universidade de aveiro
theoria poiesis praxis

DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

LICENCIATURA EM ENG. DE COMPUTADORES E INFORMÁTICA

REDES DE COMUNICAÇÕES 1

LABORATORY GUIDE NO. 3

Objectives

- The Virtual LAN (VLAN) concept
- Analysis of the IEEE802.1Q VLAN protocol
- Interconnection of VLANs

Duration

- 1 week

Note: In GNS3, a Layer 2 switch can be implemented (i) with a basic device (Ethernet switch device) that does not have console and does not support the Spanning Tree Protocol, or (ii) with a switching module in a router (EtherSwitch router device). This guide will use the latter, EtherSwitch router as Layer 2 switch using only the switching module ports (e.g., F1/0 to F1/15).

1. Experiments with Virtual LANs – Mode Access and interfaces VLAN

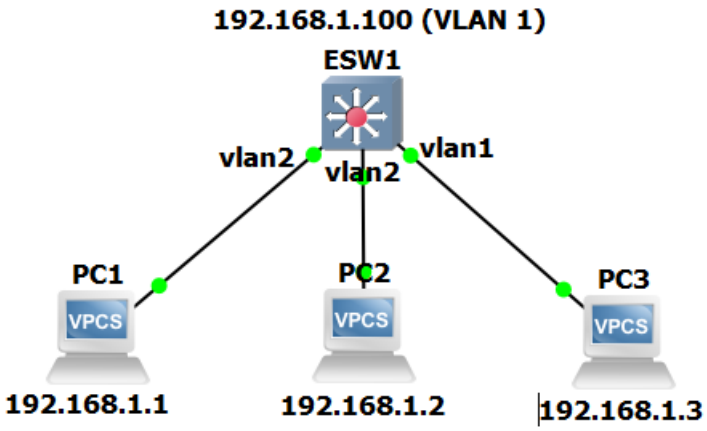


Figure 1

1.1. Set up the network shown in the figure above and configure all IP addresses with netmask 255.255.255.0. In Switch 1, check that the Spanning Tree protocol is disabled and configure two VLANs in the following way:

a) Ports numbered F1/5 to F1/8 belonging to VLAN 2 (must be created):

ESW1# vlan database
ESW1(vlan)# vlan 2
ESW1(vlan)# exit
ESW1# configure terminal
ESW1(config)# interface range F1/5 - 8
ESW1(config-if-range)# switchport access vlan 2
ESW1(config-if-range)# end
ESW1# write

b) all other ports belonging to VLAN 1 (the default/native VLAN)

c) Configure an IP address for VLAN 1 and enable the VLAN

ESW1# configure terminal
ESW1(config)# interface vlan 1
ESW1(config-if)# ip address 192.168.1.100 255.255.255.0
ESW1(config-if)# no shutdown
ESW1(config-if)# end
ESW1# write

To verify the VLAN associated with each interface, use the command:

ESW1# show vlan-switch

> Note: Cisco equipment have VLAN 1002 to 1005 by default (for proprietary protocols) that cannot be deleted

1.2. Connect the PC1 and PC2 to VLAN 2 ports and PC3 to a VLAN 1 port, as shown in the figure

1.3. From each equipment run the ping command to check which pairs of equipment (including Switch 1) have IP connectivity. Verify that only equipment in the same VLAN has IP connectivity.

1.4. Using the switch console, verify the Forwarding Table of Switch 1:

ESW1# show mac-address-table

Check that the VLAN information is in accordance with the network setup

1.5. Start captures on the links PC1-Switch1 and PC3-Switch1 and set an appropriate filter to display ARP and ICMP packets. Run the ping commands specified in the following table. For each run, register the connectivity and the filtered packets. Justify the results obtained on each case.

	Ping from:	Ping to:	Connectivity (yes or no)	Packets (PC1-Switch1 link)	Packets (PC3-Switch1 link)
1	PC2	Switch1	No	ARP Broadcast	None
2	PC2	PC3	No	ARP Broadcast	None
3	PC2	192.168.1.34	No	ARP Broadcast	None
4	PC3	Switch 1	Yes	None	ARP Broadcast & Reply
5	PC3	PC2	No	None	ARP Broadcast
6	PC3	192.168.1.34	No	None	ARP Broadcast
7	Switch1	PC3	Yes	None	ICMP Request & Reply
8	Switch1	192.168.1.34	No	None	ARP Broadcast

and ICMP Request & Reply

1. Não é possível obter conectividade, pois o Switch apenas tem uma porta configurada para a VLAN 1. O PC 2 está na VLAN 2, daí mandar o ARP para a rede local de modo a tentar descobrir quem tem esse IP.
2. Não se obteve conectivade, pois o PC2 e PC3 estão em VLANs diferentes, não foi feita nenhuma configuração de modo a comunicarem entre VLANs. É realizado um ARP na rede do PC2 de modo a tentar encontrar o IP do PC3.
3. Não houve conectividade, pois o PC2 realizada um ARP na rede local determinando que o IP destino nao existe.
4. Ocorreu conectividade, pois o PC3 e Switch 1 estão na mesma VLAN. Inicialmente é feito um ARP, pois como era uma rede nova o PC3 não sabia quem possuia o IP do Switch 1. A captura do PC1-Switch não lê nada, pois nao está na mesma VLAN.
5. Não ocorre conectividade, pois o PC3 e PC2 estão em VLANs diferentes. Apenas um ARP na rede do PC3 a tentar encontrar quem possui o IP destino.
6. Não há conectividade, pois o PC3 realiza um ARP na rede local determinando que o IP destino nao percente à rede.
7. Existe conectividade, pois ambos estão na mesma VLAN 1. Como já se conhecem devido à tentativa 4, apenas é enviado ICMPs.
8. Não há conectividade. A captura do PC3-Switch1 lê um ARP, pois o switch 1 tem ip configurado na VLAN 1. O switch faz um ARP de modo a tentar encontrar o ip destino, mas o ip nao existe na rede.

2. Experiments with Virtual LANs – Mode Trunk and interconnection

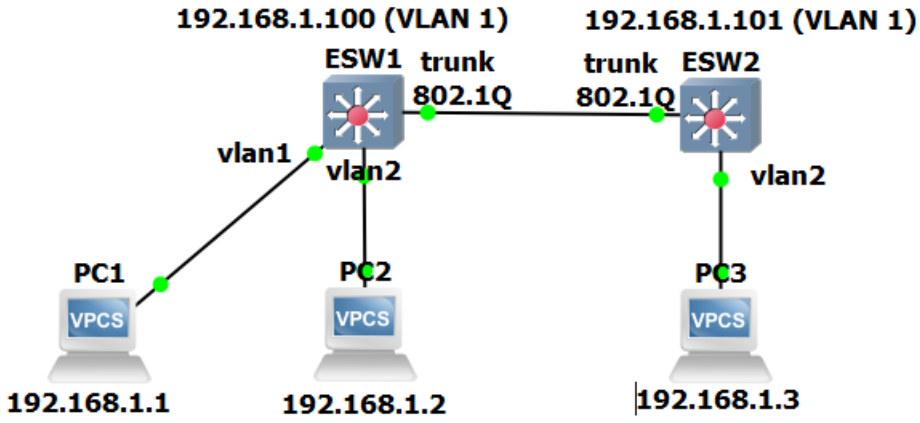


Figure 2

2.1. Reconfigure the network as specified in the figure above.

a) In the new inserted Switch 2, configure VLANs 1 and 2 in the same way as specified to Switch 1 in the previous experiments.

b) At both Switches 1 and 2, configure the ports connecting the switches as a trunk port (e.g., F1/15) in order to support both VLAN using the IEEE802.1Q VLAN protocol, as specified in the figure above.

ESW(config)# interface F1/15

ESW(config-if)# switchport mode trunk

2.2. Start new capture on the link Swicth1-Switch2 and set an appropriate filter to display ARP and ICMP packets. Run the ping commands specified in the following table. For each run, register the filtered packets and their VLAN ID value. Justify the results obtained on each case.

	Ping from:	Ping to:	Connectivity (yes or no)	Filtered packets
1	PC1	Switch 1	Yes	ARP BroadCast, ID Nativo
2	PC1	Switch 2	Yes	ARP Broadcast & Reply, ICMP Request & Reply, ID Nativo
3	PC1	PC2	No	ARP BroadCast, ID Nativo
4	PC1	PC3	No	ARP BroadCast, ID Nativo
5	PC2	Switch 1	No	ARP BroadCast, ID 2
6	PC2	Switch 2	No	ARP BroadCast, ID 2
7	PC2	PC2	Yes	No packets
8	PC2	PC3	Yes	ARP Broadcast & Reply, ICMP Request & Reply, VLAN ID 2

1. Existe conectividade entre o PC1 e o Switch 1, pois ambos estão na mesma VLAN. Não é lido nenhum pacote ICMP, pois a captura é só entre os Switches. O ARP é normal, pois o IP destino não era conhecido. Não aparece VLAN ID, pois estou a fazer pings na VLAN1 onde o ID é nativo.
2. Há conectividade, pois ambos estão na mesma VLAN. Este ping é parecido à 1º tentativa, mas desta vez aparece o ICMP por que a captura está entre a conexao do PC1 e Switch2.
3. Não há conexão, pois o PC1 e PC2 estão em VLANs diferentes. Como o ping é feito na VLAN 1 e ambos os switches têm ip configurado na VLAN 1, é possível ler a captura de um ARP.Não aparece VLAN ID, pois estou a fazer pings na VLAN1 onde o ID é nativo
4. Não há conexão, pois o PC1 e PC3 estão em VLANs diferentes. Como o ping é feito na VLAN 1 e ambos os switches têm ip configurado na VLAN 1, é possível ler a captura de um ARP.Não aparece VLAN ID, pois estou a fazer pings na VLAN1 onde o ID é nativo
5.Não há conexão, pois o PC2 e Switch 1 estão em VLANs diferentes. O VLAN ID é disposto como 2.
6.Não há conexão, pois o PC2 e Switch 2 estão em VLANs diferentes. O VLAN ID é disposto como 2.
7.Existe conexão, pois o ping é feito para o próprio PC. Como é feito para o próprio pc não há transferencia de pacotes.
8.Existe conexão, pois ambos os PCs estão na mesma VLAN. Como o PC2 está no Switch1 e o PC3 no Switch2, é possivel capturar os pacotes ARP e ICMP. O VLAN ID disposto é o 2.

Format of the Ethernet frames with and without 802.1Q tags

Ethernet frame without 802.1Q tag

Destination Address (6 *bytes*)
Source Address (6 *bytes*)
Type / Length (2 *bytes*)
Data Field

Ethernet frame with 802.1Q tag

Destination Address (6 *bytes*)
Source Address (6 *bytes*)
8100h (2 *bytes*)
Priority (3 *bits*)
CFI (1 *bit*)
VLAN ID (12 *bits*)
Type / Length (2 *bytes*)
Data Field

3. Experiments with Virtual LANs – Routing between VLANs – External

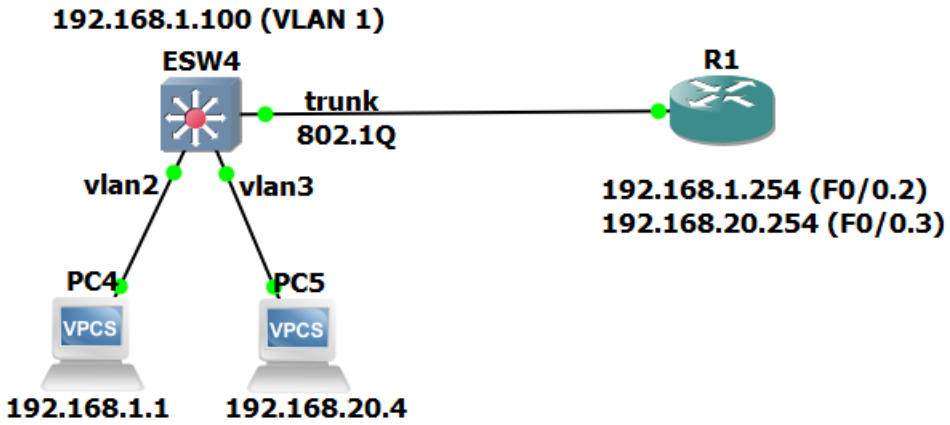


Figure 3

3.1. Reconfigure the network as specified in the figure above where the Router routes packets between VLAN 2 and VLAN 3 (each one with its own network IP address).

In Switch 4, configure the VLAN in the following way:

a) ports numbered F1/0 to F1/4 belonging to VLAN 3 (must be created);

ESW1# vlan database
ESW1(vlan)# vlan 3
ESW1(vlan)# exit
ESW1(config)# interface range F1/0 - 4
ESW1(config-if-range)# switchport access vlan 3

b) ports numbered F1/5 to F1/8 belonging to VLAN 2;

c) all other ports belonging to VLAN 1 (the default/native VLAN)

3.2. In the Router, create 2 virtual interfaces on interface F0/0, one for VLAN 2 (F0/0.2) and another for VLAN 3 (F0/0.3), with the given IP addresses:

Router (config)# interface F0/0
Router (config-if)# no shutdown
Router (config-if)# interface F0/0.2
Router (config-subif)# encapsulation dot1Q 2
Router (config-subif)# ip address 192.168.1.254 255.255.255.0
Router (config-if)# interface F0/0.3
Router (config-subif)# encapsulation dot1Q 3
Router (config-subif)# ip address 192.168.20.254 255.255.255.0

3.3. In both PCs, configure the appropriate the IPv4 address and Default Gateway address.

For PC4:

PC-4> ip 192.168.1.1/24 192.168.1.254

3.4. To verify the correctness of the configurations, check the IP connectivity between PC4 and PC5 with the ping command. Register and justify the IP routing table of the Router.

Use the command to view the IPv4 routing table:

Router# show ip route

3.5. Start new capture on the link Swicth1-Router and set an appropriate filter to display ARP and ICMP packets. Run the ping commands specified in the following table. For each run, register the filtered packets and their VLAN ID value. Justify the results obtained on each case.

	Ping from:	**Ping to:**	**Connectivity (yes or no)**	**Filtered packets**
1	PC4	Switch 4	No	ARP Broadcast
2	PC4	Router	Yes	ARP and ICMP (Request and Reply)
3	PC4	PC5	Yes	ARP and ICMP (Request and Reply)
4	PC4	192.1.1.100	No	ICMP (Host unreachable)
5	PC5	Switch 4	No	ARP Broadcast and ICMP Request
6	PC5	Router	Yes	ARP and ICMP (Request and Reply)
7	PC5	PC4	Yes	ARP Broadcast and ICMP Request
8	PC5	192.1.1.100	No	ICMP (Host unreachable)

1. Nao há conectividade, pois o PC4 e o Switch4 estão em VLANs diferentes.

2. Há conectividade devido à VLAN2 do PC4 estar configurada no Router 192.168.1.254

3. Há conectividade entre o PC4 e PC5, pois têm rotas configuradas entre si no router.

4. O PC4 procura na sua VLAN o ip 192.1.1.100. Obtendo Host unreachable como resposta determina que esse ip não existe na VLAN2.

5. Nao há conectividade, pois o PC5 e o Switch4 estão em VLANs diferentes.

6. Há conectividade devido à VLAN3 do PC5 estar configurada no Router 192.168.20.254.

7. O mesmo já testado, há conectividade entre o PC5 e PC4, pois têm rotas configuradas entre si no router.

8. O PC5 procura na sua VLAN o ip 192.1.1.100. Obtendo Host unreachable como resposta determina que esse ip não existe na VLAN3.

4. Experiments with Virtual LANs – Routing between VLANs – Internal

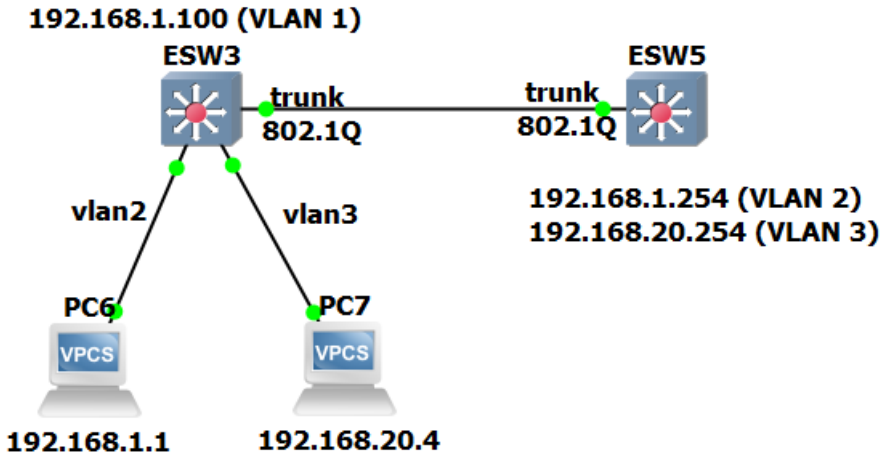


Figure 4

The previous network connectivity can be implemented using internal routing between VLANs within the L3 Switch.

In Vlans 2 and 3, configure the right IP address which will be used as gateways.

As in the previous scenario with the router sub-interfaces, with the L3 Switch we may also support different VLANs over the same connection:

ESW5# vlan database
ESW5(vlan)# vlan 2
ESW5(vlan)# vlan 3
ESW5(vlan)# exit

ESW5(config)# interface vlan 2
ESW5(config-if)# ip address 192.168.1.254 255.255.255.0
ESW5(config-if)# no shutdown

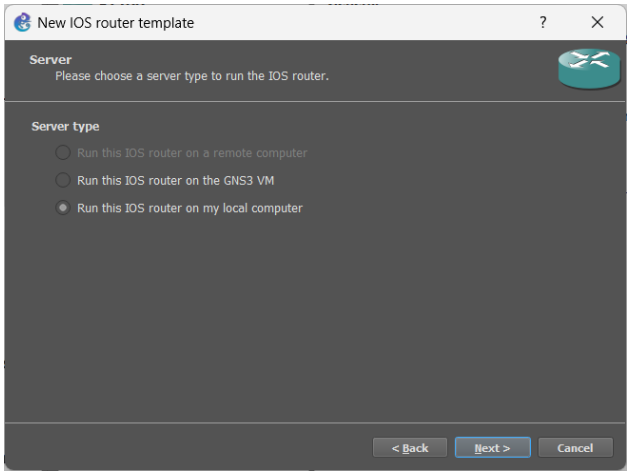
ESW5(config)# interface vlan 3
ESW5(config-if)# ip address 192.168.20.254 255.255.255.0
ESW5(config-if)# no shutdown

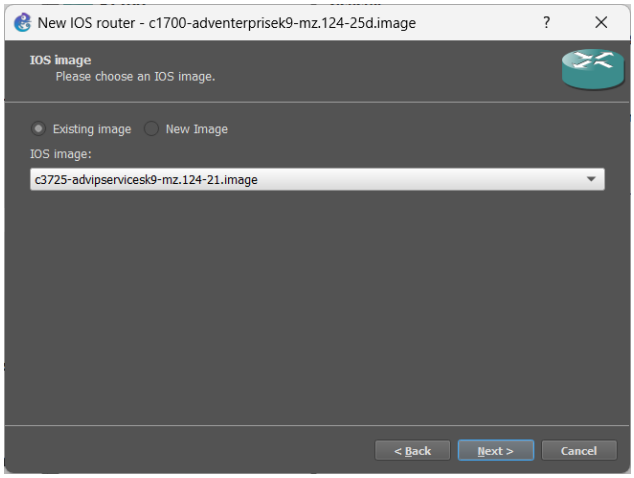
ESW5(config)# interface F1/15
ESW5(config-if)# switchport mode trunk

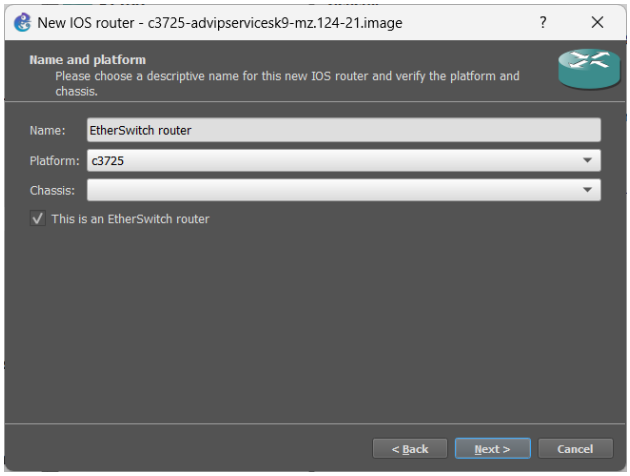
Annex A

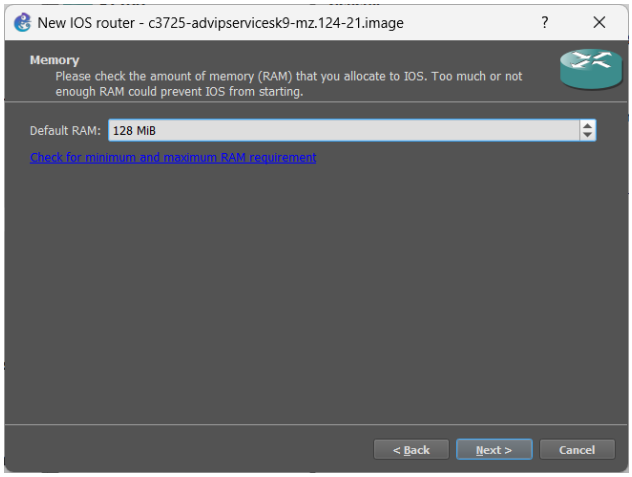
Introduction to the ESW Cisco Switch Router (L3 Switch)

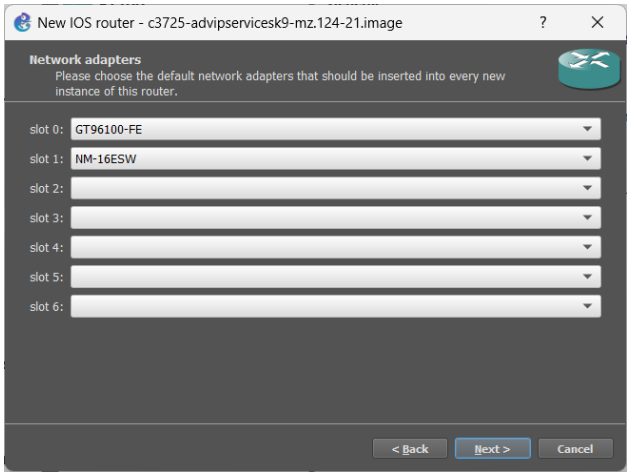
If you still do not have, you must add the ESW to your GNS installation, under Edit ➔ Preferences ➔ Dynamips ➔ IOS Routers ➔ New

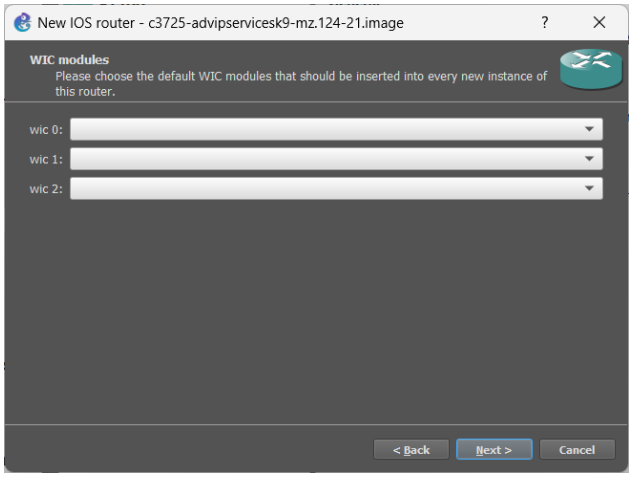


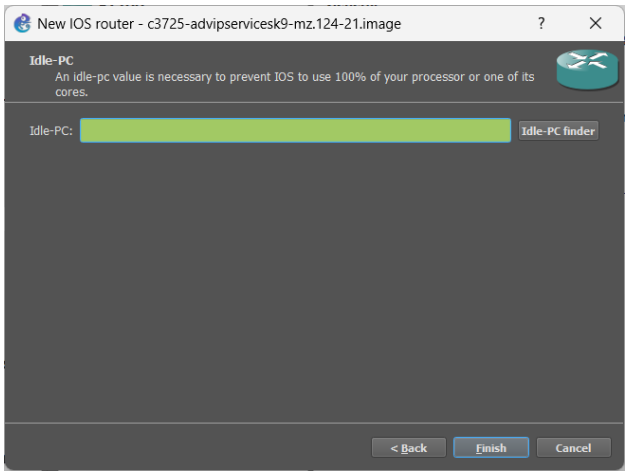


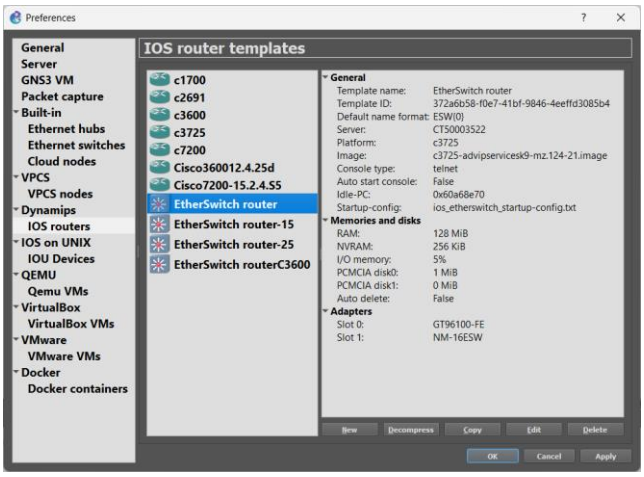




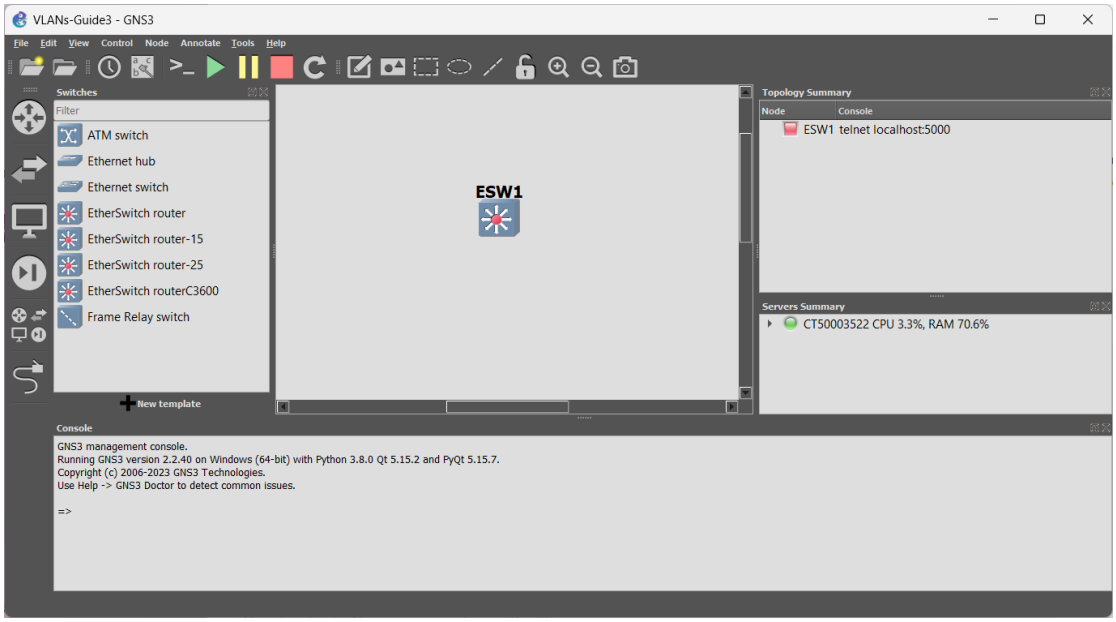




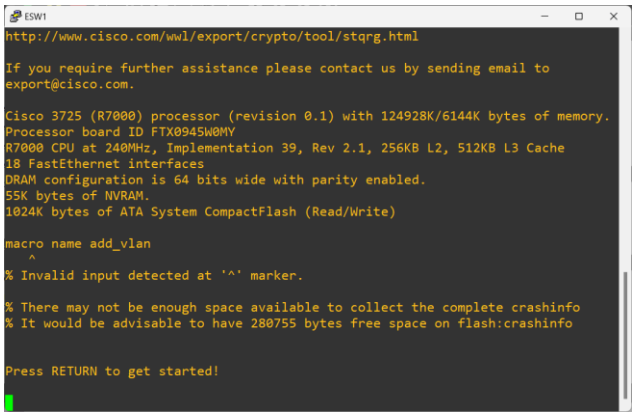


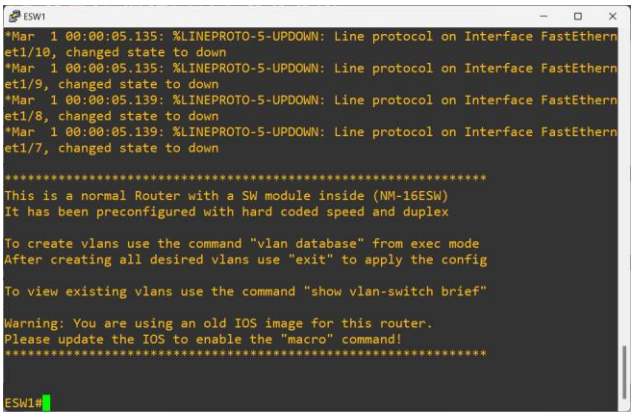


Create a new project for the VLANs Guide and add an EtherSwitch router (ESW1):

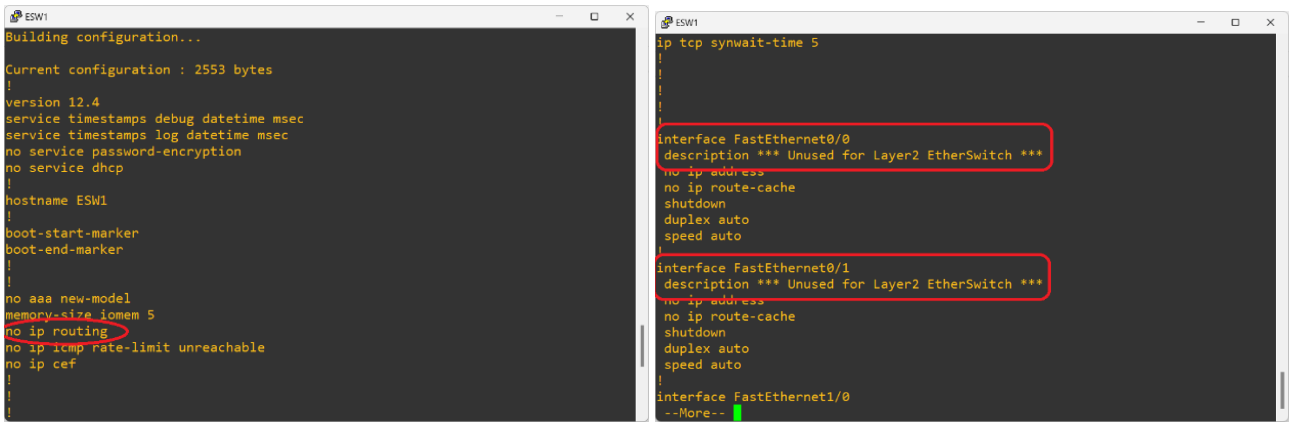


Start the device and right click over it to open the console:



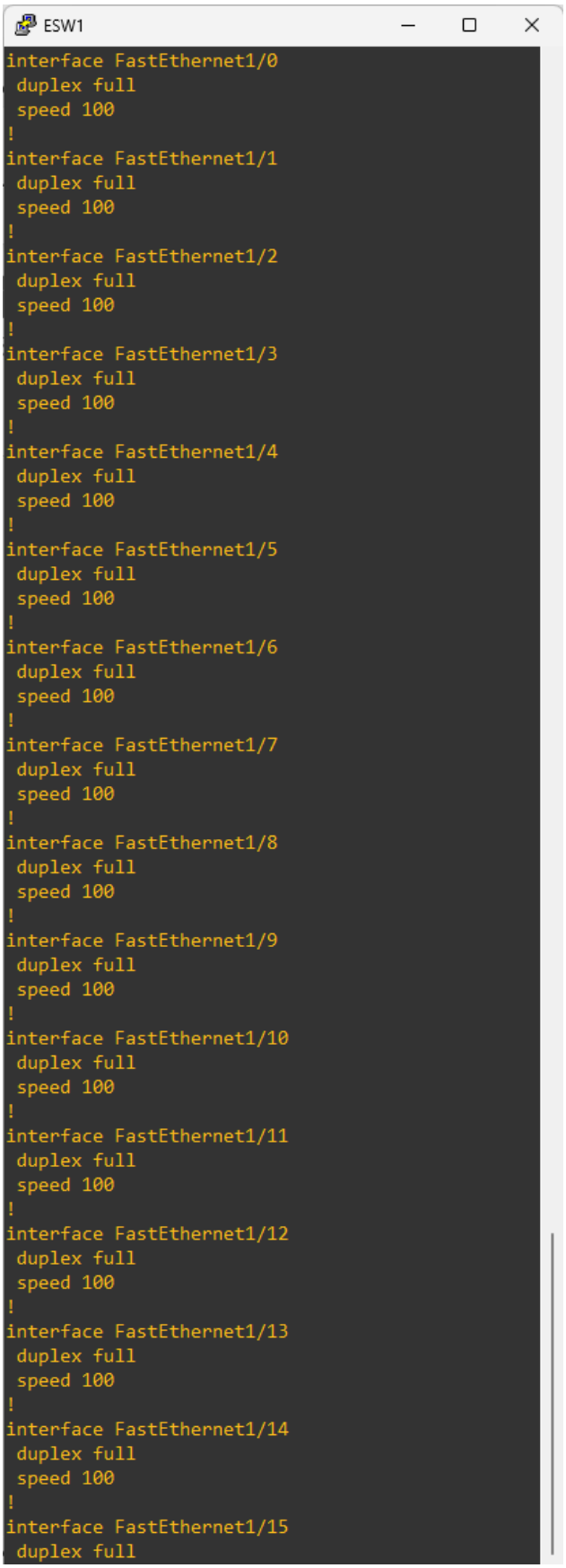


Do a show run to check its configuration, with special attention to the available interfaces.

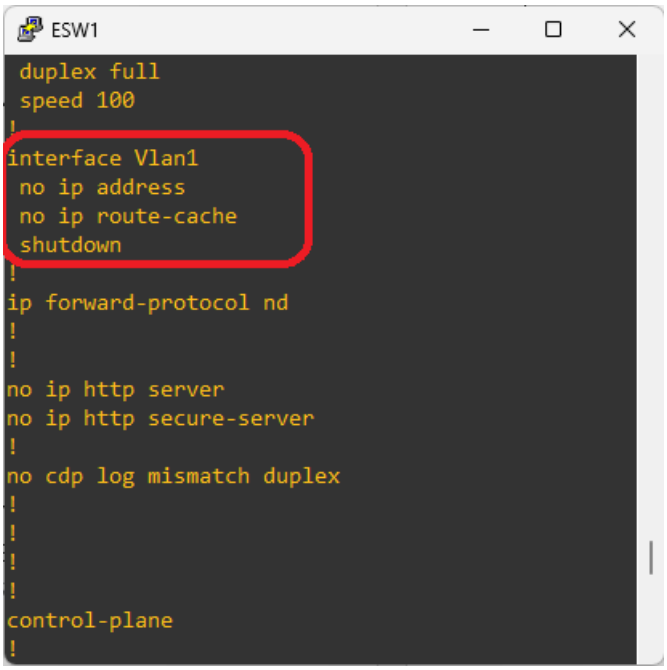


Note that:

- 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.

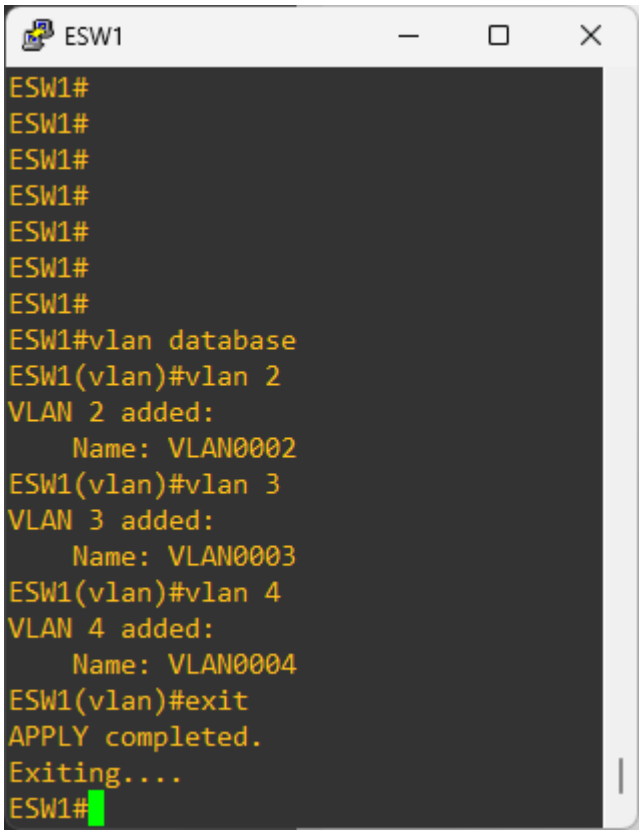


There are 16 interfaces (from F1/0 to F1/15) that "belong" to a switch card interface on the router, and these are the interfaces used for switching and VLANs.

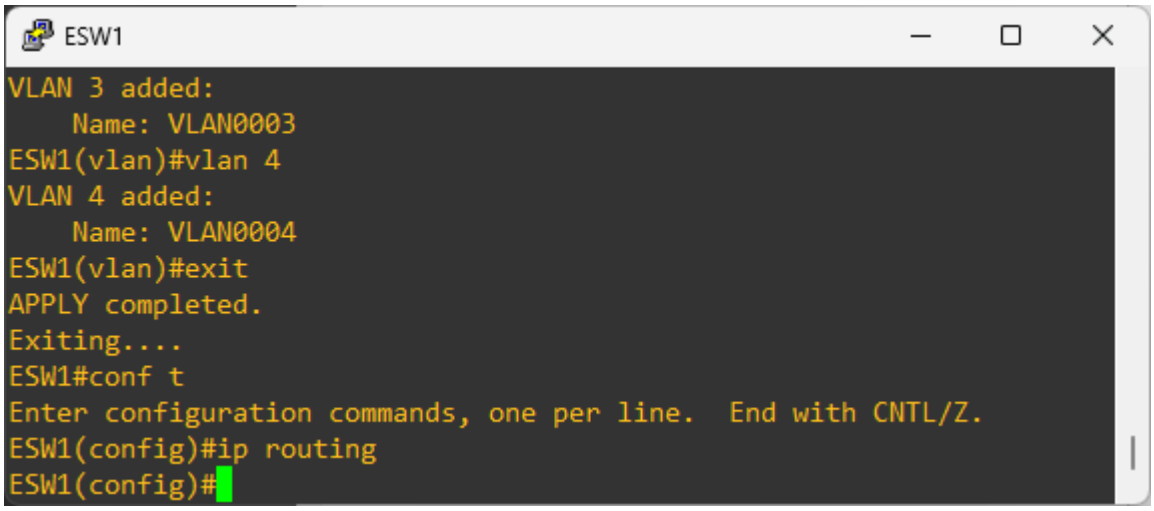


By default there is a Vlan1 interface, through which all switch ports belonging to the Vlan1 may do routing to the other routing interfaces (F0/0 and F0/1). Note that this interface is in “shutdown” by default. In order to be used, you have to do the “no shutdown” to it.

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



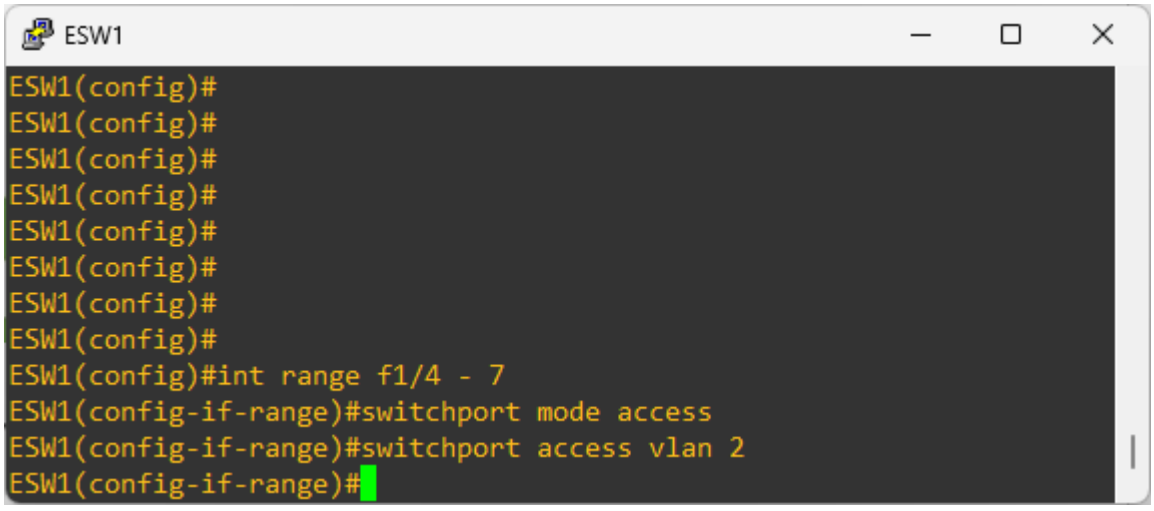
Enabling IP Routing functions on this device:



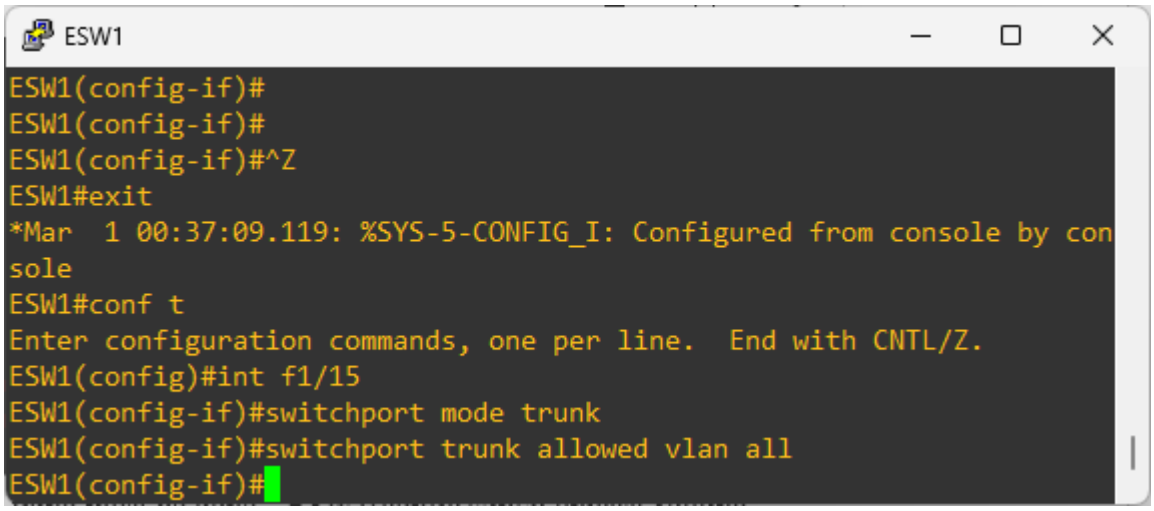
Note: for IPv6 the same thing must be done. “ESW1(config)#ipv6 unicast-routing”

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):



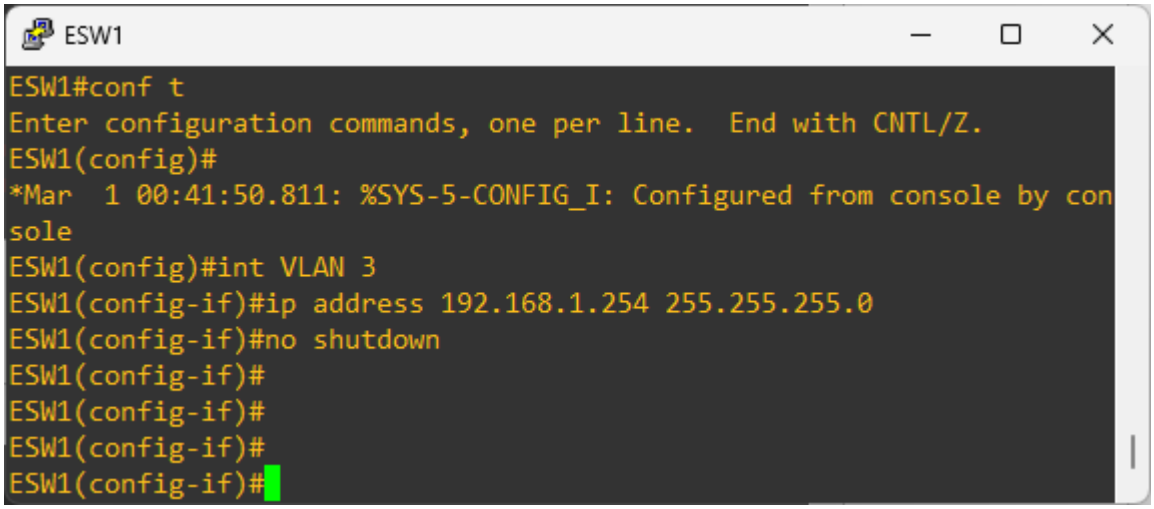
Putting a port in TUNK mode and allowing all configured VLANs to be able to come in and out of that interface (you may restrict the port to some specific interfaces, if needed):



Note:

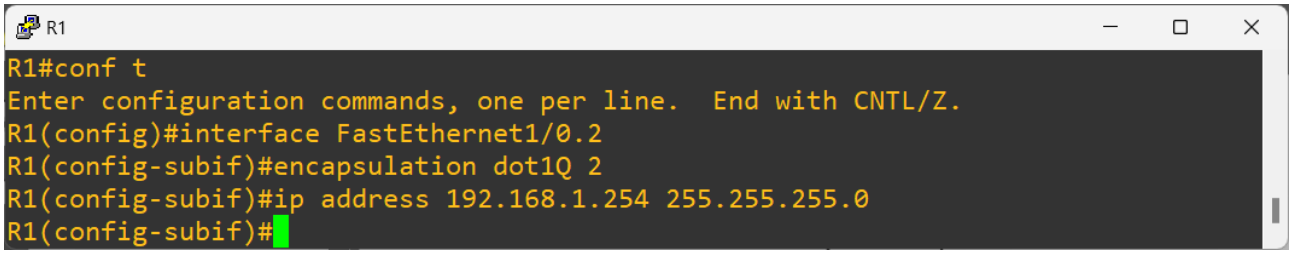
- Ports on access mode can only belong to one specific VLAN and the incoming and outgoing Ethernet frames DO NOT have VLAN TAG.
- Ports on trunk mode may input and output Ethernet frames from different VLANs and those Ethernet frames SHOULD BE TAGGED.

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



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.

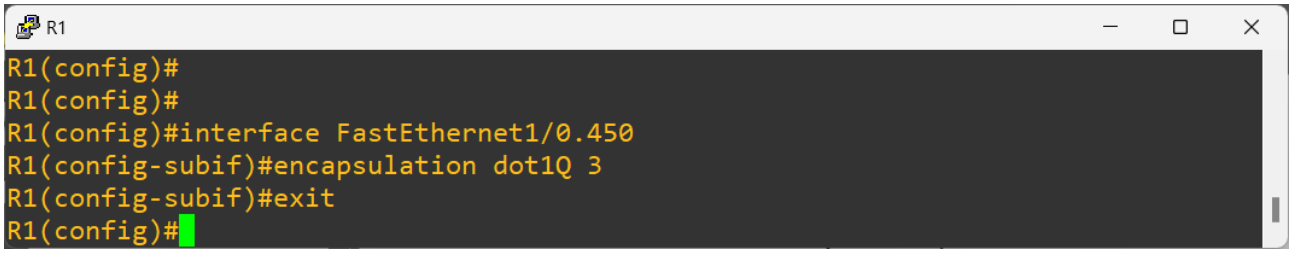
Configuring a regular router interface to send and receive Ethernet frames with VLANs



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:



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