4 Byte ASN with Cisco IOS Software
4 Byte AS

- RFC 4271 defines an AS number as 2-bytes
- Private AS Numbers = 64512 through 65535
- Public AS Numbers = 1 through 64511
  - 39000+ have already been allocated
  - We will eventually run out of AS numbers
- Need to expand AS size from 2-bytes to 4-bytes
  - 4,294,967,295 AS numbers
  - Cannot have a “flag day” solution
    - On Jan 1, 2010 - all BGP speakers must support feature FOO
    - Solution must support a gradual deployment
### 4 Byte AS

- **RFC4893** – “BGP Support for Four-octet AS Number Space”
  Provides 4-byte AS support without a flag day
- **RFC5396** – “Textual Representation of Autonomous System (AS) Numbers”

| ASDOT | • Representation is based upon the existing 2-Byte AS representation  
• The full binary 4-byte AS number is split two words of 16 bits each  
• Notation: \(<\text{higher2bytes in decimal}.<\text{lower2bytes in decimal}>\)  
For example: AS 65546 is represented as “1.10”  
• Easy to read, however hard for regular expressions  
| Note: If the higher order 16 bits represent the value of a decimal zero, then the 4-Byte AS can be represented in as the traditionally well known 2-Byte AS format |

| ASPLAIN | • IETF preferred notation  
• Continuation on how a 2-Byte AS number has been represented historically  
• Notation: The 32 bit binary AS number is translated into a Single decimal value  
Example: AS 65546 |
4-byte AS

- 4-byte AS support is advertised via BGP capability negotiation
  - Speakers who support 4-byte AS are known as NEW BGP speakers
  - Those who do not are known as OLD BGP speakers

- New Reserved AS#
  - AS_TRANS = AS #23456
  - 2-byte placeholder for a 4-byte AS number
  - Used for backward compatibility between OLD and NEW BGP speakers

- Two new attributes, both are “optional transitive”
  - AS4_AGGREGATOR
  - AS4_PATH
UPDATE Message

- Unfeasible Routes Length (2 bytes)
- Withdrawn Routes (variable)
- Total Path Attribute Length (2 bytes)
- Path Attributes (variable)
- Length (1 byte) Prefix (1 byte)
- <Length, Prefix>

Attribute can contain 4-byte AS entries: AS_PATH, AS_AGGREGATOR, RT, SoO

Unreachable Routes Information
Path Attribute Information
NLRI Information
4 Byte AS

- Formatting UPDATEs for a NEW speaker
  Encode each AS number within the AS_PATH in 4-bytes
  AS_PATH and AGGREGATOR attributes are affected
  For VPN Route-Target (RT) and Site-of-Origin (SoO) are affected also

- Formatting UPDATEs for an OLD speaker
  If the AGGREGATOR/ASPATH does not contain a non-2-byte mappable 4-byte AS we are fine
  If it does, substitute AS_TRANS (AS #23456) for each 4-byte AS
  AS4_AGGREGATOR and/or AS4_ASPATH will contain a 4-byte encoded copy of the attribute if needed
  OLD speaker will blindly pass along NEW_AGGREGATOR and NEW_ASPATH attributes
4 Byte AS

• Receiving UPDATEs from a NEW speaker
  Decode each AS number as 4-bytes
  AS_PATH and AGGREGATOR are effected

• Receiving UPDATEs from an OLD speaker
  AS4_AGGREGATOR will override AGGREGATOR
  AS4_PATH and ASPATH must be merged to form the correct as-path

• Merging NEW_ASPATH and ASPATH
  ASPATH – 275 250 225 23456 23456 200 23456 175
  NEW_ASPATH – 100.1 100.2 200 100.3 175
  Merged as-path – 275 250 225 100.1 100.2 200 100.3 175
Mappable Autonomous System Numbers

2 Byte Autonomous System

Autonomous System # 200

Translate in Binary

8 bits

11001000

16 bits

00000000 11001000

16 bits

4 Byte Autonomous System

All "ZERO"

All "ZERO"

32 bits

16 bits 16 bits

0000 0000 0000 0000 0000 0000 1100 1000

32 bits

16 bits 16 bits

0000 0000 1100 1000

Autonomous System # 50000

Translate in Binary

16 bits

11000011 01010000

16 bits

0000 0000 0000 0000 1100 0011 0101 0000

32 bits

16 bits 16 bits

0000 0000 0000 0000 0000 0000 0000 0000 1100 1000

32 bits

16 bits 16 bits

1100 0011 0101 0000
Backward Compatibility Mappable AS Numbers

NEW BGP Speaker – AS: 0.123

<table>
<thead>
<tr>
<th>4-byte AS Path</th>
<th>AS_PATH: 0.200, 0.2222, 0.300</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-byte AGGREGATOR Attribute</td>
<td>AGGREGATOR: 0.200</td>
</tr>
</tbody>
</table>

OLD BGP Speaker – AS: 100

<table>
<thead>
<tr>
<th>2-byte AS Path</th>
<th>AS_PATH: 123, 200, 2222, 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-byte AGGREGATOR Attribute</td>
<td>AGGREGATOR: 200</td>
</tr>
</tbody>
</table>

Normal AS Path Pre-pending
Backward Compatibility
Non-mappable AS Numbers

NEW BGP Speaker – AS: 123.200

100.1.1.0/24
4-byte AS Path
AS_PATH: 0.200, 100.200, 200.300

OLD BGP Speaker – AS: 100

100.1.1.0/24
2-byte AS Path
AS_PATH: 23456, 200, 23456, 23456

Each full non-Mappable AS entry will be swapped with well known AS_TRANS (23456) Autonomous Number
Backward Compatibility
Non-mappable AS Numbers (Cont.)

NEW BGP Speaker – AS: 123.200

100.1.1.0/24

4-byte AS Path
AS_PATH: 0.200, 100.200, 200.300

4-byte AGGREGATOR Attribute
AGGREGATOR: 100.200

OLD BGP Speaker – AS: 100

100.1.1.0/24

2-byte AS Path
AS_PATH: 23456, 200, 23456, 23456

4-byte AS Path
AS4_PATH: 123.200, 0.200, 100.200, 200.300

2-byte AGGREGATOR Attribute
AGGREGATOR: 23456

4-byte AGGREGATOR Attribute
AS4_AGGREGATOR: 100.200

Peers with
NEWLY CREATED ATTRAIBUTES
4 Byte AS

Operation Example

Merge AS-PATH
4 Byte AS

Aggregation Example

AS 100.1
10.1.1.1/32

AS 200
10.1.1.2/32

AS 100.2
10.1.1.3/32

10.1.1.0/24
AS_PATH: {23456,[23456,200]}
AS4_PATH: {100.3,[100.1,200,100.2]}
AGGREGATOR: 23456 1.1.1.1
AS4_AGGREGATOR: 100.3 1.1.1.1

AS 100.3

AS 100.3 creates 10.1.1.0/24 aggregate

AS 300

AS 400

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Considerations When My BGP Autonomous System Does Not Support 4-byte AS

- Filtering based on 4-byte AS Numbers is impossible on a OLD BGP speaker
- It is illegal to use the well known AS_TRANS as a BGP Autonomous System Number
- 4-byte AS Numbers can experience additional BGP memory utilization on OLD BGP speakers due to usage of AS4_PATH and AS4_AGGREGATOR attributes
- Due to AS_TRANS usage, the NetFlow v9 created traffic matrix may be gradually more and more incorrect when 4-byte AS numbers are really allocated to users on an OLD BGP speaker
- BGP route aggregation on an OLD BGP speaker may create routing BGP loops under certain conditions (ref. RFC4893)
- Upgrading an OLD BGP speaker peering with a non-mappable 4-byte neighbor AS will need a new neighbor configuration when being upgraded from an OLD BGP speaker to a NEW BGP speaker (swap AS “23456” with the real 4-byte ASN within the BGP neighbor statement)
- Due to the usage of AS_TRANS, this could result in the wrong usage of the MED metrics during BGP path selection (see next slides)
**MED - With 2-byte AS Transit**

```
bgp deterministic-med Enabled
no bgp always-compare-med
```

192.1/8

**Entry 1:** AS 65002, MED 200, RID=2.2.2.2
**Entry 2:** AS 65003, MED 100, RID=3.3.3.3

Best path is (65002 65004) since it has lowest RID.
MED - Old Speaker with 4b AS
Transit

bgp deterministic-med Enabled
no bgp always-compare-med

192.1/8
Entry 1: AS 23456, MED 100, RID=3.3.3.3
Entry 2: AS 23456, MED 200, RID=2.2.2.2

Neighbor AS is seen as “23456” on the old speaker. Hence, best path is (1.3 65004) instead since it has lowest MED

Rid=2.2.2.2

Rid=3.3.3.3

For your reference
MED - New Speaker with 4b AS Transit

- bgp deterministic-med Enabled
- no bgp always-compare-med

192.1/8
Entry 1: AS 1.2, MED 200, RID=2.2.2.2
Entry 2: AS 1.3, MED 100, RID=3.3.3.3

Neighbor AS is seen as 1.2 and 1.3 on the new speaker. Hence, best path is (1.2 65004) instead since it has lowest RID.
Configuration

router bgp 4.4
bgp log-neighbor-changes
neighbor 134.0.0.3 remote-as 3.3

R4#sh ip bgp 1.1.1.0
BGP routing table entry for 1.1.1.0/24, version 2
Paths: (1 available, best #1, table default)
Flag: 0x820
   Not advertised to any peer
   3.3 2 1.1
      134.0.0.3 from 134.0.0.3 (134.0.0.3)
         Origin IGP, localpref 100, valid, external, best

R4#sh ip bgp sum
BGP router identifier 134.0.0.4, local AS number 4.4
BGP table version is 2, main routing table version 2
1 network entries using 124 bytes of memory
1 path entries using 52 bytes of memory
2/1 BGP path/bestpath attribute entries using 184 bytes of memory
1 BGP AS-PATH entries using 40 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 400 total bytes of memory
BGP activity 1/0 prefixes, 1/0 paths, scan interval 60 secs
Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd
134.0.0.3 4 3.3 28 27 2 0 00:25:33 1
R3#sh ip rout | include B
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
B  2.2.2.0 [20/0] via 123.0.0.2, 00:11:01
B  192.0.0.0/24 [20/0] via 123.0.0.2, 00:11:01
R3#sh ip route 192.0.0.0
Routing entry for 192.0.0.0/24
Known via "bgp 3.3", distance 20, metric 0
Tag 2, type external
Redistributing via ospf 1
Advertised by ospf 1
Last update from 123.0.0.2 00:12:14 ago
Routing Descriptor Blocks:
  * 123.0.0.2, from 123.0.0.2, 00:11:09 ago
    Route metric is 0, traffic share count is 1
    AS Hops 1
    Route tag 2

ip as-path access-list 1 permit ^1\|4\$
router bgp 1
neighbor 4.4.4.4 remote-as 1.4
neighbor 4.4.4.4 route-map foo in
route-map foo permit 10
  match as-path 1

Note that the “.” must be escaped from the regular expression with a “\”
References

- RFC4893 – “BGP Support for Four-octet AS Number Space”
- RFC2842 – “Capabilities Advertisement with BGP-4 ”
- 16-bit AS Number Report
  [http://www.potaroo.net/tools/asn16/](http://www.potaroo.net/tools/asn16/)
- ARIN, AS Number Change on 1 January 2009
  [http://www.arin.net/announcements/07242008.html](http://www.arin.net/announcements/07242008.html)
- RIPE NCC, AS Number change could affect Internet routing from 1 January 2009
- APNIC, AS number change could affect Internet routing from 1 January 2009
RFC4360: BGP Extended Communities Attribute

**Type High** | **Type Low** |
---|---|

**Value**

RFC4360: Route-Target Extended Communities Attribute – 2 Byte AS

**00** | **02** |

2-Byte Autonomous System Number

RFC4360: SOO Extended Communities Attribute - 2 Byte AS

**00** | **03** |

2-Byte Autonomous System Number

For your reference
Four-octet AS Specific BGP Extended Community

Route-Target Extended Communities Attribute – 4 Byte AS

SOO Extended Communities Attribute - 4 Byte AS