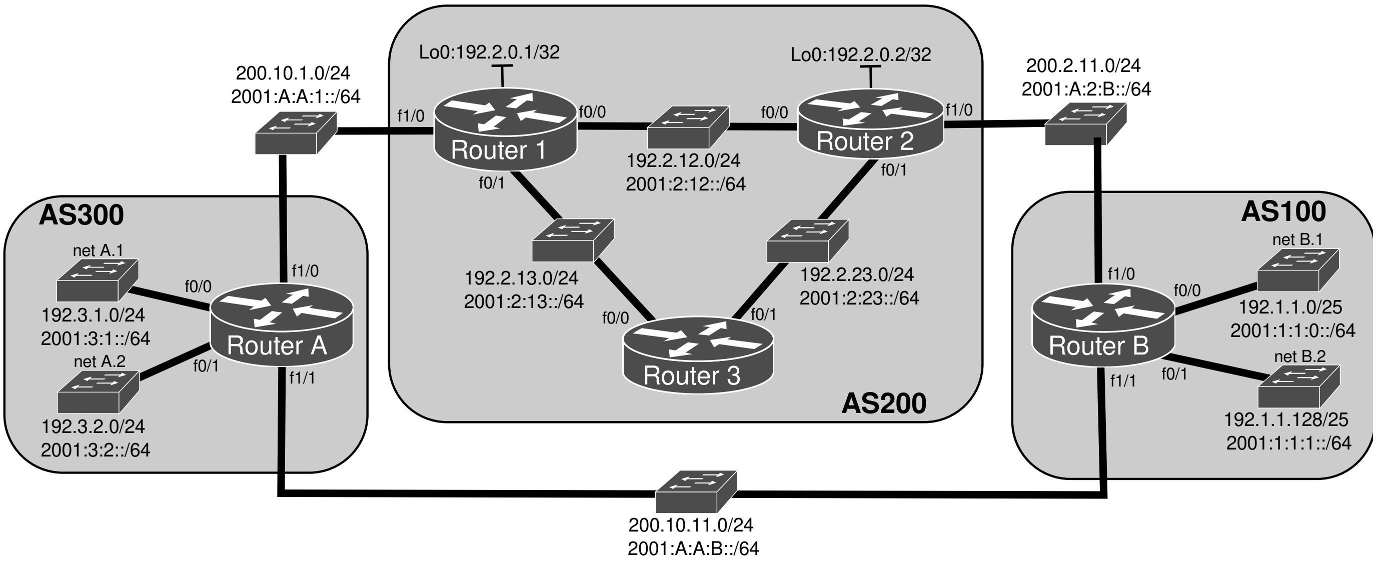
Arquitetura de Comunicações

Advanced Topics on MP-BGP

BGP Neighboring



1. Set up and configure (only IPv4 addresses) the above depicted network with three Autonomous Systems (AS). For all IP addresses not defined in the figure the last byte is equal to the network ID plus the router number/letter (use A=10, B=11). Perform all necessary configuration in order to obtain full IPv4 connectivity between the inner-AS networks using only EBGP and IBGP neighbor relations (without any IGP protocol: RIP, OSPF, etc..). Start packet captures on links RA-R1 and R1-R2. Initiate the configuration at Router1 with the following commands:

```
Router1(config)#router bgp 200
Router1(config-router)# address-family ipv4 unicast
Router1(config-router-af)# neighbor 192.2.12.2 remote-as 200   !IBGP Neighboring with R2
Router1(config-router-af)# neighbor 192.2.13.3 remote-as 200   !IBGP Neighboring with R3
Router1(config-router-af)# neighbor 200.10.1.10 remote-as 300  !EBGP Neighboring with RA
```

Configure the remaining routers. Using the following commands verify the state of the routing process:

```
Router1# show bgp summary
Router1# show ip route
Router1# show ip bgp                  !Verify Network (valid * and best >), Next Hop and Path
Router1# show ip bgp neighbors
```

Stop the captures and analyze the BGP packets. What can you conclude about the established BGP neighbor relations and exchanged routes (received/sent prefixes)?

2. Continue the packet captures on links RA-R1 and R1-R2. Explicitly add all networks (inside the AS) to the respective BGP routing process. Initiate the configuration at Router1 with the following commands:

```
Router1(config)# router bgp 200
Router1(config-router)# address-family ipv4 unicast
Router1(config-router-af)# network 192.2.12.0 mask 255.255.255.0
Router1(config-router-af)# network 192.2.13.0 mask 255.255.255.0
Router1(config-router-af)# network 192.2.0.1 mask 255.255.255.255
```

Configure the remaining routers. Verify and analyze the state of the routing process, stop the capture and analyze the BGP packets. After analyzing the BGP process **in Router 3** (show ip bgp) and its routing table, what can you conclude about the connectivity obtained and how the BGP's NEXT-HOP attribute (from an external route) is propagated inside the AS?

3. Override the way BGP's NEXT-HOP attribute is propagated inside the AS, reconfiguring the IBGP neighbor relations:

```
Router1(config)# router bgp 200
Router1(config-router)# address-family ipv4 unicast
Router1(config-router-af)# neighbor 192.2.12.2 next-hop-self
Router1(config-router-af)# neighbor 192.2.13.3 next-hop-self
```

Configure also Router 2. Reset the BGP routing processes (clear ip bgp *) and wait for the BGP processes reestablishment. Verify and analyze the state of the routing process **in Router 3 (**show ip route, show ip bgp**)**. What can you conclude about the connectivity obtained and how the BGP's attribute NEXT-HOP is now propagated inside the AS?

EBGP and IBGP with OSPF

4. **Remove all network commands from Router1 and Router 2 BGP processes, remove the BGP process from Router3 and configure an OSPF routing process (with id 100) in all routers from AS200.** A full mesh IBGP neighbor relations are mandatory between AS border routers (namely Router1 and Router2). In AS border routers BGP routes should be redistributed by OSPF:

```
Router3(config)# router ospf 100
Router3(config-router)# network 192.2.13.0 0.0.0.255 area 0
Router3(config-router)# network 192.2.23.0 0.0.0.255 area 0
---
Router1(config)# router ospf 100
Router1(config-router)# network 192.2.12.0 0.0.0.255 area 0
Router1(config-router)# network 192.2.13.0 0.0.0.255 area 0
Router1(config-router)# network 192.2.0.1 0.0.0.0 area 0
Router1(config-router)# redistribute bgp 200
```

Configure also Router2. Verify and analyze the state of the routing process (show ip route, show ip bgp). What can you conclude about the connectivity obtained (look for AS100 routes in Router 3)?

5. Include sub-netting information when redistributing BGP routes by OSPF:

```
Router1(config)# router ospf 100
Router1(config-router)# no redistribute bgp 200
Router1(config-router)# redistribute bgp 200 subnets
```

Re-configure also Router2. Verify and analyze the state of the routing process (show ip route, show ip bgp). Explain potential disadvantages of distributing all BGP routes into OSPF.

Redistribution of OSPF routes into BGP

6. Check Router A and Router B routing tables. Explain the absence of AS200 routes.

In all AS200's border routers reconfigure BGP process to redistribute all OSPF routes:

```
Router1(config)# router bgp 200
Router1(config-router)# address-family ipv4 unicast
Router1(config-router-af)# redistribute ospf 100
```

Take reconfigurations actions where necessary. Verify and analyze the state of the routing process in all AS (show ip route, show ip bgp). Re-check Router A and Router B routing tables.

Establish Neighbor relations between Loopback interfaces

7. In Router2 disable interface f0/0 (shut down), the network interface to which Router1 have establish the IBGP relation(s). Verify and analyze the state of the BGP routing process (show bgp summary, show ip bgp, show ip route). Explain the results namely Router 1's routing table entries for AS100 routes.

8. Establish Router1-Router2 IBGP relations using as neighbor IP address the respective Loopback addresses:

```
Router1(config)# router bgp 200
Router1(config-router)# address-family ipv4 unicast
Router1(config-router-af)# no neighbor 192.2.12.2 remote-as 200
Router1(config-router-af)# neighbor 192.2.0.2 remote-as 200
Router1(config-router-af)# neighbor 192.2.0.2 next-hop-self
Router1(config-router-af)# exit
Router1(config-router)# neighbor 192.2.0.2 update-source Loopback 0
```

Perform a similar configuration in Router2. Verify and analyze the state of the BGP routing process (show bgp summary). What can you conclude about the usage of Loopback interfaces to establish BGP neighbor relations?

EBGP, IBGP and OSPF (relative) administrative distances

9. Analyze Router 1's routing table (check AS100 routes). Why Router 1's routing table entries to AS routes are OSPF and not BGP?

Note: by default EBGP and IBGP route announcements have an administrative distance of 20 and 200, respectively. OSPF routes have an administrative distance of 110.

In Router 1, increase the OSPF administrative distance to 220 (prefer IBGP over OSPF).

```
Router1(config)# router ospf 100
Router1(config-router)# distance 220
```

Re-analyze Router 1's routing table (check AS100 routes). Explain the results.

Route Maps

10. Verify and analyze the state of the BGP routing process (show ip bgp) **in Router A** (check routes to AS100 networks). Disable the RA-RB link (shutdown in one of the Routers' interfaces). Re-verify the state of the BGP routing process (show ip bgp). What do you conclude about the routing process?

Re-enable the RA-RB link.

To avoid that AS200 serves as transit AS to AS100 and AS300 the routes announced by BGP must be filtered using route-maps and communities. A route-map must be created and associated with routes being sent to other AS (internal routes):

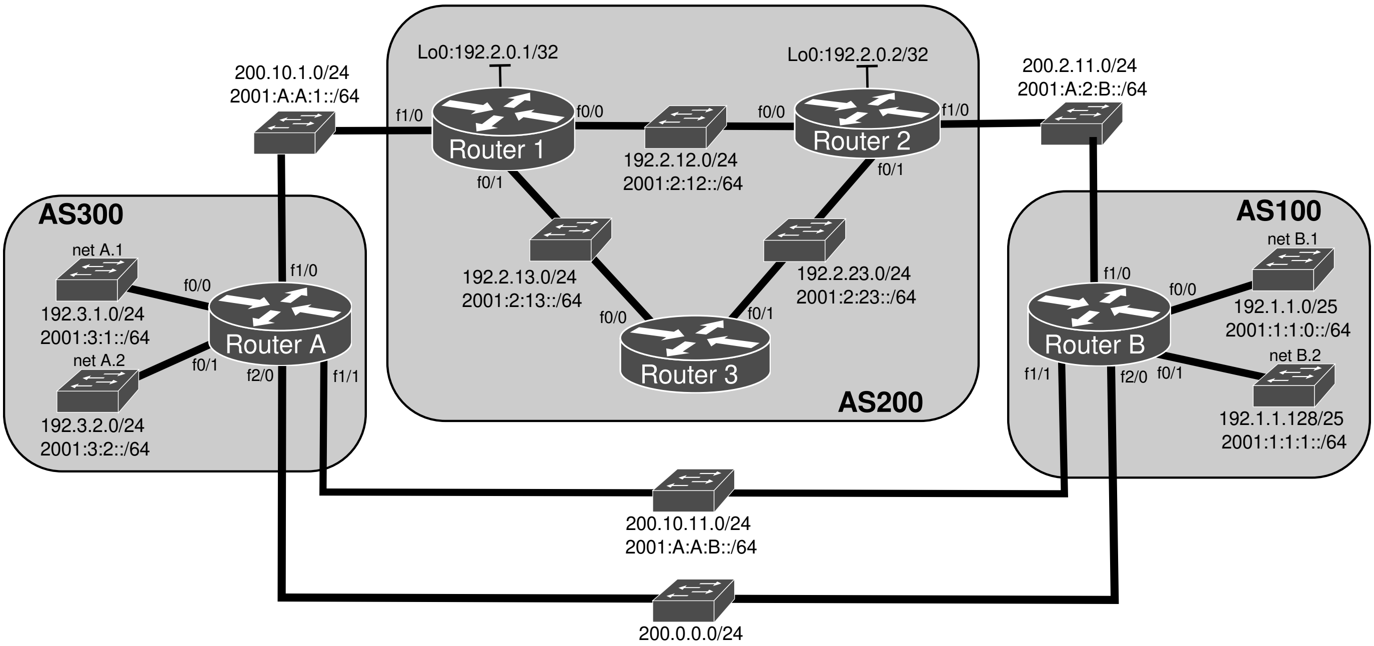
```
Router1(config)# ip as-path access-list 1 permit ^$       !Empty BGP AS path. Only local routes!
Router1(config)# route-map routes-out
Router1(config-route-map)# match as-path 1
Router1(config)# router bgp 200
Router1(config-router)# address-family ipv4 unicast
Router1(config-router-af)# neighbor 200.10.1.10 route-map routes-out out
```

Perform a similar configuration in Router2. Verify and analyze the state of the BGP routing process (show ip bgp) **in Router A** (check routes to AS100 networks). Explain the results.

Test the configuration by disabling the RA-RB link. What do you conclude?

Note: AS-paths are defined using regular expressions (e.g., ^ represents start of the string, $ represents end of the string).

Communities



Add a new link (network 200.0.0.0/24) between AS100 and AS300. Configure IPv4 addresses and create a new BGP peering relation through that new link:

```
RouterA(config)#router bgp 300
RouterA(config-router)# address-family ipv4 unicast
RouterA(config-router-af)# neighbor 200.0.0.11 remote-as 100
...
RouterB(config)#router bgp 100
RouterB(config-router)# address-family ipv4 unicast
RouterB(config-router-af)# neighbor 200.0.0.10 remote-as 300
```

>> Verify the updated BGP routes table in Router A and Router B.

11a. Communities can be used to label route announcements using multiple criteria, the label allows to filter or assign attribute values accordingly. Start a packet capture on both links RA-RB. **In RouterA** configure two different communities and send them in all UPDATES to **Router B**, one community for one link, and another for the other. The community ID new format is *AS:any_number* (e.g 300:1):

```
RouterA(config)# ip bgp-community new-format
RouterA(config)# route-map changeClink1 permit 10
RouterA(config-route-map)# set community 300:1      !Community 1
RouterA(config)# route-map changeClink2 permit 10
RouterA(config-route-map)# set community 300:2      !Community 2
RouterA(config)# router bgp 300
RouterA(config-router)# address-family ipv4 unicast
RouterA(config-router-af)# neighbor 200.10.11.11 route-map changeClink1 out
RouterA(config-router-af)# neighbor 200.10.11.11 send-community
RouterA(config-router-af)# neighbor 200.0.0.11 route-map changeClink2 out
RouterA(config-router-af)# neighbor 200.0,0.11 send-community
```

Reset the BGP routing processes (clear ip bgp *) and analyze the BGP UPDATE packets (COMMUNITIES attribute).

Verify and analyze the state of the routing process **in Router B** and **Router 2** without and with a community filter:

```
RouterB(config)# ip bgp-community new-format
RouterB# show ip bgp                              !all entries
```

RouterB# show ip bgp community 300:1 !with community filter
RouterB# show ip bgp community 300:2 !with community filter
Router2(config)# ip bgp-community new-format
Router2# show ip bgp !all entries
Router2# show ip bgp community 300:1 !with community filter
Router2# show ip bgp community 300:2 !with community filter

>> Explain the results.

11b. Make Router B send the community with the route updates:

RouterB(config)# router bgp 100
RouterB(config-router)# address-family ipv4 unicast
RouterB(config-router-af)# neighbor 200.2.11.2 send-community

Verify and analyze the state of the routing process in **Router 2** without and with a community filter:

Router2# show ip bgp !all entries
Router2# show ip bgp community 300:1 !with community filter
Router2# show ip bgp community 300:2 !with community filter

>> Explain the new results.

"Local Preference" based on "Community" value

12. L*ocal preference* attribute can be used to chose (within the AS) between multiple routes to the same destination. In Router2, configure differentiated *local preference* values to the routes received from AS300. Give a low value to routes that use link 200.0.0.0/24 between AS100 and AS300, and an high value to routes that use link 200.10.11.0/24 between AS100 and AS300:

Router2(config)# ip bgp-community new-format
Router2(config)# ip community-list 1 permit 300:1
Router2(config)# ip community-list 2 permit 300:2
Router2(config)# route-map routes-in permit 10
Router2(config-route-map)# match community 1
Router2(config-route-map)# set local-preference 22
Router2(config-route-map)# route-map routes-in permit 20
Router2(config-route-map)# match community 2
Router2(config-route-map)# set local-preference 111
Router2(config)# router bgp 200
Router2(config-router)# address-family ipv4 unicast
Router2(config-router-af)# neighbor 200.2.11.11 route-map routes-in in

>> Reset the BGP routing processes (clear ip bgp *) and analyze the state of the routing process **in Router 2** (show ip bgp).

>> Disable one of the links between AS100 and AS300 (the one chosen in Router B for networks in AS300), and analyze the state of the routing process **in Router 2** (show ip bgp).

>> Discuss possible uses of this methodology.

Remove the local-preference changing route-map:

Router2(config)# router bgp 200
Router2(config-router-af)# no neighbor 200.2.11.11 route-map routes-in in

Reset the BGP routing processes (clear ip bgp *)

BGP conflicts with IGP routing

13. **Physically remove network 192.2.12.0/24 and all BGP routes redistributions from OSPF configuration.** Update the respective OSPF configuration and configure Router 1 as OSPF's preferred default route (lower OSPF metric):

```
Router1(config)# router ospf 100
Router1(config-router)# no redistribute bgp 200 subnets
Router1(config-router)# no redistribute bgp 200                    !if present
Router1(config-router)# default-information originate always metric 5
```

Perform a similar configuration (higher OSPF metric) in Router2:

```
Router2(config)# router ospf 100
Router2(config-router)# no redistribute bgp 200 subnets
Router2(config-router)# default-information originate always metric 10
```

Analyze the state of the general routing processes **in Router 1 and Router 3** (show ip route). Start packet capture in the R1-R3 link. From Router3 execute a ping and a traceroute to RouterB f0/0 interface (192.1.1.11). What can you conclude about the lack of connectivity? Explain the BGP and IGP conflicting routes.

Note: CTRL+6 stops hanged ping and traceroute commands.

14. Define Router 1 as BGP's preferred exit from the AS (higher local-preference)

```
Router1(config)# router bgp 200
Router1(config-router)# bgp default local-preference 200
```

Verify and analyze the state of the routing process. Analyze the packets on link R1-R3. From Router3 execute a ping and a traceroute to RouterB f0/0 interface (192.1.1.11).

Define now Router 2 as BGP's default exit from the AS (higher local-preference)

```
Router2(config)# router bgp 200
Router2(config-router)# bgp default local-preference 300
```

Verify and analyze the state of the routing process (show ip route, show ip bgp). Analyze the packets on link R1-R3. From Router3 execute a ping and a traceroute to RouterB f0/0 interface (192.1.1.11). What can you conclude about the usage of BGP's local-preference values? How to solve BGP and IGP conflicts independently of BGP and IGP preferred/default routes?

Establishing BGP Neighbor relations over IP-IP tunnels

15. Configure the IP-IP tunnel end-points (Loopback 0 interfaces) using the overlay IPv4 network 10.0.0.0/30. In Router 1:

```
Router1(config)# interface Tunnel 0
Router1(config-if)# ip address 10.0.0.1 255.255.255.252
Router1(config-if)# tunnel source Loopback 0
Router1(config-if)# tunnel destination 192.2.0.2
Router1(config-if)# tunnel mode ipip
```

Perform a similar configuration in Router2:

```
Router2(config)# interface Tunnel 0
Router2(config-if)# ip address 10.0.0.2 255.255.255.252
Router2(config-if)# tunnel source Loopback 0
Router2(config-if)# tunnel destination 192.2.0.1
Router2(config-if)# tunnel mode ipip
```

Re-establish Router1-Router2 IBGP relations using as neighbor IP address the respective Tunnel 0 addresses:

```
Router1(config)# router bgp 200
Router1(config-router)# address-family ipv4 unicast
```

```
Router1(config-router-af)# no neighbor 192.2.0.2 remote-as 200
Router1(config-router-af)# neighbor 10.0.0.2 remote-as 200
Router1(config-router-af)# neighbor 10.0.0.2 next-hop-self
```

Perform a similar configuration in Router2. Verify and analyze the state of the routing process. Capture and analyze the packets on links R1-R3 and R3-R2. From Router3 execute a ping and a traceroute to RouterB f0/0 interface (192.1.1.11). What can you conclude about the usage of IP-IP Tunnels to establish BGP neighbor relations?

16. Configure all IPv6 addresses. Activate and configure an IPv6 MP-BGP relation between all routers:

```
Router1(config)# router bgp 200
Router1(config-router)# address-family ipv6 unicast
.....
```

Perform all required reconfigurations actions where necessary. Verify and analyze the state of the IPv6 routing process with:

```
show ipv6 route
show bgp ipv6 unicast summary
show ip bgp all
show bgp ipv6 unicast
show ip bgp ipv6 unicast
```

Capture and analyze the MP-BGP (BGP over IPv6) packets. What can you conclude about the established BGP neighbor relations?