BGP Part 2

~~*Empire*~~ *BGP Strikes Back!*

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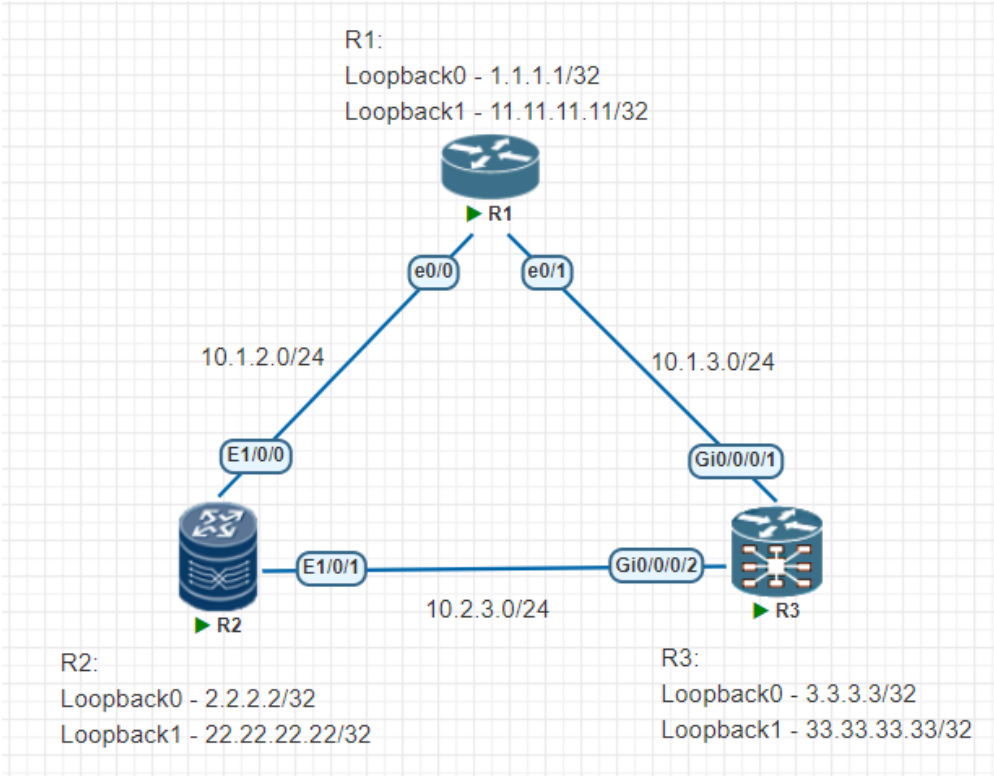
BGP – Базовая конфигурация – Cisco IOS

```
router bgp 100
 bgp router-id 1.1.1.1
 neighbor 10.1.2.2 remote-as 200
 neighbor 10.1.2.2 update-source Ethernet0/0
 neighbor 10.1.3.3 remote-as 300
 neighbor 10.1.3.3 update-source Ethernet0/1
 !
 address-family ipv4
  network 1.1.1.1 mask 255.255.255.255
  neighbor 10.1.2.2 activate
  neighbor 10.1.3.3 activate
 exit-address-family
 !
!
```



BGP – Базовая конфигурация – IOS/IOS-XE

```
R1#show bgp ipv4 unicast summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 4, main routing table version 4
3 network entries using 432 bytes of memory
5 path entries using 420 bytes of memory
5/3 BGP path/bestpath attribute entries using 800 bytes of memory
4 BGP AS-PATH entries using 96 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 1748 total bytes of memory
BGP activity 3/0 prefixes, 7/2 paths, scan interval 60 secs

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
State/PfxRcd
10.1.2.2        4          200      45      41        4    0    0 00:31:58
        2
10.1.3.3        4          300      34      36        4    0    0 00:26:37
        2
```

BGP – Базовая конфигурация – IOS/IOS-XE

```
R1#show bgp ipv4 unicast
BGP table version is 4, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
              t secondary path,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *    2.2.2.2/32       10.1.3.3                               0 300 200 i
 *>                    10.1.2.2                 0             0 200 i
 *    3.3.3.3/32       10.1.2.2                               0 200 300 i
 *>                    10.1.3.3                 0             0 300 i
```

BGP – Базовая конфигурация – Huawei VRP

```
bgp 200
 router-id 2.2.2.2
 peer 10.1.2.1 as-number 100
 peer 10.1.2.1 connect-interface Ethernet1/0/0
 peer 10.2.3.3 as-number 300
 peer 10.2.3.3 connect-interface Ethernet1/0/1
 #
 ipv4-family unicast
  network 2.2.2.2 255.255.255.255
  peer 10.1.2.1 enable
  peer 10.2.3.3 enable
 #
#
```

BGP – Базовая конфигурация – Huawei VRP

```
<R2>display bgp peer

 BGP local router ID : 2.2.2.2
 Local AS number : 200
 Total number of peers : 2                 Peers in established state : 2

  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State  PrefRcv
  10.1.2.1        4         100       19       19     0 00:11:57 Established        2
  10.2.3.3        4         300       12       14     0 00:06:51 Established        2
```

BGP – Базовая конфигурация – Huawei VRP

```
<R2>display bgp routing-table

 BGP Local router ID is 2.2.2.2
 Status codes: * - valid, > - best, d - damped, x - best external, a - add path,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete
 RPKI validation codes: V - valid, I - invalid, N - not-found


 Total Number of Routes: 5
        Network            NextHop                MED        LocPrf     PrefVal Path/Ogn

 *>     1.1.1.1/32         10.1.2.1                0                     0      100i
 *                         10.2.3.3                                      0      300 100i
 *>     2.2.2.2/32         0.0.0.0                 0                     0       i
 *>     3.3.3.3/32         10.2.3.3                0                     0      300i
 *                         10.1.2.1                                      0      100 300i
```

BGP – Базовая конфигурация – IOS-XR

```
route-policy RP_PERMIT_ANY
 pass
end-policy

router bgp 300
 bgp router-id 3.3.3.3
 !
 address-family ipv4 unicast
  network 3.3.3.3/32
 !
```

```
<..router bgp 300..>
neighbor 10.1.3.1
  remote-as 100
  update-source GigabitEthernet0/0/0/1
  address-family ipv4 unicast
   route-policy RP_PERMIT_ANY in
   route-policy RP_PERMIT_ANY out
   !
  !
 neighbor 10.2.3.2
  remote-as 200
  update-source GigabitEthernet0/0/0/2
  address-family ipv4 unicast
   route-policy RP_PERMIT_ANY in
   route-policy RP_PERMIT_ANY out
   !
```

BGP – Базовая конфигурация – IOS-XR

```
RP/0/0/CPU0:R3#show bgp ipv4 unicast summary
Tue Apr 12 15:54:25.639 UTC
BGP router identifier 3.3.3.3, local AS number 300
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 5
BGP main routing table version 5
BGP NSR Initial initsync version 5 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

BGP is operating in STANDALONE mode.


Process       RcvTblVer   bRIB/RIB   LabelVer  ImportVer  SendTblVer  StandbyVer
Speaker               5          5          5          5           5           0

Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down  St/PfxRcd
10.1.3.1          0   100      15      14        5    0    0 00:08:07           2
10.2.3.2          0   200      15      14        5    0    0 00:08:22           2
```

BGP – Базовая конфигурация – IOS-XR

```
RP/0/0/CPU0:R3#show bgp ipv4 unicast
Tue Apr 12 16:14:30.127 UTC
BGP router identifier 3.3.3.3, local AS number 300
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 9
BGP main routing table version 9
BGP NSR Initial initsync version 5 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
*> 1.1.1.1/32         10.1.3.1                 0             0 100 i
*                     10.2.3.2                               0 200 100 i
*  2.2.2.2/32         10.1.3.1                               0 100 200 i
*>                    10.2.3.2                 0             0 200 i
*> 3.3.3.3/32         0.0.0.0                  0         32768 i

Processed 3 prefixes, 5 paths
```

BGP – Базовая конфигурация – IOS-XR

```
RP/0/0/CPU0:R3(config)#router bgp 300
RP/0/0/CPU0:R3(config-bgp)#neighbor 10.2.3.2 address-family ipv4 unicast
RP/0/0/CPU0:R3(config-bgp-nbr-af)#no route-policy RP_PERMIT_ANY in
RP/0/0/CPU0:R3(config-bgp-nbr-af)#no route-policy RP_PERMIT_ANY out
RP/0/0/CPU0:R3(config-bgp-nbr-af)#commit
RP/0/0/CPU0:R3#show bgp ipv4 unicast summary | b Process
Tue Apr 12 16:04:46.597 UTC
Process       RcvTblVer   bRIB/RIB   LabelVer  ImportVer  SendTblVer  StandbyVer
Speaker               7          7          7          7           7           0

Some configured eBGP neighbors (under default or non-default vrfs)
do not have both inbound and outbound policies configured for IPv4 Unicast
address family. These neighbors will default to sending and/or
receiving no routes and are marked with '!!' in the output below.
Use the 'show bgp neighbor <nbr_address>' command for details.

Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down  St/PfxRcd
10.1.3.1          0   100      27      25        7    0    0 00:18:28           2
10.2.3.2          0   200      32      25        7    0    0 00:18:43          0!
---
<R2>display bgp peer

 BGP local router ID : 2.2.2.2
 Local AS number : 200
 Total number of peers : 2                 Peers in established state : 2

  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State  PrefRcv
  10.1.2.1        4         100       34       36     0 00:25:24 Established        2
  10.2.3.3        4         300       27       34     0 00:20:18 Established        0
```

BGP – Базовая конфигурация – IOS-XR

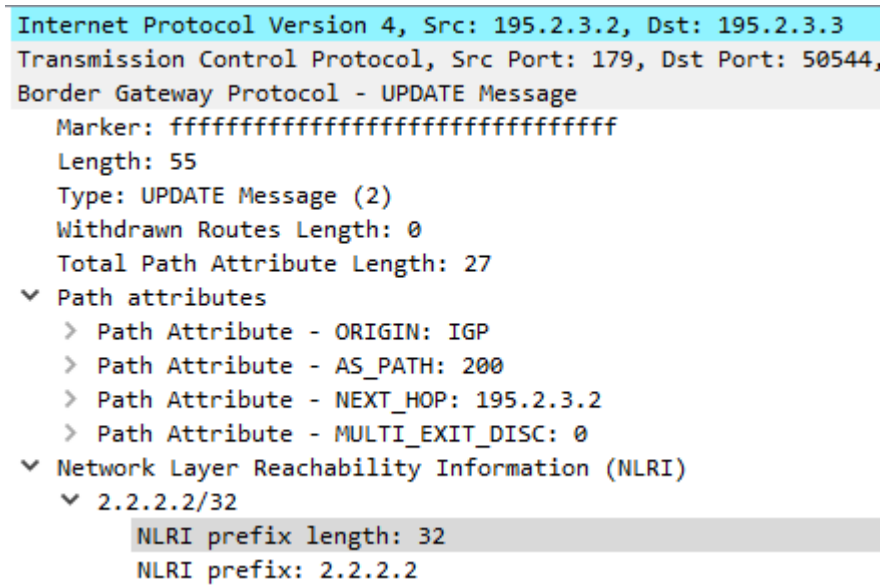
```
RP/0/0/CPU0:R3#show bgp ipv4 unicast
Tue Apr 12 16:15:32.243 UTC
BGP router identifier 3.3.3.3, local AS number 300
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 11
BGP main routing table version 11
BGP NSR Initial initsync version 5 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
*> 1.1.1.1/32         10.1.3.1                 0             0 100 i
*> 2.2.2.2/32         10.1.3.1                               0 100 200 i
*> 3.3.3.3/32         0.0.0.0                  0         32768 i

Processed 3 prefixes, 3 paths
```

BGP – Обработка маршрутов

- Манипуляции с маршрутами могут производиться на основании:
  1. Содержимое NLRI (за счет применения ACL или prefix-list)
  2. Содержимое AS_PATH
  3. Атрибута Community
  4. Атрибута Next-hop
  5. Прочие атрибуты
- Что можно сделать:
  1. Запретить получение/анонс маршрута
  2. Изменить за счет prepend длину AS_PATH
  3. Добавить/изменить/убрать коммьюнити
  4. Изменить next-hop
  5. Прочие манипуляции с атрибутами

BGP – NLRI Prefix Filtering

- NLRI представляет собой набор из префикса и его длины
- Для поиска совпадений в содержимом NLRI используются:
  - ACL
  - Prefix-list
- В подавляющем большинстве случаев, для поиска соответствия будет использоваться именно префикс-лист, т.к. он имеет более короткую и очевидную форму записи



- ACL может использоваться в том случае, если необходимо задать какой-то очень специфичный шаблон или для простых вариантов фильтрации анонсов вроде distribute-list

BGP – NLRI Prefix Filtering - ACL

ACL – Access Control List, изначально использовался для фильтрации пакетов на основе какого-то шаблона, однако, также используется для классификации трафика и для сравнения префиксов в протоколах маршрутизации.

За счет использования wildcard позволяет создавать очень гибкие фильтры, которые получить невозможно, используя prefix-list

Cisco IOS/IOS-XE:

Стандартные:

```
ip access-list standard ACL_ST_01
 10 permit 10.0.0.0 0.255.255.255
```

Расширенные:

```
ip access-list extended ACL_EXT_02
 10 permit ip 10.0.0.0 0.255.255.255 255.0.0.0
0.255.255.255
```

Huawei VRP:

Стандартные:

```
acl name ACL_BASIC_01 basic number 2000
 rule 10 permit source 10.0.0.0 0.0.0.255
```

BGP – NLRI Prefix Filtering - ACL

Before:

```
R1#show bgp ipv4 unicast neighbors 10.1.2.2 advertised-routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *>   2.2.2.2/32       10.1.2.2                 0             0 200 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i
 *>   11.11.11.0/27    0.0.0.0                  0         32768 i
 *>   11.11.11.0/24    0.0.0.0                  0         32768 i
 *>   11.11.11.11/32   0.0.0.0                  0         32768 i

Total number of prefixes 6
--
ip access-list extended ACL_ODD_PREF_AND_NARROW_MASK
 permit ip 1.0.0.0 254.255.255.255 255.255.255.128 0.0.0.127
!
router bgp 100
 address-family ipv4 unicast
  neighbor 10.1.2.2 distribute-list ACL_ODD_PREF_AND_NARROW_MASK out
--
```

After:

```
R1#show bgp ipv4 unicast neighbors 10.1.2.2 advertised-routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i
 *>   11.11.11.0/27    0.0.0.0                  0         32768 i
 *>   11.11.11.11/32   0.0.0.0                  0         32768 i

Total number of prefixes 4
```

BGP – NLRI Prefix Filtering - ACL

Before:

```
<R2>display bgp routing-table peer 10.2.3.3 received-routes

 Total Number of Routes: 3
        Network            NextHop                MED        LocPrf    PrefVal Path/Ogn

 *      1.1.1.1/32         10.2.3.3                                        0      300 100i
 *>     3.3.3.3/32         10.2.3.3                0                       0      300i
 *      11.11.11.11/32     10.2.3.3                                        0      300 100i
--
acl number 2000
 description Match only 1 or 3 in first octet
 rule 10 permit source 1.0.0.0 2.255.255.255
#
route-policy RP_MATCH_1_OR_3 permit node 10
 if-match acl 2000
#
bgp 200
 ipv4-family unicast
  peer 10.2.3.3 route-policy RP_MATCH_1_OR_3 import
--
```

After:

```
<R2>display bgp routing-table peer 10.2.3.3 received-routes

 Total Number of Routes: 2
        Network            NextHop                MED        LocPrf    PrefVal Path/Ogn

 *      1.1.1.1/32         10.2.3.3                                        0      300 100i
 *>     3.3.3.3/32         10.2.3.3                0                       0      300i
```

BGP – NLRI Prefix Filtering – Prefix-list

Prefix-list – инструмент сравнения с эталоном каких-либо префиксов
Имеет логичный и гораздо более человекочитабельный вид.
Как и в ACL, проверка идет «сверху-вниз» до первого совпадения
В большинстве систем имеет следующий вид:

```
{prefix-list operator} {network address} {prefix length} {additional operators}
```

где:

- Operator – действие (permit/deny, есть не везде)
- Network address – IP-адрес сети
- Prefix length – длина префикса (фактически, маска в битовом виде, указывается через разделитель “/” (в большинстве систем) или “ “ (в Huawei)).
- Additional operators – операторы, расширяющие возможности префикс-листов:
  - Greater or equal
  - Lesser or equal

BGP – NLRI Prefix Filtering – Prefix-list

Operator	IOS/IOS-XE	IOS-XR	Huawei VRP
Lesser or equal	le	le	less-equal
Greater or equal	ge	ge	greater-equal
Equal	-	eq	-

Запись в префикс-листе без использования доп. операторов проверяет на полное соответствие.

Например, есть такой префикс-лист:

```
ip prefix-list PL_TEST01 permit 192.168.0.0/24
```

и если сравнить префикс 192.168.0.0/25 с этим листом, то совпадения не будет.

Операторы же позволяют искать какие-то более специфичные префиксы внутри «основного» префикса.

Lesser or equal N – проверяет префиксы на вхождение в «основной» и на соответствие заданной длины префикса: он не должен быть «уже», чем N

Greater or equal N - проверяет префиксы на вхождение в «основной» и на соответствие заданной длины префикса: он не должен быть «шире», чем N

Операторы могут использоваться вместе, чтобы задать диапазон длины префикса:

- ip prefix-list PL_TEST01 permit 0.0.0.0/0 ge 16 le 24 – под данное условие подойдут любые маршруты с длиной префикса от 16 до 24 (т.е. от 255.255.0.0 до 255.255.255.0)
- ip prefix-list PL_TEST02 permit 10.0.0.0/8 ge 24 le 24 – под данное условие подойдут любые маршруты, входящие в сеть 10.0.0.0/8 и имеющие длину префикса 24 бита (т.е. 255.255.255.0)

BGP – NLRI Prefix Filtering – Prefix-list

Lesser or equal:	**Greater or equal:**	**Mixed:**
`ip prefix-list PL_TEST01 permit 10.0.0.0/16 le 24`	`ip ip-prefix PL_TEST02 permit 10.0.0.0 16 greater-equal 24`	`prefix-set PS_TEST03 10.0.0.0/16 ge 22 le 26 end-set`
• 10.0.0.0/16 – YES • 10.64.0.0/18 – YES • 10.127.255.0/24 – YES • 10.250.15.0/24 – NO • 10.0.0.0/15 – NO • 10.0.0.0/25 – NO • 10.1.1.1/32 – NO	• 10.0.0.0/16 – NO • 10.64.0.0/18 – NO • 10.127.255.0/24 – YES • 10.250.15.0/24 – NO • 10.0.0.0/15 – NO • 10.0.0.0/25 – YES • 10.1.1.1/32 – YES	• 10.0.0.0/16 – NO • 10.64.0.0/18 – NO • 10.127.255.0/24 – YES • 10.250.15.0/24 – NO • 10.0.0.0/15 – NO • 10.0.0.0/25 – YES • 10.1.1.1/32 – NO

BGP – NLRI Prefix Filtering – Prefix-list

Cisco IOS/IOS-XE:

```
ip prefix-list PL_R1_to_R2 seq 10 permit 3.3.3.3/32
ip prefix-list PL_R1_to_R2 seq 20 permit 11.11.11.0/24
le 27
ip prefix-list PL_R1_to_R2 seq 30 permit 1.1.1.1/32
ip prefix-list PL_R1_to_R3 seq 10 permit 0.0.0.0/0 ge
32
!
route-map RM_R1_to_R2 permit 10
 match ip address prefix-list PL_R1_to_R2
!
router bgp 100
 address-family ipv4
  neighbor 10.1.2.2 route-map RM_R1_to_R2 out
  neighbor 10.1.3.3 prefix-list PL_R1_to_R3 out
!
```

Before:

```
R1#show bgp ipv4 unicast neighbors 10.1.2.2 advertised-routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *>   2.2.2.2/32       10.1.2.2                 0             0 200 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i
 *>   11.11.11.0/27    0.0.0.0                  0         32768 i
 *>   11.11.11.0/24    0.0.0.0                  0         32768 i
 *>   11.11.11.11/32   0.0.0.0                  0         32768 i

R1#show bgp ipv4 unicast neighbors 10.1.3.3 advertised-routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *>   2.2.2.2/32       10.1.2.2                 0             0 200 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i
 *>   11.11.11.0/27    0.0.0.0                  0         32768 i
 *>   11.11.11.0/24    0.0.0.0                  0         32768 i
 *>   11.11.11.11/32   0.0.0.0                  0         32768 i
--
```

After:

```
R1#show bgp ipv4 unicast neighbors 10.1.2.2 advertised-routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i
 *>   11.11.11.0/27    0.0.0.0                  0         32768 i
 *>   11.11.11.0/24    0.0.0.0                  0         32768 i

R1#show bgp ipv4 unicast neighbors 10.1.3.3 advertised-routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *>   2.2.2.2/32       10.1.2.2                 0             0 200 i
 *>   11.11.11.11/32   0.0.0.0                  0         32768 i
```

BGP – NLRI Prefix Filtering – Prefix-list

Huawei VRP:

```
ip ip-prefix PL_FROM_R3 index 10 deny 11.11.11.11 32
ip ip-prefix PL_FROM_R3 index 20 permit 0.0.0.0 0 less-
equal 32
#
bgp 200
 ipv4-family unicast
  peer 10.2.3.3 ip-prefix PL_FROM_R3 import
#
```

Before:

```
<R2>display bgp routing-table peer 10.2.3.3 received-routes

 Total Number of Routes: 3
      Network           NextHop     MED    LocPrf    PrefVal    Path/Ogn

 *     1.1.1.1/32        10.2.3.3                     0         300 100i
 *>    3.3.3.3/32        10.2.3.3     0               0         300i
 *>    11.11.11.11/32    10.2.3.3                     0         300 100i
```

After:

```
<R2>display bgp routing-table peer 10.2.3.3 received-routes

 Total Number of Routes: 2
      Network           NextHop     MED    LocPrf    PrefVal    Path/Ogn

 *     1.1.1.1/32        10.2.3.3                     0         300 100i
 *>    3.3.3.3/32        10.2.3.3     0               0         300i
```

BGP – NLRI Prefix Filtering – Prefix-list

Cisco IOS-XR:

```
prefix-set PS_FROM_R3_TO_R2
  33.33.0.0/16 ge 24 le 32
end-set
!
route-policy RP_FROM_R3_TO_R2
  if destination in PS_FROM_R3_TO_R2 then
    pass
  else
    drop
  endif
end-policy
!
router bgp 300
 neighbor 10.2.3.2
  address-family ipv4 unicast
   route-policy RP_FROM_R3_TO_R2 out
  !
```

Before:

```
RP/0/0/CPU0:R3#show bgp ipv4 unicast neighbors 10.2.3.2 advertised-routes
Sun Apr 17 15:13:57.351 UTC
Network            Next Hop        From            AS Path
1.1.1.1/32         10.2.3.3        10.1.3.1        300 100i
2.2.2.2/32         10.2.3.3        10.2.3.2        300 200i
3.3.3.3/32         10.2.3.3        Local           300i
11.11.11.0/24      10.2.3.3        10.2.3.2        300 200 100i
11.11.11.0/27      10.2.3.3        10.2.3.2        300 200 100i
11.11.11.11/32     10.2.3.3        10.1.3.1        300 100i
33.33.0.0/16       10.2.3.3        Local           300i
33.33.33.0/24      10.2.3.3        Local           300i
33.33.33.33/32     10.2.3.3        Local           300i

Processed 9 prefixes, 9 paths
```

After:

```
RP/0/0/CPU0:R3#show bgp ipv4 unicast neighbors 10.2.3.2 advertised-routes
Sun Apr 17 15:14:53.277 UTC
Network            Next Hop        From            AS Path
33.33.33.0/24      10.2.3.3        Local           300i
33.33.33.33/32     10.2.3.3        Local           300i

Processed 2 prefixes, 2 paths
```

BGP – AS_PATH Filtering and Manipulation

- Атрибут AS_PATH представляет собой строку, в которой перечислены номера автономных систем, через которые проходит маршрут
- Т.к. указанный атрибут является строкой, его можно обрабатывать регулярными выражениями:
  - . - любой символ, включая пробел
  - * - ноль или больше совпадений с выражением
  - + - одно или больше совпадений с выражением
  - ? - ноль или одно совпадение с выражением
  - ^ - начало строки
  - $ - конец строки
  - _ - любой разделитель (включая, начало, конец, пробел)
  - \ - не воспринимать следующий символ как специальный
  - [ ] - совпадение с одним из символов в диапазоне
  - | - логическое или

BGP – AS_PATH Filtering and Manipulation

```
<HUAWEI_with_FV>display bgp routing-table regular-expression _43038$

 Total Number of Routes: 14

 BGP Local router ID is 2.2.2.2
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete

      Network            NextHop        MED        LocPrf    PrefVal Path/Ogn

 *>   178.17.176.0/23    198.51.100.2             101        10      8359 43038i
 * i                     198.51.100.6             101        0       8359 43038i
 *>   178.17.178.0/23    198.51.100.2             101        10      8359 43038i
 * i                     198.51.100.6             101        0       8359 43038i
 *>   178.17.180.0/23    198.51.100.2             101        10      8359 43038i
 * i                     198.51.100.6             101        0       8359 43038i
 *>   178.17.182.0/23    198.51.100.2             101        10      8359 43038i
 * i                     198.51.100.6             101        0       8359 43038i
 *>   193.33.230.0/23    198.51.100.2             101        10      8359 43038i
 * i                     198.51.100.6             101        0       8359 43038i
 *>   213.176.232.0/23   198.51.100.2             101        10      8359 43038i
 * i                     198.51.100.6             101        0       8359 43038i
 *>   213.176.234.0/23   198.51.100.2             101        10      8359 43038i
 * i                     198.51.100.6             101        0       8359 43038i
```

BGP – AS_PATH Filtering and Manipulation

```
RP/0/RSP0/CPU0:XR_with_FV#show bgp ipv4 unicast regexp _2497_
Wed Apr 13 07:18:05.705 MSK
BGP router identifier 3.3.3.3, local AS number 64500
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 3410686769
BGP main routing table version 3410686769
BGP NSR Initial initsync version 718523 (Reached)
BGP NSR/ISSU Sync-Group versions 3410686769/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
*> 1.1.64.0/19        198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.96.0/24        198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.97.0/24        198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.98.0/24        198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.99.0/24        198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.100.0/24       198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.101.0/24       198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.102.0/24       198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.103.0/24       198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.104.0/24       198.51.100.106                250      0 8359 2497 2519 i
*> 1.1.105.0/24       198.51.100.106                250      0 8359 2497 2519 i
```

BGP – AS_PATH Filtering and Manipulation

```
ios_with_fv#show bgp ipv4 unicast regexp ^8359_
BGP table version is 8159492, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>  0.0.0.0          198.51.100.201           0             0 8359 i
 *>  1.0.64.0/18      198.51.100.201           0             0 8359 7670 18144 i
 *>  1.0.128.0/19     198.51.100.201           0             0 8359 38040 23969 i
 *>  1.0.128.0/18     198.51.100.201           0             0 8359 38040 23969 i
 *>  1.0.128.0/17     198.51.100.201           0             0 8359 38040 23969 i
 *>  1.0.144.0/20     198.51.100.201           0             0 8359 38040 23969 ?
 *>  1.0.160.0/19     198.51.100.201           0             0 8359 38040 23969 i
 *>  1.0.192.0/19     198.51.100.201           0             0 8359 38040 23969 i
```

BGP – AS_PATH Filtering and Manipulation

- Фильтрация на основе AS_PATH:
  - Отбор маршрутов, с заданной длиной AS_PATH: ^[0-9]+_[0-9]+$
  - Отбор маршрутов из локальной AS: ^$
  - Отбор маршрутов, проходящих через конкретную AS: _2497_
  - Отбор маршрутов, зародившихся в конкретной AS: 43038$
  - Отбор маршрутов, начинающихся в конкретной AS: ^8359_
- Инструменты:
  - IOS/IOS-XE: AS-Path access list:

```
ip as-path access-list 1 permit _56437$
```

  - IOS-XR: AS-Path set:

```
as-path-set AS_PATH_TEST01
  originates-from '56437'
end-set
```

  - Huawei VRP: AS-Path-Filter

```
ip as-path-filter ASF_TEST permit _56437$
```

BGP – AS_PATH Filtering and Manipulation

- Модификация AS-PATH теоретически возможна несколькими способами, однако, фактически, именно в целях модификации используется только один
- Изменение AS_PATH происходит при агрегации маршрутов – в AS_PATH агрегата по умолчанию не копируются значения из составляющих
- Prepending – добавление в AS_PATH дополнительных элементов. Де-юре никто не ограничивает значения, которые можно добавить в AS_PATH, де факто добавлять необходимо только номер своей AS.
- Prepending в первую очередь нужен для управления входящим трафиком: увеличивая длину AS_PATH, мы «ухудшаем» маршрут, делая его менее выгодным для соседей

BGP – AS_PATH Filtering and Manipulation

R1 (IOS) prepends to R3:

```
route-map RM_PREPEND_3 permit 10
 set as-path prepend 100 100 100
!
router bgp 100
 address-family ipv4
  neighbor 10.1.3.3 route-map RM_PREPEND_3 out
 exit-address-family
!
```

Before prepend:

```
RP/0/0/CPU0:R3#show bgp ipv4 unicast | b Network
Wed Apr 13 16:49:03.423 UTC
   Network          Next Hop            Metric LocPrf Weight Path
*> 1.1.1.1/32       10.1.3.1                 0             0 100 i
*                   10.2.3.2                               0 200 100 i
*  2.2.2.2/32       10.1.3.1                               0 100 200 i
*>                  10.2.3.2                 0             0 200 i
*> 3.3.3.3/32       0.0.0.0                  0         32768 i
```

```
<R2>dis bgp routing-table
         Network        NextHop      MED     LocPrf     PrefVal     Path/Ogn
 *>      1.1.1.1/32     10.1.2.1     0                    0          100i
 *                      10.2.3.3                          0          300 100i
 *>      2.2.2.2/32     0.0.0.0      0                    0           i
 *>      3.3.3.3/32     10.2.3.3     0                    0          300i
 *                      10.1.2.1                          0          100 300i
```

After prepend:

```
RP/0/0/CPU0:R3#show bgp ipv4 unicast | b Network
Wed Apr 13 16:53:26.015 UTC
   Network          Next Hop            Metric LocPrf Weight Path
*  1.1.1.1/32       10.1.3.1                 0             0 100 100 100 100 i
*>                  10.2.3.2                               0 200 100 i
*  2.2.2.2/32       10.1.3.1                               0 100 100 100 100 200 i
*>                  10.2.3.2                 0             0 200 i
*> 3.3.3.3/32       0.0.0.0                  0         32768 i
```

```
<R2>display bgp routing-table
         Network        NextHop      MED     LocPrf     PrefVal     Path/Ogn
 *>      1.1.1.1/32     10.1.2.1     0                    0          100i
 *>      2.2.2.2/32     0.0.0.0      0                    0           i
 *>      3.3.3.3/32     10.2.3.3     0                    0          300i
 *                      10.1.2.1                          0          100 300i
```

BGP – AS_PATH Filtering and Manipulation

R3 (IOS-XR) prepends to R3:

```
route-policy RP_PREPEND_3
  prepend as-path own-as 3
end-policy
!
router bgp 300
 neighbor 10.2.3.2
  address-family ipv4 unicast
   route-policy RP_PREPEND_3 out
  !
```

Before:

```
<R2>display bgp routing-table
       Network       NextHop     MED    LocPrf    PrefVal    Path/Ogn
 *>    1.1.1.1/32    10.1.2.1     0                 0         100i
 *>    2.2.2.2/32    0.0.0.0      0                 0          i
 *>    3.3.3.3/32    10.2.3.3     0                 0         300i
 *                   10.1.2.1                       0         100 300i

R1#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *    2.2.2.2/32       10.1.3.3                               0 300 200 i
 *>                    10.1.2.2                 0             0 200 i
 *    3.3.3.3/32       10.1.2.2                               0 200 300 i
 *>                    10.1.3.3                 0             0 300 i
```

After:

```
<R2>dis bgp routing-table
       Network       NextHop     MED    LocPrf    PrefVal    Path/Ogn
 *>    1.1.1.1/32    10.1.2.1     0                 0         100i
 *>    2.2.2.2/32    0.0.0.0      0                 0          i
 *>    3.3.3.3/32    10.1.2.1                       0         100 300i
 *                   10.2.3.3     0                 0         300 300 300 300i

R1#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *    2.2.2.2/32       10.1.3.3                               0 300 200 i
 *>                    10.1.2.2                 0             0 200 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i
```

BGP – AS_PATH Filtering and Manipulation

R2 (Huawei VRP) prepends to R1:

```
route-policy RP_PREPEND_3 permit node 10
 apply as-path 200 200 200 additive
bgp 200
 ipv4-family unicast
  peer 10.1.2.1 route-policy RP_PREPEND_3 export
```

Before:

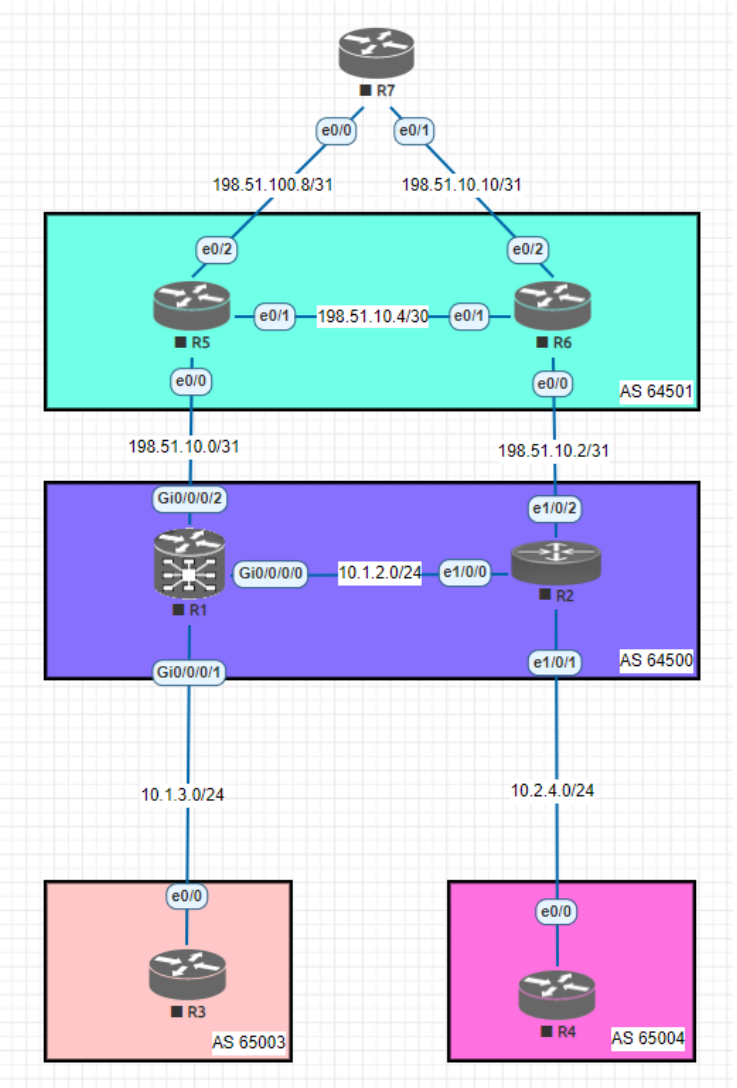
```
R1#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *    2.2.2.2/32       10.1.3.3                               0 300 200 i
 *>                    10.1.2.2                 0             0 200 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i

RP/0/0/CPU0:R3#show bgp ipv4 unicast | b  Network
Wed Apr 13 17:46:51.355 UTC
   Network            Next Hop            Metric LocPrf Weight Path
*  1.1.1.1/32         10.1.3.1                 0             0 100 100 100 100 i
*>                    10.2.3.2                               0 200 100 i
*  2.2.2.2/32         10.1.3.1                               0 100 100 100 100 200 i
*>                    10.2.3.2                 0             0 200 i
*> 3.3.3.3/32         0.0.0.0                  0         32768 i
```

After:

```
R1#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   1.1.1.1/32       0.0.0.0                  0         32768 i
 *>   2.2.2.2/32       10.1.3.3                               0 300 200 i
 *                     10.1.2.2                 0             0 200 200 200 200 i
 *>   3.3.3.3/32       10.1.3.3                 0             0 300 i

RP/0/0/CPU0:R3#show bgp ipv4 unicast | b  Network
Wed Apr 13 17:45:37.630 UTC
   Network            Next Hop            Metric LocPrf Weight Path
*  1.1.1.1/32         10.1.3.1                 0             0 100 100 100 100 i
*>                    10.2.3.2                               0 200 100 i
*> 2.2.2.2/32         10.2.3.2                 0             0 200 i
*> 3.3.3.3/32         0.0.0.0                  0         32768 i
```

BGP – Community

- Community – для управления трафиком чаще всего используются standard community
- За исключением well-known community, действия, применяемые к маршруту, определяются инженером самостоятельно, исходя из общей политики управления сетью и целей, которых необходимо достигнуть
- Well-known community позволяют добиться конкретных результатов меньшим количеством конфига и вне зависимости от вендора получать предсказуемый результат



BGP – Community – Huawei VRP

```
ip ip-prefix PL_DEFAULT_ONLY index 10 permit 0.0.0.0 0
ip ip-prefix PL_OUT index 10 permit 192.0.2.0 23 greater-equal 23
less-equal 24
#
ip community-filter basic CF_BLACKHOLE index 10 permit 64501:666
ip community-filter basic CF_R3 index 10 permit 64500:65003
ip community-filter basic CF_R4 index 10 permit 64500:65004
#
route-policy RP_OUT permit node 10
 if-match community-filter CF_BLACKHOLE
#
route-policy RP_OUT permit node 20
 if-match ip-prefix PL_OUT
#
route-policy RP_R4_IN permit node 10
 apply community 64500:65004 additive
#
route-policy RP_R4_OUT permit node 10
 if-match ip-prefix PL_DEFAULT_ONLY
#
route-policy RP_R4_OUT permit node 20
 if-match community-filter CF_R3
#
```

```
bgp 64500
 router-id 10.255.255.2
 peer 10.2.4.4 as-number 65004
 peer 10.2.4.4 connect-interface Ethernet1/0/1
 peer 10.255.255.1 as-number 64500
 peer 10.255.255.1 connect-interface LoopBack0
 peer 198.51.10.2 as-number 64501
 peer 198.51.10.2 connect-interface Ethernet1/0/2
 #
 ipv4-family unicast
  undo synchronization
  aggregate 192.0.2.0 255.255.254.0
  aggregate 192.0.2.0 255.255.255.0
  aggregate 192.0.3.0 255.255.255.0
  peer 10.2.4.4 enable
  peer 10.2.4.4 route-policy RP_R4_IN import
  peer 10.2.4.4 route-policy RP_R4_OUT export
  peer 10.2.4.4 advertise-community
  peer 10.255.255.1 enable
  peer 10.255.255.1 next-hop-local
  peer 10.255.255.1 advertise-community
  peer 198.51.10.2 enable
  peer 198.51.10.2 route-policy RP_OUT export
  peer 198.51.10.2 advertise-community
#
```

BGP – Community – Huawei VRP

```
<R2>dis bgp routing-table 192.0.2.3 32

 BGP local router ID : 10.255.255.2
 Local AS number : 64500
 Paths:   1 available, 1 best, 1 select, 0 best-external, 0 add-path
 BGP routing table entry information of 192.0.2.3/32:
 From: 10.255.255.1 (10.255.255.1)
 Route Duration: 0d00h01m08s
 Relay IP Nexthop: 10.1.2.1
 Relay IP Out-Interface: Ethernet1/0/0
 Original nexthop: 10.255.255.1
 Qos information : 0x0
 Community: <64500:65003>, <64501:666>
 AS-path 65003, origin igp, MED 0, localpref 100, pref-val 0, valid, internal, best, select, pre
255, IGP cost 2
 Advertised to such 2 peers:
    10.2.4.4
    198.51.10.2
<R2>dis bgp routing-table 192.0.2.4 32

 BGP local router ID : 10.255.255.2
 Local AS number : 64500
 Paths:   1 available, 1 best, 1 select, 0 best-external, 0 add-path
 BGP routing table entry information of 192.0.2.4/32:
 From: 10.2.4.4 (10.255.255.4)
 Route Duration: 0d00h03m11s
 Direct Out-interface: Ethernet1/0/1
 Original nexthop: 10.2.4.4
 Qos information : 0x0
 Community: <64500:65004>
 AS-path 65004, origin incomplete, MED 0, pref-val 0, valid, external, best, select, pre 255
 Advertised to such 2 peers:
    10.255.255.1
    198.51.10.2
```

Before:

```
<R2>display bgp routing-table peer 198.51.10.2 advertised-routes

 Total Number of Routes: 3
      Network         NextHop    MED    LocPrf    PrefVal    Path/Ogn

 *>    192.0.2.0/23    0.0.0.0                     0          64500?
 *>    192.0.2.0/24    0.0.0.0                     0          64500?
 *>    192.0.3.0/24    0.0.0.0                     0          64500i
```

After:

```
<R2>display bgp routing-table peer 10.2.4.4 advertised-routes

 Total Number of Routes: 5
      Network         NextHop    MED    LocPrf    PrefVal    Path/Ogn

 *>    0.0.0.0/0       0.0.0.0                     0          64500 64501i
 *>i   192.0.2.3/32    0.0.0.0                     0          64500 65003?
 *>i   192.0.2.13/32   0.0.0.0                     0          64500 65003?
 *>i   192.0.2.23/32   0.0.0.0                     0          64500 65003?
 *>i   192.0.3.0/25    0.0.0.0                     0          64500 65003i
```

BGP – Community – IOS-XR

```
prefix-set PS_OUT
  192.0.2.0/23 le 24
end-set
!
prefix-set PS_DEFAULT_ONLY
  0.0.0.0/0
end-set
!
community-set CS_R3
  64500:65003
end-set
!
community-set CS_R4
  64500:65004
end-set
!
route-policy RP_OUT
  if community matches-any (64501:666) or destination
in PS_OUT then
    pass
  else
    drop
  endif
end-policy
!
route-policy RP_R3_IN
  set community (64500:65003) additive
end-policy
!
route-policy RP_PERMIT_ANY
  pass
end-policy
!
```

```
route-policy RP_R3_OUT
  if destination in PS_DEFAULT_ONLY or community
matches-any CS_R4 then
    pass
  else
    drop
  endif
end-policy
!
router bgp 64500
 bgp router-id 10.255.255.1
 address-family ipv4 unicast
  aggregate-address 192.0.2.0/23
  aggregate-address 192.0.2.0/24
  aggregate-address 192.0.3.0/24
 !

 neighbor 10.1.3.3
  remote-as 65003
  update-source GigabitEthernet0/0/0/1
  address-family ipv4 unicast
   send-community-ebgp
   route-policy RP_R3_IN in
   route-policy RP_R3_OUT out
   default-originate
  !
 !
```

```
 !
 neighbor 198.51.10.0
  remote-as 64501
  update-source GigabitEthernet0/0/0/2
  address-family ipv4 unicast
   send-community-ebgp
   route-policy RP_PERMIT_ANY in
   route-policy RP_OUT out
  !
 !
 neighbor 10.255.255.2
  remote-as 64500
  update-source Loopback0
  address-family ipv4 unicast
   route-policy RP_PERMIT_ANY in
   route-policy RP_PERMIT_ANY out
   next-hop-self
  !
 !
!
```

BGP – Community – IOS-XR

```
RP/0/0/CPU0:R1#show bgp ipv4 unicast 192.0.2.13/32
Mon Apr 18 17:54:48.473 UTC
BGP routing table entry for 192.0.2.13/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                84          84
Last Modified: Apr 18 17:52:15.558 for 00:02:32
Paths: (1 available, best #1)
  Advertised IPv4 Unicast paths to peers (in unique update groups):
    10.255.255.2
  Path #1: Received by speaker 0
  Advertised IPv4 Unicast paths to peers (in unique update groups):
    10.255.255.2
  65003
    10.1.3.3 from 10.1.3.3 (10.255.255.3)
      Origin incomplete, metric 0, localpref 100, valid, external, best, group-best
      Received Path ID 0, Local Path ID 1, version 84
      Community: 64500:65003
      Origin-AS validity: (disabled)
RP/0/0/CPU0:R1#show bgp ipv4 unicast 192.0.2.14/32
Mon Apr 18 17:54:56.573 UTC
BGP routing table entry for 192.0.2.14/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker               103         103
Last Modified: Apr 18 17:52:33.558 for 00:02:23
Paths: (1 available, best #1)
  Advertised IPv4 Unicast paths to peers (in unique update groups):
    10.1.3.3
  Path #1: Received by speaker 0
  Advertised IPv4 Unicast paths to peers (in unique update groups):
    10.1.3.3
  65004
    10.255.255.2 (metric 1) from 10.255.255.2 (10.255.255.2)
      Origin incomplete, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 0, Local Path ID 1, version 103
      Community: 64500:65004
```

Before:

```
RP/0/0/CPU0:R1#show bgp ipv4 unicast neighbors 198.51.10.0
advertised-routes
Mon Apr 18 17:56:38.636 UTC
Network            Next Hop        From            AS Path
192.0.2.0/23       198.51.10.1     Local Aggregate 64500i
192.0.2.0/24       198.51.10.1     Local Aggregate 64500i
192.0.3.0/24       198.51.10.1     Local Aggregate 64500i

Processed 3 prefixes, 3 paths
```

After:

```
RP/0/0/CPU0:R1#show bgp ipv4 unicast neighbors 10.1.3.3
advertised-routes
Mon Apr 18 17:59:51.092 UTC
Network            Next Hop        From            AS Path
0.0.0.0/0          0.0.0.0         Local           i
192.0.2.4/32       10.1.3.1        10.255.255.2    64500 65004?
192.0.2.14/32      10.1.3.1        10.255.255.2    64500 65004?
192.0.2.24/32      10.1.3.1        10.255.255.2    64500 65004?
192.0.3.128/25     10.1.3.1        10.255.255.2    64500 65004i

Processed 5 prefixes, 5 paths
```

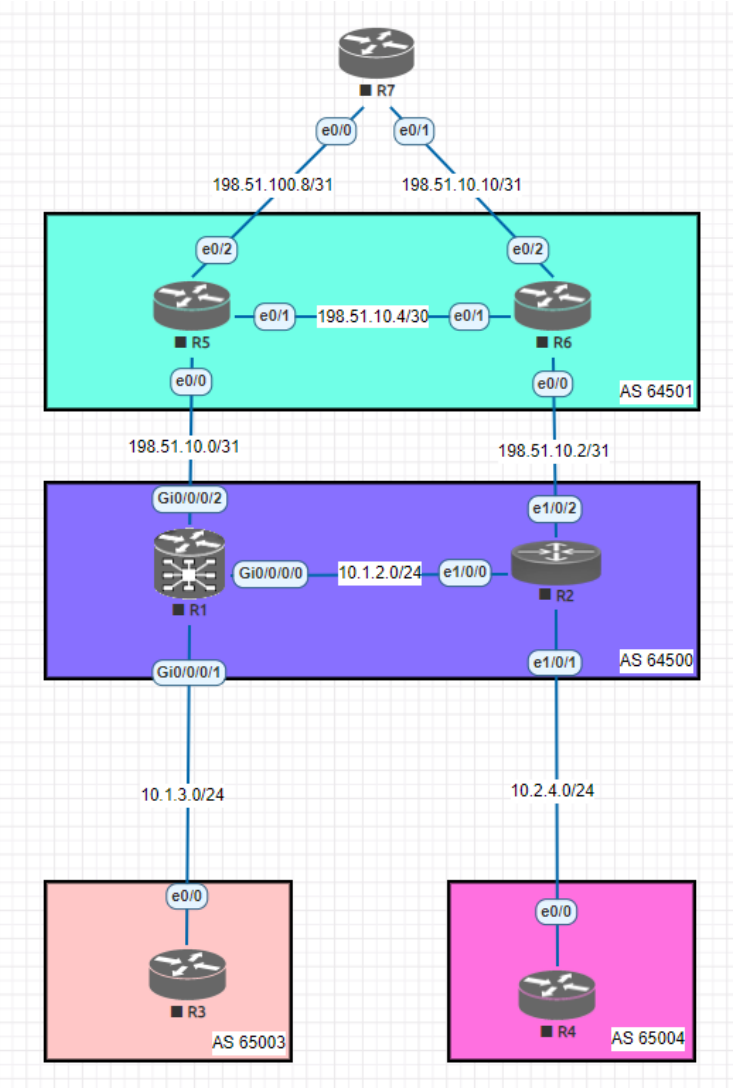
BGP – Community – IOS/IOS-XE

```
ip bgp-community new-format
!
ip prefix-list PL_RDSTB_CONNECTED seq 10 permit 192.0.2.0/23 ge 32
!
route-map RM_BLACKHOLE permit 10
 set community 64501:666
!
route-map RM_BGP_RDSTB_CONNECTED permit 10
 match ip address prefix-list PL_RDSTB_CONNECTED
!
router bgp 65003
 bgp router-id 10.255.255.3
 neighbor 10.1.3.1 remote-as 64500
 neighbor 10.1.3.1 update-source Ethernet0/0
 !
 address-family ipv4
  network 192.0.2.3 mask 255.255.255.255 route-map RM_BLACKHOLE
  network 192.0.3.0 mask 255.255.255.128
  redistribute connected route-map RM_BGP_RDSTB_CONNECTED
  neighbor 10.1.3.1 activate
  neighbor 10.1.3.1 send-community
 exit-address-family
!
```

```
R3#show bgp ipv4 unicast 192.0.2.3/32
BGP routing table entry for 192.0.2.3/32, version 67
Paths: (1 available, best #1, table default)
  Advertised to update-groups:
     3
  Refresh Epoch 1
  Local
    0.0.0.0 from 0.0.0.0 (10.255.255.3)
      Origin IGP, metric 0, localpref 100, weight 32768, valid, sourced,
local, best
      Community: 64501:666
      rx pathid: 0, tx pathid: 0x0
```

BGP – MED

- MED – Multi Exit Discriminator
- Применяется при необходимости разбалансировать трафик между несколькими стыками с **одной** AS
- За пределы соседней AS не передаются
- Достаточно слабый атрибут
- Чем меньше значение, тем лучше
- По умолчанию не проставляется (при сравнение считается равным нулю)



BGP – MED

R1:

```
route-policy RP_AGGREGATED
  set origin igp
  set med 0
end-policy
!
route-policy RP_BGP_UPLINK_OUT
  if destination in (192.0.2.0/24) or destination in (192.0.2.0/23) then
    pass
  elseif destination in (192.0.3.0/24) then
    prepend as-path own-as 3
  else
    drop
  endif
end-policy
!
router bgp 64500
 address-family ipv4 unicast
  aggregate-address 192.0.2.0/23 route-policy RP_AGGREGATED
  aggregate-address 192.0.2.0/24 route-policy RP_AGGREGATED
  aggregate-address 192.0.3.0/24 route-policy RP_AGGREGATED
 !
 neighbor 198.51.10.0
  address-family ipv4 unicast
   route-policy RP_BGP_UPLINK_OUT out
  !
```

R2:

```
ip ip-prefix PL_NO_PREPEND_OUT index 10 permit 192.0.3.0 24
ip ip-prefix PL_NO_PREPEND_OUT index 20 permit 192.0.2.0 23
ip ip-prefix PL_PREPEND_OUT index 10 permit 192.0.2.0 24
#
route-policy RP_AGGREGATED permit node 10
 apply cost 0
 apply origin igp
#
route-policy RP_BGP_UPLINK_OUT permit node 10
 if-match ip-prefix PL_NO_PREPEND_OUT
#
route-policy RP_BGP_UPLINK_OUT permit node 20
 if-match ip-prefix PL_PREPEND_OUT
 apply as-path 64500 64500 64500 additive
#
```

R5 & R6:

```
ip as-path access-list 1 permit ^64500$
!
ip prefix-list PL_WIDE_NETS seq 10 permit 0.0.0.0/0 le 24
!
route-map RM_BGP_64500_IN permit 10
 match ip address prefix-list PL_WIDE_NETS
 match as-path 1
!
router bgp 64501
 address-family ipv4
  neighbor 198.51.10.1 route-map RM_BGP_64500_IN in
!
```

BGP – MED

R1:

```
RP/0/0/CPU0:R1#show  bgp  ipv4  unicast  neighbors  198.51.10.0  advertised-routes
Fri Apr 22 17:43:44.841 UTC
Network            Next Hop        From            AS Path
192.0.2.0/23       198.51.10.1     Local Aggregate 64500i
192.0.2.0/24       198.51.10.1     Local Aggregate 64500i
192.0.3.0/24       198.51.10.1     Local Aggregate 64500 64500 64500 64500i

Processed 3 prefixes, 3 paths
```

R2:

```
<R2>dis bgp routing-table peer 198.51.10.2 advertised-routes

 Total Number of Routes: 3
    Network        NextHop  MED  LocPrf  PrefVal  Path/Ogn

*>  192.0.2.0/23   0.0.0.0   0            0       64500i
*>  192.0.2.0/24   0.0.0.0   0            0       64500 64500 64500 64500i
*>  192.0.3.0/24   0.0.0.0   0            0       64500i
```

R5:

```
R5#show bgp ipv4 uni neighbors 198.51.10.1 routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        198.51.10.1              0             0 64500 i
 *>   192.0.2.0/23     198.51.10.1              0             0 64500 i

Total number of prefixes 2
```

R6:

```
R6#show bgp ipv4 unicast neighbors 198.51.10.3 routes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0/23     198.51.10.3              0             0 64500 i
 *>   192.0.3.0        198.51.10.3              0             0 64500 i

Total number of prefixes 2
```

BGP – MED – IOS-XR and Huawei VRP

R1:

```
route-policy RP_BGP_UPLINK_MED_OUT
  if destination in (192.0.2.0/24) or destination in
(192.0.2.0/23) then
    pass
  elseif destination in (192.0.3.0/24) then
    set med 200
  else
    drop
  endif
end-policy
!
router bgp 64500
 neighbor 198.51.10.0
  address-family ipv4 unicast
   route-policy RP_BGP_UPLINK_MED_OUT out
  !
```

R2:

```
route-policy RP_BGP_UPLINK_MED_OUT permit node 10
 if-match ip-prefix PL_NO_PREPEND_OUT
#
route-policy RP_BGP_UPLINK_MED_OUT permit node 20
 if-match ip-prefix PL_PREPEND_OUT
 apply cost 200
#
```

R5:

```
R5#show bgp ipv4 unicast 192.0.2.0/23 longer-prefixes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        198.51.10.1              0             0 64500 i
 * i  192.0.2.0/23     198.51.10.6              0    100      0 64500 i
 *>                    198.51.10.1              0             0 64500 i
 *    192.0.3.0        198.51.10.1            200             0 64500 i
 *>i                   198.51.10.6              0    100      0 64500 I
```

R6:

```
R6#show bgp ipv4 unicast 192.0.2.0/23 longer-prefixes | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *    192.0.2.0        198.51.10.3            200             0 64500 i
 *>i                   198.51.10.5              0    100      0 64500 i
 * i  192.0.2.0/23     198.51.10.5              0    100      0 64500 i
 *>                    198.51.10.3              0             0 64500 i
 *>   192.0.3.0        198.51.10.3              0             0 64500 i
```

BGP – MED – IOS/IOS-XE

R5:

```
ip prefix-list PL_TO_OUTER_AS seq 10 permit 0.0.0.0/0 le 24
!
route-map RM_BGP_TO_OUTER_AS permit 10
 match ip address prefix-list PL_TO_OUTER_AS
!
router bgp 64501
 address-family ipv4 unicast
  neighbor 198.51.10.9 route-map RM_BGP_TO_OUTER_AS out
```

R6:

```
ip prefix-list PL_TO_OUTER_AS seq 10 permit 0.0.0.0/0 le 24
!
route-map RM_BGP_TO_OUTER_AS permit 10
 match ip address prefix-list PL_TO_OUTER_AS
!
router bgp 64501
 address-family ipv4 unicast
  neighbor 198.51.10.11 route-map RM_BGP_TO_OUTER_AS out
```

R2:

```
R7#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   7.7.7.7/32       0.0.0.0                  0         32768 i
 *    192.0.2.0        198.51.10.8                            0 64501 64500 i
 *>                    198.51.10.10                           0 64501 64500 i
 *    192.0.2.0/23     198.51.10.8                            0 64501 64500 i
 *>                    198.51.10.10                           0 64501 64500 i
 *    192.0.3.0        198.51.10.8                            0 64501 64500 i
 *>                    198.51.10.10                           0 64501 64500 i
 *    198.51.10.0      198.51.10.8              0             0 64501 i
 *>                    198.51.10.10             0             0 64501 i
```

BGP – MED – IOS/IOS-XE

R5:

```
ip prefix-list PL_TO_OUTER_AS_NO_MED seq 10 permit 198.51.10.0/24
!
ip prefix-list PL_TO_OUTER_AS_SET_MED seq 10 permit 0.0.0.0/0 le 24
!
route-map RM_BGP_TO_OUTER_AS_SET_MED permit 10
 match ip address prefix-list PL_TO_OUTER_AS_NO_MED
!
route-map RM_BGP_TO_OUTER_AS_SET_MED permit 20
 match ip address prefix-list PL_TO_OUTER_AS_SET_MED
 set metric 200
!
router bgp 64501
 address-family ipv4 unicast
  neighbor 198.51.10.9 route-map RM_BGP_TO_OUTER_AS_SET_MED out
```

R6:

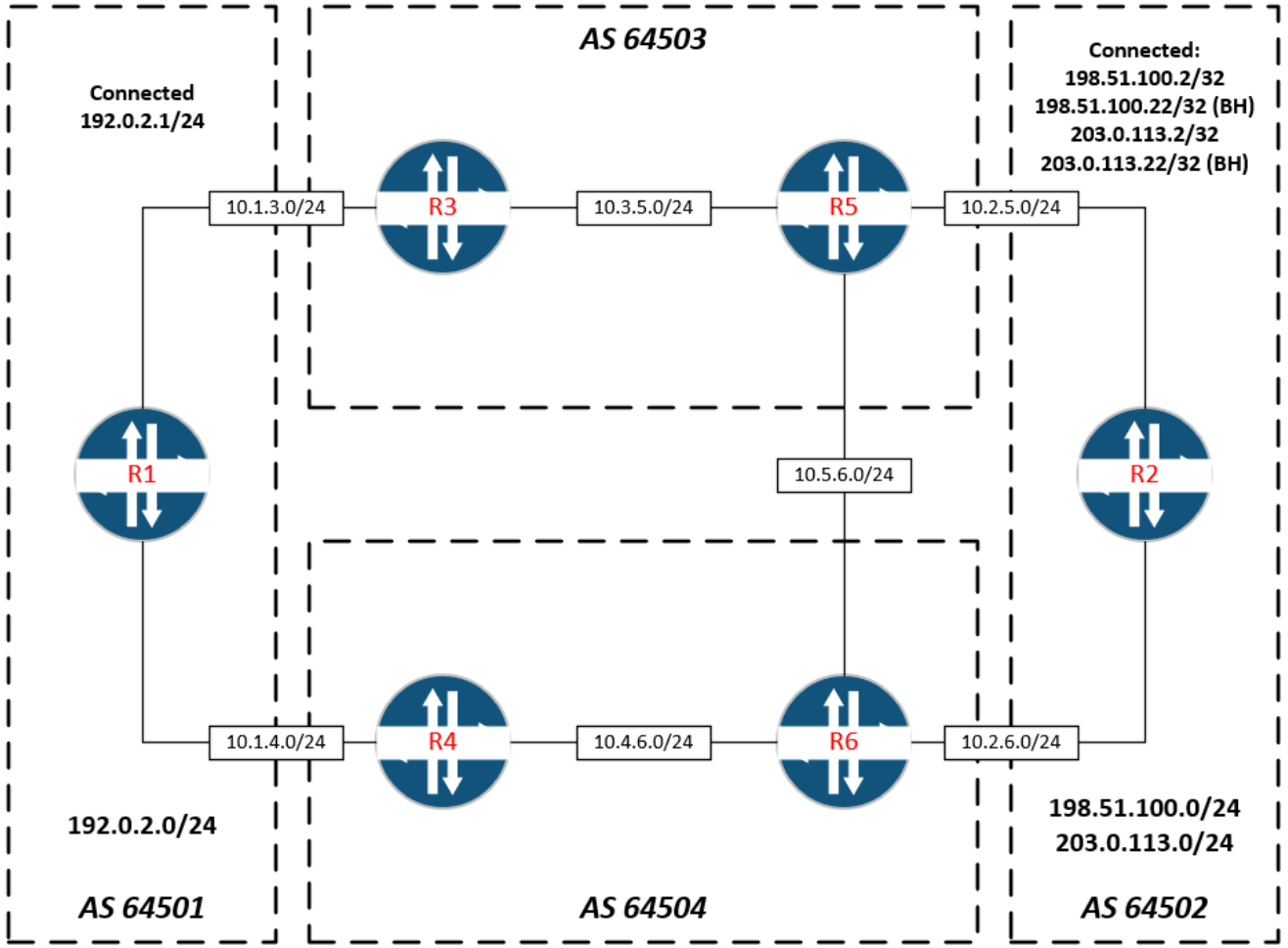
```
ip prefix-list PL_TO_OUTER_AS_SET_MED seq 10 permit 198.51.10.0/24
!
ip prefix-list PL_TO_OUTER_AS_NO_MED seq 10 permit 0.0.0.0/0 le 24
!
route-map RM_BGP_TO_OUTER_AS_SET_MED permit 10
 match ip address prefix-list PL_TO_OUTER_AS_SET_MED
 set metric 200
!
route-map RM_BGP_TO_OUTER_AS_SET_MED permit 20
 match ip address prefix-list PL_TO_OUTER_AS_NO_MED
!
router bgp 64501
 address-family ipv4 unicast
  neighbor 198.51.10.11 route-map RM_BGP_TO_OUTER_AS_SET_MED out
```

```
R7#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   7.7.7.7/32       0.0.0.0                  0         32768 i
 *    192.0.2.0        198.51.10.8            200             0 64501 64500 i
 *>                    198.51.10.10                           0 64501 64500 i
 *    192.0.2.0/23     198.51.10.8            200             0 64501 64500 i
 *>                    198.51.10.10                           0 64501 64500 i
 *    192.0.3.0        198.51.10.8            200             0 64501 64500 i
 *>                    198.51.10.10                           0 64501 64500 i
 *>   198.51.10.0      198.51.10.8              0             0 64501 i
 *                     198.51.10.10           200             0 64501 i
```

BGP – Next-hop

Как и большую часть других атрибутов, можно изменить, согласно каких-то своих политик: например, чтобы оптимизировать загрузку каналов.

Одним из вариантов использования является т.н. blackholing – умышленный сброс трафика, идущего на какой-то конкретный IP-адрес, который подвергается DoS-атаке.



BGP – Next-hop

R1:

```
router bgp 64501
 bgp router-id 192.0.2.1
 neighbor 10.1.3.3 remote-as 64503
 neighbor 10.1.3.3 update-source Ethernet0/0
 neighbor 10.1.4.4 remote-as 64504
 neighbor 10.1.4.4 update-source Ethernet0/1
 !
 address-family ipv4
  network 192.0.2.0
  neighbor 10.1.3.3 activate
  neighbor 10.1.3.3 filter-list 1 out
  neighbor 10.1.4.4 activate
  neighbor 10.1.4.4 filter-list 1 out
 exit-address-family
!
ip as-path access-list 1 permit ^$
```

```
R1#show bgp ipv4 unicast | b Network
     Network          Next Hop    Metric LocPrf Weight Path
 *>   192.0.2.0       0.0.0.0          0         32768 i
 *    198.51.100.0    10.1.4.4                       0 64504 64502 i
 *>                   10.1.3.3                       0 64503 64502 i
 *    203.0.113.0     10.1.4.4                       0 64504 64502 i
 *>                   10.1.3.3                       0 64503 64502 i

R1#ping 198.51.100.2 source 192.0.2.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 198.51.100.2, timeout is 2 seconds:
Packet sent with a source address of 192.0.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/4 ms
R1#ping 198.51.100.22 source 192.0.2.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 198.51.100.22, timeout is 2 seconds:
Packet sent with a source address of 192.0.2.1
U.U.U
Success rate is 0 percent (0/5)
```

BGP – Next-hop

R2:

```
router bgp 64502
 bgp router-id 198.51.100.2
 neighbor 10.2.5.5 remote-as 64503
 neighbor 10.2.5.5 update-source Ethernet0/0
 neighbor 10.2.6.6 remote-as 64504
 neighbor 10.2.6.6 update-source Ethernet0/1
 !
 address-family ipv4
  network 198.51.100.2 mask 255.255.255.255
  network 198.51.100.22 mask 255.255.255.255 route-map RM_SET_LOCAL_BH_COMMUNITY
  network 203.0.113.2 mask 255.255.255.255
  network 203.0.113.22 mask 255.255.255.255 route-map RM_SET_LOCAL_BH_COMMUNITY
  aggregate-address 203.0.113.0 255.255.255.0 summary-only
  aggregate-address 198.51.100.0 255.255.255.0 summary-only
  neighbor 10.2.5.5 activate
  neighbor 10.2.5.5 send-community
  neighbor 10.2.5.5 route-map RM_EBGP_AS64503_OUT out
  neighbor 10.2.5.5 unsuppress-map RM_UNSUPPRESS
  neighbor 10.2.5.5 filter-list 1 out
  neighbor 10.2.6.6 activate
  neighbor 10.2.6.6 send-community
  neighbor 10.2.6.6 route-map RM_EBGP_AS64504_OUT out
  neighbor 10.2.6.6 unsuppress-map RM_UNSUPPRESS
  neighbor 10.2.6.6 filter-list 1 out
 exit-address-family
!
ip bgp-community new-format
ip community-list standard CL_LOCAL_BLACKHOLE permit 64502:666
ip as-path access-list 1 permit ^$
ip prefix-list PL_AGGREGATE seq 10 permit 198.51.100.0/24
ip prefix-list PL_AGGREGATE seq 20 permit 203.0.113.0/24
!
route-map RM_EBGP_AS64503_OUT permit 10
 match community CL_LOCAL_BLACKHOLE
 set community 64503:666 additive
route-map RM_EBGP_AS64503_OUT permit 20
 match ip address prefix-list PL_AGGREGATE
!
route-map RM_EBGP_AS64504_OUT permit 10
 match community CL_LOCAL_BLACKHOLE
 set community 64504:666
route-map RM_EBGP_AS64504_OUT permit 20
 match ip address prefix-list PL_AGGREGATE
!
route-map RM_SET_LOCAL_BH_COMMUNITY permit 10
 set community 64502:666
!
route-map RM_UNSUPPRESS permit 10
 match community CL_LOCAL_BLACKHOLE

R2#show bgp ipv4 unicast neighbor 10.2.5.5 advertised-routes | b
Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   198.51.100.0     0.0.0.0                              32768 i
 s>   198.51.100.22/32 0.0.0.0                  0         32768 i
 *>   203.0.113.0      0.0.0.0                              32768 i
 s>   203.0.113.22/32  0.0.0.0                  0         32768 i
```

BGP – Next-hop – IOS/IOS-XE

R3:

```
router bgp 64503
 bgp router-id 10.255.255.3
 neighbor 10.1.3.1 remote-as 64501
 neighbor 10.1.3.1 update-source Ethernet0/0
 neighbor 10.255.255.5 remote-as 64503
 neighbor 10.255.255.5 update-source Loopback0
 !
 address-family ipv4
  neighbor 10.1.3.1 activate
  neighbor 10.1.3.1 route-map RM_EBGP_IN in
  neighbor 10.255.255.5 activate
  neighbor 10.255.255.5 route-map RM_IBGP_OUT out
 exit-address-family
!
ip route 172.16.0.1 255.255.255.255 Null0
!
ip prefix-list PL_PERMIT_ANY seq 10 permit 0.0.0.0/0 le 32
!
route-map RM_EBGP_IN permit 10
 match community CL_BLACKHOLE
 set community no-export additive
 set ip next-hop 172.16.0.1
!
route-map RM_EBGP_IN permit 20
 match ip address prefix-list PL_PERMIT_ANY
!
route-map RM_IBGP_OUT permit 10
 match community CL_BLACKHOLE
 set ip next-hop 172.16.0.1
!
route-map RM_IBGP_OUT permit 20
 match ip address prefix-list PL_PERMIT_ANY
 set ip next-hop peer-address
!
```

```
R3#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0         10.1.3.1                 0             0 64501 i
 *>i  198.51.100.0     10.255.255.5             0    100      0 64502 i
 *>i  198.51.100.22/32 172.16.0.1               0    100      0 64502 i
 *>i  203.0.113.0      10.255.255.5             0    100      0 64502 i
 *>i  203.0.113.22/32  172.16.0.1               0    100      0 64502 i

R3#show ip cef 198.51.100.2
198.51.100.0/24
  nexthop 10.3.5.5 Ethernet0/1
R3#show ip cef 198.51.100.22
198.51.100.22/32
  nexthop 172.16.0.1 Null0
```

BGP – Next-hop – Huawei VRP

R5:

```
bgp 64503
 router-id 10.255.255.2
 peer 10.2.5.2 as-number 64502
 peer 10.2.5.2 connect-interface GE1/0/1
 peer 10.5.6.6 as-number 64504
 peer 10.5.6.6 connect-interface GE1/0/2
 peer 10.255.255.3 as-number 64503
 peer 10.255.255.3 connect-interface LoopBack0
 #
 ipv4-family unicast
  peer 10.2.5.2 enable
  peer 10.2.5.2 route-policy RP_EBGP_IN import
  peer 10.2.5.2 default-route-advertise
  peer 10.5.6.6 enable
  peer 10.5.6.6 route-policy RP_EBGP_IN import
  peer 10.255.255.3 enable
  peer 10.255.255.3 route-policy RP_IBGP_OUT export
  peer 10.255.255.3 advertise-community
#
route-policy RP_EBGP_IN permit node 10
 if-match community-filter CF_BLACKHOLE
 apply ip-address next-hop 172.16.0.1
 apply community no-export additive
#
route-policy RP_EBGP_IN permit node 20
 if-match ip-prefix PL_PERMIT_ANY
route-policy RP_IBGP_OUT permit node 10
 if-match community-filter CF_BLACKHOLE
 apply ip-address next-hop 172.16.0.1
#
route-policy RP_IBGP_OUT permit node 20
 if-match ip-prefix PL_PERMIT_ANY
 apply ip-address next-hop peer-address
#
ip ip-prefix PL_PERMIT_ANY index 10 permit 0.0.0.0 0 less-equal 32
ip community-filter basic CF_BLACKHOLE index 10 permit 64503:666
ip community-filter basic CF_BLACKHOLE index 20 permit 64502:666
ip community-filter basic CF_BLACKHOLE index 30 permit 64501:666
ip community-filter basic CF_BLACKHOLE index 40 permit 64504:666
#
ip route-static 172.16.0.1 255.255.255.255 NULL0 description BlackHole

<R5>dis bgp routing-table
 Total Number of Routes: 5
         Network              NextHop         MED    LocPrf    PrefVal Path/Ogn
 *>i     192.0.2.0/24         10.255.255.3     0      100         0      64501i
 *>      198.51.100.0/24      10.2.5.2         0                  0      64502i
 *>      198.51.100.22/32     172.16.0.1       0                  0      64502i
 *>      203.0.113.0/24       10.2.5.2         0                  0      64502i
 *>      203.0.113.22/32      172.16.0.1       0                  0      64502i

<R5>dis ip routing-table 198.51.100.0 24 longer-match
Destination/Mask    Proto   Pre  Cost        Flags NextHop         Interface
   198.51.100.0/24  EBGP    255  0             RD  10.2.5.2        GE1/0/1
  198.51.100.22/32  EBGP    255  0             RDB 172.16.0.1      NULL0
```

BGP – Next-hop – IOS-XR

R5:

```
community-set CS_BLACKHOLE
  *:666
end-set
!
route-policy RP_EBGP_IN
  if community matches-any CS_BLACKHOLE then
    set next-hop 172.16.0.1
    set community (no-export) additive
  else
    pass
  endif
end-policy
!
route-policy RP_IBGP_OUT
  if community matches-any CS_BLACKHOLE then
    set next-hop 172.16.0.1
  else
    set next-hop self
  endif
end-policy
!
route-policy RP_PERMIT_ANY
  pass
end-policy
!
```

```
router bgp 64504
 bgp router-id 10.255.255.6
 address-family ipv4 unicast
 !
 neighbor 10.2.6.2
  remote-as 64502
  update-source
GigabitEthernet0/0/0/1
  address-family ipv4 unicast
   route-policy RP_EBGP_IN in
   route-policy RP_PERMIT_ANY out
   default-originate
  !
 !
 neighbor 10.5.6.5
  remote-as 64503
  update-source
GigabitEthernet0/0/0/2
  address-family ipv4 unicast
   route-policy RP_EBGP_IN in
   route-policy RP_PERMIT_ANY out
  !
 !
 neighbor 10.255.255.4
  remote-as 64504
  update-source Loopback0
  address-family ipv4 unicast
   route-policy RP_PERMIT_ANY in
   route-policy RP_IBGP_OUT out
```

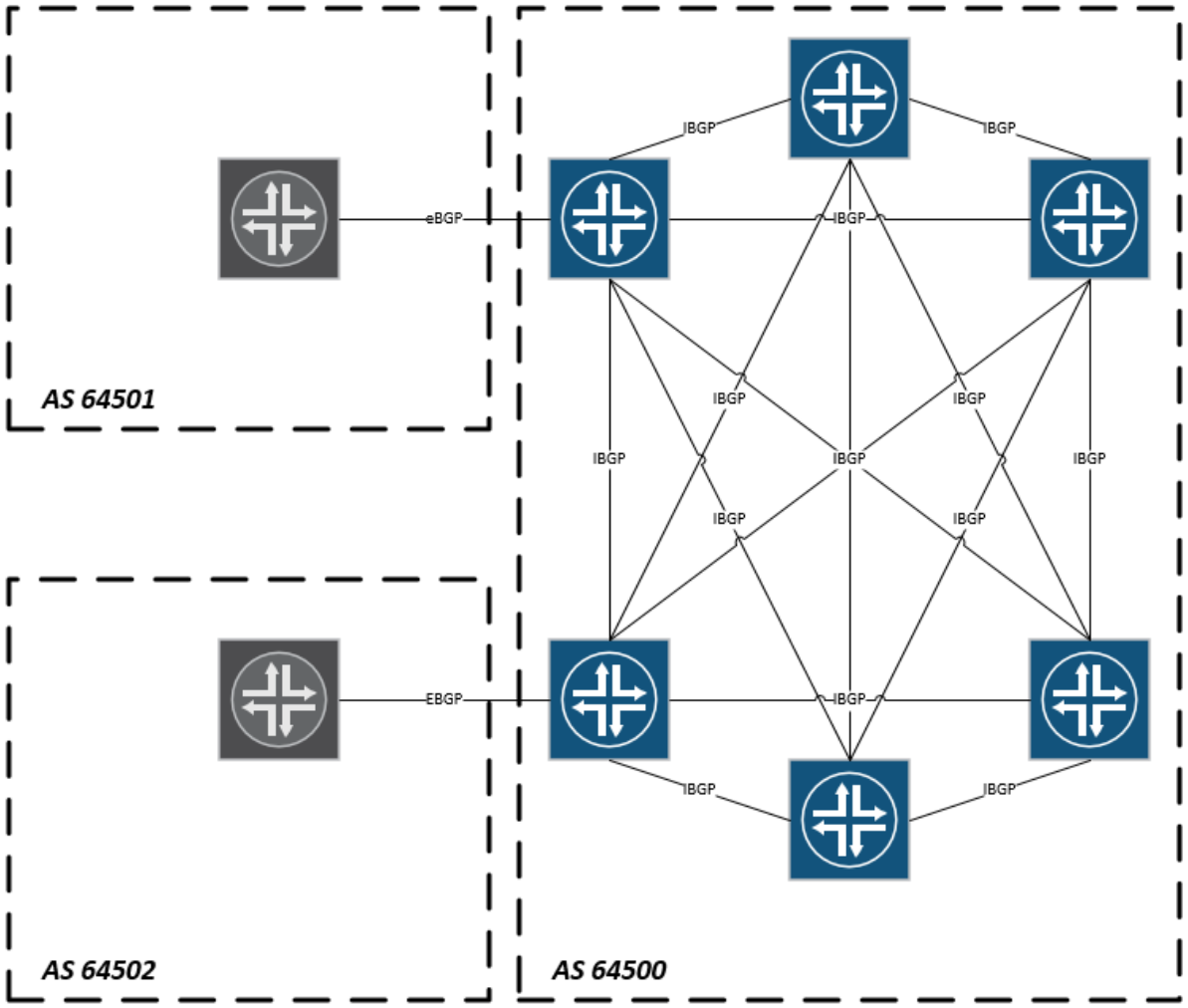
```
router static
 address-family ipv4 unicast
  172.16.0.1/32
!
RP/0/0/CPU0:R6# show bgp ipv4 unicast | b Network
Sun Apr 24 17:01:47.188 UTC
   Network            Next Hop      Metric LocPrf Weight Path
*>i192.0.2.0/24       10.255.255.4       0    100      0 64501 i
*> 198.51.100.0/24    10.2.6.2           0             0 64502 i
*> 198.51.100.22/32   172.16.0.1         0             0 64502 i
*> 203.0.113.0/24     10.2.6.2           0             0 64502 i
*> 203.0.113.22/32    172.16.0.1         0             0 64502 i

Processed 5 prefixes, 5 paths

RP/0/0/CPU0:R6#show cef 198.51.100.2 detail | b Interface
Sun Apr 24 17:02:29.775 UTC
    Hash  OK  Interface                 Address
    0     Y   GigabitEthernet0/0/0/1    10.2.6.2
RP/0/0/CPU0:R6#show cef 198.51.100.22 detail | b Interface
Sun Apr 24 17:02:33.584 UTC
    Hash  OK  Interface                 Address
    0     Y   Unknown                   null0
```

BGP – IBGP

Из-за работы split-horizon в IBGP, все BGP-устройства в одной AS должны иметь полносвязные соседства (т.е. full mesh). Количество связей в этом случае равно (N * (N – 1)) / 2.

Чтобы обойти это ограничение могут использоваться несколько способов:

- Конфедерации – RFC 5065
- Отражатель маршрутов – RFC 4456



BGP – IBGP - Confederation

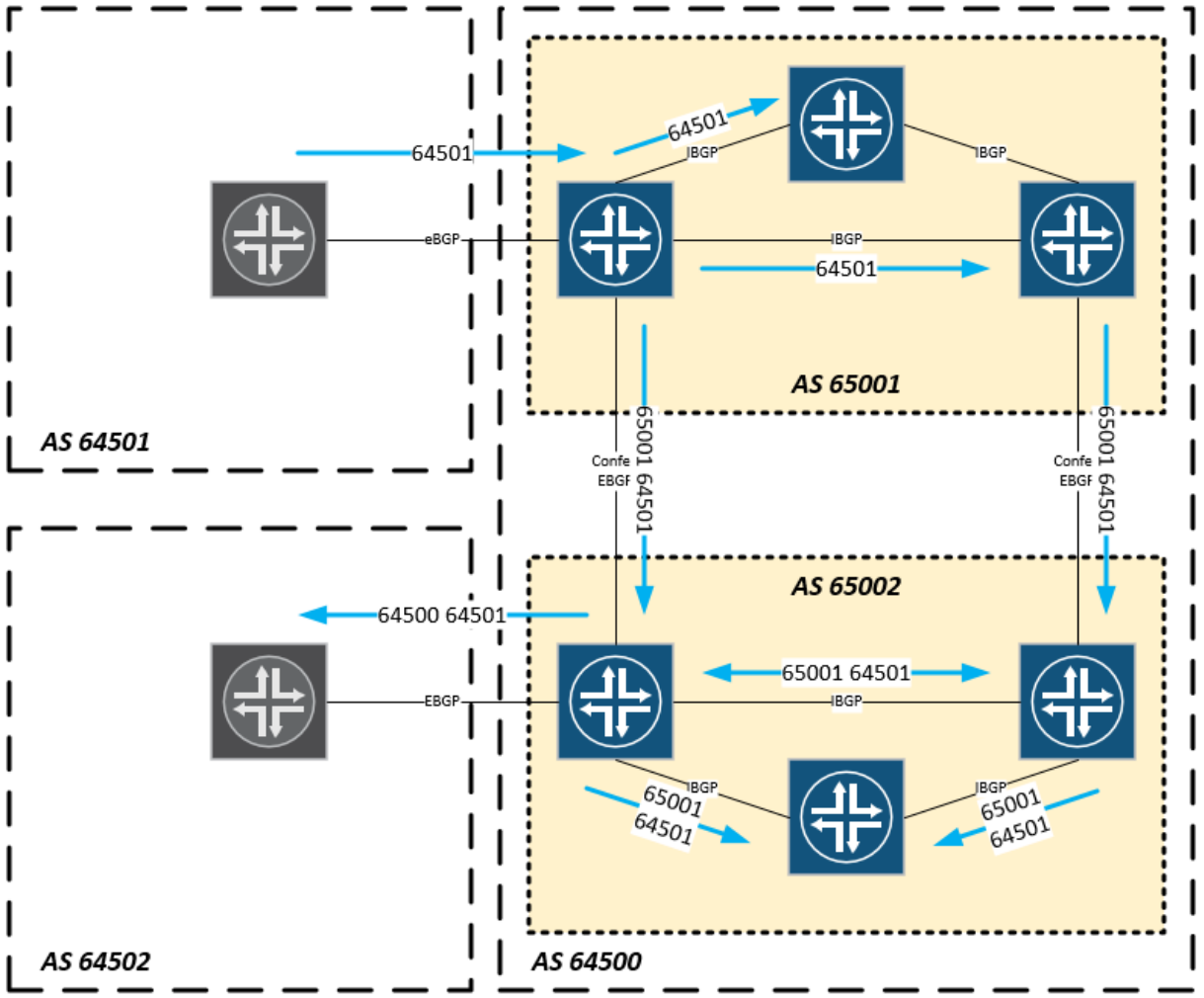
- Идея проста: единая автономная система дробится на группу отдельных AS. Внутри этих отдельных sub-AS сохраняется логика работы IBGP, а между ними – используется стандартный EBGP.
- Конфедерация – это совокупность автономных систем, передающих наружу информацию как единая отдельная AS
- AS Confederation Identifier – номер AS, видимый снаружи и идентифицирующий конфедерацию как единое целое
- Member Autonomous System (Member-AS) – AS, входящая в конфедерацию
- Member-AS Number – номер AS, идентифицирующий AS как видимый только внутри конфедерации

BGP – IBGP - Confederation

RFC 5065 добавляет два дополнительных типа в атрибут AS_PATH:

- AS_CONFED_SEQUENCE – упорядоченный набор Member-AS в локальной конфедерации, через которые прошел передаваемый маршрут
- AS_CONFED_SET – неупорядоченный набор Member-AS в локальной конфедерации, через которые прошел передаваемый маршрут

При передаче маршрутов BGP-соседу не входящему в конфедерацию из AS_PATH убираются указанные выше составляющие AS_PATH, касающиеся конфедерации, и заменяются на номер AS, указанный в AS Confederation Identifier



BGP – Confederation

R1:

```
router bgp 64501
 bgp router-id 198.51.100.1
 bgp log-neighbor-changes
 neighbor 192.0.2.0 remote-as 64500
 neighbor 192.0.2.0 update-source Ethernet0/0
 !
 address-family ipv4
  network 198.51.100.0
  neighbor 192.0.2.0 activate
 exit-address-family
!
```

R2:

```
router bgp 64502
 bgp router-id 203.0.113.2
 bgp log-neighbor-changes
 neighbor 192.0.2.2 remote-as 64500
 neighbor 192.0.2.2 update-source Ethernet0/0
 !
 address-family ipv4
  network 203.0.113.0
  neighbor 192.0.2.2 activate
 exit-address-family
```

R1:

```
AS64501-R1#show bgp ipv4 unicast summary | b Neighbor
Neighbor            V                AS  MsgRcvd  MsgSent     TblVer   InQ  OutQ  Up/Down
State/PfxRcd
192.0.2.0       4        64500      24      26        4    0    0 00:20:36        2

AS64501-R1#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        192.0.2.0                              0 64500 i
 *>   198.51.100.0     0.0.0.0                  0         32768 i
 *>   203.0.113.0      192.0.2.0                              0 64500 64502 i
```

R2:

```
AS64502-R2#show bgp ipv4 unicast summary | b Neighbor
Neighbor            V                AS  MsgRcvd  MsgSent     TblVer   InQ  OutQ  Up/Down
State/PfxRcd
192.0.2.2       4        64500      32      31        4    0    0 00:24:53        2

AS64502-R2#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        192.0.2.2                              0 64500 i
 *>   198.51.100.0     192.0.2.2                              0 64500 64501 i
 *>   203.0.113.0      0.0.0.0                  0         32768 i
```

BGP – Confederation

R3:

```
route-policy RP_PERMIT_ANY
  pass
end-policy
!
route-policy RP_BGP_OUTSIDE
  if destination in (0.0.0.0/0 le 24) then
    pass
  else
    drop
  endif
end-policy
!
router bgp 65001
 bgp confederation peers
  65002
 !
 bgp confederation identifier 64500
 address-family ipv4 unicast
  network 192.0.2.0/31
  network 192.0.2.103/32
  aggregate-address 192.0.2.0/24
!
neighbor-group 65001
 remote-as 65001
 update-source Loopback0
 address-family ipv4 unicast
  route-policy RP_PERMIT_ANY in
  route-policy RP_PERMIT_ANY out
 !
!
neighbor 192.0.2.1
 remote-as 64501
 update-source GigabitEthernet0/0/0/0
 address-family ipv4 unicast
  route-policy RP_PERMIT_ANY in
  route-policy RP_BGP_OUTSIDE out
 !
!
neighbor 10.255.255.4
 use neighbor-group 65001
!
neighbor 10.255.255.5
 use neighbor-group 65001
!
neighbor 10.255.255.6
 remote-as 65002
 ebgp-multihop 255
 update-source Loopback0
 address-family ipv4 unicast
  route-policy RP_PERMIT_ANY in
  route-policy RP_PERMIT_ANY out
 !
!
!
```

BGP – Confederation

R3:

```
RP/0/0/CPU0:R3#show bgp ipv4 unicast summary | b Neighbor
Sat Apr 30 07:06:23.784 UTC
Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down  St/PfxRcd
10.255.255.4      0 65001      31      33       22    0    0 00:24:10           1
10.255.255.5      0 65001      31      33       22    0    0 00:24:07           1
10.255.255.6      0 65002      33      22       22    0    0 00:14:27           6
192.0.2.1         0 64501      30      28       22    0    0 00:24:22           1

RP/0/0/CPU0:R3#show bgp ipv4 unicast | b Network
Sat Apr 30 07:06:34.574 UTC
   Network          Next Hop            Metric LocPrf Weight Path
*> 192.0.2.0/24     0.0.0.0                            32768 i
*                   10.255.255.6                 100      0 (65002) i
*> 192.0.2.0/31     0.0.0.0                  0         32768 i
*> 192.0.2.2/31     10.255.255.6             0    100      0 (65002) i
*> 192.0.2.103/32   0.0.0.0                  0         32768 i
*>i192.0.2.104/32   10.255.255.4             0    100      0 i
*>i192.0.2.105/32   10.255.255.5             0    100      0 i
*> 192.0.2.106/32   10.255.255.6             0    100      0 (65002) i
*> 192.0.2.107/32   10.255.255.7             0    100      0 (65002) i
*> 192.0.2.108/32   10.255.255.8             0    100      0 (65002) i
*> 198.51.100.0/24  192.0.2.1                0             0 64501 i
*> 203.0.113.0/24   192.0.2.3                0    100      0 (65002) 64502 i

Processed 11 prefixes, 12 paths
```

```
> Internet Protocol Version 4, Src: 10.255.255.5, Dst: 10.255.255.8
> Transmission Control Protocol, Src Port: 22149, Dst Port: 179, Seq: 96, Ack: 77, Len: 630
> Border Gateway Protocol - UPDATE Message
> Border Gateway Protocol - UPDATE Message
> Border Gateway Protocol - UPDATE Message
> Border Gateway Protocol - UPDATE Message
v Border Gateway Protocol - UPDATE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 67
    Type: UPDATE Message (2)
    Withdrawn Routes Length: 0
    Total Path Attribute Length: 40
  v Path attributes
    > Path Attribute - ORIGIN: IGP
    v Path Attribute - AS_PATH: (65001) 64501
      > Flags: 0x40, Transitive, Well-known, Complete
        Type Code: AS_PATH (2)
        Length: 12
      v AS Path segment: (65001)
          Segment type: AS_CONFED_SEQUENCE (3)
          Segment length (number of ASN): 1
          AS4: 65001
      v AS Path segment: 64501
          Segment type: AS_SEQUENCE (2)
          Segment length (number of ASN): 1
          AS4: 64501
    > Path Attribute - NEXT_HOP: 192.0.2.1
    > Path Attribute - MULTI_EXIT_DISC: 0
    > Path Attribute - LOCAL_PREF: 100
  v Network Layer Reachability Information (NLRI)
    > 198.51.100.0/24
> Border Gateway Protocol - UPDATE Message
```

BGP – Confederation

R4:

```
router bgp 65001
 bgp router-id 10.255.255.4
 bgp log-neighbor-changes
 bgp confederation identifier 64500
 bgp confederation peers 65002
 neighbor 65001 peer-group
 neighbor 65001 remote-as 65001
 neighbor 65001 update-source Loopback0
 neighbor 10.255.255.3 peer-group 65001
 neighbor 10.255.255.5 peer-group 65001
 !
 address-family ipv4
  network 192.0.2.104 mask 255.255.255.255
  neighbor 65001 send-community
  neighbor 65001 next-hop-self
  neighbor 10.255.255.3 activate
  neighbor 10.255.255.5 activate
 exit-address-family
!
```

R1:

```
R4#show bgp ipv4 unicast summary | b Neighbor
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
State/PfxRcd
10.255.255.3    4        65001      34      33       12    0    0 00:25:42        9
10.255.255.5    4        65001      36      36       12    0    0 00:29:35        1

R4#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0/31     10.255.255.3             0    100      0 i
 *>i  192.0.2.0        10.255.255.3                  100      0 i
 *>i  192.0.2.2/31     10.255.255.6             0    100      0 (65002) i
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>   192.0.2.104/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.105/32   10.255.255.5             0    100      0 i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 (65002) i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 (65002) i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 (65002) i
 *>i  198.51.100.0     192.0.2.1                0    100      0 64501 i
 *>i  203.0.113.0      192.0.2.3                0    100      0 (65002) 64502 i
```

BGP – Confederation

R5:

```
router bgp 65001
 bgp router-id 10.255.255.5
 bgp log-neighbor-changes
 bgp confederation identifier 64500
 bgp confederation peers 65002
 neighbor 65001 peer-group
 neighbor 65001 remote-as 65001
 neighbor 65001 update-source Loopback0
 neighbor 10.255.255.3 peer-group 65001
 neighbor 10.255.255.4 peer-group 65001
 neighbor 10.255.255.8 remote-as 65002
 neighbor 10.255.255.8 ebgp-multihop 255
 neighbor 10.255.255.8 update-source Loopback0
 !
 address-family ipv4
  network 192.0.2.105 mask 255.255.255.255
  neighbor 65001 send-community
  neighbor 65001 next-hop-self
  neighbor 10.255.255.3 activate
  neighbor 10.255.255.4 activate
  neighbor 10.255.255.8 activate
  neighbor 10.255.255.8 send-community
 exit-address-family
```

R5:

```
R5#show bgp ipv4 unicast summary | b Neighbor
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.255.255.3    4        65001      36      34       12    0    0 00:26:54        9
10.255.255.4    4        65001      37      38       12    0    0 00:30:50        1
10.255.255.8    4        65002      29      22       12    0    0 00:08:50        6
R5#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0/31     10.255.255.3             0    100      0 i
 *    192.0.2.0        10.255.255.6             0    100      0 (65002) i
 *>i                   10.255.255.3                  100      0 i
 *    192.0.2.2/31     10.255.255.6             0    100      0 (65002) i
 *>i                   10.255.255.6             0    100      0 (65002) i
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>i  192.0.2.104/32   10.255.255.4             0    100      0 i
 *>   192.0.2.105/32   0.0.0.0                  0         32768 i
 *    192.0.2.106/32   10.255.255.6             0    100      0 (65002) i
 *>i                   10.255.255.6             0    100      0 (65002) i
 *    192.0.2.107/32   10.255.255.7             0    100      0 (65002) i
 *>i                   10.255.255.7             0    100      0 (65002) i
 *    192.0.2.108/32   10.255.255.8             0    100      0 (65002) i
 *>i                   10.255.255.8             0    100      0 (65002) i
 *>i  198.51.100.0     192.0.2.1                0    100      0 64501 i
 *    203.0.113.0      10.255.255.6             0    100      0 (65002) 64502 i
 *>i                   192.0.2.3                0    100      0 (65002) 64502 i
```

BGP – Confederation

R6:

```
bgp 65002
 router-id 10.255.255.6
 confederation id 64500
 confederation peer-as 65001
 peer 10.255.255.3 as-number 65001
 peer 10.255.255.3 ebgp-max-hop 255
 peer 10.255.255.3 connect-interface LoopBack0
 peer 192.0.2.3 as-number 64502
 peer 192.0.2.3 connect-interface Ethernet1/0/0
 group 65002 internal
 peer 65002 connect-interface LoopBack0
 peer 10.255.255.7 as-number 65002
 peer 10.255.255.7 group 65002
 peer 10.255.255.8 as-number 65002
 peer 10.255.255.8 group 65002
 #
 ipv4-family unicast
  undo synchronization
  aggregate 192.0.2.0 255.255.255.0
  network 192.0.2.2 255.255.255.254
  network 192.0.2.106 255.255.255.255
  peer 10.255.255.3 enable
  peer 10.255.255.3 advertise-community
  peer 192.0.2.3 enable
  peer 192.0.2.3 ip-prefix PL_WIDE_NETS export
  peer 65002 enable
  peer 65002 next-hop-local
  peer 65002 advertise-community
  peer 10.255.255.7 enable
  peer 10.255.255.7 group 65002
  peer 10.255.255.8 enable
  peer 10.255.255.8 group 65002
```

R6:

```
<R6>dis bgp peer

  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State  PrefRcv
  10.255.255.3    4       65001       26       38     0 00:18:47 Established        6
  10.255.255.7    4       65002       39       47     0 00:31:32 Established        1
  10.255.255.8    4       65002       41       47     0 00:31:28 Established        6
  192.0.2.3       4       64502       39       40     0 00:31:39 Established        1

<R6>dis bgp routing-table

         Network            NextHop                MED        LocPrf    PrefVal Path/Ogn

 *>      192.0.2.0/24       127.0.0.1                                        0       i
 * i                        10.255.255.3                        100         0       (65001)i
 *>i     192.0.2.0/31       10.255.255.3             0          100         0       (65001)i
 * i                        10.255.255.8             0          100         0       (65001)i
 *>      192.0.2.2/31       0.0.0.0                  0                      0       i
 *>i     192.0.2.103/32     10.255.255.3             0          100         0       (65001)i
 * i                        10.255.255.8             0          100         0       (65001)i
 *>i     192.0.2.104/32     10.255.255.8             0          100         0       (65001)i
 * i                        10.255.255.4             0          100         0       (65001)i
 *>i     192.0.2.105/32     10.255.255.8             0          100         0       (65001)i
 * i                        10.255.255.5             0          100         0       (65001)i
 *>      192.0.2.106/32     0.0.0.0                  0                      0       i
 *>i     192.0.2.107/32     10.255.255.7             0          100         0       i
 *>i     192.0.2.108/32     10.255.255.8             0          100         0       i
 *>i     198.51.100.0/24    192.0.2.1                0          100         0       (65001) 64501i
 * i                        10.255.255.8             0          100         0       (65001) 64501i
 *>      203.0.113.0/24     192.0.2.3                0                      0       64502i
```

BGP – Confederation

R7:

```
router bgp 65002
 bgp router-id 10.255.255.7
 bgp log-neighbor-changes
 bgp confederation identifier 64500
 bgp confederation peers 65001
 neighbor 65002 peer-group
 neighbor 65002 remote-as 65002
 neighbor 65002 update-source Loopback0
 neighbor 10.255.255.6 peer-group 65002
 neighbor 10.255.255.8 peer-group 65002
 !
 address-family ipv4
  network 192.0.2.107 mask 255.255.255.255
  neighbor 65002 send-community
  neighbor 65002 next-hop-self
  neighbor 10.255.255.6 activate
  neighbor 10.255.255.8 activate
 exit-address-family
!
```

R7:

```
R7#show bgp ipv4 unicast summary | b Neighbor
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
State/PfxRcd
10.255.255.6    4        65002      49      41       18    0    0 00:33:28        7
10.255.255.8    4        65002      42      41       18    0    0 00:34:22        6
R7#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0/31     10.255.255.8             0    100      0 (65001) i
 * i                   10.255.255.3             0    100      0 (65001) i
 *>i  192.0.2.0        10.255.255.6                  100      0 i
 *>i  192.0.2.2/31     10.255.255.6             0    100      0 i
 *>i  192.0.2.103/32   10.255.255.8             0    100      0 (65001) i
 * i                   10.255.255.3             0    100      0 (65001) i
 *>i  192.0.2.104/32   10.255.255.8             0    100      0 (65001) i
 *>i  192.0.2.105/32   10.255.255.8             0    100      0 (65001) i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>   192.0.2.107/32   0.0.0.0                   0         32768 i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 i
 * i  198.51.100.0     10.255.255.8             0    100      0 (65001) 64501 i
 *>i                   192.0.2.1                0    100      0 (65001) 64501 i
 *>i  203.0.113.0      10.255.255.6             0    100      0 64502 i
```

BGP – Confederation

R8:

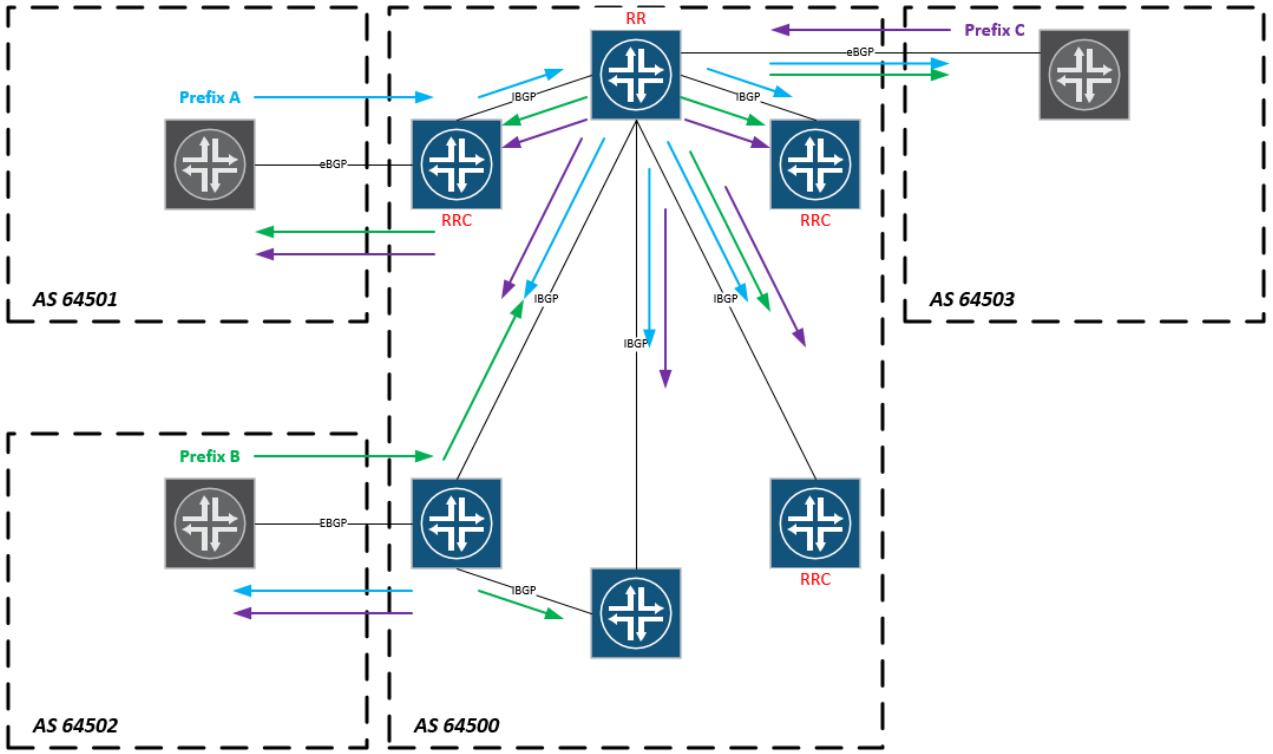
```
router bgp 65002
 bgp router-id 10.255.255.8
 bgp log-neighbor-changes
 bgp confederation identifier 64500
 bgp confederation peers 65001
 neighbor 65002 peer-group
 neighbor 65002 remote-as 65002
 neighbor 65002 update-source Loopback0
 neighbor 10.255.255.5 remote-as 65001
 neighbor 10.255.255.5 ebgp-multihop 255
 neighbor 10.255.255.5 update-source Loopback0
 neighbor 10.255.255.6 peer-group 65002
 neighbor 10.255.255.7 peer-group 65002
 !
 address-family ipv4
  network 192.0.2.108 mask 255.255.255.255
  neighbor 65002 send-community
  neighbor 65002 next-hop-self
  neighbor 10.255.255.5 activate
  neighbor 10.255.255.5 send-community
  neighbor 10.255.255.6 activate
  neighbor 10.255.255.7 activate
 exit-address-family
```

R8:

```
R8#show bgp ipv4 unicast summary | b Neighbor
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
State/PfxRcd
10.255.255.5    4        65001      27      34       17    0    0 00:13:10        6
10.255.255.6    4        65002      51      44       17    0    0 00:34:14        7
10.255.255.7    4        65002      42      43       17    0    0 00:35:12        1
R8#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0/31     10.255.255.3             0    100      0 (65001) i
 * i                   10.255.255.3             0    100      0 (65001) i
 *    192.0.2.0        10.255.255.3             0    100      0 (65001) i
 *>i                   10.255.255.6                  100      0 i
 *>i  192.0.2.2/31     10.255.255.6             0    100      0 i
 *>   192.0.2.103/32   10.255.255.3             0    100      0 (65001) i
 * i                   10.255.255.3             0    100      0 (65001) i
 *>   192.0.2.104/32   10.255.255.4             0    100      0 (65001) i
 *>   192.0.2.105/32   10.255.255.5             0    100      0 (65001) i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>   192.0.2.108/32   0.0.0.0                   0         32768 i
 *>   198.51.100.0     192.0.2.1                0    100      0 (65001) 64501 i
 * i                   192.0.2.1                0    100      0 (65001) 64501 i
 *>i  203.0.113.0      10.255.255.6             0    100      0 64502 i
```

BGP – IBGP – Route Reflector

Идея рефлектора в следующем: выбирается один (или несколько) BGP-маршрутизаторов, который будет выступать как «сервер» для остальных пиров: получив какой-то анонс от своего «клиента», он распространит его своим остальным «клиентам». Т.о. логическая топология переходит из полносвязной в «Звезду».



К рефлектору могут быть подключены не только клиенты – в этом случае требования к полносвязности остаются.

Как распространяются маршруты можно увидеть на иллюстрации на этом слайде.

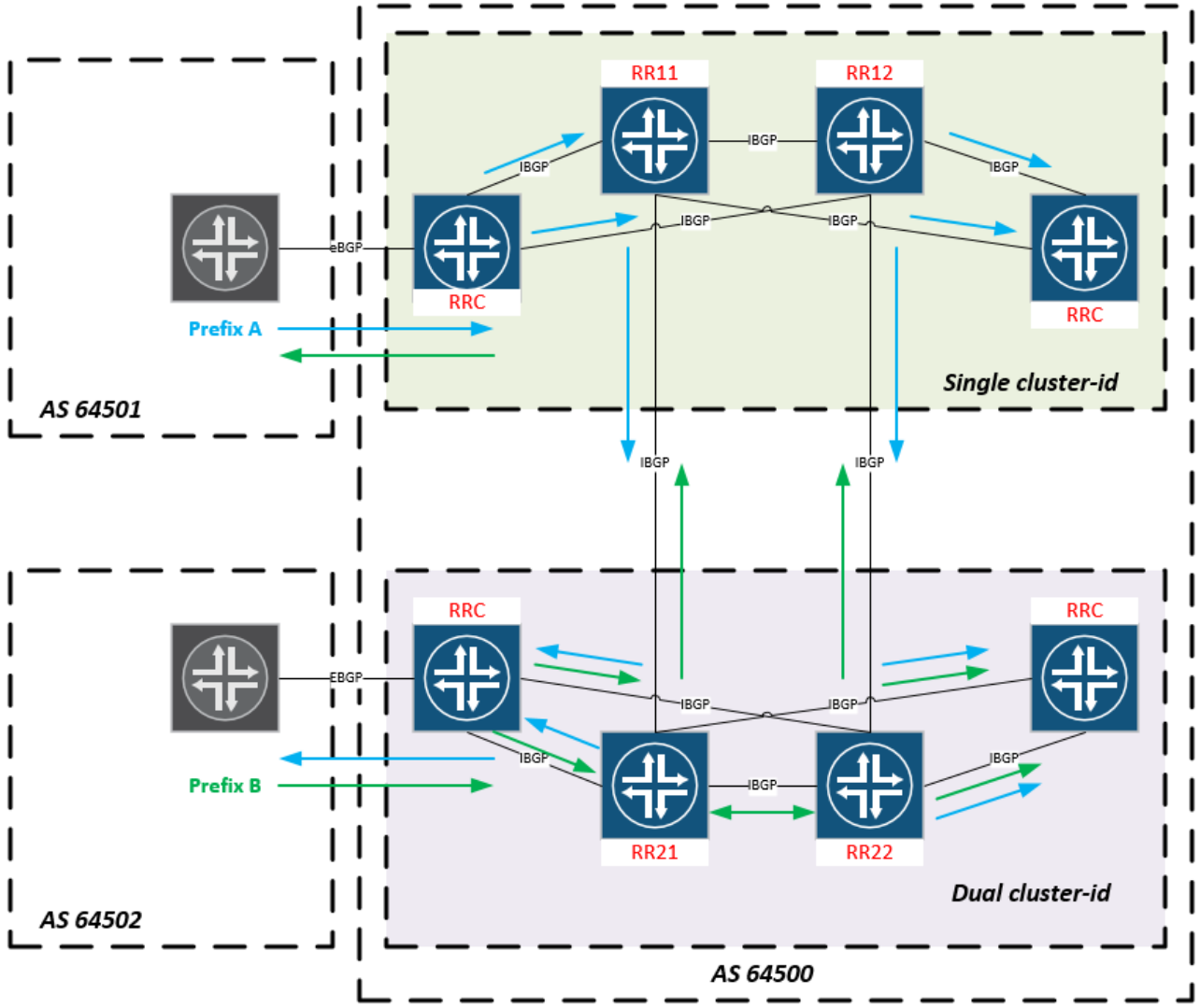
BGP – IBGP – Route Reflector

Совокупность из рефлектора(-ов) и клиентов составляет «кластер». Кластер характеризуется параметром “Cluster-ID” (по умолчанию берется из BGP Router-ID). При получении рефлектором маршрута, в него добавляются два дополнительных атрибута, которые служат для предотвращения появления петель маршрутизации:

- ORIGINATOR_ID – в него проставляется router-id маршрутизатора, от которого изначально пришел маршрут
- CLUSTER_LIST – это список, в который добавляются cluster-id рефлекторов, через который прошел маршрут

Маршруты между IBGP-соседями с одинаковым cluster-id не принимаются.

Маршрутизатор, получающий анонс с ORIGINATOR_ID равным его Router-ID, отбрасывает такой анонс



BGP – Route Reflectors – Clients (Single Cluster-ID)

R3:

```
router bgp 64500
 bgp router-id 10.255.255.3
 bgp log-neighbor-changes
 neighbor RR_C1 peer-group
 neighbor RR_C1 remote-as 64500
 neighbor RR_C1 update-source Loopback0
 neighbor 10.255.255.4 peer-group RR_C1
 neighbor 10.255.255.5 peer-group RR_C1
 neighbor 192.0.2.1 remote-as 64501
 neighbor 192.0.2.1 update-source
Ethernet0/0
 !
 address-family ipv4
  network 192.0.2.103 mask
255.255.255.255
  aggregate-address 192.0.2.0
255.255.255.0
  neighbor RR_C1 next-hop-self
  neighbor 10.255.255.4 activate
  neighbor 10.255.255.5 activate
  neighbor 192.0.2.1 activate
  neighbor 192.0.2.1 prefix-list
PL_WIDE_NETS out
 exit-address-family
```

```
R3#show bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        0.0.0.0                  0         32768 i
 *>   192.0.2.103/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.104/32   10.255.255.4             0    100      0 i
 * i                   10.255.255.4             0    100      0 i
 * i  192.0.2.105/32   10.255.255.5             0    100      0 i
 *>i                   10.255.255.5             0    100      0 i
 * i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i                   10.255.255.6             0    100      0 i
 * i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>i                   10.255.255.7             0    100      0 i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 i
 *>i  192.0.2.109/32   10.255.255.9             0    100      0 i
 * i  192.0.2.110/32   10.255.255.10            0    100      0 i
 *>i                   10.255.255.10            0    100      0 i
 *>   198.51.100.0     192.0.2.1                0             0 64501 i
 * i  203.0.113.0      10.255.255.7             0    100      0 64502 i
 *>i                   10.255.255.7             0    100      0 64502 i
```

```
R3#show bgp ipv4 unicast summary | b Neigh
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.255.255.4    4        64500      28      26       15    0    0 00:19:20        7
10.255.255.5    4        64500      18      15       15    0    0 00:06:17        7
192.0.2.1       4        64501      26      26       15    0    0 00:19:34        1
```

```
R3#show bgp ipv4 unicast neighbors 10.255.255.4 advertised-routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        0.0.0.0                  0         32768 i
 *>   192.0.2.103/32   0.0.0.0                  0         32768 i
 *>   198.51.100.0     192.0.2.1                0             0 64501 i
```

```
R3#show bgp ipv4 unicast neighbors 10.255.255.5 advertised-routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        0.0.0.0                  0         32768 i
 *>   192.0.2.103/32   0.0.0.0                  0         32768 i
 *>   198.51.100.0     192.0.2.1                0             0 64501 i
```

BGP – Route Reflectors – Clients (Dual Cluster-ID)

R7:

```
router bgp 64500
 bgp router-id 10.255.255.7
 bgp log-neighbor-changes
 neighbor RR_C2 peer-group
 neighbor RR_C2 remote-as 64500
 neighbor RR_C2 update-source Loopback0
 neighbor 10.255.255.8 peer-group RR_C2
 neighbor 10.255.255.9 peer-group RR_C2
 neighbor 192.0.2.3 remote-as 64502
 neighbor 192.0.2.3 update-source
Ethernet0/0
 !
 address-family ipv4
  network 192.0.2.107 mask
255.255.255.255
  aggregate-address 192.0.2.0
255.255.255.0
  neighbor RR_C2 next-hop-self
  neighbor 10.255.255.8 activate
  neighbor 10.255.255.9 activate
  neighbor 192.0.2.3 activate
  neighbor 192.0.2.3 prefix-list
PL_WIDE_NETS out
 exit-address-family
```

```
R7#show bgp ipv4 unicast
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        0.0.0.0                            32768 i
 * i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>i                   10.255.255.3             0    100      0 i
 *>i  192.0.2.104/32   10.255.255.4             0    100      0 i
 *>i  192.0.2.105/32   10.255.255.5             0    100      0 i
 * i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i                   10.255.255.6             0    100      0 i
 *>   192.0.2.107/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 i
 * i                   10.255.255.8             0    100      0 i
 * i  192.0.2.109/32   10.255.255.9             0    100      0 i
 *>i                   10.255.255.9             0    100      0 i
 * i  192.0.2.110/32   10.255.255.10            0    100      0 i
 *>i                   10.255.255.10            0    100      0 i
 * i  198.51.100.0     10.255.255.3             0    100      0 64501 i
 *>i                   10.255.255.3             0    100      0 64501 i
 *>   203.0.113.0      192.0.2.3                0             0 64502 i
```

```
R7#show bgp ipv4 unicast neighbors 10.255.255.8 advertised-routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>   192.0.2.0        0.0.0.0                            32768 i
 *>   192.0.2.107/32   0.0.0.0                  0         32768 i
 *>   203.0.113.0      192.0.2.3                0             0 64502 i

R7#show bgp ipv4 unicast neighbors 10.255.255.8 routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>i  192.0.2.104/32   10.255.255.4             0    100      0 i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 i
 * i  192.0.2.109/32   10.255.255.9             0    100      0 i
 *>i  192.0.2.110/32   10.255.255.10            0    100      0 i
 *>i  198.51.100.0     10.255.255.3             0    100      0 64501 i
```

```
R7#show bgp ipv4 unicast summary
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.255.255.8    4        64500      43      30       17    0    0 00:22:37        7
10.255.255.9    4        64500      25      19       17    0    0 00:10:27        7
192.0.2.3       4        64502      30      30       17    0    0 00:23:01        1
```

BGP – Route Reflectors – RR IOS-XR (Single Cluster-ID)

```
router bgp 64500
 bgp router-id 10.255.255.4
 bgp cluster-id 10.255.255.45
 address-family ipv4 unicast
  network 192.0.2.104/32
 !
 neighbor-group RRC_C1
  remote-as 64500
  update-source Loopback0
  address-family ipv4 unicast
   route-policy RP_PERMIT_ANY in
   route-reflector-client
   route-policy RP_PERMIT_ANY out
  !
 neighbor 10.255.255.3
  use neighbor-group RRC_C1
 !
 neighbor 10.255.255.5
  remote-as 64500
  update-source Loopback0
  address-family ipv4 unicast
   route-policy RP_PERMIT_ANY in
   route-policy RP_PERMIT_ANY out
  !
 neighbor 10.255.255.6
  use neighbor-group RRC_C1
 !
 neighbor 10.255.255.8
  remote-as 64500
  update-source Loopback0
  address-family ipv4 unicast
   route-policy RP_PERMIT_ANY in
   route-policy RP_PERMIT_ANY out
```

```
RP/0/0/CPU0:R4#show bgp ipv4 unicast summary
Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down  St/PfxRcd
10.255.255.3      0 64500      37      37       19    0    0 00:20:58          3
10.255.255.5      0 64500      16      16       19    0    0 00:07:52          1
10.255.255.6      0 64500      19      27       19    0    0 00:14:14          1
10.255.255.8      0 64500      41      37       19    0    0 00:26:41          5

RP/0/0/CPU0:R4#show bgp ipv4 unicast
   Network            Next Hop            Metric LocPrf Weight Path
*>i192.0.2.0/24       10.255.255.3             0    100      0 i
* i                   10.255.255.7             0    100      0 i
*>i192.0.2.103/32     10.255.255.3             0    100      0 i
*> 192.0.2.104/32     0.0.0.0                  0         32768 i
*>i192.0.2.105/32     10.255.255.5             0    100      0 i
*>i192.0.2.106/32     10.255.255.6             0    100      0 i
*>i192.0.2.107/32     10.255.255.7             0    100      0 i
*>i192.0.2.108/32     10.255.255.8             0    100      0 i
*>i192.0.2.110/32     10.255.255.10            0    100      0 i
*>i198.51.100.0/24    10.255.255.3             0    100      0 64501 i
*>i203.0.113.0/24     10.255.255.7             0    100      0 64502 i

RP/0/0/CPU0:R4#show bgp ipv4 unicast neighbors 10.255.255.3 advertised-routes
Network            Next Hop        From            AS Path
192.0.2.0/24       10.255.255.4    10.255.255.3    i
192.0.2.103/32     10.255.255.4    10.255.255.3    i
192.0.2.104/32     10.255.255.4    Local           i
192.0.2.105/32     10.255.255.5    10.255.255.5    i
192.0.2.106/32     10.255.255.6    10.255.255.6    i
192.0.2.107/32     10.255.255.7    10.255.255.8    i
192.0.2.108/32     10.255.255.8    10.255.255.8    i
192.0.2.110/32     10.255.255.10   10.255.255.8    i
198.51.100.0/24    10.255.255.4    10.255.255.3    64501i
203.0.113.0/24     10.255.255.7    10.255.255.8    64502i
```

```
RP/0/0/CPU0:R4#show bgp ipv4 unicast neighbors 10.255.255.5 advertised-routes
Network            Next Hop        From            AS Path
192.0.2.0/24       10.255.255.3    10.255.255.3    i
192.0.2.103/32     10.255.255.3    10.255.255.3    i
192.0.2.104/32     10.255.255.4    Local           i
192.0.2.106/32     10.255.255.6    10.255.255.6    i
198.51.100.0/24    10.255.255.3    10.255.255.3    64501i

RP/0/0/CPU0:R4#show bgp ipv4 unicast neighbors 10.255.255.5 routes
   Network            Next Hop            Metric LocPrf Weight Path
*>i192.0.2.105/32     10.255.255.5             0    100      0 i

RP/0/0/CPU0:R4#show bgp ipv4 unicast neighbors 10.255.255.8 advertised-routes
Network            Next Hop        From            AS Path
192.0.2.0/24       10.255.255.3    10.255.255.3    i
192.0.2.103/32     10.255.255.3    10.255.255.3    i
192.0.2.104/32     10.255.255.4    Local           i
192.0.2.106/32     10.255.255.6    10.255.255.6    i
198.51.100.0/24    10.255.255.3    10.255.255.3    64501i

RP/0/0/CPU0:R4#show bgp ipv4 unicast neighbors 10.255.255.8 routes
   Network            Next Hop            Metric LocPrf Weight Path
* i192.0.2.0/24       10.255.255.7             0    100      0 i
*>i192.0.2.107/32     10.255.255.7             0    100      0 i
*>i192.0.2.108/32     10.255.255.8             0    100      0 i
*>i192.0.2.110/32     10.255.255.10            0    100      0 i
*>i203.0.113.0/24     10.255.255.7             0    100      0 64502 i
```

BGP – Route Reflectors – RR IOS/IOS-XE (Single Cluster-ID)

R5:

```
router bgp 64500
 bgp router-id 10.255.255.5
 bgp cluster-id 10.255.255.45
 bgp log-neighbor-changes
 neighbor RRC_C1 peer-group
 neighbor RRC_C1 remote-as 64500
 neighbor RRC_C1 update-source Loopback0
 neighbor 10.255.255.3 peer-group RRC_C1
 neighbor 10.255.255.4 remote-as 64500
 neighbor 10.255.255.4 update-source
Loopback0
 neighbor 10.255.255.6 peer-group RRC_C1
 neighbor 10.255.255.9 remote-as 64500
 neighbor 10.255.255.9 update-source
Loopback0
 !
 address-family ipv4
  network 192.0.2.105 mask
255.255.255.255
  neighbor RRC_C1 route-reflector-client
  neighbor 10.255.255.3 activate
  neighbor 10.255.255.4 activate
  neighbor 10.255.255.6 activate
  neighbor 10.255.255.9 activate
 exit-address-family
```

```
R5#show bgp ipv4 unicast
     Network          Next Hop            Metric LocPrf Weight Path
 * i  192.0.2.0        10.255.255.7             0    100      0 i
 *>i                   10.255.255.3             0    100      0 i
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>i  192.0.2.104/32   10.255.255.4             0    100      0 i
 *>   192.0.2.105/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>i  192.0.2.109/32   10.255.255.9             0    100      0 i
 *>i  192.0.2.110/32   10.255.255.10            0    100      0 i
 *>i  198.51.100.0     10.255.255.3             0    100      0 64501 i
 *>i  203.0.113.0      10.255.255.7             0    100      0 64502 i

R5#show bgp ipv4 unicast neighbors 10.255.255.4 advertised-routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0        10.255.255.3             0    100      0 i
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>   192.0.2.105/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i  198.51.100.0     10.255.255.3             0    100      0 64501 i

R5#show bgp ipv4 unicast neighbors 10.255.255.4 routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.104/32   10.255.255.4             0    100      0 i

R5#show bgp ipv4 unicast summary
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.255.255.3    4        64500      19      22       11    0    0 00:10:03        3
10.255.255.4    4        64500      18      18       11    0    0 00:10:00        1
10.255.255.6    4        64500      16      22       11    0    0 00:10:03        1
10.255.255.9    4        64500      18      18       11    0    0 00:09:03        5
```

```
R5#show bgp ipv4 unicast neighbors 10.255.255.9 advertised-routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0        10.255.255.3             0    100      0 i
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>   192.0.2.105/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i  198.51.100.0     10.255.255.3             0    100      0 64501 i

R5#show bgp ipv4 unicast neighbors 10.255.255.9 routes
     Network          Next Hop            Metric LocPrf Weight Path
 * i  192.0.2.0        10.255.255.7             0    100      0 i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>i  192.0.2.109/32   10.255.255.9             0    100      0 i
 *>i  192.0.2.110/32   10.255.255.10            0    100      0 i
 *>i  203.0.113.0      10.255.255.7             0    100      0 64502 i
```

BGP – Route Reflectors – RR IOS/IOS-XE (Dual Cluster-ID)

R9:

```
router bgp 64500
 bgp router-id 10.255.255.9
 bgp cluster-id 10.255.255.9
 bgp log-neighbor-changes
 neighbor RRC_C2 peer-group
 neighbor RRC_C2 remote-as 64500
 neighbor RRC_C2 update-source Loopback0
 neighbor 10.255.255.5 remote-as 64500
 neighbor 10.255.255.5 update-source
Loopback0
 neighbor 10.255.255.7 peer-group RRC_C2
 neighbor 10.255.255.8 remote-as 64500
 neighbor 10.255.255.8 update-source
Loopback0
 neighbor 10.255.255.10 peer-group
RRC_C2
 !
 address-family ipv4
  network 192.0.2.109 mask
255.255.255.255
  neighbor RRC_C2 route-reflector-client
  neighbor 10.255.255.5 activate
  neighbor 10.255.255.7 activate
  neighbor 10.255.255.8 activate
  neighbor 10.255.255.10 activate
 exit-address-family
```

```
R9#show bgp ipv4 unicast
     Network          Next Hop            Metric LocPrf Weight Path
 * i  192.0.2.0        10.255.255.3             0    100      0 i
 *>i                   10.255.255.7             0    100      0 i
 * i                   10.255.255.7             0    100      0 i
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>i  192.0.2.105/32   10.255.255.5             0    100      0 i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 i
 * i                   10.255.255.7             0    100      0 i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 i
 *>   192.0.2.109/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.110/32   10.255.255.10            0    100      0 i
 * i                   10.255.255.10            0    100      0 i
 *>i  198.51.100.0     10.255.255.3             0    100      0 64501 i
 *>i  203.0.113.0      10.255.255.7             0    100      0 64502 i
 * i                   10.255.255.7             0    100      0 64502 i
```

```
R9#show bgp ipv4 unicast neighbors 10.255.255.8 advertised-routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0        10.255.255.7             0    100      0 i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>   192.0.2.109/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.110/32   10.255.255.10            0    100      0 i
 *>i  203.0.113.0      10.255.255.7             0    100      0 64502 i
```

```
R9#show bgp ipv4 unicast summary
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.255.255.5    4        64500      24      23       13    0    0 00:13:54        5
10.255.255.7    4        64500      23      28       13    0    0 00:13:51        3
10.255.255.8    4        64500      26      23       13    0    0 00:13:58        5
10.255.255.10   4        64500      21      28       13    0    0 00:13:51        1
```

```
R9#show bgp ipv4 unicast neighbors 10.255.255.8 routes
     Network          Next Hop            Metric LocPrf Weight Path
 * i  192.0.2.0        10.255.255.7             0    100      0 i
 * i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 i
 * i  192.0.2.110/32   10.255.255.10            0    100      0 i
 * i  203.0.113.0      10.255.255.7             0    100      0 64502 i
```

```
R9#show bgp ipv4 unicast neighbors 10.255.255.7 advertised-routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0        10.255.255.7             0    100      0 i
 *>i  192.0.2.103/32   10.255.255.3             0    100      0 i
 *>i  192.0.2.105/32   10.255.255.5             0    100      0 i
 *>i  192.0.2.106/32   10.255.255.6             0    100      0 i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>i  192.0.2.108/32   10.255.255.8             0    100      0 i
 *>   192.0.2.109/32   0.0.0.0                  0         32768 i
 *>i  192.0.2.110/32   10.255.255.10            0    100      0 i
 *>i  198.51.100.0     10.255.255.3             0    100      0 64501 i
 *>i  203.0.113.0      10.255.255.7             0    100      0 64502 i
```

```
R9#show bgp ipv4 unicast neighbors 10.255.255.7 routes
     Network          Next Hop            Metric LocPrf Weight Path
 *>i  192.0.2.0        10.255.255.7             0    100      0 i
 *>i  192.0.2.107/32   10.255.255.7             0    100      0 i
 *>i  203.0.113.0      10.255.255.7             0    100      0 64502 I
```

BGP – Route Reflectors – RR Huawei VRP (Dual Cluster-ID)

R8:

```
bgp 64500
 router-id 10.255.255.8
 peer 10.255.255.4 as-number 64500
 peer 10.255.255.4 connect-interface
LoopBack0
 peer 10.255.255.9 as-number 64500
 peer 10.255.255.9 connect-interface
LoopBack0
 group RRC_C2 internal
 peer RRC_C2 connect-interface LoopBack0
 peer 10.255.255.7 as-number 64500
 peer 10.255.255.7 group RRC_C2
 peer 10.255.255.10 as-number 64500
 peer 10.255.255.10 group RRC_C2
 #
 ipv4-family unicast
  undo synchronization
  reflector cluster-id 10.255.255.8
  network 192.0.2.108 255.255.255.255
  peer 10.255.255.4 enable
  peer 10.255.255.9 enable
  peer RRC_C2 enable
  peer RRC_C2 reflect-client
  peer 10.255.255.7 enable
  peer 10.255.255.7 group RRC_C2
  peer 10.255.255.10 enable
  peer 10.255.255.10 group RRC_C2
#
```

```
[R8]dis bgp routing-table
      Network          NextHop          MED    LocPrf    PrefVal Path/Ogn
 *>i  192.0.2.0/24     10.255.255.7       0       100          0       i
 * i                   10.255.255.7       0       100          0       i
 * i                   10.255.255.3       0       100          0       i
 *>i  192.0.2.103/32   10.255.255.3       0       100          0       i
 *>i  192.0.2.104/32   10.255.255.4       0       100          0       i
 *>i  192.0.2.106/32   10.255.255.6       0       100          0       i
 *>i  192.0.2.107/32   10.255.255.7       0       100          0       i
 * i                   10.255.255.7       0       100          0       i
 *>   192.0.2.108/32   0.0.0.0            0                    0       i
 *>i  192.0.2.109/32   10.255.255.9       0       100          0       i
 *>i  192.0.2.110/32   10.255.255.10      0       100          0       i
 * i                   10.255.255.10      0       100          0       i
 *>i  198.51.100.0/24  10.255.255.3       0       100          0    64501i
 *>i  203.0.113.0/24   10.255.255.7       0       100          0    64502i
 * i                   10.255.255.7       0       100          0    64502i
```

```
[R8]dis bgp routing-table peer 10.255.255.9 advertised-routes
      Network          NextHop          MED    LocPrf    PrefVal Path/Ogn
 *>i  192.0.2.0/24     10.255.255.7       0       100          0       i
 *>i  192.0.2.107/32   10.255.255.7       0       100          0       i
 *>   192.0.2.108/32   0.0.0.0            0       100          0       i
 *>i  192.0.2.110/32   10.255.255.10      0       100          0       i
 *>i  203.0.113.0/24   10.255.255.7       0       100          0    64502i
```

```
[R8]dis bgp peer
  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State  PrefRcv
  10.255.255.4    4       64500       41       46     0 00:31:16 Established        5
  10.255.255.7    4       64500       31       44     0 00:23:36 Established        3
  10.255.255.9    4       64500       20       23     0 00:11:33 Established        5
  10.255.255.10   4       64500       24       37     0 00:19:19 Established        1
```

```
[R8]dis bgp routing-table peer 10.255.255.9 received-routes
      Network          NextHop          MED    LocPrf    PrefVal Path/Ogn
 * i  192.0.2.0/24     10.255.255.7       0       100          0       i
 * i  192.0.2.107/32   10.255.255.7       0       100          0       i
 *>i  192.0.2.109/32   10.255.255.9       0       100          0       i
 * i  192.0.2.110/32   10.255.255.10      0       100          0       i
 * i  203.0.113.0/24   10.255.255.7       0       100          0    64502i
```

```
[R8]dis bgp routing-table peer 10.255.255.7 advertised-routes
      Network          NextHop          MED    LocPrf    PrefVal Path/Ogn
 *>i  192.0.2.0/24     10.255.255.7       0       100          0       i
 *>i  192.0.2.103/32   10.255.255.3       0       100          0       i
 *>i  192.0.2.104/32   10.255.255.4       0       100          0       i
 *>i  192.0.2.106/32   10.255.255.6       0       100          0       i
 *>i  192.0.2.107/32   10.255.255.7       0       100          0       i
 *>   192.0.2.108/32   0.0.0.0            0       100          0       i
 *>i  192.0.2.109/32   10.255.255.9       0       100          0       i
 *>i  192.0.2.110/32   10.255.255.10      0       100          0       i
 *>i  198.51.100.0/24  10.255.255.3       0       100          0    64501i
 *>i  203.0.113.0/24   10.255.255.7       0       100          0    64502i
```

```
[R8]dis bgp routing-table peer 10.255.255.7 received-routes
      Network          NextHop          MED    LocPrf    PrefVal Path/Ogn
 *>i  192.0.2.0/24     10.255.255.7       0       100          0       i
 *>i  192.0.2.107/32   10.255.255.7       0       100          0       i
 *>i  203.0.113.0/24   10.255.255.7       0       100          0    64502i
```

BGP – Route Reflectors

```
R3#show bgp ipv4 unicast 198.51.100.0
BGP routing table entry for 198.51.100.0/24, version 3
Paths: (1 available, best #1, table default)
  Advertised to update-groups:
     2
  Refresh Epoch 1
  64501
    192.0.2.1 from 192.0.2.1 (198.51.100.1)
      Origin IGP, metric 0, localpref 100, valid, external, best
      rx pathid: 0, tx pathid: 0x0
R3#show bgp ipv4 unicast 203.0.113.0
BGP routing table entry for 203.0.113.0/24, version 16
Paths: (2 available, best #1, table default)
  Advertised to update-groups:
     1
  Refresh Epoch 1
  64502
    10.255.255.7 (metric 2) from 10.255.255.4 (10.255.255.4)
      Origin IGP, metric 0, localpref 100, valid, internal, best
      Originator: 10.255.255.7, Cluster list: 10.255.255.45, 10.255.255.8
      rx pathid: 0, tx pathid: 0x0
  Refresh Epoch 1
  64502
    10.255.255.7 (metric 2) from 10.255.255.5 (10.255.255.5)
      Origin IGP, metric 0, localpref 100, valid, internal
      Originator: 10.255.255.7, Cluster list: 10.255.255.45, 10.255.255.9
      rx pathid: 0, tx pathid: 0
```

```
RP/0/0/CPU0:R4#show bgp ipv4 unicast 198.51.100.0
Sat Apr 30 10:50:08.157 UTC
BGP routing table entry for 198.51.100.0/24
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 17          17
Last Modified: Apr 30 10:48:28.569 for 00:01:39
Paths: (1 available, best #1)
  Advertised IPv4 Unicast paths to update-groups (with more than one peer):
    0.2 0.3
  Path #1: Received by speaker 0
  Advertised IPv4 Unicast paths to update-groups (with more than one peer):
    0.2 0.3
  64501, (Received from a RR-client)
    10.255.255.3 (metric 2) from 10.255.255.3 (10.255.255.3)
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 0, Local Path ID 1, version 17
RP/0/0/CPU0:R4#show bgp ipv4 unicast 203.0.113.0
Sat Apr 30 10:50:33.786 UTC
BGP routing table entry for 203.0.113.0/24
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 18          18
Last Modified: Apr 30 10:48:28.569 for 00:02:05
Paths: (1 available, best #1)
  Advertised IPv4 Unicast paths to update-groups (with more than one peer):
    0.2
  Path #1: Received by speaker 0
  Advertised IPv4 Unicast paths to update-groups (with more than one peer):
    0.2
  64502
    10.255.255.7 (metric 3) from 10.255.255.8 (10.255.255.7)
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 0, Local Path ID 1, version 18
      Originator: 10.255.255.7, Cluster list: 10.255.255.8
```

BGP – Route Reflectors

```
R5#show bgp ipv4 unicast 198.51.100.0
BGP routing table entry for 198.51.100.0/24, version 7
Paths: (1 available, best #1, table default)
  Advertised to update-groups:
     1          2
  Refresh Epoch 1
  64501, (Received from a RR-client)
    10.255.255.3 (metric 2) from 10.255.255.3 (10.255.255.3)
      Origin IGP, metric 0, localpref 100, valid, internal, best
      rx pathid: 0, tx pathid: 0x0
R5#show bgp ipv4 unicast 203.0.113.0
BGP routing table entry for 203.0.113.0/24, version 8
Paths: (1 available, best #1, table default)
  Advertised to update-groups:
     1
  Refresh Epoch 1
  64502
    10.255.255.7 (metric 3) from 10.255.255.9 (10.255.255.9)
      Origin IGP, metric 0, localpref 100, valid, internal, best
      Originator: 10.255.255.7, Cluster list: 10.255.255.9
      rx pathid: 0, tx pathid: 0x0
```

```
R9#show bgp ipv4 unicast 198.51.100.0
BGP routing table entry for 198.51.100.0/24, version 9
Paths: (1 available, best #1, table default)
Flag: 0x100
  Advertised to update-groups:
     1
  Refresh Epoch 1
  64501
    10.255.255.3 (metric 3) from 10.255.255.5 (10.255.255.5)
      Origin IGP, metric 0, localpref 100, valid, internal, best
      Originator: 10.255.255.3, Cluster list: 10.255.255.45
      rx pathid: 0, tx pathid: 0x0
R9#show bgp ipv4 unicast 203.0.113.0
BGP routing table entry for 203.0.113.0/24, version 6
Paths: (2 available, best #2, table default)
  Advertised to update-groups:
     1          2
  Refresh Epoch 1
  64502
    10.255.255.7 (metric 2) from 10.255.255.8 (10.255.255.8)
      Origin IGP, metric 0, localpref 100, valid, internal
      Originator: 10.255.255.7, Cluster list: 10.255.255.8
      rx pathid: 0, tx pathid: 0
  Refresh Epoch 1
  64502, (Received from a RR-client)
    10.255.255.7 (metric 2) from 10.255.255.7 (10.255.255.7)
      Origin IGP, metric 0, localpref 100, valid, internal, best
      rx pathid: 0, tx pathid: 0x0
```

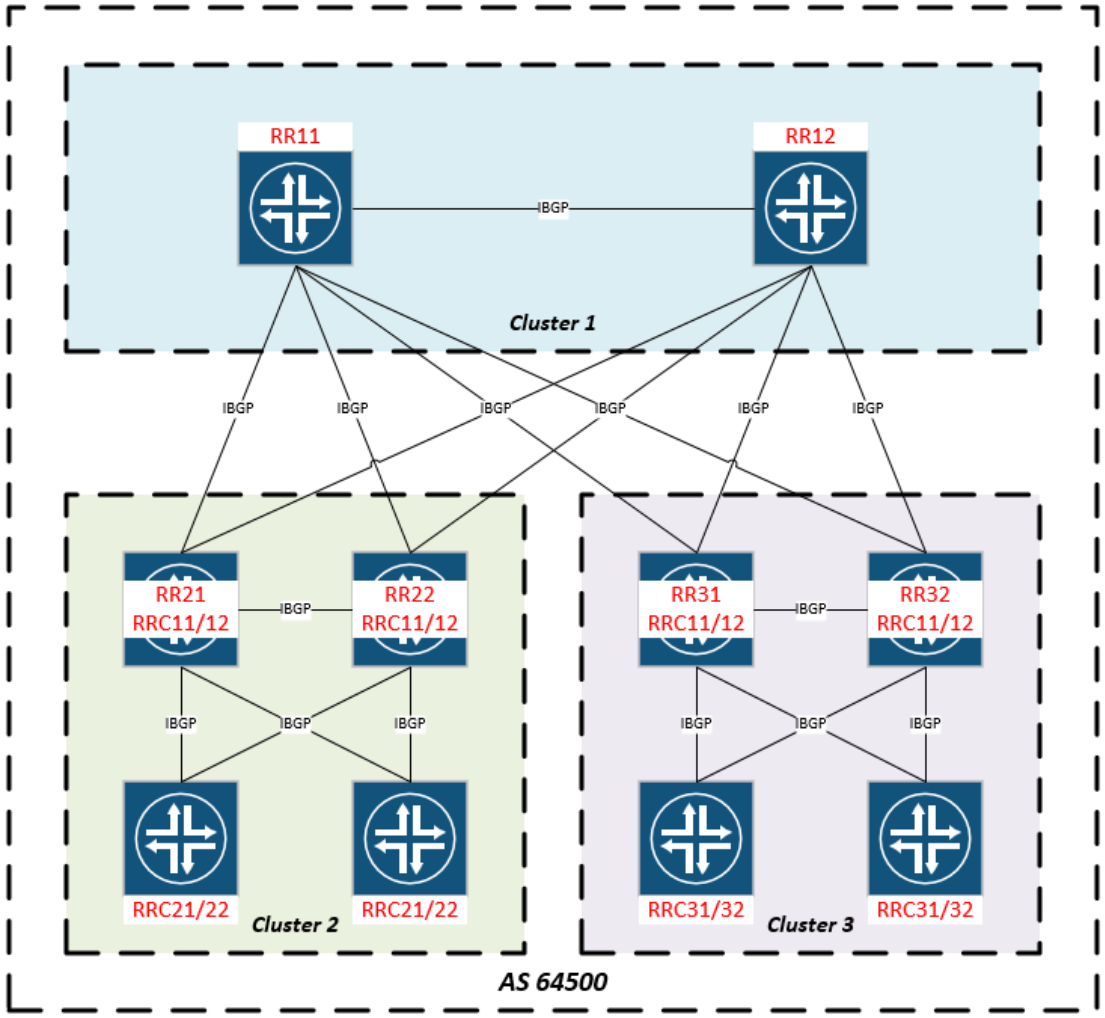
BGP – Route Reflectors

```
<R8>display bgp routing-table 198.51.100.0

 BGP local router ID : 10.255.255.8
 Local AS number : 64500
 Paths:   1 available, 1 best, 1 select, 0 best-external, 0 add-path
 BGP routing table entry information of 198.51.100.0/24:
 From: 10.255.255.4 (10.255.255.4)
 Route Duration: 0d00h04m12s
 Relay IP Nexthop: 10.4.8.4
 Relay IP Out-Interface: Ethernet1/0/3
 Original nexthop: 10.255.255.3
 Qos information : 0x0
 AS-path 64501, origin igp, MED 0, localpref 100, pref-val 0, valid, internal, best,
select, pre 255, IGP cost 3
 Originator: 10.255.255.3
 Cluster list: 10.255.255.45
 Advertised to such 2 peers:
    10.255.255.7
    10.255.255.10
```

```
<R8>display bgp routing-table 203.0.113.0

 BGP local router ID : 10.255.255.8
 Local AS number : 64500
 Paths:   2 available, 1 best, 1 select, 0 best-external, 0 add-path
 BGP routing table entry information of 203.0.113.0/24:
 RR-client route.
 From: 10.255.255.7 (10.255.255.7)
 Route Duration: 0d00h07m22s
 Relay IP Nexthop: 10.7.8.7
 Relay IP Out-Interface: Ethernet1/0/0
 Original nexthop: 10.255.255.7
 Qos information : 0x0
 AS-path 64502, origin igp, MED 0, localpref 100, pref-val 0, valid, internal, best, select,
pre 255, IGP cost 2
 Advertised to such 4 peers:
    10.255.255.7
    10.255.255.10
    10.255.255.9
    10.255.255.4

 BGP routing table entry information of 203.0.113.0/24:
 From: 10.255.255.9 (10.255.255.9)
 Route Duration: 0d00h07m17s
 Relay IP Nexthop: 10.7.8.7
 Relay IP Out-Interface: Ethernet1/0/0
 Original nexthop: 10.255.255.7
 Qos information : 0x0
 AS-path 64502, origin igp, MED 0, localpref 100, pref-val 0, valid, internal, pre 255, IGP
cost 2, not preferred for Cluster List
 Originator: 10.255.255.7
 Cluster list: 10.255.255.9
 Not advertised to any peer yet
```

BGP – IBGP – Route Reflector

При наличии большой и распределенной сети можно организовывать иерархические включения рефлекторов.
На иллюстрации справа видно, что каждый RR из кластеров 2 и 3 является также клиентом рефлекторов из кластера 1. На одном же уровне иерархии между рефлекторами в кластере поднимается обычное IBGP-соседство.



BGP – Diagnostic commands

Description	IOS/IOS-XE	IOS-XR	Huawei VRP
Посмотреть краткую информацию о соседях	show bgp ipv4 unicast summary	show bgp ipv4 unicast summary	display bgp peer
Посмотреть BGP RIB	show bgp ipv4 unicast	show bgp ipv4 unicast	display bgp routing-table
Посмотреть полную информацию по маршруту в BGP RIB	show bgp ipv4 unicast ***{{$IP_ADDRESS}}***	show bgp ipv4 unicast ***{{$IP_ADDRESS}}***	display bgp routing-table ***{{$IP_ADDRESS}}***
Найти в BGP RIB все маршруты, отвечающие регулярному выражению	show bgp ipv4 unicast regexp ***{{$REGEXP}}***	show bgp ipv4 unicast regexp ***{{$REGEXP}}***	display bgp routing-table regular-expression ***{{$REGEXP}}***
Найти в BGP RIB все маршруты, имеющие в себе указанное коммьюнити	show bgp ipv4 unicast community ***{{$COMMUNITY}}***	show bgp ipv4 unicast community **{{$COMMUNITY}}**	display bgp routing-table community ***{{$COMMUNITY}}***
Посмотреть получаемые от соседа маршруты	show bgp ipv4 unicast neighbor ***{{$NEIGHBOR_IP}}*** routes	show bgp ipv4 unicast neighbor ***{{$NEIGHBOR_IP}}*** routes	display bgp routing-table peer ***{{$NEIGHBOR_IP}}*** received-routes
Посмотреть передаваемые соседу маршруты	show bgp ipv4 unicast neighbor ***{{$NEIGHBOR_IP}}*** advertised-routes	show bgp ipv4 unicast neighbor ***{{$NEIGHBOR_IP}}*** advertised-routes	display bgp routing-table peer ***{{$NEIGHBOR_IP}}*** advertised-routes
Посмотре подробную информацию о соседе	show bgp ipv4 unicast neighbor ***{{$NEIGHBOR_IP}}***	show bgp ipv4 unicast neighbor ***{{$NEIGHBOR_IP}}***	display bgp peer ***{{$NEIGHBOR_IP}}*** verbose
Посмотреть логи по соседу (Huawei only)	-	-	display bgp peer ***{{$NEIGHBOR_IP}}*** log-info
Посмотреть маршруты, попадающие под политику (XR Only)	-	show bgp ipv4 unicast route-policy ***{{$RP_NAME}}***	-
Посмотреть политику	show route-map ***{{$RM_NAME}}***	show rpl route-policy ***{{$RP_NAME}}***	display route-policy ***{{$RP_NAME}}***
Посмотреть префикс-лист	show ip prefix-list ***{{$PL_NAME}}***	show rpl prefix-set ***{{$PS_NAME}}***	display ip ip-prefix ***{{$PL_NAME}}***
Посмотреть коммьюнити-лист	show ip community-list ***{{$COMM_LIST_NAME}}***	show rpl community-set ***{{$COMM_SET}}***	display ip community-filter ***{{$CF_NAME}}***
Посмотреть AS-Path лист	show ip as-path-access-list ***{{$ASPATH_ACL_NUM}}***	show rpl as-path-set ***{{$ASPATH_SET}}***	display ip as-path-filter ***{{$ASF_NAME}}***

BGP – Diagnostic commands

Description	IOS-XE	IOS-XR	Huawei VRP
Посмотреть краткую информацию о соседях	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}}*** summary	show bgp vrf ***{{$VRF_NAME}}*** summary	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** peer
Посмотреть BGP RIB	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}}***	show bgp vrf ***{{$VRF_NAME}}***	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** routing-table
Посмотреть полную информацию по маршруту в BGP RIB	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}} {{$IP_ADDRESS}}***	show bgp vrf ***{{$VRF_NAME}} {{$IP_ADDRESS}}***	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** routing-table ***{{$IP_ADDRESS}}***
Найти в BGP RIB все маршруты, отвечающие регулярному выражению	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}}*** regexp ***{{$REGEXP}}***	show bgp vrf ***{{$VRF_NAME}}*** regexp ***{{$REGEXP}}***	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** routing-table regular-expression ***{{$REGEXP}}***
Найти в BGP RIB все маршруты, имеющие в себе указанное коммьюнити	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}}*** community ***{{$COMMUNITY}}***	show bgp vrf ***{{$VRF_NAME}}*** community ***{{$COMMUNITY}}***	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** routing-table community ***{{$COMMUNITY}}***
Посмотреть получаемые от соседа маршруты	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}}*** neighbor ***{{$NEIGHBOR_IP}}*** routes	show bgp vrf ***{{$VRF_NAME}}*** neighbor ***{{$NEIGHBOR_IP}}*** routes	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** routing-table peer ***{{$NEIGHBOR_IP}}*** received-routes
Посмотреть передаваемые соседу маршруты	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}}*** neighbor ***{{$NEIGHBOR_IP}}*** advertised-routes	show bgp vrf ***{{$VRF_NAME}}*** neighbor ***{{$NEIGHBOR_IP}}*** advertised-routes	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** routing-table peer ***{{$NEIGHBOR_IP}}*** advertised-routes
Посмотре подробную информацию о соседе	show bgp vpnv4 unicast vrf ***{{$VRF_NAME}}*** neighbor ***{{$NEIGHBOR_IP}}***	show bgp vrf ***{{$VRF_NAME}}*** neighbor ***{{$NEIGHBOR_IP}}***	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** peer ***{{$NEIGHBOR_IP}}*** verbose
Посмотреть логи по соседу (Huawei only)	_	_	display bgp vpnv4 vpn-instance ***{{$VRF_NAME}}*** peer ***{{$NEIGHBOR_IP}}*** log-info
Посмотреть маршруты, попадающие под политику (XR Only)	_	show bgp vrf ***{{$VRF_NAME}}*** route-policy ***{{$RP_NAME}}***	_

Источники

- RFC 4456 - https://datatracker.ietf.org/doc/html/rfc4456
- RFC 5065 - https://datatracker.ietf.org/doc/html/rfc5065