

Адресация IPv4 и IPv6. Dual Stack

Лабораторная работа №6

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Цели и задачи

Изучить настройку IPv4 и IPv6, разбиение сетей на подсети, работу двойного стека (Dual Stack) и анализ сетевого трафика.

Разбиение IPv4 на подсети

Требуется подсети: 126, 62, 62 хостов.

Подсеть	Префикс	Диапазон адресов	Broadcast
1	/25	172.16.20.1 – 172.16.20.126	172.16.20.127
2	/26	172.16.20.129 – 172.16.20.190	172.16.20.191
3	/26	172.16.20.193 – 172.16.20.254	172.16.20.255

Разбиение IPv6 на подсети

1. Разбиение по идентификатору подсети (SubNetID):

- 2001:db8:c0de:0000::/49
- 2001:db8:c0de:8000::/49

2. Разбиение по идентификатору интерфейса (InterfaceID):

- 2001:db8:c0de:0000::/65
- 2001:db8:c0de:0000:8000::/65

Настройка двойного стека адресации IPv4 и IPv6 в локальной сети

Настройка устройства PC3 (IPv6)

```
PC3-ngaforov - PuTTY
PC3-ngaforov> show ip

NAME          : PC3-ngaforov[1]
IP/MASK       : 0.0.0.0/0
GATEWAY       : 0.0.0.0
DNS           :
MAC           : 00:50:79:66:68:02
LPORT        : 10022
RHOST:PORT    : 127.0.0.1:10023
MTU           : 1500

PC3-ngaforov> show ipv6

NAME          : PC3-ngaforov[1]
LINK-LOCAL SCOPE : fe80::250:79ff:fe66:6802/64
GLOBAL SCOPE    : 2001:db8:c0de:12::a/64
DNS             :
ROUTER LINK-LAYER :
MAC            : 00:50:79:66:68:02
LPORT         : 10022
RHOST:PORT     : 127.0.0.1:10023
MTU            : 1500

PC3-ngaforov>
```

Настройка устройства PC4 (IPv6)

```
PC4-ngaforov - PuTTY

PC4-ngaforov> save
Saving startup configuration to startup.vpc
. done

PC4-ngaforov> show ip
NAME           : PC4-ngaforov[1]
IP/MASK        : 0.0.0.0/0
GATEWAY        : 0.0.0.0
DNS            :
MAC            : 00:50:79:66:68:03
LPORT         : 10028
RHOST:PORT     : 127.0.0.1:10029
MTU            : 1500

PC4-ngaforov> show ipv6
NAME           : PC4-ngaforov[1]
LINK-LOCAL SCOPE : fe80::250:79ff:fe66:6803/64
GLOBAL SCOPE    : 2001:db8:c0de:13::a/64
DNS            :
ROUTER LINK-LAYER :
MAC            : 00:50:79:66:68:03
LPORT         : 10028
RHOST:PORT     : 127.0.0.1:10029
MTU            : 1500

PC4-ngaforov>
```

```
server-ngaforov - PuTTY
VPCS> show ip
NAME           : VPCS[1]
IP/MASK        : 64.100.1.10/24
GATEWAY        : 64.100.1.1
DNS            :
MAC            : 00:50:79:66:68:04
LPORT          : 10030
RHOST:PORT     : 127.0.0.1:10031
MTU            : 1500

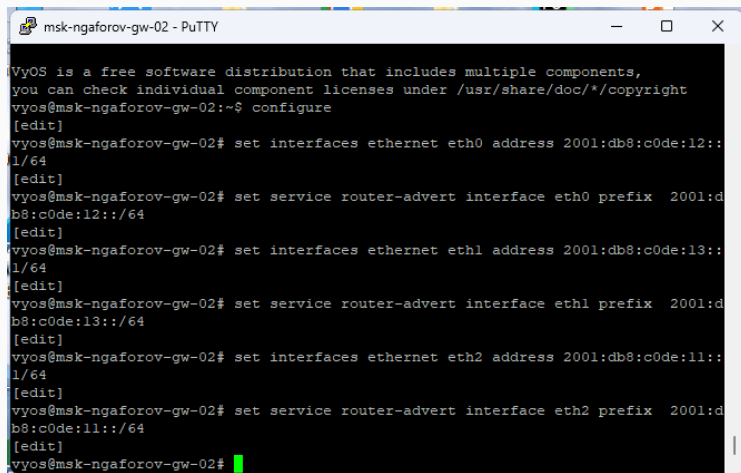
VPCS> show ipv6
NAME           : VPCS[1]
LINK-LOCAL SCOPE : fe80::250:79ff:fe66:6804/64
GLOBAL SCOPE    : 2001:db8:c0de:11::a/64
DNS            :
ROUTER LINK-LAYER :
MAC            : 00:50:79:66:68:04
LPORT          : 10030
RHOST:PORT     : 127.0.0.1:10031
MTU:           : 1500

VPCS>
```

Интерфейсы получили минимальные адреса подсети:

Интерфейс	IPv6 адрес
eth0	2001:db8:c0de:12::1/64
eth1	2001:db8:c0de:13::1/64
eth2	2001:db8:c0de:11::1/64

Настройка маршрутизатора VyOS



```
msk-ngaforov-gw-02 - PuTTY

VyOS is a free software distribution that includes multiple components,
you can check individual component licenses under /usr/share/doc/*/copyright
vyos@msk-ngaforov-gw-02:~$ configure
[edit]
vyos@msk-ngaforov-gw-02# set interfaces ethernet eth0 address 2001:db8:c0de:12::
1/64
[edit]
vyos@msk-ngaforov-gw-02# set service router-advert interface eth0 prefix 2001:d
b8:c0de:12::/64
[edit]
vyos@msk-ngaforov-gw-02# set interfaces ethernet eth1 address 2001:db8:c0de:13::
1/64
[edit]
vyos@msk-ngaforov-gw-02# set service router-advert interface eth1 prefix 2001:d
b8:c0de:13::/64
[edit]
vyos@msk-ngaforov-gw-02# set interfaces ethernet eth2 address 2001:db8:c0de:11::
1/64
[edit]
vyos@msk-ngaforov-gw-02# set service router-advert interface eth2 prefix 2001:d
b8:c0de:11::/64
[edit]
vyos@msk-ngaforov-gw-02#
```

Рис. 4: Настройка интерфейсов

Узлы успешно отправляют ICMPv6 Echo Request / Reply:

```
PC3-ngaforov> ping 2001:db8:c0de:13::a

2001:db8:c0de:13::a icmp6_seq=1 ttl=62 time=7.308 ms
2001:db8:c0de:13::a icmp6_seq=2 ttl=62 time=2.295 ms
2001:db8:c0de:13::a icmp6_seq=3 ttl=62 time=1.624 ms
2001:db8:c0de:13::a icmp6_seq=4 ttl=62 time=7.343 ms
2001:db8:c0de:13::a icmp6_seq=5 ttl=62 time=2.372 ms

PC3-ngaforov> trace 2001:db8:c0de:13::a

Trace to 2001:db8:c0de:13::a, 64 hops max
 0  2001:db8:c0de:12::1    2.770 ms  0.957 ms  0.932 ms
 1  2001:db8:c0de:13::a    1.434 ms  1.272 ms  0.900 ms

PC3-ngaforov> trace 2001:db8:c0de:11::a

Trace to 2001:db8:c0de:11::a, 64 hops max
 0  2001:db8:c0de:12::1    2.380 ms  1.118 ms  0.611 ms
 1  2001:db8:c0de:11::a    2.026 ms  1.125 ms  1.015 ms

PC3-ngaforov> ping 2001:db8:c0de:11::a

2001:db8:c0de:11::a icmp6_seq=1 ttl=62 time=3.666 ms
2001:db8:c0de:11::a icmp6_seq=2 ttl=62 time=1.932 ms
2001:db8:c0de:11::a icmp6_seq=3 ttl=62 time=1.880 ms
2001:db8:c0de:11::a icmp6_seq=4 ttl=62 time=2.336 ms
2001:db8:c0de:11::a icmp6_seq=5 ttl=62 time=2.485 ms

PC3-ngaforov> ping 172.16.20.138
```

Анализ трафика (Wireshark)

Позволяет определить MAC-адрес по IPv4-адресу.

No.	Time	Source	Destination	Protocol	Length	Info
47	129.042108	64.100.1.10	172.16.20.10	ICMP	98	Echo (ping) request id=0xfeba, seq=1/256, ttl=64 (reply in 48)
48	129.046162	172.16.20.10	64.100.1.10	ICMP	98	Echo (ping) reply id=0xfeba, seq=1/256, ttl=63 (request in 47)
49	130.048578	64.100.1.10	172.16.20.10	ICMP	98	Echo (ping) request id=0xffba, seq=2/512, ttl=64 (reply in 50)
50	130.052862	172.16.20.10	64.100.1.10	ICMP	98	Echo (ping) reply id=0xffba, seq=2/512, ttl=63 (request in 49)
51	131.054785	64.100.1.10	172.16.20.10	ICMP	98	Echo (ping) request id=0x00bb, seq=3/768, ttl=64 (reply in 52)
52	131.058696	172.16.20.10	64.100.1.10	ICMP	98	Echo (ping) reply id=0x00bb, seq=3/768, ttl=63 (request in 51)
53	132.059897	64.100.1.10	172.16.20.10	ICMP	98	Echo (ping) request id=0x01bb, seq=4/1024, ttl=64 (reply in 54)
54	132.061744	172.16.20.10	64.100.1.10	ICMP	98	Echo (ping) reply id=0x01bb, seq=4/1024, ttl=63 (request in 53)
55	133.063317	64.100.1.10	172.16.20.10	ICMP	98	Echo (ping) request id=0x02bb, seq=5/1280, ttl=64 (reply in 56)
56	133.064720	172.16.20.10	64.100.1.10	ICMP	98	Echo (ping) reply id=0x02bb, seq=5/1280, ttl=63 (request in 55)
57	134.082437	0c:61:b5:dc:00:02	Private_66:68:04	ARP	60	Who has 64.100.1.10? Tell 64.100.1.1
58	134.083506	Private_66:68:04	0c:61:b5:dc:00:02	ARP	60	64.100.1.10 is at 00:50:79:66:68:04
59	139.000031	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x09bb, seq=1, hop limit=64 (reply in 60)

> Frame 57: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface -, id 0

▼ Ethernet II, Src: 0c:61:b5:dc:00:02 (0c:61:b5:dc: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:61:b5:dc:00:02 (0c:61:b5:dc:00:02)

Type: ARP (0x0806)

[Stream index: 4]

Padding: 00000000000000000000000000000000

▼ 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:61:b5:dc:00:02 (0c:61:b5:dc: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
0010 00 00 06 04
0020 00 00 00 00
0030 00 00 00 00

11/16

Показывает успешность доставки пакетов между узлами.

No.	Time	Source	Destination	Protocol	Length	Info
65	142.810766	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x09bb, seq=4, hop limit=64 (reply in 66)
66	142.812267	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x09bb, seq=4, hop limit=62 (request in 65)
67	143.813939	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x09bb, seq=5, hop limit=64 (reply in 68)
68	143.816873	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x09bb, seq=5, hop limit=62 (request in 67)
→	69 150.904903	64.100.1.10	172.16.20.129	ICMP	98	Echo (ping) request id=0x14bb, seq=1/256, ttl=64 (reply in 70)
←	70 150.907000	172.16.20.129	64.100.1.10	ICMP	98	Echo (ping) reply id=0x14bb, seq=1/256, ttl=64 (request in 69)
	71 151.908947	64.100.1.10	172.16.20.129	ICMP	98	Echo (ping) request id=0x15bb, seq=2/512, ttl=64 (reply in 72)
	72 151.910060	172.16.20.129	64.100.1.10	ICMP	98	Echo (ping) reply id=0x15bb, seq=2/512, ttl=64 (request in 71)
	73 152.911924	64.100.1.10	172.16.20.129	ICMP	98	Echo (ping) request id=0x16bb, seq=3/768, ttl=64 (reply in 74)
	74 152.912662	172.16.20.129	64.100.1.10	ICMP	98	Echo (ping) reply id=0x16bb, seq=3/768, ttl=64 (request in 73)
	75 153.913439	64.100.1.10	172.16.20.129	ICMP	98	Echo (ping) request id=0x17bb, seq=4/1024, ttl=64 (reply in 76)
	76 153.915011	172.16.20.129	64.100.1.10	ICMP	98	Echo (ping) reply id=0x17bb, seq=4/1024, ttl=64 (request in 75)
	77 154.916613	64.100.1.10	172.16.20.129	ICMP	98	Echo (ping) request id=0x18bb, seq=5/1280, ttl=64 (reply in 78)
> Frame 70: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface -, id 0 > Ethernet II, Src: 0c:61:b5:dc:00:02 (0c:61:b5:dc: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:61:b5:dc:00:02 (0c:61:b5:dc:00:02) Type: IPv4 (0x0800) [Stream index: 4] > Internet Protocol Version 4, Src: 172.16.20.129, Dst: 64.100.1.10 0100 = Version: 4 0101 = Header Length: 20 bytes (5) > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT) Total Length: 84 Identification: 0xcfa8 (53064) > 0000 = Flags: 0x0 ...0 0000 0000 0000 = Fragment Offset: 0 Time to Live: 64 Protocol: ICMP (1) Header Checksum: 0xa961 [validation disabled] [Header checksum status: Unverified] Source Address: 172.16.20.129 Destination Address: 64.100.1.10 [Stream index: 1] > Internet Control Message Protocol Type: 0 (Echo (ping) reply) Code: 0 Checksum: 0x1350 [correct] [Checksum Status: Good] Identifier (RFI): 5307 (0x14bh)						
						0000 00 50 79 0010 00 54 cf 0020 01 0a 00 0030 0e 0f 10 0040 1e 1f 20 0050 2e 2f 30 0060 3e 3f

Аналог ICMP, используется также для Neighbor Discovery.

No.	Time	Source	Destination	Protocol	Length	Info
54	132.061744	172.16.20.10	64.100.1.10	ICMP	98	Echo (ping) reply id=0x01bb, seq=4/1024, ttl=63 (request in 53)
55	133.063317	64.100.1.10	172.16.20.10	ICMP	98	Echo (ping) request id=0x02bb, seq=5/1280, ttl=64 (reply in 56)
56	133.064720	172.16.20.10	64.100.1.10	ICMP	98	Echo (ping) reply id=0x02bb, seq=5/1280, ttl=63 (request in 55)
57	134.082437	0c:61:b5:dc:00:02	Private_66:68:04	ARP	60	Who has 64.100.1.10? Tell 64.100.1.1
58	134.083506	Private_66:68:04	0c:61:b5:dc:00:02	ARP	60	64.100.1.10 is at 00:50:79:66:68:04
59	139.800031	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x09bb, seq=1, hop limit=64 (reply in 60)
60	139.802606	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x09bb, seq=1, hop limit=62 (request in 59)
61	140.804054	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x09bb, seq=2, hop limit=64 (reply in 62)
62	140.806762	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x09bb, seq=2, hop limit=62 (request in 61)
63	141.808092	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x09bb, seq=3, hop limit=64 (reply in 64)
64	141.809701	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x09bb, seq=3, hop limit=62 (request in 63)
65	142.810766	2001:db8:c0de:11::a	2001:db8:c0de:13::a	ICMPv6	118	Echo (ping) request id=0x09bb, seq=4, hop limit=64 (reply in 66)
66	142.812267	2001:db8:c0de:13::a	2001:db8:c0de:11::a	ICMPv6	118	Echo (ping) reply id=0x09bb, seq=4, hop limit=62 (request in 65)

> Frame 62: 118 bytes on wire (944 bits), 118 bytes captured (944 bits) on interface -, id 0	0000 00 50 79 66 6
✓ Ethernet II, Src: 0c:71:94:92:00:02 (0c:71:94:92:00:02), Dst: Private_66:68:04 (00:50:79:66:68:04)	0010 00 00 00 40 3
> Destination: Private_66:68:04 (00:50:79:66:68:04)	0020 00 00 00 00 0
> Source: 0c:71:94:92:00:02 (0c:71:94:92:00:02)	0030 00 00 00 00 0
Type: IPv6 (0x86dd)	0040 02 03 04 05 0
[Stream index: 2]	0050 12 13 14 15 1
✓ Internet Protocol Version 6, Src: 2001:db8:c0de:13::a, Dst: 2001:db8:c0de:11::a	0060 22 23 24 25 2
0110 = Version: 6	0070 32 33 34 35 3
> 0000 0000 = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)	
.... 0000 0000 0000 0000 = Flow Label: 0x00000	
Payload Length: 64	
Next Header: ICMPv6 (58)	
Hop Limit: 62	
> Source Address: 2001:db8:c0de:13::a	
> Destination Address: 2001:db8:c0de:11::a	
[Stream index: 4]	
✓ Internet Control Message Protocol v6	
Type: Echo (ping) reply (129)	
Code: 0	
Checksum: 0xa04d [correct]	
[Checksum Status: Good]	
Identifier: 0x09bb	
Sequence: 2	
[Response To: 61]	
[Response Time: 2,708 ms]	

Самостоятельная часть

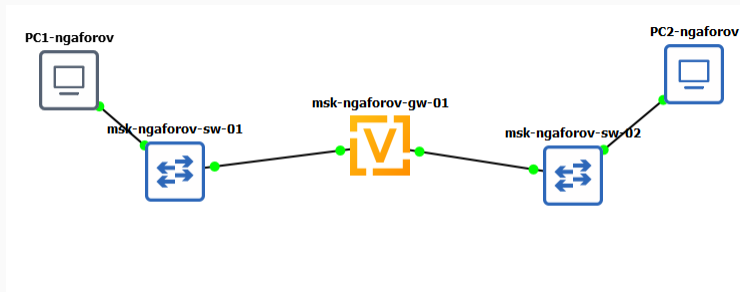


Рис. 9: Топология

Проверка связи

Передача пакетов между подсетями (IPv6 и IPv4):

```
PC1-ngaforov> ping 10.10.1.20
84 bytes from 10.10.1.20 icmp_seq=1 ttl=63 time=3.714 ms
84 bytes from 10.10.1.20 icmp_seq=2 ttl=63 time=2.351 ms
84 bytes from 10.10.1.20 icmp_seq=3 ttl=63 time=2.748 ms
84 bytes from 10.10.1.20 icmp_seq=4 ttl=63 time=5.354 ms
84 bytes from 10.10.1.20 icmp_seq=5 ttl=63 time=1.919 ms

PC1-ngaforov> ping 2001:db8:1:4::a
2001:db8:1:4::a icmp6_seq=1 ttl=62 time=6.078 ms
2001:db8:1:4::a icmp6_seq=2 ttl=62 time=3.623 ms
2001:db8:1:4::a icmp6_seq=3 ttl=62 time=2.383 ms
2001:db8:1:4::a icmp6_seq=4 ttl=62 time=3.066 ms
2001:db8:1:4::a icmp6_seq=5 ttl=62 time=3.962 ms

PC1-ngaforov> █
```

Рис. 10: Проверка

Выводы

В ходе работы выполнено:

- Разбиение IPv4 и IPv6 на подсети.
- Настройка адресов на ПК и маршрутизаторе.
- Проверка связи между узлами.
- Анализ ARP, ICMP и ICMPv6 в Wireshark.

Получены практические навыки настройки Dual Stack и анализа сетевого трафика.