Interdomain routing

BGP-4

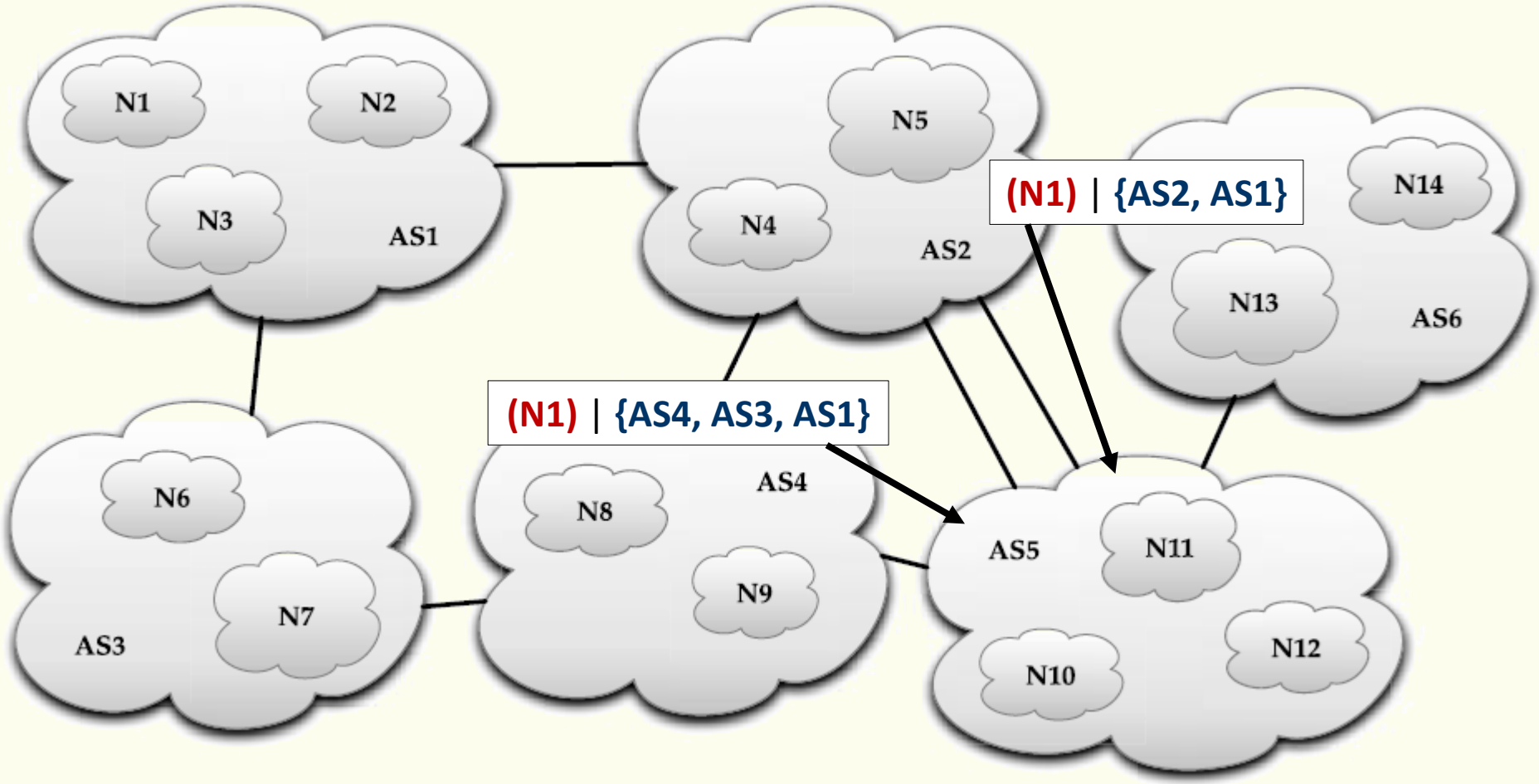
Enzo Mingozzi
Professor @ University of Pisa
enzo.mingozzi@unipi.it

BGP-4

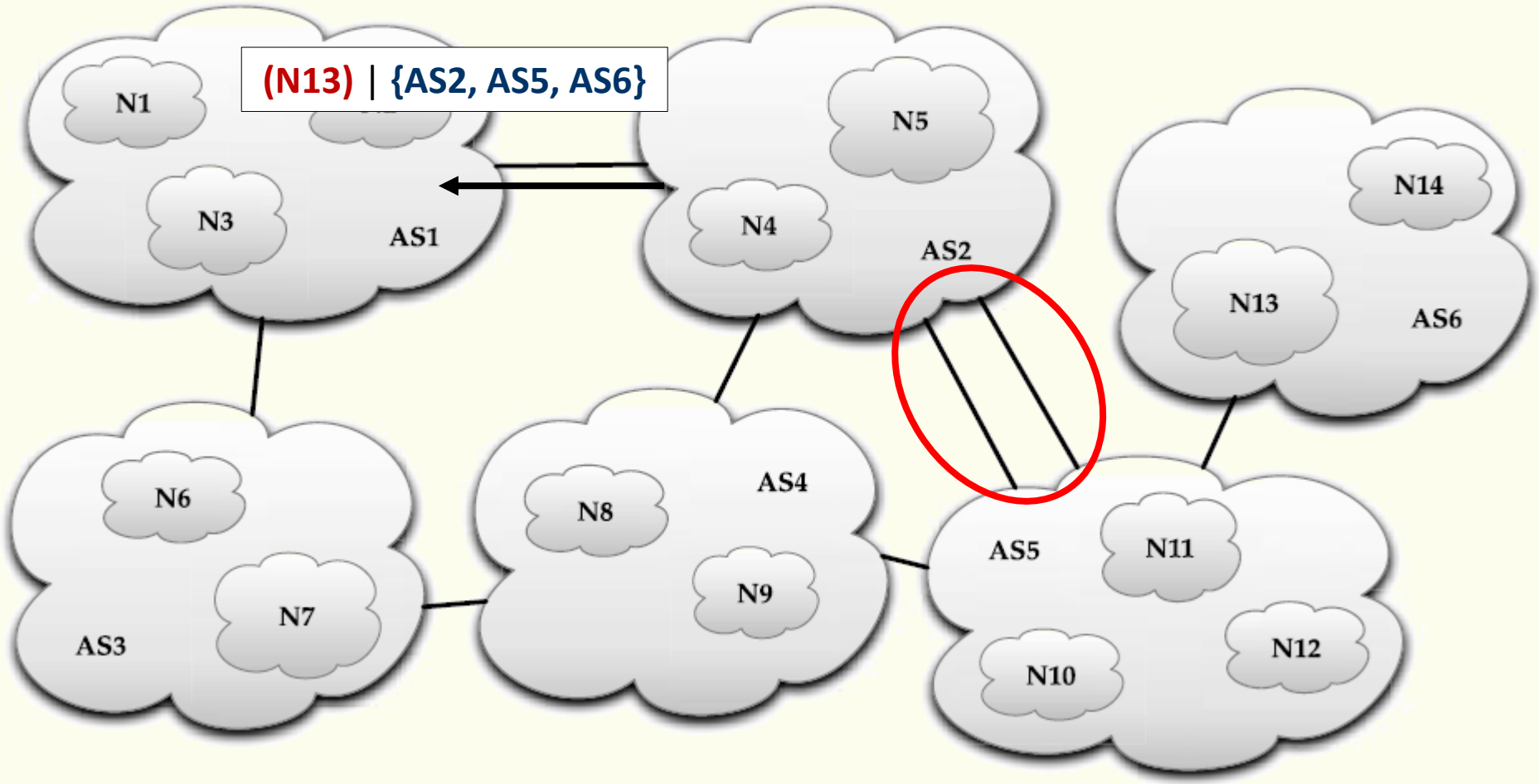
- Border Gateway Protocol v4 (rfc4271)
  - **inter-AS** routing protocol (EGP)
    - inter-AS routing usually reflects **political and business relationships** between the ISP and organizations involved
    - intra-AS routing is optimized in accordance with the required technical demands
  - *How do I filter routing updates coming from a particular neighbor AS?*
  - *How do I make sure that I use this link or this provider rather than another one?*

- Exchange **network reachability information** between BGP speaking peers
- Supports **destination-based** forwarding only (CIDR)

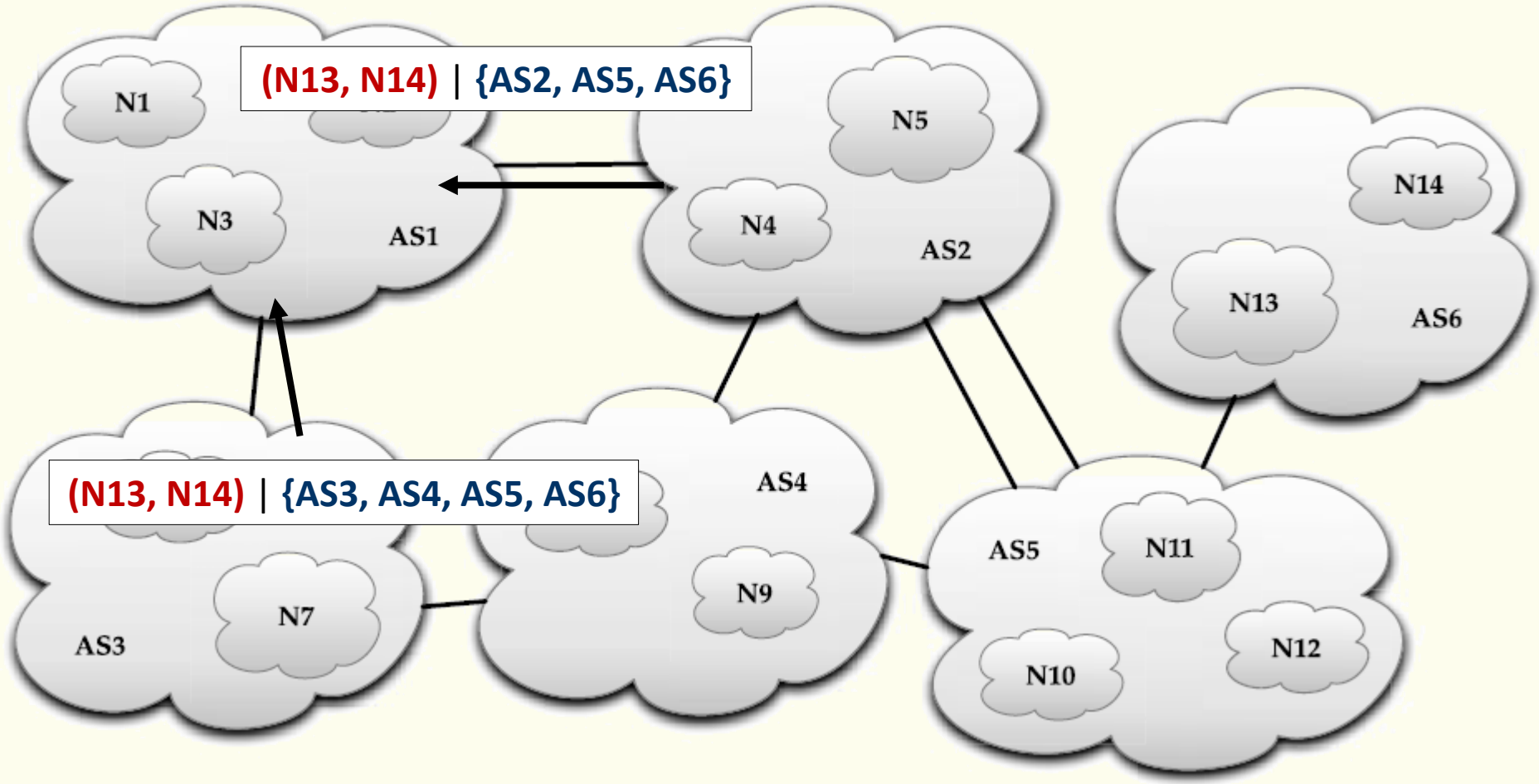
Path vector routing



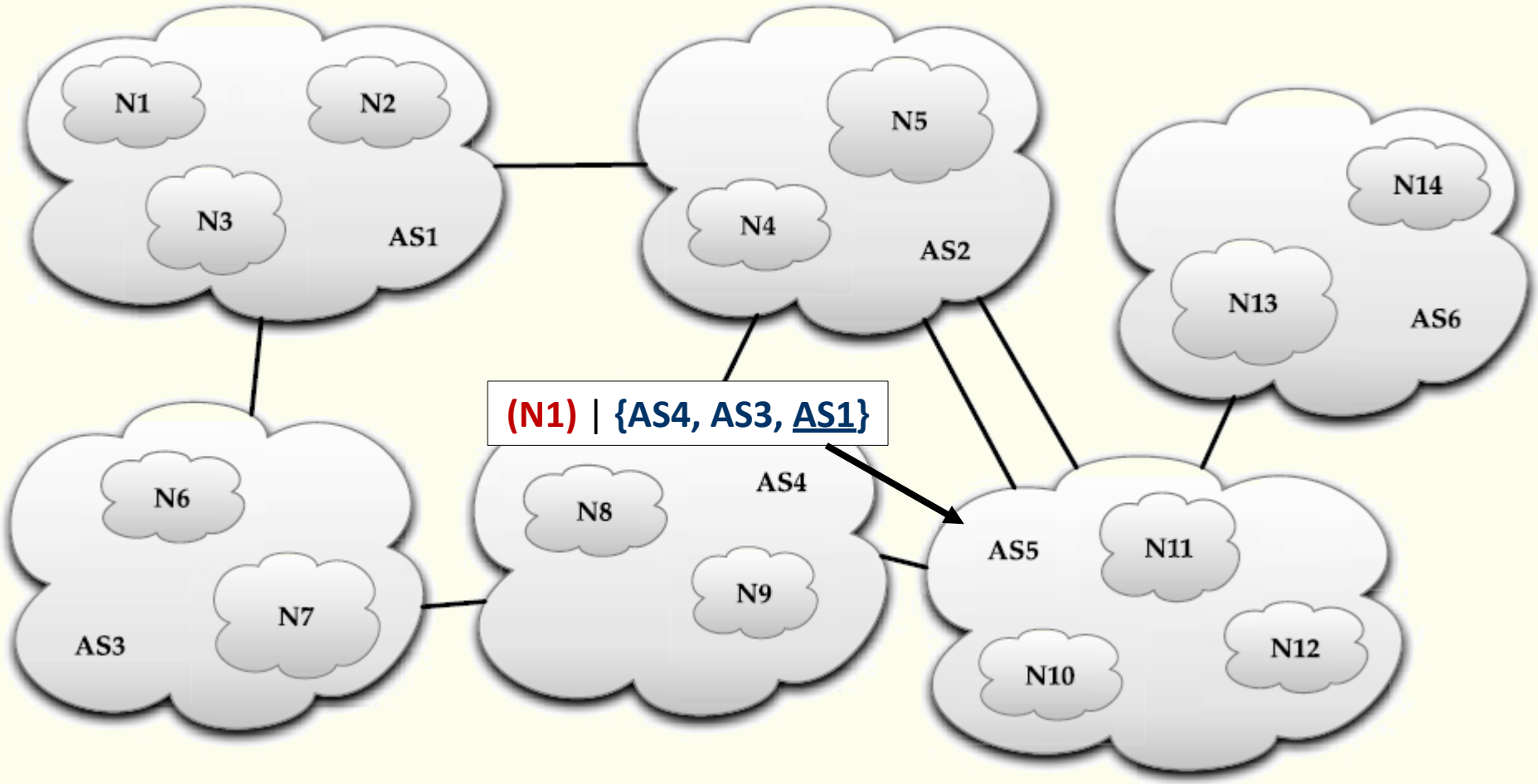
AS hop count metric



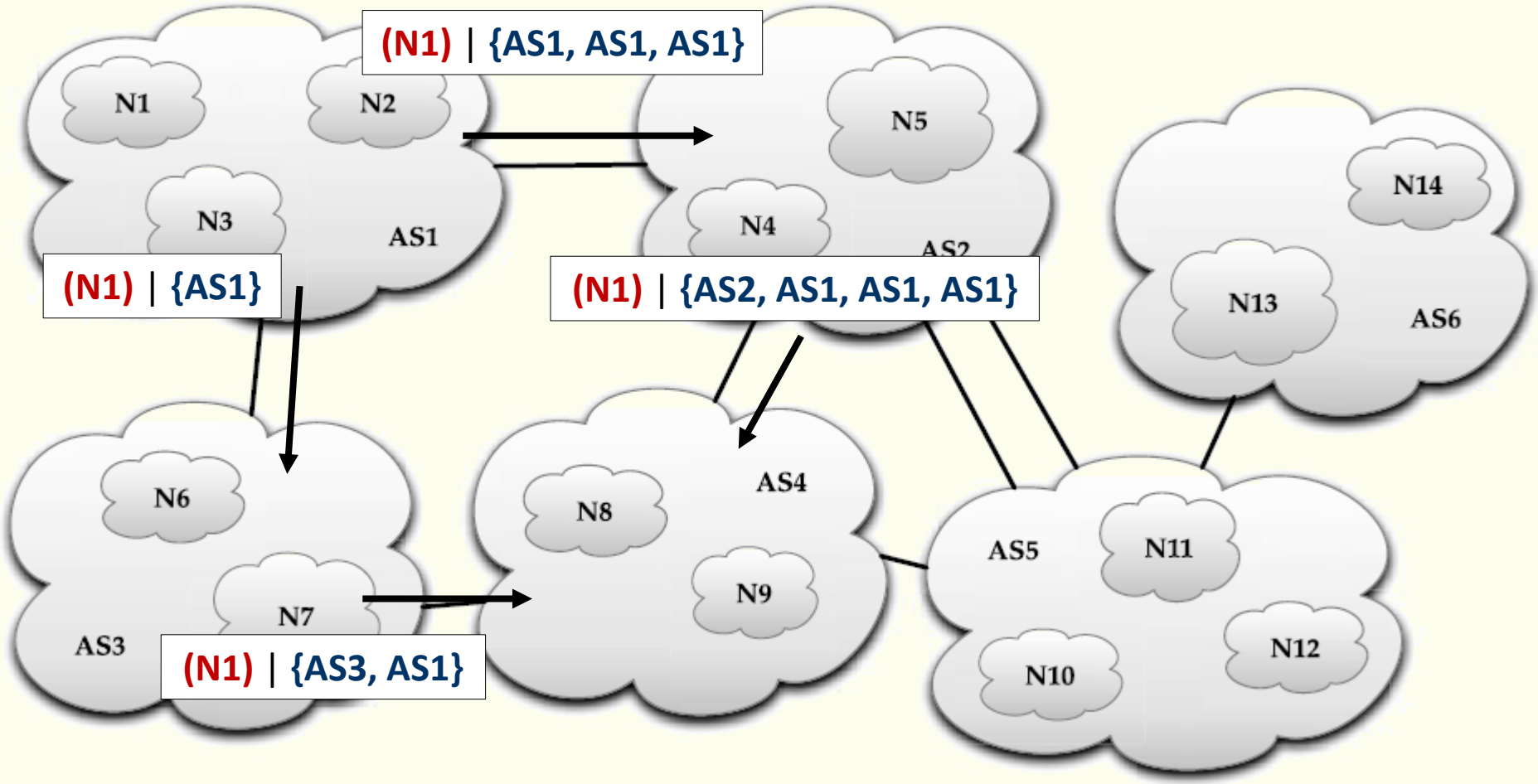
Set of networks advertisement



Home AS advertisement



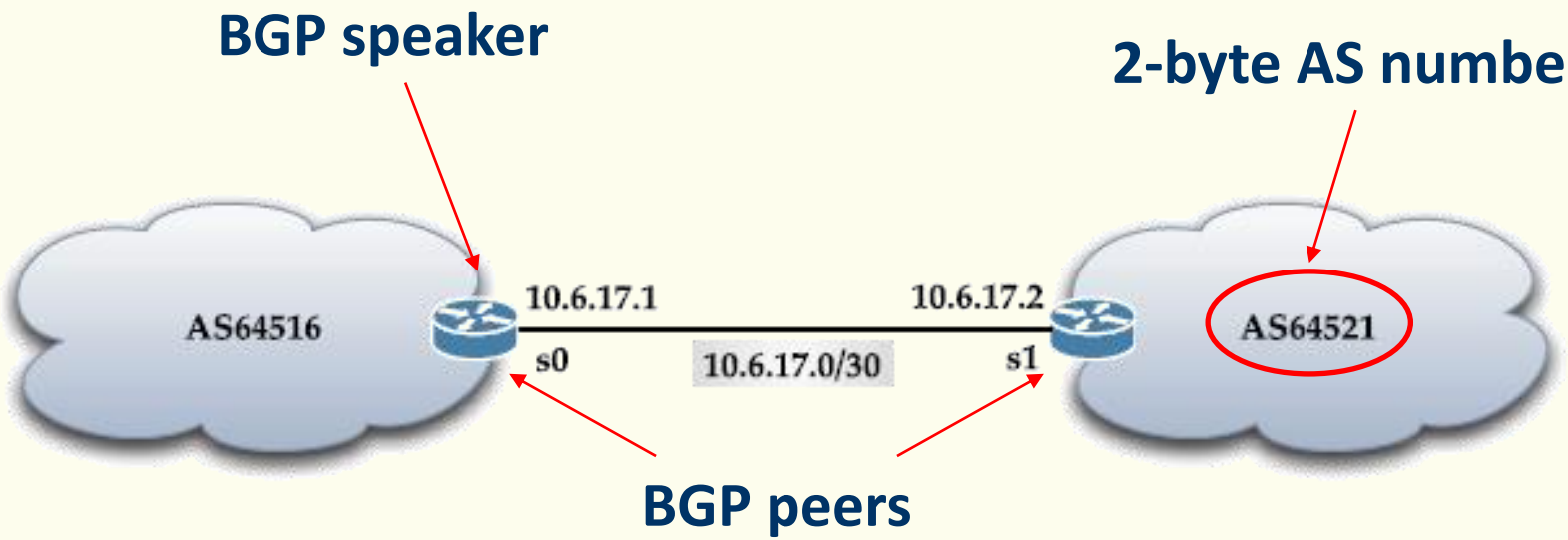
Path manipulation



Terminology

Network = IP prefix (A.B.C.D/n) → **network layer reachability information** (**NLRI**)

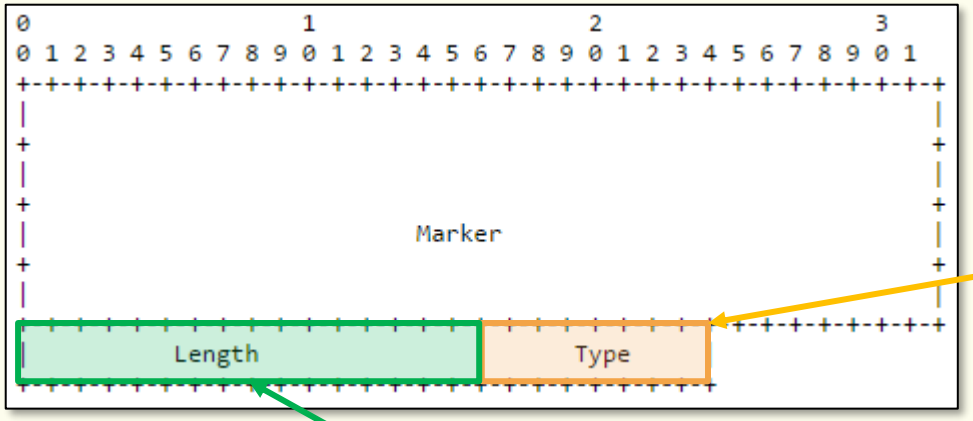
BGP route: IP prefix destination(s) → attributes of an AS–path by a receiving AS through an UPDATE message



AS number space is divided into **public** (1-64511) and **private** (64512-65534)
4-byte AS number space is also defined

BGP operations

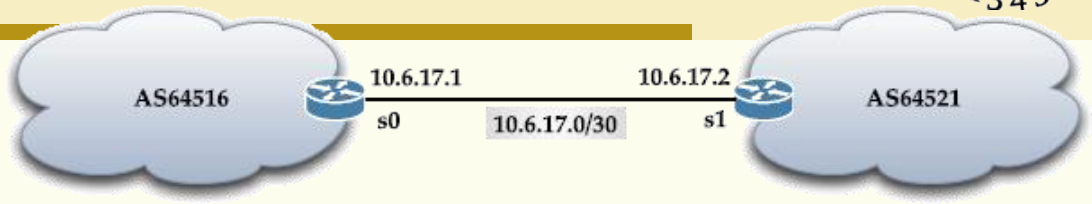
- Four BGP message types (+ 1) exchanged over TCP (port 179)



- OPEN
- UPDATE
- NOTIFICATION
- KEEPALIVE
- ROUTE-REFRESH (optional)

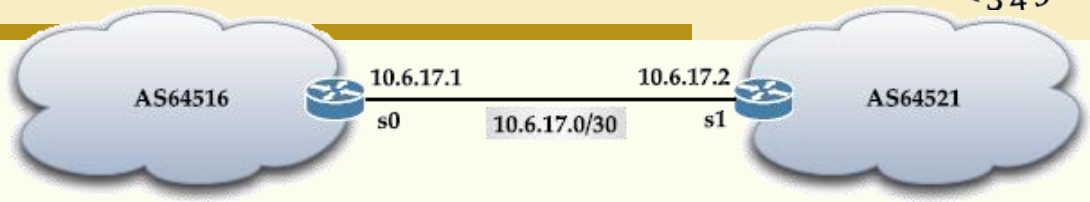
≤ 4096

BGP operations

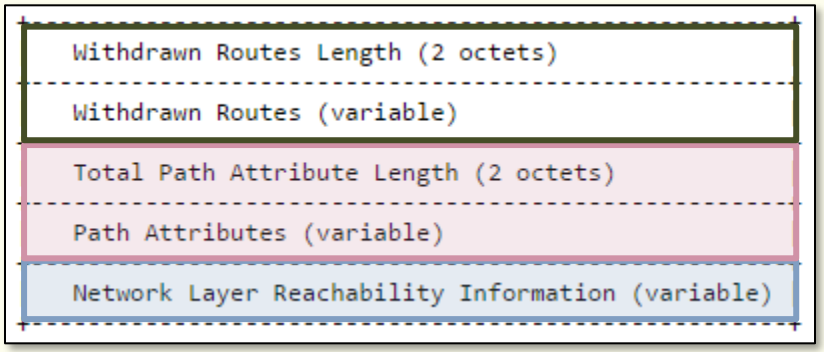


- **OPEN** message
  - First message sent to configured BGP peer (contains AS number)
- **KEEPALIVE**
  - Exchanged periodically, approximately three times every *hold time* at most
- **NOTIFICATION**
  - Closes a BGP session

BGP operations



- **UPDATE** message
  - Sent to exchange information about *networks*
  - Works in PUSH mode
  - Announced routes must be explicitly withdrawn

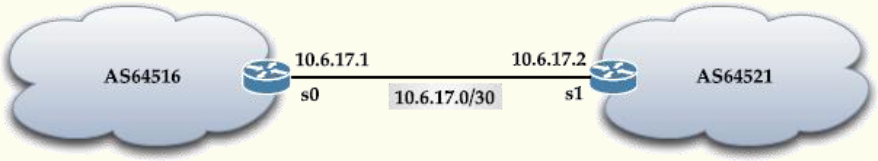


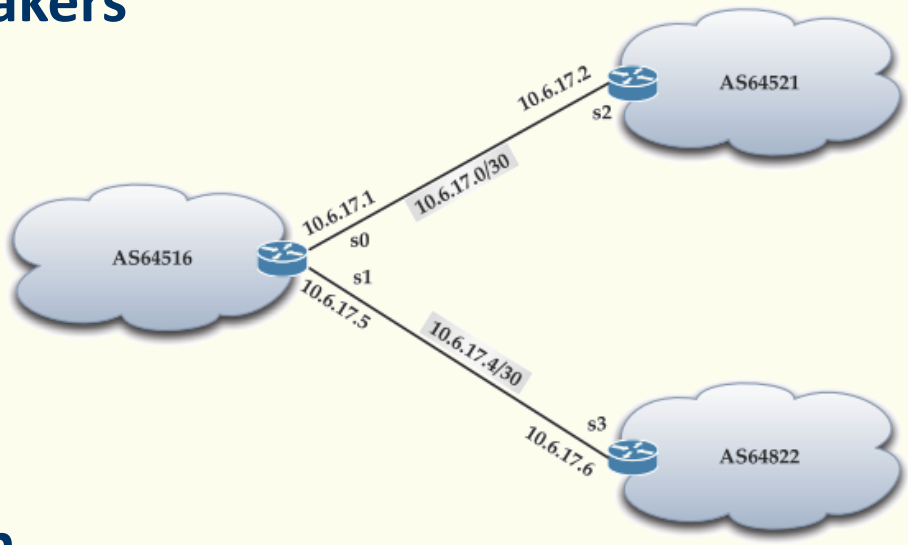
A sequence of path attributes (TLV)
- ORIGIN
- AS_PATH
- NEXT_HOP
- LOCAL_PREF
- …

List of networks {address/prefix length}

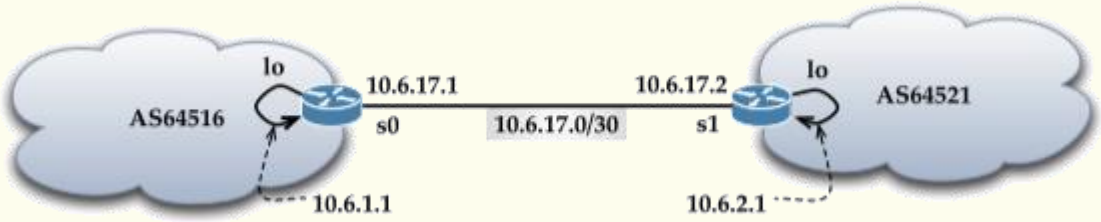
BGP initialization

p2p connections between BGP speakers





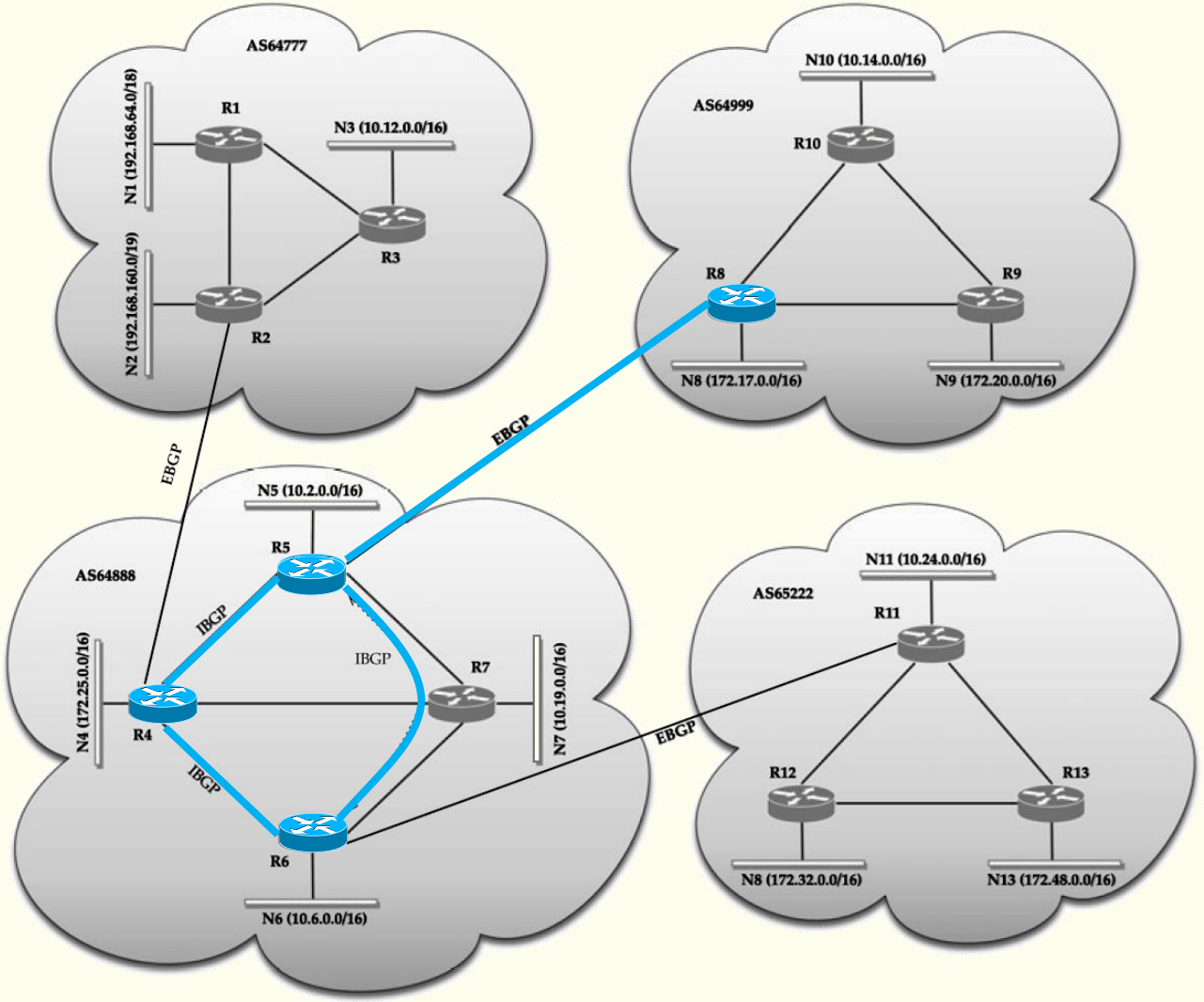
Loopback interface-based approach



(external) eBGP vs. (internal) iBGP

eBGP: BGP speakers are in different ASes, e.g. R5 and R8

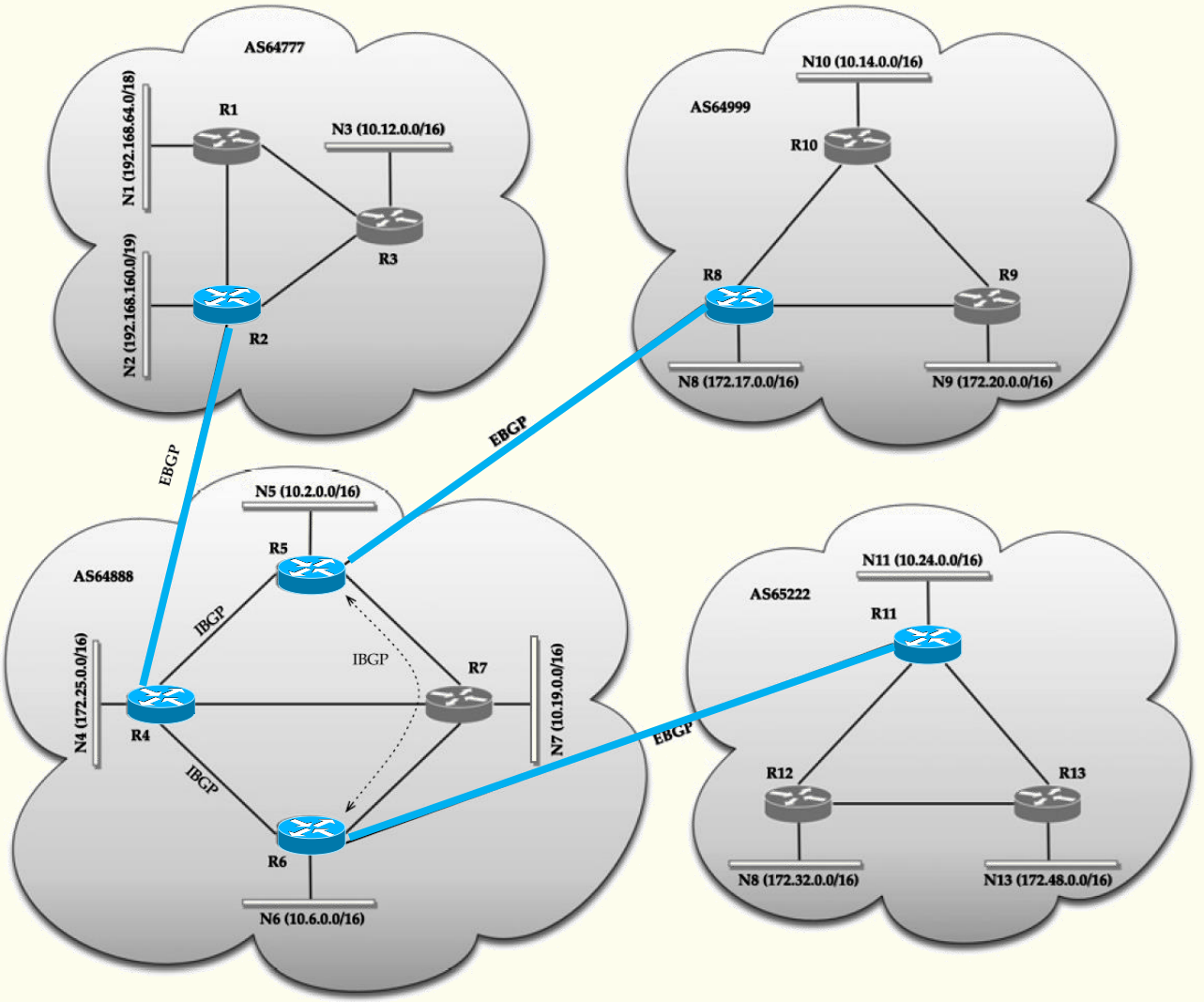
iBGP: BGP speakers are in the same AS, e.g. R5 and R6



Why iBGP?

Stub AS (e.g. AS64777): no need for eBGP speakers to redistribute BGP routes within the AS

Transit AS (e.g. AS64888): BGP routes learned by one eBGP speaker need be redistributed to the other eBGP speakers



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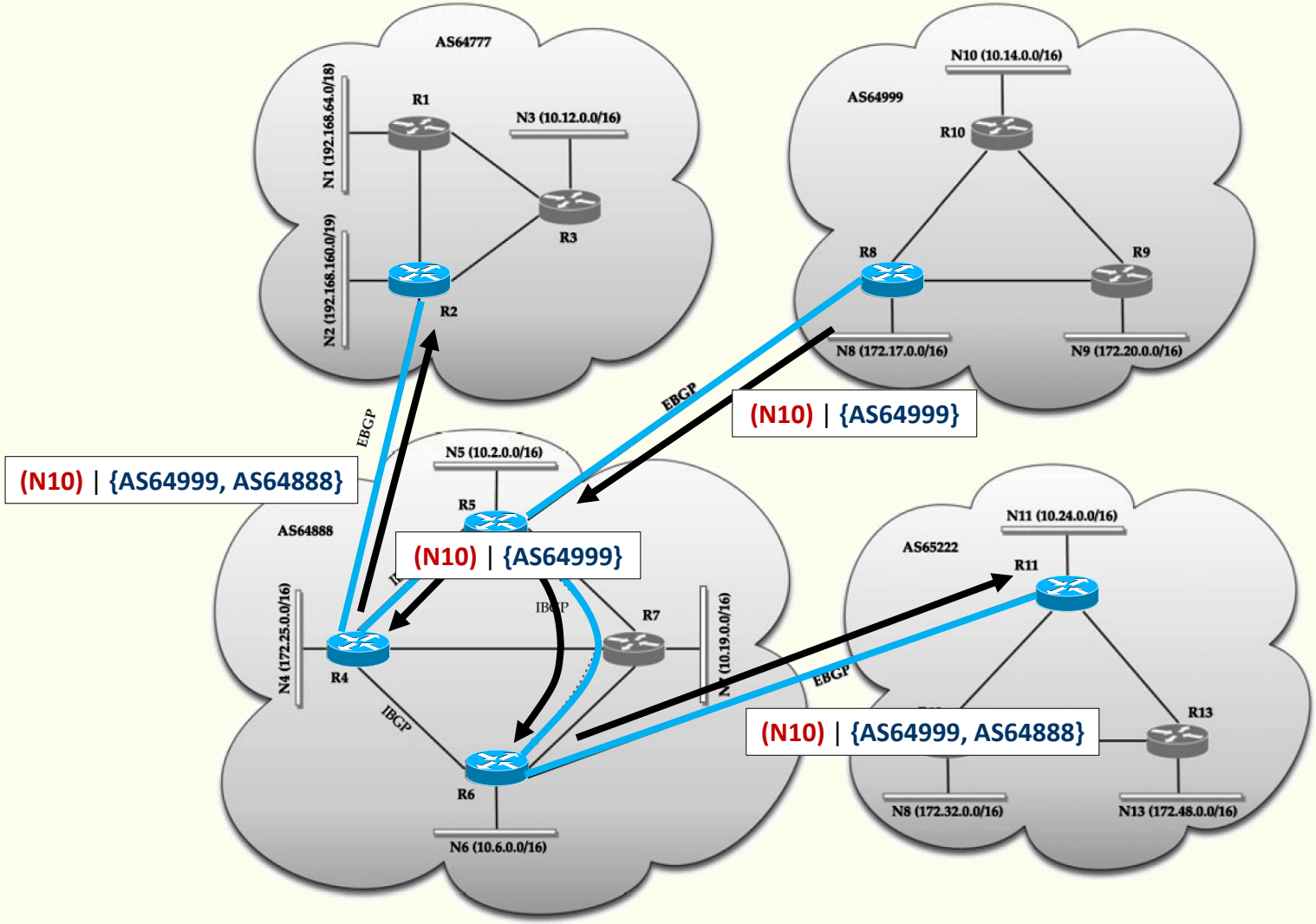

AS64777
N1 (192.168.64.0/18)
N2 (192.168.160.0/19)
R1
R2
R3
N3 (10.12.0.0/16)
AS64999
N10 (10.14.0.0/16)
R10
R8
R9
N8 (172.17.0.0/16)
N9 (172.20.0.0/16)
AS64888
N5 (10.2.0.0/16)
R5
N4 (172.25.0.0/16)
R4
R7
N7 (10.19.0.0/16)
R6
N6 (10.6.0.0/16)
IBGP
IBGP
AS65222
N11 (10.24.0.0/16)
R11
R13
N8 (172.32.0.0/16)
N13 (172.48.0.0/16)
EBGP
EBGP
EBGP
(N10) | {AS64999}
(N10) | {AS64999, AS64888}
(N10) | {AS64999}
(N10) | {AS64999, AS64888}

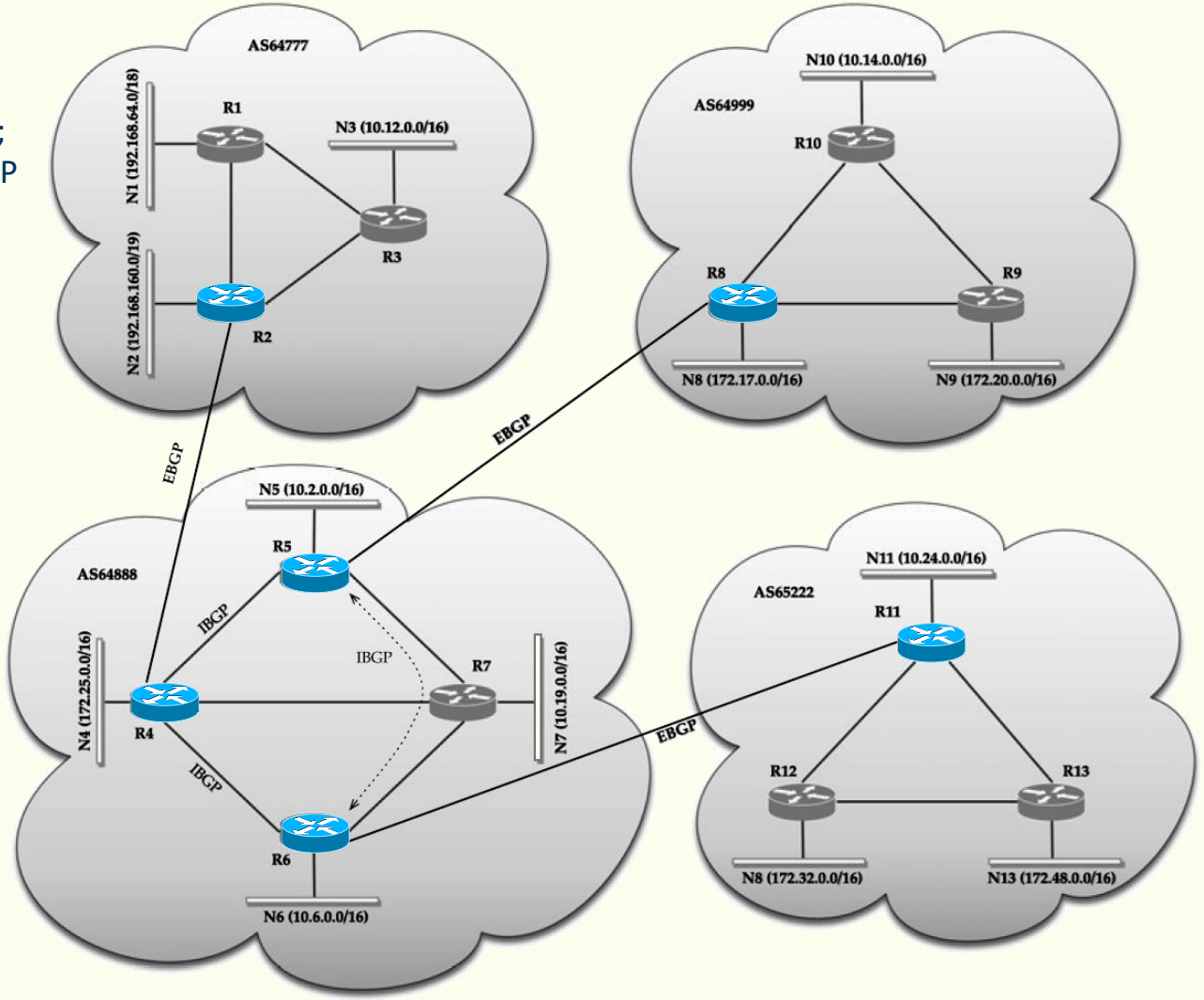
Rules

Rule 1 A BGP speaker can advertise IP prefixes it has learned from an eBGP speaker to a neighboring iBGP speaker; similarly, a BGP speaker can advertise IP prefixes it has learned from an iBGP speaker to an eBGP speaker

Rule 2 An iBGP speaker cannot advertise IP prefixes it has learned from an iBGP speaker to another peer iBGP speaker

Two reasons:

1. Avoid looping of BGP route updates within the AS
2. No need to advertise internal routes



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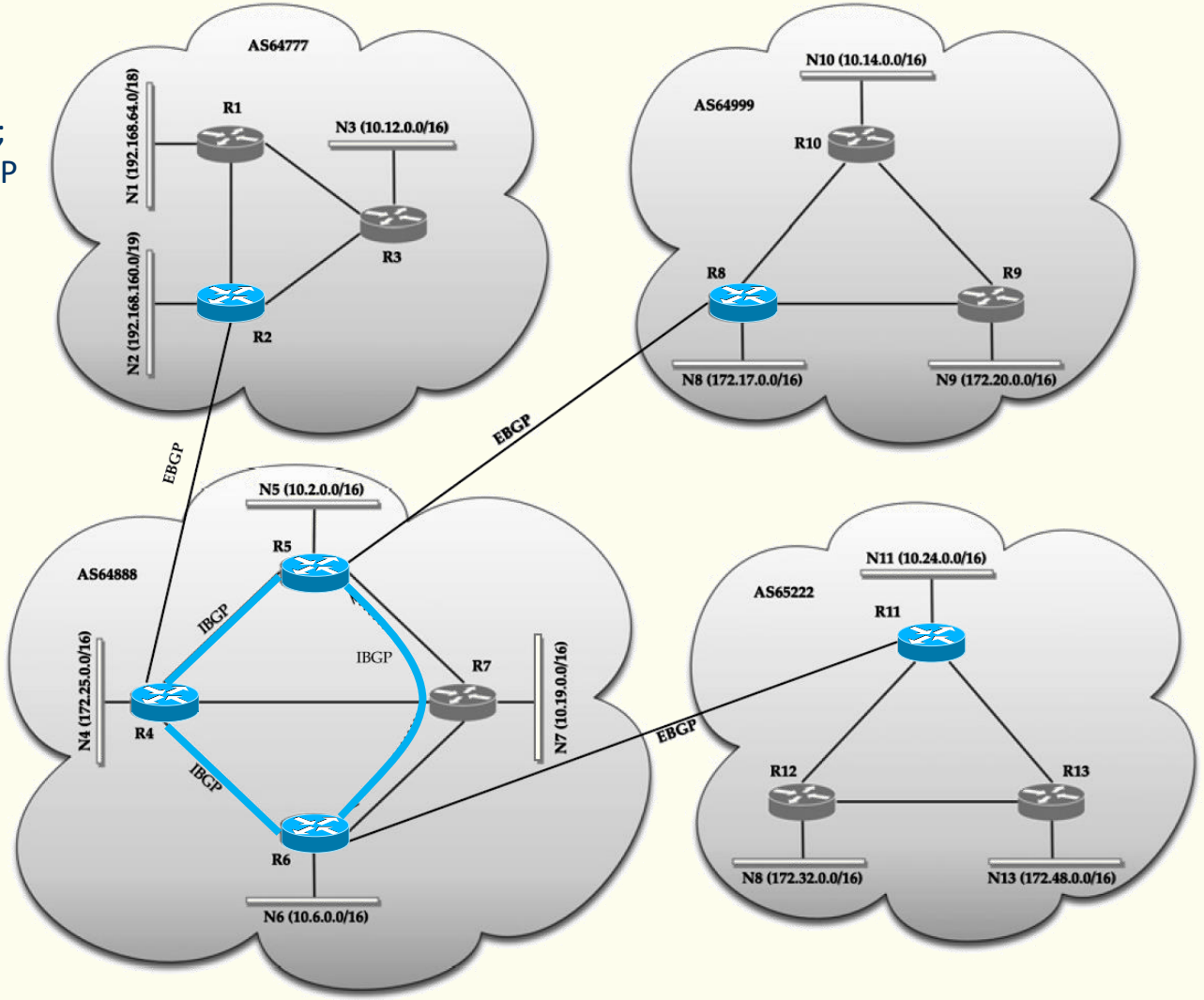
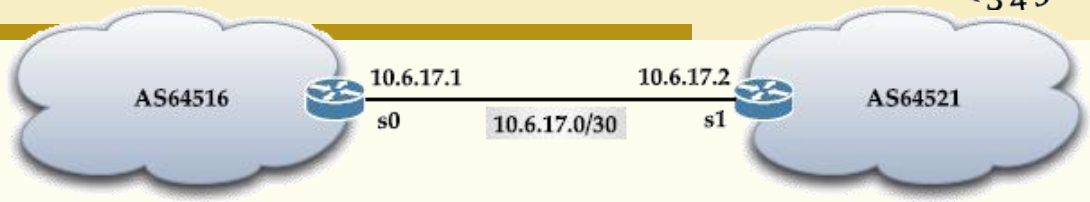
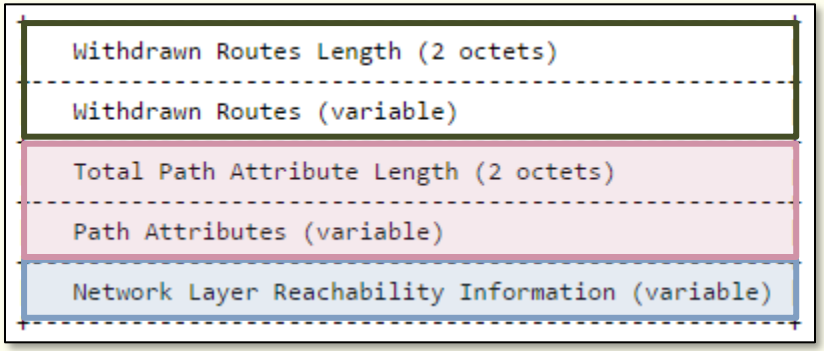
A full mesh iBGP connectivity is needed



PATH attributes



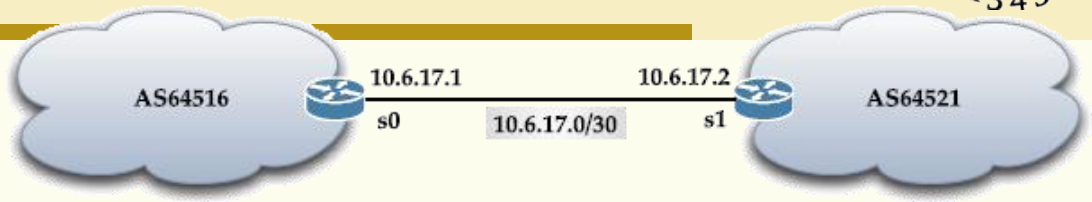
- **UPDATE** message
  - Path attributes advertised for a set of routes
  - Keep track of route-specific information such as path information, and degree of preference of a route
  - Used in the BGP filtering and route decision process



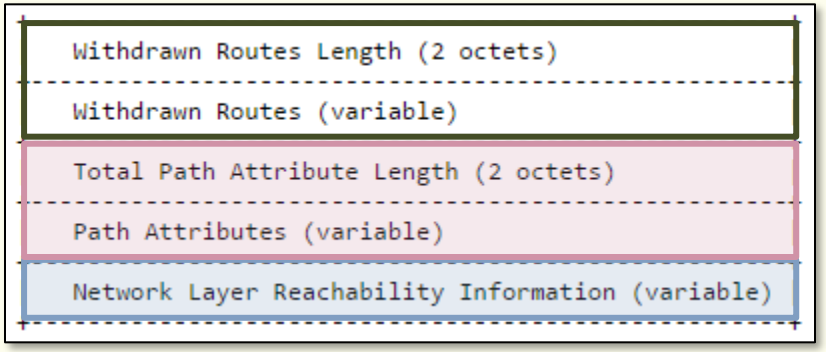
A sequence of path attributes (TLV)
- ORIGIN
- AS_PATH
- NEXT_HOP
- LOCAL_PREF
- …

List of networks {address/prefix length}

PATH attributes



- **UPDATE** message
  - **Well-known mandatory**: Must be present in all UPDATE messages
  - **Well-known discretionary**: Could be present in UPDATE messages
  - **Optional transitive**: If not recognized, are propagated to other neighbors
  - **Optional non-transitive**: Discarded if not recognized



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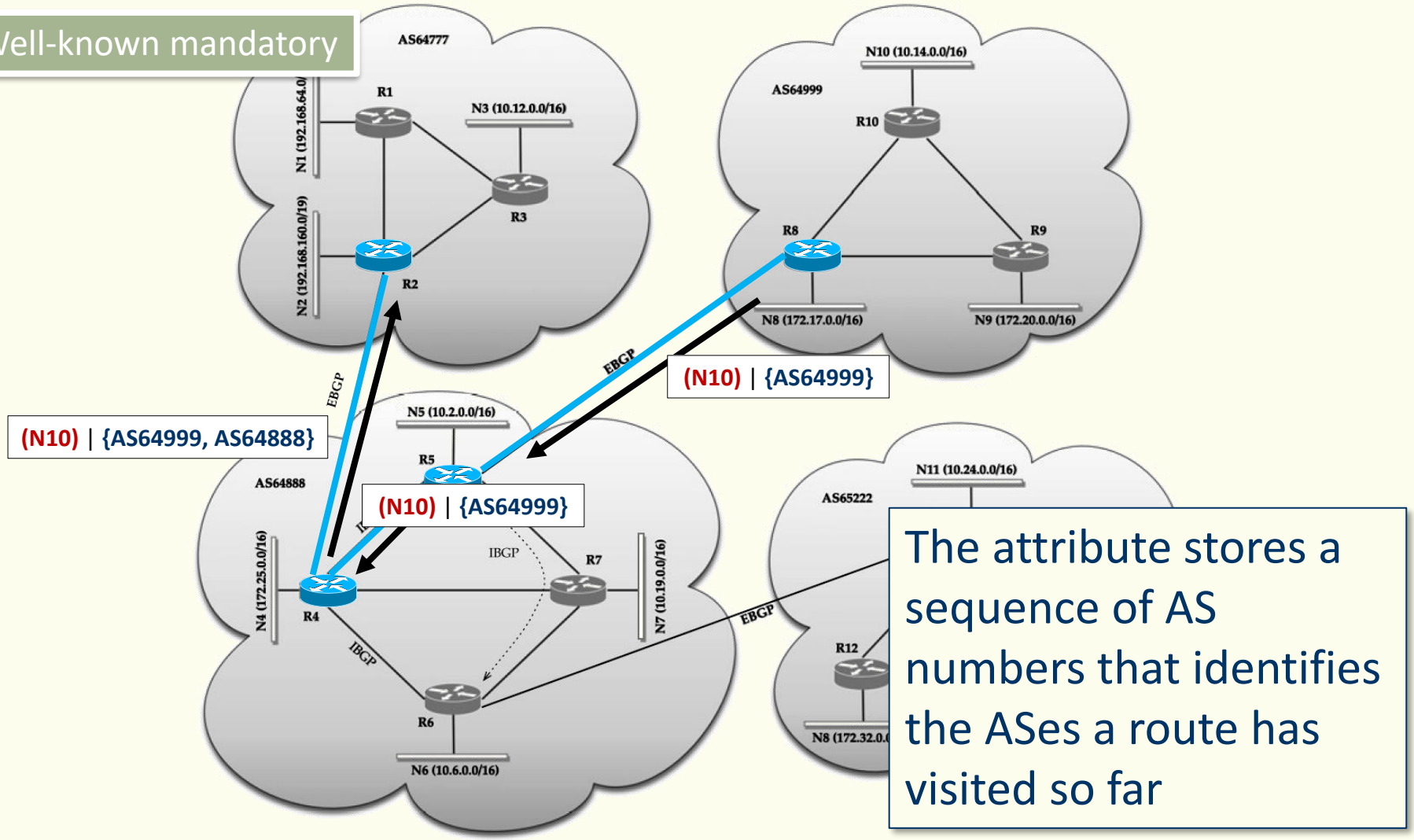
List of networks {address/prefix length}

AS_PATH

Well-known mandatory

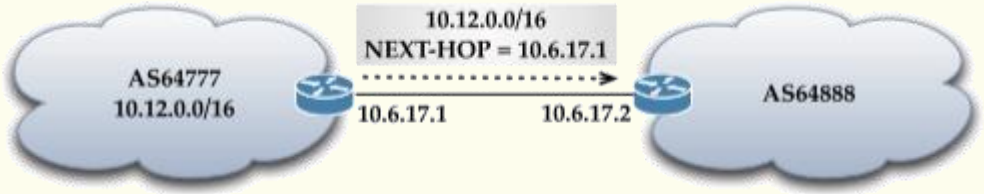


The attribute stores a sequence of AS numbers that identifies the ASes a route has visited so far

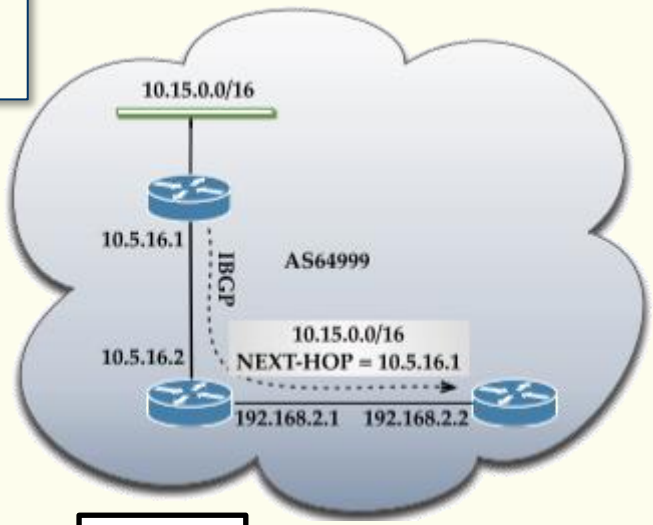
NEXT_HOP

The attribute defines the IP address of the router that SHOULD be used as the next hop (not necessarily 1-hop) to the destinations listed in the UPDATE message

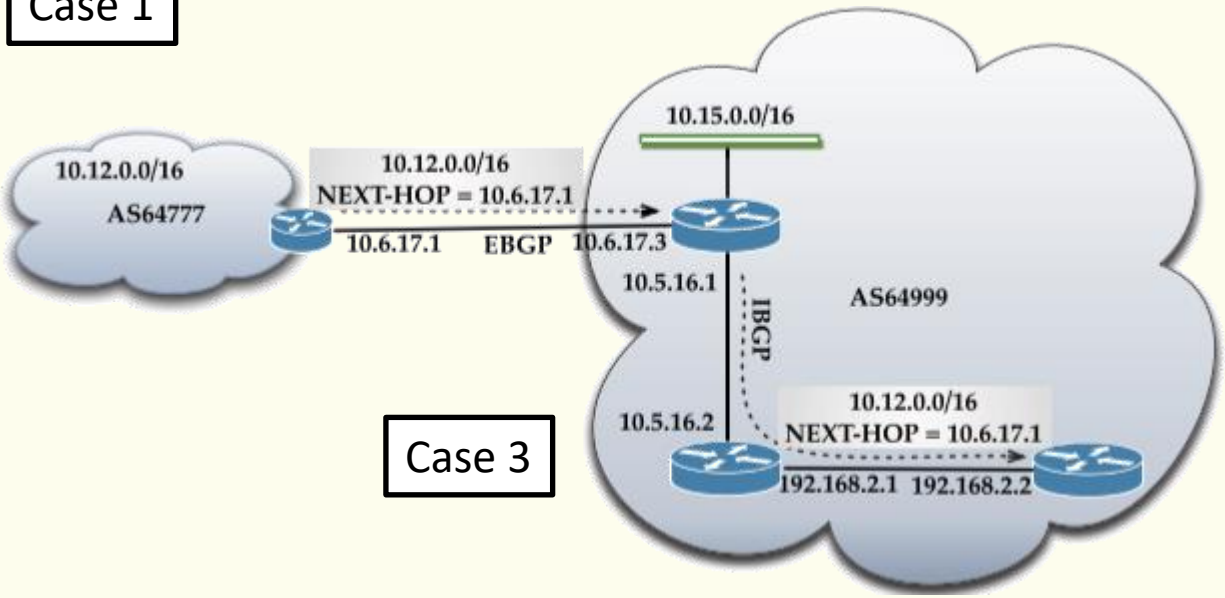
Well-known mandatory



Case 1



Case 2

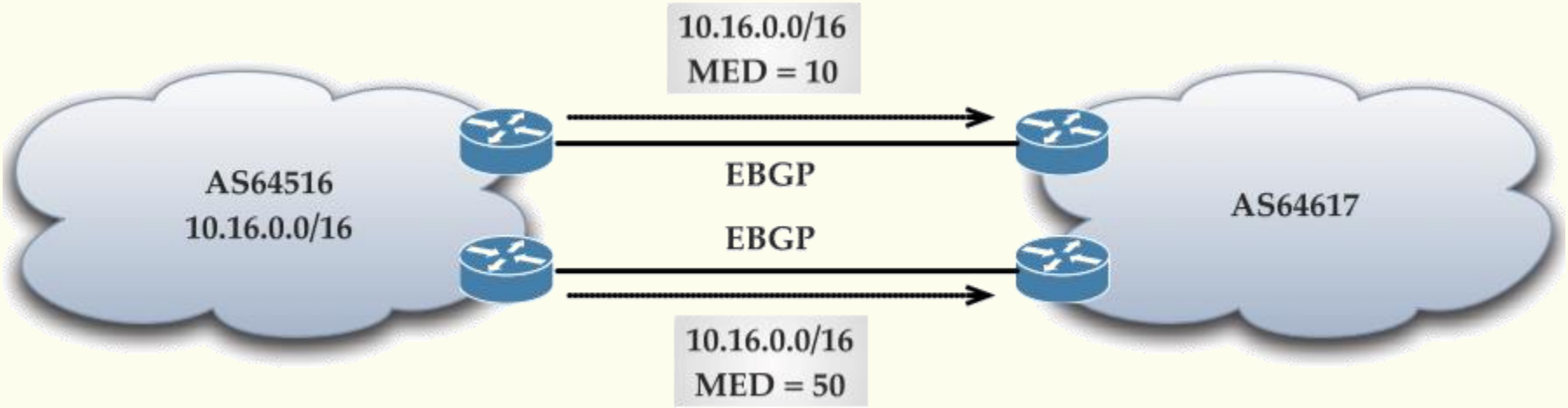


Case 3

MED (MULTI–EXIT–DISCRIMINATOR)

The attribute is a metric meant for use when there are multiple external links to a neighboring AS

Optional non-transitive



LOCAL_PREF

The attribute defines a metric used internally within an AS between BGP speakers, helpful in selection when the AS has connectivity to multiple ASes

Well-known discretionary