IPv6 Lab - Routing

Setting up IS-IS

Configuring IS-IS

Each team will need to configure IS-IS between the four routers in their AS. The core router should be straightforward to configure. It has one loopback interface, one interface connecting to the peering router, and one interface connecting to the border router. And even though we are using ethernet to connect the routers, these are only point-to-point links and IS-IS should be configured as such.

For the peering, access and border routers, IS-IS should only be activated on the internal interface, with the loopback marked as passive. Note we do not configure the interface pointing to outside of our network as we will be using *next-hop-self* for our iBGP sessions.

Here is a configuration example for the core router:

```
router isis asX0
 net 49.0001.1000.6800.X002.00
 is-type level-2-only
 metric-style wide
 set-overload-bit on-startup wait-for-bgp
 log-adjacency-changes all
 metric 100000
 passive-interface loopback0
!
 address-family ipv6
  multi-topology
  set-overload-bit on-startup wait-for-bgp
!
interface fastethernet 0/0
 description BackBone link to AX
 ip router isis asX0
 isis metric 2
 ipv6 router isis asX0
 isis ipv6 metric 2
!
interface gigabitethernet 1/0
 description BackBone link to BX
 ip router isis asX0
 isis metric 2
 ipv6 router isis asX0
 isis ipv6 metric 2
!
interface gigabitethernet 2/0
 description BackBone link to PX
 ip router isis asX0
 isis metric 2
```

```
 ipv6 router isis asX0
 isis ipv6 metric 2
!
```

For the routers with connections outside the local autonomous system, we have to be very careful not to enable IS-IS on those external links. Nor do we need to carry those external link addresses in IS-IS. So do not enable IS-IS on an interface unless the router at the other end of that link is part of your own autonomous system.

Once IS-IS is working inside your autonomous system, check that you can reach all other routers inside your AS. Easiest way to test this it to ping the IPv4 and IPv6 loopback addresses from each router. Does it all work? If not, what could be wrong?

IS-IS on Point-to-Point Ethernet Links

We need to modify IS-IS's behaviour on point-to-point broadcast media links, such as Ethernet, when there are only two devices on that media. If we declare such a situation to be point to point, then IS-IS does not try and determine a designated router; furthermore, there will be an improvement/simplification in SPF calculations and memory requirements on the router.

Those router teams which have IS-IS configured over an Ethernet interface should now convert IS-IS to point-to-point mode, for example:

```
interface fastethernet 0/0
  isis network point-to-point
```

The link is now treated like a point-to-point serial connection.

Ping Test

Check the routes via IS-IS. Make sure you can see all the networks within your AS. Ping all loopback interfaces within your AS. Use the "*show isis neighbor"* and *"show ip[v6] route"* commands. If you cannot see the other routers in your AS, you will not be able to bring up BGP in the next steps.

Telnet source address

Most Network Operators use the router Loopback address for administrative purposes as well as the anchor point for their network's iBGP sessions. In this step we will configure telnet so that it uses the loopback interface as the source address for all telnet packets (IPv4 and IPv6) originated by the router.

```
ip telnet source-interface loopback 0
```

To check that this has worked, telnet from your router to a neighbouring router and then enter the "who" command. You will see that you are logged in, and the source address will be displayed. For example, using telnet from C1 to B1 gives:

```
C1>who
    Line     User      Host(s)                 Idle Location
*  2 vty 0   v6lab     idle                00:00:00 100.68.1.2
```

Save the configuration

Don’t forget to save the configuration to NVRAM!

Configuring iBGP

The next step is to configure iBGP mesh between the four routers in each autonomous system. We’ll use a route-reflector set up to handle this, as this is very common practice today, and full mesh iBGP does not scale, as was covered in the presentations.

We will make the core router the route reflector, as is standard practice. The border router will be a client, the access router will be a client, and the peering router will also be a client. Before setting up the iBGP route reflector, we need to consider the following:

- border router connects to transit ISP, so can in theory receive the entire global routing table from the upstream (either as a default route, or as every individual announced prefix).

- peering and access routers connect to customers, private and public peers - the peering router should only hear routes that the peers should be able to receive. A common mistake is for peering routers in service provider backbones to carry the full Internet routing table, resulting in bandwidth hijack, misrouted traffic, and so on. The access router only needs routes local to the AS and the default route - it should never need to carry Internet routes.

Configuring Core Router iBGP

First we set up the core router. We create two peer groups, one for the standard iBGP mesh, the other for use with the access and peering routers. Here is an example:

```
router bgp X0
 bgp deterministic-med
 no bgp default ipv4-unicast
!
 address-family ipv4
  distance bgp 200 200 200
  neighbor ibgp-partial peer-group
  neighbor ibgp-partial description Local Routes only
  neighbor ibgp-partial remote-as X0
  neighbor ibgp-partial update-source loopback0
  neighbor ibgp-partial next-hop-self
  neighbor ibgp-partial send-community
  neighbor ibgp-partial route-reflector-client
  neighbor ibgp-partial filter-list 10 out
  neighbor ibgp-full peer-group
```

```
  neighbor ibgp-full description Local Routes only
  neighbor ibgp-full remote-as X0
  neighbor ibgp-full update-source loopback0
  neighbor ibgp-full next-hop-self
  neighbor ibgp-full send-community
  neighbor ibgp-full route-reflector-client
  neighbor 100.68.X.1 peer-group ibgp-full
  neighbor 100.68.X.1 description iBGP with BX
  neighbor 100.68.X.3 peer-group ibgp-partial
  neighbor 100.68.X.3 description iBGP with PX
  neighbor 100.68.X.4 peer-group ibgp-partial
  neighbor 100.68.X.4 description iBGP with AX
!
 address-family ipv6
  distance bgp 200 200 200
  neighbor ibgp-partialv6 peer-group
  neighbor ibgp-partialv6 remote-as X0
  neighbor ibgp-partialv6 description Local Routes only
  neighbor ibgp-partialv6 update-source Loopback0
  neighbor ibgp-partialv6 send-community
  neighbor ibgp-partialv6 route-reflector-client
  neighbor ibgp-partialv6 next-hop-self
  neighbor ibgp-partialv6 filter-list 10 out
  neighbor ibgp-fullv6 peer-group
  neighbor ibgp-fullv6 remote-as X0
  neighbor ibgp-fullv6 description Local Routes only
  neighbor ibgp-fullv6 update-source Loopback0
  neighbor ibgp-fullv6 send-community
  neighbor ibgp-fullv6 route-reflector-client
  neighbor ibgp-fullv6 next-hop-self
  neighbor 2001:DB8:X::1 peer-group ibgp-fullv6
  neighbor 2001:DB8:X::1 description iBGP with BX
  neighbor 2001:DB8:X::3 peer-group ibgp-partialv6
  neighbor 2001:DB8:X::3 description iBGP with PX
  neighbor 2001:DB8:X::4 peer-group ibgp-partialv6
  neighbor 2001:DB8:X::4 description iBGP with AX
!
ip as-path access-list 10 permit ^$
```

Notice how we have set up one peer-group called ibgp-partial for use with the access and peering routers - its only difference from the peer-group called ibgp-full is that it has one additional line only permit prefixes originated by the local AS to go to that router. So if the upstream provider sends a default route, or any prefixes from the global BGP table, they will now not make their way to the peering router. While we have used an AS-path filter here, we could also use BGP communities (much more scalable!).

Originating Prefixes

We will now originate our prefixes into iBGP. We will only do this on the core router (common practice is to originate prefixes on the core routers in a network operator’s backbone, never on the peering or

border routers). So, returning to the core router, we now add in network statements to cover our IPv4 and IPv6 address blocks. Here is an example:

```
router bgp X0
 address-family ipv4
  network 100.68.X.0 mask 255.255.255.0
 address-family ipv6
  network 2001:DB8:X::/48
!
ip route 100.68.X.0 255.255.255.0 Null0
ipv6 route 2001:DB8:X::/48 Null0
```

Don’t forget the pull up routes for the aggregate - the network statement in Cisco IOS only tells BGP to put that address block into BGP if the match block is in the global RIB - and the simplest way to install it in the global RIB is to set up a static route pointing to the Null0 interface.

Configuring Access and Peering Router iBGP

We now turn to the access and peering routers, and will configure iBGP on those as well. We’ll follow the same ideas as we used for the Core router, only the access and peering routers are route reflector clients. Here is a configuration example for either the access or peering routers:

```
router bgp X0
 bgp deterministic-med
 no bgp default ipv4-unicast
!
 address-family ipv4
  distance bgp 200 200 200
  neighbor ibgp-rr peer-group
  neighbor ibgp-rr description iBGP with RR
  neighbor ibgp-rr remote-as X0
  neighbor ibgp-rr update-source loopback0
  neighbor ibgp-rr next-hop-self
  neighbor ibgp-rr send-community
  neighbor 100.68.X.2 peer-group ibgp-rr
  neighbor 100.68.X.2 description iBGP with CX
!
 address-family ipv6
 < do the same for IPv6 >
!
```

Configuring Border Router iBGP

We now turn to the border router, and will configure iBGP on that as well. We’ll follow the same ideas as we used for the Core router, only the Border router is a route reflector client. Here is a configuration example:

```
router bgp X0
```

```
 bgp deterministic-med
 no bgp default ipv4-unicast
!
 address-family ipv4
  distance bgp 200 200 200
  neighbor ibgp-rr peer-group
  neighbor ibgp-rr description iBGP with RR
  neighbor ibgp-rr remote-as X0
  neighbor ibgp-rr update-source loopback0
  neighbor ibgp-rr next-hop-self
  neighbor ibgp-rr send-community
  neighbor 100.68.X.2 peer-group ibgp-rr
  neighbor 100.68.X.2 description iBGP with CX
!
 address-family ipv6
 < do the same for IPv6 >
!
```

Notice that the peer-group is identical to the one used on the Peering Router.

Improving Routing Security

There are a few things we need to tidy up here before we continue with the lab.

Peering Router

The peering router is just that, a router that peers with other network operators. It does not provide any transit. The peers should only see the routes that you want them to see. We've made sure of this by putting in a route filter on the core router so that the peering router can only see locally originated routes. But it is also a good idea to null route the default route, as we will soon be distributing a default route around the AS using IS-IS. So on the peering router we now do:

```
ip route 0.0.0.0 0.0.0.0 null0
ipv6 route ::/0 null0
```

Now if any of the IXP participants point a default route to the local network, the traffic will simply be dumped in the Null interface of the peering router. Only traffic for specific destinations which available in the routing table on the IXP router will be forwarded to the rest of the network. This is a very important **network security** requirement.

Border Router

The border router connects to the upstream provider, and therefore gives us access to the whole Internet. The upstream provider will usually send us a default route by eBGP (yet to be set up). Once we hear this default route, how should it be propagated around the autonomous system?

It can be propagated using iBGP, but that tends to be non-optimal, certainly when trying to load balance between two or more transit providers, as the BGP best path is just that. If we distribute the default by the IGP instead, then at least the default route becomes the nearest exit, to the nearest border router. So we will now configure this - for example:

```
router isis asX0
 default-information originate
!
 address-family ipv6
  default-information originate
!
```

We now should be ready to proceed with the next part of the lab.

Adding a customer route

Consult the address plan and now set up customer routes on the Access Router. We'll just use one IPv4 and one IPv6 customer per Autonomous System. Take the address assigned for the "End User Space 1"; as we don't have any access routers we'll simply point a static route for the customer route to the Null interface on the Access router. We'll use a /26 for IPv4 and a /52 for IPv6 out of the "End User Space 1" assignments.

Here is an example for the access router.

```
ip route 100.68.X.64 255.255.255.192 null0
ipv6 route 2001:DB8:X:4000::/52 null0
!
router bgp X0
 address-family ipv4
  network 100.68.X.64 mask 255.255.255.192
 address-family ipv6
  network 2001:DB8:X:4000::/52
!
```

Once this has been configured you should then see the customer IPv4 /26 and IPv6 /52 visible in the iBGP for the AS. Check on the Border, Peering and Core routers, and make sure the prefix is visible. Use these commands:

```
show ip bgp
show bgp ipv6 unicast
```

Configuring the link to the Transit Provider

The next step is to set up eBGP with the Transit Provider. The lab instructors will be running the routers for the two Transit Providers and will have already configured them.

Physical Link

Follow the guidelines in the [IP Address Plan](address-plan) document to configure the link to the upstream. Make sure that you can ping the upstream's router using both IPv4 and IPv6 - if it doesn't work, investigate why.

Here is an example configuration for AS60:

```
interface fastethernet 0/0
 description Link to TR2
 ip address 100.122.1.10 255.255.255.252
 ipv6 address 2001:19:0:12::1/127
!
```

IS-IS

Do not configure IS-IS towards the upstream provider! They are not part of your autonomous system.

External BGP

We now configure eBGP with the upstream. Again, the configuration on the two transit routers will have already been completed by the instructors, so once configured, the eBGP session should just come up and work.

Here is a configuration example for AS10:

```
router bgp 10
 address-family ipv4
  neighbor 100.121.1.1 remote-as 121
  neighbor 100.121.1.1 description eBGP with TRANSIT 1
!
 address-family ipv6
  neighbor 2001:18:0:10:: remote-as 121
  neighbor 2001:18:0:10:: description eBGP with TRANSIT 1
!
```

Once this has been configured, you should now see routes coming from the upstream provider, and you should be able to see your aggregate being sent to your upstream. The commands to see what you are receiving are:

```
show ip bgp neigh 100.121.1.1 routes
show bgp ipv6 uni neigh 2001:18:0:10:: routes
```

and to show what you are sending:

```
show ip bgp neigh 100.121.1.1 advertised-routes
```

```
show bgp ipv6 uni neigh 2001:18:0:10:: advertised-routes
```

Confirmation

Check on the Core and Peering Router what you now see in the BGP table. Are there differences? Can you explain what they are, and why?

What does:

```
show ip bgp 0.0.0.0 0.0.0.0
show ip route 0.0.0.0 0.0.0.0
show ipv6 route ::/0
show bgp ipv6 uni ::/0
```

show you on the core router and on the peering router?

You will notice that the default route is being propagated by BGP throughout the AS.

- On the core router, it will complain of a **RIB failure** when you look at the BGP table, because OSPF has a default route with a lower protocol distance.

- On the border router, it will complain of a **RIB failure** when you look at the BGP table, because there is a static default route to the Null interface.

While there is nothing wrong with a **RIB failure**, we can just remove the default from being propagated by the iBGP. To do this, we go back to the eBGP session, look for the default, tag it with the *no-advertise* community, and then the border router will no longer announce the default by iBGP.

Here is a configuration example for AS20:

```
ip prefix-list default-route permit 0.0.0.0/0
!
route-map tag-default permit 10
 match ip address prefix-list default-route
 set community no-advertise
!
route-map tag-default permit 20
!
ipv6 prefix-list default-v6route permit ::/0
!
route-map tag-v6default permit 10
 match ipv6 address prefix-list default-v6route
 set community no-advertise
!
route-map tag-v6default permit 20
!
router bgp 20
 address-family ipv4
  neighbor 100.121.1.5 route-map tag-default in
```

```
 address-family ipv6
  neighbor 2001:18:0:11:: route-map tag-v6default in
!
```

To confirm, has the default route now disappeared from the BGP table on the Core and Peering routers? If not, did you remember to do route-refresh after you applied the above configuration?

Testing

Once this has been completed, test the connectivity. Can you reach the other groups in the class? You should be able to ping all the IPv4 and IPv6 loopbacks across the whole classroom.

Can you see the Internet too? The lab has IPv4 connectivity to the Internet - check that this works by trying a few pings or trace routes to well known destinations (e.g. to 8.8.8.8).

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