universidade de aveiro
theoria poiesis praxis

Redes de Comunicações 2

Access and Distribution Networks

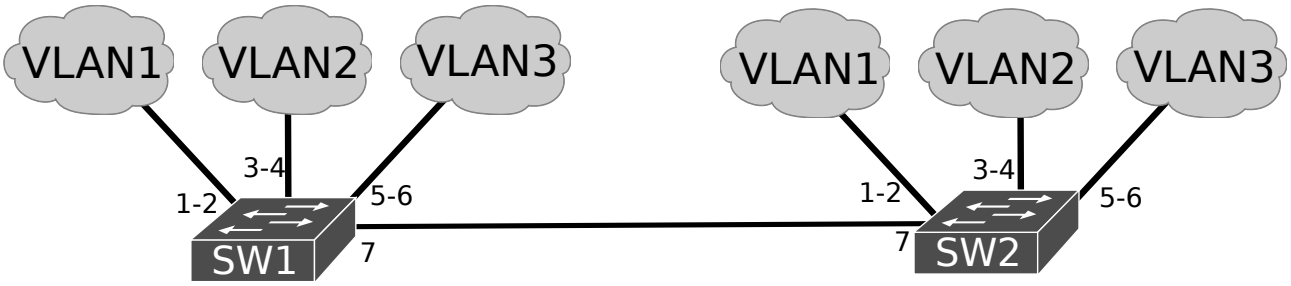
Objectives

- VLAN definition
- Inter-VLAN routing
- Usage of L2 and L3 Switches
- Access and distribution network design and interconnection
- Trunk links
- Truck links with interconnection VLAN
- Spanning-Tree

Access Network (VLAN) Deployment

1. Using GNS3, assemble the depicted network. Configure 3 VLAN at the switches:
- Ports 1-2: VLAN1,
- Ports 3-4: VLAN2,
- Ports 5-6: VLAN3,
- Ports 7-8: Inter-switch/Tagged/802.1Q (native VLAN 1).

To implement a Layer2 switch you can use a GNS3 basic "Ethernet Switch" or a switching module (NM-16SW) on a Router (GNS3 EtherSwitch router) with IP routing disabled (ports f1/0 to f1/15).
Note: A GNS3 basic "Ethernet Switch" do not support Spanning Tree Protocols.



To configure an "Ethernet Switch" use the GUI.
To configure an "EtherSwitch router" as a L2 Switch:

```
EtherSwitch# vlan database                                  !VLANs must be created on the
EtherSwitch(vlan)# vlan 1                                          ! equipment database
EtherSwitch(vlan)# vlan 2                                          !To remove a VLAN use:
EtherSwitch(vlan)# vlan 3                                          ! "no vlan x"
EtherSwitch(vlan)# exit
EtherSwitch# configure terminal
EtherSwitch(config)# no ip routing                          !Disables IPv4 routing
EtherSwitch(config)# interface f1/3
EtherSwitch(config-if)# switchport mode access              !Defines as an access port
EtherSwitch(config-if)# switchport access vlan 2            !Specifies the port VLAN
EtherSwitch(config-if)# interface f1/4
EtherSwitch(config-if)# switchport mode access
EtherSwitch(config-if)# switchport access vlan 2
EtherSwitch(config-if-range)# interface range fastEthernet 1/5 - 6        !To configure multiple ports
EtherSwitch(config-if-range)# switchport mode access
EtherSwitch(config-if-range)# switchport access vlan 3
EtherSwitch(config-if-range)# interface range fastEthernet 1/7 - 8
EtherSwitch(config-if-range)# switchport mode trunk                       !Defines as Trunk port
EtherSwitch(config-if-range)# switchport trunk encapsulation dot1q     !By default all VLAN are transported
```

Note1: To show the existing VLAN use the command: `show vlan-switch`
Note2: By default VLAN1 is already created, and all ports are configured as access ports from VLAN1.
Troubleshooting 1: When creating the VLAN, if a flash memory space error occurs, run the command

```
EtherSwitch# erase flash:
```

to erase the flash, and after, create the missing VLAN.
Troubleshooting 2: Verify if all the interfaces with connections are `up` with the command:

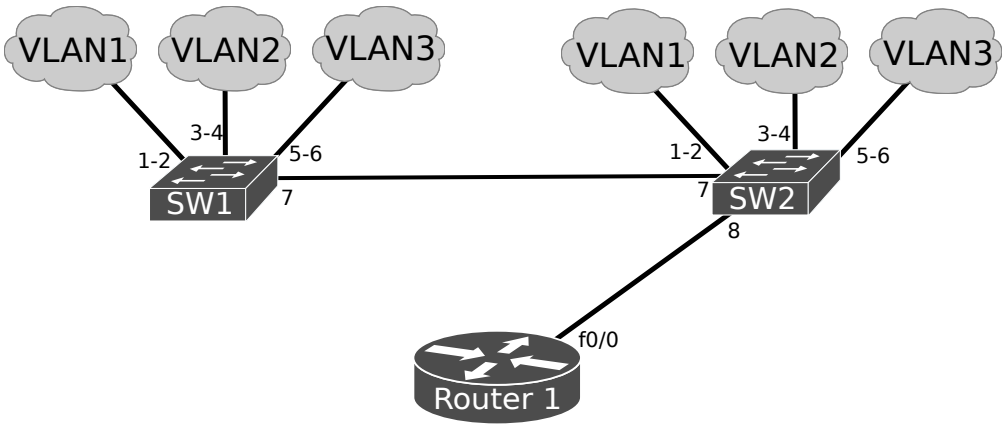
```
show ip interface brief
```

if not, perform a `shutdown` followed by a `no shutdown` on the respective interface.

2. Place a terminal connected (PC1) to a VLAN1 port using the address 10.1.1.1/24.
Place a terminal (PC2) connected to a VLAN2 port using the address 10.1.1.2/24.
Test the connectivity between PC1 and PC2.
Place a terminal connected (PC3) to a VLAN3 port using the address 10.1.1.3/24.
Test the connectivity between PC3 and PC1/PC2.
Place a terminal connected (PC4) to a VLAN1 port using the address 10.1.1.4/24.
Test the connectivity between PC4 and PC1/PC2/PC3.
>> Explain the results of the connectivity tests between terminals on different VLANs (but the same IPv4 network).
Note: In a correctly configured network, the IPv4 network of different VLANs must be different.

(Optional) Inter-VLAN Routing with Router

3.1 Assemble the depicted network by adding a router. The VLAN1 IPv4 network is 10.1.1.0/24, VLAN2 IPv4 network is 10.2.2.0/24, and VLAN3 IPv4 network is 10.3.3.0/24.



Configure the router to support sub-interfaces and Inter-VLAN (802.1Q) routing:

```
Router(config)# interface FastEthernet0/0
Router(config-if)# no shutdown
Router(config-if)# interface FastEthernet0/0.1
Router(config-if)# encapsulation dot1Q 1 native           !VLAN1
Router(config-if)# ip address 10.1.1.1 255.255.255.0
!
Router(config-if)# interface FastEthernet0/0.2
Router(config-if)# encapsulation dot1Q 2                  !VLAN2
Router(config-if)# ip address 10.2.2.1 255.255.255.0
!
Router(config-if)# interface FastEthernet0/0.3
Router(config-if)# encapsulation dot1Q 3                  !VLAN3
Router(config-if)# ip address 10.3.3.1 255.255.255.0
```

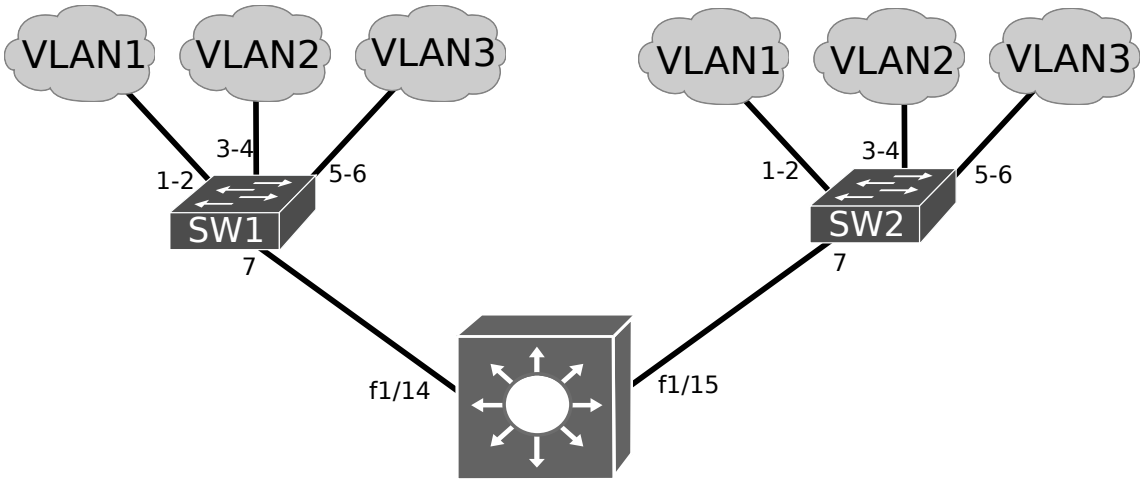
Verify the routing table.

Place terminals at the different VLAN, configure the respective IPv4 address and gateways (router sub-interfaces) and test connectivity. Capture the packets being exchanged between the Router and (right) Switch.

>> Explain how packets are assign to the respective VLAN/sub-interface.

Inter-VLAN Routing with a L3 Switch (Access-Distribution)

3.2 Assemble the depicted network by adding a Layer 3 Switch (is present, replacing the Router) and removing the direct link between the Layer2 switches. The VLAN1 IPv4 network is 10.1.1.0/24, VLAN2 IPv4 network is 10.2.2.0/24, and VLAN3 IPv4 network is 10.3.3.0/24.



Configure 3 VLAN at the L3 Switch (VLAN1 ,2 and 3):

```
RouterSW# vlan database
RouterSW(vlan)# vlan 1
RouterSW(vlan)# vlan 2
RouterSW(vlan)# vlan 3
RouterSW(vlan)# exit
```

Configure the L3 Switch's L2 ports 14-15 as Inter-switch/Trunk/802.1Q:

```
RouterSW(config)# interface range FastEthernet 1/14 - 15
RouterSW(config-if-range)# switchport mode trunk
RouterSW(config-if-range)# switchport trunk encapsulation dot1q
```

Configure the Switch L3 virtual (Vlan) interfaces (and activate IPv4 routing):

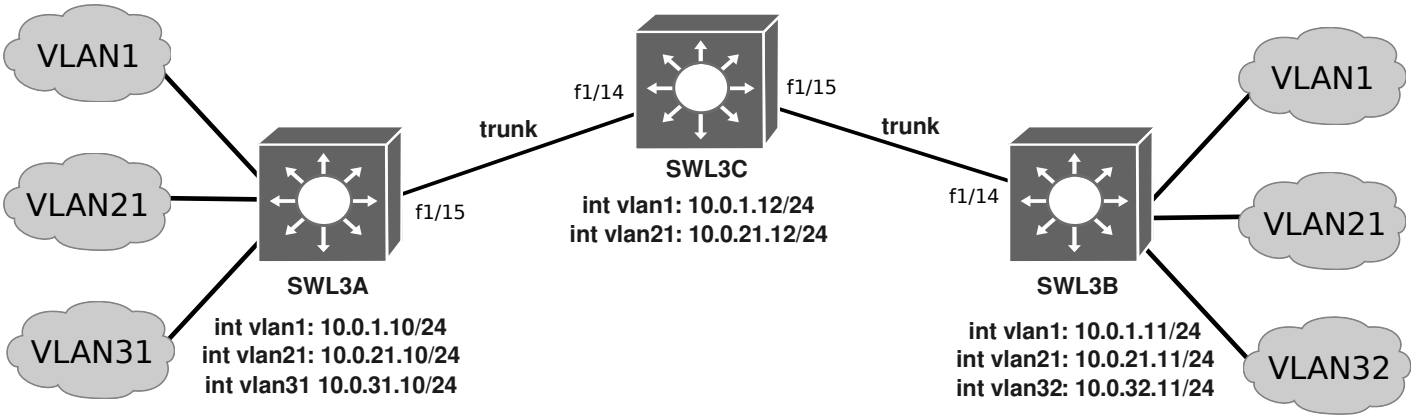
```
RouterSW(config)# ip routing                              !Activates IPv4 Routing
RouterSW(config)# interface Vlan 1
RouterSW(config-if)# ip address 10.1.1.1 255.255.255.0
RouterSW(config-if)# no shutdown
RouterSW(config-if)# no autostate                         !forces the port to be always up
RouterSW(config)# interface Vlan 2
RouterSW(config-if)# ip address 10.2.2.1 255.255.255.0
RouterSW(config-if)# no shutdown
RouterSW(config-if)# no autostate                         !forces the port to be always up
RouterSW(config)# interface Vlan 3
RouterSW(config-if)# ip address 10.3.3.1 255.255.255.0
RouterSW(config-if)# no shutdown
RouterSW(config-if)# no autostate                         !forces the port to be always up
```

Verify the routing table. Place terminals at the different VLAN, configure the respective gateways (VLAN virtual interfaces) and test connectivity.

>> Capture and explain the packets being exchanged between the L2 and L3 Switches.

Restricted trunk links

4. Assemble the following network with L3 Switches. VLANs 1 and 21 are end-to-end and all other VLAN are local.
Configure VLAN on the three Layer 3 switches: SWL3 A should have VLAN 1, 21, and 31; SWL3 C should have VLANs 1 and 21 only; and SWL3 C should have VLAN 1, 21, and 32.
Place one PC (VPCS) in each VLAN/side, configure its IPv4 address and respective gateway (use the closest SWL3).
Note: By default Cisco equipment have default VLANs that must be considered end-to-end (1002-1005) and cannot be deleted.
Note2: Usually, the IPv4 routing is disabled by default in Layer3 switches, activated it with `ip routing`



4.1 Start a packet capture on one of the trunk links and test the connectivity between all terminals (PCs).
>> Explain the connectivity results and captured packets.
>> Explain why, for some pings, Echo Request packets are captured, but no Echo Reply is capture.
>> Explain how packets from a VLAN32 PC can reach a VLAN1 or VLAN 21 PC on the other side of the network, however they do not have connectivity.

4.2 Restrict the trunk links usage just for VLAN 1 (and default Cisco VLANs).

```
SWL3*(config)# interface range FastEthernet 1/14 - 15
SWL3*(config-if-range)# switchport mode trunk
SWL3*(config-if-range)# switchport trunk allowed vlan 1,1002-1005
```

Start a packet capture on one of the trunk links and test the connectivity between all terminals (PCs).
>> Explain the connectivity results and captured packets.
>> Is VLAN21 a local VLAN now?
>> What defines if a VLAN is local or end-to-end?
Note: By default Cisco equipment have default VLANs that must be considered end-to-end (1002-1005) and cannot be deleted.

Interconnection VLAN

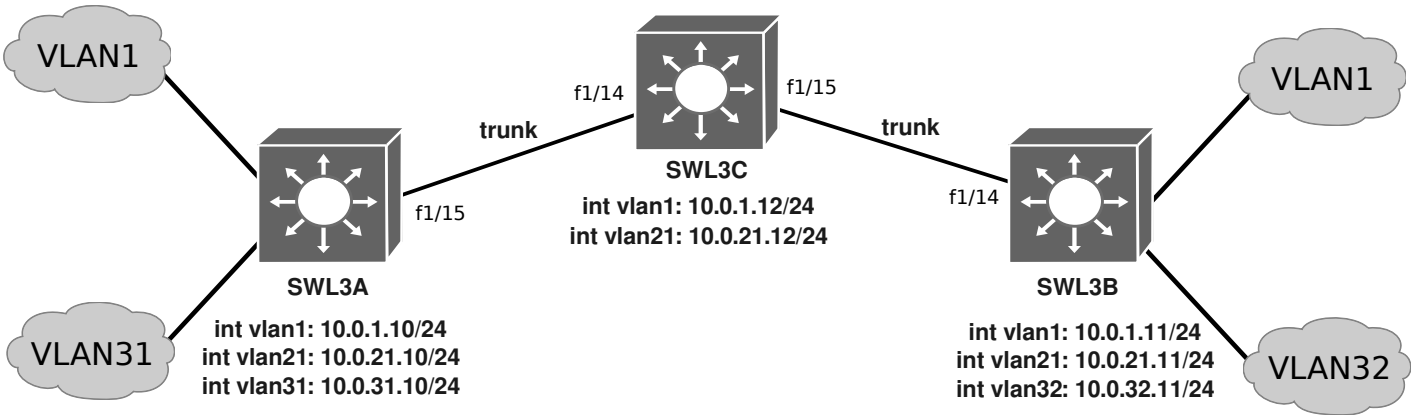
5. Remove all terminals from VLAN21 and make VLAN 21 am interconnection VLAN.
Start by changing the trunks restrictions to make VLAN 21 an end-to-end VLAN again:

```
SWL3*(config)# interface range FastEthernet 1/14 - 15
SWL3*(config-if-range)# switchport trunk allowed vlan 1,21,1002-1005
```

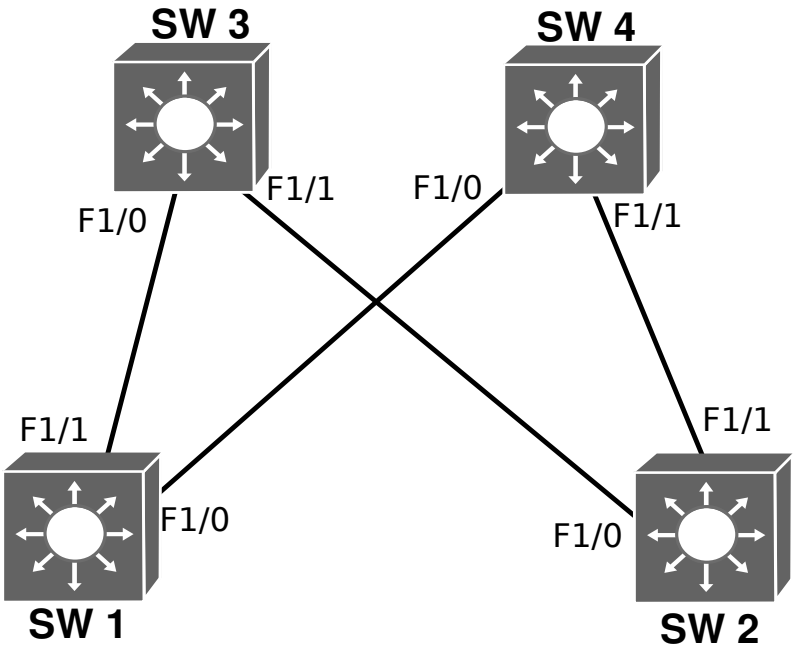
Configure the IPv4 routing to use VLAN21 as the layer3 connectivity link between the network “sides”.

```
SWL3A(config)# ip route 10.0.32.0 255.255.255.0 10.0.21.11
---
SWL3B(config)# ip route 10.0.31.0 255.255.255.0 10.0.21.10
```

>> Analyze the routing tables, test connectivity and capture/analyze the packets on the trunk links.
>> Analyze the VLAN tag of the packets sent from local VLANs.
>> Explain how a remote (local) VLAN terminal have connectivity with other local VLANs.



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 VLAN1:

```
ESW# show vlan-switch
```

Based on the result of commands

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

>> Identify 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.
>> Predict which which port(s) will be blocked?

6.1. Based on the result of commands

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

>> Analyze the STP algorithm result: root bridge, the root path cost of each bridge and blocked ports.
>> Confirm your previous predicted results.

6.2. Start a capture in one LAN segment. 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.

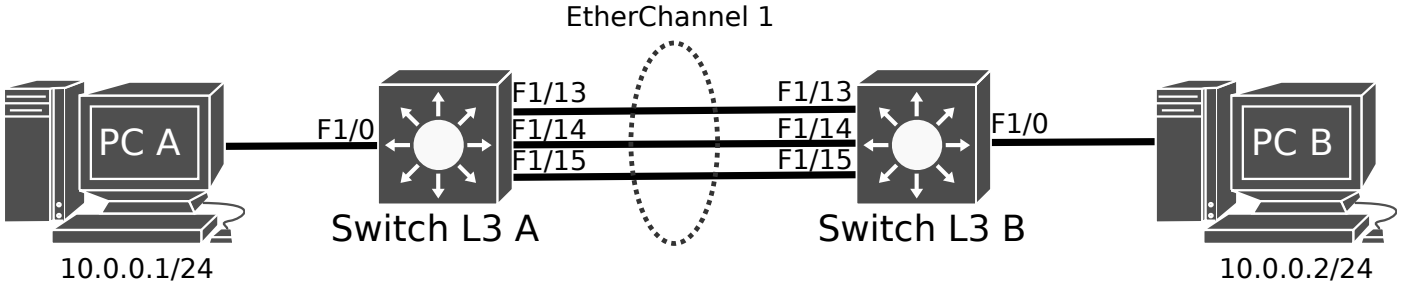
6.3. Start a capture in all LAN segments.
In order to make one of the top switches the root bridge (change side, if a top one is already root bridge), change the priority of a switch :

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

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

(Optional) Ethernet Link Aggregation (EtherChannel)

Ethernet link aggregation in Cisco switches is made using EtherChannels. An EtherChannel allows multiple physical Ethernet links to combine into one logical channel.



7.1. Assemble the depicted network creating an EtherChanel (1) between switches Layer 2 A and B with 3 Fast Ethernet links. The EtherChannel will provide a 300Mbps logical channel to interconnect remote instances of VLAN 2 using a trunk.

At Switch Layer 3 A:

```
SwitchL3A(config)# interface range FastEthernet 1/13 - 15
SwitchL3A(config-if-range)# channel-group 1 mode on
SwitchL3A(config-if)# interface Port-channel 1
SwitchL3A(config-if)# switchport mode trunk
---
SwitchL3A# vlan database
SwitchL3A(vlan)# vlan 2
SwitchL3A(vlan)# exit
---
SwitchL3A(config)# interface FastEthernet 1/0
SwitchL3A(config-if)# switchport access vlan 2
```

Perform the same configurations in Switch Layer3 B.

Verify the correct implementation of the EtherChannel:

```
SwitchL3A# show ip interface brief
SwitchL3A# show etherchannel brief
SwitchL3A# show etherchannel detail
SwitchL3A# show etherchannel summary
SwitchL3A# show etherchannel load-balance
```

7.2 Start a capture in each one of the three Ethernet links between the Switches Layer3 (you may use GNS3's topology summary to do it).

Perform pings between PC A and PC B and observe how the packets are exchange between the switches.

>> How the load (traffic) is distributed (balanced) over the physical links?