

CS 305 Lab Tutorial

Lecture 12 NAT, RIP, OSPF

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

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

class A 0.0.0.0 - 127.0.0.0	0	NetworkID (7bits)			HostID(24bits)					
class B 128.0.0.0 - 191.255.255.255	1	0	NetworkID (14bits)				HostID(16 bits)			
class C 192.0.0.0 - 223.255.255.255	1	1	0	NetworkID (21bits)				HostID(8 bits)		
class D 224.0.0.0 - 239.255.255.255	1	1	1	0	MulticastGroupID(28bits)					
class E 240.0.0.0 - 247.255.255.255	1	1	1	1	0	Reserved(27bits)				

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.
- CIDR: Classless Inter-domain Routing
 - "classless"
 - hierarchical blocks of IP addresses (referred to as prefixes)
 - /16, /24,

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)

Part B.

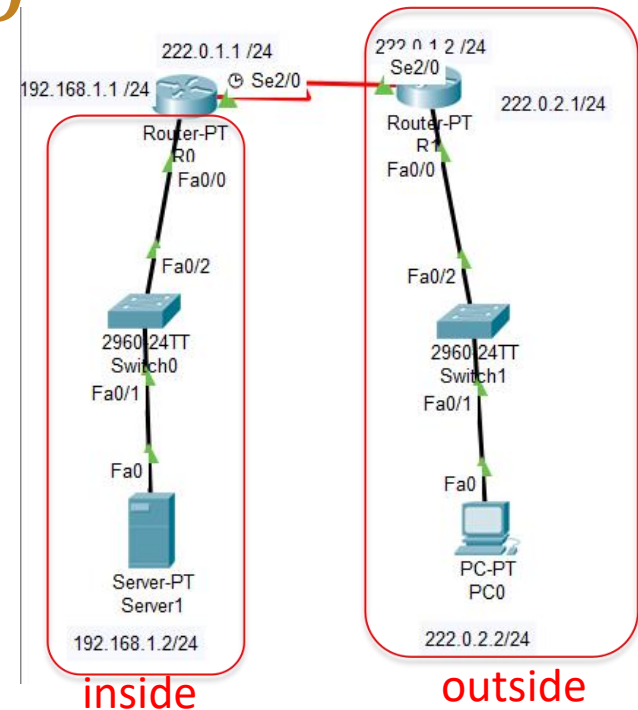
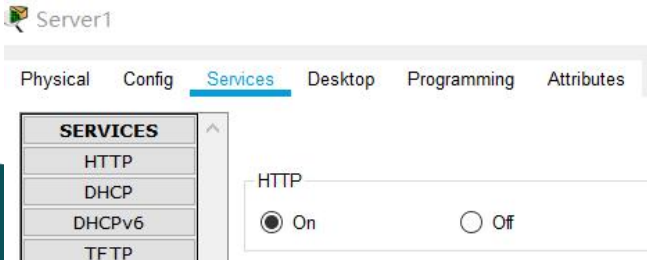
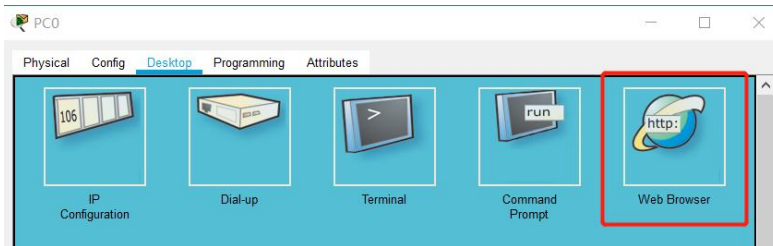
NAT - Network Address Translator

- 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.

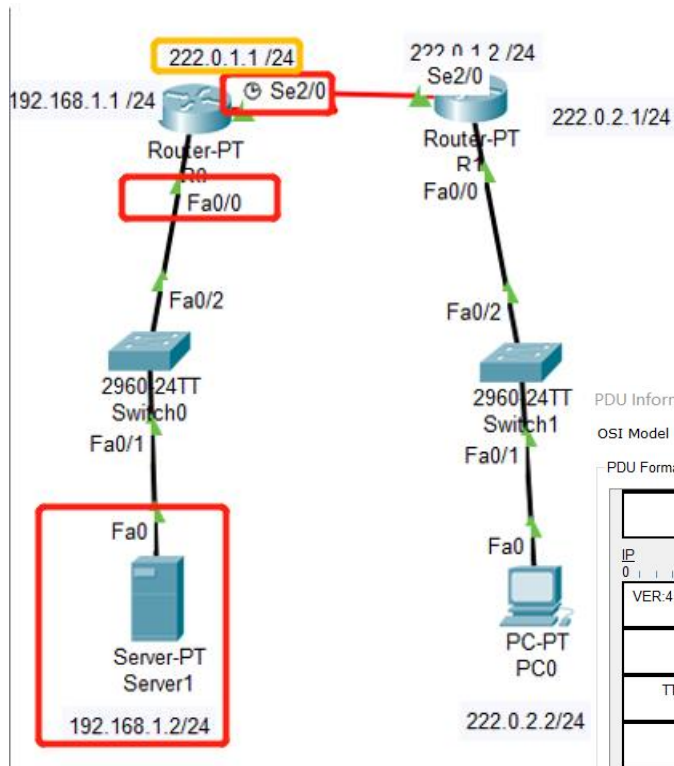
NAT(Static conversion)

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 **mapping 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**



NAT(Static conversion)



```

interface FastEthernet0/0
ip address 192.168.1.1 255.255.255.0
ip nat inside
duplex auto

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
    
```

PDU Information at Device: R0

OSI Model [Inbound PDU Details](#) [Outbound PDU Details](#)

PDU Formats

FCS:0x0000				FLG: 0x7E			
IP							
0	4	8	16	20	24	Bit	
VER:4	IHL	DSCP:0x00	TL:128				
ID:0x000b				FLAGS: 0x0	FRAG OFFSET:0x000		
TTL:127		PRO:0x01		CHKSUM			
SRC IP:222.0.2.2							
DST IP:222.0.1.3							
OPT:0x00000000						PADDING:0x00	
DATA (VARIABLE LENGTH)							

PDU Information at Device: R0

OSI Model [Inbound PDU Details](#) [Outbound PDU Details](#)

PDU Formats

SRC ADDR:0004. 9A31.B208				TYPE: 0 x0800				DATA (VARIABLE LENGTH)				FCS:0x00000000			
IP															
0		4		8		16		20		24		Bits			
VER:4		IHL		DSCP:0x00				TL:128							
ID 0x000b								FLAGS: 0x0		FRAG OFFSET:0x000					
TTL:126				PRO:0x01				CHKSUM							
SRC IP:222.0.2.2															
DST IP:192.168.1.2															
OPT:0x00000000												PADDING:0x00			
DATA (VARIABLE LENGTH)															

ICMP

0		8		16		Bits									
TYPE:0x08				CODE:0x00				CHECKSUM							
ID:0x0003								SEQ NUMBER:5							

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

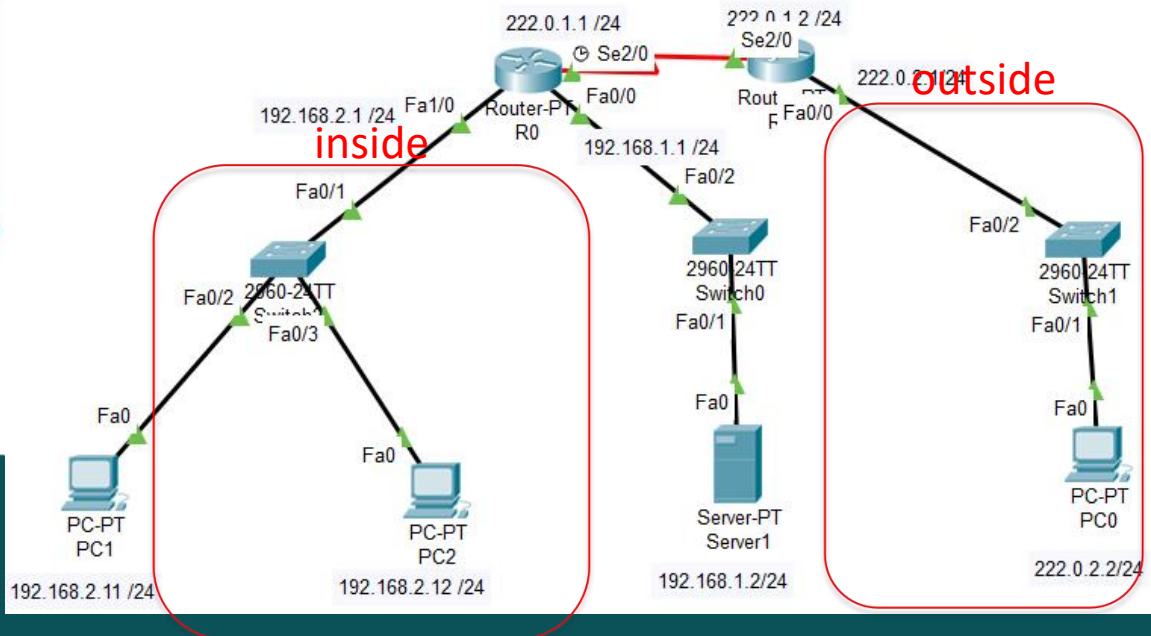
NAT(Dynamic conversion)

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 telecommunications
 - **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)#
```

The diagram illustrates a network setup for NAT. A router (R0) is connected to a switch (Fa0/2) and a server (222.0.1.12). The router has interfaces Fa1/0 and Fa0/1. The switch is labeled 'inside' and has a red box around it. The server is labeled '222.0.1.12'.



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

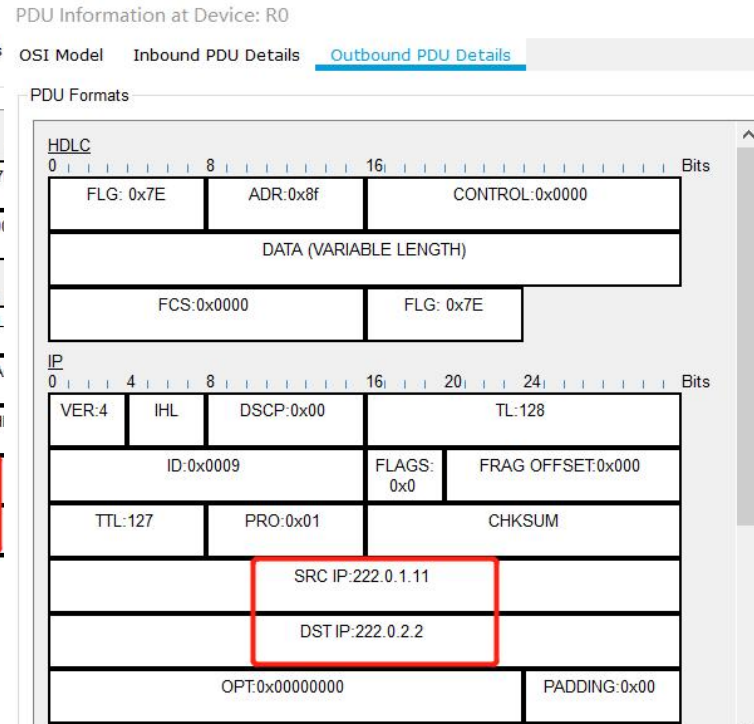
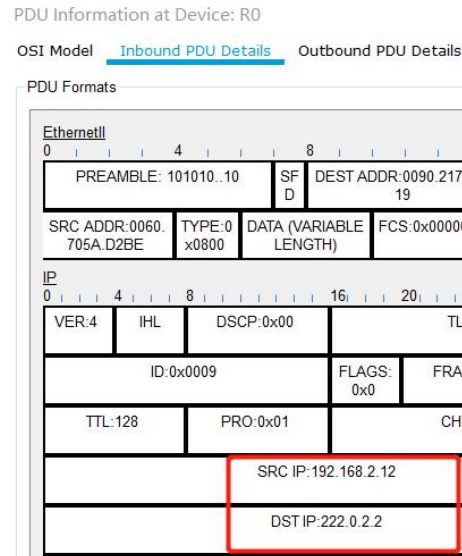
FastEthernet0 Connection: (default port)

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
    
```

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



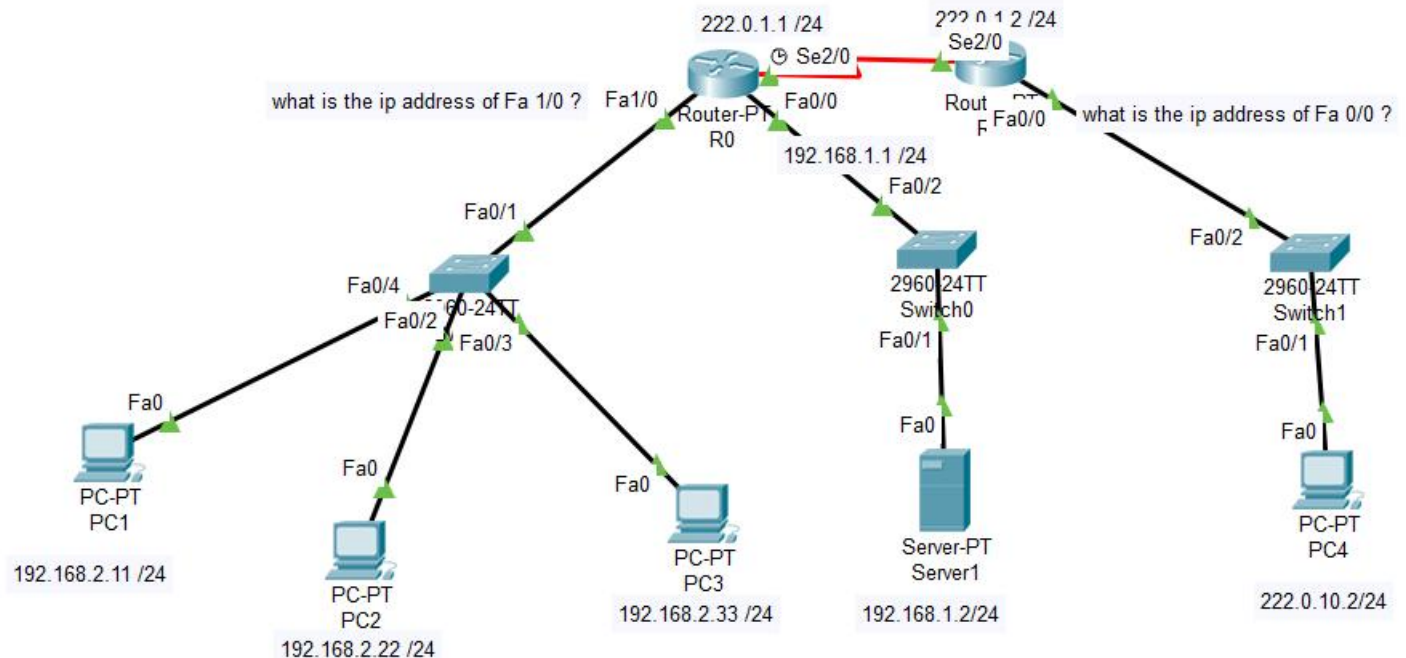
```

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
    
```

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.

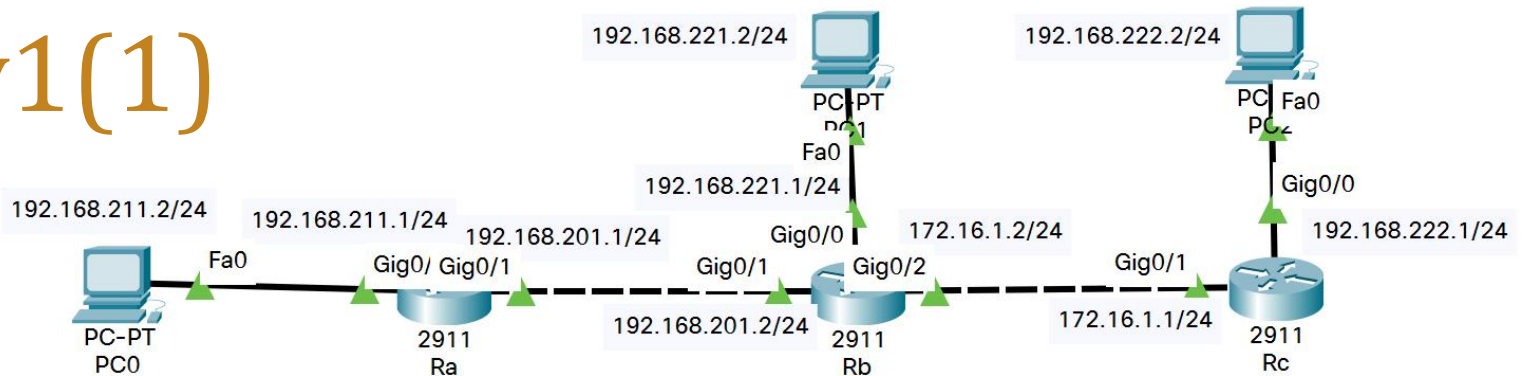


Part C.

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 <https://www.rfc-editor.org/rfc/rfc1058.txt>
- RIP V2 <https://www.rfc-editor.org/rfc/rfc1721.txt>
 <https://www.rfc-editor.org/rfc/rfc1722.txt>

RIPv1(1)



Ra

Physical **Config** CLI Attributes

GLOBAL

- Settings
- Algorithm Settings
- ROUTING**
- Static
- RIP**
- SWITCHING
- VLAN Database

RIP Routing

Network

Add

Network Address

192.168.201.0

192.168.211.0

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

Physical **Config** CLI Attributes

GLOBAL

- Settings
- Algorithm Settings
- ROUTING**
- Static
- RIP**
- SWITCHING
- VLAN Database

RIP Routing

Network

192.168.201.0

Add

Network Address

Rb

Physical **Config** CLI Attributes

GLOBAL

- Settings
- Algorithm Settings
- ROUTING**
- Static
- RIP**
- SWITCHING
- VLAN Database
- INTERFACE**
- GigabitEthernet0/0

RIP Routing

Network

Add

Network Address

172.16.0.0

192.168.201.0

192.168.221.0

Rc

Physical **Config** CLI Attributes

GLOBAL

- Settings
- Algorithm Settings
- ROUTING**
- Static
- RIP**
- SWITCHING
- VLAN Database

RIP Routing

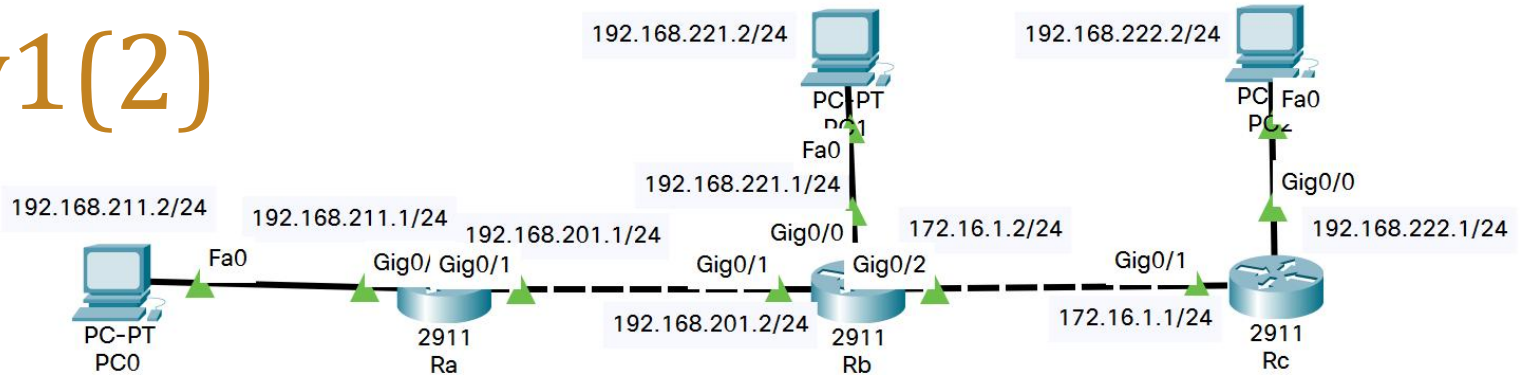
Network

Network Address

172.16.0.0

192.168.222.0

RIPv1(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]

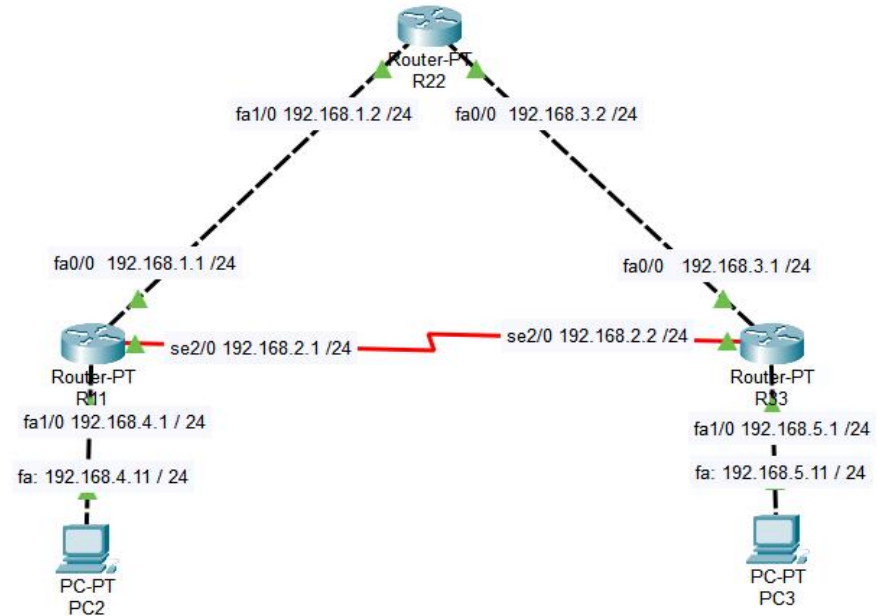
120: administrative distance

1: metric 度量值

RIPv1(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?



Simulation Panel

Event List

Vis.	Time(sec)	Last Device	At Device	Type
	13.996	--	R11	RIPv1

PDU Information at Device: R11

OSI Model Outbound PDU Details

At Device: R11
Source: R11
Destination: 255.255.255.255

In Layers

Layer7
Layer6
Layer5
Layer4
Layer3
Layer2
Layer1

Out Layers

Layer 7: RIP Version: 1, Command: 2
Layer6
Layer5
Layer 4: UDP Src Port: 520, Dst Port: 520
Layer 3: IP Header Src. IP: 192.168.1.1, Dest. IP: 255.255.255.255
Layer 2: Ethernet II Header 00D0.BC3D.96B0 >> FFFF.FFFF.FFFF
Layer 1: Port(s): FastEthernet0/0

1. The device builds a periodic RIP update packet to send out to FastEthernet0/0.
2. The device adds an update route 192.168.2.0 to the RIP packet.
3. The device adds an update route 192.168.4.0 to the RIP packet.
4. The device adds an update route 192.168.5.0 to the RIP packet.

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
```

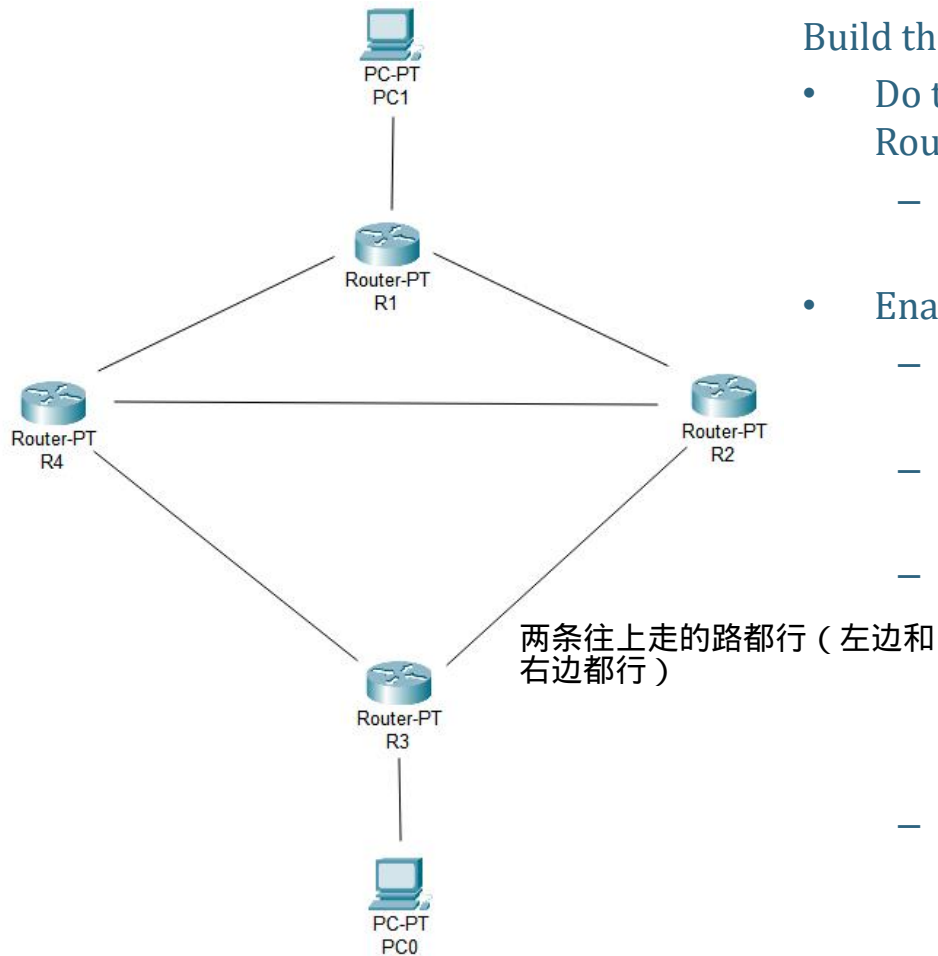

RIPv1(4)

- 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#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
```

```
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)
```


Practice 12.2(1)



Build the network

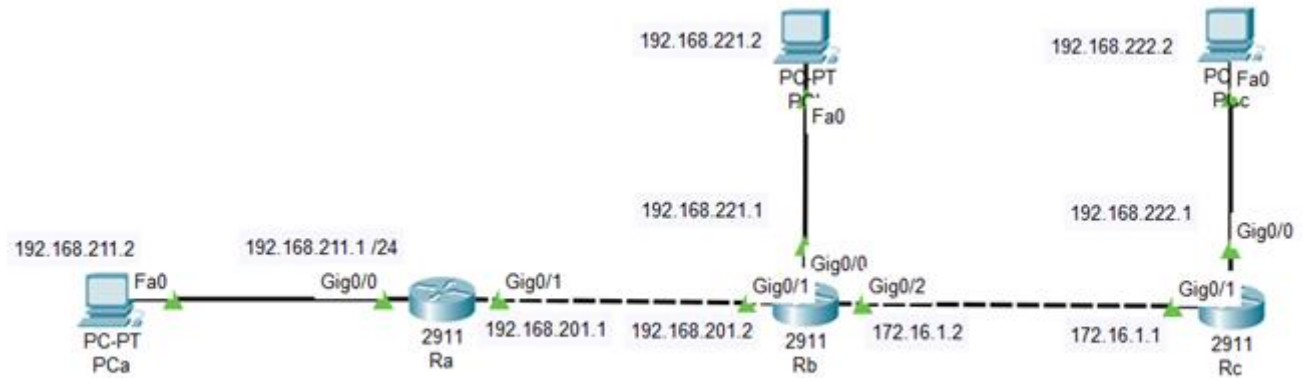
- Do the configuration on PCs and the interfaces of Routers
 - place notes near the interfaces to display its IPv4 address.
- Enable and configure RIP protocol on routers
 - make all the nodes(including PCs and Routers) reachable in the network.
 - list the route-table on each routers in the network
 - 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?
 - Enable RIPv1 version and RIPv2 version respectively, tells the differences between two versions(optional)
- **Tips:** use “no router rip” on router to disable RIP protocol

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

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 route
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#
```

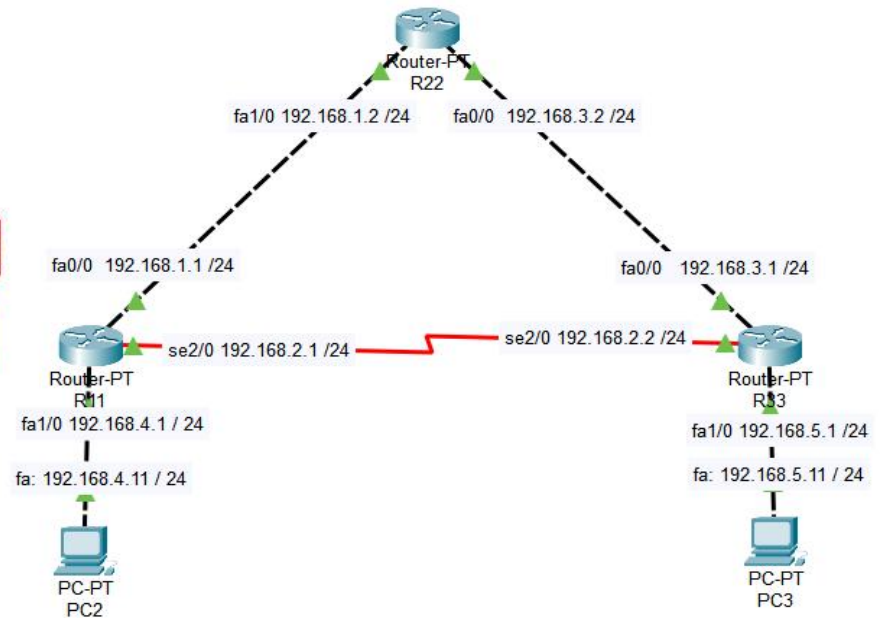
OSPF(2)

```

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?



Simulation Panel

Vis.	Time(sec)	Last Device	At Device	Type
Visible	0.168	--	R22	OSPF

PDU Information at Device: R22

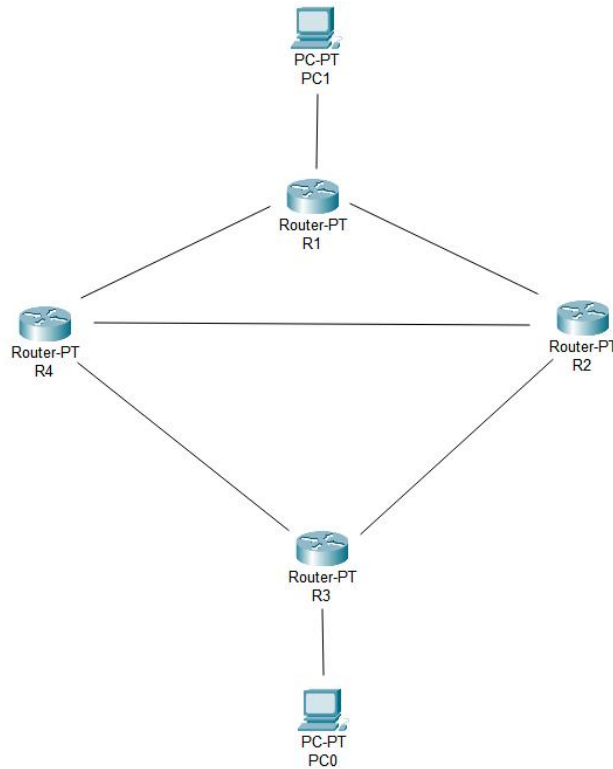
OSI Model Outbound PDU Details

At Device: R22
Source: R22
Destination: 224.0.0.5

In Layers	Out Layers
Layer7	Layer7
Layer6	Layer6
Layer5	Layer5
Layer4	Layer4
Layer3	Layer3: IP Header Src. IP: 192.168.1.2, Dest. IP: 224.0.0.5 OSPF HELLO
Layer2	Layer2: Ethernet II Header 0060.3E02.C910 >> 0100.5E00.0005
Layer1	Layer1: Port(s): FastEthernet1/0

1. The device multicasts out an OSPF Hello packet on FastEthernet1/0.
2. The device encapsulates the data into an IP packet.
3. The device sets the TTL on the packet.
4. The destination IP address is a broadcast or multicast address. The device sets the destination address as the next-hop.

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 display 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 router
 - 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.