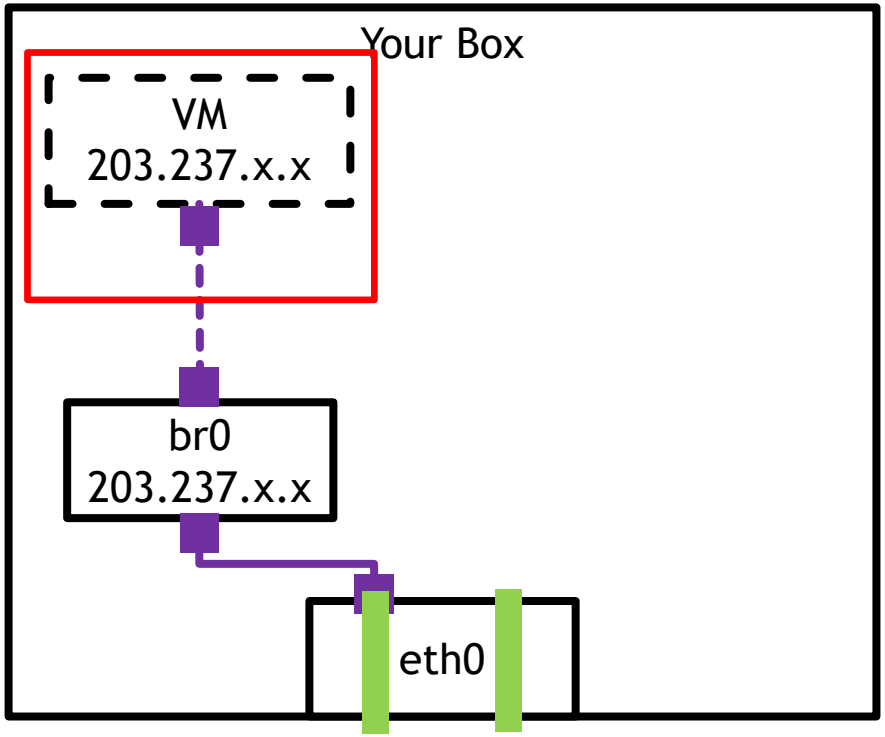
Open Vswitch
- Configure bridged networking

```
$sudo ifconfig eth0 0          // IP of eth0 → None
$sudo ifconfig br0 0           // IP of br0 → None
$sudo ifup br0                 // interface br0 turn on
$sudo ifconfig br0 up          // interface br0 turn on
$sudo ifconfig eth0 up
```

Open Vswitch
- Situation



Open Vswitch
- Goal of this section



Stop OvS setting, Now need to build KVM

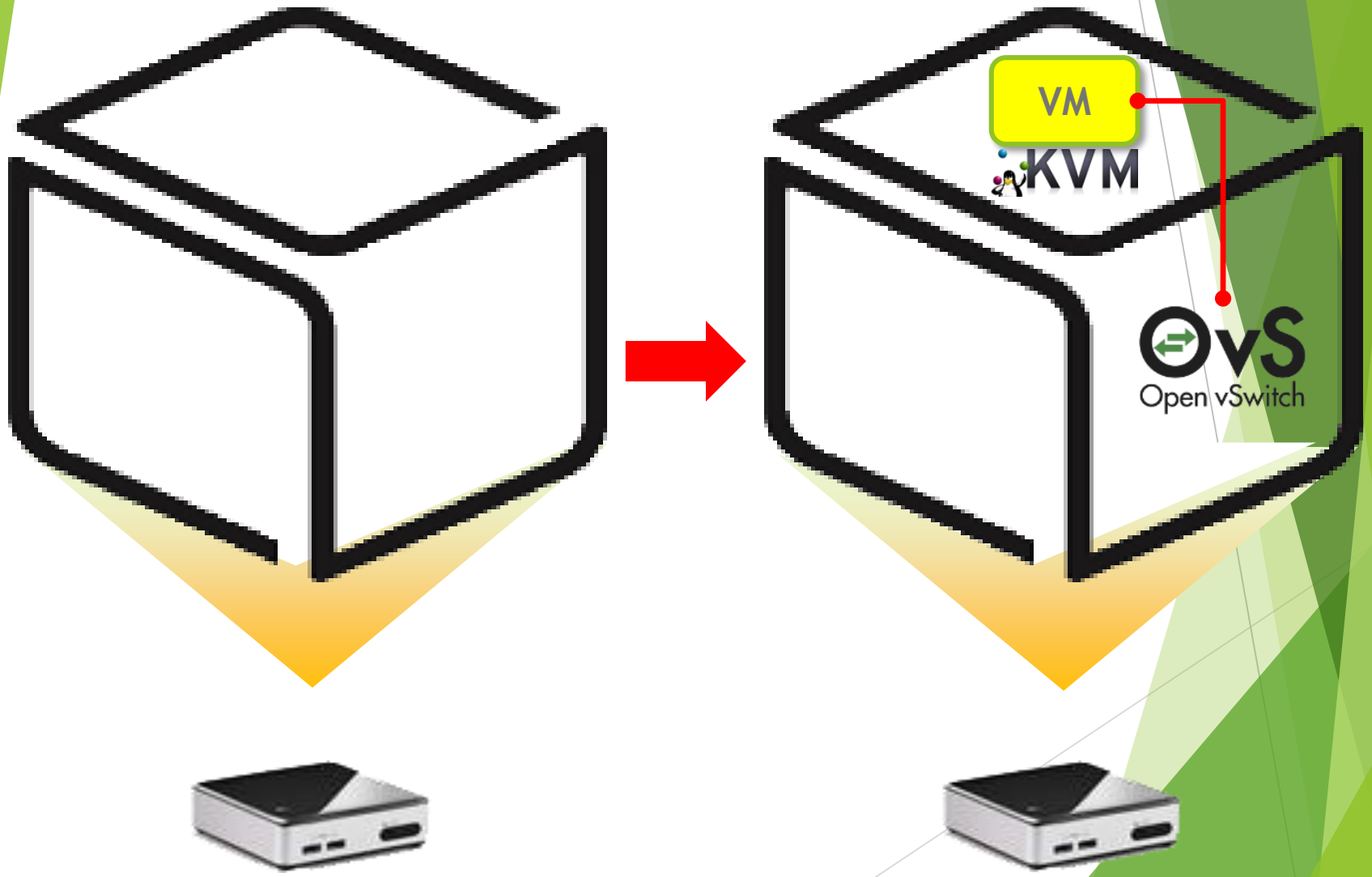
Modify
- /etc/rc.local

Modify /etc/rc.local

```
$sudo vi /etc/rc.local

ifconfig eth0 up
```

Whenever NUC is rebooted,
interface configuration is initialized
by executing commands in rc.local

KVM: Goal of this part



What is KVM?

- KVM (for Kernel-based Virtual Machine) is a full virtualization solution for Linux on x86 hardware containing virtualization extensions (Intel VT or AMD-V). It consists of a loadable kernel module, kvm.ko, that provides the core virtualization infrastructure and a processor specific module, kvm-intel.ko or kvm-amd.ko.
- Using KVM, one can run multiple virtual machines running unmodified Linux or Windows images. Each virtual machine has private virtualized hardware: a network card, disk, graphics adapter, etc.
- KVM is open source software. The kernel component of KVM is included in mainline Linux, as of 2.6.20. The userspace component of KVM is included in mainline QEMU, as of 1.3.

KVM
- install dependency to upgrade KVM

Install dependency & download Ubuntu 14.04.3 64bit server image.

$sudo apt-get install qemu-kvm libvirt-bin //upgrade KVM
//qemu is open-source emulator

$wget http://releases.ubuntu.com/14.04.3/ubuntu-14.04.3-server-amd64.iso
(official)

//If above URL is can't be downloaded, try below URL(dropbox link)

$wget https://www.dropbox.com/s/v6pwrksl9xdnvux/ubuntu-14.04.3-server-amd64.iso
(dropbox link, recommended)

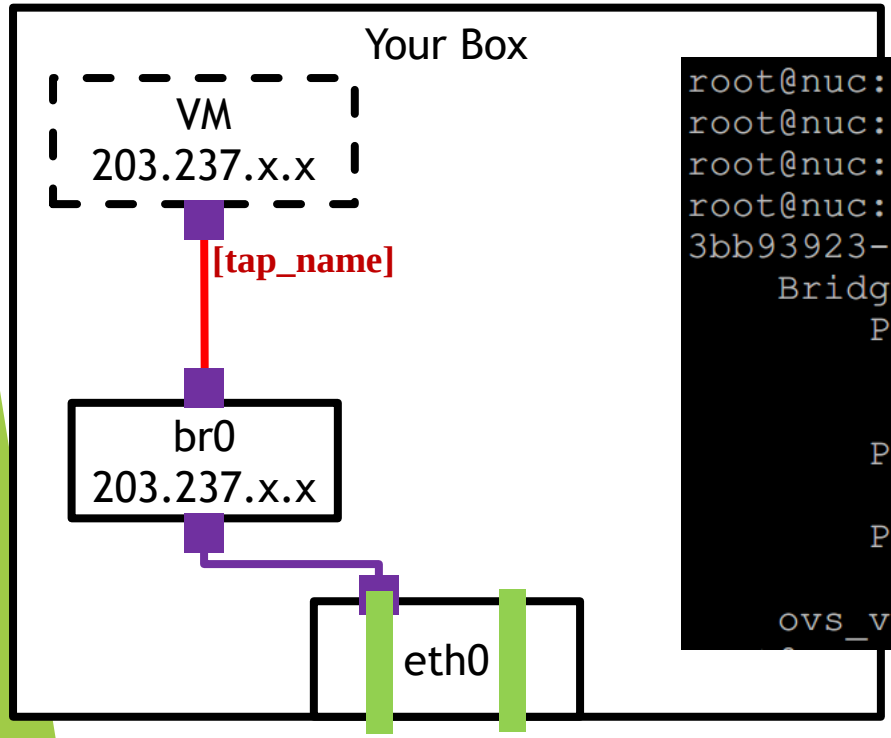
Now we are ready to make VM. So continue the setting.

Open Vswitch
- Configure bridged networking

Make a tap and attach to VM.

```
$sudo ip tuntap add mode tap [tap_name]
$sudo ifconfig [tap_name] up
$sudo ovs-vsctl add-port br0 [tap_name]          // Turn on and attach to br0
```

This tap device will be attached VM. You can think this tap as a NIC of VM.




```
root@nuc:~# ip tuntap add mode tap vport_vFunction
root@nuc:~# ifconfig vport_vFunction up
root@nuc:~# ovs-vsctl add-port br0 vport_vFunction
root@nuc:~# ovs-vsctl show
3bb93923-3eac-420a-9da9-9143aff14209
    Bridge "br0"
        Port "br0"
            Interface "br0"
                type: internal
        Port "em1"
            Interface "em1"
        Port vport_vFunction [tap_name]
            Interface vport_vFunction
    ovs_version: "2.0.2"
```

KVM
- Prepare for Ubuntu VM

Make a VM image.

$sudo qemu-img create [img_name].img -f qcow2 [storage_capacity]

```
nuc@nuc:~/VMs$ sudo qemu-img create vFunction20.img -f qcow2 10G
Formatting 'vFunction20.img', fmt=qcow2 size=10737418240 encryption=off cluster_size=65536 lazy_refcounts=off
```

Boot VM image from Ubuntu iso file (mac should be different from others).

$sudo kvm -m [memory_capacity] -name [vm_name] -smp cpus=[#cpu],maxcpus= [#maxcpu] -device virtio-net-pci,netdev=net0,mac= [EE:EE:EE:EE:EE:EE] -netdev tap,id=net0,ifname=[tap_name],script=no -boot d [img_name].img -cdrom ubuntu-14.04.3-server-amd64.iso -vnc :[#] -daemonize

```
sudo kvm -m 512 -name tt -smp cpus=1,maxcpus=1 -device virtio-net-pci,netdev=net0,mac='EE:EE:EE:EE:EE:77' -netdev tap,id=net0,ifname=vport_vFunction,script=no -boot d tt.img -cdrom ubuntu-14.04.3-server-amd64.iso -vnc :5 -daemonize
```

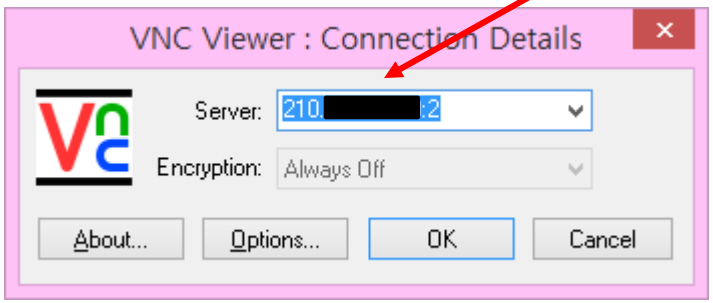
Download VNC viewer to see inside of VM

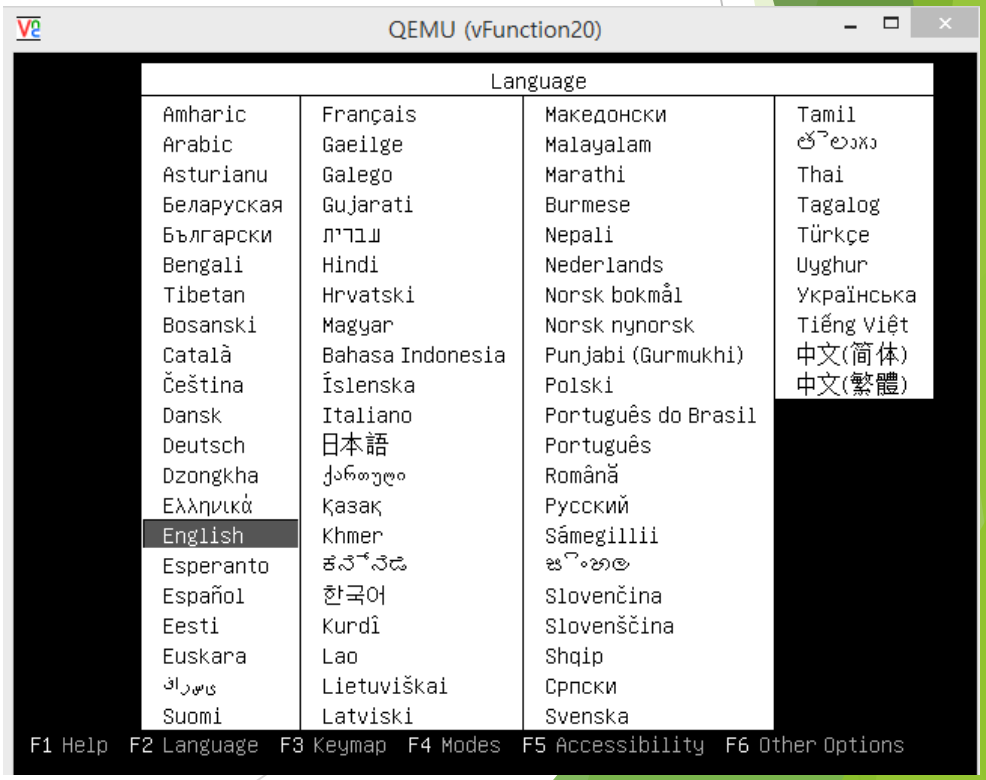
Windows : https://www.dropbox.com/s/h2mr0g8obm5mgpe/vncviewer.exe?dl=0

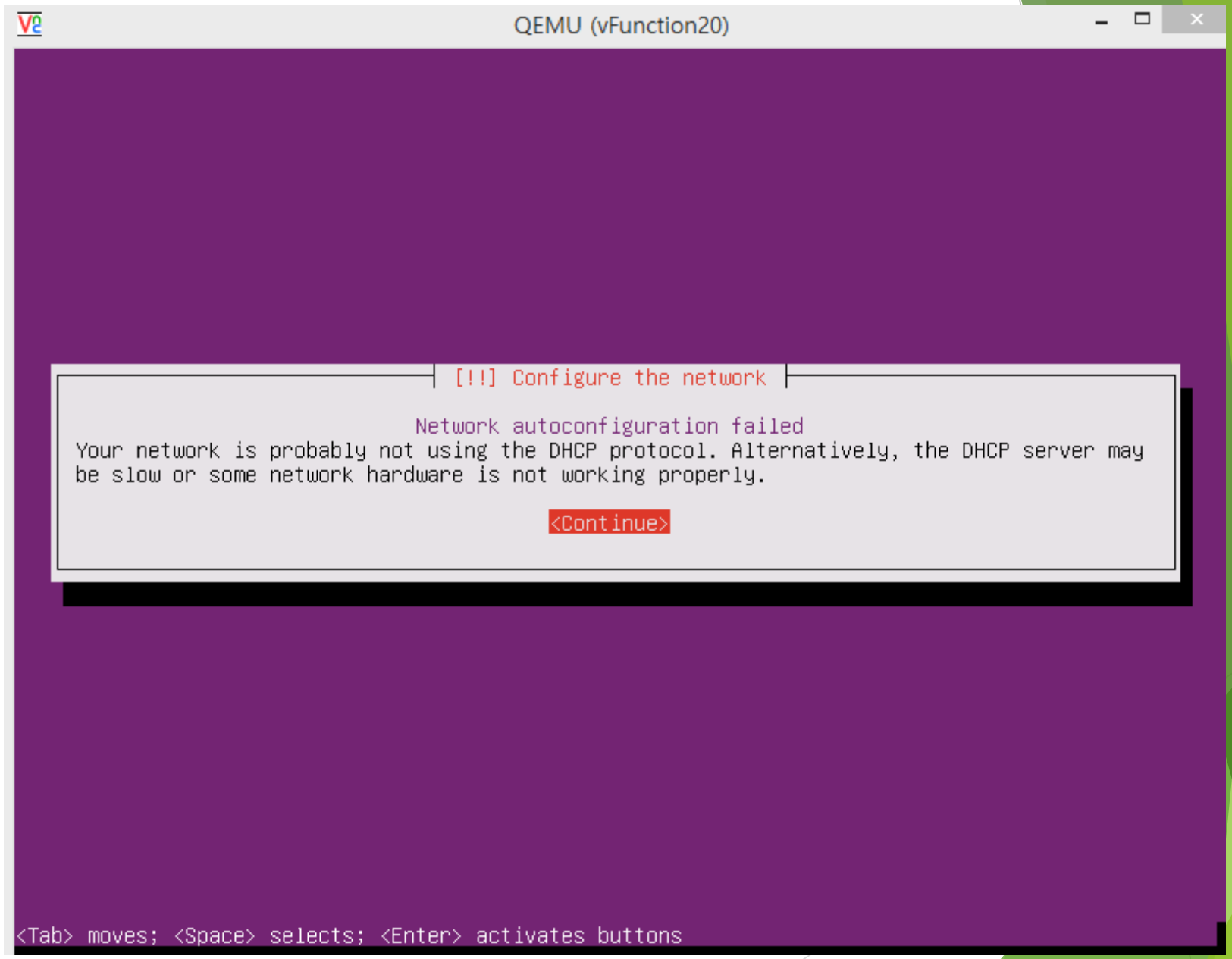
Ubuntu : sudo apt-get install xvnc4viewer

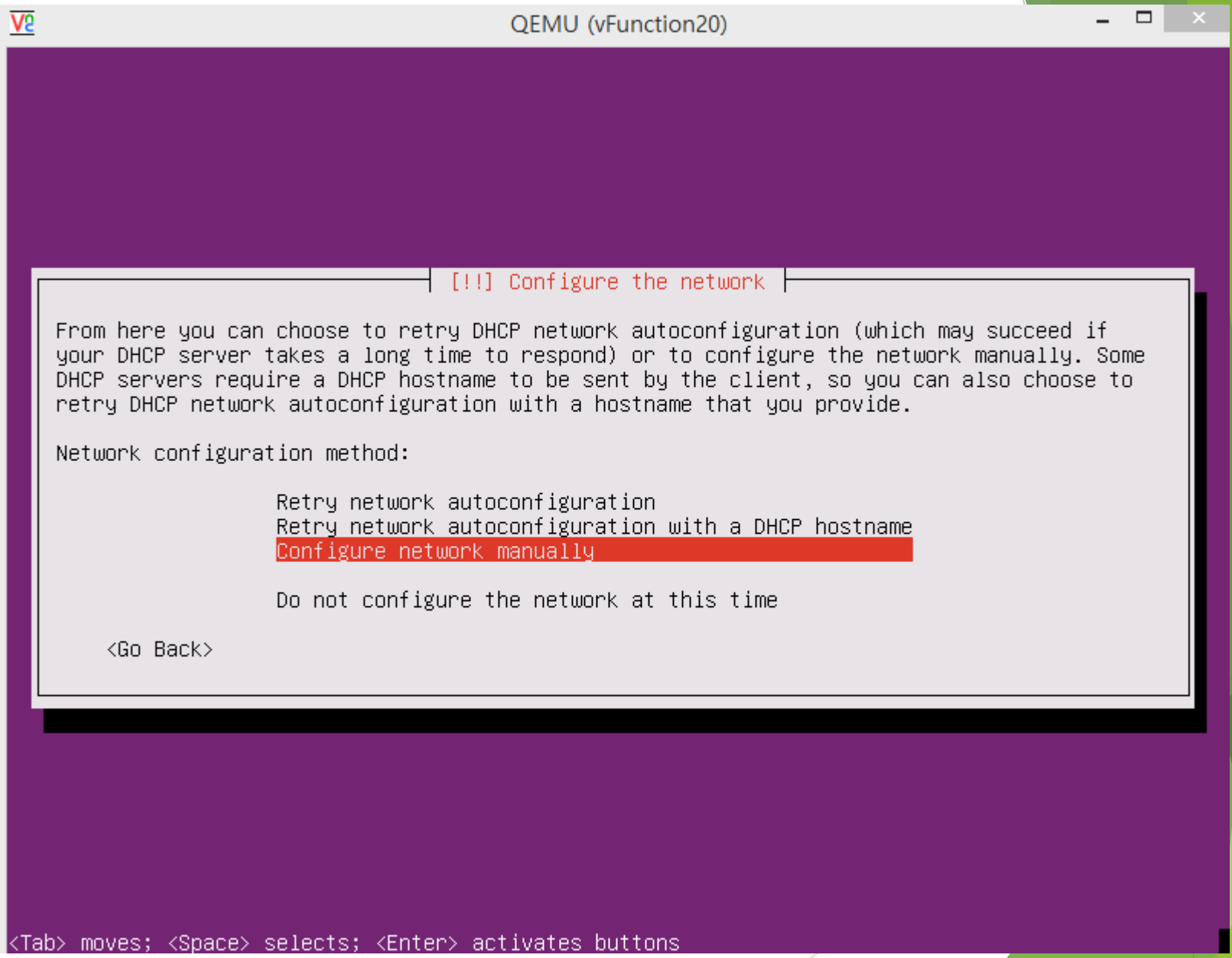
KVM
- Install Ubuntu to VM

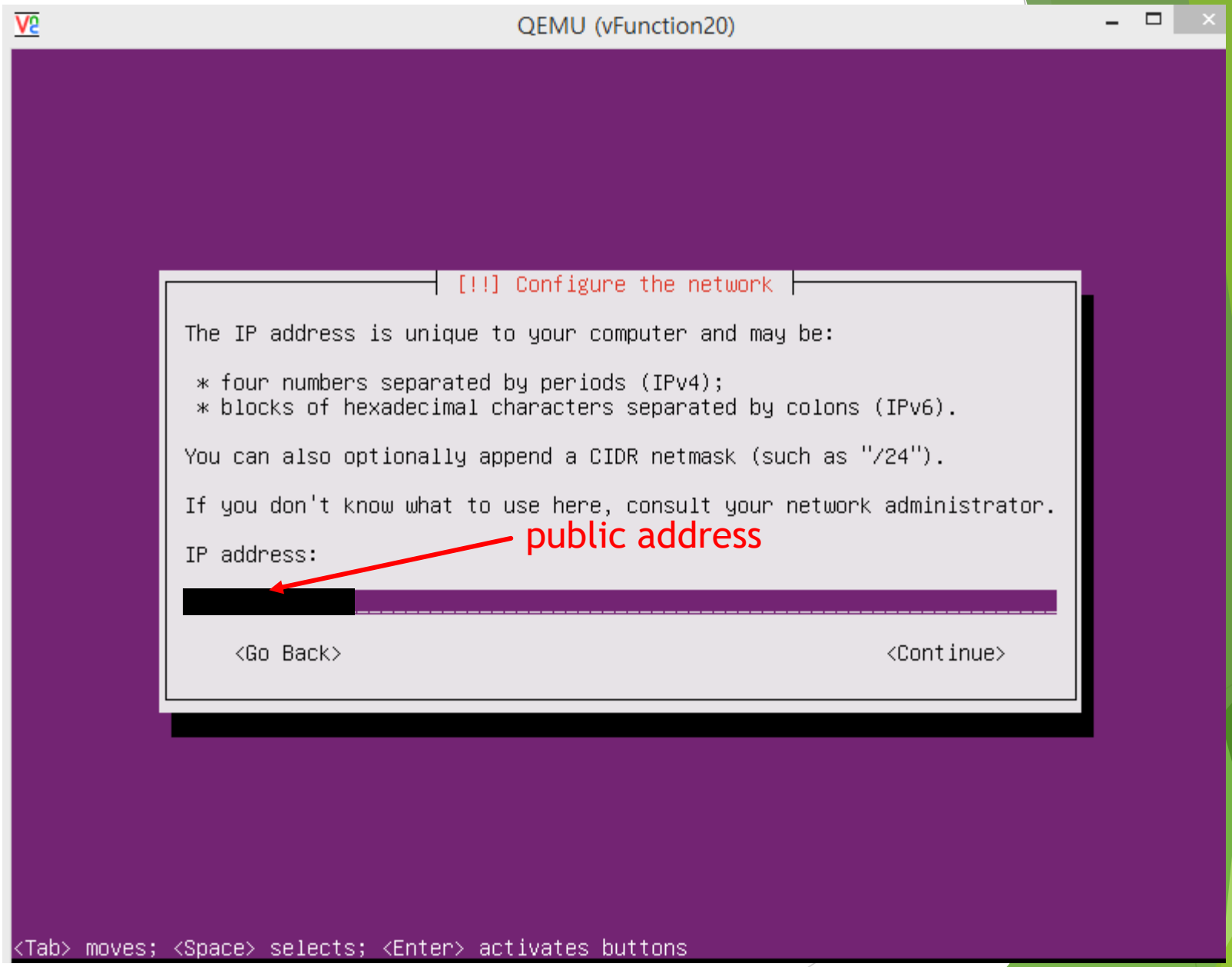
IP address:vnc number
ex) 210.203.x.x:5

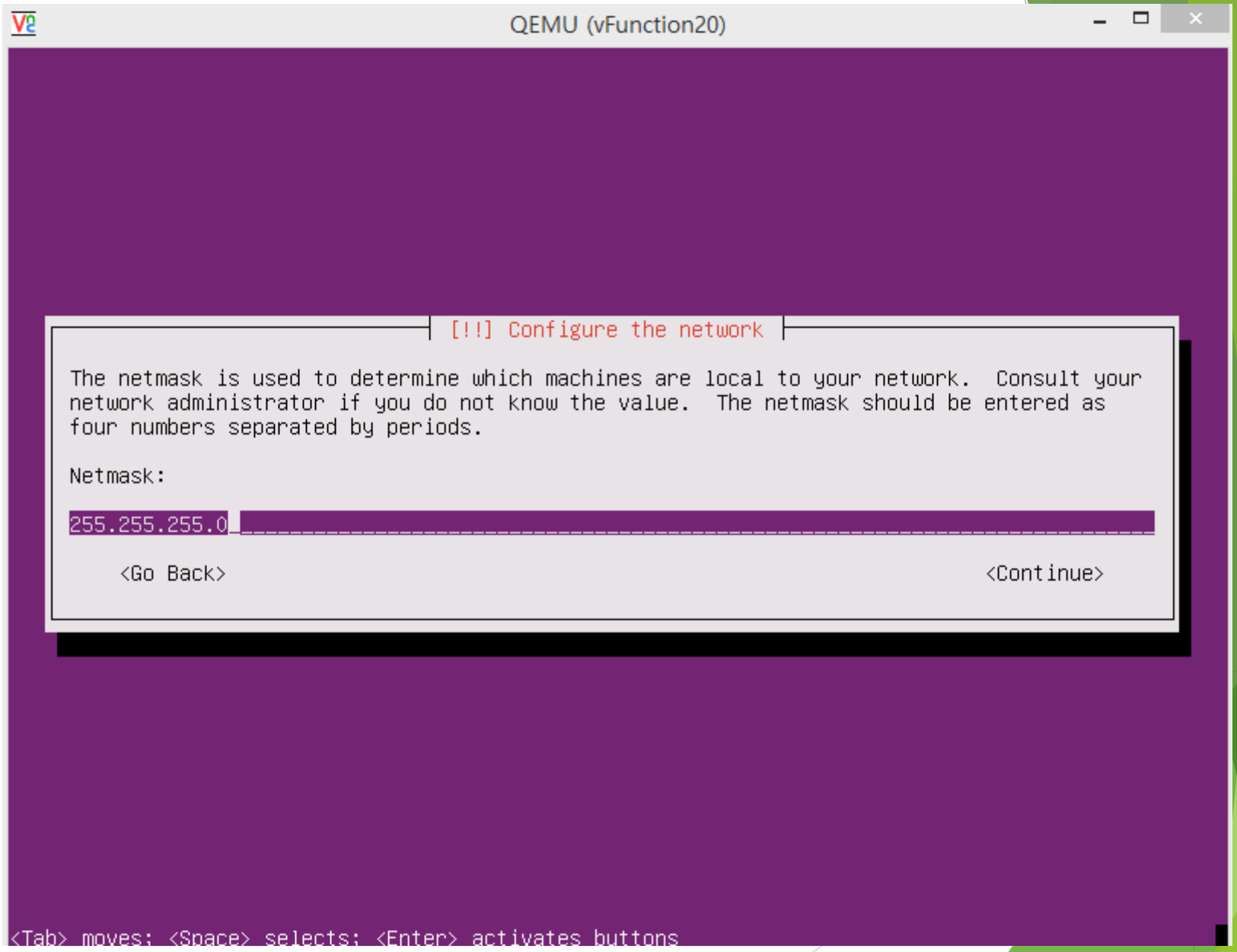


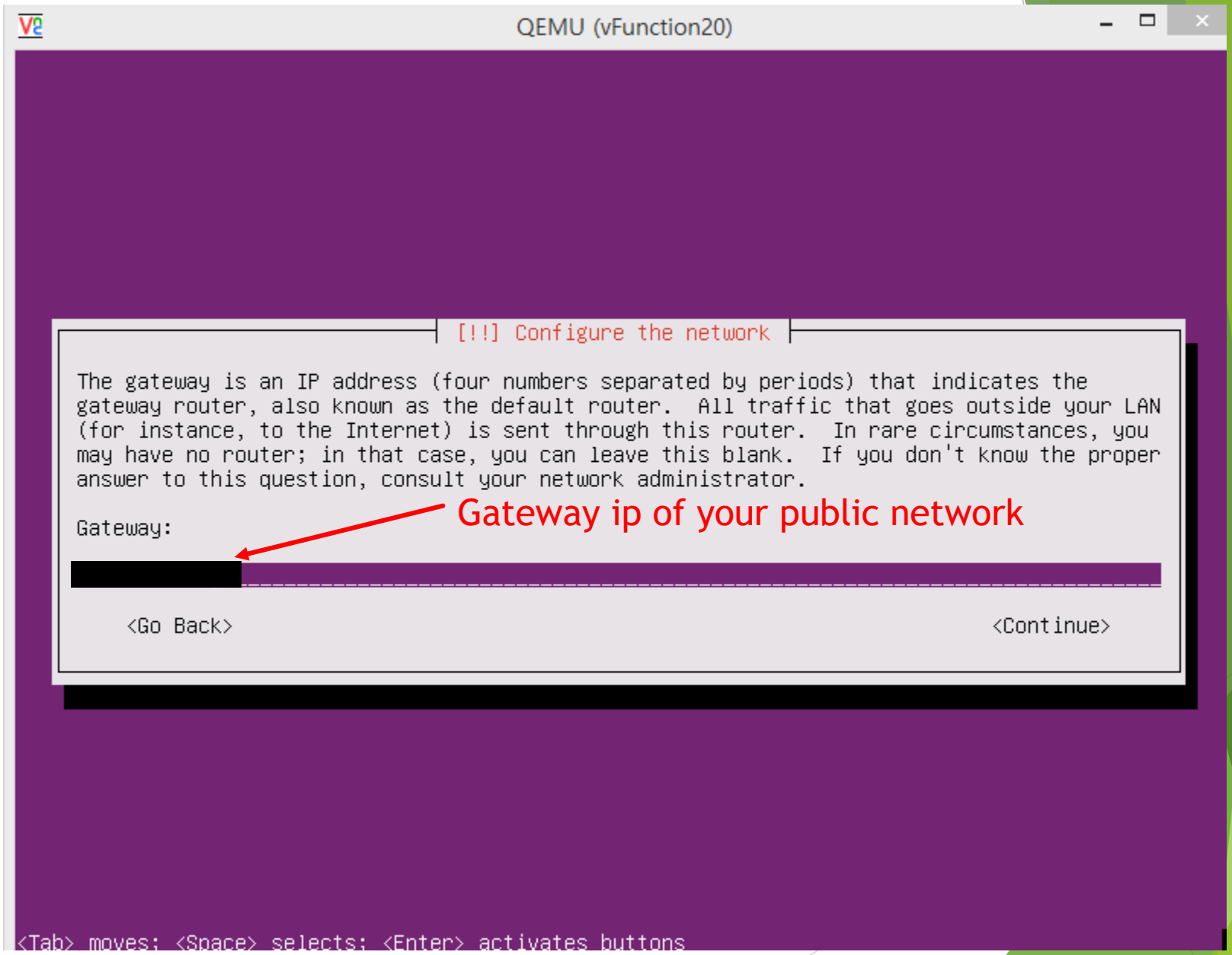


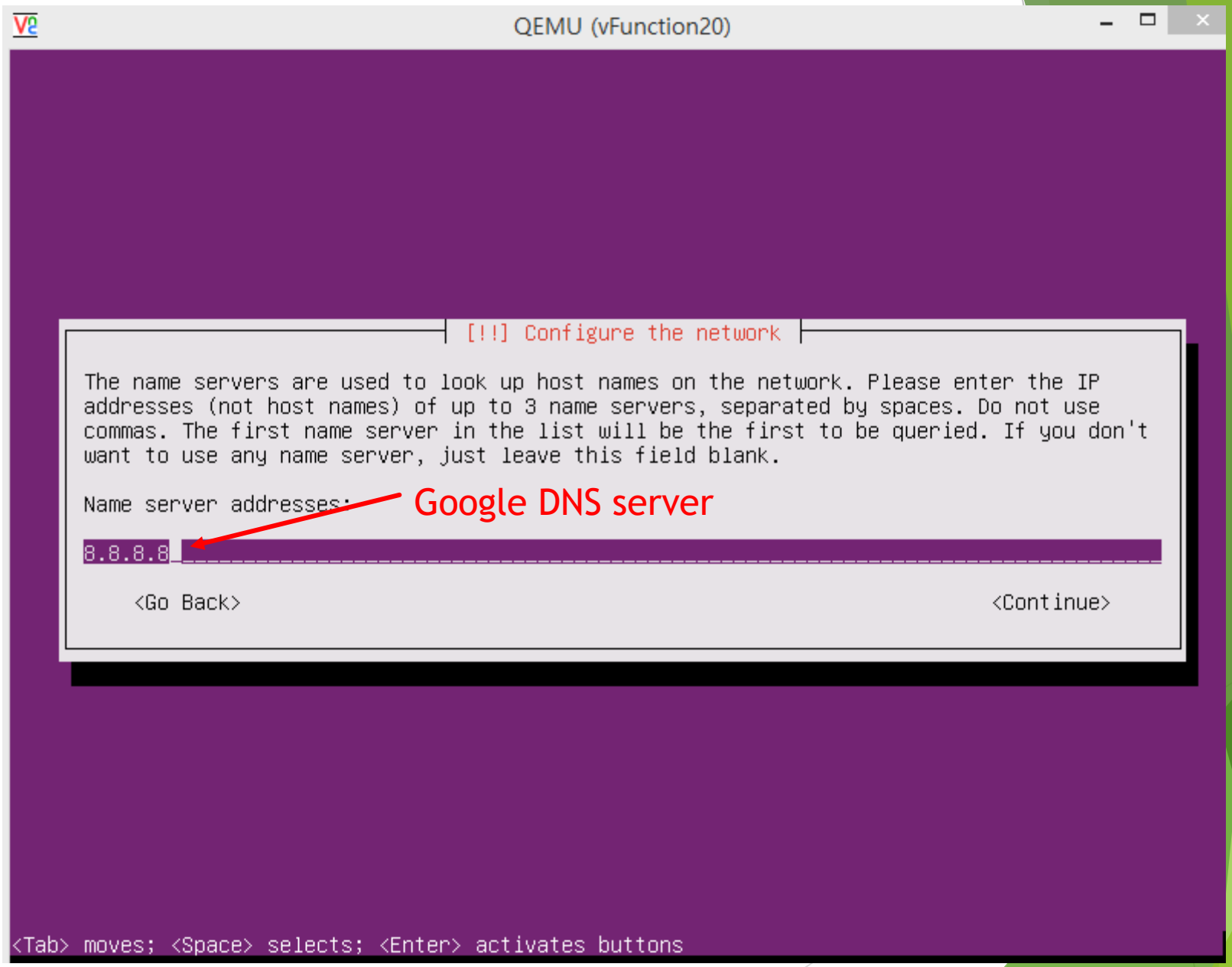

QEMU (vFunction20)
[!!] Configure the network
Network autoconfiguration failed
Your network is probably not using the DHCP protocol. Alternatively, the DHCP server may be slow or some network hardware is not working properly.
<Continue>
<Tab> moves; <Space> selects; <Enter> activates buttons

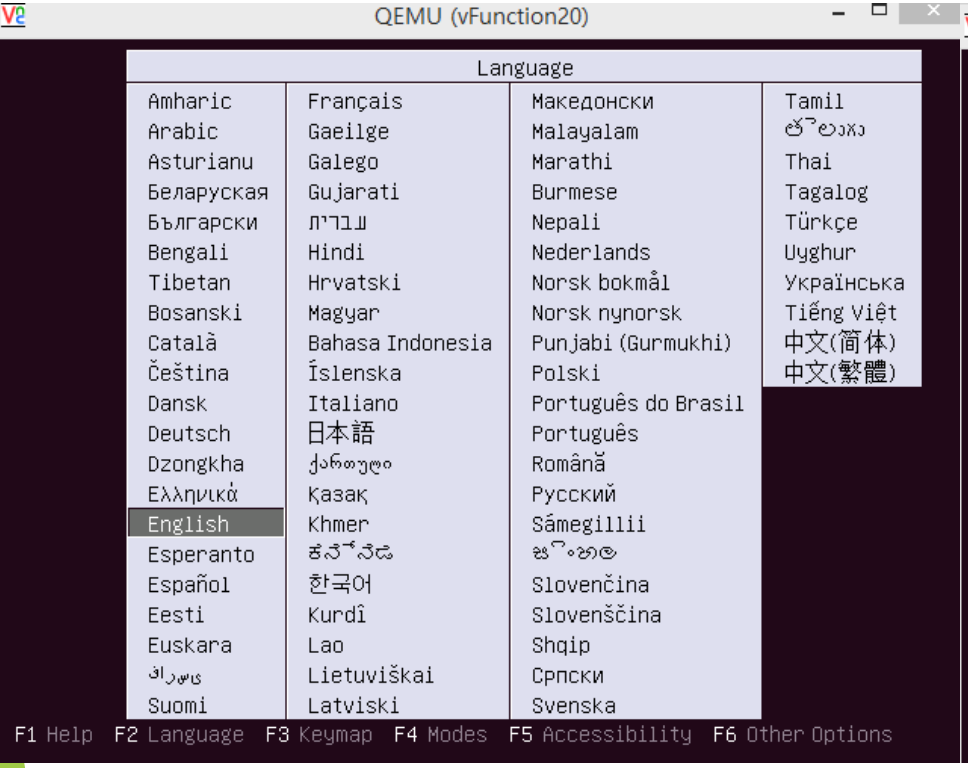

QEMU (vFunction20)
[!!] Configure the network
From here you can choose to retry DHCP network autoconfiguration (which may succeed if your DHCP server takes a long time to respond) or to configure the network manually. Some DHCP servers require a DHCP hostname to be sent by the client, so you can also choose to retry DHCP network autoconfiguration with a hostname that you provide.
Network configuration method:
Retry network autoconfiguration
Retry network autoconfiguration with a DHCP hostname
Configure network manually
Do not configure the network at this time
<Go Back>
<Tab> moves; <Space> selects; <Enter> activates buttons

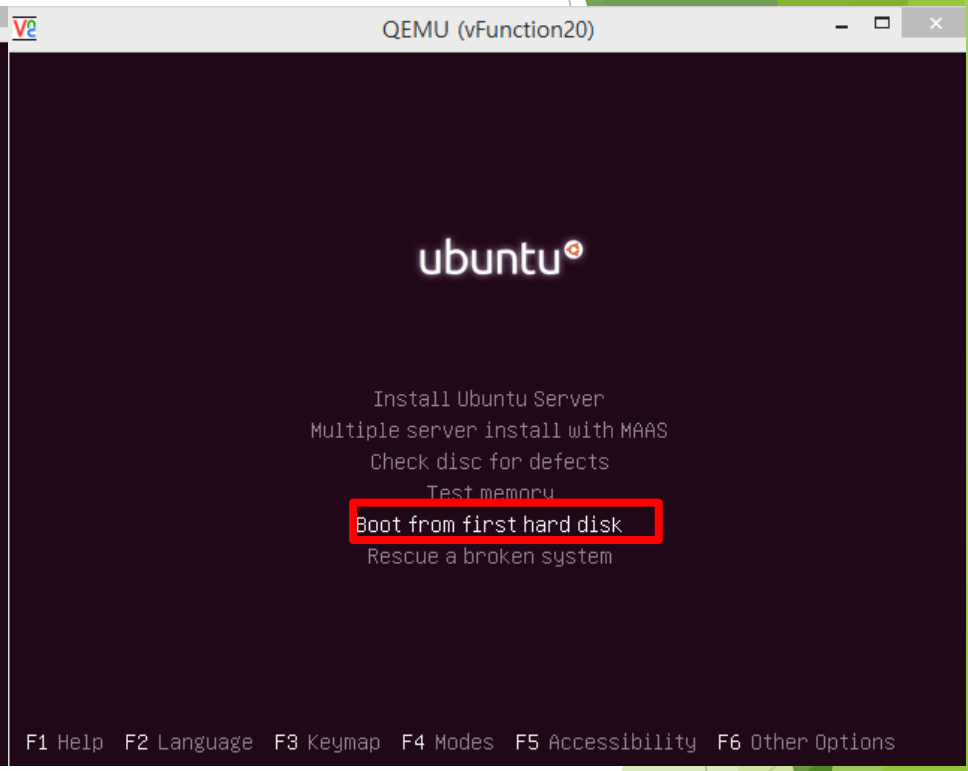

QEMU (vFunction20)
[!!] Configure the network
The IP address is unique to your computer and may be:
* four numbers separated by periods (IPv4);
* blocks of hexadecimal characters separated by colons (IPv6).
You can also optionally append a CIDR netmask (such as "/24").
If you don't know what to use here, consult your network administrator.
IP address:
public address
<Go Back>
<Continue>
<Tab> moves; <Space> selects; <Enter> activates buttons


QEMU (vFunction20)
[!!] Configure the network
The netmask is used to determine which machines are local to your network. Consult your network administrator if you do not know the value. The netmask should be entered as four numbers separated by periods.
Netmask:
255.255.255.0
<Go Back>
<Continue>
<Tab> moves; <Space> selects; <Enter> activates buttons


QEMU (vFunction20)
[!!] Configure the network
The gateway is an IP address (four numbers separated by periods) that indicates the gateway router, also known as the default router. All traffic that goes outside your LAN (for instance, to the Internet) is sent through this router. In rare circumstances, you may have no router; in that case, you can leave this blank. If you don't know the proper answer to this question, consult your network administrator.
Gateway:
Gateway ip of your public network
<Go Back>
<Continue>
<Tab> moves; <Space> selects; <Enter> activates buttons


QEMU (vFunction20)
[!!] Configure the network
The name servers are used to look up host names on the network. Please enter the IP addresses (not host names) of up to 3 name servers, separated by spaces. Do not use commas. The first name server in the list will be the first to be queried. If you don't want to use any name server, just leave this field blank.
Name server addresses:
Google DNS server
8.8.8.8
<Go Back>
<Continue>
<Tab> moves; <Space> selects; <Enter> activates buttons


QEMU (vFunction20)
Language
Amharic
Arabic
Asturianu
Беларуская
Български
Bengali
Tibetan
Bosanski
Català
Čeština
Dansk
Deutsch
Dzongkha
Ελληνικά
English
Esperanto
Español
Eesti
Euskara
فارسی
Suomi
Français
Gaeilge
Galego
Gujarati
עברית
Hindi
Hrvatski
Magyar
Bahasa Indonesia
Íslenska
Italiano
日本語
ქართული
Қазақ
Khmer
ಕನ್ನಡ
한국어
Kurdî
Lao
Lietuviškai
Latviski
Македонски
Malayalam
Marathi
Burmese
Nepali
Nederlands
Norsk bokmål
Norsk nynorsk
Punjabi (Gurmukhi)
Polski
Português do Brasil
Português
Română
Русский
Sámegillii
සිංහල
Slovenčina
Slovenščina
Shqip
Српски
Svenska
Tamil
తెలుగు
Thai
Tagalog
Türkçe
Uyghur
Українська
Tiếng Việt
中文(简体)
中文(繁體)
F1 Help F2 Language F3 Keymap F4 Modes F5 Accessibility F6 Other Options


QEMU (vFunction20)
ubuntu
Install Ubuntu Server
Multiple server install with MAAS
Check disc for defects
Test memory
Boot from first hard disk
Rescue a broken system
F1 Help F2 Language F3 Keymap F4 Modes F5 Accessibility F6 Other Options

Push esc

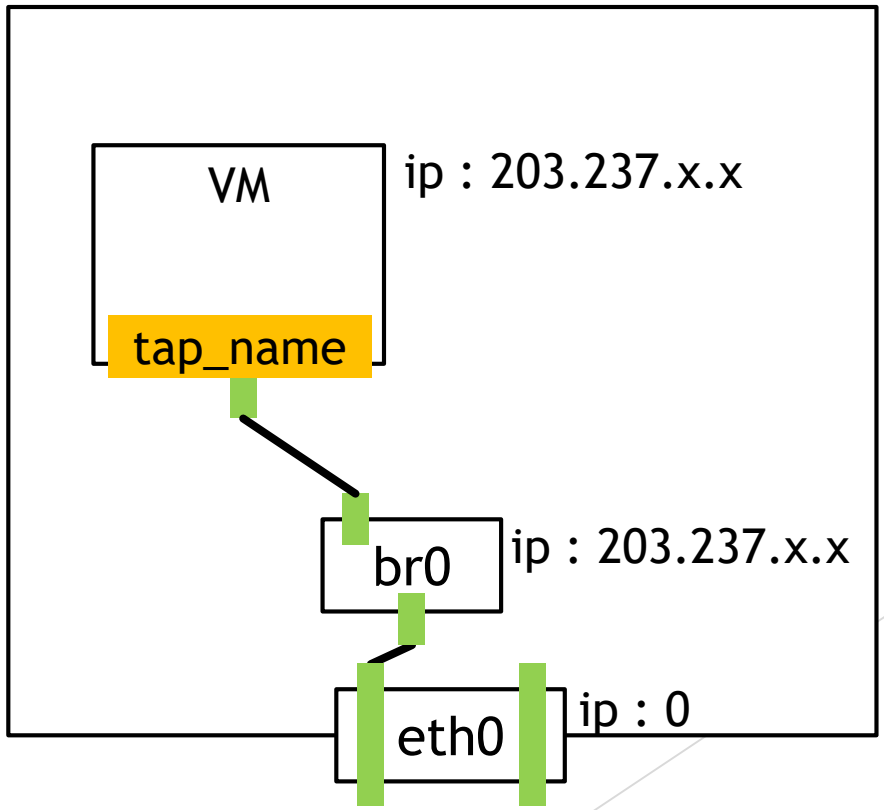
KVM
- VM boot command

If you want boot VM again (mac should be different from others).

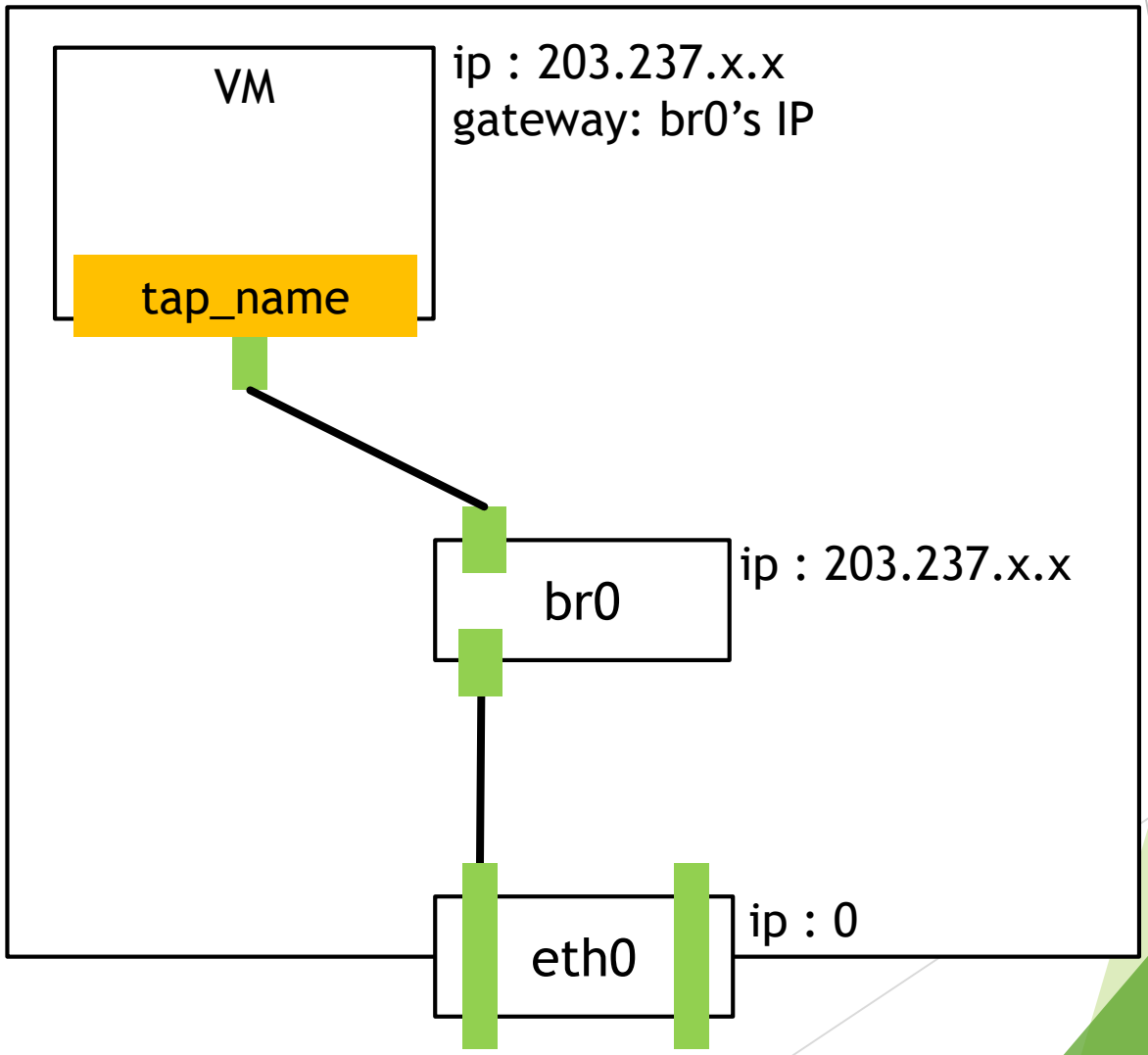
$sudo kvm -m [memory capacity] -name [name] -smp cpus=[#cpu],maxcpus= [#maxcpu] -device virtio-net-pci,netdev=net0,mac= [EE:EE:EE:EE:EE:EE] -netdev tap,id=net0,ifname= [tap_name],script=no -boot d [name].img -vnc : [#] -daemonize

Open Vswitch connects with KVM
- Situation

```
root@nuc:~# ovs-vsctl show
3bb93923-3eac-420a-9da9-9143aff14209
    Bridge "br0"
        Port "br0"
            Interface "br0"
                type: internal
        Port "em1"
            Interface "em1"
        Port vport_vFunction
            Interface vport_vFunction
    ovs_version: "2.0.2"
```



Open Vswitch connects with KVM
- Situation



KVM
- Don’t forget to install ssh in VM!

In VMs,

$sudo apt-get update
$sudo apt-get install ssh

```
nuc@nuc:~$ ssh vbox@192.168.0.3
The authenticity of host '192.168.0.3 (192.168.0.3)' can't be established.
ECDSA key fingerprint is da:c5:2c:53:5a:6f:b4:3c:03:02:04:f3:6a:17:ca:ab.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.0.3' (ECDSA) to the list of known hosts.
vbox@192.168.0.3's password:
```

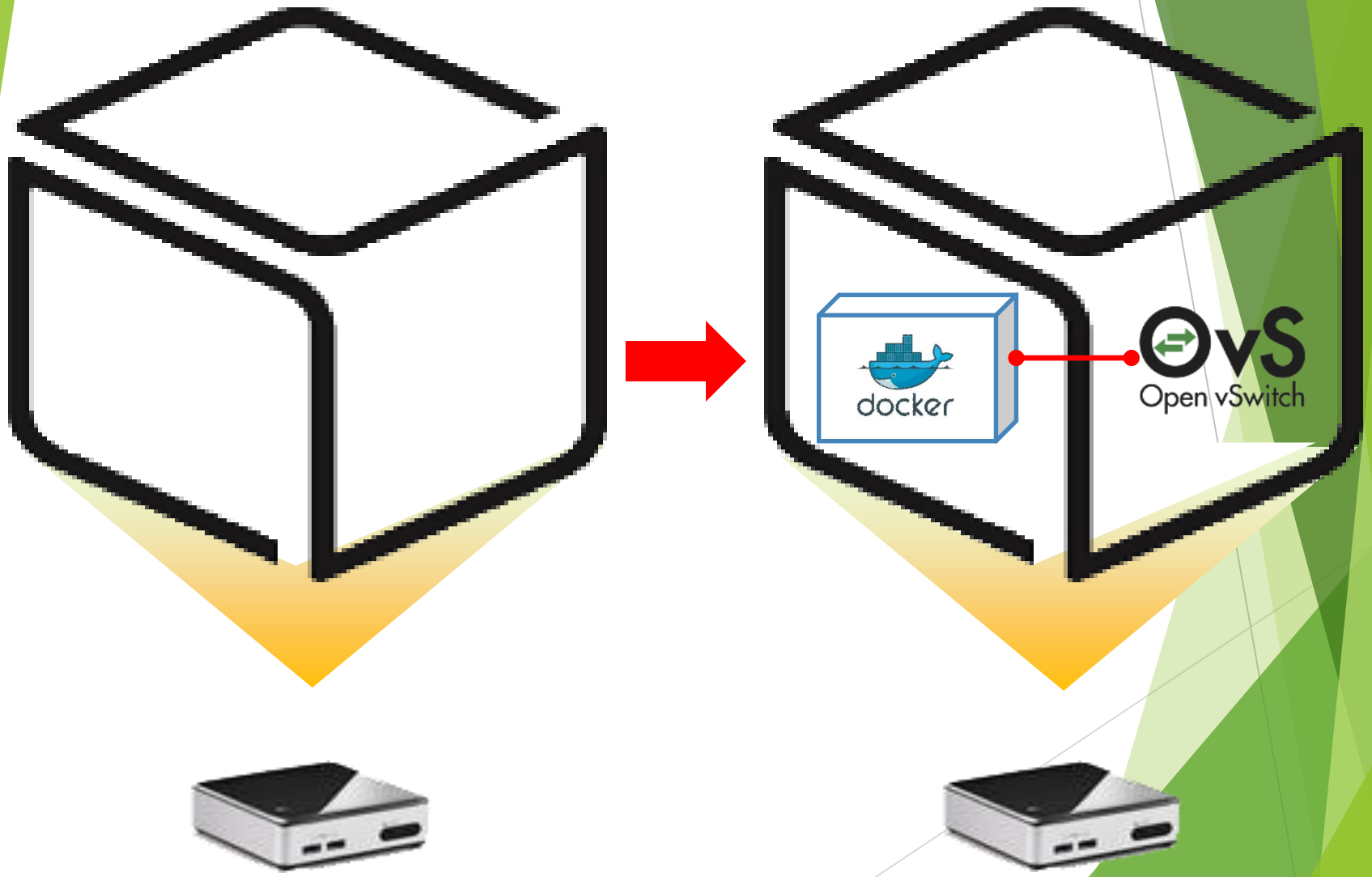
Modify
- /etc/rc.local

Modify /etc/rc.local

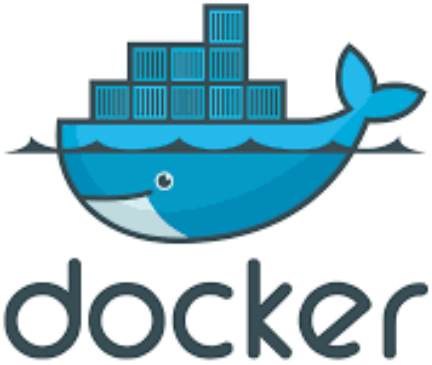
```
$sudo vi /etc/rc.local

ip tuntap add mode tap [tap_name]
ifconfig [tap_name] up
ovs-vsctl del-port br0 [tap_name]
ovs-vsctl add-port br0 [tap_name]
```

Whenever NUC is rebooted,
interface configuration and OvS ports are initialized
by executing commands in rc.local

Docker: Goal of this part



What is Docker ?



- Docker is an open platform for building, shipping and running distributed applications. It gives programmers, development teams and operations engineers the common toolbox they need to take advantage of the distributed and networked nature of modern applications.

Docker
- Installation

Docker installation.

```
$sudo wget -qO- https://get.docker.com/ | sh
$sudo adduser [your_id] docker

(Session restart)

$sudo docker run hello-world
```

reference: http://docs.docker.com/linux/step_one/

Docker
- Installation

```
Hello from Docker.
This message shows that your installation appears to be working correctly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
 3. The Docker daemon created a new container from that image which runs the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which sent it
    to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
 $ docker run -it ubuntu bash

Share images, automate workflows, and more with a free Docker Hub account:
 https://hub.docker.com

For more examples and ideas, visit:
 https://docs.docker.com/userguide/
```

Docker
- Make containers

Run docker container.

$sudo docker run -it --net=none --name [container_name] ubuntu /bin/bash

```
nuc@nuc:~$ docker run -it --net=none --name c1 ubuntu /bin/bash
root@8346684676d8:/#
root@8346684676d8:/# ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

I want to make interface that has 203.237.x.x IP address.

※ctrl + p, q → detach docker container
※docker attach [container_name] → get into docker container console

Docker
- About [--net host] option

- Pros
  - Easy to use
- Cons
  - Security problem (Violate docker's strong point:isolated)
- Solution?
  - Establish L2 tunneling
    (Can easily achieved by using ovs.
    However, ovs doesn't support raspberry pi officially.
    That's why we are using this option.)
    Related keyword : GRE, vlan, vxlan

Docker
- Connect docker container to ovs bridge

Install ovs-docker utility in host machine. (Not in inside of Docker container.)

```
$cd /usr/bin
$sudo wget https://raw.githubusercontent.com/openvswitch/ovs/master/utilities/ovs-docker
$sudo chmod a+rwx ovs-docker

$sudo ovs-docker add-port br0 eth0 [containerName] --ipaddress=[IP_address] --gateway=[Gateway_address]
```

Modify
- /etc/rc.local

Modify /etc/rc.local

$sudo vi /etc/rc.local

docker start [container_name]
ovs-docker del-port br0 eth0 [containerName] --ipaddress=[IP_address] --gateway=[Gateway_address]
ovs-docker add-port br0 eth0 [containerName] --ipaddress=[IP_address] --gateway=[Gateway_address]

Whenever NUC is rebooted,
network configuration of Docker container is initialized
by executing commands in rc.local

Docker
- Check connectivity

```
root@nuc:/usr/bin# ovs-docker add-port br0 eth0 docker1 --ipaddress=210.125.84.70/24 --gateway=210.125.84.1
root@nuc:/usr/bin# docker attach docker1

root@b8c3bab8204b:/# ifconfig
eth0      Link encap:Ethernet  HWaddr ae:e5:9c:cc:88:b7
          inet addr:210.125.84.70  Bcast:0.0.0.0  Mask:255.255.255.0
          inet6 addr: fe80::ace5:9cff:fecc:88b7/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:120 errors:0 dropped:0 overruns:0 frame:0
          TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:8842 (8.8 KB)  TX bytes:648 (648.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

root@b8c3bab8204b:/# ping google.com
PING google.com (216.58.221.238) 56(84) bytes of data.
64 bytes from hkg07s21-in-f14.1e100.net (216.58.221.238): icmp_seq=1 ttl=52 time=41.3 ms
64 bytes from hkg07s21-in-f14.1e100.net (216.58.221.238): icmp_seq=2 ttl=52 time=41.3 ms
^C
--- google.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 41.306/41.343/41.380/0.037 ms
```

Docker connect with KVM - Check connectivity

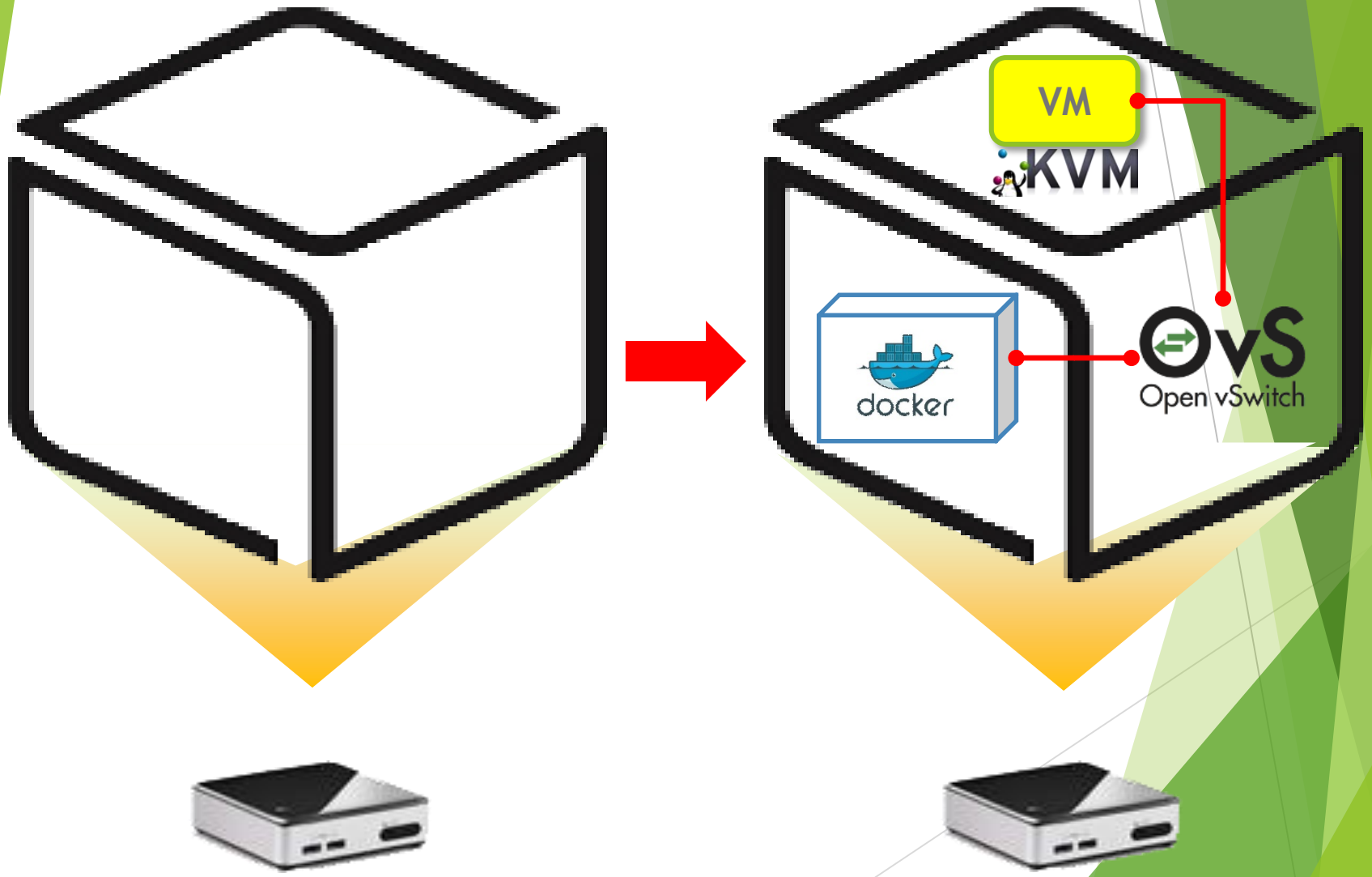
```
root@b8c3bab8204b:/# ifconfig
eth0      Link encap:Ethernet  HWaddr a2:86:d9:c2:33
          inet addr:192.168.0.3  Bcast:0.0.0.0  Mask
          inet6 addr: fe80::a086:d9ff:fec2:337b/64 S
          UP BROADCAST RUNNING MULTICAST  MTU:1500
          RX packets:136 errors:0 dropped:0 overruns
          TX packets:13 errors:0 dropped:0 overruns:
          collisions:0 txqueuelen:1000
          RX bytes:10448 (10.4 KB)  TX bytes:1043 (1

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0
          TX packets:0 errors:0 dropped:0 overruns:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

root@b8c3bab8204b:/# ping google.com
PING google.com (216.58.221.238) 56(84) bytes of dat
64 bytes from hkg07s21-in-f238.1e100.net (216.58.221
64 bytes from hkg07s21-in-f238.1e100.net (216.58.221
^C
--- google.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, t
rtt min/avg/max/mdev = 41.376/41.380/41.384/0.004 ms
root@b8c3bab8204b:/# ping 192.168.0.2
PING 192.168.0.2 (192.168.0.2) 56(84) bytes of data.
64 bytes from 192.168.0.2: icmp_seq=1 ttl=64 time=1.
64 bytes from 192.168.0.2: icmp_seq=2 ttl=64 time=0.
64 bytes from 192.168.0.2: icmp_seq=3 ttl=64 time=0.
^C
--- 192.168.0.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, t
rtt min/avg/max/mdev = 0.651/1.028/1.519/0.365 ms
root@b8c3bab8204b:/#
```

```
vbox@vFunction:~$
vbox@vFunction:~$
vbox@vFunction:~$
vbox@vFunction:~$ ifconfig
eth0      Link encap:Ethernet  HWaddr ee:ee:ee:ee:ee:01
          inet addr:192.168.0.2  Bcast:192.168.0.255  Mask:255.255.255.0
          inet6 addr: fe80::ecee:eeff:feee:ee01/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:18857 errors:0 dropped:0 overruns:0 frame:0
          TX packets:69 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:1323453 (1.3 MB)  TX bytes:3507 (3.5 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:38 errors:0 dropped:0 overruns:0 frame:0
          TX packets:38 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:3512 (3.5 KB)  TX bytes:3512 (3.5 KB)

vbox@vFunction:~$ ping 192.168.0.3
PING 192.168.0.3 (192.168.0.3) 56(84) bytes of data.
64 bytes from 192.168.0.3: icmp_seq=1 ttl=64 time=0.872 ms
64 bytes from 192.168.0.3: icmp_seq=2 ttl=64 time=0.590 ms
64 bytes from 192.168.0.3: icmp_seq=3 ttl=64 time=0.585 ms
64 bytes from 192.168.0.3: icmp_seq=4 ttl=64 time=0.573 ms
^C
--- 192.168.0.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 0.573/0.655/0.872/0.125 ms
vbox@vFunction:~$
```

Docker container

KVM VM

Box Lab: Final Goal



Thank You for Your Attention Any Questions?