РОССИЙСКИЙ УНИВЕРСИТЕТ ДРУЖБЫ НАРОДОВ

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ОТЧЕТ
ПО ЛАБОРАТОРНОЙ РАБОТЕ № 8

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МОСКВА

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Постановка задачи

1. Требуется настроить динамическую маршрутизацию по протоколам RIP, OSPF.
2. Требуется организовать туннель IPv6 поверх IPv4, позволяющий передавать данные из одной IPv6-сети в другую IPv6-сеть через сеть IPv4.

3. Выполнение работы

1.

1.1. Продублируйте в отчёте таблицы адресации

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

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

1.2. Запустите GNS3 VM и GNS3. Создайте новый проект.

1.3. В рабочем пространстве разместите и соедините устройства в соответствии с топологией. Используйте маршрутизаторы FRR.

1.4. Измените отображаемые названия устройств.

1.5. Включите захват трафика на соединении между коммутатором sw-01 и маршрутизатором gw-01, а также между коммутатором sw-02 и маршрутизатором gw-03.

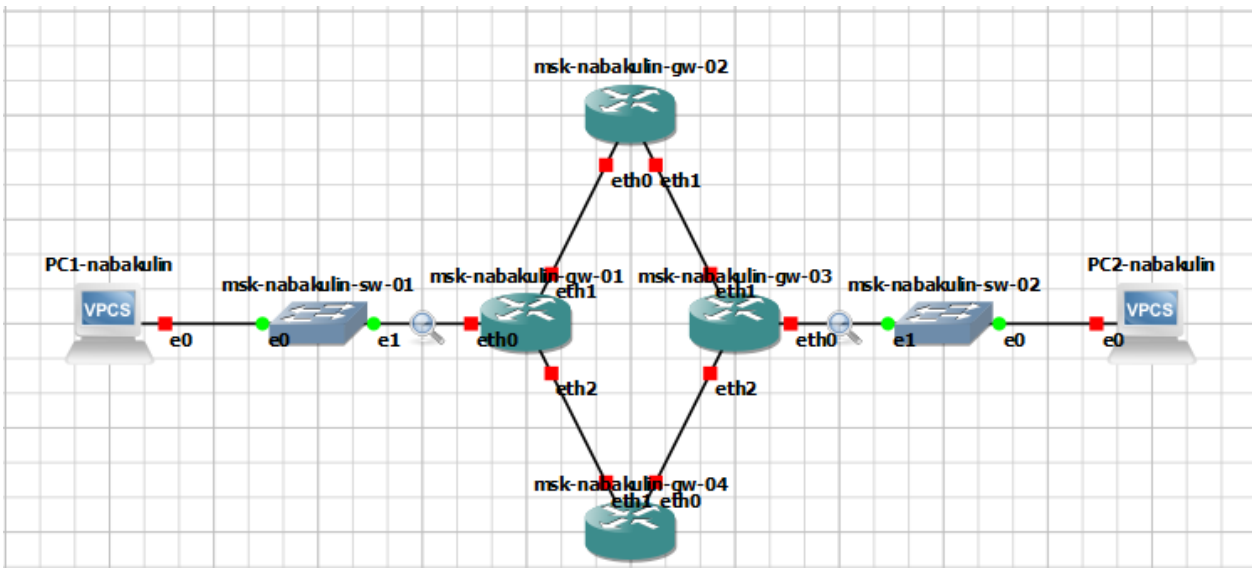

Рисунок 1

1.6. Присвойте IPv4-адреса оконечным устройствам PC1 и PC2

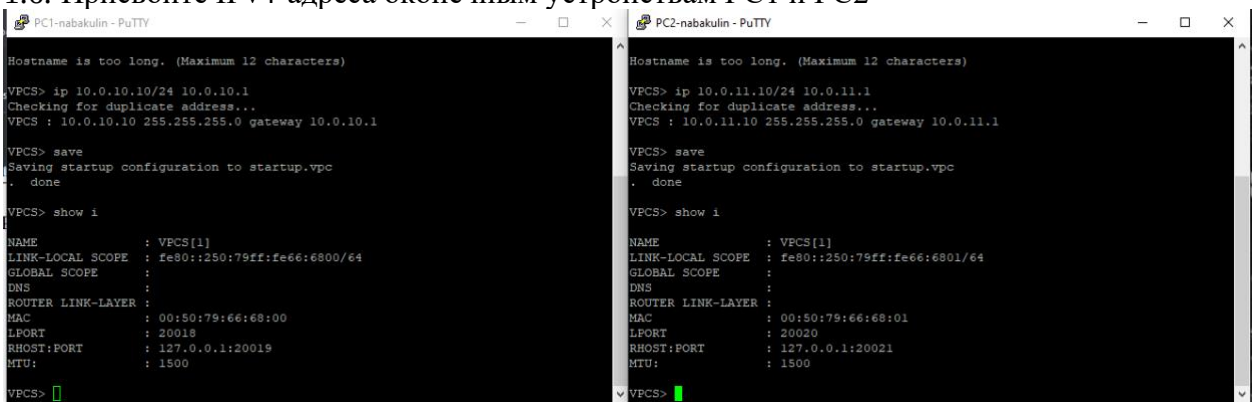

Рисунок 2

1.7. Настройте IPv4-адреса на интерфейсах маршрутизаторов

msk-nabakulin-gw-01 - PuTTY

```
Building configuration...

Current configuration:
!
frr version 8.1
frr defaults traditional
hostname frr
hostname msk-nabakulin-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
exit
!
interface eth2
 ip address 10.0.4.2/24
exit
!
end
msk-nabakulin-gw-01#
```

msk-nabakulin-gw-02 - PuTTY

```
msk-nabakulin-gw-02# write memory
Note: this version of vtysh never writes vtysh.conf
% Not all daemons are up, cannot write config.
msk-nabakulin-gw-02#  show running-config
Building configuration...

Current configuration:
!
frr version 8.1
frr defaults traditional
hostname frr
hostname msk-nabakulin-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
msk-nabakulin-gw-02#
```

msk-nabakulin-gw-03 - PuTTY

```
Building configuration...

Current configuration:
!
frr version 8.1
frr defaults traditional
hostname frr
hostname msk-nabakulin-gw-03
service integrated-vtysh-config
!
interface eth0
 ip address 10.0.11.1/24
exit
!
interface eth1
 ip address 10.0.2.2/24
exit
!
interface eth2
 ip address 10.0.3.1/24
exit
!
end
msk-nabakulin-gw-03#
```

msk-nabakulin-gw-04 - PuTTY

```
msk-nabakulin-gw-04# write memory
Note: this version of vtysh never writes vtysh.conf
% Not all daemons are up, cannot write config.
msk-nabakulin-gw-04#  show running-config
Building configuration...

Current configuration:
!
frr version 8.1
frr defaults traditional
hostname frr
hostname msk-nabakulin-gw-04
service integrated-vtysh-config
!
interface eth0
 ip address 10.0.3.2/24
exit
!
interface eth1
 ip address 10.0.4.1/24
exit
!
end
msk-nabakulin-gw-04#
```

Рисунок 3

1.8. Присвойте IPv6-адреса оконечным устройствам PC1 и PC2

PC1-nabakulin - PuTTY

```
LPORT             : 20018
RHOST:PORT        : 127.0.0.1:20019
MTU:              : 1500

VPCS> ip 2001:10::a/64
PC1 : 2001:10::a/64

VPCS> save
Saving startup configuration to startup.vpc
.  done

VPCS> show ipv6

NAME              : VPCS[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             : 20018
RHOST:PORT        : 127.0.0.1:20019
MTU:              : 1500

VPCS>
```

PC2-nabakulin - PuTTY

```
LPORT             : 20020
RHOST:PORT        : 127.0.0.1:20021
MTU:              : 1500

VPCS> ip 2001:11::a/64
PC1 : 2001:11::a/64

VPCS> save
Saving startup configuration to startup.vpc
.  done

VPCS> show ipv6

NAME              : VPCS[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             : 20020
RHOST:PORT        : 127.0.0.1:20021
MTU:              : 1500

VPCS>
```

Рисунок 4

1.9. Настройте IPv6-адреса на интерфейсах маршрутизаторов

msk-nabakulin-gw-01 - PuTTY

```
frr defaults traditional
hostname frr
hostname msk-nabakulin-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
!
interface eth1
 ip address 10.0.1.1/24
 ipv6 address 2001:1::1/64
exit
!
interface eth2
 ip address 10.0.4.2/24
 ipv6 address 2001:4::2/64
exit
!
end
msk-nabakulin-gw-01#
```

msk-nabakulin-gw-02 - PuTTY

```
% Not all daemons are up, cannot write config.
msk-nabakulin-gw-02# show running-config
Building configuration...

Current configuration:
!
frr version 8.1
frr defaults traditional
hostname frr
hostname msk-nabakulin-gw-02
service integrated-vtysh-config
!
interface eth0
 ip address 10.0.1.2/24
 ipv6 address 2001:1::2/64
exit
!
interface eth1
 ip address 10.0.2.1/24
 ipv6 address 2001:2::1/64
exit
!
end
msk-nabakulin-gw-02#
```

msk-nabakulin-gw-03 - PuTTY

```
frr defaults traditional
hostname frr
hostname msk-nabakulin-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
!
interface eth1
 ip address 10.0.2.2/24
 ipv6 address 2001:2::2/64
exit
!
interface eth2
 ip address 10.0.3.1/24
 ipv6 address 2001:3::1/64
exit
!
end
msk-nabakulin-gw-03#
```

msk-nabakulin-gw-04 - PuTTY

```
% Not all daemons are up, cannot write config.
msk-nabakulin-gw-04# show running-config
Building configuration...

Current configuration:
!
frr version 8.1
frr defaults traditional
hostname frr
hostname msk-nabakulin-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-nabakulin-gw-04#
```

Рисунок 5

1.10. На маршрутизаторах настройте RIP в качестве протокола динамической маршрутизации

msk-nabakulin-gw-01 - PuTTY

```
msk-nabakulin-gw-01# show ip route rip
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

R>* 10.0.2.0/24 [120/2] via 10.0.1.2, eth1, weight 1, 00:04:15
R>* 10.0.3.0/24 [120/2] via 10.0.4.1, eth2, weight 1, 00:03:08
R>* 10.0.11.0/24 [120/3] via 10.0.1.2, eth1, weight 1, 00:04:10
msk-nabakulin-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 02:55
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 02:55
msk-nabakulin-gw-01# show ip rip status
Routing Protocol is "rip"
  Sending updates every 30 seconds with +/-50%, next due in 6 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
    eth1             2     2
    eth2             2     2
  Routing for Networks:
    eth0
    eth1
    eth2
  Routing Information Sources:
    Gateway          BadPackets BadRoutes  Distance Last Update
    10.0.1.2                 0         0       120   00:00:21
    10.0.4.1                 0         0       120   00:00:13
  Distance: (default is 120)
msk-nabakulin-gw-01#
```

msk-nabakulin-gw-02 - PuTTY

```
R(n) 10.0.11.0/24       10.0.2.2              2 10.0.2.2          0 02:59
msk-nabakulin-gw-02# show ip route rip
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

R>* 10.0.3.0/24 [120/2] via 10.0.2.2, eth1, weight 1, 00:04:17
R>* 10.0.4.0/24 [120/2] via 10.0.1.1, eth0, weight 1, 00:04:19
R>* 10.0.10.0/24 [120/2] via 10.0.1.1, eth0, weight 1, 00:04:19
R>* 10.0.11.0/24 [120/2] via 10.0.2.2, eth1, weight 1, 00:04:17
msk-nabakulin-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 02:56
R(n) 10.0.4.0/24        10.0.1.1              2 10.0.1.1          0 02:51
R(n) 10.0.10.0/24       10.0.1.1              2 10.0.1.1          0 02:51
R(n) 10.0.11.0/24       10.0.2.2              2 10.0.2.2          0 02:56
msk-nabakulin-gw-02# 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
    eth0             2     2
    eth1             2     2
  Routing for Networks:
    eth0
    eth1
  Routing Information Sources:
    Gateway          BadPackets BadRoutes  Distance Last Update
    10.0.1.1                 0         0       120   00:00:25
    10.0.2.2                 0         0       120   00:00:20
  Distance: (default is 120)
msk-nabakulin-gw-02#
```

Рисунок 6

```
msk-nabakulin-gw-03 - PuTTY
msk-nabakulin-gw-03# show ip route rip
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

R>* 10.0.1.0/24 [120/2] via 10.0.2.1, eth1, weight 1, 00:04:00
R>* 10.0.4.0/24 [120/2] via 10.0.3.2, eth2, weight 1, 00:03:11
R>* 10.0.10.0/24 [120/3] via 10.0.2.1, eth1, weight 1, 00:04:19
msk-nabakulin-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 02:51
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 02:59
R(n) 10.0.10.0/24       10.0.2.1              3 10.0.2.1          0 02:51
C(i) 10.0.11.0/24       0.0.0.0               1 self              0
msk-nabakulin-gw-03# show ip rip status
Routing Protocol is "rip"
  Sending updates every 30 seconds with +/-50%, next due in 11 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
    eth1             2     2
    eth2             2     2
  Routing for Networks:
    eth0
    eth1
    eth2
  Routing Information Sources:
    Gateway          BadPackets BadRoutes  Distance Last Update
    10.0.2.1                 0         0       120   00:00:25
    10.0.3.2                 0         0       120   00:00:17
  Distance: (default is 120)
msk-nabakulin-gw-03#
```

```
msk-nabakulin-gw-04 - PuTTY
msk-nabakulin-gw-04# show ip route rip
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

R>* 10.0.1.0/24 [120/2] via 10.0.4.2, eth1, weight 1, 00:03:13
R>* 10.0.2.0/24 [120/2] via 10.0.3.1, eth0, weight 1, 00:03:13
R>* 10.0.10.0/24 [120/2] via 10.0.4.2, eth1, weight 1, 00:03:13
R>* 10.0.11.0/24 [120/2] via 10.0.3.1, eth0, weight 1, 00:03:13
msk-nabakulin-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 02:47
R(n) 10.0.2.0/24        10.0.3.1              2 10.0.3.1          0 02:52
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 02:47
R(n) 10.0.11.0/24       10.0.3.1              2 10.0.3.1          0 02:52
msk-nabakulin-gw-04# 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
    eth0             2     2
    eth1             2     2
  Routing for Networks:
    eth0
    eth1
    eth2
  Routing Information Sources:
    Gateway          BadPackets BadRoutes  Distance Last Update
    10.0.3.1                 0         0       120   00:00:25
    10.0.4.2                 0         0       120   00:00:30
  Distance: (default is 120)
msk-nabakulin-gw-04#
```

Рисунок 7

1.10.1. С PC1 пропингуйте PC2 и определите путь следования пакетов

1.10.2. Проверьте метрики протокола RIP

```
msk-nabakulin-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 02:33
R(n) 10.0.3.0/24        10.0.4.1              2 10.0.4.1          0 02:37
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 02:33
```

```
VPCS> 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   2.523 ms  0.508 ms  2.447 ms
 2   10.0.1.2   7.904 ms  2.113 ms  1.959 ms
 3   10.0.2.2   8.694 ms  5.058 ms  4.878 ms
 4   10.0.11.10   5.985 ms  5.451 ms  6.143 ms

VPCS>
```

Рисунок 8

1.10.3. Отключите на маршрутизаторе msk-user-gw-02 интерфейс

1.10.4. С PC1 пропингуйте PC2 и определите путь следования пакетов.

1.10.5. Включите на маршрутизаторе msk-user-gw-02 интерфейс

1.10.6. С PC1 пропингуйте PC2 и определите путь следования пакетов

```
VPCS> ping 10.0.11.10 -c 1

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=14.555 ms

VPCS> 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   2.608 ms  0.527 ms  0.817 ms
 2   10.0.4.1   5.788 ms  2.252 ms  2.275 ms
 3   10.0.3.1   9.743 ms  7.021 ms  10.605 ms
 4   10.0.11.10   15.024 ms  6.789 ms  9.118 ms

VPCS> ping 10.0.11.10 -c 1

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=10.881 ms

VPCS> 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   2.526 ms  1.036 ms  0.625 ms
 2   10.0.4.1   4.855 ms  2.247 ms  2.355 ms
 3   10.0.3.1   5.774 ms  5.991 ms  4.723 ms
 4   10.0.11.10   5.410 ms  5.158 ms  4.453 ms
```

Рисунок 9

1.10.7. Посмотрите захваченный на соединениях трафик

153	8635.517006	10.0.10.10	10.0.11.…	ICMP	98	Echo (ping) request id=0x1d78, seq=1/256, ttl=61 (reply in 154)
154	8635.517103	10.0.11.10	10.0.10.…	ICMP	98	Echo (ping) reply id=0x1d78, seq=1/256, ttl=64 (request in 153)
155	8640.585682	0c:4a:45:52…	Private_…	ARP	60	Who has 10.0.11.10? Tell 10.0.11.1
156	8640.586647	Private_66:…	0c:4a:45…	ARP	60	10.0.11.10 is at 00:50:79:66:68:01
157	8647.299796	fe80::e4a:4…	ff02::1	ICMPv6	110	Router Advertisement from 0c:4a:45:52:00:00
158	8649.637056	10.0.10.10	10.0.11.…	TCP	74	37569 → 37570 [SYN] Seq=0 Win=0 Len=0 MSS=1460 TSval=1667135531 TSecr=0 WS=2
159	8649.637142	10.0.11.10	10.0.10.…	TCP	54	[TCP Port numbers reused] 37570 → 37569 [SYN, ACK] Seq=0 Ack=1 Win=0 Len=0
160	8649.642879	10.0.10.10	10.0.11.…	TCP	74	[TCP Retransmission] [TCP Port numbers reused] 37569 → 37570 [SYN] Seq=0 Win=
161	8649.642967	10.0.11.10	10.0.10.…	TCP	54	[TCP Previous segment not captured] [TCP Port numbers reused] 37570 → 37569 [
162	8649.648233	10.0.10.10	10.0.11.…	TCP	74	[TCP Retransmission] [TCP Port numbers reused] 37569 → 37570 [SYN] Seq=0 Win=
163	8649.648322	10.0.11.10	10.0.10.…	TCP	54	[TCP Retransmission] [TCP Port numbers reused] 37570 → 37569 [SYN, ACK] Seq=0

Рисунок 10

1.11. На маршрутизаторах настройте RIPng для сетей IPv6

1.11.1. С PC1 пропингуйте PC2 и определите путь следования пакетов

1.11.2. Проверьте метрики протокола RIPng

```
msk-nabakulin-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::ec2:a4ff:fe31:0       eth1       2    0  02:19
R(n) 2001:3::/64
                fe80::ed7:b8ff:fef5:1       eth2       2    0  02:48
C(i) 2001:4::/64
                ::                          self       1    0
C(i) 2001:10::/64
                ::                          self       1    0
R(n) 2001:11::/64
                fe80::ec2:a4ff:fe31:0       eth1       3    0  02:48
```

```
VPCS>  ping 2001:11::a

2001:11::a icmp6_seq=1 ttl=58 time=10.718 ms
^C
VPCS> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1   2.412 ms  0.520 ms  0.474 ms
 2 2001:1::2   4.979 ms  2.859 ms  2.604 ms
 3 2001:2::2   7.343 ms  5.571 ms  4.128 ms
 4 2001:11::a   5.824 ms  8.039 ms  5.623 ms
```

OSPF.
й маршрутизации,
стандарт и может
SPF поддерживает
ожет обеспечивать

Рисунок 11

1.11.3. Отключите на маршрутизаторе msk-user-gw-02 интерфейс

1.11.4. Проверьте метрики протокола RIPng

1.11.5. С PC1 пропингуйте PC2 и определите путь следования пакетов

```
msk-nabakulin-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::ec2:a4ff:fe31:0       eth1       2    0  02:18
R(n) 2001:3::/64
                fe80::ed7:b8ff:fef5:1       eth2       2    0  02:42
C(i) 2001:4::/64
                ::                          self       1    0
C(i) 2001:10::/64
                ::                          self       1    0
R(n) 2001:11::/64
                fe80::ec2:a4ff:fe31:0       eth1       3    0  02:42
```

```
VPCS>  ping 2001:11::a

2001:11::a icmp6_seq=1 timeout
^C
VPCS> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1   2.724 ms  1.143 ms  0.556 ms
 2   *  *  *
 3 *2001:10::1   109.849 ms (ICMP type:1, code:3, Address unreachable)

VPCS>
```

Рисунок 12

1.11.6. Включите на маршрутизаторе msk-user-gw-02 интерфейс

1.11.7. С PC1 пропингуйте PC2 и определите путь следования пакетов

```
VPCS> ping 2001:11::a -c 1

2001:11::a icmp6_seq=1 ttl=58 time=14.294 ms

VPCS> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1   2.182 ms  3.564 ms  1.437 ms
 2 2001:1::2   2.743 ms  3.943 ms  3.355 ms
 3 2001:2::2   6.325 ms  8.376 ms  6.079 ms
 4 2001:11::a   6.641 ms  5.545 ms  6.155 ms
```

Рисунок 13

1.11.8. Посмотрите захваченный на соединениях трафик

268	9582.660965	2001:10::a	2001:11:…	ICMPv6	118	Echo (ping) request id=0xd07b, seq=1, hop limit=61 (reply in 269)
269	9582.661074	2001:11::a	2001:10:…	ICMPv6	118	Echo (ping) reply id=0xd07b, seq=1, hop limit=61 (request in 268)
270	9585.766068	10.0.11.1	224.0.0.9	RIPv2	146	Response
271	9587.699004	fe80::e4a:4…	2001:11:…	ICMPv6	86	Neighbor Solicitation for 2001:11::a from 0c:4a:45:52:00:00
272	9588.738229	fe80::e4a:4…	2001:11:…	ICMPv6	86	Neighbor Solicitation for 2001:11::a from 0c:4a:45:52:00:00
273	9589.778302	fe80::e4a:4…	2001:11:…	ICMPv6	86	Neighbor Solicitation for 2001:11::a from 0c:4a:45:52:00:00
274	9590.369461	fe80::e4a:4…	ff02::9	RIPng	186	Command Response, Version 1

Рисунок 14

1.12. На маршрутизаторах настройте OSPFv2 для сетей IPv4

1.12.1. С PC1 пропингуйте PC2 и определите путь следования пакетов

1.12.2. Проверьте таблицу маршрутизации протокола OSPFv2

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

Neighbor ID     Pri State           Dead Time Address         Interface
                RXmtL RqstL DBsmL
10.0.2.1          1 Full/Backup       35.518s 10.0.1.2        eth1:10.0.1.1
                  0     0     0
10.0.4.1          1 Full/Backup       36.795s 10.0.4.1        eth2:10.0.4.2
                  0     0     0

msk-nabakulin-gw-01#  show ip ospf route
============ OSPF network routing table ============
N    10.0.1.0/24          [100] area: 0.0.0.0
                          directly attached to eth1
N    10.0.2.0/24          [200] area: 0.0.0.0
                          via 10.0.1.2, eth1
N    10.0.3.0/24          [200] area: 0.0.0.0
                          via 10.0.4.1, eth2
N    10.0.4.0/24          [100] area: 0.0.0.0
                          directly attached to eth2
N    10.0.10.0/24         [100] area: 0.0.0.0
                          directly attached to eth0
N    10.0.11.0/24         [300] area: 0.0.0.0
                          via 10.0.1.2, eth1
                          via 10.0.4.1, eth2

============ OSPF router routing table ============

============ OSPF external routing table ===========
```

```
VPCS> ping 10.0.11.10 -c 1

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=7.425 ms

VPCS> 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   1.694 ms  0.653 ms  0.692 ms
 2   10.0.4.1   5.504 ms  2.800 ms  2.198 ms
 3   10.0.3.1   7.818 ms  10.284 ms  4.279 ms
 4   10.0.11.10   8.047 ms  13.149 ms  16.337 ms

VPCS>
```

Рисунок 15

1.12.3. Отключите на маршрутизаторе msk-user-gw-02 интерфейс

1.12.4. Проверьте таблицу маршрутизации протокола OSPFv2

1.12.5. С PC1 пропингуйте PC2 и определите путь следования пакетов

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

Neighbor ID     Pri State           Dead Time Address         Interface
                RXmtL RqstL DBsmL
10.0.2.1          1 Full/Backup       12.370s 10.0.1.2        eth1:10.0.1.1
                   1     0     0
10.0.4.1          1 Full/Backup       33.644s 10.0.4.1        eth2:10.0.4.2
                   0     0     0

msk-nabakulin-gw-01# show ip ospf route
============ OSPF network routing table ============
N    10.0.1.0/24           [100] area: 0.0.0.0
                           directly attached to eth1
N    10.0.2.0/24           [300] area: 0.0.0.0
                           via 10.0.4.1, eth2
N    10.0.3.0/24           [200] area: 0.0.0.0
                           via 10.0.4.1, eth2
N    10.0.4.0/24           [100] area: 0.0.0.0
                           directly attached to eth2
N    10.0.10.0/24          [100] area: 0.0.0.0
                           directly attached to eth0
N    10.0.11.0/24          [300] area: 0.0.0.0
                           via 10.0.4.1, eth2

============ OSPF router routing table =============

============ OSPF external routing table ===========
```

```
VPCS> ping 10.0.11.10 -c 1

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=17.301 ms

VPCS> 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   2.635 ms  0.490 ms  0.449 ms
 2   10.0.4.1   3.707 ms  3.081 ms  2.996 ms
 3   10.0.3.1   10.645 ms  8.109 ms  8.044 ms
 4   10.0.11.10   7.507 ms  6.489 ms  5.368 ms

VPCS>
```

Рисунок 16

1.12.6. Включите на маршрутизаторе msk-user-gw-02 интерфейс

1.12.7. С PC1 пропингуйте PC2 и определите путь следования пакетов

```
VPCS> ping 10.0.11.10 -c 1

84 bytes from 10.0.11.10 icmp_seq=1 ttl=61 time=14.656 ms

VPCS> 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   3.159 ms  2.322 ms  0.515 ms
 2   10.0.1.2   5.529 ms  2.488 ms  2.355 ms
 3   10.0.2.2   4.675 ms  6.283 ms  7.204 ms
 4   10.0.11.10   7.392 ms  6.836 ms  6.629 ms
```

Рисунок 17

1.13. На маршрутизаторах настройте OSPFv3 для сетей IPv6

1.13.1. С PC1 пропингуйте PC2 и определите путь следования пакетов

1.13.2. Проверьте таблицу маршрутизации протокола OSPFv3

```
msk-nabakulin-gw-01# show ipv6 ospf6 neighbor
Neighbor ID     Pri    DeadTime    State/IfState         Duration I/F[State]
2.2.2.2           1    00:00:30     Full/BDR             00:05:45 eth1[DR]
4.4.4.4           1    00:00:34     Full/BDR             00:00:53 eth2[DR]
msk-nabakulin-gw-01# show ipv6 ospf6 route
*N IA 2001:1::/64                  ::                          eth1 00:05:52
*N IA 2001:2::/64                  fe80::ec2:a4ff:fe31:0       eth1 00:05:05
*N IA 2001:3::/64                  fe80::ed7:b8ff:fef5:1       eth2 00:00:59
*N IA 2001:4::/64                  ::                          eth2 00:01:01
*N IA 2001:10::/64                 ::                          eth0 00:06:32
*N IA 2001:11::/64                 fe80::ec2:a4ff:fe31:0       eth1 00:00:59
                                   fe80::ed7:b8ff:fef5:1       eth2
```

```
VPCS> ping 2001:11::a -c 1

2001:11::a icmp6_seq=1 ttl=58 time=11.389 ms

VPCS> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1   5.200 ms  0.819 ms  5.533 ms
 2 2001:4::1   9.906 ms  5.280 ms  2.922 ms
 3 2001:3::1   6.965 ms  6.993 ms  5.748 ms
 4 2001:11::a   6.494 ms  5.848 ms  5.951 ms
```

Рисунок 18

1.13.3. Отключите на маршрутизаторе msk-user-gw-02 интерфейс

1.13.4. Проверьте таблицу маршрутизации протокола OSPFv3

1.13.5. С PC1 пропингуйте PC2 и определите путь следования пакетов

```
msk-nabakulin-gw-01# show ipv6 ospf6 route
*N IA 2001:1::/64                  ::                          eth1 00:07:27
*N IA 2001:2::/64                  fe80::ed7:b8ff:fef5:1       eth2 00:00:23
*N IA 2001:3::/64                  fe80::ed7:b8ff:fef5:1       eth2 00:02:33
*N IA 2001:4::/64                  ::                          eth2 00:02:35
*N IA 2001:10::/64                 ::                          eth0 00:08:06
*N IA 2001:11::/64                 fe80::ed7:b8ff:fef5:1       eth2 00:00:23
msk-nabakulin-gw-01#
```

8.3.2. Построение туннеля IPv6–IPv4

8.3.2.1. Постановка задачи

```
VPCS> ping 2001:11::a -c 1

2001:11::a icmp6_seq=1 ttl=58 time=18.508 ms

VPCS> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1   3.519 ms  0.584 ms  0.690 ms
 2 2001:4::1   4.151 ms  3.713 ms  3.048 ms
 3 2001:3::1   6.213 ms  4.524 ms  9.091 ms
 4 2001:11::a   5.582 ms  7.129 ms  6.605 ms
```

Рисунок 19

1.13.6. Включите на маршрутизаторе msk-user-gw-02 интерфейс

1.13.7. С PC1 пропингуйте PC2 и определите путь следования пакетов

```
VPCS> ping 2001:11::a -c 1

2001:11::a icmp6_seq=1 ttl=58 time=13.319 ms

VPCS> trace 2001:11::a

trace to 2001:11::a, 64 hops max
 1 2001:10::1   0.647 ms  0.581 ms  0.936 ms
 2 2001:4::1   4.381 ms  2.094 ms  2.979 ms
 3 2001:3::1   7.447 ms  9.550 ms  8.694 ms
 4 2001:11::a   6.817 ms  7.685 ms  10.108 ms
```

Рисунок 20

1.13.8. Посмотрите захваченный на соединениях трафик

623	10961.627442	2001:10::a	2001:11:…	ICMPv6	118	Echo (ping) request id=0x3381, seq=1, hop limit=61 (reply in 624)
624	10961.627535	2001:11::a	2001:10:…	ICMPv6	118	Echo (ping) reply id=0x3381, seq=1, hop limit=61 (request in 623)
625	10963.624324	2001:10::a	2001:11:…	UDP	126	61936 → 61937 Len=64
626	10963.624419	2001:11::a	2001:10:…	ICMPv6	174	Destination Unreachable (Port unreachable)[Malformed Packet]
627	10963.632925	2001:10::a	2001:11:…	UDP	126	61936 → 61937 Len=64
628	10963.633039	2001:11::a	2001:10:…	ICMPv6	174	Destination Unreachable (Port unreachable)[Malformed Packet]
629	10963.639972	2001:10::a	2001:11:…	UDP	126	61936 → 61937 Len=64
630	10963.640066	2001:11::a	2001:10:…	ICMPv6	174	Destination Unreachable (Port unreachable)[Malformed Packet]

Рисунок 21

2.

2.1. Создайте новый проект в GNS3

2.2. В рабочем пространстве разместите и соедините устройства в соответствии с топологией

2.3. Измените отображаемые названия устройств

2.4. На соединении между первым и третьим маршрутизаторами подключите анализатор трафика

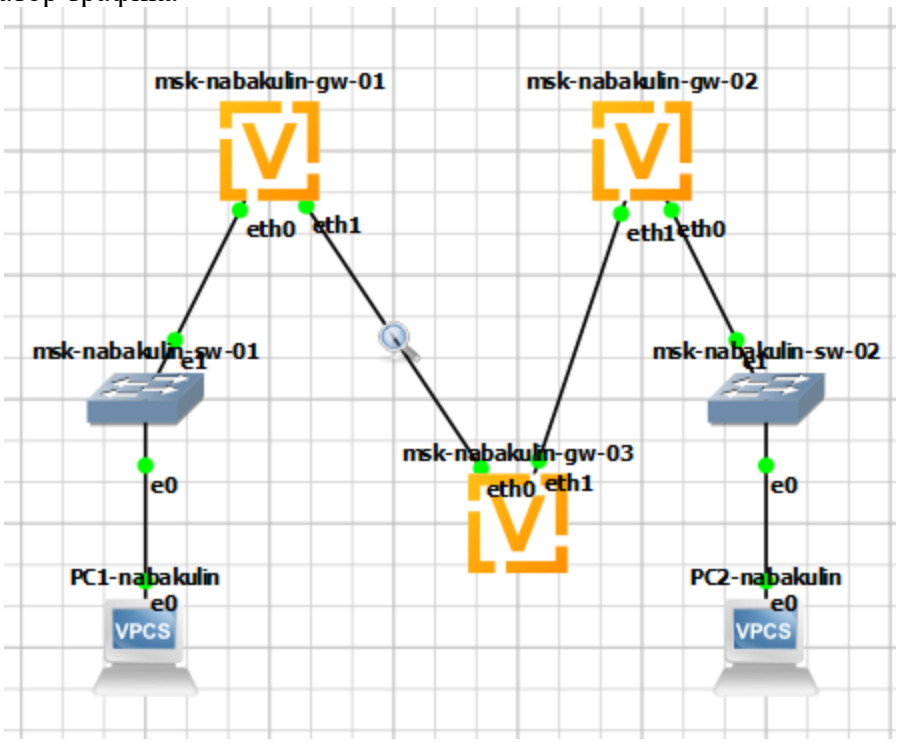

Рисунок 22

2.5. Присвойте адреса оконечным устройствам PC1 и PC2

```
PC1-nabakulin - PuTTY
Executing the startup file

Hostname is too long. (Maximum 12 characters)

VPCS> ip 1000::a/64
PC1 : 1000::a/64

VPCS> save
Saving startup configuration to startup.vpc
.  done

VPCS> show ipv6

NAME              : VPCS[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
```

```
PC2-nabakulin - PuTTY
Executing the startup file

Hostname is too long. (Maximum 12 characters)

VPCS> ip 1002::a/64
PC1 : 1002::a/64

VPCS> save
Saving startup configuration to startup.vpc
.  done

VPCS> show ipv6

NAME              : VPCS[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
```

Рисунок 23

2.6. Установите систему на маршрутизаторы VyOS
2.7. На маршрутизаторах перейдите в режим конфигурирования, измените имя устройства
2.8. Настройте адреса на интерфейсах маршрутизаторов
2.9. Убедитесь, что на PC появились адреса ближайших к ним маршрутизаторов

```
VPCS> show ipv6

NAME              : VPCS[1]
LINK-LOCAL SCOPE  : fe80::250:79ff:fe66:6800/64
GLOBAL SCOPE      : 1000::a/64
DNS               :
ROUTER LINK-LAYER : 0c:4e:82:11:00:00
MAC               : 00:50:79:66:68:00
LPORT             : 20012
RHOST:PORT        : 127.0.0.1:20013
MTU:              : 1500
```

```
VPCS> show ipv6

NAME              : VPCS[1]
LINK-LOCAL SCOPE  : fe80::250:79ff:fe66:6801/64
GLOBAL SCOPE      : 1002::a/64
DNS               :
ROUTER LINK-LAYER : 0c:a6:6a:fb:00:00
MAC               : 00:50:79:66:68:01
LPORT             : 20014
RHOST:PORT        : 127.0.0.1:20015
MTU:              : 1500
```

Рисунок 24

2.10. Проверьте маршруты с маршрутизатора R1

```
vyos@msk-nabakulin-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=1.72 ms
^C
--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.718/1.718/1.718/0.000 ms
vyos@msk-nabakulin-gw-01:~$ ping 20.0.0.1
connect: Network is unreachable
vyos@msk-nabakulin-gw-01:~$ ping 20.0.0.2
```

Рисунок 25

2.11. Настройте маршрутизацию IPv4
2.12. Проверьте маршруты

```
vyos@msk-nabakulin-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=2.02 ms
^C
--- 10.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 2.019/2.019/2.019/0.000 ms
[edit]
vyos@msk-nabakulin-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=2.91 ms
^C
--- 20.0.0.1 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 2.906/2.906/2.906/0.000 ms
[edit]
vyos@msk-nabakulin-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=10.3 ms
^C
--- 20.0.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 10.349/10.349/10.349/0.000 ms
```

Рисунок 26

2.13. Создайте туннель IPv6 через сеть IPv4

```
vyos@msk-nabakulin-gw-01# set interfaces tunnel tun0 encapsulation sit
[edit]
vyos@msk-nabakulin-gw-01# set interfaces tunnel tun0 source-address 10.0.0.1
[edit]
vyos@msk-nabakulin-gw-01# set interfaces tunnel tun0 remote 20.0.0.2
[edit]
vyos@msk-nabakulin-gw-01# set interfaces tunnel tun0 address 1001::1/64
[edit]
vyos@msk-nabakulin-gw-01# commit
[edit]
vyos@msk-nabakulin-gw-01# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-nabakulin-gw-01# set protocols static route6 1002::0/64 next-hop 1001::
2
[edit]
```

```
vyos@msk-nabakulin-gw-02# set interfaces tunnel tun0 encapsulation sit
[edit]
vyos@msk-nabakulin-gw-02# # set interfaces tunnel tun0 source-address 20.0.0.2
[edit]
vyos@msk-nabakulin-gw-02# set interfaces tunnel tun0 source-address 20.0.0.2
[edit]
vyos@msk-nabakulin-gw-02# set interfaces tunnel tun0 remote 10.0.0.1
[edit]
vyos@msk-nabakulin-gw-02# set interfaces tunnel tun0 address 1001::2/64
[edit]
vyos@msk-nabakulin-gw-02# commit
[edit]
vyos@msk-nabakulin-gw-02# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@msk-nabakulin-gw-02# set protocols static route6 1000::0/64 next-hop 1001::
1
```

Рисунок 27

2.14. Настройте статическую маршрутизацию IPv6

2.15. Проверьте доступность оконечных устройств

```
VPCS> ping 1002::a -c 1

1002::a icmp6_seq=1 ttl=60 time=13.422 ms

VPCS> trace 1002::a

trace to 1002::a, 64 hops max
 1 1000::1   0.765 ms  0.293 ms  0.471 ms
 2 1001::2   5.153 ms  3.879 ms  5.486 ms
 3 1002::a   6.375 ms  5.132 ms  5.508 ms
```

```
VPCS>  ping 1000::a -c 1

1000::a icmp6_seq=1 ttl=60 time=7.328 ms

VPCS>  trace 1000::a

trace to 1000::a, 64 hops max
 1 1002::1   0.844 ms  0.484 ms  1.831 ms
 2 1001::1   5.334 ms  5.141 ms  4.028 ms
 3 1000::a   6.607 ms  7.251 ms  5.049 ms
```

Рисунок 28

213	8540.778621	1000::a	1002::a	ICMPv6	138 Echo (ping) request id=0x2dae, seq=1, hop limit=63 (rep
214	8540.782921	1002::a	1000::a	ICMPv6	138 Echo (ping) reply id=0x2dae, seq=1, hop limit=61 (reque
215	8542.062879	1000::a	1002::a	UDP	146 54337 → 54338 Len=64
216	8542.065566	1001::2	1000::a	ICMPv6	194 Time Exceeded (hop limit exceeded in transit)
217	8542.068201	1000::a	1002::a	UDP	146 54337 → 54338 Len=64
218	8542.070440	1001::2	1000::a	ICMPv6	194 Time Exceeded (hop limit exceeded in transit)
219	8542.072897	1000::a	1002::a	UDP	146 54337 → 54338 Len=64
220	8542.076012	1001::2	1000::a	ICMPv6	194 Time Exceeded (hop limit exceeded in transit)
221	8542.079823	1000::a	1002::a	UDP	146 54337 → 54338 Len=64
222	8542.083393	1002::a	1000::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Pa
223	8542.086810	1000::a	1002::a	UDP	146 54337 → 54338 Len=64
224	8542.091715	1002::a	1000::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Pa
225	8542.094514	1000::a	1002::a	UDP	146 54337 → 54338 Len=64
226	8542.100508	1002::a	1000::a	ICMPv6	194 Destination Unreachable (Port unreachable)[Malformed Pa

Рисунок 29