

REVISED PACKET TRACER (4) – CONNECTION AMONG ROUTERS

The Internet Structure is referred to as a Network of Networks in **Chapter 1 - Introduction**. In our previous works, we built a network on a small scale. In this work, we create an improved version that connects among geographically scattered routers in this study.

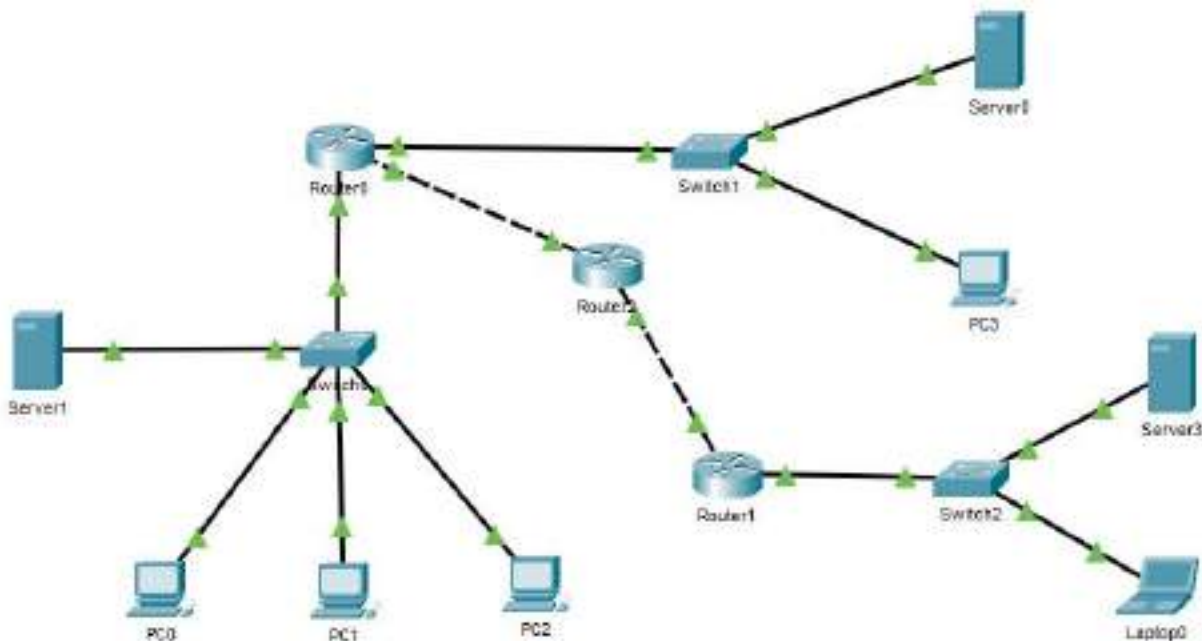


Figure 1 Inter (sub)network connection



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I. Overview

We create a network connect inter AS and each AS has some area routers as the

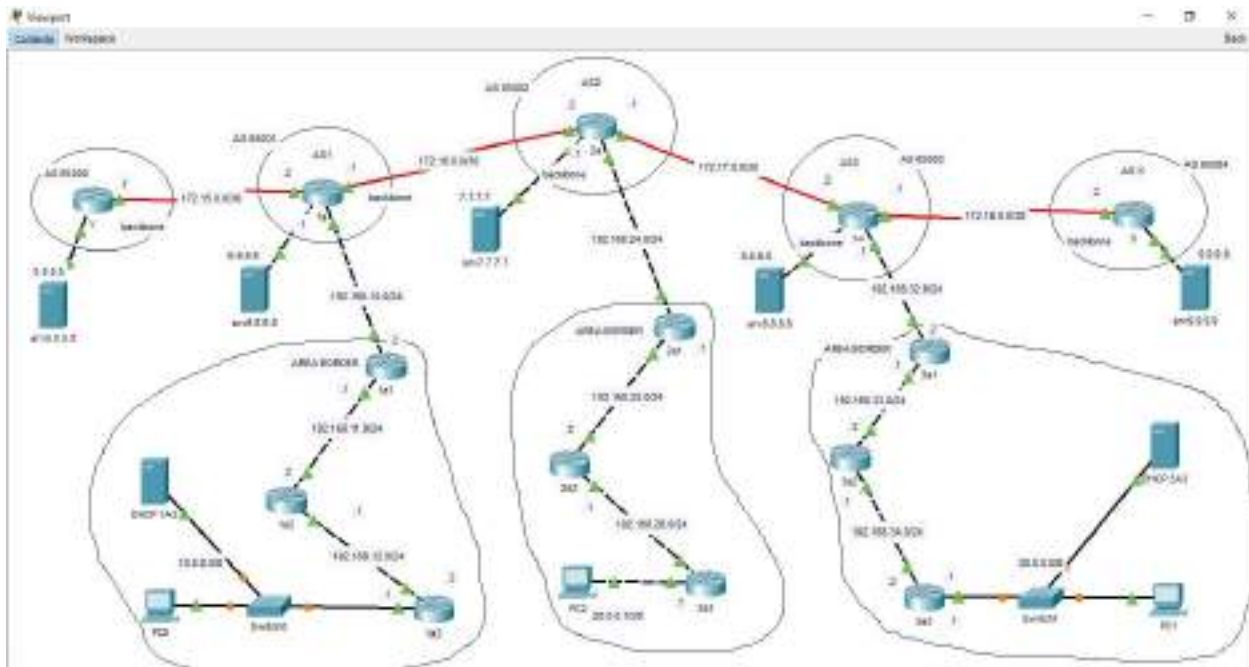


Figure 2 System overview

II. Background

This experiment is based on the theory sample network in “Chapter 5: Network Layer Control Plane”.

a. BGP connectivities among backbone.

In this chapter, BGP (Border Gateway Protocol) is described as the de facto inter-domain routing protocol as “glue that holds the Internet together”

- eBGP: obtain subnet reachability information from neighboring ASes
- iBGP: propagate reachability information to all A S-internal routers.

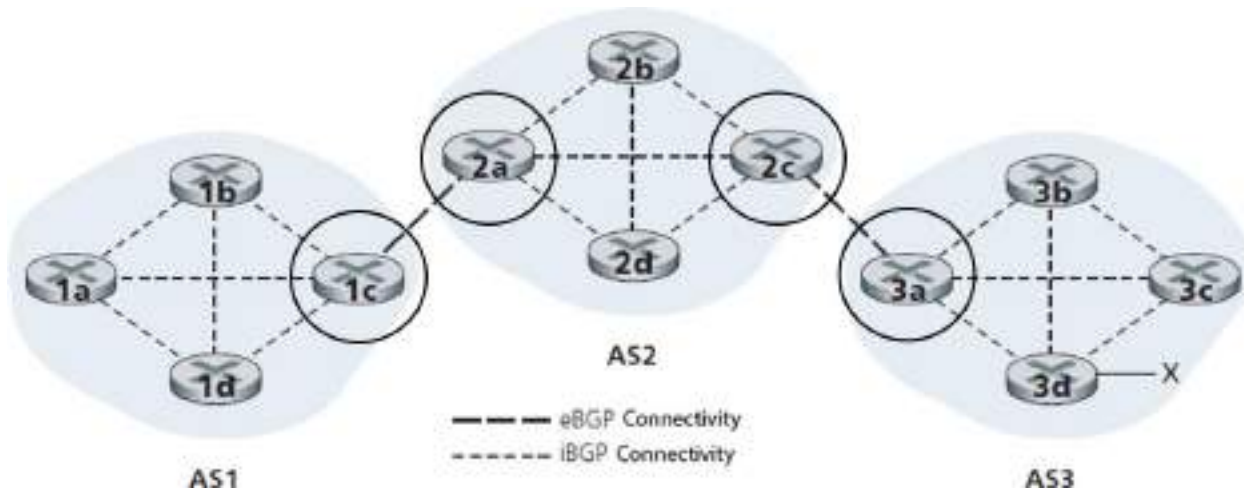


Figure 3 BGP Connections

We don't have an implementation of iBGP because the Packet Tracer simulation environment's support is limited instead, we designed each AS to be represented by a backbone router, and the connection between these backbone routers is made by eBGP as in Figure 4.

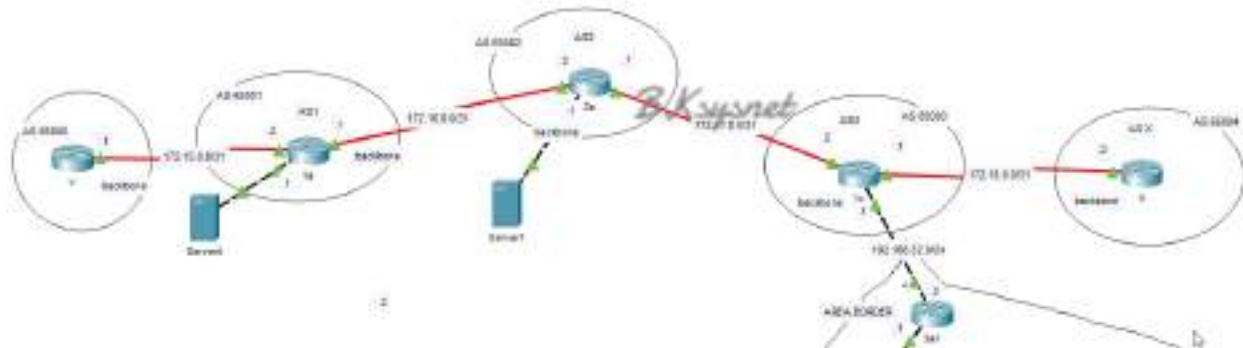


Figure 4 Inter-AS routing

b. Area connectivities with link-state advertisements

In two-level hierarchy: the network of router is divided into 2 levels local area and backbone.

- link-state advertisements only in area
- each nodes has detailed area topology; only know direction (shortest path) to nets in other areas.

Area border routers: “summarize” distances to nets in own area, advertise to other Area Border routers. Backbone routers: run OSPF routing limited to backbone

Due to the simulation tool's limited computing capacity, we restricted each area in this experiment to having only one area border and skipped these advertisements between area borders in the same AS. The backbone routers act as boundary router to and hence, they connect to other Ass.

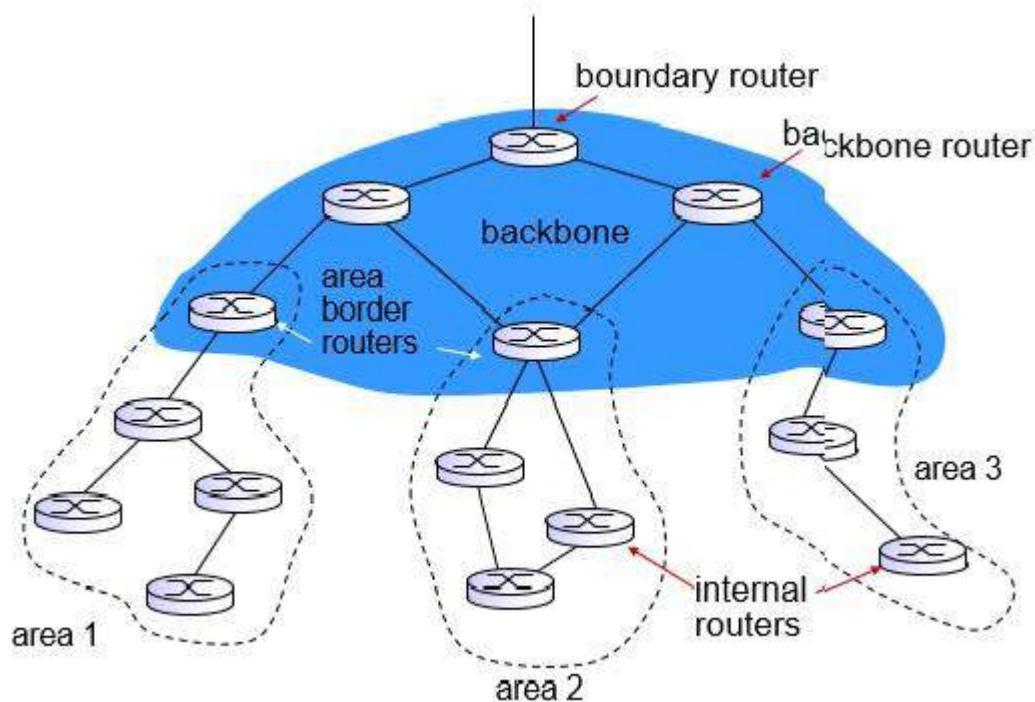


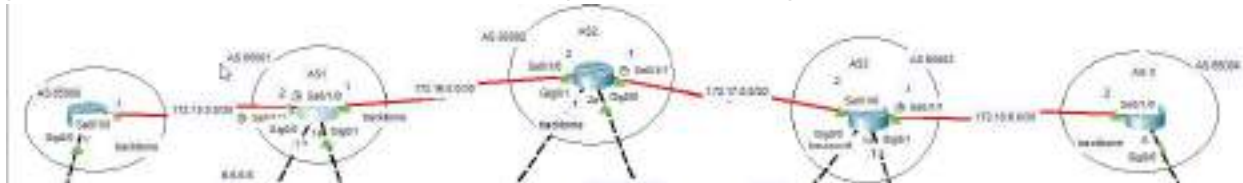
Figure 5 Hierarchical OSPF

III. Hardware Plugin

The router need to add more connection port in order to implement our experiment model.

a. Add Router serial port

We use the router model 1941 in this lab. By default, this model comes with 2 Gigabit Ethernet ports. We need to add the HWIC-2T which provides 2 serial ports.



Add the module HWIC-2T to the router named Y, 1a, 2a, 3a and X
And then, connect them serially by serial port cable.

1a


Physical Config CLI Attributes

MODULES

- HWIC-1GE-SFP
- HWIC-2T**
- HWIC-4ESW
- HWIC-8A
- WIC-Cover
- GLC-LH-SMD

Physical Device View

Zoom In Original Size Zoom Out




Remember to power-off device BEFORE plugging-in card

Remember to power-on the device AFTER plugging-in card

Customize Icon in Physical View Customize Icon in Logical View

The HWIC-2T is a Cisco 2-Port Serial High-Speed WAN Interface Card, providing 2 serial ports.

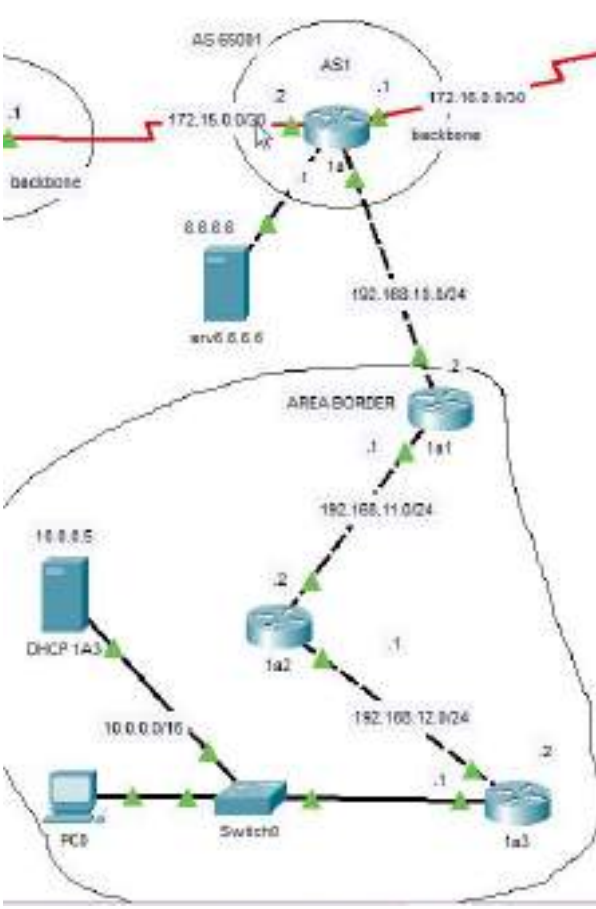


☐ Top

IV. IP Address configuration

a. AS 1 (65001)

Router

Diagram	Configurations
	<p>Srv6.6.6.6:</p> <ul style="list-style-type: none"> - IP 6.6.6.6/8 - Default gateway 6.6.6.1/8 (/8 netmask 255.0.0.0) <p>Router 1a (Model 1941):</p> <ul style="list-style-type: none"> - Serial 0/1/0: 172.15.0.2/30 - Serial 0/1/1: 172.16.0.1/30 - GigE 0/0 6.6.6.1/8 - GigE 0/1: 192.168.10.1/24 <p>(*Hint* if you are missing serial ports, you missed the previous step of installing extension module)</p> <p>(/30 netmask 255.255.255.252) (/16 netmask 255.255.0.0) (/8 netmask 255.0.0.0) (/24 netmask 255.255.255.0)</p> <p>Router 1a1 (Model 1941), port index is flexible based on your connection</p> <ul style="list-style-type: none"> - GigE to 1a: 192.168.10.2/24 - GigE to 1a2: 192.168.11.1/24 <p>Router 1a2 (Model 1941), port index is flexible based on your connection</p> <ul style="list-style-type: none"> - GigE to 1a1: 192.168.11.2/24 - GigE to 1a3: 192.168.12.1/24 <p>Router 1a3 (Model 1941), port index is flexible based on your connection</p> <ul style="list-style-type: none"> - GigE to 1a2: 192.168.12.2/24 - GigE to Switch0: 10.0.0.1/16



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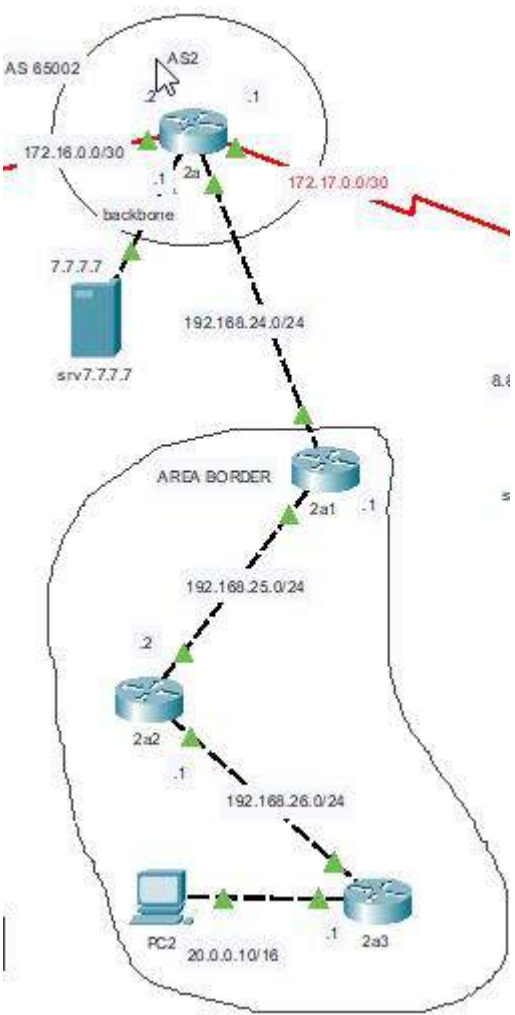
Computer Network 1 – Revised Packet Tracer

Subnet:

Item	IP	Other configurations
Switch0	N/A	N/A
DHCP Server 1A3	10.0.0.5/16	DHCP server Default Gateway: 10.0.0.1 Start 10.0.0.100 Mask 255.255.0.0 Number of IP address 10000
PC0	DHCP Client	N/A

b. AS 2 (65002)

Diagram	Configurations
---------	----------------



Srv7.7.7.7:

- IP 7.7.7.7/8
- Default gateway 7.7.7.1/8 (/8 netmask 255.0.0.0)

Router 1a (Model 1941):

- Serial 0/1/0: 172.16.0.2/30
- Serial 0/1/1: 172.17.0.1/30
- GigE 0/0 7.7.7.1/8
- GigE 0/1: 192.168.24.1/24

(*Hint* if you are missing serial ports, you missed the previous step of installing extension module)

(/30 netmask 255.255.255.252)
(/16 netmask 255.255.0.0)
(/8 netmask 255.0.0.0)
(/24 netmask 255.255.255.0)

Router 2a1 (Model 1941), port index is flexible based on your connection

- GigE to 1a: 192.168.24.2/24
- GigE to 1a2: 192.168.25.1/24

Router 2a2 (Model 1941), port index is flexible based on your connection

- GigE to 1a1: 192.168.25.2/24
- GigE to 1a3: 192.168.26.1/24

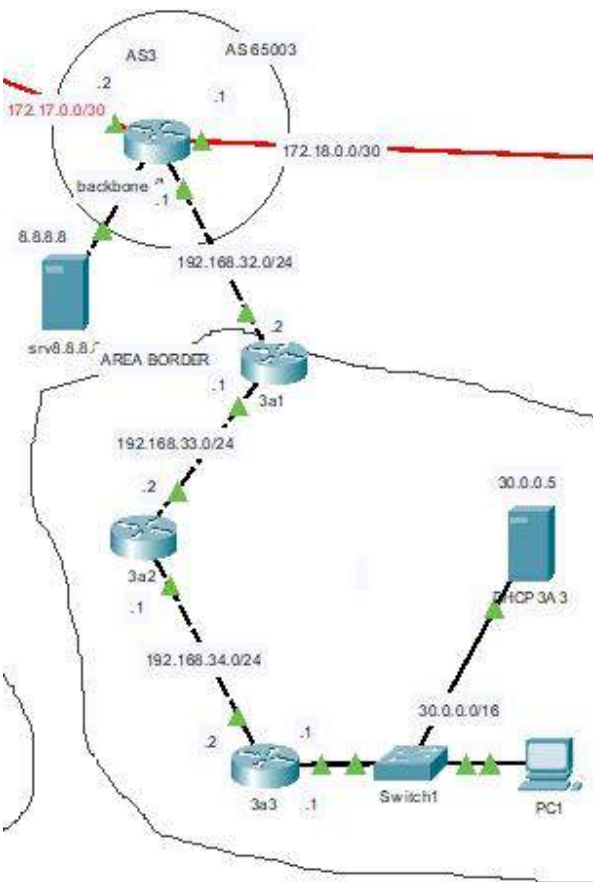
Router 1a3 (Model 1941), port index is flexible based on your connection

- GigE to 1a2: 192.168.26.2/24
- GigE to PC2: 20.0.0.1/16

Subnet:

Item	IP	Other configurations
PC2	20.0.0.10/16	N/A

c. AS 3 (65003)

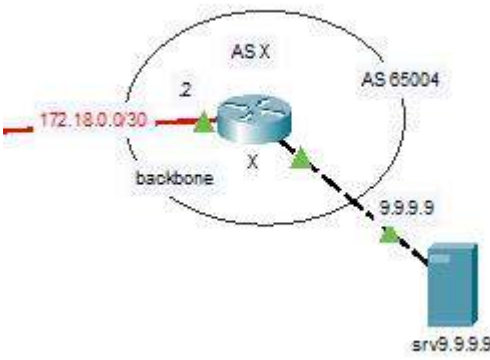
Diagram	Configurations
	<p>Srv8.8.8.8:</p> <ul style="list-style-type: none"> - IP 8.8.8.8/8 - Default gateway 8.8.8.1/8 (/8 netmask 255.0.0.0) <p>Router 3a (Model 1941):</p> <ul style="list-style-type: none"> - Serial 0/1/0: 172.17.0.2/30 (/30 netmask 255.255.252) - Serial 0/1/1: 172.18.0.1/30 (/16 netmask 255.255.0.0) - GigE 0/0 8.8.8.1/8 (/8 netmask 255.0.0.0) - GigE 0/1: 192.168.32.1/24 (/24 netmask 255.255.255.0) <p>Router 3a1 (Model 1941), port index is flexible based on your connection</p> <ul style="list-style-type: none"> - GigE to 1a: 192.168.32.2/24 - GigE to 1a2: 192.168.33.1/24 <p>Router 3a2 (Model 1941), port index is flexible based on your connection</p> <ul style="list-style-type: none"> - GigE to 1a1: 192.168.33.2/24 - GigE to 1a3: 192.168.34.1/24 <p>Router 1a3 (Model 1941), port index is flexible based on your connection</p> <ul style="list-style-type: none"> - GigE to 1a2: 192.168.34.2/24 - GigE to Switch0: 30.0.0.1/16

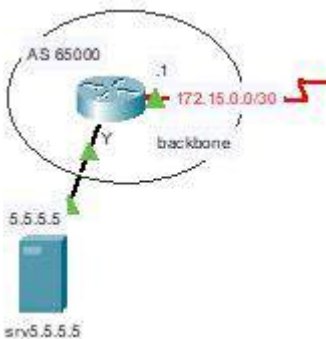


Subnet:

Item	IP	Other configurations
Switch0	N/A	N/A
DHCP Server 3A3	30.0.0.5/16	DHCP server Default Gateway: 30.0.0.1 Start 30.0.0.100 Mask 255.255.0.0 Number of IP address 10000
PC3	DHCP Client	N/A

d. AS X and AS Y

Diagram	Configurations
	<p>Srv9.9.9.9:</p> <ul style="list-style-type: none">- IP 9.9.9.9/8- Default gateway 9.9.9.1/8 (/8 netmask 255.0.0.0) <p>Router X (Model 1941):</p> <ul style="list-style-type: none">- Serial 0/1/0: 172.18.0.2/30- Sercial 0/1/1: <not set>- GigE 0/0 9.9.9.1/8- GigE 0/1: <not set> <p>(*Hint* if you are missing serial ports, you missed the previous step of installing extension module) (/30 netmask 255.255.255.252) (/16 netmask 255.255.0.0) (/8 netmask 255.0.0.0) (/24 netmask 255.255.255.0)</p>

	<p>Srv5.5.5.5:</p> <ul style="list-style-type: none"> - IP 5.5.5.5/8 - Default gateway 5.5.5.1/8 (/8 netmask 255.0.0.0) <p>Router X (Model 1941):</p> <ul style="list-style-type: none"> - Serial 0/1/0: 172.15.0.1/30 - Serial 0/1/1: <not set> - GigE 0/0 5.5.5.1/8 - GigE 0/1: <not set> <p>(*Hint* if you are missing serial ports, you missed the previous step of installing extension module)</p> <p>(/30 netmask 255.255.255.252) (/16 netmask 255.255.0.0) (/8 netmask 255.0.0.0) (/24 netmask 255.255.255.0)</p>
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Verification of IP Address:

The IP validation can be verified by ping between the two direct connect nodes. Verify all the IP addresses before doing the next step.

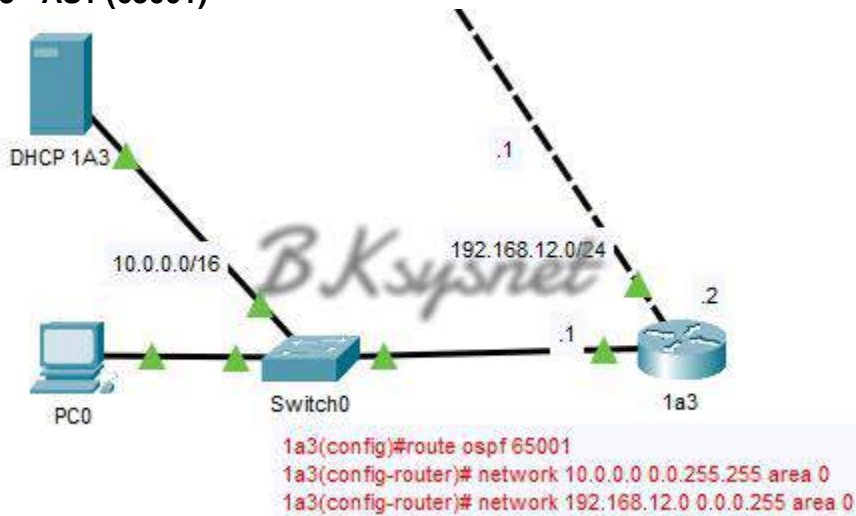
V. Routing Configuration

There are 4 types of router:

- Backbone routers
- Area border routers
- Area routers
- Edge routers

a. Edge routers:

1a3 - AS1 (65001)

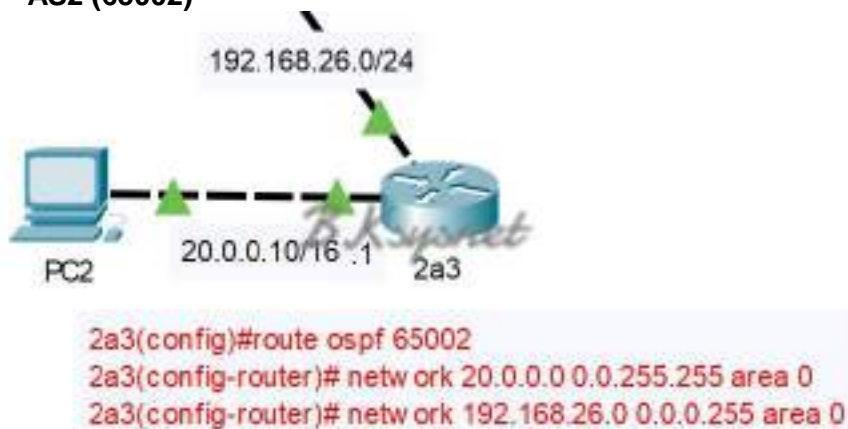


```
1a3(config)#route ospf 65001
```

```
1a3(config-router)# network 10.0.0.0 0.255.255.255 area 0
```

```
1a3(config-router)# network 192.168.12.0 0.0.0.255 area 0
```

2a3 – AS2 (65002)

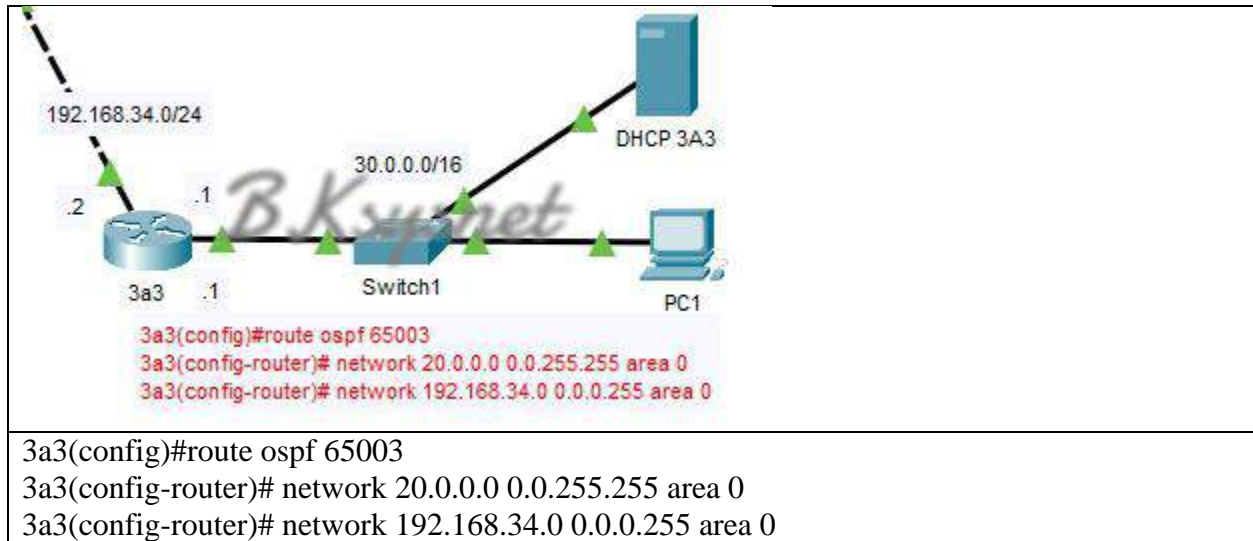


```
2a3(config)#route ospf 65002
```

```
2a3(config-router)# network 20.0.0.0 0.0.255.255 area 0
```

```
2a3(config-router)# network 192.168.26.0 0.0.0.255 area 0
```

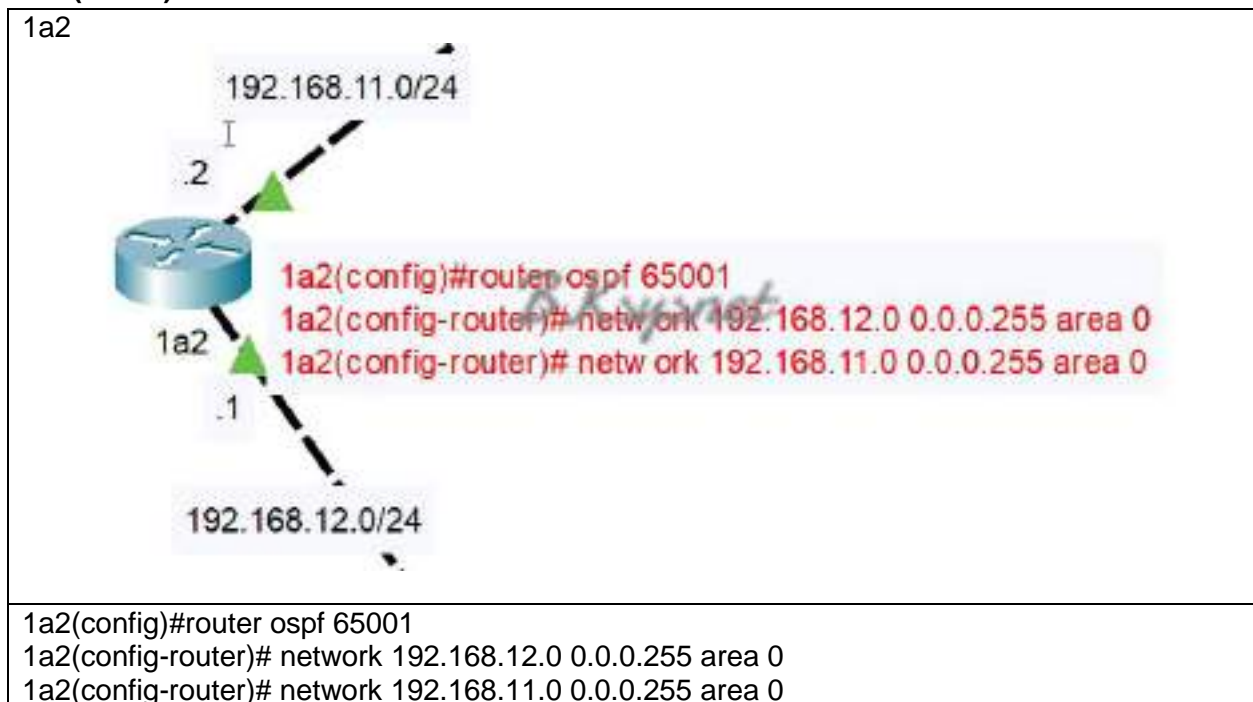
3a3 – AS3 (65003)



b. Area and area border routers:

Area router is named XaY where X is AS number and Y is the indexing number.

AS1 (65001)





1a1



```
1a1(config)#router ospf 65001
1a1(config-router)# network 192.168.10.0 0.0.0.255 area 0
1a1(config-router)# network 192.168.11.0 0.0.0.255 area 0
```

AS2 (65002)

2a2



```
2a2(config)#router ospf 65002
2a2(config-router)# network 192.168.25.0 0.0.0.255 area 0
2a2(config-router)# network 192.168.26.0 0.0.0.255 area 0
```




2a1



```
2a1(config)#router ospf 65002
2a1(config-router)# network 192.168.24.0 0.0.0.255 area 0
2a1(config-router)# network 192.168.25.0 0.0.0.255 area 0
```

AS3 (65003)

3a2



```
3a2(config)#router ospf 65003
3a2(config-router)# network 192.168.33.0 0.0.0.255 area 0
3a2(config-router)# network 192.168.34.0 0.0.0.255 area 0
```

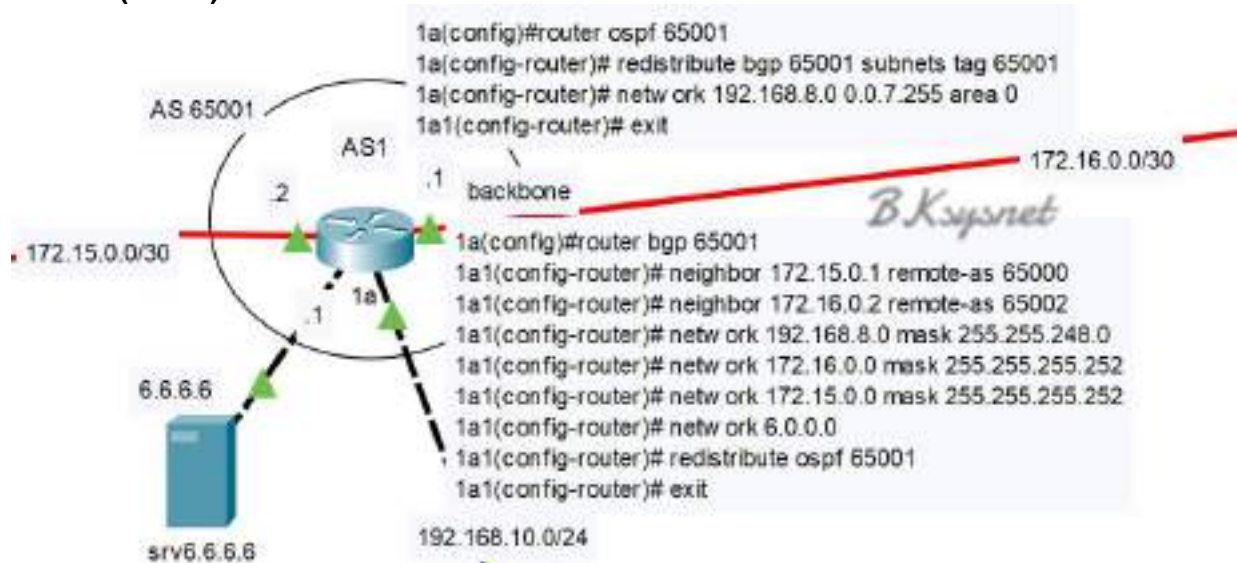
3a1



```
3a1(config)#router ospf 65003
3a1(config-router)# network 192.168.32.0 0.0.0.255 area 0
3a1(config-router)# network 192.168.33.0 0.0.0.255 area 0
```

c. Backbone routers

1a-AS1 (65001)



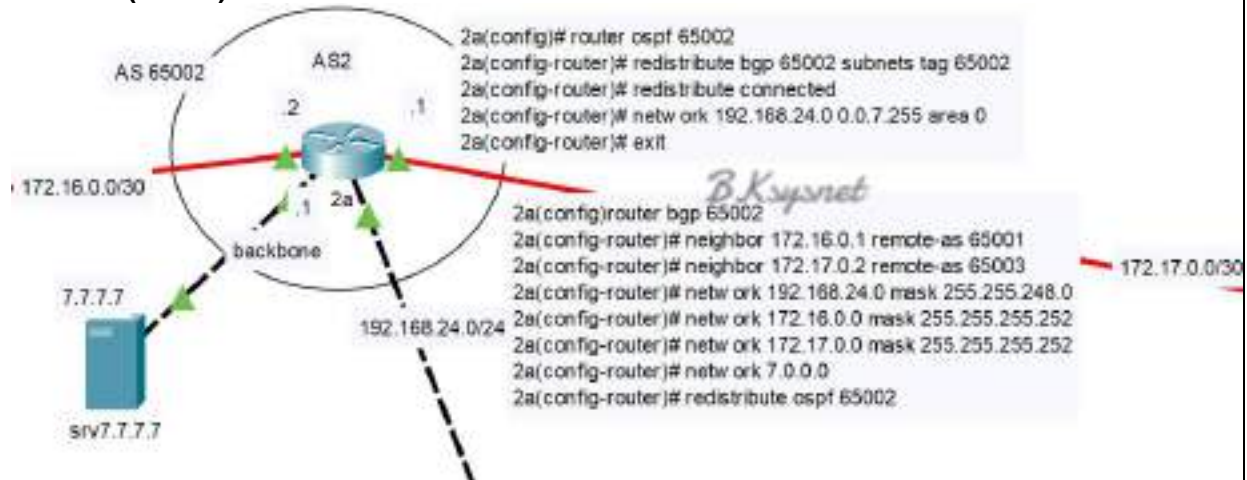
```
1a(config)#router ospf 65001
1a(config-router)# redistribute bgp 65001 subnets tag 65001
1a(config-router)# network 192.168.8.0 0.0.7.255 area 0
1a1(config-router)# exit
```

```
1a1(config)#router bgp 65001
1a1(config-router)# neighbor 172.15.0.1 remote-as 65000
1a1(config-router)# neighbor 172.16.0.2 remote-as 65002
```



```
1a1(config-router)# network 192.168.8.0 mask 255.255.248.0
1a1(config-router)# network 172.16.0.0 mask 255.255.255.252
1a1(config-router)# network 172.15.0.0 mask 255.255.255.252
1a1(config-router)# network 6.0.0.0
1a1(config-router)# redistribute ospf 65001
1a1(config-router)# exit
```

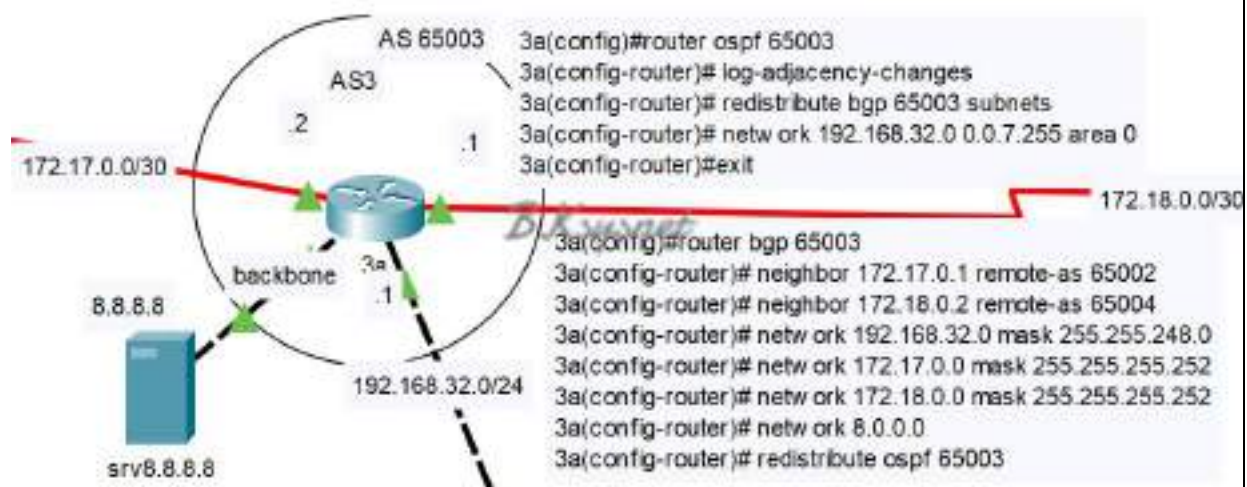
2a- AS3 (65002)



```
2a(config)# router ospf 65002
2a(config-router)# redistribute bgp 65002 subnets tag 65002
2a(config-router)# redistribute connected
2a(config-router)# network 192.168.24.0 0.0.7.255 area 0
2a(config-router)# exit
```

```
2a(config)# router bgp 65002
2a(config-router)# neighbor 172.16.0.1 remote-as 65001
2a(config-router)# neighbor 172.17.0.2 remote-as 65003
2a(config-router)# network 192.168.24.0 mask 255.255.248.0
2a(config-router)# network 172.16.0.0 mask 255.255.255.252
2a(config-router)# network 172.17.0.0 mask 255.255.255.252
2a(config-router)# network 7.0.0.0
2a(config-router)# redistribute ospf 65002
```

3a- AS3 (65003)



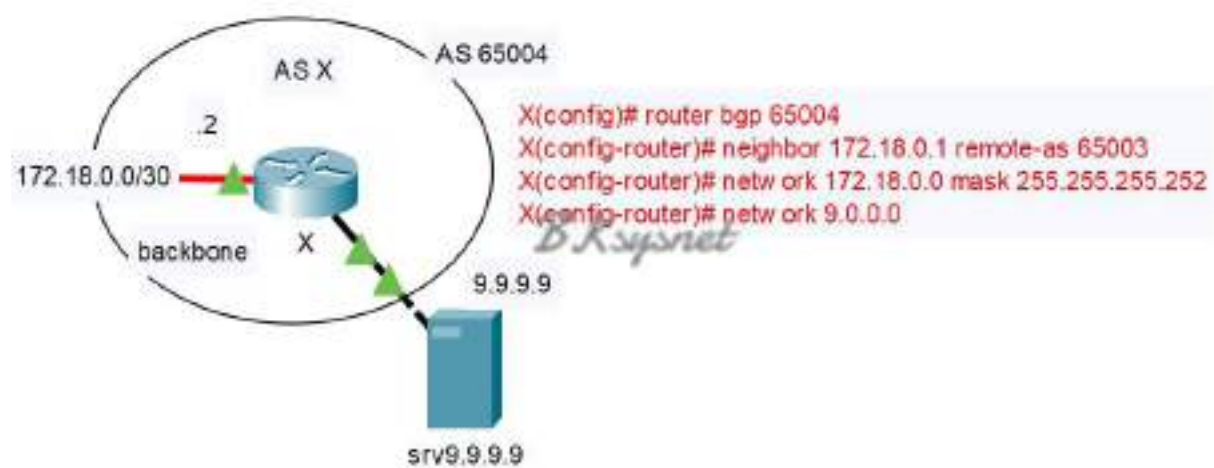
```

3a(config)#router ospf 65003
3a(config-router)# log-adjacency-changes
3a(config-router)# redistribute bgp 65003 subnets
3a(config-router)# network 192.168.32.0 0.0.7.255 area 0
3a(config-router)#exit
  
```

```

3a(config)#router bgp 65003
3a(config-router)# neighbor 172.17.0.1 remote-as 65002
3a(config-router)# neighbor 172.18.0.2 remote-as 65004
3a(config-router)# network 192.168.32.0 mask 255.255.248.0
3a(config-router)# network 172.17.0.0 mask 255.255.255.252
3a(config-router)# network 172.18.0.0 mask 255.255.255.252
3a(config-router)# network 8.0.0.0
3a(config-router)# redistribute ospf 65003
  
```

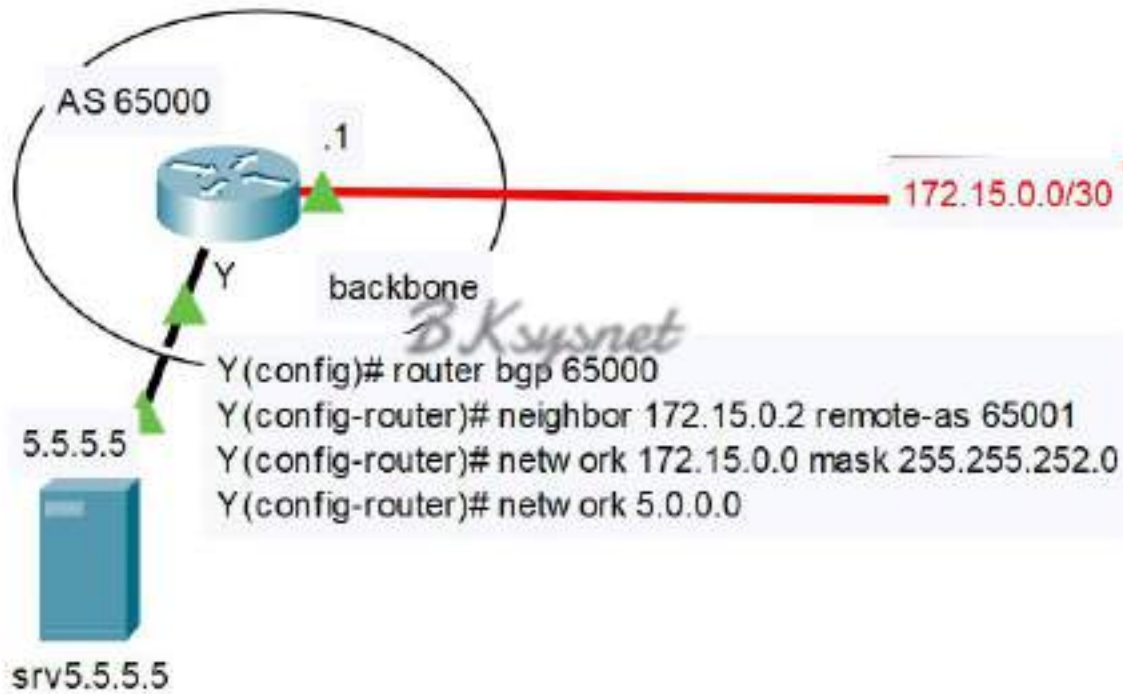
X – AS X (65004)





```
X(config)# router bgp 65004
X(config-router)# neighbor 172.18.0.1 remote-as 65003
X(config-router)# network 172.18.0.0 mask 255.255.255.252
X(config-router)# network 9.0.0.0
```

Y – AS Y (65000)



```
Y(config)# router bgp 65000
Y(config-router)# neighbor 172.15.0.2 remote-as 65001
Y(config-router)# network 172.15.0.0 mask 255.255.252.0
Y(config-router)# network 5.0.0.0
```

VI. Setting validation

Routing Table

Using the command show ip route to see the entries in routing tables.

```
1a#show ip route
```

BGP information

Summary

```
1a#show ip bgp summary
BGP router identifier 192.168.110.1, local AS number 65001
BGP table version is 5, main routing table version 6
4 network entries using 528 bytes of memory
```



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```
4 path entries using 208 bytes of memory
4/4 BGP path/bestpath attribute entries using 736 bytes of memory
2 BGP AS-PATH entries using 48 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 1552 total bytes of memory
BGP activity 4/0 prefixes, 4/0 paths, scan interval 60 secs
```

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	
State/PfxRcd									
172.15.0.1	4	65000	19	19	5	0	0	00:17:25	4
172.16.0.2	4	65002	23	19	5	0	0	00:17:24	4

Neighbors' details

```
1a#show ip bgp neighbors
```

OSPF information

Retrieve the information of each ospf ID

```
1a#show ip ospf <ID number>
```

Eg. 1a#show ip ospf 65001

Get the database information

```
1a#show ip ospf database
Router Link States (Area 0)

Link ID          ADV Router      Age              Seq#             Checksum Link count
192.168.10.1     192.168.10.1   33              0x80000001      0x006392 1

Type-5 AS External Link States

Link ID          ADV Router      Age              Seq#             Checksum Tag
172.16.0.0       192.168.10.1   33              0x80000001      0x002a80 65001
....
```

Other ospf information

```
1a#show ip ospf neighbor

Neighbor ID      Pri   State           Dead Time      Address         Interface
192.168.11.1     1     FULL/DR         00:00:30      192.168.10.2   GigabitEthernet0/1

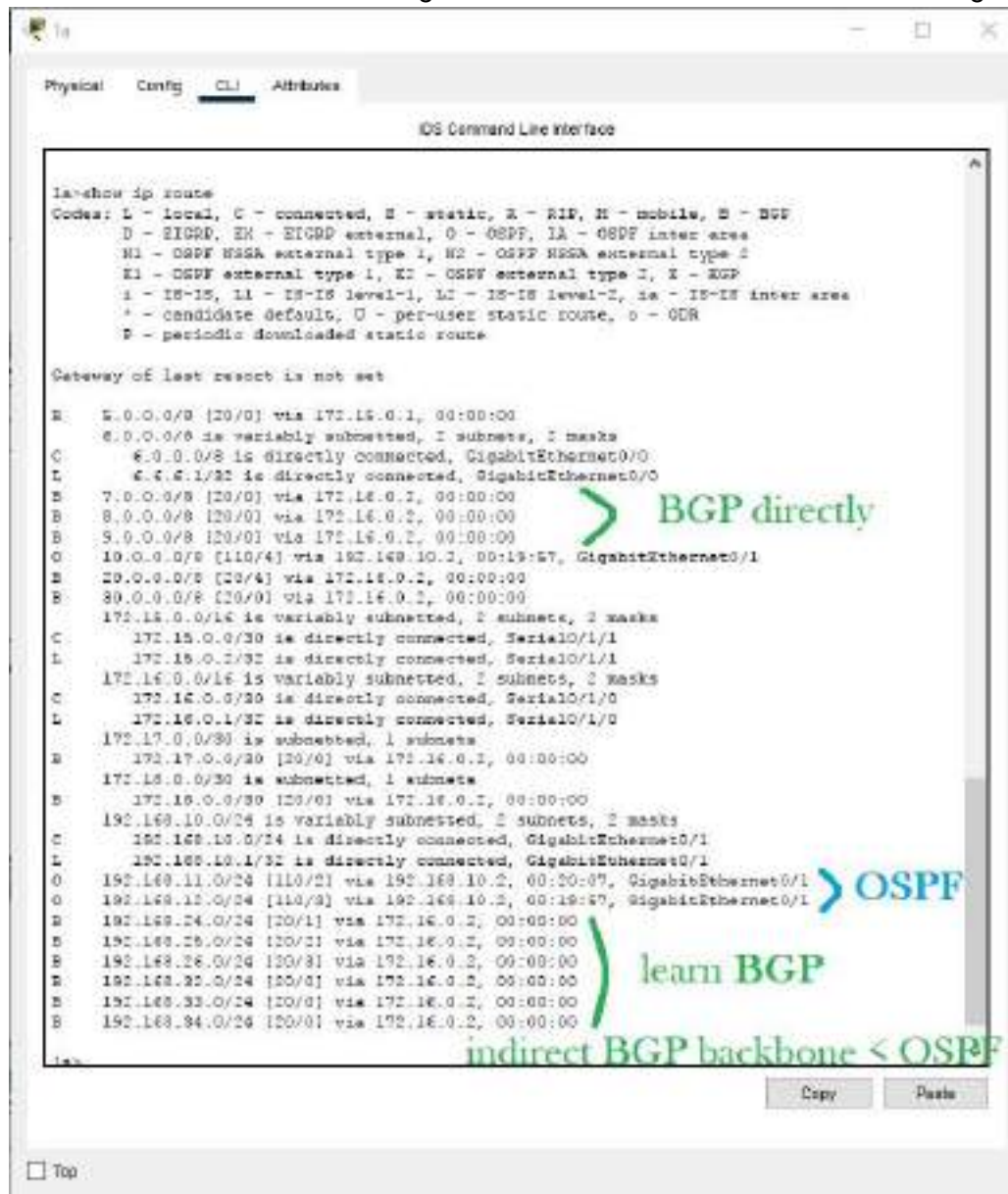
1a#show ip ospf interface
1a#show ip ospf virtual-links
1a#show ip ospf border-routers
```

VII. Traffic verification

a. Inter-AS traffic

Backbone (router 1a):

It learns some routing from inside AS with OSPF and from other AS from BGP. The BGP helps distributed to AS1 the route using BGP the route entries inside AS2 & AS3 got from OSPF.



```

1a>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, I - ISP
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

R: 5.0.0.0/8 [20/0] via 172.16.0.1, 00:00:00
   6.0.0.0/8 is variably subnetted, 1 subnets, 2 masks
C: 6.0.0.0/8 is directly connected, GigabitEthernet0/0
L: 6.4.6.1/32 is directly connected, GigabitEthernet0/0
R: 7.0.0.0/8 [20/0] via 172.16.0.1, 00:00:00
B: 8.0.0.0/8 [20/0] via 172.16.0.2, 00:00:00
B: 9.0.0.0/8 [20/0] via 172.16.0.2, 00:00:00
O: 10.0.0.0/8 [110/4] via 192.168.10.2, 00:19:57, GigabitEthernet0/1
R: 10.0.0.0/8 [20/4] via 172.16.0.2, 00:00:00
B: 30.0.0.0/8 [20/0] via 172.16.0.2, 00:00:00
   172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C:   172.16.0.0/30 is directly connected, Serial10/1/1
L:   172.16.0.1/32 is directly connected, Serial10/1/1
   172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C:   172.16.0.0/30 is directly connected, Serial10/1/0
L:   172.16.0.1/32 is directly connected, Serial10/1/0
   172.17.0.0/30 is subnetted, 1 subnets
R:   172.17.0.0/30 [20/0] via 172.16.0.2, 00:00:00
   172.18.0.0/30 is subnetted, 1 subnets
B:   172.18.0.0/30 [20/0] via 172.16.0.2, 00:00:00
   192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C:   192.168.10.0/24 is directly connected, GigabitEthernet0/1
L:   192.168.10.1/32 is directly connected, GigabitEthernet0/1
O: 192.168.11.0/24 [110/2] via 192.168.10.2, 00:20:07, GigabitEthernet0/1
O: 192.168.12.0/24 [110/3] via 192.168.10.2, 00:19:57, GigabitEthernet0/1
R: 192.168.24.0/24 [20/1] via 172.16.0.2, 00:00:00
B: 192.168.26.0/24 [20/1] via 172.16.0.2, 00:00:00
B: 192.168.28.0/24 [20/3] via 172.16.0.2, 00:00:00
R: 192.168.32.0/24 [20/0] via 172.16.0.2, 00:00:00
B: 192.168.33.0/24 [20/0] via 172.16.0.2, 00:00:00
B: 192.168.34.0/24 [20/0] via 172.16.0.2, 00:00:00
  
```

Handwritten Annotations:

- BGP directly** (green arrow pointing to routes 7.0.0.0/8, 8.0.0.0/8, 9.0.0.0/8)
- OSPF** (blue arrow pointing to route 192.168.11.0/24)
- learn BGP** (green arrow pointing to routes 192.168.24.0/24, 192.168.26.0/24, 192.168.28.0/24)
- indirect BGP backbone < OSPF** (green arrow pointing to routes 192.168.32.0/24, 192.168.33.0/24, 192.168.34.0/24)



b. Intra-AS traffic

Border area (router 1a1) It learns its local through OSPF and other redistributed routing OSPF the content the local backbone got by BGP from other AS

1a1

Physical Config **CLI** Attributes

IOS Command Line Interface

```
1a1>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

O E2 5.0.0.0/8 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 6.0.0.0/8 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 7.0.0.0/8 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 8.0.0.0/8 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 9.0.0.0/8 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O   10.0.0.0/8 [110/3] via 192.168.11.2, 00:09:16, FastEthernet0/0
O E2 20.0.0.0/8 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 30.0.0.0/8 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
    172.15.0.0/30 is subnetted, 1 subnets
O E2   172.15.0.0 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
    172.16.0.0/30 is subnetted, 1 subnets
O E2   172.16.0.0 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
    172.17.0.0/30 is subnetted, 1 subnets
O E2   172.17.0.0 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
    172.18.0.0/30 is subnetted, 1 subnets
O E2   172.18.0.0 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
C   192.168.10.0/24 is directly connected, FastEthernet0/1
C   192.168.11.0/24 is directly connected, FastEthernet0/0
O   192.168.12.0/24 [110/2] via 192.168.11.2, 00:09:16, FastEthernet0/0
O E2 192.168.24.0/24 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 192.168.25.0/24 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 192.168.26.0/24 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 192.168.32.0/24 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 192.168.33.0/24 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1
O E2 192.168.34.0/24 [110/20] via 192.168.10.1, 00:09:16, FastEthernet0/1

1a1>
```

OSPF

indirect OSPF (BGP redistribute)

OSPF

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Internal router (1a3): It learn the direct local connect PC and local area through OSPF. Other AS or area routing is get from in direct OSPF external.

1a3

Physical Config CLI Attributes

IOS Command Line Interface

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

O E2 5.0.0.0/8 [110/20] via 192.168.12.1, 00:04:49, FastEthernet0/0
O E2 6.0.0.0/8 [110/20] via 192.168.12.1, 00:04:49, FastEthernet0/0
O E2 7.0.0.0/8 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 8.0.0.0/8 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 9.0.0.0/8 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
C 10.0.0.0/8 is directly connected, FastEthernet0/1
O E2 20.0.0.0/8 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 30.0.0.0/8 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
172.15.0.0/30 is subnetted, 1 subnets
O E2 172.15.0.0 [110/20] via 192.168.12.1, 00:04:49, FastEthernet0/0
172.16.0.0/30 is subnetted, 1 subnets
O E2 172.16.0.0 [110/20] via 192.168.12.1, 00:04:49, FastEthernet0/0
172.17.0.0/30 is subnetted, 1 subnets
O E2 172.17.0.0 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
172.18.0.0/30 is subnetted, 1 subnets
O E2 172.18.0.0 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O 192.168.10.0/24 [110/3] via 192.168.12.1, 00:04:49, FastEthernet0/0
O 192.168.11.0/24 [110/2] via 192.168.12.1, 00:04:49, FastEthernet0/0
C 192.168.12.0/24 is directly connected, FastEthernet0/0
O E2 192.168.24.0/24 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 192.168.25.0/24 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 192.168.26.0/24 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 192.168.32.0/24 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 192.168.33.0/24 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0
O E2 192.168.34.0/24 [110/20] via 192.168.12.1, 00:04:38, FastEthernet0/0

1a3>

local PC directly connect
indirect OSPF (BGP redistribute)
OSPF

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c. The Completed tracing route

The packets are routed from internal router (internal VN) to border area router and backbone router in each AS (i.e. from VN). Then they traverse among backbone routers to reach the destination AS (i.e. Asian ISP). Finally, they go down inside the destination AS (America continental) to destination border area and then internal destination area routers (some site in US).

```
Cisco Packet Tracer PC Command Line 1.0
C:\>tracert 30.0.0.5

Tracing route to 30.0.0.5 over a maximum of 30 hops:

  1  0 ms    0 ms    0 ms    10.0.0.1
  2  0 ms    0 ms    0 ms    192.168.12.1
  3  11 ms   27 ms   11 ms   192.168.11.1
  4  10 ms   12 ms   11 ms   192.168.10.1
  5  11 ms   12 ms   13 ms   172.16.0.2
  6  22 ms    3 ms   22 ms   172.17.0.2
  7  11 ms   32 ms   21 ms   192.168.32.2
  8  1 ms    12 ms   11 ms   192.168.33.2
  9  12 ms   43 ms   21 ms   192.168.34.2
 10  12 ms   21 ms   11 ms   30.0.0.5

Trace complete.

C:\>
```

Handwritten annotations on the right side of the output:

- intra AS** (blue text, next to hops 1-4)
- transit between backbones** (red text, next to hops 5-6)
- destination AS** (green text, next to hops 7-10)

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