

Лабораторная работа №8

Сетевые технологии

Иванов Сергей Владимирович, НПИбд-01-23

19 декабря 2025

Российский университет дружбы народов, Москва, Россия

Цель

Изучение принципов маршрутизации в IPv4- и IPv6-сетях и принципов настройки сетевого оборудования.

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Продублируем таблицы адресации. (рис. 1, 2)

Таблица адресов сетей		
Устройства	Сеть IPv4	Сеть IPv6
PC1 – gw-01	10.0.10.0/24	2001:10::/64
PC2 – gw-03	10.0.11.0/24	2001:11::/64
gw-01 – gw-02	10.0.1.0/24	2001:1::/64
gw-02 – gw-03	10.0.2.0/24	2001:2::/64
gw-03 – gw-04	10.0.3.0/24	2001:3::/64
gw-04 – gw-01	10.0.4.0/24	2001:4::/64

Рис. 1: Таблица адресов сетей

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Таблица адресации

Устройство	Интерфейс	Адрес IP/префикс	Шлюз по умолчанию	Следующее устройство
gw-01	eth0	10.0.10.1/24	n/a	PC1
	eth0	2001:10::1/64	n/a	PC1
	eth1	10.0.1.1/24	n/a	gw-02
	eth1	2001:1::1/64	n/a	gw-02
	eth2	10.0.4.2/24	n/a	gw-04
	eth2	2001:4::2/64	n/a	gw-04
gw-02	eth0	10.0.1.2/24	n/a	gw-01
	eth0	2001:1::2/64	n/a	gw-01
	eth1	10.0.2.1/24	n/a	gw-03
	eth1	2001:2::1/64	n/a	gw-03
gw-03	eth0	10.0.11.1/24	n/a	PC2
	eth0	2001:11::1/64	n/a	PC2
	eth1	10.0.2.2/24	n/a	gw-02
	eth1	2001:2::2/64	n/a	gw-02
	eth2	10.0.3.1/24	n/a	gw-04
	eth2	2001:3::1/64	n/a	gw-04
gw-04	eth0	10.0.3.2/24	n/a	gw-03
	eth0	2001:3::2/64	n/a	gw-03
	eth1	10.0.4.1/24	n/a	gw-01
	eth1	2001:4::1/64	n/a	gw-01
PC1	NIC	10.0.10.10/24	10.0.10.1	gw-01
PC1	NIC	2001:10::a/64	n/a	gw-01
PC2	NIC	10.0.11.10/24	10.0.11.1	gw-03
PC2	NIC	2001:11::a/64	n/a	gw-03

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Схема L1 (рис. 3)

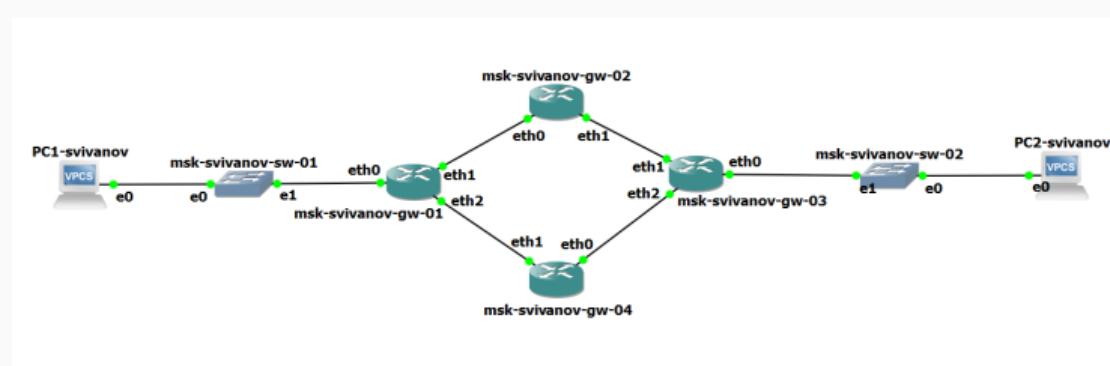


Рис. 3: Схема L1

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Схема L3 (рис. 4)

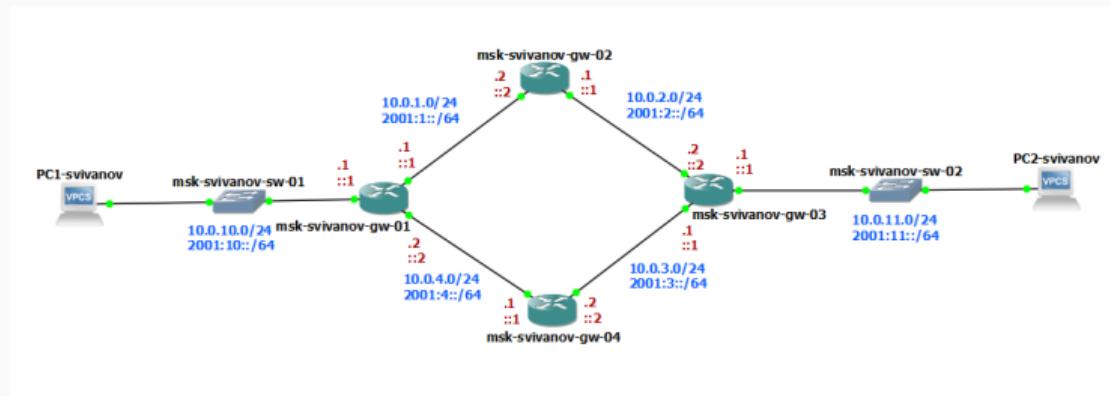


Рис. 4: Схема L3

Настройка динамической маршрутизации в сетях IPv4 и IPv6

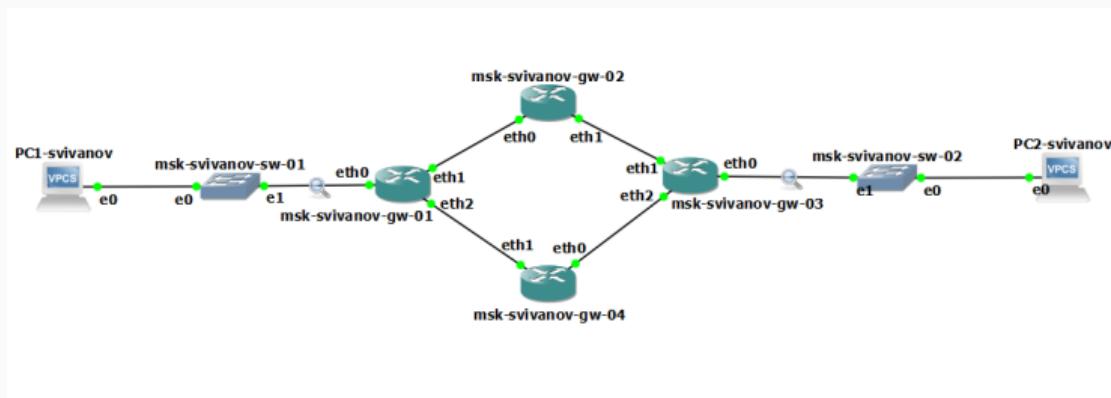


Рис. 5: Создание сети

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Присвоим IPv4-адреса устройствам PC1 и PC2:

```
PC1-svivanov> ip 10.0.10.10/24 10.0.10.1
Checking for duplicate address...
PC1-svivanov : 10.0.10.10 255.255.255.0 gateway 10.0.10.1

PC1-svivanov> save
Saving startup configuration to startup.vpc
. done

PC1-svivanov> show ip

NAME      : PC1-svivanov[1]
IP/MASK   : 10.0.10.10/24
GATEWAY   : 10.0.10.1
DNS       :
MAC       : 00:50:79:66:68:00
LPORT     : 20064
RHOST:PORT: 127.0.0.1:20065
MTU       : 1500

PC1-svivanov> █
```

Рис. 6: Настройка PC1

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
PC2-svivanov> ip 10.0.11.10/24 10.0.11.1
Checking for duplicate address...
PC2-svivanov : 10.0.11.10 255.255.255.0 gateway 10.0.11.1

PC2-svivanov> save
Saving startup configuration to startup.vpc
. done

PC2-svivanov> show ip

NAME      : PC2-svivanov[1]
IP/MASK   : 10.0.11.10/24
GATEWAY   : 10.0.11.1
DNS       :
MAC       : 00:50:79:66:68:01
LPORT     : 20082
RHOST:PORT : 127.0.0.1:20083
MTU       : 1500

PC2-svivanov> █
```

Рис. 7: Настройка PC2

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Настроим IPv4-адреса на интерфейсах маршрутизаторов:

```
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-01
service integrated-vtysh-config
!
interface eth0
 ip address 10.0.10.1/24
exit
!
interface eth1
 ip address 10.0.1.1/24
```

Рис. 8: Настройка gw-01

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-02
service integrated-vtysh-config
!
interface eth0
 ip address 10.0.1.2/24
exit
!
interface eth1
 ip address 10.0.2.1/24
exit
!
end
```

Рис. 9: Настройка gw-02

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# interface eth2
msk-svivanov-gw-03(config-if)# ip address 10.0.3.1/24
msk-svivanov-gw-03(config-if)# no shutdown
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-03
service integrated-vtysh-config
!
```

Рис. 10: Настройка gw-03

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
msk-svivanov-gw-04(config-if)# ip address 10.0.4.1/24
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-04
service integrated-vtysh-config
!
interface eth0
    ip address 10.0.3.2/24
exit
```

Рис. 11: Настройка gw-04

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Присвоим IPv6-адреса устройствам PC1 и PC2:

```
PC1-svivanov> ip 2001:10::a/64
PC1 : 2001:10::a/64

PC1-svivanov> save
Saving startup configuration to startup.vpc
. done

PC1-svivanov> show ipv6

NAME : PC1-svivanov[1]
LINK-LOCAL SCOPE : fe80::250:79ff:fe66:6800/64
GLOBAL SCOPE : 2001:10::a/64
DNS :
ROUTER LINK-LAYER :
MAC : 00:50:79:66:68:00
LPORT : 20064
RHOST:PORT : 127.0.0.1:20065
MTU: : 1500

PC1-svivanov> █
```

Рис. 12: Настройка PC1

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
PC2-svivanov> ip 2001:11::a/64
PC1 : 2001:11::a/64

PC2-svivanov> save
Saving startup configuration to startup.vpc
. done

PC2-svivanov> show ipv6

NAME           : PC2-svivanov[1]
LINK-LOCAL SCOPE : fe80::250:79ff:fe66:6801/64
GLOBAL SCOPE    : 2001:11::a/64
DNS            :
ROUTER LINK-LAYER :
MAC             : 00:50:79:66:68:01
LPORT           : 20082
RHOST:PORT      : 127.0.0.1:20083
MTU:            : 1500

PC2-svivanov> █
```

Рис. 13: Настройка PC2

Настройка динамической маршрутизации в сетях IPv4 и IPv6

Настроим IPv6-адреса на интерфейсах маршрутизаторов: (рис. 14-17)

```
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-01
service integrated-vtysh-config
!
interface eth0
  ip address 10.0.10.1/24
  ipv6 address 2001:10::1/64
  ipv6 nd prefix 2001:10::/64
  no ipv6 nd suppress-ra
exit
```

Рис. 14: Настройка gw-01

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
msk-svivanov-gw-02(config-if)# ipv6 address 2001:1::2/64
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth1
msk-svivanov-gw-02(config-if)# ipv6 address 2001:2::1/64
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-02
service integrated-vtysh-config
!
```

Рис. 15: Настройка gw-02

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-03
service integrated-vtysh-config
!
interface eth0
 ip address 10.0.11.1/24
 ipv6 address 2001:11::1/64
 ipv6 nd prefix 2001:11::/64
 no ipv6 nd suppress-ra
exit.
```

Рис. 16: Настройка gw-03

Настройка динамической маршрутизации в сетях IPv4 и IPv6

```
msk-svivanov-gw-04# show running-config
Building configuration...

Current configuration:
!
frr version 8.2.2
frr defaults traditional
hostname frr
hostname msk-svivanov-gw-04
service integrated-vtysh-config
!
interface eth0
    ip address 10.0.3.2/24
    ipv6 address 2001:3::2/64
exit
!
interface eth1
    ip address 10.0.4.1/24
    ipv6 address 2001:4::1/64
exit
!
end
msk-svivanov-gw-04#
```

Рис. 17: Настройка gw-04

Настройка динамической маршрутизации по протоколу RIP

На маршрутизаторах настроим RIP

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# router rip
msk-svivanov-gw-01(config-router)# version 2
msk-svivanov-gw-01(config-router)# network eth0
msk-svivanov-gw-01(config-router)# network eth1
msk-svivanov-gw-01(config-router)# network eth2
msk-svivanov-gw-01(config-router)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# □
```

Рис. 18: Настройка gw-01

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# router rip
msk-svivanov-gw-02(config-router)# version 2
msk-svivanov-gw-02(config-router)# network eth0
msk-svivanov-gw-02(config-router)# network eth1
msk-svivanov-gw-02(config-router)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# memory
% Unknown command: memory
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# □
```

Рис. 19: Настройка gw-02

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-03# configure terminal
msk-svivanov-gw-03(config)# router rip
msk-svivanov-gw-03(config-router)# version 2
msk-svivanov-gw-03(config-router)# network eth0
msk-svivanov-gw-03(config-router)# network eth1
msk-svivanov-gw-03(config-router)# network eth2
msk-svivanov-gw-03(config-router)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03# █
```

Рис. 20: Настройка gw-03

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# router rip
msk-svivanov-gw-04(config-router)# version 2
msk-svivanov-gw-04(config-router)# network eth0
msk-svivanov-gw-04(config-router)# network eth1
msk-svivanov-gw-04(config-router)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# █
```

Рис. 21: Настройка gw-04

Настройка динамической маршрутизации по протоколу RIP

Убедимся, что маршрутизация по RIP настроена:

```
msk-svivanov-gw-01# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface

      Network          Next Hop          Metric From        Tag Time
C(i) 10.0.1.0/24      0.0.0.0           1 self            0
R(n) 10.0.2.0/24      10.0.1.2          2 10.0.1.2       0 02:45
R(n) 10.0.3.0/24      10.0.4.1          2 10.0.4.1       0 02:56
C(i) 10.0.4.0/24      0.0.0.0           1 self            0
C(i) 10.0.10.0/24     0.0.0.0           1 self            0
R(n) 10.0.11.0/24     10.0.1.2          3 10.0.1.2       0 02:45
msk-svivanov-gw-01# show ip rip status
Routing Protocol is "rip"
  Sending updates every 30 seconds with +/-50%, next due in 8 seconds
  Timeout after 180 seconds, garbage collect after 120 seconds
  Outgoing update filter list for all interface is not set
  Incoming update filter list for all interface is not set
  Default redistribution metric is 1
  Redistributing:
    Default version control: send version 2, receive version 2
      Interface      Send      Recv      Key-chain
      -+--0          2         2
```

Рис. 22: Проверка настроек rip

Настройка динамической маршрутизации по протоколу RIP

```
R>* 10.0.10.0/24 [120/2] via 10.0.1.1, eth0, weight 1, 00:03:46
R>* 10.0.11.0/24 [120/2] via 10.0.2.2, eth1, weight 1, 00:02:36
msk-svivanov-gw-02# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface

      Network          Next Hop          Metric From        Tag Time
C(i) 10.0.1.0/24      0.0.0.0           1 self            0
C(i) 10.0.2.0/24      0.0.0.0           1 self            0
R(n) 10.0.3.0/24      10.0.2.2          2 10.0.2.2       0 02:26
R(n) 10.0.4.0/24      10.0.1.1          2 10.0.1.1       0 02:30
R(n) 10.0.10.0/24     10.0.1.1          2 10.0.1.1       0 02:30
R(n) 10.0.11.0/24     10.0.2.2          2 10.0.2.2       0 02:26
msk-svivanov-gw-02# show ip rip status
Routing Protocol is "rip"
  Sending updates every 30 seconds with +/-50%, next due in 14 seconds
  Timeout after 180 seconds, garbage collect after 120 seconds
  Outgoing update filter list for all interface is not set
  Incoming update filter list for all interface is not set
  Default redistribution metric is 1
  Redistributing:
    Default version control: send version 2, receive version 2
```

Рис. 23: Проверка настроек rip

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-03# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface

      Network          Next Hop          Metric From        Tag Time
R(n) 10.0.1.0/24      10.0.2.1          2 10.0.2.1       0 02:34
C(i) 10.0.2.0/24      0.0.0.0           1 self            0
C(i) 10.0.3.0/24      0.0.0.0           1 self            0
R(n) 10.0.4.0/24      10.0.3.2          2 10.0.3.2       0 02:46
R(n) 10.0.10.0/24     10.0.2.1          3 10.0.2.1       0 02:34
C(i) 10.0.11.0/24     0.0.0.0           1 self            0
msk-svivanov-gw-03# show ip rip status
Routing Protocol is "rip"
    Sending updates every 30 seconds with +/-50%, next due in 17 seconds
    Timeout after 180 seconds, garbage collect after 120 seconds
    Outgoing update filter list for all interface is not set
    Incoming update filter list for all interface is not set
    Default redistribution metric is 1
    Redistributing:
        Default version control: send version 2, receive version 2
        Interface      Send  Recv  Key-chain
          eth0          2     2
```

Рис. 24: Проверка настроек rip

Настройка динамической маршрутизации по протоколу RIP

```
R>* 10.0.10.0/24 [120/2] via 10.0.4.2, eth1, weight 1, 00:03:15
R>* 10.0.11.0/24 [120/2] via 10.0.3.1, eth0, weight 1, 00:03:17
msk-svivanov-gw-04# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface

      Network          Next Hop          Metric From        Tag Time
R(n) 10.0.1.0/24      10.0.4.2          2 10.0.4.2        0 02:43
R(n) 10.0.2.0/24      10.0.3.1          2 10.0.3.1        0 02:47
C(i) 10.0.3.0/24      0.0.0.0           1 self            0
C(i) 10.0.4.0/24      0.0.0.0           1 self            0
R(n) 10.0.10.0/24     10.0.4.2          2 10.0.4.2        0 02:43
R(n) 10.0.11.0/24     10.0.3.1          2 10.0.3.1        0 02:47
msk-svivanov-gw-04# show ip rip status
Routing Protocol is "rip"
    Sending updates every 30 seconds with +/-50%, next due in 3 seconds
    Timeout after 180 seconds, garbage collect after 120 seconds
    Outgoing update filter list for all interface is not set
    Incoming update filter list for all interface is not set
    Default redistribution metric is 1
    Redistributing:
        Default version control: send version 2, receive version 2
```

Рис. 25: Проверка настроек rip

Настройка динамической маршрутизации по протоколу RIP

С PC1 пропингуем PC2. Пакеты идут через gw-02 (рис. 26)

```
PC1-svivanov> ping 10.0.11.10

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=11.111 ms
84 bytes from 10.0.11.10 icmp_seq=2 ttl=61 time=4.249 ms
84 bytes from 10.0.11.10 icmp_seq=3 ttl=61 time=3.318 ms
84 bytes from 10.0.11.10 icmp_seq=4 ttl=61 time=4.617 ms
84 bytes from 10.0.11.10 icmp_seq=5 ttl=61 time=10.784 ms

PC1-svivanov> trace 10.0.11.10 -P 6
trace to 10.0.11.10, 8 hops max (TCP), press Ctrl+C to stop
 1  10.0.10.1    3.671 ms  2.113 ms  1.137 ms
 2  10.0.1.2     12.166 ms  2.370 ms  2.261 ms
 3  10.0.2.2     4.366 ms  2.535 ms  2.797 ms
 4  10.0.11.10   3.572 ms  2.570 ms  3.350 ms

PC1-svivanov>
```

Рис. 26: Отправка пакетов

Настройка динамической маршрутизации по протоколу RIP

Проверим метрики протокола RIP

```
msk-svivanov-gw-01# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface

      Network          Next Hop          Metric From        Tag Time
C(i) 10.0.1.0/24      0.0.0.0          1 self           0
R(n) 10.0.2.0/24      10.0.1.2         2 10.0.1.2       0 02:41
R(n) 10.0.3.0/24      10.0.4.1         2 10.0.4.1       0 02:34
C(i) 10.0.4.0/24      0.0.0.0          1 self           0
C(i) 10.0.10.0/24     0.0.0.0          1 self           0
R(n) 10.0.11.0/24     10.0.1.2         3 10.0.1.2       0 02:41
msk-svivanov-gw-01#
```

Рис. 27: Проверка метрик

Настройка динамической маршрутизации по протоколу RIP

Отключим на gw-02 интерфейс:

```
msk-svivanov-gw-01# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface

      Network          Next Hop          Metric From        Tag Time
C(i) 10.0.1.0/24      0.0.0.0          1 self           0
R(n) 10.0.2.0/24      10.0.1.2         2 10.0.1.2       0 02:30
R(n) 10.0.3.0/24      10.0.4.1         2 10.0.4.1       0 02:51
C(i) 10.0.4.0/24      0.0.0.0          1 self           0
C(i) 10.0.10.0/24     0.0.0.0          1 self           0
R(n) 10.0.11.0/24     10.0.1.2         3 10.0.1.2       0 02:30
msk-svivanov-gw-01# [ ]
```

Рис. 28: Отключение интерфейса и проверка метрик

Настройка динамической маршрутизации по протоколу RIP

С PC1 пропингуем PC2. Видим, что маршрут изменился.

```
PC1-svivanov> ping 10.0.11.10

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=6.477 ms
84 bytes from 10.0.11.10 icmp_seq=2 ttl=61 time=6.683 ms
84 bytes from 10.0.11.10 icmp_seq=3 ttl=61 time=5.895 ms
84 bytes from 10.0.11.10 icmp_seq=4 ttl=61 time=6.477 ms
84 bytes from 10.0.11.10 icmp_seq=5 ttl=61 time=7.637 ms

PC1-svivanov> trace 10.0.11.10 -P 6
trace to 10.0.11.10, 8 hops max (TCP), press Ctrl+C to stop
 1  10.0.10.1    0.652 ms   1.504 ms   0.948 ms
 2  10.0.4.1    3.644 ms   3.173 ms   2.906 ms
 3  10.0.3.1    3.489 ms   2.453 ms   2.171 ms
 4  10.0.11.10   3.199 ms   5.079 ms   3.005 ms

PC1-svivanov> █
```

Рис. 29: Пинг и путь следования

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-02(config-if)# interface eth0
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# █
```

Рис. 30: Включение интерфейса

Настройка динамической маршрутизации по протоколу RIP

С PC1 пропингуем PC2. (рис. 31)

```
PC1-svivanov> ping 10.0.11.10

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=7.917 ms
84 bytes from 10.0.11.10 icmp_seq=2 ttl=61 time=5.622 ms
84 bytes from 10.0.11.10 icmp_seq=3 ttl=61 time=9.534 ms
84 bytes from 10.0.11.10 icmp_seq=4 ttl=61 time=2.747 ms
84 bytes from 10.0.11.10 icmp_seq=5 ttl=61 time=8.850 ms

PC1-svivanov> trace 10.0.11.10 -P 6
trace to 10.0.11.10, 8 hops max (TCP), press Ctrl+C to stop
 1  10.0.10.1    0.851 ms   1.736 ms   0.927 ms
 2  10.0.4.1    2.641 ms   1.584 ms   1.643 ms
 3  10.0.3.1    2.633 ms   2.650 ms   2.312 ms
 4  10.0.11.10   4.118 ms   3.233 ms   3.359 ms

PC1-svivanov> █
```

Рис. 31: Отправка пинга

Настройка динамической маршрутизации по протоколу RIP

Посмотрим захваченный на соединениях трафик.

1	0.000000	10.0.10.1	224.0.0.9	RIPv2	146 Response
2	26.008854	10.0.10.1	224.0.0.9	RIPv2	146 Response
3	53.815592	Private_66:68:00	Broadcast	ARP	64 Who has 10.0.10.1? Tell 10.0.10.10
4	53.821741	0c:01:b4:78:00:00	Private_66:68:00	ARP	60 10.0.10.1 is at 0c:01:b4:78:00:00
5	53.824813	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x4bf8, seq=1/256, ttl=64 (r)
6	53.832982	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x4bf8, seq=1/256, ttl=61 (r)
7	54.834101	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x4cf8, seq=2/512, ttl=64 (r)
8	54.838776	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x4cf8, seq=2/512, ttl=61 (r)
9	55.840113	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x4df8, seq=3/768, ttl=64 (r)
10	55.844433	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x4df8, seq=3/768, ttl=61 (r)
11	56.019452	10.0.10.1	224.0.0.9	RIPv2	146 Response
12	56.847582	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x4ef8, seq=4/1024, ttl=64 (r)
13	56.852750	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x4ef8, seq=4/1024, ttl=61 (r)
14	57.855115	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x4ff8, seq=5/1280, ttl=64 (r)
15	57.861410	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x4ff8, seq=5/1280, ttl=61 (r)
16	58.884070	0c:01:b4:78:00:00	Private_66:68:00	ARP	60 Who has 10.0.10.10? Tell 10.0.10.1
17	58.884196	Private_66:68:00	0c:01:b4:78:00:00	ARP	60 10.0.10.10 is at 0c:01:b4:78:00:00
18	68.355179	10.0.10.10	10.0.11.10	TCP	74 18336 > 18337 [SYN] Seq=0 Win=0 Len=0 MSS=1460 TStamp=0
19	68.361753	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
20	68.363844	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 > 18337 [SYN] Seq=0 Win=0
21	68.367062	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
22	68.368430	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 > 18337 [SYN] Seq=0 Win=0
23	68.370182	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
24	68.372107	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 > 18337 [SYN] Seq=0 Win=0
25	68.375217	10.0.1.2	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
26	68.377399	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 > 18337 [SYN] Seq=0 Win=0
27	68.378218	10.0.1.2	10.0.10.10	TCP	102 Time-to-live exceeded (Time to live exceeded in transmission)

```
> Frame 1: Packet, 146 bytes on wire (1168 bits), 146 bytes captured (1
> Ethernet II, Src: 0c:01:b4:78:00:00 (0c:01:b4:78:00:00), Dst: IPv4mca
> Internet Protocol Version 4, Src: 10.0.10.1, Dst: 224.0.0.9
> User Datagram Protocol, Src Port: 520, Dst Port: 520
> Routing Information Protocol
```

```
0000 01 00 5e 00 00 00 0c 01 b4 78 00 00 08 00 45 c0 
0010 00 84 85 6e 40 00 01 11 ff 30 0a 00 0a 01 e0 00 
0020 00 09 02 08 02 00 00 70 c2 d9 02 02 00 00 00 02 
0030 00 00 0a 00 01 0f ff ff 00 00 00 00 00 00 00 00 
0040 00 01 00 02 00 00 0a 00 02 00 ff ff 00 00 00 00 00 
0050 00 00 00 00 00 02 00 02 00 00 0a 00 03 00 ff ff 
0060 ff 00 00 00 00 00 00 00 00 02 00 02 00 00 0a 00 
0070 04 00 ff ff ff 00 00 00 00 00 00 00 00 00 01 00 02 
0080 00 00 0a 00 0b 00 ff ff ff 00 00 00 00 00 00 00 00 
0090 00 03
```

Настройка динамической маршрутизации по протоколу RIP

13	56.852750	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x4ef8, seq=4/1024, ttl=61 (
14	57.855115	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x4ff8, seq=5/1280, ttl=64 (
15	57.861410	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x4ff8, seq=5/1280, ttl=61 (
16	58.884070	0c:01:b4:78:00:00	Private_66:68:00	ARP	60 Who has 10.0.10.10? Tell 10.0.10.1
17	58.884196	Private_66:68:00	0c:01:b4:78:00:00	ARP	60 10.0.10.10 is at 00:50:79:66:68:00
18	68.355179	10.0.10.10	10.0.11.10	TCP	74 18336 + 18337 [SYN] Seq=0 Win=0 Len=0 MSS=1460 TStamp=
19	68.361753	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
20	68.363844	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
21	68.367062	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
22	68.368430	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
23	68.370182	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
24	68.372107	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
25	68.375217	10.0.1.2	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
26	68.377399	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
27	68.378338	10.0.1.2	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
28	68.378490	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
29	68.380784	10.0.1.2	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
30	68.382497	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
31	68.386611	10.0.2.2	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
32	68.387874	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
33	68.391172	10.0.2.2	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
34	68.391875	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
35	68.396449	10.0.2.2	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transmission)
36	68.397811	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 18336 → 18337 [SYN] Seq=0 Win=0
37	68.404041	10.0.11.10	10.0.10.10	TCP	60 18337 → 18336 [SYN, ACK] Seq=0 Ack=1 Win=0 Len=0
38	68.404742	10.0.10.10	10.0.11.10	TCP	74 [TCP Out-Of-Order] 18336 → 18337 [SYN] Seq=0 Win=0 Len=0
39	68.406452	10.0.11.10	10.0.10.10	TCP	60 [TCP Out-of-order received] 18337 → 18336 [SYN, ACK] Seq=1 Win=0 Len=0


```
> Frame 1: Packet, 146 bytes on wire (1168 bits), 146 bytes captured (1
> Ethernet II, Src: 0c:01:b4:78:00:00 (0c:01:b4:78:00:00), Dst: IPv4mca
> Internet Protocol Version 4, Src: 10.0.10.1, Dst: 224.0.0.9
> User Datagram Protocol, Src Port: 520, Dst Port: 520
> Routing Information Protocol
```

0000	01 00 5e 00 00 09 0c 01 b4 78 00 00 08 00 45 c0 ..^
0010	00 84 85 6e 40 00 01 11 ff 30 0a 00 0a 01 e0 00 ..
0020	00 09 02 08 02 00 00 70 c2 d9 02 02 00 00 00 02 ..
0030	00 00 0a 00 01 00 ff ff 00 00 00 00 00 00 00 00 ..
0040	00 01 00 02 00 00 0a 00 02 00 ff ff 00 00 00 00 ..
0050	00 00 00 00 00 02 00 02 00 00 00 00 03 00 ff ff ..
0060	ff 00 00 00 00 00 00 00 00 02 00 00 00 0a 00 ..
0070	04 00 ff ff 00 00 00 00 00 02 00 02 00 00 00 02 ..
0080	00 00 0a 00 00 00 ff ff ff 00 00 00 00 00 00 00 ..
0090	00 03 ..

Рис. 33: Захваченный трафик

Настройка динамической маршрутизации по протоколу RIP

112 265.098149	0c:01:b4:78:00:00	Private_66:68:00	ARP	60 Who has 10.0.10.10? Tell 10.0.10.1
113 265.098267	Private_66:68:00	0c:01:b4:78:00:00	ARP	60 10.0.10.10 is at 00:50:79:66:68:00
114 265.108991	10.0.10.1	224.0.0.9	RIPv2	146 Response
115 283.151664	10.0.10.1	224.0.0.9	RIPv2	86 Response
116 297.124739	10.0.10.1	224.0.0.9	RIPv2	146 Response
117 302.802879	10.0.10.1	224.0.0.9	RIPv2	86 Response
118 321.119239	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x57f9, seq=1/256, ttl=64 (r)
119 321.134466	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x57f9, seq=1/256, ttl=61 (r)
120 322.135363	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x58f9, seq=2/512, ttl=64 (r)
121 322.145141	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x58f9, seq=2/512, ttl=61 (r)
122 323.147951	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x59f9, seq=3/768, ttl=64 (r)
123 323.151599	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x59f9, seq=3/768, ttl=61 (r)
124 324.153718	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x5af9, seq=4/1024, ttl=64 (r)
125 325.162215	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x5af9, seq=4/1024, ttl=61 (r)
126 325.164568	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0x5bf9, seq=5/1280, ttl=64 (r)
127 325.176461	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0x5bf9, seq=5/1280, ttl=61 (r)
128 326.158194	0c:01:b4:78:00:00	Private_66:68:00	ARP	60 Who has 10.0.10.10? Tell 10.0.10.1
129 326.158470	Private_66:68:00	0c:01:b4:78:00:00	ARP	60 10.0.10.10 is at 00:50:79:66:68:00
130 331.138609	10.0.10.1	224.0.0.9	RIPv2	146 Response
131 362.152421	10.0.10.1	224.0.0.9	RIPv2	146 Response
132 390.524240	10.0.10.10	10.0.11.10	TCP	74 6913 → 6914 [SYN] Seq=0 Win=0 Len=0 MSS=1460 TStamp=1
133 390.526059	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
134 390.526445	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 6913 → 6914 [SYN] Seq=0 Win=0 L
135 390.526910	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
136 390.528476	10.0.10.10	10.0.11.10	TCP	74 [TCP Retransmission] 6913 → 6914 [SYN] Seq=0 Win=0 L
137 390.528518	10.0.10.1	10.0.10.10	TCP	74 Time-to-live exceeded (Time to live exceeded in transit)

```
> Frame 1: Packet, 146 bytes on wire (1168 bits), 146 bytes captured (1
> Ethernet II, Src: 0c:01:b4:78:00:00 (0c:01:b4:78:00:00), Dst: IPv4mca
> Internet Protocol Version 4, Src: 10.0.10.1, Dst: 224.0.0.9
> User Datagram Protocol, Src Port: 528, Dst Port: 528
> Routing Information Protocol
```

0000	01 00 5e 00 00 09 0c 01	b4 78 00 00 08 00 45 c0	...
0010	00 84 85 6e 48 00 01 11	ff 30 0a 00 0a 01 e0 00	...
0020	00 09 02 08 02 08 00 70	c2 d9 02 02 00 00 00 02	...
0030	00 00 0a 00 01 00 ff ff	ff 00 00 00 00 00 00 00	...
0040	00 01 00 02 00 00 0a 00	02 00 ff ff 00 00 00	...
0050	00 00 00 00 00 02 00 02	00 00 0a 00 03 00 ff ff	...
0060	ff 00 00 00 00 00 00 00	00 02 00 02 00 00 0a 00	...
0070	04 00 ff ff 00 00 00 00	00 00 00 00 00 01 00 02	...
0080	00 00 0a 00 0b 00 ff ff	ff 00 00 00 00 00 00 00	...
0090	00 03		...

Рис. 34: Захваченный трафик

Настройка динамической маршрутизации по протоколу RIP

На маршрутизаторах настроим RIPng для сетей IPv6:

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# router ripng
msk-svivanov-gw-01(config-router)# network eth0
msk-svivanov-gw-01(config-router)# network eth1
msk-svivanov-gw-01(config-router)# network eth2
msk-svivanov-gw-01(config-router)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# █
```

Рис. 35: Настройка gw-01

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# router ripng
msk-svivanov-gw-02(config-router)# network eth0
msk-svivanov-gw-02(config-router)# network eth1
msk-svivanov-gw-02(config-router)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02#
```

Рис. 36: Настройка gw-02

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-03(config)# router ripng
msk-svivanov-gw-03(config-router)# network eth0
msk-svivanov-gw-03(config-router)# network eth2
msk-svivanov-gw-03(config-router)# network eth1
msk-svivanov-gw-03(config-router)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03# █
```

Рис. 37: Настройка gw-03

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-04(config)# router ripng
msk-svivanov-gw-04(config-router)# network eth0
msk-svivanov-gw-04(config-router)# network eth1
msk-svivanov-gw-04(config-router)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# █
```

Рис. 38: Настройка gw-04

Настройка динамической маршрутизации по протоколу RIP

С PC1 пропингуем PC2. Пакеты идут через gw-04.

```
PC1-svivanov> ping 2001:11::a  
  
2001:11::a icmp6_seq=1 ttl=58 time=5.887 ms  
2001:11::a icmp6_seq=2 ttl=58 time=7.491 ms  
2001:11::a icmp6_seq=3 ttl=58 time=9.083 ms  
2001:11::a icmp6_seq=4 ttl=58 time=3.581 ms  
2001:11::a icmp6_seq=5 ttl=58 time=3.915 ms
```

```
PC1-svivanov> trace 2001:11::a  
  
trace to 2001:11::a, 64 hops max  
 1 2001:10::1    1.888 ms  0.883 ms  0.696 ms  
 2 2001:4::1    7.570 ms  1.786 ms  1.319 ms  
 3 2001:3::1    4.571 ms  2.456 ms  3.859 ms  
 4 2001:11::a    3.073 ms  3.169 ms  2.448 ms
```

```
PC1-svivanov> █
```

Настройка динамической маршрутизации по протоколу RIP

Проверим метрики протокола RIPng:

```
msk-svivanov-gw-01# show ipv6 ripng
Codes: R - RIPng, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface, (a/S) - aggregated/Suppressed

      Network      Next Hop          Via      Metric Tag Time
C(i) 2001:1::/64
                  ::                self      1      0
R(n) 2001:2::/64
                  fe80::e70:ffff:fe26:1  eth2      3      0  02:26
R(n) 2001:3::/64
                  fe80::e70:ffff:fe26:1  eth2      2      0  02:26
C(i) 2001:4::/64
                  ::                self      1      0
C(i) 2001:10::/64
                  ::                self      1      0
R(n) 2001:11::/64
                  fe80::e70:ffff:fe26:1  eth2      3      0  02:26
msk-svivanov-gw-01# █
```

Рис. 40: Проверка метрик

Настройка динамической маршрутизации по протоколу RIP

Пакет проходит через gw-04. Отключим на gw-04 интерфейс:

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# shutdown
msk-svivanov-gw-04(config-if)# █
```

Рис. 41: Отключение интерфейса

Настройка динамической маршрутизации по протоколу RIP

Проверим метрики протокола RIPng:

```
msk-svivanov-gw-01# show ipv6 ripng
Codes: R - RIPng, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface, (a/S) - aggregated/Suppressed

      Network      Next Hop          Via      Metric Tag Time
C(i) 2001:1::/64
                  ::                self      1      0
R(n) 2001:2::/64
                  fe80::e70:ffff:fe26:1  eth2      16     0  01:34
R(n) 2001:3::/64
                  fe80::e70:ffff:fe26:1  eth2      16     0  01:34
C(i) 2001:4::/64
                  ::                self      1      0
C(i) 2001:10::/64
                  ::                self      1      0
R(n) 2001:11::/64
                  fe80::e70:ffff:fe26:1  eth2      16     0  01:34
msk-svivanov-gw-01# █
```

Рис. 42: Проверка метрик

Настройка динамической маршрутизации по протоколу RIP

С PC1 пропингуем PC2. Пакеты идут через gw-02.

```
PC1-svivanov> ping 2001:11::a  
  
2001:11::a icmp6_seq=1 ttl=58 time=9.632 ms  
2001:11::a icmp6_seq=2 ttl=58 time=6.731 ms  
2001:11::a icmp6_seq=3 ttl=58 time=6.908 ms  
2001:11::a icmp6_seq=4 ttl=58 time=10.036 ms  
2001:11::a icmp6_seq=5 ttl=58 time=4.439 ms  
  
PC1-svivanov> trace 2001:11::a -P 6  
  
trace to 2001:11::a, 6 hops max  
 1 2001:10::1    2.983 ms  0.513 ms  0.437 ms  
 2 2001:1::2    4.413 ms  2.422 ms  2.621 ms  
 3 2001:2::2    4.277 ms  2.207 ms  2.581 ms  
 4 2001:11::a    3.718 ms  4.247 ms  2.639 ms
```

```
PC1-svivanov> █
```

Рис. 43: Отправка пинга

Настройка динамической маршрутизации по протоколу RIP

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# shutdown
msk-svivanov-gw-04(config-if)# interface eth0
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# █
```

Рис. 44: Включение интерфейса

Настройка динамической маршрутизации по протоколу RIP

С PC1 пропингуем PC2. Пакеты идут через gw-02.

```
PC1-svivanov> ping 2001:11::a

2001:11::a icmp6_seq=1 ttl=58 time=13.569 ms
2001:11::a icmp6_seq=2 ttl=58 time=6.891 ms
2001:11::a icmp6_seq=3 ttl=58 time=5.233 ms
2001:11::a icmp6_seq=4 ttl=58 time=6.433 ms
2001:11::a icmp6_seq=5 ttl=58 time=12.517 ms

PC1-svivanov> trace 2001:11::a -P 6

trace to 2001:11::a, 6 hops max
 1 2001:10::1    1.702 ms  1.529 ms  1.488 ms
 2 2001:1::2    2.035 ms  1.447 ms  1.291 ms
 3 2001:2::2    4.459 ms  2.536 ms  3.007 ms
 4 2001:11::a    3.084 ms  2.880 ms  2.295 ms

PC1-svivanov> █
```

Рис. 45: Отправка пинга

Настройка динамической маршрутизации по протоколу RIP

Посмотрим захваченный на соединениях трафик

283 1024.218586 fe80::e01:b4ff:fe78.. ff02::9	RIPng	86 Command Response, Version 1
204 1029.624804 2001:10::a	2001:11::a	ICMPv6 118 Echo (ping) request id=0xb1fc, seq=1, hop limit=64 (reply in 207)
205 1029.630045 fe80::e01:b4ff:fe78.. ff02::1:ffff00:a	ICMPv6	86 Neighbor Solicitation for 2001:10::a from 0c:01:b4:78:00:00
206 1029.630130 2001:10::a	fe80::e01:b4ff:fe78.. ICMPv6	86 Neighbor Advertisement 2001:10::a (sol, ovr) is at 00:50:79:66:68:00
207 1029.630540 2001:11::a	2001:10::a	ICMPv6 118 Echo (ping) reply id=0xb1fc, seq=1, hop limit=58 (request in 204)
208 1030.632911 2001:10::a	2001:11::a	ICMPv6 118 Echo (ping) request id=0xb1fc, seq=2, hop limit=64 (reply in 209)
209 1030.640089 2001:11::a	2001:10::a	ICMPv6 118 Echo (ping) reply id=0xb1fc, seq=2, hop limit=58 (request in 208)
210 1031.640955 2001:11::a	2001:11::a	ICMPv6 118 Echo (ping) request id=0xb1fc, seq=3, hop limit=64 (reply in 211)
211 1031.649601 2001:11::a	2001:10::a	ICMPv6 118 Echo (ping) reply id=0xb1fc, seq=3, hop limit=58 (request in 210)
212 1032.652389 2001:10::a	2001:11::a	ICMPv6 118 Echo (ping) request id=0xb1fc, seq=4, hop limit=64 (reply in 213)
213 1032.655698 2001:11::a	2001:10::a	ICMPv6 118 Echo (ping) reply id=0xb1fc, seq=4, hop limit=58 (request in 212)
214 1033.661648 2001:10::a	2001:11::a	ICMPv6 118 Echo (ping) request id=0xb1fc, seq=5, hop limit=64 (reply in 215)
215 1033.665408 2001:11::a	2001:10::a	ICMPv6 118 Echo (ping) reply id=0xb1fc, seq=5, hop limit=58 (request in 214)
216 1035.240848 fe80::e01:b4ff:fe78.. ff02::9	RIPng	186 Command Response, Version 1
217 1039.677854 2001:10::a	2001:11::a	UDP 126 43168 + 43169 Len=64
218 1039.679543 2001:10::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)
219 1039.681352 2001:10::a	2001:11::a	UDP 126 43168 + 43169 Len=64
220 1039.682000 2001:10::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)
221 1039.682423 2001:10::a	2001:10::a	UDP 126 43168 + 43169 Len=64
222 1039.682962 2001:10::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)
223 1039.685390 2001:10::a	2001:11::a	UDP 126 43168 + 43169 Len=64
224 1039.692959 2001:4::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)
225 1039.693243 2001:10::a	2001:11::a	UDP 126 43168 + 43169 Len=64
226 1039.694883 2001:4::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)
227 1039.695928 2001:10::a	2001:11::a	UDP 126 43168 + 43169 Len=64
228 1039.697117 2001:4::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)
229 1039.698835 2001:10::a	2001:11::a	UDP 126 43168 + 43169 Len=64
230 1039.703278 2001:3::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)
231 1039.704305 2001:10::a	2001:11::a	UDP 126 43168 + 43169 Len=64
232 1039.706666 2001:3::1	2001:10::a	ICMPv6 174 Time Exceeded (Hop limit exceeded in transit)

Рис. 46: Просмотр трафика

Настройка динамической маршрутизации по протоколу RIP

458 2066.033181	2001:2::2	2001:10::8	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
459 2066.035352	2001:10::8	2001:11::8	UDP	126 31348 + 31345 Len:64
460 2066.036116	2001:2::2	2001:10::8	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
461 2066.039882	2001:10::8	2001:11::8	UDP	126 31348 + 31345 Len:64
462 2066.042330	2001:11::8	2001:10::8	ICMPv6	174 Destination Unreachable (Port unreachable)[Malformed Packet]
463 2066.043983	2001:10::8	2001:11::8	UDP	126 31348 + 31345 Len:64
464 2066.046956	2001:11::8	2001:10::8	ICMPv6	174 Destination Unreachable (Port unreachable)[Malformed Packet]
465 2066.048529	2001:10::8	2001:11::8	UDP	126 31348 + 31345 Len:64
466 2066.051129	2001:11::8	2001:10::8	ICMPv6	174 Destination Unreachable (Port unreachable)[Malformed Packet]
467 2066.101862	fe80::e01:b4ff:fe78..	2001:10::8	ICMPv6	86 Neighbor Solicitation for 2001:10::8 from 0c:01:b4:78:00:00
468 2067.141564	fe80::e01:b4ff:fe78..	2001:10::8	ICMPv6	86 Neighbor Solicitation for 2001:10::8 from 0c:01:b4:78:00:00
469 2073.314557	10.0.10.1	224.0.0.9	RIPv2	146 Response
470 2073.424701	fe80::e01:b4ff:fe78..ff02::1:ff00:8		RIPng	186 Command Response, Version 1
471 2079.386446	2001:10::8	2001:11::8	ICMPv6	118 Echo (ping) request id:0x3500, seq=1, hop limit=64 (reply in 474)
472 2079.399293	fe80::e01:b4ff:fe78..ff02::1:ff00:8		ICMPv6	86 Neighbor Solicitation for 2001:10::8 from 0c:01:b4:78:00:00
473 2079.399463	2001:10::8	fe80::e01:b4ff:fe78..	ICMPv6	86 Neighbor Advertisement 2001:10::8 (sol, ovr) at 00:58:79:66:68:00
474 2079.399796	2001:11::8	2001:10::8	ICMPv6	118 Echo (ping) reply id:0x3500, seq=1, hop limit=58 (request in 471)
475 2080.402172	2001:10::8	2001:11::8	ICMPv6	118 Echo (ping) request id:0x3500, seq=2, hop limit=58 (reply in 476)
476 2080.408429	2001:11::8	2001:10::8	ICMPv6	118 Echo (ping) reply id:0x3500, seq=2, hop limit=58 (request in 475)
477 2081.409995	2001:11::8	2001:11::8	ICMPv6	118 Echo (ping) request id:0x3500, seq=3, hop limit=64 (reply in 478)
478 2081.414896	2001:11::8	2001:10::8	ICMPv6	118 Echo (ping) reply id:0x3500, seq=3, hop limit=58 (request in 477)
479 2082.418444	2001:10::8	2001:11::8	ICMPv6	118 Echo (ping) request id:0x3500, seq=4, hop limit=64 (reply in 480)
480 2082.424456	2001:11::8	2001:10::8	ICMPv6	118 Echo (ping) reply id:0x3500, seq=4, hop limit=58 (request in 479)
481 2083.426431	2001:10::8	2001:11::8	ICMPv6	118 Echo (ping) request id:0x3500, seq=5, hop limit=64 (reply in 482)
482 2083.438564	2001:11::8	2001:10::8	ICMPv6	118 Echo (ping) reply id:0x3500, seq=5, hop limit=58 (request in 481)
483 2085.399723	2001:10::8	2001:11::8	UDP	126 12576 + 12577 Len:64
484 2085.399058	2001:10::1	2001:10::8	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
485 2085.400756	2001:10::8	2001:11::8	UDP	126 12576 + 12577 Len:64
486 2085.401807	2001:10::1	2001:10::8	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
487 2085.402614	2001:10::8	2001:11::8	UDP	126 12576 + 12577 Len:64

Рис. 47: Просмотр трафика

Настройка динамической маршрутизации по протоколу OSPF

На маршрутизаторах настроим OSPFv2 для сетей IPv4:

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# router ospf
[msk-svivanov-gw-01(config-router)]# network 10.0.10.0/24 area 0.0.0.0
[msk-svivanov-gw-01(config-router)]# network 10.0.1.0/24 area 0.0.0.0
[msk-svivanov-gw-01(config-router)]# network 10.0.4.0/24 area 0.0.0.0
[msk-svivanov-gw-01(config-router)]# exit
[msk-svivanov-gw-01(config)]# exit
msk-svivanov-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-svivanov-gw-01# █
```

Рис. 48: Настройка gw-01

Настройка динамической маршрутизации по протоколу OSPF

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# router ospf
msk-svivanov-gw-02(config-router)# network 10.0.1.0/24 area 0.0.0.0
msk-svivanov-gw-02(config-router)# network 10.0.2.0/24 area 0.0.0.0
msk-svivanov-gw-02(config-router)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# █
```

Рис. 49: Настройка gw-02

Настройка динамической маршрутизации по протоколу OSPF

```
msk-svivanov-gw-03# configure terminal
msk-svivanov-gw-03(config)# router ospf
msk-svivanov-gw-03(config-router)# network 10.0.11.0/24 area 0.0.0.0
msk-svivanov-gw-03(config-router)# network 10.0.2.0/24 area 0.0.0.0
msk-svivanov-gw-03(config-router)# network 10.0.3.0/24 area 0.0.0.0
msk-svivanov-gw-03(config-router)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03# █
```

Рис. 50: Настройка gw-03

Настройка динамической маршрутизации по протоколу OSPF

```
msk-svivanov-gw-04(config)# router ospf
msk-svivanov-gw-04(config-router)# network 10.0.3.0/24 area 0.0.0.0
msk-svivanov-gw-04(config-router)# network 10.0.4.0/24 area 0.0.0.0
msk-svivanov-gw-04(config-router)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04#
```

Рис. 51: Настройка gw-04

Настройка динамической маршрутизации по протоколу OSPF

С PC1 пропингуем PC2. Путь проходит через gw-04. (рис. 52)

```
PC1-svivanov> ping 10.0.11.10

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=9.918 ms
84 bytes from 10.0.11.10 icmp_seq=2 ttl=61 time=8.020 ms
84 bytes from 10.0.11.10 icmp_seq=3 ttl=61 time=7.553 ms
84 bytes from 10.0.11.10 icmp_seq=4 ttl=61 time=9.833 ms
84 bytes from 10.0.11.10 icmp_seq=5 ttl=61 time=8.605 ms

PC1-svivanov> trace 10.0.11.10 -P 6
trace to 10.0.11.10, 8 hops max (TCP), press Ctrl+C to stop
 1  10.0.10.1    2.191 ms  0.863 ms  1.895 ms
 2  10.0.4.1    5.001 ms  4.481 ms  1.486 ms
 3  10.0.2.2    4.704 ms  2.539 ms  3.365 ms
 4  10.0.11.10   4.618 ms  5.165 ms  2.501 ms

PC1-svivanov> █
```

Рис. 52: Отправка пинга

Настройка динамической маршрутизации по протоколу OSPF

Проверим таблицу маршрутизации протокола OSPFv2: (рис. 53)

```
msk-svivanov-gw-01# show ip ospf neighbor

Neighbor ID      Pri State            Up Time           Dead Time Address      In
terface
                    RXmtL RqstL DBsml
10.0.2.1          1 Full/Backup    4m59s             34.877s  10.0.1.2      et
h1:10.0.1.1
10.0.4.1          1 Full/Backup    2m01s             34.345s  10.0.4.1      et
h2:10.0.4.2

msk-svivanov-gw-01#
```

Рис. 53: Проверка таблицы маршрутизации

Настройка динамической маршрутизации по протоколу OSPF

Отключим на gw-04 интерфейс:

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04 (config)# interface eth0
msk-svivanov-gw-04 (config-if)# shutdown
msk-svivanov-gw-04 (config-if)#[ ]
```

Рис. 54: Выключение интерфейса

Настройка динамической маршрутизации по протоколу OSPF

Проверим таблицу маршрутизации протокола OSPFv2:

```
msk-svivanov-gw-01# show ip ospf neighbor

Neighbor ID      Pri State            Up Time           Dead Time Address      Interface
10.0.2.1          1 Full/Backup    7m48s             35.838s  10.0.1.2      et
h1:10.0.1.1
10.0.4.1          1 Full/Backup    4m50s             35.321s  10.0.4.1      et
h2:10.0.4.2

msk-svivanov-gw-01#
```

Рис. 55: Проверка таблицы маршрутизации

Настройка динамической маршрутизации по протоколу OSPF

С PC1 пропингуем PC2. Путь проходит через gw-02.

```
PC1-svivanov> ping 10.0.11.10
84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=5.998 ms
84 bytes from 10.0.11.10 icmp_seq=2 ttl=61 time=3.466 ms
84 bytes from 10.0.11.10 icmp_seq=3 ttl=61 time=3.482 ms
84 bytes from 10.0.11.10 icmp_seq=4 ttl=61 time=3.913 ms
84 bytes from 10.0.11.10 icmp_seq=5 ttl=61 time=3.721 ms

PC1-svivanov> trace 10.0.11.10 -P 6
trace to 10.0.11.10, 8 hops max (TCP), press Ctrl+C to stop
: 1 10.0.10.1    4.916 ms   0.490 ms   0.750 ms
: 2 10.0.1.2     3.705 ms   1.803 ms   1.334 ms
: 3 10.0.2.2     3.126 ms   2.545 ms   2.133 ms
: 4 10.0.11.10   3.629 ms   3.011 ms   2.685 ms

PC1-svivanov> █
```

Рис. 56: Отправка пинга

Настройка динамической маршрутизации по протоколу OSPF

Включим на маршрутизаторе gw-04 интерфейс:

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# shutdown
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# █
```

Рис. 57: Включение интерфейса

Настройка динамической маршрутизации по протоколу OSPF

С PC1 пропингуем PC2. Путь проходит через gw-04.

```
PC1-svivanov> ping 10.0.11.10

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=5.318 ms
84 bytes from 10.0.11.10 icmp_seq=2 ttl=61 time=4.187 ms
84 bytes from 10.0.11.10 icmp_seq=3 ttl=61 time=3.484 ms
84 bytes from 10.0.11.10 icmp_seq=4 ttl=61 time=6.232 ms
84 bytes from 10.0.11.10 icmp_seq=5 ttl=61 time=6.463 ms

PC1-svivanov> trace 10.0.11.10 -P 6
trace to 10.0.11.10, 8 hops max (TCP), press Ctrl+C to stop
 1  10.0.10.1    0.718 ms  0.639 ms  0.453 ms
 2  10.0.4.1    3.550 ms  1.311 ms  4.006 ms
 3  10.0.2.2    3.434 ms  3.021 ms  2.647 ms
 4  10.0.11.10   3.271 ms  2.806 ms  2.923 ms

PC1-svivanov> █
```

Рис. 58: Отправка пинга

Настройка динамической маршрутизации по протоколу OSPF

Посмотрим захваченный на соединениях трафик.

667	2955.514892	10.0.10.1	224.0.0.9	RIPv2	146 Response
668	2962.462667	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
669	2965.636004	fe80::e01:b4ff:fe78... ff02::9		RIPng	186 Command Response, Version 1
670	2972.465727	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
671	2982.468746	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
672	2988.524612	10.0.10.1	224.0.0.9	RIPv2	146 Response
673	2992.471582	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
674	3001.466243	Private_66:68:00	Broadcast	ARP	64 Who has 10.0.10.1? Tell 10.0.10.10
675	3001.467663	0c:01:b4:78:00:00	Private_66:68:00	ARP	60 10.0.10.1 is at 0c:01:b4:78:00:00
676	3001.469159	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0xcf03, seq=1/256, ttl=64 (r
677	3001.474676	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0xcf03, seq=1/256, ttl=61 (r
678	3002.474385	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
679	3002.476974	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0xd003, seq=2/512, ttl=64 (r
680	3002.480340	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0xd003, seq=2/512, ttl=61 (r
681	3003.481788	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0xd103, seq=3/768, ttl=64 (r
682	3003.485130	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0xd103, seq=3/768, ttl=61 (r
683	3004.486334	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0xd203, seq=4/1024, ttl=64 (
684	3004.490060	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0xd203, seq=4/1024, ttl=61 (
685	3005.492642	10.0.10.10	10.0.11.10	ICMP	98 Echo (ping) request id=0xd303, seq=5/1280, ttl=64 (
686	3005.496181	10.0.11.10	10.0.10.10	ICMP	98 Echo (ping) reply id=0xd303, seq=5/1280, ttl=61 (
687	3006.481755	0c:01:b4:78:00:00	Private_66:68:00	ARP	60 Who has 10.0.10.10? Tell 10.0.10.1
688	3006.482268	Private_66:68:00	0c:01:b4:78:00:00	ARP	60 10.0.10.10 is at 00:50:79:66:68:00
689	3009.650364	fe80::e01:b4ff:fe78... ff02::9		RIPng	186 Command Response, Version 1
690	3012.478889	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
691	3013.221880	10.0.10.10	10.0.11.10	TCP	74 13649 > 13650 [SYN] Seq=0 Win=0 Len=0 MSS=1460 TStamp
692	3013.226426	10.0.10.1	10.0.10.10	ICMP	102 Time-to-live exceeded (Time to live exceeded in tra
693	3013.226209	10.0.10.10	10.0.11.10	TCP	74 13649 > 13650 [SYN] Seq=0 Win=0

Рис. 59: Захваченный трафик

Настройка динамической маршрутизации по протоколу OSPF

688	3006.482268	Private_66:68:00	0c:01:b4:78:00:00	ARP	60	10.0.10.10 is at 00:50:79:66:68:00
689	3009.650364	fe80::e01:b4ff:fe78..	ff02::9	RIPng	186	Command Response, Version 1
690	3012.478889	10.0.10.1	224.0.0.5	OSPF	78	Hello Packet
691	3013.221880	10.0.10.10	10.0.11.10	TCP	74	13649 → 13650 [SYN] Seq=0 Win=0 Len=0 MSS=1460 TSval
692	3013.226426	10.0.10.1	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
693	3013.228399	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
694	3013.228737	10.0.10.1	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
695	3013.231510	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
696	3013.232061	10.0.10.1	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
697	3013.232575	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
698	3013.236090	10.0.1.2	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
699	3013.237387	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
700	3013.238853	10.0.1.2	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
701	3013.239913	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
702	3013.241119	10.0.1.2	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
703	3013.242160	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
704	3013.245182	10.0.2.2	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
705	3013.245607	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
706	3013.248070	10.0.2.2	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
707	3013.250156	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
708	3013.252192	10.0.2.2	10.0.10.10	ICMP	102	Time-to-live exceeded (Time to live exceeded in trans)
709	3013.253182	10.0.10.10	10.0.11.10	TCP	74	[TCP Retransmission] 13649 → 13650 [SYN] Seq=0 Win=0
710	3013.256643	10.0.11.10	10.0.10.10	TCP	60	13650 → 13649 [SYN, ACK] Seq=0 Ack=1 Win=0 Len=0
711	3013.257068	10.0.10.10	10.0.11.10	TCP	74	[TCP Out-Of-Order] 13649 → 13650 [SYN] Seq=0 Win=0 L
712	3013.259949	10.0.11.10	10.0.10.10	TCP	60	[TCP Port numbers reused] 13650 → 13649 [SYN, ACK] S
713	3013.261327	10.0.10.10	10.0.11.10	TCP	74	13649 → 13650 [SYN] Seq=0 Win=0 Len=0 MSS=1460 TSval
714	3013.262095	10.0.11.10	10.0.10.10	TCP	60	[TCP Port numbers reused] 13650 → 13649 [SYN, ACK]

Рис. 60: Отправка пинга

Настройка динамической маршрутизации по протоколу OSPF

На маршрутизаторах настроим OSPFv3 для сетей IPv6:

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# router ospf6
msk-svivanov-gw-01(config-ospf6)# ospf6 router-id 1.1.1.1
msk-svivanov-gw-01(config-ospf6)# exit
msk-svivanov-gw-01(config)# interface eth0
msk-svivanov-gw-01(config-if)# ipv6 ospf6 area0
% Unknown command: ipv6 ospf6 area0
msk-svivanov-gw-01(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth1
msk-svivanov-gw-01(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth2
msk-svivanov-gw-01(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-gw-01# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
```

Рис. 61: Настройка gw-01

Настройка динамической маршрутизации по протоколу OSPF

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# router ospf6
msk-svivanov-gw-02(config-ospf6)# ospf6 router-id 2.2.2.2
msk-svivanov-gw-02(config-ospf6)# exit
msk-svivanov-gw-02(config)# interface eth0
msk-svivanov-gw-02(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth1
msk-svivanov-gw-02(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# □
```

Рис. 62: Настройка gw-02

Настройка динамической маршрутизации по протоколу OSPF

```
msk-svivanov-gw-03# configure terminal
msk-svivanov-gw-03(config)# router ospf6
msk-svivanov-gw-03(config-ospf6)# ospf6 router-id 3.3.3.3
msk-svivanov-gw-03(config-ospf6)# exit
msk-svivanov-gw-03(config)# interface eth0
msk-svivanov-gw-03(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# interface eth1
msk-svivanov-gw-03(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# interface eth2
msk-svivanov-gw-03(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03#
```

Рис. 63: Настройка gw-03

Настройка динамической маршрутизации по протоколу OSPF

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# shutdown
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# router ospf6
msk-svivanov-gw-04(config-ospf6)# ospf6 router-id 4.4.4.4
msk-svivanov-gw-04(config-ospf6)# exit
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# interface eth1
msk-svivanov-gw-04(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# █
```

Рис. 64: Настройка gw-04

Настройка динамической маршрутизации по протоколу OSPF

С PC1 пропингуем PC2. Пакеты идут через gw-02

```
PC1-svivanov> ping 2001:11::a

2001:11::a icmp6_seq=1 ttl=58 time=10.112 ms
2001:11::a icmp6_seq=2 ttl=58 time=6.438 ms
2001:11::a icmp6_seq=3 ttl=58 time=4.586 ms
2001:11::a icmp6_seq=4 ttl=58 time=4.923 ms
2001:11::a icmp6_seq=5 ttl=58 time=3.238 ms

PC1-svivanov> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1  5.411 ms  1.190 ms  2.019 ms
 2 2001:1::2  5.189 ms  3.162 ms  1.616 ms
 3 2001:2::2  3.634 ms  2.420 ms  2.562 ms
 4 2001:11::a  4.416 ms  4.124 ms  2.726 ms

PC1-svivanov> █
```

Рис. 65: Отправка пинга

Настройка динамической маршрутизации по протоколу OSPF

Проверим таблицу маршрутизации протокола OSPFv3:

```
msk-svivanov-gw-01# show ipv6 ospf6 neighbor
Neighbor ID      Pri     DeadTime      State/IfState          Duration I/F[State]
2.2.2.2           1     00:00:33      Full/BDR               00:04:32 eth1[DR]
4.4.4.4           1     00:00:36      Full/BDR               00:01:31 eth2[DR]
msk-svivanov-gw-01# show ipv6 ospf6 route
*N IA 2001:1::/64          ::          eth1 00:01:58
*N IA 2001:2::/64          fe80::e3a:99ff:feab:0  eth1 00:01:58
*N IA 2001:3::/64          fe80::e70:bfff:fe26:1  eth2 00:01:58
*N IA 2001:4::/64          ::          eth2 00:01:58
*N IA 2001:10::/64         ::          eth0 00:01:58
*N IA 2001:11::/64         fe80::e3a:99ff:feab:0  eth1 00:01:58
                                         fe80::e70:bfff:fe26:1  eth2
msk-svivanov-gw-01# █
```

Рис. 66: Таблица маршрутизации

Настройка динамической маршрутизации по протоколу OSPF

Пакет проходит через gw-02. Отключим на gw-02 интерфейс:

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# interface eth0
msk-svivanov-gw-02(config-if)# shutdown
msk-svivanov-gw-02(config-if)#{
```

Рис. 67: Отключение интерфейса

Настройка динамической маршрутизации по протоколу OSPF

Проверим таблицу маршрутизации протокола OSPFv3:

```
msk-svivanov-gw-01# show ipv6 ospf6 route
*N IA 2001:1::/64          ::          eth1 00:00:23
*N IA 2001:2::/64          fe80::e70:ffff:fe26:1  eth2 00:00:23
*N IA 2001:3::/64          fe80::e70:ffff:fe26:1  eth2 00:00:23
*N IA 2001:4::/64          ::          eth2 00:00:23
*N IA 2001:10::/64         ::          eth0 00:00:23
*N IA 2001:11::/64         fe80::e70:ffff:fe26:1  eth2 00:00:23
msk-svivanov-gw-01# █
```

Рис. 68: Таблица маршрутизации

Настройка динамической маршрутизации по протоколу OSPF

С PC1 пропингуем PC2. Пакеты идут через gw-04.

```
PC1-svivanov> ping 2001:11::a

2001:11::a icmp6_seq=1 ttl=58 time=4.252 ms
2001:11::a icmp6_seq=2 ttl=58 time=3.671 ms
2001:11::a icmp6_seq=3 ttl=58 time=6.777 ms
2001:11::a icmp6_seq=4 ttl=58 time=4.392 ms
2001:11::a icmp6_seq=5 ttl=58 time=4.465 ms

PC1-svivanov> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1    6.533 ms  0.860 ms  0.859 ms
 2 2001:4::1    3.405 ms  1.518 ms  1.510 ms
 3 2001:3::1    2.608 ms  2.061 ms  3.149 ms
 4 2001:11::a   2.984 ms  2.651 ms  3.251 ms

PC1-svivanov> █
```

Рис. 69: Отправка пинга

Настройка динамической маршрутизации по протоколу OSPF

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# interface eth0
msk-svivanov-gw-02(config-if)# shutdown
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)#[█]
```

Рис. 70: Включение интерфейса

Настройка динамической маршрутизации по протоколу OSPF

С PC1 пропингуем PC2. Пакеты идут через gw-02.

```
PC1-svivanov> ping 2001:11::a

2001:11::a icmp6_seq=1 ttl=58 time=7.598 ms
2001:11::a icmp6_seq=2 ttl=58 time=6.100 ms
2001:11::a icmp6_seq=3 ttl=58 time=5.310 ms
2001:11::a icmp6_seq=4 ttl=58 time=7.805 ms
2001:11::a icmp6_seq=5 ttl=58 time=8.670 ms

PC1-svivanov> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1  2.439 ms  0.709 ms  0.522 ms
 2 2001:1::2  1.711 ms  2.013 ms  1.060 ms
 3 2001:2::2  2.392 ms  1.919 ms  2.160 ms
 4 2001:11::a  2.255 ms  2.636 ms  3.152 ms

PC1-svivanov> █
```

Рис. 71: Отправка пинга

Настройка динамической маршрутизации по протоколу OSPF

Посмотрим захваченный на соединениях трафик.

1027	4067.646405	10.0.10.1	224.0.0.9	RIPv2	146 Response
1028	4072.505427	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
1029	4077.019936	fe80::e01:b4ff:fe78.. ff02::5		OSPF	90 Hello Packet
1030	4078.780070	fe80::e01:b4ff:fe78.. ff02::9		RIPng	186 Command Response, Version 1
1031	4082.508464	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
1032	4083.878480	2001:10::a	2001:11::a	ICMPv6	118 Echo (ping) request id=0x0908, seq=1, hop limit=64 (
1033	4083.882373	2001:11::a	2001:10::a	ICMPv6	118 Echo (ping) reply id=0x0908, seq=1, hop limit=58 (re
1034	4084.885621	2001:10::a	2001:11::a	ICMPv6	118 Echo (ping) request id=0x0908, seq=2, hop limit=64 (
1035	4084.889031	2001:11::a	2001:10::a	ICMPv6	118 Echo (ping) reply id=0x0908, seq=2, hop limit=58 (re
1036	4085.890365	2001:10::a	2001:11::a	ICMPv6	118 Echo (ping) request id=0x0908, seq=3, hop limit=64 (
1037	4085.896690	2001:11::a	2001:10::a	ICMPv6	118 Echo (ping) reply id=0x0908, seq=3, hop limit=58 (re
1038	4086.899246	2001:10::a	2001:11::a	ICMPv6	118 Echo (ping) request id=0x0908, seq=4, hop limit=64 (
1039	4086.903465	2001:11::a	2001:10::a	ICMPv6	118 Echo (ping) reply id=0x0908, seq=4, hop limit=58 (re
1040	4087.023118	fe80::e01:b4ff:fe78.. ff02::5		OSPF	90 Hello Packet
1041	4087.905732	2001:10::a	2001:11::a	ICMPv6	118 Echo (ping) request id=0x0908, seq=5, hop limit=64 (
1042	4087.910032	2001:11::a	2001:10::a	ICMPv6	118 Echo (ping) reply id=0x0908, seq=5, hop limit=58 (re
1043	4088.893062	fe80::e01:b4ff:fe78.. 2001:10::a		ICMPv6	86 Neighbor Solicitation for 2001:10::a from 0c:01:b4:7
1044	4089.931051	fe80::e01:b4ff:fe78.. 2001:10::a		ICMPv6	86 Neighbor Solicitation for 2001:10::a from 0c:01:b4:7
1045	4090.970743	fe80::e01:b4ff:fe78.. 2001:10::a		ICMPv6	86 Neighbor Solicitation for 2001:10::a from 0c:01:b4:7
1046	4092.510329	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
1047	4097.026155	fe80::e01:b4ff:fe78.. ff02::5		OSPF	90 Hello Packet
1048	4098.652938	10.0.10.1	224.0.0.9	RIPv2	146 Response
1049	4102.514245	10.0.10.1	224.0.0.5	OSPF	78 Hello Packet
1050	4104.262076	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1051	4104.267224	2001:10::1	ff02::1:ff00:a	ICMPv6	86 Neighbor Solicitation for 2001:10::a from 0c:01:b4:7
1052	4104.267611	2001:10::a	2001:10::1	ICMPv6	86 Neighbor Advertisement 2001:10::a (sol, ovr) is at 0

Рис. 72: Просмотр трафика

Настройка динамической маршрутизации по протоколу OSPF

1051	4104.267224	2001:10::1	ff02::1:ff00:a	ICMPv6	86 Neighbor Solicitation for 2001:10::a from 0c:01:b4:7
1052	4104.267611	2001:10::a	2001:10::1	ICMPv6	86 Neighbor Advertisement 2001:10::a (sol, ovr) is at 0
1053	4104.268190	2001:10::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1054	4104.269188	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1055	4104.269822	2001:10::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1056	4104.270488	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1057	4104.271172	2001:10::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1058	4104.271818	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1059	4104.275010	2001:4::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1060	4104.275409	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1061	4104.276801	2001:4::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1062	4104.278691	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1063	4104.280102	2001:4::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1064	4104.281055	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1065	4104.283553	2001:3::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1066	4104.283914	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1067	4104.285873	2001:3::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1068	4104.286223	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1069	4104.289226	2001:3::1	2001:10::a	ICMPv6	174 Time Exceeded (Hop limit exceeded in transit)
1070	4104.289675	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1071	4104.292578	2001:11::a	2001:10::a	ICMPv6	174 Destination Unreachable (Port unreachable)[Malformed]
1072	4104.293944	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1073	4104.296516	2001:11::a	2001:10::a	ICMPv6	174 Destination Unreachable (Port unreachable)[Malformed]
1074	4104.298153	2001:10::a	2001:11::a	UDP	126 2993 + 2994 Len=64
1075	4104.300732	2001:11::a	2001:10::a	ICMPv6	174 Destination Unreachable (Port unreachable)[Malformed]
1076	4107.030950	fe80::e01:b4ff:fe78... ff02::5		OSPF	90 Hello Packet

Рис. 73: Просмотр трафика

Построение туннеля IPv6–IPv4

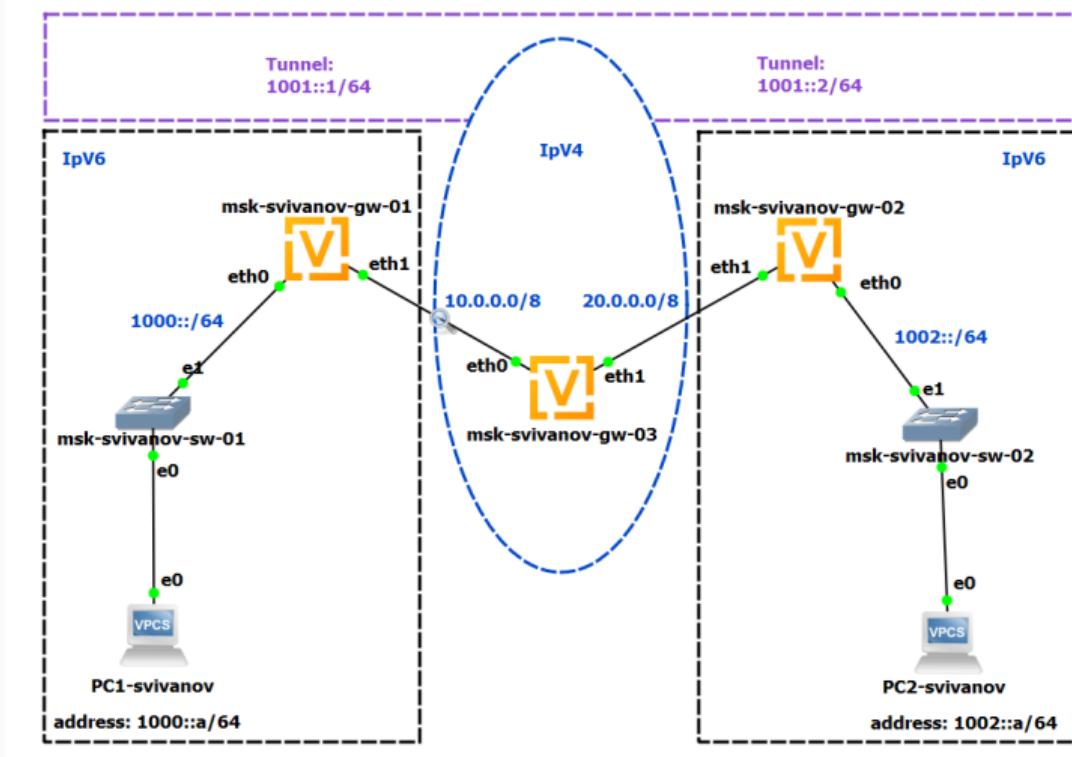


Рис. 74: Просмотр трафика

Построение туннеля IPv6–IPv4

Присвоим адреса устройствам PC1 и PC2:

```
PC1-svivanov> ip 1000::a/64
PC1 : 1000::a/64

PC1-svivanov> save
Saving startup configuration to startup.vpc
. done

PC1-svivanov> show ipv6

NAME          : PC1-svivanov[1]
LINK-LOCAL SCOPE  : fe80::250:79ff:fe66:6800/64
GLOBAL SCOPE    : 1000::a/64
DNS           :
ROUTER LINK-LAYER :
MAC            : 00:50:79:66:68:00
LPORT          : 20012
RHOST:PORT     : 127.0.0.1:20013
MTU:           : 1500

PC1-svivanov> █
```

Рис. 75: Настройка PC1

Построение туннеля IPv6–IPv4

```
PC2-svivanov> ip 1002::a/64
PC1 : 1002::a/64

PC2-svivanov> save
Saving startup configuration to startup.vpc
. done

PC2-svivanov> show ipv6

NAME          : PC2-svivanov[1]
LINK-LOCAL SCOPE : fe80::250:79ff:fe66:6801/64
GLOBAL SCOPE   : 1002::a/64
DNS           :
ROUTER LINK-LAYER :
MAC           : 00:50:79:66:68:01
LPORT          : 20014
RHOST:PORT     : 127.0.0.1:20015
MTU:          : 1500

PC2-svivanov> █
```

Рис. 76: Настройка PC2

Построение туннеля IPv6–IPv4

На маршрутизаторах настроим адреса на интерфейсах:

```
VyOS is a free software distribution that includes multiple components,  
you can check individual component licenses under /usr/share/doc/*/copyright  
vyos@msk-user-gw-01:~$ configure  
[edit]  
vyos@msk-user-gw-01# set interfaces ethernet eth0 address 1000::1/64  
[edit]  
vyos@msk-user-gw-01# set interfaces ethernet eth1 address 10.0.0.1/8  
[edit]  
vyos@msk-user-gw-01# set service router-advert interface eth0 prefix 1000::/64  
[edit]  
vyos@msk-user-gw-01# commit  
[edit]  
vyos@msk-user-gw-01# save  
Saving configuration to '/config/config.boot'...  
Done  
[edit]  
vyos@msk-user-gw-01# █
```

Рис. 77: Настройка gw-01

Построение туннеля IPv6–IPv4

```
vyos@msk-user-gw-02# set interfaces ethernet eth0 address 1002::1/64
[edit]
vyos@msk-user-gw-02# set interfaces ethernet eth1 address 20.0.0.2/8
[edit]
vyos@msk-user-gw-02# set service router-advert interface eth0 prefix 1002::/64
[edit]
vyos@msk-user-gw-02# commit
[edit]
vyos@msk-user-gw-02# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-user-gw-02# [ ]
```

Рис. 78: Настройка gw-02

Построение туннеля IPv6–IPv4

```
vyos@msk-svivanov-gw-03:~$ configure
[edit]
vyos@msk-svivanov-gw-03# set interfaces ethernet eth0 address 10.0.0.2/8
[edit]
vyos@msk-svivanov-gw-03# set interfaces ethernet eth1 address 20.0.0.1/8
[edit]
vyos@msk-svivanov-gw-03# commit

Can't configure both static IPv4 and DHCP address on the same interface

[[interfaces ethernet eth0]] failed
Commit failed
[edit]
vyos@msk-svivanov-gw-03# delete interfaces ethernet eth0 address dhcp
[edit]
vyos@msk-svivanov-gw-03# commit
[edit]
vyos@msk-svivanov-gw-03# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-svivanov-gw-03# █
```

Рис. 79: Настройка gw-03

Построение туннеля IPv6–IPv4

Проверим маршруты с маршрутизатора R1:

```
vyos@msk-user-gw-01# ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=7.71 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=1.49 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=3.13 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=1.20 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=1.17 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=1.64 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=1.54 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=1.23 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=4.00 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=1.71 ms
^C
--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 29ms
rtt min/avg/max/mdev = 1.165/2.479/7.707/1.954 ms
[edit]
vyos@msk-user-gw-01# ping 20.0.0.1
connect: Network is unreachable
[edit]
vyos@msk-user-gw-01# ping 20.0.0.2
connect: Network is unreachable
[edit]
vyos@msk-user-gw-01#
```

Рис. 80: Проверка маршрутов

Построение туннеля IPv6–IPv4

21 341.018465	0.0.0.0	255.255.255.255	DHCP	342 DHCP Discover - Transaction ID 0x6ca67073
22 349.670945	0.0.0.0	255.255.255.255	DHCP	342 DHCP Discover - Transaction ID 0x6ca67073
23 474.998493	0c:00:7a:e3:00:01	Broadcast	ARP	42 Who has 10.0.0.2? Tell 10.0.0.1
24 475.001722	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 10.0.0.2 is at 0c:0d:79:dd:00:00
25 475.003021	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=1/256, ttl=64 (reply in 26)
26 475.004301	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=1/256, ttl=64 (request in 25)
27 475.999415	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=2/512, ttl=64 (reply in 28)
28 476.000161	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=2/512, ttl=64 (request in 27)
29 477.004836	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=3/768, ttl=64 (reply in 30)
30 477.006481	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=3/768, ttl=64 (request in 29)
31 478.006613	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=4/1024, ttl=64 (reply in 32)
32 478.007371	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=4/1024, ttl=64 (request in 31)
33 479.009342	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=5/1280, ttl=64 (reply in 34)
34 479.010956	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=5/1280, ttl=64 (request in 33)
35 480.011128	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=6/1536, ttl=64 (reply in 36)
36 480.012304	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=6/1536, ttl=64 (request in 35)
37 480.381333	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 Who has 10.0.0.1? Tell 10.0.0.2
38 480.383395	0c:00:7a:e3:00:01	0c:0d:79:dd:00:00	ARP	42 10.0.0.1 is at 0c:00:7a:e3:00:01
39 481.012519	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=7/1792, ttl=64 (reply in 40)
40 481.013487	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=7/1792, ttl=64 (request in 39)
41 482.014540	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=8/2048, ttl=64 (reply in 42)
42 482.015289	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=8/2048, ttl=64 (request in 41)
43 483.016211	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=9/2304, ttl=64 (reply in 44)
44 483.018013	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=9/2304, ttl=64 (request in 43)
45 484.016432	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0xd71, seq=10/2560, ttl=64 (reply in 46)
46 484.017464	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0xd71, seq=10/2560, ttl=64 (request in 45)

Рис. 81: Результаты проверки

Построение туннеля IPv6–IPv4

Настроим маршрутизацию IPv4: (рис. 82-84)

```
vyos@msk-user-gw-01# set protocols rip network 10.0.0.0/8
[edit]
vyos@msk-user-gw-01# commit
[edit]
vyos@msk-user-gw-01# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-user-gw-01# 
```

Рис. 82: Настройка gw-01

Построение туннеля IPv6–IPv4

```
vyos@msk-user-gw-02# set protocols rip network 10.0.0.0/8
[edit]
vyos@msk-user-gw-02# delete protocols rip network 10.0.0.0/8
[edit]
vyos@msk-user-gw-02# set protocols rip network 20.0.0.0/8
[edit]
vyos@msk-user-gw-02# commit
[edit]
vyos@msk-user-gw-02# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-user-gw-02#
```

Рис. 83: Настройка gw-02

Построение туннеля IPv6–IPv4

```
vyos@msk-svivanov-gw-03# set protocols rip network 10.0.0.0/8
[edit]
vyos@msk-svivanov-gw-03# set protocols rip network 20.0.0.0/8
[edit]
vyos@msk-svivanov-gw-03# commit
[edit]
vyos@msk-svivanov-gw-03# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-svivanov-gw-03# █
```

Рис. 84: Настройка gw-03

Построение туннеля IPv6–IPv4

Проверим маршруты:

```
rtt min/avg/max/mdev = 1.304/2.049/2.919/0.584 ms
[edit]
vyos@msk-user-gw-01# ping 20.0.0.1
PING 20.0.0.1 (20.0.0.1) 56(84) bytes of data.
64 bytes from 20.0.0.1: icmp_seq=1 ttl=64 time=1.33 ms
64 bytes from 20.0.0.1: icmp_seq=2 ttl=64 time=2.75 ms
64 bytes from 20.0.0.1: icmp_seq=3 ttl=64 time=1.04 ms
64 bytes from 20.0.0.1: icmp_seq=4 ttl=64 time=1.82 ms
64 bytes from 20.0.0.1: icmp_seq=5 ttl=64 time=1.19 ms
^C
--- 20.0.0.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 13ms
rtt min/avg/max/mdev = 1.037/1.624/2.747/0.621 ms
[edit]
vyos@msk-user-gw-01# ping 20.0.0.2
PING 20.0.0.2 (20.0.0.2) 56(84) bytes of data.
64 bytes from 20.0.0.2: icmp_seq=1 ttl=63 time=7.90 ms
64 bytes from 20.0.0.2: icmp_seq=2 ttl=63 time=5.00 ms
^C
--- 20.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 3ms
rtt min/avg/max/mdev = 4.996/6.448/7.901/1.454 ms
[edit]
vyos@msk-user-gw-01# █
```

Рис. 85: Проверка маршрутов

Построение туннеля IPv6–IPv4

53 855.040525	10.0.0.2	224.0.0.9	RIPv2	66 Response
54 877.042110	10.0.0.2	224.0.0.9	RIPv2	66 Response
55 908.045669	10.0.0.2	224.0.0.9	RIPv2	66 Response
56 935.851920	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0x0e39, seq=1/256, ttl=64 (reply in 57)
57 935.853068	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e39, seq=1/256, ttl=64 (request in 56)
58 936.854174	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0x0e39, seq=2/512, ttl=64 (reply in 59)
59 936.855040	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e39, seq=2/512, ttl=64 (request in 58)
60 937.855995	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0x0e39, seq=3/768, ttl=64 (reply in 61)
61 937.857346	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e39, seq=3/768, ttl=64 (request in 60)
62 938.857904	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0x0e39, seq=4/1024, ttl=64 (reply in 63)
63 938.860824	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e39, seq=4/1024, ttl=64 (request in 62)
64 939.859497	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0x0e39, seq=5/1280, ttl=64 (reply in 65)
65 939.860251	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e39, seq=5/1280, ttl=64 (request in 64)
66 940.861767	10.0.0.1	10.0.0.2	ICMP	98 Echo (ping) request id=0x0e39, seq=6/1536, ttl=64 (reply in 67)
67 940.862557	10.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e39, seq=6/1536, ttl=64 (request in 66)
68 941.032933	0c:00:7a:e3:00:01	0c:00:79:dd:00:00	ARP	42 Who has 10.0.0.2? Tell 10.0.0.1
69 941.033616	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 10.0.0.2 is at 0c:0d:79:dd:00:00
70 941.051043	10.0.0.2	224.0.0.9	RIPv2	66 Response
71 941.180097	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 Who has 10.0.0.1? Tell 10.0.0.2
72 941.181022	0c:00:7a:e3:00:01	0c:0d:79:dd:00:00	ARP	42 10.0.0.1 is at 0c:00:7a:e3:00:01
73 946.591324	10.0.0.1	20.0.0.1	ICMP	98 Echo (ping) request id=0x0e3a, seq=1/256, ttl=64 (reply in 74)
74 946.592055	20.0.0.1	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e3a, seq=1/256, ttl=64 (request in 73)
75 947.593695	10.0.0.1	20.0.0.1	ICMP	98 Echo (ping) request id=0x0e3a, seq=2/512, ttl=64 (reply in 76)
76 947.595214	20.0.0.1	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e3a, seq=2/512, ttl=64 (request in 75)
77 948.595007	10.0.0.1	20.0.0.1	ICMP	98 Echo (ping) request id=0x0e3a, seq=3/768, ttl=64 (reply in 78)
78 948.595558	20.0.0.1	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e3a, seq=3/768, ttl=64 (request in 77)
79 949.597219	10.0.0.1	20.0.0.1	ICMP	98 Echo (ping) request id=0x0e3a, seq=4/1024, ttl=64 (reply in 80)
80 949.598455	20.0.0.1	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e3a, seq=4/1024, ttl=64 (request in 79)
81 950.600395	10.0.0.1	20.0.0.1	ICMP	98 Echo (ping) request id=0x0e3a, seq=5/1280, ttl=64 (reply in 82)
82 950.601187	20.0.0.1	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e3a, seq=5/1280, ttl=64 (request in 81)
83 954.297539	10.0.0.1	20.0.0.2	ICMP	98 Echo (ping) request id=0x0e3b, seq=1/256, ttl=64 (reply in 84)
84 954.304665	20.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e3b, seq=1/256, ttl=63 (request in 83)
85 955.299636	10.0.0.1	20.0.0.2	ICMP	98 Echo (ping) request id=0x0e3b, seq=2/512, ttl=64 (reply in 86)
86 955.303229	20.0.0.2	10.0.0.1	ICMP	98 Echo (ping) reply id=0x0e3b, seq=2/512, ttl=63 (request in 85)
87 970.052332	10.0.0.2	224.0.0.9	RIPv2	66 Response

Рис. 86: Результаты проверки

Построение туннеля IPv6–IPv4

Создадим туннель IPv6 через сеть IPv4:

```
vyos@msk-user-gw-01# set interfaces tunnel tun0 sour
source-address      source-interface
[edit]
vyos@msk-user-gw-01# set interfaces tunnel tun0 source-address 10.0.0.1
[edit]
vyos@msk-user-gw-01# set interfaces tunnel tun0 remote 20.0.0.2
[edit]
vyos@msk-user-gw-01# set interfaces tunnel tun0 address 1001::1/64
[edit]
vyos@msk-user-gw-01# commit
[edit]
vyos@msk-user-gw-01# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-user-gw-01# [ ]
```

Рис. 87: Создание туннеля

Построение туннеля IPv6–IPv4

```
vyos@msk-user-gw-02# set interfaces tunnel tun0 encapsulation sit
[edit]
vyos@msk-user-gw-02# set interfaces tunnel tun0 sour
source-address      source-interface
[edit]
vyos@msk-user-gw-02# set interfaces tunnel tun0 source-address 20.0.0.2
[edit]
vyos@msk-user-gw-02# set interfaces tunnel tun0 remote 10.0.0.1
[edit]
vyos@msk-user-gw-02# set interfaces tunnel tun0 address 1001::2/64
[edit]
vyos@msk-user-gw-02# commit
[edit]
vyos@msk-user-gw-02# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-user-gw-02# █
```

Рис. 88: Создание туннеля

Построение туннеля IPv6–IPv4

Настроим статическую маршрутизацию IPv6:

```
vyos@msk-user-gw-01# set protocols static route6 1002::0/64 next-hop 1001::2
[edit]
vyos@msk-user-gw-01# commit
[edit]
vyos@msk-user-gw-01# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-user-gw-01# █
```

Рис. 89: Настройка gw-01

Построение туннеля IPv6–IPv4

```
vyos@msk-user-gw-02# set protocols static route6 1000::0/64 next-hop 1001::1
[edit]
vyos@msk-user-gw-02# commit
[edit]
vyos@msk-user-gw-02# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-user-gw-02# █
```

Рис. 90: Настройка gw-02

Построение туннеля IPv6–IPv4

Проверим доступность оконечных устройств:

```
PC1-svivanov> ping 1002::a  
  
1002::a icmp6_seq=1 ttl=60 time=20.886 ms  
1002::a icmp6_seq=2 ttl=60 time=4.828 ms  
1002::a icmp6_seq=3 ttl=60 time=3.243 ms  
1002::a icmp6_seq=4 ttl=60 time=5.471 ms  
1002::a icmp6_seq=5 ttl=60 time=2.886 ms  
  
PC1-svivanov> trace 1002::a  
  
trace to 1002::a, 64 hops max  
 1 1000::1    2.960 ms  0.639 ms  0.432 ms  
 2 1001::2    5.782 ms  2.411 ms  2.094 ms  
 3 1002::a    3.570 ms  2.551 ms  5.682 ms  
  
PC1-svivanov> █
```

Рис. 91: Отправка пинга

Построение туннеля IPv6–IPv4

```
PC2-svivanov> ping 1000::a  
  
1000::a icmp6_seq=1 ttl=60 time=6.694 ms  
1000::a icmp6_seq=2 ttl=60 time=6.872 ms  
1000::a icmp6_seq=3 ttl=60 time=7.887 ms  
1000::a icmp6_seq=4 ttl=60 time=5.591 ms  
1000::a icmp6_seq=5 ttl=60 time=4.985 ms
```

```
PC2-svivanov> trace 1000::a
```

```
trace to 1000::a, 64 hops max  
1 1002::1    2.201 ms  0.366 ms  0.374 ms  
2 1001::1    4.772 ms  2.933 ms  2.777 ms  
3 1000::a    4.054 ms  2.287 ms  2.082 ms
```

```
PC2-svivanov> █
```

Рис. 92: Отправка пинга

Построение туннеля IPv6–IPv4

182 1366.514435	1002::a	1000::a	ICMPv6	138 Echo (ping) reply id=0x763e, seq=1, hop limit=61 (request in 101)
183 1367.521626	1000::a	1002::a	ICMPv6	138 Echo (ping) request id=0x763e, seq=2, hop limit=63 (reply in 104)
184 1367.524625	1002::a	1000::a	ICMPv6	138 Echo (ping) reply id=0x763e, seq=2, hop limit=61 (request in 103)
185 1368.528948	1000::a	1002::a	ICMPv6	138 Echo (ping) request id=0x763e, seq=3, hop limit=63 (reply in 106)
186 1368.531115	1002::a	1000::a	ICMPv6	138 Echo (ping) reply id=0x763e, seq=3, hop limit=61 (request in 105)
187 1369.533441	1000::a	1002::a	ICMPv6	138 Echo (ping) request id=0x763e, seq=4, hop limit=63 (reply in 108)
188 1369.536928	1002::a	1000::a	ICMPv6	138 Echo (ping) reply id=0x763e, seq=4, hop limit=61 (request in 107)
189 1370.539558	1000::a	1002::a	ICMPv6	138 Echo (ping) request id=0x763e, seq=5, hop limit=63 (reply in 110)
190 1370.541456	1002::a	1000::a	ICMPv6	138 Echo (ping) reply id=0x763e, seq=5, hop limit=61 (request in 109)
111 1371.625811	0c:00:7a:e3:00:01	0c:0d:79:dd:00:00	ARP	42 Who has 10.0.0.2? Tell 10.0.0.1
112 1371.626679	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 10.0.0.2 is at 0c:0d:79:dd:00:00
113 1371.772795	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 Who has 10.0.0.1? Tell 10.0.0.2
114 1371.774151	0c:00:7a:e3:00:01	0c:0d:79:dd:00:00	ARP	42 10.0.0.1 is at 0c:00:7a:e3:00:01
115 1377.098816	1000::a	1002::a	UDP	146 11057 + 11058 Len=64
116 1377.103413	1001::2	1000::a	ICMPv6	194 Time Exceeded (Hop limit exceeded in transit)
117 1377.105707	1000::a	1002::a	UDP	146 11057 + 11058 Len=64
118 1377.107149	1001::2	1000::a	ICMPv6	194 Time Exceeded (Hop limit exceeded in transit)
119 1377.110204	1000::a	1002::a	UDP	146 11057 + 11058 Len=64
120 1377.111625	1001::2	1000::a	ICMPv6	194 Time Exceeded (Hop limit exceeded in transit)
121 1377.111313	1000::a	1002::a	UDP	146 11057 + 11058 Len=64
122 1377.116009	1002::a	1000::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Packet]
123 1377.117952	1000::a	1002::a	UDP	146 11057 + 11058 Len=64
124 1377.119488	1002::a	1000::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Packet]
125 1377.122643	1000::a	1002::a	UDP	146 11057 + 11058 Len=64
126 1377.127124	1002::a	1000::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Packet]
127 1394.098944	10.0.0.2	224.0.0.9	RIPv2	66 Response
128 1415.411878	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=1, hop limit=63 (reply in 129)
129 1415.414735	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=1, hop limit=61 (request in 128)
130 1416.413992	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=2, hop limit=63 (reply in 131)
131 1416.422396	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=2, hop limit=61 (request in 130)
132 1417.429487	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=3, hop limit=63 (reply in 133)
133 1417.432984	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=3, hop limit=61 (request in 132)
134 1418.438912	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=4, hop limit=63 (reply in 135)
135 1418.441378	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=4, hop limit=61 (request in 134)
136 1419.447039	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=5, hop limit=63 (reply in 137)
137 1419.448449	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=5, hop limit=61 (request in 136)

Рис. 93: Анализ

Построение туннеля IPv6–IPv4

127 1394.098944	10.0.0.2	224.0.0.9	RIPv2	66 Response
128 1415.411878	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=1, hop limit=63 (reply in 129)
129 1415.414735	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=1, hop limit=61 (request in 128)
130 1416.419902	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=2, hop limit=63 (reply in 131)
131 1416.422396	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=2, hop limit=61 (request in 130)
132 1417.429487	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=3, hop limit=63 (reply in 133)
133 1417.432984	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=3, hop limit=61 (request in 132)
134 1418.438912	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=4, hop limit=63 (reply in 135)
135 1418.441378	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=4, hop limit=61 (request in 134)
136 1419.447809	1002::a	1000::a	ICMPv6	138 Echo (ping) request id=0xa73e, seq=5, hop limit=63 (reply in 137)
137 1419.448449	1000::a	1002::a	ICMPv6	138 Echo (ping) reply id=0xa73e, seq=5, hop limit=61 (request in 136)
138 1420.413263	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 Who has 10.0.0.1? Tell 10.0.0.1
139 1420.414122	0c:00:7a:e3:00:01	0c:0d:79:dd:00:00	ARP	42 10.0.0.1 is at 0c:00:7a:e3:00:01
140 1420.779985	0c:00:7a:e3:00:01	0c:0d:79:dd:00:00	ARP	42 Who has 10.0.0.2? Tell 10.0.0.1
141 1420.781074	0c:0d:79:dd:00:00	0c:00:7a:e3:00:01	ARP	42 10.0.0.2 is at 0c:0d:79:dd:00:00
142 1424.325063	1002::a	1000::a	UDP	146 11057 + 11058 Len=64
143 1424.326467	1001::1	1002::a	ICMPv6	194 Time Exceeded (Hop limit exceeded in transit)
144 1424.331585	1002::a	1000::a	UDP	146 11057 + 11058 Len=64
145 1424.332196	1001::1	1002::a	ICMPv6	194 Time Exceeded (Hop limit exceeded in transit)
146 1424.335975	1002::a	1000::a	UDP	146 11057 + 11058 Len=64
147 1424.336613	1001::1	1002::a	ICMPv6	194 Time Exceeded (Hop limit exceeded in transit)
148 1424.339503	1002::a	1000::a	UDP	146 11057 + 11058 Len=64
149 1424.341744	1000::a	1002::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Packet]
150 1424.345972	1002::a	1000::a	UDP	146 11057 + 11058 Len=64
151 1424.346604	1000::a	1002::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Packet]
152 1424.348713	1002::a	1000::a	UDP	146 11057 + 11058 Len=64
153 1424.349359	1000::a	1002::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Packet]
154 1429.103836	10.0.0.2	224.0.0.9	RIPv2	66 Response
155 1464.108250	10.0.0.2	224.0.0.9	RIPv2	66 Response

Рис. 94: Анализ

Задание для самостоятельного выполнения

Настроить динамическую маршрутизацию сетей IPv4 и IPv6 для протоколов RIP, OSPF, проверить соединения и маршруты.

Таблица адресов сетей

Устройства	Сеть IPv4	Сеть IPv6
PC1-gw-01	10.10.1.96/27	2001:db8:1:1::/64
PC2-gw-02	10.10.1.64/28	2001:db8:1:6::/64
gw-01-gw-03	10.10.1.4/30	2001:db8:1:2::/64
gw-01-gw-04	10.10.1.8/30	2001:db8:1:3::/64
gw-03-gw-02	10.10.1.16/30	2001:db8:1:4::/64
gw-04-gw-02	10.10.1.32/30	2001:db8:1:5::/64

Рис. 95: Таблица адресов сетей

Задание для самостоятельного выполнения

Устройство	Интерфейс	Адрес/Префикс	Шлюз по умолчанию	Следующее устройство
gw-01	eth0	10.10.1.97/27	n/a	PC1
gw-01	eth0	2001:db8:1:1::1/64	n/a	PC1
gw-01	eth1	10.10.1.5/30	n/a	gw-03
gw-01	eth1	2001:db8:1:2::1/64	n/a	gw-03
gw-01	eth2	10.10.1.9/30	n/a	gw-04
gw-01	eth2	2001:db8:1:3::1/64	n/a	gw-04
gw-02	eth0	10.10.1.65/28	n/a	PC2
gw-02	eth0	2001:db8:1:6::1/64	n/a	PC2
gw-02	eth1	10.10.1.17/30	n/a	gw-03
gw-02	eth1	2001:db8:1:4::1/64	n/a	gw-03
gw-02	eth2	10.10.1.33/30	n/a	gw-04
gw-02	eth2	2001:db8:1:5::1/64	n/a	gw-04
gw-03	eth0	10.10.1.6/30	n/a	gw-01
gw-03	eth0	2001:db8:1:2::2/64	n/a	gw-01
gw-03	eth1	10.10.1.18/30	n/a	gw-02
gw-03	eth1	2001:db8:1:4::2/64	n/a	gw-02
gw-04	eth0	10.10.1.34/30	n/a	gw-02
gw-04	eth0	2001:db8:1:5::2/64	n/a	gw-02
gw-04	eth1	10.10.1.10/30	n/a	gw-01
gw-04	eth1	2001:db8:1:3::2/64	n/a	gw-01
PC1	NIC	10.10.1.100/27	10.10.1.97	gw-01
PC1	NIC	2001:db8:1:1::a/64	n/a	gw-01
PC2	NIC	10.10.1.70/28	10.10.1.65	gw-02
PC2	NIC	2001:db8:1:6::a/64	n/a	gw-02

Задание для самостоятельного выполнения

Схема L1 (рис. 97)

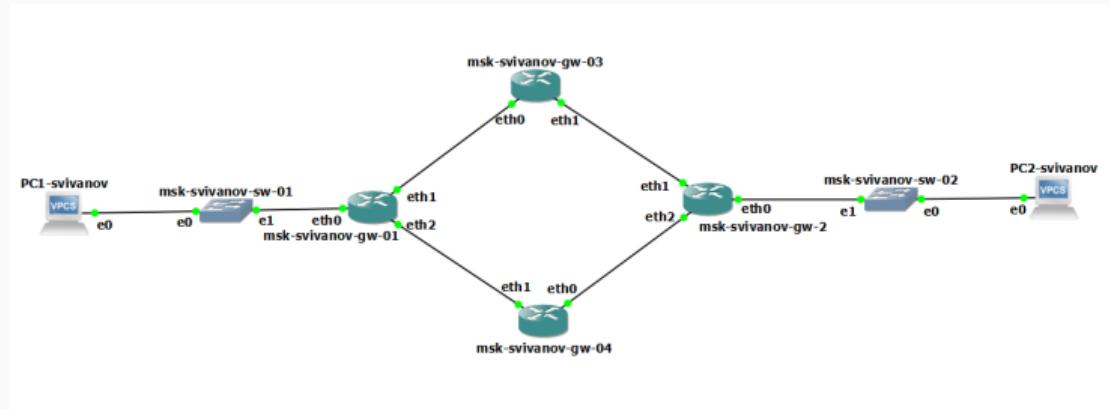


Рис. 97: Схема L1

Задание для самостоятельного выполнения

Схема L3 (рис. 98)

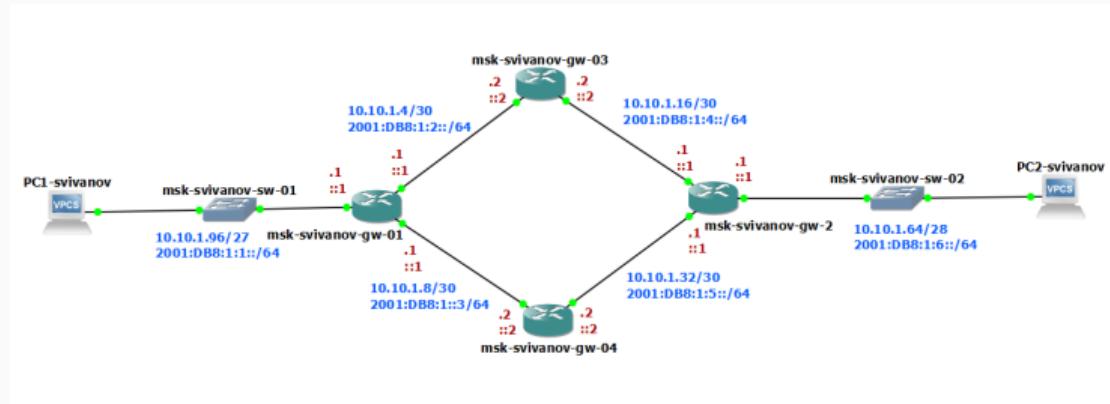


Рис. 98: Схема L3

Задание для самостоятельного выполнения

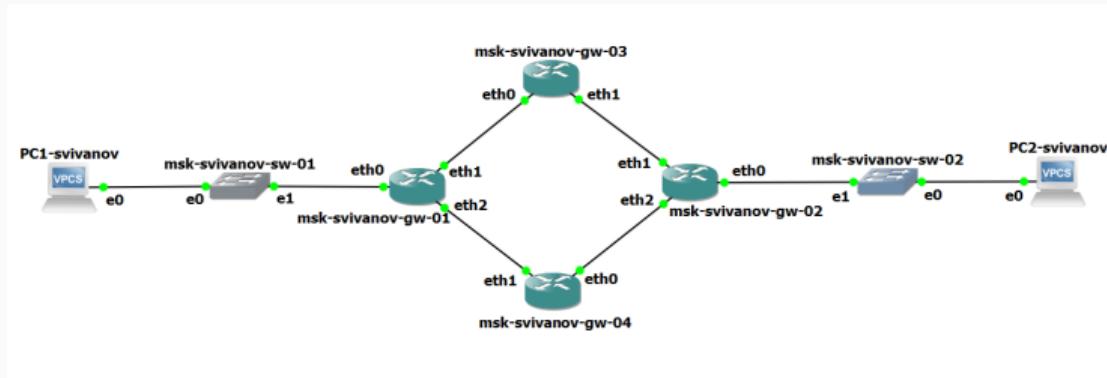


Рис. 99: Создание сети

Задание для самостоятельного выполнения

Присвоим IPv4-адреса устройствам PC1 и PC2:

```
PC1-svivanov> ip 10.10.1.100/27 10.10.1.97/27
Checking for duplicate address...
PC1-svivanov : 10.10.1.100 255.255.255.224 gateway 10.10.1.97

PC1-svivanov> save
Saving startup configuration to startup.vpc
. done

PC1-svivanov> show ip

NAME      : PC1-svivanov[1]
IP/MASK   : 10.10.1.100/27
GATEWAY   : 10.10.1.97
DNS       :
MAC       : 00:50:79:66:68:00
LPORT     : 20064
RHOST:PORT : 127.0.0.1:20065
MTU       : 1500

PC1-svivanov> █
```

Рис. 100: Настройка PC1

Задание для самостоятельного выполнения

```
PC2-svivanov> ip 10.10.1.70/28 10.10.1.65/28
Checking for duplicate address...
PC2-svivanov : 10.10.1.70 255.255.255.240 gateway 10.10.1.65

PC2-svivanov> save
Saving startup configuration to startup.vpc
. done

PC2-svivanov> show ip

NAME      : PC2-svivanov[1]
IP/MASK   : 10.10.1.70/28
GATEWAY   : 10.10.1.65
DNS       :
MAC       : 00:50:79:66:68:01
LPORT     : 20082
RHOST:PORT : 127.0.0.1:20083
MTU       : 1500

PC2-svivanov> █
```

Рис. 101: Настройка PC2

Задание для самостоятельного выполнения

Настроим IPv4-адреса на интерфейсах маршрутизаторов:

```
frr# configure terminal
frr(config)# hostname msk-svivanov-gw-01
msk-svivanov-gw-01(config)# interface eth0
msk-svivanov-gw-01(config-if)# ip address 10.10.1.97/27
msk-svivanov-gw-01(config-if)# no shutdown
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth1
msk-svivanov-gw-01(config-if)# ip address 10.10.1.5/30
msk-svivanov-gw-01(config-if)# no shutdown
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth2
msk-svivanov-gw-01(config-if)# ip address 10.10.1.9/30
msk-svivanov-gw-01(config-if)# no shutdown
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# show running-config
```

Рис. 102: Настройка gw-01

Задание для самостоятельного выполнения

```
frr# configure terminal
frr(config)# hostname msk-svivanov-gw-02
msk-svivanov-gw-02(config)# interface eth0
msk-svivanov-gw-02(config-if)# ip address 10.10.1.65/28
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth1
msk-svivanov-gw-02(config-if)# ip address 10.10.1.17/30
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth2
msk-svivanov-gw-02(config-if)# ip address 10.10.1.33/30
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# show running-config
```

Рис. 103: Настройка gw-02

Задание для самостоятельного выполнения

```
msk-svivanov-gw-03# configure terminal
msk-svivanov-gw-03(config)# interface eth0
msk-svivanov-gw-03(config-if)# ip address 10.10.1.6/30
msk-svivanov-gw-03(config-if)# no shutdown
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# interface eth1
msk-svivanov-gw-03(config-if)# ip address 10.10.1.18/30
msk-svivanov-gw-03(config-if)# no shutdown
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03#
```

Рис. 104: Настройка gw-03

Задание для самостоятельного выполнения

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# ip address 10.10.1.34/30
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# interface eth1
msk-svivanov-gw-04(config-if)# ip address 10.10.1.10/30
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04#
```

Рис. 105: Настройка gw-04

Задание для самостоятельного выполнения

Присвоим IPv6-адреса устройствам PC1 и PC2:

```
PC1-svivanov> ip 2001:db8:1:1::a/64
PC1 : 2001:db8:1:1::a/64

PC1-svivanov> save
Saving startup configuration to startup.vpc
. done

PC1-svivanov> show ipv6

NAME          : PC1-svivanov[1]
LINK-LOCAL SCOPE  : fe80::250:79ff:fe66:6800/64
GLOBAL SCOPE    : 2001:db8:1:1::a/64
DNS           :
ROUTER LINK-LAYER :
MAC           : 00:50:79:66:68:00
LPORT          : 20064
RHOST:PORT     : 127.0.0.1:20065
MTU:           : 1500

PC1-svivanov> □
```

Рис. 106: Настройка PC1

Задание для самостоятельного выполнения

```
PC2-svivanov> ip 2001:db8:1:6::a/64
PC1 : 2001:db8:1:6::a/64

PC2-svivanov> save
Saving startup configuration to startup.vpc
. done

PC2-svivanov> show ipv6

NAME          : PC2-svivanov[1]
LINK-LOCAL SCOPE  : fe80::250:79ff:fe66:6801/64
GLOBAL SCOPE    : 2001:db8:1:6::a/64
DNS           :
ROUTER LINK-LAYER :
MAC           : 00:50:79:66:68:01
LPORT          : 20082
RHOST:PORT     : 127.0.0.1:20083
MTU:           : 1500

PC2-svivanov> █
```

Рис. 107: Настройка PC2

Задание для самостоятельного выполнения

Настроим IPv6-адреса на интерфейсах маршрутизаторов:

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# ipv6 forwarding
msk-svivanov-gw-01(config)# interface eth0
msk-svivanov-gw-01(config-if)# ipv6 address 2001:db8:1:1::1/64
msk-svivanov-gw-01(config-if)# no ipv6 nd suppress-ra
msk-svivanov-gw-01(config-if)# ipv6 nd prefix 2001:db8:1:1::/64
msk-svivanov-gw-01(config-if)# no shutdown
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth1
msk-svivanov-gw-01(config-if)# ipv6 address 2001:db8:1:2::1/64
msk-svivanov-gw-01(config-if)# no shutdown
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth2
msk-svivanov-gw-01(config-if)# ipv6 address 2001:db8:1:3::1/64
msk-svivanov-gw-01(config-if)# no shutdown
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# show running-config
Building configuration...
```

Рис. 108: Настройка gw-01

Задание для самостоятельного выполнения

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# ipv6 forwarding
msk-svivanov-gw-02(config)# interface eth0
msk-svivanov-gw-02(config-if)# ipv6 address 2001:db8:1:6::1/64
msk-svivanov-gw-02(config-if)# no ipv6 nd suppress-ra
msk-svivanov-gw-02(config-if)# ipv6 nd prefix 2001:db8:1:6::/64
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth1
msk-svivanov-gw-02(config-if)# ipv6 address 2001:db8:1:4::1/64
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth2
msk-svivanov-gw-02(config-if)# ipv6 address 2001:db8:1:5::1/64
msk-svivanov-gw-02(config-if)# no shutdown
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# □
```

Рис. 109: Настройка gw-02

Задание для самостоятельного выполнения

```
msk-svivanov-gw-03# configure
msk-svivanov-gw-03(config)# ipv6 forwarding
msk-svivanov-gw-03(config)# interface eth0
msk-svivanov-gw-03(config-if)# ipv6 address 2001:db8:1:2::2/64
msk-svivanov-gw-03(config-if)# no shutdown
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# interface eth1
msk-svivanov-gw-03(config-if)# ipv6 address 2001:db8:1:4::2/64
msk-svivanov-gw-03(config-if)# no shutdown
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03# █
```

Рис. 110: Настройка gw-03

Задание для самостоятельного выполнения

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# ipv6 forwarding
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# ipv6 address 2001:db8:1:5::2/64
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# interface eth1
msk-svivanov-gw-04(config-if)# ipv6 address 2001:db8:1:3::2/64
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04#
```

Рис. 111: Настройка gw-04

Задание для самостоятельного выполнения

На маршрутизаторах настроим RIP в качестве протокола динамической маршрутизации:

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# router rip
msk-svivanov-gw-01(config-router)# version
% Command incomplete: version
msk-svivanov-gw-01(config-router)# version 2
msk-svivanov-gw-01(config-router)# network eth0
msk-svivanov-gw-01(config-router)# network eth1
msk-svivanov-gw-01(config-router)# network eth2
msk-svivanov-gw-01(config-router)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# □
```

Рис. 112: Настройка gw-01

Задание для самостоятельного выполнения

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# router rip
msk-svivanov-gw-02(config-router)# version 2
msk-svivanov-gw-02(config-router)# network eth0
msk-svivanov-gw-02(config-router)# network eth1
msk-svivanov-gw-02(config-router)# network eth2
msk-svivanov-gw-02(config-router)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-qw-02# □
```

Рис. 113: Настройка gw-02

Задание для самостоятельного выполнения

```
msk-svivanov-gw-03# configure terminal
msk-svivanov-gw-03(config)# router rip
msk-svivanov-gw-03(config-router)# version 2
msk-svivanov-gw-03(config-router)# network eth0
msk-svivanov-gw-03(config-router)# network eth1
msk-svivanov-gw-03(config-router)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# memory
% Unknown command: memory
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03#
```

Рис. 114: Настройка gw-03

Задание для самостоятельного выполнения

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# router rip
msk-svivanov-gw-04(config-router)# version 2
msk-svivanov-gw-04(config-router)# network eth0
msk-svivanov-gw-04(config-router)# network eth1
msk-svivanov-gw-04(config-router)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# □
```

Рис. 115: Настройка gw-04

Задание для самостоятельного выполнения

С PC1 пропингуем PC2. Пакеты идут через gw-03

```
PC1-svivanov> ping 10.10.1.70

84 bytes from 10.10.1.70 icmp_seq=1 ttl=61 time=3.926 ms
84 bytes from 10.10.1.70 icmp_seq=2 ttl=61 time=3.990 ms
84 bytes from 10.10.1.70 icmp_seq=3 ttl=61 time=3.565 ms
84 bytes from 10.10.1.70 icmp_seq=4 ttl=61 time=5.832 ms
84 bytes from 10.10.1.70 icmp_seq=5 ttl=61 time=5.021 ms

PC1-svivanov> trace 10.10.1.70 -P 6
trace to 10.10.1.70, 8 hops max (TCP), press Ctrl+C to stop
 1  10.10.1.97    5.641 ms   0.555 ms   0.296 ms
 2  10.10.1.6    4.849 ms   2.517 ms   2.652 ms
 3  10.10.1.17   8.736 ms   1.800 ms   1.625 ms
 4  10.10.1.70   2.535 ms   2.400 ms   2.570 ms

PC1-svivanov> █
```

Рис. 116: Отправка пинга

Задание для самостоятельного выполнения

Проверим метрики протокола RIP: (рис. 117)

```
msk-svivanov-gw-01# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
    (n) - normal, (s) - static, (d) - default, (r) - redistribute,
    (i) - interface

      Network          Next Hop          Metric From        Tag Time
C(i) 10.10.1.4/30      0.0.0.0           1 self          0
C(i) 10.10.1.8/30      0.0.0.0           1 self          0
R(n) 10.10.1.16/30     10.10.1.6          2 10.10.1.6      0 02:54
R(n) 10.10.1.32/30     10.10.1.10          2 10.10.1.10      0 02:43
R(n) 10.10.1.64/28     10.10.1.6          3 10.10.1.6      0 02:54
C(i) 10.10.1.96/27     0.0.0.0           1 self          0
msk-svivanov-gw-01#
```

Рис. 117: Проверка метрик

Задание для самостоятельного выполнения

Пакет проходит через gw-03. Отключим на gw-03 интерфейс. Теперь пакеты идут через gw-04.

```
PC1-svivanov> ping 10.10.1.70

84 bytes from 10.10.1.70 icmp_seq=1 ttl=61 time=7.636 ms
84 bytes from 10.10.1.70 icmp_seq=2 ttl=61 time=6.249 ms
84 bytes from 10.10.1.70 icmp_seq=3 ttl=61 time=8.910 ms
84 bytes from 10.10.1.70 icmp_seq=4 ttl=61 time=3.982 ms
84 bytes from 10.10.1.70 icmp_seq=5 ttl=61 time=4.137 ms

PC1-svivanov> trace 10.10.1.70 -P 6
trace to 10.10.1.70, 8 hops max (TCP), press Ctrl+C to stop
 1  10.10.1.97    0.753 ms  0.677 ms  0.608 ms
 2  10.10.1.10    3.962 ms  1.725 ms  1.980 ms
 3  10.10.1.33    2.248 ms  1.713 ms  3.151 ms
 4  10.10.1.70    2.152 ms  2.616 ms  2.920 ms

PC1-svivanov> █
```

Рис. 118: Отключение интерфейса и отправка пинга

Задание для самостоятельного выполнения

На маршрутизаторах настроим RIPng для сетей IPv6:

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# router ripng
msk-svivanov-gw-01(config-router)# network eth0
msk-svivanov-gw-01(config-router)# network eth1
msk-svivanov-gw-01(config-router)# network eth2
msk-svivanov-gw-01(config-router)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# █
```

Рис. 119: Настройка gw-01

Задание для самостоятельного выполнения

```
msk-svivanov-gw-02(config)# router ripng
msk-svivanov-gw-02(config-router)# network eth0
msk-svivanov-gw-02(config-router)# network eth1
msk-svivanov-gw-02(config-router)# network eth2
msk-svivanov-gw-02(config-router)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# █
```

Рис. 120: Настройка gw-02

Задание для самостоятельного выполнения

```
msk-svivanov-gw-03(config)# router ripng
msk-svivanov-gw-03(config-router)# network eth0
msk-svivanov-gw-03(config-router)# network eth1
msk-svivanov-gw-03(config-router)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03# █
```

Рис. 121: Настройка gw-03

Задание для самостоятельного выполнения

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# router ripng
msk-svivanov-gw-04(config-router)# network eth0
msk-svivanov-gw-04(config-router)# network eth1
msk-svivanov-gw-04(config-router)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# █
```

Рис. 122: Настройка gw-04

Задание для самостоятельного выполнения

С PC1 пропингуем PC2. Пакеты идут через gw-03.

```
PC1-svivanov> ping 2001:db8:1:6::a/64

2001:db8:1:6::a icmp6_seq=1 ttl=58 time=10.478 ms
2001:db8:1:6::a icmp6_seq=2 ttl=58 time=3.379 ms
2001:db8:1:6::a icmp6_seq=3 ttl=58 time=4.604 ms
2001:db8:1:6::a icmp6_seq=4 ttl=58 time=3.503 ms
2001:db8:1:6::a icmp6_seq=5 ttl=58 time=3.431 ms

PC1-svivanov> trace 2001:db8:1:6::a/64

trace to 2001:db8:1:6::a, 64 hops max
 1 2001:db8:1:1::1    2.836 ms  4.261 ms  4.406 ms
 2 2001:db8:1:2::2    11.506 ms  1.293 ms  1.505 ms
 3 2001:db8:1:4::1    3.842 ms  1.829 ms  1.586 ms
 4 2001:db8:1:6::a    1.446 ms  2.244 ms  1.908 ms

PC1-svivanov>
```

Рис. 123: Отправка пинга

Задание для самостоятельного выполнения

Проверим метрики протокола RIPng:

```
msk-svivanov-gw-01# show ipv6 ripng
Codes: R - RIPng, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
      (n) - normal, (s) - static, (d) - default, (r) - redistribute,
      (i) - interface, (a/S) - aggregated/Suppressed

      Network          Next Hop            Via      Metric Tag Time
C(i) 2001:db8:1:1::/64
                  ::                      self     1      0
C(i) 2001:db8:1:2::/64
                  ::                      self     1      0
C(i) 2001:db8:1:3::/64
                  ::                      self     1      0
R(n) 2001:db8:1:4::/64
                  fe80::e2d:88ff:fe7c:0  eth1     2      0  02:51
R(n) 2001:db8:1:5::/64
                  fe80::e2e:95ff:fed7:1  eth2     2      0  02:41
R(n) 2001:db8:1:6::/64
                  fe80::e2d:88ff:fe7c:0  eth1     3      0  02:51
msk-svivanov-gw-01#
```

Рис. 124: Проверка метрик

Задание для самостоятельного выполнения

Пакет проходит через gw-03. Отключим на gw-03 интерфейс. Теперь пакеты идут через gw-04.

```
PC1-svivanov> ping 2001:db8:1:6::a/64

2001:db8:1:6::a icmp6_seq=1 ttl=58 time=5.087 ms
2001:db8:1:6::a icmp6_seq=2 ttl=58 time=3.092 ms
2001:db8:1:6::a icmp6_seq=3 ttl=58 time=7.114 ms
2001:db8:1:6::a icmp6_seq=4 ttl=58 time=4.400 ms
2001:db8:1:6::a icmp6_seq=5 ttl=58 time=2.991 ms

PC1-svivanov> trace 2001:db8:1:6::a/64

trace to 2001:db8:1:6::a, 64 hops max
 1 2001:db8:1:1::1    1.519 ms  0.693 ms  0.382 ms
 2 2001:db8:1:3::2    2.756 ms  1.947 ms  0.836 ms
 3 2001:db8:1:5::1    2.261 ms  2.707 ms  1.523 ms
 4 2001:db8:1:6::a    4.077 ms  2.777 ms  1.783 ms

PC1-svivanov> █
```

Рис. 125: Отключение интерфейса и отправка пинга

Задание для самостоятельного выполнения

На маршрутизаторах настроим OSPFv2 для сетей IPv4:

```
msk-svivanov-gw-01(config)# router ospf
msk-svivanov-gw-01(config-router)# network 10.10.1.96/27 area 0.0.0.0
msk-svivanov-gw-01(config-router)# network 10.10.1.4/30 area 0.0.0.0
msk-svivanov-gw-01(config-router)# network 10.10.1.8/30 area 0.0.0.0
msk-svivanov-gw-01(config-router)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01# [ ]
```

Рис. 126: Настройка gw-01

Задание для самостоятельного выполнения

```
msk-svivanov-gw-02(config)# router ospf
msk-svivanov-gw-02(config-router)# network 10.10.1.64/28 area 0.0.0.0
msk-svivanov-gw-02(config-router)# network 10.10.1.16/30 area 0.0.0.0
msk-svivanov-gw-02(config-router)# network 10.10.1.32/30 area 0.0.0.0
msk-svivanov-gw-02(config-router)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# █
```

Рис. 127: Настройка gw-02

Задание для самостоятельного выполнения

```
msk-svivanov-gw-03(config)# router ospf
msk-svivanov-gw-03(config-router)# network
% Command incomplete: network
msk-svivanov-gw-03(config-router)# network 10.10.1.4/30 area 0.0.0.0
msk-svivanov-gw-03(config-router)# network 10.10.1.16/30 area 0.0.0.0
msk-svivanov-gw-03(config-router)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03#
```

Рис. 128: Настройка gw-03

Задание для самостоятельного выполнения

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# router ospf
msk-svivanov-gw-04(config-router)# network 10.10.1.8/30 area 0.0.0.0
msk-svivanov-gw-04(config-router)# network 10.10.1.32/30 area 0.0.0.0
msk-svivanov-gw-04(config-router)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# [ ]
```

Рис. 129: Настройка gw-04

Задание для самостоятельного выполнения

С PC1 пропингуем PC2. Пакеты идут через gw-04.

```
PC1-svivanov> ping 10.10.1.70

84 bytes from 10.10.1.70 icmp_seq=1 ttl=61 time=9.988 ms
84 bytes from 10.10.1.70 icmp_seq=2 ttl=61 time=5.196 ms
84 bytes from 10.10.1.70 icmp_seq=3 ttl=61 time=4.334 ms
84 bytes from 10.10.1.70 icmp_seq=4 ttl=61 time=6.450 ms
84 bytes from 10.10.1.70 icmp_seq=5 ttl=61 time=3.520 ms

PC1-svivanov> trace 10.10.1.70 -P 6
trace to 10.10.1.70, 8 hops max (TCP), press Ctrl+C to stop
 1  10.10.1.97    1.029 ms   0.288 ms   0.444 ms
 2  10.10.1.10    2.422 ms   1.938 ms   1.595 ms
 3  10.10.1.17    3.267 ms   2.292 ms   1.736 ms
 4  10.10.1.70    2.431 ms   1.749 ms   1.654 ms

PC1-svivanov> █
```

Рис. 130: Отправка пинга

Задание для самостоятельного выполнения

Пакет проходит через gw-04. Отключим на gw-04 интерфейс:

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# interface eth1
msk-svivanov-gw-04(config-if)# shutdown
msk-svivanov-gw-04(config-if)# █
```

Рис. 131: Отключение интерфейса

Задание для самостоятельного выполнения

С PC1 пропингуем PC2. Пакеты идут через gw-03.

```
PC1-svivanov> ping 10.10.1.70

84 bytes from 10.10.1.70 icmp_seq=1 ttl=61 time=5.917 ms
84 bytes from 10.10.1.70 icmp_seq=2 ttl=61 time=2.880 ms
84 bytes from 10.10.1.70 icmp_seq=3 ttl=61 time=6.305 ms
84 bytes from 10.10.1.70 icmp_seq=4 ttl=61 time=3.892 ms
84 bytes from 10.10.1.70 icmp_seq=5 ttl=61 time=3.376 ms

PC1-svivanov> trace 10.10.1.70 -P 6
trace to 10.10.1.70, 8 hops max (TCP), press Ctrl+C to stop
 1  10.10.1.97    1.335 ms  0.404 ms  0.418 ms
 2  10.10.1.6    1.919 ms  2.079 ms  1.838 ms
 3  10.10.1.17   1.688 ms  1.990 ms  1.347 ms
 4  10.10.1.70   1.848 ms  1.999 ms  1.694 ms

PC1-svivanov>
```

Рис. 132: Отправка пинга

Задание для самостоятельного выполнения

На маршрутизаторах настроим OSPFv3 для сетей IPv6:

```
msk-svivanov-gw-01# configure terminal
msk-svivanov-gw-01(config)# router ospf6
msk-svivanov-gw-01(config-ospf6)# ospf6 router-id 1.1.1.1
msk-svivanov-gw-01(config-ospf6)# exit
msk-svivanov-gw-01(config)# interface eth0
msk-svivanov-gw-01(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth1
msk-svivanov-gw-01(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# interface eth2
msk-svivanov-gw-01(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-01(config-if)# exit
msk-svivanov-gw-01(config)# exit
msk-svivanov-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-svivanov-gw-01#
```

Рис. 133: Настройка gw-01

Задание для самостоятельного выполнения

```
msk-svivanov-gw-02# configure terminal
msk-svivanov-gw-02(config)# router ospf6
msk-svivanov-gw-02(config-ospf6)# ospf6 router-id 2.2.2.2
msk-svivanov-gw-02(config-ospf6)# exit
msk-svivanov-gw-02(config)# interface eth0
msk-svivanov-gw-02(config-if)# ipv6 ospf area 0
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth1
msk-svivanov-gw-02(config-if)# ipv6 ospf area 0
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# interface eth2
msk-svivanov-gw-02(config-if)# ipv6 ospf area 0
msk-svivanov-gw-02(config-if)# exit
msk-svivanov-gw-02(config)# exit
msk-svivanov-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-02# █
```

Рис. 134: Настройка gw-02

Задание для самостоятельного выполнения

```
msk-svivanov-gw-03# configure terminal
msk-svivanov-gw-03(config)# router ospf6
msk-svivanov-gw-03(config-ospf6)# ospf6 router-id 3.3.3.3
msk-svivanov-gw-03(config-ospf6)# exit
msk-svivanov-gw-03(config)# interface eth0
msk-svivanov-gw-03(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# interface eth1
msk-svivanov-gw-03(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-03(config-if)# exit
msk-svivanov-gw-03(config)# exit
msk-svivanov-gw-03# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-03#
```

Рис. 135: Настройка gw-03

Задание для самостоятельного выполнения

```
msk-svivanov-gw-04# configure terminal
msk-svivanov-gw-04(config)# interface eth1
msk-svivanov-gw-04(config-if)# shutdown
msk-svivanov-gw-04(config-if)# no shutdown
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# router ospf6
msk-svivanov-gw-04(config-ospf6)# ospf6 router-id 4.4.4.4
msk-svivanov-gw-04(config-ospf6)# exit
msk-svivanov-gw-04(config)# interface eth0
msk-svivanov-gw-04(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# interface eth1
msk-svivanov-gw-04(config-if)# ipv6 ospf6 area 0
msk-svivanov-gw-04(config-if)# exit
msk-svivanov-gw-04(config)# exit
msk-svivanov-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
msk-svivanov-gw-04# █
```

Рис. 136: Настройка gw-04

Задание для самостоятельного выполнения

С PC1 пропингуем PC2. Пакеты идут через gw-03.

```
PC1-svivanov> ping 2001:db8:1:6::a/64

2001:db8:1:6::a icmp6_seq=1 ttl=58 time=5.041 ms
2001:db8:1:6::a icmp6_seq=2 ttl=58 time=6.896 ms
2001:db8:1:6::a icmp6_seq=3 ttl=58 time=3.557 ms
2001:db8:1:6::a icmp6_seq=4 ttl=58 time=3.201 ms
2001:db8:1:6::a icmp6_seq=5 ttl=58 time=4.032 ms

PC1-svivanov> trace 2001:db8:1:6::a/64

trace to 2001:db8:1:6::a, 64 hops max
 1 2001:db8:1:1::1    3.157 ms   1.216 ms   1.011 ms
 2 2001:db8:1:2::2    2.169 ms   1.161 ms   0.945 ms
 3 2001:db8:1:4::1    1.887 ms   1.802 ms   1.772 ms
 4 2001:db8:1:6::a    1.762 ms   2.492 ms   2.695 ms

PC1-svivanov>
```

Рис. 137: Отправка пинга

Задание для самостоятельного выполнения

Пакет проходит через gw-03. Отключим на gw-03 интерфейс:

```
msk-svivanov-gw-03# configure
msk-svivanov-gw-03(config)# configure te
% Unknown command: configure te
msk-svivanov-gw-03(config)# interface eth0
msk-svivanov-gw-03(config-if)# shutdown
msk-svivanov-gw-03(config-if)# █
```

Рис. 138: Отключение интерфейса

Задание для самостоятельного выполнения

С PC1 пропингуем PC2. Пакеты идут через gw-04.

```
PC1-svivanov> ping 2001:db8:1:6::a/64

2001:db8:1:6::a icmp6_seq=1 ttl=58 time=3.235 ms
2001:db8:1:6::a icmp6_seq=2 ttl=58 time=3.739 ms
2001:db8:1:6::a icmp6_seq=3 ttl=58 time=3.494 ms
2001:db8:1:6::a icmp6_seq=4 ttl=58 time=3.115 ms
2001:db8:1:6::a icmp6_seq=5 ttl=58 time=5.924 ms

PC1-svivanov> trace 2001:db8:1:6::a/64

trace to 2001:db8:1:6::a, 64 hops max
 1 2001:db8:1:1::1    1.128 ms  1.116 ms  0.873 ms
 2 2001:db8:1:3::2    3.434 ms  1.493 ms  1.076 ms
 3 2001:db8:1:5::1    1.825 ms  1.632 ms  1.559 ms
 4 2001:db8:1:6::a    4.097 ms  3.063 ms  2.918 ms

PC1-svivanov> █
```

Рис. 139: Отправка пинга

Вывод

Вывод

В ходе выполнения лабораторной работы мы изучили принципы маршрутизации в IPv4- и IPv6-сетях и принципов настройки сетевого оборудования.