Chapter 12: Configuring Effective Internet Routing Policies

I. Redundancy, Symmetry, and Load Balancing

1. Dynamically Learned Defaults
   1. Use the router bgp neighbor command `neighbor x.x.x.x default-originate` do direct a default route to that neighbor only
   2. Can also advertise a default to all neighbors by using the `network 0.0.0.0` command. The local router must have a default route in it's routing table in order to advertise it through BGP.
   3. Below is an example, RTA directing a default to RTC only.

   ![Diagram](image)

   **Figure 12-1** Dynamically Learned Defaults

2. Example 12-1 RTA Configuration for Dynamically Learned Defaults

```
router bgp 3
no synchronization
network 172.16.1.0 mask 255.255.255.0
neighbor 172.16.20.1 remote-as 1
neighbor 172.16.20.1 default-originate
no auto-summary
```

3. f
4. BGP/IPv Routing Tables for RTC

```
Example 12-2    BGP/IPv Routing Tables for RTC

RTCA#show ip bgp
BGP table version is 14, local router ID is 192.08.11.1
Status codes: s suppressed, d damped, h history, * valid, > best,
               i - internal Origin codes: i - IGP, e - EGP, ? - incomplete

    Network     Next Hop       Metric LocPrf Weight Path
  * 172.16.20.2  172.16.20.2     0     0          1 1
  * 172.16.20.2  172.16.20.2     0     0          1 1
  * 192.08.11.0  0.0.0.0        0     0            1 1

RTCA#show ip route
```

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4. BGP/IPv Routing Tables for RTC (Continued)

```
Codes: c - connected, s - static, i - IGRP, r - RIP, m - mobile, b - BGP
       d - EIGRP, e - EIGRP external, o - OSPF, a - OSPF inter area
       e1 - OSPF external type 1, e2 - OSPF external type 2, x - BGP
       ? - candidate default u - per-user static route
     * - best
Gateway of last resort is 172.16.20.2 to network 0.0.0.0
C 192.08.11.0/24 is directly connected, Ethernet0/0
C 172.16.20.0/24 is directly connected, Serial2/1
B+ 0.0.0.0/0 [20/0] via 172.16.20.2, 00:04:40
```

5. Originating Defaults Over All BGP Peers: RTA Configuration

```
Example 12-3    Originating Defaults Over All BGP Peers: RTA Configuration

    router bgp 3
    no synchronization
    network 0.0.0.0
    network 172.16.1.0 mask 255.255.255.0
    neighbor 172.16.20.1 remote-as 1
    no auto-summary
```
6. Statically Set Defaults
   1. Syntax
      1. ip route prefix mask \{address | interface\} [distance]
      2. Three main ways to set a default route
         1. 0/0 pointing to a network
         2. 0/0 pointing to a next-hop address
         3. 0/0 pointing to an address that is farther than the next-hop
            1. All of the above can also be configured with an outgoing interface.
      2. The best option in my opinion is to set the default to a network address of which has been advertised to the local router from multiple paths. This way if one path fails the static route will simply use the other path to the network. As long as the network stays in the routing table, the static route will function. If the network is withdrawn from the routing table, the static route will be withdrawn as well.
      3. The other option is to use next-hop or an address that's farther away. If using a unicast address you need to manually configure them for redundancy. You can either have them both in the routing table for load balancing, or configure one of the static routes with a numerically higher AD - this will make the static route with a numerically higher AD not be installed into the routing table only to show up if the primary route fails.
      4. See below for examples.

   7. f

   8. f
Example 12.6  
RTC BGP Table

RTC#show ip bgp
BGP table version is 8, local router ID is 192.68.11.1
Status codes: 0 suppressed, d damped, h history, * valid, > best,
1 - internal Origin codes: i - IGRP, e - EGP, ? - incomplete

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
<th>Metric LocPrf Weight Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 192.68.11.0</td>
<td>0.0.0.0</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 192.78.0.0/16</td>
<td>172.16.20.2</td>
<td>0 3 7 6 1</td>
</tr>
<tr>
<td>*</td>
<td>192.68.6.1</td>
<td>0 2 7 0 1</td>
</tr>
</tbody>
</table>

9. f

Example 12.6  
RTC IP Table

RTC#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
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,
* - candidate default U - per-user static route
Gateway of last resort is 192.78.0.0 to network 0.0.0.0
C 192.68.0.0/24 is directly connected, Ethernet0/1
C 192.68.11.0/24 is directly connected, Ethernet0/0
B 192.78.0.0/16 [20/0] via 172.16.20.2, 00:00:00
C 172.16.20.0/16 is directly connected, Serial2/1
S* 0.0.0.0/0 [1/0] via 192.78.0.0

10.f

Example 12.7  
Using distance to Prefer One Default Over Another: RTC Configuration

router bgp 1
network 192.68.11.0
neighbor 172.16.20.2 remote-as 3
neighbor 192.68.6.1 remote-as 2
no auto-summary
ip route 0.0.0.0 0.0.0.0 172.16.20.2 40
ip route 0.0.0.0 0.0.0.0 192.68.6.1 50

11.f

Example 12.8  
RTC Routing Table

RTC#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
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,
* - candidate default U - per-user static route
Gateway of last resort is 172.16.20.2 to network 0.0.0.0
C 192.68.0.0/24 is directly connected, Ethernet0/1
C 192.68.11.0/24 is directly connected, Ethernet0/0
B 192.78.0.0/16 [20/0] via 172.16.20.2, 00:45:00
C 172.16.20.0/24 is directly connected, Serial2/1
S* 0.0.0.0/0 [40/0] via 172.16.20.2

12.f
13.f
14. Multihoming to a Single Provider
   1. Default Only, One Primary Link, and One Backup Link
      1. Outbound traffic from AS3 should always go on the NY link unless that link
         fails, in which case it should switch to the other link. This can be achieved by
         configuring two static routes in RTA pointing the defaults toward the two links.
         The default via the NY link will be set with a lower distance to be more
         preferred.
      2. Inbound traffic toward AS3 should always come on the NY link unless that link
         fails, in which case it should switch to the other link. This can be achieved by
         having RTA send different metrics toward AS1 on both links, with a lower metric
         on the NY link. This way, inbound traffic coming from AS1 will always come
         via the NY link. Other attributes can also be used to accomplish this (that is,
         BGP communities and associated remote ingress policies.)
      3. Prevent any BGP updates from coming into AS3. This can be achieved by
         having AS3 configure a route map or prefix list that will block all incoming BGP
         routing updates. Usually, the provider (AS1, in this case) will not send you any
         updates per your request. Nevertheless, you should always protect your AS
         against the unknown. The provider could make a mistake and send you all his
         routes, and your AS would be vulnerable.
1. The below configurations is an example (from the above diagram) configurations to filter all updates from getting into AS3 from AS1, as well as setting MED so that the NY link is utilized for incoming traffic, and the static default routes one of which has a numerically higher AD so that traffic will always go out to NY unless it goes down.

```
Example 12-10  Default Only, One Primary Link, and One Backup Link: RTA Configuration

router bgp 3  
  network 172.16.220.0 mask 255.255.255.0  
  neighbor 172.16.20.1 remote-as 1  
  neighbor 172.16.20.1 route-map BLOCK in  
  neighbor 172.16.20.1 route-map SETMETRIC1 out  
  neighbor 192.68.9.2 remote-as 1  
  neighbor 192.68.9.2 route-map BLOCK in  
  neighbor 192.68.9.2 route-map SETMETRIC2 out  
  no auto-summary  
  ip route 0.0.0.0 0.0.0.0 172.16.20.1 30  
  ip route 0.0.0.0 0.0.0.0 192.68.9.2 40  
  route-map SETMETRIC1 permit 10  
  set metric 100  
  route-map SETMETRIC2 permit 10  
  set metric 50  
  route-map BLOCK deny 10
```

2. Below you can see the routing table of RTA showing that the lower AD static route has been injected into the routing table by RTM; however the other static route has not been injected. You COULD have both static routes in if they had the same AD, however the goal of this was to use the NY link as the primary.

```
Example 12-11  RTA IP Routing Table

RTA#show ip route
Codes: C - connected, S - static, I - IGMP, R - RIP, M - mobile, B - BGP  
D - EIGRP, EX - EIGRP external, 0 - OSPF, IA - OSPF inter area  
E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP  
S - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,  
* - candidate default

Gateway of last resort is 192.68.9.2 to network 0.0.0.0

C  192.68.9.0 is directly connected, Ethernet0  
172.16.0.0 255.255.255.0 is subnetted, 2 subnets  
C  172.16.220.0 is directly connected, Ethernet1  
C  172.16.20.0 is directly connected, Serial0  
S* 0.0.0.0 0.0.0.0 [40/0] via 192.68.9.2
```

3. The below shows RTCs BGP table showing the MED values that AS3 advertised for it's subnets. To get to 172.16.220.0, RTC must go through RTD sending traffic over the NY link.

```
Example 12-12  RTC BGP Table

RTC#show ip bgp  
BGP table version is 11, local router ID is 192.68.11.1  
Status codes: o suppressed, d damped, h history, * valid, > best,  
i internal Origin codes: i - IGP, e - EGP, ? - incomplete

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
<th>Metric LocPrf Weight Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>*&gt; 172.16.220.0/24</td>
<td>192.68.6.1</td>
<td>50 100 0 3 1</td>
</tr>
<tr>
<td>*</td>
<td>172.16.20.2</td>
<td>100 0 3 1</td>
</tr>
<tr>
<td>*&gt; 172.16.11.0</td>
<td>0.0.0.0</td>
<td>0 32768 1</td>
</tr>
</tbody>
</table>
```
3. Default, Primary, and Backup, Plus Partial Routing
   1. Policies used on the below network
      1. AS3 will accept only AS1's local routes and its customer's routes, such as AS6. AS3 will also accept one route from the Internet to set its default toward the provider AS1.
      2. For all outbound traffic toward AS1 and AS6 (the partial routes), AS3 should use the SF link. In case of failure, the other link is used.
      3. For all other outbound traffic toward the Internet, AS3 should use the NY link as the primary link by following a default route. In case of failure, the default via the other link should be used.
      4. For inbound traffic, AS3 will instruct AS1 to use the SF link for network 172.16.220.0/24.
      5. For all other inbound traffic, the NY link is the primary.
### 7. f

**Default, Primary, and Backup, Plus Partial Routing: RTA Configuration**

```plaintext
router bgp 3
no synchronization
network 172.16.1.0 mask 255.255.255.0
network 172.16.10.0 mask 255.255.255.0
network 172.16.65.0 mask 255.255.255.192
network 172.16.220.0 mask 255.255.255.0
neighbor 172.16.1.2 remote-as 3
neighbor 172.16.1.2 update-source Loopback0
neighbor 172.16.1.2 next-hop-self
neighbor 172.16.20.1 remote-as 1
neighbor 172.16.20.1 route-map SET_OUTBOUND_TRAFFIC in
neighbor 172.16.20.1 route-map SET_INBOUND_TRAFFIC out
neighbor 172.16.20.1 filter-list 10 out
no auto-summary
ip route 0.0.0.0 0.0.0.0 193.78.0.0
ip as-path access-list 10 permit ^$
ip as-path access-list 4 permit ^1 6$
ip as-path access-list 4 permit ^1$
access-list 2 permit ip 172.16.220.0 0.0.0.255
access-list 101 permit ip 193.78.0.0 0.0.255.255 255.255.0.0 0.0.0.0
route-map SET_OUTBOUND_TRAFFIC permit 10
match ip address 101
set local-preference 200
route-map SET_OUTBOUND_TRAFFIC permit 20
match as-path 4
set local-preference 300
route-map SET_INBOUND_TRAFFIC permit 10
match ip address 2
set metric 200
route-map SET_INBOUND_TRAFFIC permit 20
set metric 300
```

### Default, Primary, and Backup, Plus Partial Routing: RTF Configuration

```plaintext
router bgp 3
no synchronization
network 172.16.1.0 mask 255.255.255.0
network 172.16.10.0 mask 255.255.255.0
network 172.16.65.0 mask 255.255.255.192
network 172.16.220.0 mask 255.255.255.0
neighbor 172.16.2.254 remote-as 3
neighbor 172.16.2.254 next-hop-self
neighbor 192.68.5.2 remote-as 1
neighbor 192.68.5.2 route-map SET_OUTBOUND_TRAFFIC in
neighbor 192.68.5.2 route-map SET_INBOUND_TRAFFIC out
neighbor 192.68.5.2 filter-list 10 out
no auto-summary
ip route 0.0.0.0 0.0.0.0 193.78.0.0
ip as-path access-list 10 permit ^$
ip as-path access-list 4 permit ^1 6$
ip as-path access-list 4 permit ^1$
access-list 101 permit ip 193.78.0.0 0.0.255.255 255.255.0.0 0.0.0.0
route-map SET_OUTBOUND_TRAFFIC permit 10
match ip address 101
set local-preference 200
route-map SET_OUTBOUND_TRAFFIC permit 20
match as-path 4
set local-preference 250
route-map SET_INBOUND_TRAFFIC permit 20
set metric 200
```
8. The configuration of RTA above shows the following -

1. Route map SET_OUTBOUND_TRAFFIC is applied on RTA’s EBGP session to AS1. This route map will help specify which outbound traffic goes over which link. The first instance (10) will allow only one network, 193.78.0.0/16, to be accepted from the Internet. This network is used to set the default. This will be given a local preference of 200, which is lower than the local preference of 250 coming from RTF. This will cause all traffic toward the Internet to follow the default via the NY link.

2. The second instance (20) will set all prefixes coming from AS1 and AS6 with a local preference of 300, which is higher than local preference 250 coming from RTF. This will make the SF link the primary link to reach AS1 and its customer AS6. Note that this route map will allow only partial routes (AS1 and AS6) to be injected into AS3 by specifying the AS_PATH to be either AS1 (^1$) or AS6 (^1 6$).

3. Instead of listing all the customers of AS1 one by one as was done in AS path access list 4, a regular expression of the form ^1 ?\[0-9\]*$ could have been used to identify all the AS paths that start with 1 and that are of length 2 - that is, AS1 and its direct customers. The form of the access list would have been `ip as-path access-list 4 permit ^1 \[0-9\]*$` (to enter the ?, press Ctrl-V first). Be careful, though. In the case where AS1 is directly connected to another major provider with a direct link (rather than via a NAP), the preceding regular expression would also give you the local routes of that second provider.

4. Route map SET_INBOUND_TRAFFIC is also applied on RTA’s EBGP link to AS1. The first instance (10) will cause prefix 172.16.220.0/24 to be sent with a metric of 200, which is lower than the metric 250 sent by RTF. This will ensure that traffic from AS1 toward this destination will take the SF link. All other updates will be sent with a metric of 300, which is higher than metric 250 sent by RTF. This will cause all other inbound traffic to take the NY link.

5. The filter list 10 will prevent AS3 from becoming a transit AS

6. The `ip route 0.0.0.0 0.0.0.0` statement sets the default to 193.78.0.0/16.
9. The above shows RTA's BGP table, indicating that the default route pointing to network 193.78.0.0 is best through RTF with a higher (more desirable) local preference than RTA's own route to RTC. Outbound traffic towards routes for AS1 and AS6 are more desirable going directly through RTC from RTA. RTA doesn't have any routes in its BGP table for AS1 and AS6 going through RTF as RTF isn't advertising them to RTA as the Routes going directly from RTA to RTC are best.

![Example 12-16 RTA IP Routing Table](image)

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Example 12-16  **RTA IP Routing Table (Continued)**

```
  Gateway of last resort is 193.78.0.0 to network 0.0.0.0
  192.68.10.0/24 [20] via 172.16.20.1, 00:07:34
  192.68.11.0/24 [20] via 172.16.20.1, 00:07:34
  192.68.40.0/24 via 172.16.20.1, 00:07:34
  192.16.0.0/16 is variably subnetted, 3 subnets, 3 masks
  C  172.16.2.254/32 is directly connected, Loopback0
  C  172.16.220.0/24 is directly connected, Ethernet0
  C  172.16.20.0/24 is directly connected, Serial0
  O  172.16.10.0/24 [110/20] via 172.16.1.2, 01:29:52, Ethernet1
  C  172.16.1.0/24 is directly connected, Ethernet1
  O  172.16.6.0/26 [110/20] via 172.16.1.2, 01:29:52, Ethernet1
  S* 0.0.0.0/0 [1/0] via 192.68.0.0
  B  193.78.0.0/16 [200/24] via 172.16.1.2, 00:02:07
```

Example 12-17  **RTD BGP Table**

```
  BGP table version is 14, local router ID is 192.68.10.1
  Status codes: o suppressed, d damped, h history, * valid, > best, i internal Origin codes: i IGP, e EGP, ? incomplete
  Network    Next Hop    Metric     LocPrf    Weight
  172.16.1.0/24 192.68.5.1  250         0     1
  172.16.10.0/24 192.68.5.1  250        0     1
  172.16.65.0/26 192.68.5.1  250        0     1
  *172.16.220.0/24 192.68.6.2  200 100       1
  * 192.68.5.1  250        0     1
  * 192.68.10.0  0.0.0.0    0         0     1
  *1192.68.11.0  192.68.6.2  0 100       0
  *1192.68.48.0  192.68.6.2  0 100       0
  * 193.78.0.0/16 192.68.10.2  0  100       0
```

1. RTD can reach all networks in AS3 via the RTD-RTF direct link, except for prefix 172.16.220.0/24, which can be reached via the RTC-RTA link because of the better metric 200.
4. Load Balancing with BGP Multipath

1. In the below diagram, RTA is load balancing for networks 192.68.40.0 and 192.68.11.0 due to the configuration of `maximum-paths 2` bgp router subcommand. Under normal conditions, there can only be one best path which would be chosen by the lowest BGP ROUER-ID.

![Diagram of Load Balancing](image)

2. Below is the example of the `maximum-paths 2` bgp router subcommand.

```
router bgp 3
  no synchronization
  neighbor 172.16.1.2 remote-as 3
  neighbor 172.16.1.2 update-source Loopback0
  neighbor 172.16.20.1 remote-as 1
  neighbor 172.16.20.1 filter-list 10 out
  neighbor 172.16.60.1 remote-as 1
  neighbor 172.16.60.1 filter-list 10 out
  maximum-paths 2
  no auto-summary
  ip as-path access-list 10 permit ^$ 
```
3. RTA's BGP table showing that for both 192.68.11.0 and 192.68.40.0 routes, that the best path has been chosen based on the lowest BGP ROUTER_ID.

4. However due to the **maximum-paths 2** command, both routes have been installed in the routing table. Load balancing will occur based on the router's switching switching mode.

5. Sense RTF is an IBGP neighbor, RTA will only advertise one route to RTF, and the next hop in this case is RTA due to the **next-hop-self** bgp neighbor command. If RTA hadn't configured **next-hop-self**, the next hop would have been from the EBGP router with the lowest router-id, which would be 172.16.20.1. Also, if RTA had another external peer in another AS, RTA would have also advertised only the best path as well.
5. **Balancing Between Two Routers Sharing Multiple Paths**

1. RTA and RTC are able to load balance to each other because they are both using loopbacks as their update-source, and have both installed two static routes to get to each others loopback interface.

![Diagram](image)

6.  

Example 12-22  *Balancing Between Two Routers Sharing Multiple Paths: RTA Configuration*

```plaintext
interface Loopback0
 ip address 172.16.2.254 255.255.255.255

router bgp 3
 no synchronization
 neighbor 172.16.1.2 next-hop-self
 neighbor 172.16.1.2 remote-as 3
 neighbor 172.16.1.2 update-source Loopback0
 neighbor 172.16.90.1 remote-as 1
 neighbor 172.16.90.1 ebgp-multihop 2
 neighbor 172.16.90.1 update-source Loopback0
 no auto-summary
```

---

Example 12-22  *Balancing Between Two Routers Sharing Multiple Paths: RTA Configuration (Continued)*

```
ip route 172.16.90.1 255.255.255.255 172.16.28.1
ip route 172.16.90.1 255.255.255.255 172.16.68.1
```
Example 12-23  Balancing Between Two Routers Sharing Multiple Paths: RTC Configuration

```plaintext
interface Loopback0
 ip address 172.16.90.1 255.255.255.255

router bgp 1
 network 192.168.11.0
 neighbor 172.16.2.254 remote-as 3
 neighbor 172.16.2.254 ebgp-multihop 2
 neighbor 172.16.2.254 update-source Loopback0
 no auto-summary

ip route 172.16.2.254 255.255.255.255 172.16.20.2
ip route 172.16.2.254 255.255.255.255 172.16.60.2
```

Example 12-24  RTA BGP Table

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
<th>Metric</th>
<th>LocPrf</th>
<th>Weight</th>
<th>Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.16.10.0/24</td>
<td>172.16.1.2</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>192.168.11.0</td>
<td>172.16.90.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Example 12-25  RTA IP Routing Table

```
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
 D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSFP 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,
 * - candidate default U - per-user static route, o - OSPF
```

Continues

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Example 12-25  RTA IP Routing Table (Continued)

```
Gateway of last resort is not set
B 192.168.11.0/24 [20/0] via 172.16.90.1, 00:00:41
  172.16.0.0/16 is variably subnetted, 8 subnets, 2 masks
C 172.16.2.254/32 is directly connected, Loopback0
C 172.16.60.0/24 is directly connected, Ethernet0
C 172.16.20.0/24 is directly connected, Serial0
S 172.16.10.0/24 [110/20] via 172.16.1.2, 02:17:34, Etherent1
C 172.16.1.0/24 is directly connected, Ethernet1
S 172.16.60.1/24 [1/0] via 172.16.20.1
```

[1/0] via 172.16.60.1
15. Multihoming to Different Providers

1. AS3 is Dual Multihomed to AS1 and AS2. AS1 and AS2 also send and received routing updates and traffic with AS6 via a NAP. They all peer with RTE also, which is a route server.

2. The desired policy is as follows:
   1. AS3 will accept AS1's local and customer routes only via the SF link. All other Internet routes will be accepted via the NY link (primary).
   2. AS3 will accept a default route from AS1 just in case there is a failure in the NY link. AS3 prefers that the SF network 172.16.220.0/24 be reachable by the outside world via the SF link and that the NY networks 172.16.10.0/24 and 172.16.65.0/26 be reachable via the NY link.
   3. AS3 cannot be a transit network for AS1 and AS2, which means that under no circumstances will AS1 use AS3 to reach AS2.

Figure 12-7 Multiple Providers (Default, Primary and Backup, Full/Partial)
3. RTA's configuration (above). The following configurations explained:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>neighbor 172.16.20.1 route-map ACCEPT_LOCAL in</td>
<td>This neighbor command is referencing RTC and using route-map ACCEPT_LOCAL to either filter or modify the attributes of incoming advertisements.</td>
</tr>
<tr>
<td>route-map ACCEPT_LOCAL permit 10 match as-path 1 ip as-path access-list 1 permit ^1 ?[0-9]*$</td>
<td>The route-map is permitting everything, and for everything that is permitted use as-path access-list 1 as-path access-list 1 is using a regular expression to only accept local routes from AS1. The regular expression is doing the following: ^1 ? = Beginning of the string should always be a 1 with an option have a space or not to</td>
</tr>
</tbody>
</table>
have a space. If there's no space this means that the AS will be only a 1 and nothing else, meaning this is a route from AS1 only.

\[0-9]^*\$ = This part of the regex is saying to match any digits from 0-9 and has the option of being nothing, or repeated infinity. In simple terms this means the AS can simply not exist or can be 1, or 1111, or 2324123214343 for example.... $ simply means end of string. So as a whole, the AS has the option to be a 1 (and any AS here) and that's it. This is how the regular expression accomplishes the task of selecting only local routes or customer routes of AS1.

<table>
<thead>
<tr>
<th>neighbor 172.16.20.1 route-map PREPEND_PATH out</th>
<th>This neighbor command is referencing RTC and using route-map PREPEND_PATH to either filter or modify the attributes of outgoing advertisements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>route-map PREPEND_PATH permit 10</td>
<td>sequence 10 of the route map is permitting only the prefixes of access-list 1. Those prefixes will be advertised out with an as-path that has 3 prepended (added) to the beginning of the AS_PATH PA.</td>
</tr>
<tr>
<td>match ip address 1 set as-path prepend 3</td>
<td>sequence 20 is permitting all prefixes to be advertised out and is subjected to as-path access-list 2. Description of as-path access-list 2 below</td>
</tr>
<tr>
<td>route-map PREPEND_PATH permit 20</td>
<td>as-path access-list 2 is permitting all prefixes (NLRI) that matches the regular expression ^$.</td>
</tr>
<tr>
<td>match as-path 2</td>
<td>^ means the beginning part of the string or line</td>
</tr>
<tr>
<td></td>
<td>$ means the end of the string or line. Together ^$ simple means at the beginning and the end of the string, there shouldn't be anything. So RTA will be advertising only local routes to RTC, because the AS-PATH is blank until RTA actually advertises the NLRI and adds it's own AS.</td>
</tr>
</tbody>
</table>
Example 12-27  *Multiple Providers (Default, Primary and Backup, Full/Partial): RTF Configuration*

```
router bgp 3
  no synchronization
  network 172.16.1.0 mask 255.255.255.0
  network 172.16.10.0 mask 255.255.255.0
  network 172.16.65.0 mask 255.255.255.192
  network 172.16.210.0 mask 255.255.255.0
  neighbor 172.16.2.254 remote-as 3
  neighbor 172.16.2.254 next-hop-self
  neighbor 192.68.5.2 remote-as 2
  neighbor 192.68.5.2 route-map PREPEND_PATH out
  auto-summary
  ip as-path access-list 2 permit ^S
  access-list 1 permit 172.16.220.0 0.0.0.255

route-map PREPEND_PATH permit 10
  match ip address 1
  set as-path prepend 3

route-map PREPEND_PATH permit 20
  match as-path 2
```

**16.f**

*Example 12-28  RTA BGP Table*

```
Router# show ip bgp
BGP table version is 13, local router ID is 172.16.2.64
Status codes: s suppressed, d damped, h history, * valid, > best,
  i internal Origin codes: i - IGP, e - EGP, ? - incomplete
         Network     Next Hop       Metric  LocPrf  Weight  Path
>  0.0.0.0     172.16.20.1     0       0        0 i
> 172.16.1.0/24  0.0.0.0        0       0        32768 i
* i 172.16.12       0       100       0 i
> 172.16.10.0/24  172.16.12      20      32768 i
  i 172.16.12       0       100       0 i
> 172.16.65.0/24  172.16.12      20      32768 i
  i 172.16.12       0       100       0 i
> 172.16.220.0/24  0.0.0.0        0       32768 i
  i 172.16.12      20      100       0 i
>192.68.5.0      172.16.12      0       100       0 i
> 192.68.11.0     172.16.20.1     0       0       1 i
>199.78.0.0/16    172.16.12     100       0       2 i
```

**17.f**

*Example 12-29  RTG BGP Table*

```
Router# show ip bgp
BGP table version is 9, local router ID is 192.68.40.1
Status codes: s suppressed, d damped, h history, * valid, > best,
  i internal Origin codes: i - IGP, e - EGP, ? - incomplete
         Network     Next Hop       Metric  LocPrf  Weight  Path
>  172.16.1.0/24  192.68.10.1     0       2       3 i
> 172.16.10.0/24  192.68.10.1     0       2       3 i
> 172.16.65.0/24  192.68.10.1     0       2       3 i
> 172.16.220.0/24  192.68.10.3     0       7       3 i
  192.68.6.0     192.68.10.1     0       7       2 i
  192.68.11.0     192.68.10.3     0       7       1 i
> 192.68.10.0     0.0.0.0        0       32768 i
> 193.78.0.0/16    192.68.10.2     0       7       0 i
```
18. Customers of the Same Provider with a Backup Link

1. The below is an example of AS1 and AS2 being the customers of provider AS3. Also, AS1 and AS2 have a private link that they use to reach each others local routes, as well as provide each other a backup to the internet.

*Figure 12-8 Backup Private Link Used as Primary*
2. In order to accomplish this task, RTC is configured as follows:
3. neighbor 172.16.20.2 route-map PREF_FROM_AS3 in
   1. This route-map is filtering or applying attributes for incoming advertisements from RTA in AS3.
2. route-map PREF_FROM_AS3 permit 10
   1. sequence 10 is permitting the statements under it (if no matching statements, all prefixes are matched implicitly.
3. match as-path 1
   1. match statement references as-path access-list 1 for matching criteria
4. ip as-path access-list 1 permit _2_
   1. this as-path access-list is permitting all advertisements that have AS2 somewhere in the AS-PATH.
5. set local-preference 100
   1. The matching criteria was as-path access-list 1 and now you are setting the local-pref to 100 for those that were matched by the as-path access-list.
6. route-map PREF_FROM_AS3 permit 20
   1. sequence 20 is permitting the statements under it (if no matching statements, all prefixes are matched implicitly.
7. set local-preference 300
   1. As stated above, no matching statements therefore all prefixes are matched, and for all advertisements coming in, set local-pref to 300.
4. neighbor 192.68.6.1 route-map PREF_FROM_AS2 in
   1. This route-map is filtering or applying attributes for incoming advertisements from RTD in AS2
2. route-map PREF_FROM_AS2 permit 10
   1. sequence 10 is permitting the statements under it (if no matching statements, all prefixes are matched implicitly)
3. set local-preference 200
   1. As stated above, there aren't any matching statements, therefore all prefixes are matched by default (implicitly). For all advertisements coming in, set the local-pref to 200
5. RTC's bgp table: 192.68.10.0/24 as an example, is coming from AS3 has a local preference of 100 because its AS_PATH 3 2 contains 2. All other routes coming from AS3 have a local preference of 300. Remember that the higher the local-pref, the more desirable it becomes.
19. Customers of Different Providers with a Backup Link

1. The COMMUNITY Approach

   1. The below diagram is an example of AS1 and AS2 getting their internet connection from two different providers but also sharing a private link between them to directly connect to each others local networks, but also use each other as a backup just in case they lose their provider connection.

   ![Multiple ASs with Multiple Providers](image)

   2. RTA is setting the local-pref to 40 for bgp updates that have community 4:40
   3. RTA is also setting the local-pref to 60 for bgp updates that have community 4:60
   4. For all other prefixes, set the local-pref to 100.

1. This is being done set for inbound updates from both RTF and RTC.

5. RTC's and RTF's configuration define communities 4:40 and 4:60 below.

   Example 12-32

   **Backup Links for Multiple ASs with Multiple Providers Via COMMUNITY: RTA Configuration**

   ```
   router bgp 4
   network 172.16.220.0 mask 255.255.255.0
   neighbor 172.16.1.2 remote-as 3
   neighbor 172.16.1.2 route-map CHECK_COMMUNITY in
   neighbor 172.16.20.1 remote-as 1
   neighbor 172.16.20.1 route-map CHECK_COMMUNITY in
   no auto-summary
   ip community-list 2 permit 4:40
   ip community-list 3 permit 4:60
   route-map CHECK_COMMUNITY permit 10
   match community 2
   set local-preference 40
   route-map CHECK_COMMUNITY permit 20
   match community 3
   set local-preference 60
   route-map CHECK_COMMUNITY permit 30
   set local-preference 100
   ```
6. RTC's configuration.

Example 12-33 Backup Links for Multiple ASs with Multiple Providers Via COMMUNITY: RTC Configuration

```
router bgp 1
 network 192.68.11.0
 neighbor 172.16.20.2 remote-as 4
 neighbor 172.16.20.2 send-community
 neighbor 172.16.20.2 route-map setcommunity out
 neighbor 172.16.20.2 filter-list 10 out
 neighbor 192.66.6.1 remote-as 2
 no auto-summary

ip as-path access-list 2 permit _2_

ip as-path access-list 10 permit ^5
ip as-path access-list 10 permit ^25

route-map setcommunity permit 10
 match as-path 2
```

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Example 12-33 Backup Links for Multiple ASs with Multiple Providers Via COMMUNITY: RTC Configuration (Continued)

```
set community 4:40
route-map setcommunity permit 20
```

2. RTC's configuration doing a few things; sending a community string as well as filtering based on an as-path access list, both of which are outbound to RTA.
   1. First, any routes that are either local to AS2 or are AS2’s customers, the community is set to 4:40 sent to RTA in AS4.
   2. A filter-list is also configured outbound to RTA which references as-path access-list 10. The goal here is to only advertise local routes and AS2’s local routes.
   3. RTD should be configured the same way as RTC.
3. RTF is configured to send all advertisements to RTA with a community of 4:60. That's all it's configured for other than the normal bgp peer commands.

1. Bottom line, RTA prefers RTC's local routes with a local-pref of 100 and a local-pref of 40 for RTD's routes coming from RTC - making RTF the preferred path for RTD routes. All routes coming from RTF, which includes RTD's routes have a local-pref of 60 which is why RTF is the preferred path for RTD routes.

4. **The AS_PATH Approach**
   1. RTC is simply prepending 1 to the AS-PATH for routes that are from AS2 that are being advertised from RTC to RTA.
2. The BGP table of RTA is showing the results of the AS_PATH prepend on RTC. As you can see that the path for 192.68.10.0 is preferred through RTF.

3. **NOTE** when you are labeling this up in GNS3 or using routers, keep in mind that you have control over the ISP and the Enterprise... in real life scenarios, you would need to coordinate with your ISP in order to make sure they aren't using AS_PATH access-lists that would otherwise filter routes with a prepended AS_PATH. For example, if the ISP only accepted routes from you with the following regular expressions: ^1$ (meaning from your AS only) or ^1 2$ (meaning from your AS and directly from AS2 to you) then the routes you prepended a 1 to will be filtered.

```
Example 12-37 Achieving Desired Routing Behavior Via AS_PATH Manipulation: RTA BGP Table

RTA#show ip bgp
BGP table version is 0, local router ID is 127.16.2.254
Status codes: s suppressed, d damped, h history, * valid, > best,
```

```

Example 12-37 Achieving Desired Routing Behavior Via AS_PATH Manipulation: RTA BGP Table (Continued)

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
<th>Metric</th>
<th>LocPrf</th>
<th>Weight</th>
<th>Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.16.10.0/24</td>
<td>172.16.12.0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>172.16.16.0/20</td>
<td>172.16.12.0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>172.16.220.0/24</td>
<td>0.0.0.0</td>
<td>0</td>
<td>32368</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>172.68.10.0</td>
<td>172.16.12.0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>172.16.20.1</td>
<td>172.16.20.1</td>
<td>100</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>172.68.11.0</td>
<td>172.16.20.1</td>
<td>100</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
```

5. f
II. Following Defaults Inside an AS

1. Below is an example of AS3 Edge routers (RTA and RTF) running BGP and OSPF, while the internal router RTG is running OSPF only, following the default routes advertised from the edge routers using the default-information originate always command on both edge routers. RTG is using RTA as the gateway of last resort as the metric is lower for that route compared to the one from RTF. Either way, the edge routers will decide which path is shorter and send traffic between each other depending on which path should be taken. See configurations and show output below.

![Diagram of AS3 network](image)

2. Following Defaults Inside the AS: Border Routers Connected

   

   **Example 12-38** Following Defaults Inside the AS: Border Routers Connected: RTA Configuration

   ```
   router ospf 10
   passive-interface Serial0
   network 172.16.0.0 0.0.255.255 area 0
   
   default-information originate always
   
   router bgp 3
   no synchronization
   network 172.16.1.0 mask 255.255.255.0
   network 172.16.70.0 mask 255.255.255.0
   network 172.16.220.0 mask 255.255.255.0
   neighbor 172.16.20.1 remote-as 1
   neighbor 172.16.20.1 filter-list 10 out
   neighbor 172.16.1.2 remote-as 3
   no auto-summary
   
   ip as-path access-list 10 permit ^$```

   ```
3. f

Example 12-39  Following Defaults Inside the AS: Border Routers Connected: RTF Configuration

```
router ospf 10
    network 172.16.0.0 0.0.255.255 area 0
    default-information originate always

router bgp 3
    no synchronization
    network 172.16.1.0 mask 255.255.255.0
    network 172.16.50.0 mask 255.255.255.0
    neighbor 172.16.1.1 remote-as 3
    neighbor 172.16.1.1 next-hop-self
    neighbor 192.68.5.2 remote-as 2
    neighbor 192.68.5.2 filter-list 10 out
    no auto-summary
```

ip as-path access-list 10 permit *$4. f

Example 12-40  Following Defaults Inside the AS: Border Routers Connected: RTG Configuration

```
router ospf 10
    network 172.16.0.0 0.0.255.255 area 0
```

5. f

Example 12-41  Following Defaults Inside the AS: Border Routers Connected: RTG IP Routing Table

```
! 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,
        * - candidate default, U - per-user static route, o - ODR
Gateway of last resort is 172.16.70.1 to network 0.0.0.0
172.16.0.0/16 is subnetted, 5 subnets
O  172.16.220.0/24 [110/74] via 172.16.70.1, 00:03:27, Serial0
O  172.16.220.0/24 is directly connected, Serial1
O  172.16.220.0/24 [110/74] via 172.16.70.1, 00:03:27, Serial0
O  172.16.10.0/24 [110/74] via 172.16.70.1, 00:03:27, Serial0
O  172.16.70.0/24 is directly connected, Serial0
O*E2  0.0.0.0/0 [110/1] via 172.16.70.1, 00:03:27, Serial0
```
6. BGP Policies Conflicting with the Internal Default

1. The below diagram is showing AS3 edge routers in a primary backup scenario, where RTF is the primary link and RTA is the backup. All routes advertised via IBGP from RTF to RTA has a higher local preference than routes learned via RTA EBGP link so that all traffic goes to RTF for internet bound traffic. RTG is the internal router running an IGP only and is following defaults to reach the internet. In order for RTG to successfully send traffic out to the internet without a loop being created, RTG must follow RTF’s default route, otherwise a loop will be created if RTG tries to send traffic to RTA instead.

2. The following happens when RTG follows RTA’s default route.
   1. RTG tries to send traffic to a destination outside AS3
   2. RTG follows the default toward RTA
   3. RTA has its BGP policies set to use RTF as the exit point
   4. To reach RTF, RTA uses RTG as a first hop
   5. RTG receives the traffic destined to the outside destination and forwards it back to RTA, and the loop occurs.

![Figure 12-11: Following Defaults Inside the AS: Border Routers Not Connected]
3. In order to avoid the loop issue explained above, you could use 1 of 4 possible solutions -
   1. Make sure that RTA does not inject a 0/0 in the IGP unless the primary link goes down. In normal conditions, all traffic will follow the default toward RTF and will be able to exit the AS. In case of a NY link failure, RTA should start sending defaults in the IGP. This method works most easily in a primary/backup environment. In cases where the exit point is not defined, it is hard to figure out which router should send the default. In such cases, any border router that receives the traffic should be able to send it on its direct external link.
   2. Make sure that the border router (RTA) does not send the traffic back to the internal router (RTG), which already used it (RTA) as the default. This could be done by providing a shorter path (metric-wise) via the BGP routers - for example, by having a direct physical link between RTA and RTF. If RTG uses RTA as default, RTA will use its directly connected link to send the traffic back to RTF.
   3. Run a full IBGP mesh between RTA, RTG, and RTF. RTG would learn all routes via BGP.
   4. Manipulate the metrics in such a way that the internal router (RTG) always gets a lower metric via the primary.
2. Using OSPF as the IGP
   1. Below is an example of RTA being configured to only inject a default route into OSPF if the default route is coming from the EBGP connection and if the next-hop is that of RTC. The same has been configured for RTF: the primary router for the internet connection. This works because RTA has also been configured to set the local-preference to be more desirable for all routes being advertised from RTF via iBGP including RTF's default route. This means that RTA will prefer RTF's default route and therefore the matching conditions for RTA to inject its own default into OSPF will not be met until RTF's internet connection goes down.

   Example 12-42 Using a Default Only Under Certain Conditions: RTA Configuration

   ```
   router ospf 10
   passive-interface Serial0
   network 172.16.0.0 0.0.255.255 area 0
   default-information originate route-map SEND_DEFAULT_IF
   
   router bgp 3
   no synchronization
   network 172.16.220.0 mask 255.255.255.0
   network 172.16.70.0 mask 255.255.255.0
   neighbor 172.16.20.1 remote-as 1
   neighbor 172.16.20.1 filter-list 10 out
   neighbor 172.16.50.1 remote-as 3
   neighbor 172.16.50.1 route-map setlocalpref in
   no auto-summary
   
   ip as-path access-list 10 permit "S"
   access-list 1 permit 0.0.0.0
   access-list 2 permit 172.16.20.1
   route-map setlocalpref permit 10
   set local-preference 300
   route-map SEND_DEFAULT_IF permit 10
   match ip address 1
   match ip next-hop 2
   ```

3. f

Example 12-43 Stop Advertisement of Default Under Specific Conditions: RTF Configuration

```
router ospf 10
network 172.16.0.0 0.0.255.255 area 0
default-information originate route-map SEND_DEFAULT_IF

router bgp 3
no synchronization
network 172.16.50.0 mask 255.255.255.0
neighbor 172.16.70.1 remote-as 3
neighbor 172.16.70.1 next-hop-self
neighbor 192.68.5.2 remote-as 2
neighbor 192.68.5.2 filter-list 10 out
no auto-summary

ip as-path access-list 10 permit "S"
access-list 1 permit 0.0.0.0
access-list 2 permit 192.68.5.2
route-map SEND_DEFAULT_IF permit 10
match ip address 1
match ip next-hop 2
```
5. **Example 12-45**  
**RTA IP Routing Table**

```
router ospf 10
network 172.16.0.0 0.0.255.255 area 0
```

```
Gateway of last resort is 172.16.50.1 to network 0.0.0.0

B 192.68.6.0/24 [200/8] via 172.16.50.1, 00:02:06
B 192.68.11.0/24 [200/0] via 172.16.50.1, 00:03:06
B 192.78.0.0/16 [200/8] via 172.16.50.1, 00:02:06
172.16.0.0/16 subnetwork, 4 subnets
C 172.16.20.0/24 is directly connected, Serial0
C 172.16.220.0/24 is directly connected, Ethernet0
D 172.16.50.0/24 [110/104] via 172.16.70.2, 02:17:37, Serial1
C 172.16.70.0/24 is directly connected, Serial1
B 192.68.6.0/8 [200/0] via 172.16.58.1, 00:03:07
```

6. **Example 12-46**  
**RTG IP Routing Table**

```
router ospf 10
network 172.16.0.0 0.0.255.255 area 0
```

```
Gateway of last resort is 172.16.50.1 to network 0.0.0.0

172.16.0.0/16 is subnetwork, 4 subnets
O 172.16.20.0/24 [110/128] via 172.16.70.1, 02:21:04, Serial0
O 172.16.220.0/24 [110/74] via 172.16.70.1, 02:21:04, Serial0
C 172.16.50.0/24 is directly connected, Serial1
C 172.16.70.0/24 is directly connected, Serial1
*E2 0.0.0.0/0 [110/1] via 172.16.50.1, 00:41:20, Serial1
```

7. **f**
8. **Using RIP as the IGP**
   1. Using RIP to solve the possible loop issue is more simple than OSPF. In this example, RTA yet again sets the local preference higher for all routes via IBGP from RTF. RTA sets the default-metric to 5 for all redistributed routes and RTF sets it's default-metric to 1. With RIP, the default routes advertised by RTA's and RTF's providers is automatically injected into RIP. RTG, the internal router, will use RTF's default as the gateway of last resort due to it's more desirable (lower) metric.

   **Example 12-47 Using RIP as the IGP: RTA Configuration**

   ```
   router rip
   passive-interface Serial0
   default-metric 5

   router bgp 3
   no synchronization
   network 172.16.0.0 mask 255.255.255.0
   network 172.16.70.0 mask 255.255.255.0
   neighbor 172.16.20.1 remote-as 1
   neighbor 172.16.20.1 filter-list 10 out
   neighbor 172.16.50.1 remote-as 3
   neighbor 172.16.50.1 route-map setlocalpref in
   no auto-summary

   ip as-path access-list 10 permit 'S
   route-map setlocalpref permit 10
   set local-preference 300
   ```

9. **f**

   **Example 12-48 Using RIP as the IGP: RTF Configuration**

   ```
   router rip
   network 172.16.0.0
   default-metric 1

   router bgp 3
   no synchronization
   network 172.16.50.0 mask 255.255.255.0
   neighbor 172.16.70.1 remote-as 3
   neighbor 172.16.70.1 next-hop-self
   neighbor 192.168.5.2 remote-as 2
   neighbor 192.168.5.2 filter-list 10 out
   no auto-summary

   ip as-path access-list 10 permit 'S
   ```

10. **f**

   **Example 12-49 Using RIP as the IGP: RTG Configuration**

   ```
   router rip
   network 172.16.0.0
   ```

11. **f**
12. f
13. Using EIGRP as the IGP
   1. The loop prevention solution to be used with EIGRP is just as simple as RIP, except in this case we must manually redistribute the default route into EIGRP. RTF will set the metric for the default route to be much more desirable than that of RTA's default route.

Example 12-51 Using EIGRP as the IGP: RTA Configuration

```
router eigrp 1
  redistribute bgp 3 route-map DEFAULT_ONLY
  passive-interface Serial0
  network 172.16.0.0
default-metric 5 100 250 100 1500

route bgp 3
  no synchronization
  network 172.16.255.0 mask 255.255.255.0
gateway 172.16.255.0 mask 255.255.255.0
gateway 172.16.0.0 remote-as 1
gateway 172.16.255.0 remote-as 3
gateway 172.16.255.0 route-map setlocalpref in
no auto-summary
ip as-path access-list 10 permit "$"
access-list 5 permit 0.0.0.0
route-map setlocalpref permit 10
  set local-preference 300
route-map DEFAULT_ONLY permit 10
match ip address 5
```
Example 12-52  Using EIGRP as the IGP: RTF Configuration

```
router eigrp 1
  redistribute bgp 3 route-map DEFAULT_ONLY
  network 172.16.0.0
default-metric 1000 100 250 100 1500

router bgp 3
  no synchronization
  network 172.16.50.0 mask 255.255.255.0
  neighbor 172.16.70.1 remote-as 3
  neighbor 172.16.70.1 next-hop-self
  neighbor 192.68.5.2 remote-as 2
  neighbor 192.68.52 filter-list 10 out
  no auto-summary

  ip as-path access-list 10 permit ^$1
  access-list 5 permit 0.0.0.0
  route-map DEFAULT_ONLY permit 10
    match ip address 5
```

15. f

Example 12-53  Using EIGRP as the IGP: RTF Configuration

```
router eigrp 1
  network 172.16.0.0
```

16. f

Example 12-54  RTG IP Routing Table

```
RTG>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
        L1 - IS-IS Level 1,  L2 - IS-IS Level 2,  * - candidate default
        U - per-user static route,  O - older route
```

Example 12-54  RTG IP Routing Table (Continued)

```
Gateway of last resort is 172.16.0.0 to network 0.0.0.0
```

17. f
18. Using IGRP as the IGP

1. Same as EIGRP above, except that IGRP does not understand the concept of 0.0.0.0, and therefore RTA and RTF must advertise an ip default-network classful-network, and then when both routers redistribute the classful-network from the bgp table into IGRP, RTF will set the metrics to be more desirable making RTG set RTF's redistributed network be the gateway of last resort.

Example 12-55  Using IGRP as the IGP: RTA Configuration

```
router igrp 1
  passive-interface Serial0
  redistribute bgp 3 route-map DEFAULT_ONLY
  network 172.16.0.0
default-metric 5 100 250 100 1500

router bgp 3
  no synchronization
  network 172.16.70.0 mask 255.255.255.0
  network 172.16.220.0 mask 255.255.255.0
  neighbor 172.16.20.1 remote-as 1
  neighbor 172.16.20.1 filter-list 10 out
  neighbor 172.16.50.1 remote-as 3
  neighbor 172.16.50.1 route-map setlocalpref in
  no auto-summary
  ip default-network 192.68.6.0
  ip as-path access-list 10 permit "$"
  access-list 5 permit 192.68.6.0 0.0.0.255
  route-map setlocalpref permit 10
  set local-preference 300
  route-map DEFAULT_ONLY permit 10
  match ip address 5
```

Example 12-56  Using IGRP as the IGP: RTF Configuration

```
router igrp 1
  redistribute bgp 3 route-map DEFAULT_ONLY
  network 172.16.0.0
default-metric 1000 100 250 100 1500

router bgp 3
  no synchronization
  network 172.16.50.0 mask 255.255.255.0
  neighbor 172.16.70.1 remote-as 3
  neighbor 172.16.70.1 next-hop-self
  neighbor 192.68.5.2 remote-as 2
  neighbor 192.68.5.2 filter-list 10 out
  no auto-summary
  ip default-network 192.68.6.0
  ip as-path access-list 10 permit "$"
  access-list 5 permit 192.68.6.0 0.0.0.255
  route-map DEFAULT_ONLY permit 10
  match ip address 5
```

Example 12-57  Using IGRP as the IGP: RTG Configuration

```
router igrp 1
  network 172.16.0.0
```
22. Using IS-IS as the IGP

1. IS-IS uses the default-information originate just like ospf, and therefore uses the same route-map configurations as the solution.

Example 12-59  Using IS-IS as the IGP: RTA Configuration

```
router isis 100
   redistribute connected
default-information originate route-map SEND_DEFAULT_IF
   net 49.0001.0000.00:00.000a.00
router bgp 3
   no synchronization
   network 172.16.220.0 mask 255.255.255.0
   network 172.16.70.0 mask 255.255.255.0
   neighbor 172.16.20.1 remote-as 1
   neighbor 172.16.20.1 filter-list 10 out
   neighbor 172.16.50.1 remote-as 3
   neighbor 172.16.50.1 route-map setlocalpref in
   no auto-summary
   ip as-path access-list 10 permit ^$?
   access-list 1 permit 0.0.0.0
   access-list 2 permit 172.16.20.1
   route-map SEND_DEFAULT_IF permit 10
   match ip address 1
   match ip next-hop 2
```
Example 12-60 Using IS-IS as the IGP: RTF Configuration

```
router isis 100
default-information originate route-map SEND_DEFAULT_IF
net 49.0001.0000.0000.0000.00

router bgp 3
no synchronization
network 172.16.50.0 mask 255.255.255.0
neighbor 172.16.70.1 remote-as 3
```

Example 12-60 Using IS-IS as the IGP: RTF Configuration (Continued)

```
neighbor 172.16.70.1 next-hop-self
neighbor 192.68.5.2 remote-as 2
neighbor 192.68.5.2 filter-list 10 out
no auto-summary
ip as-path access-list 10 permit ^S
access-list 1 permit 0.0.0.0
access-list 2 permit 192.68.5.2
route-map SEND_DEFAULT_IF permit 10
match ip address 1
match ip next-hop 2
```

Example 12-61 Using IS-IS as the IGP: RTG Configuration

```
router isis 100
net 49.0001.0000.0000.0000.00
```

Example 12-62 RTG IP Routing Table

```
Gateway of last resort is 172.16.50.1 to network 0.0.0.0

172.16.0.0/16 is subnetted, 4 subnets
1 L1 172.16.220.0/24 [115/20] via 172.16.70.1, Serial0
1 L1 172.16.20.0/24 [115/20] via 172.16.70.1, Serial0
C 172.16.50.0/24 is directly connected, Serial1
O 172.16.70.0/24 is directly connected, Serial0
i* L2 0.0.0.0/0 [115/20] via 172.16.50.1, Serial1
```

25. f

26. f

27. f
III. Policy Routing

1. The below diagram is an example of RTA configuring policy routing to make anything source from 172.16.10.0/24 to AS2, and anything source from 172.16.112.0/24 to AS1.

Figure 12-12 Policy Routing Scenario
2. route-map CHECK_SOURCE has been created which matches one subnet from access-list 1 and sets the next hop to AS2, and then sequence 20 matches the other subnet referencing access-list 2 and setting the next-hop to AS1.
3. The only other required configuration is to set the policy on the incoming interface which is S1.
4. The default behavior if the next-hop is unreachable is to default to the routing table.

```
Example 12-63  Policy Routing: RTA Configuration

interface Ethernet0
ip address 172.16.80.1 255.255.255.0

interface Serial1
ip address 172.16.70.1 255.255.255.0
ip policy route-map CHECK_SOURCE

router ospf 10
```

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```
Example 12-63  Policy Routing: RTA Configuration (Continued)

passive-interface Serial10
passive-interface Ethernet0
network 172.16.0.0 0.0.255.255 area 0
default-information originate always

router bgp 3
network 172.16.60.0 mask 255.255.255.0
network 172.16.70.0 mask 255.255.255.0
network 172.16.80.0 mask 255.255.255.0
neighbor 172.16.60.1 remote-as 1
neighbor 172.16.70.1 filter-list 10 out
neighbor 172.16.80.2 remote-as 2
neighbor 172.16.80.2 filter-list 10 out
no auto-summary
ip as-path access-list 10 permit $
access-list 1 permit 172.16.10.0 0.0.0.255
access-list 2 permit 172.16.112.0 0.0.0.255
route-map CHECK_SOURCE permit 10
match ip address 1
set ip next-hop 172.16.80.2

route-map CHECK_SOURCE permit 20
match ip address 2
set ip next-hop 172.16.20.1 172.16.80.2
```

2. f
1. Traceroute while policy routing is in effect.

2. Traceroute when S0 fails, showing that regular routing occurs.

3. f
IV. Route Reflectors

1. The below diagram is an example of configuring route reflectors and peer-groups. Both RTG and RTF are route-reflectors with their own cluster.
2. RTF is configuring two peer groups. One for REFLECTORS and one for CLIENTS. Both peer groups are created with and both have a neighbor command remote-as 3... since the peer groups are configured, all you need to do is create a neighbor command with the neighbor ip address and then peer-group and the peer group name.

3. Route-reflector clients need to be configured on the route reflector. Below RTF has configured it on the CLIENT peer group using the `neighbor CLIENTS route-reflector-client` command. The clients don't need to know that they are a RR client and don't require any configuration to create RRs.

```
Example 12-67  Route Refectors: RTF Configuration

router bgp 3
  no synchronization
  network 172.16.05.0 mask 255.255.255.192
  network 172.16.50.0 mask 255.255.255.0
  network 172.16.25.0 mask 255.255.255.0
  network 172.16.39.0 mask 255.255.255.0
  neighbor REFLECTORS peer-group
  neighbor REFLECTORS remote-as 3
  neighbor CLIENTS peer-group
```

4. The below are the rest of the routers configuration.

```
Example 12-68  Route Refectors: RTD Configuration

router bgp 3
  no synchronization
  network 172.16.05.0 mask 255.255.255.0
  network 172.16.25.0 mask 255.255.255.0
  neighbor 172.16.30.1 remote-as 3
  neighbor 172.16.30.1 next-hop-self
  neighbor 192.08.20.2 remote-as 2
  neighbor 192.08.20.2 filter-list 10 out
  no auto-summary

  ip as-path access-list 10 permit ^5
```
Example 12-69  *Route Reflectors: RTG Configuration*

```plaintext
router bgp 3
  no synchronization
  network 172.16.112.0 mask 255.255.255.0
  network 172.16.50.0 mask 255.255.255.0
  network 172.16.70.0 mask 255.255.255.0
  neighbor 172.16.50.1 remote-as 3
  neighbor 172.16.70.1 remote-as 3
  neighbor 172.16.70.1 route-reflector-client
  no auto-summary
```

3. f

Example 12-70  *Route Reflectors: RTA Configuration (Continued)*

```plaintext
neighbor 172.16.20.1 filter-list 10 out
neighbor 172.16.70.2 remote-as 3
neighbor 172.16.70.2 next-hop-self
no auto-summary

ip as-path access-list 10 permit ^$```

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Chapter 12: Configuring Effective Internet Routing Policies

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From the Library of Joshua.
1. Notice that the route shown above shows a Cluster list field, showing the ROUTER_IDs of all the route reflectors it passed through.

2. If you are configuring more than one Route Reflector within the same cluster you must configure a cluster-id on each route reflector within the cluster using the `bgp cluster-id number` command. Note that you can't have any clients currently configured on the route reflector when configuring a cluster-id. So if you already have clients configured you will need to deconfigure them to configure the cluster-id and then reconfigure the clients.

1. Cluster-id's are used for loop prevention.
V. Confederations

1. AS3 is subdivided into sub-ASes AS65050 and AS65060 which are within the private range of ASes. Each sub-AS is using an independent instance of OSPF. That's one of the good features of confederations and segmenting your AS into sub-ASes using BGP.

2. RTA is configured as normal except for one addition configuration. **bgp confederation identifier 3** which is used to identify AS3 to EBGP neighbors as confederation 3.

Example 12-73  **Confederations: RTA Configuration**

```
router ospf 10
passive-interface Serial0
network 172.16.0.0 0.0.255.255 area 6

router bgp 65060
no synchronization
bgp confederation identifier 3
network 172.16.220.0 mask 255.255.255.0
network 172.16.70.0 mask 255.255.255.0
neighbor 172.16.20.1 remote-as 1
neighbor 172.16.20.1 filter-list 10 out
neighbor 172.16.70.2 remote-as 65050
no auto-summary

ip as-path access-list 10 permit ^$`
```

3. Below is an example of the normal configuration for RTC in relation to RTA. Nothing different here.

Example 12-74  **Confederations: RTC Configuration**

```
router bgp 1
network 192.88.11.0
neighbor 172.16.20.2 remote-as 3
neighbor 192.88.6.1 remote-as 2
no auto-summary
```
4. RTG's configuration below shows a couple confederation configurations. One is the already familiar `bgp confederation identifier 3`; the other is `bgp confederation peers 65060`. This command makes the EBGP connection to sub-AS 65060 act like an IBGP connection, preserving all the IBGP attributes such as `local_pref` and `next-hop`.

```
Example 12-75  Confederations: RTG Configuration

router ospf 10
  passive-interface Serial1
  network 172.16.70.0 0.0.0.0 area 5
  network 172.16.0.0 0.0.255.255 area 0

router bgp 65060
  no synchronization
  bgp confederation identifier 3
  bgp confederation peers 65060
  network 172.16.112.0 mask 255.255.255.0
```

5. RTF has the same type of configuration as RTG. However RTF is using a peer group to group together all BGP routers internal to the sub-AS 65060.

```
Example 12-76  Confederations: RTF Configuration

router ospf 10
  passive-interface Serial1/1
  network 172.16.25.0 mask 255.255.255.0
  network 172.16.0.0 0.0.255.255 area 0

router bgp 65060
  no synchronization
  bgp confederation identifier 3
  bgp confederation peers 65060
  network 172.16.0.0 mask 255.255.255.192
  network 172.16.0.0 mask 255.255.255.0
  network 172.16.25.0 mask 255.255.255.0
  network 172.16.30.0 mask 255.255.255.0
  neighbor SUB_A0_65060 peer-group
  neighbor SUB_A0_65060 remote-as 65060
  neighbor 172.16.25.2 peer-group SUB_A0_65060
  neighbor 172.16.30.2 peer-group SUB_A0_65060
  neighbor 172.16.50.2 remote-as 65060
  neighbor 172.16.60.2 next-hop-self
```
6. RTD’s configuration is normal with the exception of the **bgp confederation identifier 3** command. Also since RTD is not advertising the direct internet link connected to AS2 into OSPF, RTD must use the **next-hop-self** neighbor command in order for all the other BGP routers to reach internet routes.

![](Example 12-77 Confederations: RTD Configuration)

7. RTE is an IBGP router in sub-AS 65060 and everything is normal BGP config here except for the **bgp confederation identifier 3** command.

![](Example 12-78 Confederations: RTE Configuration)

8. RTH is AS2 has normal BGP configuration.

![](Example 12-79 Confederations: RTH Configuration)
9. Below is RTH's BGP table showing that the sub-ASes are not showing up. RTH is getting routes directly from AS3 and also from AS1 from AS3.

![Example 12-80](image)

10. RTA's BGP table shows something interesting for route 192.68.222.0. The internal path has been chosen as the best path because sub-ASes (in parenthesis) because the sub-ASes are not counted in the AS_PATH PA, meaning if the Path shows only (65060) it actually means that the path has a length of 0.

![Example 12-81](image)
11. RTF’s BGP table below for prefix 172.16.220.0 (advertised from RTA in confederation 65050) is considered confed-external. EBGP routes are most preferred over confed-external, and confed-external are more preferred than internal.

**Example 12-82** Confederations: RTA BGP Table

<table>
<thead>
<tr>
<th>RTF#show ip bgp 172.16.220.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGP routing table entry for 172.16.220.0/24, version 22</td>
</tr>
<tr>
<td>Paths: (1 available, best #1, advertised over IDGP)</td>
</tr>
<tr>
<td>(58680)</td>
</tr>
<tr>
<td>172.16.50.2 from 172.16.50.2 (172.16.112.1)</td>
</tr>
<tr>
<td>Origin IDGP, metric 0, localpref 100, valid, confed-external, best</td>
</tr>
</tbody>
</table>

2.

VI. Controlling Route and Cache Invalidation

1. In order to set policies, you have to reset the adjacency with the peer that you have modified policies for, whether it's inbound or outbound.

2. **Methods**

   1. **The source of the BGP route could manually trigger readvertisement of the route.**
      1. Unfortunately, you will not have access to the source router in the real world

   2. **The entire TCP session could be reset**
      1. This works but brings down all the routes associated with the peer and takes a bit of time to reestablish and receive the advertisements again.

   3. **BGP soft reconfiguration can be used to store the peer's Adj-RIB-In in memory.**
      1. Soft reconfiguration is a very nice approach but consumes a lot of memory

   4. **BGP Route Refresh could be used to ask the peer to readvertise its respective Adj-RIB-Out.**
      1. Best solution

2. **BGP Soft Reconfiguration**

   1. Allows new policies to take effect without resetting the BGP TCP session.
      1. Exec command to do soft reconfiguration
         1. `clear ip bgp [* | address | peer-group][soft [in | out]]`

3. **Outbound Soft Reconfiguration**

   1. Outbound soft reconfiguration requires no additional memory.
   2. Specific exec command to do outbound soft reconfiguration:
      1. `clear ip bgp [* | address | peer-group] soft out`

4. **Inbound Soft Reconfiguration**

   1. In order to use the exec command for inbound soft reconfiguration, you must first configure the bgp neighbor command - **neighbor {address | peer-group} soft-reconfiguration inbound**. This will allow the local router to start storing the received updates for the specified peer or peer group.
   2. Exec command
      1. `clear ip bgp [* | address | peer-group] soft in`
   3. If you have control over both sides of a bgp connection then it's better to connect to the other router to do a soft outbound reconfiguration to save on memory.
   4. If in or out is not specified, both are done.
5. The example above, showing soft-reconfiguration inbound being configured. Again this is only needed for inbound soft reconfiguration.

6. Above, RTA is clearing the bgp session with another router. Showing the debug output for BGP you can see (Below) how much overhead there is when doing a brute force clearing.
Example 12-84  Inbound Soft-Reconfiguration: Clearing the BGP Session Between Two Routers (Continued)

```
BGP: 172.16.20.1 reset by @x275740
BGP: 172.16.20.1 went from Established to Idle
BGP: nettable_walker 192.68.11.0/255.255.255.0 no path best path selected
BGP: 172.16.20.1 went from Idle to Active
BGP: 172.16.70.2 computing updates, neighbor version 21, table version 23, starting at 0.0.0.0
BGP: 172.16.70.2 send UPDATE 192.68.11.0/24 -- unreachable
BGP: 172.16.70.2 1 updates enqueued (average=27, maximum=27)
BGP: 172.16.70.2 update run completed, ran for 8ms, neighbor version 21, start version 23, throttled to 25, check point net 0.0.0.0
BGP: scanning routing tables
BGP: 172.16.20.1 went from Active to OpenSent
BGP: 172.16.20.1 went to OpenConfirm
BGP: 172.16.20.1 went from OpenConfirm to Established
BGP: 172.16.20.1 computing updates, neighbor version 0, table version 23, starting at 0.0.0.0
BGP: 172.16.20.1 send UPDATE 172.16.25.0/24, next 172.16.28.2, metric 5000, path 3
BGP: 172.16.20.1 send UPDATE 172.16.30.0/24, next 172.16.28.2, path (65000)
BGP: 172.16.20.1 send UPDATE 172.16.50.0/24, next 172.16.28.2, metric 5000, path 3
BGP: 172.16.20.1 send UPDATE 172.16.60.0/24, next 172.16.28.2, path (65000)
BGP: 172.16.20.1 send UPDATE 172.16.70.0/24, next 172.16.28.2, metric 5000, path 3
BGP: 172.16.20.1 send UPDATE 172.16.80.0/24, next 172.16.28.2, path (65000)
BGP: 172.16.20.1 send UPDATE 172.16.112.0/24, next 172.16.28.2, path (65000)
BGP: 172.16.20.1 send UPDATE 172.16.220.0/24, next 172.16.20.2, path
BGP: 172.16.20.1 send UPDATE 192.68.222.0/24, next 172.16.20.2, metric 5000, path 3
BGP: 172.16.20.1 4 updates enqueued (average=58, maximum=68)
BGP: 172.16.20.1 update run completed, ran for 24ms, neighbor version 0, start version 23, throttled to 23, check point net 0.0.0.0
BGP: 172.16.20.1 rcv UPDATE about 192.68.11.0/24, next hop 172.16.20.1, path 1 metric 2000
BGP: 172.16.20.1 rcv UPDATE about 192.68.222.0/24, next hop 172.16.20.1, path 1 metric 2000
BGP: 172.16.20.1 rcv UPDATE about 172.16.25.0/24 -- denied
BGP: 172.16.20.1 rcv UPDATE about 172.16.30.0/24 -- denied
BGP: 172.16.20.1 rcv UPDATE about 172.16.50.0/24 -- denied
BGP: 172.16.20.1 rcv UPDATE about 172.16.60.0/24 -- denied
BGP: 172.16.20.1 rcv UPDATE about 172.16.70.0/24 -- denied
BGP: 172.16.20.1 rcv UPDATE about 172.16.80.0/24 -- denied
BGP: 172.16.20.1 rcv UPDATE about 172.16.112.0/24 -- denied
BGP: 172.16.20.1 rcv UPDATE about 172.16.220.0/24 -- denied
BGP: nettable_walker 192.68.11.0/255.255.255.0 calling revise_route
BGP: reuse route installing 192.68.11.0/255.255.255.0 => 172.16.28.1
BGP: 172.16.70.2 computing updates, neighbor version 23, table version 24, starting at 0.0.0.0
BGP: NEXT_HOP part 1 net 192.68.11.0/24, neigh 172.16.70.2, next 172.16.20.1
BGP: 172.16.70.2 send UPDATE 192.68.11.0/24, next 172.16.20.1, metric 2000, path 1
BGP: 172.16.70.2 1 updates enqueued (average=59, maximum=59)
BGP: 172.16.70.2 update run completed, ran for 4ms, neighbor version 23,
```

Example 12-84  Inbound Soft-Reconfiguration: Clearing the BGP Session Between Two Routers (Continued)

```
start version 24, throttled to 24, check point net 0.0.0.0
BGP: 172.16.20.1 rcv UPDATE about 172.16.25.0/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.28.2/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.30.0/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.50.0/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.60.0/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.70.0/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.80.0/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.112.0/24 -- withdrawn
BGP: 172.16.20.1 rcv UPDATE about 172.16.220.0/24 -- withdrawn
BGP: 172.16.20.1 computing updates, neighbor version 22, table version 24, starting at 0.0.0.0
BGP: 172.16.20.1 update run completed, ran for 0ms, neighbor version 22,
start version 24, throttled to 24, check point net 0.0.0.0
BGP: scanning routing tables
```
5. f

6. BGP Route Refresh

   1. If the router is capable of Route Refresh, it will say so under `show ip bgp neighbor address` output. Shown below -

```
Example 12-85  BGP Route Refresh Verification

r1# show ip bgp 1.1.2.2
BGP neighbor is 1.1.2.2, remote AS 2, external link
BGP version 4, remote router ID 3.3.3.1
BGP state = Established, up for 24hrs
Last read 00:00:15, hold time is 180, keepalive interval is 30 seconds
Neighbor capabilities:
   Route refresh: advertised and received
   Address family IPv4 Unicast: advertised and received
   Received 26674 messages, 0 notifications, 0 in queue
   Sent 20075 messages, 0 notifications, 0 in queue
   Route refresh request: received 1, sent 2
   Minimum time between advertisement runs is 30 seconds

   For address family: IPv4 Unicast
   BGP table version 0, neighbor version 0
   index 1, Offset 0, Mask 0x2
   NEXT_HOP is always this router
   Community attribute sent to this neighbor
   1 accepted prefixes consume 36 bytes
   Prefix advertised 4, suppressed 0, withdrawn 0
   Connections established 1; dropped 0
   Last reset never
```
7. Here you see that Route Refresh replaces inbound soft reconfiguration using the same exec command.

Example 12-86  BGP Route Refresh Verification (Continued)

<table>
<thead>
<tr>
<th>Connection state is ESTAB, I/O status: 1, unread input bytes: 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local host: 1.1.2.1, Local port: 179</td>
</tr>
<tr>
<td>Foreign host: 1.1.2.2, Foreign port: 11000</td>
</tr>
<tr>
<td>Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)</td>
</tr>
</tbody>
</table>

Event Timers (current time is 0x46ED7420):  
- Timer  
  - Starts  
  - Wakeup  
  - Next  
- Retrans: 20675  
- TimeOut: 0  
- AckHold: 20674  
- SendWnd: 19530  
- KeepAlive: 0  
- GiveUp: 0  
- PmtuAgent: 0  
- DeadWait: 0

iss: 108172359  
snduna: 1082116474  
sndnxt: 1082116474  
sndwnd: 15567  
irs: 1087714341  
rcvnx: 1087906685  
rownd: 15608  
delrownd: 770  
SRTT: 391 ms  
RTT: 621 ms  
RTV: 0 ms  
KRTT: 0 ms  
minRTT: 4 ms  
maxRTT: 600 ms  
ACK hold: 200 ms  
Flags: passive open, nagle, son tcb

Datagrams (max data segment is 1460 bytes):  
- Rcvd: 39791 (out of order: 0), with data: 20674, total data bytes: 397991  
- Sent: 48743 (retransmit: 0), with data: 20674, total data bytes: 392914

Example 12-87  Forcing a Peer to Readvertise Adj-RIB-Out

```
!# clear ip bgp 1.1.2.2 soft in
!#
!# 2w6d: BGP: 1.1.2.2 sending REFRESH_REQ for afi/safi: 1/1
!# 2w6d: BGP: 1.1.2.2 send message type 126, length (incl. header) 23
!# 2w6d: BGP: 1.1.2.2 send message type 4, length (incl. header) 19
!# 2w6d: BGP: 1.1.2.2 rcv message Type 4, length (excl. header) 0
```

8.  
9.  
10.  
11.  

VII. BGP Outbound Request Filter Capability  
1. BGP ORF is not advertised to peers by default. If using BGP ORF, it allows the local routers peers to advertise to push their inbound prefix filters so as to make them your outbound filter along with whatever other filters you are currently using.  
2. Benefits  
   1. The local BGP speaker will no longer consume resources generating routing update messages that will be filtered by the neighbor on input.  
   2. Link bandwidth will not be consumed by the routing updates.  
   3. The neighbor router will not need to consume resources processing routing updates that will be discarded once a filter lookup occurs.  
3. BGP ORF Syntax varies based on IOS version.
VIII. Route Dampening

1. `bgp dampening [route-map map-name] [half-life-time reuse-value suppress-value maximum-suppress-time]`
   1. `half-life-time` is in the range of 1 to 45 minutes. The current default is 15 minutes.
   2. `reuse-value` is in the range of 1 to 20000. The default is 750.
   3. `suppress-value` is in the range of 1 to 20000. The default is 2000.
   4. `maximum-suppress-time` is the maximum duration that a route can be suppressed. The range is 1 to 255. The default is $4 \times \text{half-life-time}$

![Route Dampening Diagram](image-url)

2. **Example 12-88** *Route Dampening: RTG Configuration*

   ```
   router bgp 3
   no synchronization
   network 172.16.112.0 mask 255.255.255.0
   neighbor 172.16.70.1 remote-as 3
   no auto-summary
   ```

3. **Example 12-89** *Route Dampening: RTA Configuration*

   ```
   router bgp 3
   no synchronization
   network 172.16.220.0 mask 255.255.255.0
   network 172.16.70.0 mask 255.255.255.0
   neighbor 172.16.20.1 remote-as 1
   neighbor 172.16.70.2 remote-as 3
   neighbor 172.16.70.2 next-hop-self
   no auto-summary
   ```
4.

Example 12-90  Route Dampening: RTC Configuration

```
router ospf 10
  redistribute bgp 1 subnets
  network 192.68.0.0 0.0.255.255 area 0

router bgp 1
  bgp dampening route-map SELECTIVE_DAMPENING
```

continues

5.

Example 12-90  Route Dampening: RTC Configuration (Continued)

```
network 192.68.11.0
neighbor 172.16.20.2 remote-as 3
neighbor 192.68.6.1 remote-as 1
  no auto-summary

access-list 1 permit 172.16.220.0 0.0.0.255

route-map SELECTIVE_DAMPENING permit 10
  match ip address 1
  set dampening 20 960 2500 0

route-map SELECTIVE_DAMPENING permit 20
```

6.

Example 12-91  Route Dampening: RTC BGP Table Before Route Flapping

```
Router# show ip bgp 172.16.220.0
BGP routing table entry for 172.16.220.0/24, version 326
Paths: (1 available, best #1, advertised over IGBP)
  1
  172.16.20.2 from 172.16.20.2 (172.16.220.1)
    Origin IGP, metric 0, valid, external, best
```

7.

Example 12-92  Route Dampening: RTC BGP Table After the First Instance of Route Flapping

```
Router# show ip bgp 172.16.220.0
BGP routing table entry for 172.16.220.0/24, version 327
Paths: (1 available, no best path, advertised over IGBP)
  2 (history entry)
    172.16.20.2 from 172.16.20.2 (172.16.220.1)
      Origin IGP, metric 0, external
    Dampinfo: penalty 997, flapped 1 times in 00:00:00
```
Example 12-93  Route Dampening: RTC BGP Table After the Second Instance of Route Flapping

```
RTCh#show ip bgp 172.16.220.0
BGP routing table entry for 172.16.220.0/24, version 029
Paths: (1 available, best #1, advertised over IBGP)
3
```

Example 12-93  Route Dampening: RTC BGP Table After the Second Instance of Route Flapping (Continued)

```
172.16.20.2 from 172.16.20.2 (172.16.220.1)
Origin IGP, metric 0, valid, external, best
Dampinfo: penalty 1454, flapped 2 times in 00:01:20
```

8.

Example 12-94  Route Dampening: RTC BGP Table After Four Instances of Route Flapping

```
RTCh#show ip bgp 172.16.220.0
BGP routing table entry for 172.16.220.0/24, version 029
Paths: (1 available, no best path, advertised over IBGP)
3, (suppressed due to dampening)
172.16.20.2 from 172.16.20.2 (172.16.220.1)
Origin IGP, metric 0, valid, external
Dampinfo: penalty 2551, flapped 4 times in 00:03:05, reuse in 00:31:40
```

9.

Example 12-95  Route Dampening: RTC BGP Table After Six Instances of Route Flapping

```
RTCh#show ip bgp 172.16.220.0
BGP routing table entry for 172.16.220.0/24, version 036
Paths: (1 available, no best path, advertised over IBGP)
3, (suppressed due to dampening)
172.16.20.2 from 172.16.20.2 (172.16.220.1)
Origin IGP, metric 0, valid, external
Dampinfo: penalty 2959, flapped 6 times in 00:08:21, reuse in 00:08:10
```