Layer 3 – Exercises

All participants will work within their groups in pairs. Each group has three routers and three switches to work with.

The lab is divided into four components:

1. Static Routing
2. Dynamic routing with OSPF
3. iBGP
4. eBGP

There is a certain dependency between the labs as the exercises progress. Make sure to maintain your configuration unless otherwise instructed. All exercises will use a common IP addressing scheme and network topology. Given the limited number of interfaces we will be using VLAN interfaces to facilitate the exercise and the different features we will be using.

As you go through the exercises all the examples are given from the point of view of R11, the border router in group 1. Make sure that you take the examples and adapt them to your own router, network topology and addressing scheme.

Address Space Allocation

Group 1: 10.10.0.0/16 ASN: 10
Group 2: 10.20.0.0/16 ASN: 20
Group 3: 10.30.0.0/16 ASN: 30
Group 4: 10.40.0.0/16 ASN: 40
Group 5: 10.50.0.0/16 ASN: 50

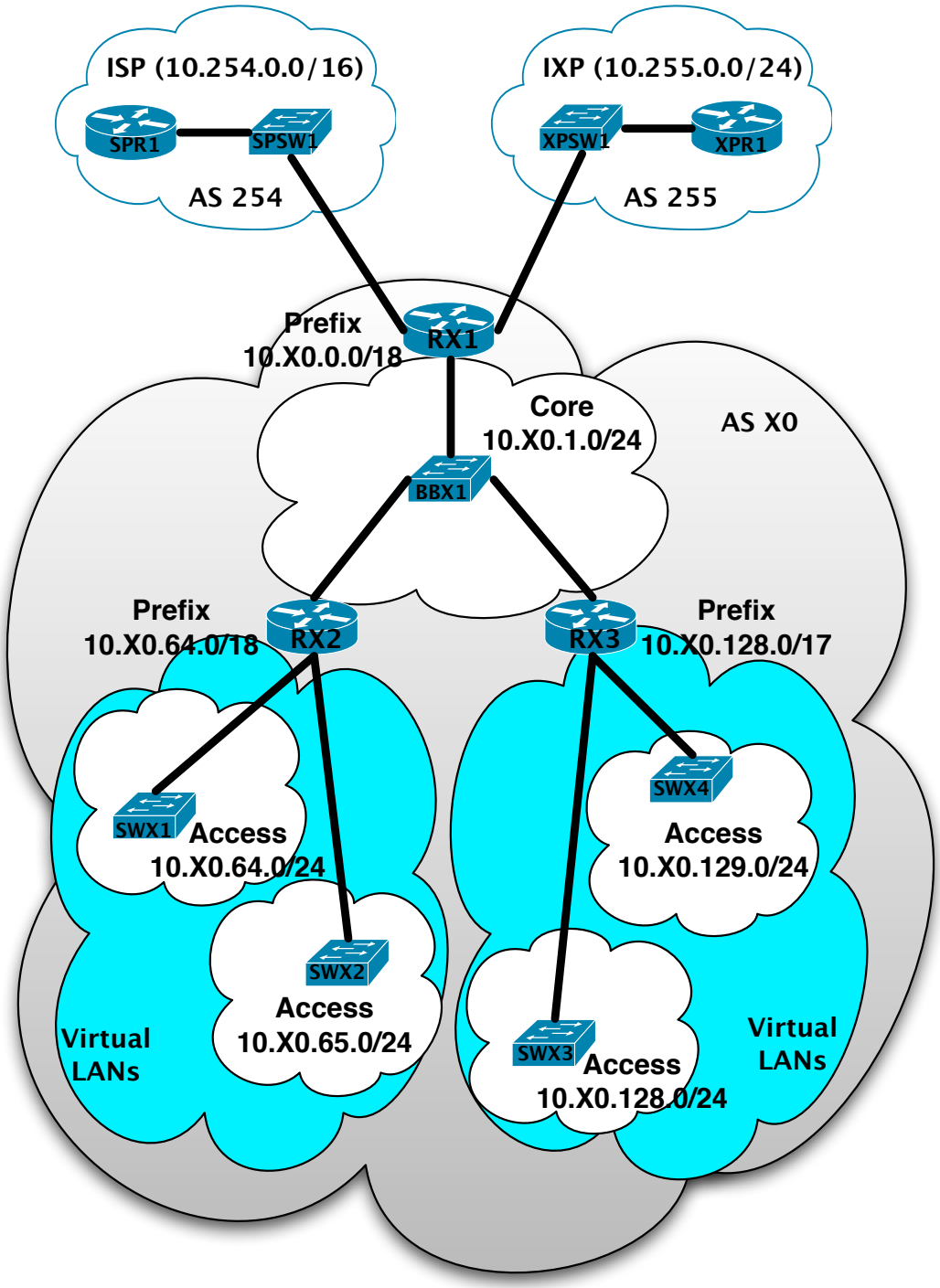
Each group will then further partition their space:

10.X0.1.0/24 – Core Network
10.X0.64.0/24 – Access Subnet (VLAN 64)
10.X0.65.0/24 – Access Subnet (VLAN 65)
10.X0.128.0/24 – Access Subnet (VLAN 128)
10.X0.129.0/24 – Access Subnet (VLAN 129)
10.X0.254.0/24 – Router Loopback Subnet

10.254.X0.0/30 – Connection to ISP
10.255.0.X0/24 – Connection to IXP

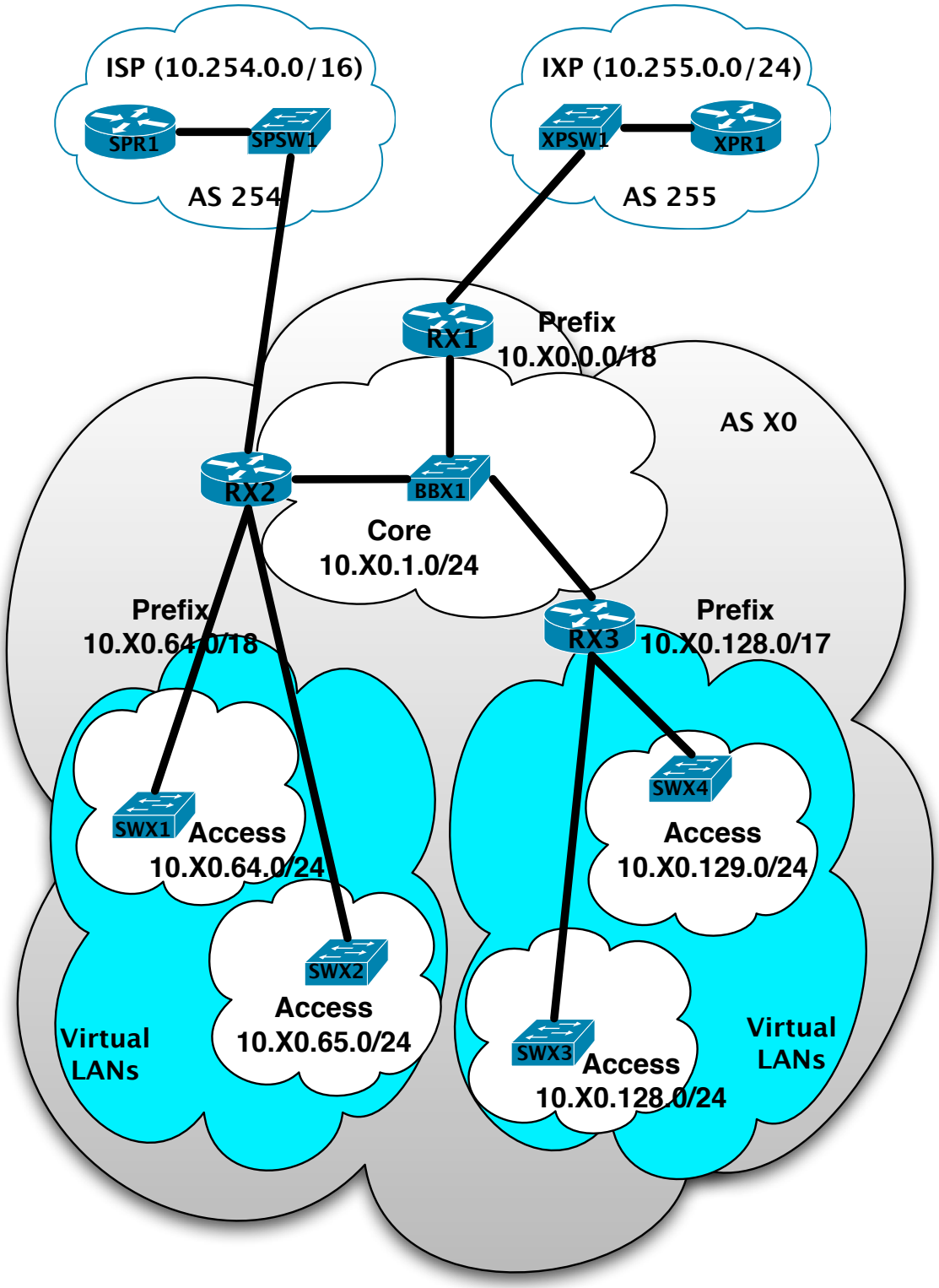
With X being your group number (1,2,3,4,5)

Network Topology



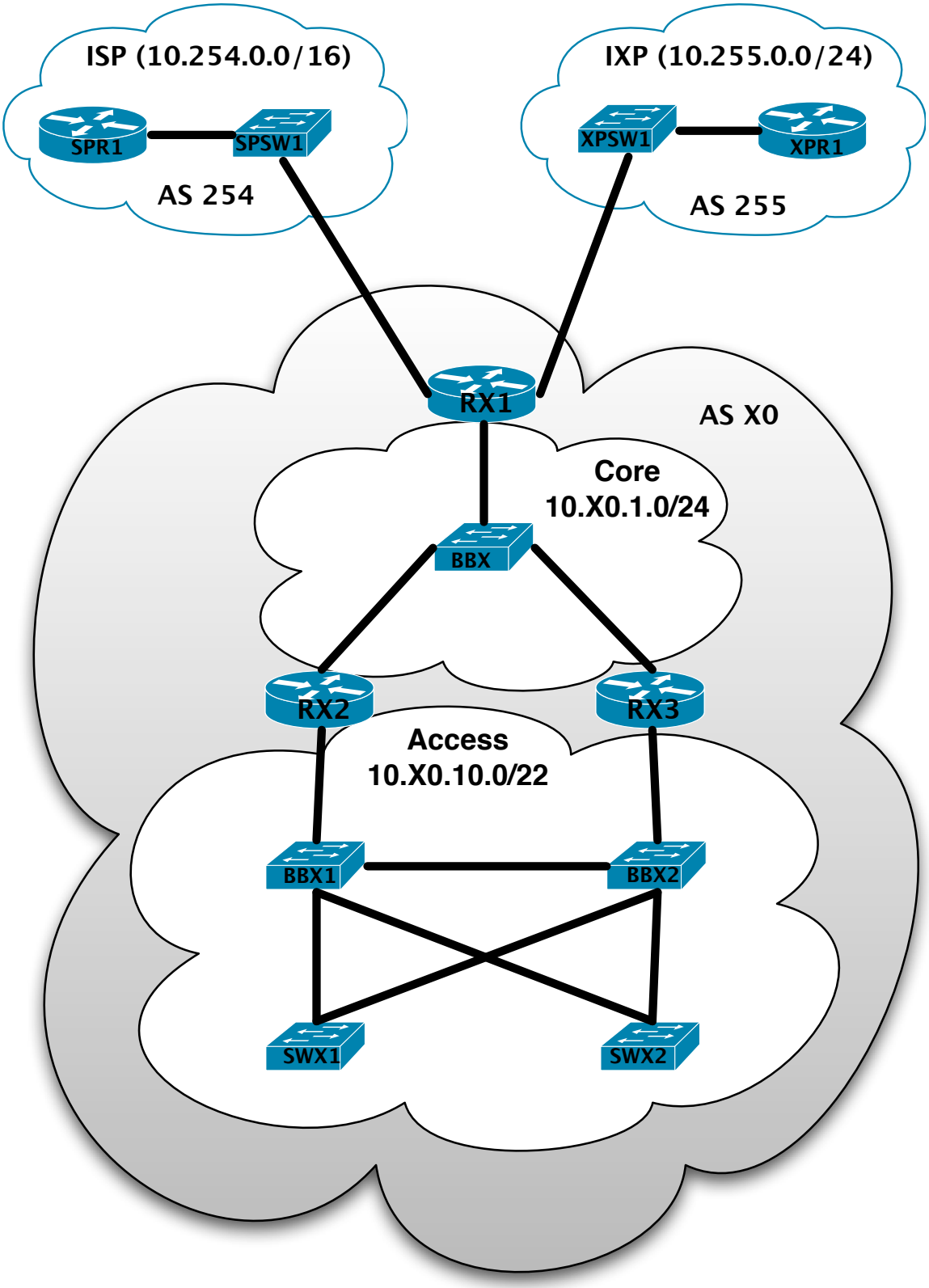
X = Refers to your group number (1-5)

Alternate Network Topology 1



X = Refers to your group number (1-5)

Alternate Network Topology 2



X = Refers to your group number (1-5)

Basic Router Configuration

1. Name the router.

```
Router> enable
Router# config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# hostname R11
R11(config)#
```

2. Deactivate domain name resolution.

```
R11 (config)# no ip domain-lookup
```

3. Create a username and password.

```
R11 (config(# username walc secret nsrc
R11 (config)# enable secret nsrc
R11 (config)# service password-encryption
```

4. Activate remote login access to the router

```
R11 (config)# aaa new-model
R11 (config)# aaa authentication login default local
R11 (config)# aaa authentication enable default enable
```

5. Make sure the router understands CIDR

```
R11 (config)# ip subnet-zero
R11 (config)# ip classless
```

6. Activate IPv6 routing.

```
R11 (config)# ipv6 unicast-routing
```

7. Save the configuration and checkpoint.

```
R11(config)#^Z
R11# write memory
Building configuration...
[OK]
R11#
```

8. Configure your interfaces.

```
R11(config)# interface FastEthernet0/1
R11(config-if)# ip address 10.10.1.1 255.255.255.0
R11(config-if)# description Link to Core
R11(config-if)# no ip redirects
R11(config-if)# no ip directed-broadcast
R11(config-if)# no ip proxy-arp
R11(config-if)# no shutdown
R11(config)#^Z
R11#
```

Or from the point of view of R12 where you will use VLANs

```
R12(config)# interface FastEthernet0/1
R12(config)# no ip address
R12(config)# interface FastEthernet0/1.64
R12(config)# encapsulation dot1Q 64
R12(config-subif)# ip address 10.10.64.1 255.255.255.0
R12(config-subif)# description Link VLAN 64
R12(config-subif)# no ip redirects
R12(config-subif)# no ip directed-broadcast
R12(config-subif)# no ip proxy-arp
R12(config-subif)# no shutdown
R12(config-subif)#^Z
R12#
```

9. Do some ping tests.

```
R11# ping 10.10.2.2
```

and then very the output of the following commands

IPv4:

`show arp`	: Shows ARP cache
`show interface <int> <number>`	: Shows interface state and configuration
`show ip interface`	: Shows interface IP state and config

IPv6:

`show ipv6 neighbors`	: Shows IPv6 neighbors
`show ipv6 interface <int> <number>`	: Shows interface state and configuration
`show ipv6 interface`	: Shows interface state and configuration

10. Create loopback interface.

```
R11(config)#interface loopback 0
R11(config-if)#ip address 10.10.254.1 255.255.255.255
R11(config-if)#^Z
R11#
```

11. Save the configuration and checkpoint.

```
R11# write memory
Building configuration...
[OK]
R11#
```

Static Routing

1. **Try pinging some of the addresses with your AS.**

```
R11# ping 10.10.254.2
R11# ping 10.10.254.3
R11# ping 10.10.10.1
R11# ping 10.10.11.1
R11# ping 10.10.128.1
R11# ping 10.10.129.1
```

2. **Create static routes.**

```
R11(config)# ip route 10.10.254.2 255.255.255.255 10.10.1.2
R11(config)# ip route 10.10.254.3 255.255.255.255 10.10.1.3
R11(config)# ip route 10.10.10.0 255.255.255.0 10.10.1.2
R11(config)# ip route 10.10.11.0 255.255.255.0 10.10.1.2
R11(config)# ip route 10.10.128.0 255.255.255.0 10.10.1.3
R11(config)# ip route 10.10.129.0 255.255.255.0 10.10.1.3
R11(config)#^Z
R11#
```

3. **Do the same ping tests.**

```
R11# ping 10.10.254.2
R11# ping 10.10.254.3
R11# ping 10.10.10.1
R11# ping 10.10.11.1
R11# ping 10.10.128.1
R11# ping 10.10.129.1
```

4. **STOP -- Checkpoint.** What happens when a new network is added?

Dynamic Routing with OSPF

1. **Configure a new OSPF routing process.**

IPv4:

```
R11(config)#router ospf 100
R11(config)#^Z
R11#
```

IPv6:

```
R11(config)#ipv6 router ospf 200
R11(config)#^Z
R11#
```

2. **Add the networks.**

IPv4:

```
R11(config)#router ospf 100
R11(config-router)#network 10.10.1.0 0.0.0.255 area 0
R11(config-router)#network 10.10.254.1 0.0.0.0 area 0
R11(config)#^Z
R11#
```

IPv6:

```
R11(config)#interface loopback 0
R11(config-if)#ipv6 ospf 200 area 0
R11(config)#^Z
R11#
```

3. **Disable OSPF for interfaces.**

IPv4

```
R11(config)#router ospf 100
R11(config-router)#passive-interface Loopback 0
R11(config-router)#passive-interface FastEthernet0/0
R11(config)#^Z
R11#
```

IPv6:

Don't configure OSPF in the given interface

4. Log OSPF Adjacencies.

IPv4:

```
R11(config)#router ospf 100
R11(config-router)#ospf log-adjacency-changes
R11(config)#^Z
R11#
```

IPv6:

```
R11(config)#ipv6 router ospf 200
R11(config-rtr)#log-adjacency-changes
R11(config)#^Z
R11#
```

5. STOP -- Checkpoint 1.

IPv4:

`show ip route`	: show routes in routing table
`show ip ospf`	: shows general OSPF information
`show ip ospf interface`	: shows the status of OSPF in an interface
`show ip ospf neighbor`	: shows OSPF neighbor list.

IPv6:

```
show ipv6 route
show ipv6 ospf
show ipv6 ospf interface
show ipv6 ospf neighbor
```

6. Which routes are preferred?

7. Remove the old static route entries.

```
R11(config)# no ip route 10.10.254.2 255.255.255.255 10.10.1.2
R11(config)# no ip route 10.10.254.3 255.255.255.255 10.10.1.3
R11(config)# no ip route 10.10.10.0 255.255.255.0 10.10.1.2
R11(config)# no ip route 10.10.11.0 255.255.255.0 10.10.1.2
R11(config)# no ip route 10.10.128.0 255.255.255.0 10.10.1.3
R11(config)# no ip route 10.10.129.0 255.255.255.0 10.10.1.3
R11(config)#^Z
R11#
```

8. **STOP -- Checkpoint 2.**

IPv4:

```
show ip route
```
: show routes in routing table

IPv6:

```
show ipv6 route
```

9. **Try pinging some of the addresses with your AS.**

```
R11# ping 10.10.254.2
R11# ping 10.10.254.3
R11# ping 10.10.10.1
R11# ping 10.10.11.1
R11# ping 10.10.128.1
R11# ping 10.10.129.1
```

iBGP

1. **Verify that we still have good connectivity to each of the loopback interfaces.**

```
R11# ping 10.10.254.2
R11# ping 10.10.254.3
R11# ping 10.10.10.1
R11# ping 10.10.11.1
R11# ping 10.10.128.1
R11# ping 10.10.129.1
```

IPv4:

```
show ip ospf                : shows general OSPF information
show ip ospf interface      : shows the status of OSPF in an interface
show ip ospf neighbor       : shows OSPF neighbor list.
show ip ospf database       : shows OSPF topology DB
```

IPv6:

```
show ipv6 ospf
show ipv6 ospf interface
show ipv6 ospf neighbor
show ipv6 ospf database
```

2. **Log the BGP neighbor changes and other global parameters.**

```
R11(config)#router bgp 10
R11(config-router)# bgp log-neighbor-changes
R11(config-router)# no synchronization
R11(config-router)# no auto-summary
R11(config)#^Z
R11#
```

3. **Configure iBGP neighbors.**

```
R11(config)# router bgp 10
R11(config-router)# neighbor 10.10.254.2 remote-as 10
R11(config-router)# neighbor 10.10.254.2 update-source loopback 0
R11(config-router)# neighbor 10.10.254.2 description iBGP to R12
R11(config-router)# neighbor 10.10.254.2 soft-reconfiguration inbound
R11(config)#
R11(config-router)# neighbor 10.10.254.3 remote-as 10
R11(config-router)# neighbor 10.10.254.3 update-source loopback 0
R11(config-router)# neighbor 10.10.254.3 description iBGP to R13
R11(config-router)# neighbor 10.10.254.3 soft-reconfiguration inbound
R11(config)#^Z
R11#
```

4. **STOP -- Checkpoint 1.**

IPv4:

```
show ip bgp summary          : shows BGP infomration and neighbors
show ip bgp                  : shows a list of learned BGP paths
show ip route                : shows all installed routes
```

IPv6:

```
show bgp ipv6 summary
show bgp ipv6
show ipv6 route
```

5. **Create BGP networks to advertis**e.

```
R11(config)# router bgp 10
R11(config-router)# network 10.10.0.0 mask 255.255.192.0
R11(config)#^Z
R11#
```

6. **STOP -- Checkpoint 2.** Why isn't the prefix being advertised?

```
R11# show ip bgp neighbors 10.10.254.2 advertised-routes
R11# show ip bgp neighbors 10.10.254.2 routes
R11# show ip bgp neighbors 10.10.254.2 received-routes
```

7. **Create a static route for your prefix.**

```
R11(config)# ip route 10.10.0.0 255.255.192.0 Null0
R11(config)#^Z
R11#
```

8. **Check connectivity.**

```
R11# ping 10.10.254.2
R11# ping 10.10.254.3
R11# ping 10.10.10.1
R11# ping 10.10.11.1
R11# ping 10.10.128.1
R11# ping 10.10.129.1
```

eBGP

1. **Configure your interface to the ISP.** Some networks will only connect to the ISP.

```
R11(config)# interface GigabitEthernet0/0
R11(config-if)# ip address 10.254.10.2 255.255.255.252
R11(config-if)# description Link to ISP
R11(config-if)# no ip redirects
R11(config-if)# no ip directed-broadcast
R11(config-if)# no ip proxy-arp
R11(config-if)# no shutdown
R11(config)#^Z
R11#
```

2. **Configure your interface to the IXP.** Some networks will only connect to the IXP.

```
R11(config)# interface GigabitEthernet0/0
R11(config-if)# ip address 10.254.0.10 255.255.255.0
R11(config-if)# description Link to IXP
R11(config-if)# no ip redirects
R11(config-if)# no ip directed-broadcast
R11(config-if)# no ip proxy-arp
R11(config-if)# no shutdown
R11(config)#^Z
R11#
```

3. **Configure eBGP session to external peers.**

```
R11(config)# router bgp 10
R11(config-router)# neighbor 10.254.10.1 remote-as 254
R11(config-router)# neighbor 10.254.10.1 description eBGP to ISP
```

Or you if connect to the IXP

```
R11(config)# router bgp 10
R11(config-router)# neighbor 10.255.0.20 remote-as 20
R11(config-router)# neighbor 10.255.0.20 description IXP to AS20
R11(config)#^Z
R11#
```

4. **STOP -- Checkpoint 1.**

```
R11# show ip bgp summary
R11# show ip bgp neighbors 10.254.10.1
R11# show ip bgp neighbors 10.254.10.1 advertised-routes
```

```
R11# show ip bgp neighbors 10.254.10.1 routes
R11# show ip bgp neighbors 10.254.10.1 received-routes
R11# show ip bgp
```

5. Aggregate CIDR blocks.

```
R11(config)# router bgp 10
R11(config-router)# aggregate-address 10.10.0.0 255.255.0.0
R11(config-router)#^Z
R11#
```

6. STOP -- Checkpoint 2.

```
R11# show ip bgp neighbors 10.254.10.1 advertised-routes
R11# show ip bgp neighbors 10.254.10.1 routes
R11# show ip bgp neighbors 10.254.10.1 received-routes
```

7. Advertise only a summary aggregate.

```
R11(config)# router bgp 10
R11(config-router)# no aggregate-address 10.10.0.0 255.255.0.0
R11(config-rtr)# aggregate-address 10.10.0.0 255.255.0.0 summary-only
R11(config-router)#^Z
R11#
```

Another option would be:

```
R11(config)# router bgp 10
R11(config-rtr)#no aggregate-address 10.10.0.0 255.255.0.0 summary-only
R11(config-router)# network 10.10.0.0 mask 255.255.0.0
R11(config-router)# exit
R11(config)# ip route 10.10.0.0 255.255.0.0 Null0 250
R11(config)#^Z
R11#
```

8. Create prefix lists for inbound/outbound policies.

```
R11(config)# ip prefix-list out-peer permit 10.10.0.0/16 le 32
R11(config)# ip prefix-list out-peer deny 0.0.0.0/0 le 32
R11(config)# ip prefix-list as20-in-peer permit 10.20.0.0/16 le 32
R11(config)# ip prefix-list as20-in-peer deny 0.0.0.0/0 le 32
R11(config)#^Z
R11#
```

9. Create input and output policies.

```
R11(config)# router bgp 10
R11(config-router)# neighbor 10.255.0.20 remote-as 255
R11(config-router)# neighbor 10.255.0.20 description IXP to AS20
R11(config-router)# neighbor 10.255.0.20 out-peer out
R11(config-router)# neighbor 10.255.0.20 as20-in-peer in
R11(config-router)# neighbor 10.255.0.20
R11(config)#^Z
R11#
```

10. STOP -- Checkpoint 3.

```
R11# show ip bgp summary
R11# show ip bgp
R11# ping <ip_address>
R11# traceroute <ip_address>
```