



**DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES
E INFORMÁTICA**

LICENCIATURA EM ENGENHARIA DE COMPUTADORES E INFORMÁTICA

ANO 2024/2025

REDES DE COMUNICAÇÕES II

LABORATORY GUIDE NO. 1:

VIRTUAL LANS + SPANNING TREE

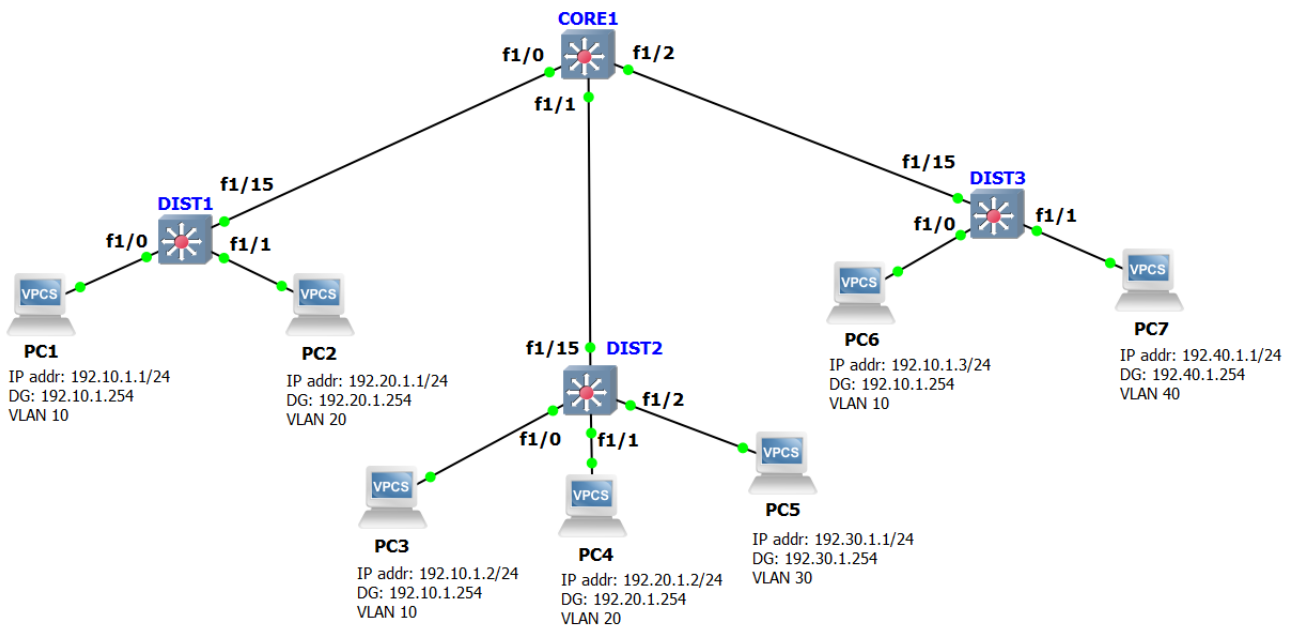
In this Laboratory Guide, all switches should be implemented as L3 Switches with the IOS image 12.4(21) of routers 3725 (provided in the elearning page of RC II) and with two network adapters:

- GT96100-FE, providing 2 FastEthernet routing interfaces: fe0/0 and fe0/1
- NM-16ESW, providing 16 FastEthernet switching interfaces: fe1/0, fe1/1, ..., fe1/15

NOTE: Choose option "This is an EtherSwitch router" when defining the template of the L3 Switches.

1. Virtual LANs

Consider the following network setup composed of 1 core switch (CORE1), 3 distribution switches (DIST1, DIST2 and DIST3) and 7 PCs. Create a GNS3 template with all equipment and all links. Run the template and configure the IP and Default Gateway addresses of all PCs (let all switches on their default configuration and ignore by now the VLAN information of PCs).



Configuration of IP address and Default Gateway in PC1:

```
PC1> ip 192.10.1.1/24 192.10.1.254
PC1> save
```

Check the resulting configuration:

```
PC1> show ip
```

- By default, all switches work as L2 Switches (all used interfaces are switching interfaces). Run the command `show vlan-switch` on each switch to check that all interfaces belong to the default VLAN 1.
- Start a Wireshark capture in link DIST3-PC7. Execute a ping command from each PC to each IP address as specified next. Register the result of each ping and the packets captured in link DIST3-PC7 related to the executed ping. Justify the obtained results.

From:	To:	Result of Ping	Packets in DIST3-PC7 link
PC1	192.10.1.3		
PC1	192.10.1.10		
PC1	192.20.1.2		
PC2	192.20.1.2		
PC2	192.30.1.1		
PC2	192.40.1.1		

Now, configure the switches to support all existing VLANs and the interfaces connected to the PCs in the VLANs specified in the figure. Configure also all links between switches as trunk links with 802.1q encapsulation supporting all VLANs.

Configuration of VLANs and trunk ports in switch DIST1:

```
DIST1# vlan database
DIST1(vlan)# vlan 10
DIST1(vlan)# vlan 20
DIST1(vlan)# vlan 30
DIST1(vlan)# vlan 40
DIST1(vlan)# exit
DIST1# configure terminal
DIST1(config)# interface f1/0
DIST1(config-if)# switchport mode access
DIST1(config-if)# switchport access vlan 10
DIST1(config-if)# interface f1/1
DIST1(config-if)# switchport mode access
DIST1(config-if)# switchport access vlan 20
DIST1(config-if)# interface f1/15
DIST1(config-if)# switchport mode trunk
DIST1(config-if)# end
DIST1# write
```

Check the resulting configuration:

```
DIST1# show configuration
DIST1# show vlan-switch
```

- 1.c.** Start two Wireshark captures: one in link DIST3-PC7 and another in link CORE1-DIST3. Execute a ping command from each PC to each IP address as specified next. Register the result of each ping and the packets captured in the links related to the executed ping. In the analysis of the captured packets, register also the VLAN information in their 802.1q header. For each ping, justify the results and the differences with the results obtained in **1.b**.

From:	To:	Result of Ping	Packets in DIST3-PC7	Packets in CORE1-DIST3
PC1	192.10.1.3			
PC1	192.10.1.10			
PC1	192.20.1.2			
PC2	192.20.1.2			
PC2	192.30.1.1			
PC2	192.40.1.1			

IMPORTANT: Save the current GNS3 template to be used as the initial setup of each of the following sections.

2. Centralized Routing between VLANs

Copy the previous saved GNS3 template to a new template. In the new template, configure CORE1 as a L3 Switch to route the packets between the IP networks associated with all VLANs and following the default gateway addresses configured on the PCs.

Routing configuration of CORE1:

```
CORE1# configure terminal
CORE1(config)# ip routing           (to activate the routing function)
CORE1(config)# interface vlan10
CORE1(config-if)# ip address 192.10.1.254 255.255.255.0
CORE1(config-if)# no shutdown
CORE1(config-if)# interface vlan20
CORE1(config-if)# ip address 192.20.1.254 255.255.255.0
CORE1(config-if)# no shutdown
CORE1(config-if)# interface vlan30
CORE1(config-if)# ip address 192.30.1.254 255.255.255.0
CORE1(config-if)# no shutdown
CORE1(config-if)# interface vlan40
CORE1(config-if)# ip address 192.40.1.254 255.255.255.0
CORE1(config-if)# no shutdown
CORE1(config-if)# end
CORE1# write
```

Check the resulting configuration:

```
CORE1# show ip interface brief
```

Check the resulting IP routing table:

```
CORE1# show ip route
```

- 2.a. Check the IP routing table of CORE1 and justify it. Test the connectivity between all pairs of PCs. You should conclude that all PCs have connectivity between them (if not, there are configuration errors that must be identified and corrected).
- 2.b. What are the connections belonging to the broadcast domain of each existing VLAN? Why?
- 2.c. Start two Wireshark captures: one in link CORE1-DIST1 and another in link CORE1-DIST3. Execute a ping command from each PC to each IP address as specified next. Register the result of each ping and the packets captured in the two links related to the executed ping. In the analysis of the captured packets, register also the VLAN information in the 802.1q header. Justify these results.

From:	To:	Result of Ping	Packets in CORE1-DIST1	Packets in CORE1-DIST3
PC1	192.10.1.3			
PC1	192.10.1.10			
PC1	192.20.1.2			
PC2	192.20.1.2			
PC2	192.30.1.1			
PC2	192.40.1.1			
PC2	192.40.1.10			

RECALL FROM THEORETICAL CLASS – In this centralized routing setup, IP routing is centralized in CORE1 equipment. This approach has 2 advantages: (i) no need of IP routing in the distribution switches (L2 Switches are much less expensive than L3 Switches) and (ii) new PCs in any existing VLAN can be connected to any distribution switch with very little configuration (just configure the access mode and the VLAN ID of the interface connecting each new PC).

3. Distributed Routing between VLANs

Copy the GNS3 template saved at the end of Section 1 to a new template. In the new template, the aim is to configure the network routing with a distributed approach:

- (a) VLAN 10 and VLAN 20 are end-to-end VLANs: configure CORE1 to route the packets from/to the IP networks associated with these VLANs
 - o VLAN 20 reaches only distribution switches DIST1 and DIST2: remove VLAN 20 from the trunk connected to DIST3
- (b) VLAN 30 is a local VLAN in DIST2: configure DIST2 to route the packets from/to the IP network associated with VLAN 30 and remove VLAN 30 from all trunks
- (c) VLAN 40 is a local VLAN in DIST3: configure DIST3 to route the packets from/to the IP network associated with VLAN 40 and remove VLAN 40 from all trunks
- (d) since there are now 3 switches (CORE1, DIST2 and DIST3) with the routing function activated, configure an interconnection VLAN (with a new associated IP network address) between them to allow IP routing between all existing VLANs.

Configure the new GNS3 template following the distributed approach described in (a)–(d). In (d), consider that VLAN 50 is the interconnection VLAN with the associated IP network 192.1.1.0/24. In this new VLAN 50, assign the IP addresses 192.1.1.1 to CORE1, 192.1.1.2 to DIST2 and 192.1.1.3 to DIST3.

Elimination of VLANs 20, 30 and 40 in the trunk CORE1-DIST3:

In CORE1:

```
CORE1# configure terminal
CORE1(config)# interface f1/2
CORE1(config-if)# switchport trunk allowed vlan 20,30,40
CORE1(config-if)# end
CORE1# write
CORE1# show configuration    (to check the resulting configuration)
```

In DIST3:

```
DIST3# configure terminal
DIST3(config)# interface f1/15
DIST3(config-if)# switchport trunk allowed vlan remove 20,30,40
DIST3(config-if)# end
DIST3# write
DIST2# show configuration    (to check the resulting configuration)
```

3.a. Check the IP routing tables of CORE1, DIST2 and DIST 3 and justify each routing table. Test the connectivity between all pairs of PCs using the ping command. Identify the pairs of PCs that still do not have connectivity between them and explain why.

3.b. What are the connections belonging to the broadcast domain of each existing VLAN? Why?

Now, configure in all switches with the routing function activated (i.e., CORE1, DIST2 and DIST 3) appropriate IP static routes to reach full network IP connectivity.

Configuration of IP static routes in DIST2 for the IP networks that are not directly connected to it):

```
DIST2# configure terminal
DIST2(config)# ip route 192.10.1.0 255.255.255.0 192.1.1.1
DIST2(config)# ip route 192.20.1.0 255.255.255.0 192.1.1.1
DIST2(config)# ip route 192.40.1.0 255.255.255.0 192.1.1.3
DIST2# write
```

- 3.c.** Check the IP routing tables of CORE1, DIST2 and DIST 3 and justify each routing table. Test the connectivity between all pairs of PCs. You should conclude that all PCs have connectivity between them (if not, there are configuration errors that must be identified and corrected).
- 3.d.** Start two Wireshark captures: one in link CORE1-DIST1 and another in link CORE1-DIST3. Execute a ping command from each PC to each IP address as specified next. Register the result of each ping and the packets captured in the two links related to the executed ping. In the analysis of the captured packets, register also the VLAN information in the 802.1q header. Justify these results.

From:	To:	Result of Ping	Packets in CORE1-DIST1	Packets in CORE1-DIST3
PC1	192.10.1.3			
PC1	192.10.1.10			
PC1	192.20.1.1			
PC1	192.30.1.1			
PC1	192.40.1.1			
PC4	192.10.1.2			
PC4	192.40.1.1			
PC5	192.40.1.1			
PC5	192.40.1.10			

RECALL FROM THEORETICAL CLASS – In this distributed routing setup, IP routing is distributed between CORE1, DIST2 and DIST3 equipment. This approach has the advantage of being a more scalable solution, i.e., a larger number of distribution switches can be deployed without significant grow of the broadcast domains (avoiding their performance issues) and maintaining an equal routing effort among all equipment.

4. Redundant LANs with Spanning Tree

(TO BE COMPLETED)