

## Лабораторная работа № 11

**Тема:** Сетевые сервисы на Linux. Роутер на Linux.

**Цель работы:** Создать и настроить маршрутизатор на базе операционной системы Linux.

**Необходимое оборудование и программное обеспечение:** Виртуальные машины под управлением Linux (CentOS, Ubuntu или др.).

### Пример настройки серверов.

Тестовый стенд состоит из трех виртуальных машин на Centos 7.

#### R1:

Nic1 – NAT (что бы был доступ в Интернет)

Nic2 – внутренняя сеть (lan1) 192.168.13.1/24

Lo – loopback 1.1.1.1/32

#### R2:

Nic1 – NAT (что бы был доступ в Интернет)

Nic2 – внутренняя сеть (lan1) 192.168.13.2/24

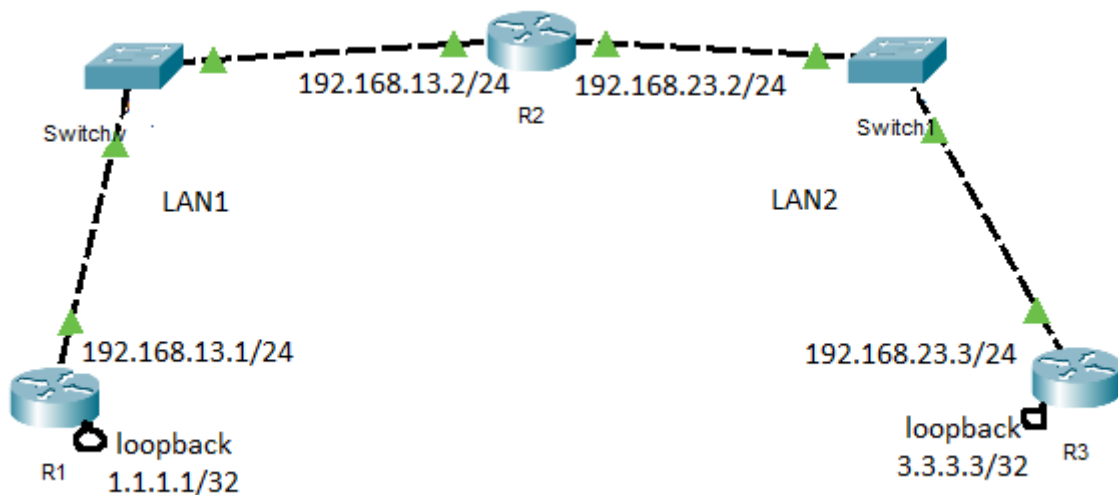
Nic3 – внутренняя сеть (lan2) 192.168.23.2/24

#### R3:

Nic1 – NAT (что бы был доступ в Интернет)

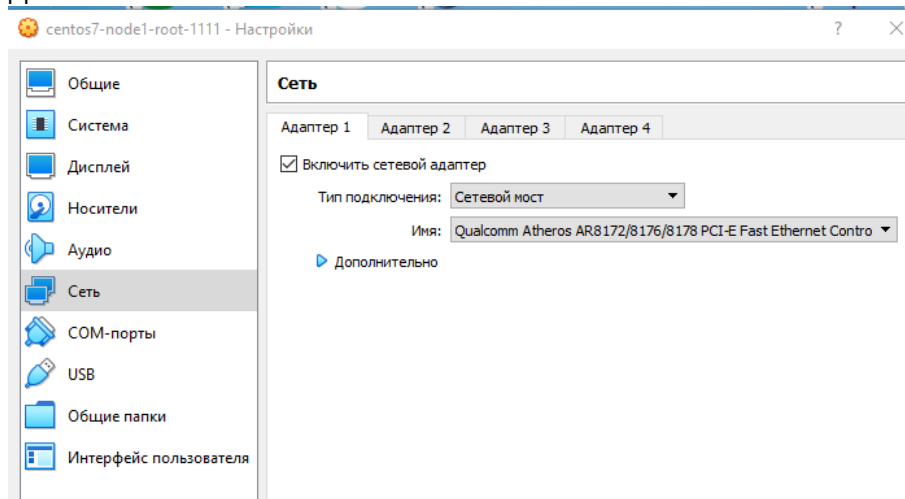
Nic2 – внутренняя сеть (lan2) 192.168.23.3/24

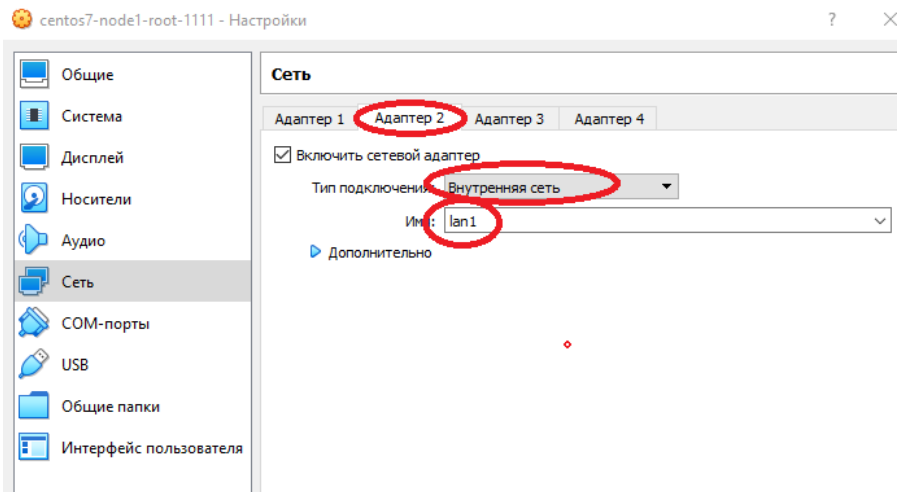
Lo – loopback 3.3.3.3/32



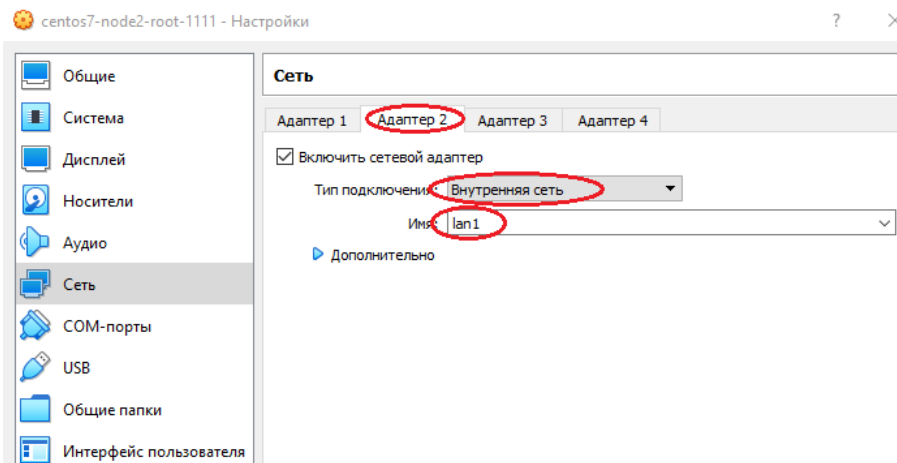
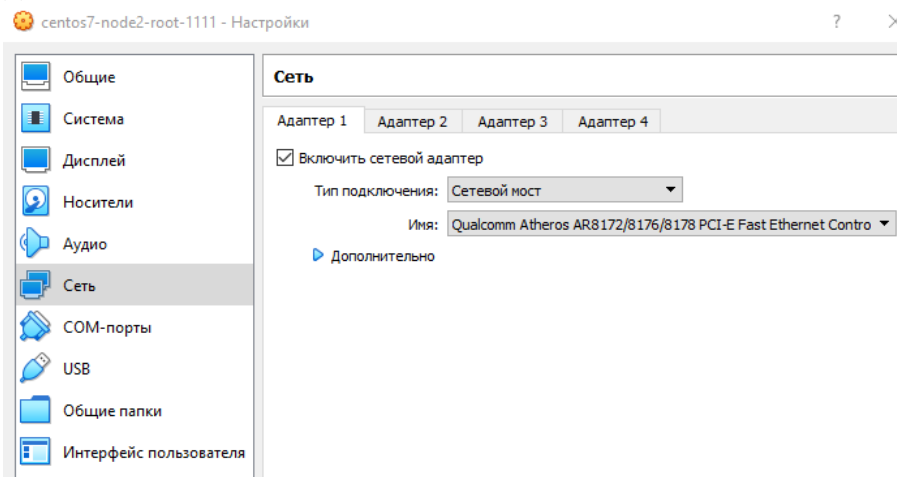
Настройка сетевых адаптеров в Virtual Box.

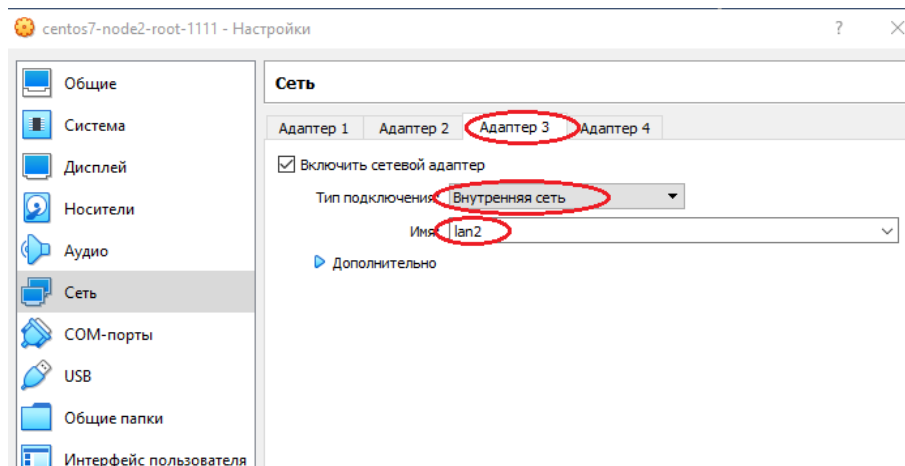
Для R1:



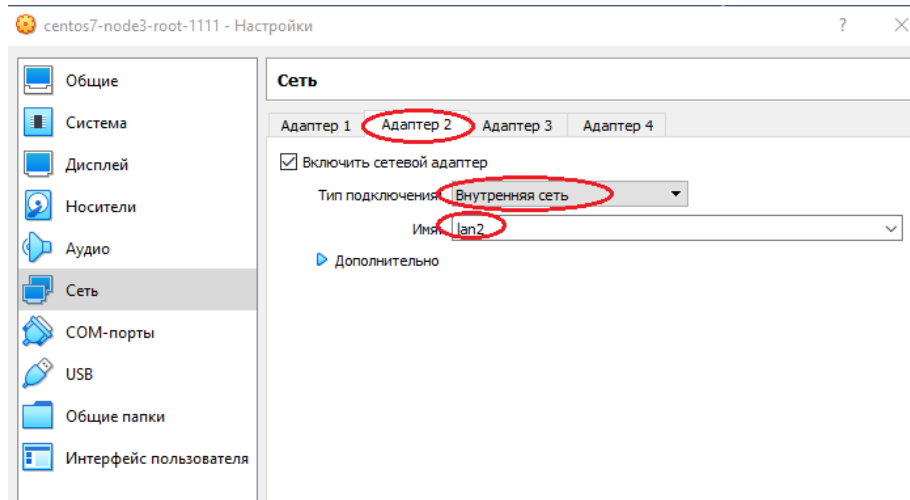
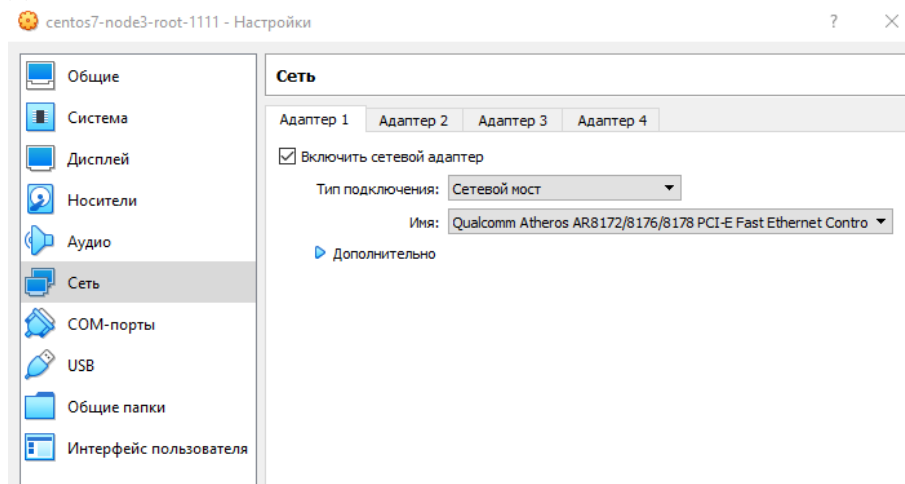


Для R2:





Для R3:



Для R1:

Для удобства нужно задать имена серверов с помощью команды:

```
# hostnamectl set-hostname r1
```

Настройка сетевых интерфейсов:

```
[root@r1 ~]# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:0b:5e:bd brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.158/24 brd 192.168.1.255 scope global noprefixroute dynamic enp0s3
        valid_lft 84836sec preferred_lft 84836sec
    inet6 fe80::eda2:beld:1730:52c7:64 scope link noprefixroute
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:e6:5d:4f brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fe7:fc22:a680:3404/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
[root@r1 ~]#
```

Конфигурационные файлы интерфейсов находятся в папке:

**/etc/sysconfig/network-scripts/**

Создадим и отредактируем конф. файл для интерфейса **enp0s8**:

```
[root@r1 ~]# nano /etc/sysconfig/network-scripts/ifcfg-enp0s8
```

```
DEVICE=enp0s8
BOOTPROTO=static
IPADDR=192.168.13.1
NETMASK=255.255.255.0
ONBOOT=yes
NM_CONTROLLED=yes
```

```
GNU nano 2.3.1 File: /etc/sysconfig/network-scripts/ifcfg-enp0s8
DEVICE=enp0s8
BOOTPROTO=static
IPADDR=192.168.13.1
NETMASK=255.255.255.0
ONBOOT=yes
NM_CONTROLLED=yes
```

Перезапустим сетевую службу:

```
[root@r1 ~]# systemctl restart NetworkManager
```

Проверяем:

```
[root@r1 ~]# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:0b:5e:bd brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.158/24 brd 192.168.1.255 scope global noprefixroute dynamic enp0s3
        valid_lft 86399sec preferred_lft 86399sec
    inet6 fe80::eda2:beld:1730:52c7:64 scope link noprefixroute
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:e6:5d:4f brd ff:ff:ff:ff:ff:ff
    inet 192.168.13.1/24 brd 192.168.13.255 scope global noprefixroute enp0s8
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fee6:5d4f/64 scope link
        valid_lft forever preferred_lft forever
[root@r1 ~]#
```

Настроим loopback:

```
[root@r1 ~]# ip link add dummy0 type dummy
[root@r1 ~]# ip addr add 1.1.1.1/32 dev dummy0
[root@r1 ~]# ip link set dummy0 up
[root@r1 ~]# ip a s dummy0
4: dummy0: <BROADCAST,NOARP,UP,LOWER_UP> mtu 1500 qdisc noqueue state
    1000
    link/ether 3a:64:e6:11:39:dc brd ff:ff:ff:ff:ff:ff
    inet 1.1.1.1/32 scope global dummy0
        valid_lft forever preferred_lft forever
    inet6 fe80::3864:e6ff:fe11:39dc/64 scope link
        valid_lft forever preferred_lft forever
[root@r1 ~]#
```

## Аналогично настраиваем R2 ...

```
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:f8:b9:2f brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.233/24 brd 192.168.1.255 scope global noprefixroute dynamic enp0s3
        valid_lft 86312sec preferred_lft 86312sec
    inet6 fe80::eda2:beld:1730:52c7/64 scope link tentative noprefixroute dadfailed
        valid_lft forever preferred_lft forever
    inet6 fe80::cac:f81d:f90c:ee2b/64 scope link tentative noprefixroute dadfailed
        valid_lft forever preferred_lft forever
    inet6 fe80::c9e:dfdc:8a08:1454/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:80:26:76 brd ff:ff:ff:ff:ff:ff
    inet 192.168.13.2/24 brd 192.168.13.255 scope global noprefixroute enp0s8
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fe80:2676/64 scope link
        valid_lft forever preferred_lft forever
4: enp0s9: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:4a:e8:88 brd ff:ff:ff:ff:ff:ff
    inet 192.168.23.2/24 brd 192.168.23.255 scope global noprefixroute enp0s9
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fe4a:e888/64 scope link
        valid_lft forever preferred_lft forever
5: dummy0: <BROADCAST,NOARP,UP,LOWER_UP> mtu 1500 qdisc noqueue state UNKNOWN group default qlen 1000
    link/ether 52:f8:d7:f0:96:3f brd ff:ff:ff:ff:ff:ff
    inet 2.2.2.2/32 scope global dummy0
        valid_lft forever preferred_lft forever
    inet6 fe80::50f8:d7ff:fe0:963f/64 scope link
        valid_lft forever preferred_lft forever
[root@r2 ~]#
```

## ... и R3:

```
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default
    qlen 1000
    link/ether 08:00:27:99:ff:71 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.242/24 brd 192.168.1.255 scope global noprefixroute dynamic enp0s3
        valid_lft 86396sec preferred_lft 86396sec
    inet6 fe80::eda2:beld:1730:52c7/64 scope link tentative noprefixroute dadfailed
        valid_lft forever preferred_lft forever
    inet6 fe80::cac:f81d:f90c:ee2b/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default
    qlen 1000
    link/ether 08:00:27:59:e5:2f brd ff:ff:ff:ff:ff:ff
    inet 192.168.23.3/24 brd 192.168.23.255 scope global noprefixroute enp0s8
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fe59:e52f/64 scope link
        valid_lft forever preferred_lft forever
4: dummy0: <BROADCAST,NOARP,UP,LOWER_UP> mtu 1500 qdisc noqueue state UNKNOWN group default q
    len 1000
    link/ether ba:85:72:0d:0c:8c brd ff:ff:ff:ff:ff:ff
    inet 3.3.3.3/32 scope global dummy0
        valid_lft forever preferred_lft forever
    inet6 fe80::b885:72ff:fe0d:c8c/64 scope link
        valid_lft forever preferred_lft forever
```

Проверим связь:

R1 => R2:

```
[root@r1 ~]# ping 192.168.13.2
PING 192.168.13.2 (192.168.13.2) 56(84) bytes of data.
64 bytes from 192.168.13.2: icmp_seq=1 ttl=64 time=4.31 ms
64 bytes from 192.168.13.2: icmp_seq=2 ttl=64 time=2.94 ms
64 bytes from 192.168.13.2: icmp_seq=3 ttl=64 time=3.37 ms
```

R2 => R3:

```
[root@r2 ~]# ping 192.168.23.3
PING 192.168.23.3 (192.168.23.3) 56(84) bytes of data.
64 bytes from 192.168.23.3: icmp_seq=1 ttl=64 time=4.13 ms
64 bytes from 192.168.23.3: icmp_seq=2 ttl=64 time=9.91 ms
64 bytes from 192.168.23.3: icmp_seq=3 ttl=64 time=4.07 ms
```

R1 => R3: (связь отсутствует, это нормально, т.к. маршрутизация не настроена)

```
[root@r1 ~]# ping 192.168.23.2
PING 192.168.23.2 (192.168.23.2) 56(84) bytes of data.
```

## Настройка маршрутизации.

Для R1:

Включаем маршрутизацию в ядре.

Создадим файл `/etc/sysctl.d/90-routing-sysctl.conf` и пропишем в нем значения `net.ipv4.conf.all.forwarding=1` и `net.ipv6.conf.all.forwarding=1`

- 0: Отключает пересылку IPv4 пакетов.
- 1: Включает пересылку IPv4 пакетов (аналогично IPv6).
- 2: Включает пересылку IPv4 пакетов и разрешает отправку, если это не нарушает политику фильтрации пакетов.

Затем применим настройки ядра командой:

**`sysctl -p /etc/sysctl.d/90-routing-sysctl.conf`**

И перезапустим сетевую службу:

**`systemctl restart NetworkManager`**

```
[root@r1 ~]# nano /etc/sysctl.d/90-routing-sysctl.conf
```

```
GNU nano 2.3.1 File: /etc/sysctl.d/90-routing-sysctl.conf
net.ipv4.conf.all.forwarding=1
net.ipv6.conf.all.forwarding=1
```

```
[root@r1 ~]# sysctl -p /etc/sysctl.d/90-routing-sysctl.conf
net.ipv4.conf.all.forwarding = 1
net.ipv6.conf.all.forwarding = 1
```

```
[root@r1 ~]# systemctl restart NetworkManager
```

Устанавливаем frr:

Вариант 1:

`FRRVER="frr-stable"`

`curl -O https://rpm.frrouting.org/repo/$FRRVER-repo-1-0.el7.noarch.rpm`

`sudo yum install ./FRRVER*`

```
sudo yum install frr
```

Вариант 2:

```
sudo yum install epel-release
sudo yum install snapd
sudo systemctl enable --now snapd.socket
sudo ln -s /var/lib/snapd/snap /snap
sudo snap install frr
```

Вариант 3 (Centos 9):

**dnf install frr**

Используем 1-й вариант:

```
[root@r1 ~]# yum install -y https://github.com/FRRouting/frr/releases/download/frr-5.0.1/frr-5.0.1-2018070501.el7.centos.x86_64.rpm
```

```
Installed:
  frr.x86_64 0:5.0.1-2018070501.el7.centos

Dependency Installed:
  c-ares.x86_64 0:1.10.0-3.el7_9.1

Complete!
[root@r1 ~]#
```

Проверяем:

```
[root@r1 ~]# systemctl status frr
● frr.service - FRRouting (FRR)
   Loaded: loaded (/usr/lib/systemd/system/frr.service; disabled; vendor preset: disabled)
   Active: inactive (dead)
[root@r1 ~]#
```

Включение нужных протоколов маршрутизации:

```
[root@r1 ~]# nano /etc/frr/daemons
```

```
GNU nano 2.3.1      File: /etc/frr/daemons

#
# When activation a daemon at the first time, a config file, even if it is
# empty, has to be present *and* be owned by the user and group "frr", else
# the daemon will not be started by /usr/lib/frr/frr. The permissions should
# be u=rw,g=r,o=.
# When using "vtysh" such a config file is also needed. It should be owned by
# group "frrvty" and set to ug=rw,o= though. Check /etc/pam.d/frr, too.
#
watchfrr_enable=yes
watchfrr_options=(-b_ "-r/usr/lib/frr/frr_restart_%s" "-s/usr/lib/frr/frr_start_%s"
#
zebra=yes
bgpd=no
ospfd=yes
ospf6d=yes
ripd=no
ripngd=no
isisd=no
ldpd=no
pimd=no
nhrrpd=no
```

Запускаем и проверяем:

```
[root@r1 ~]# systemctl start frr
[root@r1 ~]# systemctl status frr
● frr.service - FRRouting (FRR)
   Loaded: loaded (/usr/lib/systemd/system/frr.service; disabled; vendor preset: disabled)
   Active: active (running) since Mon 2024-03-04 09:29:11 EST; 5s ago
   Process: 12941 ExecStart=/usr/lib/frr/frr start (code=exited, status=0/SUCCESS)
   CGroup: /system.slice/frr.service
           └─12959 /usr/lib/frr/zebra -d -A 127.0.0.1
             └─12968 /usr/lib/frr/ospfd -d -A 127.0.0.1
               └─12977 /usr/lib/frr/ospf6d -d -A ::1
                 └─12987 /usr/lib/frr/watchfrr -d -b_ -r/usr/lib/frr/frr_restart_%s -s/usr/lib/frr/...

Mar 04 09:29:10 r1 frr[12941]: ospfd [ OK ]
Mar 04 09:29:10 r1 frr[12941]: ospf6d [ OK ]
Mar 04 09:29:10 r1 frr[12941]: Starting FRRouting monitor daemon:
Mar 04 09:29:10 r1 watchfrr[12987]: watchfrr 5.0.1 watching [zebra ospfd ospf6d]
Mar 04 09:29:11 r1 watchfrr[12987]: ospfd state -> up : connect succeeded
Mar 04 09:29:11 r1 watchfrr[12987]: ospf6d state -> up : connect succeeded
Mar 04 09:29:11 r1 watchfrr[12987]: zebra state -> up : connect succeeded
Mar 04 09:29:11 r1 watchfrr[12987]: Watchfrr: Notifying Systemd we are up and running
Mar 04 09:29:11 r1 frr[12941]: watchfrr[ OK ]
Mar 04 09:29:11 r1 systemd[1]: Started FRRouting (FRR).
[root@r1 ~]#
```

разрешим в firewalld OSPF-трафик:

```
[root@r1 ~]# firewall-cmd --add-protocol=ospf --permanent --zone=public
success
[root@r1 ~]# firewall-cmd --add-protocol=ospf --zone=public
success
[root@r1 ~]#
```

Аналогичные действия выполняем на хостах R2 и R3.

### Настройка роутера:

```
[root@r1 ~]# vtysh

Hello, this is FRRouting (version 5.0.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

r1# conf t
r1(config-router)# router ospf
r1(config-router)# network 192.168.13.0/24 area 0
r1(config-router)# network 1.1.1.1/32 area 0
r1(config-router)# exit
r1(config)# exit
r1# wr
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Configuration saved to /etc/frr/zebra.conf
Configuration saved to /etc/frr/ospfd.conf
Configuration saved to /etc/frr/ospf6d.conf
r1# exit
[root@r1 ~]#
```

Для второго хоста:



```
[root@r2 ~]# vtysh

Hello, this is FRRouting (version 5.0.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

r2# conf t
r2(config)# router ospf
r2(config-router)# network 192.168.13.0/24 area 0
r2(config-router)# network 192.168.23.0/24 area 0
r2(config-router)# exit
r2(config)# exit
r2# wr
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Configuration saved to /etc/frr/zebra.conf
Configuration saved to /etc/frr/ospfd.conf
Configuration saved to /etc/frr/ospf6d.conf
r2# exit
[root@r2 ~]#
```

Для третьего хоста:

```
[root@r3 ~]# vtysh

Hello, this is FRRouting (version 5.0.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

r3# conf t
r3(config)# router ospf
r3(config-router)# network 192.168.23.0/24 area 0
r3(config-router)# network 3.3.3.3/32 area 0
r3(config-router)# exit
r3(config)# exit
r3# wr
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Configuration saved to /etc/frr/zebra.conf
Configuration saved to /etc/frr/ospfd.conf
Configuration saved to /etc/frr/ospf6d.conf
r3# exit
[root@r3 ~]#
```

Проверяем:

Маршруты добавились:

```
[root@r1 ~]# vtysh

Hello, this is FRRouting (version 5.0.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

r1# show ip route
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, D - SHARP,
       F - PBR,
       > - selected route, * - FIB route

K>* 0.0.0.0/0 [0/100] via 192.168.1.1, enp0s3, 00:25:33
O  1.1.1.1/32 [110/10] via 0.0.0.0, dummy0 onlink, 00:10:53
C>* 1.1.1.1/32 is directly connected, dummy0, 00:25:33
O>* 3.3.3.3/32 [110/210] via 192.168.13.2, enp0s8, 00:02:38
C>* 192.168.1.0/24 is directly connected, enp0s3, 00:25:33
O  192.168.13.0/24 [110/100] is directly connected, enp0s8, 00:11:07
C>* 192.168.13.0/24 is directly connected, enp0s8, 00:25:33
O>* 192.168.23.0/24 [110/200] via 192.168.13.2, enp0s8, 00:04:27
r1#
```

Пингуем:

```
√C
eq pldes row 3.3.3.3: icmp_seq=3 ttl=63 time=4.03 ms
eq pldes row 3.3.3.3: icmp_seq=5 ttl=63 time=3.23 ms
eq pldes row 3.3.3.3: icmp_seq=7 ttl=63 time=4.04 ms
БИС 3.3.3.3 (3.3.3.3) de(84) pldes of 844.
[rooft@r1 ~]# ping 3.3.3.3
```

Трассируем:

```
[root@r1 ~]# mtr 3.3.3.3
```

```
My traceroute  [v0.85]
r1 (0.0.0.0) Mon Mar 4 09:58:45 2024
Keys:  Help  Display mode  Restart statistics  Order of fields  quit
      Packets
Host    Loss%  Snt   Last   Avg    Best  Wrst StDev
1. 192.168.13.2  0.0%   7    3.7    3.2    2.1   4.0   0.6
2. 3.3.3.3      0.0%   6    3.8    4.1    3.8   4.4   0.0
```

```
[root@r1 ~]# mtr 192.168.23.3
```

```
My traceroute  [v0.85]
r1 (0.0.0.0) Mon Mar 4 10:18:01 2024
Keys:  Help  Display mode  Restart statistics  Order of fields  quit
      Packets
Host    Loss%  Snt   Last   Avg    Best  Wrst StDev
1. 192.168.13.2  0.0%   9    3.8    2.9    2.3   3.8   0.0
2. 192.168.23.3  0.0%   9    3.7    3.8    3.3   4.5   0.0
```

Задание:

- 1. Подготовить лабораторный стенд. Установить операционную систему Centos 7 (Centos 9, Fedora, Ubuntu) на виртуальных машинах. Настроить сетевые адаптеры в Virtual Box.
- 2. Настроить сетевые интерфейсы. Присвоить IP-адреса сетевым интерфейсам каждой виртуальной машины, согласно своему варианту. Настроить лупбэки.
- 3. Активация IP-маршрутизации. Включить IP-маршрутизацию на серверах с помощью настройки ядра и/или использования утилиты sysctl.
- 4. Настроить протоколы динамической маршрутизации (например, OSPF).
- 5. Настроить межсетевой экран для фильтрации трафика и обеспечения безопасности сети.
- 6. Проверить работоспособность маршрутов с помощью команд, таких как ping, traceroute.
- 7. Сделать выводы и составить отчет.

№ варианта	LAN 1	LAN 2
1	192.168.10.0/24	192.168.20.0/24
2	192.168.30.0/24	192.168.40.0/24
3	192.168.50.0/24	192.168.60.0/24
4	192.168.70.0/24	192.168.80.0/24
5	192.168.100.0/24	192.168.110.0/24
6	192.168.120.0/24	192.168.130.0/24
7	192.168.140.0/24	192.168.150.0/24
8	192.168.200.0/24	192.168.210.0/24
9	192.168.220.0/24	192.168.230.0/24
10	192.168.240.0/24	192.168.250.0/24
11	192.168.10.0/24	192.168.20.0/24
12	192.168.30.0/24	192.168.40.0/24
13	192.168.50.0/24	192.168.60.0/24
14	192.168.70.0/24	192.168.80.0/24
15	192.168.100.0/24	192.168.110.0/24
16	192.168.120.0/24	192.168.130.0/24
17	192.168.140.0/24	192.168.150.0/24
18	192.168.200.0/24	192.168.210.0/24
19	192.168.220.0/24	192.168.230.0/24
20	192.168.240.0/24	192.168.250.0/24