

Настройка DHCP для IPv4 и IPv6 в GNS3

Лабораторная работа №7

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Цель работы

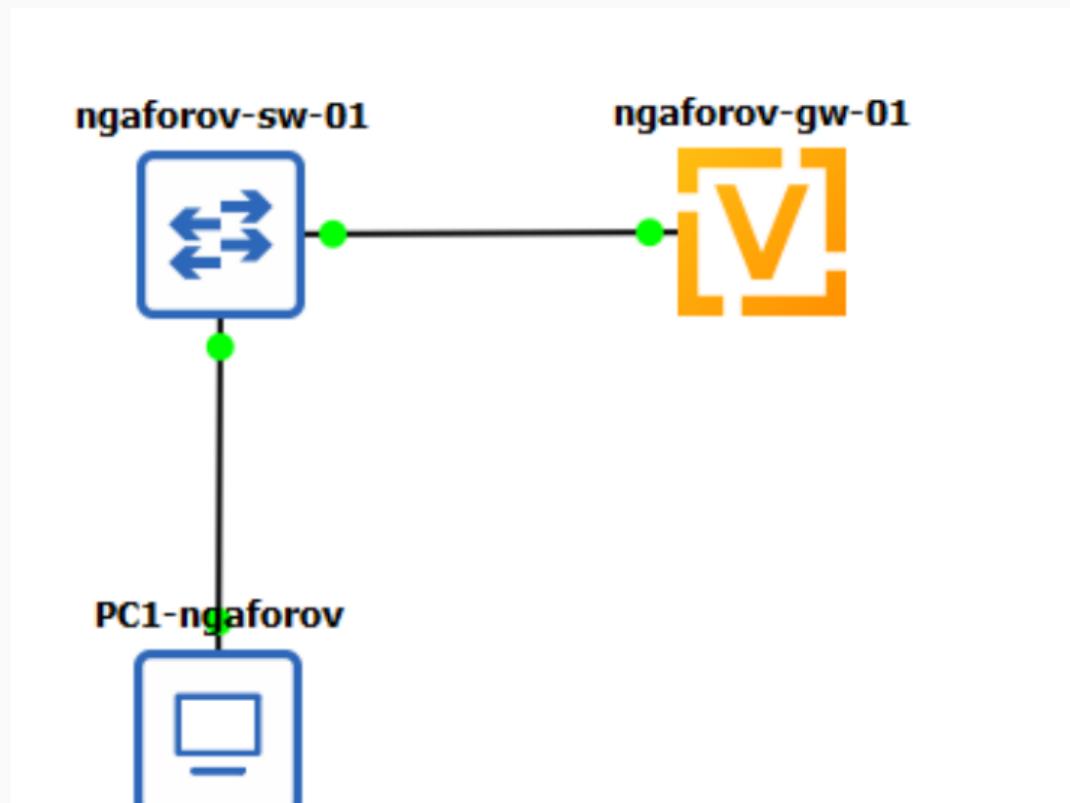
Цель работы

Получить практические навыки настройки механизмов **DHCP**, **DHCPv6 (Stateless/Stateful)** и автоматической конфигурации IPv6 (**SLAAC, RA**) в среде **GNS3** с использованием маршрутизатора **VyOS** и клиентских узлов.

Ход выполнения

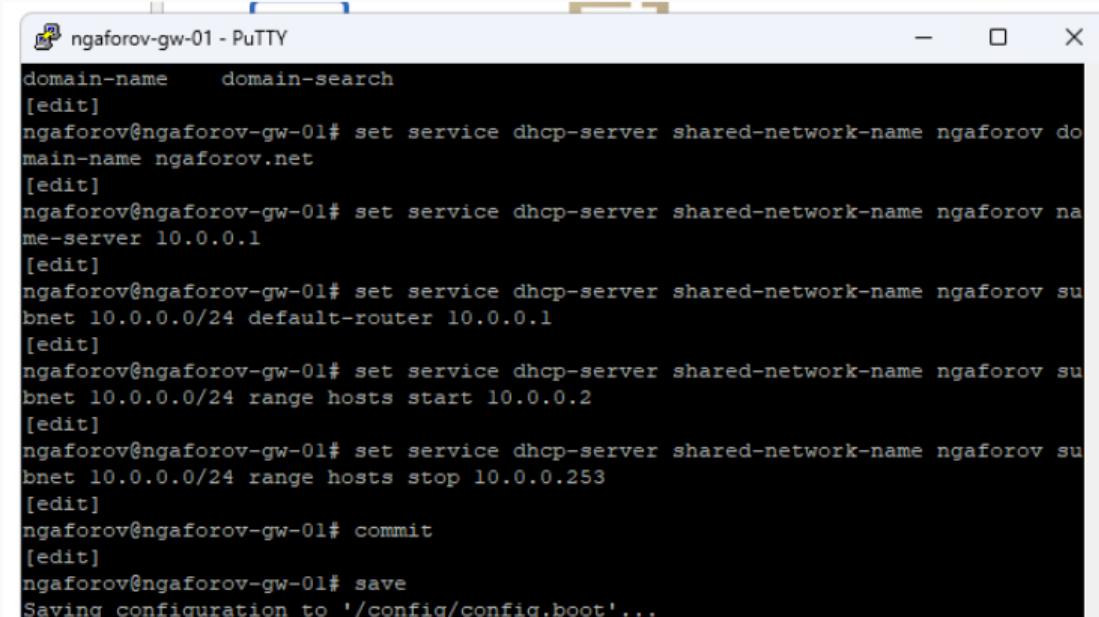
Первичная топология и настройка IPv4 DHCP

В GNS3 создана базовая сеть, включающая маршрутизатор, коммутатор и хост PC1-ngaforov.



Настройка DHCP для IPv4

- сеть: 10.0.0.0/24
- диапазон: 10.0.0.2 – 10.0.0.253
- шлюз: 10.0.0.1
- DNS: 10.0.0.1



```
ngaforov-gw-01 - PuTTY
domain-name      domain-search
[edit]
ngaforov@ngaforov-gw-01# set service dhcp-server shared-network-name ngaforov do
main-name ngaforov.net
[edit]
ngaforov@ngaforov-gw-01# set service dhcp-server shared-network-name ngaforov na
me-server 10.0.0.1
[edit]
ngaforov@ngaforov-gw-01# set service dhcp-server shared-network-name ngaforov su
bnet 10.0.0.0/24 default-router 10.0.0.1
[edit]
ngaforov@ngaforov-gw-01# set service dhcp-server shared-network-name ngaforov su
bnet 10.0.0.0/24 range hosts start 10.0.0.2
[edit]
ngaforov@ngaforov-gw-01# set service dhcp-server shared-network-name ngaforov su
bnet 10.0.0.0/24 range hosts stop 10.0.0.253
[edit]
ngaforov@ngaforov-gw-01# commit
[edit]
ngaforov@ngaforov-gw-01# save
Saving configuration to '/config/config.boot'...
```

Получение IPv4-адреса клиентом

Узел PC1-ngaforov получил адрес 10.0.0.2/24 через полный цикл DORA:

Discover → Offer → Request → Ack.

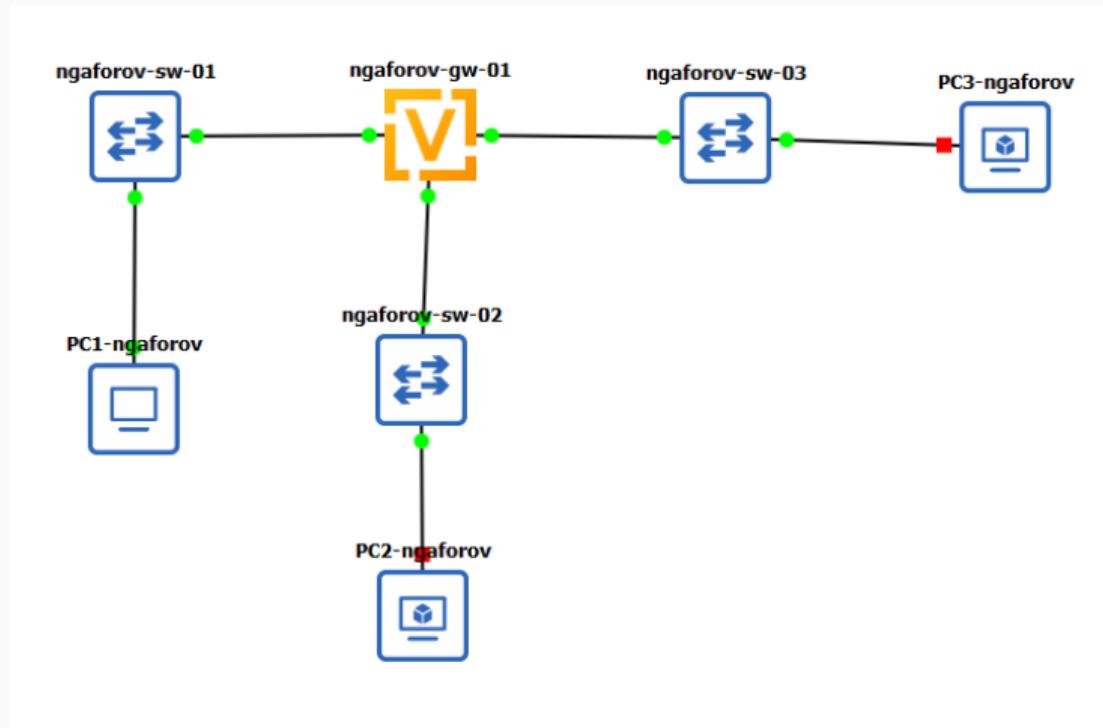
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	0.0.0.0	255.255.255.255	DHCP	406	DHCP Discover - Transaction ID 0xe5be3432
2	0.012650	0c:1d:79:e3:00:00	Broadcast	ARP	60	Who has 10.0.0.2? Tell 10.0.0.1
3	1.001178	0.0.0.0	255.255.255.255	DHCP	406	DHCP Discover - Transaction ID 0xe5be3432
4	1.015340	10.0.0.1	10.0.0.2	DHCP	342	DHCP Offer - Transaction ID 0xe5be3432
5	1.022136	0c:1d:79:e3:00:00	Broadcast	ARP	60	Who has 10.0.0.2? Tell 10.0.0.1
6	2.046447	0c:1d:79:e3:00:00	Broadcast	ARP	60	Who has 10.0.0.2? Tell 10.0.0.1
7	4.001630	0.0.0.0	255.255.255.255	DHCP	406	DHCP Request - Transaction ID 0xe5be3432
8	4.009905	10.0.0.1	10.0.0.2	DHCP	342	DHCP ACK - Transaction ID 0xe5be3432
9	5.003412	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 10.0.0.2 (Request)
10	6.002919	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 10.0.0.2 (Request)
11	7.003664	Private_66:68:00	Broadcast	ARP	64	Gratuitous ARP for 10.0.0.2 (Request)
12	30.199600	Private_66:68:00	Broadcast	ARP	64	Who has 10.0.0.1? Tell 10.0.0.2
13	30.201811	0c:1d:79:e3:00:00	Private_66:68:00	ARP	60	10.0.0.1 is at 0c:1d:79:e3:00:00

> Frame 4: 342 bytes on wire (2736 bits), 342 bytes captured (2736 bits) on interface -, id 0
> Ethernet II, Src: 0c:1d:79:e3:00:00 (0c:1d:79:e3:00:00), Dst: Private_66:68:00 (00:50:79:66:68:00)
> Internet Protocol Version 4, Src: 10.0.0.1, Dst: 10.0.0.2
> User Datagram Protocol, Src Port: 67, Dst Port: 68
 Dynamic Host Configuration Protocol (Offer)
 Message type: Boot Reply (2)
 Hardware type: Ethernet (0x01)
 Hardware address length: 6
 Hops: 0
 Transaction ID: 0xe5be3432
 Seconds elapsed: 0
 Boot flags: 0x0000 (Unicast)
 Client IP address: 0.0.0.0
 Your (client) IP address: 10.0.0.2
 Next server IP address: 0.0.0.0
 Relay agent IP address: 0.0.0.0
 Client MAC address: Private_66:68:00 (00:50:79:66:68:00)
 Client hardware address padding: 000000000000000000000000
 Server host name not given
 Boot file name not given
 Magic cookie: DHCP
 Option: (53) DHCP Message Type (Offer)
 Option: (54) DHCP Server Identifier (10.0.0.1)
 Option: (51) IP Address Lease Time
 Option: (1) Subnet Mask (255.255.255.0)
 Option: (3) Router
 Option: (6) Domain Name Server
 Option: (15) Domain Name

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Расширение топологии для IPv6

Добавлены коммутаторы `ngaforov-sw-02`, `ngaforov-sw-03` и клиент `PC2-ngaforov` (Kali Linux), поддерживающий DHCPv6.



Настройка IPv6-адресов на маршрутизаторе

Назначены адреса:

- eth1 → 2000::1/64
- eth2 → 2001::1/64

```
ngaforov@ngaforov-gw-01:~$ configure
[edit]
ngaforov@ngaforov-gw-01# set interfaces ethernet eth1 address 2000::1/64
[edit]
ngaforov@ngaforov-gw-01# set interfaces ethernet eth2 address 2001::1/64
[edit]
ngaforov@ngaforov-gw-01# show interfaces
ethernet eth0 {
    address 10.0.0.1/24
    hw-id 0c:1d:79:e3:00:00
}
ethernet eth1 {
+    address 2000::1/64
    hw-id 0c:1d:79:e3:00:01
}
ethernet eth2 {
+    address 2001::1/64
    hw-id 0c:1d:79:e3:00:02
}
loopback lo {
```

Настройка SLAAC + DHCPv6 Stateless

- префикс: 2000::/64
- флаг **other-config-flag**

DHCPv6 Stateless выдаёт только параметры: DNS, домен.

```
ngaforov@ngaforov-gw-01# set service router-advert interface eth1 other-config-flag
[edit]
ngaforov@ngaforov-gw-01# set service dhcpv6-server shared-network-name ngaforov-stateless
[edit]
ngaforov@ngaforov-gw-01# set service dhcpv6-server shared-network-name ngaforov-statelesssub
Possible completions:
  > <text>      DHCPv6 shared network name [REQUIRED]
  >

[edit]
ngaforov@ngaforov-gw-01# set service dhcpv6-server shared-network-name ngaforov-stateless subnet 2000::0/64
[edit]
ngaforov@ngaforov-gw-01# set service dhcpv6-server shared-network-name ngaforov-stateless common-options name-server 2000::1
[edit]
ngaforov@ngaforov-gw-01# set service dhcpv6-server shared-network-name ngaforov-stateless common-options domain-search ngaforov.net
```

Результат на клиенте PC2

PC2 получил IPv6-адрес по SLAAC и параметры DNS через DHCPv6 Stateless.

```
(kali㉿kali)-[~]
└─$ ifconfig eth0
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
      inet6 2000::536c:94f6:e071:143e prefixlen 64 scopeid 0x0<global>
      inet6 fe80::8e8a:2fc9:de3:987 prefixlen 64 scopeid 0x20<link>
      ether 0c:0e:6b:d3:00:00 txqueuelen 1000 (Ethernet)
      RX packets 5 bytes 544 (544.0 B)
      RX errors 0 dropped 0 overruns 0 frame 0
      TX packets 24 bytes 3696 (3.6 KiB)
      TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

(kali㉿kali)-[~]
└─$ route -n -A inet6
Kernel IPv6 routing table
Destination          Next Hop           Flag Met Ref Use If
::1/128              ::                U     256 2    0 lo
2000::/64             ::                U     100 1    0 eth0
fe80::/64             ::                U     100 1    0 eth0
::/0                  fe80::e1d:79ff:fee3:1 UG    100 1    0 eth0
::1/128              ::                Un   0    4    0 lo
2000::536c:94f6:e071:143e/128 ::                Un   0    2    0 eth0
fe80::8e8a:2fc9:de3:987/128 ::                Un   0    3    0 eth0
ff00::/8              ::                U     256 3    0 eth0
::/0                  ::                !n   -1   1    0 lo

(kali㉿kali)-[~]
└─$ ping 2000::1 -c 2
PING 2000::1(2000::1) 56 data bytes
64 bytes from 2000::1: icmp_seq=1 ttl=64 time=2.55 ms
64 bytes from 2000::1: icmp_seq=2 ttl=64 time=2.15 ms

--- 2000::1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 2.145/2.345/2.545/0.200 ms

(kali㉿kali)-[~]
└─$ cat /etc/resolv.conf
```

DHCPv6 Stateless в Wireshark

Фиксация пакетов:

- Router Advertisement
- DHCPv6 Information-Request / Reply
- Neighbor Discovery

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	fe80::8e8a:2fc9:dea.. ff02::1:2		DHCPv6	98	Information-request XID: 0x58f3a5 CID: 000300010c0e6bd30000
2	0.001313	fe80::e1d:79ff:fee3.. fe80::8e8a:2fc9:dea..	DHCPv6	136	Reply XID: 0x58f3a5 CID: 000300010c0e6bd30000	
3	5.099892	fe80::e1d:79ff:fee3.. fe80::8e8a:2fc9:dea..	ICMPv6	86	Neighbor Solicitation for fe80::8e8a:2fc9:dea3:987 from 0c:1d:79:e3:00:01	
4	5.103254	fe80::8e8a:2fc9:dea.. fe80::e1d:79ff:fee3..	ICMPv6	78	Neighbor Advertisement fe80::8e8a:2fc9:dea3:987 (sol)	
5	7.346796	0.0.0.0	255.255.255.255	DHCP	324	DHCP Discover - Transaction ID 0xa79a3758
6	8.904812	2000::536c:94f6:e07.. 2000::1	ICMPv6	118	Echo (ping) request id=0x0f25, seq=1, hop limit=64 (reply in 7)	
7	8.905338	2000::1	2000::536c:94f6:e07..	ICMPv6	118	Echo (ping) reply id=0x0f25, seq=1, hop limit=64 (request in 6)
8	9.906856	2000::536c:94f6:e07.. 2000::1	ICMPv6	118	Echo (ping) request id=0x0f25, seq=2, hop limit=64 (reply in 9)	
9	9.907584	2000::1	2000::536c:94f6:e07..	ICMPv6	118	Echo (ping) reply id=0x0f25, seq=2, hop limit=64 (request in 8)
10	18.203950	fe80::8e8a:2fc9:dea.. fe80::e1d:79ff:fee3..	ICMPv6	86	Neighbor Solicitation for fe80::e1d:79ff:fee3:1 from 0c:0e:6b:d3:00:00	
11	18.204777	fe80::e1d:79ff:fee3.. fe80::8e8a:2fc9:dea..	ICMPv6	78	Neighbor Advertisement fe80::e1d:79ff:fee3:1 (rtr, sol)	
12	14.316283	fe80::e1d:79ff:fee3.. 2000::536c:94f6:e07..	ICMPv6	86	Neighbor Solicitation for 2000::536c:94f6:e071:143e from 0c:1d:79:e3:00:01	
13	14.317008	2000::536c:94f6:e07.. fe80::e1d:79ff:fee3..	ICMPv6	78	Neighbor Advertisement 2000::536c:94f6:e071:143e (sol)	

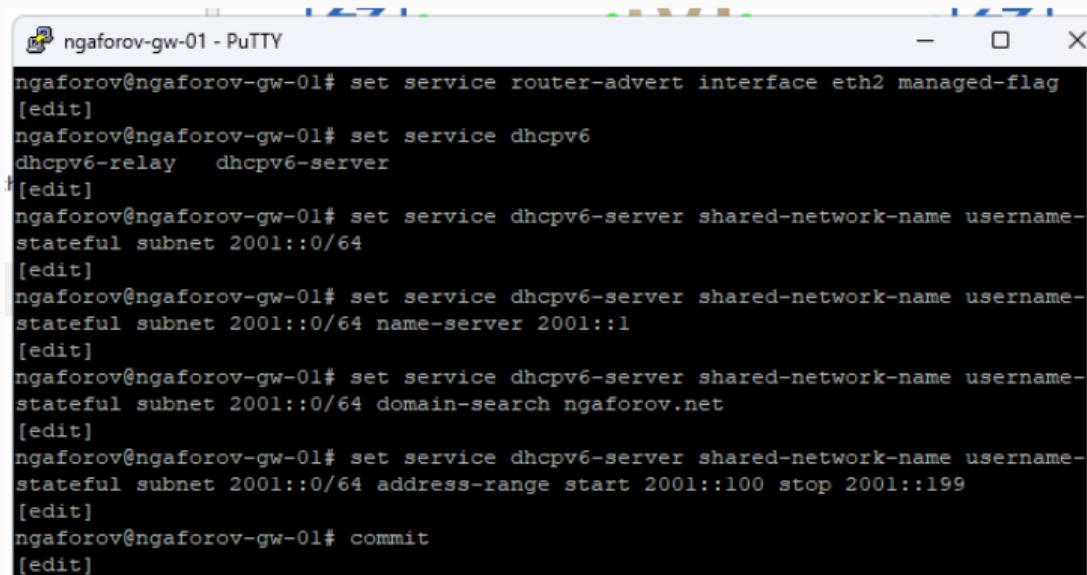
> Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0
> Ethernet II, Src: 0c:0e:6b:d3:00:00 (0c:0e:6b:d3:00:00), Dst: IPv6mcast_01:00:02 (33:33:00:01:00:02)
> Internet Protocol Version 6, Src: fe80::8e8a:2fc9:dea3:987, Dst: ff02::1:2
> User Datagram Protocol, Src Port: 546, Dst Port: 547
▼ DHCPv6
 Message type: Information-request (11)
 Transaction ID: 0x58f3a5
 ▼ Client Identifier
 Option: Client Identifier (1)
 Length: 10
 DUID: 000300010c0e6bd30000
 DUID Type: link-layer address (3)
 Hardware type: Ethernet (1)
 Link-layer address: 0c:0e:6b:d3:00:00
 Link-layer address (Ethernet): 0c:0e:6b:d3:00:00 (0c:0e:6b:d3:00:00)

0000 33 33 00 01 00
0010 df 3e 00 2c 11
0020 2f c9 de a3 09
0030 00 00 00 01 00
0040 f3 a5 00 01 00
0050 00 06 00 08 00
0060 00 00

Настройка DHCPv6 Stateful

Создан DHCPv6-пул:

- диапазон: 2001::100 — 2001::199
- DNS: 2001::1
- domain-search: ngaforov.net



```
ngaforov@ngaforov-gw-01# set service router-advert interface eth2 managed-flag
[edit]
ngaforov@ngaforov-gw-01# set service dhcpcv6
dhcpcv6-relay    dhcpcv6-server
[edit]
ngaforov@ngaforov-gw-01# set service dhcpcv6-server shared-network-name username-
stateful subnet 2001::0/64
[edit]
ngaforov@ngaforov-gw-01# set service dhcpcv6-server shared-network-name username-
stateful subnet 2001::0/64 name-server 2001::1
[edit]
ngaforov@ngaforov-gw-01# set service dhcpcv6-server shared-network-name username-
stateful subnet 2001::0/64 domain-search ngaforov.net
[edit]
ngaforov@ngaforov-gw-01# set service dhcpcv6-server shared-network-name username-
stateful subnet 2001::0/64 address-range start 2001::100 stop 2001::199
[edit]
ngaforov@ngaforov-gw-01# commit
[edit]
```

Получение IPv6-адреса PC3

Команда `dhclient -6 -v eth0` получила адрес из диапазона DHCPv6 Stateful — 2001::198/128.

```
[root@kali kali] ~$ sudo dhclient -6 -v eth0
Internet Systems Consortium DHCP Client 4.4.1
Copyright 2004-2018 Internet Systems Consortium.
All rights reserved.
For info, please visit https://www.isc.org/software/dhcp/

Listening on Socket/eth0
Sending on  Socket/eth0
Created duid "\000\001\000\0010\272\304\267\014\350\267x\000\000".
PRC: Soliciting for leases (INIT).
XMT: Forming Solicit, 0 ms elapsed.
XMT: X-- IA_NA b7:78:00:00
XMT: | X-- Request renew in +3600
XMT: | X-- Request rebind in +5400
XMT: Solicit on eth0, interval 1080ms.
RCV: Advertise message on eth0 from fe80::e1d:79ff:fee3:2.
RCV: X-- IA_NA b7:78:00:00
RCV: | X-- starts 1764231224
RCV: | X-- t1 - renew +0
RCV: | X-- t2 - rebind +0
RCV: | X-- [Options]
RCV: | | X-- IAADDR 2001::198
RCV: | | X-- Preferred lifetime 27000.
RCV: | | X-- Max lifetime 43200.
RCV: X-- Server ID: 00:01:00:01:30:ba:c0:db:0c:1d:79:e3:00:01
RCV: Advertisement recorded.
PRC: Selecting best advertised lease.
PRC: Considering best lease.
PRC: X-- Initial candidate 00:01:00:01:30:ba:c0:db:0c:1d:79:e3:00:01 (s: 10105, p: 0).
XMT: Forming Request, 0 ms elapsed.
XMT: X-- IA_NA b7:78:00:00
XMT: | X-- Requested renew +3600
XMT: | X-- Requested rebind +5400
XMT: | | X-- IAADDR 2001::198
XMT: | | X-- Preferred lifetime +7200
XMT: | | X-- Max lifetime +7500
```

Проверка маршрутизации и связности

Появился non-temporary IPv6-адрес, маршруты обновлены.

Ping до 2001::1 успешен.

```
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
      inet6 2001::198  prefixlen 128 scopeid 0x0<global>
      inet6 2001::199  prefixlen 128 scopeid 0x0<global>
      inet6 fe80::ffd2:fe52:907a:4316  prefixlen 64 scopeid 0x20<link>
        ether 0c:e8:b7:78:00:00  txqueuelen 1000 (Ethernet)
          RX packets 9 bytes 1158 (1.1 KiB)
          RX errors 0 dropped 0 overruns 0 frame 0
          TX packets 33 bytes 5174 (5.0 KiB)
            TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

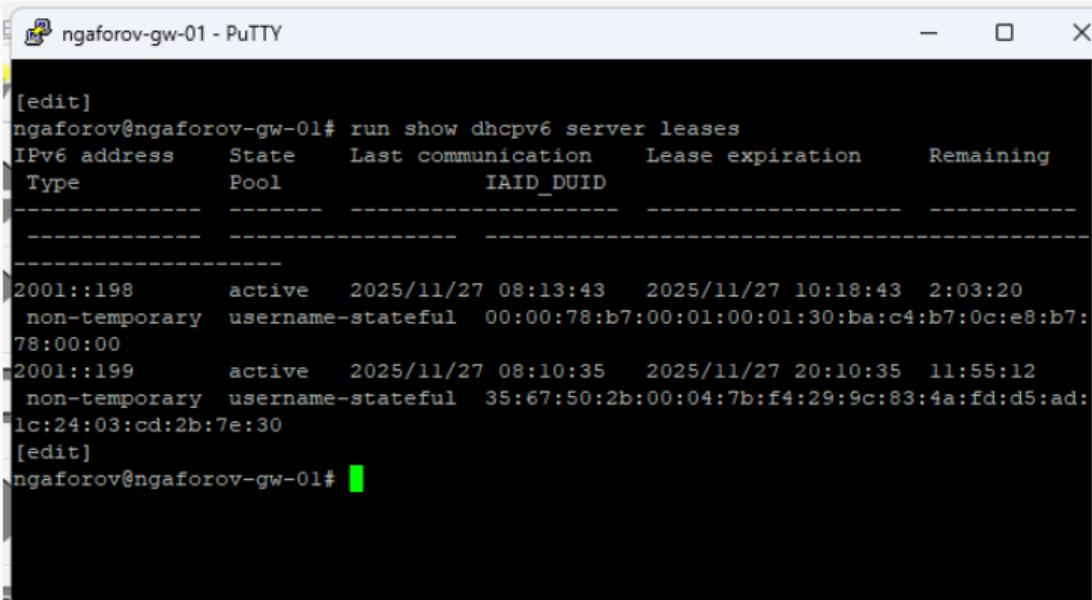
(kali㉿kali)-[~]
└─$ route -n -A inet6
Kernel IPv6 routing table
Destination           Next Hop          Flag Met Ref Use If
::/128                ::               U   256  2    0   lo
2001::198/128         ::               U   256  1    0   eth0
2001::199/128         ::               U   100  2    0   eth0
fe80::/64              ::               U   100  1    0   eth0
::/0                  fe80::e1d:79ff:fee3:2  UG  100  1    0   eth0
::/128                ::               Un  0    4    0   lo
2001::198/128         ::               Un  0    2    0   eth0
2001::199/128         ::               Un  0    3    0   eth0
fe80::ffd2:fe52:907a:4316/128 ::               Un  0    3    0   eth0
ff00::/8               ::               U   256  3    0   eth0
::/0                  ::               !n  -1   1    0   lo

(kali㉿kali)-[~]
└─$ ping 2001::1 -c 2
PING 2001::1(2001::1) 56 data bytes
64 bytes from 2001::1: icmp_seq=1 ttl=64 time=2.06 ms
64 bytes from 2001::1: icmp_seq=2 ttl=64 time=3.26 ms
```

Таблица DHCPv6 Stateful

Маршрутизатор показывает активные аренды:

- 2001::198
- 2001::199



```
[edit]
ngaforov@ngaforov-gw-01# run show dhcpv6 server leases
IPv6 address      State      Last communication      Lease expiration      Remaining
Type             Pool          IAID_DUID
-----  -----  -----
-----  -----
2001::198        active     2025/11/27 08:13:43    2025/11/27 10:18:43  2:03:20
non-temporary   username-stateful  00:00:78:b7:00:01:00:01:30:ba:c4:b7:0c:e8:b7:
78:00:00
2001::199        active     2025/11/27 08:10:35    2025/11/27 20:10:35  11:55:12
non-temporary   username-stateful  35:67:50:2b:00:04:7b:f4:29:9c:83:4a:fd:d5:ad:
lc:24:03:cd:2b:7e:30
[edit]
ngaforov@ngaforov-gw-01#
```

DHCPv6 Stateful в Wireshark

Зафиксирован полный обмен:

- Solicit
- Advertise
- Request
- Reply

The screenshot shows a Wireshark capture window titled "Захват из Standard input [ngaforov-gw-01 eth2 to ngaforov-sw-03 Ethernet1]". The packet list pane displays a sequence of DHCPv6 messages. The first few frames are DHCP Discover messages from the client (fe80::1) to the server (fe80::1). Frame 34 is a DHCPv6 Request message from the client to the server. Frame 35 is a DHCPv6 Reply message from the server to the client. The details pane shows the structure of the Request and Reply messages, including fields like Transaction ID, Client Identifier, and IP address. The bottom status bar indicates the total number of bytes captured and transmitted.

No.	Time	Source	Destination	Protocol	Length	Info
27	36.152381	fe80::1	fe80::1:79ff:fee3.. fe80::ffd2:fe52:907..	ICMPv6	78	Neighbor Advertisement fe80::1:79ff:fee3:2 (rtr, sol)
28	44.264378	0.0.0.0	255.255.255.255	DHCP	324	DHCP Discover - Transaction ID 0x3ab8dble
29	61.171832	0.0.0.0	255.255.255.255	DHCP	324	DHCP Discover - Transaction ID 0xe7df332
30	93.798834	0.0.0.0	255.255.255.255	DHCP	324	DHCP Discover - Transaction ID 0x56898246
31	157.8999561	0.0.0.0	255.255.255.255	DHCP	324	DHCP Discover - Transaction ID 0xef6c232
32	218.5808321	fe80::1:ffd2:fe52:907.. ff02::1:2	DHCPv6	118	Solicit XID: 0xb25c3f CID: 0001000130bac4b70ce8b7780000	
33	218.593938	fe80::1:79ff:fee3.. fe80::ffd2:fe52:907..	DHCPv6	184	Advertise XID: 0xb25c3f IAA: 2001::198 CID: 0001000130bac4b70ce8b7780000	
34	219.662331	fe80::1:ffd2:fe52:907.. ff02::1:2	DHCPv6	164	Request XID: 0x97b2f7 CID: 0001000130bac4b70ce8b7780000 IAA: 2001::198	
35	219.664927	fe80::1:79ff:fee3.. fe80::ffd2:fe52:907..	DHCPv6	184	Reply XID: 0x97b2f7 IAA: 2001::198 CID: 0001000130bac4b70ce8b7780000	
36	219.690043	fe80::1:ffd2:fe52:907.. ff02::1:16	ICMPv6	130	Multicast Listener Report Message v2	
37	219.810558	fe80::1:ffd2:fe52:907.. ff02::1:16	ICMPv6	130	Multicast Listener Report Message v2	
38	219.890151	::	ff02::1:ff00:198	ICMPv6	86	Neighbor Solicitation for 2001::198
39	222.852019	0.0.0.0	255.255.255.255	DHCP	324	DHCP Discover - Transaction ID 0x6fc47dff

> Frame 34: 164 bytes on wire (1312 bits), 164 bytes captured (1312 bits) on interface -, id 0
> Ethernet II, Src: 0:c:e8:b7:78:00:00 (0:c:e8:b7:78:00:00), Dst: IPv6mcast_01:00:02 (33:33:00:01:00:02)
> Internet Protocol Version 6, Src: fe80::1:ffd2:fe52:907a:4316, Dst: ff02::1:2
> User Datagram Protocol, Src Port: 546, Dst Port: 547
↳ DHCPv6
 Message type: Request (3)
 Transaction ID: 0x97b2f7
 Client Identifier
 _{Obligatory Client Identification (1)}

0000 33 33 00 01 00
0010 a3 98 00 6e 11
0020 fe 52 90 7a 43
0030 00 00 00 01 00
0040 b2 f7 00 01 00
0050 b7 78 00 00 00
0060 0c 1d 79 e3 00
0070 00 1f 00 00 00
0080 00 00 00 18 00
0090 00 00 00 00 00
00a0 00 00 00 00 00

Выводы

Выводы

В ходе работы:

- Выполнена настройка DHCP для IPv4 и IPv6.
- Исследованы два режима DHCPv6: **Stateless** и **Stateful**.
- Подтверждена корректная работа **SLAAC**, **RA**, **DHCPv6**.
- В Wireshark детально проанализированы циклы обмена:
 - **DORA** (IPv4)
 - **Information-Request / Reply** (**Stateless**)
 - **Solicit → Advertise → Request → Reply** (**Stateful**)

Работа позволила закрепить навыки построения IPv4/IPv6-сетей, настройки VyOS и анализа трафика.