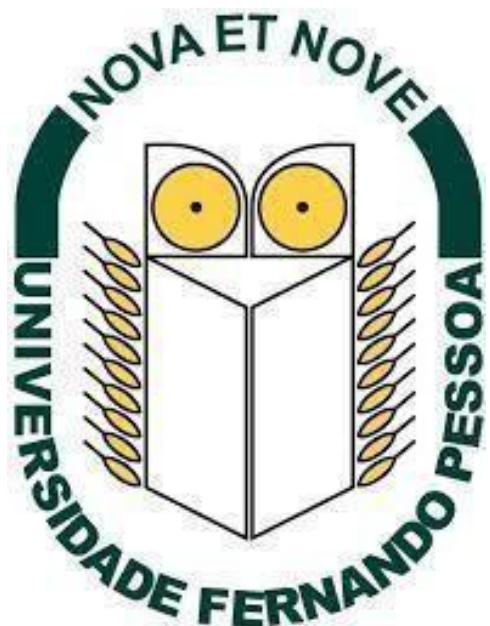


Redes de Computadores I



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OsvaldoDMVS	Osvaldo Silva

Relatório Final - Projeto



Índice

Resumo.....	<u>pag. 2</u>
Grupo 1 - Configurar, testar, monitorar e reparar ligações agregadas baseadas no protocolo LACP (Link Aggregation Control Protocol)	<u>pag. 5</u>
Grupo 2 - Configurar, testar, monitorar e reparar interfaces de rede na presença de VLANs.....	<u>pag. 24</u>
Grupo 3 - Configurar, testar, monitorizar e reparar o protocolo VTP (Vlan Trunking Protocol).....	<u>pag. 28</u>
Grupo 4 - Configurar, testar, monitorar e reparar o protocolo Spanning Tree (802.1D e PVST+) numa topologia de rede local.....	<u>pag. 31</u>
Grupo 5.....	<u>pag. 34</u>



Resumo:

Este trabalho foi elaborado no intuito de um projeto final na cadeira de Redes 1, em que foi necessário configurar uma Topologia de redes complexa no programa GNS3. Esta configuração inclui testes feitos em aparelhos (Switches/Routers) CISCO e Arista, análise de dados da rede através do Wireshark, criação de um Servidor Linux como parte da topologia, configuração e vários testes feitos em VLANs (como elas se comportam e reagem) e a análise de protocolos:

- Spanning-tree (IEEE 802.1D);
- Link Aggregation Control Protocol;
- RSTP (IEEE 802.1 W);
- PVST+;
- Rapid PVST+;
- VLANs.

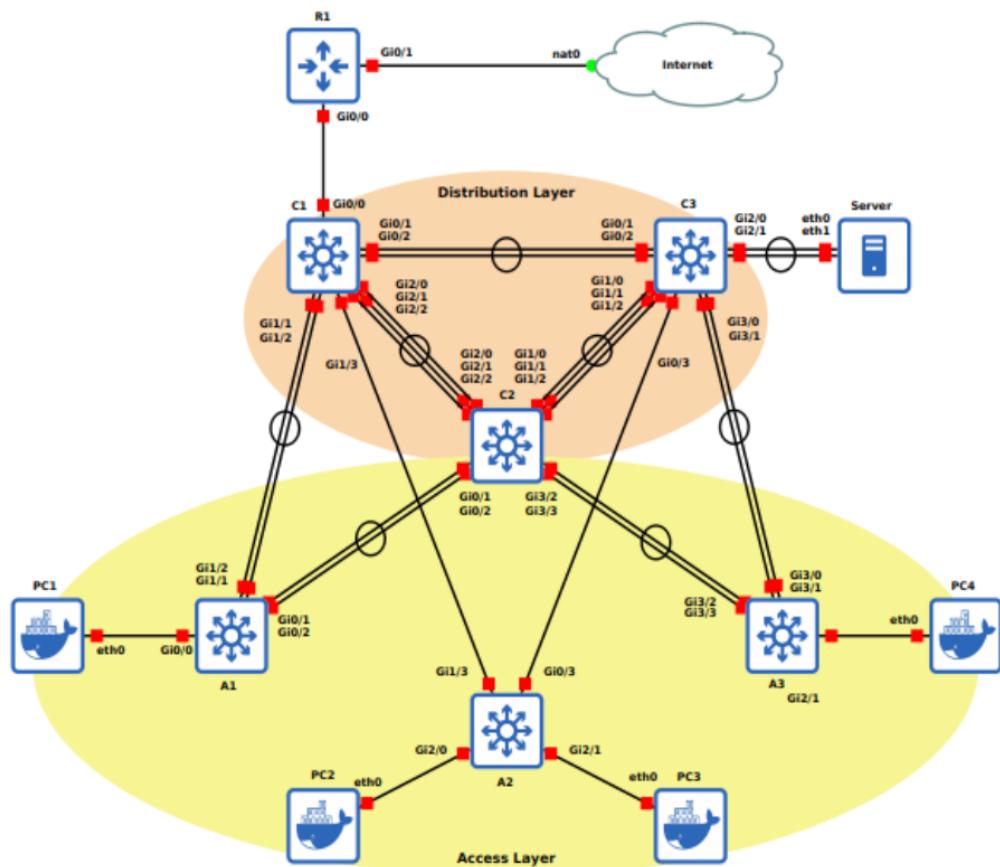


Figura 1 - Topologia proposta do projeto



Grupo 1

Configurar, testar, monitorar e reparar ligações agregadas baseadas no protocolo LACP (Link Aggregation Control Protocol)

- 1.1) Criar interfaces EtherChannel

Exemplo: *Assumindo que existe o Switch 1 e o Switch 2, ambos conectados através das interfaces *gi0/0* e *gi0/1*, e sendo *X* o etherchannel que se pretende criar*

SWITCH 1 e 2:

```
int range gi0/0-1 + switchport + no sh + channel-group x mode active
```

- 1.2) Associar interfaces físicas ao EtherChannel e analisar os diferentes modos de associação LACP (on, passive ou active)

Foram criados 7 interfaces Etherchannel, apresentados na seguinte lista:

C1:	Po1 (C3)
	Po2 (A1)
	Po3 (C2)
C2:	Po3 (C1)
	Po4 (C3)
	Po5 (A3)
	Po6 (A1)
C3:	Po1 (C1)
	Po2 (A3)
	Po4 (C2)
A1:	Po2 (C1)
	Po6 (C2)
A3:	Po2 (C3)
	Po5 (A3)

- 1.3) Descrever o propósito de configurar a prioridade LACP numa porta do switch.

Este protocolo permite que várias interfaces de um dispositivo (neste caso um Switch) sejam agregadas em conjunto para criar uma tolerância de falha da rede, e permite que o tráfego desta mesma rede seja distribuído mais eficientemente na largura de banda disponível.



- 1.4) Descrever e testar os diferentes modos de balanceamento da carga no EtherChannel.

src-dst-ip: Source and destination IP addresses;

src-dst-mac: Source and destination MAC addresses;

dst-ip: Destination IP address;

dst-mac: Destination MAC address:

src-ip: Source IP address;

src-mac: Source MAC address.

Cada método de平衡amento depende de uma interface física que irá enviar os packets, como descrito na lista em cima, estas interfaces variam de endereços IP/MAC e as suas respetivas fontes ou destinos.

 Two screenshots of a terminal window showing Cisco IOS XE CLI output. The left window (C1) shows the configuration of an EtherChannel group (Group 2) using LACP protocol, connecting ports G1/1(P) and G1/2(P). The right window (A1) shows the configuration of an EtherChannel load-balancing mode set to 'src-dst-ip'. Both windows also display information about the load-balancing addresses used per protocol: Non-IP, IPv4, and IPv6.

```

C1
Group Port-channel Protocol Ports
2 Po2(SU) LACP G1/1(P) G1/2(P)

Switch#sh etherchannel load-balance
EtherChannel Load-Balancing Configuration:
  src-dst-ip

EtherChannel Load-Balancing Addresses Used Per-Protocol:
Non-IP: Source XOR Destination MAC address
IPv4: Source XOR Destination IP address
IPv6: Source XOR Destination IP address

Switch#.

A1
Jan 7 00:34:13.239: %SYS-5-CONFIG_I: Configured from console by console
Switch#
Switch#sh etherchannel load-balance
EtherChannel Load-Balancing Configuration:
  src-dst-ip

EtherChannel Load-Balancing Addresses Used Per-Protocol:
Non-IP: Source XOR Destination MAC address
IPv4: Source XOR Destination IP address
IPv6: Source XOR Destination IP address

Switch#
    
```

Figura 2 - Load-balance src-dst-ip

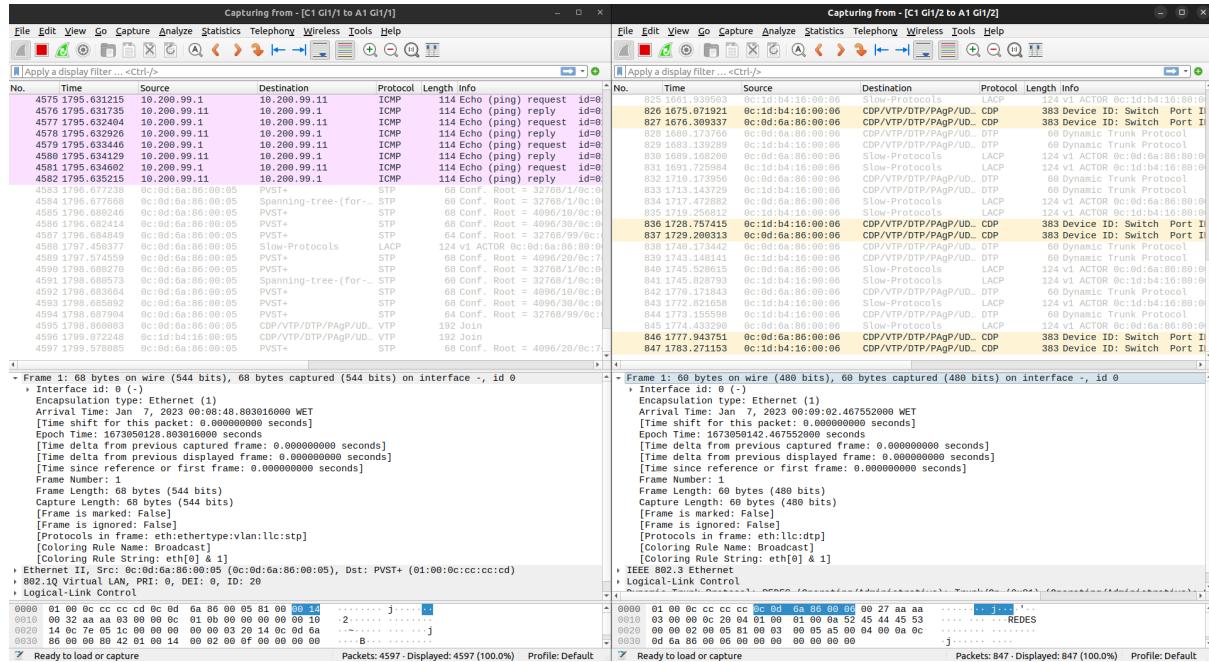


Figura 3 - Load-balance src-dst-ip Wireshark

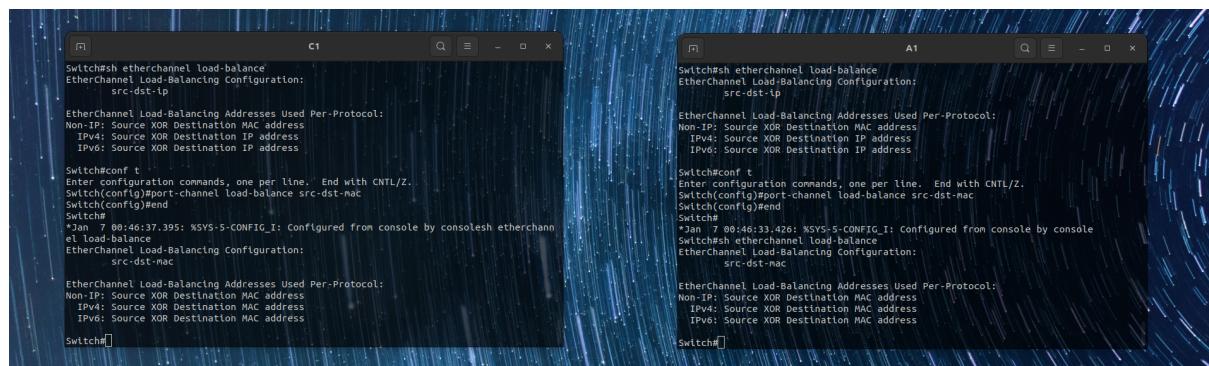


Figura 4 - Load-balance src-dst-mac

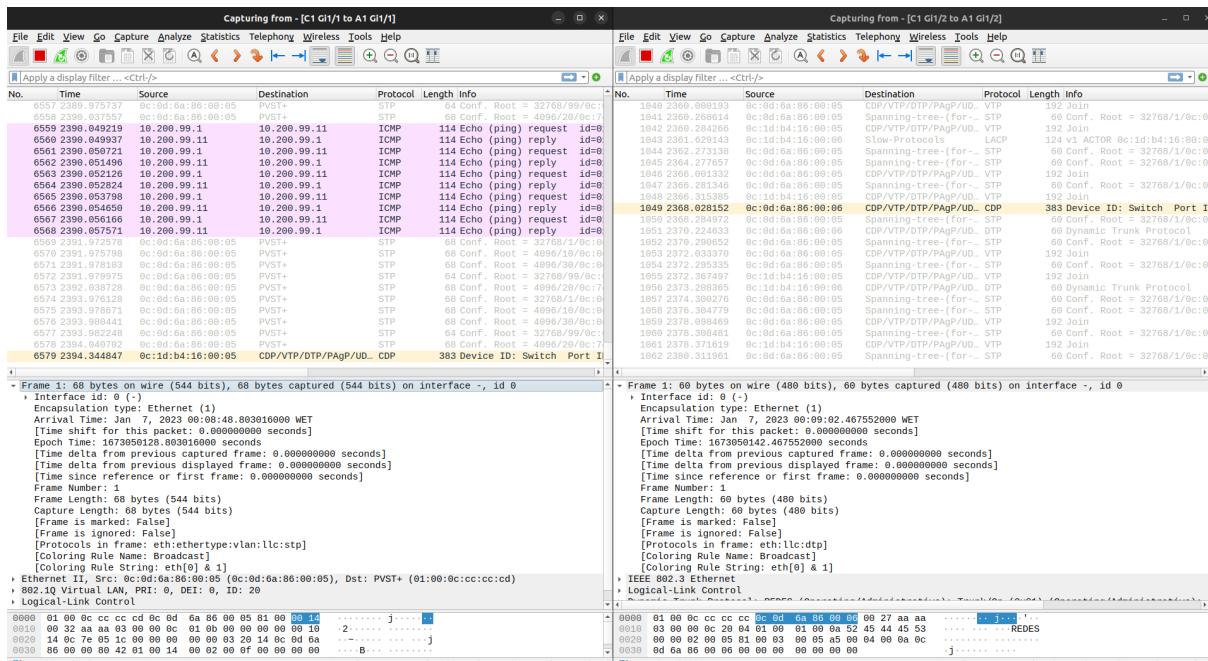


Figura 5 - Load-balance src-dst-mac Wireshark

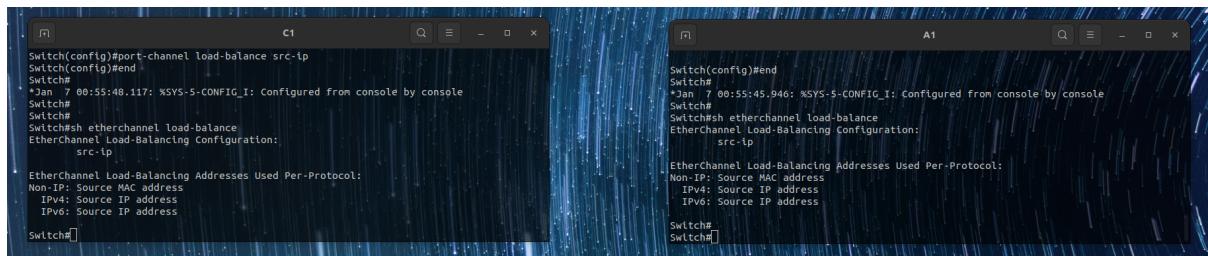


Figura 6 - Load-balance src-ip

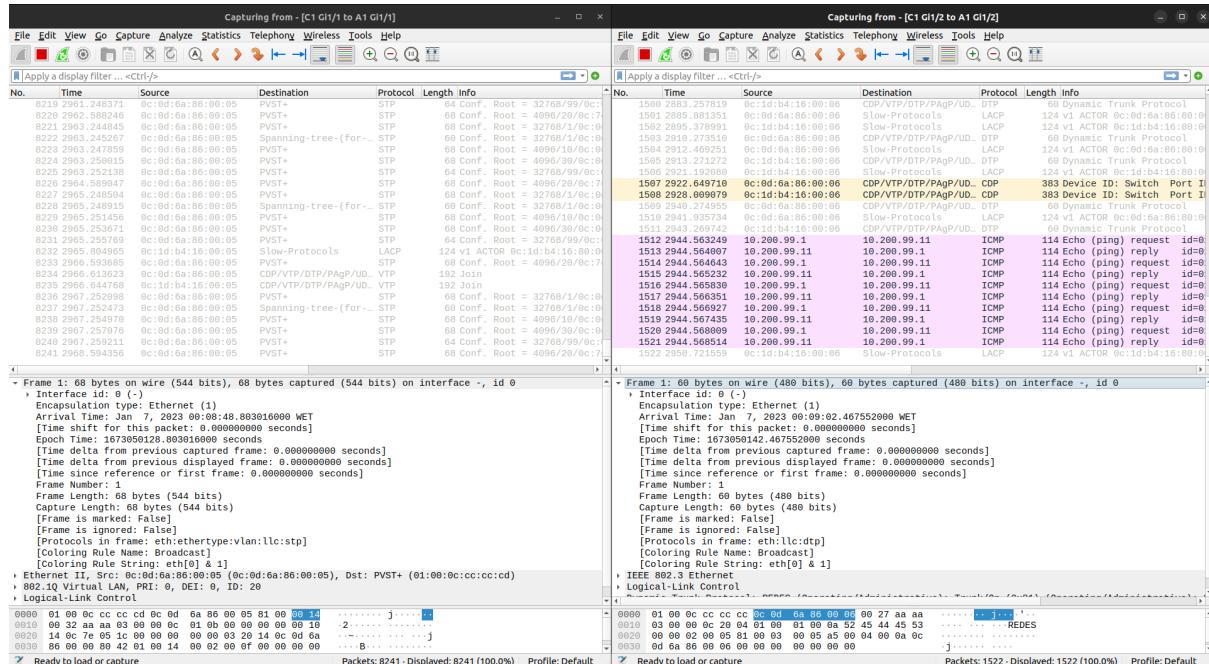


Figura 7 - Load-balance src-ip Wireshark

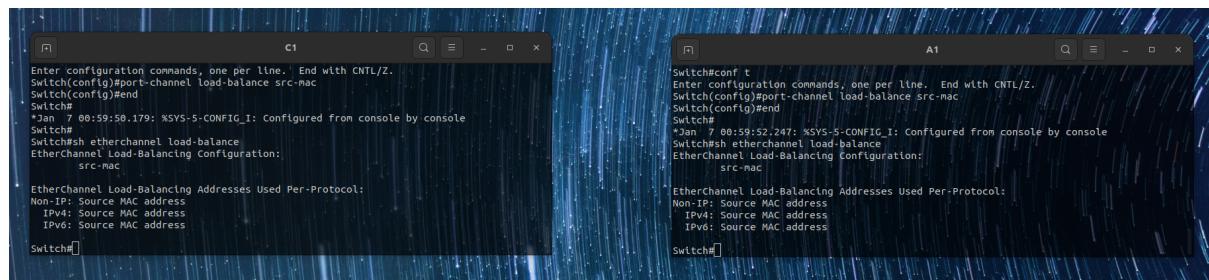


Figura 8 - Load-balance src-mac

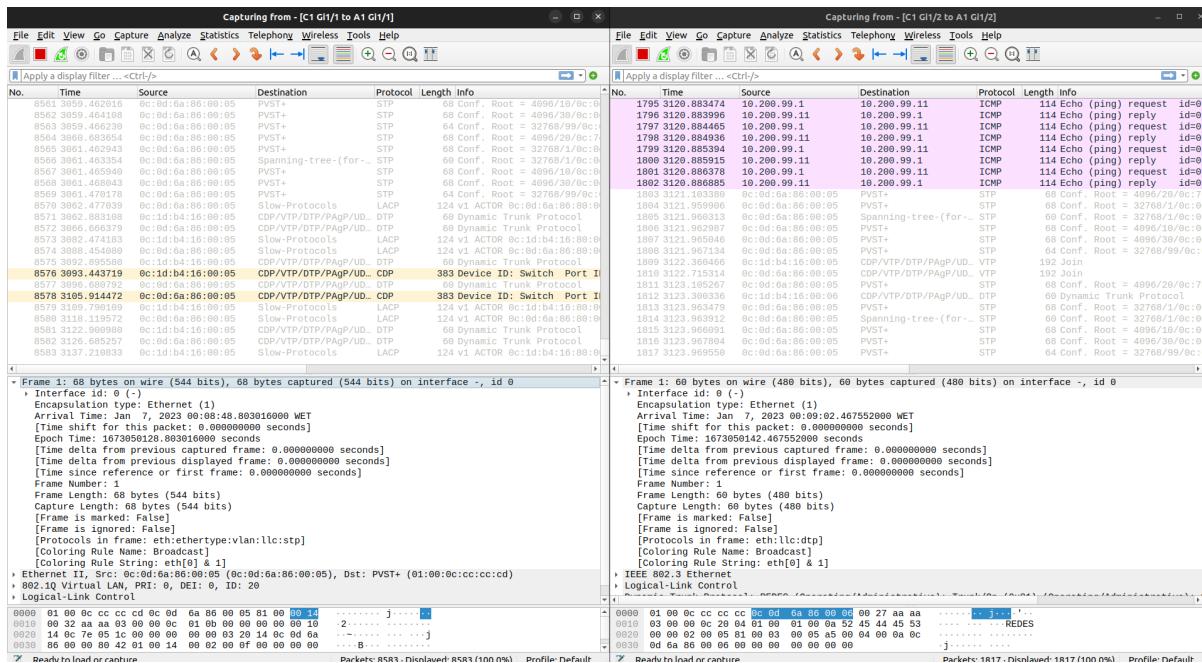


Figura 9 - Load-balance src-mac Wireshark

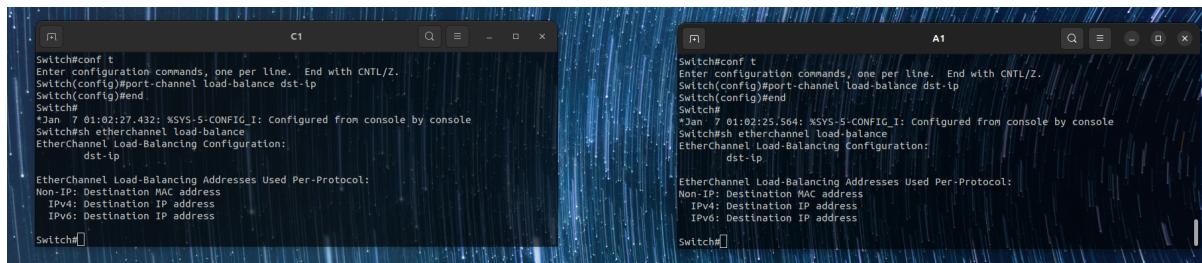


Figura 10 - Load-balance dst-ip

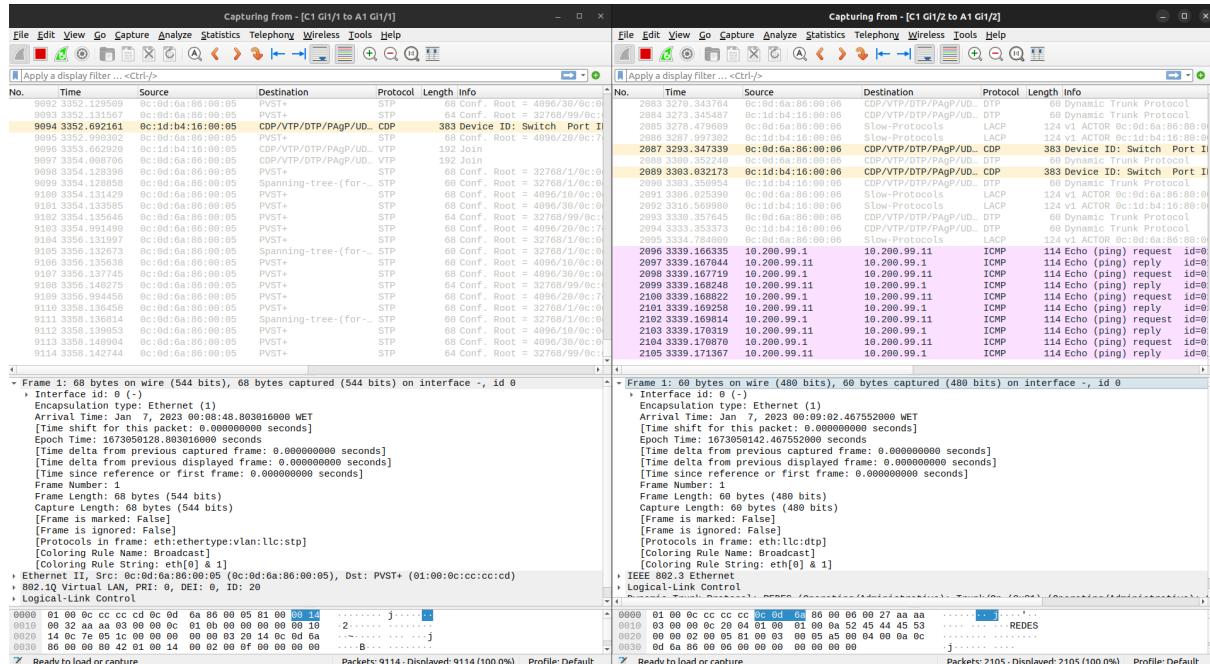


Figura 11 - Load-balance dst-ip Wireshark

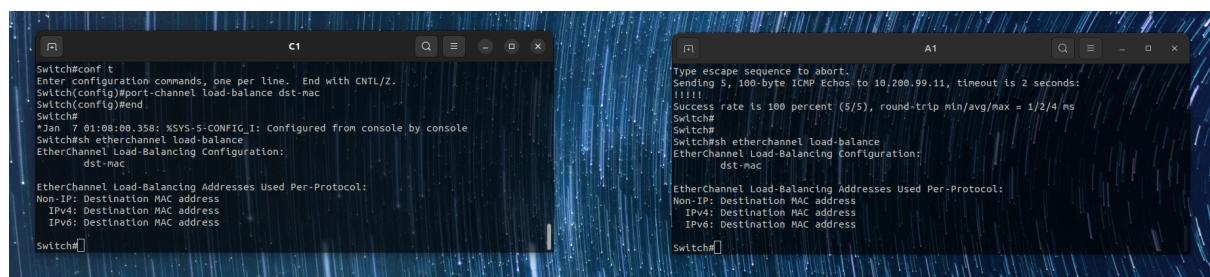


Figura 12 - Load-balance dst-mac

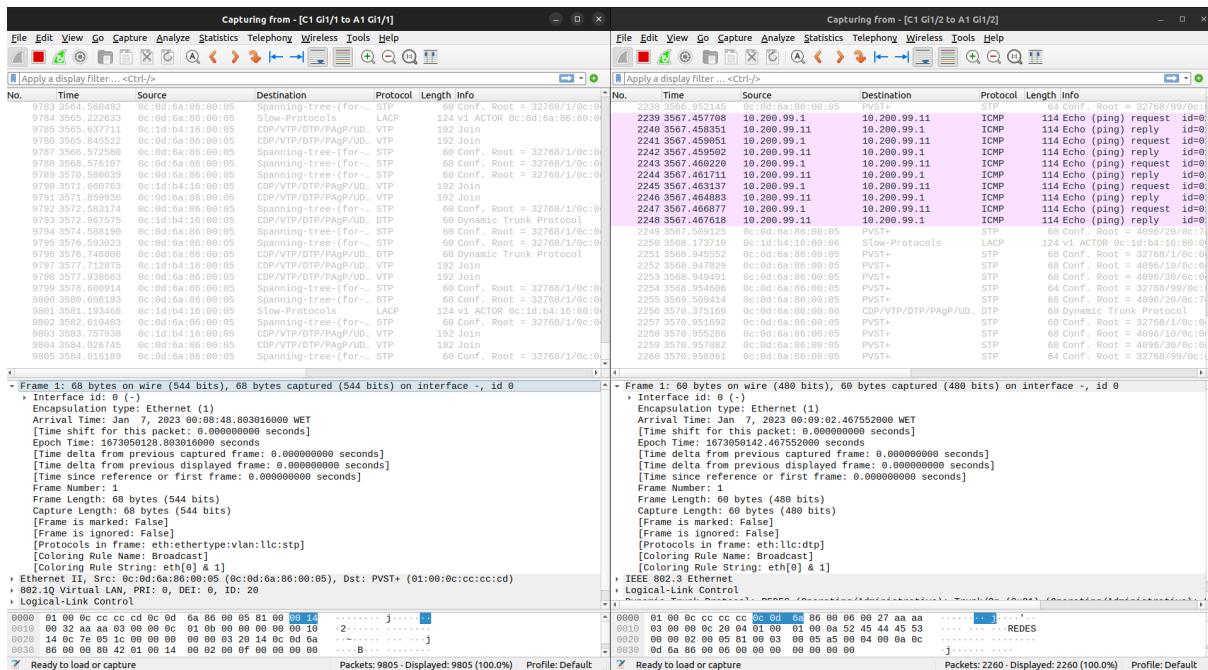


Figura 13 - Load-balance dst-mac

- 1.5) Descrever o significado da saída dos comandos **show etherchannel summary** e **show etherchannel port**.

Etherchannel summary: Indica o estado do port-channel (Figura 14)

Etherchannel port: Indica uma informação mais detalhada sobre o port-channel, inclusive, a sobre outros grupos vizinhos. (Figura 15)

A screenshot of a terminal window titled "C1". The window displays the output of the command "Switch#sh etherchannel summary". The output includes a legend of flags, information about channel-groups and aggregators, and a table detailing three port-channel groups (Po1, Po2, Po3) and their corresponding ports.

```
Switch#sh etherchannel summary
Flags: D - down      P - bundled in port-channel
      I - stand-alone S - suspended
      H - Hot-standby (LACP only)
      R - Layer3       S - Layer2
      U - in use       N - not in use, no aggregation
      f - failed to allocate aggregator

      M - not in use, minimum links not met
      m - not in use, port not aggregated due to minimum links not met
      u - unsuitable for bundling
      w - waiting to be aggregated
      d - default port

      A - formed by Auto LAG

Number of channel-groups in use: 3
Number of aggregators: 3

Group  Port-channel  Protocol    Ports
-----+-----+-----+
1      Po1(SU)      LACP        Gi0/1(P)   Gi0/2(P)
2      Po2(SU)      LACP        Gi1/1(P)   Gi1/2(P)
3      Po3(SU)      LACP        Gi2/0(P)   Gi2/1(P)   Gi2/2(P)

Switch#
```

Figura 14 - Etherchannel summary no Switch C1



```

Switch#sh etherchannel port
      Channel-group listing:
      -----
      Group: 1
      -----
      Ports in the group:
      Port: Gi0/1
      -----
      Port state    = Up Mstr Assoc In-Bndl
      Channel group = 1          Mode = Active           Gcchange = -
      Port-channel  = Po1        GC   =   -              Pseudo port-channel = Po1
      Port index    = 0          Load = 0x00           Protocol = LACP
      Flags: S - Device is sending Slow LACPDU斯  F - Device is sending fast LACPDU斯
             A - Device is in active mode.       P - Device is in passive mode.

      Local information:
      Port     Flags     State      LACP port      Admin     Oper     Port      Port
      Gi0/1   SA        bndl      32768       0x1       0x1       0x2       0x3D
      Partner's information:
      Port     Flags     Priority   LACP port      Admin     Oper     Port      Port
      Gi0/1   SA        32768     Dev ID       Age      key     Key      Number  State
                           0c87.6cf7.8000 10s     0x0     0x1     0x2     0x3D
      Age of the port in the current state: 0d:01h:21m:55s

      Port: Gi0/2
      -----
      Port state    = Up Mstr Assoc In-Bndl
      Channel group = 1          Mode = Active           Gcchange = -
      Port-channel  = Po1        GC   =   -              Pseudo port-channel = Po1
      Port index    = 0          Load = 0x00           Protocol = LACP
      Flags: S - Device is sending Slow LACPDU斯  F - Device is sending fast LACPDU斯
             A - Device is in active mode.       P - Device is in passive mode.

      Local information:
      Port     Flags     State      LACP port      Admin     Oper     Port      Port
      Gi0/2   SA        bndl      32768       0x1       0x1       0x3       0x3D
      Partner's information:
      Port     Flags     Priority   LACP port      Admin     Oper     Port      Port
      Gi0/2   SA        32768     Dev ID       Age      key     Key      Number  State
                           0c87.6cf7.8000 16s     0x0     0x1     0x3     0x3D
  
```

Figura 15 - Etherchannel port no Switch C1

Para evitar o sobre uso de imagens neste relatório, podem encontrar na pasta de “Screenshots” deste projeto as várias fotos tiradas ao Etherchannel Porto do Switch C1, que engloba os Po1-3.¹

1

Etherchannel_port C1_1.png, Etherchannel_portC1_2.png, Etherchannel_portC1_3.png e Etherchannel_port_C1_3_2.png



```

Switch#sh etherchannel summary
Flags: D - down      P - bundled in port-channel
      I - stand-alone S - suspended
      H - Hot-standby (LACP only)
      R - Layer3       S - Layer2
      U - in use       N - not in use, no aggregation
      f - failed to allocate aggregator
      M - not in use, minimum links not met
      m - not in use, port not aggregated due to minimum links not met
      u - unsuitable for bundling
      w - waiting to be aggregated
      d - default port
      A - formed by Auto LAG

Number of channel-groups in use: 3
Number of aggregators: 3

Group Port-channel Protocol Ports
-----+-----+-----+
1   Po1(SU)     LACP    Gi0/1(P)  Gi0/2(P)
2   Po2(SU)     LACP    Gi1/1(P)  Gi1/2(P)
3   Po3(SU)     LACP    Gi2/0(P)  Gi2/1(P)  Gi2/2(P)

Switch#
    
```

Figura 16 - Output do comando Etherchannel Summary na Switch C1

```

Switch#sh etherchannel port
      Channel-group listing:
      -----
      Group: 1
      -----
          Ports in the group:
          -----
          Port: Gi0/1
          -----
          Port state = Up Mstr Assoc In-Bndl
          Channel group = 1 Mode = Active Gcchange = -
          Port-channel = Po1 GC = - Pseudo port-channel = Po1
          Port index = 0 Load = 0x00 Protocol = LACP
          Flags: S - Device is sending Slow LACPDU斯 F - Device is sending fast LACPDU斯
                  A - Device is in active mode. P - Device is in passive mode.

          Local information:
          LACP port Admin Oper Port Port
          Port Flags State Priority Key Key Number State
          Gi0/1 SA bndl 32768 0x1 0x1 0x2 0x3D

          Partner's information:
          LACP port Admin Oper Port Port
          Port Flags Priority Dev ID Age key Key Number State
          Gi0/1 SA 32768 0c87.6cf7.8000 10s 0x0 0x1 0x2 0x3D

          Age of the port in the current state: 0d:01h:21m:55s

          Port: Gi0/2
          -----
          Port state = Up Mstr Assoc In-Bndl
          Channel group = 1 Mode = Active Gcchange = -
          Port-channel = Po1 GC = - Pseudo port-channel = Po1
          Port index = 0 Load = 0x00 Protocol = LACP
          Flags: S - Device is sending Slow LACPDU斯 F - Device is sending fast LACPDU斯
                  A - Device is in active mode. P - Device is in passive mode.

          Local information:
          LACP port Admin Oper Port Port
          Port Flags State Priority Key Key Number State
          Gi0/2 SA bndl 32768 0x1 0x1 0x3 0x3D

          Partner's information:
          LACP port Admin Oper Port Port
          Port Flags Priority Dev ID Age key Key Number State
          Gi0/2 SA 32768 0c87.6cf7.8000 16s 0x0 0x1 0x3 0x3D
    
```

Figura 17 - Output do comando Etherchannel Port na Switch C1 [Po1]



```

Age of the port in the current state: 0d:01h:21m:53s

Group: 2
-----
      Ports in the group:
Port: Gi1/1
-----
Port state   = Up Mstr Assoc In-Bndl          Gcchange = -
Channel group = 2           Mode = Active
Port-channel = Po2          GC   = -
Port index   = 0           Load = 0x00          Pseudo port-channel = Po2
                           Protocol = LACP

Flags: S - Device is sending slow LACPDU斯  F - Device is sending fast LACPDU斯.
       A - Device is in active mode.          P - Device is in passive mode.

Local information:
Port     Flags    State      LACP port      Admin      Oper      Port      Port
Gi1/1    SA       bndl      32768        0x2        0x2        0x102     0x3D

Partner's information:
Port     Flags    Priority  LACP port      Admin      Oper      Port      Port
Gi1/1    SA       32768    0cid.b416.8000  17s       0x0        0x2        0x102     0x3D

Age of the port in the current state: 0d:00h:44m:58s

Port: Gi1/2
-----
Port state   = Up Mstr Assoc In-Bndl          Gcchange = -
Channel group = 2           Mode = Active
Port-channel = Po2          GC   = -
Port index   = 0           Load = 0x00          Pseudo port-channel = Po2
                           Protocol = LACP

Flags: S - Device is sending Slow LACPDU斯  F - Device is sending fast LACPDU斯.
       A - Device is in active mode.          P - Device is in passive mode.

Local information:
Port     Flags    State      LACP port      Admin      Oper      Port      Port
Gi1/2    SA       bndl      32768        0x2        0x2        0x103     0x3D

Partner's information:
Port     Flags    Priority  LACP port      Admin      Oper      Port      Port
Gi1/2    SA       32768    0cid.b416.8000  8s        0x0        0x2        0x103     0x3D

Age of the port in the current state: 0d:00h:44m:56s

```

Figura 18 - Output do comando Etherchannel Port na Switch C1 [Po2]



```

Group: 3
-----
      Ports in the group:
Port: Gi2/0
-----
Port state   = Up Mstr Assoc In-Bndl          Gcchange = -
Channel group = 3                 Mode = Active
Port-channel = Po3                GC  = -
Port index   = 0                 Load = 0x00          Pseudo port-channel = Po3
                                Protocol = LACP

Flags: S - Device is sending Slow LACPDUUs.  F - Device is sending fast LACPDUUs.
       A - Device is in active mode.          P - Device is in passive mode.

Local information:
      LACP port      Admin      Oper      Port      Port
Port   Flags  State  Priority  Key    Key  Number  State
Gi2/0  SA    bndl   32768   0x3   0x3  0x201  0x3D

Partner's information:
      LACP port      Admin      Oper      Port      Port
Port   Flags  Priority  Dev ID   Age   key  Key  Number  State
Gi2/0  SA    32768   0c7e.051c.8000 29s  0x0   0x3  0x201  0x3D

Age of the port in the current state: 0d:01h:21m:54s

Port: Gi2/1
-----
Port state   = Up Mstr Assoc In-Bndl          Gcchange = -
Channel group = 3                 Mode = Active
Port-channel = Po3                GC  = -
Port index   = 0                 Load = 0x00          Pseudo port-channel = Po3
                                Protocol = LACP

Flags: S - Device is sending Slow LACPDUUs.  F - Device is sending fast LACPDUUs.
       A - Device is in active mode.          P - Device is in passive mode.

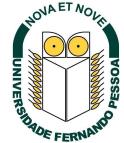
Local information:
      LACP port      Admin      Oper      Port      Port
Port   Flags  State  Priority  Key    Key  Number  State
Gi2/1  SA    bndl   32768   0x3   0x3  0x202  0x3D

Partner's information:
      LACP port      Admin      Oper      Port      Port
Port   Flags  Priority  Dev ID   Age   key  Key  Number  State
Gi2/1  SA    32768   0c7e.051c.8000 5s   0x0   0x3  0x202  0x3D

Age of the port in the current state: 0d:01h:21m:54s

Port: Gi2/2
-----
```

Figura 19 - Output do comando Etherchannel Port na Switch C1 [Po3]



```

Port: Gi2/2
-----
Port state      = Up Mstr Assoc In-Bndl
Channel group   = 3          Mode = Active           Gcchange = -
Port-channel    = Po3        GC   = -                Pseudo port-channel = Po3
Port index      = 0          Load  = 0x00            Protocol = LACP

Flags: S - Device is sending Slow LACPDU斯   F - Device is sending fast LACPDU斯
       A - Device is in active mode.          P - Device is in passive mode.

Local information:
Port      Flags     State      LACP port      Admin      Oper      Port      Port
Gi2/2    SA        bndl      Priority      Key        Key       Number     State
                  32768

Partner's information:
Port      Flags     Priority   LACP port      Dev ID      Age       Admin      Oper      Port      Port
Gi2/2    SA        32768     0c7e.051c.8000  0s         0x0       0x3        0x203    0x3D

Age of the port in the current state: 0d:01h:21m:54s

```

Figura 20 - Output do comando Etherchannel Port na Switch C1 [Po3]

- 1.6) Explicar o que acontece quando elementos do EtherChannel ficam indisponíveis. Demonstrar com casos práticos.

Uma das portas irá ficar no estado *Suspended* (s). É enviada uma notificação no terminal, a informar que uma interface física não está em modo Up ou, má configurada e irá continuamente ao longo do tempo re-enviar esta mensagem até ser corrigido.



- 1.7) Configurar o protocolo LACP no Servidor Linux2 instalando e ativando e configurando os módulos necessários. Testar a operação do LACP entre o CISCO IOS e o LINUX.

```
interfaces - /etc/network - Geany
Ficheiro Editar Procurar Ver Documento Projeto Gerar Ferramentas Ajuda
Novo Abrir Gravar Gravar tudo Copiar Colar Desfazer Refazer Localizar Localizar e substituir
interfaces x
4 source /etc/network/interfaces.d/*
5
6 # The loopback network interface
7 auto lo
8 iface lo inet loopback
9
10 auto bond0
11 iface bond0 inet manual
12     bond-slaves ens33 ens35 ens36
13 # bond-mode 4 = 802.3ad AKA LACP
14     bond-mode 4
15     bond-milmon 100
16     bond-downdelay 200
17     bond-updelay 200
18     bond-lacp-rate 1
19     bond-xmit-hash-policy layer 2
20     up ifconfig bond0 0.0.0.0 up
21
22 ### trunked interface (configured as an 802.3ad AKA LACP bond on upstream switch)
23 # split out vian 10 and vian 20 from this bond on seperate interfaces
24
25 # vlan 10
26 auto bond0.10
27 iface bond0.10 inet static
28
29     address 10.200.10.253
30     netmask 255.255.255.0
31     mtu 1500
32     gateway 10.200.10.254
33     vlan-raw-device bond0
34     post-up ifconfig bond0.10 mtu 1500
35
36 # vlan 20
37 auto bond0.20
38 iface bond0.20 inet static
39
40     address 10.200.20.253
41     netmask 255.255.255.0
42     mtu 9000
43     gateway 10.200.20.254
44     vlan-raw-device bond0
45     post-up ifconfig bond0.20 mtu 9000
46     post-up ifconfig ens33 mtu 1500 && ifconfig ens35 mtu 1500 && ifconfig ens36 mtu 1500 && ifconfig bond0 mtu 9000 && ifconfig bond0.20 9000
```

Figura 21 - Configuração das interfaces do servidor Linux

```
user@bunsenlabs:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens33: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast master bond0 state UP group default qlen 1000
    link/ether 00:0c:29:6a:f9:54 brd ff:ff:ff:ff:ff:ff
3: ens34: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast master bond0 state UP group default qlen 1000
    link/ether 00:0c:29:6a:f9:54 brd ff:ff:ff:ff:ff:ff
4: ens36: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast master bond0 state UP group default qlen 1000
    link/ether 00:0c:29:6a:f9:54 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::20c:29ff:fe:f954/64 scope link tentative noprefixroute
        valid_lft forever preferred_lft forever
5: bond0: <BROADCAST,MULTICAST,MASTER,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 00:0c:29:6a:f9:54 brd ff:ff:ff:ff:ff:ff
    inet 10.20.10.253/24 brd 10.20.10.255 scope global bond0.10
        valid_lft forever preferred_lft forever
    inet6 fe80::20c:29ff:fe:f954/64 scope link
        valid_lft forever preferred_lft forever
6: bond0.10@bond0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 00:0c:29:6a:f9:54 brd ff:ff:ff:ff:ff:ff
    inet 10.20.10.253/24 brd 10.20.10.255 scope global bond0.10
        valid_lft forever preferred_lft forever
    inet6 fe80::20c:29ff:fe:f954/64 scope link
        valid_lft forever preferred_lft forever
7: bond0.20@bond0: <NO-CARRIER,BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 00:0c:29:6a:f9:54 brd ff:ff:ff:ff:ff:ff
    inet 10.20.10.253/24 brd 10.20.10.255 scope global bond0.20
        valid_lft forever preferred_lft forever
    inet6 fe80::20c:29ff:fe:f954/64 scope link
        valid_lft forever preferred_lft forever
user@bunsenlabs:~$
```

Figura 22 - Estado das interfaces do servidor Linux

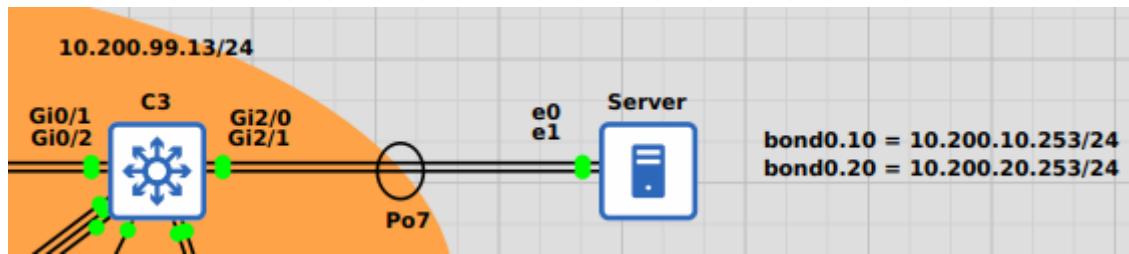


Figura 23 - Topologia GNS3 da conexão entre Switch C3 e Servidor Linux

A terminal window titled "C3" displaying the output of the "show interface Po7" command. The output shows detailed information about the port-channel, including its status, hardware type, MTU, reliability, encapsulation, and various counters and statistics over time intervals.

Figura 24 - Informação do channel-group 7 (C3 - Linux)



```

Switch# 
Switch#sh etherchannel 7 summary
Flags: D - down      P - bundled in port-channel
      I - stand-alone S - suspended
      H - Hot-standby (LACP only)
      R - Layer3       S - Layer2
      U - in use       N - not in use, no aggregation
      f - failed to allocate aggregator

      M - not in use, minimum links not met
      m - not in use, port not aggregated due to minimum links not met
      u - unsuitable for bundling
      w - waiting to be aggregated
      d - default port

      A - formed by Auto LAG

Number of channel-groups in use: 4
Number of aggregators: 4

Group Port-channel Protocol Ports
-----+-----+-----+-----+
 7    Po7(SU)      LACP     Gi2/0(P)   Gi2/1(P)

Switch#
Switch#

```

Figura 25 - Informação do channel-group 7 (C3 - Linux) [2]

- 1.8) Recorrendo ao wireshark de capturar as frames referentes ao protocolo LACP (IEEE 802.3ad) e analisar o seu conteúdo.

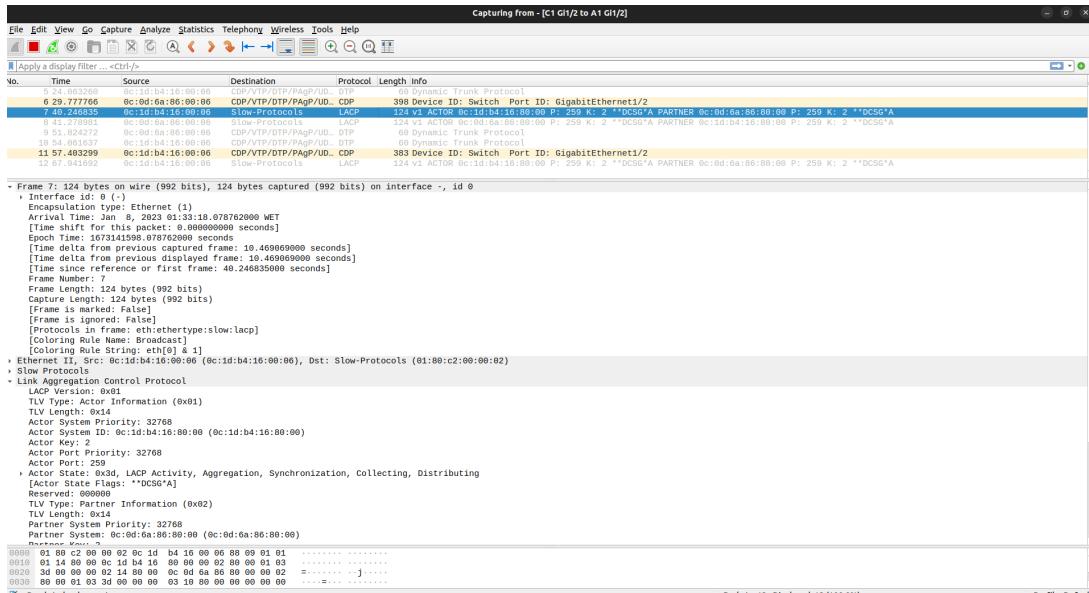


Figura 26 - Captura do Wireshark protocolo LACP

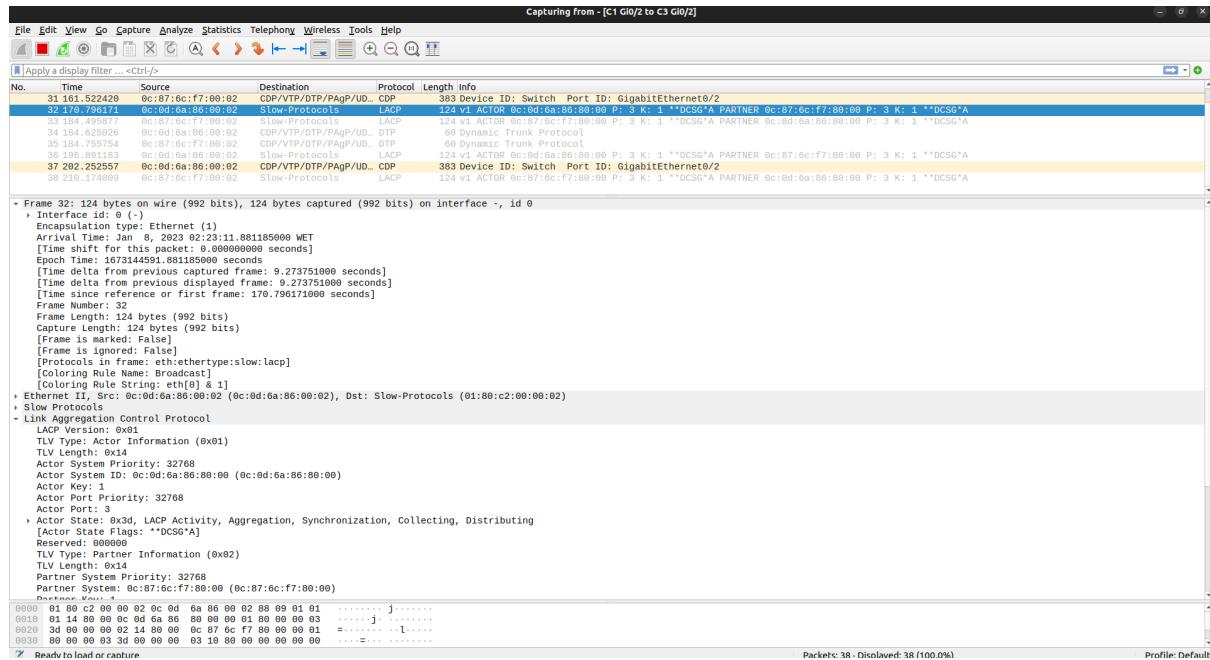


Figura 27 - Captura do Wireshark protocolo LACP [2]

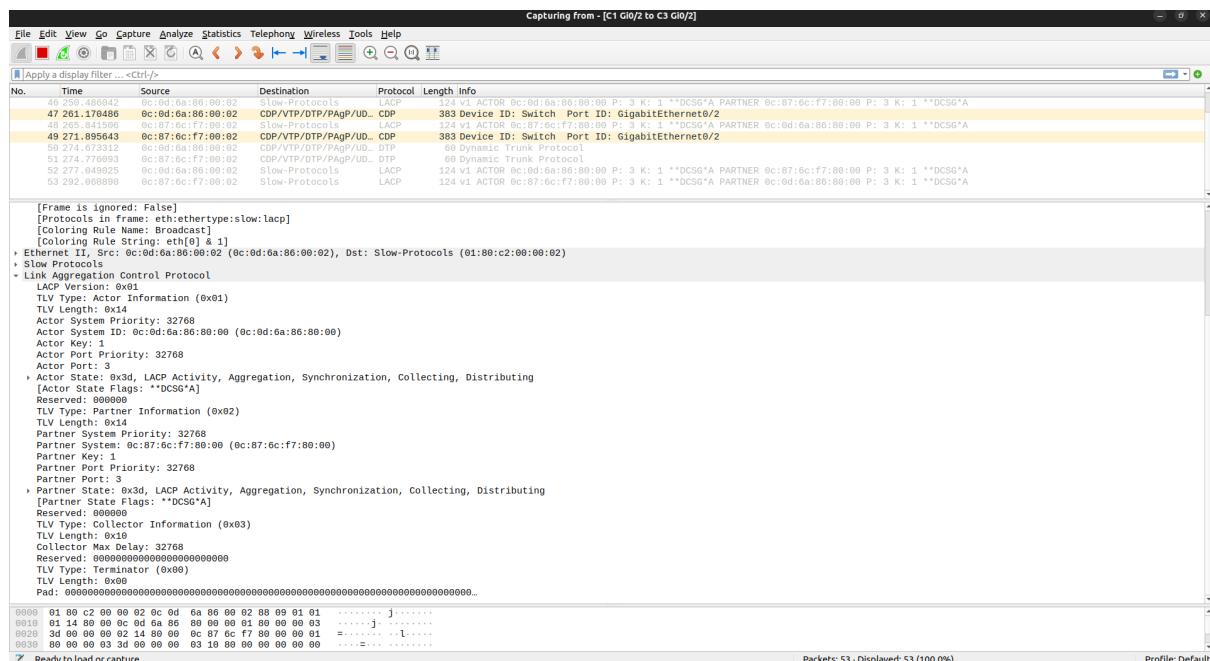


Figura 28 - Captura do Wireshark protocolo LACP [3]



- 1.9) Explorar e implementar a possibilidade de substituir C2 por um switch de outro fabricante (e.g. Arista) (LACP Multivendor)

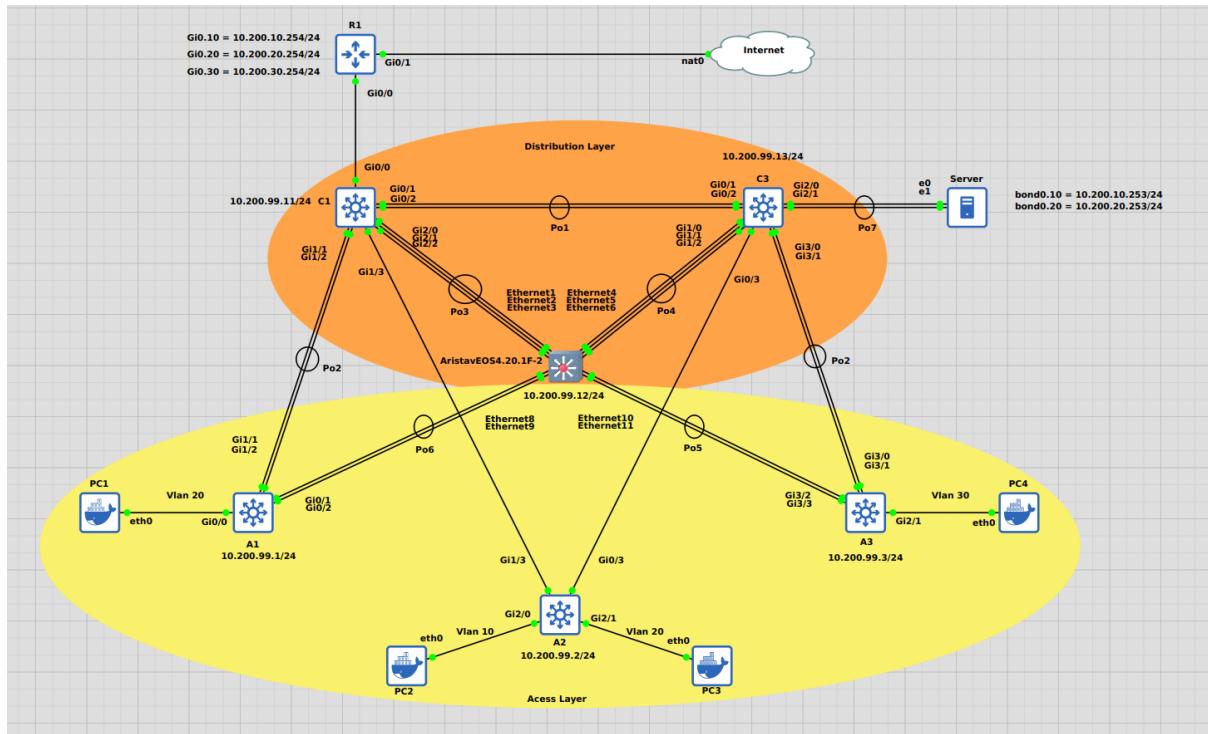


Figura 29 - Topologia do projeto com uma Switch Arista

Não é possível configurar switch port trunking, visto que as Switches da CISCO e da Arista tem interfaces físicas diferentes, nem colocar a VLAN 99 como nativa.



Grupo 2

Configurar, testar, monitorar e reparar interfaces de rede na presença de VLANs

- **2.1) Descrever o protocolo IEEE 802.1q.**

Este protocolo permite a criação de VLANs através de adição de endereços 32-bits (802.1Q Tags) nos frames de Ethernet, informando assim todos os outros dispositivos (Switches e bridges) de Data Link Layer presentes na rede.

- **2.2) Configurar interfaces em modo access e trunk de acordo com o exigido na figura 1.**

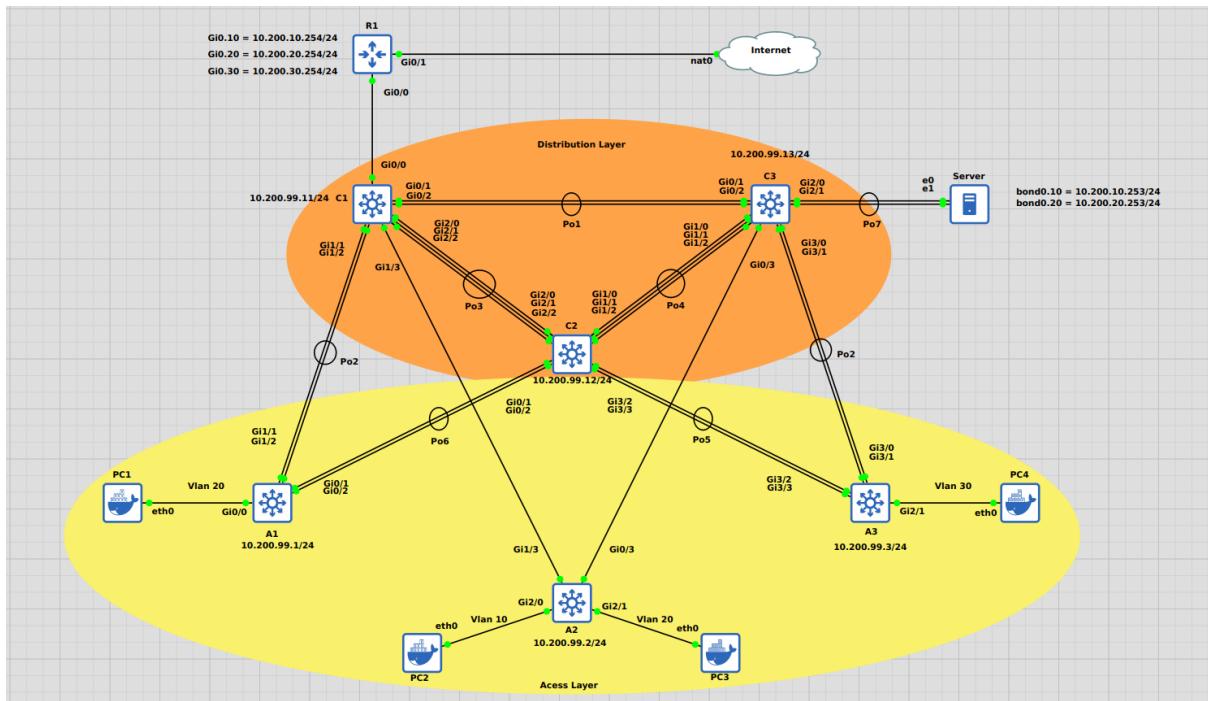


Figura 30 - Topologia do projeto



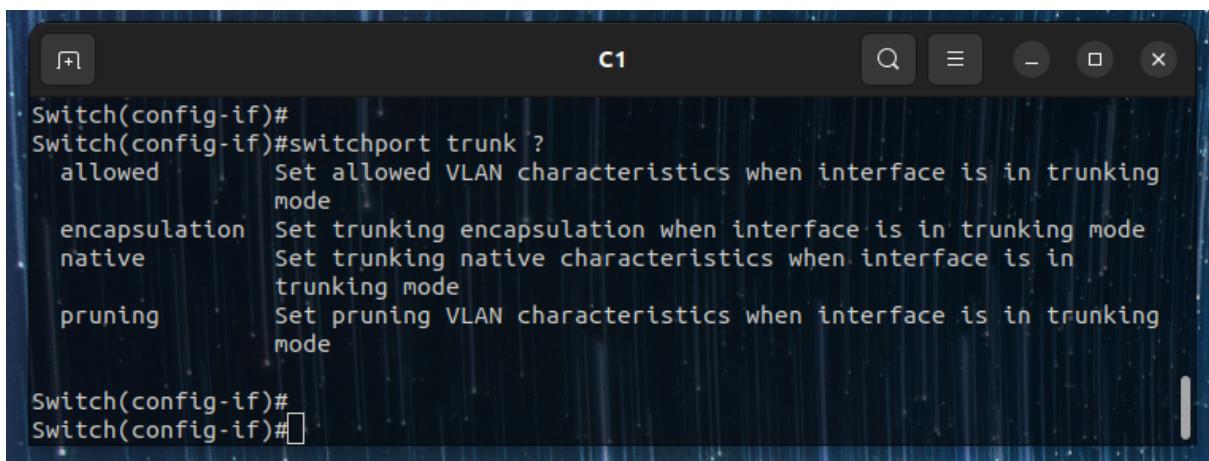
- **2.3) Descrever e testar os diferentes modos de configuração do Dynamic Trunking Protocol(DTP) (Switch (config-if)# switchport trunk ?).**

Allowed: Permite o tráfego de uma ou mais VLANs numa interface física escolhida;

Encapsulation: Permite o encapsulamento do trunk, geralmente usado com o método de encapsulation dot1Q (como configurado neste projeto)

Native: Permite definir a VLAN nativa que circula no trunk entre os dispositivos.

Pruning: Permite ativar as características de Pruning VLAN.



A screenshot of a terminal window titled 'c1'. The window shows the command 'Switch(config-if)# switchport trunk ?' followed by a list of options: 'allowed', 'encapsulation', 'native', and 'pruning'. Each option is described with its function. At the bottom of the window, there are two more command lines: 'Switch(config-if)#' and 'Switch(config-if)#'.

```
Switch(config-if)#
Switch(config-if)#switchport trunk ?
allowed      Set allowed VLAN characteristics when interface is in trunking mode
encapsulation Set trunking encapsulation when interface is in trunking mode
native       Set trunking native characteristics when interface is in trunking mode
pruning      Set pruning VLAN characteristics when interface is in trunking mode

Switch(config-if)#
Switch(config-if)#[
```

Figura 31 - Diferentes modos de Switchport trunk

- **2.4) Configurar interfaces VLAN (L3) nos Switches, Servidor Linux e no Router (“ROAS-Router On A Stick”).**

Esta configuração encontra-se presente no ficheiro GNS3_Commands.txt.



- 2.5) Estudar e implementar a possibilidade de eliminar da topologia o Router assumindo C2 esse papel recorrendo a SVIs (Switch Virtual Interfaces) e portas físicas L3 (“routed ports”)

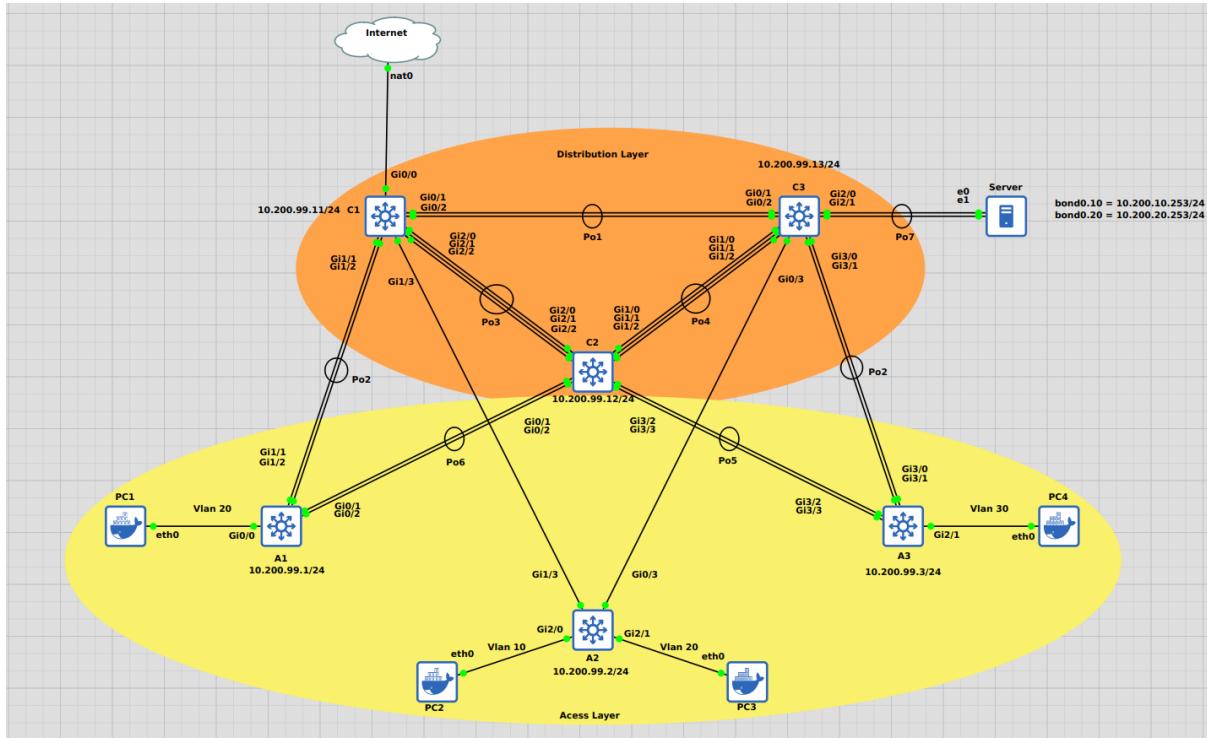


Figura 32 - Topologia em que Switch C1 age como router

Ao colocar o Switch C1 como router, é necessário ativar um modo especial neste Switch para ele fazer inter-VLAN routing, substituindo assim o Router. Para ativar este modo é preciso adicionar IP's a todas as VLAN's presentes no Switch (exceto a VLAN1, que nesta topologia não é a VLAN nativa) e de seguida, executar o comando `Ip Routing`.

- 2.6) Analisar o estado das interfaces relativamente às VLANs (`Switch#show interfaces <intf>switchport` ; `Switch#show interfaces trunk`)

Para evitar o sobre uso de imagens neste relatório, podem encontrar na pasta de “Screenshots” deste projeto as várias fotos tiradas aos estados das interface em modo trunk nos Switches A1, A2, A3, C1, C2,C3. ²

2

Trunk_A1.png, Trunk_A2.png, Trunk_A3.png, Trunk_C1.png, Trunk_C2.png, Trunk_C3.png



```

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Switch>en
Switch#sh int trunk

Port      Mode          Encapsulation  Status        Native vlan
Po2       auto          802.1q         trunking    99
Po6       on            802.1q         trunking    99

Port      Vlans allowed on trunk
Po2       1-4094
Po6       1-4094

Port      Vlans allowed and active in management domain
Po2       1,10,20,30,99
Po6       1,10,20,30,99

Port      Vlans in spanning tree forwarding state and not pruned
Po2       1,10,30,99
Po6       1,20

Switch#

```

Figura 33 - Informação das interfaces em modo trunk no Switch A1

- **2.7) Recorrendo ao wireshark capturar as frames referentes ao protocolo IEEE 802.3q e analisar o seu conteúdo**

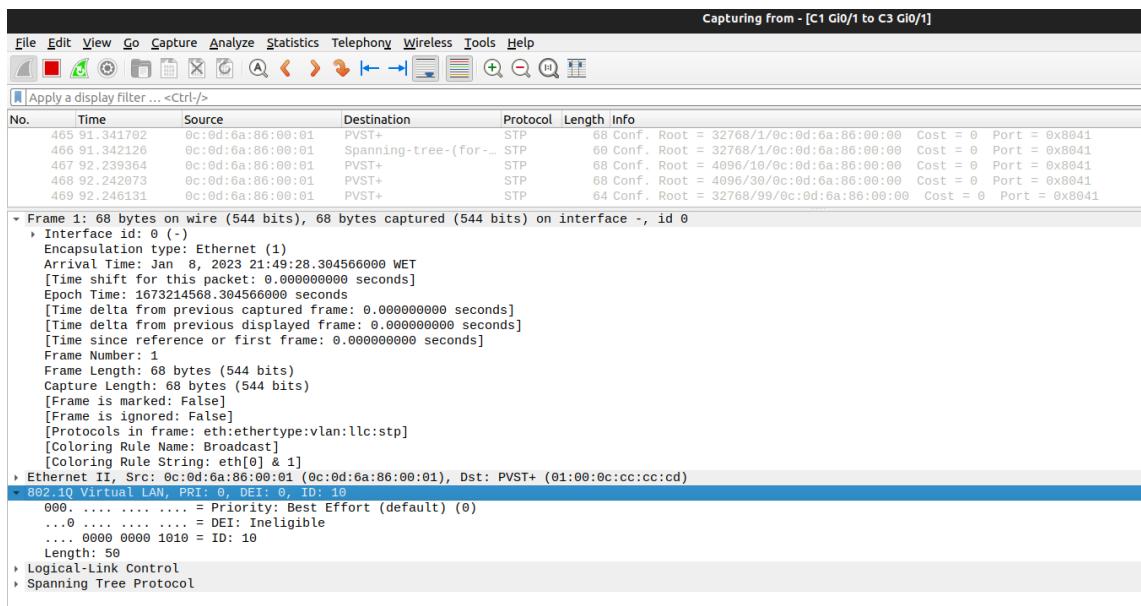


Figura 34 - Captura do Wireshark protocolo IEEE 802.3q



Grupo 3

Configurar, testar, monitorizar e reparar o protocolo VTP (Vlan Trunking Protocol)

- 3.1) Descrever os domínios, modos e diferentes anúncios do protocolo VTP

Domínio VTP: Conjunto de switches ligadas em modo trunk;

Server Mode: Contém informação sobre o nome e número de todas as VLANs presentes no VTP;

Client Mode: Recebem informações da Switch em Server mode e nunca transmite informação sobre as outras switches;

Transparent Mode: Ignora as informações recebidas sobre as outras VLANs e pode ser modificada sem afetar as outras switches.

• 3.2) Criar as VLANs necessárias:

Figura 35 - Informação das VLANs no Switch A1

Para evitar o sobre uso de imagens neste relatório, podem encontrar na pasta de "Screenshots" deste projeto as várias fotos tiradas aos estados das VLANs nos Switches A1, A2, A3, C1, C2,C3.³

3

VLANs_A1.png, VLANs_A1_2.png, VLANs_A2.png, VLANs_A3.png, VLANs_A3_2.png,
VLANs_C1.png, VLANs_C1_2.png, VLANs_C2.png, VLANs_C3.png, VLANs_C3_2.png,
VLANs_R1.png, VLANs_R1_2.png.



- 3.3)Configurar C2 como servidor VTP e os restantes switches como clientes VTP.

 A screenshot of a Cisco Switch terminal window titled "C2". The terminal displays the output of the command "sh vtp status". The output shows that VTP is enabled and running version 1 in domain "REDES". The switch is configured as a VTP server. The configuration includes details like device ID, last modified time, and MD5 digest.

```

Switch>
Switch>en
Switch#
Switch#sh vtp status
VTP Version capable      : 1 to 3
VTP version running      : 1
VTP Domain Name          : REDES
VTP Pruning Mode         : Enabled
VTP Traps Generation     : Disabled
Device ID                 : 0c7e.051c.8000
Configuration last modified by 10.200.99.12 at 1-4-23 23:48:01
Local updater ID is 10.200.99.12 on interface Vl99 (lowest numbered VLAN interface found)

Feature VLAN:
-----
VTP Operating Mode       : Server
Maximum VLANs supported locally   : 1005
Number of existing VLANs        : 9
Configuration Revision        : 5
MD5 digest                 : 0x4C 0x3F 0x83 0x64 0x0C 0x70 0xF4 0x32
                           : 0xA1 0x95 0x3F 0xCC 0x69 0xEB 0x45 0x33

Switch#
    
```

Figura 36 - Configurar o switch C2 como VTP Server

 A screenshot of a Cisco Switch terminal window titled "C3". The terminal displays the output of the command "sh vtp status". The output shows that VTP is enabled and running version 1 in domain "REDES". The switch is configured as a VTP client. The configuration includes details like device ID, last modified time, and MD5 digest.

```

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Switch>en
Switch#sh vtp status
VTP Version capable      : 1 to 3
VTP version running      : 1
VTP Domain Name          : REDES
VTP Pruning Mode         : Enabled
VTP Traps Generation     : Disabled
Device ID                 : 0c87.6cf7.8000
Configuration last modified by 10.200.99.12 at 1-4-23 23:48:01

Feature VLAN:
-----
VTP Operating Mode       : Client
Maximum VLANs supported locally   : 1005
Number of existing VLANs        : 9
Configuration Revision        : 5
MD5 digest                 : 0x4C 0x3F 0x83 0x64 0x0C 0x70 0xF4 0x32
                           : 0xA1 0x95 0x3F 0xCC 0x69 0xEB 0x45 0x33

Switch#
    
```

Figura 37 - Configurar o Switch C3 como VTP Client

Os Switches A1, A2, A3, e C1 também estão configurados como VTP Client, podem encontrá-los⁴ na pasta de screenshots.

⁴ VTP_A1.png, VTP_A2.png, VTP_A3.png, VTP_C1.png.



- 3.4) Analisar o estado do protocolo VTP (Switch#show vtp status)

Referir à Figura X e a nota de rodapé 4.

- 3.5) Discutir a importância do VTP pruning.

É importante visto que reduz tráfego desnecessário nos interfaces em modo Trunk, faz prune às VLANs que não estão com conexões ativas. E informa a rede quando existe uma configuração nova graças ao VTP Revision Number.

- 3.6) Recorrendo ao wireshark de capturar as frames referentes ao protocolo VTP e analisar o seu conteúdo.

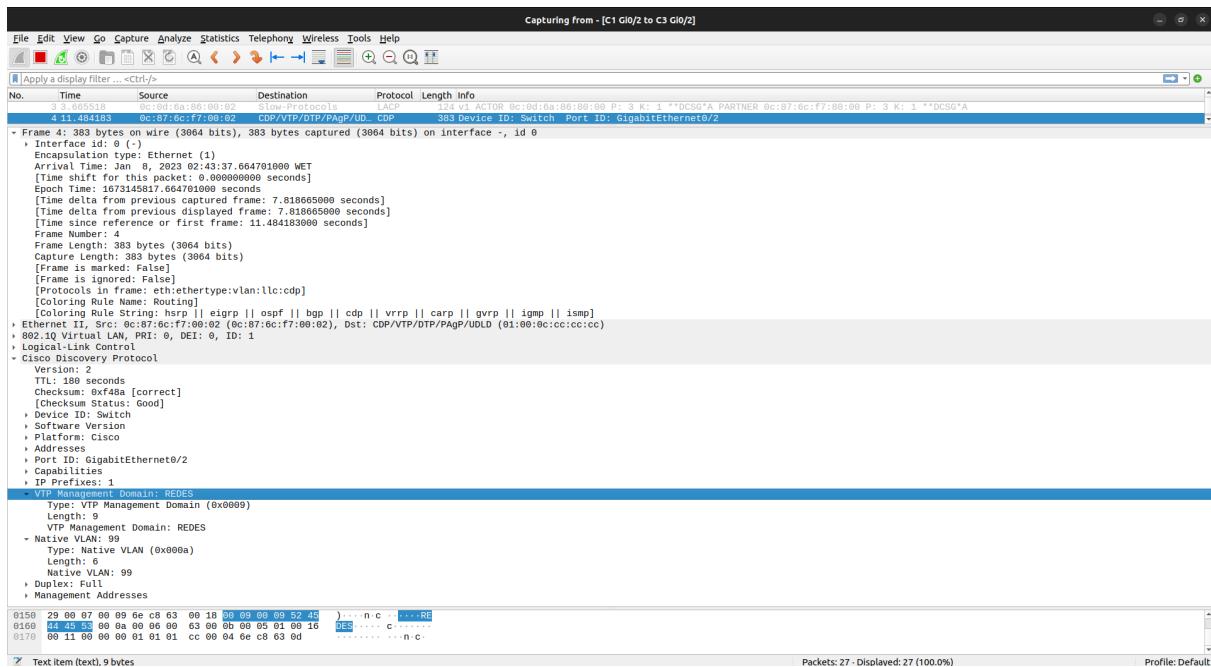


Figura 38 - Captura do Wireshark protocolo VTP



Grupo 4

Configurar, testar, monitorar e reparar o protocolo Spanning Tree (802.1D e PVST+) numa topologia de rede local

- **4.1) Descrever a operação do protocolo STP (IEEE 802.1D) e conhecer as principais diferenças para os protocolos RSTP (IEEE 802.1w), PVST+ e Rapid PVST +.**

STP (IEEE 802.1D): Permite a descoberta do caminho mais curto para a root através de uma soma total de todos os custos de cada conexão, o qual cria uma figura idêntica a uma árvore denominada por Spanning Tree. Normalmente usado por Switches e Bridges Ethernet para construir o caminho mais curto sem loop.

RSTP (IEEE 802.1w): Permite que as Switches configuradas na rede gerem os seus próprios BPDU's, em vez de esperar pela Root Bridge (Como no protocolo SPT).

PVST+: Melhoria do STP, garante um protocolo STP para cada VLAN presente na rede.

Rapid PVST+: Melhoria do PVST+, garante um protocolo 802.1W para cada VLAN presente na rede.

- **4.2) Configurar as prioridades dos Switch:**

Esta configuração encontra-se presente no ficheiro GNS3_Commands.txt



- 4.3) Analisar o estado do protocolo STP (Switch#show spanning-tree vlan <id>) para cada uma das VLANs existentes na topologia.

Para evitar o sobre uso de imagens neste relatório, podem encontrar na pasta de “Screenshots” deste projeto as várias fotos tiradas aos estados das Spanning-tree VLANs nos Switches A1, A2, A3, C1, C2,C3.⁵

```

ion of this software is expressly prohibited.

Switch>en
Switch#sh spanning-tree vlan 10

VLAN0010
  Spanning tree enabled protocol ieee
    Root ID    Priority    4106
                Address     0c0d.6a86.0000
                Cost         3
                Port        65 (Port-channel2)
                Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

    Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
                Address     0c1d.b416.0000
                Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
                Aging Time   300 sec

    Interface      Role Sts Cost      Prio.Nbr Type
    -----          --  --  --          --  --  --
    Po2            Root FWD 3          128.65  P2p
    Po6            Altn BLK 3          128.66  P2p

```

Figura 39 - Output da spanning-tree VLAN 10 no Switch A1

- 4.4) Explicar os conceitos de PortFast, UplinkFast e BackboneFast e aplicá-los na topologia indicada.

PortFast: O port passa para estado Forward, mas quando um BPDU é recebido, a porta deixa de estar no modo de PortFast e é “transformada” para o protocolo SPT para evitar Loop.

UplinkFast: Idêntico ao PortFast, mas também permite ter portas em estado de

⁵

SPT_A1_VLAN10.png, SPT_A1_VLAN20.png, SPT_A1_VLAN30.png,
 SPT_A2_VLAN10.png, SPT_A2_VLAN20.png, SPT_A2_VLAN30.png,
 SPT_A3_VLAN10.png, SPT_A3_VLAN20.png, SPT_A3_VLAN30.png,
 SPT_C1_VLAN10.png, SPT_C1_VLAN20.png, SPT_C1_VLAN30.png,
 SPT_C2_VLAN10.png, SPT_C2_VLAN20.png,
 SPT_C2_VLAN30.png, SPT_C3_VLAN10.png, SPT_C3_VLAN20.png,
 SPT_C3_VLAN30.png



Blocking além de Forwarding, caso a porta primária falhe (Estado forwarding) uma das portas Blocking passa para Forwarding.

Backbone Fast: Quando existe uma falha na porta Root/primária, este protocolo envia uma mensagem “Root Link Query” para determinar qual é o caminho mais curto para a próxima porta primária. Quando encontra, este protocolo troca imediatamente a rota velha pela nova rota.

- **4.5) Recorrendo ao wireshark de capturar os BPDUs referentes ao protocolo STP quando este converge e analisar o seu conteúdo.**

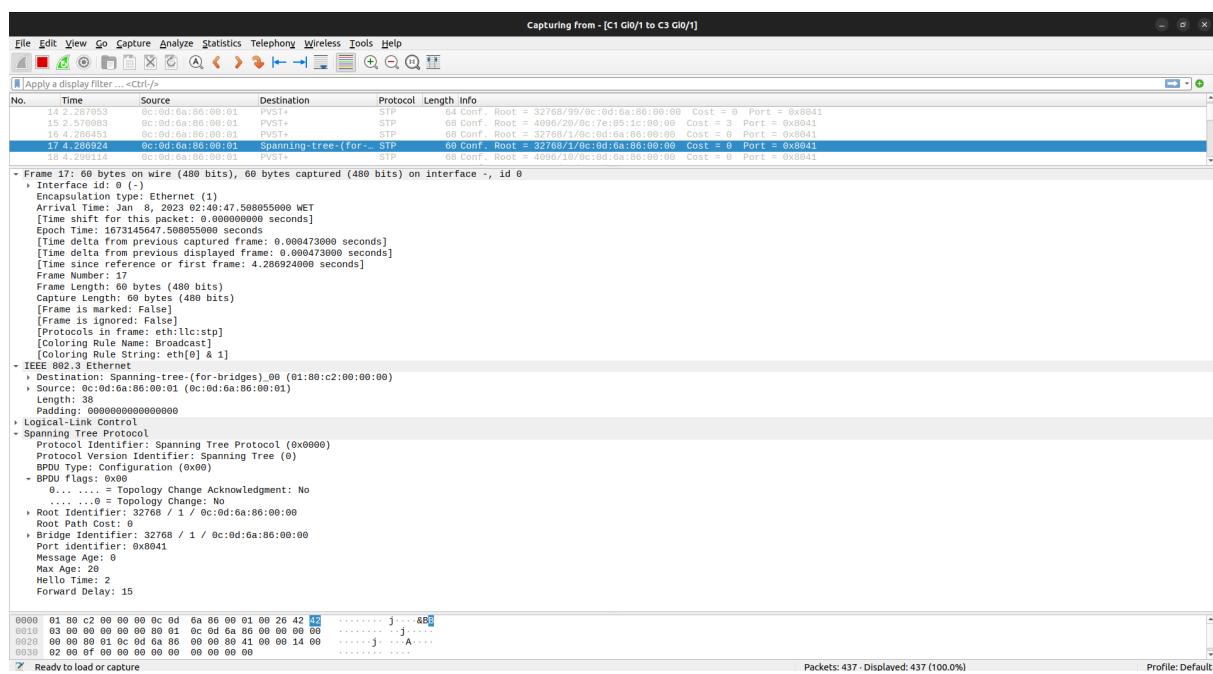


Figura 40 - Captura do Wireshark protocolo STP



Grupo 5

- 5.1) Exibir e explicar as tabelas de endereços MAC dos Switches

A screenshot of a terminal window titled "A1". The window shows the output of the command "Switch#sh mac address-table". The output displays a table of MAC addresses, their types, and the ports they are associated with. The table includes rows for VLANs 1, 20, 10, 30, 99, and a total count of 12 entries.

Vlan	Mac Address	Type	Ports
1	0c0d.6a86.0005	DYNAMIC	Po2
1	0c0d.6a86.0006	DYNAMIC	Po2
1	0c7e.051c.0001	DYNAMIC	Po6
1	0c7e.051c.0002	DYNAMIC	Po6
20	0c7e.051c.0001	DYNAMIC	Po6
10	0c0d.6a86.0006	DYNAMIC	Po2
30	0c0d.6a86.0006	DYNAMIC	Po2
99	0c0d.6a86.0005	DYNAMIC	Po2
99	0c0d.6a86.0006	DYNAMIC	Po2
99	0c7e.051c.0001	DYNAMIC	Po6
99	0c7e.051c.0002	DYNAMIC	Po6
99	0cb7.be7d.0000	DYNAMIC	Po2
Total Mac Addresses for this criterion: 12			

Figura 41 - Output dos endereços MAC do Switch A1

Para evitar o sobre uso de imagens neste relatório, podem encontrar na pasta de “Screenshots” deste projeto as várias fotos tiradas aos endereços MAC dos Switches A1, A2, A3, C1, C2,C3.⁶

⁶

MacAdresses_A1.png, MacAdresses_A2.png, MacAdresses_A3.png,
Mac_Adresses_C1.png, MacAdresses_C2.png, MacAdresses_C3.png



- 5.3) Configurar o acesso à Internet recorrendo ao dispositivo NAT do GNS3 (a operação deste protocolo está fora do âmbito do trabalho e será vista no próximo semestre).**

```

*****
Router#
Router#
Router#
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int gi0/1
Router(config-if)#ip add dhcp
Router(config-if)#
*Jan 8 19:23:11.218: %DHCP-6-ADDRESS_ASSIGN: Interface GigabitEthernet0/1 assigned
DHCP address 192.168.122.69, mask 255.255.255.0, hostname Router

Router(config-if)#duplex auto
Router(config-if)#speed auto
Router(config-if)#media-type rj45
Router(config-if)#no sh
Router(config-if)#end
Router#
*Jan 8 19:23:56.937: %SYS-5-CONFIG_I: Configured from console by console
Router#
Router#
```

Figura 42 - Configuração do router para ter acesso à internet

- 5.5) Executar testes de conectividade usando o ping e o traceroute e ser capaz de explicar o seu resultado.**

```

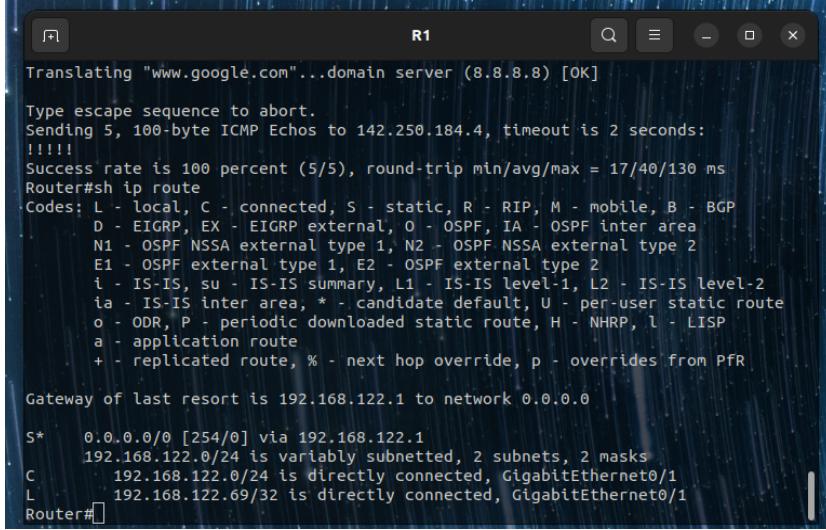
root@PC1:/# ping 10.200.30.2
PING 10.200.30.2 (10.200.30.2) 56(84) bytes of data.
64 bytes from 10.200.30.2: icmp_seq=1 ttl=63 time=5.12 ms
64 bytes from 10.200.30.2: icmp_seq=2 ttl=63 time=4.93 ms
...
root@PC1:/# traceroute 10.200.30.2
traceroute to 10.200.30.2 (10.200.30.2), 30 hops max, 60 byte packets
1 10.200.20.254 (10.200.20.254) 3.056 ms 3.655 ms 3.751 ms
2 10.200.30.2 (10.200.30.2) 8.092 ms 8.095 ms 8.094 ms
root@PC1:/# 
```



```

root@PC4:/# ping 10.200.20.1
PING 10.200.20.1 (10.200.20.1) 56(84) bytes of data.
64 bytes from 10.200.20.1: icmp_seq=1 ttl=63 time=0.31 ms
64 bytes from 10.200.20.1: icmp_seq=2 ttl=63 time=4.08 ms
...
root@PC4:/# traceroute 10.200.20.1
traceroute to 10.200.20.1 (10.200.20.1), 30 hops max, 60 byte packets
1 10.200.30.254 (10.200.30.254) 3.528 ms 3.520 ms 4.477 ms
2 10.200.20.1 (10.200.20.1) 6.139 ms 6.142 ms 6.608 ms
root@PC4:/# 
```

Figura 43 - Ping e traceroute entre PC4 e PC1



A terminal window titled "R1" showing the output of a ping command. The output includes escape sequences, route codes, and specific route entries for 0.0.0.0/0 and 192.168.122.0/24.

```
R1
Translating "www.google.com"...domain server (8.8.8.8) [OK]
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 142.250.184.4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 17/40/130 ms
Router#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      a - application route
      + - replicated route, % - next hop override, p - overrides from PFR

Gateway of last resort is 192.168.122.1 to network 0.0.0.0

S*   0.0.0.0/0 [254/0] via 192.168.122.1
     192.168.122.0/24 is varably subnetted, 2 subnets, 2 masks
C     192.168.122.0/24 is directly connected, GigabitEthernet0/1
L     192.168.122.69/32 is directly connected, GigabitEthernet0/1
Router#
```

Figura 45 - Ping do Router para www.google.com