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Description automatically generated

**Purpose**

This lab helped further develop our routing knowledge and skills related to different routing protocols, such as BGP and OSPF. We learned how to implement BGP and OSPF in a network configured with internal BGP (iBGP).  
  
**Background Information**

As we learned in our previous labs, BGP (Border Gateway Protocol) is one of the many routing protocols that are used to navigate the Internet. The protocol helps determine the best route for data travel by analyzing all available paths and optimizing the quickest and most efficient path. In this lab we also implemented the OSPF protocol again—we knew how to configure OSPF from the previous two labs.

iBGP, standing for Internal Border Gateway Protocol, is a protocol used by routers within the same Autonomous System (AS) to exchange routing information. An AS is a collection of IP networks and routers which present a similar routing policy to the Internet. An AS primarily allows the routing of IP packets within the Internet, allowing seamless transmission of data across networks to their ultimate destination. In a network environment, iBGP can be utilized to travel between devices that have the same AS, unlike BGP which we used to route between devices with different AS.

In addition to its role within an AS, iBGP has unique characteristics that differentiate it from external BGP. iBGP does not modify the next-hop attribute when advertising routes to other routers within the same AS, which means that the next-hop IP address remains unchanged and allows for routers within the same AS to forward to the original next-hop.

iBGP also requires a full mesh topology, which we discovered while completing this lab. This ensures that all routers within an AS have consistent routing information. Without a full mesh network, routing inconsistencies may occur and lead to failed data transmission.

Moreover, BGP route aggregation, the combining of multiple routes into a singe route, is another critical concept when handling border gateway protocols. This helps reduce the size of the routing table and improves scalability. Aggregating has to be done carefully, to prevent connectivity issues and make sure that routing information is not lost.

Another thing about iBGP that we also discovered during the lab was that it only works on full BGP synchronization. BGP synchronization makes routers only advertise routes from iBGP peers to each other when that route is present in the IGP (Interior Gateway Protocol) routing table. This also prevents any forwarding loops from when routes are advertised early.

Overall, iBGP is crucial when routing amongst devices with the same AS in a network and plays a key role in ensuring the reliability and efficiency in a larger network. However, using iBGP requires specific configurations to ensure correct operation.  
  
**Lab Summary**

To complete this lab, we followed these procedures:

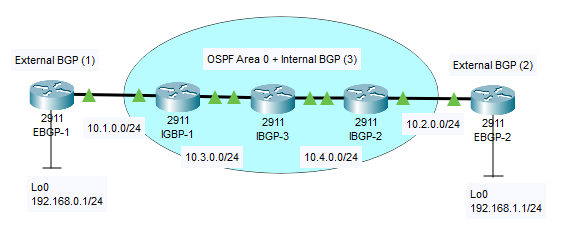
1. Designed a topology with five routers, three running with internal BGP and OSPF, and two routers on the ends running with external BGP. The lab is designed to be able to connect three different autonomous systems with eBGP and iBGP—2 ASNs on both outside routers and one AS on the inner three routers.
2. On each router, we set up basic configurations, such as interfaces, IP addresses, and routing protocols.
3. Cabled the topology in a real-world environment.
4. Using previously learned knowledge from labs using BGP, we configured the two outside routers, EBGP-1 and EBGP-2, to run with eBGP.
5. We then set the three inside routers to run on iBGP.
6. Configure OSPF on the inside routers and redistribute OSPF into BGP routes.
7. Test connectivity through pings and check iBGP status.

**Lab Commands**

Most of the commands necessary for this lab were learned when completing previous labs and draw from familiar routing concepts. Some of the main commands we used to complete iBGP routing are below:

**router bgp** [autonomous-system-number]  
Enables BGP configuration mode.  
 **network** [ipv4 address] **mask** [subnet mask]  
Sets the BGP network address and subnet mask in BGP configuration mode.  
 **address-family ipv4**  
Enters address family mode.  
 **neighbor** [ipv4 address] **remote-as** [autonomous-system-number]  
Configured in address family mode. Redistributes and receives BGP routes through neighbors.  
 **neighbor** [ipv4 address] **update-source** [interface]  
Tells BGP which interface to source packets out of in order for the source to reach its iBGP neighbor.  
  
**redistribute ospf** [area]  
Propagates OSPF routes into BGP routing.

**Topology & IP Scheme**



|  |  |  |  |
| --- | --- | --- | --- |
|  | G0/0/0 | G0/0/1 | Lo0 |
| EBGP-1 | 10.1.0.1/24 | N/A | 192.168.0.1/24 |
| EBGP-2 | 10.2.0.1/24 | N/A | 192.168.1.1/24 |
| IBGP-1 | 10.1.0.2/24 | 10.3.0.1/24 | N/A |
| IBGP-2 | 10.2.0.2/24 | 10.4.0.1/24 | N/A |
| IBGP-3 | 10.4.0.2/24 | 10.3.0.2/24 | N/A |

**Configurations**

**EBGP-1:**

**Running Configuration:**

Current configuration : 1565 bytes

! Last configuration change at 16:53:29 UTC Mon Feb 12 2024

version 15.5

no service timestamps debug uptime

no service timestamps log uptime

no platform punt-keepalive disable-kernel-core

hostname EBGP-1

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21491LXV

license accept end user agreement

license boot level securityk9

spanning-tree mode pvst

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.1 255.255.255.0

interface GigabitEthernet0/0/0

ip address 10.1.0.1 255.255.255.0

negotiation auto

interface GigabitEthernet0/0/1

no ip address

shutdown

negotiation auto

interface Serial0/1/0

interface Serial0/1/1

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router bgp 1

bgp log-neighbor-changes

network 10.1.0.0 mask 255.255.255.0

network 192.168.0.0

redistribute ospf 10

neighbor 10.1.0.2 remote-as 3

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**IP Routes:**

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 - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks

C 10.1.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.1.0.1/32 is directly connected, GigabitEthernet0/0/0

B 10.2.0.0/24 [20/0] via 10.1.0.2, 00:22:01

B 10.3.0.0/24 [20/0] via 10.1.0.2, 00:36:01

B 10.4.0.0/24 [20/0] via 10.1.0.2, 00:36:01

192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.0.0/24 is directly connected, Loopback0

L 192.168.0.1/32 is directly connected, Loopback0

B 192.168.1.0/24 [20/0] via 10.1.0.2, 00:21:30

**EBGP-2:**

**Running Configuration:**

Current configuration : 1743 bytes

! Last configuration change at 16:54:34 UTC Mon Feb 12 2024

version 15.5

no service timestamps debug uptime

no service timestamps log uptime

no platform punt-keepalive disable-kernel-core

hostname EBGP-2

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21482HYV

spanning-tree mode pvst

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 2,10,20

vlan 996

name CUSTOMER\_NATIVE

interface Loopback0

ip address 192.168.1.1 255.255.255.0

interface GigabitEthernet0/0/0

ip address 10.2.0.1 255.255.255.0

negotiation auto

interface GigabitEthernet0/0/1

no ip address

shutdown

negotiation auto

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router bgp 2

bgp log-neighbor-changes

network 10.2.0.0 mask 255.255.255.0

network 192.168.1.0

redistribute ospf 10

neighbor 10.2.0.2 remote-as 3

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**IP Routes:**

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 - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks

B 10.1.0.0/24 [20/3] via 10.2.0.2, 00:40:42

C 10.2.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.2.0.1/32 is directly connected, GigabitEthernet0/0/0

B 10.3.0.0/24 [20/2] via 10.2.0.2, 00:40:42

B 10.4.0.0/24 [20/0] via 10.2.0.2, 00:35:46

B 192.168.0.0/24 [20/0] via 10.2.0.2, 00:27:33

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

**IBGP-1:**

**Running Configuration:**

Current configuration : 1746 bytes

! Last configuration change at 17:45:37 UTC Mon Feb 12 2024

version 15.5

no service timestamps debug uptime

no service timestamps log uptime

no platform punt-keepalive disable-kernel-core

hostname IBGP-1

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420QQ

license accept end user agreement

license boot level securityk9

spanning-tree mode pvst

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

ip address 10.1.0.2 255.255.255.0

ip ospf 10 area 0

negotiation auto

interface GigabitEthernet0/0/1

ip address 10.3.0.1 255.255.255.0

negotiation auto

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

network 10.3.0.0 0.0.0.255 area 0

router bgp 3

bgp log-neighbor-changes

network 10.1.0.0 mask 255.255.255.0

network 10.3.0.0 mask 255.255.255.0

neighbor 10.1.0.1 remote-as 1

neighbor 10.3.0.2 remote-as 3

neighbor 10.3.0.2 update-source GigabitEthernet0/0/1

neighbor 10.4.0.1 remote-as 3

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**IP Routes:**

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 - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

C 10.1.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.1.0.2/32 is directly connected, GigabitEthernet0/0/0

B 10.2.0.0/24 [200/0] via 10.4.0.1, 00:23:12

C 10.3.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.3.0.1/32 is directly connected, GigabitEthernet0/0/1

O 10.4.0.0/24 [110/2] via 10.3.0.2, 01:03:59, GigabitEthernet0/0/1

B 192.168.0.0/24 [20/0] via 10.1.0.1, 00:37:17

B 192.168.1.0/24 [200/0] via 10.2.0.1, 00:23:12

**IBGP-2:**

**Running Configuration:**

Current configuration : 1786 bytes

! Last configuration change at 17:18:02 UTC Mon Feb 12 2024

version 15.5

no service timestamps debug uptime

no service timestamps log uptime

no platform punt-keepalive disable-kernel-core

hostname IBGP-2

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214333H6

license boot level securityk9

spanning-tree mode pvst

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface GigabitEthernet0/0/0

ip address 10.2.0.2 255.255.255.0

negotiation auto

interface GigabitEthernet0/0/1

ip address 10.4.0.1 255.255.255.0

ip ospf 10 area 0

negotiation auto

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

network 10.4.0.0 0.0.0.255 area 0

router bgp 3

bgp log-neighbor-changes

network 10.2.0.0 mask 255.255.255.0

network 10.4.0.0 mask 255.255.255.0

redistribute ospf 10

neighbor 10.2.0.1 remote-as 2

neighbor 10.3.0.1 remote-as 3

neighbor 10.4.0.2 remote-as 3

neighbor 10.4.0.2 update-source GigabitEthernet0/0/1

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**IP Routes:**

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 - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O 10.1.0.0/24 [110/3] via 10.4.0.2, 01:16:29, GigabitEthernet0/0/1

C 10.2.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.2.0.2/32 is directly connected, GigabitEthernet0/0/0

O 10.3.0.0/24 [110/2] via 10.4.0.2, 01:18:02, GigabitEthernet0/0/1

C 10.4.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.4.0.1/32 is directly connected, GigabitEthernet0/0/1

B 192.168.0.0/24 [200/0] via 10.1.0.1, 00:26:19

B 192.168.1.0/24 [20/0] via 10.2.0.1, 00:45:14

**IBGP-3:**

**Running configuration:**

Current configuration : 1705 bytes

! Last configuration change at 17:49:08 UTC Mon Feb 12 2024

version 15.5

no service timestamps debug uptime

no service timestamps log uptime

no platform punt-keepalive disable-kernel-core

hostname IBGP-3

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420HY

license boot level securityk9

spanning-tree mode pvst

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface GigabitEthernet0/0/0

ip address 10.4.0.2 255.255.255.0

ip ospf 10 area 0

negotiation auto

interface GigabitEthernet0/0/1

ip address 10.3.0.2 255.255.255.0

ip ospf 10 area 0

negotiation auto

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router ospf 10

network 10.3.0.0 0.0.0.255 area 0

network 10.4.0.0 0.0.0.255 area 0

router bgp 3

bgp log-neighbor-changes

network 10.3.0.0 mask 255.255.255.0

network 10.4.0.0 mask 255.255.255.0

neighbor 10.3.0.1 remote-as 3

neighbor 10.4.0.1 remote-as 3

neighbor 10.4.0.1 update-source GigabitEthernet0/0/0

ip forward-protocol nd

no ip http server

no ip http secure-server

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**IP Routes:**

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 - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O 10.1.0.0/24 [110/2] via 10.3.0.1, 01:14:24, GigabitEthernet0/0/1

B 10.2.0.0/24 [200/0] via 10.4.0.1, 00:33:02

C 10.3.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.3.0.2/32 is directly connected, GigabitEthernet0/0/1

C 10.4.0.0/24 is directly connected, GigabitEthernet0/0/0

L 10.4.0.2/32 is directly connected, GigabitEthernet0/0/0

B 192.168.0.0/24 [200/0] via 10.1.0.1, 00:38:14

B 192.168.1.0/24 [200/0] via 10.2.0.1, 00:32:57

**Show IP BGP:**

BGP table version is 8, local router ID is 10.4.0.2

Status codes: s suppressed, d damped, h history, \* valid, > best, i - internal,

r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,

x best-external, a additional-path, c RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

Network Next Hop Metric LocPrf Weight Path

r>i 10.1.0.0/24 10.3.0.1 0 100 0 i

\*>i 10.2.0.0/24 10.4.0.1 0 100 0 i

\* i 10.3.0.0/24 10.3.0.1 0 100 0 i

\*> 0.0.0.0 0 32768 i

\* i 10.4.0.0/24 10.4.0.1 0 100 0 i

\*> 0.0.0.0 0 32768 i

\*>i 192.168.0.0 10.1.0.1 0 100 0 1 i

\*>i 192.168.1.0 10.2.0.1 0 100 0 2 i

**Show BGP Neighbors:**

BGP neighbor is 10.3.0.1, remote AS 3, internal link

BGP version 4, remote router ID 10.3.0.1

BGP state = Established, up for 00:42:26

Last read 00:00:43, last write 00:00:02, hold time is 180, keepalive interval is 60 seconds

Neighbor sessions:

1 active, is not multisession capable (disabled)

Neighbor capabilities:

Route refresh: advertised and received(new)

Four-octets ASN Capability: advertised and received

Address family IPv4 Unicast: advertised and received

Enhanced Refresh Capability: advertised and received

Multisession Capability:

Stateful switchover support enabled: NO for session 1

**Problems**

When configuring internal BGP routers as neighbors, we configured only one instead of two which left the configuration incomplete. To solve this, we configured the neighbor [ipv4 address] remote-as [autonomous-system-number] command on each of the routers to ensure a “full mesh” of the iBGP neighbors and reliable packet transmission.

When we first finished our lab set up and began testing, we realized we were able to ping the outer routers and their loopback interfaces from each other, but unable to ping to the internal iBGP ones. We figured out that OSPF was not redistributed into BGP, so we solved this through the redistribute ospf [area] command.

We could not figure out else was missing in our configuration to allow for internal BGP updates to go through. That’s when we found the neighbor [ipv4 address] update-source [interface] command which would determine the interface through which iBGP routers would receive updates from.

Lastly, we had issues with integrating OSPF into our BGP configuration. To solve this problem, we had to not only redistribute OSPF into BGP but also the other way around so that all routes learned by eBGP were BGP routes.

**Conclusion**

Overall, completing this lab helped further develop our routing knowledge and lab skills when dealing with different routing protocols, mainly BGP and OSPF. We learned how to implement previous BGP and OSPF skills when creating a network configured with internal BGP (iBGP).

**Lab Signoff**

