Network Simulation
Traffic engineering study case

European MUM – 2015

Prague / Czech Republic

Wardner Maia

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English:

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Introduction

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.

Introduction

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 an 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/

Agenda

Motivations and General Talking about Network Simulators

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

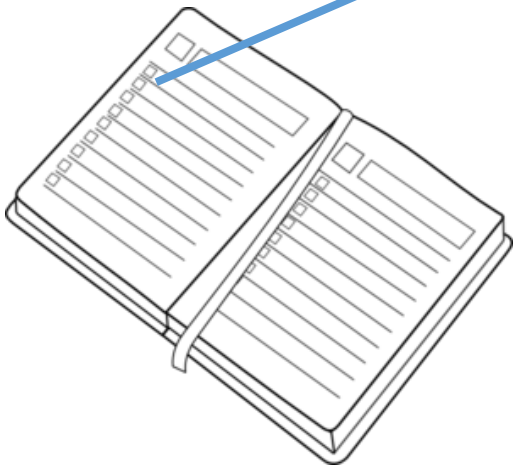
Creating a Simple and a Base Project and interacting with them;

A real case demonstration – Traffic Engineering Scenario;

Final considerations, conclusions and download links.

6’

Agenda



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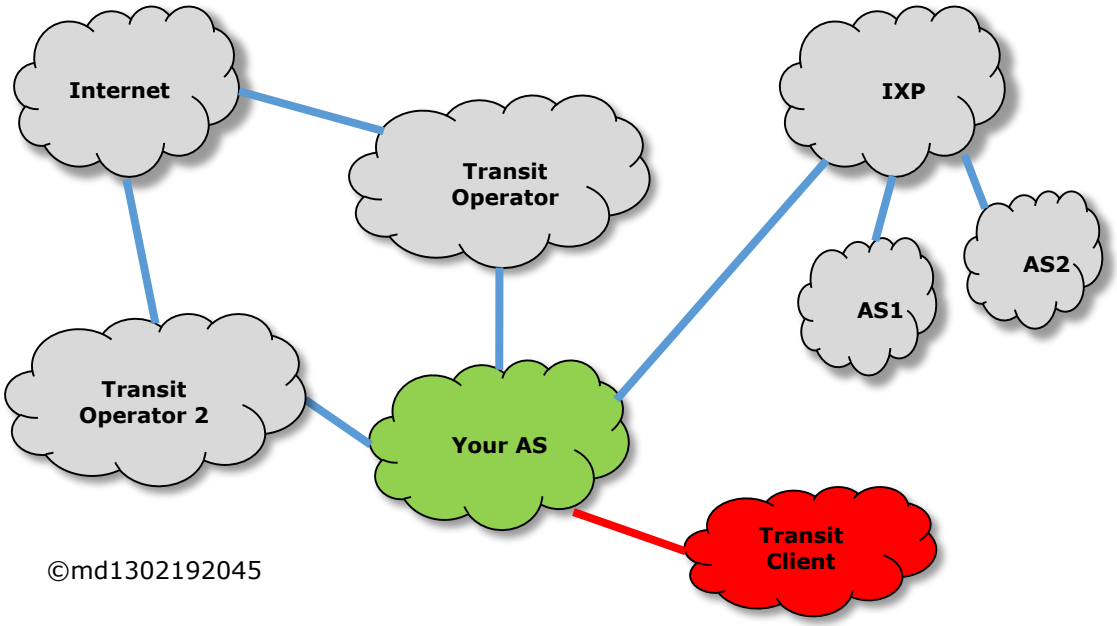
Motivations

We do love REAL Routers, but...

Motivation

Presentation about BGP Filtering in Zagreb (2013):

(5 routers)

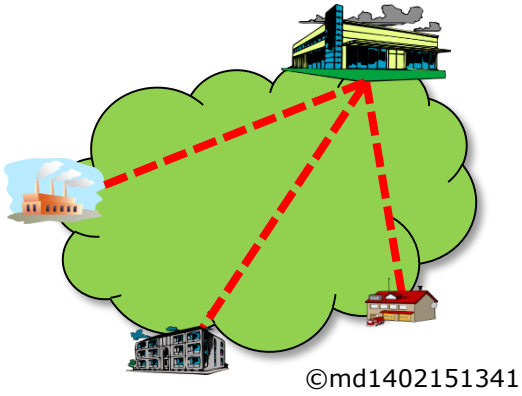


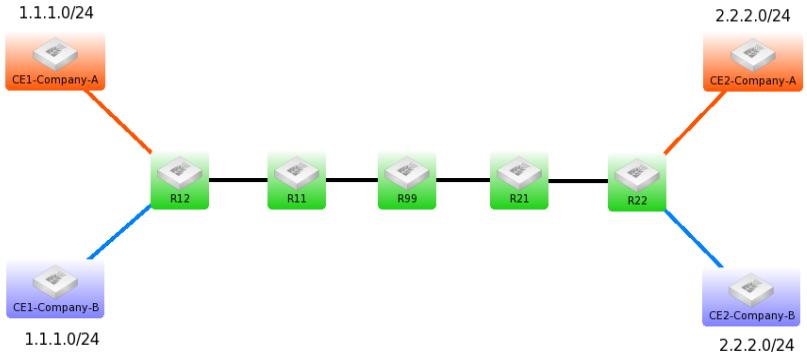
To simulate the scenario 5 real routers were used, cables, power supplies, etc.

Motivation

Presentation about MPLS Security in Venice (2014):

(9 routers)



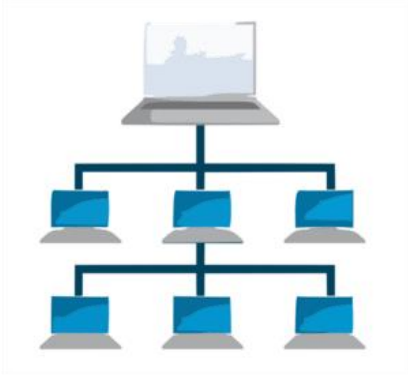


With a simulator, no physical router, no cables, no power supply – no pain ☺

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

Applications of a Network Simulator

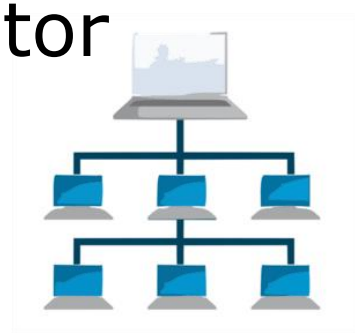
Network Simulator



Prediction Tool

Teaching / Learning Tool

Applications of a Network Simulator



As a Prediction Tool:

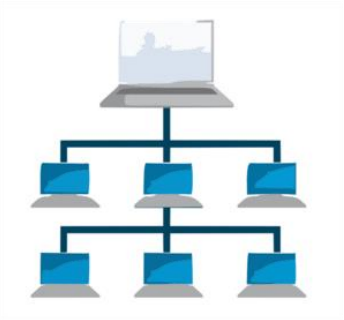
Operators can anticipate how new implementations will work before deploying them in the “real world”;

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.

Success case Prediction Tool



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.

Success Case
Teaching / Learning Tool

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;

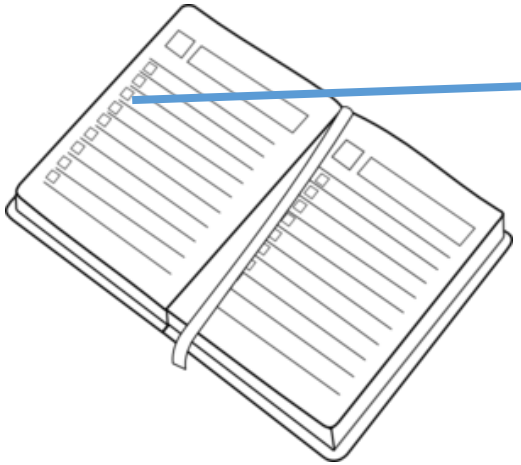
Operators:

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

Mikrotik Community in general:

Can share information and scenarios

Agenda



Motivations and General Talking about Network Simulators

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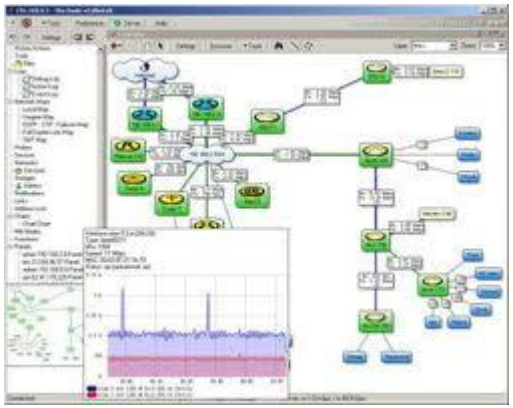
Tools we'll use for Simulating Networks

GNS3

+

Qemu

+



Dude

Ubuntu Gnome 14.04 LTS

GNS3

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

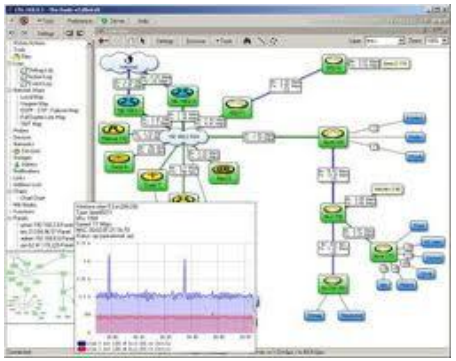
http://virtualbox.org

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

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

Installation on Ubuntu

 # 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

Installation on Ubuntu

 # preparing the dependencies (cont.):

apt-get install git

apt-get install cmake

apt-get install bison

apt-get install flex

 # installing phyton and pip:

wget -O get-pip.py https://raw.github.com/pypa/pip/master/contrib/get-pip.py

python3 get-pip.py

pip3 install pyzmq && pip3 install tornado

Installation

 # 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

Installation

 # 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 ..

Installation

 # Installing Dynamips

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

cd dynamips
mkdir build
cd build
cmake ..

make install
cd ~/GNS3

Installation

 # 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).
```

Installation

 # 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

Installation

 # 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

Installation

 # 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

Installation

 # 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"
```

Installation

 # 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
```

Installation

 # 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

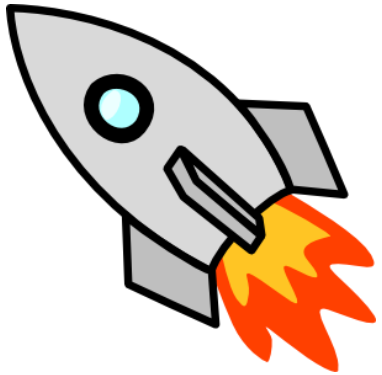
 # If you don’t have wine, install it and after the Dude

sudo apt-get install wine

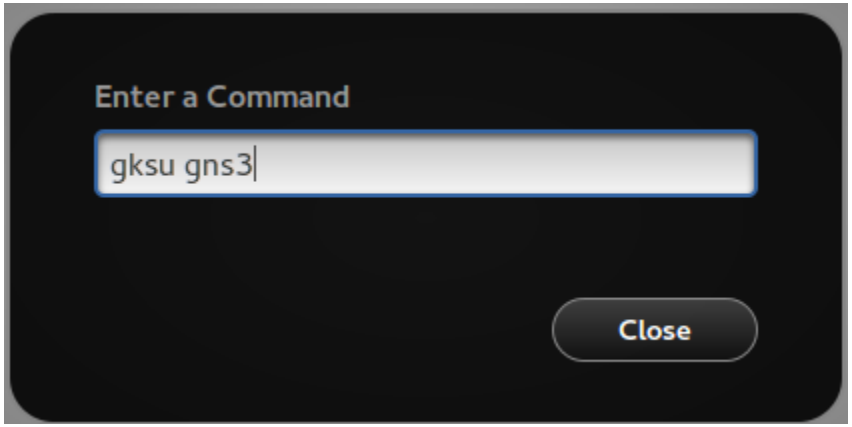
dude.exe

Running GNS3

 # Launch GNS3 as superuser



Alt F2



Creating RouterOS image to GNS3

RouterOS Image

 # Create the RouterOS image with 256 Mbytes for Ubuntu.

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

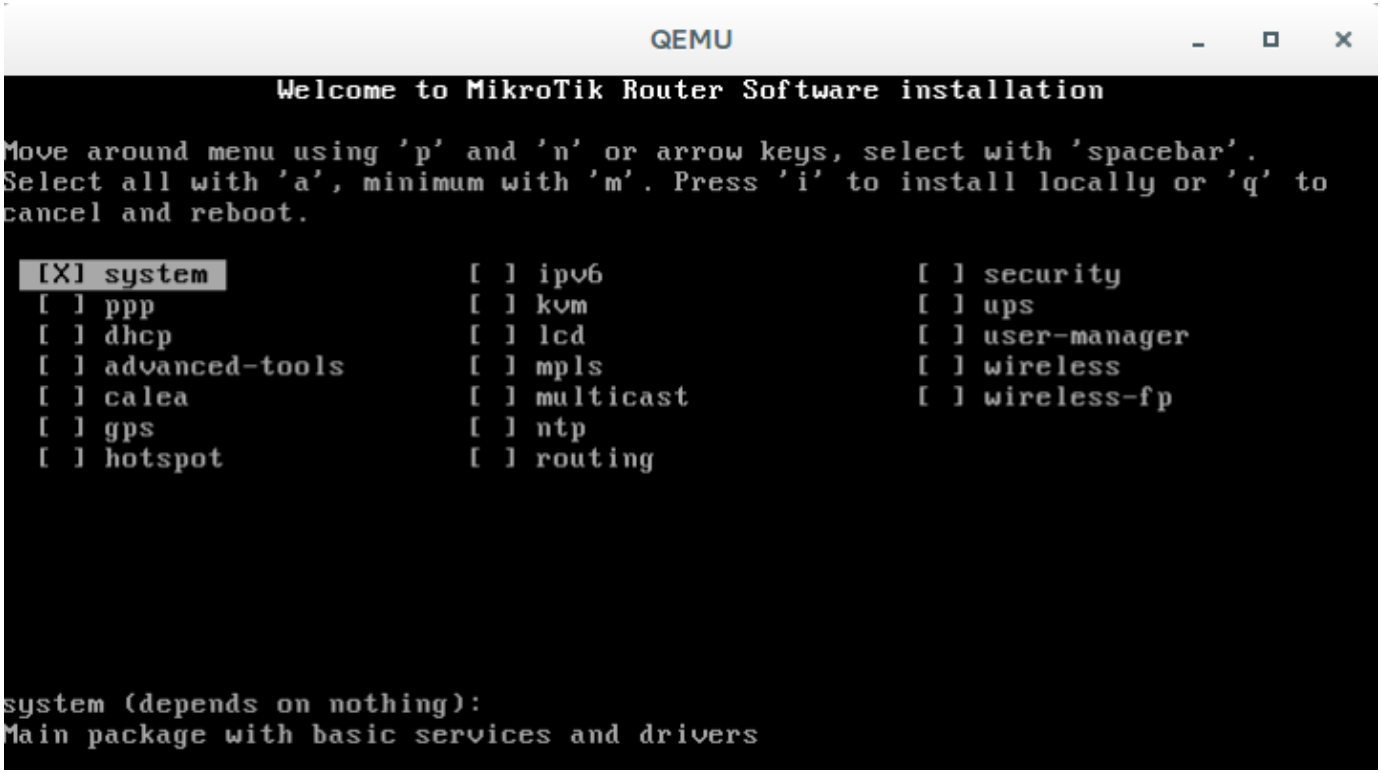
Qemu supports several image types. qcow2 is more flexible and can be ported to other systems.

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

RouterOS Image

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

sudo quemu-system-x86_64 RouterOS.img –cdrom mikrotik.6.27.iso



RouterOS Image

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

RouterOS Image

 # 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).

RouterOS Image

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=nic0 <imagefile>

RouterOS Image

 # 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.

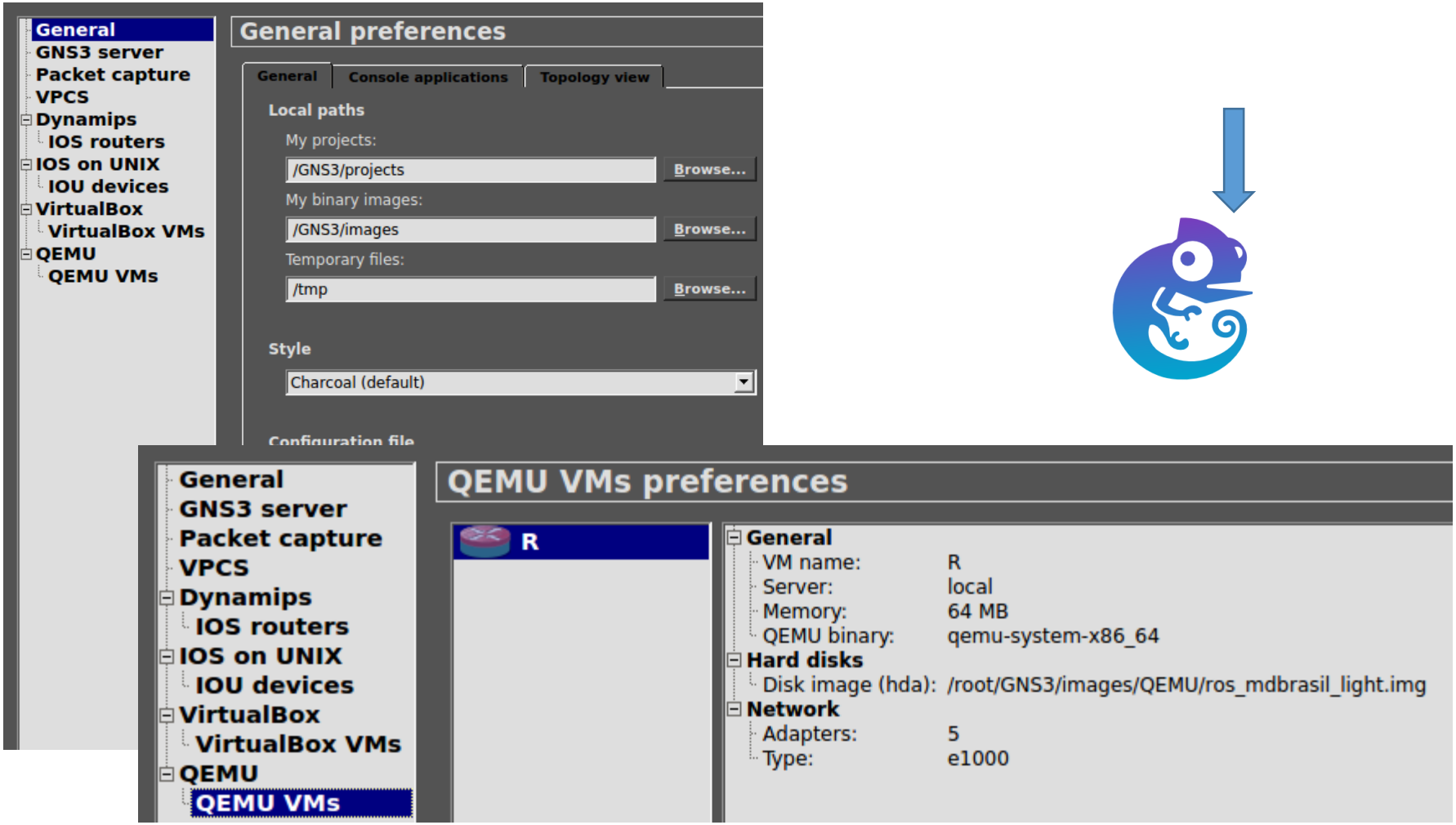
So, remember to reset the MAC to avoid problems:

/interface Ethernet reset-mac-address interface=ether1

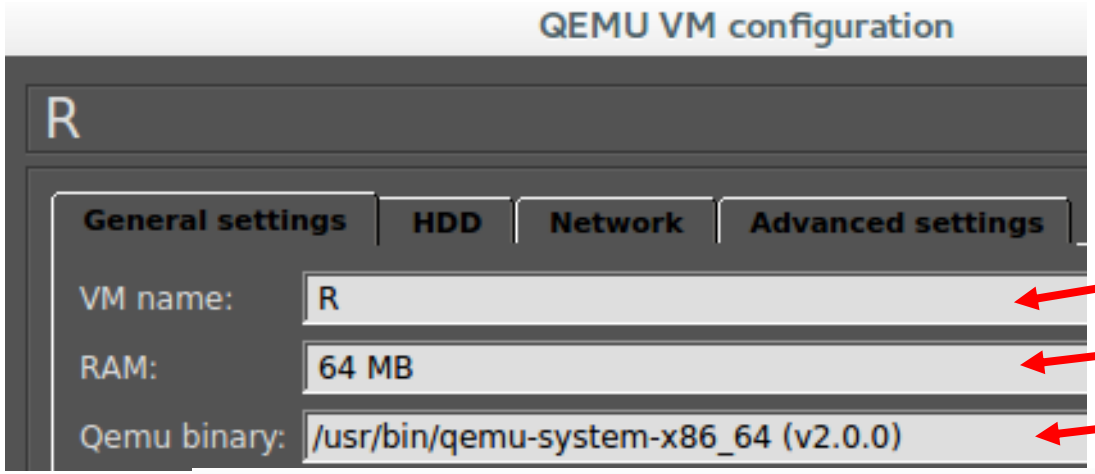
N.B. ether0 (GNS3) = ether1 (RouterOS)

Inserting the image in GNS3 and creating a Base Project

Inserting RouterOS image in GNS3



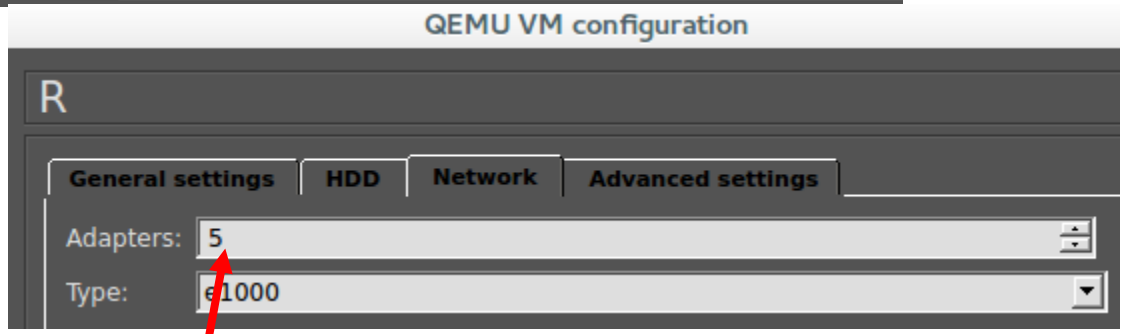
Inserting RouterOS image in GNS3



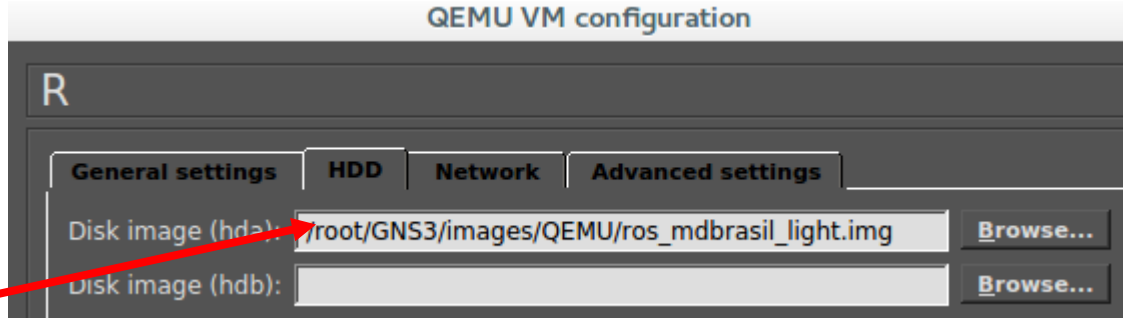
VM name

Memory

Path to Qemu binary



Number of adapters

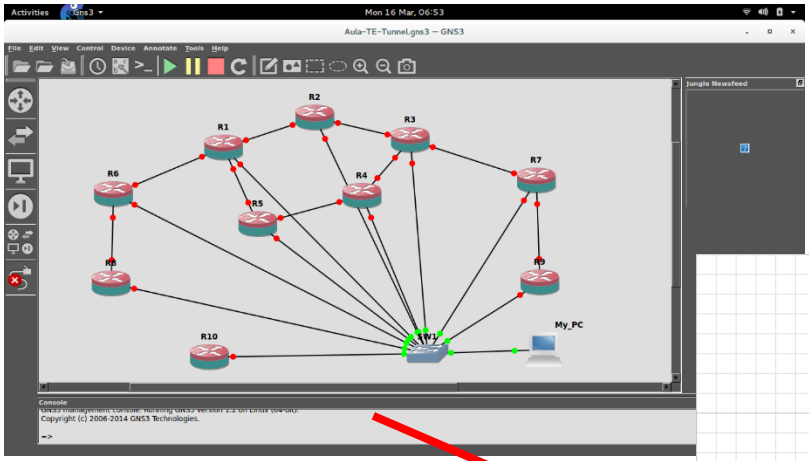


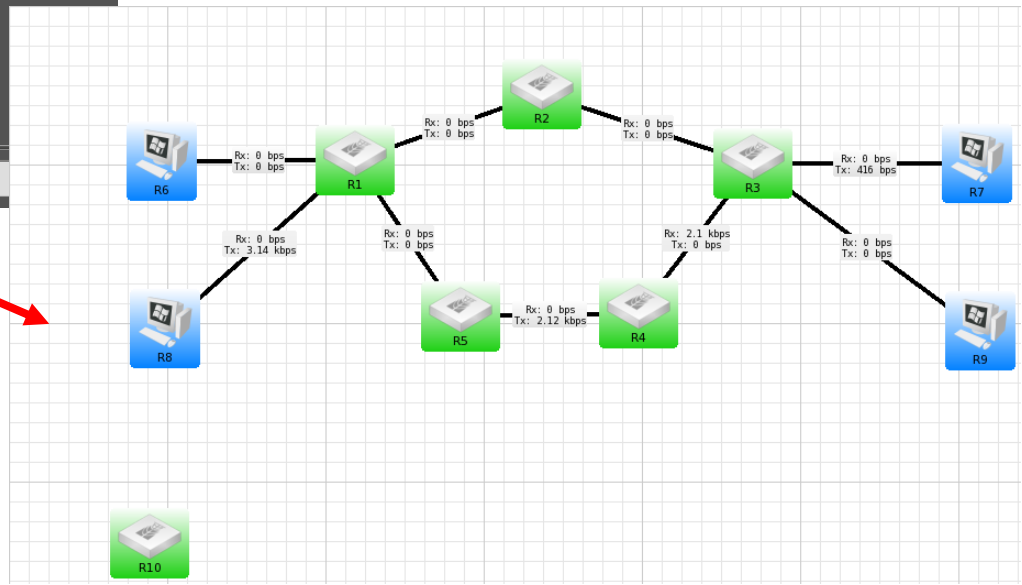
Path to RouterOS image

Using The Dude as a frontend to the virtual network

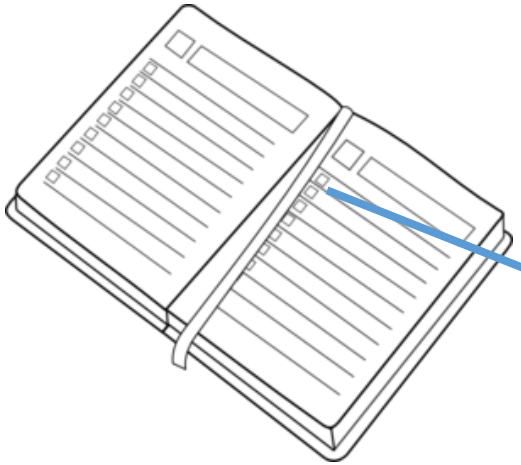
Using The Dude as a frontend

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





Agenda



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35’

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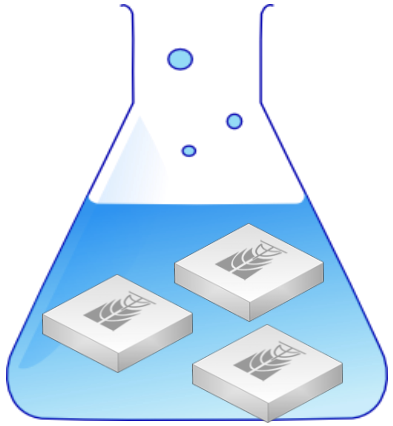
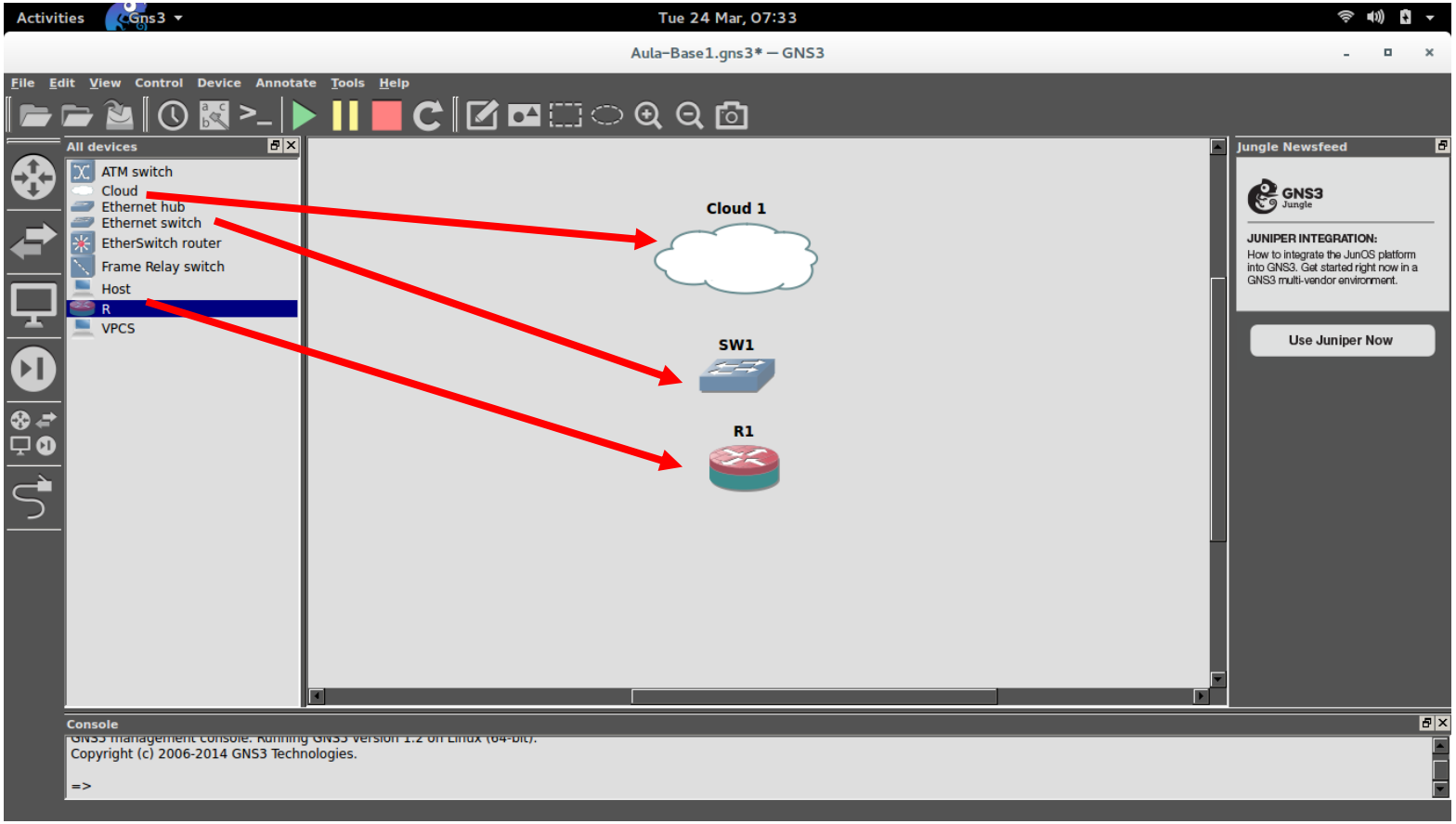


Hands ON

Creating a Simple Project

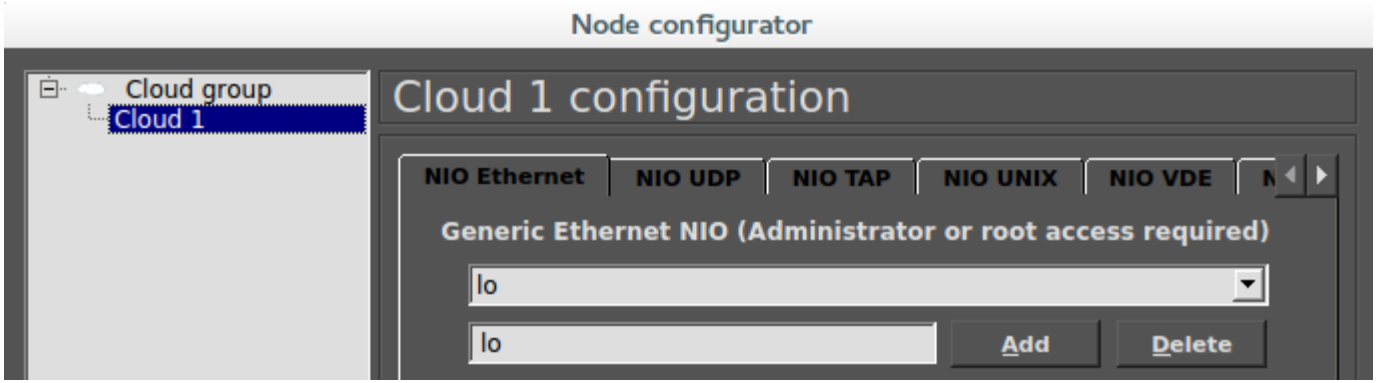
Creating a project

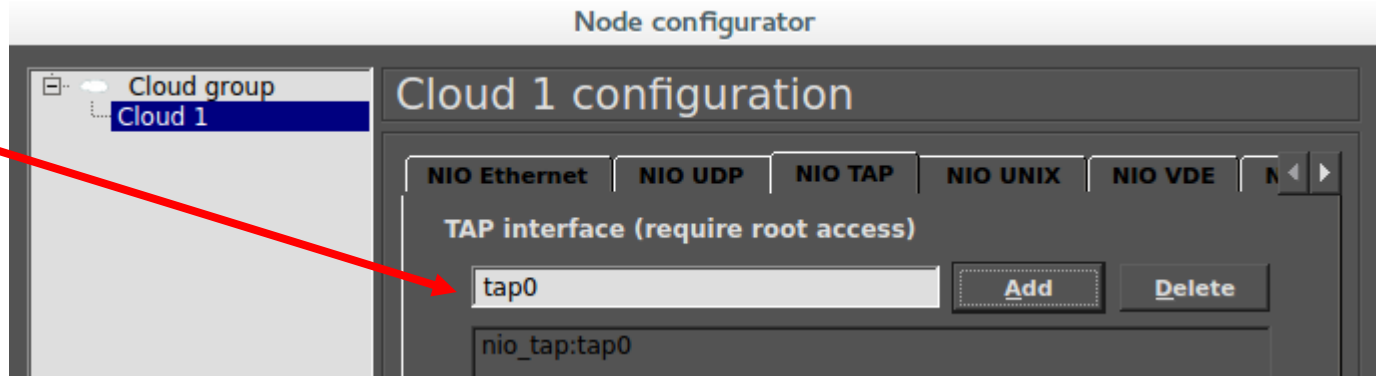
Creating the devices



Creating a project

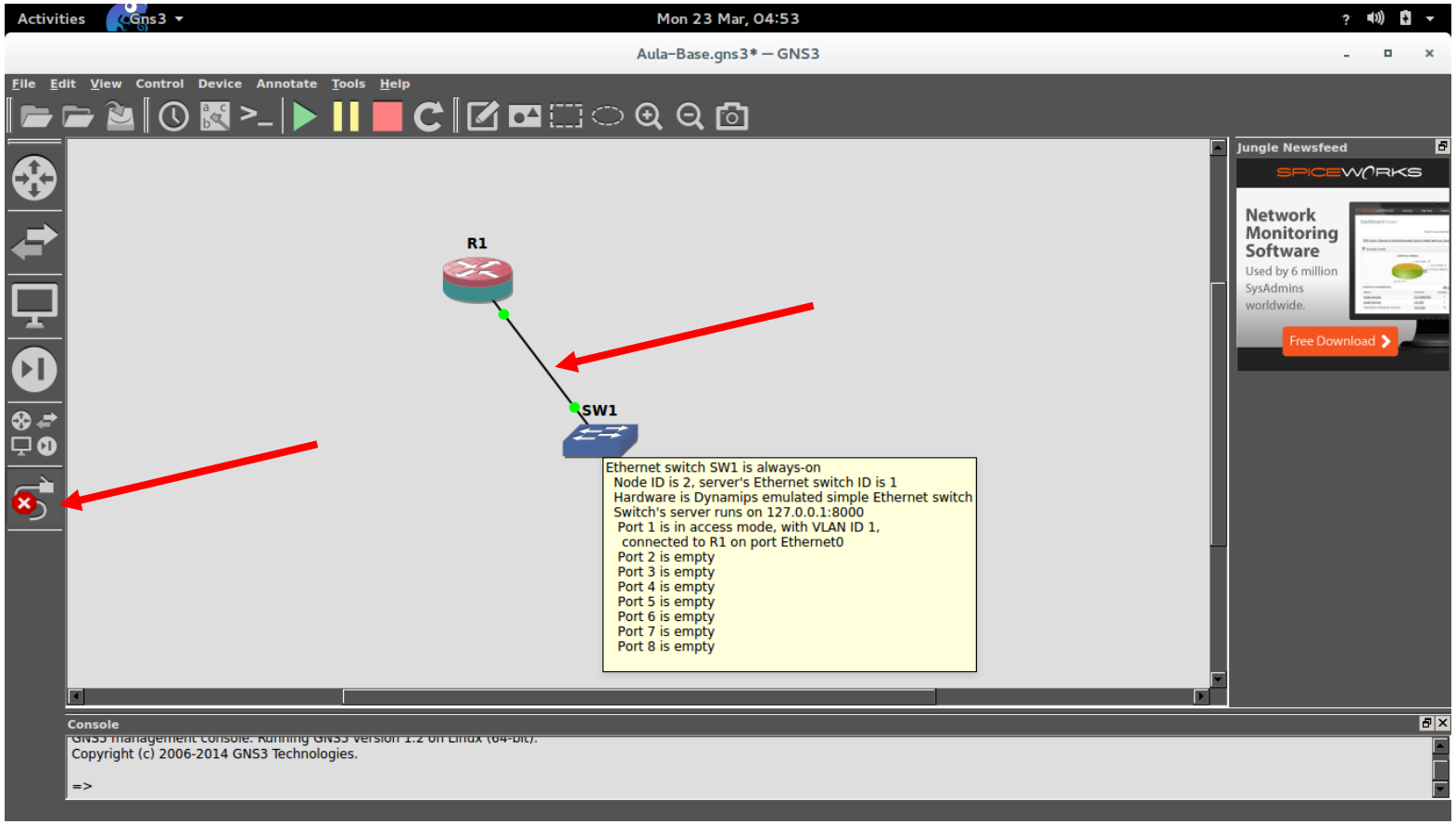
Configuring the “cloud” (pseudo device for external connections)





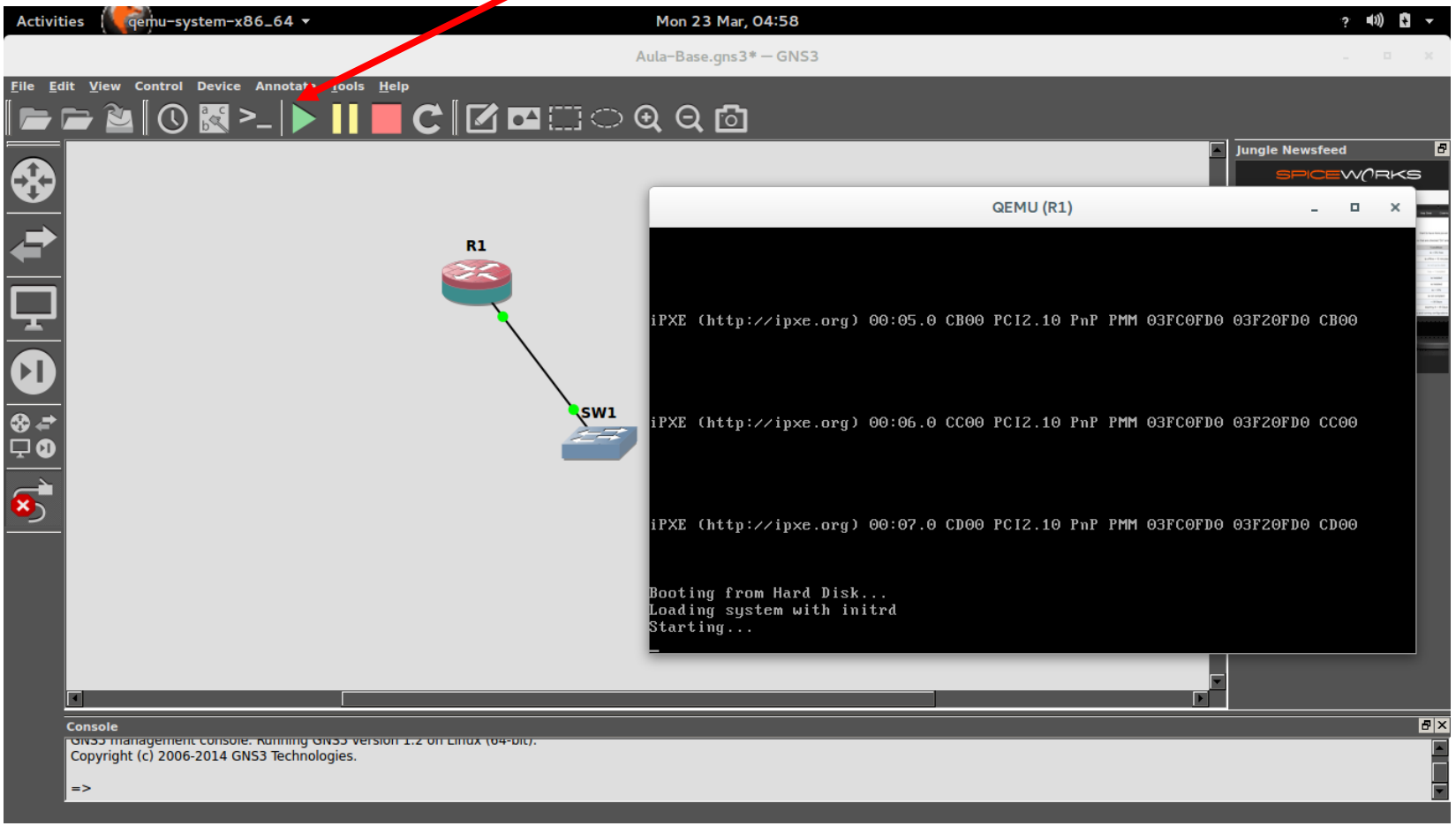
Creating a project

Making the links



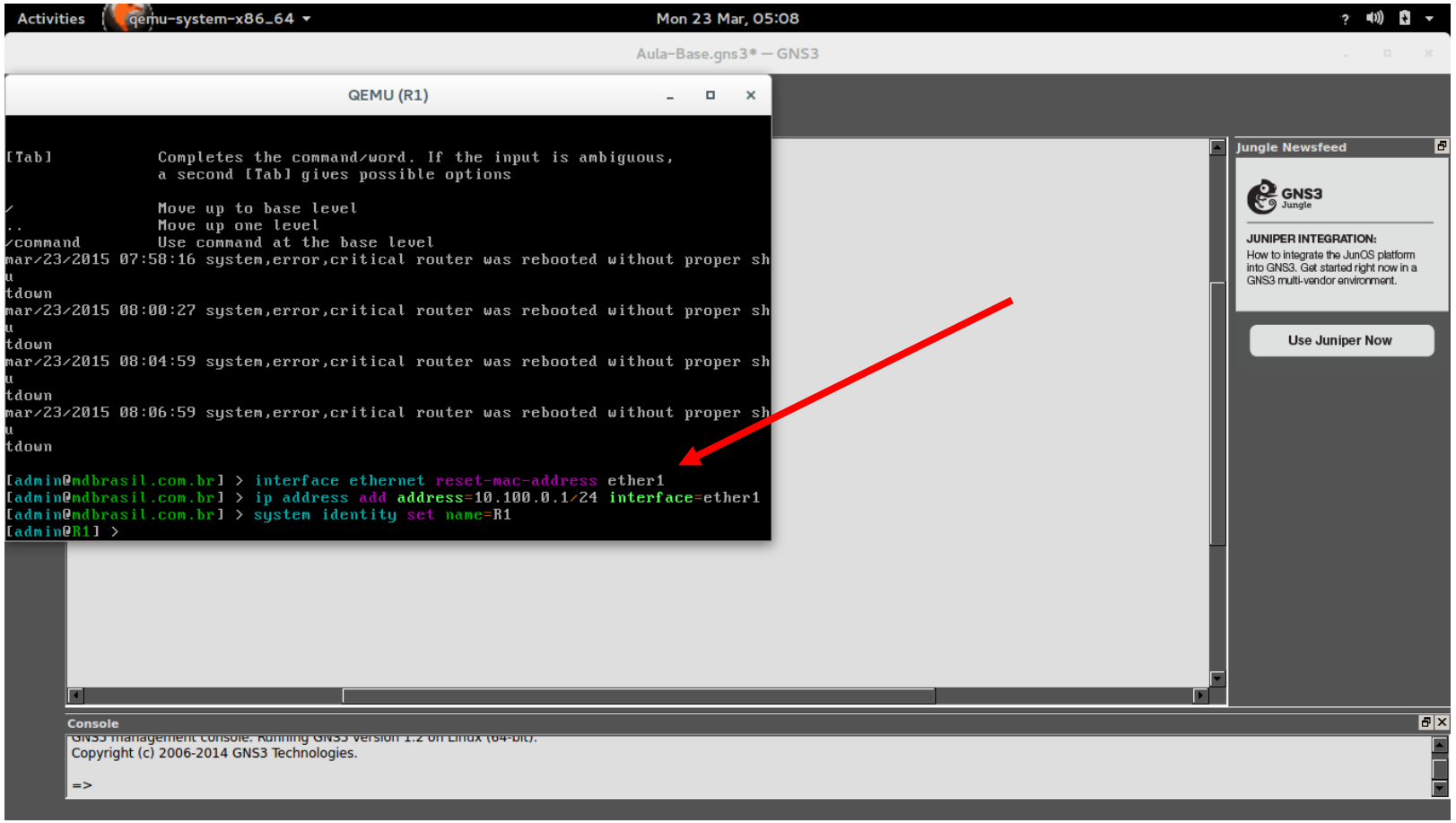
Creating a project

Starting the Router



Creating a project

Important initial commands



Binding your machine to the virtual environment

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

Binding your machine to the virtual environment

 # Type the below script and give it exec permissions

```
#!/bin/bash
sudo modprobe tun
sudo tunctl -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)
```

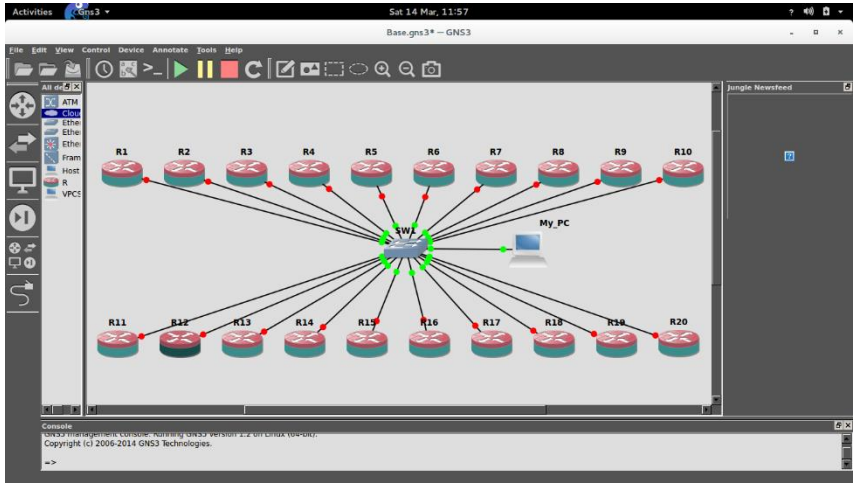
Binding your machine to the virtual environment

 # Check bridge and tap configuration

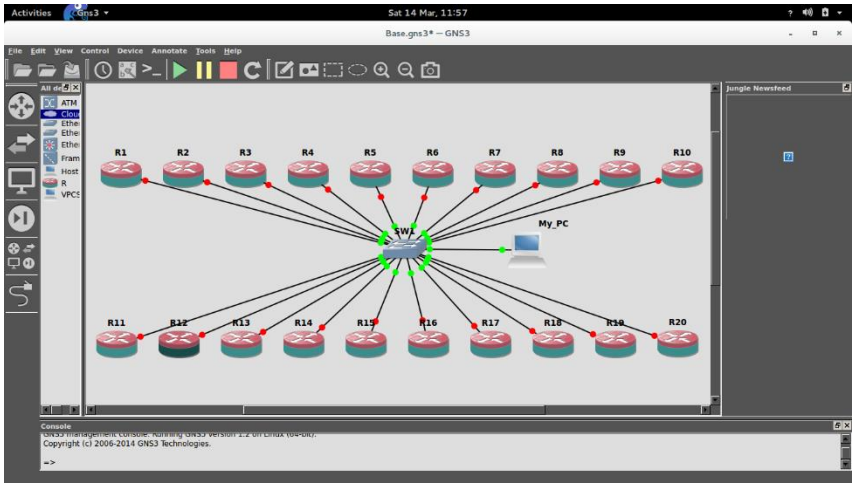
```
maia@galago:~$ brctl show
bridge name     bridge id               STP enabled     interfaces
br0             8000.0090f5f993dd       no              eth0
                                                        tap0
maia@galago:~$ ifconfig br0
br0       Link encap:Ethernet  HWaddr 00:90:f5:f9:93:dd
          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)
```

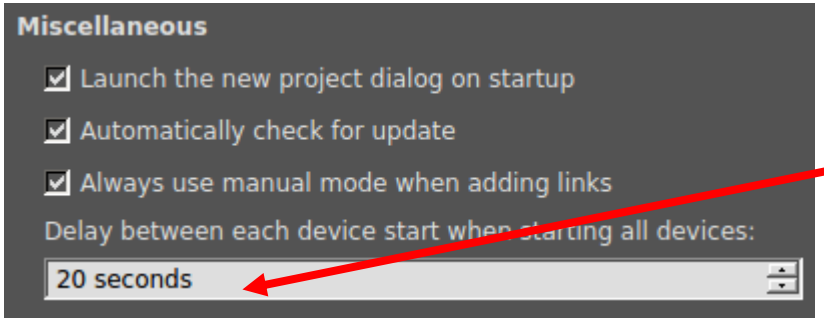
Hint:
Make a “Base” Project

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



Hint:
Make a “Base” Project

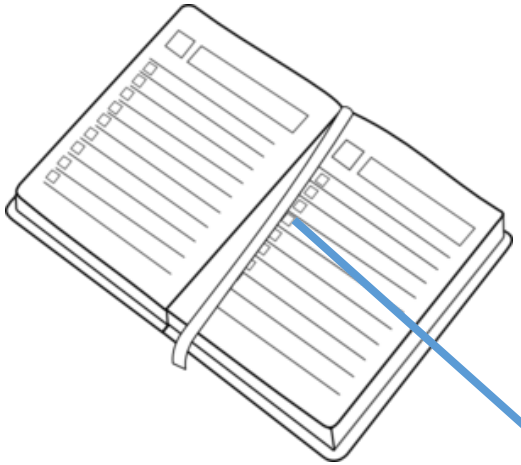




To avoid overload your CPU you may consider delay the machine boots.

(not working on version 1.2.3) ☹

Agenda



Motivations and General Talking about Network Simulators

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

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A real case demonstration – Traffic Engineering Scenario;

Final considerations, conclusions and download links.

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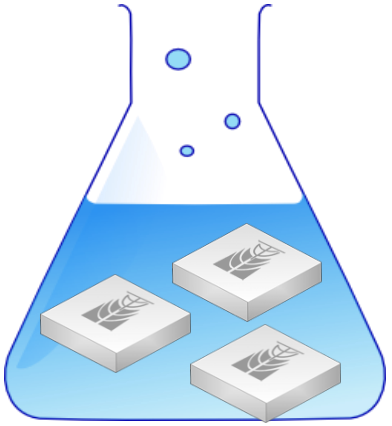
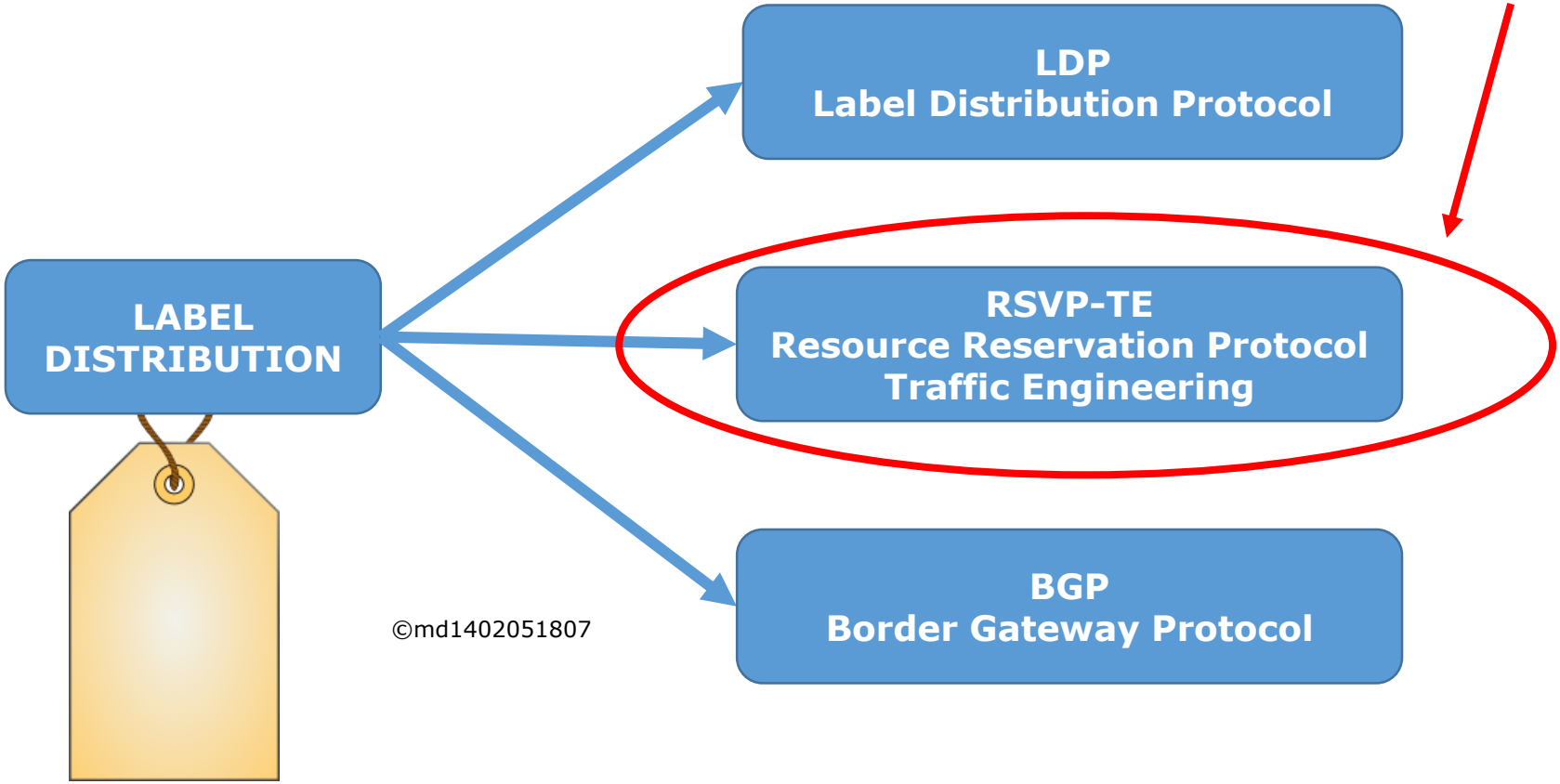


Hands ON

Traffic Engineering Study Case

Label Distribution:

There are 3 methods for Label distribution:



RSVP-TE (Resource Reservation Protocol – Traffic Engineering)

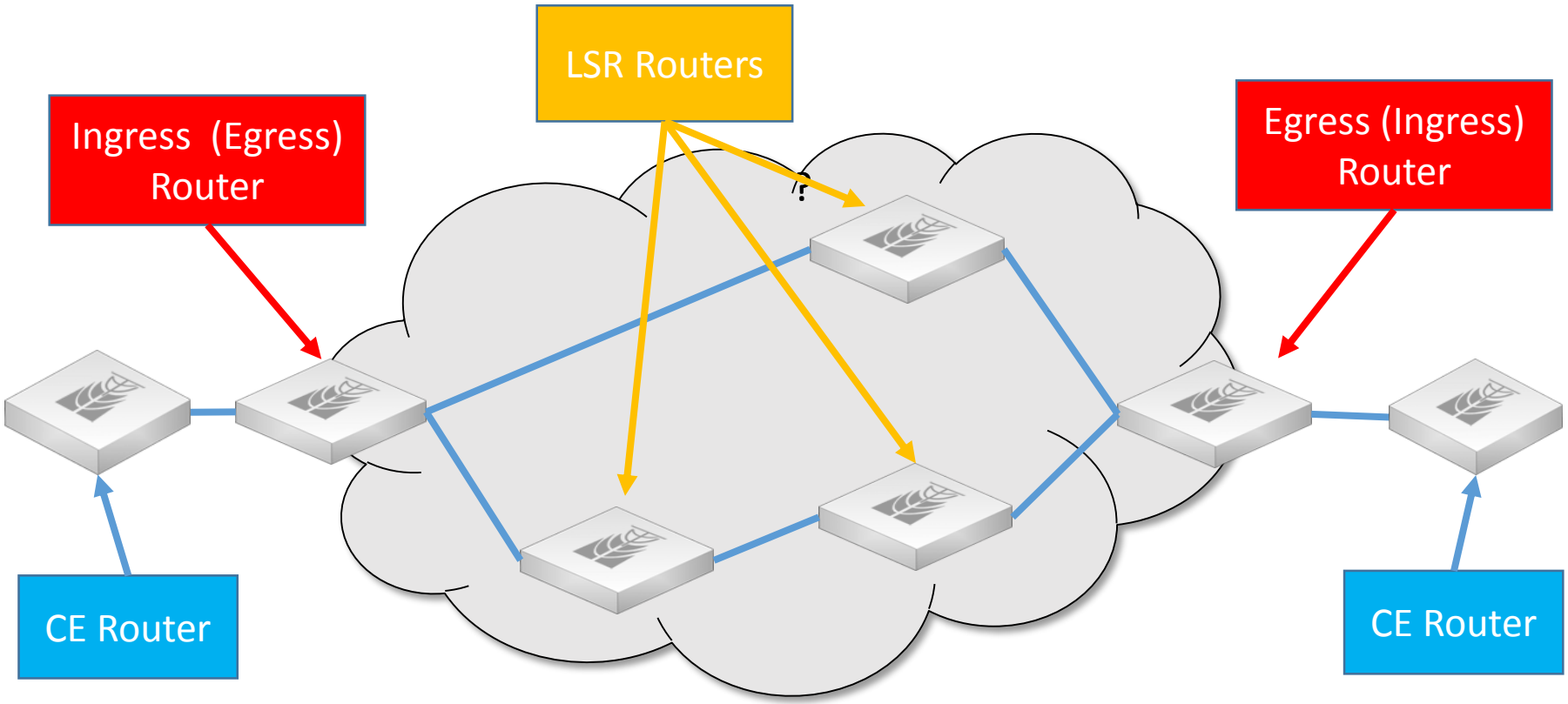
→ RSVP-TE is an extension of RSVP protocol and supports the reservation of resources across an IP Network;

→ 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.

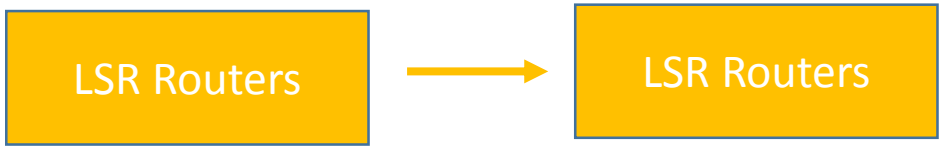
Some TE/MPLS Background

Topology and naming



Some TE/MPLS Background

RSVP Path messages with the necessary parameters to the LSP;



Propagate messages along the LSR

RSVP Resv sent back reserving the resources for the tunnel in all routers;

TE example

In this example, we are doing the following things:

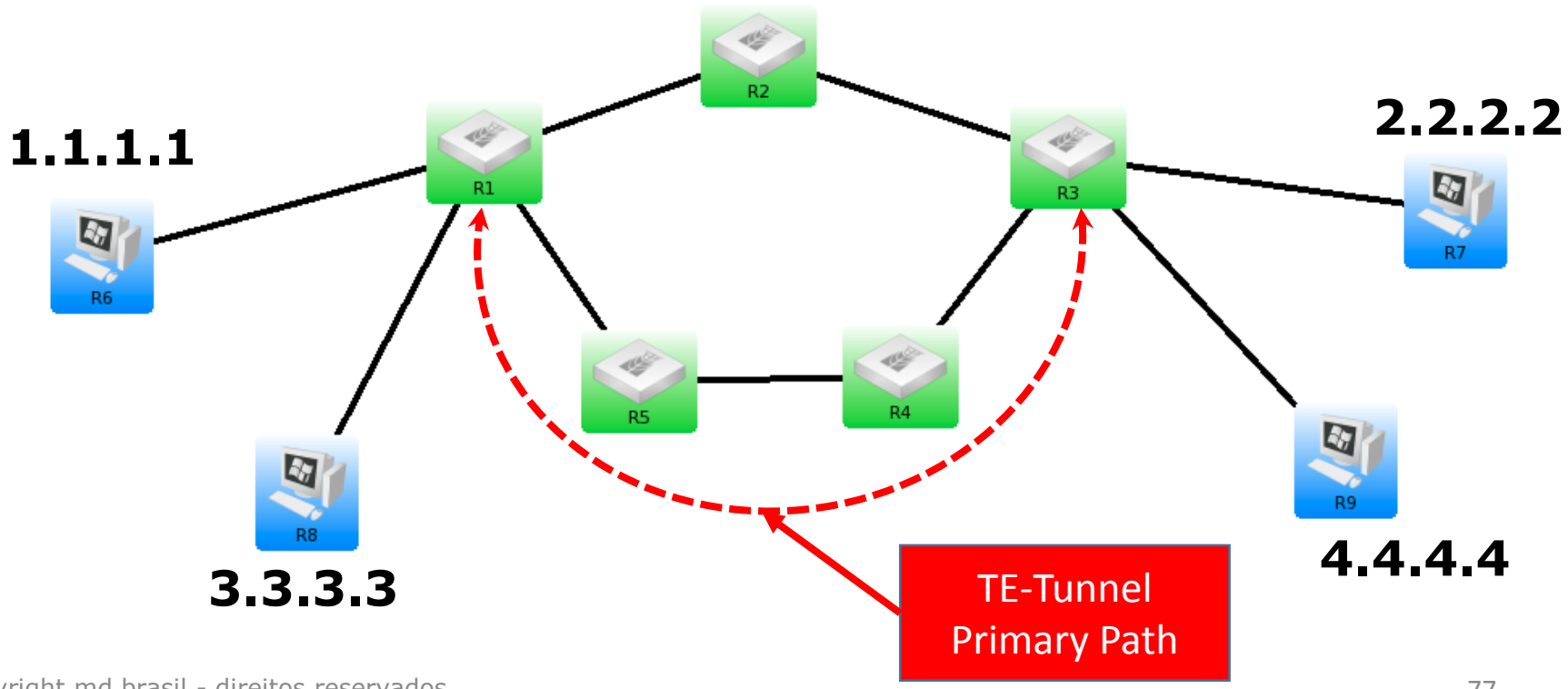
→ OSPF operational in all routers;

→ 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

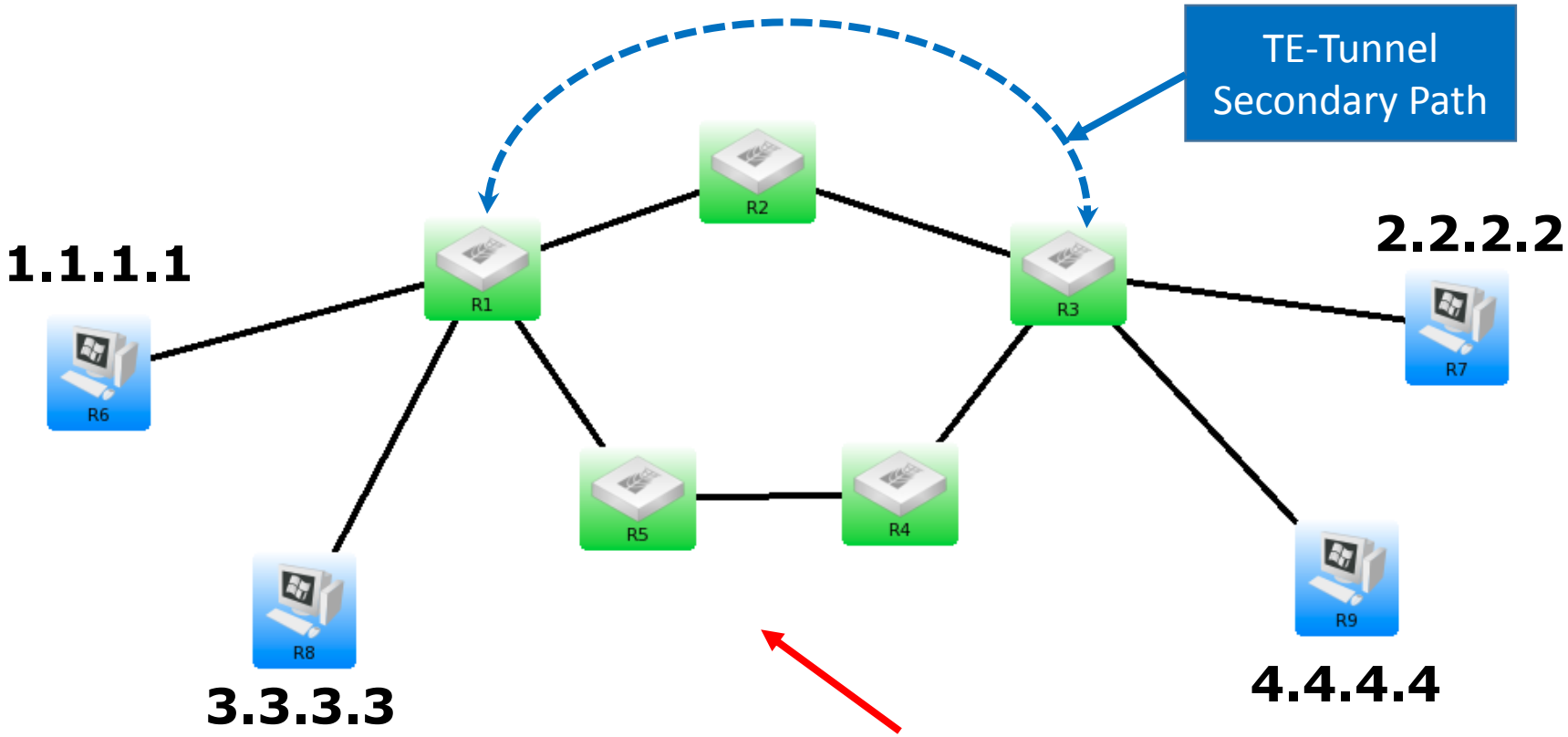
TE Scenario Example

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



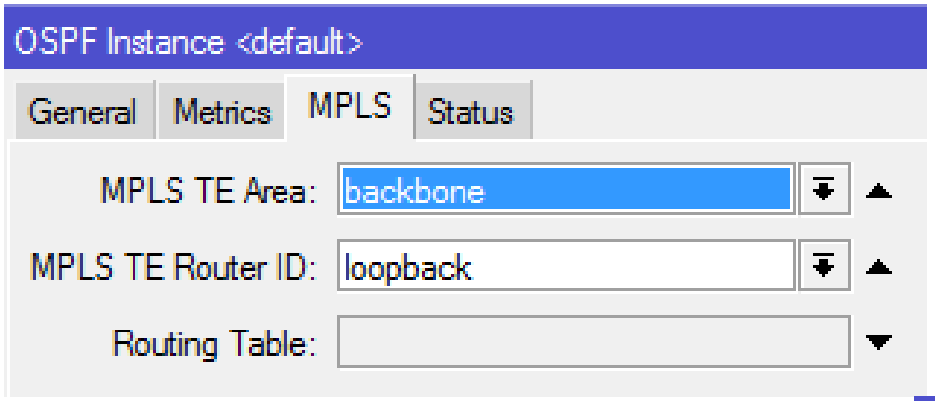
TE Scenario Example

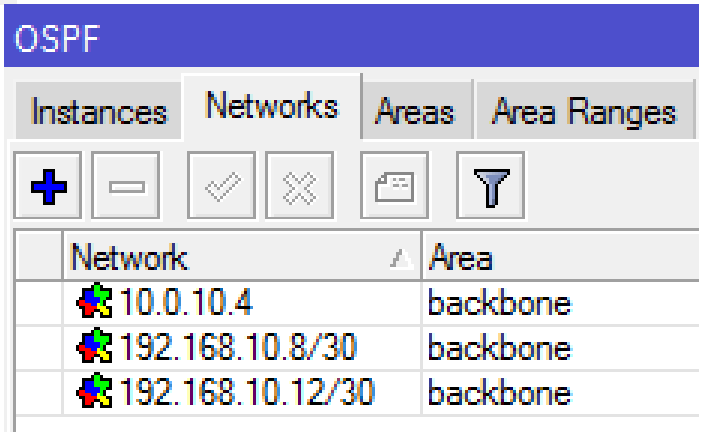
Path through R2 will be secondary in case of link failure



TE Scenario Configuration
OSPF stuff

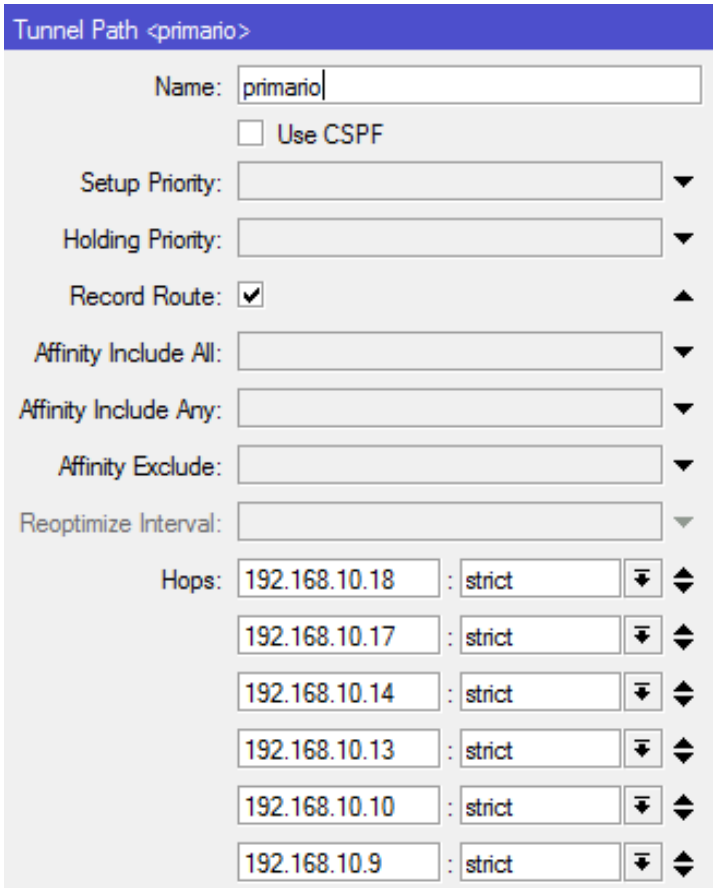
All routers have basic OSPF configuration, with MPLS TE Area and TE router ID configured

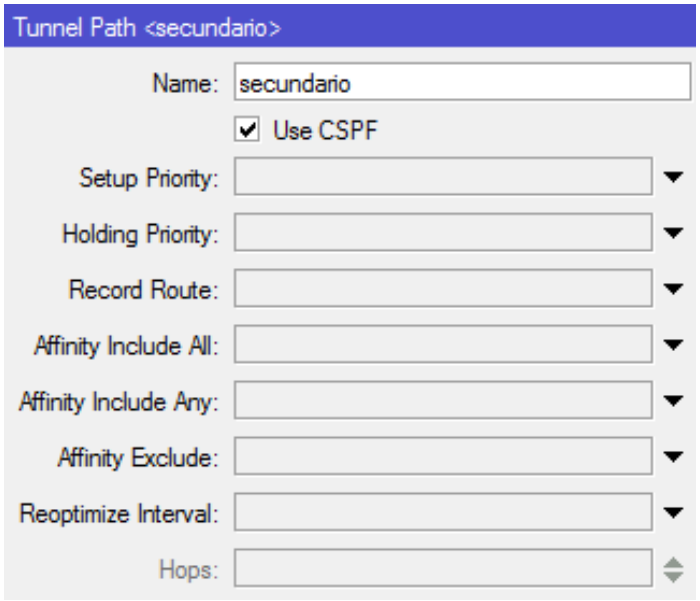




TE Scenario Configurations Primary and Secondary Paths

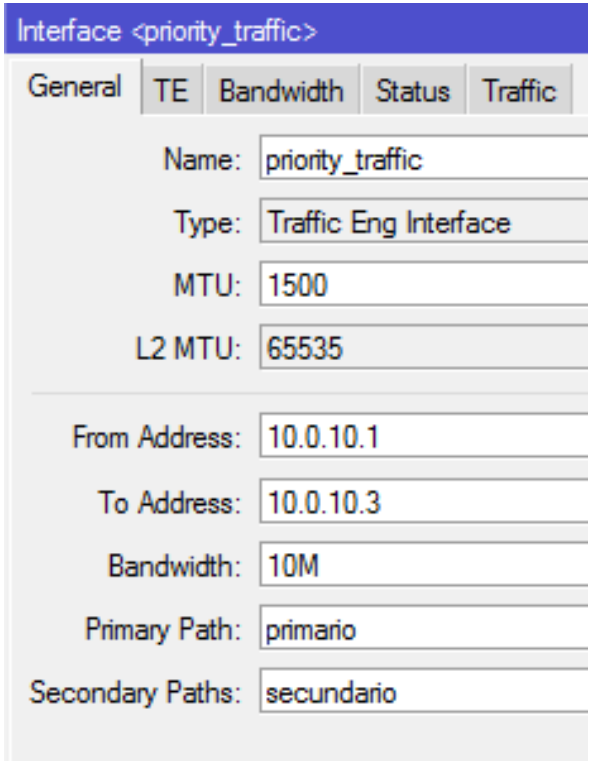
Primary path will use strict routes pointing to all IP addresses the flow goes through. Secondary Path is configured to use OSPF routes.

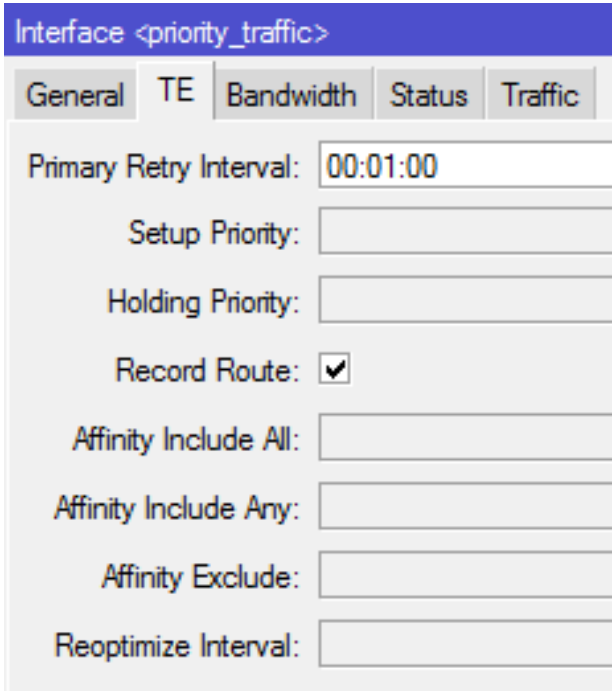


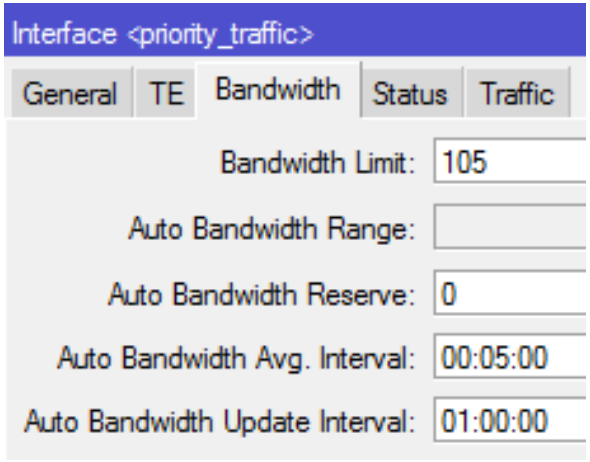


TE Scenario Configuration
Interface TE parameters

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

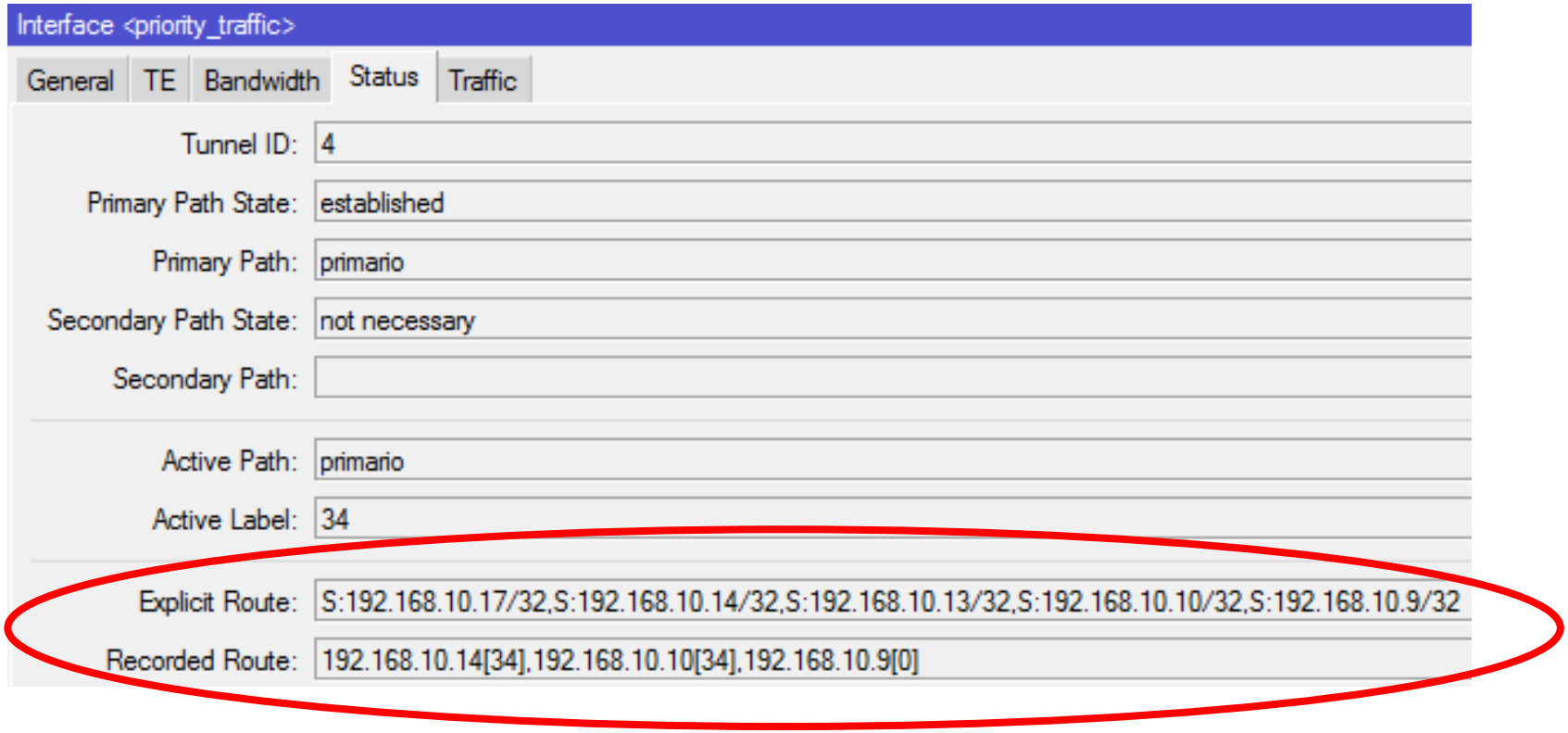






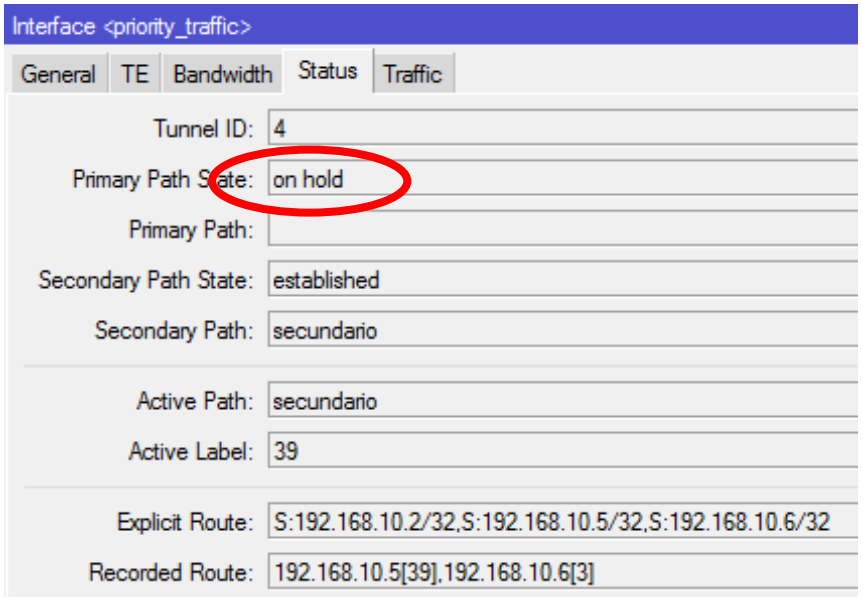
TE Scenario Configurations Redundancy in action

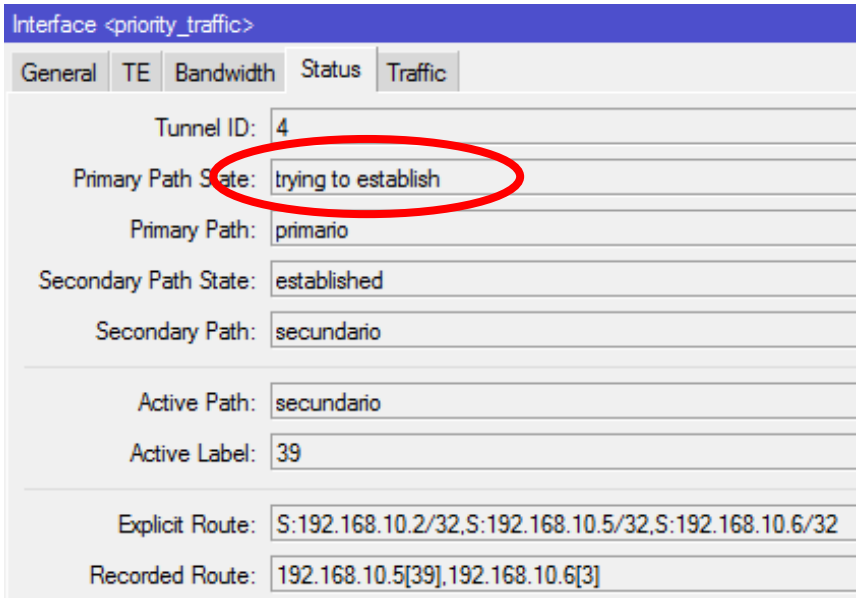
This is the primary path established. Look at the explicit route and recorded route



TE Scenario Configurations Redundancy in action

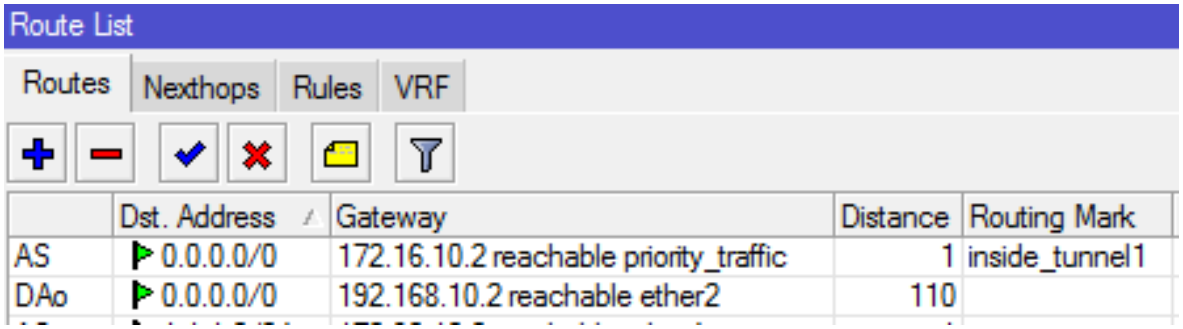
If primary path fails, secondary is used and primary is "on hold" until primary is up again. State passes through "trying to establish" and finally primary is established again.

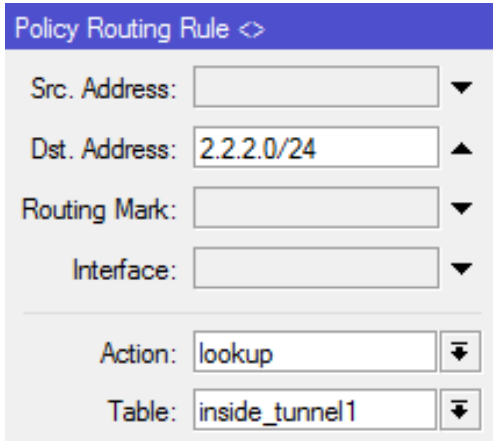


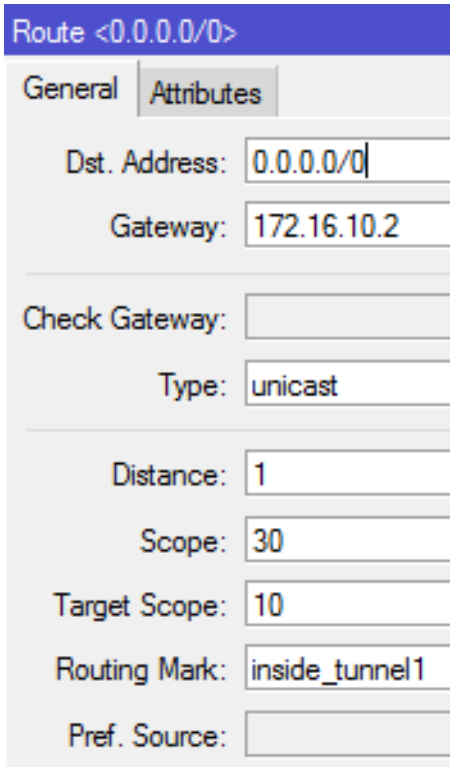


TE Scenario Configurations
Routes and Route Policy

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



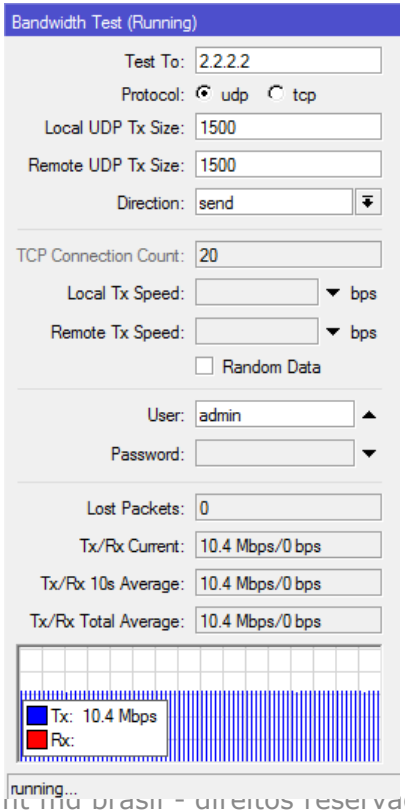


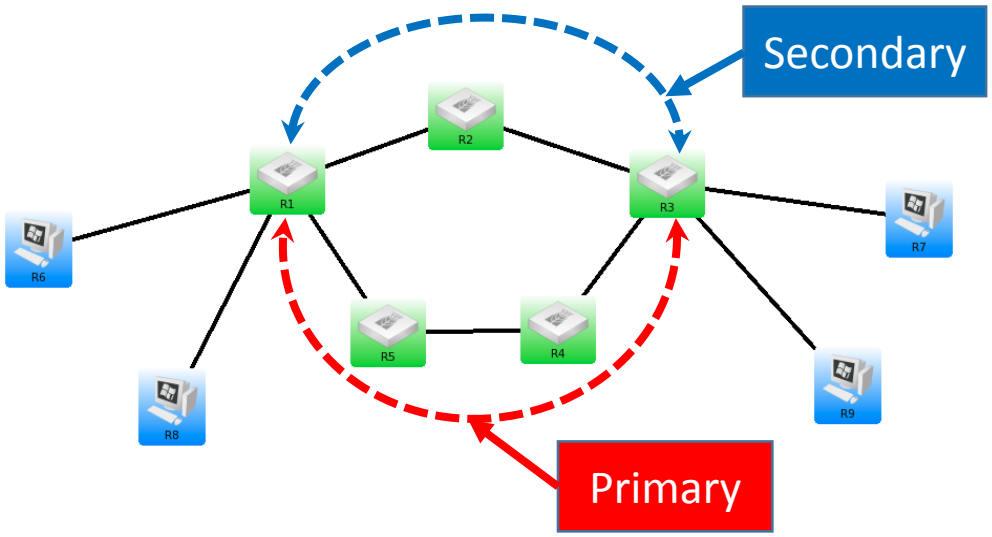


TE Scenario Configurations

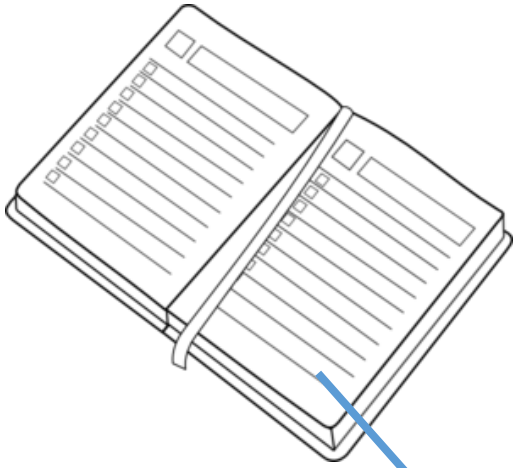
Testing routing and limitation

```
[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
```





Agenda



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Final considerations, references and download links.

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Issues and Limitations

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.

Live CD/USB

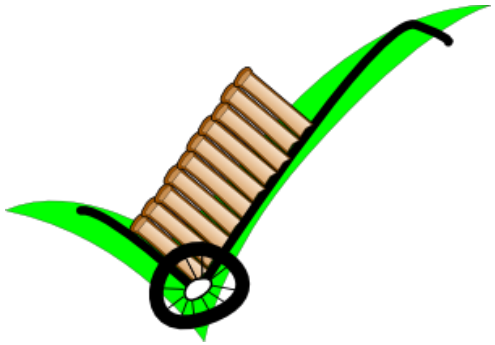
To circumvent issues related to installation we have developed an .iso image that can be run as a Live USB or a Live CD;

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-routeros-x86-on-gns3/

https://wiki.debian.org/QEMU

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

Thanks to

Many Thanks to

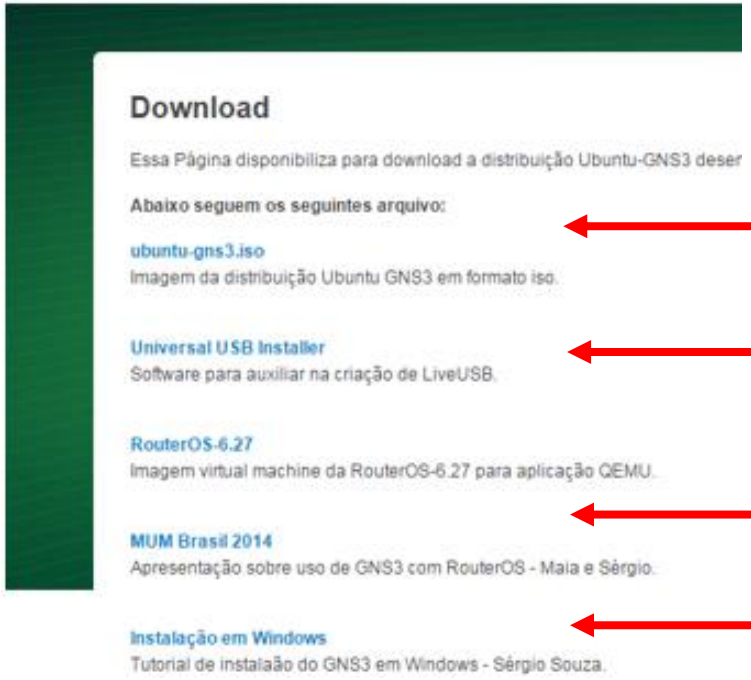
Sergio Souza who helped a lot with debugging the installations and who exchange with me a lot of projects;

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.

Download Page

Presentation and related material can be obtained in the URL:
http://mdbrasil.com.br/downloads/gns3



ISO image

USB installer

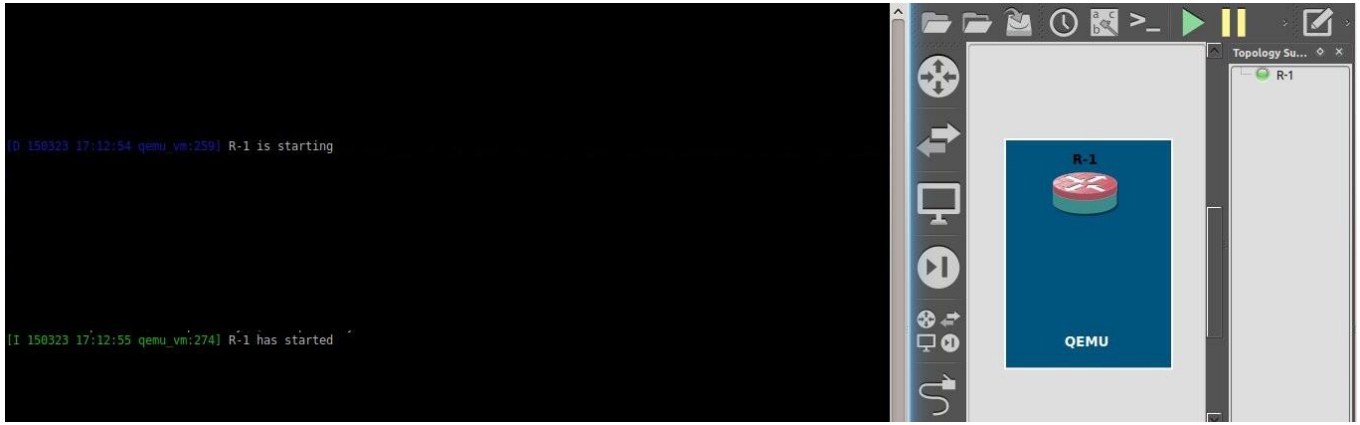
RouterOS image for Qemu

Windows Installation (Portuguese)

Extra Slides

Extra Slides
VirtualBox x Qemu

Qemu x VirtualBox



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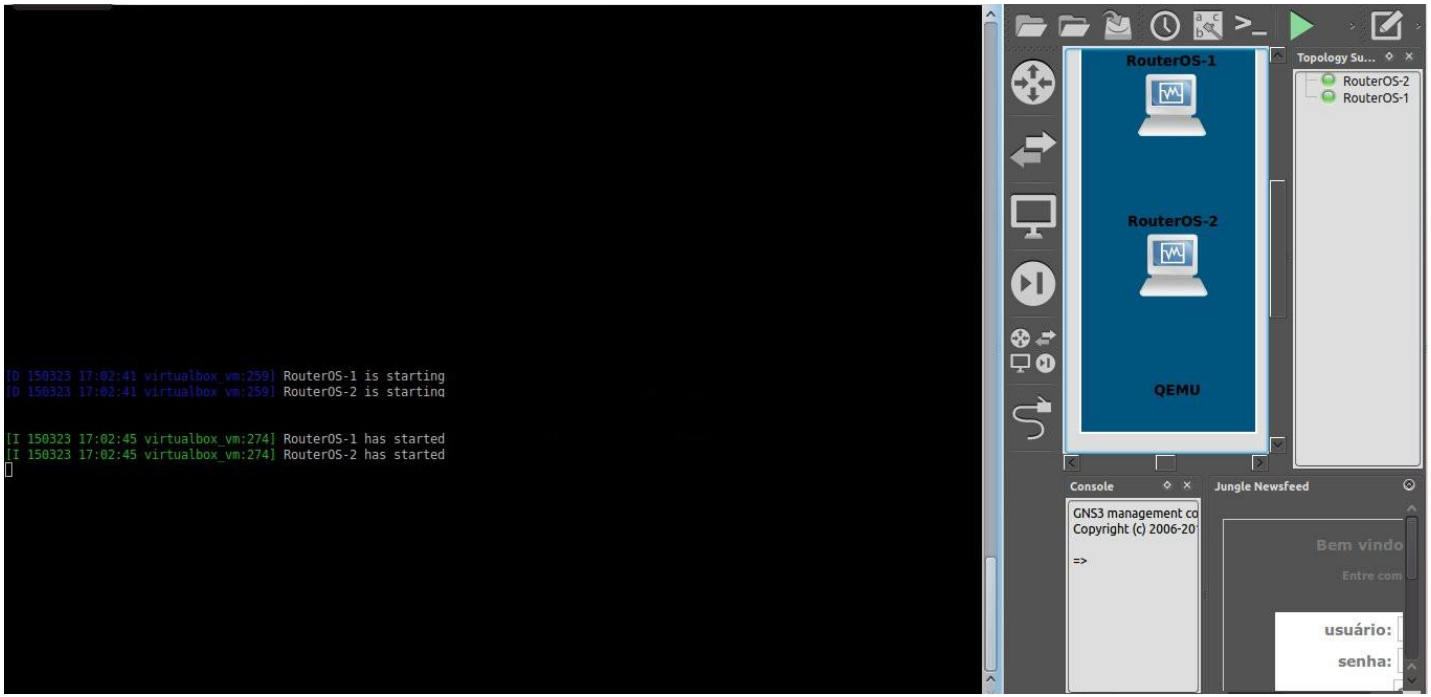

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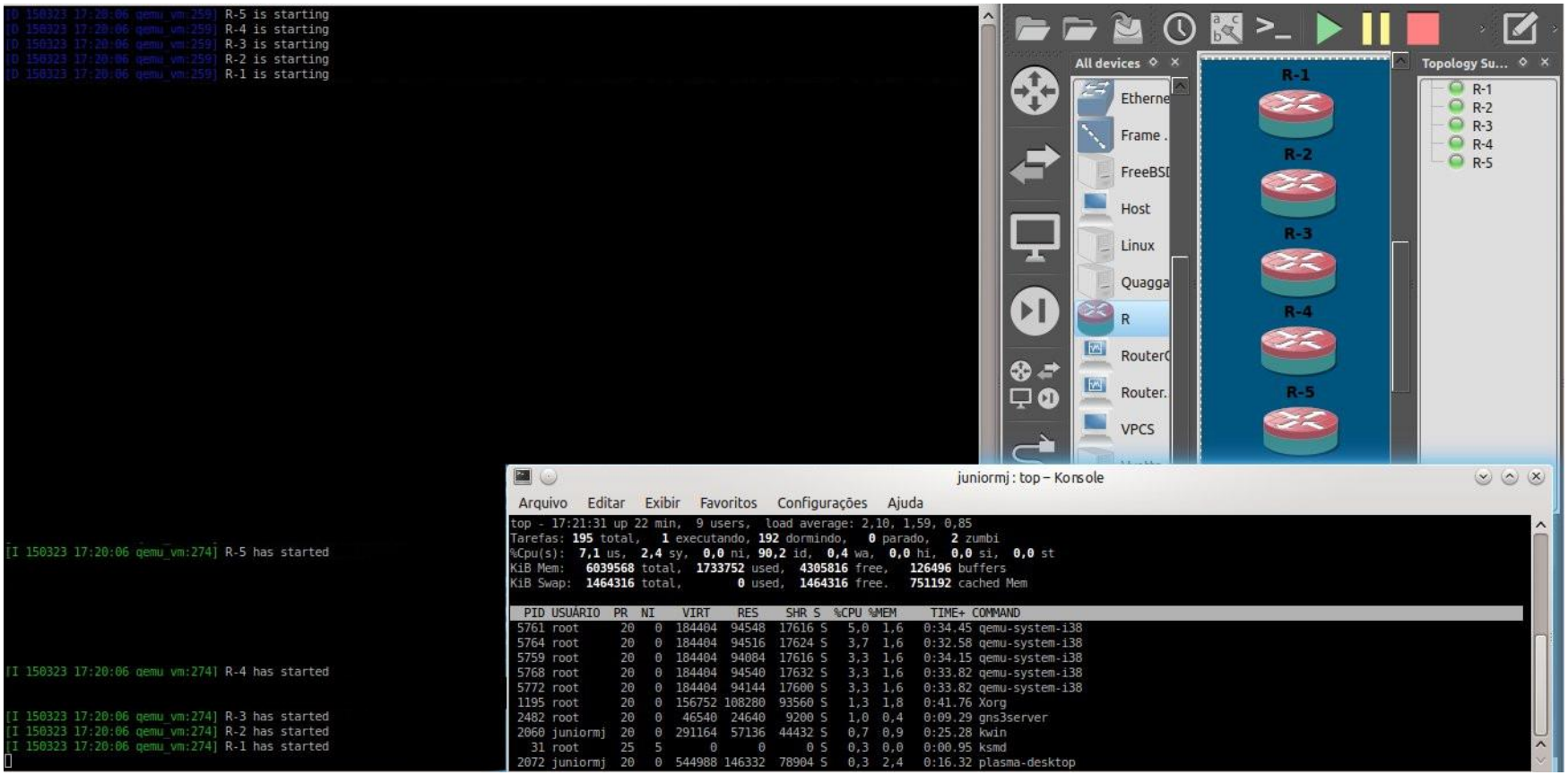

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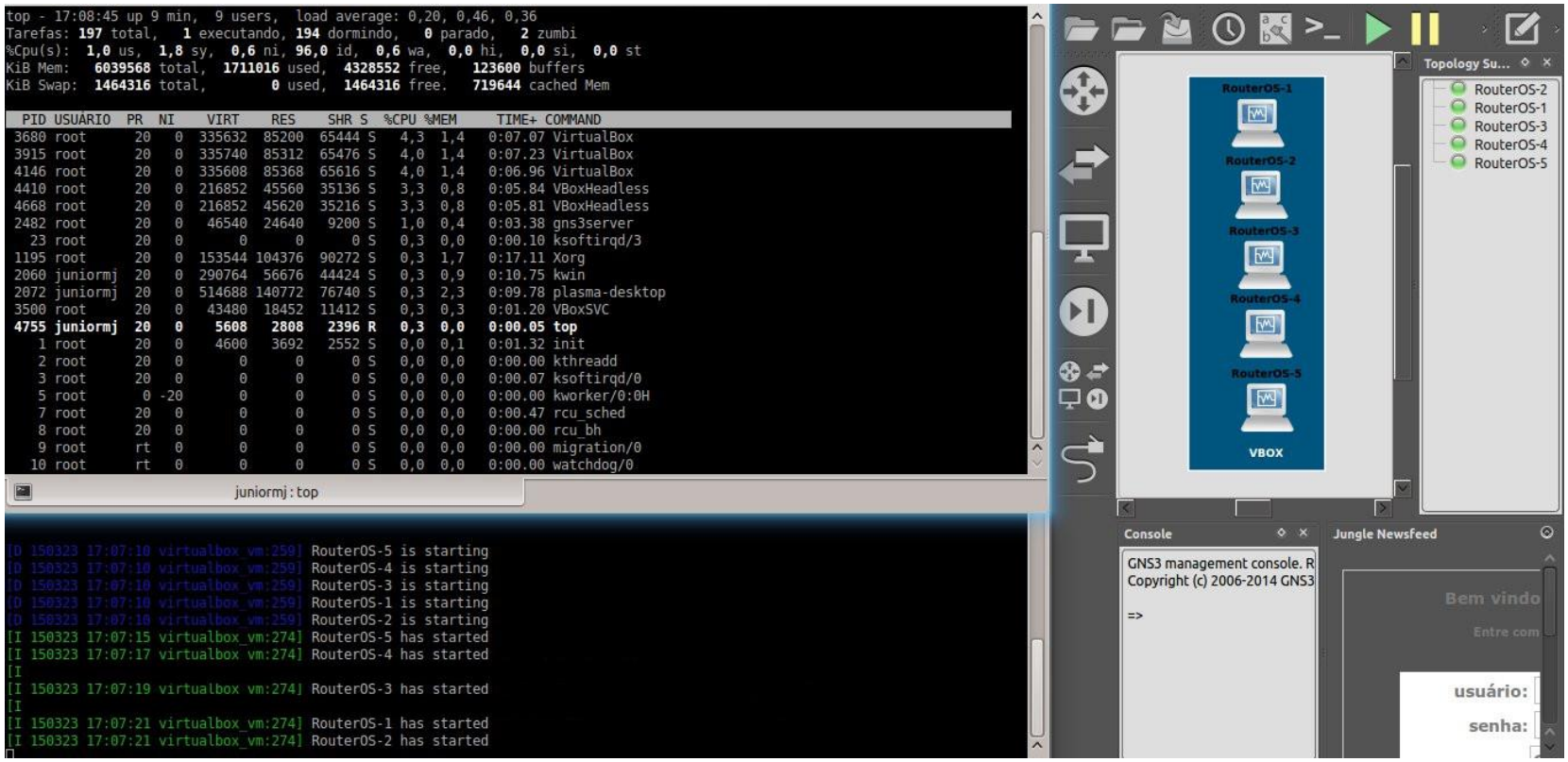

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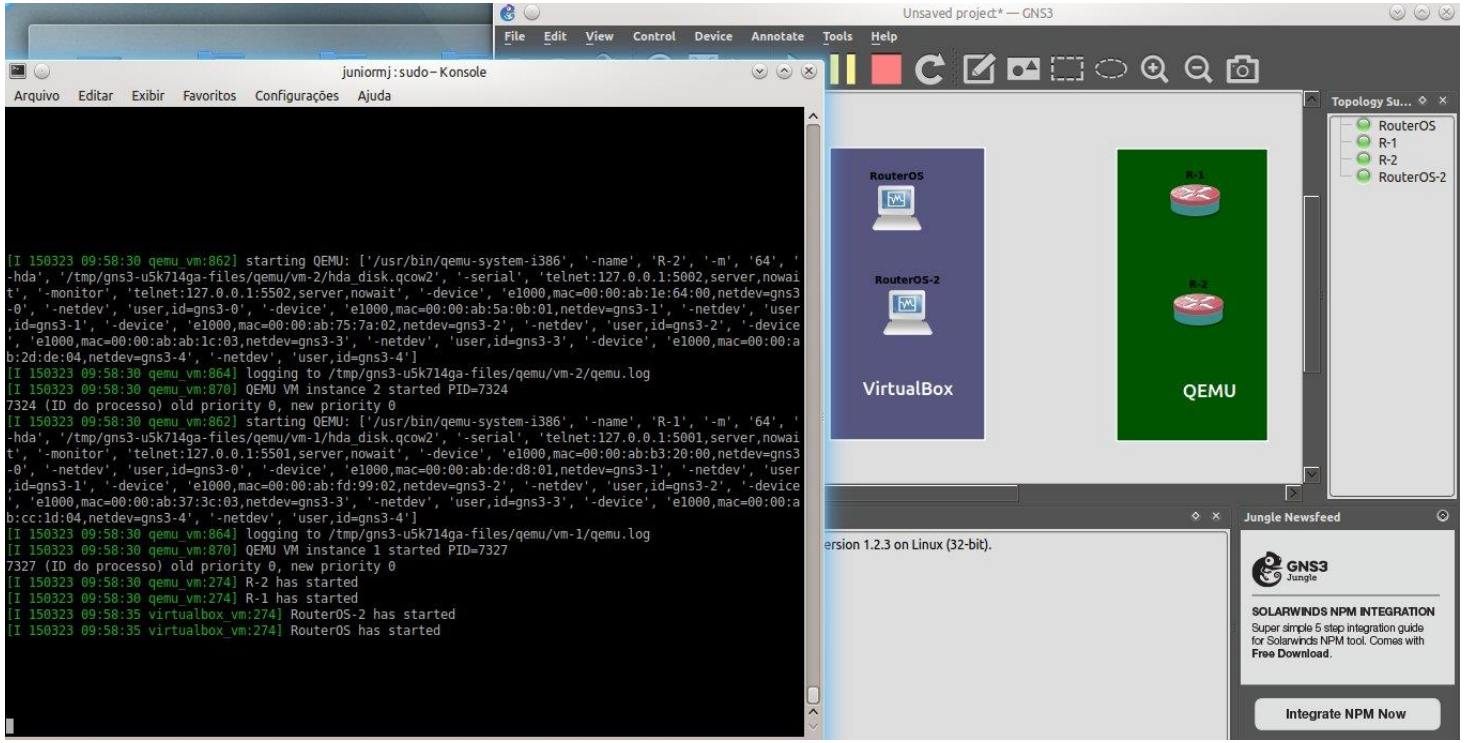

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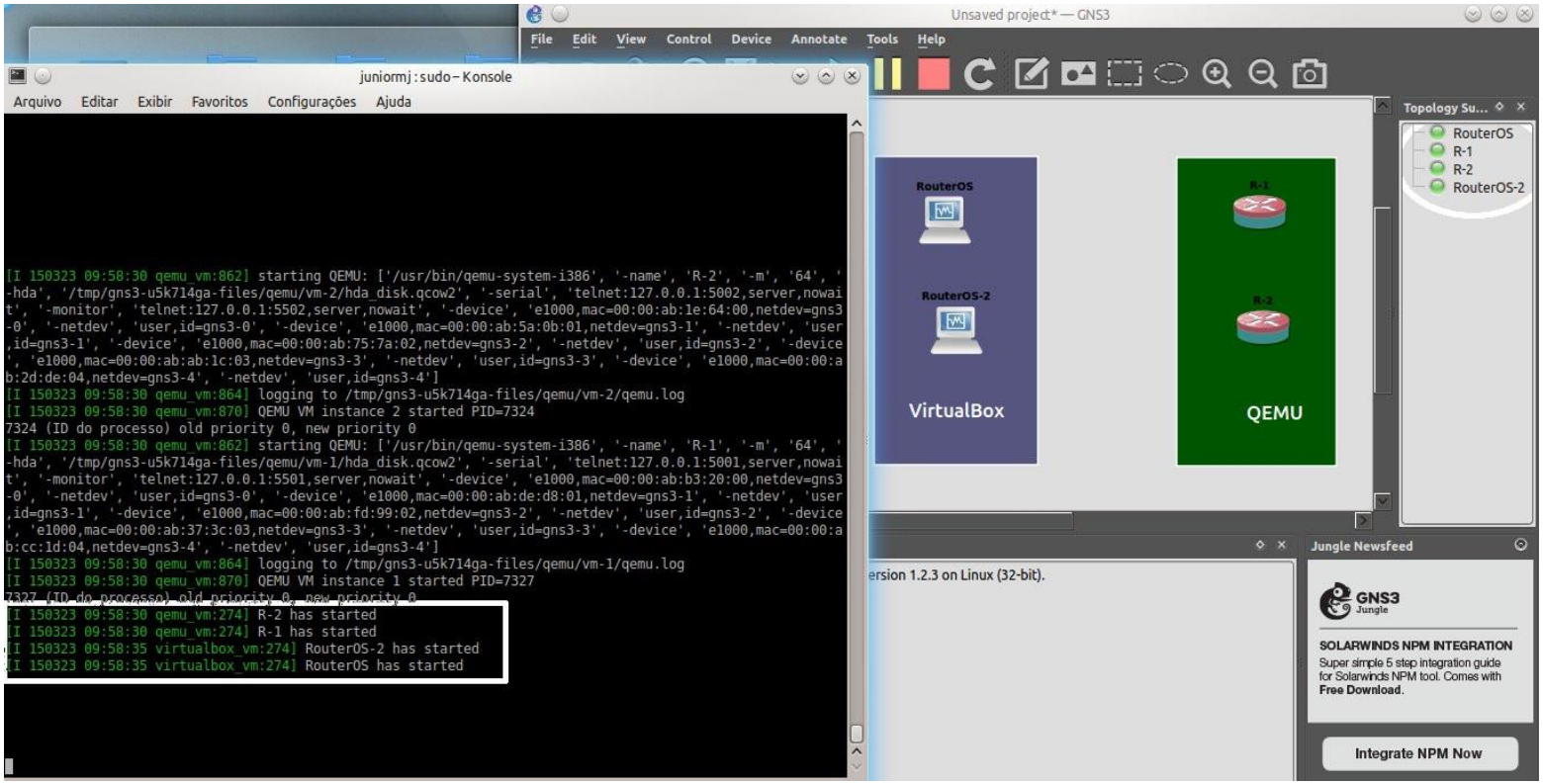

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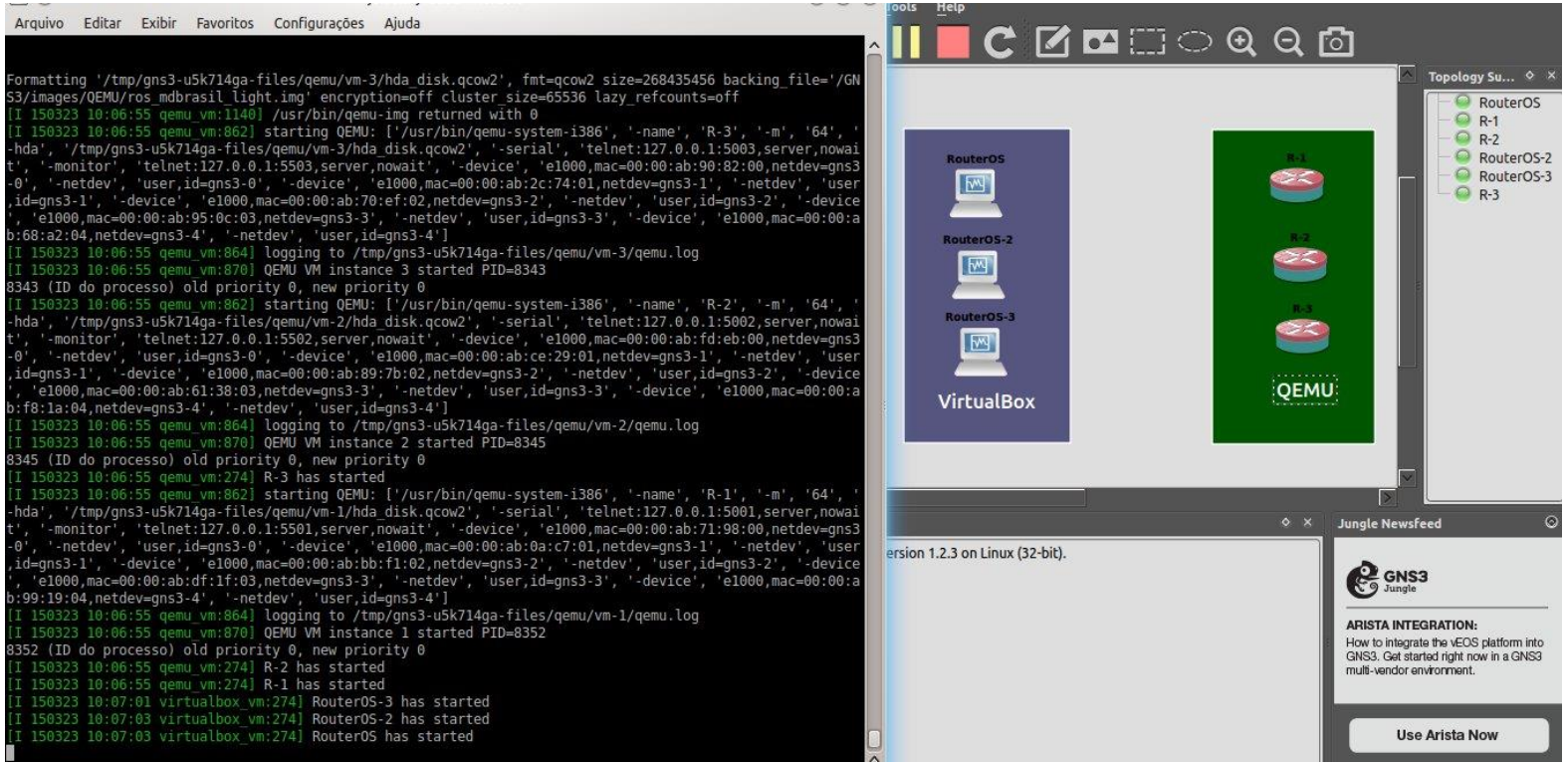

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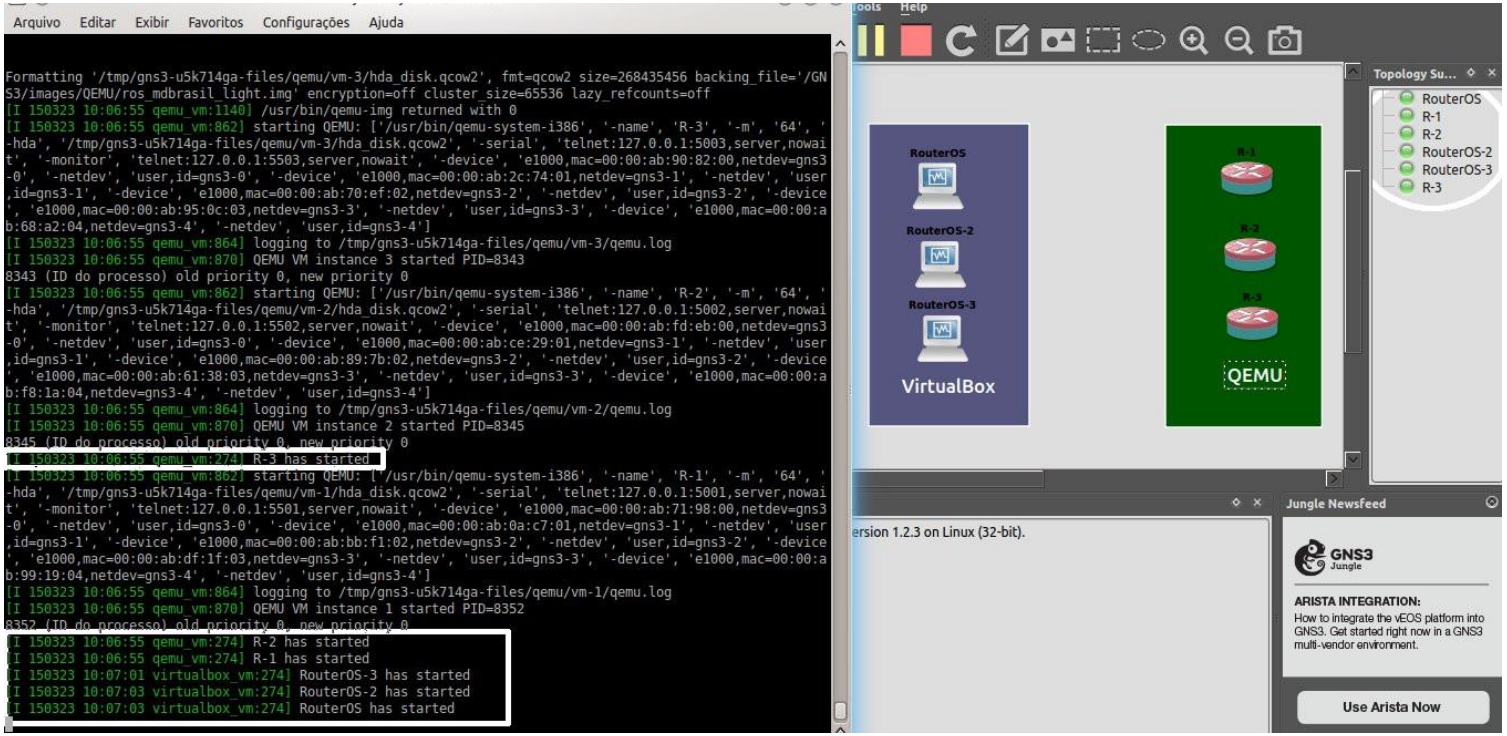

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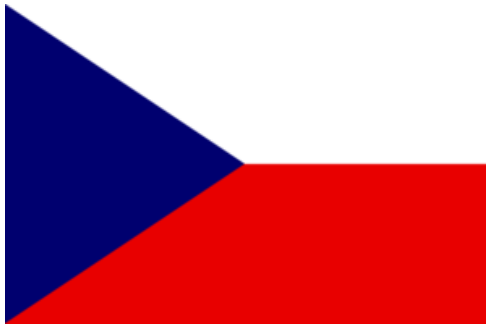

Děkuji