



Network Simulation Traffic engineering study case



European MUM – 2015
Prague / Czech Republic
Wardner Maia

English:

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Portuguese:

Este material é um esforço que visa aprimorar o grau de conhecimento de profissionais que trabalham com Mikrotik RouterOS e deve ser usado apenas com objetivos de auto estudo.

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Wardner Maia

Electronic and Telecommunications Engineer;
Internet Service Provider since 1995;
Training Business since 2002;
Certified Mikrotik Trainer since 2007;
MD Brasil IT & Telecom CTO;
Member of the board of directors of LACNIC.

MD Brasil IT & Telecom

Internet Access Provider in São Paulo state - Brazil;
Telecom equipment manufacturer and integrator;
Mikrotik Training Center since 2007;
Consulting services worldwide.

<http://mdbrasil.com.br>

<http://mikrotikbrasil.com.br>

Previous Participations on European MUMs

Wireless Security (2008 – Krakow/PL)

Wireless Security for OLPC project (2009 – Prague/CZ)

Layer 2 Security (2010 – Wroclaw/PL)

Routing Security (2011 – Budapest/HU)

IPv6 Security (2012 - Warsaw/PL)

BGP Filtering (2013 – Zagreb/CR)

MPLS VPNs Security (2014 – Venice/IT)

<http://mikrotikbrasil.com.br/artigos>

Network Simulation

Subject and goals

Subject

Network Simulation with focus on Mikrotik RouterOS

Goals

To share our experience with the use of GNS3

To foster the use of simulators as a prediction and learning tool

To present a clear tutorial on how to install and use it.

Previous Work from other Trainers

Previous work on installation and use of GNS3:

- Indonesia 2013 - Rofik Fauzi
GNS3 on Windows, and Qemu as RouterOS emulator
- USA 2014 – Rick Frei
GNS3 on Windows, and VirtualBox as RouterOS emulator

Network Simulators

There are many Network Simulators for several platforms and purposes:

ClooniX, Core, Imunes, Marionnet, Mininet, Netkit, Psimulator, VirtualSquare, GNS3, etc;

The link below is an excellent guide to some Open Source Network simulators:

<http://www.brianlinkletter.com/open-source-network-simulators/>



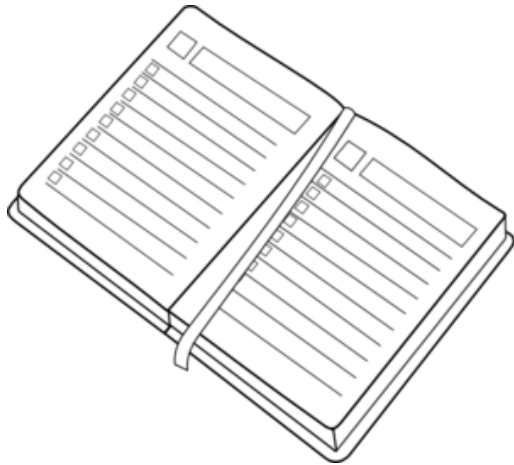
Motivations and General Talking about Network Simulators

Installing all the stuff necessary to simulate any type of IP network;

Creating a Simple and a Base Project and interacting with them;

A real case demonstration – Traffic Engineering Scenario;

Final considerations, conclusions and download links.



6'



Motivations and General Talking about Network Simulators

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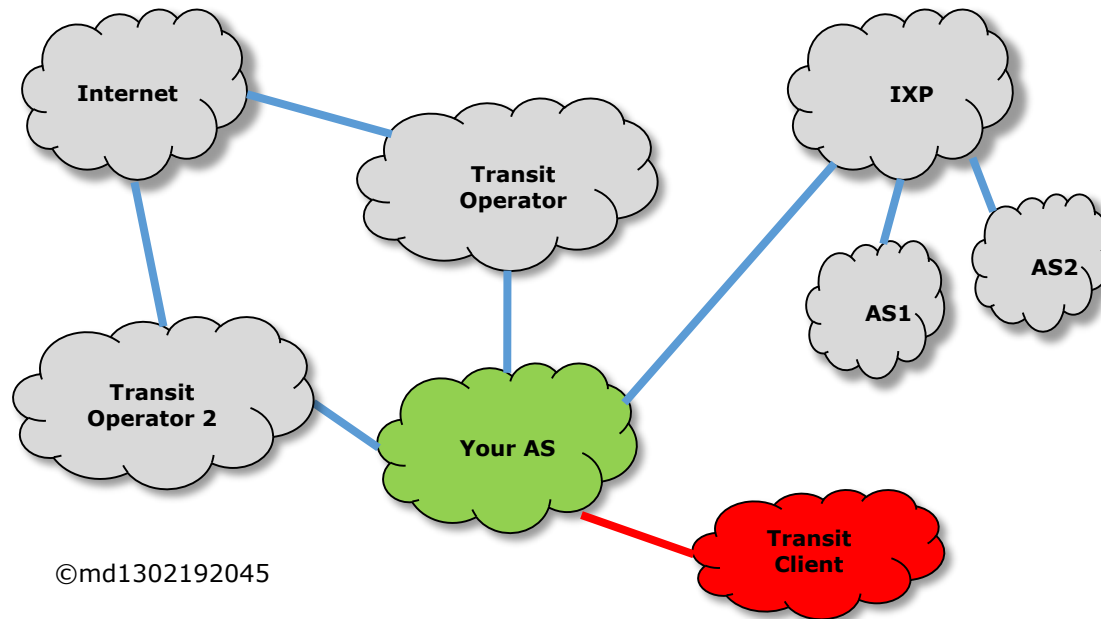


4'

Motivations

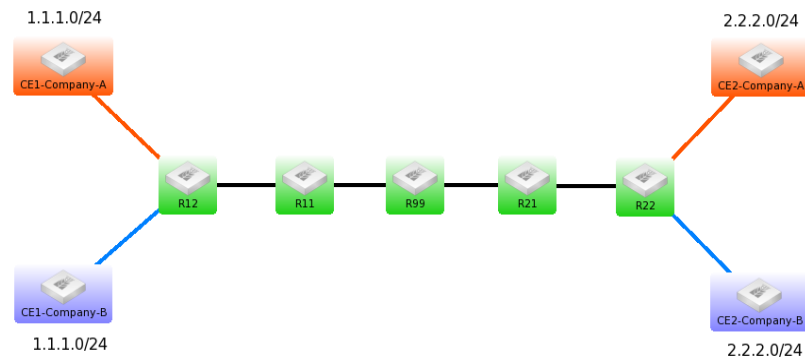
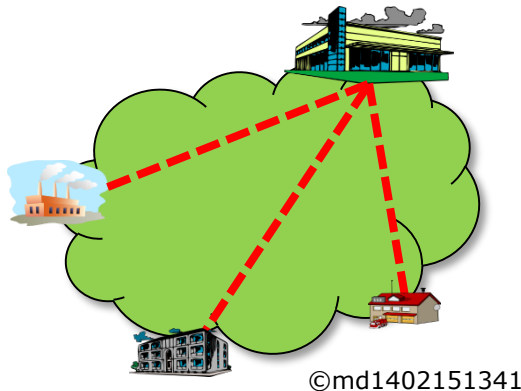
We do love REAL Routers, but...

Presentation about BGP Filtering in Zagreb (2013): (5 routers)



To simulate the scenario 5 real routers were used, cables, power supplies, etc.

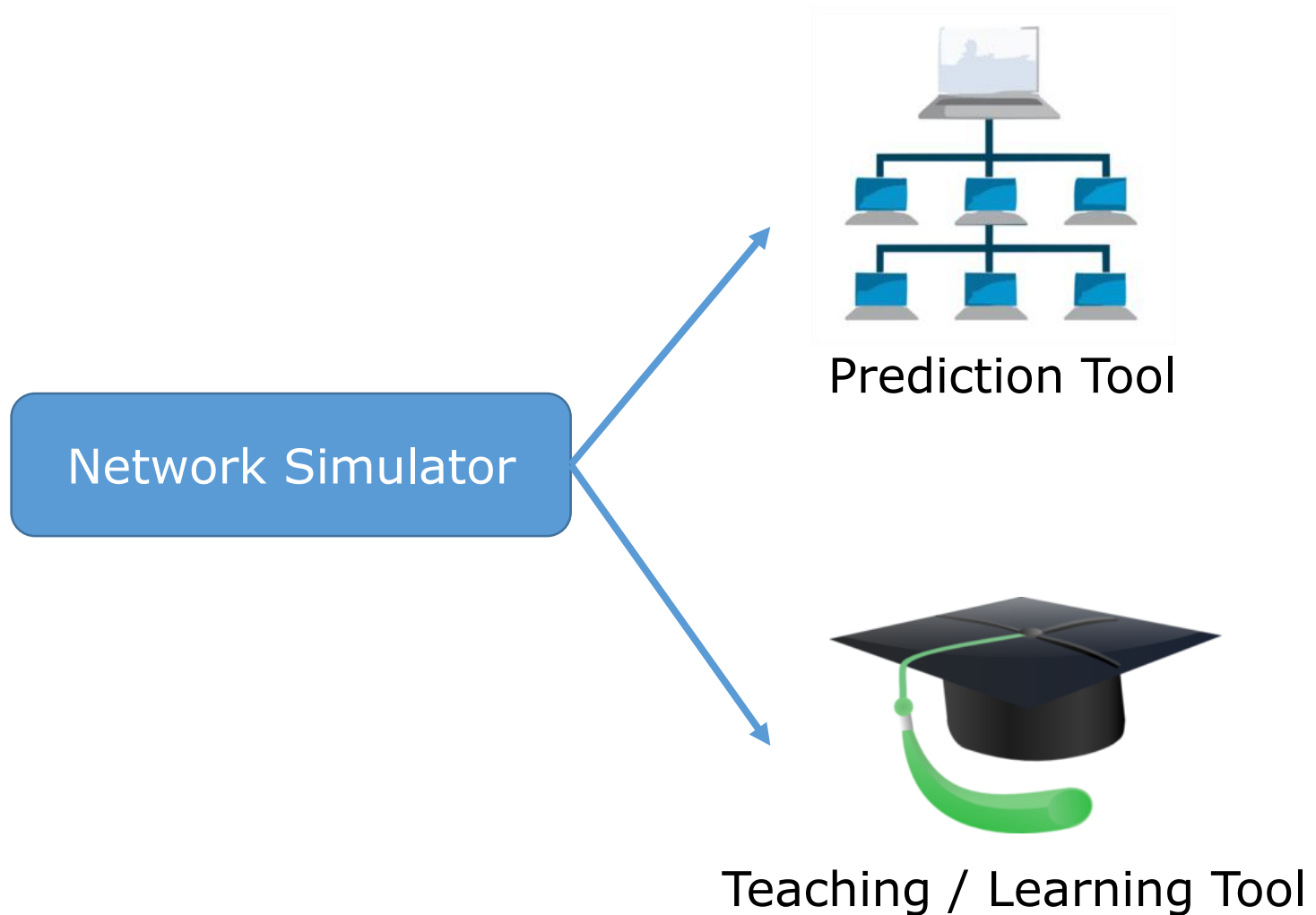
Presentation about MPLS Security in Venice (2014): (9 routers)



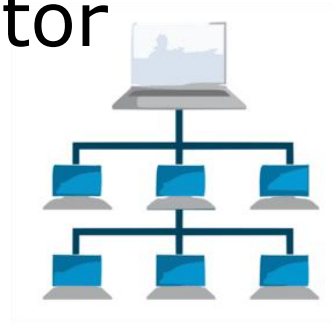
With a simulator, no physical router, no cables, no power supply – no pain 😊

→ Several questions asking about the tool used for the presentation.

Applications of a Network Simulator



Applications of a Network Simulator



As a Prediction Tool:

Operators can anticipate how new implementations will work before deploying them in the “real world”;

Software versions updates can be tested before the real implementation avoiding problems;

Interoperation with other Vendors can be tested and tuned without the need of the hardware;

In consulting services making possible fast and low cost “proof of concepts” to customers.

Brazilian Army Network – 41 CT (Region of Amazon rain forest)

Existing Network:

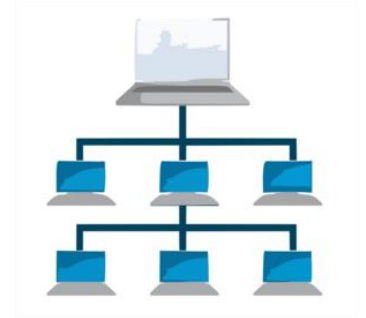
Network interconnecting several units, many in hard to reach locations.

Scope of the work:

Implementation of dynamic routing, IPSec encryption and QoS.

Challenge:

To make all implementations in a productions network without any interruption.



Applications of a Network Simulator



As a Teaching / Learning Tool:

Trainers can easily explain Protocols and complex scenarios without the need of lots of equipment;

Students can have “on their pockets” all scenarios used in class and reproduce them by their own;

On line trainings do not depend on physical hardware. Scenarios can be exported and sent to the students.

MD Brasil – Trainings



- Virtual environment simulating a “real” Internet for BGP Labs. Students connect with real routers to this network and can practice BGP filtering, traffic manipulation, etc as they are connected to the Internet;
- All MPLS Labs are now improved showing first what we want with some setups and after doing so in real routers
- In our 2015 roadmap several new labs, now possible with simulation

Who will Benefit?



Trainers:

Can improve their methods of teaching;

Students:

Can get more from a Training with “scenarios memories” and test their skills;

Operators:

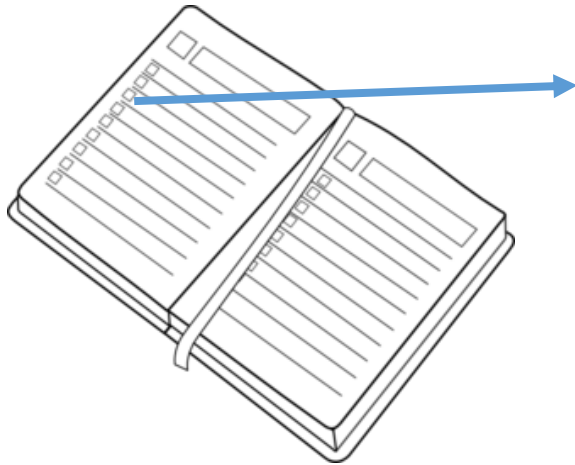
Can use in their daily operations as a predicting and testing tool

Mikrotik Community in general:

Can share information and scenarios



Motivations and General Talking about Network Simulators



Installing all the stuff necessary to simulate any type of IP network;

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Tools we'll use for Simulating Networks

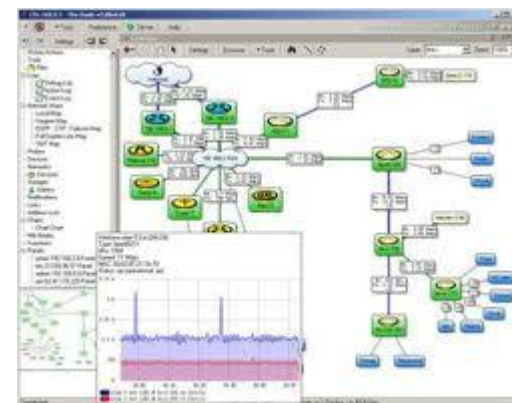


+



Qemu

+



Dude



**Ubuntu Gnome
14.04 LTS**

GNS3:

- Originally developed with focus on Cisco;
- Uses Dynamips for emulating Cisco Routers;
- Offers support for emulation with other systems like Qemu and VirtualBox;



<http://gns3.net>

Qemu

Qemu (Quick Emulator) is an open source software that can be used either as an emulator or a virtualization system;



As an emulator, Qemu can run operating Systems in a regular PC

Used as a Virtualization platform, Qemu runs the guest system directly on the host machine using KVM.

<http://qemu.org>

Several architectures are supported, like Mips, ARM, PPC, x86, etc.

Qemu x VirtualBox



<http://qemu.org>



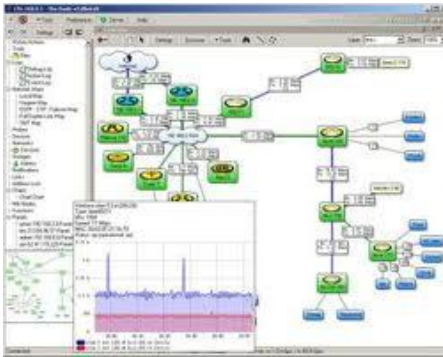
<http://virtualbox.org>

Another possibility could be use VirtualBox instead of Qemu.

According to our tests Qemu is faster and saves CPU resources. (see some tests at the end of this presentation)

The Dude

Our good and old friend “The Dude” will be used only as a kind of front end to make things easier, specially for Mikrotik users community. It will allow:



<http://mikrotik.com>

- Make the maps more clean and friendly, hiding details not necessary for the studies;
- Direct access to the routers facilitating the configurations and visualizations;
- Mass upgrades and or downgrades of all devices, using Dude facilities.

Installing the Stuff

Installation successful for Ubuntu-gnome 14.04 LTS

all following commands should run as root

```
sudo su
```

all the stuff at root directory will make things easier when sharing projects

```
mkdir /GNS3
```

```
cd /GNS3
```



preparing the dependencies:

```
apt-get update  
apt-get install build-essential  
apt-get install libelf-dev  
apt-get install uuid-dev  
apt-get install libpcap-dev  
apt-get install python3-dev  
apt-get install python3-pyqt4  
apt-get install python3-netifaces
```



preparing the dependencies (cont.):

```
apt-get install git  
apt-get install cmake  
apt-get install bison  
apt-get install flex
```



installing python and pip:

```
wget -O get-pip.py  
https://raw.githubusercontent.com/pypa/pip/master/contrib/get-pip.py  
python3 get-pip.py  
pip3 install pyzmq && pip3 install tornado
```

stuff for i386 support

```
dpkg --add-architecture i386
```

```
apt-get update
```

```
apt-get install libc6:i386
```

```
apt-get install libstdc++6:i386
```

```
apt-get install libssl1.0.0:i386
```

```
ln -s /lib/i386-linux-gnu/libcrypto.so.1.0.0 /lib/i386-linux-gnu/libcrypto.so.4
```



stuff for i386 support (cont.)

```
wget http://ndevilla.free.fr/iniparser/iniparser-3.1.tar.gz
```

```
tar xf iniparser-3.1.tar.gz
```

```
cd iniparser/
```

```
makecp libiniparser* /usr/lib
```

```
cp src/*.h /usr/include
```

```
cd ..
```



Installing Dynamips

```
git clone git://github.com/GNS3/dynamips.git
```

```
cd dynamips
```

```
mkdir build
```

```
cd build
```

```
cmake ..
```

```
make install
```

```
cd ~/GNS3
```



Testing Dynamips

```
maia@galago:/GNS3$ sudo dynamips -H 7200
```



```
root@galago:/home/maia/GNS3# dynamips -H 7200
Cisco Router Simulation Platform (version 0.2.14-amd64/Linux stable)
Copyright (c) 2005-2011 Christophe Fillot.
Build date: Sep 29 2014 20:14:18
```

```
Local UUID: 7f743860-8e5e-4ce6-804a-14a526118a0c
```

```
Hypervisor TCP control server started (port 7200).
```

Installing GNS3

wget <https://github.com/GNS3/gns3-server/archive/v1.2.3.zip>

```
unzip v1.2.3.zip
```

```
cd gns3-server-1.2.3
```

```
python3 setup.py install
```

```
cd ..
```

```
rm -r v1.2.3.zip
```



Installing GNS3 GUI

wget <https://github.com/GNS3/gns3-gui/archive/v1.2.3.zip>

```
unzip v1.2.3.zip
```

```
cd gns3-gui-1.2.3/
```

```
python3 setup.py install
```

```
cd ..
```

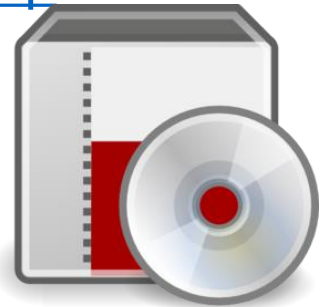
```
rm -r v1.2.3.zip
```



Installing IOU

get <https://github.com/GNS3/iouyap/archive/master.zip>

```
unzip master.zip  
cd iouyap-master/  
make install  
cp iouyap /usr/local/bin/iouyap  
cd ..  
rm -r master.zip
```



Creating License file for Cisco

pico CiscoKeyGen



```
! /usr/bin/python
print "*****"
print "Cisco IOU License Generator - Kal 2011, python port of 2006 C
version"
import os
import socket
import hashlib
import struct
```



Creating License file for Cisco (cont.)

```
# get the host id and host name to calculate the hostkey  
hostid=os.popen("hostid").read().strip()  
hostname = socket.gethostname()  
ioukey=int(hostid,16)  
for x in hostname:  
    ioukey = ioukey + ord(x)  
print "hostid=" + hostid + ", hostname="+ hostname + ", ioukey=" +  
hex(ioukey)[2:]
```



Creating License file for Cisco (cont.)

```
# create the license using md5sum  
iouPad1='\x4B\x58\x21\x81\x56\x7B\x0D\xF3\x21\x43\x9B\x7E\xAC\x1D\xE6\x8A'  
iouPad2='\x80' + 39*'\0'  
md5input=iouPad1 + iouPad2 + struct.pack('!L', ioukey) + iouPad1  
iouLicense=hashlib.md5(md5input).hexdigest()[:16]  
print "\nAdd the following text to ~/.iourc:"  
print "[license]\n" + hostname + " = " + iouLicense + ";\n"  
print "You can disable the phone home feature with something like:"  
print " echo '127.0.0.127 xml.cisco.com' >> /etc/hosts\n"
```


Give exec permissions and run it

```
chmod +x CiscoKeyGen  
./CiscoKeyGen
```



Output

```
maia@galago:/GNS3$ ./CiscoKeyGen  
*****  
Cisco IOU License Generator - Kal 2011, python port of 2006 C version  
hostid=007f0101, hostname=galago, ioukey=7f036c
```

```
Add the following text to ~/.iourc:  
[license]  
galago = 866eb729771e8752;
```

```
You can disable the phone home feature with something like:  
echo '127.0.0.127 xml.cisco.com' >> /etc/hosts
```

Add license to iourc.txt

pico iourc.txt

```
[license]
```

```
galago = 866eb729771e8752;
```



Disable the phone feature

```
echo '127.0.0.127 xml.cisco.com' >> /etc/hosts
```

Installation

Install Qemu

```
apt-get install qemu
```



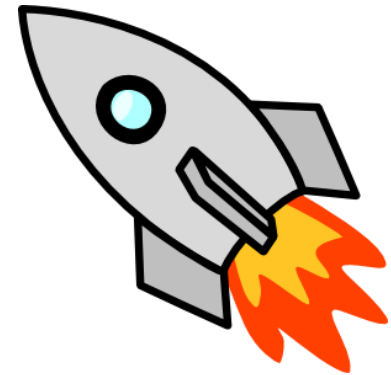
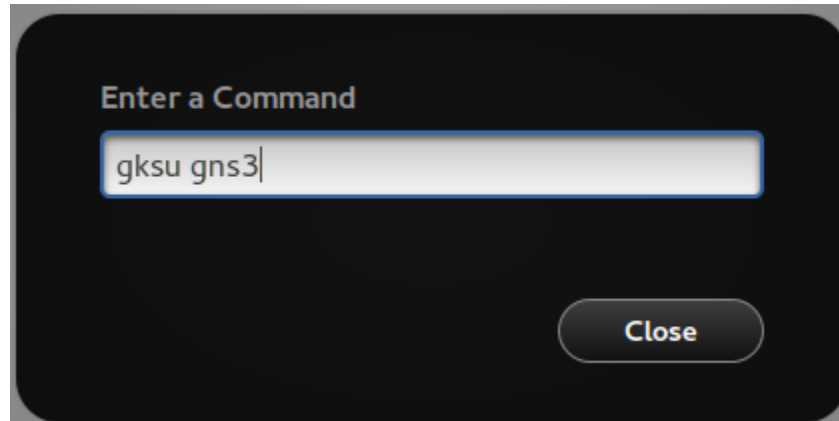
Install The DUDE

If you don't have wine, install it and after the Dude

```
sudo apt-get install wine  
dude.exe
```

Launch GNS3 as superuser

Alt F2



Creating RouterOS image to GNS3

Create the RouterOS image with 256 Mbytes for Ubuntu.

```
sudo qemu-img create -f qcow2 RouterOS.img 256M
```

Qemu supports several image types. qcow2 is more flexible and can be ported to other systems.

We didn't see difference on performance when using the raw format.

Download the latest .iso image from Mikrotik to the same directory and install

```
sudo qemu-system-x86_64 RouterOS.img -cdrom mikrotik.6.27.iso
```



```
QEMU
Welcome to MikroTik Router Software installation

Move around menu using 'p' and 'n' or arrow keys, select with 'spacebar'.
Select all with 'a', minimum with 'm'. Press 'i' to install locally or 'q' to
cancel and reboot.

[X] system          [ ] ipv6          [ ] security
[ ] ppp             [ ] kvm           [ ] ups
[ ] dhcp            [ ] lcd           [ ] user-manager
[ ] advanced-tools  [ ] mpls          [ ] wireless
[ ] cala            [ ] multicast     [ ] wireless-fp
[ ] gps             [ ] ntp
[ ] hotspot         [ ] routing

system (depends on nothing):
Main package with basic services and drivers
```

Install as usual and you'll have a RouterOS running over Qemu.



```
QEMU (R1)

888888b.d88888 888      888      888 "88b      888
888Y88888P888 888      888      888 .88P 888d888 88888b. .d88888b 888 888
888 Y888P 888 888      888      88888888K. 888P"      "88b 88K      888 888
888 Y8P 888 888      888      888      888 .d888888 "Y88888b. 888 888
888 " 888 888 .d88P      888 d88P 888      888 888      X88 888 888
888      888 8888888P"      88888888P" 888      "Y888888 88888P' 888 888

MDBrasil RouterOS 6.13 (c) 1999-2014      http://www.mdbrasil.com.br

[?]          Gives the list of available commands
command [?]  Gives help on the command and list of arguments

[Tab]        Completes the command/word. If the input is ambiguous,
              a second [Tab] gives possible options

/            Move up to base level
..           Move up one level
/command     Use command at the base level

[admin@R1] >
```


Licensing the image

You can use the demo license without problems, but if you want to license the router, you can:

Type each character of the license by hand



or

You can communicate via Winbox after binding your machine to the virtual environment (see further slides in this presentation).



Even if you skip the licensing part, you can access direct your router anytime by typing the script below:



Licensing the image

```
qemu-system-x86_64 -enable-kvm -m 1024 -netdev  
tap,id=t0,ifname=tap0,script=no,downscript=no -device  
e1000,netdev=t0,id=nico <imagefile>
```



Licensing the image



When you use the previous licensed image in a project, every time you create a new Router, interface ether0 (GNS3) will have the same MAC address.

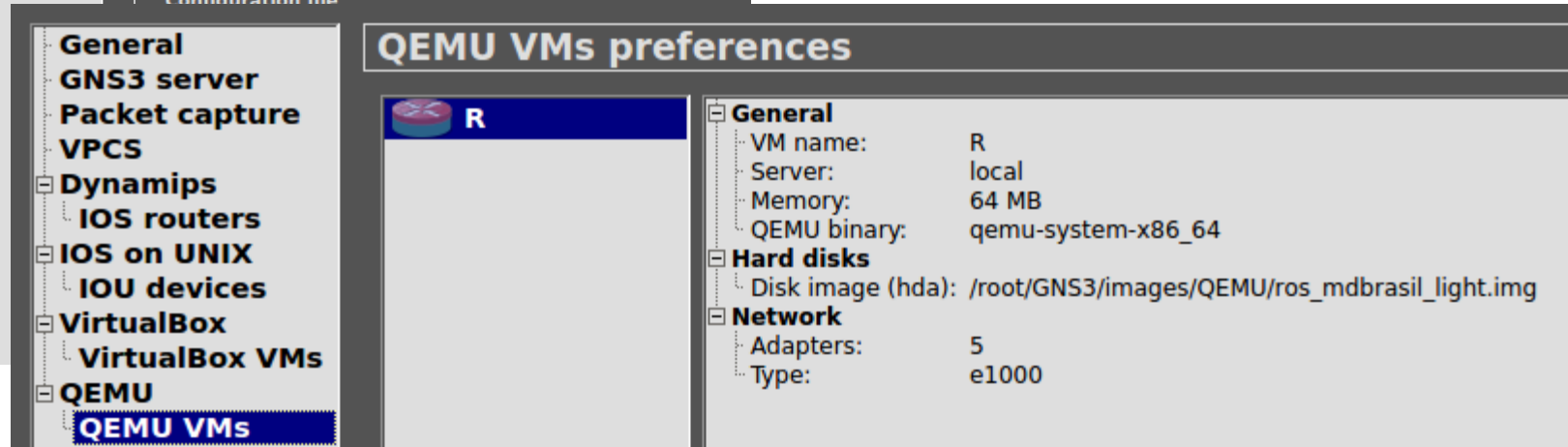
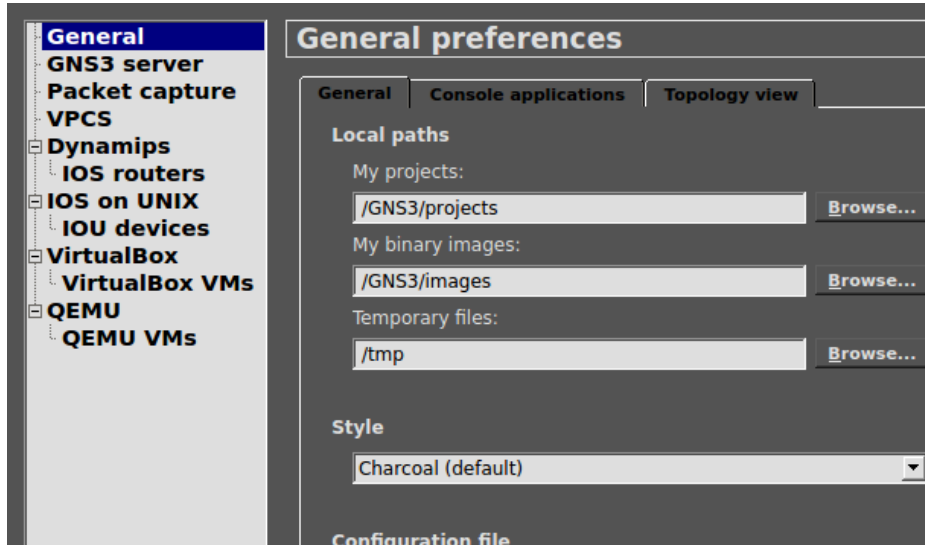
So, remember to reset the MAC to avoid problems:

```
/interface Ethernet reset-mac-address interface=ether1
```

N.B. ether0 (GNS3) = ether1 (RouterOS)

Inserting the image in GNS3 and creating a Base Project

Inserting RouterOS image in GNS3



Inserting RouterOS image in GNS3



QEMU VM configuration

R

General settings | HDD | Network | Advanced settings

VM name: R

RAM: 64 MB

Qemu binary: /usr/bin/qemu-system-x86_64 (v2.0.0)

VM name

Memory

Path to Qemu binary

QEMU VM configuration

R

General settings | HDD | Network | Advanced settings

Adapters: 5

Type: e1000

Number of adapters

Path to RouterOS image

QEMU VM configuration

R

General settings | HDD | Network | Advanced settings

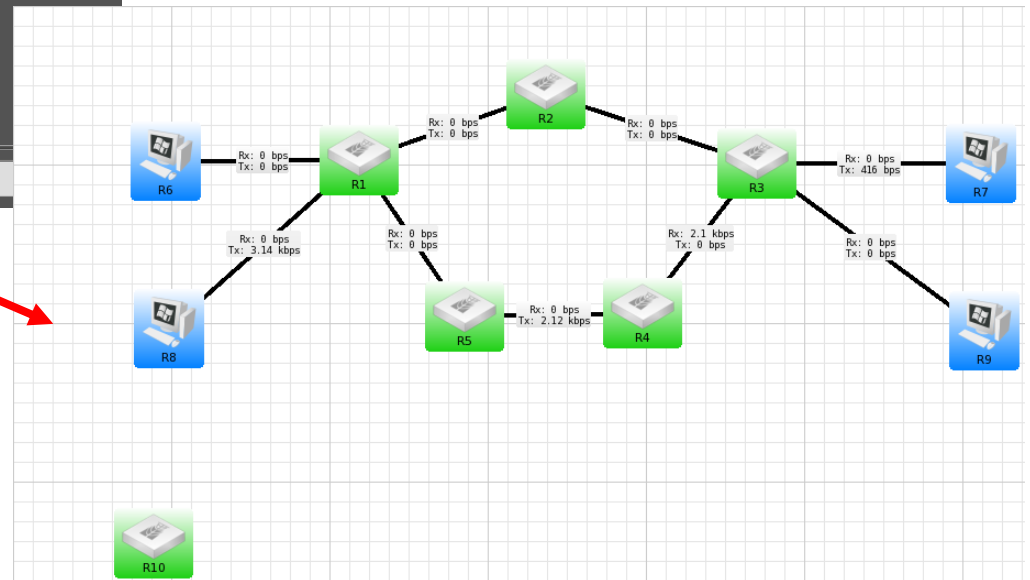
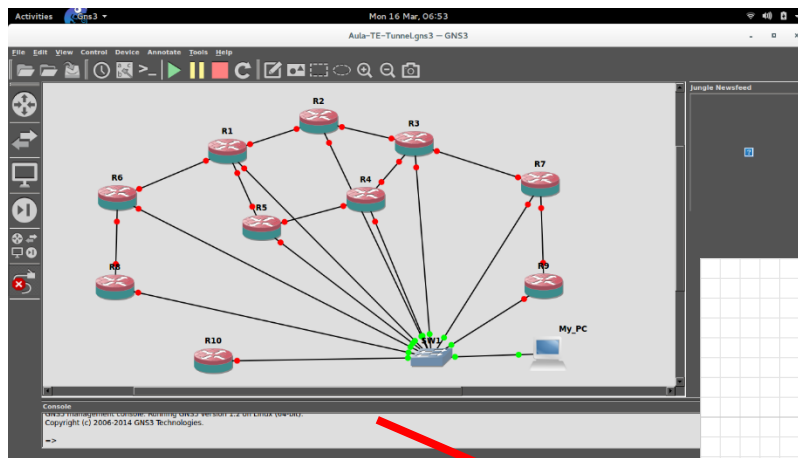
Disk image (hda): /root/GNS3/images/QEMU/ros_mdbrasil_light.img

Disk image (hdb):

Using The Dude as a frontend to the virtual network

Using The Dude as a frontend

Network maps can be customized direct in GNS3, but for RouterOS users, The Dude is sure much more friendly

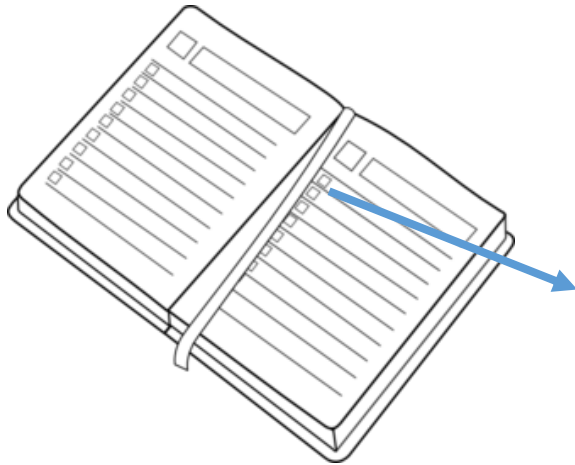




Motivations and General Talking about Network Simulators



Installing all the stuff necessary to simulate any type of IP network;



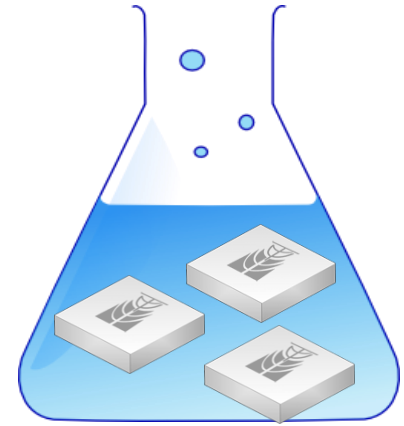
Creating a Simple and a Base Project and interacting with them;

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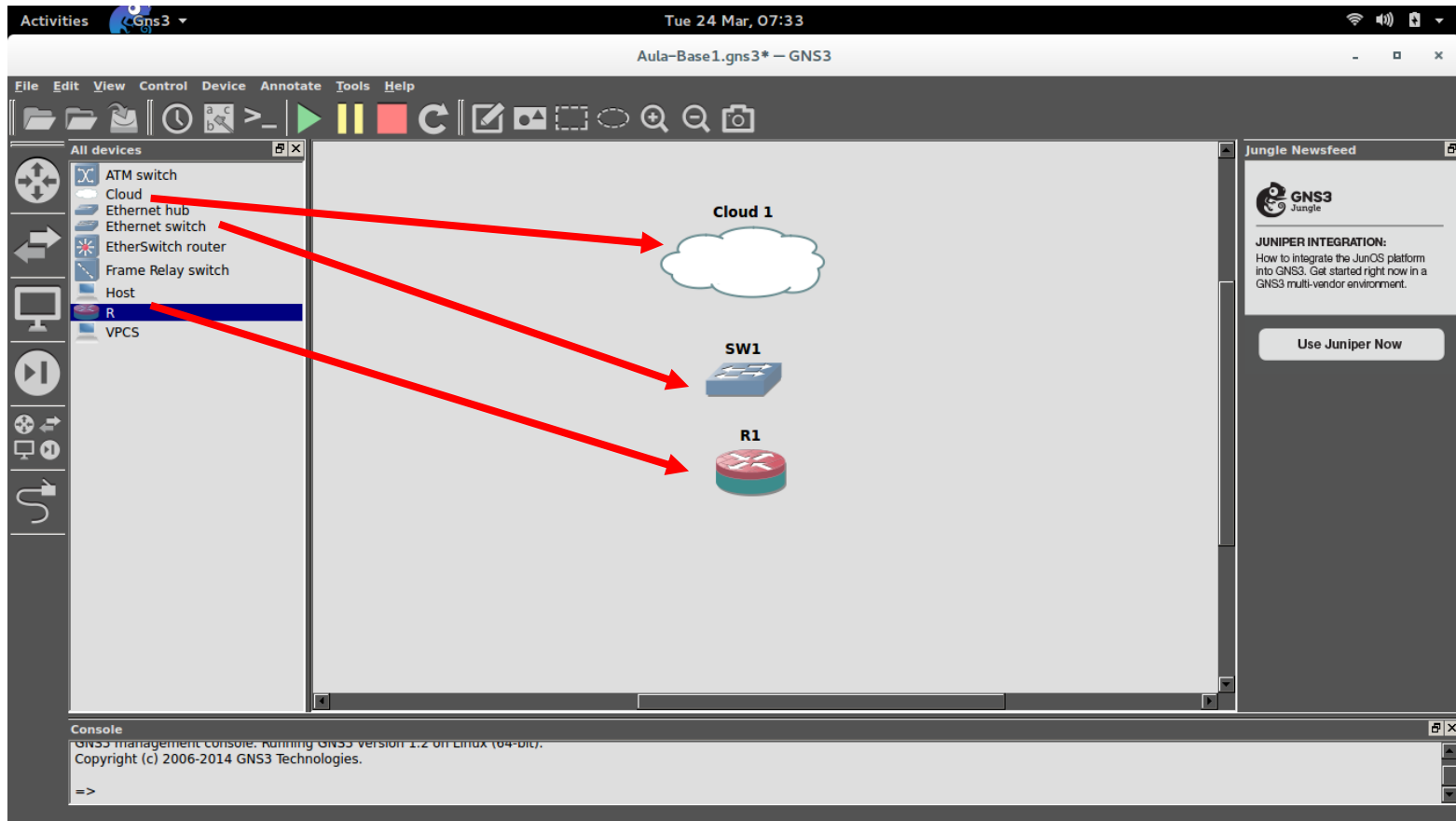
35'



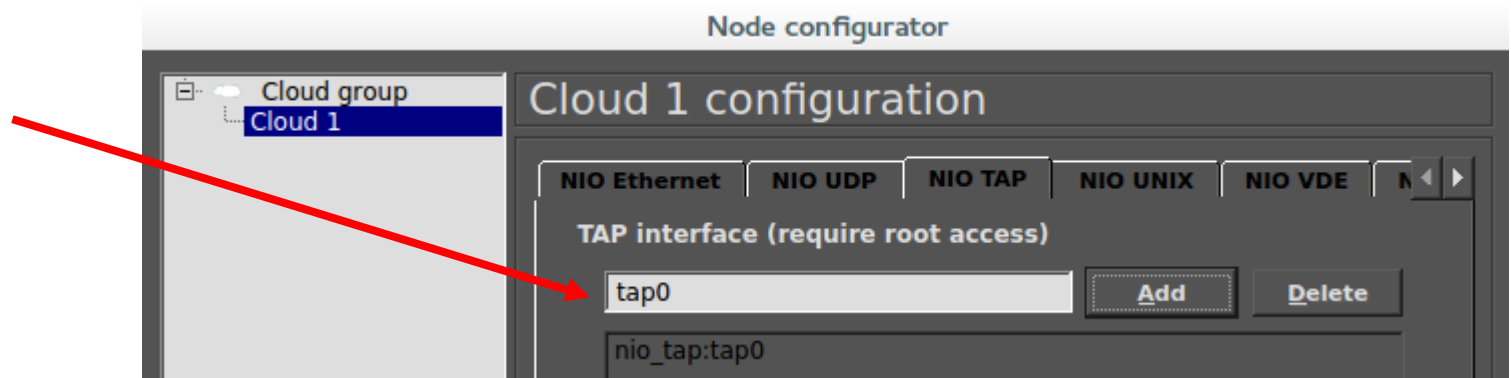
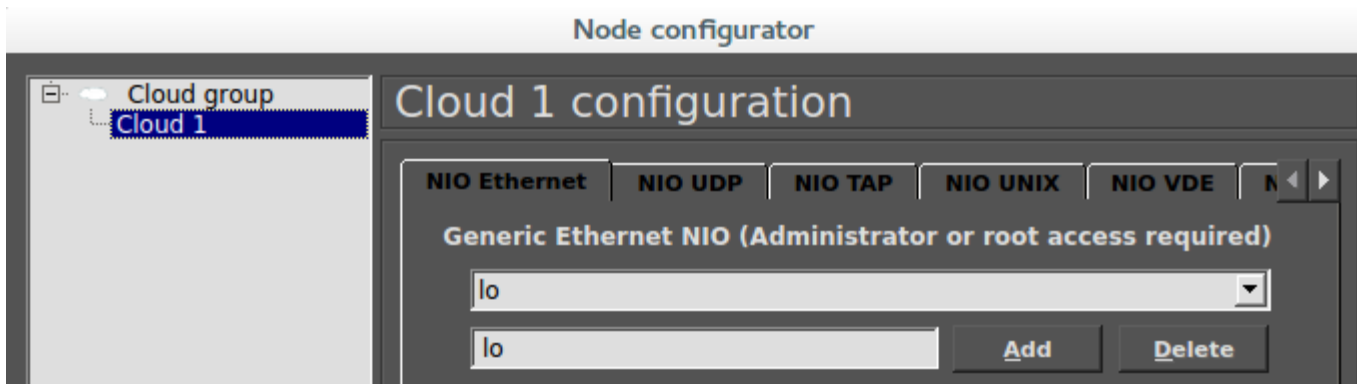
Hands ON

Creating a Simple Project

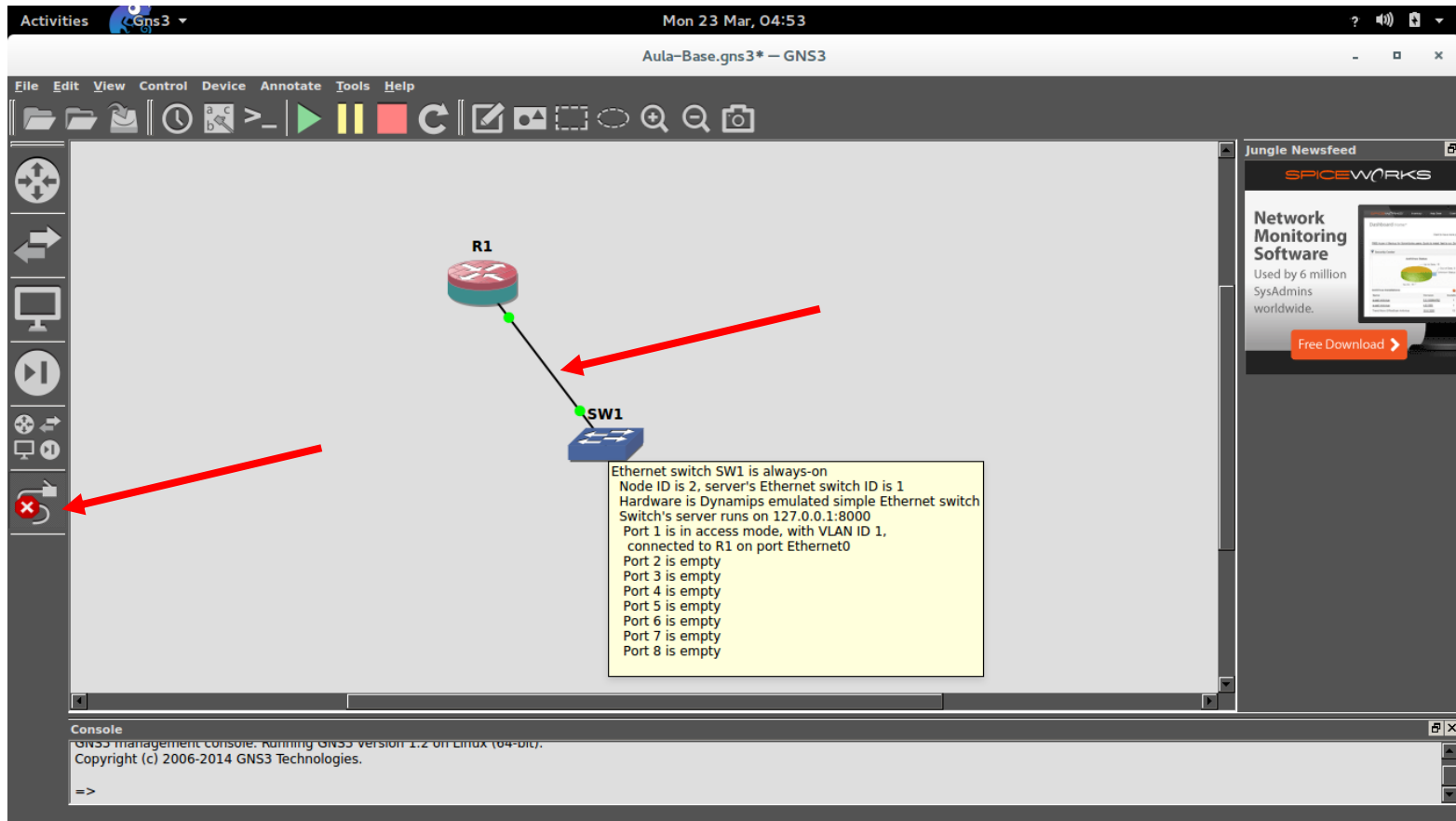
Creating the devices



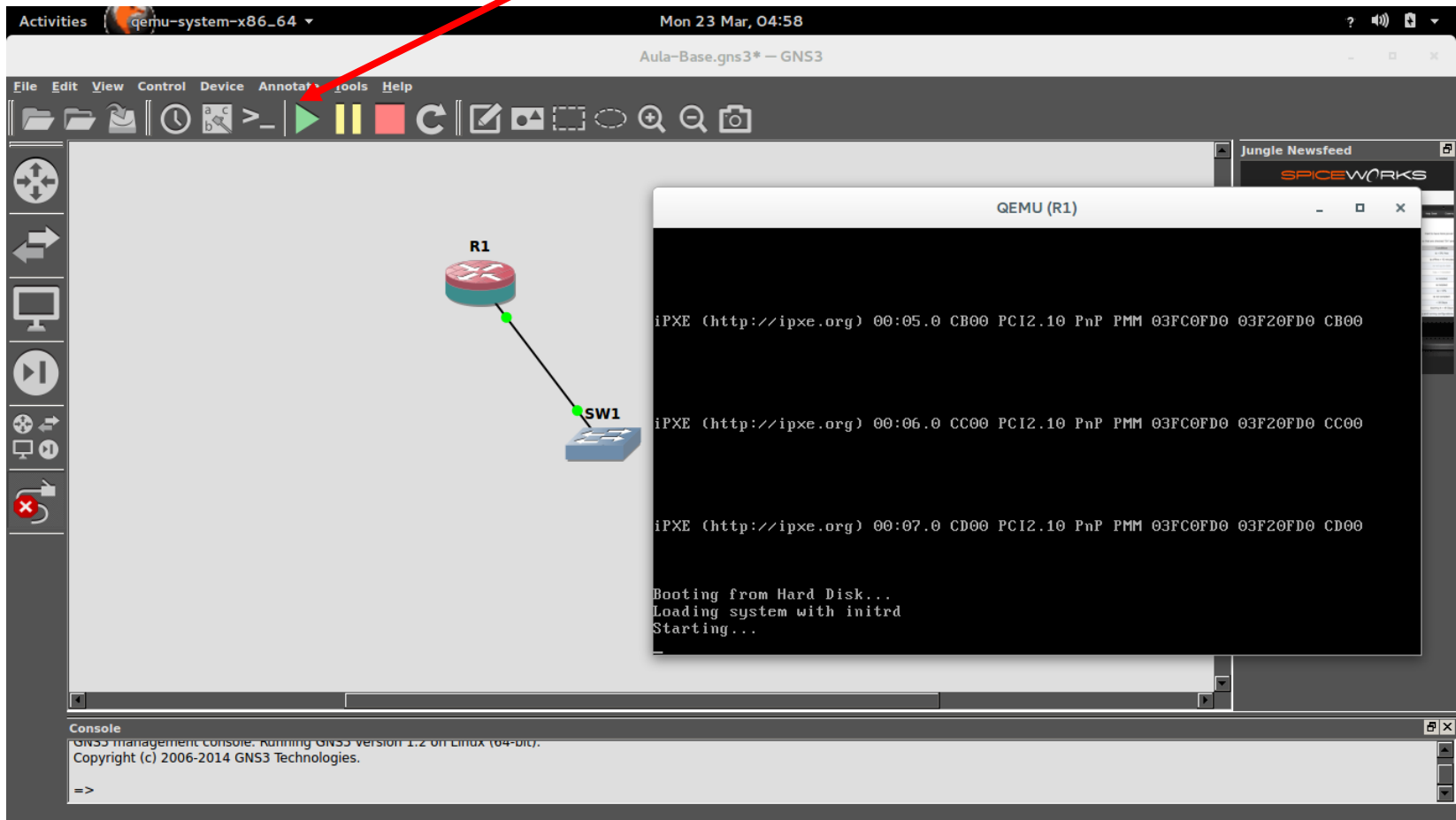
Configuring the “cloud” (pseudo device for external connections)



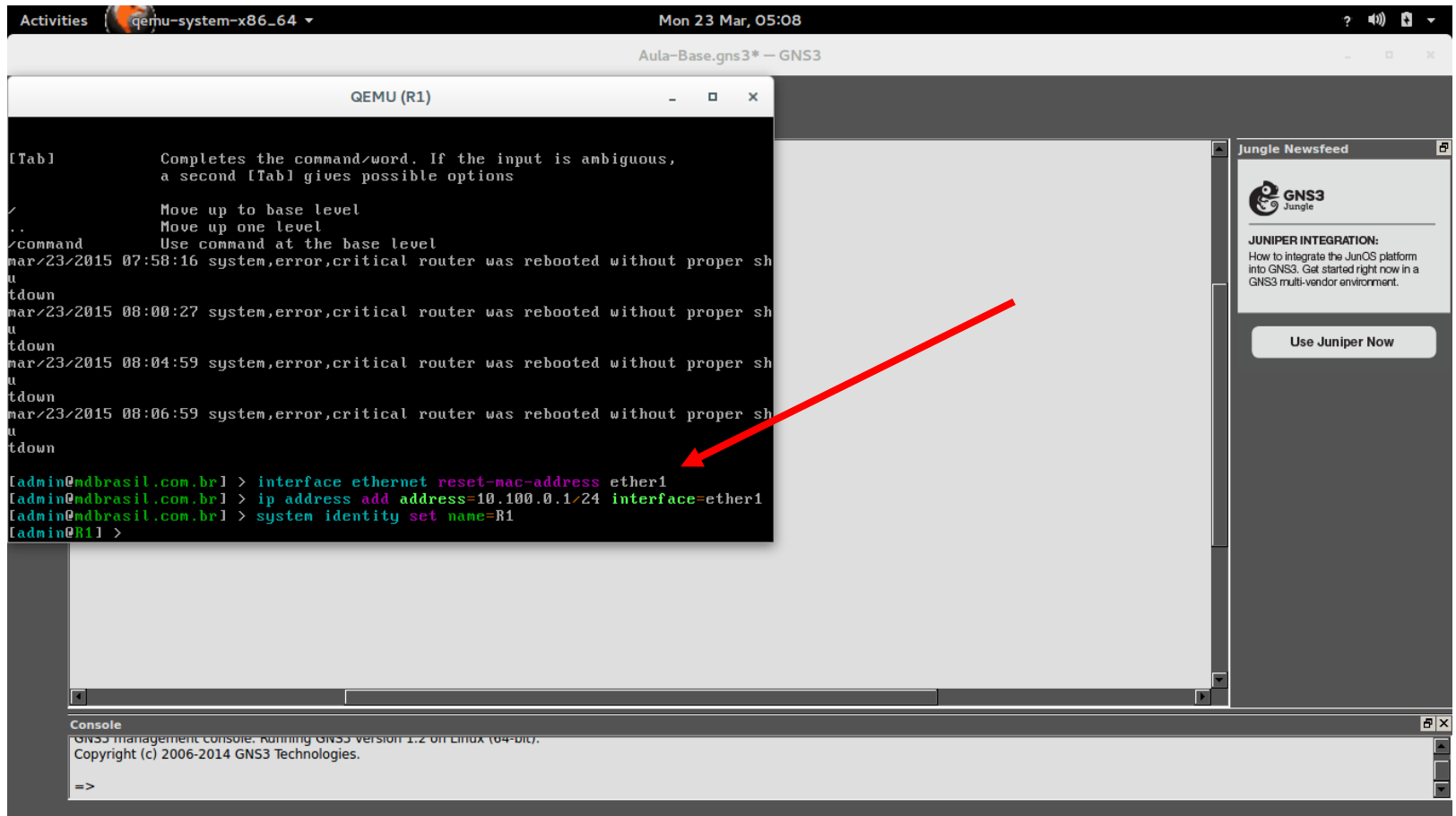
Making the links



Starting the Router



Important initial commands



The screenshot shows the GNS3 management console. A terminal window titled 'QEMU (R1)' is open, displaying the following commands and output:

```
[Tab]          Completes the command/word. If the input is ambiguous,
                a second [Tab] gives possible options

/              Move up to base level
..            Move up one level
/command      Use command at the base level

mar/23/2015 07:58:16 system,error,critical router was rebooted without proper sh
u
tdown
mar/23/2015 08:00:27 system,error,critical router was rebooted without proper sh
u
tdown
mar/23/2015 08:04:59 system,error,critical router was rebooted without proper sh
u
tdown
mar/23/2015 08:06:59 system,error,critical router was rebooted without proper sh
u
tdown

[admin@mdbrasil.com.br] > interface ethernet reset-mac-address ether1
[admin@mdbrasil.com.br] > ip address add address=10.100.0.1/24 interface=ether1
[admin@mdbrasil.com.br] > system identity set name=R1
[admin@R1] >
```

A red arrow points from the 'interface ethernet reset-mac-address ether1' command to the 'Jungle Newsfeed' sidebar on the right. The sidebar contains the GNS3 logo, a 'JUNIPER INTEGRATION' section with a link to 'How to integrate the JunOS platform into GNS3', and a 'Use Juniper Now' button.

At the bottom of the console, the text reads: 'GNS3 management console. Running GNS3 version 1.2 on Linux (64-bit). Copyright (c) 2006-2014 GNS3 Technologies. =>'

Binding your machine to the virtual environment

Install utilities for configuring the Linux Ethernet bridge

```
sudo apt-get install bridge-utils
```

Install utilities for user mode Linux

```
sudo apt-get install uml-utilities
```



Type the below script and give it exec permissions

```
#!/bin/bash
```

```
sudo modprobe tun
```

```
sudo tuncctl -t tap0
```

```
sudo ifconfig tap0 0.0.0.0 promisc up
```

```
sudo ifconfig wlan0 0.0.0.0 promisc up
```

```
sudo brctl addbr br0
```

```
sudo brctl addif br0 tap0
```

```
sudo brctl addif br0 eth0brctl show
```

```
sudo ifconfig br0 up
```

```
sudo ifconfig br0 x.x.x.x/x (IP to communicate with all devices)
```



Check bridge and tap configuration

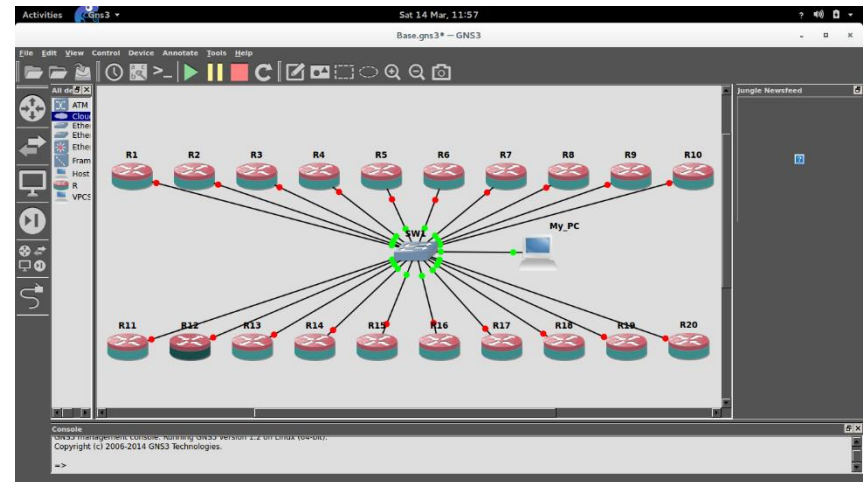
```
maia@galago:~$ brctl show
bridge name      bridge id                STP enabled  interfaces
br0              8000.0090f5f993dd        no           eth0
                                                         tap0

maia@galago:~$ ifconfig br0
br0              Link encap:Ethernet  HWaddr 00:90:f5:f9:93:dd
                inet addr:10.100.0.254  Bcast:10.100.0.255  Mask:255.255.255.0
                inet6 addr: fe80::290:f5ff:fef9:93dd/64 Scope:Link
                UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
                RX packets:30397 errors:0 dropped:0 overruns:0 frame:0
                TX packets:38196 errors:0 dropped:0 overruns:0 carrier:0
                collisions:0 txqueuelen:0
                RX bytes:2557523 (2.5 MB)  TX bytes:2775144 (2.7 MB)
```

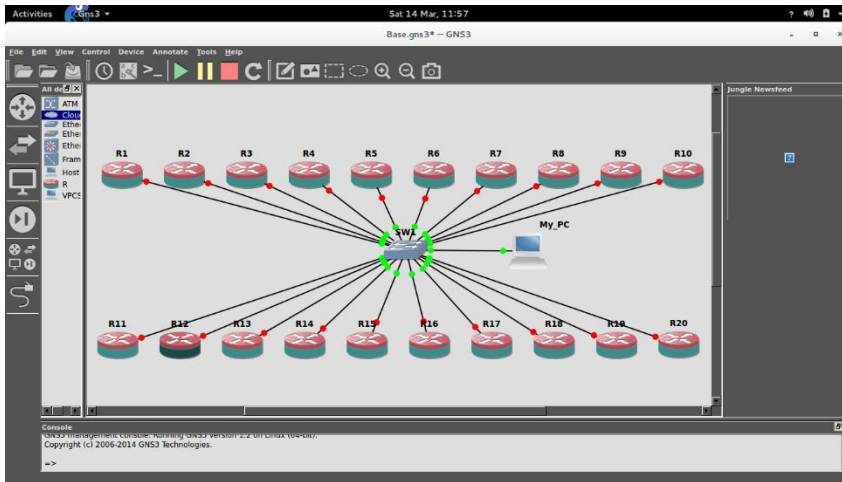
Hint:
Make a "Base" Project



To avoid repetition, create a base project fitted to your hardware capabilities and use it for all scenarios.



Hint:
Make a "Base" Project



Miscellaneous

- ☒ Launch the new project dialog on startup
 - ☒ Automatically check for update
 - ☒ Always use manual mode when adding links
- Delay between each device start when starting all devices:

20 seconds

To avoid overload your CPU you may consider delay the machine boots.

(not working on version 1.2.3) ☹



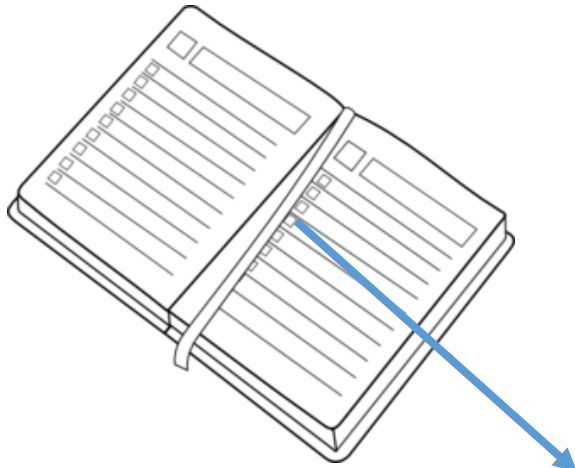
Motivations and General Talking about Network Simulators



Installing all the stuff necessary to simulate any type of IP network;



Creating a Simple and a Base Project and interacting with them;

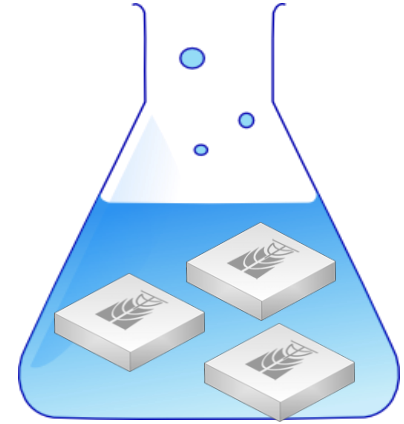


A real case demonstration – Traffic Engineering Scenario;

Final considerations, conclusions and download links.



47'

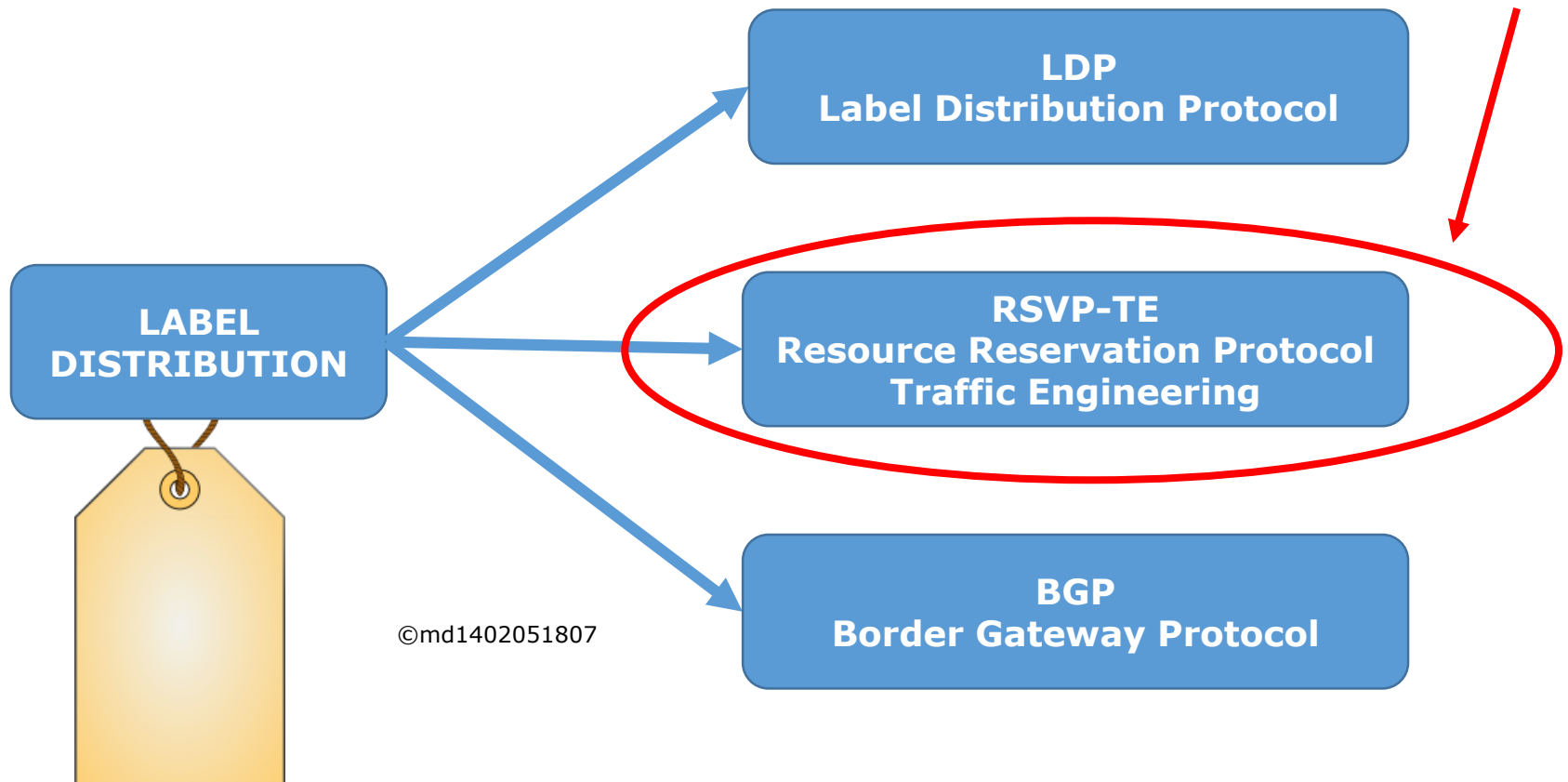


Hands ON

Traffic Engineering Study Case

Label Distribution:

There are 3 methods for Label distribution:

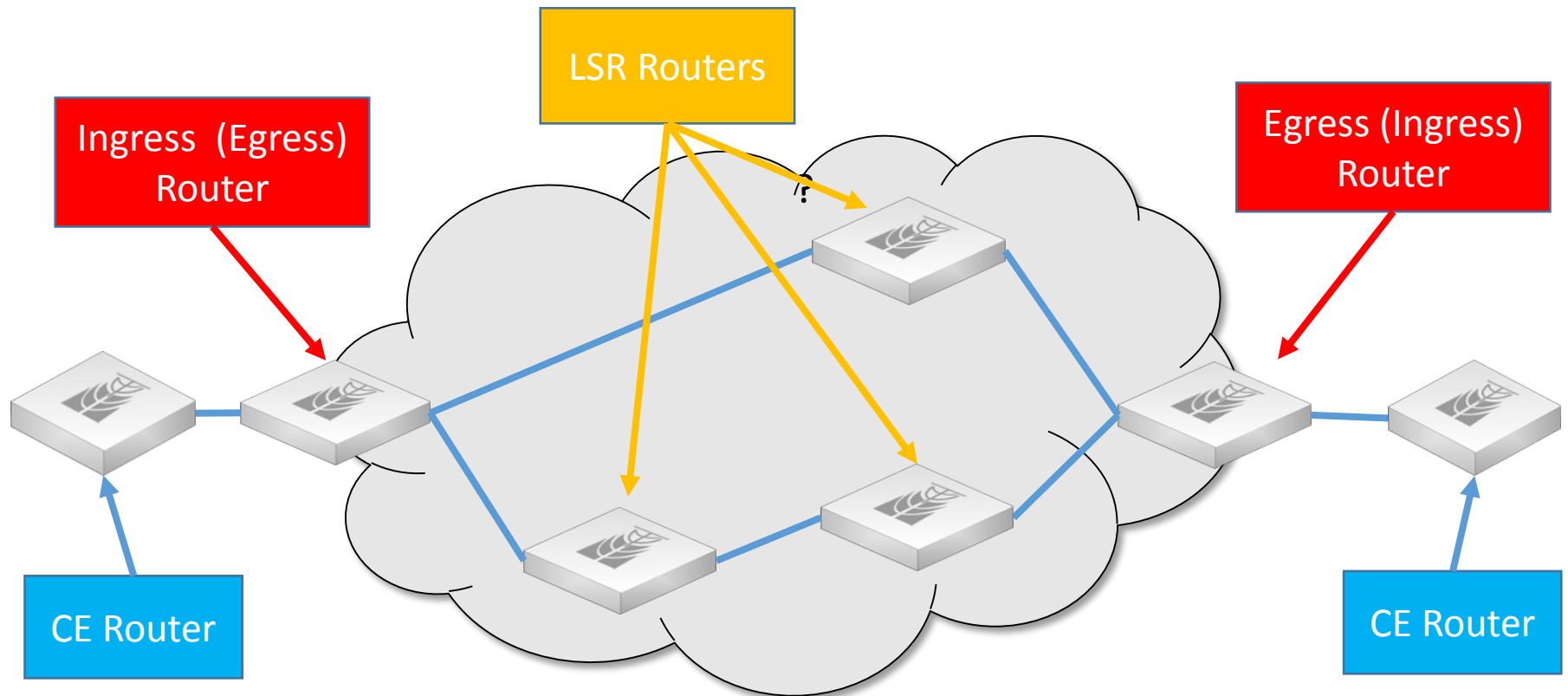


RSVP-TE (Resource Reservation Protocol – Traffic Engineering)

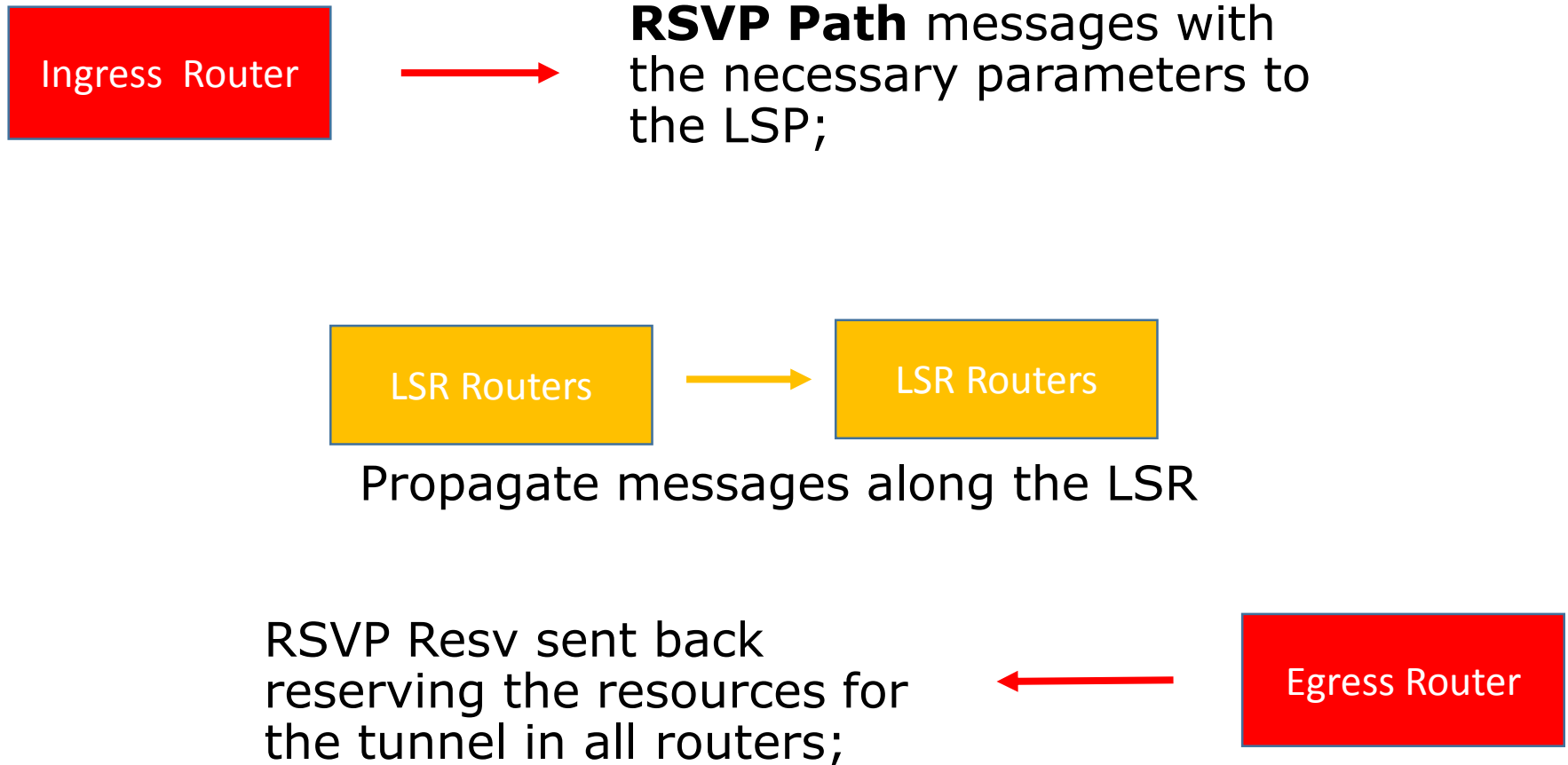
- RSVP-TE is an extension of RSVP protocol and supports the reservation of resources across an IP Network;
- Applications running on IP end systems can use RSVP to indicate to other nodes the nature of the packet streams they want to receive.
- RSVP-TE generally allows the establishment of MPLS label switched paths (LSPs), taking into consideration network constraint parameters such as available bandwidth and explicit hops.



Topology and naming



Some TE/MPLS Background

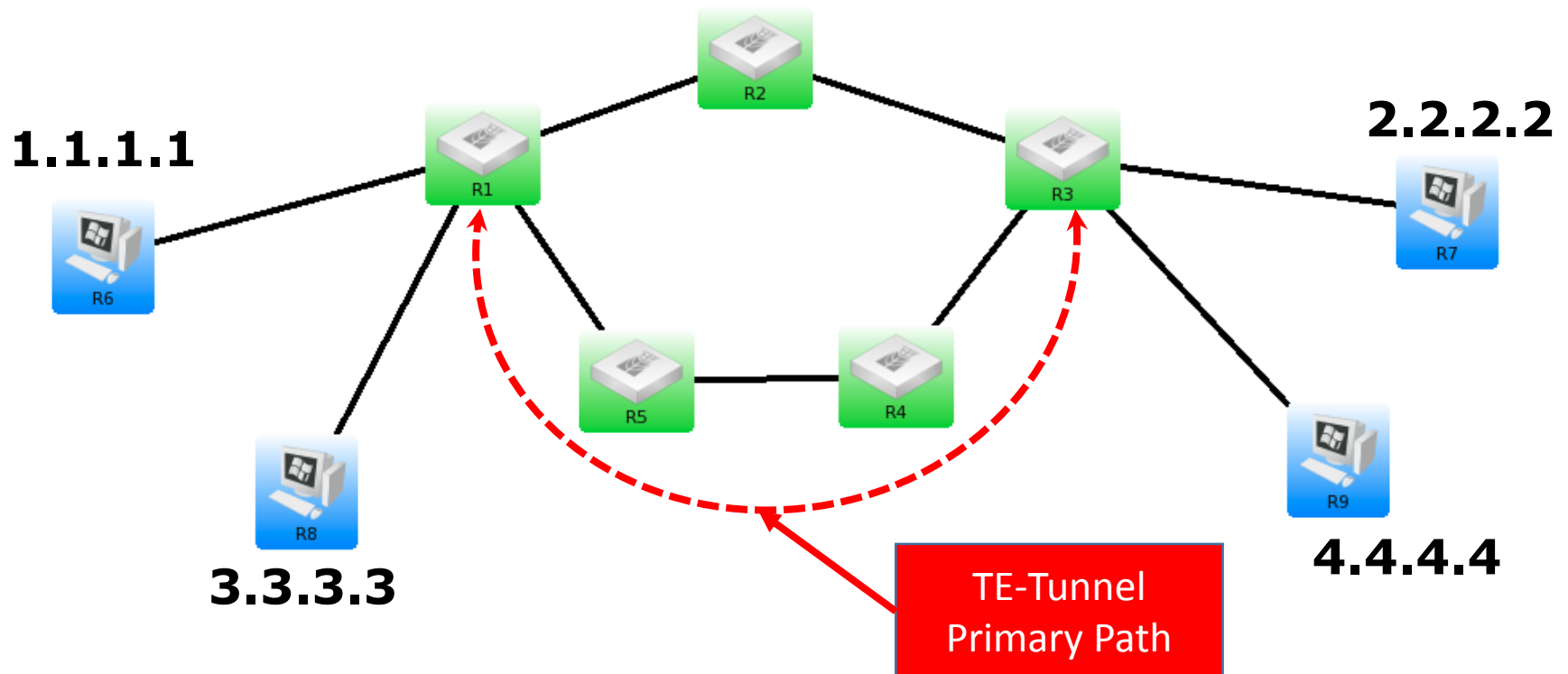


In this example, we are doing the following things:

- OSPF operational in all routers;
- Tunnel established between Ingress and Egress routers using loopback interfaces to guarantee redundancy in case of link failure;
- Primary strict path administratively defined and secondary via OSPF

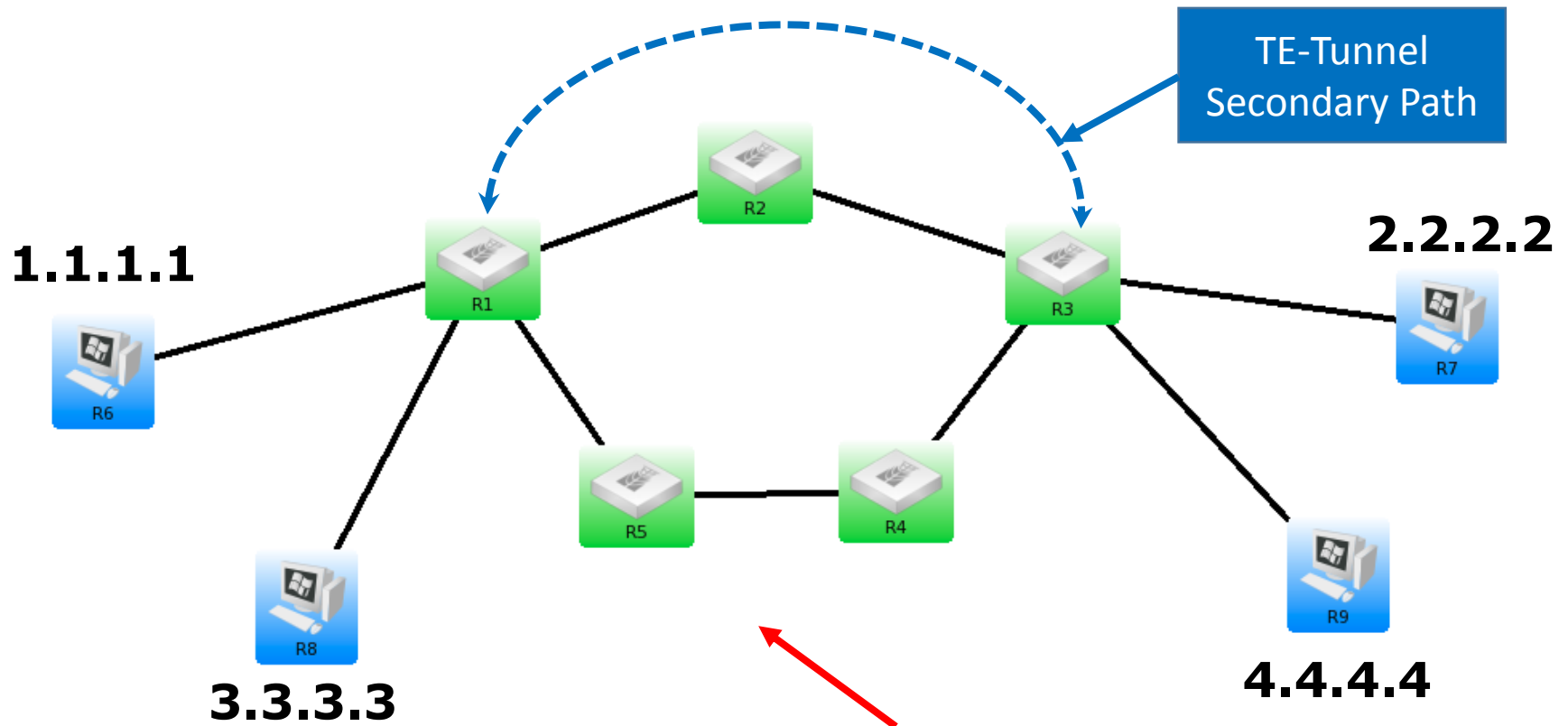
TE Scenario Example

Although the path through R2 is shorter, we want for some reason that the tunnel our primary path goes through R5 and R4.



TE Scenario Example

Path through R2 will be secondary in case of link failure



All routers have basic OSPF configuration, with MPLS TE Area and TE router ID configured

OSPF Instance <default>












General Metrics MPLS Status

MPLS TE Area:

MPLS TE Router ID:

Routing Table:

OSPF

Instances	Networks	Areas	Area Ranges
			
			
Network	Area		
 10.0.10.4	backbone		
 192.168.10.8/30	backbone		
 192.168.10.12/30	backbone		

TE Scenario Configurations

Primary and Secondary Paths

Primary path will use strict routes pointing to all IP addresses the flow goes through. Secondary Path is configured to use OSPF routes.

Tunnel Path <primario>

Name:

☐ Use CSPF

Setup Priority:

Holding Priority:

Record Route: ☒

Affinity Include All:

Affinity Include Any:

Affinity Exclude:

Reoptimize Interval:

Hops:

<input type="text" value="192.168.10.18"/>	:	<input type="text" value="strict"/>	<input type="button" value="v"/>	<input type="button" value="u"/>
<input type="text" value="192.168.10.17"/>	:	<input type="text" value="strict"/>	<input type="button" value="v"/>	<input type="button" value="u"/>
<input type="text" value="192.168.10.14"/>	:	<input type="text" value="strict"/>	<input type="button" value="v"/>	<input type="button" value="u"/>
<input type="text" value="192.168.10.13"/>	:	<input type="text" value="strict"/>	<input type="button" value="v"/>	<input type="button" value="u"/>
<input type="text" value="192.168.10.10"/>	:	<input type="text" value="strict"/>	<input type="button" value="v"/>	<input type="button" value="u"/>
<input type="text" value="192.168.10.9"/>	:	<input type="text" value="strict"/>	<input type="button" value="v"/>	<input type="button" value="u"/>

Tunnel Path <secundario>

Name:

☒ Use CSPF

Setup Priority:

Holding Priority:

Record Route:

Affinity Include All:

Affinity Include Any:

Affinity Exclude:

Reoptimize Interval:

Hops:

TE Scenario Configuration

Interface TE parameters

R1 is ingress and R3 egress. 10 Mbps is reserved with a margin of 5%.

Interface <priority_traffic>	
General	TE
Name:	priority_traffic
Type:	Traffic Eng Interface
MTU:	1500
L2 MTU:	65535
From Address:	10.0.10.1
To Address:	10.0.10.3
Bandwidth:	10M
Primary Path:	primario
Secondary Paths:	secundario

Interface <priority_traffic>	
General	TE
Primary Retry Interval:	00:01:00
Setup Priority:	
Holding Priority:	
Record Route:	<input checked="" type="checkbox"/>
Affinity Include All:	
Affinity Include Any:	
Affinity Exclude:	
Reoptimize Interval:	

Interface <priority_traffic>	
General	TE
Bandwidth Limit:	105
Auto Bandwidth Range:	
Auto Bandwidth Reserve:	0
Auto Bandwidth Avg. Interval:	00:05:00
Auto Bandwidth Update Interval:	01:00:00

This is the primary path established. Look at the explicit route and recorded route

Interface <priority_traffic>	
General	TE
Tunnel ID:	4
Primary Path State:	established
Primary Path:	primario
Secondary Path State:	not necessary
Secondary Path:	
Active Path:	primario
Active Label:	34
Explicit Route:	S:192.168.10.17/32,S:192.168.10.14/32,S:192.168.10.13/32,S:192.168.10.10/32,S:192.168.10.9/32
Recorded Route:	192.168.10.14[34],192.168.10.10[34],192.168.10.9[0]

TE Scenario Configurations

Redundancy in action

If primary path fails, secondary is used and primary is “on hold” until primary is up again. State passes through “trying to establish” and finally primary is established again.

Interface <priority_traffic>	
General	TE
Tunnel ID:	4
Primary Path State:	on hold
Primary Path:	
Secondary Path State:	established
Secondary Path:	secundario
Active Path:	secundario
Active Label:	39
Explicit Route:	S:192.168.10.2/32,S:192.168.10.5/32,S:192.168.10.6/32
Recorded Route:	192.168.10.5[39],192.168.10.6[3]

Interface <priority_traffic>	
General	TE
Tunnel ID:	4
Primary Path State:	trying to establish
Primary Path:	primario
Secondary Path State:	established
Secondary Path:	secundario
Active Path:	secundario
Active Label:	39
Explicit Route:	S:192.168.10.2/32,S:192.168.10.5/32,S:192.168.10.6/32
Recorded Route:	192.168.10.5[39],192.168.10.6[3]

Below an example of policy, where all traffic sent to network 2.2.2.0/24 (or marked with the same mark) will be limited. Other traffic will follow OSPF routes

Route List				
Routes Nexthops Rules VRF				
<div> <div>+</div> <div>-</div> <div>✓</div> <div>✗</div> <div>📁</div> <div>🔍</div> </div>				
	Dst. Address	Gateway	Distance	Routing Mark
AS	0.0.0.0/0	172.16.10.2 reachable priority_traffic	1	inside_tunnel1
DAo	0.0.0.0/0	192.168.10.2 reachable ether2	110	

Policy Routing Rule <>

Src. Address:

▼

Dst. Address:

2.2.2.0/24

▲

Routing Mark:

▼

Interface:

▼

Action:

lookup

▼

Table:

inside_tunnel1

▼

Route <0.0.0.0/0>

General

Attributes

Dst. Address:

0.0.0.0/0

Gateway:

172.16.10.2

Check Gateway:

Type:

unicast

Distance:

1

Scope:

30

Target Scope:

10

Routing Mark:

inside_tunnel1

Pref. Source:

Testing routing and limitation

```
[admin@R1] > tool traceroute 2.2.2.2
```

#	ADDRESS	LOSS	SENT	LAST	AVG	BEST	WORST	STD-DEV	STATUS
1	192.168.10.17	0%	17	3.6ms	2.6	1.3	7.4	1.5	<MPLS:L=30,E=0>
2	192.168.10.13	0%	17	2.4ms	1.6	0.7	3.8	0.9	<MPLS:L=30,E=0>
3	2.2.2.2	0%	17	1.1ms	1.5	0.6	3.4	0.8	

Bandwidth Test (Running)

Test To:

Protocol: ☒ udp ☐ tcp

Local UDP Tx Size:

Remote UDP Tx Size:

Direction:

TCP Connection Count:

Local Tx Speed: bps

Remote Tx Speed: bps

☐ Random Data

User:

Password:

Lost Packets:

Tx/Rx Current:

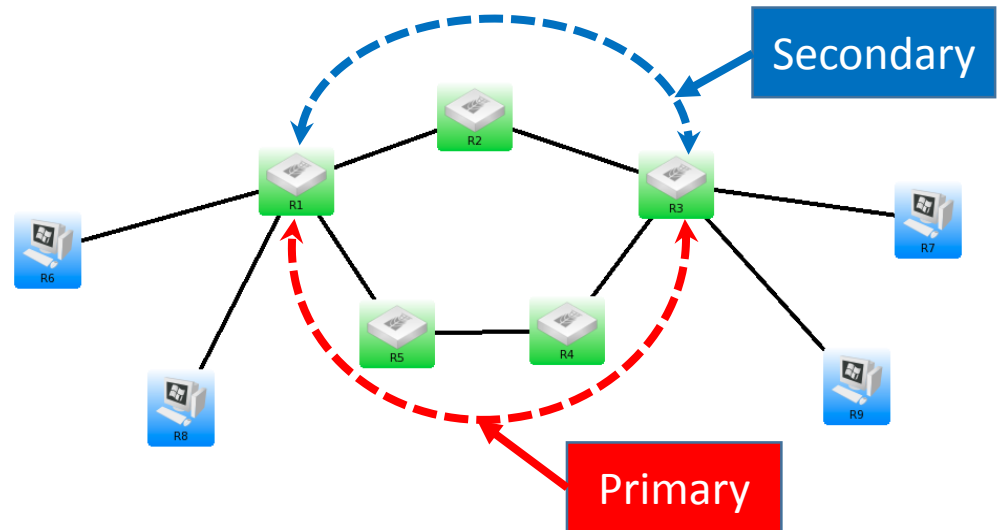
Tx/Rx 10s Average:

Tx/Rx Total Average:

☐ Tx: 10.4 Mbps

☐ Rx:

running...





Motivations and General Talking about Network Simulators



Installing all the stuff necessary to simulate any type of IP network;



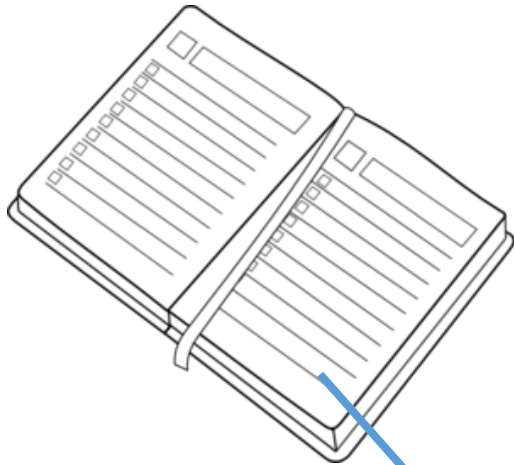
Creating a Simple and a Base Project and interacting with them;



A real case demonstration – Traffic Engineering Scenario;



Final considerations, references and download links.



50'



Unfortunately we cannot simulate and predict all practical situations because of hardware specific things, like:

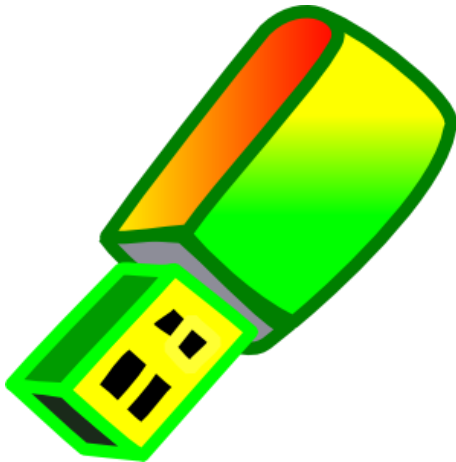
- Wireless capabilities;
- Switching features;
- Problems related to interface negotiation, MTU issues;
- etc.

Also software installation (Qemu and GNS3) could be tricky for some users depending on operating system, hardware and other dependencies not satisfied.

Trainings using simulators should be planned in advance to avoid delays.



To circumvent issues related to installation we have developed an .iso image that can be run as a Live USB or a Live CD;



At the time of this writing, the current version of this image is using Ubuntu 14.04 LTS 32 bit and GNS3 1.2.3.

Downloads can be made at MD Brasil Web site:

<http://mdbrasil.com.br/downloads/gns3>

Feedbacks are welcome:

maia@mdbrasil.com.br

References

<http://gns3.net>

<http://qemu.org>

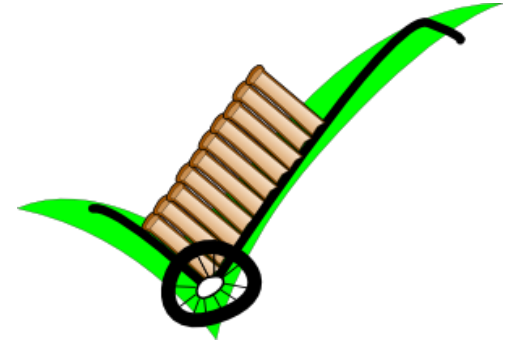
<http://virtualbox.org>

<http://sourceforge.net/projects/gns-3/>

<http://brezular.com/2014/07/09/running-mikrotik-routers-x86-on-gns3/>

<https://wiki.debian.org/QEMU>

<http://mum.mikrotik.com/presentations/ID13/rofiq.pdf>



Thanks to



Many Thanks to

Sergio Souza who helped a lot with debugging the installations and who exchange with me a lot of projects;

Tom Smyth and **Patrik Schaub** for commercial cooperation and technical information exchange;

Jaromir Cihák for the usual hospitality here in Prague and for the efforts in the routed world project.



Presentation and related material can be obtained in the URL:

<http://mdbrasil.com.br/downloads/gns3>



Download	
Essa Página disponibiliza para download a distribuição Ubuntu-GNS3 deser	
Abaixo seguem os seguintes arquivo:	
ubuntu-gns3.iso Imagem da distribuição Ubuntu GNS3 em formato iso.	← ISO image
Universal USB Installer Software para auxiliar na criação de LiveUSB.	← USB installer
RouterOS-6.27 Imagem virtual machine da RouterOS-6.27 para aplicação QEMU.	← RouterOS image for Qemu
MUM Brasil 2014 Apresentação sobre uso de GNS3 com RouterOS - Maia e Sérgio.	
Instalação em Windows Tutorial de instalação do GNS3 em Windows - Sérgio Souza.	← Windows Installation (Portuguese)

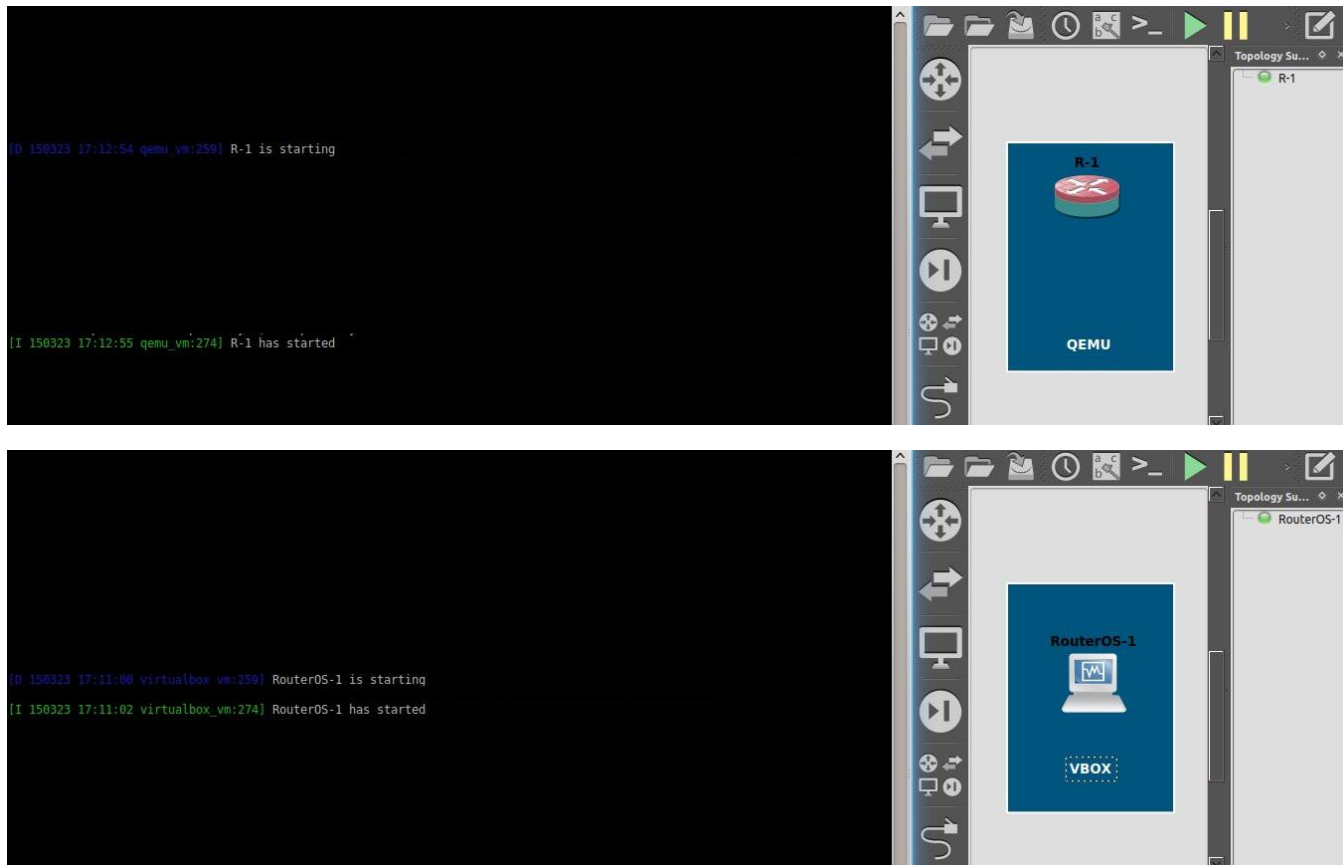


Extra Slides

Extra Slides VirtualBox x Qemu



Qemu x VirtualBox



The image displays two side-by-side network topology diagrams, each with a corresponding terminal window on the left showing the startup sequence.

Top Screenshot (QEMU):

- Terminal:**
[0 150323 17:12:54 qemu_vm:259] R-1 is starting
[I 150323 17:12:55 qemu_vm:274] R-1 has started
- Topology Diagram:** A blue box labeled "QEMU" contains a red router icon labeled "R-1". The right sidebar shows "Topology Su..." and "R-1".

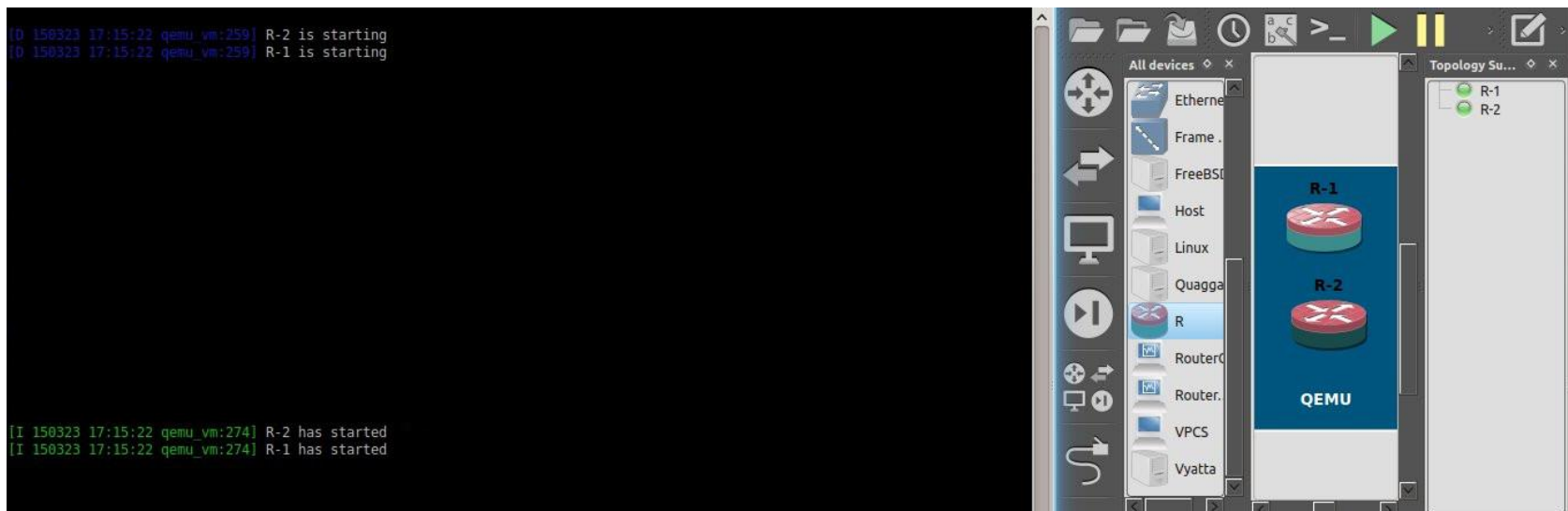
Bottom Screenshot (VBOX):

- Terminal:**
[0 150323 17:11:00 virtualbox_vm:259] RouterOS-1 is starting
[I 150323 17:11:02 virtualbox_vm:274] RouterOS-1 has started
- Topology Diagram:** A blue box labeled "VBOX" contains a white router icon labeled "RouterOS-1". The right sidebar shows "Topology Su..." and "RouterOS-1".

Extra Slides VirtualBox x Qemu



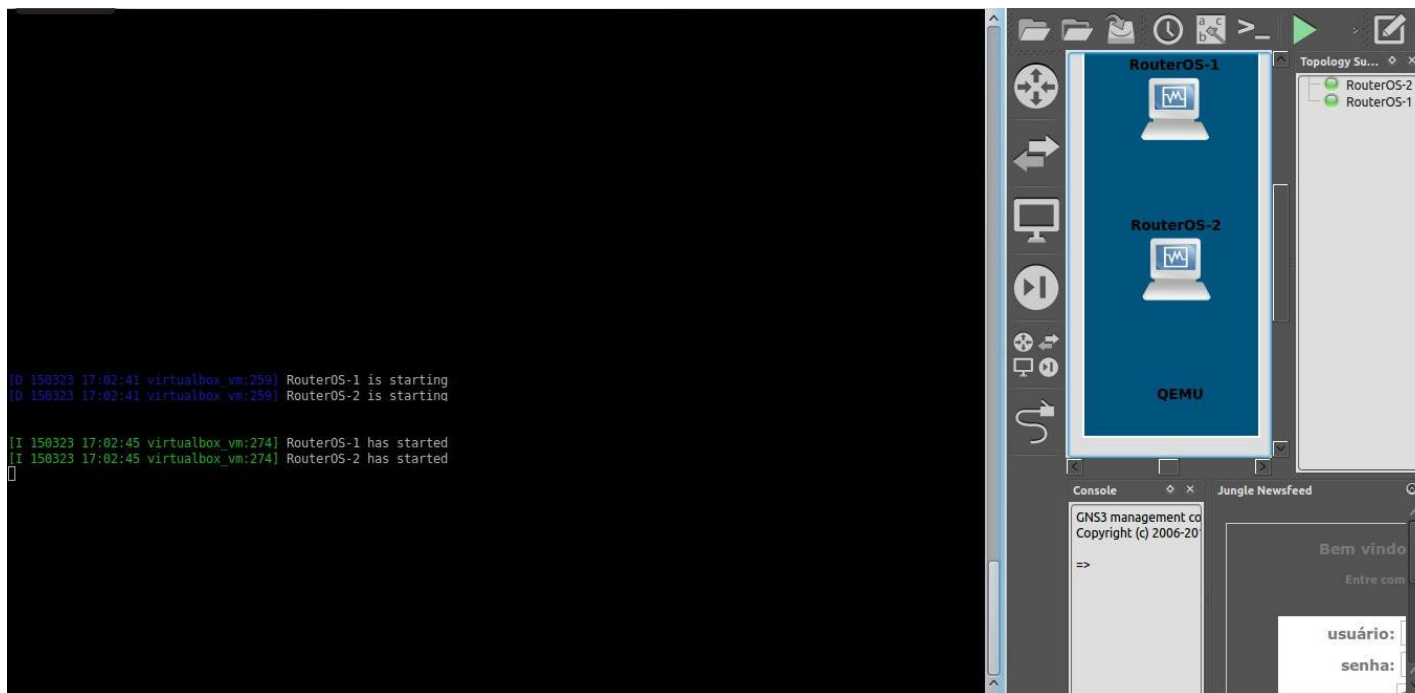
Qemu x VirtualBox



Extra Slides VirtualBox x Qemu

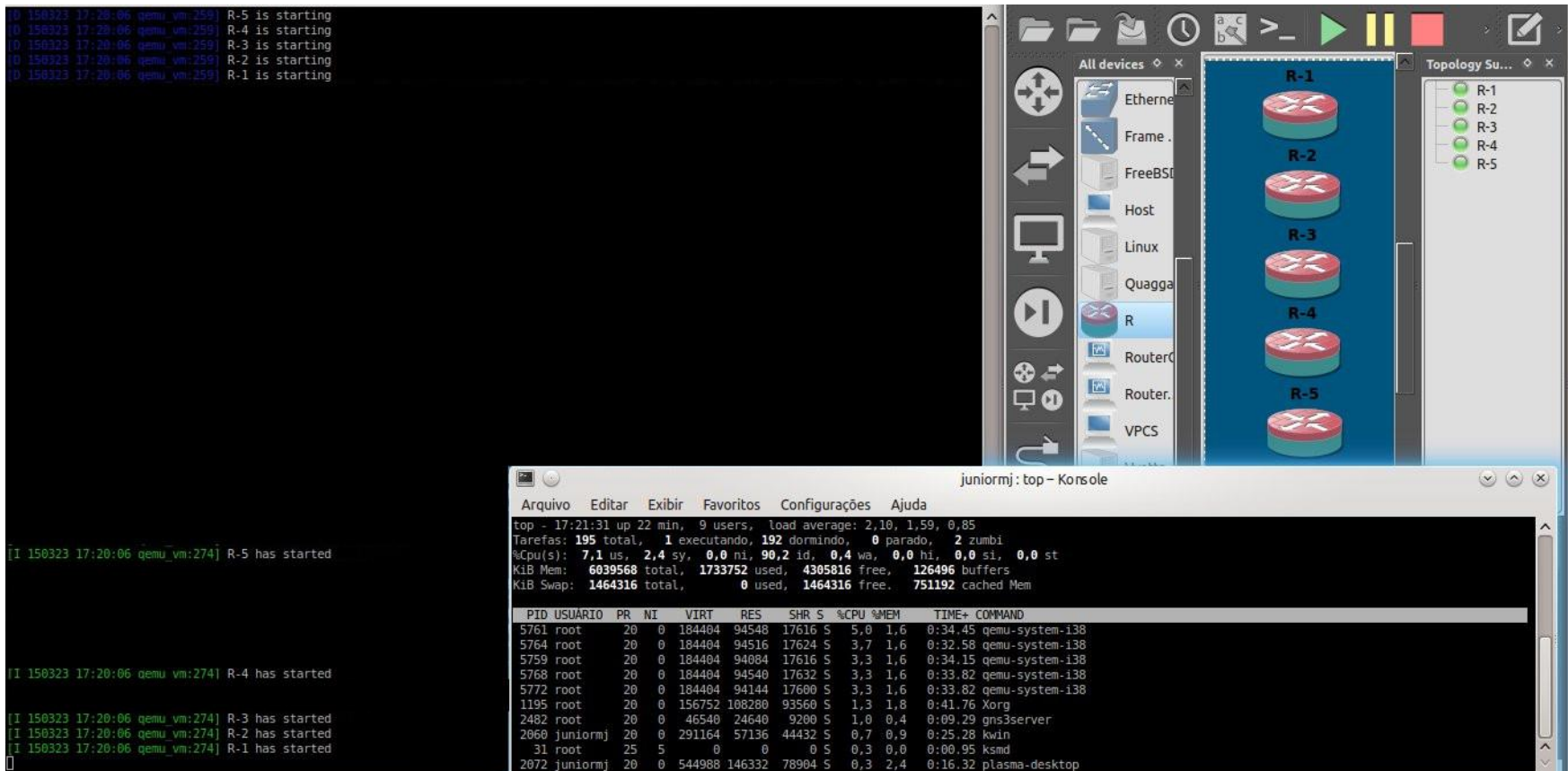


Qemu x VirtualBox





Qemu x VirtualBox



The screenshot displays a VirtualBox VM window with a Qemu terminal and a network topology diagram.

Qemu Terminal Output:

```

[0 150323 17:20:06 qemu_vm:259] R-5 is starting
[0 150323 17:20:06 qemu_vm:259] R-4 is starting
[0 150323 17:20:06 qemu_vm:259] R-3 is starting
[0 150323 17:20:06 qemu_vm:259] R-2 is starting
[0 150323 17:20:06 qemu_vm:259] R-1 is starting

```

Network Topology Diagram:

The diagram shows a vertical stack of five red circular nodes labeled R-1, R-2, R-3, R-4, and R-5, connected by a central vertical line. The nodes are arranged from bottom to top in the order R-1, R-2, R-3, R-4, R-5.

Qemu Terminal Output (Continued):

```

[I 150323 17:20:06 qemu_vm:274] R-5 has started
[I 150323 17:20:06 qemu_vm:274] R-4 has started
[I 150323 17:20:06 qemu_vm:274] R-3 has started
[I 150323 17:20:06 qemu_vm:274] R-2 has started
[I 150323 17:20:06 qemu_vm:274] R-1 has started

```

Qemu Terminal Output (System Information):

```

top - 17:21:31 up 22 min, 9 users, load average: 2.10, 1.59, 0.85
Tarefas: 195 total, 1 executando, 192 dormindo, 0 parado, 2 zumbi
%Cpu(s): 7.1 us, 2.4 sy, 0.0 ni, 90.2 id, 0.4 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem: 6039568 total, 1733752 used, 4305816 free, 126496 buffers
KiB Swap: 1464316 total, 0 used, 1464316 free, 751192 cached Mem

```

Qemu Terminal Output (Process List):

PID	USUARIO	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
5761	root	20	0	184404	94548	17616	S	5.0	1.6	0:34.45	qemu-system-i386
5764	root	20	0	184404	94516	17624	S	3.7	1.6	0:32.58	qemu-system-i386
5759	root	20	0	184404	94084	17616	S	3.3	1.6	0:34.15	qemu-system-i386
5768	root	20	0	184404	94540	17632	S	3.3	1.6	0:33.82	qemu-system-i386
5772	root	20	0	184404	94144	17600	S	3.3	1.6	0:33.82	qemu-system-i386
1195	root	20	0	156752	108280	93560	S	1.3	1.8	0:41.76	Xorg
2482	root	20	0	46540	24640	9200	S	1.0	0.4	0:09.29	gnss3server
2060	juniormj	20	0	291164	57136	44432	S	0.7	0.9	0:25.28	kwIn
31	root	25	5	0	0	0	S	0.3	0.0	0:00.95	ksmd
2072	juniormj	20	0	544988	146332	78904	S	0.3	2.4	0:16.32	plasma-desktop



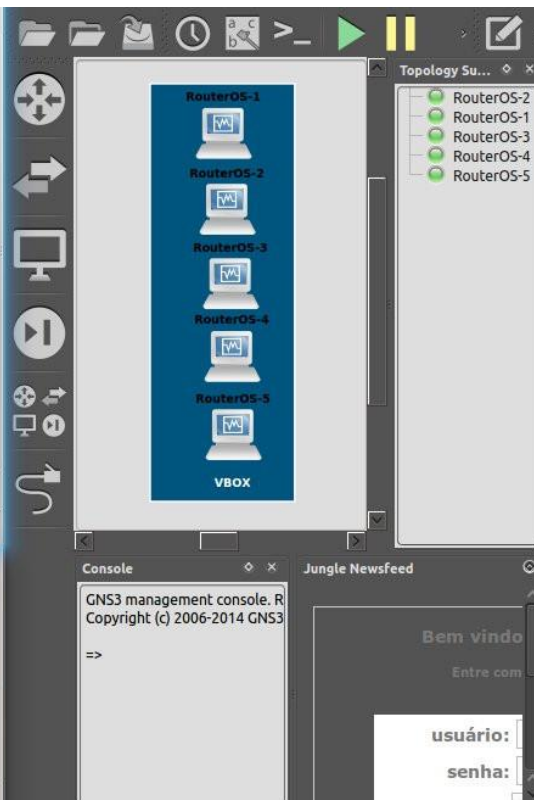
Qemu x VirtualBox

```
top - 17:08:45 up 9 min, 9 users, load average: 0,20, 0,46, 0,36
Tarefas: 197 total, 1 executando, 194 dormindo, 0 parado, 2 zumbi
%Cpu(s): 1,0 us, 1,8 sy, 0,6 ni, 96,0 id, 0,6 wa, 0,0 hi, 0,0 si, 0,0 st
KiB Mem: 6039568 total, 1711016 used, 4328552 free, 123600 buffers
KiB Swap: 1464316 total, 0 used, 1464316 free, 719644 cached Mem
```

PID	USUARIO	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
3680	root	20	0	335632	85200	65444	S	4,3	1,4	0:07.07	VirtualBox
3915	root	20	0	335740	85312	65476	S	4,0	1,4	0:07.23	VirtualBox
4146	root	20	0	335608	85368	65616	S	4,0	1,4	0:06.96	VirtualBox
4410	root	20	0	216852	45560	35136	S	3,3	0,8	0:05.84	VBoxHeadless
4668	root	20	0	216852	45620	35216	S	3,3	0,8	0:05.81	VBoxHeadless
2482	root	20	0	46540	24640	9200	S	1,0	0,4	0:03.38	gns3server
23	root	20	0	0	0	0	S	0,0	0,0	0:00.10	ksoftirqd/3
1195	root	20	0	153544	104376	90272	S	0,3	1,7	0:17.11	Xorg
2060	juniormj	20	0	290764	56676	44424	S	0,3	0,9	0:10.75	kwin
2072	juniormj	20	0	514688	140772	76740	S	0,3	2,3	0:09.78	plasma-desktop
3500	root	20	0	43480	18452	11412	S	0,3	0,3	0:01.20	VBoxSVC
4755	juniormj	20	0	5608	2808	2396	R	0,3	0,0	0:00.05	top
1	root	20	0	4600	3692	2552	S	0,0	0,1	0:01.32	init
2	root	20	0	0	0	0	S	0,0	0,0	0:00.00	kthreadd
3	root	20	0	0	0	0	S	0,0	0,0	0:00.07	ksoftirqd/0
5	root	0	-20	0	0	0	S	0,0	0,0	0:00.00	kworker/0:0H
7	root	20	0	0	0	0	S	0,0	0,0	0:00.47	rcu_sched
8	root	20	0	0	0	0	S	0,0	0,0	0:00.00	rcu_bh
9	root	rt	0	0	0	0	S	0,0	0,0	0:00.00	migration/0
10	root	rt	0	0	0	0	S	0,0	0,0	0:00.00	watchdog/0

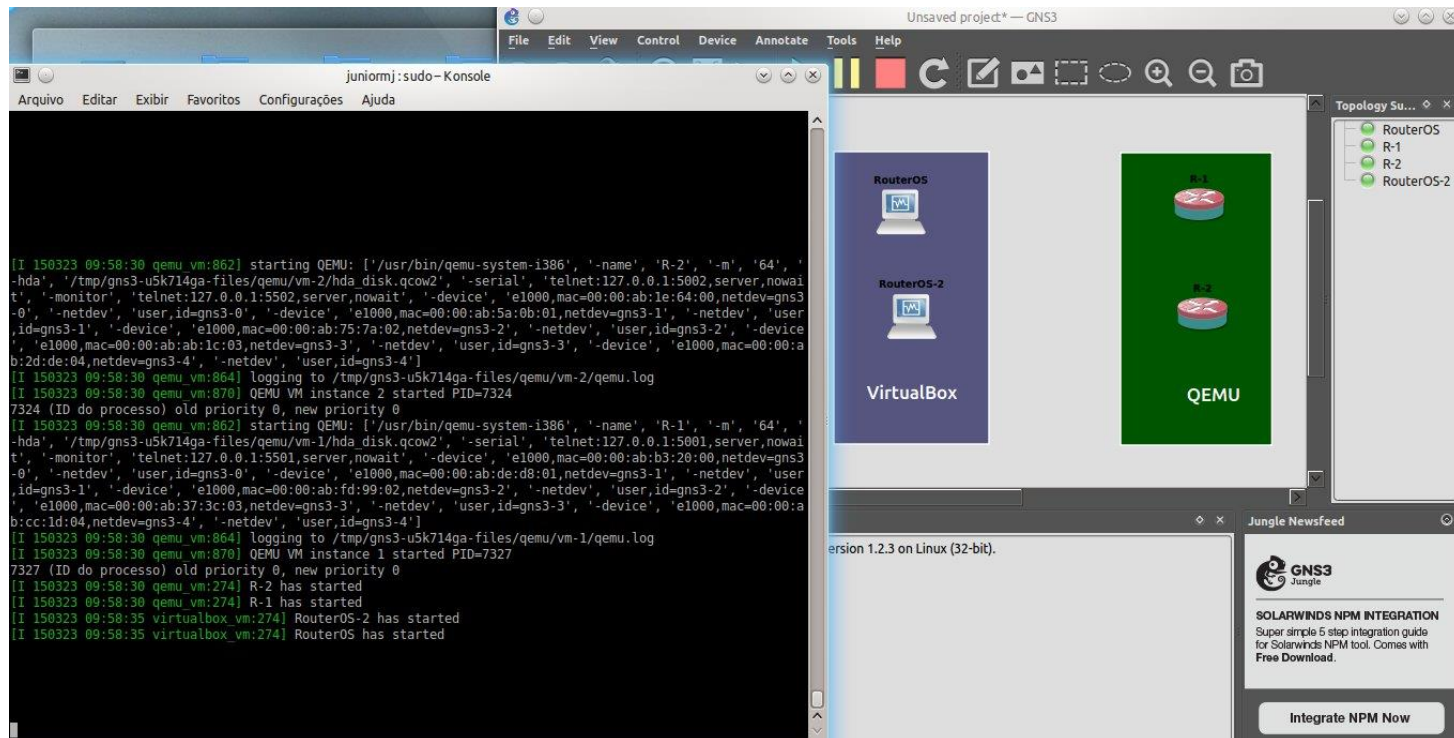
```
juniormj: top
```

```
[D 150323 17:07:10 virtualbox_vm:250] RouterOS-5 is starting
[D 150323 17:07:10 virtualbox_vm:250] RouterOS-4 is starting
[D 150323 17:07:10 virtualbox_vm:250] RouterOS-3 is starting
[D 150323 17:07:10 virtualbox_vm:250] RouterOS-1 is starting
[D 150323 17:07:10 virtualbox_vm:250] RouterOS-2 is starting
[I 150323 17:07:15 virtualbox_vm:274] RouterOS-5 has started
[I 150323 17:07:17 virtualbox_vm:274] RouterOS-4 has started
[I 150323 17:07:19 virtualbox_vm:274] RouterOS-3 has started
[I 150323 17:07:21 virtualbox_vm:274] RouterOS-1 has started
[I 150323 17:07:21 virtualbox_vm:274] RouterOS-2 has started
```



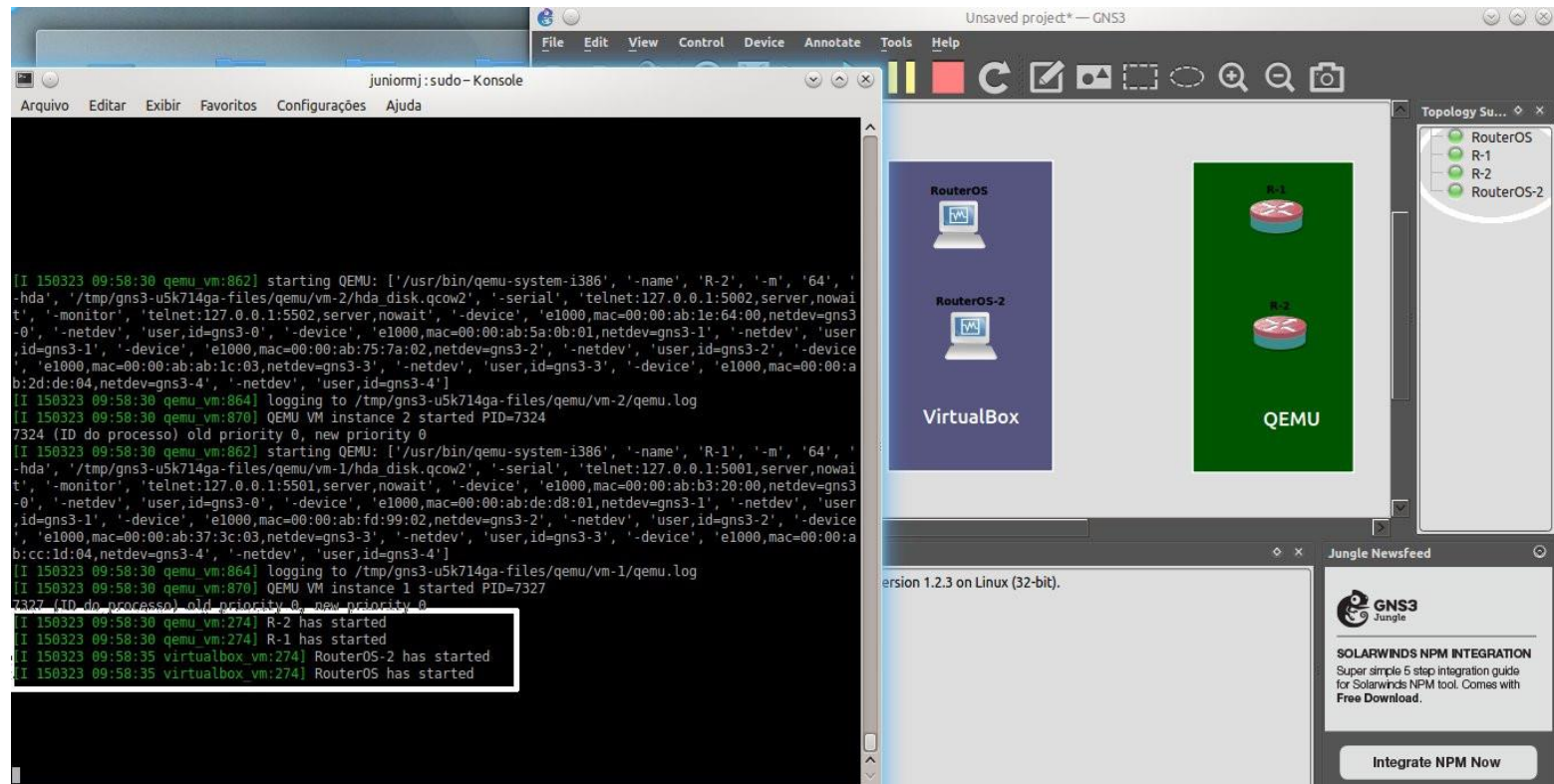


Qemu x VirtualBox





Qemu x VirtualBox

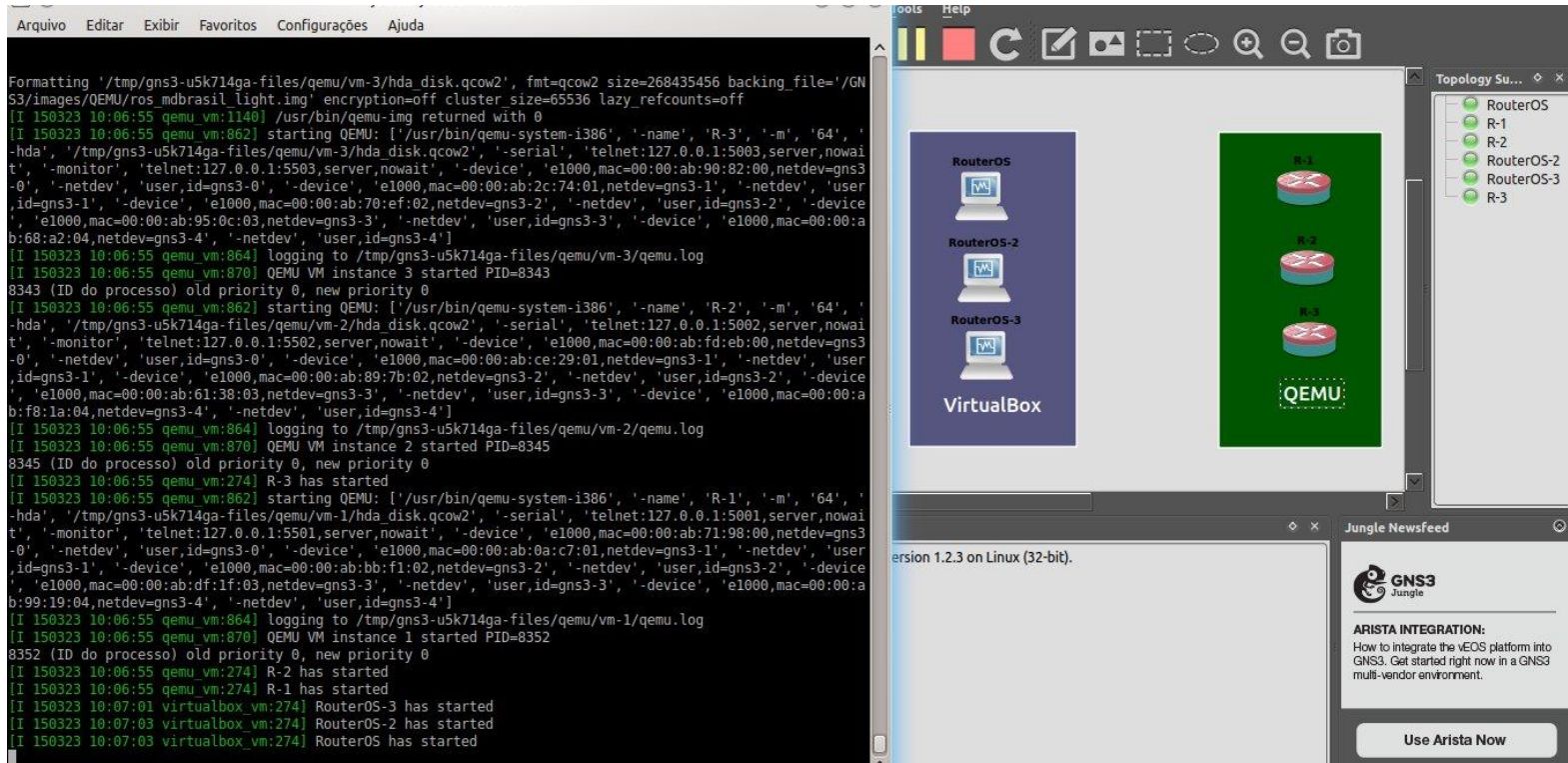


The screenshot displays the GNS3 interface with a network topology diagram. The topology includes RouterOS, R-1, R-2, and RouterOS-2. The console window on the left shows the startup logs for QEMU VMs, indicating that the VMs are starting successfully.

```
[I 150323 09:58:30 qemu_vm:862] starting QEMU: [/usr/bin/qemu-system-i386, '-name', 'R-2', '-m', '64', '-hda', '/tmp/gns3-u5k714ga-files/qemu/vm-2/hda_disk.qcow2', '-serial', 'telnet:127.0.0.1:5002,server,nowait', '-monitor', 'telnet:127.0.0.1:5502,server,nowait', '-device', 'e1000,mac=00:00:ab:1e:64:00,netdev=gns3-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:5a:0b:01,netdev=gns3-1', '-netdev', 'user,id=gns3-1', '-device', 'e1000,mac=00:00:ab:75:7a:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device', 'e1000,mac=00:00:ab:ab:1c:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:ab:2d:de:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']  
[I 150323 09:58:30 qemu_vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-2/qemu.log  
[I 150323 09:58:30 qemu_vm:870] QEMU VM instance 2 started PID=7324  
7324 (ID do processo) old priority 0, new priority 0  
[I 150323 09:58:30 qemu_vm:862] starting QEMU: [/usr/bin/qemu-system-i386, '-name', 'R-1', '-m', '64', '-hda', '/tmp/gns3-u5k714ga-files/qemu/vm-1/hda_disk.qcow2', '-serial', 'telnet:127.0.0.1:5001,server,nowait', '-monitor', 'telnet:127.0.0.1:5501,server,nowait', '-device', 'e1000,mac=00:00:ab:b3:20:00,netdev=gns3-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:de:d8:01,netdev=gns3-1', '-netdev', 'user,id=gns3-1', '-device', 'e1000,mac=00:00:ab:fd:99:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device', 'e1000,mac=00:00:ab:37:3c:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:ab:cc:1d:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']  
[I 150323 09:58:30 qemu_vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-1/qemu.log  
[I 150323 09:58:30 qemu_vm:870] QEMU VM instance 1 started PID=7327  
7327 (ID do processo) old priority 0, new priority 0  
[I 150323 09:58:30 qemu_vm:274] R-2 has started  
[I 150323 09:58:30 qemu_vm:274] R-1 has started  
[I 150323 09:58:35 virtualbox_vm:274] RouterOS-2 has started  
[I 150323 09:58:35 virtualbox_vm:274] RouterOS has started
```




Qemu x VirtualBox



The terminal window on the left shows the following output:

```

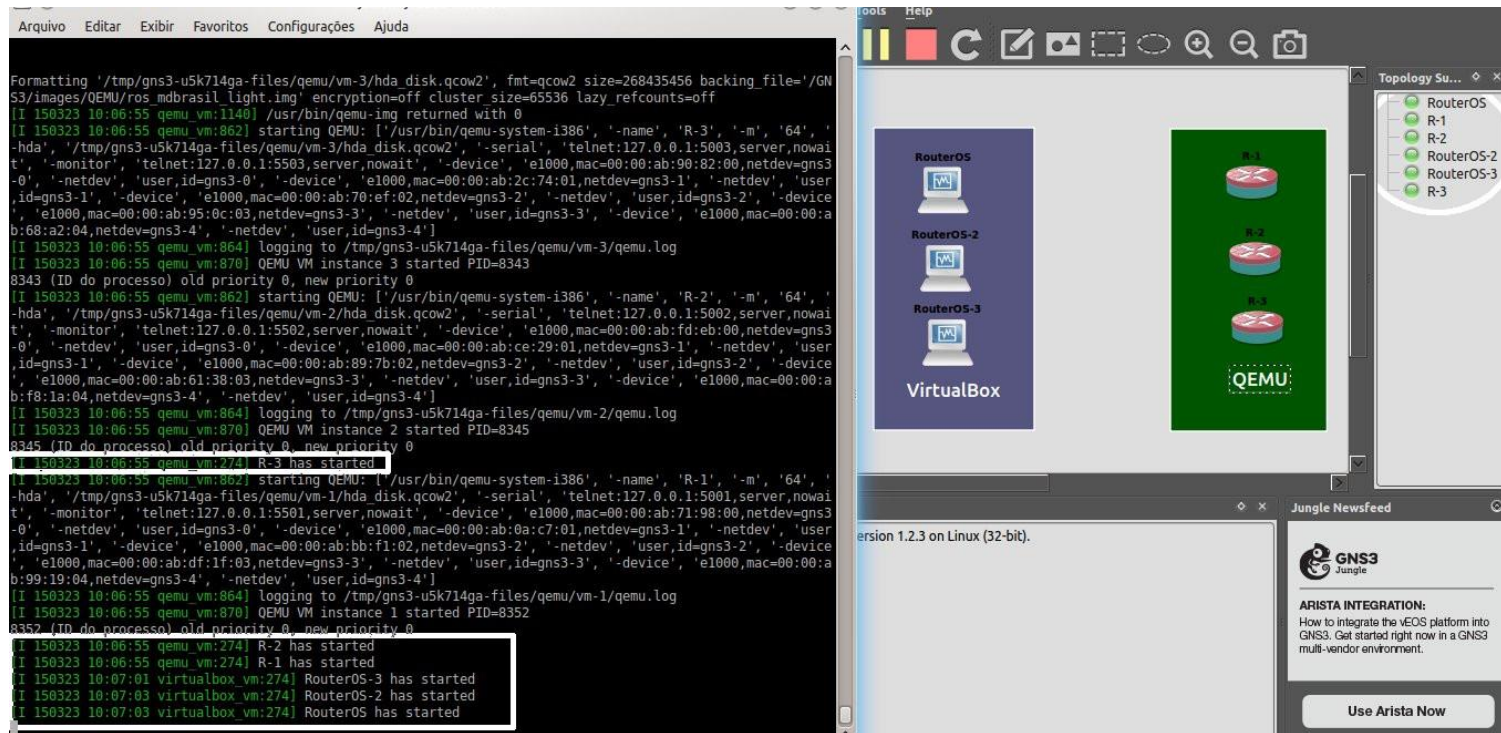
Arquivo  Editar  Exibir  Favoritos  Configurações  Ajuda

Formatting '/tmp/gns3-u5k714ga-files/qemu/vm-3/hda_disk.qcow2', fmt=qcow2 size=268435456 backing_file='/GN
S3/images/QEMU/ros_mdbrasil_light.img' encryption=off cluster size=65536 lazy_refcounts=off
[150323 10:06:55 qemu_vm:1140] /usr/bin/qemu-img returned with 0
[150323 10:06:55 qemu_vm:862] starting QEMU: [/usr/bin/qemu-system-i386, '-name', 'R-3', '-m', '64', '-
hda', '/tmp/gns3-u5k714ga-files/qemu/vm-3/hda_disk.qcow2', '-serial', 'telnet:127.0.0.1:5003,server,nowai
t', '-monitor', 'telnet:127.0.0.1:5503,server,nowait', '-device', 'e1000,mac=00:00:ab:90:82:00,netdev=gns3
-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:2c:74:01,netdev=gns3-1', '-netdev', 'user
,id=gns3-1', '-device', 'e1000,mac=00:00:ab:70:ef:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device
', 'e1000,mac=00:00:ab:95:0c:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:a
b:68:a2:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']
[150323 10:06:55 qemu_vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-3/qemu.log
[150323 10:06:55 qemu_vm:870] QEMU VM instance 3 started PID=8343
8343 (ID do processo) old priority 0, new priority 0
[150323 10:06:55 qemu_vm:862] starting QEMU: [/usr/bin/qemu-system-i386, '-name', 'R-2', '-m', '64', '-
hda', '/tmp/gns3-u5k714ga-files/qemu/vm-2/hda_disk.qcow2', '-serial', 'telnet:127.0.0.1:5002,server,nowai
t', '-monitor', 'telnet:127.0.0.1:5502,server,nowait', '-device', 'e1000,mac=00:00:ab:fd:eb:00,netdev=gns3
-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:ce:29:01,netdev=gns3-1', '-netdev', 'user
,id=gns3-1', '-device', 'e1000,mac=00:00:ab:89:7b:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device
', 'e1000,mac=00:00:ab:61:38:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:a
b:f8:1a:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']
[150323 10:06:55 qemu_vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-2/qemu.log
[150323 10:06:55 qemu_vm:870] QEMU VM instance 2 started PID=8345
8345 (ID do processo) old priority 0, new priority 0
[150323 10:06:55 qemu_vm:274] R-3 has started
[150323 10:06:55 qemu_vm:862] starting QEMU: [/usr/bin/qemu-system-i386, '-name', 'R-1', '-m', '64', '-
hda', '/tmp/gns3-u5k714ga-files/qemu/vm-1/hda_disk.qcow2', '-serial', 'telnet:127.0.0.1:5001,server,nowai
t', '-monitor', 'telnet:127.0.0.1:5501,server,nowait', '-device', 'e1000,mac=00:00:ab:71:98:00,netdev=gns3
-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:0a:c7:01,netdev=gns3-1', '-netdev', 'user
,id=gns3-1', '-device', 'e1000,mac=00:00:ab:bb:f1:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device
', 'e1000,mac=00:00:ab:df:1f:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:a
b:99:19:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']
[150323 10:06:55 qemu_vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-1/qemu.log
[150323 10:06:55 qemu_vm:870] QEMU VM instance 1 started PID=8352
8352 (ID do processo) old priority 0, new priority 0
[150323 10:06:55 qemu_vm:274] R-2 has started
[150323 10:06:55 qemu_vm:274] R-1 has started
[150323 10:07:01 virtualbox_vm:274] RouterOS-3 has started
[150323 10:07:03 virtualbox_vm:274] RouterOS-2 has started
[150323 10:07:03 virtualbox_vm:274] RouterOS has started
  
```

The VirtualBox window on the right shows a network topology diagram with three routers (R-1, R-2, R-3) connected to a central switch. The terminal output shows the QEMU process starting and logging in.



Qemu x VirtualBox



The screenshot displays a terminal window on the left and a VirtualBox topology diagram on the right. The terminal shows the process of starting three QEMU VM instances (R-1, R-2, R-3) and their connection to a central QEMU host. The topology diagram on the right shows a central 'QEMU' box connected to three 'RouterOS' boxes (R-1, R-2, R-3) via 'VirtualBox' boxes. The terminal output includes the following key lines:

```

[I 150323 10:06:55 qemu vm:1140] /usr/bin/qemu-system-i386, '-name', 'R-3', '-m', '64', '-hda', '/tmp/gns3-u5k714ga-files/qemu/vm-3/hda.disk.qcow2', '-serial', 'telnet:127.0.0.1:5003,server,nowait', '-monitor', 'telnet:127.0.0.1:5503,server,nowait', '-device', 'e1000,mac=00:00:ab:90:82:00,netdev=gns3-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:2c:74:01,netdev=gns3-1', '-netdev', 'user,id=gns3-1', '-device', 'e1000,mac=00:00:ab:70:ef:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device', 'e1000,mac=00:00:ab:95:0c:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:ab:68:a2:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']
[I 150323 10:06:55 qemu vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-3/qemu.log
[I 150323 10:06:55 qemu vm:870] QEMU VM instance 3 started PID=8343
8343 (ID do processo) old priority 0, new priority 0
[I 150323 10:06:55 qemu vm:862] starting QEMU: [/usr/bin/qemu-system-i386, '-name', 'R-2', '-m', '64', '-hda', '/tmp/gns3-u5k714ga-files/qemu/vm-2/hda.disk.qcow2', '-serial', 'telnet:127.0.0.1:5002,server,nowait', '-monitor', 'telnet:127.0.0.1:5502,server,nowait', '-device', 'e1000,mac=00:00:ab:fd:eb:00,netdev=gns3-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:ce:29:01,netdev=gns3-1', '-netdev', 'user,id=gns3-1', '-device', 'e1000,mac=00:00:ab:89:7b:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device', 'e1000,mac=00:00:ab:61:38:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:ab:f8:1a:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']
[I 150323 10:06:55 qemu vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-2/qemu.log
[I 150323 10:06:55 qemu vm:870] QEMU VM instance 2 started PID=8345
8345 (ID do processo) old priority 0, new priority 0
[I 150323 10:06:55 qemu vm:274] R-3 has started
[I 150323 10:06:55 qemu vm:862] starting QEMU: [/usr/bin/qemu-system-i386, '-name', 'R-1', '-m', '64', '-hda', '/tmp/gns3-u5k714ga-files/qemu/vm-1/hda.disk.qcow2', '-serial', 'telnet:127.0.0.1:5001,server,nowait', '-monitor', 'telnet:127.0.0.1:5501,server,nowait', '-device', 'e1000,mac=00:00:ab:71:98:00,netdev=gns3-0', '-netdev', 'user,id=gns3-0', '-device', 'e1000,mac=00:00:ab:0a:c7:01,netdev=gns3-1', '-netdev', 'user,id=gns3-1', '-device', 'e1000,mac=00:00:ab:bb:f1:02,netdev=gns3-2', '-netdev', 'user,id=gns3-2', '-device', 'e1000,mac=00:00:ab:df:1f:03,netdev=gns3-3', '-netdev', 'user,id=gns3-3', '-device', 'e1000,mac=00:00:ab:b9:19:04,netdev=gns3-4', '-netdev', 'user,id=gns3-4']
[I 150323 10:06:55 qemu vm:864] logging to /tmp/gns3-u5k714ga-files/qemu/vm-1/qemu.log
[I 150323 10:06:55 qemu vm:870] QEMU VM instance 1 started PID=8352
8352 (ID do processo) old priority 0, new priority 0
[I 150323 10:06:55 qemu vm:274] R-2 has started
[I 150323 10:06:55 qemu vm:274] R-1 has started
[I 150323 10:07:01 virtualbox vm:274] RouterOS-3 has started
[I 150323 10:07:03 virtualbox vm:274] RouterOS-2 has started
[I 150323 10:07:03 virtualbox vm:274] RouterOS has started
  
```

The topology diagram on the right shows a central 'QEMU' box connected to three 'RouterOS' boxes (R-1, R-2, R-3) via 'VirtualBox' boxes. The diagram is titled 'Topology Su...' and includes a legend on the right side.



Děkuji