

Сетевые технологии

Лабораторная работа №5

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Цели и задачи работы

Цель лабораторной работы

Построение простейших моделей сети в **GNS3**: - сеть на базе **Ethernet-коммутатора** и двух VPCS - сеть на базе маршрутизатора **FRR** + коммутатор + VPCS - сеть на базе маршрутизатора **VyOS** + коммутатор + VPCS

Дополнительно: - захват и анализ трафика в **Wireshark** - изучение протоколов **ARP** и **ICMP**, а также режимов эхо-запросов **ICMP/UDP/TCP**

Ход выполнения работы

Топология (коммутатор + 2 ПК)

- Коммутатор: msk-elsaiedadel-sw-01
- Узлы: PC1-elsaiedadel, PC2-elsaiedadel
- Соединение VPCS ↔ switch, отображение интерфейсов включено

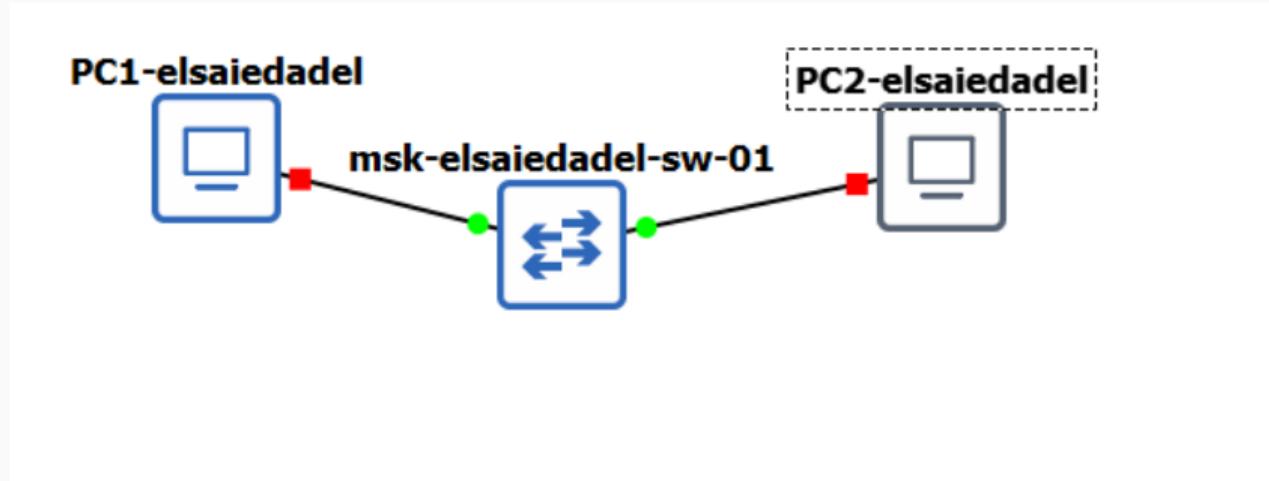


Рис. 1: Топология сети на базе коммутатора

Настройка VPCS и проверка связи

- На VPCS просмотрена справка команд (проверка синтаксиса)
- Задана IP-адресация в 192.168.1.0/24

```
For more information, please visit wiki.freecode.com.cn.

Press '?' to get help.

Executing the startup file

Hostname is too long. (Maximum 12 characters)

VPCS> ?

?

arp Print help
      Shortcut for: show arp. Show arp table
clear ARG Clear IPv4/IPv6, arp/neighbor cache, command history
dhcp [OPTION] Shortcut for: ip dhcp. Get IPv4 address via DHCP
disconnect Exit the telnet session (daemon mode)
echo TEXT Display TEXT in output. See also set echo ?
help Print help
history Shortcut for: show history. List the command history
ip ARG ... [OPTION] Configure the current VPC's IP settings. See ip ?
load [FILENAME] Load the configuration/script from the file FILENAME
ping HOST [OPTION ...] Ping HOST with ICMP (default) or TCP/UDP. See ping ?
quit Quit program
relay ARG ... Configure packet relay between UDP ports. See relay ?
rlogin [ip] port Telnet to port on host at ip (relative to host PC)
save [FILENAME] Save the configuration to the file FILENAME
set ARG ... Set VPC name and other options. Try set ?
show [ARG ...] Print the information of VPCs (default). See show ?
```

Настройка VPCS и проверка связи

- Связность проверена ping между узлами

```
Press '?' to get help.

Executing the startup file

Hostname is too long. (Maximum 12 characters)

VPCS> ip 192.168.1.12/24 192.168.1.1
Checking for duplicate address...
VPCS : 192.168.1.12 255.255.255.0 gateway 192.168.1.1

VPCS> save
Saving startup configuration to startup.vpc
. done

VPCS> ping 192.168.1.11

84 bytes from 192.168.1.11 icmp_seq=1 ttl=64 time=0.871 ms
84 bytes from 192.168.1.11 icmp_seq=2 ttl=64 time=1.056 ms
84 bytes from 192.168.1.11 icmp_seq=3 ttl=64 time=1.669 ms
84 bytes from 192.168.1.11 icmp_seq=4 ttl=64 time=0.939 ms
```

Запуск захвата и ARP (Gratuitous ARP)

- Захват включён на линии PC1 ↔ switch
- При старте узлов фиксируются ARP-кадры
- Наблюдаются **Gratuitous ARP** для объявления адреса и проверки конфликтов

No.	Time	Source	Destination	Protocol	Length Info
1	0.000000	::	ff02::2	ICMPv6	62 Router Solicitation
2	0.000455	::	ff02::2	ICMPv6	62 Router Solicitation
3	0.050452	Private_66:68:00	Broadcast	ARP	64 Gratuitous ARP for 192.168.1.11 (Request)
4	0.051247	Private_66:68:01	Broadcast	ARP	64 Gratuitous ARP for 192.168.1.12 (Request)
5	1.050677	Private_66:68:00	Broadcast	ARP	64 Gratuitous ARP for 192.168.1.11 (Request)
6	1.051621	Private_66:68:01	Broadcast	ARP	64 Gratuitous ARP for 192.168.1.12 (Request)

Frame 3: Packet, 64 bytes on wire (512 bits), 64 bytes captured (512 bits) on interface -, id 0
Ethernet II, Src: Private_66:68:00 (00:50:79:66:68:00), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
Destination: Broadcast (ff:ff:ff:ff:ff:ff)
Source: Private_66:68:00 (00:50:79:66:68:00)
Type: ARP (0x0806)
[Stream index: 2]
Padding: 00000000000000000000000000000000
Frame check sequence: 0x00000000 [unverified]
[FCS Status: Unverified]
Address Resolution Protocol (request/gratuitous ARP)
Hardware type: Ethernet (1)
Protocol type: IPv4 (0x0800)
Hardware size: 6
Protocol size: 4
Opcode: request (1)
[Is gratuitous: True]
Sender MAC address: Private_66:68:00 (00:50:79:66:68:00)
Sender IP address: 192.168.1.11
Target MAC address: Broadcast (ff:ff:ff:ff:ff:ff)

ICMP Echo (ping) – запрос и ответ

- С PC2 отправлен одиночный ICMP Echo на PC1
- В Wireshark видны Echo Request и Echo Reply
- Подтверждена корректная доставка и ответ

```
VPCS> ping 192.168.1.11 -c 1
84 bytes from 192.168.1.11 icmp_seq=1 ttl=64 time=1.102 ms

VPCS> ping 192.168.1.11 -c 1 -2
84 bytes from 192.168.1.11 udp_seq=1 ttl=64 time=2.097 ms

VPCS> ping 192.168.1.11 -c 1 -3
Connect    7@192.168.1.11 seq=1 ttl=64 time=2.787 ms
SendData   7@192.168.1.11 seq=1 ttl=64 time=2.414 ms
Close      7@192.168.1.11 seq=1 ttl=64 time=3.997 ms

VPCS> █
```

Рис. 5: ICMP эхо-запрос и ответ

Эхо-запрос в UDP-режиме

- Выполнен одиночный эхо-запрос в UDP-режиме
- В трафике видны заголовки Ethernet/IPv4/UDP и полезная нагрузка

No.	Time	Source	Destination	Protocol	Length	Info
7	2.051224	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.11
8	2.052481	Private_66:68:01	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.12
9	85.152503	Private_66:68:01	Broadcast	ARP	64	Who has 192.168.1.11? Tell 192.1
10	85.153038	Private_66:68:00	Private_66:68:01	ARP	64	192.168.1.11 is at 00:50:79:66:6
→ 11	85.155007	192.168.1.12	192.168.1.11	ICMP	98	Echo (ping) request id=0x0732,
← 12	85.155574	192.168.1.11	192.168.1.12	ICMP	98	Echo (ping) reply id=0x0732,

Frame 11: Packet, 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0
Ethernet II, Src: Private_66:68:01 (00:50:79:66:68:01), Dst: Private_66:68:00 (00:50:79:66:68:00)
 ↳ Destination: Private_66:68:00 (00:50:79:66:68:00)
 ↳ Source: Private_66:68:01 (00:50:79:66:68:01)
 Type: IPv4 (0x0800)
 [Stream index: 4]
 Internet Protocol Version 4, Src: 192.168.1.12, Dst: 192.168.1.11
 0100 = Version: 4
 0101 = Header Length: 20 bytes (5)
 Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 84
 Identification: 0x3207 (12807)
 000. = Flags: 0x0
 ...0 0000 0000 0000 = Fragment Offset: 0
 Time to Live: 64
 Protocol: ICMP (1)
 Header Checksum: 0xc53a [validation disabled]
 [Header checksum status: Unverified]
 Source Address: 192.168.1.12
 Destination Address: 192.168.1.11
 [Stream index: 0]
 Internet Control Message Protocol
 Type: Echo (ping) request (8)

Эхо-запрос в TCP-режиме

- Выполнен одиничный эхо-запрос в TCP-режиме
- В трафике наблюдается установление соединения (SYN/SYN-ACK/ACK), передача данных и завершение

10	85.153038	Private_66:68:00	Private_66:68:01	ARP	64	192.168.1.11 is at 00:50:79:66:00:00
11	85.155007	192.168.1.12	192.168.1.11	ICMP	98	Echo (ping) request id=0x0732, 00:50:79:66:00:00
12	85.155574	192.168.1.11	192.168.1.12	ICMP	98	Echo (ping) reply id=0x0732, 00:50:79:66:00:00
13	92.696887	192.168.1.12	192.168.1.11	ECHO	98	Request 00:50:79:66:00:00
14	92.697936	192.168.1.11	192.168.1.12	ECHO	98	Response 00:50:79:66:00:00

Frame 13: Packet, 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0
Ethernet II, Src: Private_66:68:01 (00:50:79:66:68:01), Dst: Private_66:68:00 (00:50:79:66:68:00)
Internet Protocol Version 4, Src: 192.168.1.12, Dst: 192.168.1.11
 0100 = Version: 4
 0101 = Header Length: 20 bytes (5)
 Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 84
 Identification: 0x320f (12815)
 000. = Flags: 0x0
 ...0 0000 0000 0000 = Fragment Offset: 0
 Time to Live: 64
 Protocol: UDP (17)
 Header Checksum: 0xc522 [validation disabled]
 [Header checksum status: Unverified]
 Source Address: 192.168.1.12
 Destination Address: 192.168.1.11
 [Stream index: 0]
User Datagram Protocol, Src Port: 25338, Dst Port: 7
 Source Port: 25338
 Destination Port: 7
 Length: 64

Топология (FRR + switch + ПК)

- PC1-elsaiedadel \leftrightarrow msk-elsaiedadel-sw-01 \leftrightarrow msk-elsaiedadel-gw-01
- Захват трафика включён на линии switch \leftrightarrow FRR

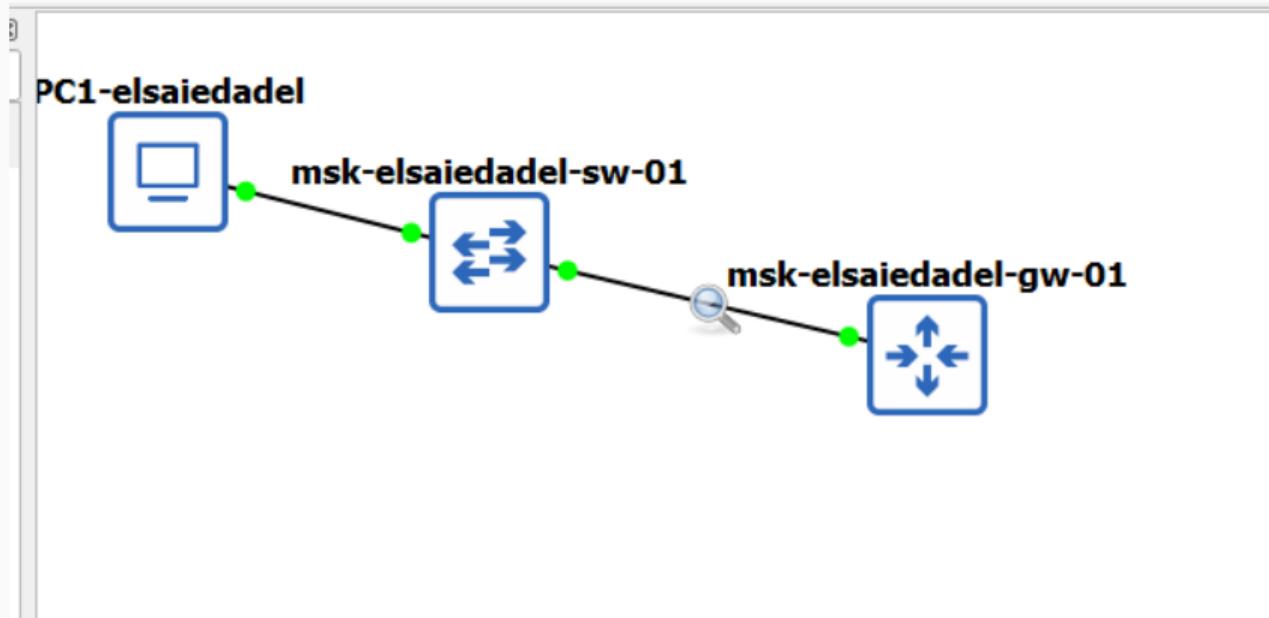


Рис. 8: Топология сети с FRR

Настройка IP на PC1

- Адрес узла: 192.168.1.10/24
- Шлюз: 192.168.1.1
- Конфигурация сохранена, параметры проверены

```
VPCS>
VPCS> ip 192.168.1.10/24 192.168.1.1
Checking for duplicate address...
VPCS : 192.168.1.10 255.255.255.0 gateway 192.168.1.1
```

```
VPCS> save
Saving startup configuration to startup.vpc
. done
```

```
VPCS> show ip

NAME      : VPCS [1]
IP/MASK   : 192.168.1.10/24
GATEWAY   : 192.168.1.1
DNS       :
MAC       : 00:50:79:66:68:00
LPORT     : 10004
```

Настройка FRR (eth0 = 192.168.1.1/24)

- Установлен hostname: msk-elsaiedadel-gw-01
- На eth0 задан адрес 192.168.1.1/24
- Конфигурация сохранена

```
* Seeding 256 bits and crediting
* Saving 256 bits of creditable seed for next boot
* Starting busybox acpid ... [ ok ]
* Starting busybox crond ... [ ok ]
Started watchfrr
* Starting sshd ... [ ok ]

Hello, this is FRRouting (version 8.2.2).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

frr# configure terminal
frr(config)# hostname msk-elsaiedadel-gw-01
msk-elsaiedadel-gw-01(config)# interface eth0
msk-elsaiedadel-gw-01(config-if)# ip address 192.168.1.1/24
msk-elsaiedadel-gw-01(config-if)# no shutdown
msk-elsaiedadel-gw-01(config-if)# exit
```

Проверка конфигурации FRR

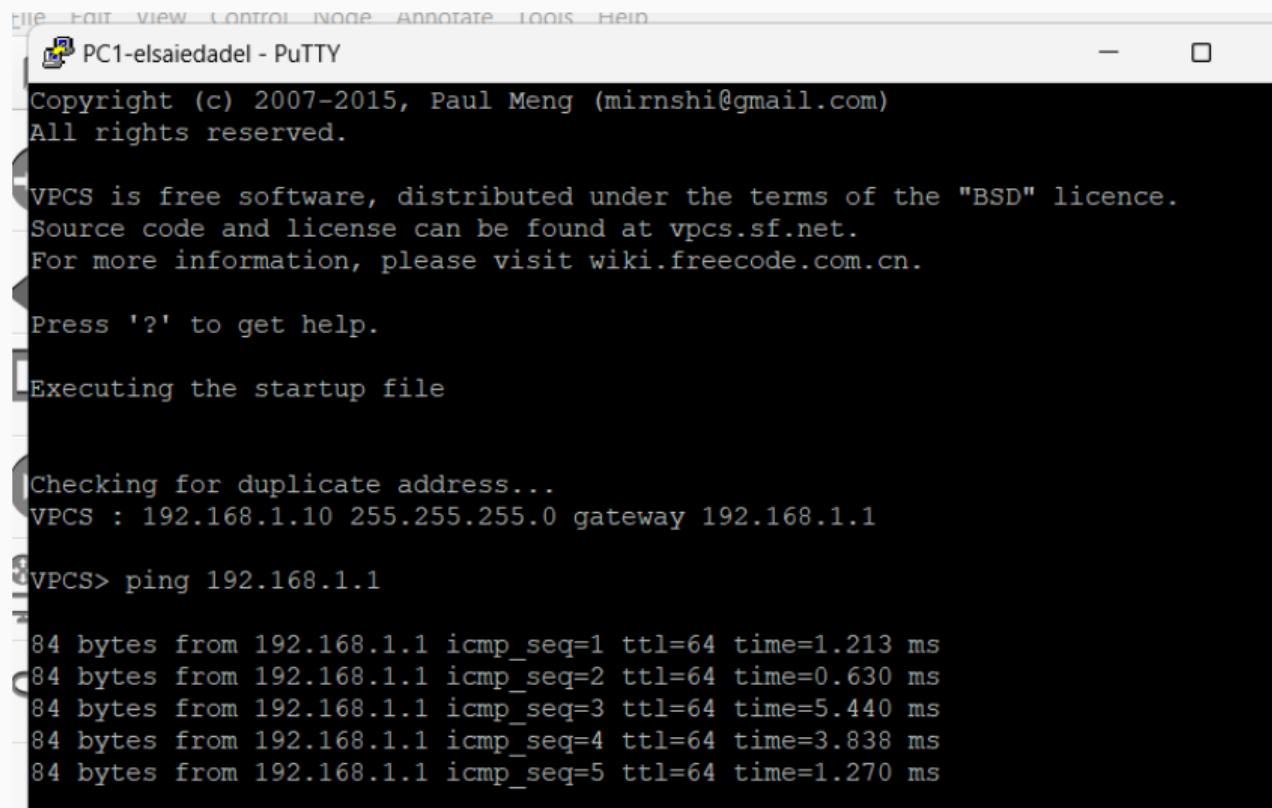
- Просмотр конфигурации и статуса интерфейсов
- Подтверждено состояние интерфейса `eth0` (`up`) и корректный адрес

```
msk-elsaiedadel-gw-01# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-elsaiedadel-gw-01
service integrated-vtysh-config
!
interface eth0
 ip address 192.168.1.1/24
exit
!
end
msk-elsaiedadel-gw-01# show interface brief
Interface      Status    VRF          Addresses
-----        -----    ---          -----
eth0           up       default      192.168.1.1/24
eth1           down     default
eth2           down     default
eth3           down     default
eth4           down     default
eth5           down     default
```

Проверка связи и анализ трафика

- С PC1 выполнен ping на 192.168.1.1



The screenshot shows a PuTTY terminal window titled "PC1-elsaiedadel - PuTTY". The window displays the following text:

```
File Edit View Control Node Annotate Tools Help
PC1-elsaiedadel - PuTTY
Copyright (c) 2007-2015, Paul Meng (mirnshi@gmail.com)
All rights reserved.

VPCS is free software, distributed under the terms of the "BSD" licence.
Source code and license can be found at vpcs.sf.net.
For more information, please visit wiki.freecode.com.cn.

Press '?' to get help.

Executing the startup file

Checking for duplicate address...
VPCS : 192.168.1.10 255.255.255.0 gateway 192.168.1.1

VPCS> ping 192.168.1.1

84 bytes from 192.168.1.1 icmp_seq=1 ttl=64 time=1.213 ms
84 bytes from 192.168.1.1 icmp_seq=2 ttl=64 time=0.630 ms
84 bytes from 192.168.1.1 icmp_seq=3 ttl=64 time=5.440 ms
84 bytes from 192.168.1.1 icmp_seq=4 ttl=64 time=3.838 ms
84 bytes from 192.168.1.1 icmp_seq=5 ttl=64 time=1.270 ms
```

Проверка связи и анализ трафика

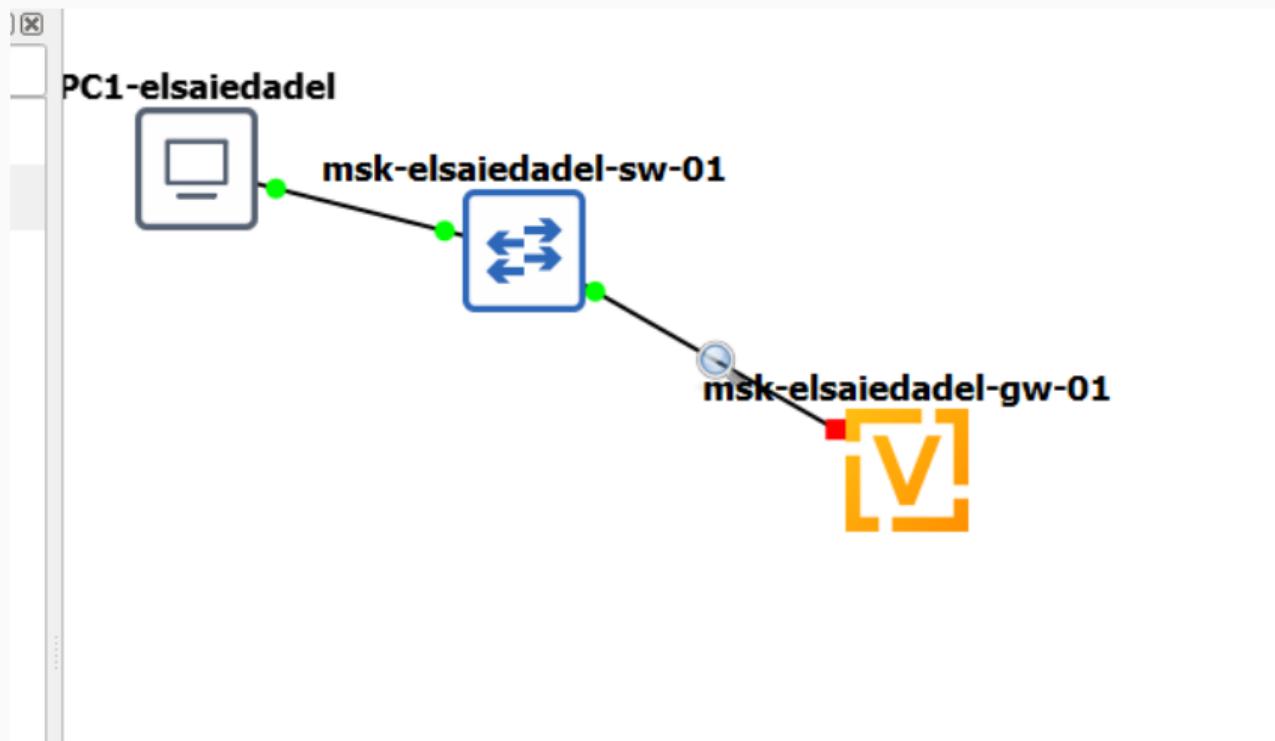
- В Wireshark фиксируются ARP и ICMP пакеты между узлом и маршрутизатором

No.	Time	Source	Destination	Protocol	Length Info
13	60.643285	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0x9235, seq=1
→ 14	61.645727	192.168.1.10	192.168.1.1	ICMP	98 Echo (ping) request id=0x9335, seq=2
← 15	61.649834	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0x9335, seq=1
16	62.651770	192.168.1.10	192.168.1.1	ICMP	98 Echo (ping) request id=0x9435, seq=2
17	62.654052	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0x9435, seq=1
18	63.655827	192.168.1.10	192.168.1.1	ICMP	98 Echo (ping) request id=0x9535, seq=2
19	63.656692	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0x9535, seq=1
20	64.645455	0c:52:ae:e5:00:00	Private_66:68:00	ARP	60 Who has 192.168.1.10? Tell 192.168.1.10
21	64.647251	Private_66:68:00	0c:52:ae:e5:00:00	ARP	60 192.168.1.10 is at 00:50:79:66:68

Frame 14: Packet, 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0
Ethernet II, Src: Private_66:68:00 (00:50:79:66:68:00), Dst: 0c:52:ae:e5:00:00 (0c:52:ae:e5:00:00)
Internet Protocol Version 4, Src: 192.168.1.10, Dst: 192.168.1.1
 0100 = Version: 4
 0101 = Header Length: 20 bytes (5)
 Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
 Total Length: 84
 Identification: 0x3593 (13715)
 000. = Flags: 0x0
 ...0 0000 0000 0000 = Fragment Offset: 0
 Time to Live: 64
 Protocol: ICMP (1)
 Header Checksum: 0xc1ba [validation disabled]
 [Header checksum status: Unverified]
 Source Address: 192.168.1.10
 Destination Address: 192.168.1.1
 [Stream index: 0]
Internet Control Message Protocol
 Type: Echo (ping) request (8)
 Code: 0
 Checksum: 0x8cd3 [correct]
 [Checksum Status: Good]

Топология (VyOS + switch + ПК)

- PC1-elsaiedadel \leftrightarrow msk-elsaiedadel-sw-01 \leftrightarrow msk-elsaiedadel-gw-01
- Захват трафика включён на линии switch \leftrightarrow VyOS



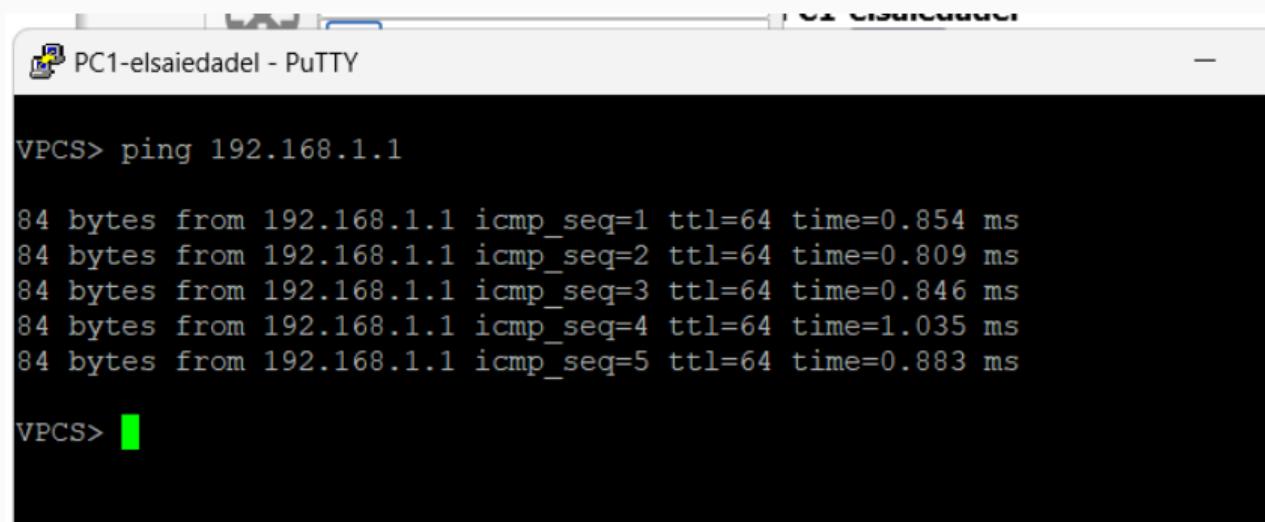
Настройка IP на PC1

- Адрес узла: 192.168.1.10/24
- Шлюз: 192.168.1.1
- Конфигурация сохранена и проверена

```
vyos@vyos# compare
[edit interfaces ethernet eth0]
-address dhcp
+address 192.168.1.1/24
[edit system]
>host-name msk-elsaiedadel-gw-01
[edit]
vyos@vyos# commit
[edit]
vyos@vyos# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@vyos# show interfaces
ethernet eth0 {
    address 192.168.1.1/24
    hw-id 0c:4b:7e:61:00:00
}
ethernet eth1 {
    hw-id 0c:4b:7e:61:00:01
}
```

Настройка VyOS (host-name и eth0)

- В режиме конфигурирования:
 - host-name: msk-elsaiedadel-gw-01
 - eth0: 192.168.1.1/24
- Изменения применены `commit` и сохранены `save`
- Проверены интерфейсы (`show interfaces`)



```
VPCS> ping 192.168.1.1

84 bytes from 192.168.1.1 icmp_seq=1 ttl=64 time=0.854 ms
84 bytes from 192.168.1.1 icmp_seq=2 ttl=64 time=0.809 ms
84 bytes from 192.168.1.1 icmp_seq=3 ttl=64 time=0.846 ms
84 bytes from 192.168.1.1 icmp_seq=4 ttl=64 time=1.035 ms
84 bytes from 192.168.1.1 icmp_seq=5 ttl=64 time=0.883 ms

VPCS>
```

Проверка связи и анализ трафика

- С PC1 выполнен ping на 192.168.1.1
- В Wireshark наблюдаются ARP и ICMP кадры при установлении взаимодействия

No.	Time	Source	Destination	Protocol	Length Info	
25	188.831013	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0xd636, seq 0000	
26	189.832197	192.168.1.10	192.168.1.1	ICMP	98 Echo (ping) request id=0xd736, seq 0010	
27	189.832773	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0xd736, seq 0020	
28	190.834209	192.168.1.10	192.168.1.1	ICMP	98 Echo (ping) request id=0xd836, seq 0030	Frame 28: Packet, 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0
29	190.834814	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0xd836, seq 0040	Ethernet II, Src: Private_66:68:00 (00:50:79:66:68:00), Dst: 0c:4b:7e:61:00:00 (0c:4b:7e:61:00:00)
30	191.835760	192.168.1.10	192.168.1.1	ICMP	98 Echo (ping) request id=0xd936, seq 0050	Internet Protocol Version 4, Src: 192.168.1.10, Dst: 192.168.1.1
31	191.836345	192.168.1.1	192.168.1.10	ICMP	98 Echo (ping) reply id=0xd936, seq 0060	0100 = Version: 4
32	193.273141	0c:4b:7e:61:00:00	Private_66:68:00	ARP	60 Who has 192.168.1.10? Tell 192.168.1.1 0101 = Header Length: 20 bytes (5)
33	193.273415	Private_66:68:00	0c:4b:7e:61:00:00	ARP	60 192.168.1.10 is at 00:50:79:66:68:00	> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
						Total Length: 84
						Identification: 0x36d8 (14040)
						> 000. = Flags: 0x0
						...0 0000 0000 0000 = Fragment Offset: 0
						Time to Live: 64
						Protocol: ICMP (1)
						Header Checksum: 0xc075 [validation disabled]
						[Header checksum status: Unverified]
						Source Address: 192.168.1.10
						Destination Address: 192.168.1.1
						[Stream index: 1]
				Internet Control Message Protocol		
				Type: Echo (ping) request (8)		
				Code: 0		
				Checksum: 0x47d1 [correct]		

Итоги

- Построены и проверены три простые модели сети в GNS3:
 - коммутатор + 2 VPCS
 - FRR + коммутатор + VPCS
 - VyOS + коммутатор + VPCS
- Настроена IP-адресация в **192.168.1.0/24**, проверена связность ping
- Выполнен захват и анализ трафика в **Wireshark**
- На практике изучены:
 - ARP (включая Gratuitous ARP)
 - ICMP Echo Request/Reply
 - особенности эхо-запросов в режимах ICMP/UDP/TCP