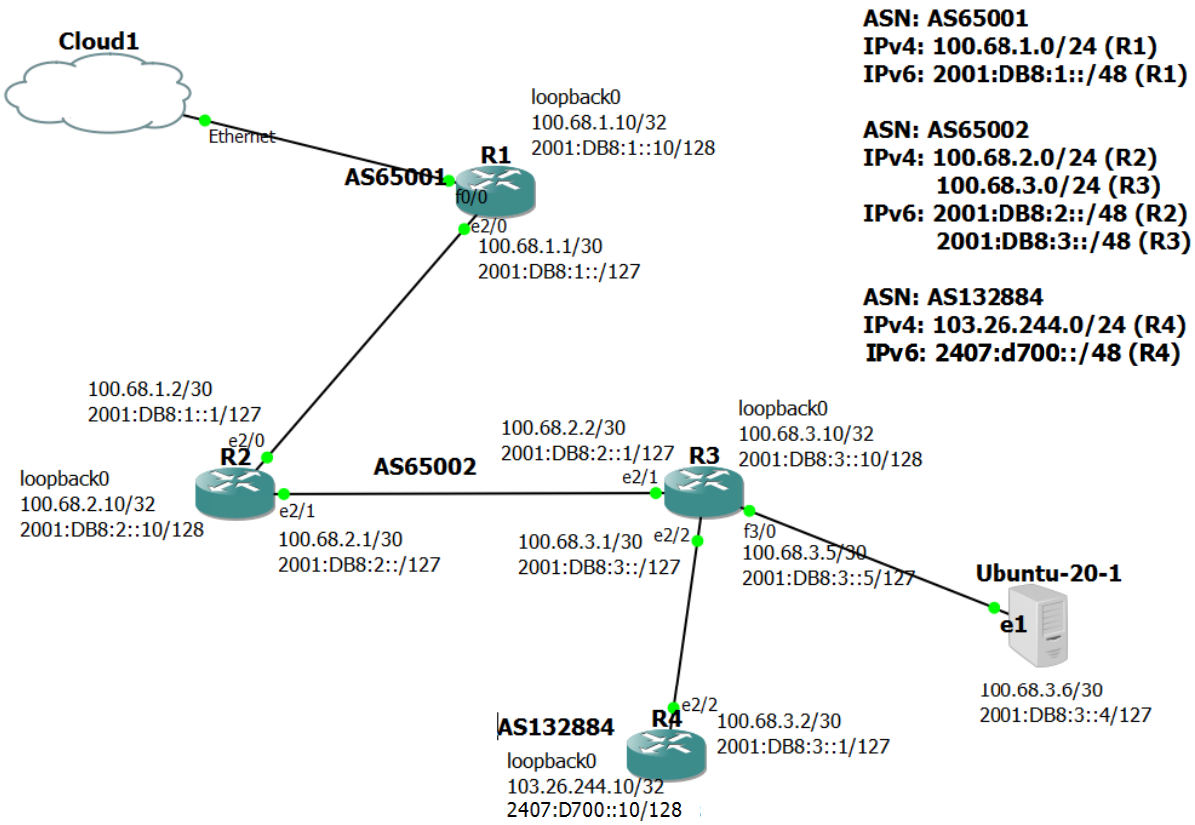
Efficient and Secure Internet Routing Best Practices and Automation: LAB

Lab Topology



Device List

Device Name	Function	IP address
R1	Access to internet, Router of AS65001	100.68.1.10
R2	Core Router of AS65002	100.68.2.10
R3	Access Router of AS65002	100.68.3.10
R4	Router of AS132884	103.26.244.10
Server	RPKI and Automation	100.68.3.6

Prefix and ASN:

ASN	IPv4 Prefix	IPv6 Prefix	Originating Router
AS65001	100.68.1.0/24	2001:DB8:1::/48	R1
AS65002	100.68.2.0/24	2001:DB8:2::/48	R2
	100.68.3.0/24	2001:DB8:3::/48	R3
AS132884	103.26.244.0/24	2407:d700::/48	R4

Credentials:

Command	Description
`routers`	username: lab password: apnic
`server`	username: lab password: apnic root: training

IP Allocations:

Router	Interface	IPv4	IPv6	Remark
R1	e2/0	100.68.1.1/30	2001:DB8:1::/127	R1-R2 Uplink
	loopback0	100.68.1.10/32	2001:DB8:1::10/128	R1 loopback
R2	e2/0	100.68.1.2/30	2001:DB8:1::1/127	R1-R2 Uplink
	loopback0	100.68.2.10/32	2001:DB8:2::10/128	R2 loopback
	e2/1	100.68.2.1/30	2001:DB8:2::/127	R2-R3 Uplink
R3	e2/1	100.68.2.2/30	2001:DB8:2::1/127	R2-R3 Uplink
	loopback0	100.68.3.10/32	2001:DB8:3::10/128	R3 loopback
	f3/0	100.68.3.5/30	2001:DB8:3::5/127	Server Uplink
	e2/2	100.68.3.1/30	2001:DB8:3::/127	R3-R4 Uplink
R4	e2/2	100.68.3.2/30	2001:DB8:3::1/127	R3-R4 Uplink
	loopback0	103.26.244.10/32	2407:d700::10/128	R4 loopback
Server		100.68.3.6/30	2001:DB8:3::4/127	

Interface Connection:

R1 e2/0 <> e2/0 R2

R2 e2/1 <> e2/1 R3

R3 e2/2 <> e2/2 R4

R3 f3/0 <> e1 server

R1 f0/0 <> ethernet Cloud

Router Config:

R1:

Config hostname and IPv6 unicast routing:

```
hostname R1
ipv6 unicast-routing
```

Config internet:

```
ip route 0.0.0.0 0.0.0.0 192.168.164.2


interface FastEthernet0/0
 ip address 192.168.164.128 255.255.255.0
 duplex full
 ipv6 address autoconfig default
```

Interface IPv4 and IPv6 Config:

```
interface Loopback0
 ip address 100.68.1.10 255.255.255.255
 ipv6 address 2001:DB8:1::10/128
!
interface Ethernet2/0
 description R1-R2
 ip address 100.68.1.1 255.255.255.252
 duplex full
 ipv6 address 2001:DB8:1::/127
```

Config prefix list for in and out filter for both IPv4 and IPv6:

```
ip prefix-list customer seq 5 permit 100.68.2.0/23 le 24
ip prefix-list customer seq 10 permit 103.26.244.0/24

ip prefix-list default seq 5 permit 0.0.0.0/0

ipv6 prefix-list customer seq 5 permit 2001:DB8:2::/48
ipv6 prefix-list customer seq 6 permit 2001:DB8:3::/48
ipv6 prefix-list customer seq 7 permit 2407:D700::/48

ipv6 prefix-list default seq 5 permit ::/0
```

bgp config:

```
router bgp 65001
 bgp log-neighbor-changes
 neighbor 2001:DB8:1::1 remote-as 65002
 neighbor 2001:DB8:1::1 description ASN65002
 neighbor 100.68.1.2 remote-as 65002
 neighbor 100.68.1.2 description ASN65002
```

```
 !
 address-family ipv4
  neighbor 100.68.1.2 activate
  neighbor 100.68.1.2 default-originate
  neighbor 100.68.1.2 prefix-list customer in
  neighbor 100.68.1.2 prefix-list default out
  neighbor 100.68.1.2 maximum-prefix 10 warning-only
 exit-address-family
 !
 address-family ipv6
  network 2001:DB8:1::/48
  neighbor 2001:DB8:1::1 activate
  neighbor 2001:DB8:1::1 default-originate
  neighbor 2001:DB8:1::1 prefix-list customer in
  neighbor 2001:DB8:1::1 prefix-list default out
  neighbor 2001:DB8:1::1 maximum-prefix 10 warning-only
 exit-address-family
```

R2:

Config hostname and IPv6 unicast routing:

```
hostname R2
ipv6 unicast-routing
```

Interface IPv4 and IPv6 Config:

```
interface Loopback0
 ip address 100.68.2.10 255.255.255.255
 ip ospf 1 area 0
 ipv6 address 2001:DB8:2::10/128
 ipv6 ospf 1 area 0
!

interface Ethernet2/0
 description R2-R1
 ip address 100.68.1.2 255.255.255.252
 duplex full
 ipv6 address 2001:DB8:1::1/127
!
interface Ethernet2/1
 description R2-R3
 ip address 100.68.2.1 255.255.255.252
 ip ospf 1 area 0
 duplex full
 ipv6 address 2001:DB8:2::1/127
 ipv6 ospf 1 area 0
```

```
!
```

Config router id of ospfv3:

```
router ospfv3 1
 router-id 100.68.2.10
 !
 address-family ipv6 unicast
 exit-address-family
!
```

Config router id of ospf:

```
router ospf 1
 router-id 100.68.2.10
!
```

Config prefix list for in and out filter for both IPv4 and IPv6:

```
ip prefix-list default seq 5 permit 0.0.0.0/0
!
ip prefix-list export seq 5 permit 100.68.2.0/24
ip prefix-list export seq 10 permit 100.68.3.0/24
ip prefix-list export seq 15 permit 103.26.244.0/24
!
ip prefix-list upstream seq 5 permit 0.0.0.0/0
!
!
ipv6 prefix-list default-v6 seq 5 permit ::/0
!
ipv6 prefix-list export-v6 seq 5 permit 2001:DB8:2::/48
ipv6 prefix-list export-v6 seq 6 permit 2001:DB8:3::/48
ipv6 prefix-list export-v6 seq 7 permit 2407:D700::/48
!
ipv6 prefix-list upstream-v6 seq 5 permit ::/0
!
```

bgp config:

```
router bgp 65002
 bgp log-neighbor-changes
 neighbor 2001:DB8:1:: remote-as 65001
 neighbor 2001:DB8:1:: description AS65002
 neighbor 2001:DB8:3::10 remote-as 65002
 neighbor 2001:DB8:3::10 description IBGP
 neighbor 2001:DB8:3::10 update-source Loopback0
 neighbor 100.68.1.1 remote-as 65001
 neighbor 100.68.3.10 remote-as 65002
 neighbor 100.68.3.10 description iBGP
 neighbor 100.68.3.10 update-source Loopback0
 !
 address-family ipv4
  network 100.68.2.0 mask 255.255.255.0
```

```
  neighbor 100.68.1.1 activate
  neighbor 100.68.1.1 prefix-list upstream in
  neighbor 100.68.1.1 prefix-list export out
  neighbor 100.68.1.1 maximum-prefix 5 restart 5
  neighbor 100.68.3.10 activate
  neighbor 100.68.3.10 next-hop-self
 exit-address-family
 !
 address-family ipv6
  network 2001:DB8:2::/48
  neighbor 2001:DB8:1:: activate
  neighbor 2001:DB8:1:: prefix-list eupstream-v6 in
  neighbor 2001:DB8:1:: prefix-list export-v6 out
  neighbor 2001:DB8:1:: maximum-prefix 5 restart 5
  neighbor 2001:DB8:3::10 activate
  neighbor 2001:DB8:3::10 next-hop-self
 exit-address-family
!
```

Null0 routes to originate the prefix:

```
ip route 100.68.2.0 255.255.255.0 Null0
!
ipv6 route 2001:DB8:2::/48 Null0
```

R3:

Config hostname and IPv6 unicast routing:

```
hostname R3
ipv6 unicast-routing
```

Config and enable SSH:

```
#ip domain name summitiig.net
#crypto key generate rsa
The name for the keys will be: R4.summitiig.net
Choose the size of the key modulus in the range of 360 to 4096 for
your
  General Purpose Keys. Choosing a key modulus greater than 512 may
take
  a few minutes.

How many bits in the modulus [512]: 1024
% Generating 1024 bit RSA keys, keys will be non-exportable...
[OK] (elapsed time was 2 seconds)


username lab privilege 15 secret apnic
!
ip ssh version 2
```

```
line vty 0 4
 login local
```

Interface IPv4 and IPv6 Config:

```
interface Loopback0
 ip address 100.68.3.10 255.255.255.255
 ip ospf 1 area 0
 ipv6 address 2001:DB8:3::10/128
 ipv6 ospf 1 area 0
!
interface FastEthernet0/0
 description TO-CUST-01
 ip address 10.0.0.0 255.255.255.254
 duplex full
 ipv6 address 2001:DB8:1::/127
!
interface Ethernet2/1
 description R2-R3
 ip address 100.68.2.2 255.255.255.252
 ip ospf 1 area 0
 duplex full
 ipv6 address 2001:DB8:2::2/127
 ipv6 ospf 1 area 0
!
interface Ethernet2/2
 description R4-R3
 ip address 100.68.3.1 255.255.255.252
 duplex full
 ipv6 address 2001:DB8:3::/127
!
interface FastEthernet3/0
 description SERVER1
 ip address 100.68.3.5 255.255.255.252
 duplex full
 ipv6 address 2001:DB8:3::5/127
!
```

Config router id of ospfv3:

```
router ospfv3 1
 router-id 100.68.3.10
 !
 address-family ipv6 unicast
 exit-address-family
```

Config router id of ospf:

```
router ospf 1
 router-id 100.68.3.10
```

Config prefix list for in and out filter for both IPv4 and IPv6:

```
ip prefix-list BOGONS seq 5 deny 0.0.0.0/0
ip prefix-list BOGONS seq 10 deny 0.0.0.0/8 le 32
ip prefix-list BOGONS seq 15 deny 10.0.0.0/8 le 32
ip prefix-list BOGONS seq 20 deny 100.64.0.0/10 le 32
ip prefix-list BOGONS seq 25 deny 101.10.0.0/19 le 32
ip prefix-list BOGONS seq 30 deny 127.0.0.0/8 le 32
ip prefix-list BOGONS seq 35 deny 169.254.0.0/16 le 32
ip prefix-list BOGONS seq 40 deny 172.16.0.0/12 le 32
ip prefix-list BOGONS seq 45 deny 192.0.0.0/24 le 32
ip prefix-list BOGONS seq 50 deny 192.0.2.0/24 le 32
ip prefix-list BOGONS seq 55 deny 192.168.0.0/16 le 32
ip prefix-list BOGONS seq 60 deny 198.18.0.0/15 le 32
ip prefix-list BOGONS seq 65 deny 198.51.100.0/24 le 32
ip prefix-list BOGONS seq 70 deny 203.0.113.0/24 le 32
ip prefix-list BOGONS seq 75 deny 224.0.0.0/3 le 32
ip prefix-list BOGONS seq 80 deny 0.0.0.0/0 ge 25



ip prefix-list client seq 5 permit 103.26.244.0/24

ip prefix-list default seq 5 permit 0.0.0.0/0


ipv6 prefix-list BOGONS seq 5 deny ::/8 le 128
ipv6 prefix-list BOGONS seq 10 deny 100::/64 le 128
ipv6 prefix-list BOGONS seq 15 deny 2001:2::/48 le 128
ipv6 prefix-list BOGONS seq 20 deny 2001:10::/28 le 128
ipv6 prefix-list BOGONS seq 25 deny 2001:DB8::/32 le 128
ipv6 prefix-list BOGONS seq 30 deny 2002::/16 le 128
ipv6 prefix-list BOGONS seq 35 deny 3FFE::/16 le 128
ipv6 prefix-list BOGONS seq 40 deny FC00::/7 le 128
ipv6 prefix-list BOGONS seq 45 deny FE80::/10 le 128
ipv6 prefix-list BOGONS seq 50 deny FEC0::/10 le 128
ipv6 prefix-list BOGONS seq 55 deny FF00::/8 le 128



ipv6 prefix-list client-v6 seq 5 permit 2407:D700::/48


ipv6 prefix-list default-v6 seq 5 permit ::/0
```

Config route-map for in and out filter for both IPv4 and IPv6:

```
route-map DEFAULT-V6 permit 10
 match ipv6 address prefix-list default-v6
!
route-map DEFAULT-V6 deny 100


route-map CLIENT-IN deny 10
 match ip address prefix-list default
!
route-map CLIENT-IN deny 20
 match ip address prefix-list BOGONS
!
route-map CLIENT-IN permit 30
 match ip address prefix-list client
 match rpki valid
 set local-preference 1000
!
route-map CLIENT-IN permit 40
 match ip address prefix-list client
 match rpki not-found
 set local-preference 1000


route-map DEFAULT permit 10
 match ip address prefix-list default
!
route-map DEFAULT deny 100


route-map CLIENT-V6-IN deny 20
 match ipv6 address prefix-list BOGONS
!
route-map CLIENT-V6-IN permit 30
 match rpki valid
 match ipv6 address prefix-list client-v6
 set local-preference 1000
!
route-map CLIENT-V6-IN permit 40
 match rpki not-found
 match ipv6 address prefix-list client-v6
 set local-preference 1000
```

bgp config:

```
router bgp 65002
```

```
 bgp log-neighbor-changes
 bgp rpki server tcp 2001:DB8:3::4 port 3323 refresh 900
 bgp rpki server tcp 100.68.3.6 port 3323 refresh 900
 neighbor 2001:DB8:2::10 remote-as 65002
 neighbor 2001:DB8:2::10 description iBGP
 neighbor 2001:DB8:2::10 update-source Loopback0
 neighbor 2001:DB8:3::1 remote-as 132884
 neighbor 2001:DB8:3::1 description AS132884
 neighbor 100.68.2.10 remote-as 65002
 neighbor 100.68.2.10 description iBGP
 neighbor 100.68.2.10 update-source Loopback0
 neighbor 100.68.3.2 remote-as 132884
 neighbor 100.68.3.2 description AS132884
 !
 address-family ipv4
  network 100.68.3.0 mask 255.255.255.0
  neighbor 100.68.2.10 activate
  neighbor 100.68.2.10 next-hop-self
  neighbor 100.68.3.2 activate
  neighbor 100.68.3.2 soft-reconfiguration inbound
  neighbor 100.68.3.2 route-map CLIENT-IN in
  neighbor 100.68.3.2 route-map DEFAULT out
  neighbor 100.68.3.2 maximum-prefix 10 warning-only
 exit-address-family
 !
 address-family ipv6
  network 2001:DB8:3::/48
  neighbor 2001:DB8:2::10 activate
  neighbor 2001:DB8:2::10 next-hop-self
  neighbor 2001:DB8:3::1 activate
  neighbor 2001:DB8:3::1 soft-reconfiguration inbound
  neighbor 2001:DB8:3::1 route-map CLIENT-V6-IN in
  neighbor 2001:DB8:3::1 route-map DEFAULT-V6 out
  neighbor 2001:DB8:3::1 maximum-prefix 10 warning-only
 exit-address-family
```

Null0 routes to originate the prefix:

```
ip route 100.68.3.0 255.255.255.0 Null0

ipv6 route 2001:DB8:3::/48 Null0
```

R4:

Config hostname and IPv6 unicast routing:

```
hostname R4

ipv6 unicast-routing
```

Interface IPv4 and IPv6 Config:

```
interface Loopback0
 ip address 103.26.244.10 255.255.255.255
 ipv6 address 2407:D700::10/128
!
interface Ethernet2/2
 description R4-R3
 ip address 100.68.3.2 255.255.255.252
 duplex full
 ipv6 address 2001:DB8:3::1/127
!
```

Config prefix list for in and out filter for both IPv4 and IPv6:

```
ip prefix-list BOGONS seq 5 deny 0.0.0.0/0
ip prefix-list BOGONS seq 10 deny 0.0.0.0/8 le 32
ip prefix-list BOGONS seq 15 deny 10.0.0.0/8 le 32
ip prefix-list BOGONS seq 20 deny 100.64.0.0/10 le 32
ip prefix-list BOGONS seq 25 deny 101.10.0.0/19 le 32
ip prefix-list BOGONS seq 30 deny 127.0.0.0/8 le 32
ip prefix-list BOGONS seq 35 deny 169.254.0.0/16 le 32
ip prefix-list BOGONS seq 40 deny 172.16.0.0/12 le 32
ip prefix-list BOGONS seq 45 deny 192.0.0.0/24 le 32
ip prefix-list BOGONS seq 50 deny 192.0.2.0/24 le 32
ip prefix-list BOGONS seq 55 deny 192.168.0.0/16 le 32
ip prefix-list BOGONS seq 60 deny 198.18.0.0/15 le 32
ip prefix-list BOGONS seq 65 deny 198.51.100.0/24 le 32
ip prefix-list BOGONS seq 70 deny 203.0.113.0/24 le 32
ip prefix-list BOGONS seq 75 deny 224.0.0.0/3 le 32
ip prefix-list BOGONS seq 80 deny 0.0.0.0/0 ge 25

ip prefix-list default seq 5 permit 0.0.0.0/0

ip prefix-list export seq 1 permit 103.26.244.0/24


ipv6 prefix-list BOGONS seq 5 deny ::/8 le 128
ipv6 prefix-list BOGONS seq 10 deny 100::/64 le 128
ipv6 prefix-list BOGONS seq 15 deny 2001:2::/48 le 128
ipv6 prefix-list BOGONS seq 20 deny 2001:10::/28 le 128
ipv6 prefix-list BOGONS seq 25 deny 2001:DB8::/32 le 128
ipv6 prefix-list BOGONS seq 30 deny 2002::/16 le 128
ipv6 prefix-list BOGONS seq 35 deny 3FFE::/16 le 128
ipv6 prefix-list BOGONS seq 40 deny FC00::/7 le 128
ipv6 prefix-list BOGONS seq 45 deny FE80::/10 le 128
ipv6 prefix-list BOGONS seq 50 deny FEC0::/10 le 128
ipv6 prefix-list BOGONS seq 55 deny FF00::/8 le 128

ipv6 prefix-list default-v6 seq 5 permit ::/0
```

```
ipv6 prefix-list export-v6 seq 1 permit 2407:D700::/48
```

Config route-map for in and out filter for both IPv4 and IPv6:

```
route-map EXPORT deny 5
 match ip address prefix-list BOGONS
!
route-map EXPORT permit 10
 match ip address prefix-list export


route-map UPSTREAM deny 5
 match ip address prefix-list BOGONS
!
route-map UPSTREAM permit 10
 match ip address prefix-list default


route-map EXPORT-V6 deny 5
 match ipv6 address prefix-list BOGONS
!
route-map EXPORT-V6 permit 10
 match ipv6 address prefix-list export-v6


route-map UPSTREAM-V6 deny 5
 match ipv6 address prefix-list BOGONS
!
route-map UPSTREAM-V6 permit 10
 match ipv6 address prefix-list default-v6
```

bgp config:

```
router bgp 132884
 bgp log-neighbor-changes
 neighbor 2001:DB8:3:: remote-as 65002
 neighbor 2001:DB8:3:: description AS65002
 neighbor 100.68.3.1 remote-as 65002
 !
 address-family ipv4
  network 103.26.244.0 mask 255.255.255.0
  neighbor 100.68.3.1 activate
  neighbor 100.68.3.1 soft-reconfiguration inbound
  neighbor 100.68.3.1 route-map UPSTREAM in
  neighbor 100.68.3.1 route-map EXPORT out
 exit-address-family
```

```
 !
 address-family ipv6
  network 2407:D700::/48
  neighbor 2001:DB8:3:: activate
  neighbor 2001:DB8:3:: soft-reconfiguration inbound
  neighbor 2001:DB8:3:: route-map UPSTREAM-V6 in
  neighbor 2001:DB8:3:: route-map EXPORT-V6 out
 exit-address-family
!
```

Null0 routes to originate the prefix:

```
ip route 103.26.244.0 255.255.255.0 Null0
!
ipv6 route 2407:D700::/48 Null0
```

Server Config:

Please find the file ***Ansible-lab.pdf*** and ***Routinator-lab.pdf***

Check list:

BGP routes check:

In R1:

```
#sh bgp

#sh bgp ipv6 unicast

#sh ip bgp neighbors 100.68.1.2 routes

#sh ip bgp neighbors 100.68.1.2 advertised-routes

#sh bgp ipv6 unicast neighbors 2001:DB8:1::1 routes

#sh bgp ipv6 unicast neighbors 2001:DB8:1::1 advertised-routes
```

Internet reachability check:

From R4:

```
R4#ping 2001:DB8:1::10 source 2407:D700::10

R4#ping 100.68.1.10 source 103.26.244.10

#ping 2001:4860:4860::8888

#ping 2606:4700:4700::1111
```

RPKI check:

From R3:

```
R3#sh ip bgp rpki server
R3#sh ip bgp rpki table
R3#sh bgp ipv6 unicast rpki table
R3#sh ip bgp neighbors 100.68.3.1 routes
R3#sh bgp ipv6 unicast neighbors 2001:DB8:3::1 routes
R3#sh bgp 103.26.244.0
R3#sh bgp ipv6 unicast 2407:D700::/48
```

Automation Check:

From R3:

```
R3(config)#no route-map CLIENT-IN
R3(config)#no route-map CLIENT-V6-IN
R3(config)#router bgp 65002
R3(config-router)#no  neighbor 100.68.3.2
R3(config)#router bgp 65002
R3(config-router)#no  neighbor 2001:DB8:3::1
```

In Server:

```
root@server1:/home/lab# ansible-playbook  routemap-r3.yml
Enter the route map name: : CLIENT-IN
Enter the prefix list name: : client

root@server1:/home/lab# ansible-playbook  routemap-r3-v6.yml
Enter the route map name: : CLIENT-V6-IN
Enter the prefix list name: : client-v6

root@server1:/home/lab# ansible-playbook  ebgp-r3.yml
```

```
Enter Neighbor IP: 100.68.3.2
Enter the remote-as: 132884
Enter the Neighbor description: AS132884
Enter Prefix limit for this Neighbor: 10
Enter the route-map in name: CLIENT-IN
Enter the route-map out name: DEFAULT

root@server1:/home/lab# ansible-playbook  ebgp-r3-v6.yml
Enter Neighbor IPv6: 2001:DB8:3::1
Enter the remote-as: 132884
Enter the Neighbor description: AS132884
Enter Prefix limit for this Neighbor: 10
Enter the route-map in name: CLIENT-IN
Enter the route-map out name: DEFAULT
```

In R3:

```
R3# sh ip bgp sum
R3# sh bgp ipv6 unicast sum
R3#sh bgp neighbors 100.68.3.2 routes
R3#sh bgp ipv6 unicast neighbors 2001:DB8:3::1 routes
```