CS 305 Lab Tutorial
Lecture 11 NAT, RIP, OSPF

Dept. Computer Science and Engineering
Southern University of Science and Technology

SUSTech
Southern University
of Science and Technology

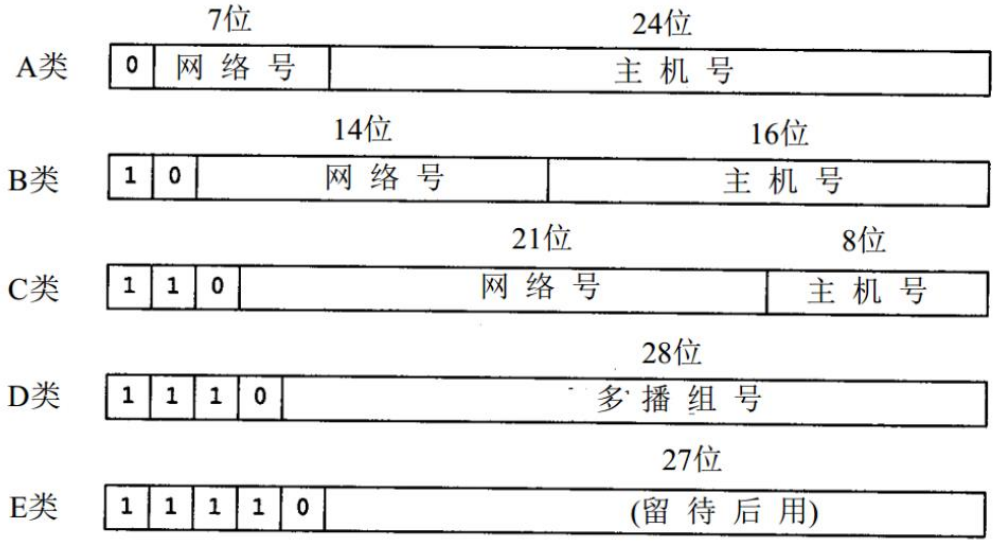
Thanks to Wei Wang

Topic

- IPv4 Addressing
- NAT
  - Static conversion
  - Dynamic conversion
- Routing Protocol
  - RIP
  - OSPF
- Practice
  - Build network on simulator
  - Configure
  - Test

Part A. IPv4 Addressing (1)

- Class A/B/C network address assignment
  - class A, class B, class C
  - parts of this were eventually defined (MSB '1110') for use with IPv4 multicast and parts are still reserved



类型	范 围
A	0.0.0.0 到 127.255.255.255
B	128.0.0.0 到 191.255.255.255
C	192.0.0.0 到 223.255.255.255
D	224.0.0.0 到 239.255.255.255
E	240.0.0.0 到 247.255.255.255

IPv4 Addressing (2)

- Major problems of class A/B/C network numbers:
  - Exhaustion of the Class B network address space.
  - Growth of routing tables in Internet routers beyond the ability of current software, hardware, and people to effectively manage.
  - Eventual exhaustion of the 32-bit IPv4 address space.
- CDIR: Classless Inter-domain Routing
  - "classless“
  - hierarchical blocks of IP addresses (referred to as prefixes)
  - /16, /24, ……

https://www.rfc-editor.org/rfc/rfc4632.txt

IPv4 Addressing(3)

- Public: require IP addresses that are globally unambiguous
  - hosts that need network layer access outside the enterprise
- Private: may be ambiguous between enterprises
  - hosts that do not require access to hosts in other enterprises or the Internet at large
  - hosts that need access to a limited set of outside services which can be handled by mediating gateways
- Private address space
  - 10.0.0.0 - 10.255.255.255 (10/8 prefix)
  - 172.16.0.0 - 172.31.255.255 (172.16/12 prefix)
  - 192.168.0.0 - 192.168.255.255 (192.168/16 prefix)

https://www.rfc-editor.org/rfc/rfc1918.txt

Part B.
NAT - Network Address Translator

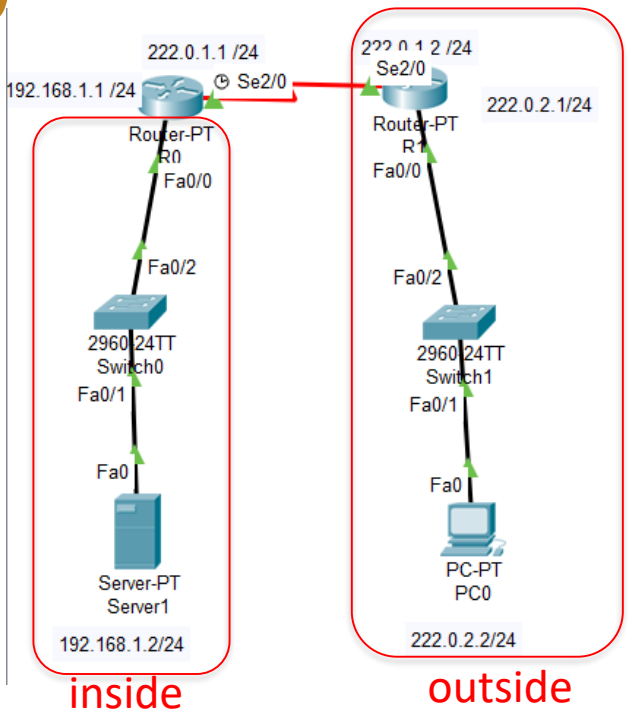
- The need for IP Address translation arises when a network's internal IP addresses cannot be used outside the network either for privacy reasons or because they are invalid for use outside the network.
- Traditional NAT, provide a mechanism to connect a realm with private addresses to an external realm with globally unique registered addresses.
  - Basic Network Address Translation or Basic NAT: IP addresses are mapped from one group to another.
  - Network Address Port Translation, or NAPT: many network addresses and their TCP/UDP ports are translated into a single network address and its TCP/UDP ports.

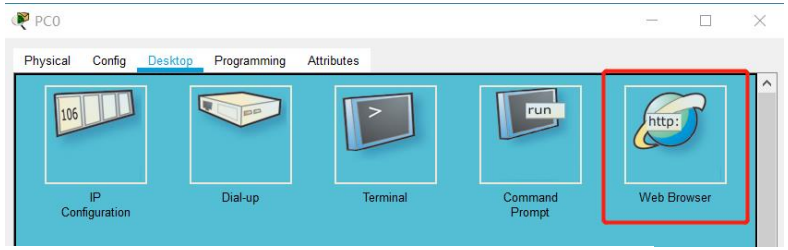
https://www.rfc-editor.org/rfc/rfc3022.txt

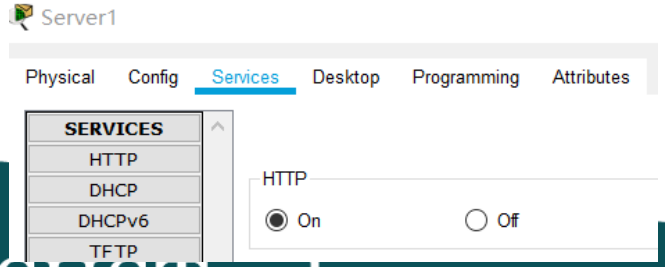
NAT(Static conversion)

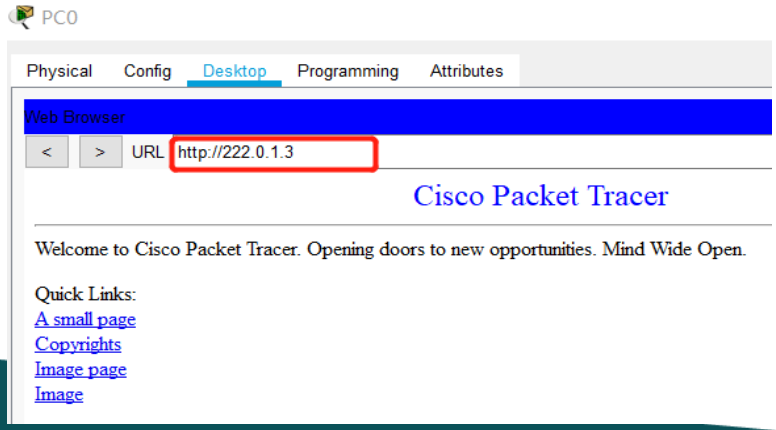
The mapping relationship of IP addresses is one-to-one and remains unchanged.

- With the help of static conversion, the access of external network to some special servers in internal network can be realized.
- Configuration steps:
  - 1. Set **maping relationship** between internal address and external address on router R0:
    - **ip nat inside source static 192.168.1.2 222.0.1.3**
  - 2. **Enable nat on the interfaces** on router R0 :
    - Specify external interfaces : **ip nat outside**
    - Specify internal interfaces : **ip nat inside**



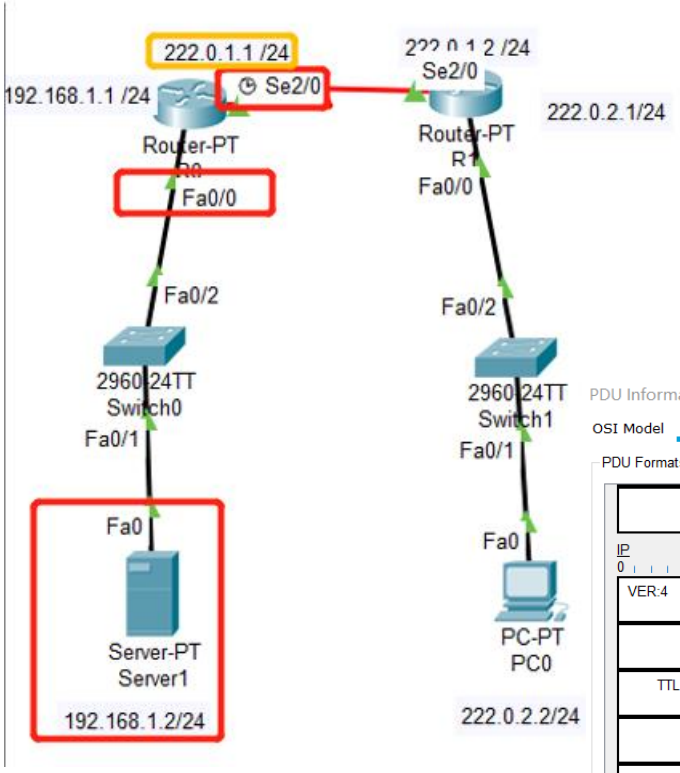






SUSTech
Southern University of Science and Technology

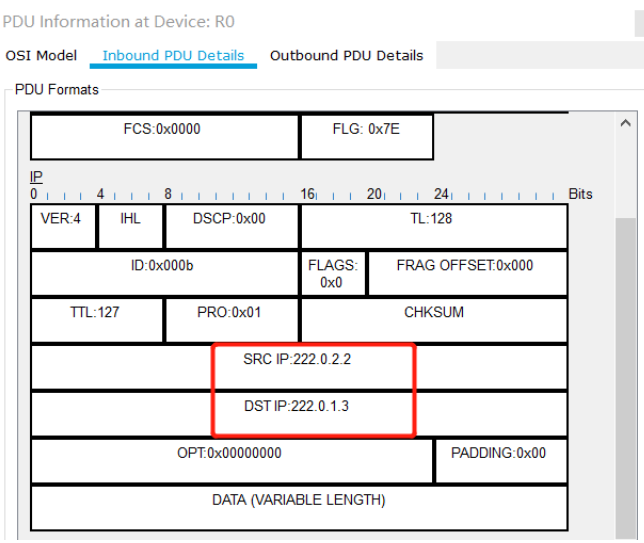
NAT(Static conversion)

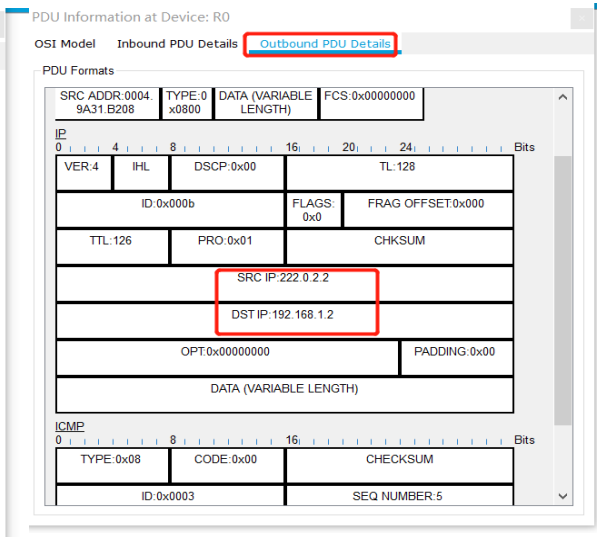



```
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 ip nat inside
```

```
interface Serial2/0
 ip address 222.0.1.1 255.255.255.0
 ip nat outside
 clock rate 64000
```

```
ip nat inside source static 192.168.1.2 222.0.1.3
```





Tips: do not forget to configure static routing item on both routers.

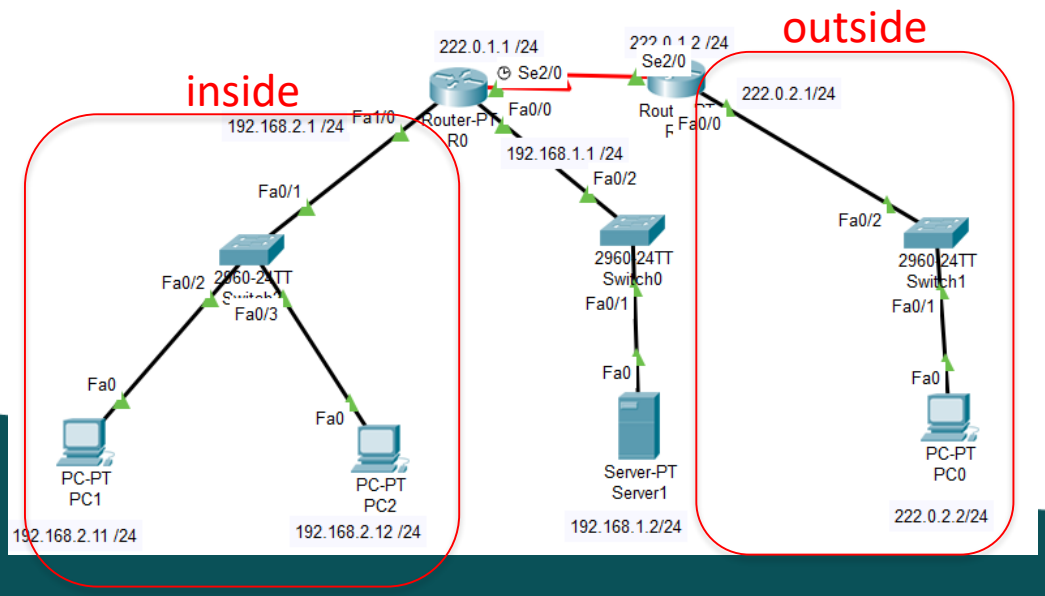
SUSTech
Southern University
of Science and Technology

NAT(Dynamic conversion)

The mapping relationship of IP addresses is uncertain and random. All private addresses authorized to access the Internet can be randomly converted to any designated legitimate external IP address.

- It is suitable for scenarios where the number of hosts accessing the Internet at the same time in an internal network is less than the number of IP addresses in the configured legitimate address.
- Configuration steps:
  - 1. Configure **ACL** to limit **the range of intranets that can be addressed**
  - 2. Configuring **address pools** given by telecommunicati**ons**
  - **3. Set up the mapping relationship between ACL and address pool** to match the data stream for address translation.
  - 4. Specify **internal and external interfaces**

```
R0(config)#access-list 1 permit 192.168.2.0 0.0.0.255
R0(config)#ip nat pool np 222.0.1.11 222.0.1.15 netmask 255.255.255.0
R0(config)#ip nat inside source list 1 pool np
R0(config)#interface fa1/0
R0(config-if)#ip nat ind
R0(config-if)#ip nat inside
R0(config-if)#exit
R0(config)#inter
R0(config)#interface se2/0
R0(config-if)#ip nat outside
R0(config-if)#exit
R0(config)#
```



SUSTech
Southern University
of Science and Technology

NAT(Dynamic conversion)

PC2

Physical Config Desktop Programming Attributes

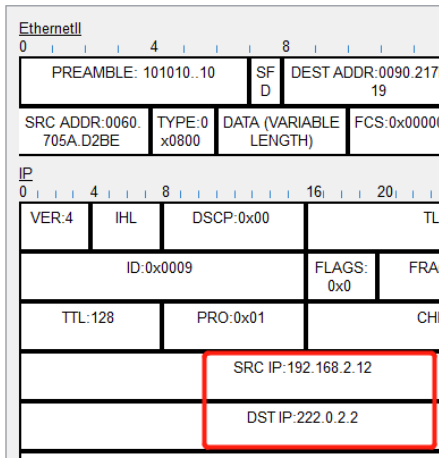
Command Prompt

```
Ping statistics for 222.0.2.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 2ms, Average = 1ms

C:\>ping  222.0.2.2

Pinging 222.0.2.2 with 32 bytes of data:

Reply from 222.0.2.2: bytes=32 time=10ms TTL=126
Reply from 222.0.2.2: bytes=32 time=10ms TTL=126

Ping statistics for 222.0.2.2:
    Packets: Sent = 2, Received = 2, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 10ms, Maximum = 10ms, Average = 10ms

Control-C
^C
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Link-local IPv6 Address.....: FE80::260:70FF:FE5A:D2BE
   IP Address.....: 192.168.2.12
   Subnet Mask.....: 255.255.255.0
   Default Gateway.....: 192.168.2.1
```

PDU Information at Device: R0

OSI Model | Inbound PDU Details | Outbound PDU Details

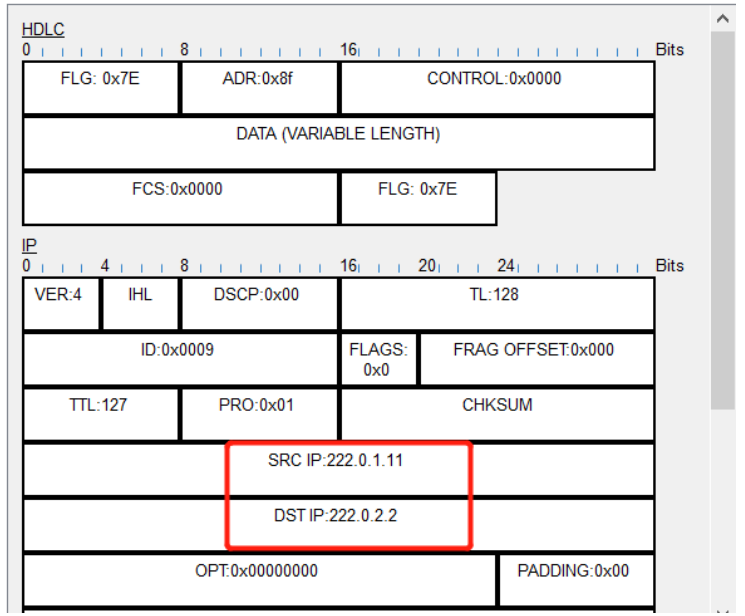
PDU Formats



PDU Information at Device: R0

OSI Model | Inbound PDU Details | Outbound PDU Details

PDU Formats



Simulation Panel

Event List

Vis.	Time(sec)	Last Device	At Device	Type
	1.538	PC2	Switch2	ICMP
	1.539	Switch2	R0	ICMP
	1.540	R0	R1	ICMP
	1.541	R1	Switch1	ICMP

```
Router#show ip nat translations
Router#show ip nat translations
Pro  Inside global     Inside local       Outside local      Outside global
icmp 222.0.1.11:25     192.168.2.12:25    222.0.2.2:25       222.0.2.2:25
icmp 222.0.1.11:26     192.168.2.12:26    222.0.2.2:26       222.0.2.2:26
icmp 222.0.1.11:27     192.168.2.12:27    222.0.2.2:27       222.0.2.2:27
icmp 222.0.1.11:28     192.168.2.12:28    222.0.2.2:28       222.0.2.2:28
```

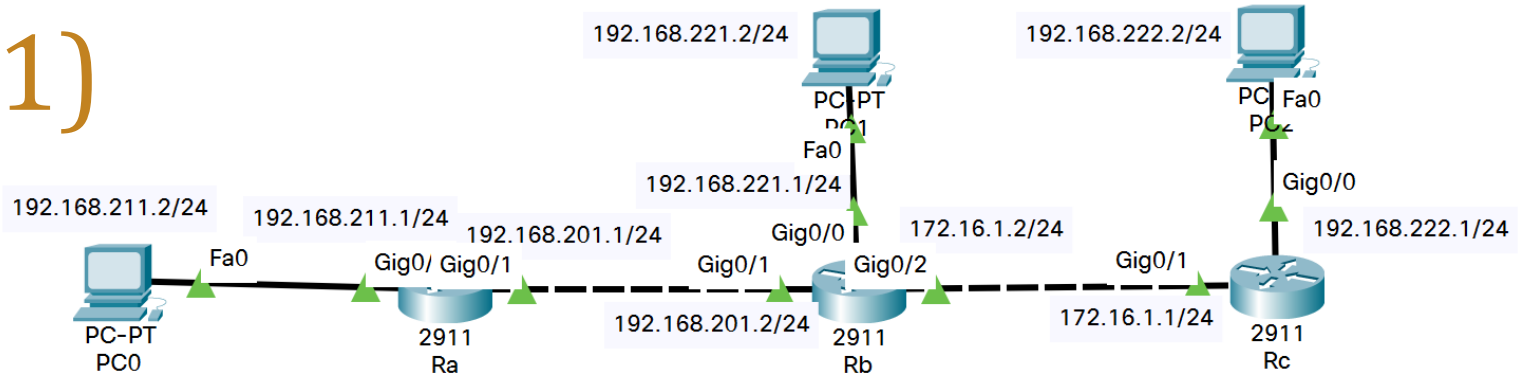
SUSTech
Southern University of Science and Technology

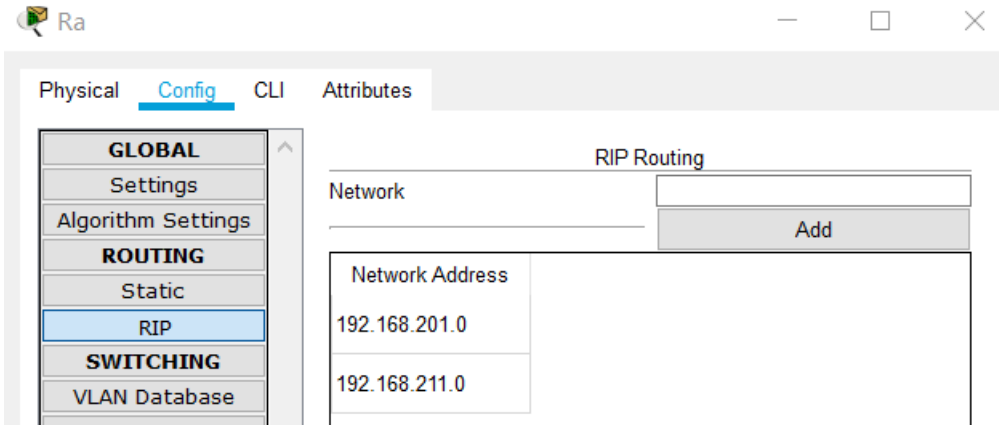
Part C.
RIP - Routing Information Protocol

- Distance Vector or Ford-Fulkerson algorithms
- This protocol is most useful as an "interior gateway protocol“ (IGP)
- represents the metric as a sum of "costs" for individual hops
- every gateway that participates in routing sends an update message to all its neighbors once every **30** seconds
- wait for **180** seconds before timing out a route
- RIP V1
- RIP V2

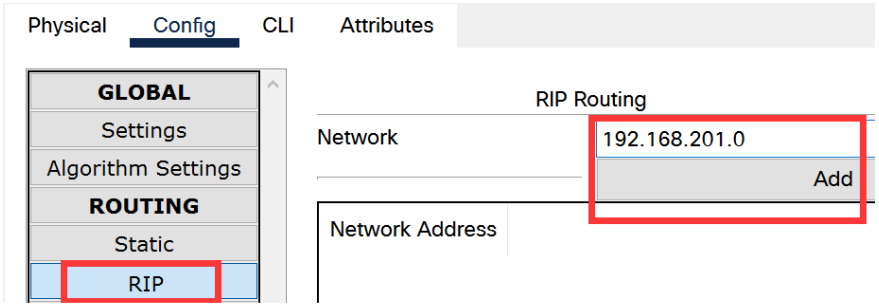
https://www.rfc-editor.org/rfc/rfc1058.txt

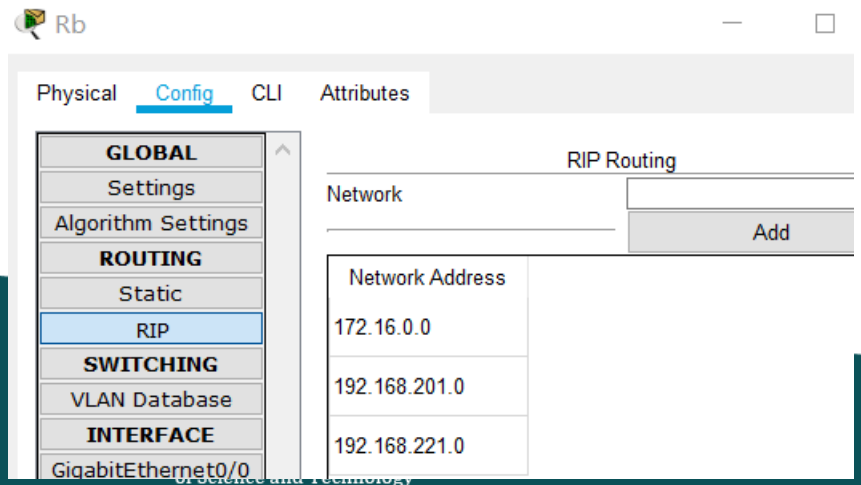
RIP(1)

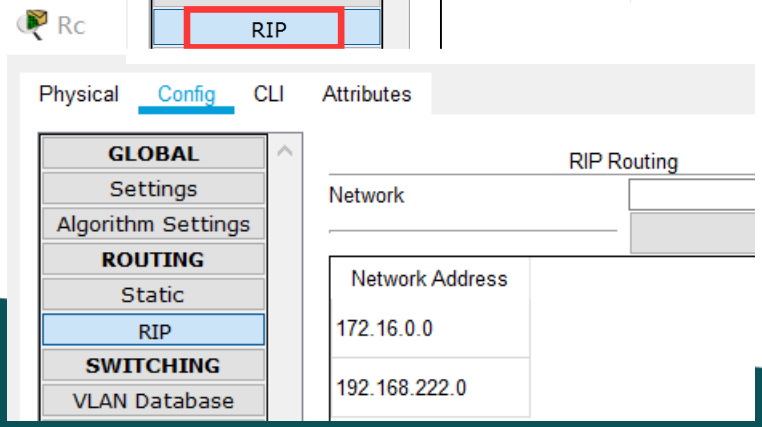




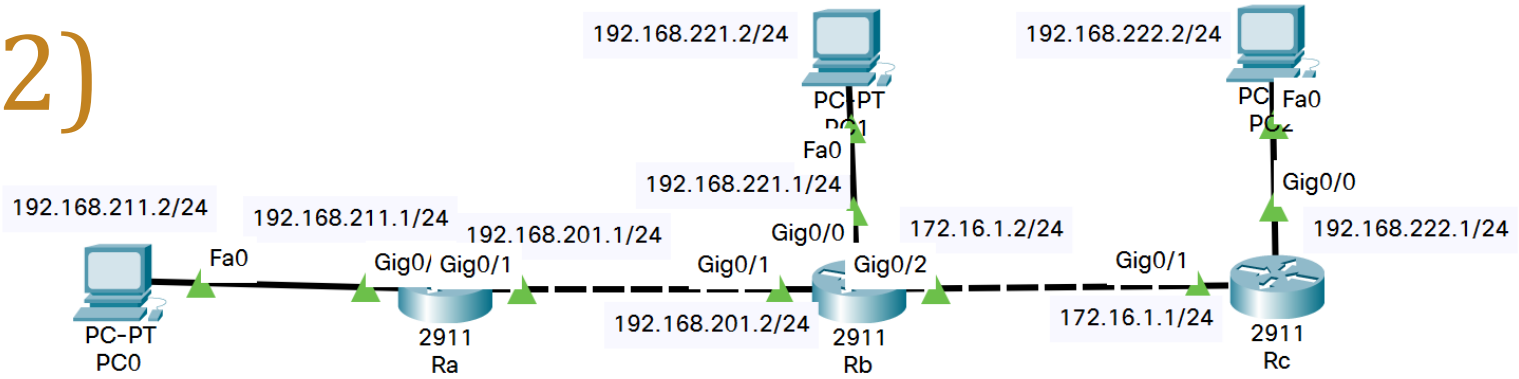

```
Router(config)#router rip
Router(config-router)#network 192.168.201.0
Router(config-router)#network 192.168.211.0
Router(config-router)#end
```







RIP(2)




```
Router#show ip route
Codes: L - local, C - connected, S - static, 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

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.0.0/16 is directly connected, GigabitEthernet0/2
L       172.16.1.2/32 is directly connected, GigabitEthernet0/2
     192.168.201.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.201.0/24 is directly connected, GigabitEthernet0/1
L       192.168.201.2/32 is directly connected, GigabitEthernet0/1
R    192.168.211.0/24 [120/1] via 192.168.201.1, 00:00:20, GigabitEthernet0/1
     192.168.221.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.221.0/24 is directly connected, GigabitEthernet0/0
L       192.168.221.1/32 is directly connected, GigabitEthernet0/0
R    192.168.222.0/24 [120/1] via 172.16.1.1, 00:00:03, GigabitEthernet0/2
```

[120/1]

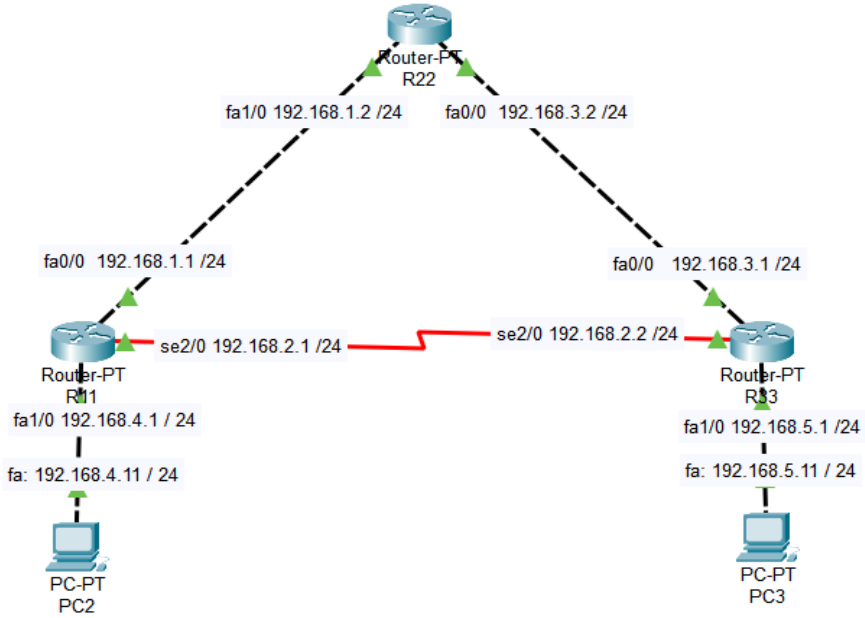
120: administrative distance

1: metric 度量值

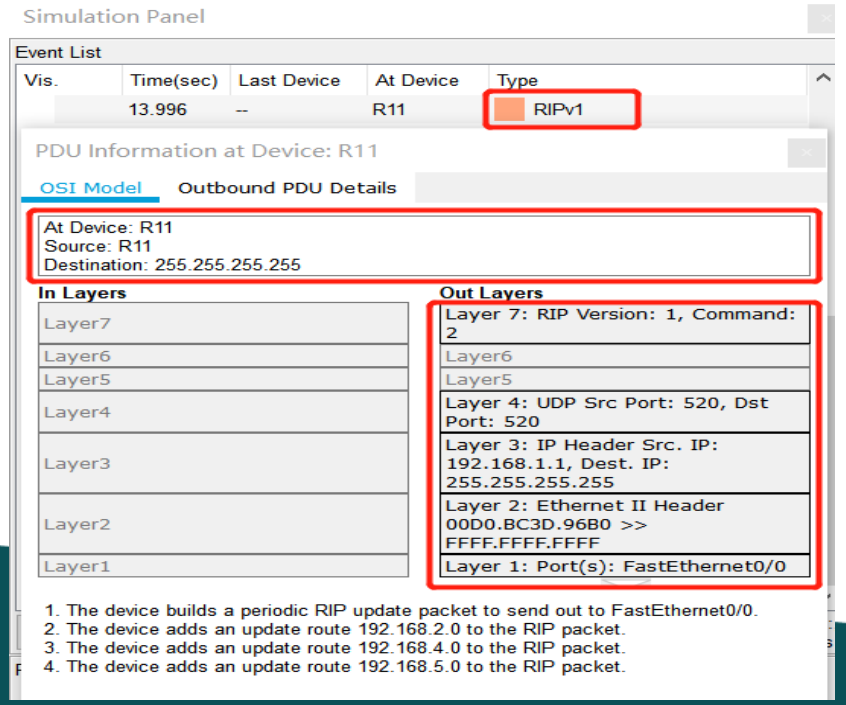
RIP(3)

Q: which router in the network has following routing-table?

Q: using “ping” on R33 to check if “192.168.1.1” is reachable, while ICMP request packet leave from R33, what's its routing path? why?




```
Router#show ip route

R    192.168.1.0/24 [120/1] via 192.168.3.2, 00:00:23, FastEthernet0/0
                    [120/1] via 192.168.2.1, 00:00:18, Serial2/0
C    192.168.2.0/24 is directly connected, Serial2/0
C    192.168.3.0/24 is directly connected, FastEthernet0/0
R    192.168.4.0/24 [120/1] via 192.168.2.1, 00:00:18, Serial2/0
C    192.168.5.0/24 is directly connected, FastEthernet1/0
```



RIP(4)

- More CLI commands
  - R# show ip protocols: display information of the running routing protocol on the router.
  - R# debug ip rip: display routing update packages in real time.

```
Router#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 5 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 1, receive any version
  Interface             Send  Recv  Triggered RIP  Key-chain
  Serial2/0             1     2 1
  FastEthernet0/0       1     2 1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
            192.168.2.0
            192.168.3.0
Passive Interface(s):
Routing Information Sources:
            Gateway         Distance      Last Update
            192.168.2.1          120      00:00:13
            192.168.3.2          120      00:00:00
Distance: (default is 120)
```

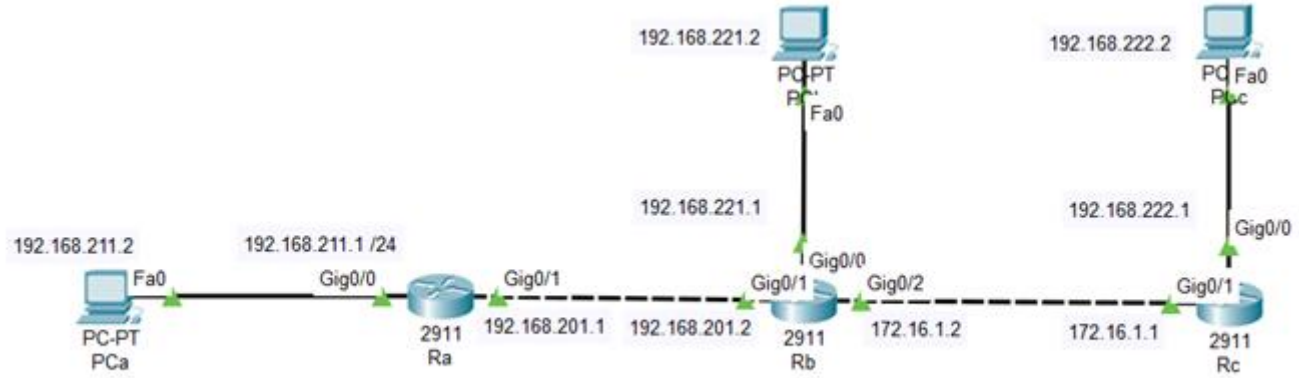
```
Router#debug ip rip
RIP protocol debugging is on
Router#debug ip rip
RIP protocol debugging is on
Router#RIP: received v1 update from 192.168.2.1 on Serial2/0
      192.168.1.0 in 1 hops
      192.168.4.0 in 1 hops
RIP: received v1 update from 192.168.3.2 on FastEthernet0/0
      192.168.1.0 in 1 hops
      192.168.4.0 in 2 hops
RIP: sending  v1 update to 255.255.255.255 via Serial2/0 (192.168.2.2)
RIP: build update entries
      network 192.168.3.0 metric 1
RIP: sending  v1 update to 255.255.255.255 via FastEthernet0/0 (192.168.3.1)
RIP: build update entries
      network 192.168.2.0 metric 1
      network 192.168.4.0 metric 2
```

Part D.
OSPF – Open Shortest Path First

- A link-state routing protocol
- OSPF is classified as an Interior Gateway Protocol (IGP)
- Each router maintains a database describing the Autonomous System's topology

https://www.rfc-editor.org/rfc/rfc2328.txt

OSPF(1)




```
router ospf 1
 log-adjacency-changes
 network 192.168.211.0 0.0.0.255 area 0
 network 192.168.201.0 0.0.0.255 area 0
```

```
router ospf 1
 log-adjacency-changes
 network 192.168.201.0 0.0.0.255 area 0
 network 192.168.221.0 0.0.0.255 area 0
 network 172.16.1.0 0.0.0.255 area 0
```

```
log-adjacency-changes
network 172.16.1.0 0.0.0.255 area 0
network 192.168.222.0 0.0.0.255 area 0
network 172.16.11.0 0.0.0.255 area 0
network 172.16.12.0 0.0.0.255 area 0
```

Ra

Physical Config CLI Attributes

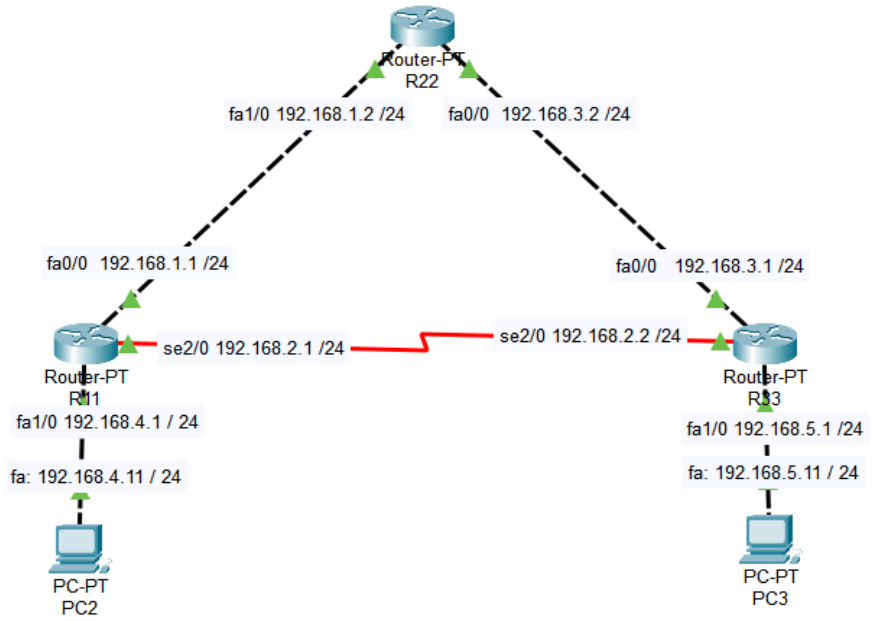
IOS Command Line Interface

```
Ra#show ip rout
Ra#show ip route
Codes: L - local, C - connected, S - static, 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

     172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
O       172.16.1.0/24 [110/2] via 192.168.201.2, 00:10:00, GigabitEthernet0/1
O       172.16.11.1/32 [110/3] via 192.168.201.2, 00:10:00, GigabitEthernet0/1
O       172.16.12.1/32 [110/3] via 192.168.201.2, 00:10:00, GigabitEthernet0/1
     192.168.201.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.201.0/24 is directly connected, GigabitEthernet0/1
L       192.168.201.1/32 is directly connected, GigabitEthernet0/1
     192.168.211.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.211.0/24 is directly connected, GigabitEthernet0/0
L       192.168.211.1/32 is directly connected, GigabitEthernet0/0
O    192.168.221.0/24 [110/2] via 192.168.201.2, 00:10:00, GigabitEthernet0/1
O    192.168.222.0/24 [110/3] via 192.168.201.2, 00:10:00, GigabitEthernet0/1

Ra#
```

SUSTech
Southern University
of Science and Technology

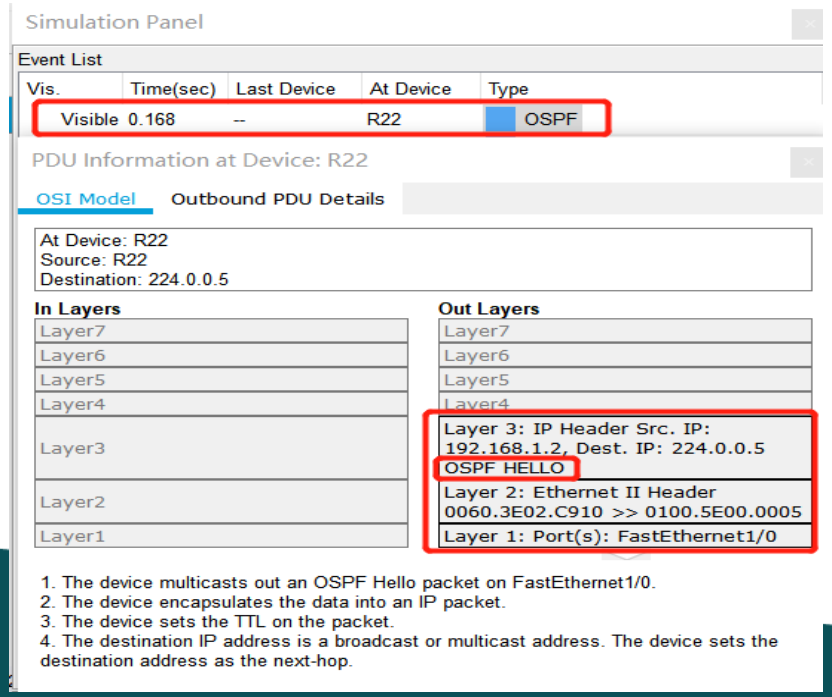
OSPF(2)

```
C    192.168.1.0/24 is directly connected, FastEthernet1/0
O    192.168.2.0/24 [110/65] via 192.168.1.1, 01:51:24, FastEthernet1/0
                    [110/65] via 192.168.3.1, 01:51:24, FastEthernet0/0
C    192.168.3.0/24 is directly connected, FastEthernet0/0
O    192.168.4.0/24 [110/2] via 192.168.1.1, 01:51:34, FastEthernet1/0
O    192.168.5.0/24 [110/2] via 192.168.3.1, 01:51:24, FastEthernet0/0
```



Q: which router in the network has following routing-table?

Q: using “ping” on PC2 to check if PC3 is reachable, while ICMP request packet leave from PC2, what's its routing path? why?



SUSTech
Southern University of Science and Technology

Practice 12.1

Build the following network topology, complete the basic configuration, achieve the following functions

① **fa1/0 of R0** is the gateway of **LAN 192.168.2.0/24**. Please set its IP address.

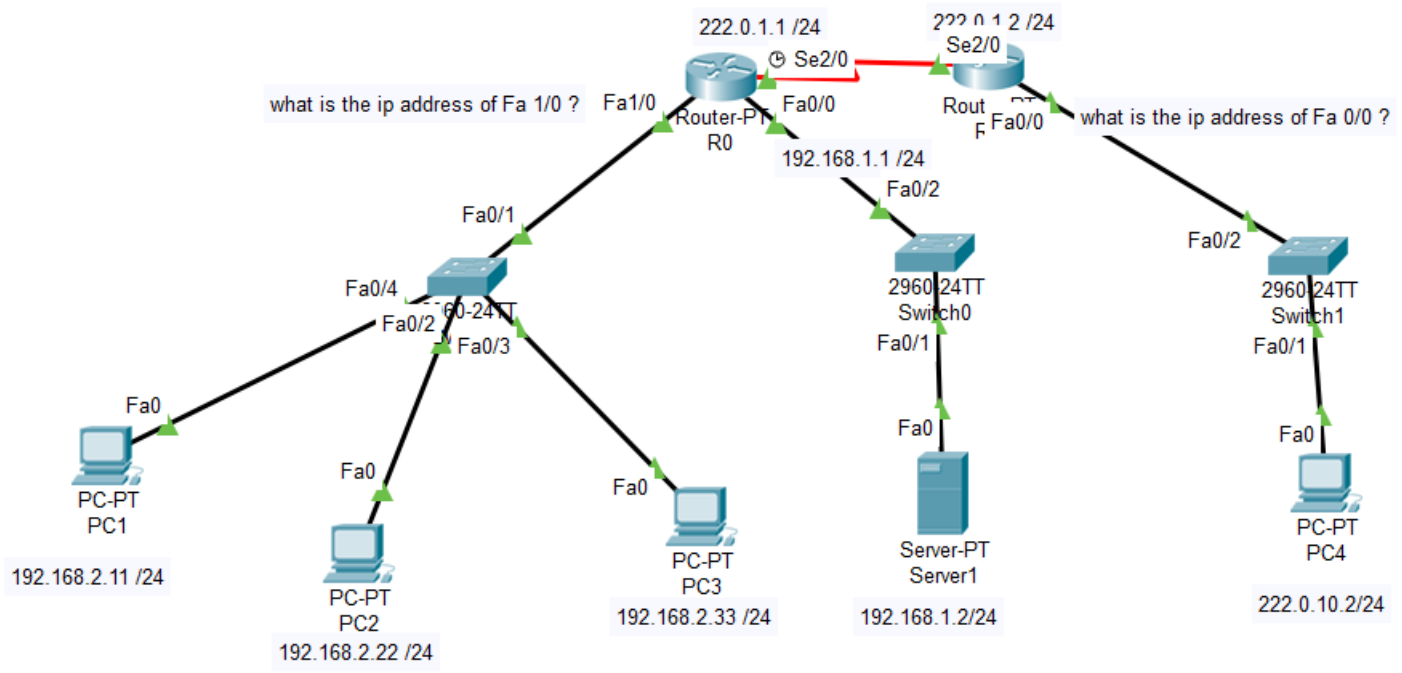
② **fa0/0 of R1** is the gateway of **LAN 222.0.10.0/24**. Please set its IP address.

③ Configure the router

I. By using **static routing**, **192.168.2.0/24** network segment interacts with **222.0.10.0/24** network segment.

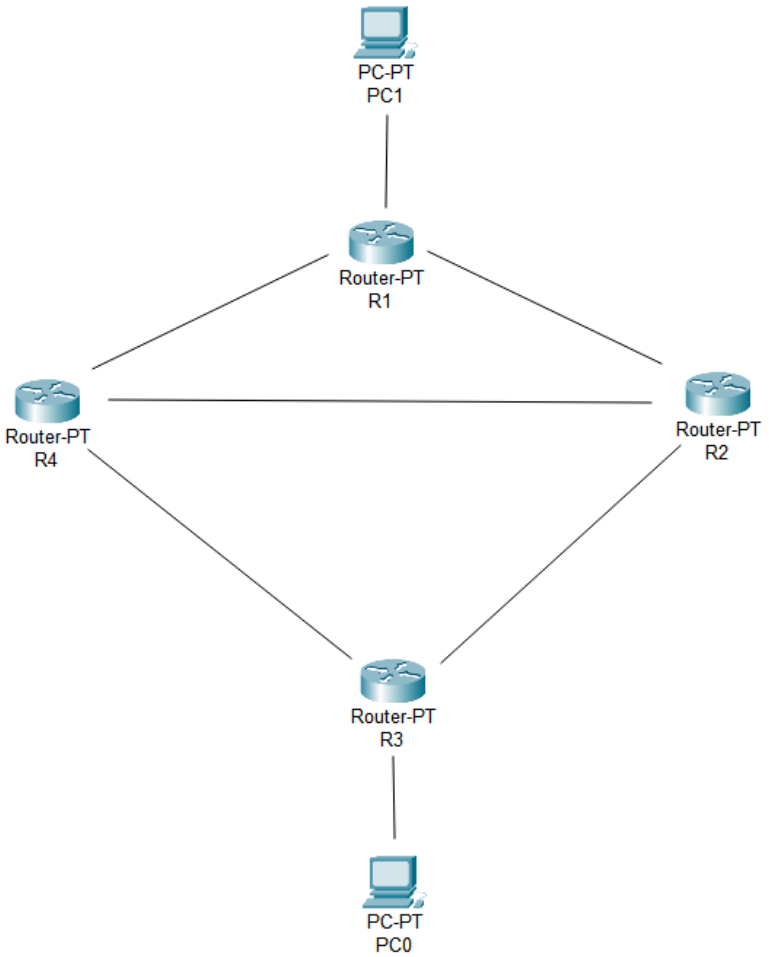
II. Internal IP address **range 192.168.2.11 to 192.168.2.33 dynamically maps** to external available addresses **222.0.1.10 to 222.0.1.15** through **NAT**

III. Web server 192.168.1.2/24 maps to external available address **222.0.1.3/24** through NAT static mapping, so that PC4 can access the server through external IP address.



SUSTech
Southern University
of Science and Technology

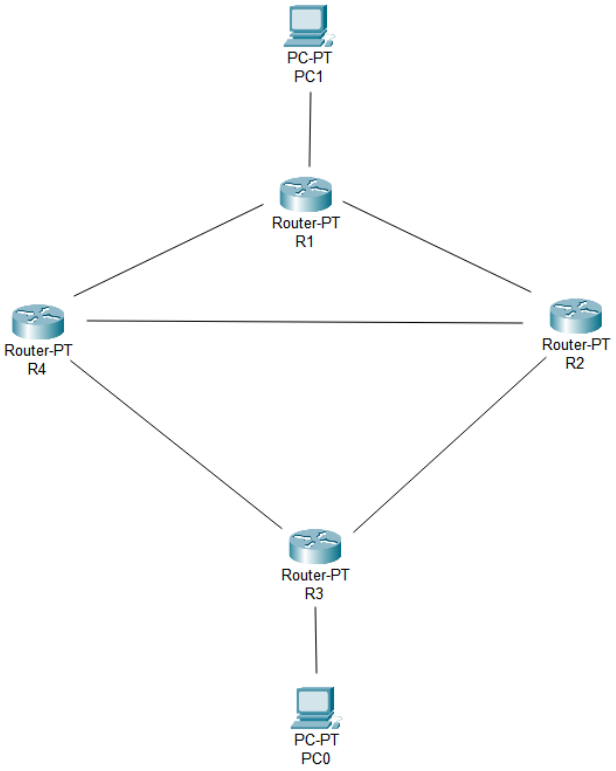
Practice 12.2(1)



Build the network

- Do the configuration on PCs and the interfaces of Routers
  - place notes near the interfaces to displace its IPv4 address.
- Enable and configure RIP protocol on routers
  - make all the nodes(including PCs and Routers) reachable in the network.
  - list the route-table on each routers in the network
  - using "ping" on PC1 to check if PC0 is reachable, while ICMP request packet leave from PC1, what's its routing path? is it the shortest path (here shortest path means minimum hops) between two nodes?
- **Tips**: use *"no router rip"* on router to disable RIP protocol

Practice 12.2(2)



Simulation Panel

Event List

Vis.	Time(sec)	Last Device	At Device	Type
	0.000	--	PC1	ICMP
	0.001	PC1	R1	ICMP
	0.002	R1	R2	ICMP
	0.003	R2	R4	ICMP
	0.004	R4	R3	ICMP
Visible	0.005	R3	PC0	ICMP

Build the network

- Do the configuration on PCs and the interfaces of Routers
  - place notes near the interfaces to displace its IPv4 address.
- Enable and configure OSPF protocol on routers
  - make all the nodes(including PCs and Routers) reachable in the network.
  - list the route-table on each routers
  - using “ping” on PC1 to check if PC0 is reachable, while ICMP request packet leave from PC1, what's its routing path? if the routing path is not “R1->R2->R4->R3”, try to make it.
  - **Tips**: use CLI commands on router interface to change the cost of the links, such as “*bandwidth number*” or *“ip ospf cost number”.*
- List the differences between RIP and OSPF protocol(at least 3 aspects) , using this practice to improve it.