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.

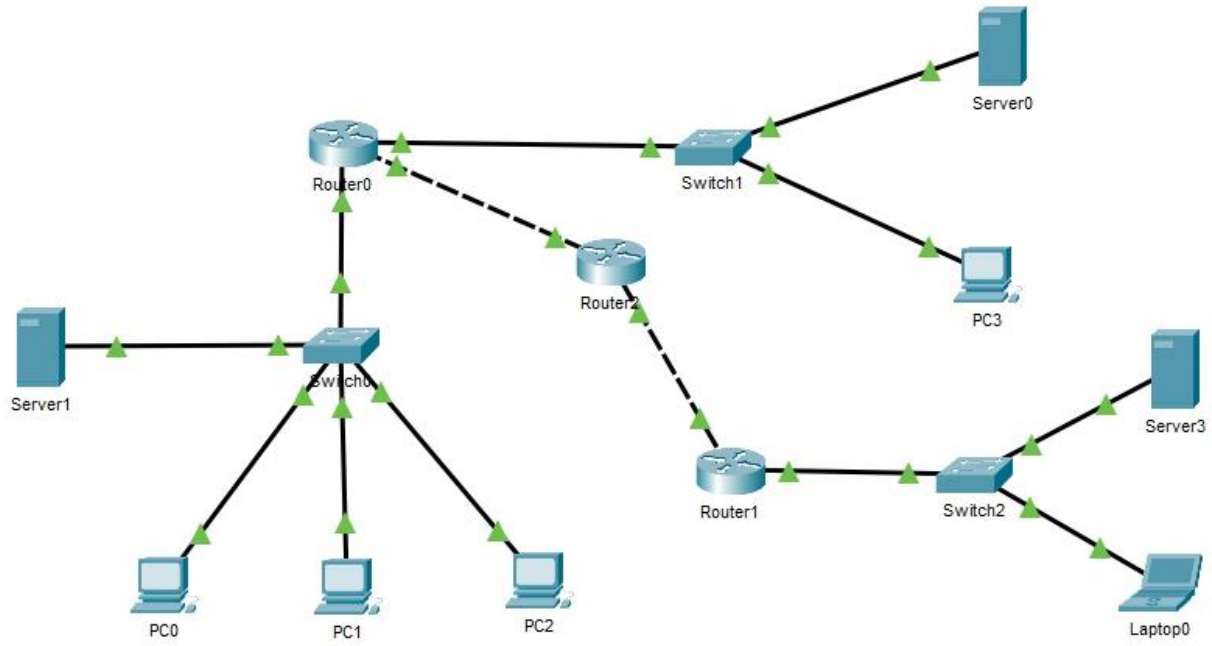

Figure 1 Inter (sub)nework connection

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I. Overview

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

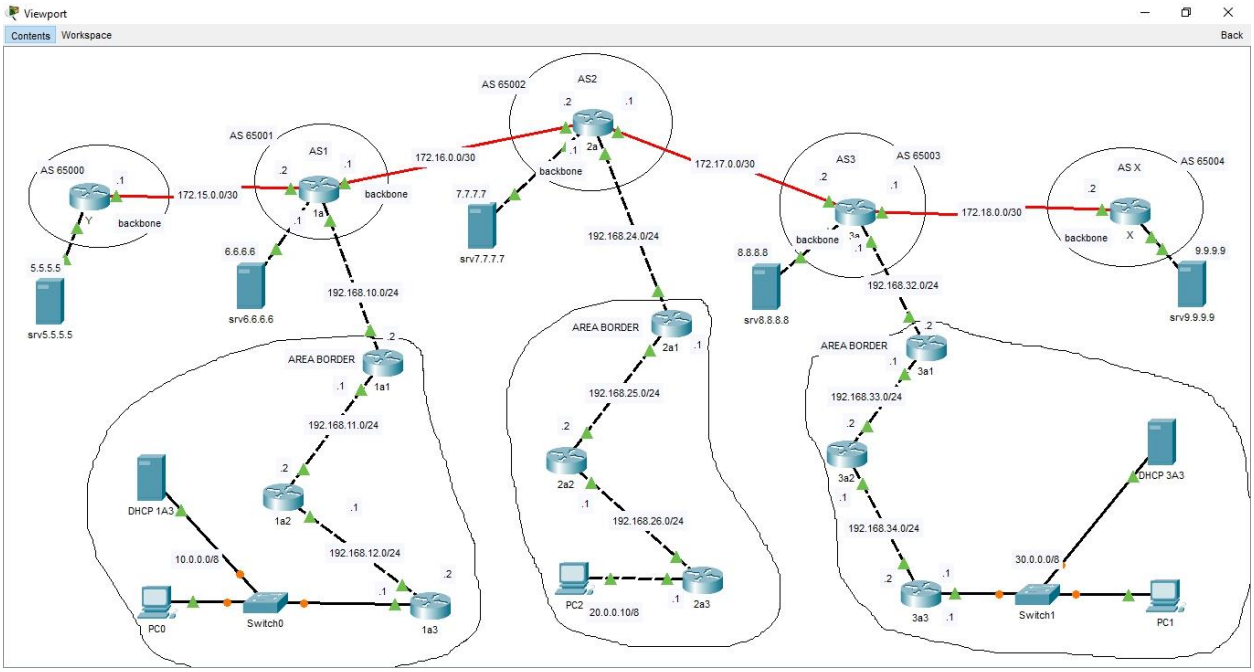


Figure 2 System overview

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.

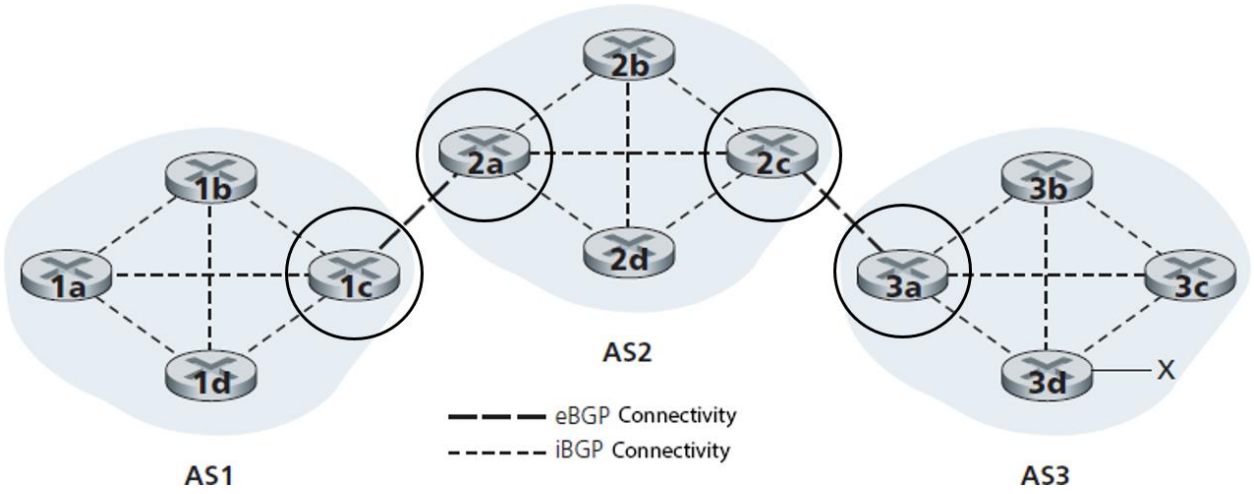


Figure 3BGP Connections

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.

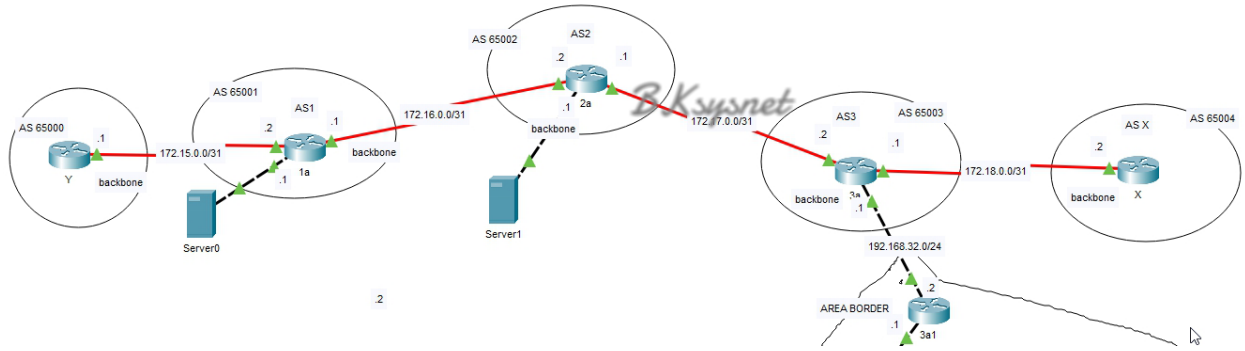


Figure 4 Inter-AS routing

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.

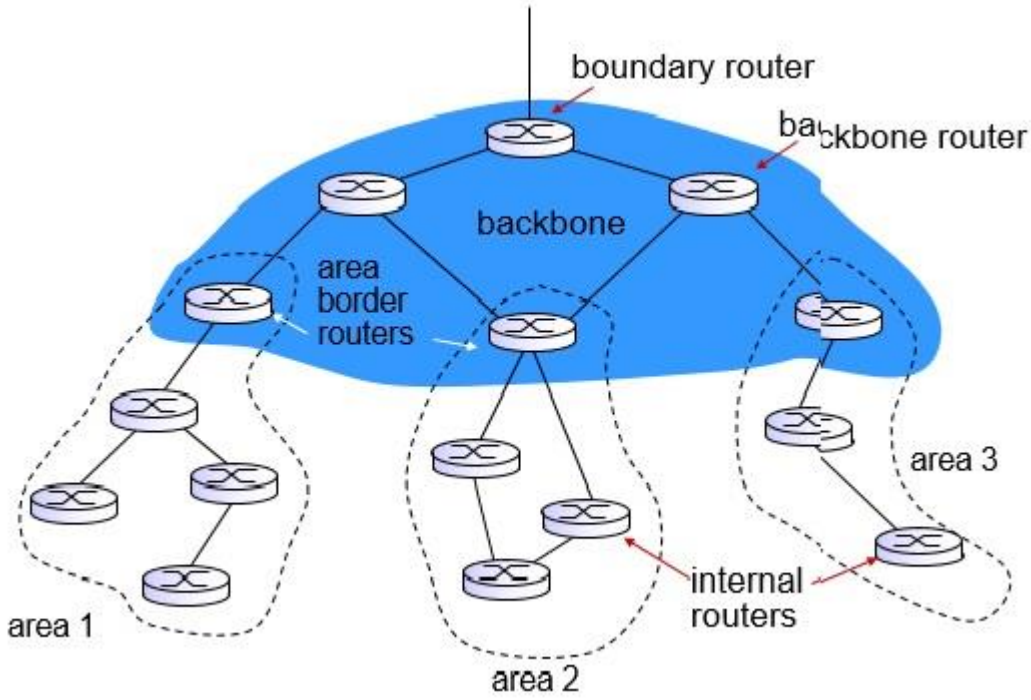


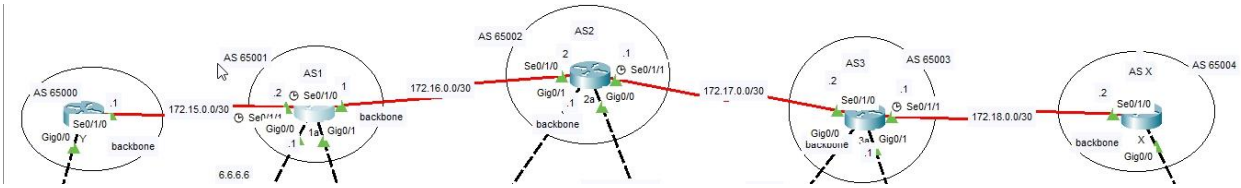
Figure 5 Hierarchical OSPF

III. Hardware Plugin

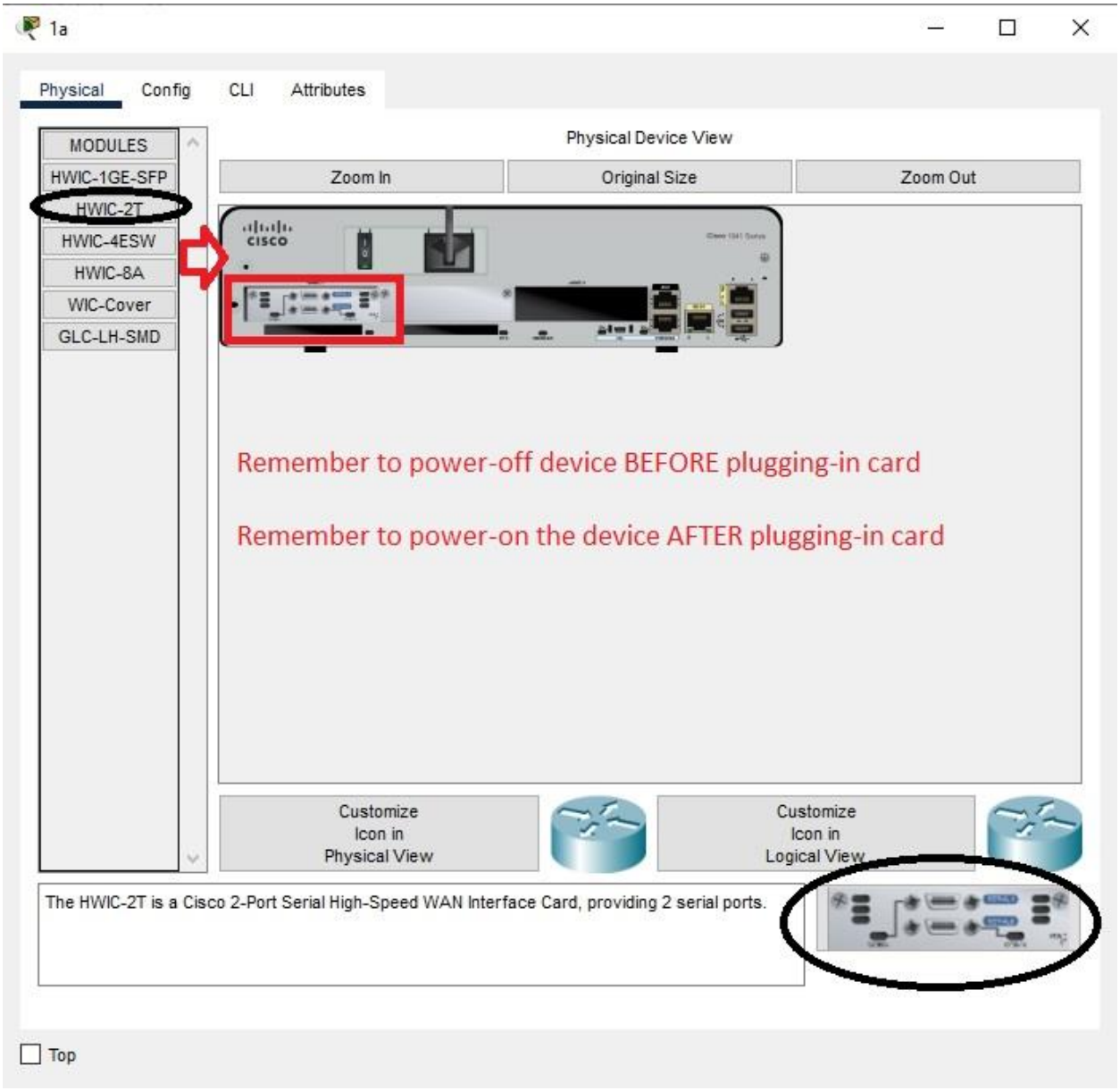
The router need to add more connection port in order to implement our experiment model.

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.



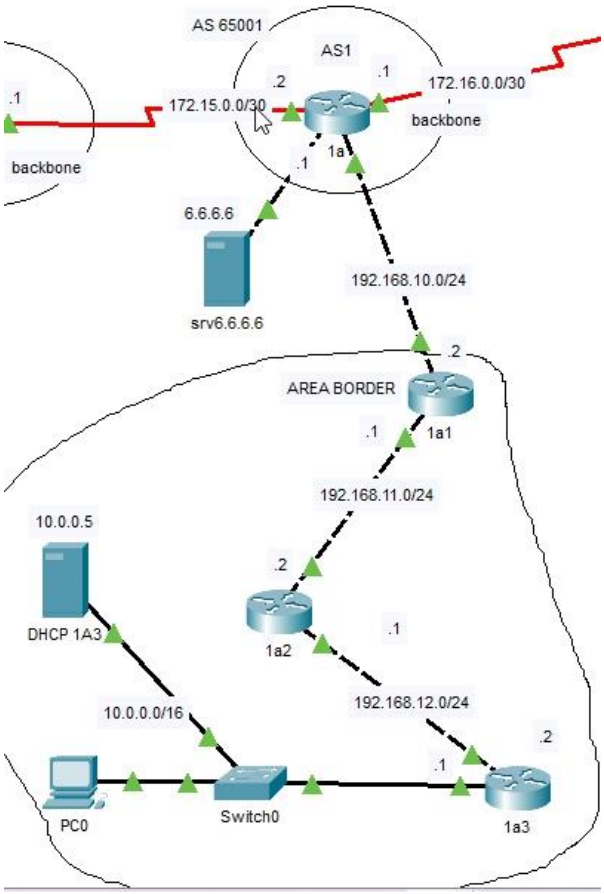
Add the module HWIC-2T to the router named Y, 1a, 2a, 3a and X
And then, connect them serially by serial port cable.


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
cisco
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

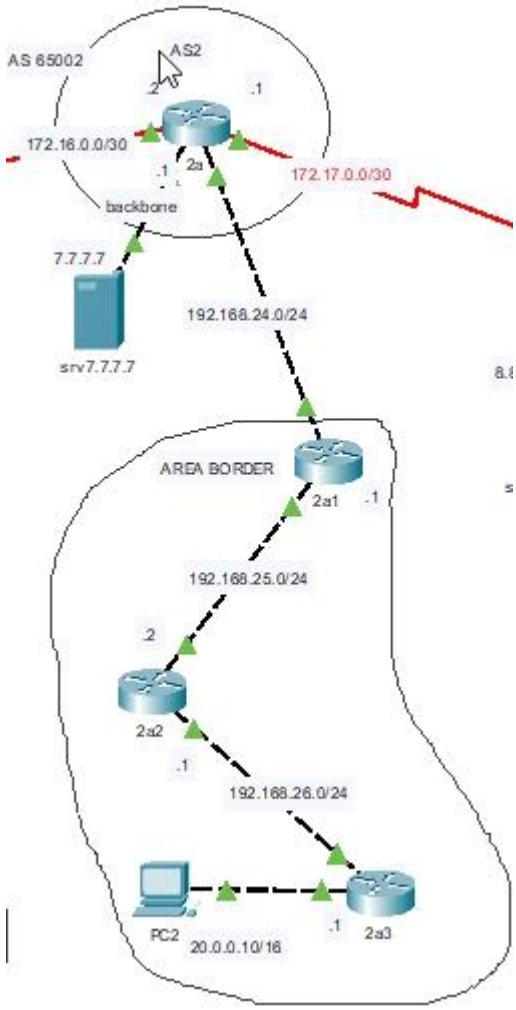
Diagram	Configurations
	Srv6.6.6.6: - IP 6.6.6.6/8 - Default gateway 6.6.6.1/8 (/8 netmask 255.0.0.0) Router 1a (Model 1941): - Serial 0/1/0: 172.15.0.2/30 - Sercial 0/1/1: 172.16.0.1/30 - GigE 0/0 6.6.6.1/8 - GigE 0/1: 192.168.10.1/24 (*Hint* if you are missing serial ports, you missed the previous 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 1a1 (Model 1941), port index is flexible based on your connection - GigE to 1a: 192.168.10.2/24 - GigE to 1a2: 192.168.11.1/24 Router 1a2 (Model 1941), port index is flexible based on your connection - GigE to 1a1: 192.168.11.2/24 - GigE to 1a3: 192.168.12.1/24 Router 1a3 (Model 1941), port index is flexible based on your connection - GigE to 1a2: 192.168.12.2/24 - GigE to Switch0: 10.0.0.1/16

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
- Sercial 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

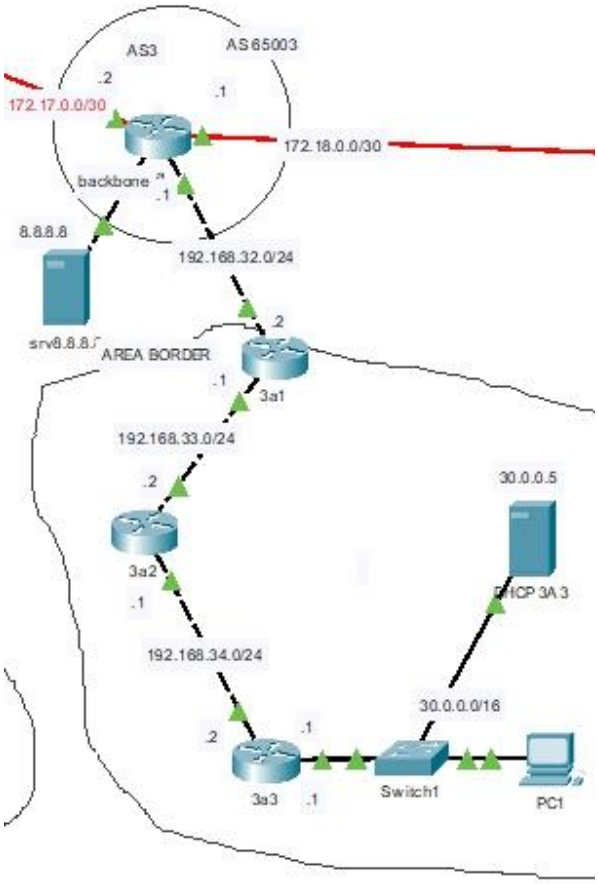
Router 2a2 (Model 1941), port index is flexible based on your connection
- GigE to 1a1: 192.168.25.2/24
- GigE to 1a3: 192.168.26.1/24

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

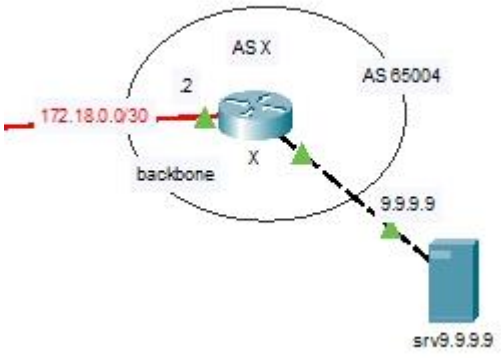
c. AS 3 (65003)

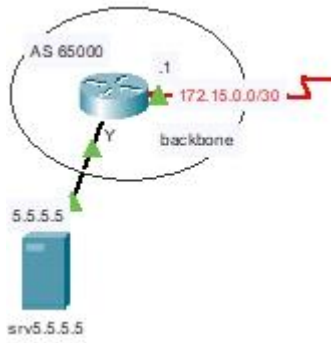
Diagram	Configurations
	Srv8.8.8.8: - IP 8.8.8.8/8 - Default gateway 8.8.8.1/8 (/8 netmask 255.0.0.0) Router 3a (Model 1941): - Serial 0/1/0: 172.17.0.2/30 - Sercial 0/1/1: 172.18.0.1/30 - GigE 0/0 8.8.8.1/8 - GigE 0/1: 192.168.32.1/24 (*Hint* if you are missing serial ports, you missed the previous 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 3a1 (Model 1941), port index is flexible based on your connection - GigE to 1a: 192.168.32.2/24 - GigE to 1a2: 192.168.33.1/24 Router 3a2 (Model 1941), port index is flexible based on your connection - GigE to 1a1: 192.168.33.2/24 - GigE to 1a3: 192.168.34.1/24 Router 1a3 (Model 1941), port index is flexible based on your connection - 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
	Srv9.9.9.9: - IP 9.9.9.9/8 - Default gateway 9.9.9.1/8 (/8 netmask 255.0.0.0) Router X (Model 1941): - 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> (*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)

<table>
<tr>
<td> 
</td>
<td>Srv5.5.5.5:
- IP 5.5.5.5/8
- Default gateway 5.5.5.1/8
(/8 netmask 255.0.0.0)

Router X (Model 1941):
- Serial 0/1/0: 172.15.0.1/30
- Sercial 0/1/1: <not set>
- GigE 0/0 5.5.5.1/8
- GigE 0/1: <not set>

(*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)</td>
</tr>
</table>

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.

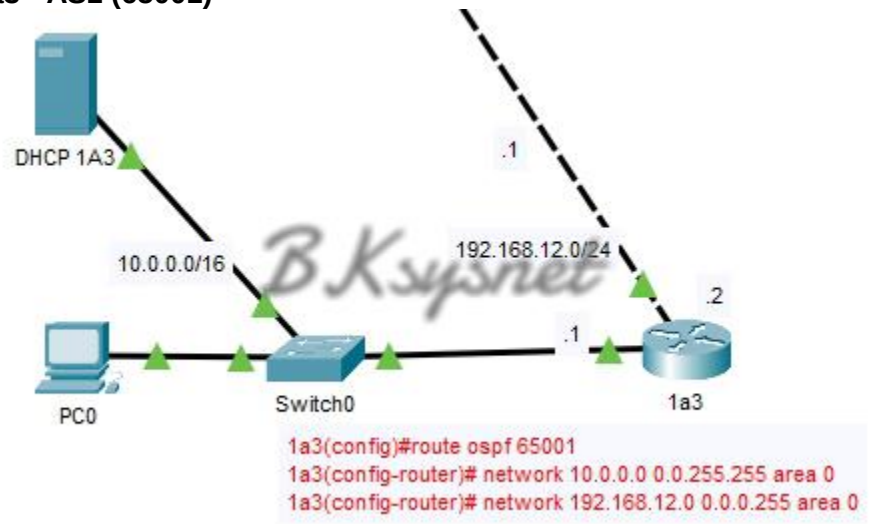
V. Routing Configuration

There are 4 types of router:

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

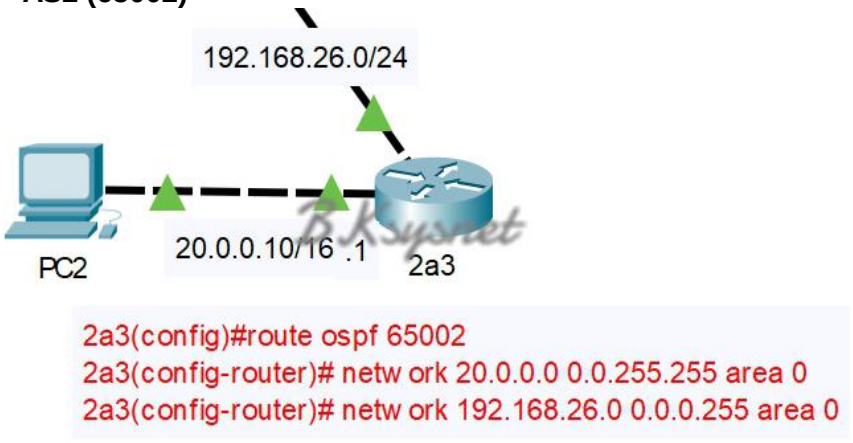
a. Edge routers:

1a3 - AS1 (65001)



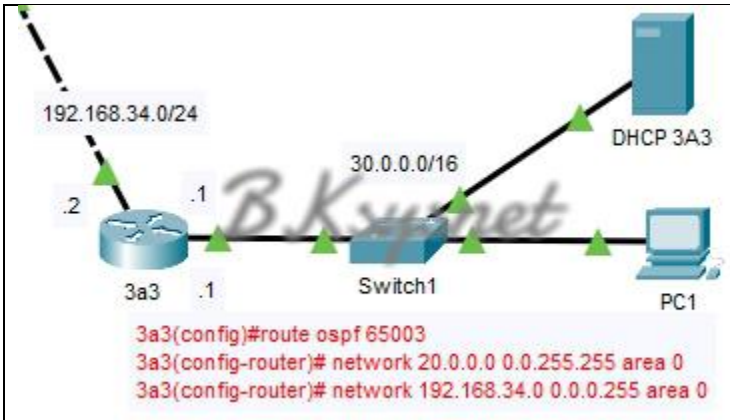

```
1a3(config)#route ospf 65001
1a3(config-router)# network 10.0.0.0 0.255.255.255 area 0
1a3(config-router)# network 192.168.12.0 0.0.0.255 area 0
```

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)




```
3a3(config)#route ospf 65003
3a3(config-router)# network 20.0.0.0 0.0.255.255 area 0
3a3(config-router)# network 192.168.34.0 0.0.0.255 area 0
```

b. Area and area border routers:

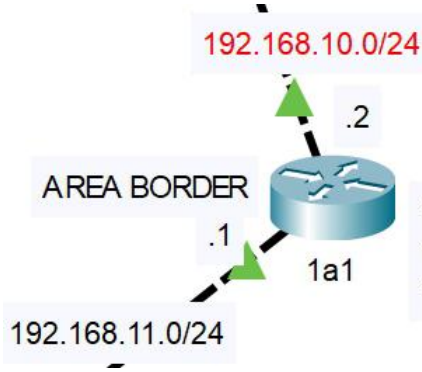
Area router is named XaY where X is AS number and Y is the indexing number.

AS1 (65001)

1a2


```
1a2(config)#router ospf 65001
1a2(config-router)# network 192.168.12.0 0.0.0.255 area 0
1a2(config-router)# network 192.168.11.0 0.0.0.255 area 0
```

1a1

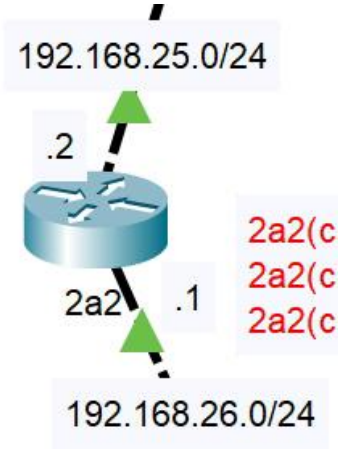



```
1a2(config)#router ospf 65001
1a2(config-router)# netw ork 192.168.12.0 0.0.0.255 area 0
1a2(config-router)# netw ork 192.168.11.0 0.0.0.255 area 0
```

```
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)# netw ork 192.168.25.0 0.0.0.255 area 0
2a2(config-router)# netw ork 192.168.26.0 0.0.0.255 area 0
```

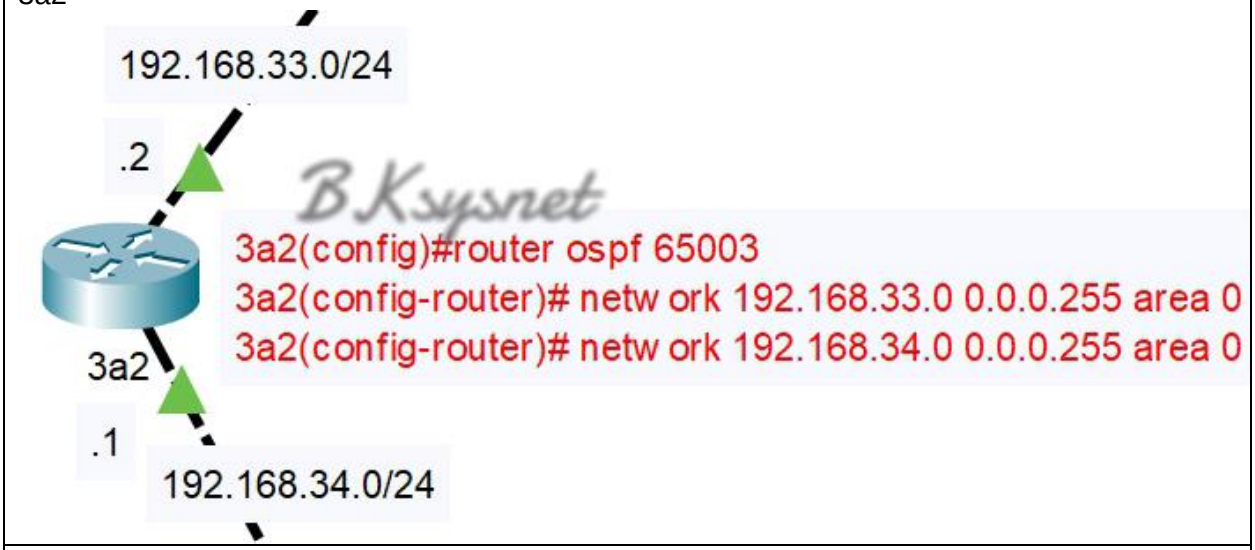
```
2a2(config)#router ospf 65002
2a2(config-router)# network 192.168.25.0 0.0.0.255 area 0
2a2(config-router)# network 192.168.26.0 0.0.0.255 area 0
```

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



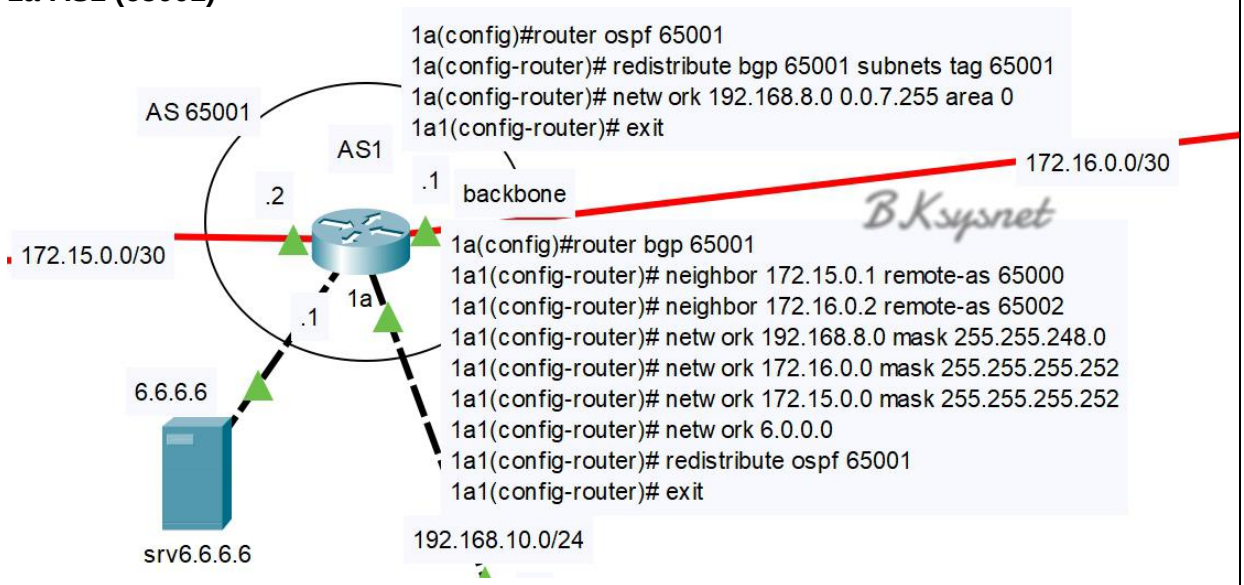

```
3a2(config)#router ospf 65003
3a2(config-router)# network 192.168.33.0 0.0.0.255 area 0
3a2(config-router)# network 192.168.34.0 0.0.0.255 area 0
```

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

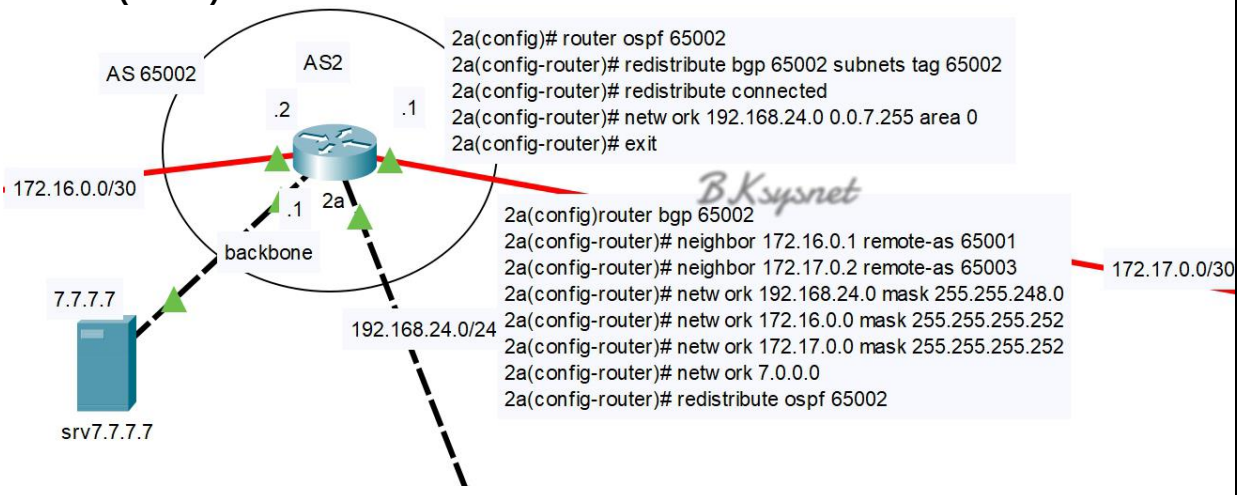
1a-AS1 (65001)




```
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

1a(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

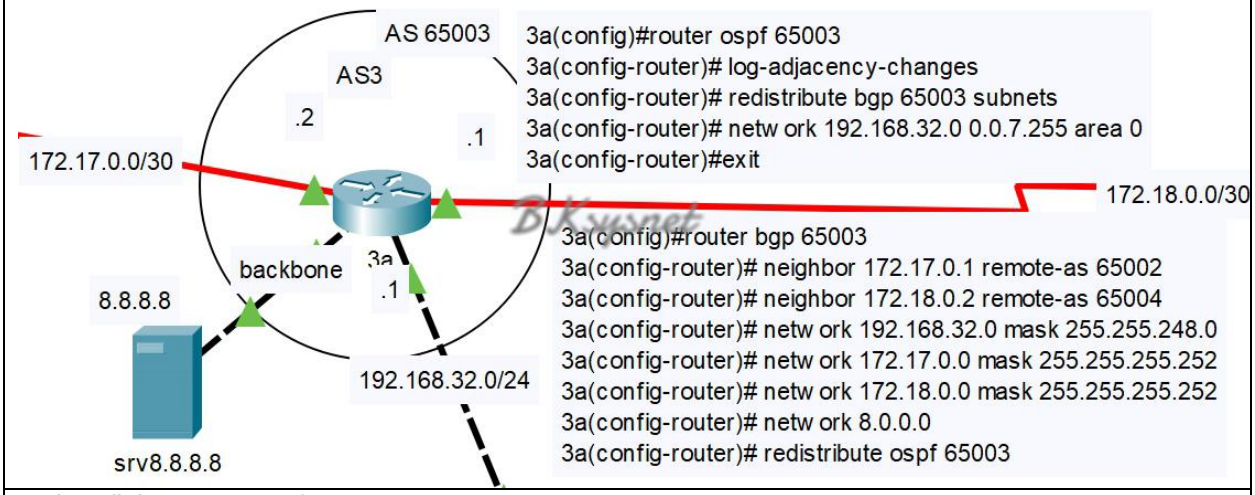
2a- AS3 (65002)



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

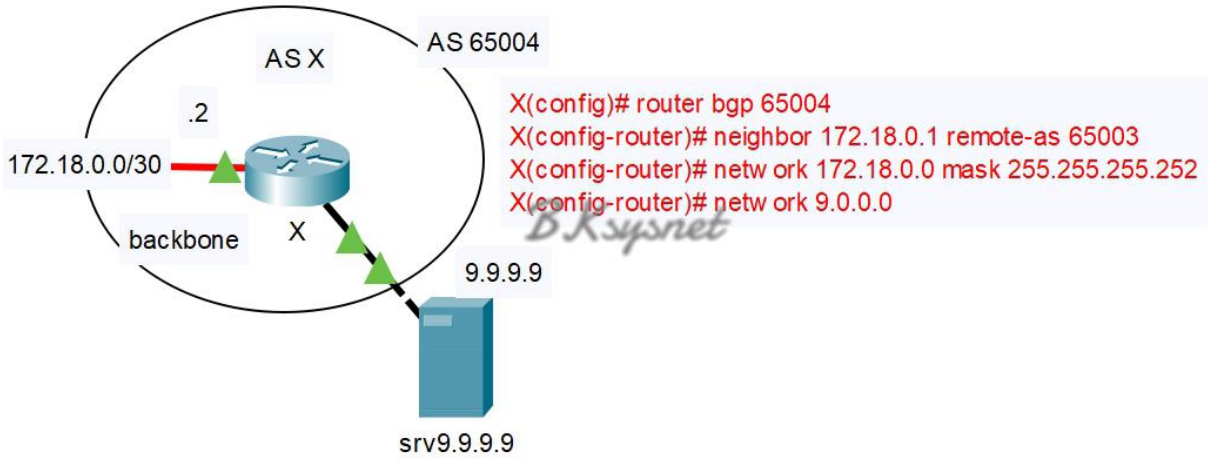
3a- AS3 (65003)



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

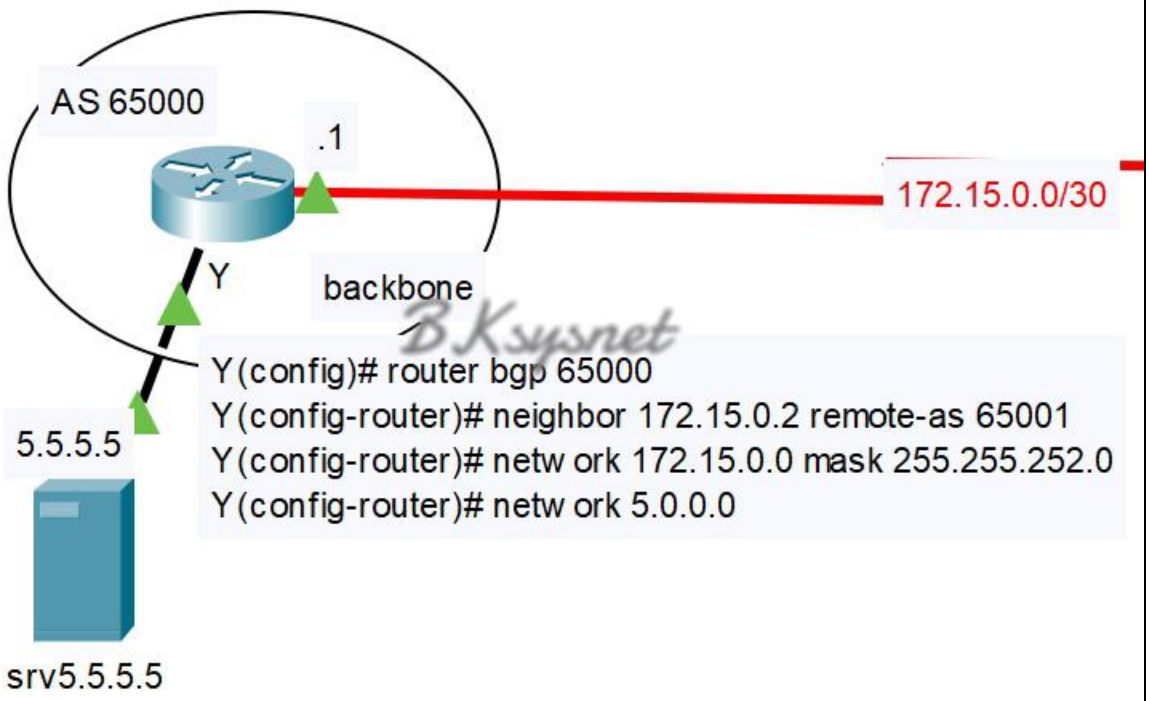
3a(config)#router bgp 65003
3a(config-router)# neighbor 172.17.0.1 remote-as 65002
3a(config-router)# neighbor 172.18.0.2 remote-as 65004
3a(config-router)# network 192.168.32.0 mask 255.255.248.0
3a(config-router)# network 172.17.0.0 mask 255.255.255.252
3a(config-router)# network 172.18.0.0 mask 255.255.255.252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

```
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

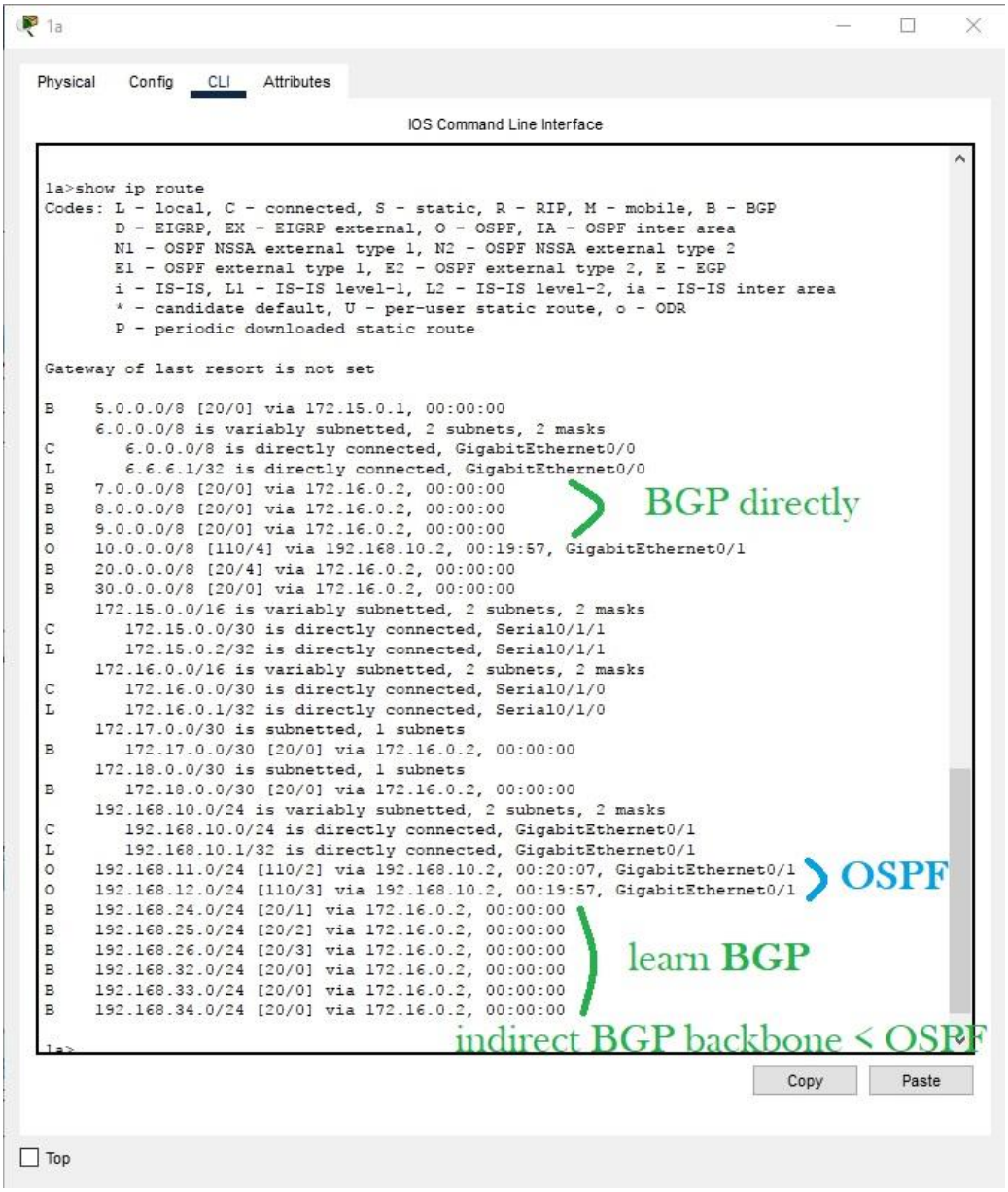
```
1a#show ip ospf neighbor


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

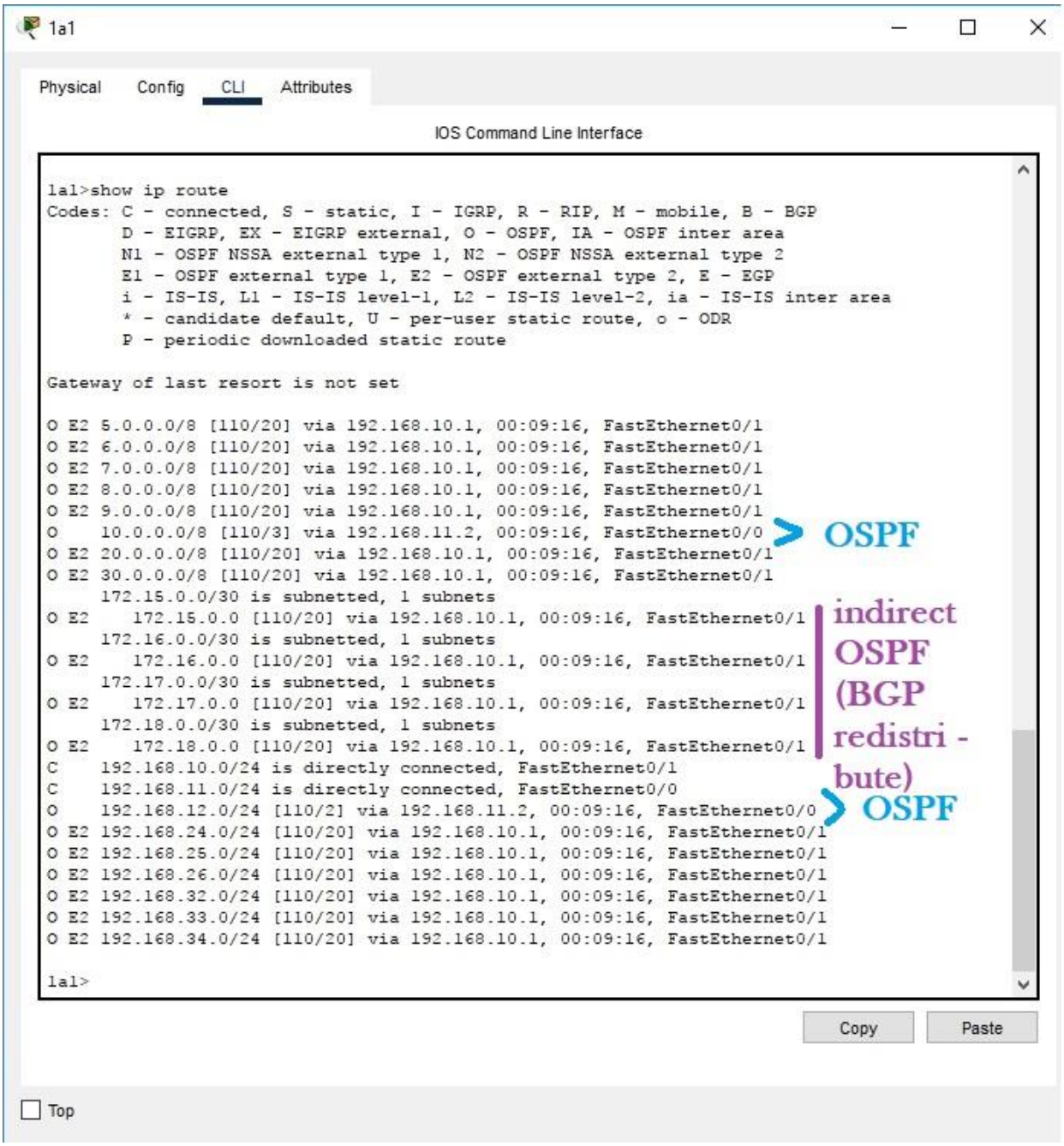
Backbone (router 1a):

It learns so me 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.

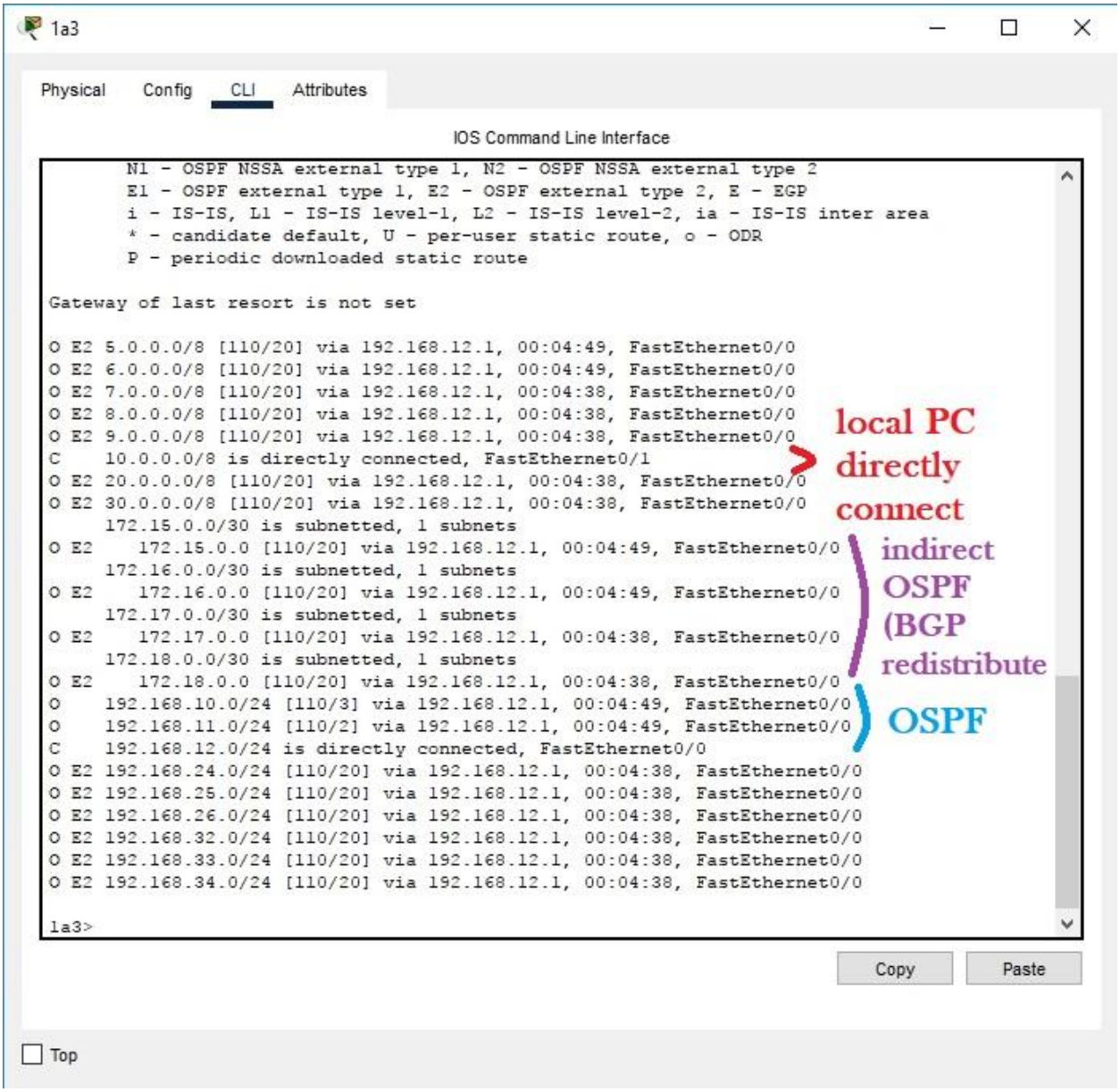


b. Intra-AS traffic

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



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.



c. The Completed tracing route

The packets are routed from internal router (internal VN) to border area router and backbond 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 continential) to destination border area and then internal destination area routers (some site in US).