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:**
	     <higher2bytes in decimal>.<lower2bytes in decimal>
	     For example: AS 65546 is represented as "1.10"
	• **Easy to read, however hard for regular expressions**
	<u>Note:</u> 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#

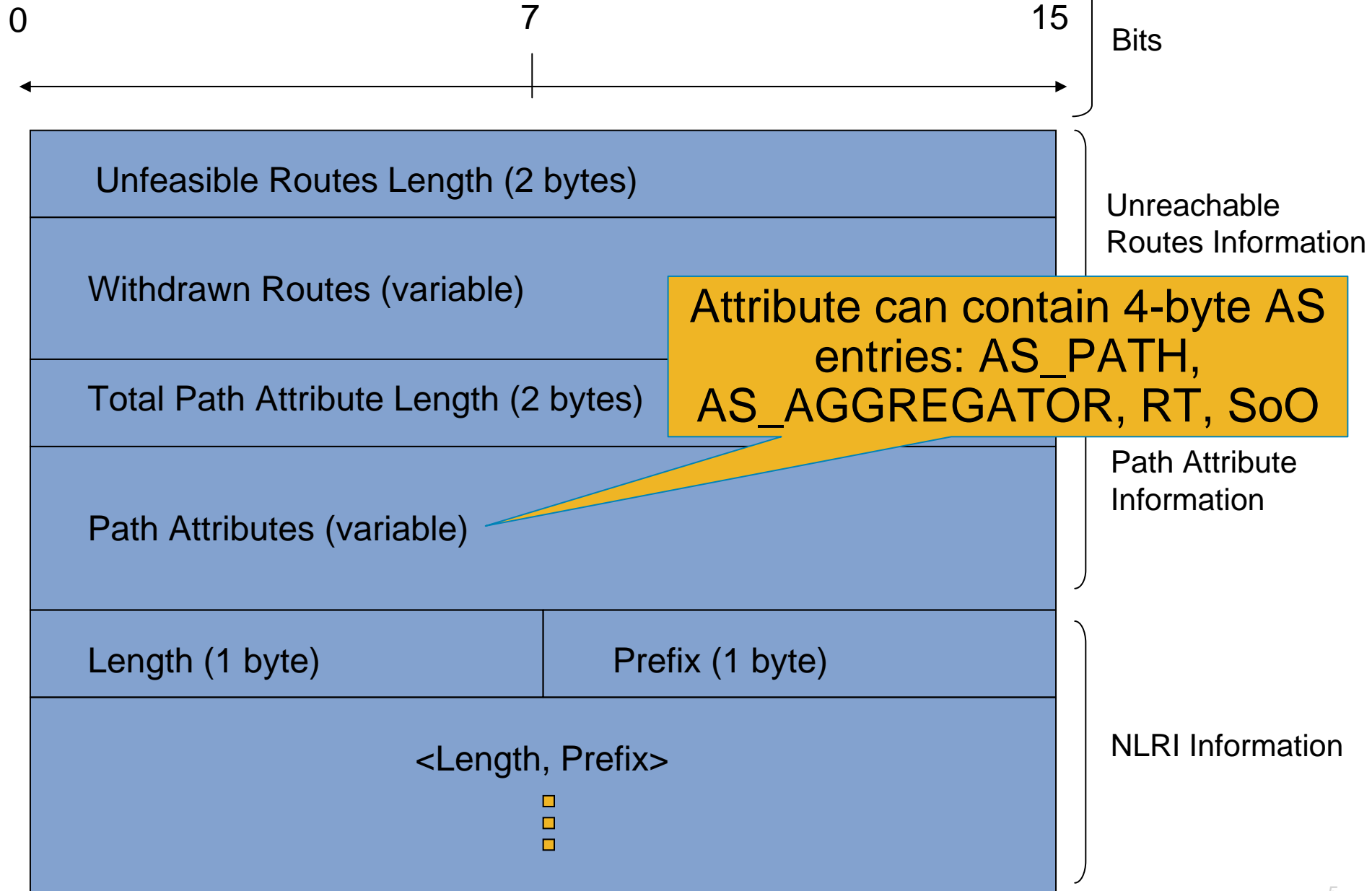 AS_TRANS = AS #23456

  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

0   7   15   Bits

Unfeasible Routes Length (2 bytes)

> Unreachable Routes Information

Withdrawn Routes (variable)

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

Total Path Attribute Length (2 bytes)

> Path Attribute Information

Path Attributes (variable)

Length (1 byte)	Prefix (1 byte)

<Length, Prefix>

▪
▪
▪

> 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
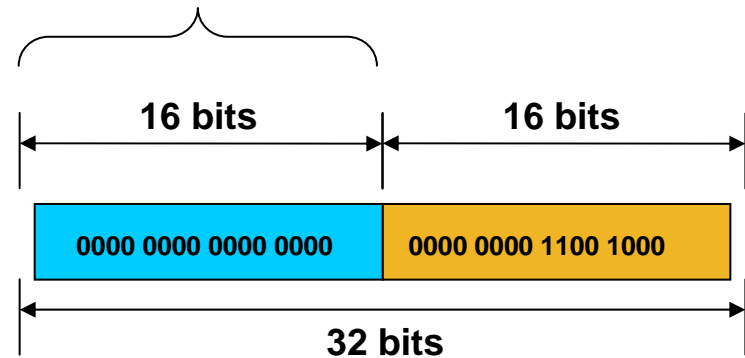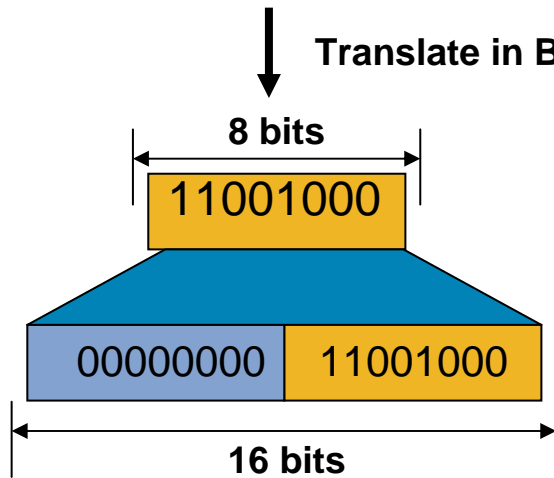
- Merging NEW_ASPATH and ASPATH

    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
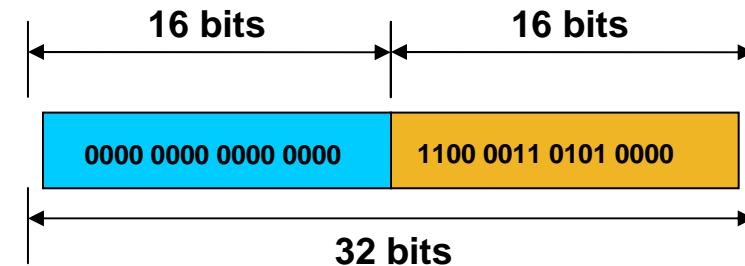
Mappable Autonomous System Numbers

2 Byte Autonomous System → **Mappable AS** → 4 Byte Autonomous System

Autonomous System # 200   All "ZERO"

Translate in Binary

8 bits

11001000

00000000 | 11001000

16 bits

16 bits | **16 bits**

0000 0000 0000 0000 | 0000 0000 1100 1000

32 bits

Autonomous System # 50000

Translate in Binary

16 bits

11000011 01010000

16 bits | **16 bits**

0000 0000 0000 0000 | 1100 0011 0101 0000

32 bits
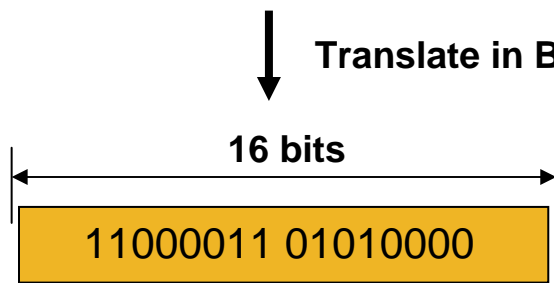
Backward Compatibility Mappable AS Numbers

NEW BGP Speaker – AS: 0.123

200.1.1.0/24

4-byte AS Path
AS_PATH: 0.200, 0.2222, 0.300

4-byte AGGREGATOR Attribute
AGGREGATOR: 0.200

Peers with →

OLD BGP Speaker – AS: 100

200.1.1.0/24

2-byte AS Path
AS_PATH: 123, 200, 2222, 300

2-byte AGGREGATOR Attribute
AGGREGATOR: 200

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

Peers with

OLD BGP Speaker – AS: 100

100.1.1.0/24

2-byte AS Path

AS_PATH: 23456, 200, 23456, 23456

**Normal AS Path
Pre-pending**

Each full non-Mappable AS entry will be swapped
with well known AS_TRANS (23456) Autonomous Number

Backward Compatibility
Non-mappable AS Numbers (Cont.)
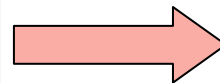
NEW BGP Speaker – AS: 123.200

> 100.1.1.0/24

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

> **4-byte AGGREGATOR Attribute**
> AGGREGATOR: 100.200

Peers with →

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

Newly created Attributes

4 Byte AS

Operation Example

AS_PATH: {100.1}

AS 100.1

10.0.0.0/8

AS_PATH: {700,100.1}

AS 700

AS 100.2

AS_PATH: {900,800,100.2,700,100.1}

AS 1000

AS_PATH: {23456,700,23456}
AS4_PATH: {100.2,700,100.1}

AS 800

AS 900

AS 100.3

Merge AS-PATH

AS_PATH: {800,23456,700,23456}
AS4_PATH: {100.2,700,100.1}

AS_PATH: {900,800,23456,700,23456}
AS4_PATH: {700,100.1}
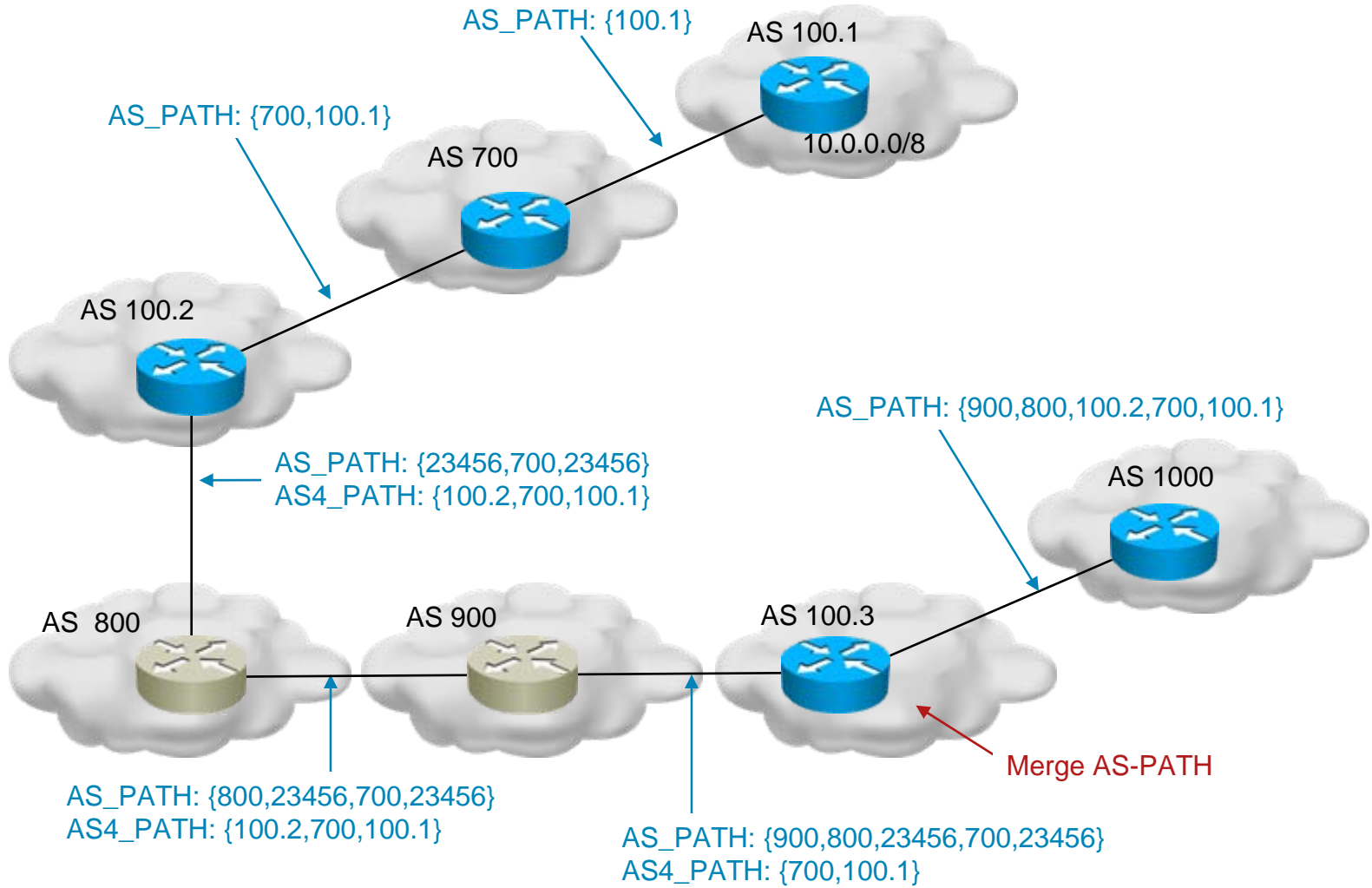
4 Byte AS
Aggregation Example

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

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

AS 100.3

AS 300

AS 400
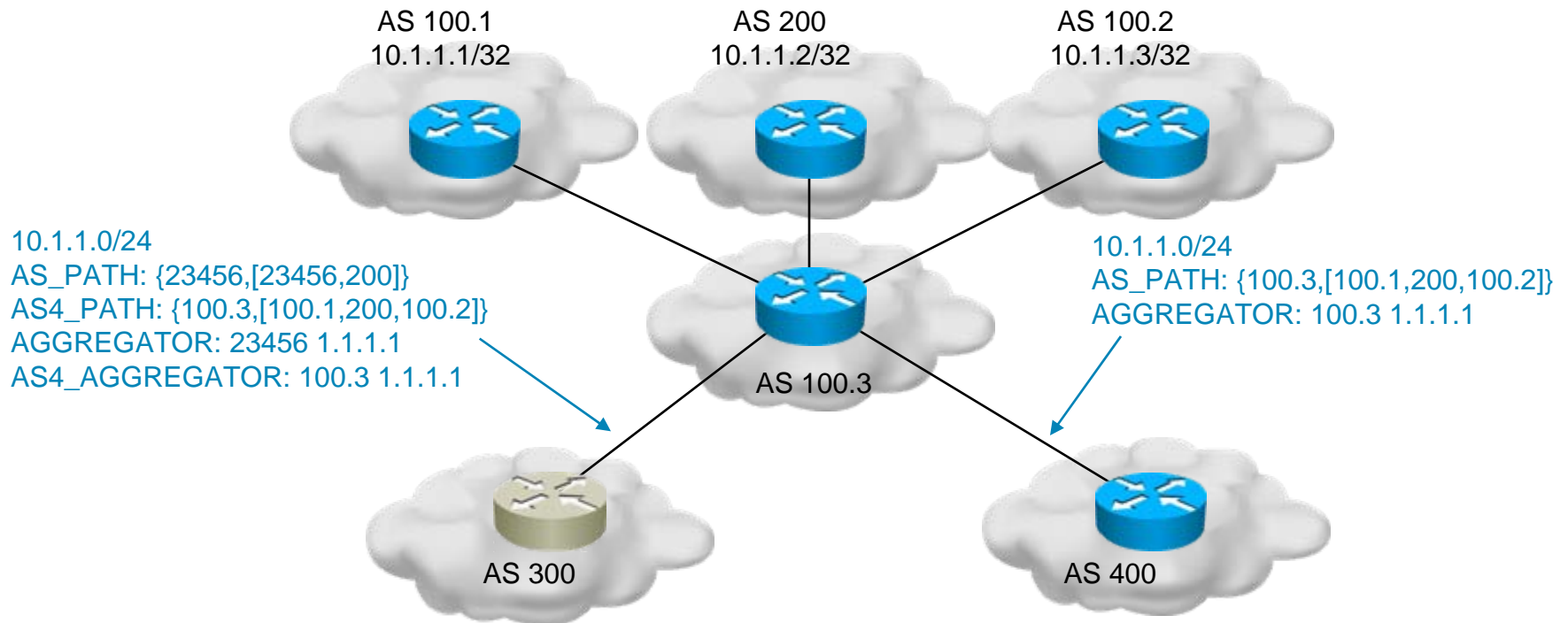
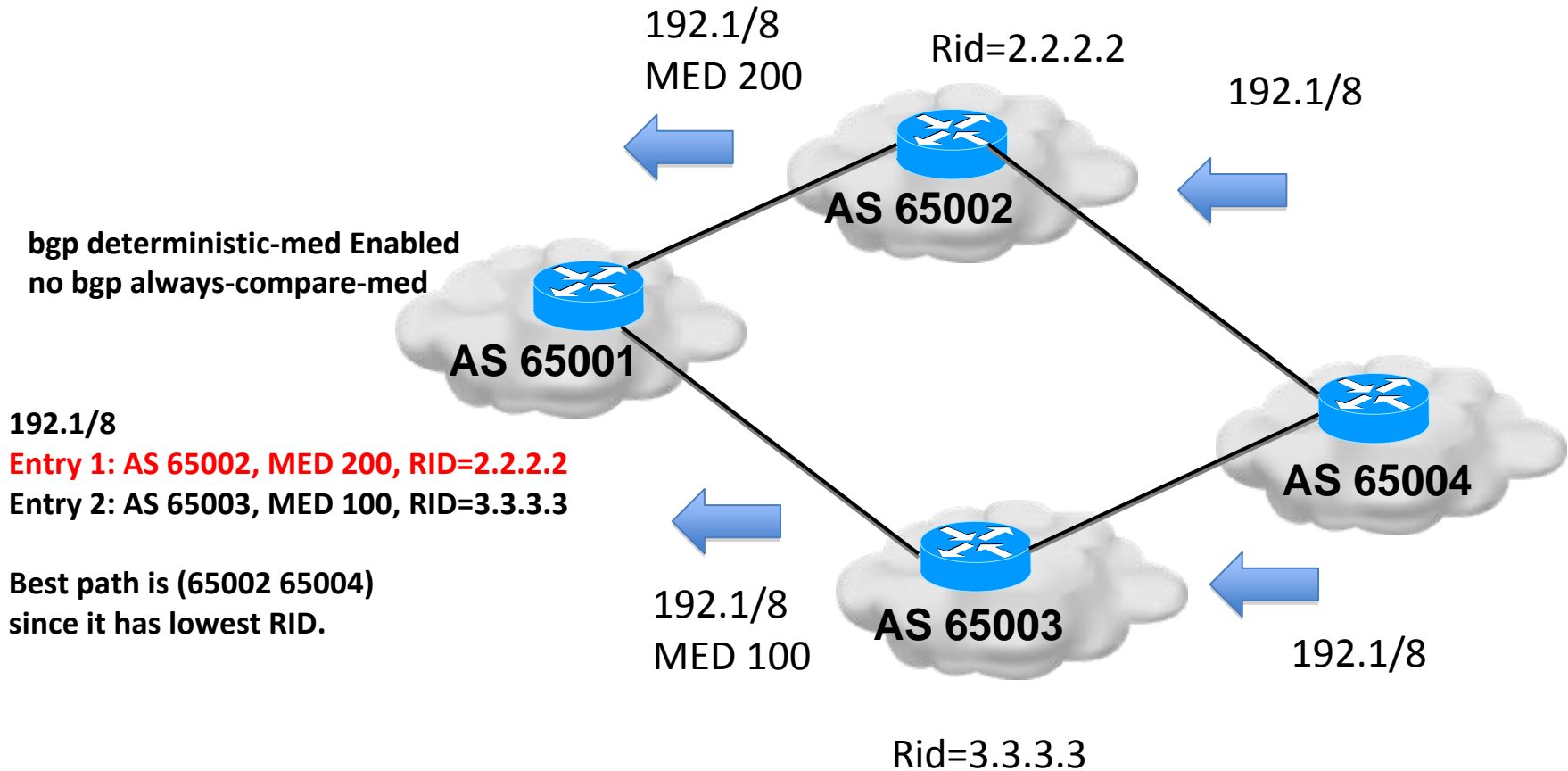- AS 100.3 creates 10.1.1.0/24 aggregate

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

192.1/8
MED 200

Rid=2.2.2.2

192.1/8

AS 65002

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

AS 65001

AS 65004

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.

192.1/8
MED 100

AS 65003

192.1/8

Rid=3.3.3.3

MED - Old Speaker with 4b AS Transit

192.1/8
MED 200

Rid=2.2.2.2

192.1/8

AS 1.2

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

OLD

AS 65001

Best BGP Path

AS 65004

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

192.1/8
MED 100

AS 1.3

192.1/8

Rid=3.3.3.3
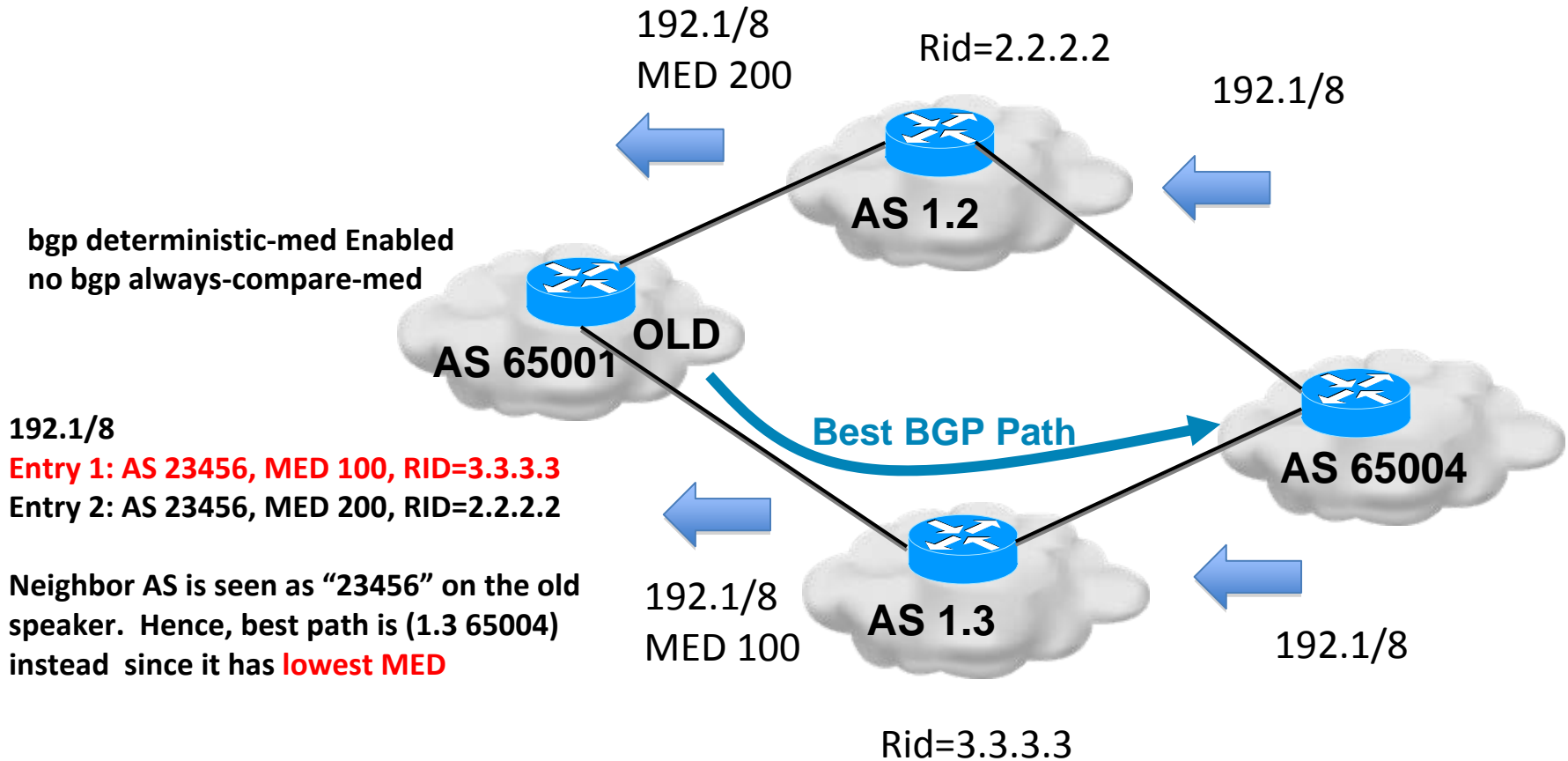
MED - New Speaker with 4b AS Transit

192.1/8
MED 200

Rid=2.2.2.2

192.1/8

AS 1.2

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

Best BGP Path

NEW

AS 65001

AS 65004

**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.**

192.1/8
MED 100

AS 1.3

192.1/8

Rid=3.3.3.3
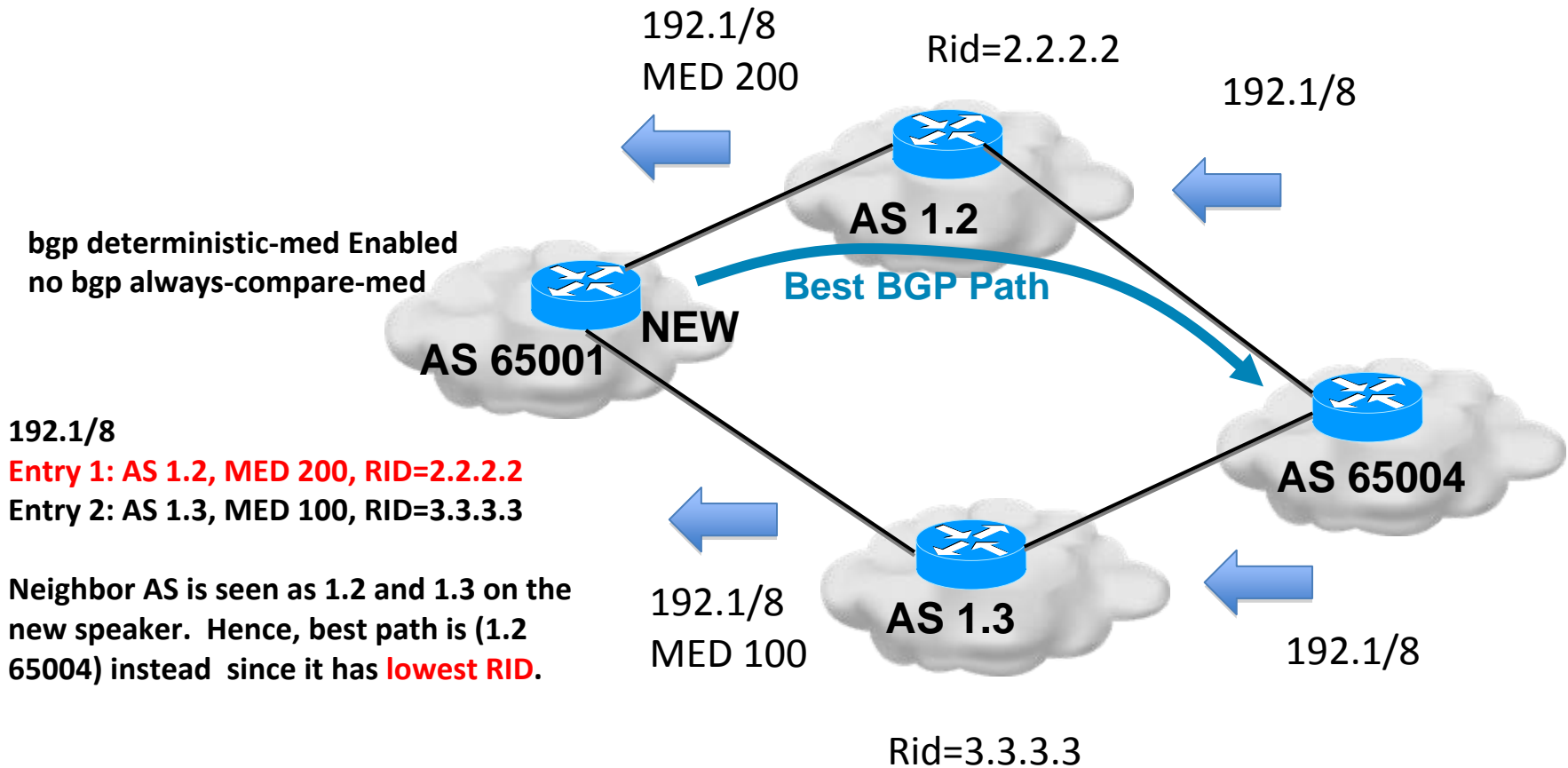
Configuration

For your reference

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

Neighbor Configuration

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

BGP Show Command

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
134.0.0.3	4	**3.3**	28	27	2	0	0	00:25:33	1

Configuration

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

Routing Show Commands

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 "\"
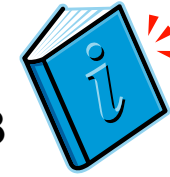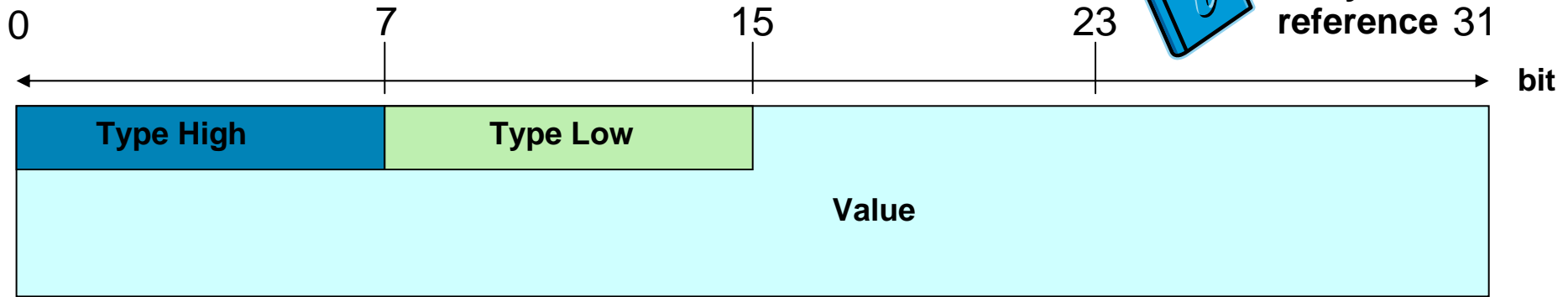
AS-PATH Filter for ASDOT notation

References

- RFC4893 – "BGP Support for Four-octet AS Number Space"

- RFC5396 – "Textual Representation of Autonomous System (AS) Numbers "

- RFC2842 – "Capabilities Advertisement with BGP-4 "

- 16-bit AS Number Report

  http://www.potaroo.net/tools/asn16/

- ARIN, AS Number Change on 1 January 2009

  http://www.arin.net/announcements/07242008.html

- RIPE NCC, AS Number change could affect Internet routing from 1 January 2009

  http://www.ripe.net/news/asn-32-pr2008.html

- APNIC, AS number change could affect Internet routing from 1 January 2009

  http://www.apnic.net/news/2008/0725.html

RFC4360: BGP Extended Communities Attribute

For your reference

```
0               7               15              23              31
|---------------|---------------|---------------|---------------|---> bit

| Type High     | Type Low      |                               |
|                        Value                                  |
```

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

```
0               7               15              23              31
|---------------|---------------|---------------|---------------|---> bit

| 00            | 02            |                               |
|              2-Byte Autonomous System Number                  |
```
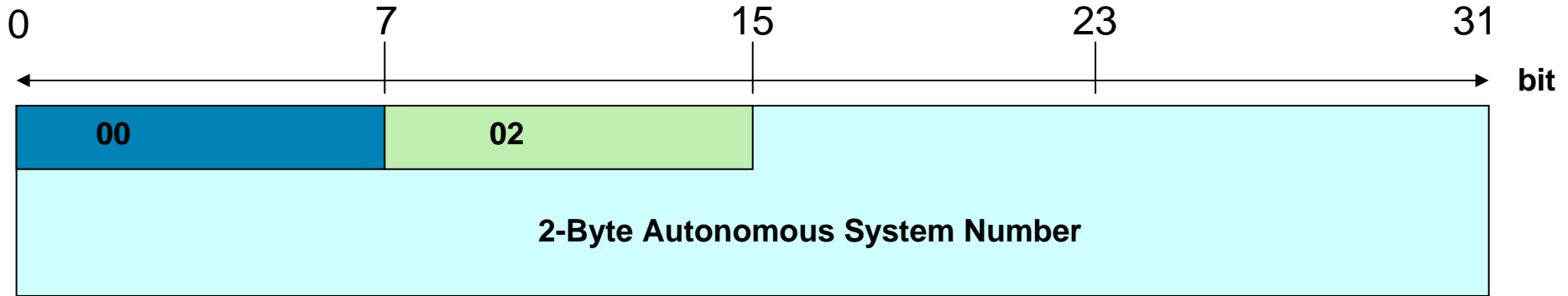
RFC4360: SOO Extended Communities Attribute - 2 Byte AS

```
0               7               15              23              31
|---------------|---------------|---------------|---------------|---> bit

| 00            | 03            |                               |
|              2-Byte Autonomous System Number                  |
```
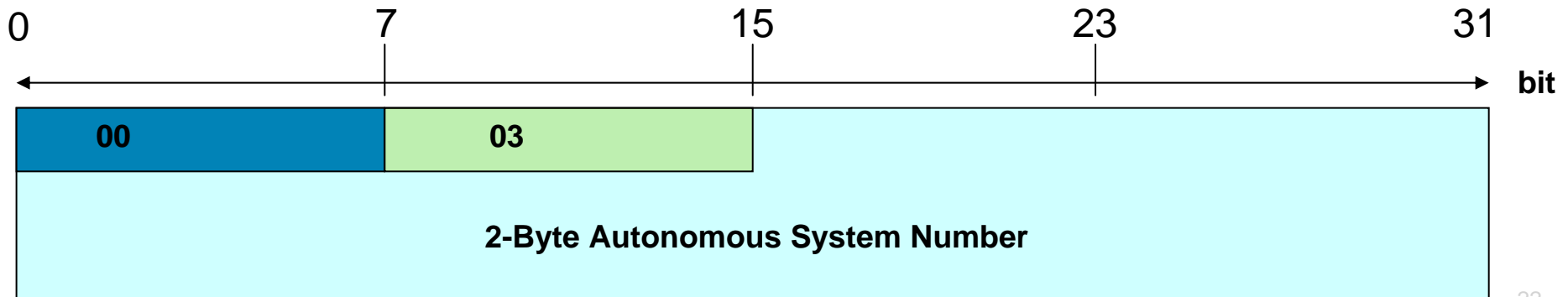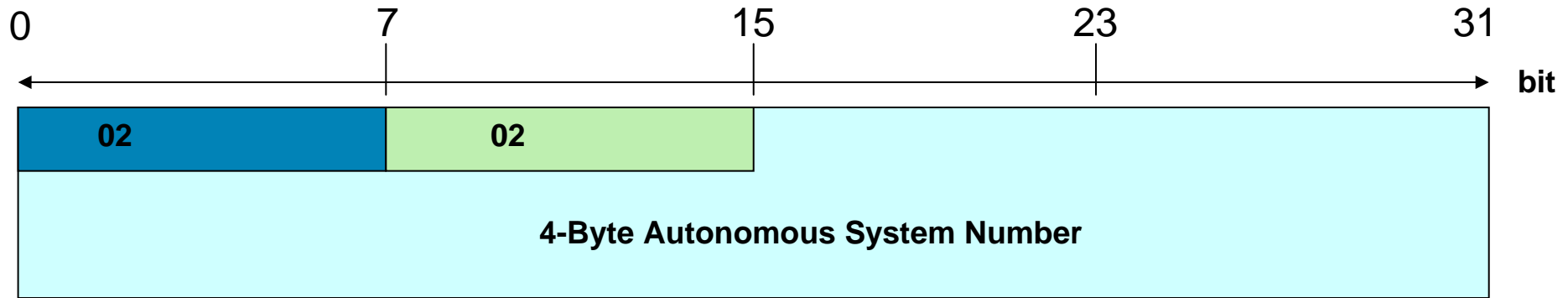
Four-octet AS Specific BGP Extended Community
(ietf-l3vpn-as4octet-ext-community-02.txt)

For your reference

Route-Target Extended Communities Attribute – 4 Byte AS

0	7	15	23	31

bit

02	02

4-Byte Autonomous System Number

SOO Extended Communities Attribute - 4 Byte AS

0	7	15	23	31

bit

02	03

4-Byte Autonomous System Number