МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

Федеральное государственное автономное образовательное учреждение высшего образования

Санкт-Петербургский национальный исследовательский университет ИТМО

Мегафакультет трансляционных информационных технологий

Факультет информационных технологий и программирования

Практическая работа №5. Маршрутизация в IP сетях

По дисциплине «Телекоммуникационные системы и технологии»

Выполнил:

студент группы №M3306

Тимофеев Вячеслав

Проверил:

Самигуллин [redacted]

УНИВЕРСИТЕТ ИТМО

Санкт-Петербург

2025

Цель работы: получить представление о работе IP маршрутизатора; получить опыт в составлении таблиц маршрутизации и работе протоколов внутренней и внешней маршрутизации.

Схема модели:

Настраиваем маршрутизаторы

Router0

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname Router0
Router0(config)#interface fastEthernet 0/0
Router0(config-if)#ip address 192.168.0.1 255.255.255.248
Router0(config-if)#no shutdown
Router0(config-if)#exit
Router0(config)#interface fastEthernet 1/0
Router0(config-if)#ip address 192.168.0.9 255.255.255.248
Router0(config-if)#no shutdown
Router0(config-if)#exit
```

Router1

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname Router1
Router1(config)#interface fastEthernet 0/0
Router1(config-if)#ip address 192.168.0.17 255.255.255.248
Router1(config-if)#no shutdown
Router1(config-if)#exit
Router1(config)#interface fastEthernet 1/0
Router1(config-if)#ip address 192.168.0.10 255.255.255.248
Router1(config-if)#no shutdown
Router1(config-if)#exit
```

Router2

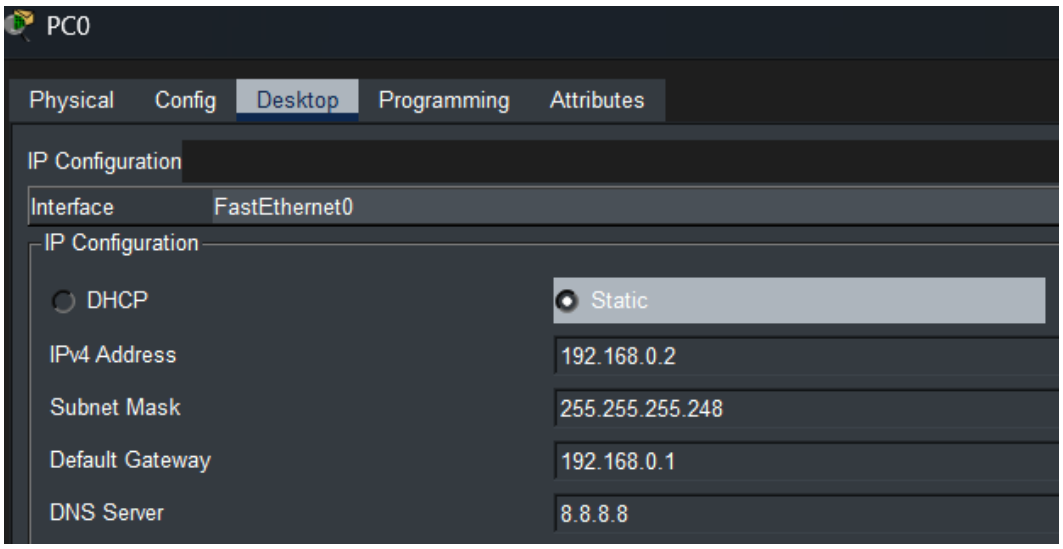
```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname Router2
Router2(config)#interface fastEthernet 0/0
Router2(config-if)#ip address 192.168.0.33 255.255.255.248
Router2(config-if)#no shutdown
Router2(config-if)#exit
Router2(config)#interface fastEthernet 1/0
Router2(config-if)#ip address 192.168.0.18 255.255.255.248
Router2(config-if)#no shutdown
Router2(config-if)#exit
```

Router3

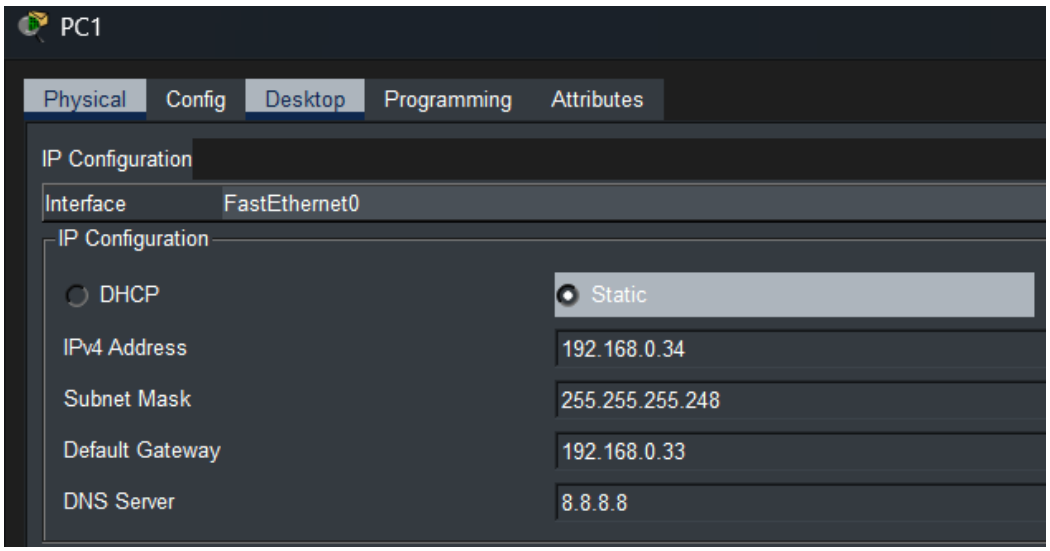
```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname Router3
Router3(config)#interface fastEthernet 0/0
Router3(config-if)#ip address 192.168.0.25 255.255.255.248
Router3(config-if)#no shutdown
Router3(config-if)#exit
Router3(config)#interface fastEthernet 1/0
Router3(config-if)#ip address 192.168.0.19 255.255.255.248
Router3(config-if)#no shutdown
Router3(config-if)#exit
```

Настраиваем компьютеры:

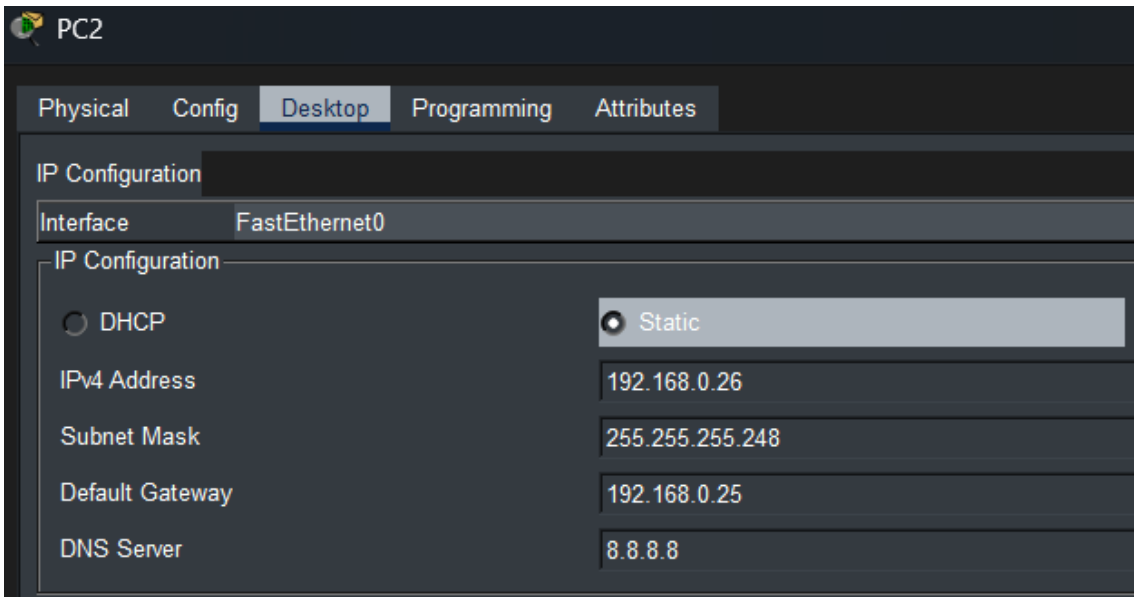
PC0


PC0
Physical
Config
Desktop
Programming
Attributes
IP Configuration
Interface
FastEthernet0
IP Configuration
DHCP
Static
IPv4 Address
192.168.0.2
Subnet Mask
255.255.255.248
Default Gateway
192.168.0.1
DNS Server
8.8.8.8

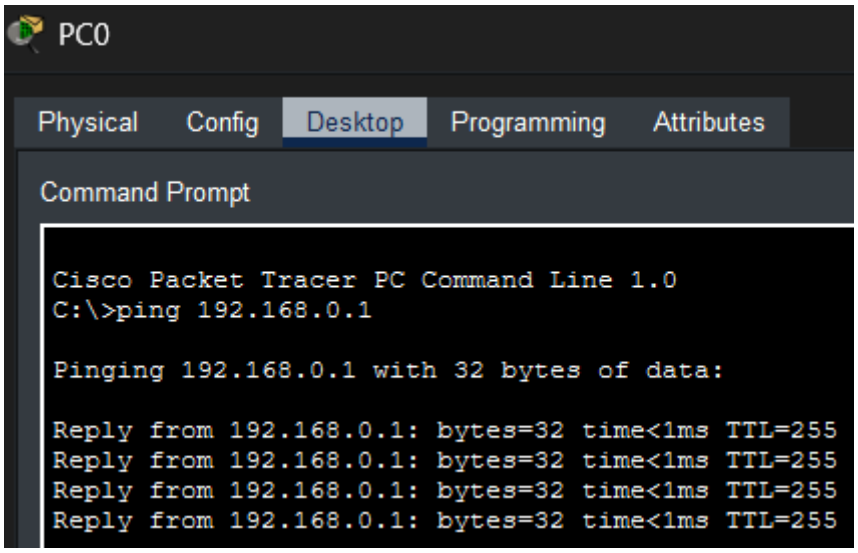
PC1

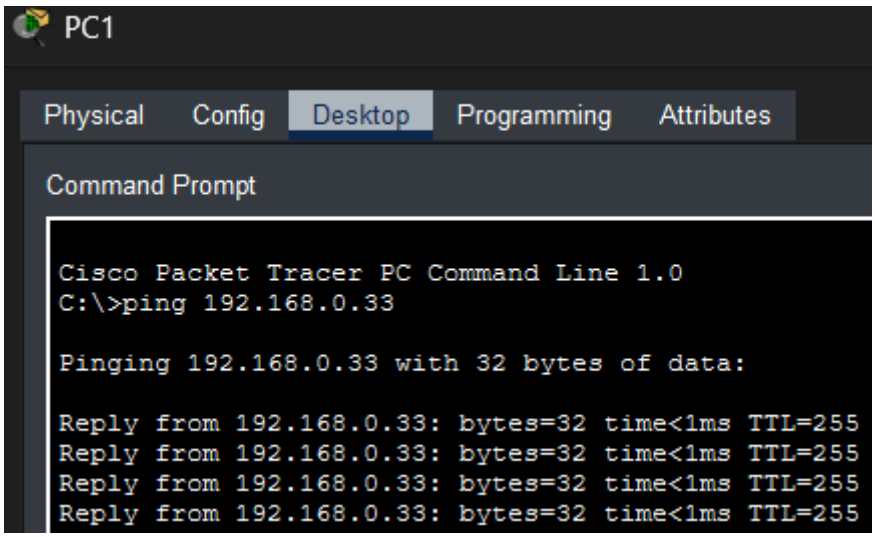

PC1
Physical
Config
Desktop
Programming
Attributes
IP Configuration
Interface
FastEthernet0
IP Configuration
DHCP
Static
IPv4 Address
192.168.0.34
Subnet Mask
255.255.255.248
Default Gateway
192.168.0.33
DNS Server
8.8.8.8

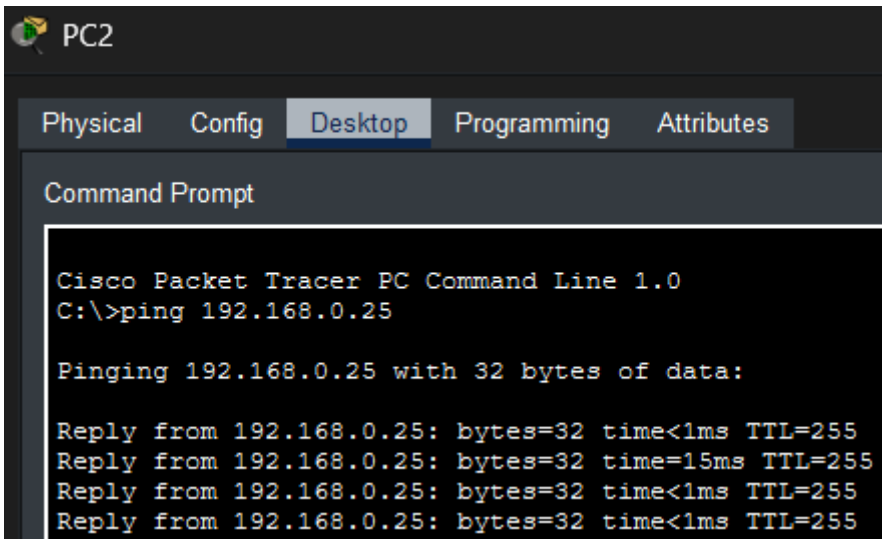
PC2



Проверяем пинг ближайших соседей:







Часть2

Настройка статических маршрутов

Router0

```
Router0>en
Router0#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router0(config)#ip route 192.168.0.16 255.255.255.248 192.168.0.10
Router0(config)#ip route 192.168.0.24 255.255.255.248 192.168.0.10
Router0(config)#ip route 192.168.0.32 255.255.255.248 192.168.0.10
Router0(config)#exit
```

Route1

```
Router1>en
Router1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)#ip route 192.168.0.0 255.255.255.248 192.168.0.9
Router1(config)#ip route 192.168.0.24 255.255.255.248 192.168.0.19
Router1(config)#ip route 192.168.0.32 255.255.255.248 192.168.0.18
Router1(config)#exit
```

Route2

```
Router2>en
Router2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router2(config)#ip route 192.168.0.0 255.255.255.248 192.168.0.17
Router2(config)#ip route 192.168.0.8 255.255.255.248 192.168.0.17
Router2(config)#ip route 192.168.0.24 255.255.255.248 192.168.0.19
Router2(config)#exit
```

Route3

```
Router3>en
Router3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router3(config)#ip route 192.168.0.0 255.255.255.248 192.168.0.17
Router3(config)#ip route 192.168.0.8 255.255.255.248 192.168.0.17
Router3(config)#ip route 192.168.0.32 255.255.255.248 192.168.0.18
Router3(config)#exit
```

Проверка маршрутизации:

Router0

```
     192.168.0.0/29 is subnetted, 5 subnets
C       192.168.0.0 is directly connected, FastEthernet0/0
C       192.168.0.8 is directly connected, FastEthernet1/0
S       192.168.0.16 [1/0] via 192.168.0.10
S       192.168.0.24 [1/0] via 192.168.0.10
S       192.168.0.32 [1/0] via 192.168.0.10
```

Router1

```
     192.168.0.0/29 is subnetted, 5 subnets
S       192.168.0.0 [1/0] via 192.168.0.9
C       192.168.0.8 is directly connected, FastEthernet1/0
C       192.168.0.16 is directly connected, FastEthernet0/0
S       192.168.0.24 [1/0] via 192.168.0.19
S       192.168.0.32 [1/0] via 192.168.0.18
```

Router2

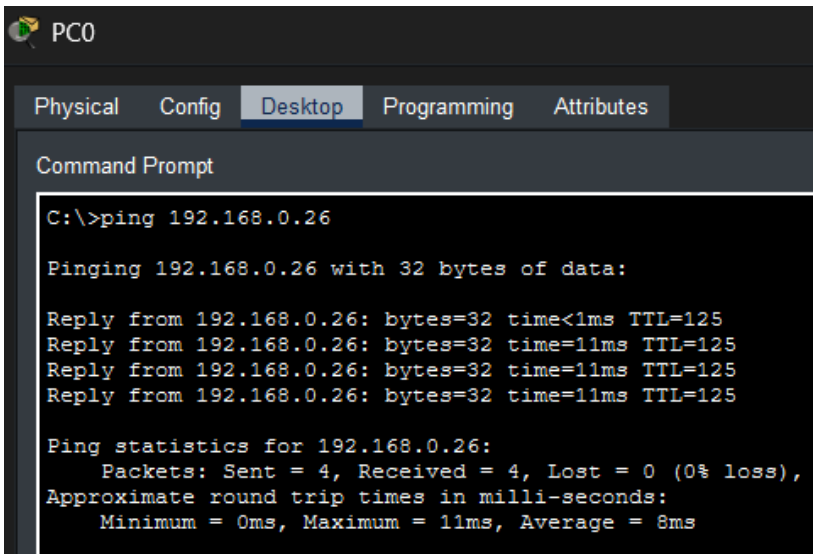
```
     192.168.0.0/29 is subnetted, 5 subnets
S       192.168.0.0 [1/0] via 192.168.0.17
S       192.168.0.8 [1/0] via 192.168.0.17
C       192.168.0.16 is directly connected, FastEthernet1/0
S       192.168.0.24 [1/0] via 192.168.0.19
C       192.168.0.32 is directly connected, FastEthernet0/0
```

Router3

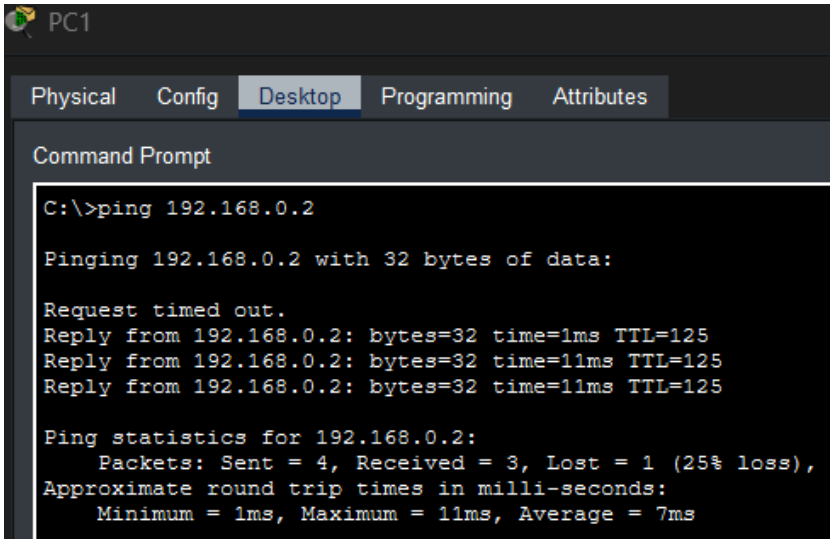
```
     192.168.0.0/29 is subnetted, 5 subnets
S       192.168.0.0 [1/0] via 192.168.0.17
S       192.168.0.8 [1/0] via 192.168.0.17
C       192.168.0.16 is directly connected, FastEthernet1/0
C       192.168.0.24 is directly connected, FastEthernet0/0
S       192.168.0.32 [1/0] via 192.168.0.18
```

Пропингуем PC:

PC0->PC2



PC1->PC0



2.3 Таблицы маршрутизации

```
Router0>en
Router0#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     192.168.0.0/29 is subnetted, 5 subnets
C       192.168.0.0 is directly connected, FastEthernet0/0
C       192.168.0.8 is directly connected, FastEthernet1/0
S       192.168.0.16 [1/0] via 192.168.0.10
S       192.168.0.24 [1/0] via 192.168.0.10
S       192.168.0.32 [1/0] via 192.168.0.10
```

```
Router1>en
Router1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     192.168.0.0/29 is subnetted, 5 subnets
S       192.168.0.0 [1/0] via 192.168.0.9
C       192.168.0.8 is directly connected, FastEthernet1/0
C       192.168.0.16 is directly connected, FastEthernet0/0
S       192.168.0.24 [1/0] via 192.168.0.19
S       192.168.0.32 [1/0] via 192.168.0.18
```

```
Router2>en
Router2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     192.168.0.0/29 is subnetted, 5 subnets
S       192.168.0.0 [1/0] via 192.168.0.17
S       192.168.0.8 [1/0] via 192.168.0.17
C       192.168.0.16 is directly connected, FastEthernet1/0
S       192.168.0.24 [1/0] via 192.168.0.19
C       192.168.0.32 is directly connected, FastEthernet0/0
```

```
Router3>en
Router3#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     192.168.0.0/29 is subnetted, 5 subnets
S       192.168.0.0 [1/0] via 192.168.0.17
S       192.168.0.8 [1/0] via 192.168.0.17
C       192.168.0.16 is directly connected, FastEthernet1/0
C       192.168.0.24 is directly connected, FastEthernet0/0
S       192.168.0.32 [1/0] via 192.168.0.18
```

Часть 3

Router0(1)

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface fastEthernet 0/0
Router(config-if)#ip address 192.168.1.1 255.255.255.248
Router(config-if)#interface fastEthernet 1/0
Router(config-if)#ip address 192.168.1.9 255.255.255.248
Router(config-if)#exit
Router(config)#hotname Router0(1)
                  ^
% Invalid input detected at '^' marker.

Router(config)#hostname Router0(1)
```

Router1(1)

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface fastEthernet 0/0
Router(config-if)#ip address 192.168.1.17 255.255.255.248
Router(config-if)#interface fastEthernet 1/0
Router(config-if)#ip address 192.168.1.10 255.255.255.248
Router(config-if)#hostname Router1(1)
Router1(1)(config)#exit
```

r

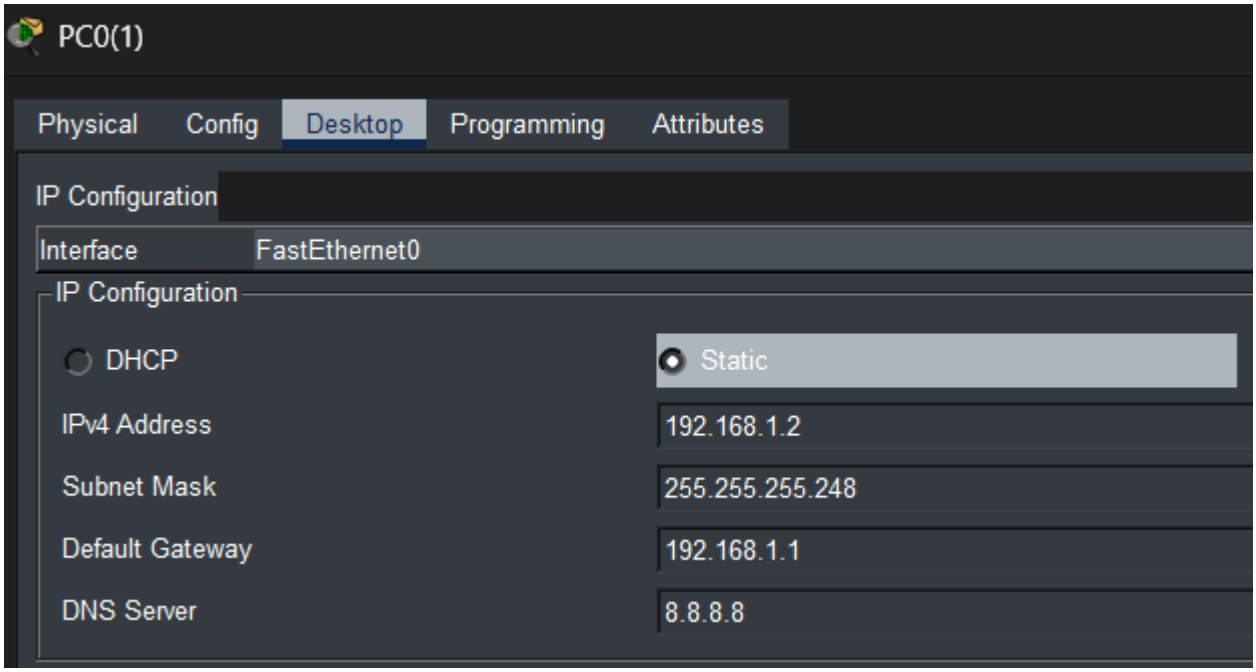
Router2(1)

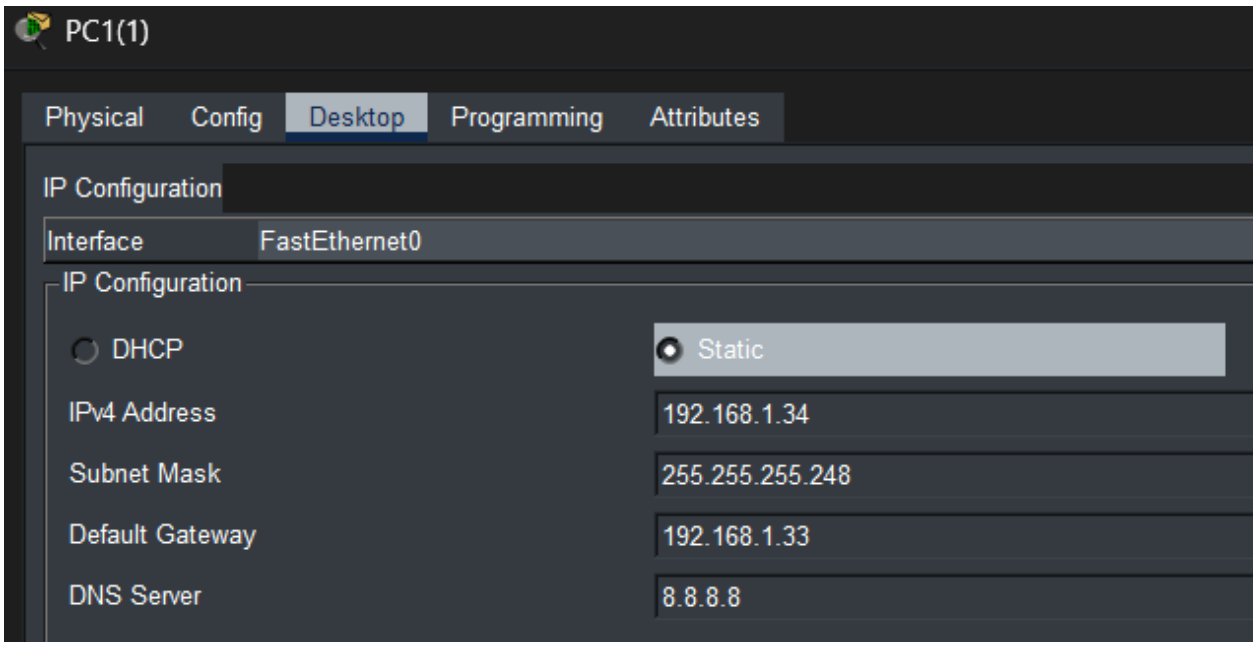
```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname Router2(1)
Router2(1)(config)#interface fastEthernet 0/0
Router2(1)(config-if)#ip address 192.168.1.33 255.255.255.248
Router2(1)(config-if)#interface fastEthernet 1/0
Router2(1)(config-if)#ip address 192.168.1.18 255.255.255.248
Router2(1)(config-if)#exit
```

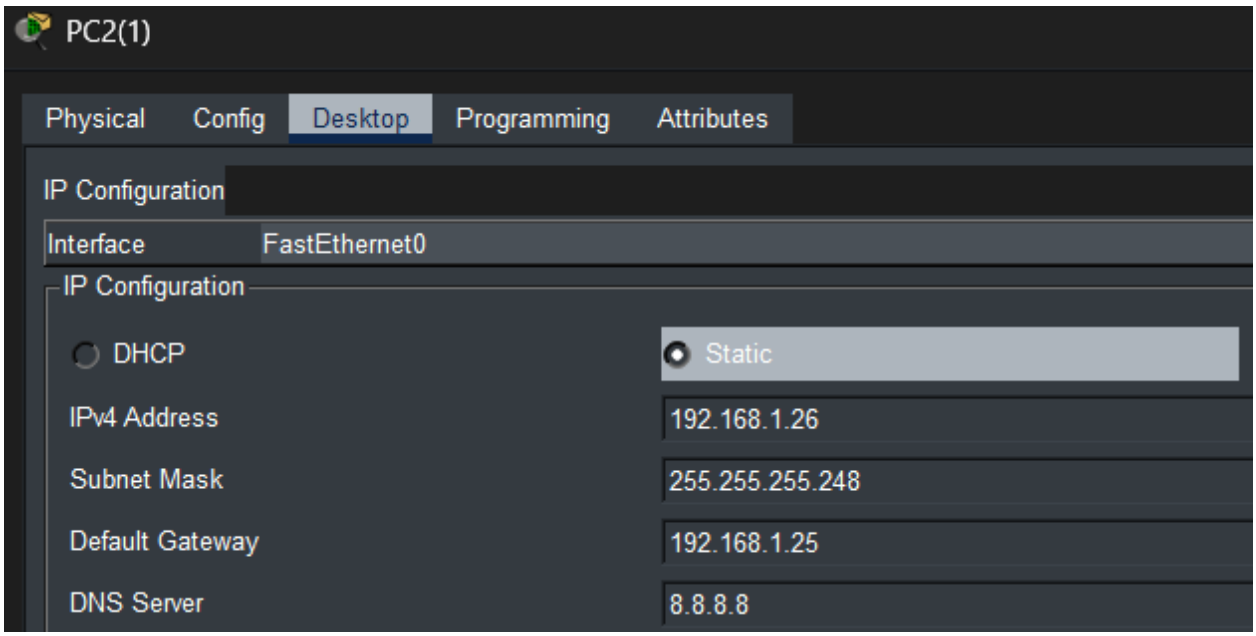
Router3(1)

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname Router3(1)
Router3(1)(config)#interface fastEthernet 0/0
Router3(1)(config-if)#ip address 192.168.1.25 255.255.255.248
Router3(1)(config-if)#interface fastEthernet 1/0
Router3(1)(config-if)#ip address 192.168.1.19 255.255.255.248
Router3(1)(config-if)#exit
```

Настраиваем компьютеры новой сети:







На каждом маршрутизаторе второй сети удаляем статические маршруты (IP-адреса с буквой S в выводе команды show ip route), чтобы остались только подключенные (буква C):

Пример для Route0(1)

```
Gateway of last resort is not set

     192.168.1.0/29 is subnetted, 2 subnets
C       192.168.1.0 is directly connected, FastEthernet0/0
C       192.168.1.8 is directly connected, FastEthernet1/0
```

Настройка RIP v2 и проверка работы:

Router0(1)

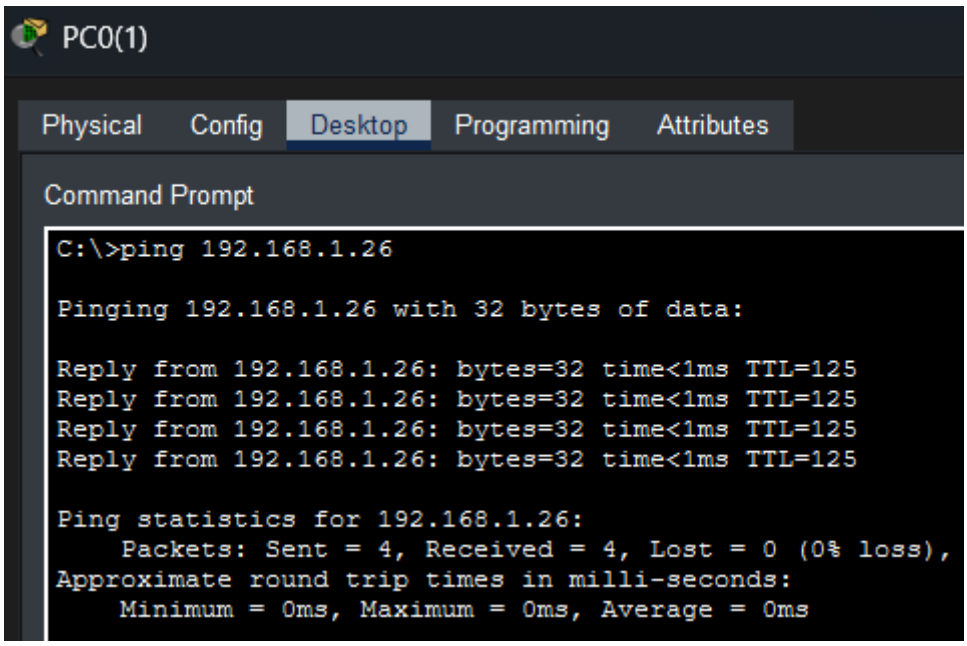
```
Router0(1)>en
Router0(1)#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router0(1)(config)#router rip
Router0(1)(config-router)#version 2
Router0(1)(config-router)#no auto-summary
Router0(1)(config-router)#network 192.168.1.0
Router0(1)(config-router)#network 192.168.1.8
Router0(1)(config-router)#exit
```

```
Router0(1)#debug ip rip
RIP protocol debugging is on
Router0(1)#RIP: sending  v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.1.1
RIP: build update entries
      192.168.1.8/29 via 0.0.0.0, metric 1, tag 0
      192.168.1.16/29 via 0.0.0.0, metric 2, tag 0
      192.168.1.24/29 via 0.0.0.0, metric 3, tag 0
      192.168.1.32/29 via 0.0.0.0, metric 3, tag 0
RIP: sending  v2 update to 224.0.0.9 via FastEthernet1/0 (192.168.1.9)
RIP: build update entries
      192.168.1.0/29 via 0.0.0.0, metric 1, tag 0
RIP: received v2 update from 192.168.1.10 on FastEthernet1/0
      192.168.1.16/29 via 0.0.0.0 in 1 hops
      192.168.1.24/29 via 0.0.0.0 in 2 hops
      192.168.1.32/29 via 0.0.0.0 in 2 hops
RIP: sending  v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.1.1)
RIP: build update entries
      192.168.1.8/29 via 0.0.0.0, metric 1, tag 0
      192.168.1.16/29 via 0.0.0.0, metric 2, tag 0
      192.168.1.24/29 via 0.0.0.0, metric 3, tag 0
      192.168.1.32/29 via 0.0.0.0, metric 3, tag 0
RIP: sending  v2 update to 224.0.0.9 via FastEthernet1/0 (192.168.1.9)
RIP: build update entries
      192.168.1.0/29 via 0.0.0.0, metric 1, tag 0

Router0(1)#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     192.168.1.0/29 is subnetted, 5 subnets
C       192.168.1.0 is directly connected, FastEthernet0/0
C       192.168.1.8 is directly connected, FastEthernet1/0
R       192.168.1.16 [120/1] via 192.168.1.10, 00:00:24, FastEthernet1/0
R       192.168.1.24 [120/2] via 192.168.1.10, 00:00:24, FastEthernet1/0
R       192.168.1.32 [120/2] via 192.168.1.10, 00:00:24, FastEthernet1/0
```



Router1(1)

```
Router1(1)>en
Router1(1)#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(1)(config)#router rip
Router1(1)(config-router)#version 2
Router1(1)(config-router)#no auto-summary
Router1(1)(config-router)#network 192.168.1.8
Router1(1)(config-router)#network 192.168.1.16
Router1(1)(config-router)#exit
```

```
Router1(1)#debug ip rip
RIP protocol debugging is on
Router1(1)#RIP: received v2 update from 192.168.1.9 on FastEthernet1/0
      192.168.1.0/29 via 0.0.0.0 in 1 hops
RIP: received v2 update from 192.168.1.19 on FastEthernet0/0
      192.168.1.24/29 via 0.0.0.0 in 1 hops
RIP: received v2 update from 192.168.1.18 on FastEthernet0/0
      192.168.1.32/29 via 0.0.0.0 in 1 hops
RIP: sending  v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.1.17)
RIP: build update entries
      192.168.1.0/29 via 0.0.0.0, metric 2, tag 0
      192.168.1.8/29 via 0.0.0.0, metric 1, tag 0
RIP: sending  v2 update to 224.0.0.9 via FastEthernet1/0 (192.168.1.10)
```

```
Gateway of last resort is not set

     192.168.1.0/29 is subnetted, 5 subnets
R       192.168.1.0 [120/1] via 192.168.1.9, 00:00:12, FastEthernet1/0
C       192.168.1.8 is directly connected, FastEthernet1/0
C       192.168.1.16 is directly connected, FastEthernet0/0
R       192.168.1.24 [120/1] via 192.168.1.19, 00:00:06, FastEthernet0/0
R       192.168.1.32 [120/1] via 192.168.1.18, 00:00:22, FastEthernet0/0
```

Route2(1)

```
Router2(1)>en
Router2(1)#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router2(1)(config)#router rip
Router2(1)(config-router)#version 2
Router2(1)(config-router)#no auto-summary
Router2(1)(config-router)#network 192.168.1.16
Router2(1)(config-router)#network 192.168.1.32
Router2(1)(config-router)#exit
```

```
Router2(1)>en
Router2(1)#debug ip rip
RIP protocol debugging is on
Router2(1)#RIP: received v2 update from 192.168.1.19 on FastEthernet1/0
      192.168.1.24/29 via 0.0.0.0 in 1 hops
RIP: sending  v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.1.33)
RIP: build update entries
      192.168.1.0/29 via 0.0.0.0, metric 3, tag 0
      192.168.1.8/29 via 0.0.0.0, metric 2, tag 0
      192.168.1.16/29 via 0.0.0.0, metric 1, tag 0
      192.168.1.24/29 via 0.0.0.0, metric 2, tag 0
RIP: sending  v2 update to 224.0.0.9 via FastEthernet1/0 (192.168.1.18)
RIP: build update entries
      192.168.1.32/29 via 0.0.0.0, metric 1, tag 0
RIP: received v2 update from 192.168.1.17 on FastEthernet1/0
      192.168.1.0/29 via 0.0.0.0 in 2 hops
      192.168.1.8/29 via 0.0.0.0 in 1 hops
RIP: received v2 update from 192.168.1.19 on FastEthernet1/0
      192.168.1.24/29 via 0.0.0.0 in 1 hops
RIP: sending  v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.1.33)
```

```
     192.168.1.0/29 is subnetted, 5 subnets
R       192.168.1.0 [120/2] via 192.168.1.17, 00:00:05, FastEthernet1/0
R       192.168.1.8 [120/1] via 192.168.1.17, 00:00:05, FastEthernet1/0
C       192.168.1.16 is directly connected, FastEthernet1/0
R       192.168.1.24 [120/1] via 192.168.1.19, 00:00:19, FastEthernet1/0
C       192.168.1.32 is directly connected, FastEthernet0/0
```

Route3(1)

```
Router3(1)>en
Router3(1)#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router3(1)(config)#router rip
Router3(1)(config-router)#version 2
Router3(1)(config-router)#no auto-summary
Router3(1)(config-router)#network 192.168.1.16
Router3(1)(config-router)#network 192.168.1.24
Router3(1)(config-router)#exit
```

```
Router3(1)#debug ip rip
RIP protocol debugging is on
Router3(1)#RIP: received v2 update from 192.168.1.18 on FastEthernet1/0
      192.168.1.32/29 via 0.0.0.0 in 1 hops
RIP: received v2 update from 192.168.1.17 on FastEthernet1/0
      192.168.1.0/29 via 0.0.0.0 in 2 hops
      192.168.1.8/29 via 0.0.0.0 in 1 hops
RIP: sending  v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.1.25)
RIP: build update entries
      192.168.1.0/29 via 0.0.0.0, metric 3, tag 0
      192.168.1.8/29 via 0.0.0.0, metric 2, tag 0
      192.168.1.16/29 via 0.0.0.0, metric 1, tag 0
      192.168.1.32/29 via 0.0.0.0, metric 2, tag 0
RIP: sending  v2 update to 224.0.0.9 via FastEthernet1/0 (192.168.1.19)
```

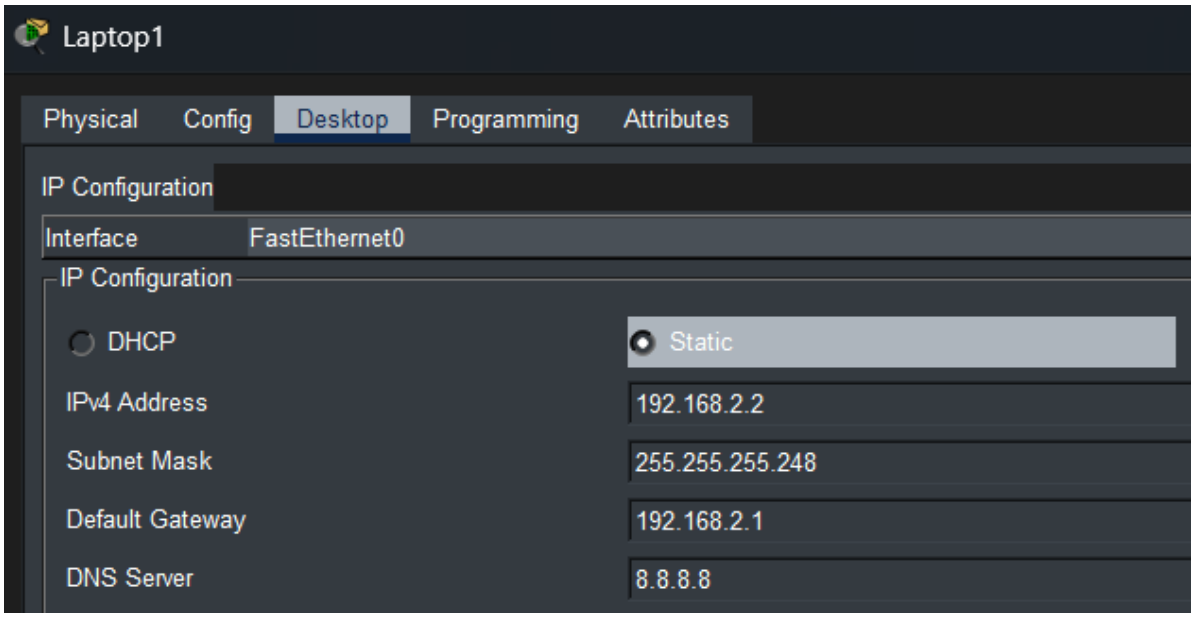
```
Gateway of last resort is not set

     192.168.1.0/29 is subnetted, 5 subnets
R       192.168.1.0 [120/2] via 192.168.1.17, 00:00:13, FastEthernet1/0
R       192.168.1.8 [120/1] via 192.168.1.17, 00:00:13, FastEthernet1/0
C       192.168.1.16 is directly connected, FastEthernet1/0
C       192.168.1.24 is directly connected, FastEthernet0/0
R       192.168.1.32 [120/1] via 192.168.1.18, 00:00:16, FastEthernet1/0
```

Часть 4

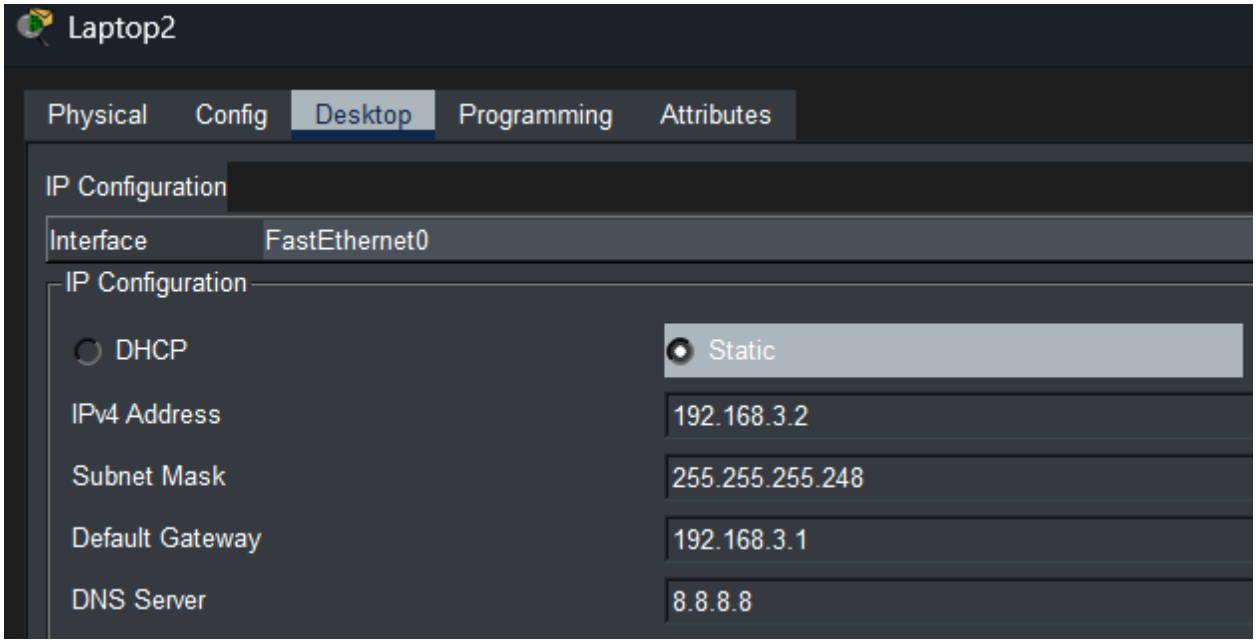
4.1(а) Добавили маршрутизатор Router4 и подключили к нему Laptop1

```
AS102_Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
AS102_Router(config)#hostname AS102_Router
AS102_Router(config)#interface fastEthernet 0/0
AS102_Router(config-if)#ip address 192.168.2.1 255.255.255.0
AS102_Router(config-if)#no shutdown
AS102_Router(config-if)#exit
AS102_Router(config)#exit
```



4.1(б) Добавили маршрутизатор Router5 и подключили к нему Laptop2

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname AS103_Router
AS103_Router(config)#interface fastEthernet 0/0
AS103_Router(config-if)#ip address 192.168.3.1 255.255.255.0
AS103_Router(config-if)#no shutdown
AS103_Router(config-if)#exit
```



Часть 5

5.1 Соединяем автономные системы

Статическая маршрутизация (AS100)

```
Router1>en
Router1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)#router bgp 100
Router1(config-router)#exit
```

Динамическая маршрутизация (AS101)

```
Router1(1)>en
Router1(1)#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(1)(config)#router bgp 101
Router1(1)(config-router)#exit
```

Дополнительная сеть (AS102)

```
AS102_Router#en
AS102_Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
AS102_Router(config)#router bgp 102
AS102_Router(config-router)#exit
```

Дополнительная сеть (AS103)

```
AS103_Router>en
AS103_Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
AS103_Router(config)#router bgp 103
AS103_Router(config-router)#exit
```

5.2 Настройка между AS интерфейсов (AS100)

```
Router1>en
Router1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(config)#interface fastEthernet 4/0
Router1(config-if)#ip address 10.0.1.1 255.255.255.252
Router1(config-if)#no shutdown

%LINK-5-CHANGED: Interface FastEthernet4/0, changed state to down
Router1(config-if)#exit
Router1(config)#interface serial 2/0
Router1(config-if)#ip address 10.0.2.1 255.255.255.252
Router1(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial2/0, changed state to down
Router1(config-if)#exit
Router1(config)#interface serial 3/0
Router1(config-if)#ip address 10.0.3.1 255.255.255.252
Router1(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial3/0, changed state to down
Router1(config-if)#exit
```

5.3 Настройка BGP

(AS100)

```
Router1(config)#conf t
%Invalid hex value
Router1(config)#router bgp 100
Router1(config-router)#bgp log-neighbor-changes
Router1(config-router)#neighbor 10.0.1.2 remote-as 101
Router1(config-router)#neighbor 10.0.2.2 remote-as 102
Router1(config-router)#neighbor 10.0.3.2 remote-as 103
Router1(config-router)#network 192.168.0.0 mask 255.255.255.0
Router1(config-router)#exit
```

(AS101)

```
Router1(1)>en
Router1(1)#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(1)(config)#ip route 192.168.1.0 255.255.255.0 Null0
Router1(1)(config)#router bgp 101
Router1(1)(config-router)#bgp log-neighbor-changes
Router1(1)(config-router)#neighbor 10.0.1.1 remote-as 100
Router1(1)(config-router)#neighbor 10.0.4.2 remote-as 102
Router1(1)(config-router)#neighbor 10.0.5.2 remote-as 103
Router1(1)(config-router)#network 192.168.1.0 mask 255.255.255.0
Router1(1)(config-router)#exit
```

(AS102)

```
AS102_Router#en
AS102_Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
AS102_Router(config)#router bgp 102
AS102_Router(config-router)#bgp log-neighbor-changes
AS102_Router(config-router)#neighbor 10.0.2.1 remote-as 100
AS102_Router(config-router)#neighbor 10.0.4.1 remote-as 101
AS102_Router(config-router)#network 192.168.2.0 mask 255.255.255.0
AS102_Router(config-router)#exit
```

(AS103)

```
AS103_Router>en
AS103_Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
AS103_Router(config)#router bgp 103
AS103_Router(config-router)#bgp log-neighbor-changes
AS103_Router(config-router)#neighbor 10.0.3.1 remote-as 100
AS103_Router(config-router)#neighbor 10.0.5.1 remote-as 101
AS103_Router(config-router)#network 192.168.3.0 mask 255.255.255.0
AS103_Router(config-router)#exit
```

5.4 Проверка BGP

(AS100)

```
Router1#show ip bgp summary
BGP router identifier 192.168.0.17, local AS number 100
BGP table version is 1, main routing table version 6
0 network entries using 0 bytes of memory
0 path entries using 0 bytes of memory
0/0 BGP path/bestpath attribute entries using 0 bytes of memory
0 BGP AS-PATH entries using 0 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 32 total bytes of memory
BGP activity 0/0 prefixes, 0/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.1.2        4   101       0       0        1    0    0 01:18:11        4
10.0.2.2        4   102       0       0        1    0    0 01:18:11        4
10.0.3.2        4   103       0       0        1    0    0 01:18:11        4

Router1#show ip bgp neighbors
BGP neighbor is 10.0.1.2,  remote AS 101, external link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active, up for 01:18:18
  Last read 01:18:18, last write 01:18:18, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                         Sent       Rcvd
    Opens:                  0          0
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             0          0
    Route Refresh:          0          0
    Total:                  0          0
  Default minimum time between advertisements runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 6/0
```

```
Router1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     192.168.0.0/29 is subnetted, 5 subnets
S       192.168.0.0 [1/0] via 192.168.0.9
C       192.168.0.8 is directly connected, FastEthernet1/0
C       192.168.0.16 is directly connected, FastEthernet0/0
S       192.168.0.24 [1/0] via 192.168.0.19
S       192.168.0.32 [1/0] via 192.168.0.18
```

(AS101)

```
Router1(1)#show ip bgp summary
BGP router identifier 192.168.1.17, local AS number 101
BGP table version is 1, main routing table version 6
0 network entries using 0 bytes of memory
0 path entries using 0 bytes of memory
0/0 BGP path/bestpath attribute entries using 0 bytes of memory
0 BGP AS-PATH entries using 0 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 32 total bytes of memory
BGP activity 0/0 prefixes, 0/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.1.1        4   100       0       0        1    0    0 01:20:34        4
10.0.4.2        4   102       0       0        1    0    0 01:20:34        4
10.0.5.2        4   103       0       0        1    0    0 01:20:34        4
```

```
Router1(1)#show ip bgp neighbors
BGP neighbor is 10.0.1.1,  remote AS 100, external link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active, up for 01:20:40
  Last read 01:20:40, last write 01:20:40, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                         Sent       Rcvd
    Opens:                  0          0
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             0          0
    Route Refresh:          0          0
    Total:                  0          0
  Default minimum time between advertisements runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 6/0
  Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                               Sent       Rcvd
  Prefix activity:             ----       ----
    Prefixes Current:             0          0 (Consumes 0 bytes)
    Prefixes total:               0          0
    Implicit Withdraw:            0          0
    Explicit Withdraw:            0          0
    Used as bestpath:           n/a          1
    Used as multipath:          n/a          0

                                    Outbound    Inbound
      Local Policy Denied Prefixes:    --------    -------
        Total:                            0          0
      Number of NLRIs in the update sent: max 3, min 1

  Connections established 0; dropped 0
  Last reset never
  Transport(tcp) path-mtu-discovery is enabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Minimum incoming TTL 0, Outgoing TTL 1
Connection tableid (VRF): 0

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xC69F4):
Timer          Starts    Wakeups            Next
Retrans             0          0             0x0
TimeWait            0          0             0x0
 --More--
```

```
AckHold              0          0             0x0
SendWnd              0          0             0x0
KeepAlive            0          0             0x0
GiveUp               0          0             0x0
PmtuAger             0          0             0x0
DeadWait             0          0             0x0
Linger               0          0             0x0
ProcessQ             0          0             0x0

iss: 2057115318  snduna: 2057115748  sndnxt: 2057115748     sndwnd:  15955
irs: 3480424370  rcvnxt: 3480424751  rcvwnd:      16004  delrcvwnd:    380

SRTT: 259 ms, RTTO: 579 ms, RTV: 320 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Status Flags: passive open, gen tcbs
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 0 (out of order: 0), with data: 0, total data bytes: 0
Sent: 0 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 0, total data
bytes: 0
 Packets received in fast path: 0, fast processed: 0, slow path: 0
 fast lock acquisition failures: 0, slow path: 0

BGP neighbor is 10.0.4.2,  remote AS 102, external link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active, up for 01:20:40
  Last read 01:20:40, last write 01:20:40, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                         Sent       Rcvd
    Opens:                  0          0
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             0          0
    Route Refresh:          0          0
    Total:                  0          0
  Default minimum time between advertisements runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 6/0
  Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                               Sent       Rcvd
  Prefix activity:             ----       ----
    Prefixes Current:             0          0 (Consumes 0 bytes)
 --More-- |
```

```
    Prefixes total:                 0          0
    Implicit Withdraw:              0          0
    Explicit Withdraw:              0          0
    Used as bestpath:             n/a          1
    Used as multipath:            n/a          0

                                    Outbound    Inbound
      Local Policy Denied Prefixes:    --------    -------
        Total:                              0          0
      Number of NLRIs in the update sent: max 3, min 1

  Connections established 0; dropped 0
  Last reset never
  Transport(tcp) path-mtu-discovery is enabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Minimum incoming TTL 0, Outgoing TTL 1
Connection tableid (VRF): 0

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xC69F4):
Timer          Starts    Wakeups            Next
Retrans             0          0             0x0
TimeWait            0          0             0x0
AckHold             0          0             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0
Linger              0          0             0x0
ProcessQ            0          0             0x0

iss: 2057115318  snduna: 2057115748  sndnxt: 2057115748     sndwnd:  15955
irs: 3480424370  rcvnxt: 3480424751  rcvwnd:      16004  delrcvwnd:    380

SRTT: 259 ms, RTTO: 579 ms, RTV: 320 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Status Flags: passive open, gen tcbs
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 0 (out of order: 0), with data: 0, total data bytes: 0
Sent: 0 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 0, total data
bytes: 0
 Packets received in fast path: 0, fast processed: 0, slow path: 0
 fast lock acquisition failures: 0, slow path: 0

BGP neighbor is 10.0.5.2,  remote AS 103, external link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active, up for 01:20:40
  Last read 01:20:40, last write 01:20:40, hold time is 180, keepalive interval is 60 seconds
 --More--
```

```
  Last read 01:20:40, last write 01:20:40, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                         Sent       Rcvd
    Opens:                  0          0
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             0          0
    Route Refresh:          0          0
    Total:                  0          0
  Default minimum time between advertisements runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 6/0
  Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                               Sent       Rcvd
  Prefix activity:             ----       ----
    Prefixes Current:             0          0 (Consumes 0 bytes)
    Prefixes total:               0          0
    Implicit Withdraw:            0          0
    Explicit Withdraw:            0          0
    Used as bestpath:           n/a          1
    Used as multipath:          n/a          0

                                    Outbound    Inbound
      Local Policy Denied Prefixes:    --------    -------
        Total:                                0          0
      Number of NLRIs in the update sent: max 3, min 1

  Connections established 0; dropped 0
  Last reset never
  Transport(tcp) path-mtu-discovery is enabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Minimum incoming TTL 0, Outgoing TTL 1
Connection tableid (VRF): 0

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xC69F4):
Timer          Starts    Wakeups            Next
Retrans             0          0             0x0
TimeWait            0          0             0x0
AckHold             0          0             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
 --More--
```

```
PmtuAger           0          0            0x0
DeadWait           0          0            0x0
Linger             0          0            0x0
ProcessQ           0          0            0x0

iss: 2057115318  snduna: 2057115748  sndnxt: 2057115748     sndwnd:  15955
irs: 3480424370  rcvnxt: 3480424751  rcvwnd:      16004  delrcvwnd:    380

SRTT: 259 ms, RTTO: 579 ms, RTV: 320 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Status Flags: passive open, gen tcbs
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 0 (out of order: 0), with data: 0, total data bytes: 0
Sent: 0 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 0, total data
bytes: 0
 Packets received in fast path: 0, fast processed: 0, slow path: 0
 fast lock acquisition failures: 0, slow path: 0
```

(AS102)

```
AS102_Router#show ip bgp summary
BGP router identifier 192.168.2.1, local AS number 102
BGP table version is 1, main routing table version 6
0 network entries using 0 bytes of memory
0 path entries using 0 bytes of memory
0/0 BGP path/bestpath attribute entries using 0 bytes of memory
0 BGP AS-PATH entries using 0 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 32 total bytes of memory
BGP activity 0/0 prefixes, 0/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.2.1        4   100       0       0        1    0    0 01:23:05        4
10.0.4.1        4   101       0       0        1    0    0 01:23:05        4

AS102_Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

(AS103)

```
AS103_Router#show ip bgp summary
BGP router identifier 192.168.3.1, local AS number 103
BGP table version is 1, main routing table version 6
0 network entries using 0 bytes of memory
0 path entries using 0 bytes of memory
0/0 BGP path/bestpath attribute entries using 0 bytes of memory
0 BGP AS-PATH entries using 0 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 32 total bytes of memory
BGP activity 0/0 prefixes, 0/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.3.1        4   100       0       0        1    0    0 01:23:38        4
10.0.5.1        4   101       0       0        1    0    0 01:23:38        4

AS103_Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.3.0/24 is directly connected, FastEthernet0/0
```

5.6-5.7 Настройка маршрута по умолчанию

(AS100) для Router0, Router2, Router3:

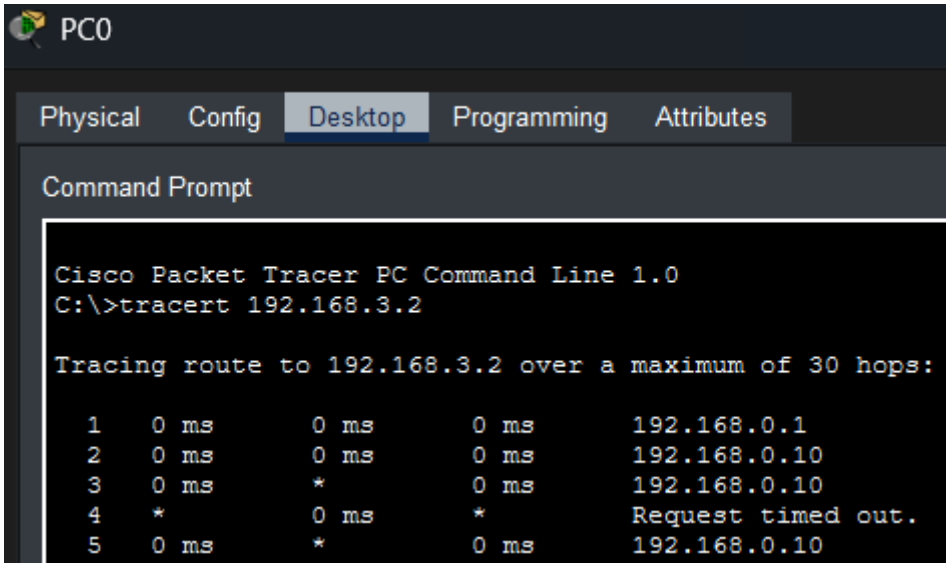
```
·en
·conf t
nfiguration commands, one per line.  End with CNTL/Z.
(config)#ip route 0.0.0.0 0.0.0.0 192.168.0.17
(config)#exit
```

(AS101) Router1:

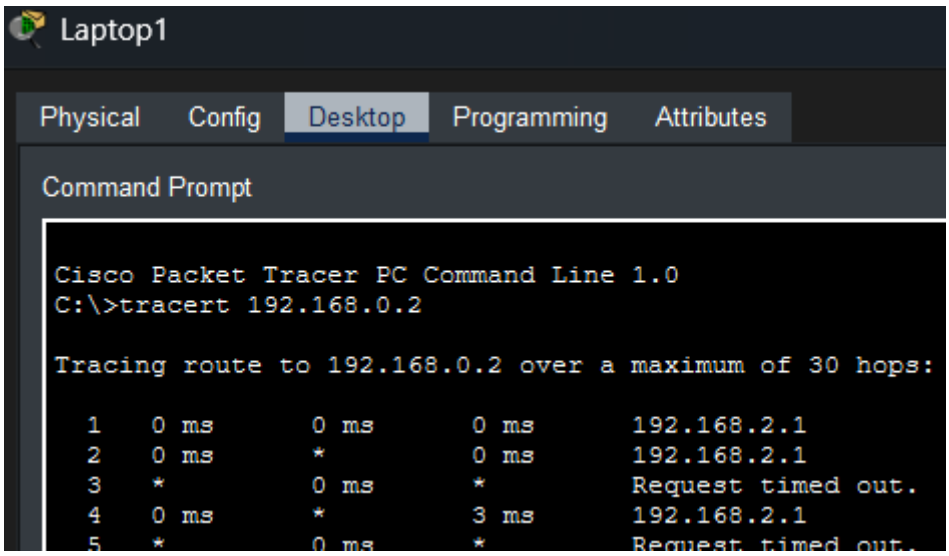
```
Router1(1)#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router1(1)(config)#router rip
Router1(1)(config-router)#default-information originate
Router1(1)(config-router)#
Router1(1)(config-router)#exit
```

5.8 Трассировка маршрута

(AS100) PC0 -> AS103



(AS102) Laptop1 -> AS100



Вопросы и задания:

1. Поясните результаты, полученные в Части 5, п.8.

При трассировке с PC0 (AS100) до сети AS103 пакеты доходят только до Router1 (192.168.0.10), после чего происходит таймаут. Аналогично, трассировка из AS102 в AS100 прерывается на третьем хопе. Получили неполную маршрутизацию между автономными системами.

2. Как, имея доступ к консоли маршрутизатора узнать, что проходят обновления информации bgp?

Для отслеживания обновлений BGP используются команды:

- show ip bgp summary - статус сессий и счетчики обновлений
- show ip bgp neighbors - детальная информация о пирах
- debug ip bgp updates - просмотр обновлений в реальном времени
- show ip route bgp - просмотр полученных через BGP маршрутов

3. Какие различия в настройке и работе протоколов bgp и rip вы отметили по ходу

выполнения работы?

- **BGP** - внешний протокол (EGP), работает между AS, использует атрибуты пути, ручная настройка пирингов, TCP-порт 179
- **RIP** - внутренний протокол (IGP), работает внутри AS, использует хоп-счет, автоматическое соседство, UDP-порт 520
- **BGP** - векторно-путевой, сохраняет полные пути
- **RIP** - дистанционно-векторный, хранит только метрики

Понятийный минимум:

1**. IP сеть** - Логическая группировка устройств с общим префиксом IP-адресов, обеспечивающая коммуникацию в рамках заданного адресного пространства.

2. **Маршрут** - Путь следования пакета от источника к получателю, определяемый на основе таблицы маршрутизации.

3. **Метрика** - Числовой показатель стоимости маршрута, используемый для выбора оптимального пути при наличии альтернатив.

4. **Таблица маршрутизации** - База данных в маршрутизаторе, содержащая информацию о доступных сетях, интерфейсах и метриках для принятия решений о пересылке пакетов.

5. **Default Gateway** - Маршрутизатор, используемый устройством для отправки трафика в сети, для которых нет явного маршрута.

6. **Порядок поиска маршрута по таблице маршрутизации** - Поиск выполняется от наиболее специфичного к наименее специфичному: host → subnet → network → supernet → default route.

7. **RIP, принципы распространения маршрутной информации** - Дистанционно-векторный протокол, рассылает полные таблицы маршрутизации каждые 30 секунд, использует хоп-счет как метрику (максимум 15 хопов).

8. **BGP, принцип распространения маршрутной информации** - Векторно-путевой протокол внешней маршрутизации, устанавливает TCP-сессии между пирами, обменивается инкрементальными обновлениями, использует сложные атрибуты пути.

9. **BGP пир** - Установленная TCP-сессия между BGP-маршрутизаторами разных автономных систем для обмена маршрутной информацией.

10. **BGP анонс сети** - Процесс объявления маршрутов через BGP, при котором маршрутизатор сообщает своим пирам о доступности определенных IP-сетей.