REDES DE COMUNICAÇÕES 2

Note: In GNS3, a Layer 2 switch may 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).

Virtual LAN

1.1. Set up the network shown in the following figure and configure all IP addresses with netmask 255.255.255.0.

In Switch 1, configure two VLANs in the following way:

a) Create VLAN 2 (VLAN 1 already exists by default):

```
ESW1# vlan database
ESW1(vlan)# vlan 2
ESW1(vlan)# exit
```

b) Ports numbered F1/5 to F1/8 belonging to VLAN 2:

```
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
```

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

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

```
ESW1# show vlan-switch
```

Configure VLAN 1 IPv4 address of Switch1:

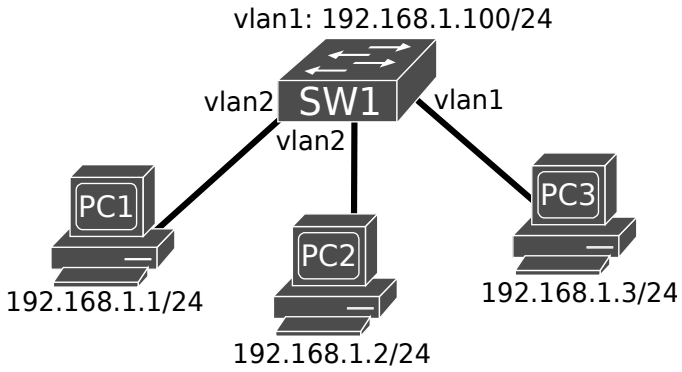
```
ESW1(config)# interface vlan 1
ESW1(config-if)# ip address 192.168.1.100 255.255.255.0
ESW1(config-if)# no shutdown
ESW1(config-if)# end
ESW1# write
```

In all PCs, configure the appropriate the IPv4 address.

For PC1:

```
PC-1> ip 192.168.1.1/24
```

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



Troubleshooting 1: When creating the VLAN, if a flash memory space error occurs, run the command

```
ESW1# erase flash:
```

to erase the flash, and after, create the missing VLAN. Also verify on your EtherSwitch router that you have at least 1MB in the PCMCIA disk 0 (configure→ Memories and Disks).

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

>> Verify that the status of the switch's interfaces is "up/up" for the ones in use. Use the command:

```
ESW1# show ip interface brief
```

>> Analyze the Switch's Forwarding table.

```
ESW1# show mac-address-table
```

>> Verify that the MAC addresses of the PC appear on the correct port and VLAN.

Troubleshooting 2: If the status of a switch port in use is administratively down, perform a "`no shutdown`" on the respective interface. If the protocol status is down (no cable detected), perform a "`shutdown`" followed by a "`no shutdown`" on the respective interface (the cable detection mechanism will be run for all ports).

1.3. 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.

Ping from:	Ping to:	Connectivity (yes or no)	Packets (PC1-Switch1 link)	Packets (PC3-Switch1 link)
PC2	Switch1 (vlan 1)	não	arp request	nada
PC2	PC3	não	arq request	nada
PC2	192.168.1.34	não	arp request	nada
PC3	Switch 1 (vlan 1)	sim	nada	arp request/reply, icmp request/reply
PC3	PC2	não	nada	arp request
PC3	192.168.1.34	não	nada	arp request
Switch1	PC3	sim	nada	arp request/reply, icmp request/reply
Switch1	192.168.1.34	não	nada	arp request

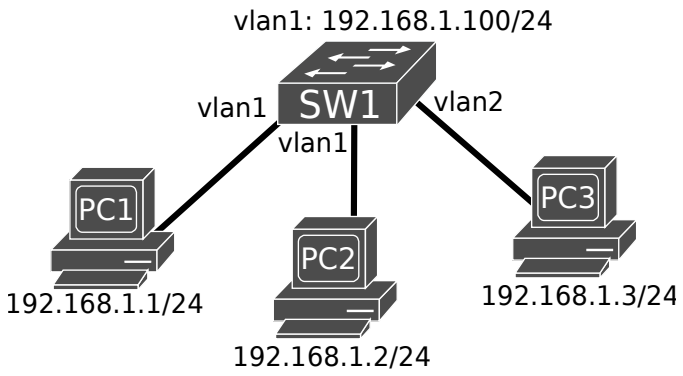
>> What do you conclude from the connectivity tests based on the VLAN of the devices?

>> What do you conclude about the way a broadcast packet is propagated?

Note: Different switches OS may allow to define (i) just an IP address for one VLAN (administration) or (ii) different IP addresses in multiple VLAN.

Os broadcasts não se propagam entre vlans, só há conectividade entre elementos da mesma vlan

2.1. In Switch 1, change the connections in order to connect PC1 and PC2 to VLAN 1 ports and PC3 to a VLAN 2 port (as specified in the next figure). Once again, verify that the status of the switch's connected interfaces is "up/up" for the ones in use.



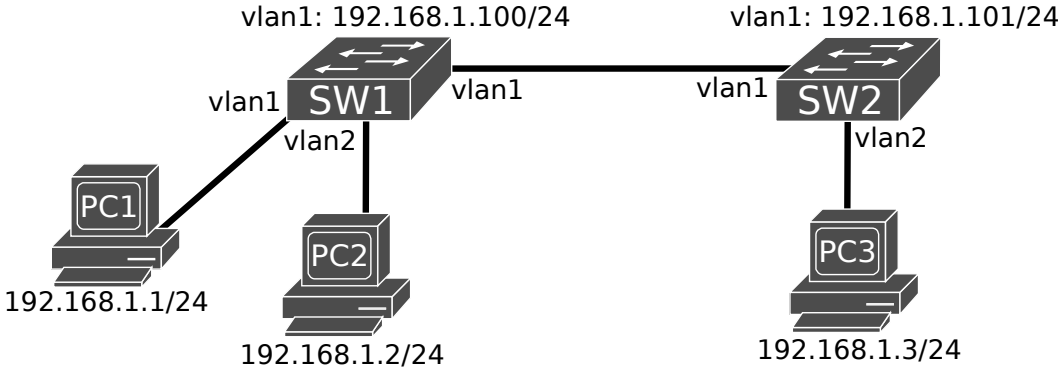
2.2. Start new captures on the links PC1-Switch1 and PC3-Switch1 and set an appropriate filter to display ARP and ICMP packets. Run the ping commands specified in the following table. For each run, register the connectivity and the filtered packets.

Ping from:	Ping to:	Connectivity (yes or no)	Packets (PC1-Switch1 link)	Packets (PC3-Switch1 link)
PC2	Switch1 (vlan 1)	sim	arp request	nada
PC2	PC3	não	arp request	nada
PC2	192.168.1.34	não	arp request	nada
PC3	Switch1 (vlan 1)	não	nada	arp request
PC3	PC2	não	nada	arp request
PC3	192.168.1.34	não	nada	arp request
Switch1	PC3	não	arp request	nada
Switch1	192.168.1.34	não	arp request	nada

>> Confirm the previous conclusion about device connectivity between different VLAN.
>> Confirm the previous conclusion about the broadcast domains of each VLAN.

Trunk Ports/Links

3. Reconfigure the network as specified in the following figure. In the new inserted Switch 2, configure VLANs 1 and 2 in the same way as specified to Switch 1 in the previous experiments.



3.1. Start new capture on the link Switch1-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 connectivity and the filtered packets.

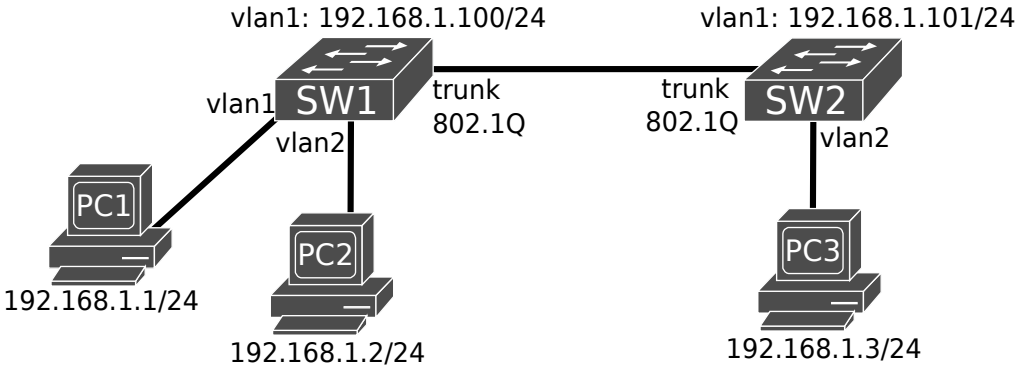
Ping from:	Ping to:	Connectivity(yes or no)	Filtered packets
PC1	Switch 1	sim	arp request
PC1	Switch 2	sim	arp request/reply icmp request/reply
PC1	PC3	não	arp request
PC2	Switch 1	não	nada
PC2	Switch 2	não	nada
PC2	PC3	não	nada
PC3	PC1	não	nada
PC3	PC2	não	nada

>> What do you conclude from the connectivity tests between devices on different switches?
>> What do you conclude about the way a broadcast packet is propagated?

Concluímos que, uma vez que os PCs que pertencem à vlan 2 estão separados por 2 SWs cuja sua ligação pertence às interfaces que compõem a vlan 1, qualquer ping de um pc da vlan 2 para o outro, não irá atingir o destino. Da mesma forma que os broadcasts não se propagam de vlans para vlans. Caso ativassemos o trunk nas interfaces que ligam os sws os PCs da Vlan 2 já teriam conectividade.

3.2. 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 following figure.

```
ESW3(config)# interface F1/15
ESW3(config-if)# switchport mode trunk
```



4.1. Start new capture on the link Switch1-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.

Ping from:	Ping to:	Connectivity(yes or no)	Filtered packets
PC1	Switch 1	sim	arp request
PC1	Switch 2	sim	arp request/reply icmp request/reply
PC1	PC3	não	arp request
PC2	Switch 1	não	arp request
PC2	Switch 2	não	arp request
PC2	PC3	sim	arp request/reply icmp request/reply
PC3	PC1	não	arp request
PC3	PC2	sim	icmp request/reply

>> Identify the purpose of the VLAN ID field in each Ethernet frame.

>> What do you conclude about the importance of trunk links/ports?

Note: Different switches OS may not tag Ethernet frames from the default/native VLAN. In Cisco devices, VLAN 1 (native VLAN) ate not tagged. Any not tagged packet is assumed to belong to VLAN 1.

Format of the Ethernet frames with and without 802.1Q tags

Ethernet frame without 802.1Q tag

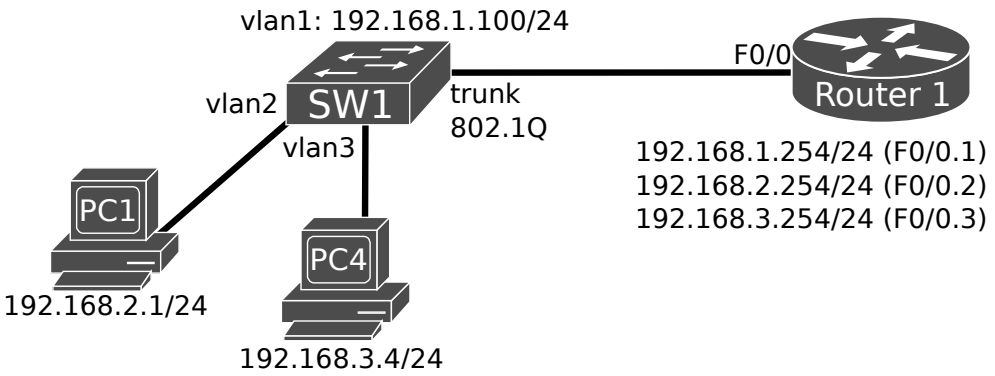
Destination Address (6 *bytes*)
Source Address (6 *bytes*)
Type / Length (2 *bytes*)
Data Field

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

O frame da trama ethernet já leva o id da vlan pois na ligação entre os 2 sws existe uma ligação em modo trunk, o que faz com que todas as vlans possam atravessar essa mesma ligação, assim, esse VLAN ID irá identificar a vlan source/destino do frame, diferenciando assim as tramas ethernet

os portos e as ligações trunk permitem a comunicação entre vlans separadas por sws sem que tenha de existir uma ligação a um porto para cada vlan



5.1. Reconfigure the network as specified in the previous figure where Router 1 routes packets between VLAN 2 and VLAN 3 (each one with its own network IP address).

In Switch 1, 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) configure the SW1 default gateway for VLAN 1:

```
ESW1(config)# ip default-gateway 192.168.1.254
```

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

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

In the Router, create 3 virtual sub-interfaces on interface F0/0, one for VLAN 1 (F0/0.1) , 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 F0/0.1
Router (config-subif)# encapsulation dot1Q 1
Router (config-subif)# ip address 192.168.1.254 255.255.255.0
Router (config-if)# interface F0/0.2
Router (config-subif)# encapsulation dot1Q 2
Router (config-subif)# ip address 192.168.2.254 255.255.255.0
Router (config-subif)# interface F0/0.3
Router (config-subif)# encapsulation dot1Q 3
Router (config-subif)# ip address 192.168.3.254 255.255.255.0
```

In both PCs, configure the appropriate IPv4 address and default gateway address:

```
PC1> ip 192.168.2.1/24 192.168.2.254
PC4> ip 192.168.3.4/24 192.168.3.254
```

5.2. In order to verify the correctness of the configurations, check the IP connectivity between PC1 and PC4 with the ping command.

Use the following command to view the IPv4 routing table:

```
Router# show ip route
```

>> Register and justify the IP routing table of the Router.

5.3. Start new capture on the link Switch1-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.

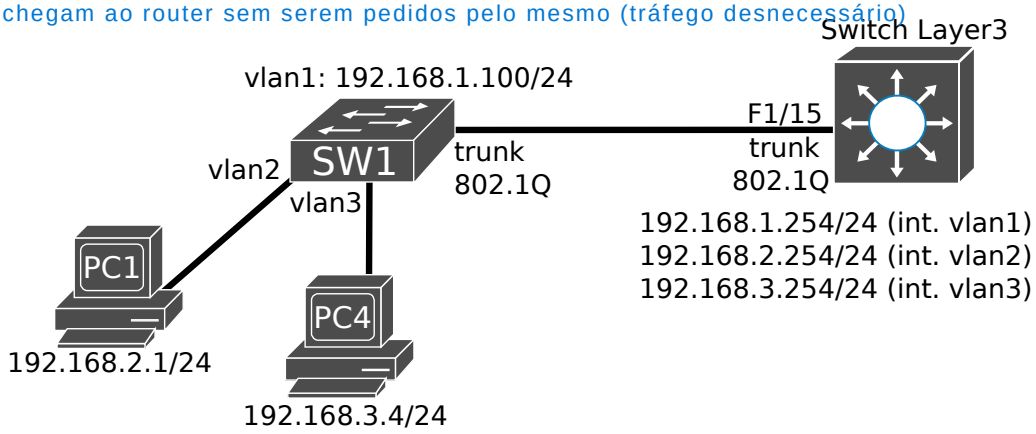
Ping from:	Ping to:	Connectivity (yes or no)	Filtered packets
PC1	Switch 1	sim	arp request/reply icmp request/reply
PC1	Router	sim	arp request/reply icmp request/reply
PC1	PC4	sim	arp request/reply icmp request/reply
PC1	192.1.1.100	não	icmp request/ icmp destination unreachable
PC4	Switch 1	sim	arp request/reply icmp request/reply
PC4	Router	sim	arp request/reply icmp request/reply
PC4	PC1	sim	arp request/reply icmp request/reply
PC4	192.1.1.100	não	icmp request/ icmp destination unreachable

>> Identify “the same” IPv4 packets that appear twice in different Ethernet frames with different 802.1Q tagging. Parecem semelhantes, no entanto têm VLAN IDs diferentes

>> Identify the purpose of the VLAN ID field in each Ethernet frame. Igual ao ex. 4

>> What do you conclude about the way packets are routed between different VLAN?

Os pacotes chegam ao router sem serem pedidos pelo mesmo (tráfego desnecessário)



5.4. Reconfigure the network as specified in the previous figure where the inter-VLAN routing is performed by a Layer 3 switch (GNS3 *EtherSwitch Router*). Replace Router 1 by a Layer 3 switch.

Create VLANs 2 and 3 at the L3 Switch (VLAN2 and 3):

```
ESWL3# vlan database
ESWL3(vlan)# vlan 2
ESWL3(vlan)# vlan 3
ESWL3(vlan)# exit
```

Activate IPv4 routing (most times is active by default):

```
ESWL3(config)# ip routing
```

Configure the ports that connects to Switch1 as trunk (802.1Q):

```
ESWL3(config)# interface F1/15
ESWL3(config-if)# switchport mode trunk
```

Configure the Switch L3 virtual (Vlan) interfaces:

```
ESWL3(config)# interface Vlan 1
ESWL3(config-if)# ip address 192.168.1.254 255.255.255.0
ESWL3(config-if)# no autostate                      !forces the port to be always up
ESWL3(config)# interface Vlan 2
ESWL3(config-if)# ip address 192.168.2.254 255.255.255.0
ESWL3(config-if)# no autostate                      !forces the port to be always up
ESWL3(config)# interface Vlan 3
```

```
ESWL3(config-if)# ip address 192.168.3.254 255.255.255.0
ESWL3(config-if)# no autostate                        !forces the port to be always up
```

Check the IP connectivity between PC1 and PC4 with the ping command.

>> Register and justify the IP routing table of the Layer 3 switch.

>> What do you conclude about the way packets are routed between different VLAN using a Layer3 switch? Is any difference from routing with a router with sub-interfaces?

>> Do you identify advantages on using Layer3 switches versus Routers? Assume a network with multiple access zones.

5.4.

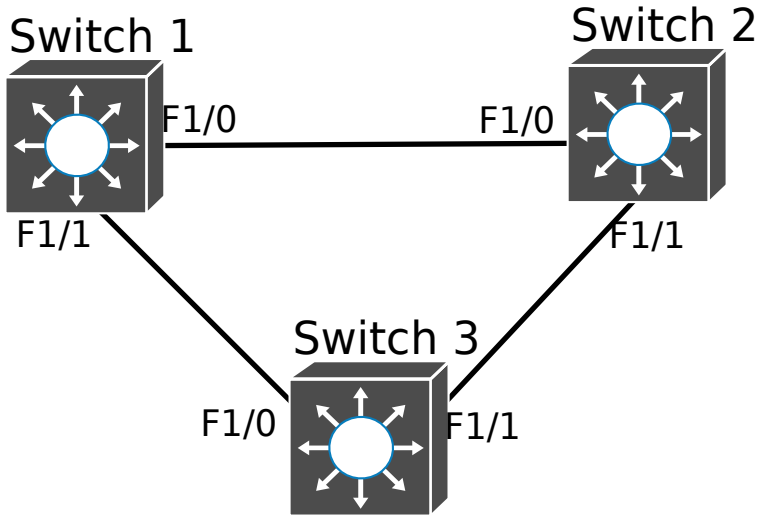
>> C 192.168.2.0/24 is directly connected, Vlan2
   C 192.168.3.0/24 is directly connected, Vlan3

O switch Layer 3 tem configurado em sim as Vlans 2 e 3 bem como um porto trunk que permite a comunicação entre Vlans e que faz com que este switch faça de intermediário nessas comunicações.

>> Não existe diferenças na maneira como os pacotes são encaminhados entres VLAN diferentes que usam switch Layer3.

>> É mais vantajoso usar switches Layer3 pois temos as diferentes Vlan's configuradas em 2 sítios diferentes e em caso de falha de um dos pontos de acesso poderemos aceder na mesma à Vlan.

Spanning Tree Protocol (STP)



6. In GNS3 configure a network as specified in the following figure, using the connections of the switching module (ports F1/0 to F1/15) of the *"EtherSwitch Routers"*. Verify that all used ports belong to VLAN 1:

```
ESW1# show vlan-switch
```

Based on the result of commands

```
ESW1# show spanning-tree bridge
ESW1# show spanning-tree interface f1/0 brief
ESW1# show spanning-tree interface f1/1 brief
```

6.
>> f1/0 interface - MAC: c201.3e6c.0000 Prioridade: 128
BridgeID: 32768 PortID: 41 PortCost: 19

f1/1 interface - MAC: c201.3e6c.0000 Prioridade: 128
BridgeID: 32768 PortID: 42 PortCost: 19

>> Identify and register the following information: (base) MAC address of each bridge, priority of each bridge, *bridge IDs and ports' IDs and costs.*

>> *Predict which switch will be the root and which port(s) will be blocked?*

6.1. Based on the result of commands

```
ESW1# show spanning-tree brief
ESW1# show spanning-tree summary
ESW1# show spanning-tree vlan 1
```

>> Identify and register the STP algorithm result: root bridge, designated bridges for each LAN, root port for each bridge, designated ports for each bridge, the root path cost of each bridge and the cost of all ports.

>> Confirm your previous predicted results.

6.2. Start a capture in each LAN (SW1-SW2, SW1-SW3 e SW2-SW3). Analyse the BPDU/STP captured packets, register its contents and confirm their coherence with the results obtained in the previous experiments.

>> Identify the relevant fields of each BPDU.

>> Which *bridge* is responsible for sending BPDUs in each local network (designated bridge)?

Format of the configuration BPDU packets

#octets				
2	Protocol Identifier			
1	Version			
1	Message Type			
1	TCA	Reserved		TC
8	Root ID			
4	Cost of Path to Root			
8	Bridge ID			
2	Port ID			
2	Message Age			
2	Max Age			
2	Hello Time			
2	Forward Delay			

6.3. Pause the two *switches* with the lowest bridge IDs. Start a capture in the Ethernet network that interconnects the two switches with the higher IDs. Execute the following sequence of actions:

(i) Wait two minutes and analyse the sequence of captured BPDU/STP packets;

(ii) Restart the *switch* with the second lowest *Bridge* ID, wait two minutes and analyse the sequence of captured BPDU/STP packets;

(iii) Restart the *switch* with the lowest *Bridge* ID, wait two minutes and analyse the sequence of captured BPDU/STP packets.

>> Identify how the bridge root change upon each action.

>> Explain the root election process.

6.4. Start a capture in all LANs (SW1-SW2, SW1-SW3 and SW2-SW3). Change the priority of one *bridge* in such a way that it becomes the *root bridge*.

```
ESW1# configure terminal
ESW1(config)# spanning-tree vlan 1 priority <value>
```

>> Analyse the captured BPDU/STP packets and explain the re-election process of the root *bridge*.

6.5. Start a capture in all LANs (SW1-SW2, SW1-SW3 and SW2-SW3). Change in the designated bridge of the network that is not connected to the root bridge the cost of its root port in such a way that it stops being the designated bridge, using the following commands:

```
ESW1# configure terminal
ESW1(config)# interface <interface>
ESW1(config-if)# spanning-tree cost <value>
```

Since there was a change in the *Spanning Tree* protocol parameters, the topology change notification mechanism is triggered. Let the capture last for a period of at least 1 minute after changing the port cost.

>> Analyse the sequence of captured packets and verify if BPDU packets of the TCN type were sent.

>> Identify any changes on the TC and TCA *flags* of the *Configuration BPDU* packets.

>> Explain how changes on topology are notified and and how period of change are managed by the STP.

Format of the TCN (*Topology Change Notification*) packets

#octets	
2	Protocol Identifier
1	Version
1	Message Type

6.6. Start a capture on the Ethernet network that is not directly connected to the *root bridge*.

The bridge *Hello Time* parameter can be changed with the following commands

```
ESW# configure terminal
ESW1(config)# spanning-tree vlan 1 hello-time <value>
```

Execute the following sequence of actions:

(i) change the *Hello time* parameter of the *bridge* with the second lowest bridge ID to 6 seconds and, using Wireshark, verify the periodicity of the generated BPDU packets;

(ii) change the *Hello time* parameter of the *root bridge* to 6 seconds and, using Wireshark, verify the periodicity of the generated BPDU packets;

>> What do you conclude about the effect of configuring the *Hello Time* parameter in different *switches* on the general interval between BPDU packets in all networks?