

# Сетевые технологии

## Простые сети в GNS3. Анализ трафика

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## Цель работы

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Построение простейших моделей сети на базе коммутатора и маршрутизаторов **FRR** и **VyOS** в **GNS3**, анализ трафика посредством **Wireshark**.

## Простая сеть на базе коммутатора

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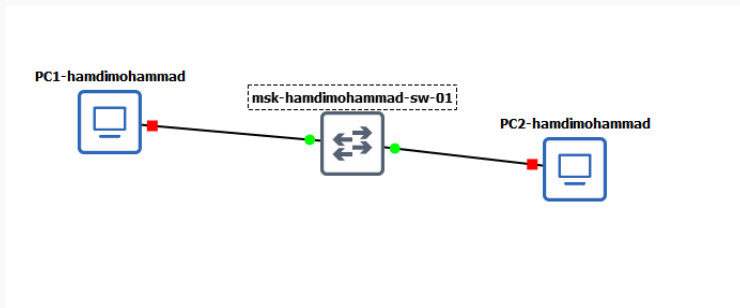


Рис. 1: Топология сети в GNS3

```
VPCS>  
VPCS> ip 192.168.1.11/24 192.168.1.1  
Checking for duplicate address...  
VPCS : 192.168.1.11 255.255.255.0 gateway 192.168.1.1  
  
VPCS> save  
Saving startup configuration to startup.vpc  
. done  
  
VPCS> █
```

Рис. 2: Настройка IP-адреса на PC1

```
VPCS>  
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>  
VPCS> ping 192.168.1.11  
  
84 bytes from 192.168.1.11 icmp_seq=1 ttl=64 time=2.892 ms  
84 bytes from 192.168.1.11 icmp_seq=2 ttl=64 time=1.475 ms  
84 bytes from 192.168.1.11 icmp_seq=3 ttl=64 time=0.747 ms  
84 bytes from 192.168.1.11 icmp_seq=4 ttl=64 time=1.193 ms  
84 bytes from 192.168.1.11 icmp_seq=5 ttl=64 time=0.937 ms  
  
VPCS> █
```

Рис. 3: Проверка связности между PC1 и PC2

## Анализ трафика Wireshark

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No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	::	ff02::2	ICMPv6	62	Router Solicitation
2	0.001459	::	ff02::2	ICMPv6	62	Router Solicitation
3	0.050950	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.11 (Request)
4	0.052354	Private_66:68:01	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.12 (Request)
5	1.051444	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.11 (Request)
6	1.052792	Private_66:68:01	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.12 (Request)
7	2.052319	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.11 (Request)
8	2.053738	Private_66:68:01	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.12 (Request)

```

> Frame 3: 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)
▼ 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)
    Target IP address: 192.168.1.11
  
```

No.	Time	Source	Destination	Protocol	Length	Info
5	1.051444	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.11 (Request)
6	1.052792	Private_66:68:01	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.12 (Request)
7	2.052319	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.11 (Request)
8	2.053738	Private_66:68:01	Broadcast	ARP	64	Gratuitous ARP for 192.168.1.12 (Request)
9	136.488132	Private_66:68:00	Broadcast	ARP	64	Who has 192.168.1.12? Tell 192.168.1.11
10	136.488828	Private_66:68:01	Private_66:68:00	ARP	64	192.168.1.12 is at 00:50:79:66:68:01
→ 11	136.489563	192.168.1.11	192.168.1.12	ICMP	98	Echo (ping) request id=0xaa7f, seq=1/256, ttl=64 (reply in 12)
← 12	136.490251	192.168.1.12	192.168.1.11	ICMP	98	Echo (ping) reply id=0xaa7f, seq=1/256, ttl=64 (request in 11)

> Frame 11: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0	0000 00 50 79 66 68 01 00
> Ethernet II, Src: Private_66:68:00 (00:50:79:66:68:00), Dst: Private_66:68:01 (00:50:79:66:68:01)	0010 00 54 7f aa 00 00 4e
> Internet Protocol Version 4, Src: 192.168.1.11, Dst: 192.168.1.12	0020 01 0c 08 00 75 8b aa
▼ Internet Control Message Protocol	0030 0e 0f 10 11 12 13 14
Type: 8 (Echo (ping) request)	0040 1e 1f 20 21 22 23 24
Code: 0	0050 2e 2f 30 31 32 33 34
Checksum: 0x758b [correct]	0060 3e 3f
[Checksum Status: Good]	
Identifier (BE): 43647 (0xaa7f)	
Identifier (LE): 32682 (0x7faa)	
Sequence Number (BE): 1 (0x0001)	
Sequence Number (LE): 256 (0x0100)	
[Response frame: 12]	
> Data (56 bytes)	

Рис. 5: ICMP-запрос и ответ

## UDP и TCP-запросы

No.	Time	Source	Destination	Protocol	Length	Info
13	32.216550	192.168.1.11	192.168.1.12	ECHO	98	Request
14	32.218051	192.168.1.12	192.168.1.11	ECHO	98	Response
15	37.024191	192.168.1.11	192.168.1.12	TCP	74	12660 → 7 [SYN] Seq=0 Win=2920 Len=0 MSS=1460 TSval=1761378568 TSecr=0 WS=2
16	37.024841	192.168.1.12	192.168.1.11	TCP	54	7 → 12660 [SYN, ACK] Seq=0 Ack=1 Win=2920 Len=0
17	37.026762	192.168.1.11	192.168.1.12	TCP	66	12660 → 7 [ACK] Seq=1 Ack=1 Win=2920 Len=0 TSval=1761378568 TSecr=0
18	37.028674	192.168.1.11	192.168.1.12	ECHO	122	Request
19	37.029600	192.168.1.12	192.168.1.11	TCP	54	7 → 12660 [ACK] Seq=1 Ack=57 Win=2920 Len=0
20	37.032789	192.168.1.11	192.168.1.12	TCP	66	12660 → 7 [FIN, PSH, ACK] Seq=57 Ack=1 Win=2920 Len=0 TSval=1761378568 TSecr=0
21	37.033877	192.168.1.12	192.168.1.11	TCP	54	7 → 12660 [ACK] Seq=1 Ack=58 Win=2920 Len=0
22	37.033955	192.168.1.12	192.168.1.11	TCP	54	7 → 12660 [FIN, ACK] Seq=1 Ack=58 Win=2920 Len=0
23	37.037537	192.168.1.11	192.168.1.12	TCP	66	12660 → 7 [ACK] Seq=58 Ack=2 Win=2920 Len=0 TSval=1761378568 TSecr=0

No.	Time	Source	Destination	Protocol	Length	Info
>	Frame 19: 54 bytes on wire (432 bits), 54 bytes captured (432 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					
>	Transmission Control Protocol, Src Port: 7, Dst Port: 12660, Seq: 1, Ack: 57, Len: 0					
>	Source Port: 7					
>	Destination Port: 12660					
>	[Stream index: 0]					
>	[Stream Packet Number: 5]					
>	[Conversation completeness: Complete, WITH_DATA (31)]					
>	[TCP Segment Len: 0]					
>	Sequence Number: 1 (relative sequence number)					
>	Sequence Number (raw): 23403566					
>	[Next Sequence Number: 1 (relative sequence number)]					
>	Acknowledgment Number: 57 (relative ack number)					
>	Acknowledgment number (raw): 1330086426					
>	0101 .... = Header Length: 20 bytes (5)					
>	Flags: 0x010 (ACK)					
>	Window: 2920					
>	[Calculated window size: 2920]					
>	[Window size scaling factor: -2 (no window scaling used)]					
>	Checksum: 0x00dc [unverified]					
>	[Checksum Status: Unverified]					
>	Urgent Pointer: 0					
>	[Timestamps]					
>	[SEQ/ACK analysis]					
>	[This is an ACK to the segment in frame: 18]					
>	[The RTT to ACK the segment was: 0.000926000 seconds]					
>	[IRTT: 0.002571000 seconds]					

Рис. 6: ТСР-эхо-запрос

## Сеть с маршрутизатором FRR

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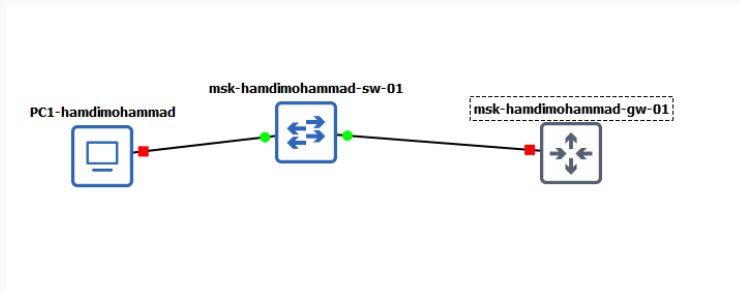
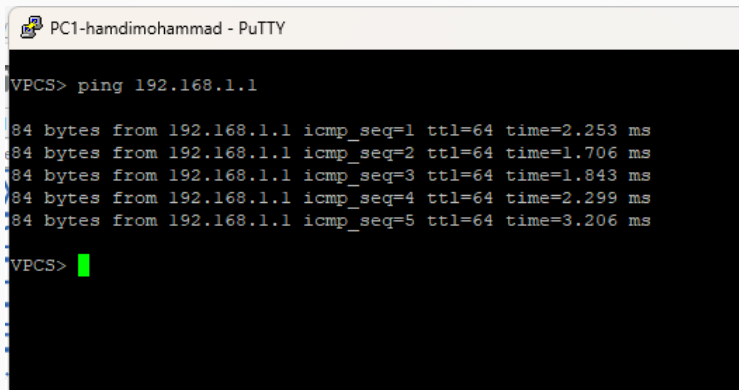


Рис. 7: Топология сети с маршрутизатором FRR

```
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)# 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# configure terminal
msk-hamdimohammad-gw-01(config)# interface eth0
msk-hamdimohammad-gw-01(config-if)# ip address 192.168.1.1/24
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#
```



The image shows a PuTTY terminal window titled "PC1-hamdimohammad - PuTTY". The terminal displays a command prompt "VPCS>" followed by the command "ping 192.168.1.1". The output shows five successful ping responses, each indicating 84 bytes received from 192.168.1.1 with varying ICMP sequence numbers (1 to 5) and TTL values (all 64). The response times are 2.253 ms, 1.706 ms, 1.843 ms, 2.299 ms, and 3.206 ms respectively. The prompt "VPCS>" is followed by a green cursor.

```
PC1-hamdimohammad - PuTTY

VPCS> ping 192.168.1.1

84 bytes from 192.168.1.1 icmp_seq=1 ttl=64 time=2.253 ms
84 bytes from 192.168.1.1 icmp_seq=2 ttl=64 time=1.706 ms
84 bytes from 192.168.1.1 icmp_seq=3 ttl=64 time=1.843 ms
84 bytes from 192.168.1.1 icmp_seq=4 ttl=64 time=2.299 ms
84 bytes from 192.168.1.1 icmp_seq=5 ttl=64 time=3.206 ms

VPCS> 
```

Рис. 9: Проверка соединения между ПК и маршрутизатором

## Анализ трафика FRR

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No.	Time	Source	Destination	Protocol	Length	Info
4	0.006315	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xec82, seq=1/256, ttl=64 (request in 3)
5	1.007815	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xed82, seq=2/512, ttl=64 (reply in 6)
6	1.009098	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xed82, seq=2/512, ttl=64 (request in 5)
7	2.011201	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xee82, seq=3/768, ttl=64 (reply in 8)
8	2.012341	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xee82, seq=3/768, ttl=64 (request in 7)
9	3.015170	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xef82, seq=4/1024, ttl=64 (reply in 10)
10	3.016665	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xef82, seq=4/1024, ttl=64 (request in 9)
11	4.018009	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xf082, seq=5/1280, ttl=64 (reply in 12)
12	4.020464	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xf082, seq=5/1280, ttl=64 (request in 11)
13	5.037038	0c:d7:29:63:00:00	Private_66:68:00	ARP	60	Who has 192.168.1.10? Tell 192.168.1.1
14	5.037764	Private_66:68:00	0c:d7:29:63:00:00	ARP	60	192.168.1.10 is at 00:50:79:66:68:00

<p>&gt; Frame 12: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0</p> <p>&gt; Ethernet II, Src: 0c:d7:29:63:00:00 (0c:d7:29:63:00:00), Dst: Private_66:68:00 (00:50:79:66:68:00)</p> <p>&gt; Internet Protocol Version 4, Src: 192.168.1.1, Dst: 192.168.1.10</p> <p>▼ Internet Control Message Protocol</p> <p>Type: 0 (Echo (ping) reply)</p> <p>Code: 0</p> <p>Checksum: 0x3784 [correct]</p> <p>[Checksum Status: Good]</p> <p>Identifier (BE): 61570 (0xf082)</p> <p>Identifier (LE): 33520 (0x82f0)</p> <p>Sequence Number (BE): 5 (0x0005)</p> <p>Sequence Number (LE): 1280 (0x0500)</p> <p><a href="#">[Request frame: 11]</a></p> <p>[Response time: 2,435 ms]</p> <p>&gt; Data (56 bytes)</p>	<pre> 0000  00 50 79 66 0010  00 54 f9 f9 0020  01 0a 00 00 0030  0e 0f 10 11 0040  1e 1f 20 21 0050  2e 2f 30 31 0060  3e 3f                     </pre>
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Рис. 10: Анализ ICMP-трафика в Wireshark

## Сеть с маршрутизатором VyOS

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```
Check out project news at https://blog.vyos.io
and feel free to report bugs at https://vyos.dev

You can change this banner using "set system login banner post-login" command.

VyOS is a free software distribution that includes multiple components,
you can check individual component licenses under /usr/share/doc/*/copyright
vyos@vyos:~$ install image
You are trying to install from an already installed system. An ISO
image file to install or URL must be specified.
Exiting...
vyos@vyos:~$ configure
[edit]
vyos@vyos# set system host-name msk-hamdimohammad-gw-01
[edit]
vyos@vyos# set interfaces ethernet eth0 address 192.168.1.1/24
[edit]
vyos@vyos# compare
[edit interfaces ethernet eth0]
+address 192.168.1.1/24
[edit system]
>host-name msk-hamdimohammad-gw-01
[edit]
vyos@vyos# commit
```

Рис. 11: Настройка маршрутизатора VyOS

```
[edit]
vyos@vyos# show interfaces
  ethernet eth0 {
    address 192.168.1.1/24
    hw-id 0c:96:7e:5a:00:00
  }
  ethernet eth1 {
    hw-id 0c:96:7e:5a:00:01
  }
  ethernet eth2 {
    hw-id 0c:96:7e:5a:00:02
  }
  loopback lo {
  }
[edit]
vyos@vyos#
```

Рис. 12: Просмотр интерфейсов VyOS

```
VPCS>  
VPCS> ping 192.168.1.1  
  
84 bytes from 192.168.1.1 icmp_seq=1 ttl=64 time=2.775 ms  
84 bytes from 192.168.1.1 icmp_seq=2 ttl=64 time=2.233 ms  
84 bytes from 192.168.1.1 icmp_seq=3 ttl=64 time=4.229 ms  
84 bytes from 192.168.1.1 icmp_seq=4 ttl=64 time=2.681 ms  
84 bytes from 192.168.1.1 icmp_seq=5 ttl=64 time=2.798 ms  
  
VPCS>
```

Рис. 13: Проверка связи между ПК и маршрутизатором VyOS

## Анализ трафика VyOS

---

# Обмен ICMP Echo

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xa584, seq=1/256, ttl=64 (reply in 2)
2	0.002004	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xa584, seq=1/256, ttl=64 (request in 1)
3	1.003784	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xa684, seq=2/512, ttl=64 (reply in 4)
4	1.005253	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xa684, seq=2/512, ttl=64 (request in 3)
5	2.008156	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xa784, seq=3/768, ttl=64 (reply in 6)
6	2.011016	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xa784, seq=3/768, ttl=64 (request in 5)
7	3.012660	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xa884, seq=4/1024, ttl=64 (reply in 8)
8	3.014549	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xa884, seq=4/1024, ttl=64 (request in 7)
9	4.017875	192.168.1.10	192.168.1.1	ICMP	98	Echo (ping) request id=0xa984, seq=5/1280, ttl=64 (reply in 10)
10	4.019807	192.168.1.1	192.168.1.10	ICMP	98	Echo (ping) reply id=0xa984, seq=5/1280, ttl=64 (request in 9)

```

> Frame 10: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0
> Ethernet II, Src: 0c:96:7e:5a:00:00 (0c:96:7e:5a:00:00), Dst: Private_66:68:00 (00:50:79:66:68:00)
< Internet Protocol Version 4, Src: 192.168.1.1, Dst: 192.168.1.10
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
    > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 84
    Identification: 0xeb51 (60241)
    > 0000 .... = Flags: 0x0
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: ICMP (1)
    Header Checksum: 0x0bfc [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.1.1
    Destination Address: 192.168.1.10
    [Stream index: 0]
< Internet Control Message Protocol
    Type: 0 (Echo (ping) reply)
    Code: 0
    Checksum: 0x7e82 [correct]
    [Checksum Status: Good]
    Identifier (BE): 43396 (0xa984)
    Identifier (LE): 33961 (0x84a9)
    Sequence Number (BE): 5 (0x0005)
    Sequence Number (LE): 1280 (0x0500)
    [Request frame: 9]
    [Response time: 1,932 ms]
    > Data (56 bytes)

```

```

0000 00 50 79 :
0010 00 54 eb :
0020 01 0a 00 :
0030 0e 0f 10 :
0040 1e 1f 20 :
0050 2e 2f 30 :
0060 3e 3f :

```

## Заключение

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В результате лабораторной работы:

- Смоделированы три топологии сети — на базе коммутатора, FRR и VyOS.
- Выполнена настройка IP-адресации и проверена связность между устройствами.
- Проанализированы пакеты **ARP** и **ICMP** в **Wireshark**.
- Все конфигурации работали корректно, подтверждая правильность сетевых настроек.