

Сетевые технологии

Двойной стек IPv4/IPv6. Анализ трафика в GNS3

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Цель работы

Основная цель

Построение сети с маршрутизаторами FRR и VyOS в GNS3, настройка двойного стека IPv4 и IPv6, анализ трафика в Wireshark.

Разбиение адресного пространства

- Разбивка **172.16.20.0/24** на подсети с VLSM:
 - **/25** → 126 хостов
 - **/26** → 62 хоста
 - **/26** → 62 хоста
- Пример:

172.16.20.0/25 – диапазон **172.16.20.1–126**

- Исходная сеть: `2001:db8:c0de::/48`
- Разбиение:
 - по Subnet ID → две сети `/49`
 - по Interface ID → два диапазона `/65`

Построение сети в GNS3

Топология

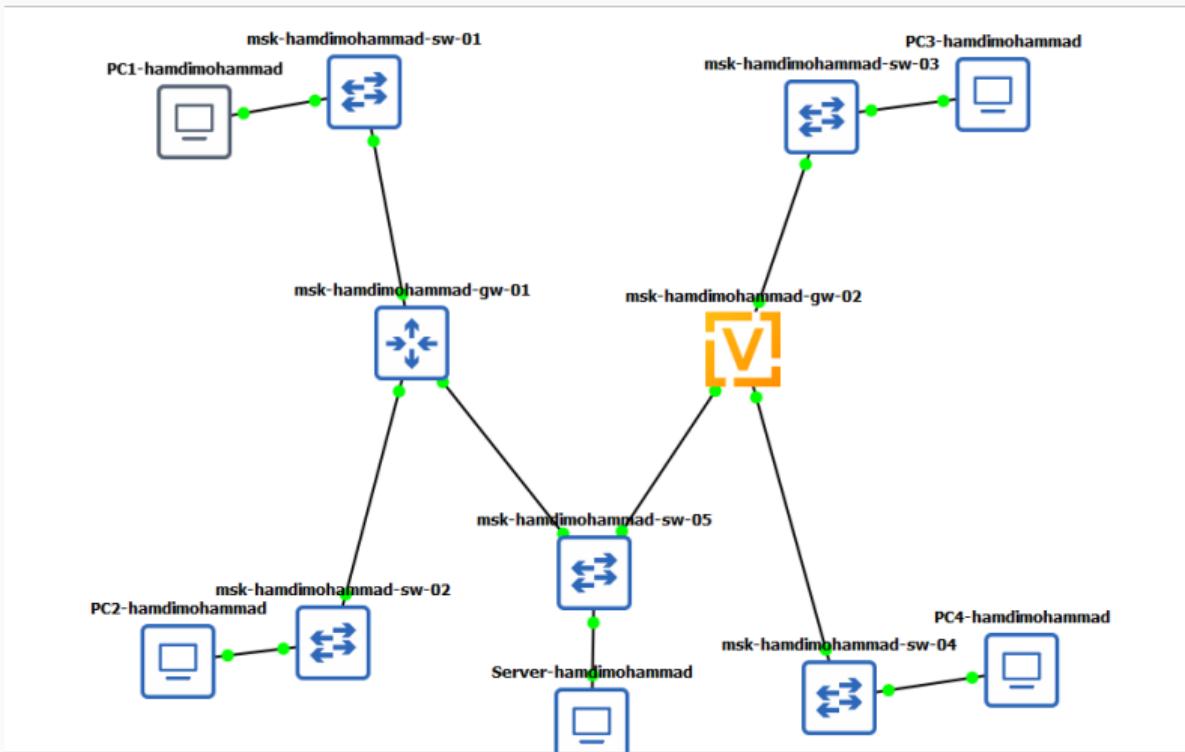
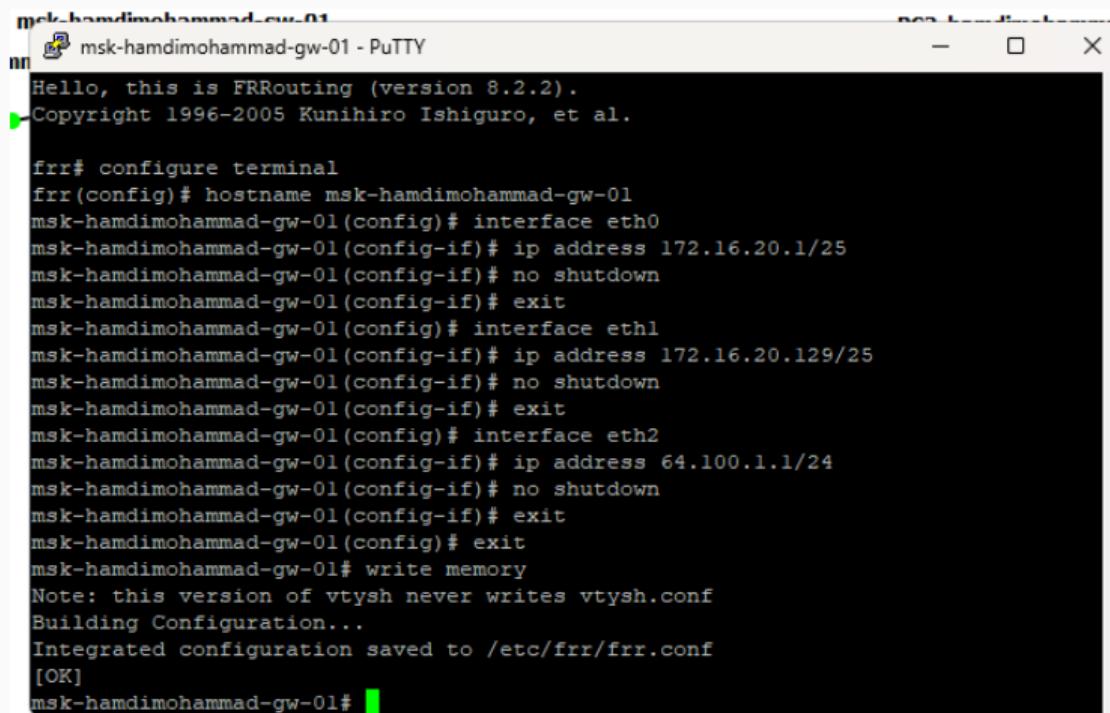


Рис. 1: Топология сети

IPv4 (VPCS)

Узел	Адрес
PC1	172.16.20.10/25
PC2	172.16.20.138/25
Server	64.100.1.10/24

IPv4 (маршрутизатор FRR)

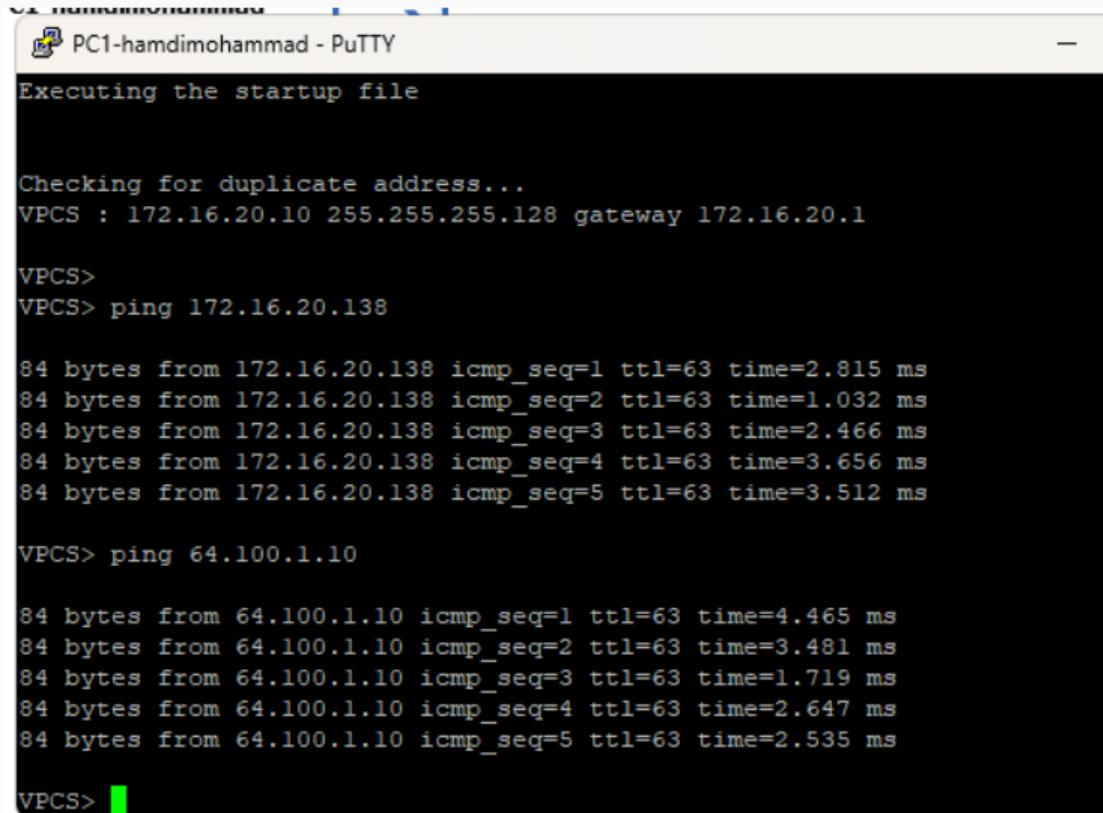


```
Hello, this is FRRouting (version 8.2.2).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

frr# configure terminal
frr(config)# hostname msk-hamdimohammad-gw-01
msk-hamdimohammad-gw-01(config)# interface eth0
msk-hamdimohammad-gw-01(config-if)# ip address 172.16.20.1/25
msk-hamdimohammad-gw-01(config-if)# no shutdown
msk-hamdimohammad-gw-01(config-if)# exit
msk-hamdimohammad-gw-01(config)# interface eth1
msk-hamdimohammad-gw-01(config-if)# ip address 172.16.20.129/25
msk-hamdimohammad-gw-01(config-if)# no shutdown
msk-hamdimohammad-gw-01(config-if)# exit
msk-hamdimohammad-gw-01(config)# interface eth2
msk-hamdimohammad-gw-01(config-if)# ip address 64.100.1.1/24
msk-hamdimohammad-gw-01(config-if)# no shutdown
msk-hamdimohammad-gw-01(config-if)# exit
msk-hamdimohammad-gw-01(config)# exit
msk-hamdimohammad-gw-01# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-hamdimohammad-gw-01#
```

Рис. 2: FRR config

Проверка связности (IPv4)



PC1-hamdimohammad - PuTTY

```
Executing the startup file

Checking for duplicate address...
VPCS : 172.16.20.10 255.255.255.128 gateway 172.16.20.1

VPCS>
VPCS> ping 172.16.20.138

84 bytes from 172.16.20.138 icmp_seq=1 ttl=63 time=2.815 ms
84 bytes from 172.16.20.138 icmp_seq=2 ttl=63 time=1.032 ms
84 bytes from 172.16.20.138 icmp_seq=3 ttl=63 time=2.466 ms
84 bytes from 172.16.20.138 icmp_seq=4 ttl=63 time=3.656 ms
84 bytes from 172.16.20.138 icmp_seq=5 ttl=63 time=3.512 ms

VPCS> ping 64.100.1.10

84 bytes from 64.100.1.10 icmp_seq=1 ttl=63 time=4.465 ms
84 bytes from 64.100.1.10 icmp_seq=2 ttl=63 time=3.481 ms
84 bytes from 64.100.1.10 icmp_seq=3 ttl=63 time=1.719 ms
84 bytes from 64.100.1.10 icmp_seq=4 ttl=63 time=2.647 ms
84 bytes from 64.100.1.10 icmp_seq=5 ttl=63 time=2.535 ms

VPCS>
```

Рис. 3: Ping IPv4

Адресация узлов PC3, PC4, Server

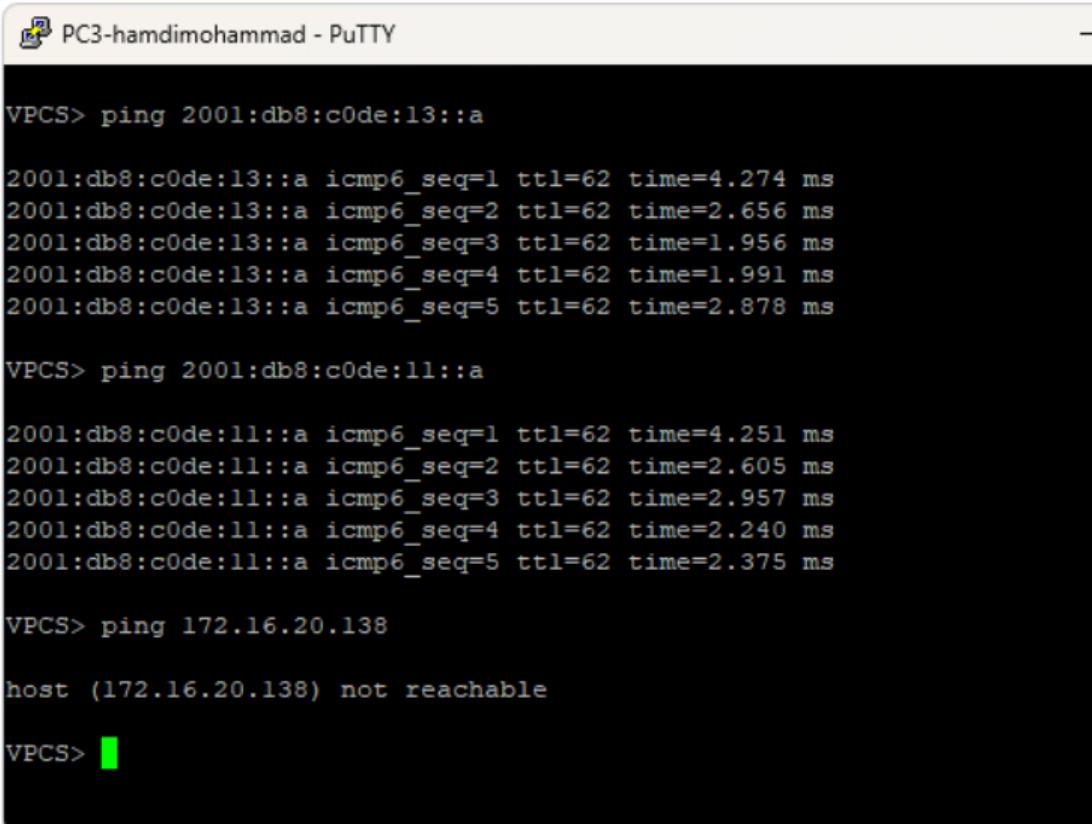
Узел	IPv6 адрес
PC3	2001:db8:c0de:12::a/64
PC4	2001:db8:c0de:13::a/64
Server	2001:db8:c0de:11::a/64

IPv6 (маршрутизатор VyOS)

```
you can check individual component licenses under /usr/share/doc/*copyright
vyos@msk-hamdimohammad-gw-02:~$ con
configure connect
vyos@msk-hamdimohammad-gw-02:~$ configure
[edit]
vyos@msk-hamdimohammad-gw-02# set interfaces ethernet eth0 address 2001:db8:c0de
:12::1/64
[edit]
vyos@msk-hamdimohammad-gw-02# set service router-advert interface eth0 prefix 2
001:db8:c0de:12::/64
[edit]
vyos@msk-hamdimohammad-gw-02# set interfaces ethernet eth1 address 2001:db8:c0de
:13::1/64
[edit]
vyos@msk-hamdimohammad-gw-02# set service router-advert interface eth1 prefix 2
001:db8:c0de:13::/64
[edit]
vyos@msk-hamdimohammad-gw-02# set interfaces ethernet eth2 address 2001:db8:c0de
:11::1/64
[edit]
vyos@msk-hamdimohammad-gw-02# set service router-advert interface eth2 prefix 2
001:db8:c0de:11::/64
[edit]
vyos@msk-hamdimohammad-gw-02#
```

Рис. 4: VyOS

Проверка связности (IPv6)



PC3-hamdimohammad - PuTTY

```
VPCS> ping 2001:db8:c0de:13::a
2001:db8:c0de:13::a icmp6_seq=1 ttl=62 time=4.274 ms
2001:db8:c0de:13::a icmp6_seq=2 ttl=62 time=2.656 ms
2001:db8:c0de:13::a icmp6_seq=3 ttl=62 time=1.956 ms
2001:db8:c0de:13::a icmp6_seq=4 ttl=62 time=1.991 ms
2001:db8:c0de:13::a icmp6_seq=5 ttl=62 time=2.878 ms

VPCS> ping 2001:db8:c0de:11::a
2001:db8:c0de:11::a icmp6_seq=1 ttl=62 time=4.251 ms
2001:db8:c0de:11::a icmp6_seq=2 ttl=62 time=2.605 ms
2001:db8:c0de:11::a icmp6_seq=3 ttl=62 time=2.957 ms
2001:db8:c0de:11::a icmp6_seq=4 ttl=62 time=2.240 ms
2001:db8:c0de:11::a icmp6_seq=5 ttl=62 time=2.375 ms

VPCS> ping 172.16.20.138
host (172.16.20.138) not reachable

VPCS>
```

Анализ трафика Wireshark

ARP

No.	Time	Source	Destination	Protocol	Length	Info		
23	46.408585	64.100.1.10	172.16.20.138	ICMP	98	Echo (ping) request id=0x2374, seq=5/1280, ttl=64 (reply in 24)		
24	46.410751	172.16.20.138	64.100.1.10	ICMP	98	Echo (ping) reply id=0x2374, seq=5/1280, ttl=63 (request in 23)		
25	47.475629	0c:2a:f8:51:00:02	Private_66:68:04	ARP	60	Who has 64.100.1.10? Tell 64.100.1.1		
26	47.476360	Private_66:68:04	0c:2a:f8:51:00:02	ARP	60	64.100.1.10 is at 00:50:79:66:68:04		
27	59.185552	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=1, hop limit=64 (reply in 28)		
28	59.188704	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=1, hop limit=62 (request in 27)		
29	60.190810	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=2, hop limit=64 (reply in 30)		
30	60.192857	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=2, hop limit=62 (request in 29)		
31	61.194773	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=3, hop limit=64 (reply in 32)		
32	61.197557	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=3, hop limit=62 (request in 31)		
33	62.199006	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=4, hop limit=64 (reply in 34)		

> Frame 25: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface -, id 0

✗ Ethernet II, Src: 0c:2a:f8:51:00:02 (0c:2a:f8:51:00:02), Dst: Private_66:68:04 (00:50:79:66:68:04)

 > Destination: Private_66:68:04 (00:50:79:66:68:04)

 > Source: 0c:2a:f8:51:00:02 (0c:2a:f8:51:00:02)

 Type: ARP (0x0806)

 [Stream index: 3]

 Padding: 00

✗ Address Resolution Protocol (request)

 Hardware type: Ethernet (1)

 Protocol type: IPv4 (0x0800)

 Hardware size: 6

 Protocol size: 4

 Opcode: request (1)

 Sender MAC address: 0c:2a:f8:51:00:02 (0c:2a:f8:51:00:02)

 Sender IP address: 64.100.1.1

 Target MAC address: 00:00:00:00:00:00 (00:00:00:00:00:00)

 Target IP address: 64.100.1.10

0000 00 50 79 66 68 04
0010 08 00 06 04 00 01
0020 00 00 00 00 00 00
0030 00 00 00 00 00 00

Рис. 6: Wireshark ARP

ICMP

No.	Time	Source	Destination	Protocol	Length	Info
17	43.399313	64.100.1.10	172.16.20.138	ICMP	98	Echo (ping) request id=0x2074, seq=2/512, ttl=64 (reply in 18)
18	43.400898	172.16.20.138	64.100.1.10	ICMP	98	Echo (ping) reply id=0x2074, seq=2/512, ttl=63 (request in 17)
19	44.402510	64.100.1.10	172.16.20.138	ICMP	98	Echo (ping) request id=0x2174, seq=3/768, ttl=64 (reply in 20)
20	44.403586	172.16.20.138	64.100.1.10	ICMP	98	Echo (ping) reply id=0x2174, seq=3/768, ttl=63 (request in 19)
→ 21	45.405611	64.100.1.10	172.16.20.138	ICMP	98	Echo (ping) request id=0x2274, seq=4/1024, ttl=64 (reply in 22)
← 22	45.407074	172.16.20.138	64.100.1.10	ICMP	98	Echo (ping) reply id=0x2274, seq=4/1024, ttl=63 (request in 21)
23	46.408585	64.100.1.10	172.16.20.138	ICMP	98	Echo (ping) request id=0x2374, seq=5/1280, ttl=64 (reply in 24)
24	46.418751	172.16.20.138	64.100.1.10	ICMP	98	Echo (ping) reply id=0x2374, seq=5/1280, ttl=63 (request in 23)
25	47.475629	0c:2a:f8:51:00:02	Private_66:68:04	ARP	60	Who has 64.100.1.10? Tell 64.100.1.1
26	47.476360	Private_66:68:04	0c:2a:f8:51:00:02	ARP	60	64.100.1.10 is at 00:50:79:66:68:04
27	59.185552	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=1, hop limit=64 (reply in 28)
> Frame 21: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0						
Ethernet II, Src: Private_66:68:04 (00:50:79:66:68:04), Dst: 0c:2a:f8:51:00:02 (0c:2a:f8:51:00:02)						
> Destination: 0c:2a:f8:51:00:02 (0c:2a:f8:51:00:02)						
> Source: Private_66:68:04 (00:50:79:66:68:04)						
Type: IPv4 (0x0800)						
[Stream index: 3]						
Internet Protocol Version 4, Src: 64.100.1.10, Dst: 172.16.20.138						
0100 = Version: 4						
.... 0101 = Header Length: 20 bytes (5)						
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)						
Total Length: 84						
Identification: 0x7422 (29730)						
> 000. = Flags: 0x0						
.... 0000 0000 0000 = Fragment Offset: 0						
Time to Live: 64						
Protocol: ICMP (1)						
Header Checksum: 0x047f [validation disabled]						
[Header checksum status: Unverified]						
Source Address: 64.100.1.10						
Destination Address: 172.16.20.138						
[Stream index: 0]						
Internet Control Message Protocol						
Type: 8 (Echo (ping) request)						
Code: 0						
Checksum: 0xfd93 [correct]						
[Checksum Status: Good]						
Identifier (BE): 8820 (0x2274)						
Identifier (LE): 29730 (0x7422)						
Sequence Number (BE): 4 (0x0004)						
Sequence Number (LE): 1024 (0x0400)						
[Response frame: 22]						
Data (56 bytes)						
0000 0c 2a f8 51 00 02 00 50						
0010 00 54 74 22 00 00 40 01						
0020 14 8a 08 00 fd 93 22 74						
0030 0e 0f 10 11 12 13 14 15						
0040 1e 1f 20 21 22 23 24 25						
0050 2e 2f 30 31 32 33 34 35						
0060 3e 3f						

ICMPv6

No.	Time	Source	Destination	Protocol	Length	Info
26	47.476360	Private_66:68:04	0c:2a:f8:51:00:02	ARP	60	64.100.1.10 is at 00:50:79:66:68:04
27	59.185552	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=1, hop limit=64 (reply in 28)
28	59.188704	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=1, hop limit=62 (request in 27)
29	60.190810	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=2, hop limit=64 (reply in 30)
30	60.192857	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=2, hop limit=62 (request in 29)
31	61.194773	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=3, hop limit=64 (reply in 32)
*	32 61.197557	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=3, hop limit=62 (request in 31)
33	62.199006	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=4, hop limit=64 (reply in 34)
34	62.201520	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=4, hop limit=62 (request in 33)
35	63.203701	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x2f74, seq=5, hop limit=64 (reply in 36)
36	63.206051	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x2f74, seq=5, hop limit=62 (request in 35)

```

> Frame 31: 118 bytes on wire (944 bits), 118 bytes captured (944 bits) on interface -, id 0
└> Ethernet II, Src: Private_66:68:04 (00:50:79:66:68:04), Dst: 0c:49:01:40:00:02 (0c:49:01:40:00:02)
    > Destination: 0c:49:01:40:00:02 (0c:49:01:40:00:02)
    > Source: Private_66:68:04 (00:50:79:66:68:04)
        Type: IPv6 (0x86dd)
        [Stream index: 1]
└> Internet Protocol Version 6, Src: 2001:db8:c0de:11::a, Dst: 2001:db8:c0de:13::a
    0110 .... = Version: 6
    > .... 0000 0000 .... .... .... .... = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)
    .... 0000 0000 0000 0000 0000 = Flow Label: 0x00000
    Payload Length: 64
    Next Header: ICMPv6 (58)
    Hop Limit: 64
    > Source Address: 2001:db8:c0de:11::a
    > Destination Address: 2001:db8:c0de:13::a
        [Stream index: 3]
└> Internet Control Message Protocol v6
    Type: Echo (ping) request (128)
    Code: 0
    Checksum: 0x7b93 [correct]
        [Checksum Status: Good]
    Identifier: 0x2f74
    Sequence: 3
        [Response_In: 32]
    > Data (56 bytes)

```

0000	0c 49 0:
0010	00 00 00
0020	00 00 00
0030	00 00 00
0040	02 03 0:
0050	12 13 1:
0060	22 23 2:
0070	32 33 3:

Самостоятельная часть

Разбиение IPv4 и IPv6 на подсети

Подсеть	IPv4	IPv6
LAN1	10.10.1.96/27	2001:db8:1:1::/64
LAN2	10.10.1.16/28	2001:db8:1:4::/64

Разбиение IPv4 и IPv6 на подсети

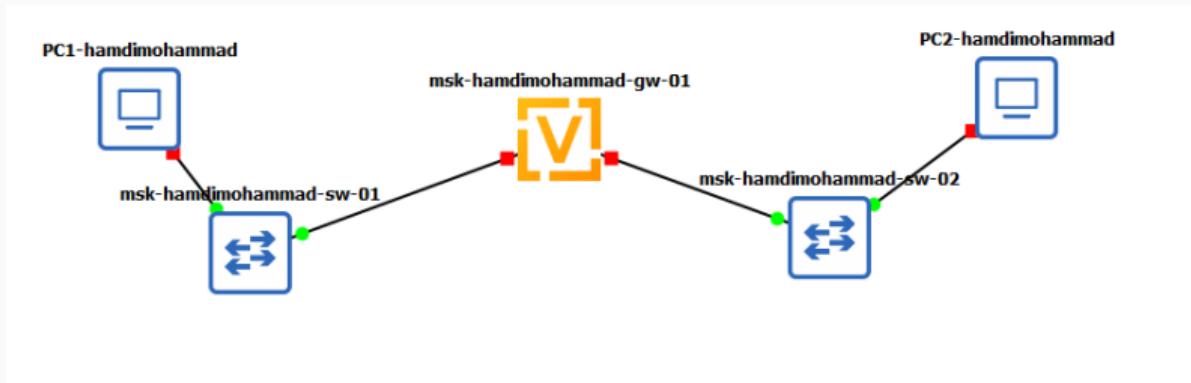
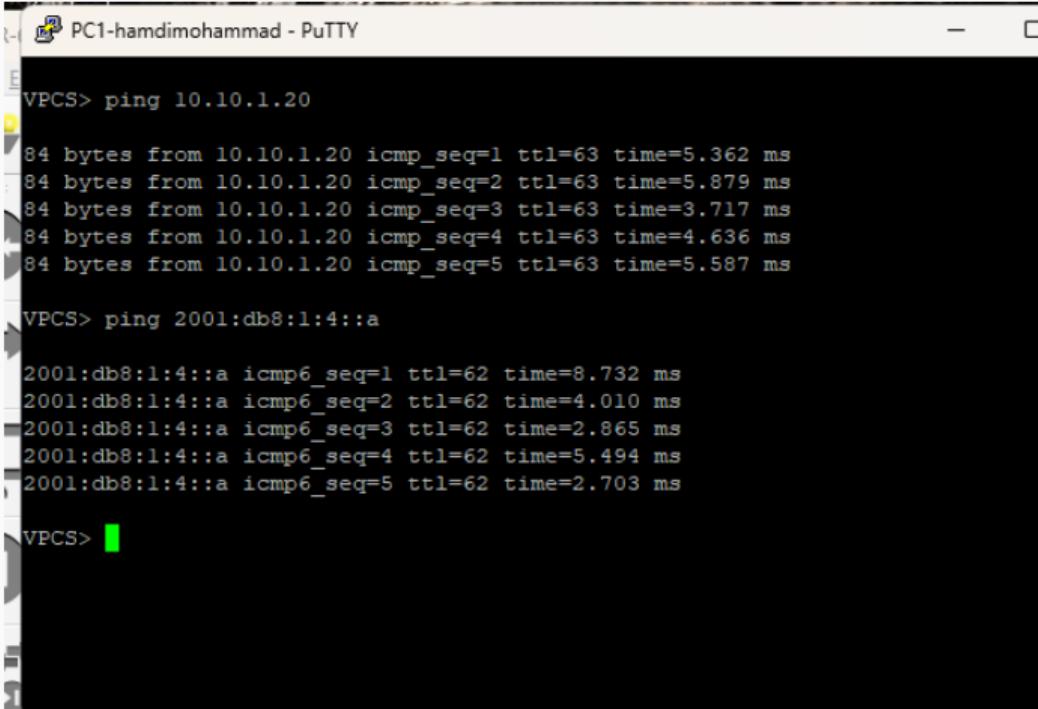


Рис. 9: Топология подсетей

Проверка связности между подсетями



```
PC1-hamdimohammad - PuTTY
VPCS> ping 10.10.1.20
84 bytes from 10.10.1.20 icmp_seq=1 ttl=63 time=5.362 ms
84 bytes from 10.10.1.20 icmp_seq=2 ttl=63 time=5.879 ms
84 bytes from 10.10.1.20 icmp_seq=3 ttl=63 time=3.717 ms
84 bytes from 10.10.1.20 icmp_seq=4 ttl=63 time=4.636 ms
84 bytes from 10.10.1.20 icmp_seq=5 ttl=63 time=5.587 ms

VPCS> ping 2001:db8:1:4::a
2001:db8:1:4::a icmp6_seq=1 ttl=62 time=8.732 ms
2001:db8:1:4::a icmp6_seq=2 ttl=62 time=4.010 ms
2001:db8:1:4::a icmp6_seq=3 ttl=62 time=2.865 ms
2001:db8:1:4::a icmp6_seq=4 ttl=62 time=5.494 ms
2001:db8:1:4::a icmp6_seq=5 ttl=62 time=2.703 ms

VPCS>
```

Рис. 10: Ping final

Итог

Результаты

- Сети с IPv4 и IPv6 успешно настроены.
- FRR обеспечивает маршрутизацию IPv4, VyOS — IPv6.
- Wireshark подтвердил корректную работу ARP, ICMP и ICMPv6.