# Deploying 32-bit ASNs

AfNOG 2012 AR-E Workshop

# 32-bit ASNs

- Standards documents
  - Description of 32-bit ASNs
    - www.rfc-editor.org/rfc/rfc4893.txt
  - Textual representation
    - www.rfc-editor.org/rfc/rfc5396.txt
  - New extended community
    - www.rfc-editor.org/rfc/rfc5668.txt
- AS 23456 is reserved as interface between 16-bit and 32-bit ASN world

# 32-bit ASNs – terminology

- 16-bit ASNs
  - Refers to the range 0 to 65535
- 32-bit ASNs
  - Refers to the range 65536 to 4294967295
  - (or the extended range)
- 32-bit ASN pool
  - Refers to the range 0 to 4294967295

# Getting a 32-bit ASN

- Sample RIR policy
  - www.apnic.net/docs/policy/asn-policy.html
- From 1st January 2007
  - 32-bit ASNs were available on request
- From 1st January 2009
  - 32-bit ASNs were assigned by default
  - 16-bit ASNs were only available on request
- From 1st January 2010
  - No distinction – ASNs assigned from the 32-bit pool

# Representation (1)

- Initially three formats proposed for the 0-4294967295 ASN range :
  - asplain
  - asdot
  - asdot+
- In reality:
  - **Most operators favour traditional plain format**
  - A few prefer dot notation (X.Y):
    - asdot for 65536-4294967295, e.g 2.4
    - asdot+ for 0-4294967295, e.g 0.64513
  - But regular expressions will have to be completely rewritten for asdot and asdot+ !!!

# Representation (2)

- Rewriting regular expressions for asdot/asdot+ notation
- Example:
  - ^[0-9]+$ matches any ASN (16-bit and asplain)
  - This and equivalents extensively used in BGP multihoming configurations for traffic engineering
- Equivalent regexp for asdot is:
  - ^([0-9]+)|([0-9]+\.[0-9]+)$
- Equivalent regexp for asdot+ is:
  - ^[0-9]+\.[0-9]+$

# Changes

- 32-bit ASNs are backward compatible with 16-bit ASNs
- **There is no flag day**
- You do NOT need to:
  - Throw out your old routers
  - Replace your 16-bit ASN with a 32-bit ASN
- You do need to be aware that:
  - Your customers will come with 32-bit ASNs
  - ASN 23456 is not a bogon!
  - You will need a router supporting 32-bit ASNs to use a 32-bit ASN locally
- If you have a proper BGP implementation, 32-bit ASNs will be transported silently across your network

# How does it work?

- If local router and remote router supports configuration of 32-bit ASNs
  - BGP peering is configured as normal using the 32-bit ASN
- If local router and remote router does not support configuration of 32-bit ASNs
  - BGP peering can only use a 16-bit ASN
- If local router only supports 16-bit ASN and remote router/network has a 32-bit ASN
  - Compatibility mode is initiated…

# Compatibility Mode (1)

- Local router only supports 16-bit ASN and remote router uses 32-bit ASN
- BGP peering initiated:
  - Remote asks local if 32-bit supported (BGP capability negotiation)
  - When local says “no”, remote then presents AS23456
  - Local needs to be configured to peer with remote using AS23456
- ⇒ Operator of local router has to configure BGP peering with AS23456

# Compatibility Mode (2)

- Local router supports only 16-bit ASNs, peering with router supporting 32-bit ASNs
  - Peering set up with AS23456 (transition AS)

```
router bgp 64510
 neighbor 192.168.2.1 remote-as 23456
 neighbor 192.168.2.1 descr eBGP with AS 131076
 neighbor 192.168.2.1 prefix-list AS131076-in in
 neighbor 192.168.2.1 prefix-list AS131076-out out
!
```

  - Remote router configures normal BGP peering:

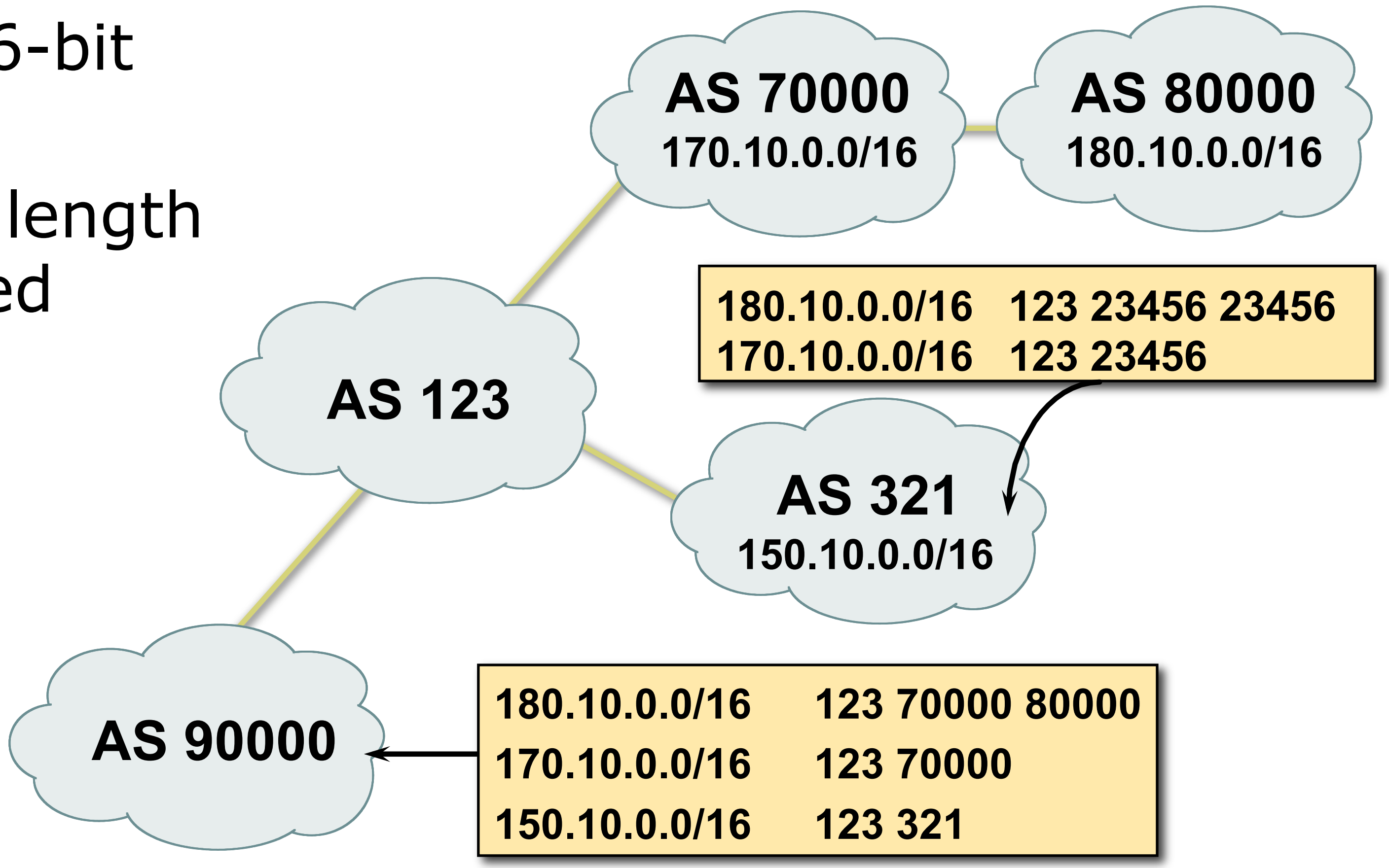
```
router bgp 131076
 neighbor 192.168.2.2 remote-as 64510
 neighbor 192.168.2.2 descr eBGP with AS 64510
 neighbor 192.168.2.2 prefix-list AS64510-in in
 neighbor 192.168.2.2 prefix-list AS64510-out out
!
```

# Compatibility Mode (3)

- BGP peering initiated (cont):
  - BGP session established using AS23456
  - 32-bit ASN included in a new BGP attribute called AS4_PATH
    - (as opposed to AS_PATH for 16-bit ASNs)
- Result:
  - 16-bit ASN world sees 16-bit ASNs and 23456 standing in for each 32-bit ASN
  - 32-bit ASN world sees 16 and 32-bit ASNs

# Example:

- Internet with 32-bit and 16-bit ASNs
- AS-PATH length maintained



# What has changed?

- Two new BGP attributes:
  - AS4_PATH
    - Carries 32-bit ASN path info
  - AS4_AGGREGATOR
    - Carries 32-bit ASN aggregator info
  - Well-behaved BGP implementations will simply pass these along if they don’t understand them
- AS23456 (AS_TRANS)

# What do they look like?

- IPv4 prefix originated by AS196613

asplain format

```
as4-7200#sh ip bgp 145.125.0.0/20
BGP routing table entry for 145.125.0.0/20, version
  58734
Paths: (1 available, best #1, table default)
  131072 12654 196613
    204.69.200.25 from 204.69.200.25 (204.69.200.25)
      Origin IGP, localpref 100, valid, internal, best
```

- IPv4 prefix originated by AS3.5

asdot format

```
as4-7200#sh ip bgp 145.125.0.0/20
BGP routing table entry for 145.125.0.0/20, version
  58734
Paths: (1 available, best #1, table default)
  2.0 12654 3.5
    204.69.200.25 from 204.69.200.25 (204.69.200.25)
      Origin IGP, localpref 100, valid, internal, best
```

# What do they look like?

- IPv4 prefix originated by AS196613
  - But 16-bit AS world view:

```
BGP-view1>sh ip bgp 145.125.0.0/20
BGP routing table entry for 145.125.0.0/20, version
  113382
Paths: (1 available, best #1, table Default-IP-Routing-
  Table)
23456 12654 23456
    204.69.200.25 from 204.69.200.25 (204.69.200.25)
      Origin IGP, localpref 100, valid, external, best
```

Transition AS

# If 32-bit ASN not supported:

- Inability to distinguish between peer ASes using 32-bit ASNs
  - They will all be represented by AS23456
  - Could be problematic for transit provider's policy
- Inability to distinguish prefix's origin AS
  - How to tell whether origin is real or fake?
  - The real and fake both represented by AS23456
  - **(There should be a better solution here!)**
- Incorrect NetFlow summaries:
  - Prefixes from 32-bit ASNs will all be summarised under AS23456
  - Traffic statistics need to be measured per prefix and aggregated
  - Makes it hard to determine peerability of a neighbouring network

# Implementations

- Cisco IOS-XR 3.4 onwards
- Cisco IOS-XE 2.3 onwards
- Cisco IOS 12.0(32)S12, 12.4(24)T, 12.2SRE, 12.2(33)SXI1 onwards
- Cisco NX-OS 4.0(1) onwards
- Quagga 0.99.10 (patches for 0.99.6)
- OpenBGPd 4.2 (patches for 3.9 & 4.0)
- Juniper JunOSe 4.1.0 & JunOS 9.1 onwards
- Redback SEOS
- Force10 FTOS7.7.1 onwards

- http://as4.cluepon.net/index.php/Software_Support for a complete list

# Cisco Routers Supporting 4-byte ASNs

- CRS
  - IOS-XR 3.4 onwards
- GSR
  - IOS-XR 3.4 onwards
  - IOS 12.0(32)S12, 12.0(33)S and 12.0(32)SY8 onwards
- ASR1000
  - IOS-XE 2.3 onwards
- Nexus Switches
  - NX-OS 4.0(1) onwards

# Cisco Routers Supporting 4-byte ASNs

- Catalyst 6500
  - IOS 12.2(33)SXI1 onwards
- 7600
  - IOS 12.2(33)SRE1 onwards
- 7200 series
  - IOS 12.0(32)S12, 12.0(33)S, 12.2(33)SRE1, 12.4(24)T, 15.0 onwards
- 7301
  - IOS 12.2(33)SRE1, 12.4(24)T, 15.0 onwards

# Cisco Routers Supporting 4-byte ASNs

- 3900/2900/1900 series
  - IOS 15.0 onwards
- 3800/2800/1800/800 series
  - IOS 12.4(24)T and IOS 15.0 onwards
- 3745/3725
  - IOS 12.4(24)T
- AS5350/5400
  - IOS 12.4(24)T and IOS 15.0 onwards

# Cisco Routers NOT supporting 4-byte ASNs

- Routers which will never support 4-byte ASNs include:
  - 2500 series
  - 2600 series
  - 3600 series
  - AS5300
  - 7304

# Deployment Tips

How to deploy 32-bit ASNs in the backbone network

# Deployment Scenarios

- Typical ISP design is thus:
  - ISIS/OSPF for IGP, carrying loopback and point to point link addresses
  - iBGP mesh (full/RR/Confederation) to carry customer and Internet prefixes
- All routers support 4-byte ASNs:
  - Proceed with iBGP design as normal
- Not all routers support 4-byte ASNs:
  - Three viable options

# iBGP options

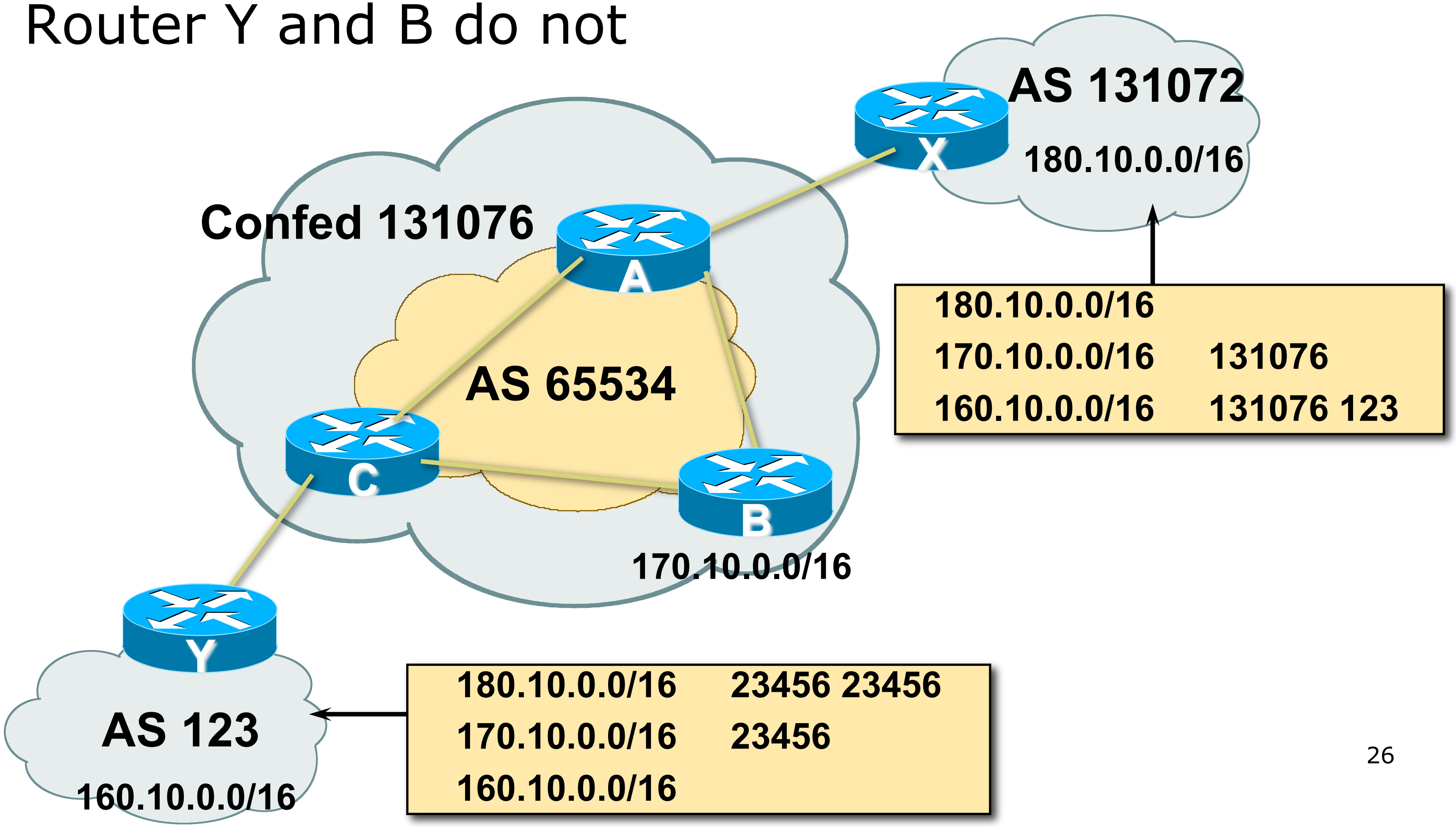
1. Return 4-byte ASN to the RIR and request 2-byte ASN instead
   - Works if RIR is willing to do so
   - Works as long as there are 2-byte ASNs remaining
2. Routers which support 4-byte ASNs run iBGP mesh
   - Routers which do not support 4-byte ASNs either run in private ASN (as a pseudo-customer) or do not run BGP at all
3. The BGP Confederation “hack”

# BGP Confederation "hack"

- Useful if only border routers can support 4-byte ASNs
  - Remaining backbone and aggregation routers cannot support 4-byte ASNs
- How?
  - The entire network runs within one private AS
  - The border routers declare to their eBGP neighbours that they are really in 4-byte ASN confederation

# Example:

- Routers X, A and C support 4-byte ASNs
- Router Y and B do not



# The Rules

- All routers with eBGP neighbours (customer, peer, upstream) must support 4-byte ASNs
- Remaining routers within the network do not have to support 4-byte ASNs
- Entire backbone operates in AS65534
  - Or any one private ASN from 64512 to 65534
- Only the eBGP speaking routers are confederation aware

# Router X Configuration

- Router X is in AS131072
  - Supports 4-byte ASNs

```
interface FastEthernet 0/0
 description Link to RouterA
 ip address 192.168.1.1 255.255.255.252
!
router bgp 131072
 neighbor 192.168.1.2 remote 131076
 neighbor 192.168.1.2 eBGP with RouterA
 network 180.10.0.0 mask 255.255.0.0
!
ip route 180.10.0.0 255.255.0.0 null0
```

# Router A Configuration

```
interface Loopback 0
 ip address 192.168.2.1 255.255.255.255
!
interface FastEthernet 0/0
 description Link to RouterX
 ip address 192.168.1.2 255.255.255.252
!
router bgp 65534
 bgp confederation identifier 131076
 neighbor 192.168.1.1 remote 131072
 neighbor 192.168.1.1 eBGP with RouterX
 neighbor 192.168.2.2 remote 65534
 neighbor 192.168.2.2 iBGP with RouterB
 neighbor 192.168.2.2 next-hop-self
 neighbor 192.168.2.3 remote 65534
 neighbor 192.168.2.3 iBGP with RouterC
 neighbor 192.168.2.3 next-hop-self
!
```

# Router B Configuration

- Router B is in AS65534 (Confederation 131076)
  - Does not support configuration of 4-byte ASNs

```
interface Loopback 0
 ip address 192.168.2.2 255.255.255.255
!
router bgp 65534
 neighbor 192.168.2.1 remote 65534
 neighbor 192.168.2.1 iBGP with RouterA
 neighbor 192.168.2.1 next-hop-self
 neighbor 192.168.2.3 remote 65534
 neighbor 192.168.2.3 iBGP with RouterC
 neighbor 192.168.2.3 next-hop-self
 network 170.10.0.0 mask 255.255.0.0
!
ip route 170.10.0.0 255.255.0.0 null0
```

# Router C Configuration

```
interface Loopback 0
 ip address 192.168.2.3 255.255.255.255
!
interface FastEthernet 0/0
 description Link to RouterY
 ip address 192.168.3.1 255.255.255.252
!
router bgp 65534
 bgp confederation identifier 131076
 neighbor 192.168.3.2 remote 123
 neighbor 192.168.3.2 eBGP with RouterY
 neighbor 192.168.2.1 remote 65534
 neighbor 192.168.2.1 iBGP with RouterA
 neighbor 192.168.2.1 next-hop-self
 neighbor 192.168.2.2 remote 65534
 neighbor 192.168.2.2 iBGP with RouterB
 neighbor 192.168.2.2 next-hop-self
!
```

# Router Y Configuration

- Router Y is in AS123
  - Does not support configuration of 4-byte ASNs

```
interface FastEthernet 0/0
 description Link to RouterC
 ip address 192.168.3.2 255.255.255.252
!
router bgp 123
 neighbor 192.168.3.1 remote 23456
 neighbor 192.168.3.1 descr eBGP with RouterC in AS131076
 network 160.10.0.0 mask 255.255.0.0
!
ip route 160.10.0.0 255.255.0.0 null0
```

# Commentary

- Only the edge routers, Router A and C, need to know about the confederation and carry the confederation configuration
  - Router B (and any other router participating in the iBGP) believe they are running in AS65534
  - The edge routers will remove the internal AS and present the confederation AS to eBGP neighbours

# BGP on Router X

- Router X supports 4-byte ASNs
  - Sees AS131076 and AS123 transit

```
RouterX>sh ip bgp
BGP table version is 4, local router ID is 192.168.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
   internal, r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop         Metric LocPrf Weight Path
*> 160.10.0.0       192.168.1.2                         0 131076 123 i
*> 170.10.0.0       192.168.1.2                         0 131076 i
*> 180.10.0.0       0.0.0.0               0         32768 i
```

# BGP on Router A

- Router A supports 4-byte ASNs
  - iBGP with B and C, eBGP with X

```
RouterA>sh ip bgp
BGP table version is 4, local router ID is 192.168.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
   internal, r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i160.10.0.0       192.168.2.3              0    100      0 123 i
*>i170.10.0.0       192.168.2.2              0    100      0 i
*> 180.10.0.0       192.168.1.1              0             0 131072 i
```

# BGP on Router B

- Router B does not support 4-byte ASNs
  - iBGP with B and C; 4-byte ASNs seen as AS23456

```
RouterB>sh ip bgp
BGP table version is 4, local router ID is 192.168.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i -
   internal, r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i160.10.0.0       192.168.2.3              0    100      0 123 i
*> 170.10.0.0       0.0.0.0                  0         32768 i
*>i180.10.0.0       192.168.2.1              0    100      0 23456 i
```

# BGP on Router C

- Router C supports 4-byte ASNs
  - iBGP with A and B, eBGP with Y

```
RouterC>sh ip bgp
BGP table version is 4, local router ID is 192.168.2.3
Status codes: s suppressed, d damped, h history, * valid, > best, i -
   internal, r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 160.10.0.0       192.168.3.2              0             0 123 i
*>i170.10.0.0       192.168.2.2              0    100      0 i
*>i180.10.0.0       192.168.2.1              0    100      0 131072 i
```

# BGP on Router Y

- Router Y does not support 4-byte ASNs
  - eBGP with C; 4-byte ASNs seen as AS23456

```
RouterY>sh ip bgp
BGP table version is 4, local router ID is 192.168.3.2
Status codes: s suppressed, d damped, h history, * valid, > best, i -
   internal, r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 160.10.0.0       0.0.0.0                  0         32768 i
*> 170.10.0.0       192.168.3.1                            0 23456 i
*> 180.10.0.0       192.168.3.1                            0 23456 23456 i
```

# BGP Confederation “hack”

- Not really a hack, but a workaround so that non-eBGP speaking backbone routers can participate in iBGP using 4-byte ASNs
- Important:
  - eBGP routers (border and aggregation edge) must support 4-byte ASNs
  - Multiple internal ASNs can work provided that internal AS edge routers (eiBGP speakers) support 4-byte ASNs too; they require:

```
bgp confederation identifier <4-byte-ASN>
```

# Summary

- Deploying 4-byte ASNs can be done three ways:
  - Entire iBGP mesh (upgrading software and/or routers as appropriate)
  - Omit non-4-byte ASN routers from iBGP mesh, or treat them as pseudo BGP customers (like RFC2270)
  - Using the BGP Confederation "hack"
- Or return 4-byte ASN to RIR in exchange for 2-byte ASN (if possible)

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