BGP Attributes and BGP Path Selection

AfNOG 2012 AR-E Workshop

BGP Attributes

The “tools” available for the job

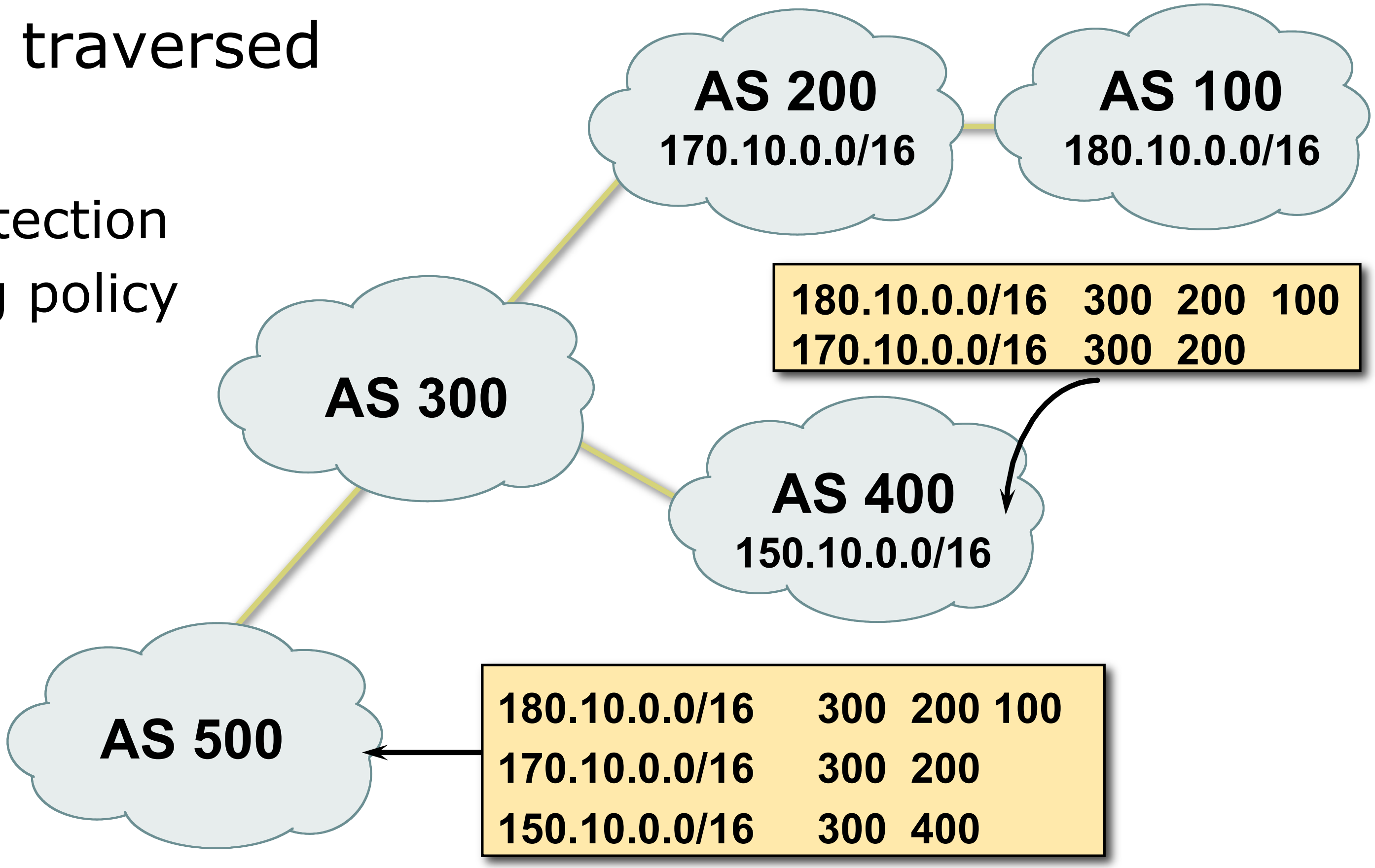
What Is an Attribute?

…	Next Hop	AS Path	MED	…	…

- Describes the characteristics of prefix
- Transitive or non-transitive
- Some are mandatory

AS-Path

- Sequence of ASes a route has traversed
- Used for:
  - Loop detection
  - Applying policy



AS 200
170.10.0.0/16

AS 100
180.10.0.0/16

AS 300

AS 400
150.10.0.0/16

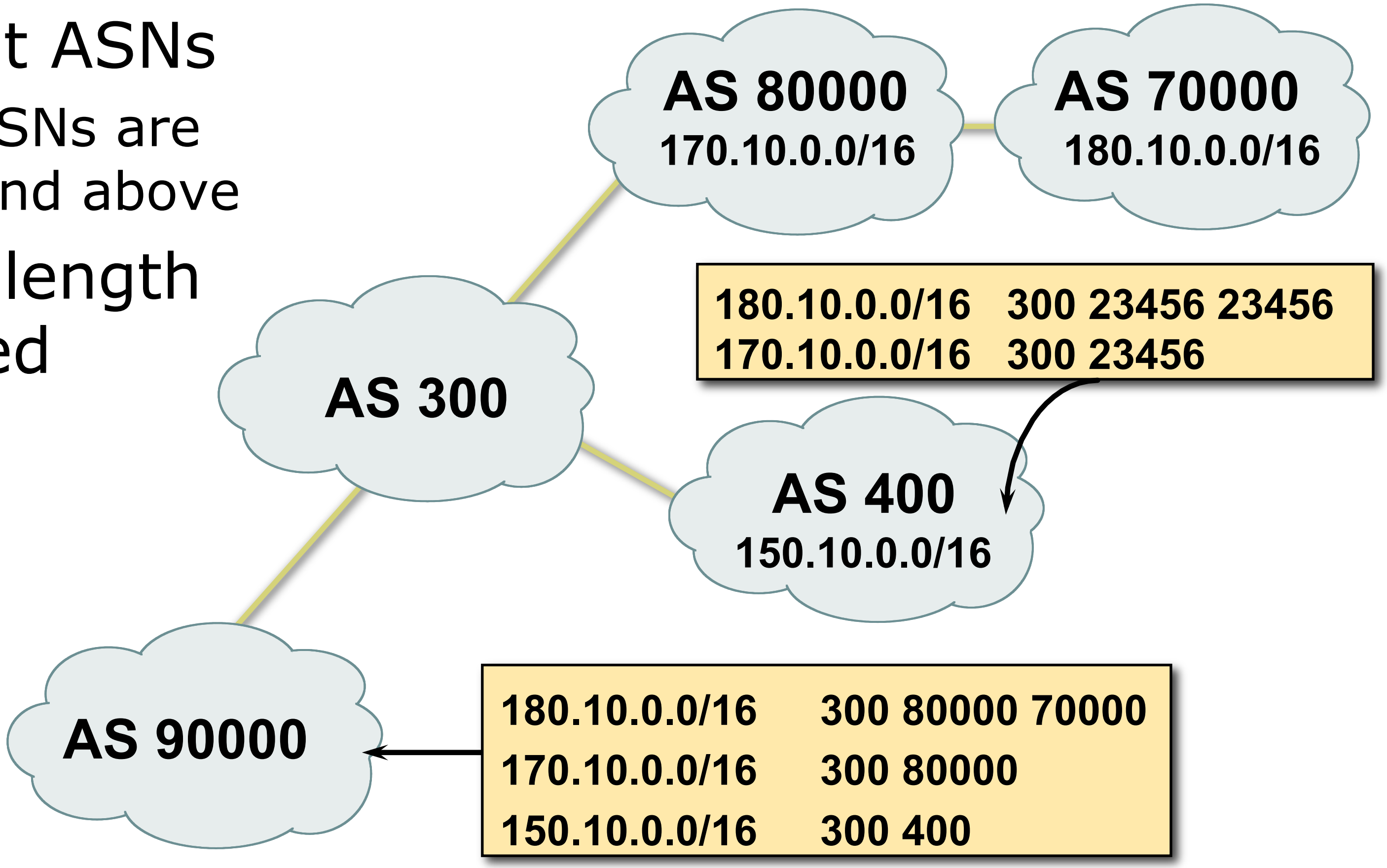
AS 500

180.10.0.0/16	300 200 100
170.10.0.0/16	300 200

180.10.0.0/16	300 200 100
170.10.0.0/16	300 200
150.10.0.0/16	300 400

AS-Path (with 16 and 32-bit ASNs)

- Internet with 16-bit and 32-bit ASNs
  - 32-bit ASNs are 65536 and above
- AS-PATH length maintained



AS 80000
170.10.0.0/16

AS 70000
180.10.0.0/16

AS 300

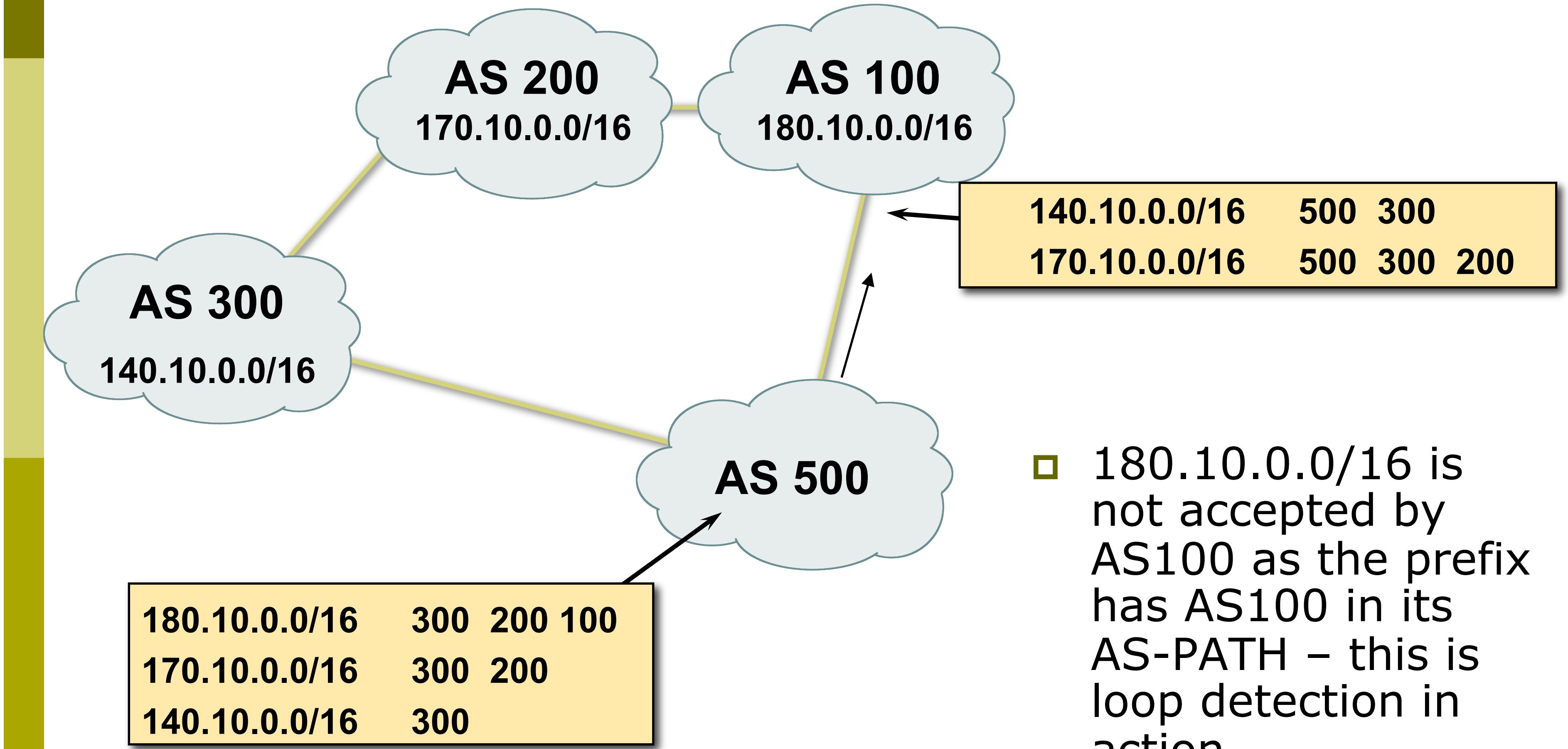
AS 400
150.10.0.0/16

AS 90000

180.10.0.0/16	300 23456 23456
170.10.0.0/16	300 23456

180.10.0.0/16	300 80000 70000
170.10.0.0/16	300 80000
150.10.0.0/16	300 400

AS-Path loop detection

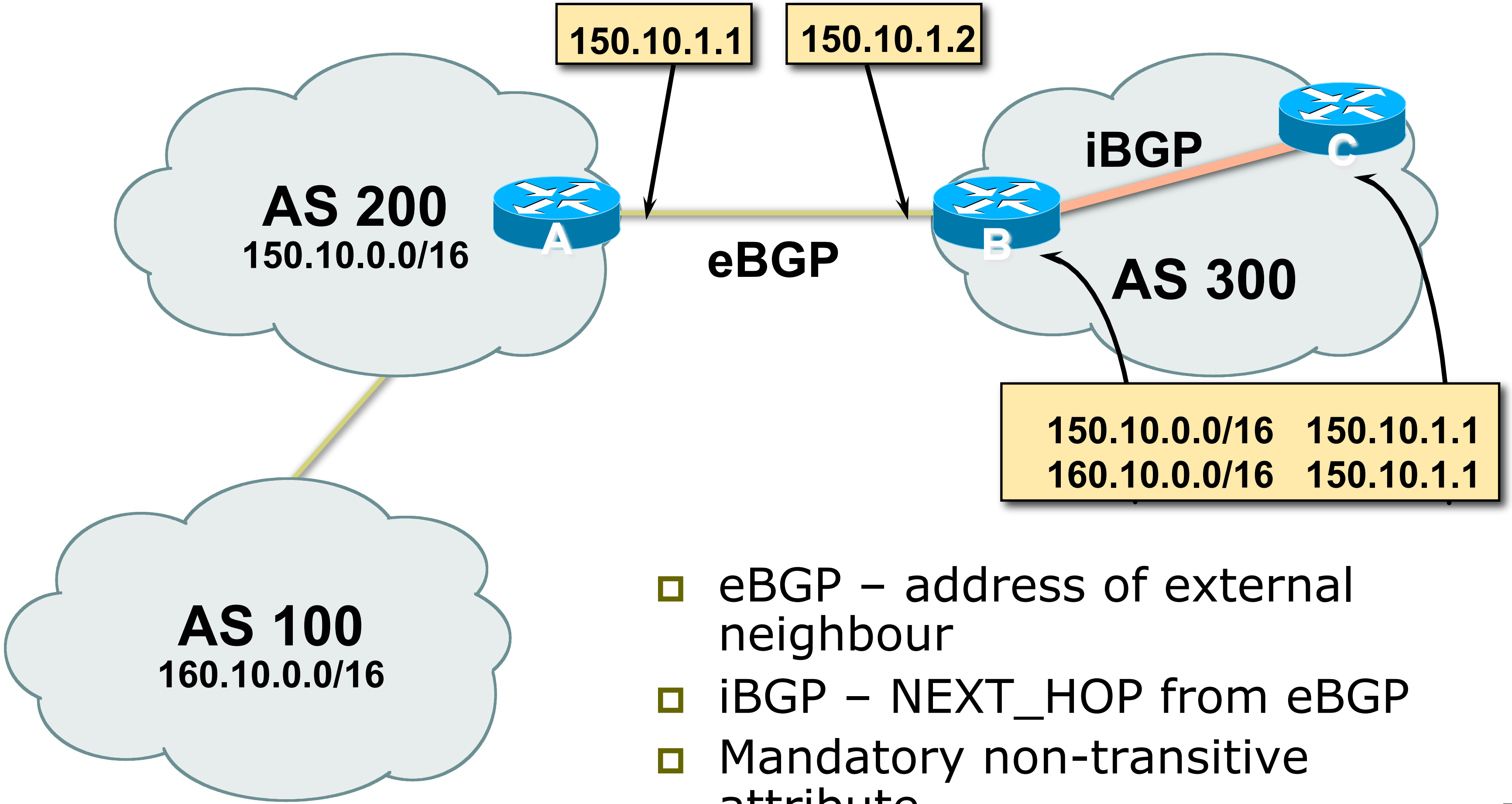


140.10.0.0/16	500 300
170.10.0.0/16	500 300 200

180.10.0.0/16	300 200 100
170.10.0.0/16	300 200
140.10.0.0/16	300

- 180.10.0.0/16 is not accepted by AS100 as the prefix has AS100 in its AS-PATH – this is loop detection in action

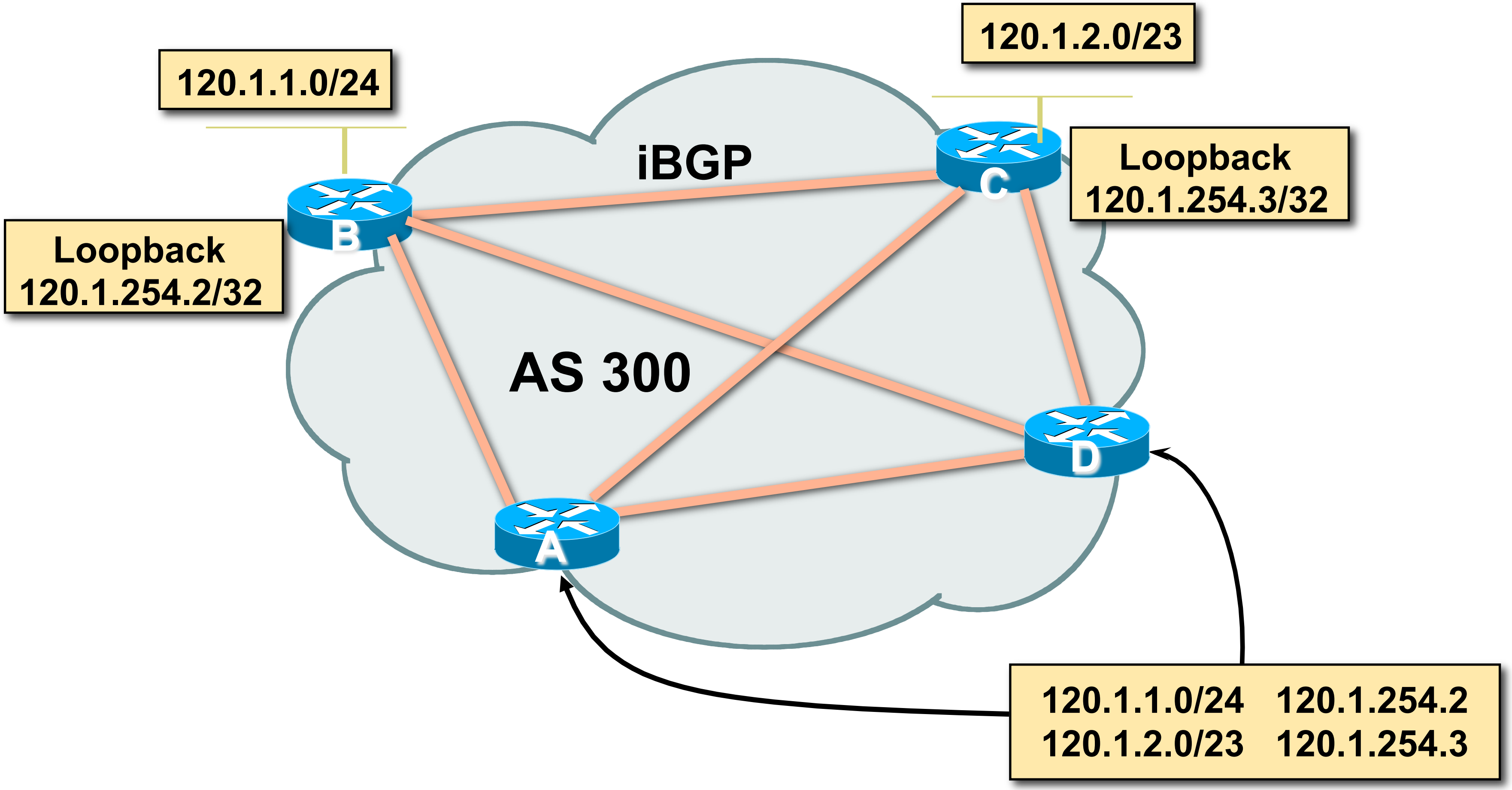
Next Hop



150.10.0.0/16	150.10.1.1
160.10.0.0/16	150.10.1.1

- eBGP – address of external neighbour
- iBGP – NEXT_HOP from eBGP
- Mandatory non-transitive attribute

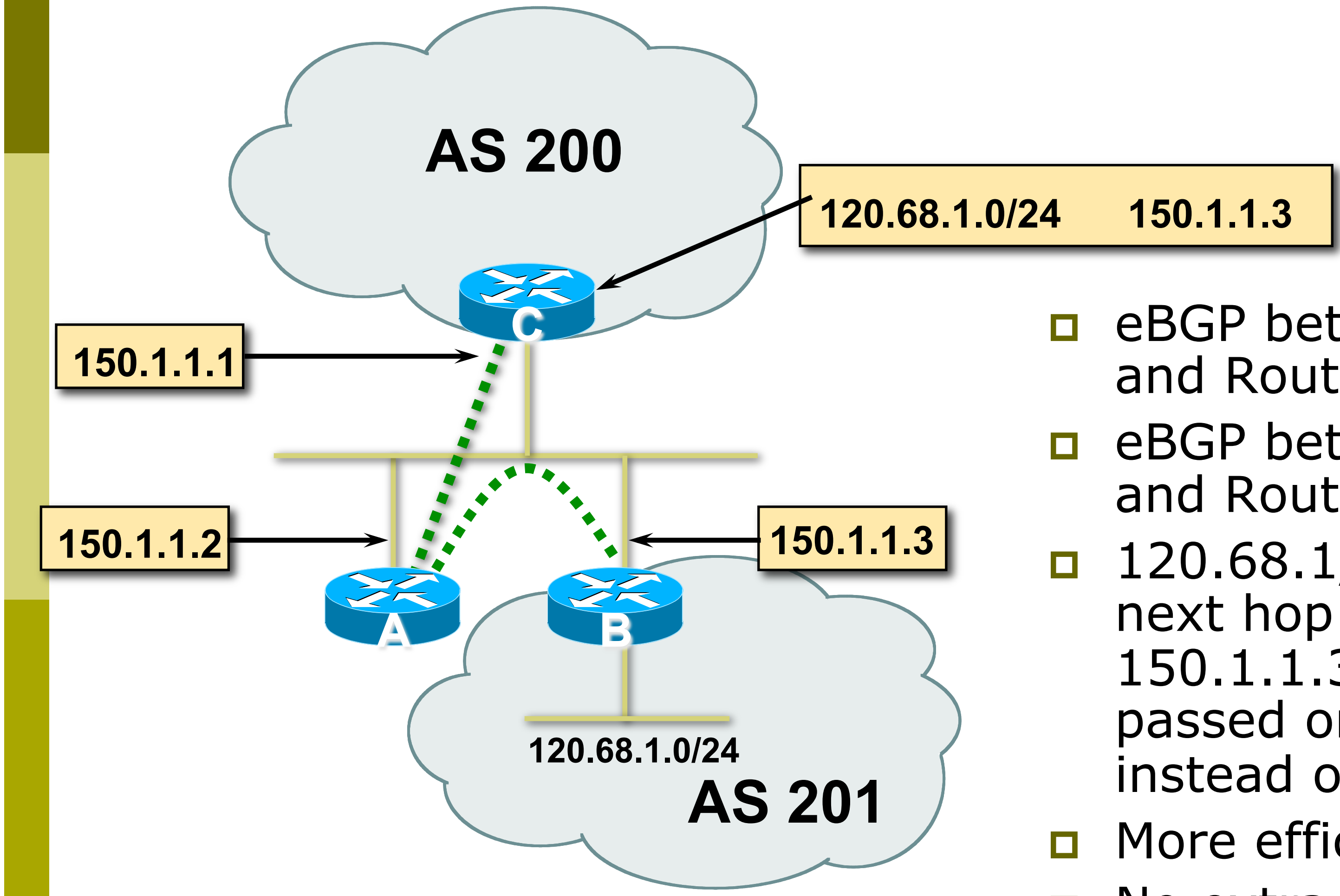
iBGP Next Hop



120.1.1.0/24	120.1.254.2
120.1.2.0/23	120.1.254.3

- Next hop is ibgp router loopback address
- Recursive route look-up

Third Party Next Hop



- eBGP between Router A and Router C
- eBGP between RouterA and RouterB
- 120.68.1/24 prefix has next hop address of 150.1.1.3 – this is passed on to RouterC instead of 150.1.1.2
- More efficient
- No extra config needed

Next Hop Best Practice

- Cisco IOS default is for external next-hop to be propagated unchanged to iBGP peers
  - This means that IGP has to carry external next-hops
  - Forgetting means external network is invisible
  - With many eBGP peers, it is unnecessary extra load on IGP
- ISP Best Practice is to change external next-hop to be that of the local router

```
neighbor x.x.x.x next-hop-self
```

Next Hop (Summary)

- IGP should carry route to next hops
- Recursive route look-up
- Unlinks BGP from actual physical topology
- Use “next-hop-self” for external next hops
- Allows IGP to make intelligent forwarding decision

Origin

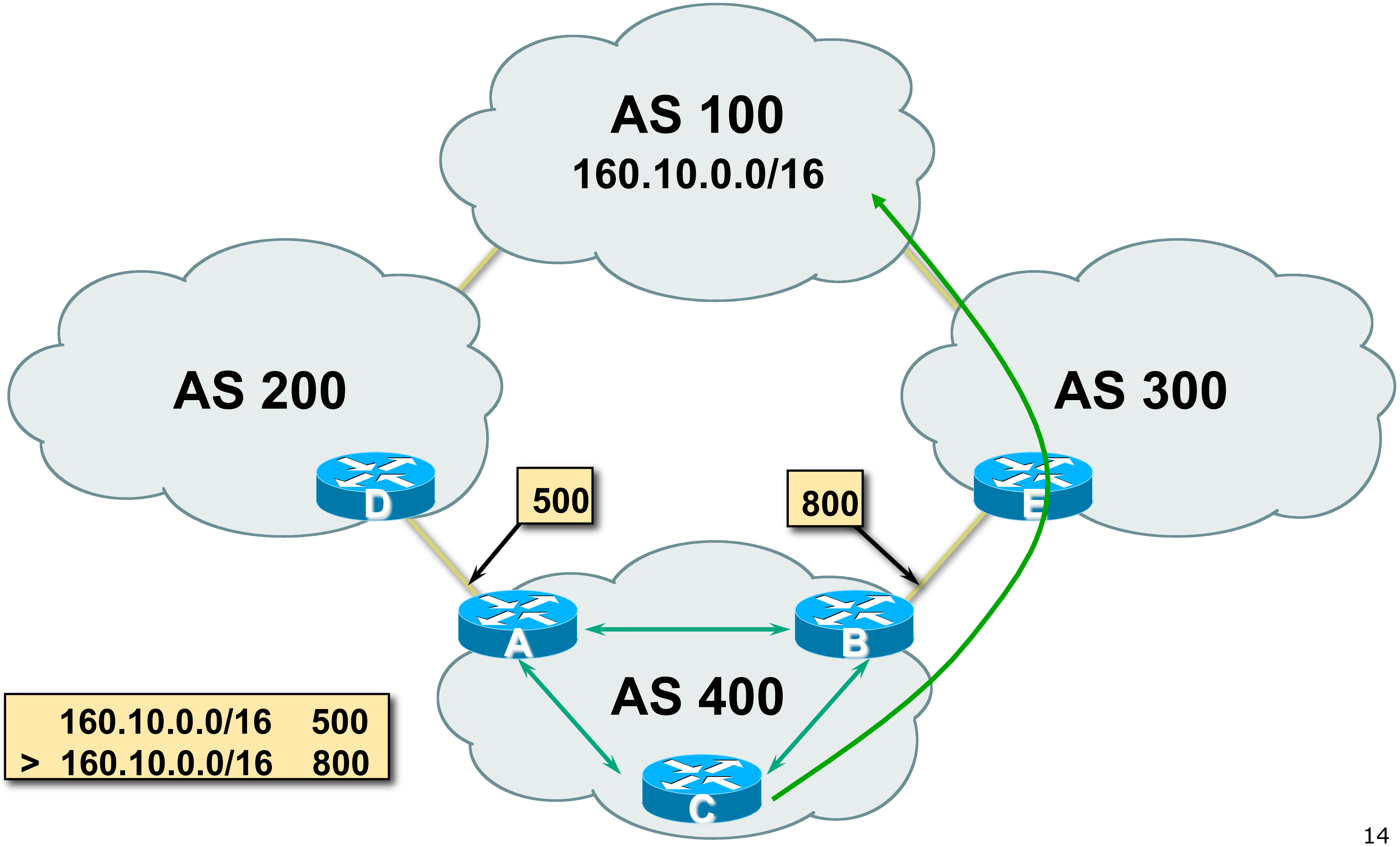
- Conveys the origin of the prefix
- Historical attribute
  - Used in transition from EGP to BGP
- Transitive and Mandatory Attribute
- Influences best path selection
- Three values: IGP, EGP, incomplete
  - IGP – generated by BGP network statement
  - EGP – generated by EGP
  - incomplete – redistributed from another routing protocol

Aggregator

- Conveys the IP address of the router or BGP speaker generating the aggregate route
- Optional & transitive attribute
- Useful for debugging purposes
- Does not influence best path selection
- Creating aggregate using “aggregate-address” sets the aggregator attribute:

```
router bgp 100
 aggregate-address 100.1.0.0 255.255.0.0
```

Local Preference



```
   160.10.0.0/16    500
>  160.10.0.0/16    800
```

Local Preference

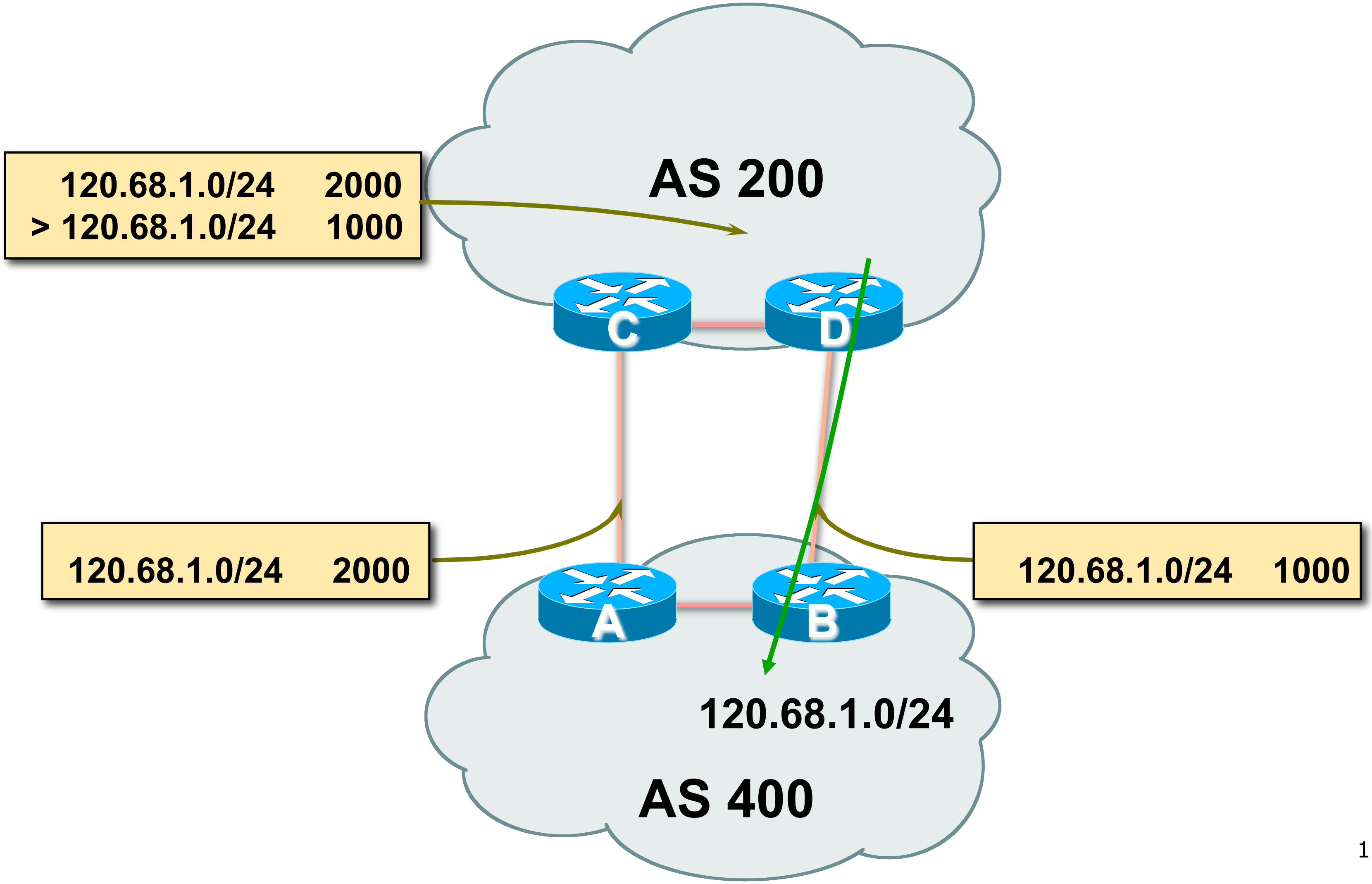
- Non-transitive and optional attribute
- Local to an AS only
  - Default local preference is 100 (IOS)
- Used to influence BGP path selection
  - determines best path for *outbound* traffic
- Path with highest local preference wins

Local Preference

- Configuration of Router B:

```
router bgp 400
 neighbor 120.5.1.1 remote-as 300
 neighbor 120.5.1.1 route-map local-pref in
!
route-map local-pref permit 10
 match ip address prefix-list MATCH
 set local-preference 800
route-map local-pref permit 20
!
ip prefix-list MATCH permit 160.10.0.0/16
```

Multi-Exit Discriminator (MED)



Multi-Exit Discriminator

- Inter-AS – non-transitive & optional attribute
- Used to convey the relative preference of entry points
  - determines best path for inbound traffic
- Comparable if paths are from same AS
  - **`bgp always-compare-med`** allows comparisons of MEDs from different ASes
- Path with lowest MED wins
- Absence of MED attribute implies MED value of **zero** (RFC4271)

MED & IGP Metric

- IGP metric can be conveyed as MED
  - **`set metric-type internal`** in route-map
    - enables BGP to advertise a MED which corresponds to the IGP metric values
    - changes are monitored (and re-advertised if needed) every 600s
    - **`bgp dynamic-med-interval <secs>`**

Multi-Exit Discriminator

- Configuration of Router B:

```
router bgp 400
 neighbor 120.5.1.1 remote-as 200
 neighbor 120.5.1.1 route-map set-med out
!
route-map set-med permit 10
 match ip address prefix-list MATCH
 set metric 1000
route-map set-med permit 20
!
ip prefix-list MATCH permit 120.68.1.0/24
```

Weight

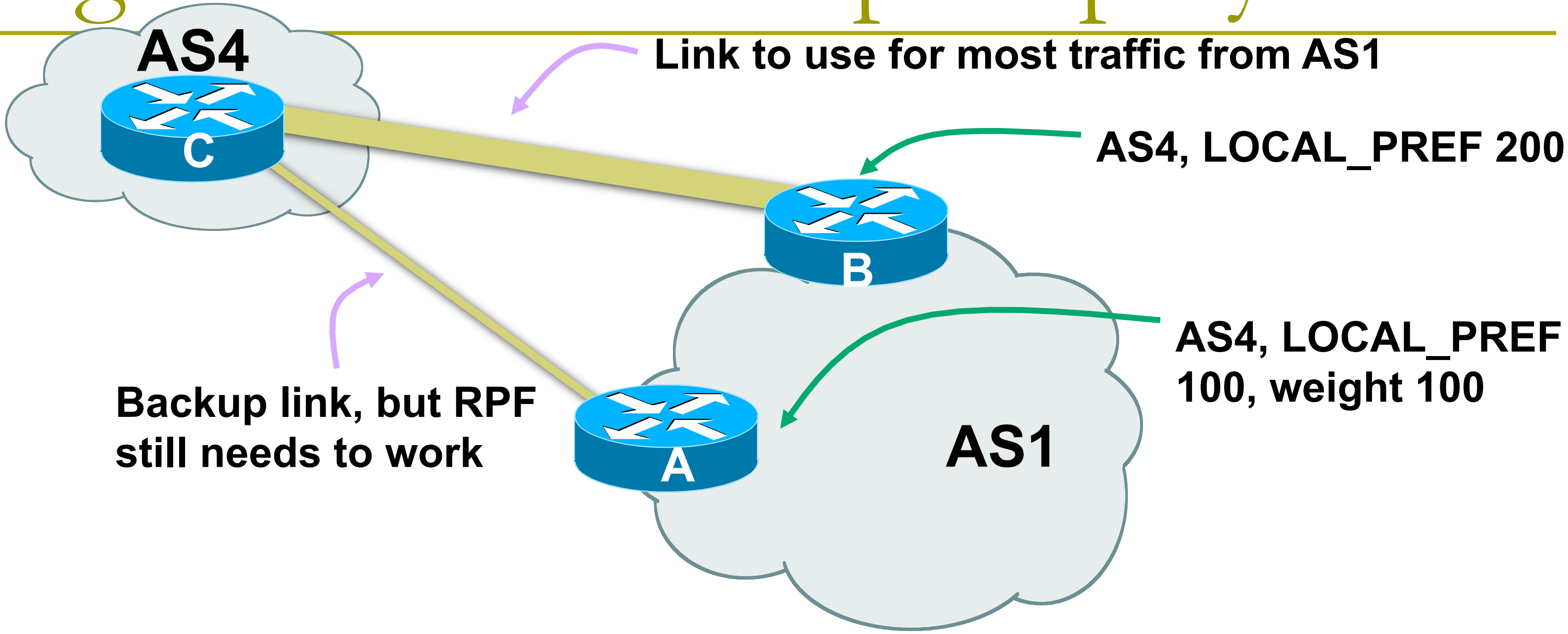
- Not really an attribute – local to router
- Highest weight wins
- Applied to all routes from a neighbour

```
neighbor 120.5.7.1 weight 100
```

- Weight assigned to routes based on filter

```
neighbor 120.5.7.3 filter-list 3 weight 50
```

Weight – Used to help Deploy RPF



Link to use for most traffic from AS1

AS4, LOCAL_PREF 200

AS4, LOCAL_PREF 100, weight 100

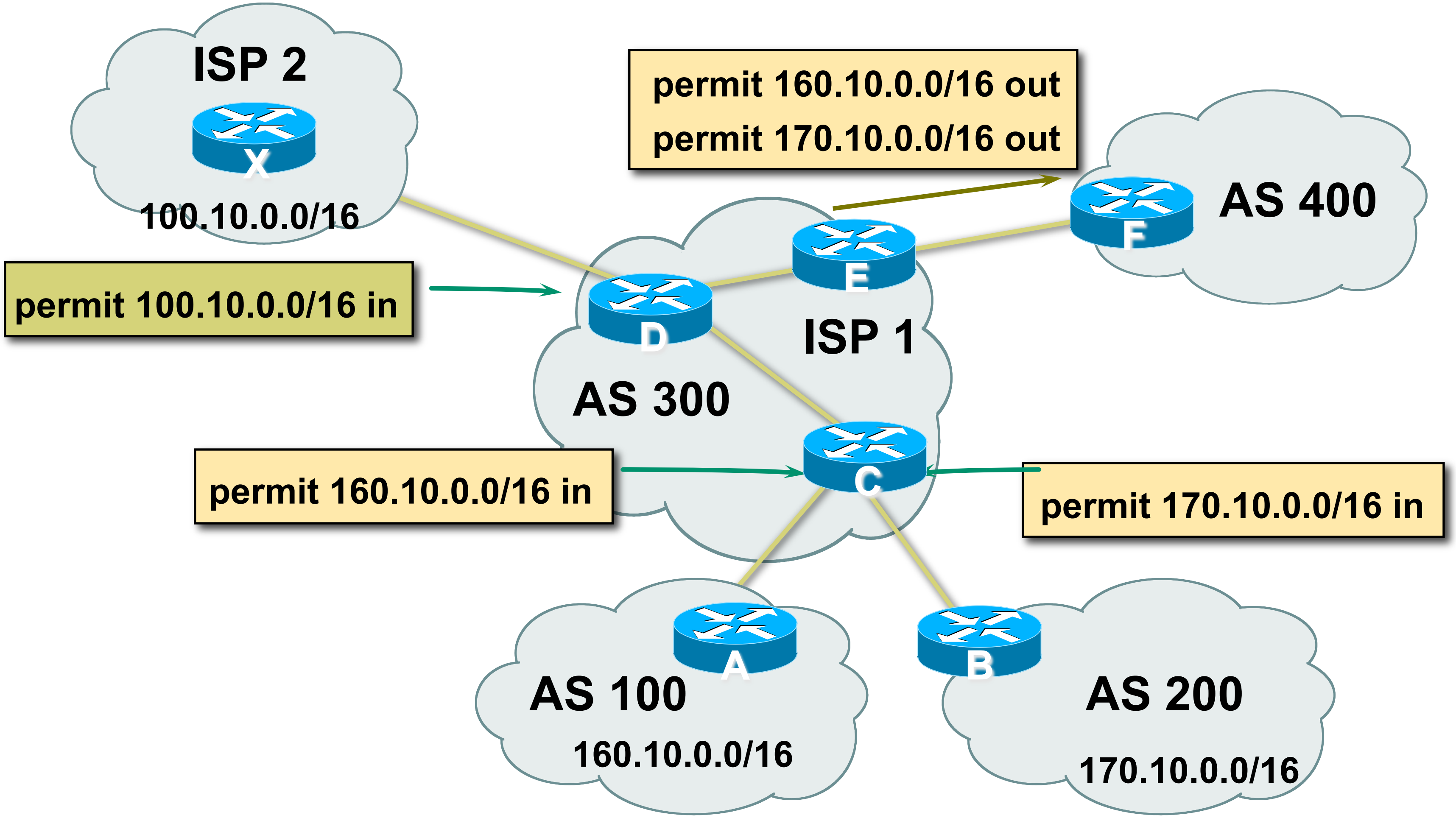
Backup link, but RPF still needs to work

- Best path to AS4 from AS1 is always via B due to local-pref
- But packets arriving at A from AS4 over the direct C to A link will pass the RPF check as that path has a priority due to the weight being set
  - If weight was not set, best path back to AS4 would be via B, and the RPF check would fail

Community

- Communities are described in RFC1997
  - Transitive and Optional Attribute
- 32 bit integer
  - Represented as two 16 bit integers (RFC1998)
  - Common format is <local-ASN>:xx
  - 0:0 to 0:65535 and 65535:0 to 65535:65535 are reserved
- Used to group destinations
  - Each destination could be member of multiple communities
- Very useful in applying policies within and between ASes

Community Example (before)



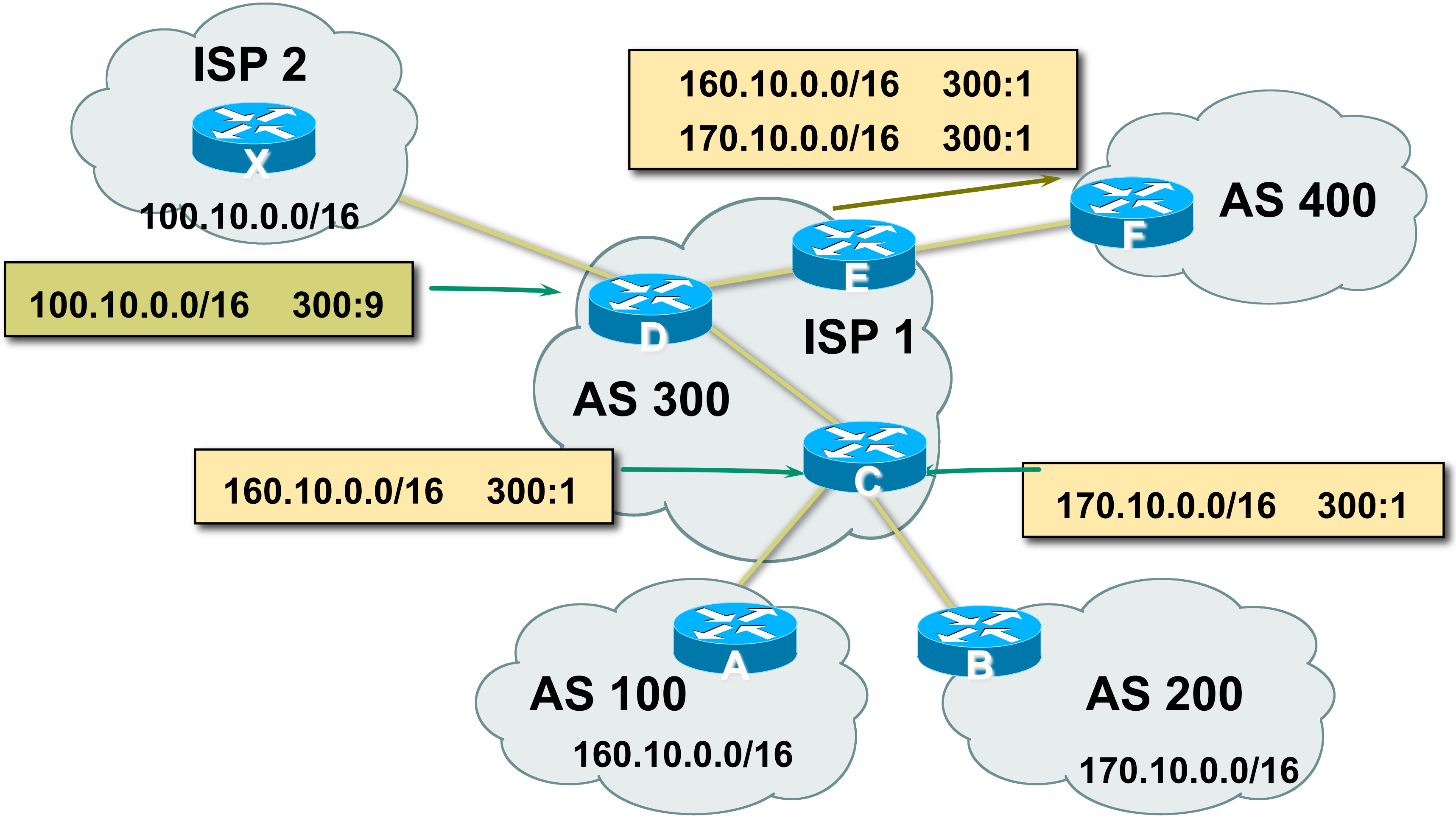
permit 160.10.0.0/16 out
permit 170.10.0.0/16 out

permit 100.10.0.0/16 in

permit 160.10.0.0/16 in

permit 170.10.0.0/16 in

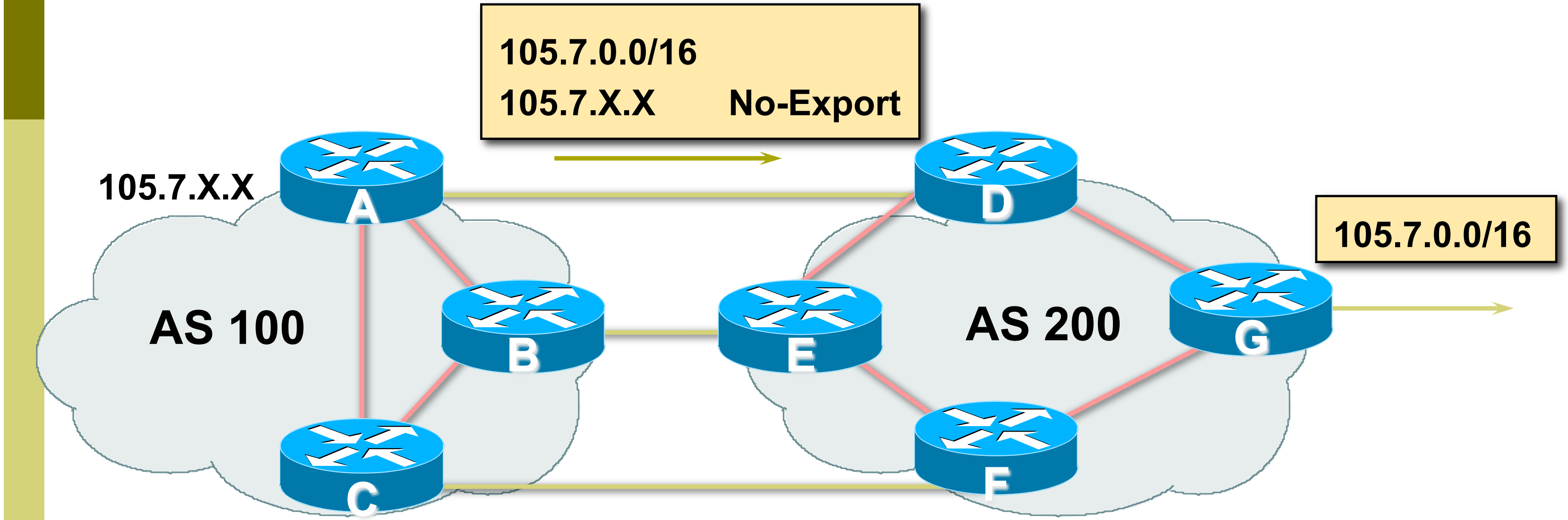
Community Example (after)



Well-Known Communities

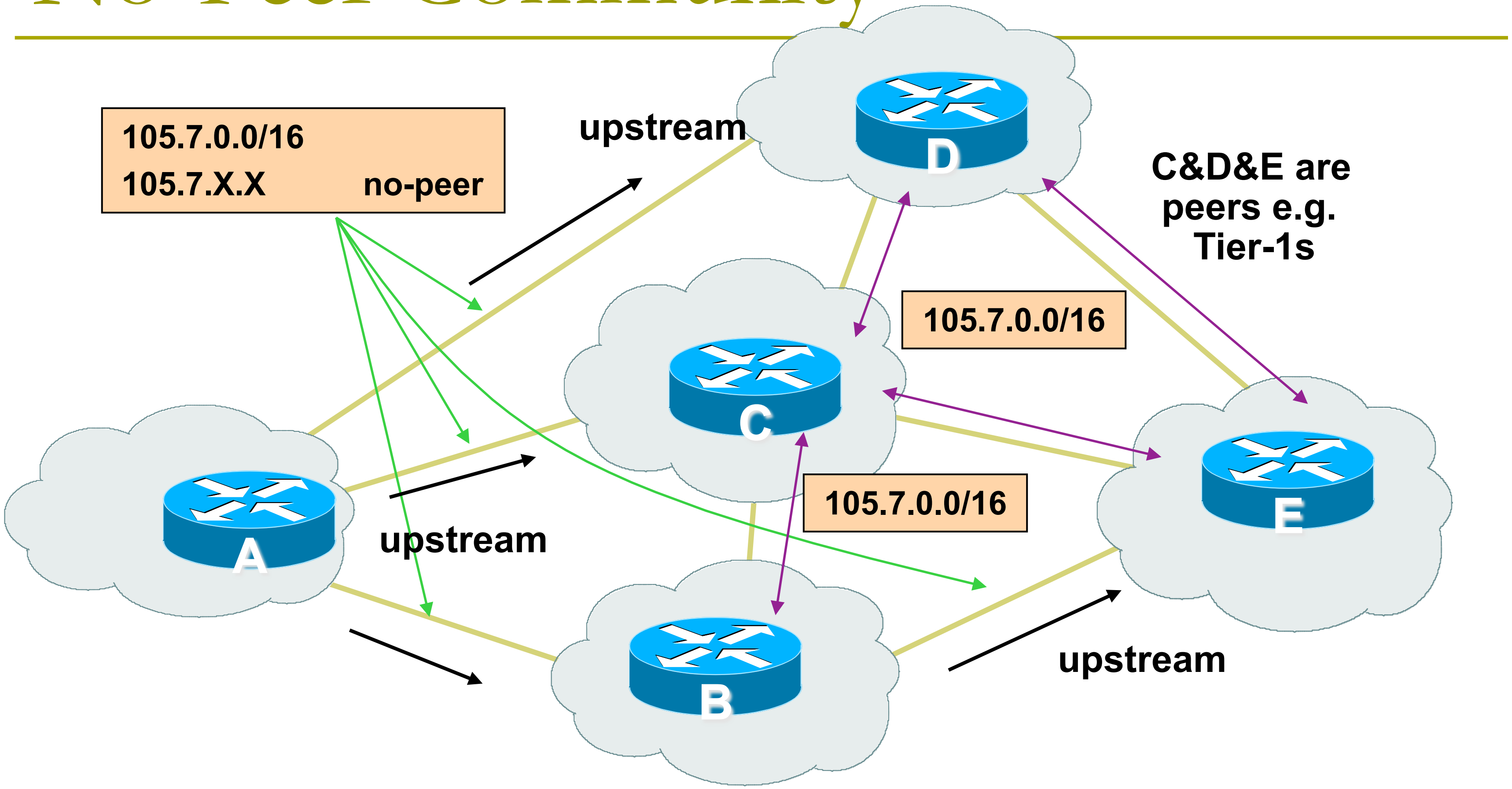
- Several well known communities
  - www.iana.org/assignments/bgp-well-known-communities
- no-export 65535:65281
  - do not advertise to any eBGP peers
- no-advertise 65535:65282
  - do not advertise to any BGP peer
- no-export-subconfed 65535:65283
  - do not advertise outside local AS (only used with confederations)
- no-peer 65535:65284
  - do not advertise to bi-lateral peers (RFC3765)

No-Export Community



- AS100 announces aggregate and subprefixes
  - Intention is to improve loadsharing by leaking subprefixes
- Subprefixes marked with no-export community
- Router G in AS200 does not announce prefixes with no-export community set

No-Peer Community



- Sub-prefixes marked with no-peer community are not sent to bi-lateral peers
  - They are only sent to upstream providers

What about 4-byte ASNs?

- Communities are widely used for encoding ISP routing policy
  - 32 bit attribute
- RFC1998 format is now “standard” practice
  - ***ASN:number***
- Fine for 2-byte ASNs, but 4-byte ASNs cannot be encoded
- Solutions:
  - Use “private ASN” for the first 16 bits
  - Wait for http://datatracker.ietf.org/doc/draft-ietf-idr-as4octet-extcomm-generic-subtype/ to be implemented

Summary
Attributes in Action

```
Router6>sh ip bgp
BGP table version is 30, local router ID is 10.0.15.246
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
*>i10.0.0.0/26      10.0.15.241              0    100      0 i
*>i10.0.0.64/26     10.0.15.242              0    100      0 i
*>i10.0.0.128/26    10.0.15.243              0    100      0 i
*>i10.0.0.192/26    10.0.15.244              0    100      0 i
*>i10.0.1.0/26      10.0.15.245              0    100      0 i
*> 10.0.1.64/26     0.0.0.0                  0         32768 i
...
```

BGP Path Selection Algorithm

Why is this the best path?

BGP Path Selection Algorithm for Cisco IOS: Part One

- Do not consider path if no route to next hop
- Do not consider iBGP path if not synchronised (Cisco IOS)
- Highest weight (local to router)
- Highest local preference (global within AS)
- Prefer locally originated route
- Shortest AS path

BGP Path Selection Algorithm for Cisco IOS: Part Two

- Lowest origin code
  - IGP < EGP < incomplete
- Lowest Multi-Exit Discriminator (MED)
  - If bgp deterministic-med, order the paths before comparing
  - If bgp always-compare-med, then compare for all paths
  - otherwise MED only considered if paths are from the same AS (default)

BGP Path Selection Algorithm for Cisco IOS: Part Three

- Prefer eBGP path over iBGP path
- Path with lowest IGP metric to next-hop
- For eBGP paths:
  - If multipath is enabled, install N parallel paths in forwarding table
  - If router-id is the same, go to next step
  - If router-id is not the same, select the oldest path

BGP Path Selection Algorithm for Cisco IOS: Part Four

- Lowest router-id (originator-id for reflected routes)
- Shortest cluster-list
  - Client must be aware of Route Reflector attributes!
- Lowest neighbour address

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