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DEPARTAMENTO DE ELECTRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA
LICENCIATURA EM ENG. DE COMPUTADORES E INFORMÁTICA

REDES DE COMUNICAÇÃO I

LAB GUIDE

PC ENVIRONMENT

Objectives

- Set up the PC environment for the lab classes and project execution:
  - Putty installation
  - WireShark Installation
  - VirtualBox Installation
    - Importing pre-prepared Virtual Machine
  - GNS3 Installation
    - Server Preferences
    - Adding Cisco IOS for routers and Ether Switch Router
    - Importing VirtualBox VM
    - VPCs Configuration
    - Connect a GNS network to a real network

- How to modify network configurations on the PC
- Important network debug utilities
  - ping
  - traceroute
  - nslookup

Duration

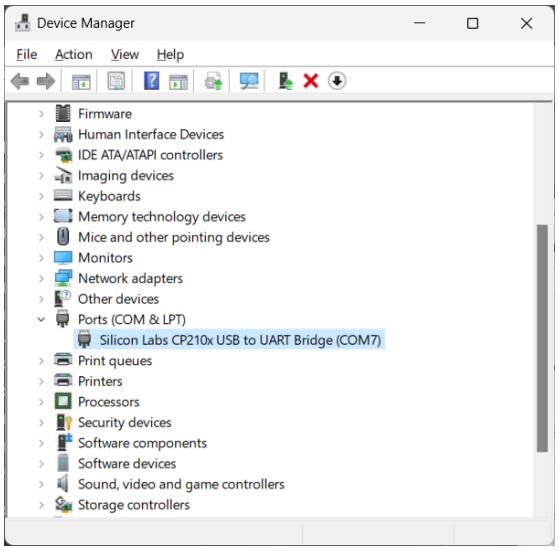
Tasks to be (mostly) performed out of class

1. Installation Putty

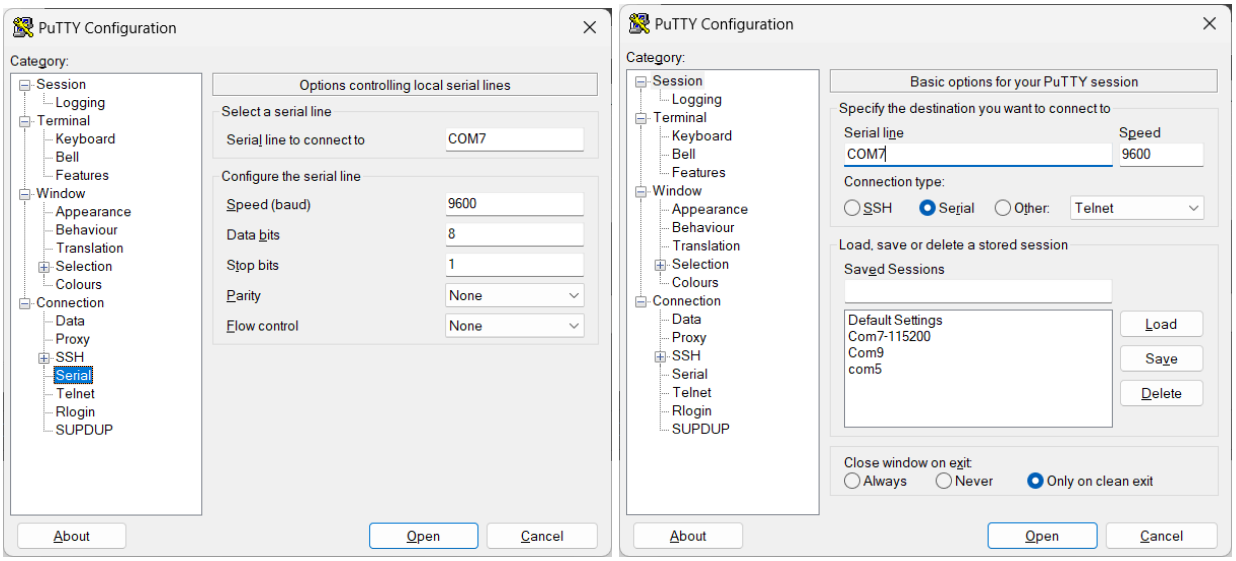
Download and install Putty: https://www.putty.org/

In order to access the routers and switches console ports you will need to use a USB serial adapter.

Depending on the adapter you are using, you will need to find it on the device manager, under "Ports" (COM & LPT) to identify the right COM port:



To access the routers and switches console, you need to configure it as shown below:



For Linux, use **picocom**:

```
sudo apt install picocom
sudo picocom -b 9600 /dev/ttyUSB0
```

(check under /dev which is the ttyUSB you have)

Putty is also available for Linux, if you desire:

```
sudo apt update
sudo apt install putty
```

For macOS:

PuTTY is not natively available for macOS, but you can use alternatives like Terminal or iTerm2 for SSH connections.

If you prefer PuTTY specifically, you can use a tool like Homebrew to install it.
Open a terminal window.
Install PuTTY (Alternative using Homebrew):

If you haven't installed Homebrew yet, you can do so by running the following command:
/bin/bash -c "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"

Once Homebrew is installed, you can install PuTTY using the following command:

```
brew install putty
```

The same cable/adapter may be used to access the routers and the switches and you may switch from one to the other without stopping putty.

2. Installation of Wireshark

Visit the official Wireshark website: https://www.wireshark.org/

Click on the "Download" link and select the Windows version.
Choose either the 32-bit or 64-bit installer, depending on your system architecture.
Follow the on-screen instructions to download the installer.
You may be prompted to install additional components like WinPcap or Npcap; follow the prompts if necessary.

You may need administrative privileges to capture network traffic, so ensure you run Wireshark as an administrator if needed.

Linux:
Open a terminal window.
Use your distribution's package manager to install Wireshark. For Debian/Ubuntu-based systems, you can use:

```
sudo apt update
sudo apt install wireshark
```

During the installation process, you may be prompted to add your user to the 'wireshark' group to allow capturing packets without root privileges. Follow the on-screen instructions to do so if desired.
After installation, you may need to configure Wireshark to allow non-root users to capture packets. Run the following command in the terminal:

```
sudo dpkg-reconfigure wireshark-common
```

Select "Yes" to allow non-superusers to capture packets and follow any additional prompts.

Once installed and configured, you can launch Wireshark from the applications menu or by typing 'wireshark' in the terminal.

macOS:

Download Wireshark: https://www.wireshark.org/

Download the macOS version of Wireshark.

You may need to install XQuartz if you haven't already, as Wireshark for macOS requires it to run. You can download XQuartz from https://www.xquartz.org/ and follow the installation instructions.

3. Installation of Virtual Box

Go to https://www.virtualbox.org/wiki/Downloads

Select the package according to your system and install it, following the necessary steps.

In case you have problems on **Linux**, you may try the following **alternative steps**

To install VirtualBox on Linux, you can follow these general steps. Note that specific commands may vary slightly depending on your Linux distribution:

Before installing any software, it's a good idea to update your package lists to ensure you're installing the latest version of VirtualBox and its dependencies. Open a terminal and run the following command:

```
sudo apt update
```

VirtualBox may require some dependencies to be installed on your system. Run the following command to install these dependencies:

```
sudo apt install -y dkms build-essential linux-headers-$(uname -r)
```

This command will install DKMS (Dynamic Kernel Module Support), which is required for VirtualBox to manage kernel modules, as well as other necessary packages.

VirtualBox provides an official repository for Linux distributions. Add the VirtualBox repository to your system by importing the repository key and adding the repository to your system's software sources list. Run the following commands:

```
wget -q https://www.virtualbox.org/download/oracle_vbox_2016.asc -O- | sudo apt-key add -
wget -q https://www.virtualbox.org/download/oracle_vbox.asc -O- | sudo apt-key add -
sudo add-apt-repository "deb [arch=amd64] http://download.virtualbox.org/virtualbox/debian $(lsb_release -cs) contrib"
```

After adding the VirtualBox repository, update your package lists again and install VirtualBox using the following commands:

```
sudo apt update
sudo apt install virtualbox
```

---

4. Installation of GNS3

Download GNS3: https://www.gns3.com/

Click on the "Download" link and select the Windows version, Linux or MAC OS according to your system.

Linux:

sudo apt update

sudo apt install gns3

(Linux) Install from repositories; AUR for Arch/Manjaro distributions and PPA https://launchpad.net/~gns3/+archive/ubuntu/ppa for Debian/Ubuntu based distributions. Install packages gns3-server, gns3-gui, wireshark-qt, virtualbox, and VPCS. Add your user name to the wireshark group (usermod -a -G wireshark USERNAME) and restart.

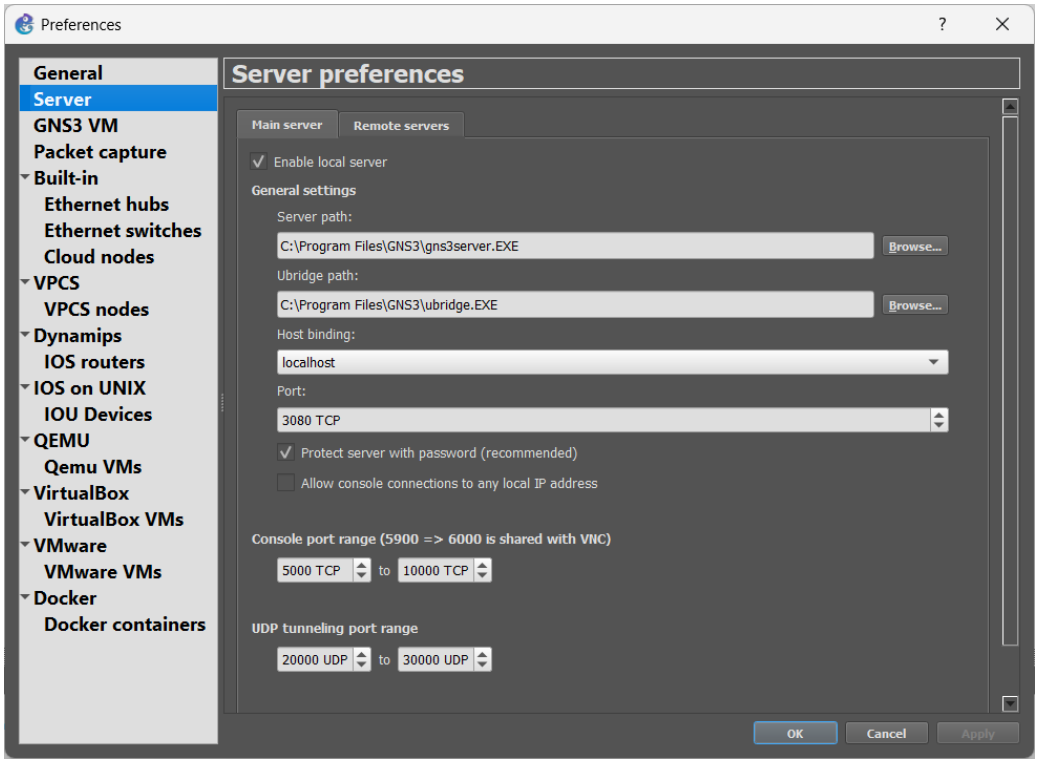
At (Preferences-General), verify/setup all storing and program paths, avoiding paths with spaces and non ASCII characters.

At (Preferences-Server) enable local server, define 127.0.0.1 as host binding address.

Note: **You do not need an external virtual machine (VM)** to run emulation/simulation software. At (Preferences-GNS3 VM) **disable** the option “Enable the GNS3 VM”.

Open GNS3. Do not open a project. Wait for the server to start.

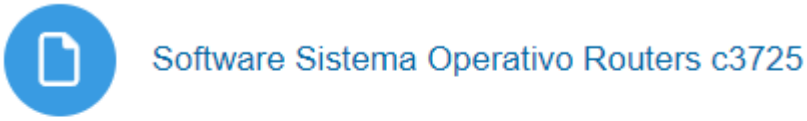
Go to: Edit ➔ preferences ➔ server

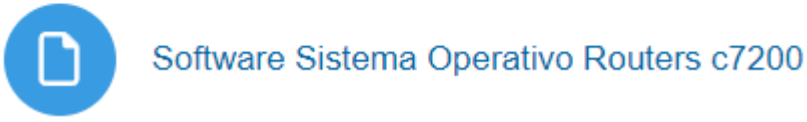


Change UDP tunneling port range from 10000-20000 to **20000 UDP to 30000 UDP**

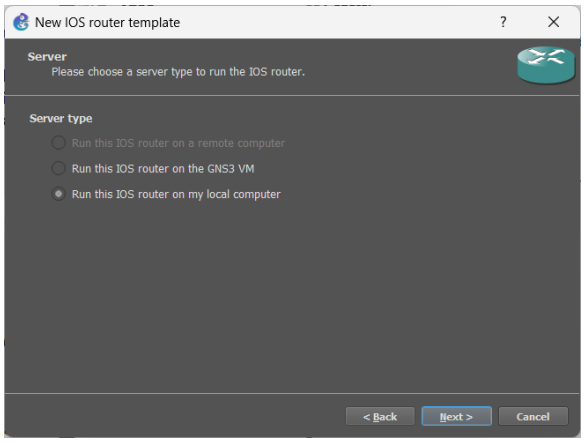
Close GNS3. Open it again.

Download the following routers' firmware: (i) Router 7200 Firmware 15.1(4) IOS Image, and (ii) Router 3725 Firmware 12.4(21) IOS Image.





At (Preferences-Dynamips-IOS Routers") create three new router templates ("New" button on the bottom left):

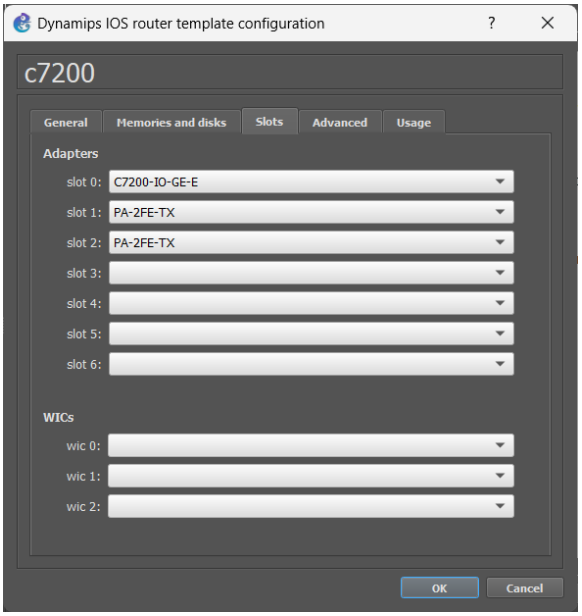


4.1. Router 7200

Recommended IOS image: 7200 with IOS 15.1(4) and network adapters:

C7200-IO-GE-E

2x PA-2FE-TX (1 Ethernet →Eth0/0 + 1 GigabitEthernet → GE0/0 + 4 FastEthernet → F1/0,F1/1+F2/0,F2/1)

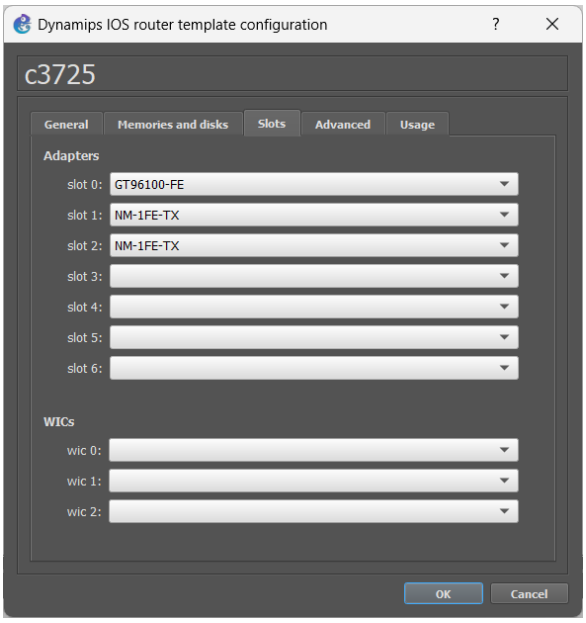


4.2. Router 3725

Recommended IOS image: 3725 with IOS 12.4(21) and network adapters:

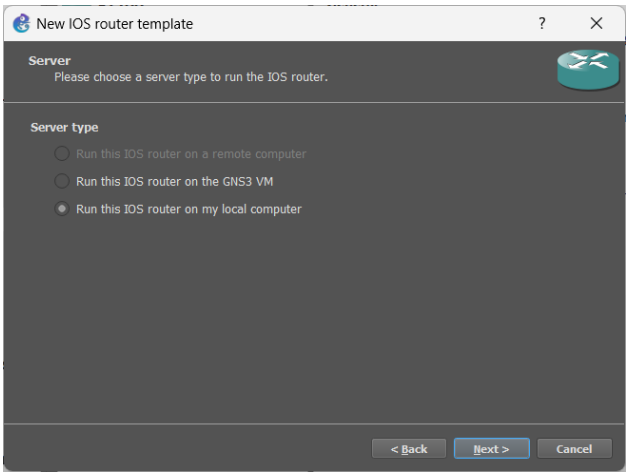
GT96100-FE

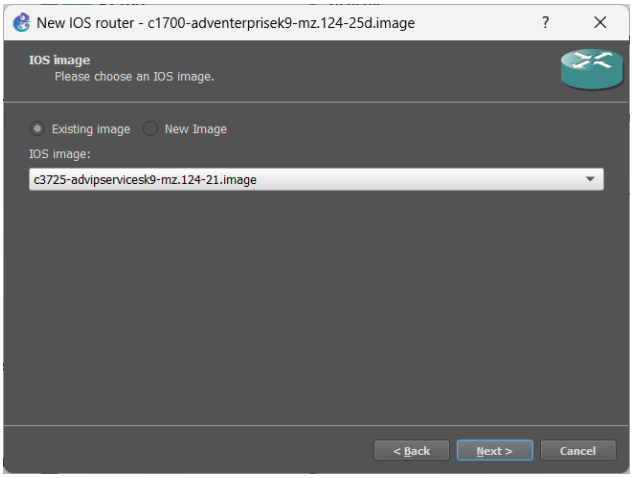
2x NM-1FE-TX (4 FastEthernet → F0/0, F0/1, F1/0, F2/0), all other values can be the default ones;

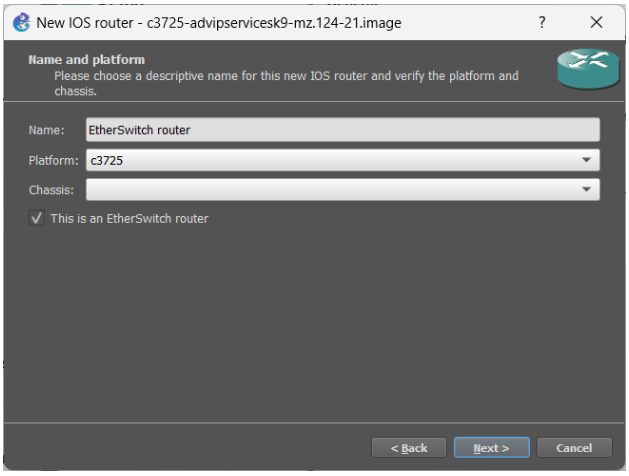


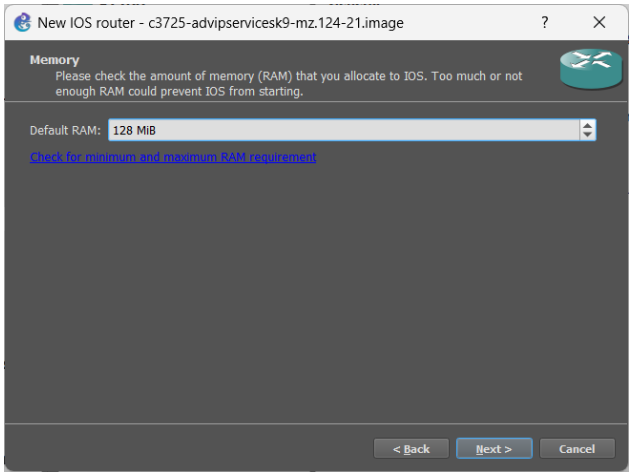
4.3. ESW Cisco Switch Router (L3 Switch)

If you still do not have, you must add the ESW to your GNS installation, under Edit ➔ Preferences ➔ Dynamips ➔ IOS Routers ➔ New





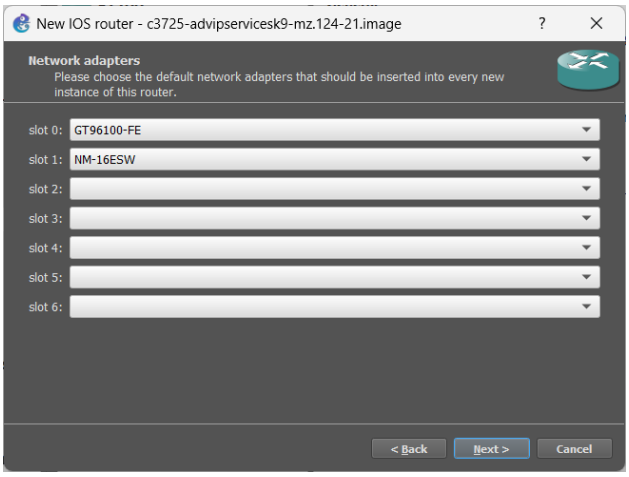


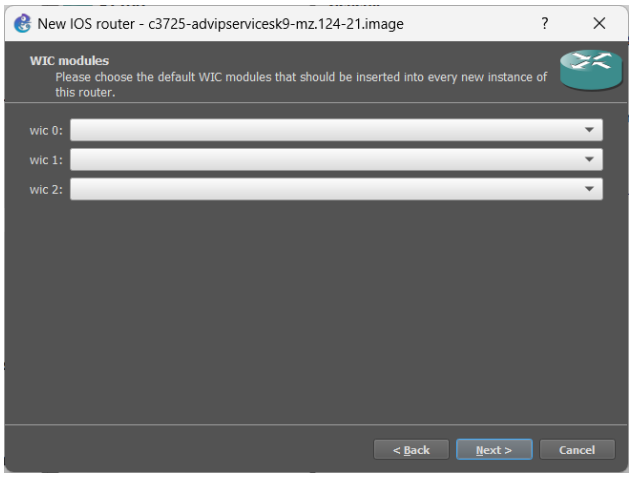


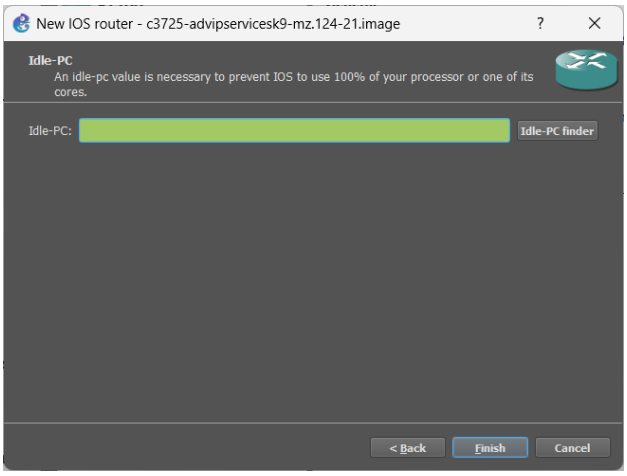
Choose adapters

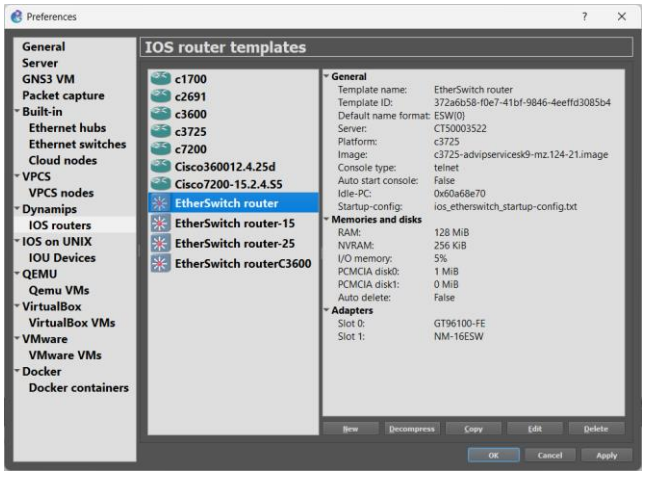
GT96100-FE

NM-16ESW (2 FastEthernet for routing only → F0/0, F0/1 + 16 port switch module for switching → F1/0 to F1/15).









The definition of the “Idle-PC” value will allow the host machine to assign the correct amount of resources to the virtual devices. You must repeat this procedures every time your PC CPU reaches values higher than 90%. Check the CPU utilization with the “Task Manager” in Windows, top command in Linux and “monitor” in MacOS.

To define the “Idle-PC” value:

- Click "Idle-PC finder" during template setup, OR
- Add router to project, start it (should be the only one ON), open console (wait for prompt), left click the device and choose option "Auto Idle-PC", OR
- Add router to project, start it (should be the only one ON), open console (wait for prompt), left click the device and choose option "Idle-PC", choose one value (prefer the ones marked with *) and verify the CPU utilization. If any "dynamips" process is using more than 5%-10% CPU choose another value.

This must be done for each router template, NOT each router! Each template will have a different “Idle-PC” value. All routers from the same template will share the same value.

Note 1: All devices from the same template must be equal in terms of virtual hardware.

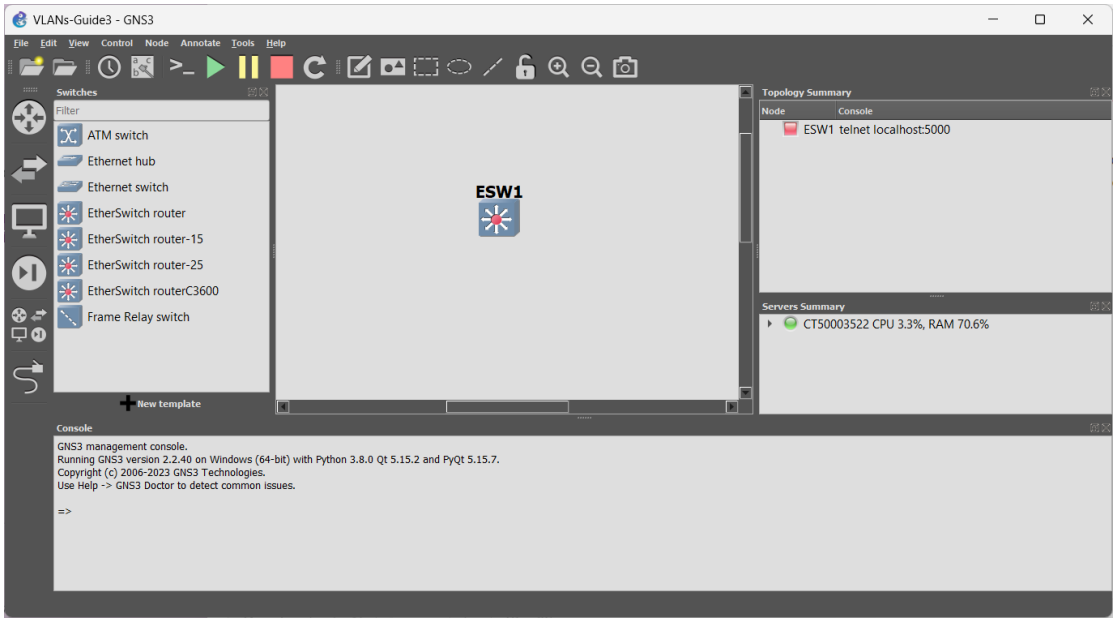
Note 2: After changing any device hardware characteristic or adding/removing network modules, the “Idle-PC” value must be changed in the template. If necessary, create a new template with different characteristics/modules.

Note: At this phase your GNS3 installation should have (at least):

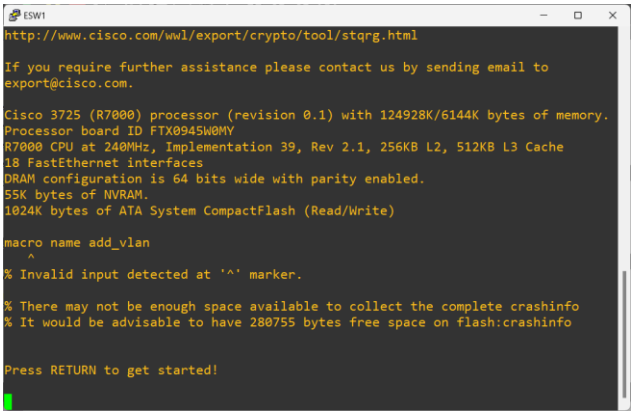
- 2 Routers: a Cisco c7200 and a Cisco c3725;
- An “EtherSwitch” (Layer 3 switch) based on a router c3725 with a 16 port switch module;
- An “Ethernet Switch”, consumes less memory and CPU, but does not have an IP address;

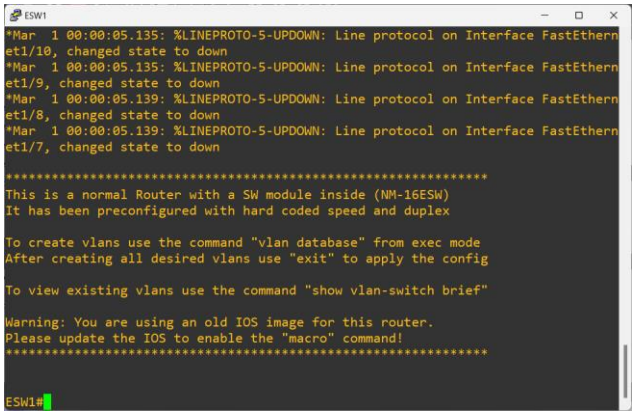
4.4. How to use the EtherSwitchL3 (ESW)

Create a new project for the VLANs Guide and add an EtherSwitch router (ESW1):

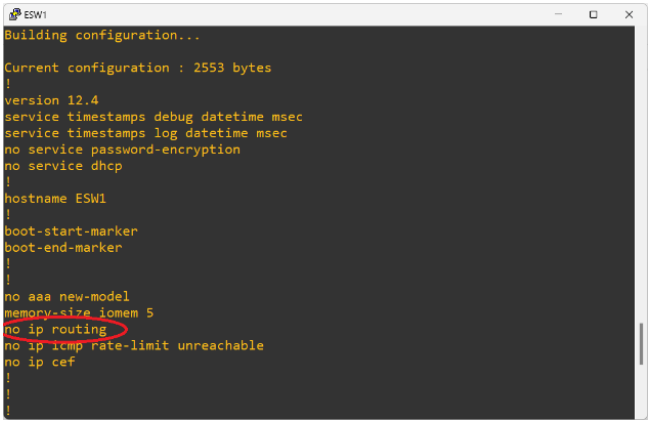


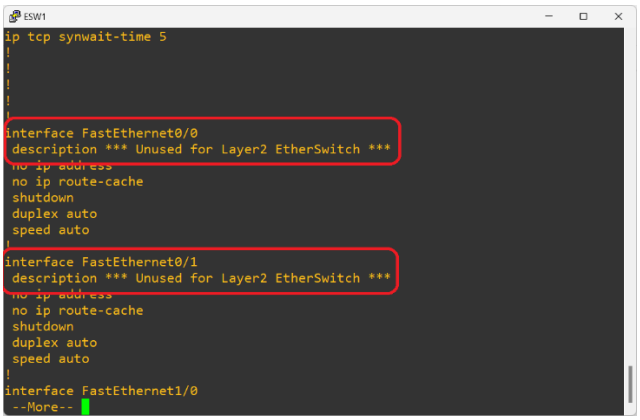
Start the device and right click over it to open the console:





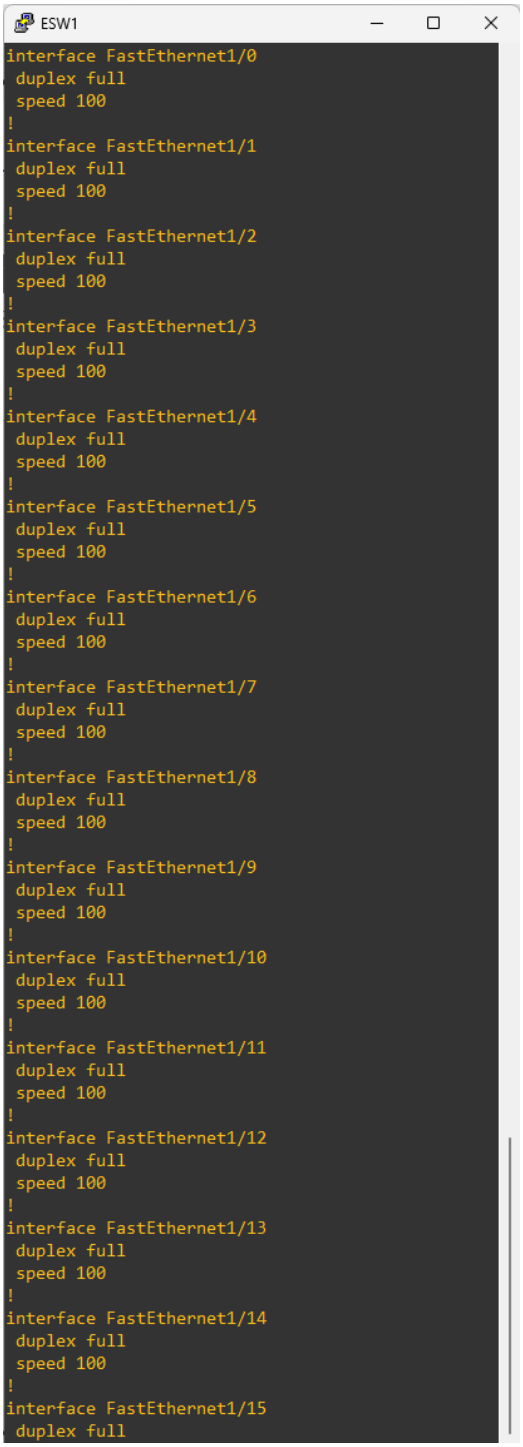
Do a show run to check its configuration, with special attention to the available interfaces.



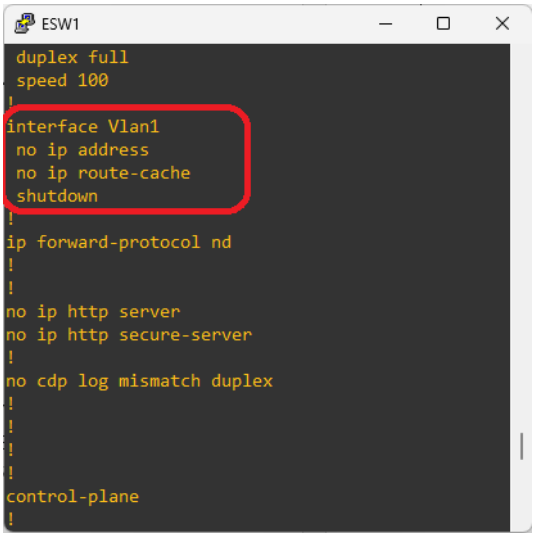


Note that:

- By default, this device will not work as a router. You will need to enable the routing engine.
- There are two interfaces (F0/0 and F0/1) that are ROUTING interfaces only. They should NOT BE USED for switching purposes.

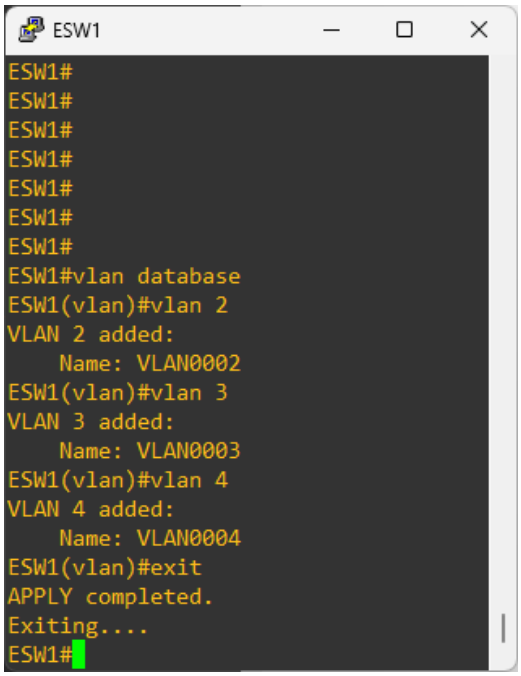


There are 16 interfaces (from F1/0 to F1/15) that “belong” to a switch card interface on the router, and these are the interfaces used for switching and VLANs.

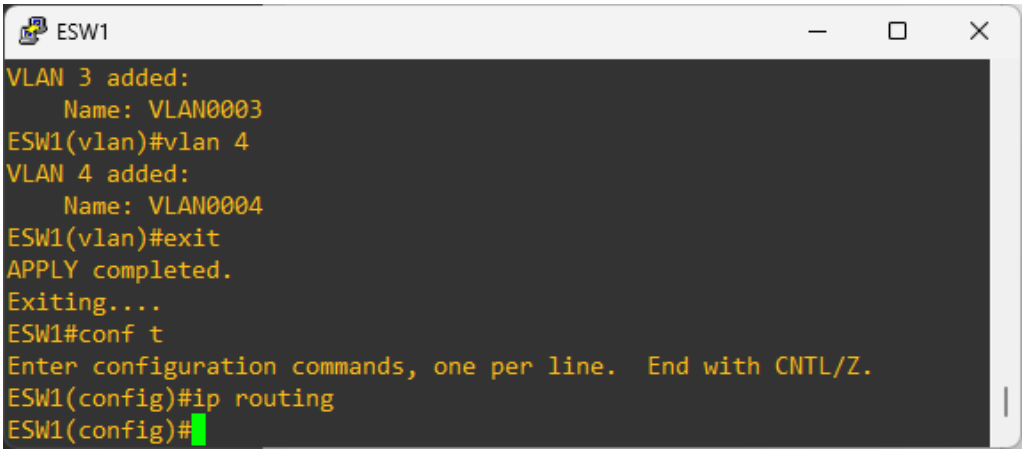


By default there is a Vlan1 interface, through which all switch ports belonging to the Vlan1 may do routing to the other routing interfaces (F0/0 and F0/1). Note that this interface is in "shutdown" by default. In order to be used, you have to do the "no shutdown" to it.

In order to have more Vlan interfaces, they must be added to the Vlan database according to the needs:



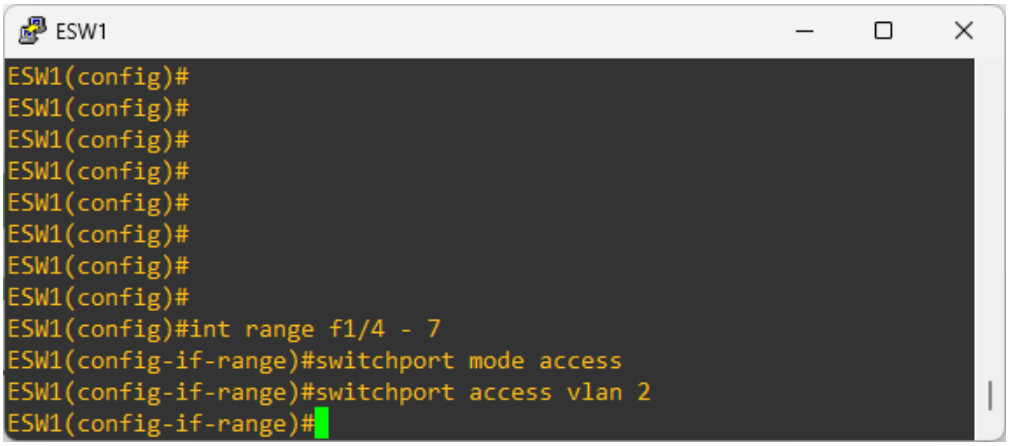
Enabling IP Routing functions on this device:



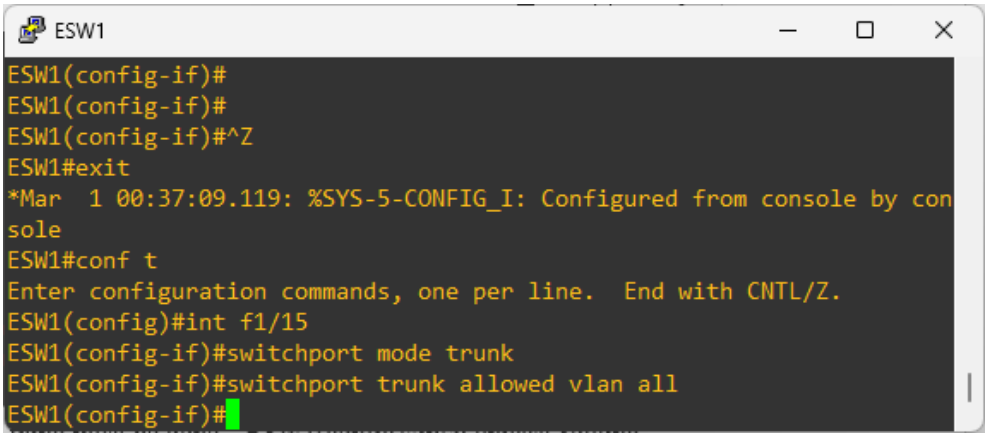
Note: for IPv6 the same thing must be done. "ESW1(config)#ipv6 unicast-routing"

Putting a switch port in access mode and associating it to a specific VLAN:

Applying the same configuration to a range of interfaces (F1/4, F1/5, F1/6 and F1/7):



Putting a port in TUNK mode and allowing all configured VLANs to be able to come in and out of that interface (you may restrict the port to some specific interfaces, if needed):



Note:

- Ports on access mode can only belong to one specific VLAN and the incoming and outgoing Ethernet frames DO NOT have VLAN TAG.
- Ports on trunk mode may input and output Ethernet frames from different VLANs and those Ethernet frames SHOULD BE TAGGED.

In order to have routing between VLANs, and Interface VLAN should be created and configured for each VLAN:

```
ESW1
ESW1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ESW1(config)#
*Mar  1 00:41:50.811: %SYS-5-CONFIG_I: Configured from console by con
sole
ESW1(config)#int VLAN 3
ESW1(config-if)#ip address 192.168.1.254 255.255.255.0
ESW1(config-if)#no shutdown
ESW1(config-if)#
ESW1(config-if)#
ESW1(config-if)#
ESW1(config-if)#
```

IMPORTANT: DUE TO A LIMITATION OF GNS3 WHEN USING THIS IOS AS A L3 SWITCH, AFTER THE VLANS AND INTERFACES ARE CONFIGURED, IT IS NECESSARY TO WRITE THE CONFIGURATION (ESW#write) AND AFTER THAT, STOP AND START AGAIN THE L3 SWITCH.

Configuring a regular router interface to send and receive Ethernet frames with VLANs

```
R1
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface FastEthernet1/0.2
R1(config-subif)#encapsulation dot1Q 2
R1(config-subif)#ip address 192.168.1.254 255.255.255.0
R1(config-subif)#
```

Note that a sub-interface was created (F1/0.2), belonging to the physical interface F1/0.

We then configured this sub-interface to send and receive tagged frames (with the command "encapsulation dot1Q" followed by the VLAN ID we want to use on this sub-interface)

We may add more sub-interfaces to the same physical interface (e.g. F1/0.3, F1/0.450, etc). The ID of the interface ".3", ".450" may be different from the VLAN ID we want to use on that sub-interface:

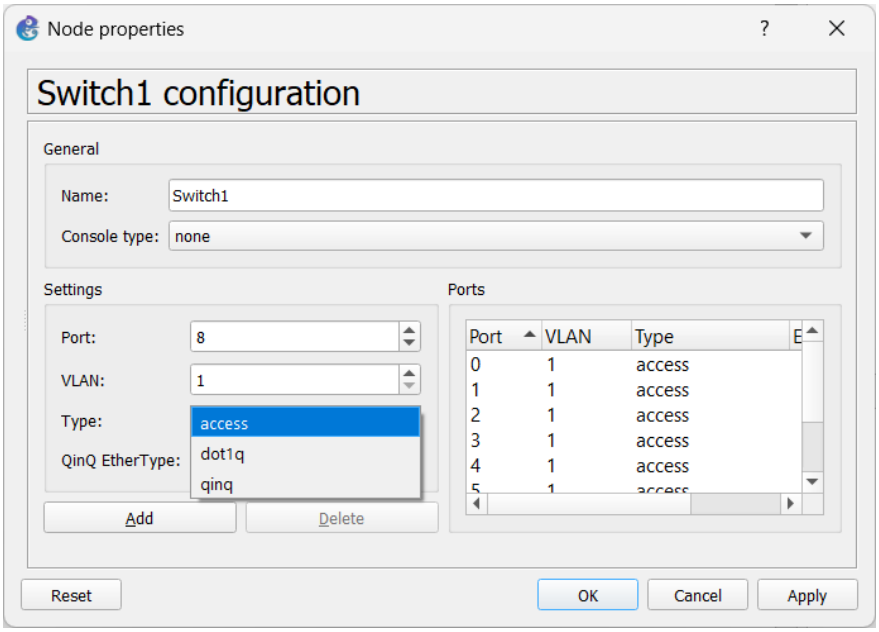
```
R1
R1(config)#
R1(config)#
R1(config)#interface FastEthernet1/0.450
R1(config-subif)#encapsulation dot1Q 3
R1(config-subif)#exit
R1(config)#
```

To be able to use these sub-interfaces, the "mother" interface must be enabled:

```
R1
R1(config)#interface FastEthernet1/0
R1(config-if)#no shutdown
R1(config-if)#
*Oct 10 23:29:21.727: %LINK-3-UPDOWN: Interface FastEthernet1/0, changed state t
o up
*Oct 10 23:29:22.727: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthern
```

4.5. Configuring the simple Ethernet Switches on GNS3

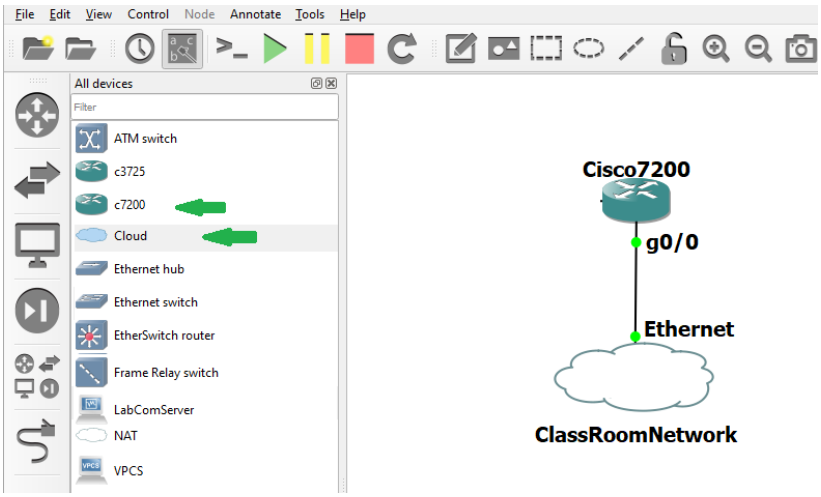
The Ethernet Switches are configured through the "configure" option when you "right click" the switch.



Type "dot1q" is equivalent to "trunk-mode"

4.6. Connecting your GNS3 project to a real network

Build the configuration shown below (please note that the Cisco Interface may be different depending on how your router was defined in GNS).



2 - Configure the router:

Cisco7200(config)# interface GigabitEthernet0/0 #replace by the correct interface of your router
ip address 192.168.101.10#G 255.255.255.0
no shutdown

3 - Attach that router interface to a GNS3 Cloud (not the NAT cloud) and select your PC Ethernet adapter to attach the cloud (if your PC does not have an Ethernet interface, please use a USB dongle). The name of your PC Ethernet interface may differ (eg, Ethernet 2).

4 – Use an Ethernet cable to attach your PC ethernet interface to the RJ-45 Ethernet socket on the work desk (the default will the second RJ-45 port)

5 - Test the connectivity to the classroom router:

Cisco7200# ping 192.168.101.10

Note: sometimes it is necessary to delete and insert again the connection between the Router and the Cloud to enable connectivity (it is a GNS3 bug).

4.7. Interconnection with virtual machines (VirtualBox)

Go to (Edit-Preferences-VirtualBox-VirtualBox VMs" and create a new VM template based on an existing VirtualBox machine. Use an Debian LXDE VirtualBox appliance available to download here (login/password: labcom/labcom).

Note1: To use the VM in GNS3, the VM should be powered off and the network adapter should be "not attached".

Note2: To connect the VM to the Internet, start the VM from VitualBox GUI with the network adapter attached to "NAT".

Note3: To use multiple VM instances, you may clone the original machine.

Interconnection with virtual machines (QEMU)

Go to (Edit-Preferences-QEMU-QEMU VMs" and create a new VM template based on an existing virtual disk image (*.img). Use an Debian LXDE QEMU virtual disk (LabComServer2.qcow2) available to download here (login/password: labcom/labcom). Choose console type "none".

Note1: To use the VM in GNS3, the VM should be powered off.

Note2: To connect the VM to the Internet, start the VM from the command line (or virt-manager) using the command "qemu-system-x86_64 -m 1024 -enable-kvm LabComServer2.qcow2".

Note3: To use multiple VM instances, you may copy the original VM disk file "LabComServer2.img" and start another VM.

Note4: In Windows, QEMU requires HAXM, see how to install here. Also, replace option "-enable-kvm" with option "-accel hax" when running from the command line.

Add a PC as an end device based on the created VM template. Configure its IPv4 address and gateway, as root do:

ip link set up dev enp1s0

ip addr add 192.168.2.102/24 dev enp1s0

ip route add default via 192.168.2.1

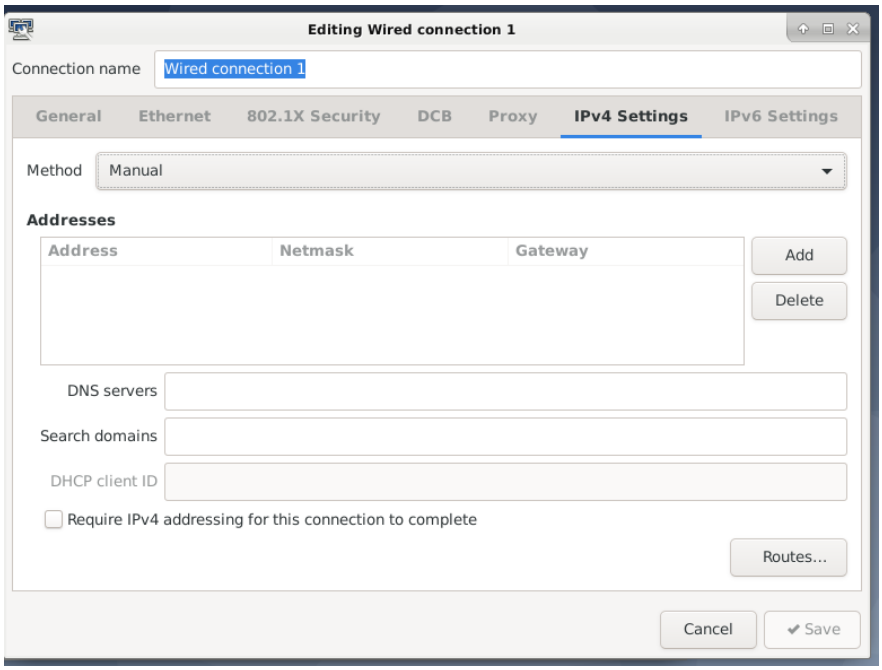
Test connectivity to the other GNS3 network elements.

Note: your virtual Ethernet port may have another name. List devices with ip addr to identify it.

Connect an Ubuntu VM to GNS3 in a MacBook M1 (using VMware)

- Verify if you don't have issues running GNS3. It should run normally, as it uses Rosetta x86 emulation.
- Install the free version of VMware Fusion Public Tech Preview. Download from https://customerconnect.vmware.com/downloads/get-download?downloadGroup=FUS-PUBTP-2021H1.
- Download Ubuntu 20.04 Arm from https://cdimage.ubuntu.com/focal/daily-live/current/focal-desktop-arm64.iso.
- Create Ubuntu Arm VM in VMware using the downloaded Ubuntu image.
- Close VMware. On your Mac, go to /Applications folder and rename the app "VMware Fusion Tech Preview" to "VMware Fusion".
- Open GNS3, go to the VMware tab in Preferences, and import the new Ubuntu image.

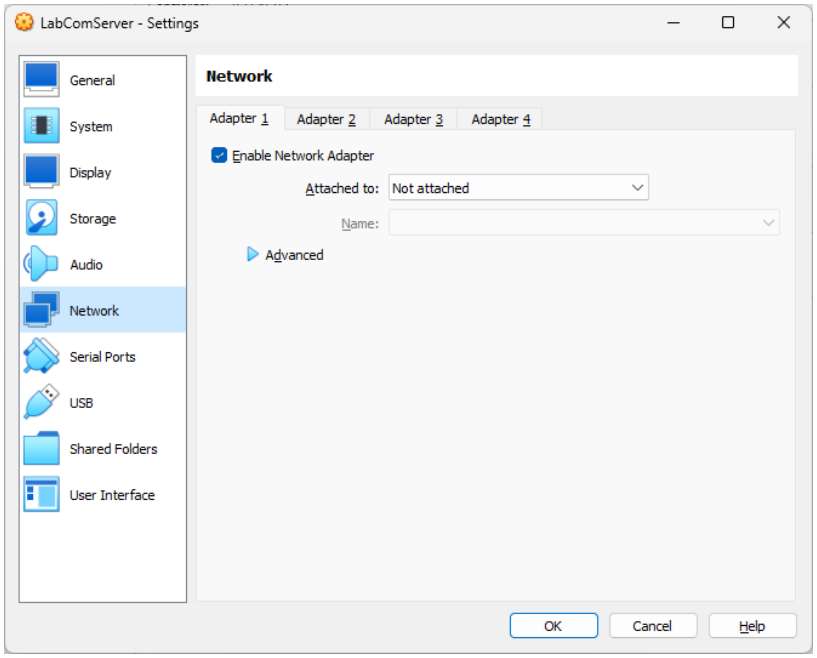
4.8. Making IP configurations permanent on the Linux VM



⇨ Applications ➔ Settings ➔ Advanced Network Configuration

Double click on wired connection ➔ IPv4 Settings ➔ Manual
"Save" to make it permanent.

To use the VM inside GNS, open VirtualBox (with GNS3 closed)(and go to the LabCom VM settings. On the Network Settings, adapter 1 configure it as "not attached":



4.9. Configuring VPC in GNS3

Simple PC terminal with VPCS.

Configuration of the VPCs (configuring and IP address):

PC1> ip 10.0.0.1/24

Use show and show ip commands to verify addresses and configuration.

Use the save and load commands to save/load configurations. Use ? to check all available (sub) commands.

Note: /24 defines IPv4 address mask as 255.255.255.0.

Configuration of the default route in the VPCs (configuring and IP address and adding a gateway):

PC1> ip 10.0.0.1/24 10.0.0.254

Configuring through DHCP:

PC1> ip dhcp

Autoconfiguring IPv6

PC1> ip auto

Run ping in the VPCs with TTL:

PC1> ping 10.0.2.4 -T 1

PC1> ping 10.0.2.4 -T 2

Run traceroute in the VPCs:

PC1> trace 10.0.2.4

5. PC, Switch and Router configuration

PC configuration:

Configuration of the PC in *Windows*

To configure the PC IP address, its Gateway, and even the DNS server, go to Settings and Network and Internet to the configuration pane.

Configuration of the PC in *Linux*

To configure the PC IP address, execute the following command:

```
sudo ifconfig eth0 <IPaddress> netmask <IPmask>
```

The interface name may not be eth0 (remember Guide1). Check on your environment the correct interface name, running `ifconfig`

To configure the Gateway of the PC, execute the following command:

```
sudo route add default gw <IPaddress>
```

The command `route -n` shows the routing table of the PC and the configured *Gateway*.

Switch configuration:

Connect the Switch to the PC. After a while, the Switch prompt will appear:

```
#
```

To configure the IP address of the Switch, execute the following command (the following example refers to Group 1):

```
#config ipif System ipaddress 192.1.1.21/24
#show ipif
```

To show the switching table of the switch:

```
#show fdb
```

To create a default gateway on the switch:

```
#create iproute default 192.1.1.11 1
#show iproute
```

☞ **Execution of command *ping***

```
#ping 192.1.1.1 times 4
```

Router configuration:

Connect the Router to the PC. After a while, the Router prompt will appear:

```
router>
```

To configure the IP address of the Router interface (assuming its name is `FastEthernet 0/0`), execute the following commands (the following example refers to Group 1):

```
router>enable
router#show run
```

observe the router configuration and the name of the interfaces

```
router#configure terminal
router(config)#
router(config)#interface FastEthernet 0/0
router(config-if)#ip address 192.1.1.11 255.255.255.0
router(config-if)#no shutdown
router(config-if)#end
router#write
Building configuration...
[OK]
router#
```

Error while executing `interface FastEthernet 0/0`? Why? How can I find out the right name of the interface?

☞ **Execution of command *ping***

At the Router:

```
router#ping 192.1.1.1
```

At the PC:

```
C:\ping 192.1.1.11
```