SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COURSE NAME :19IT401 COMPUTER NETWORKS

II YEAR /IV SEMESTER

Unit 3-**Network layer**

Topic 9 : Unicast routing protocols

Three common protocols used in the Internet:

1.Routing Information Protocol (RIP), based on the distance-vector algorithm,
2.Open Shortest Path First (OSPF), based on the link-state algorithm,
3.Border Gateway Protocol (BGP), based on the path-vector algorithm.

Routing Information Protocol

The Routing Information Protocol (RIP) is one of the most widely used intradomain routing protocols based on the distance-vector routing algorithm we described earlier. RIP was started as part of the Xerox Network System (XNS), but it was the Berkeley Software Distribution (BSD) version of UNIX that helped make the use of RIP widespread.

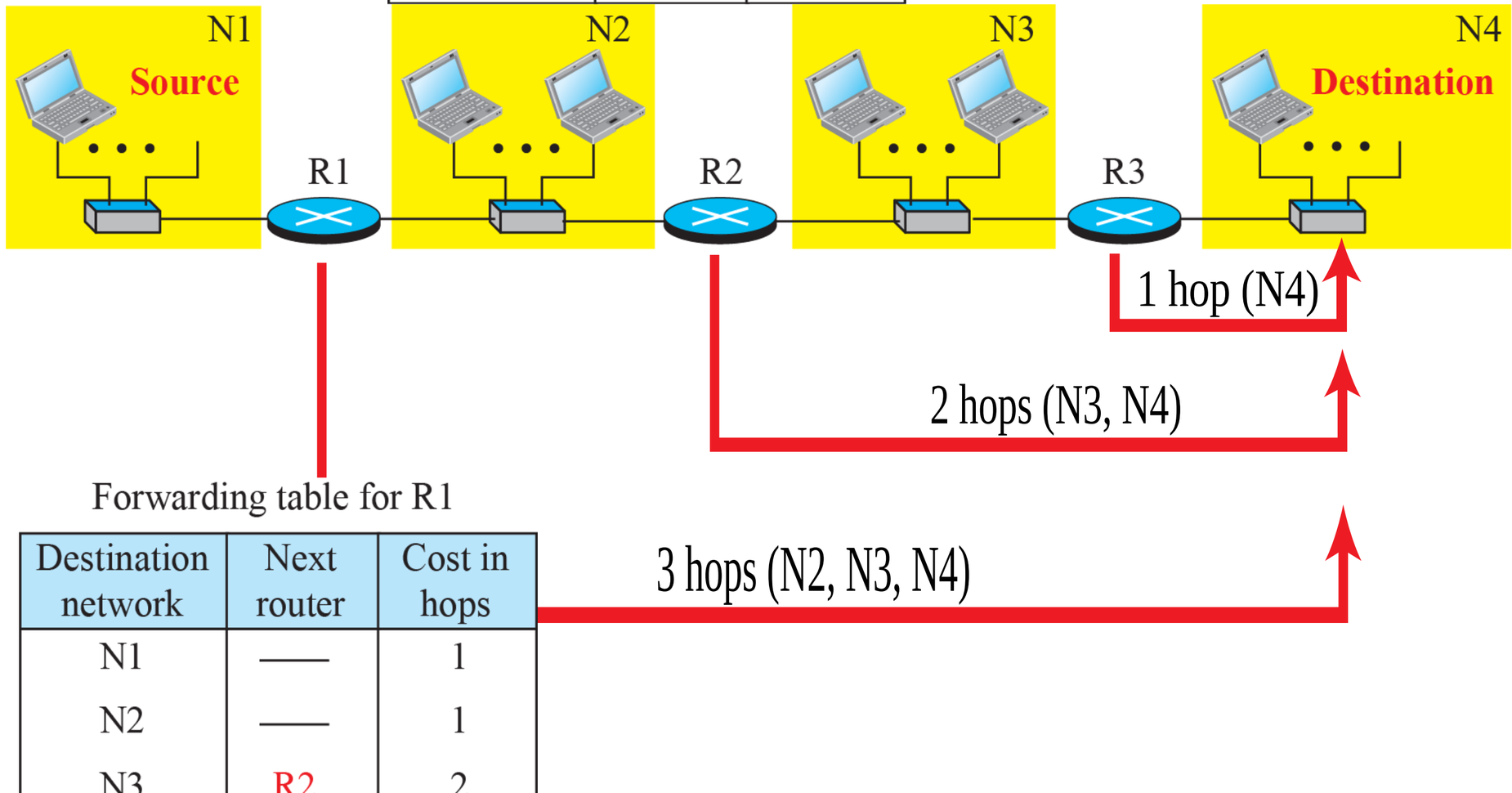
Hop counts in RIP

Forwarding table for R2

Destination network	Next router	Cost in hops
N1	R1	2
N2	——	1
N3	——	1
N4	R3	2

Forwarding table for R3

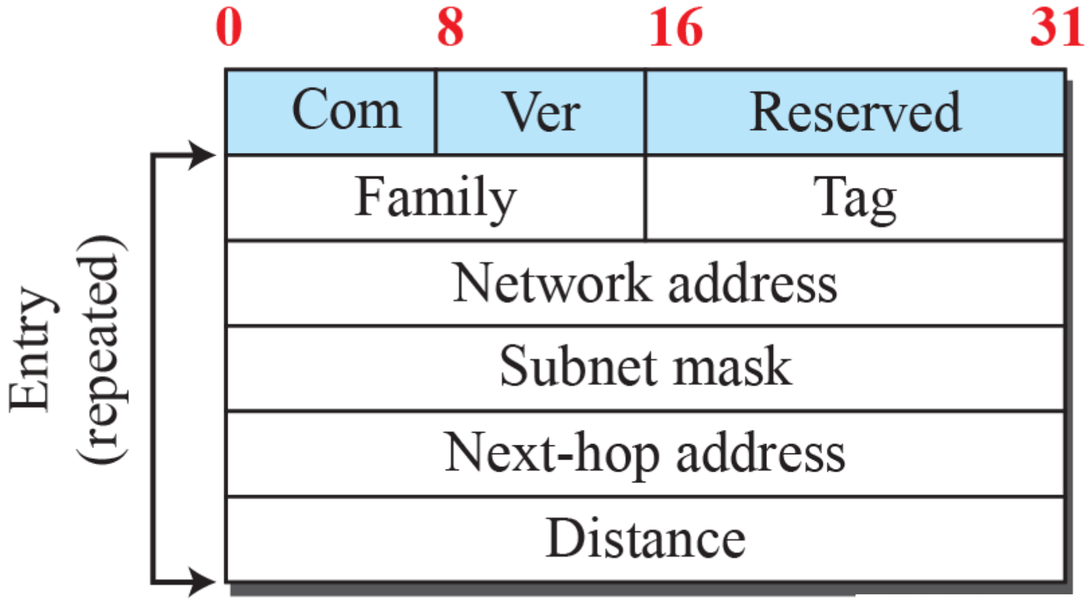
Destination network	Next router	Cost in hops
N1	R2	3
N2	R2	2
N3	——	1
N4	——	1



Forwarding table for R1

Destination network	Next router	Cost in hops
N1	——	1
N2	——	1
N3	R2	2
N4	R2	3

RIP message format

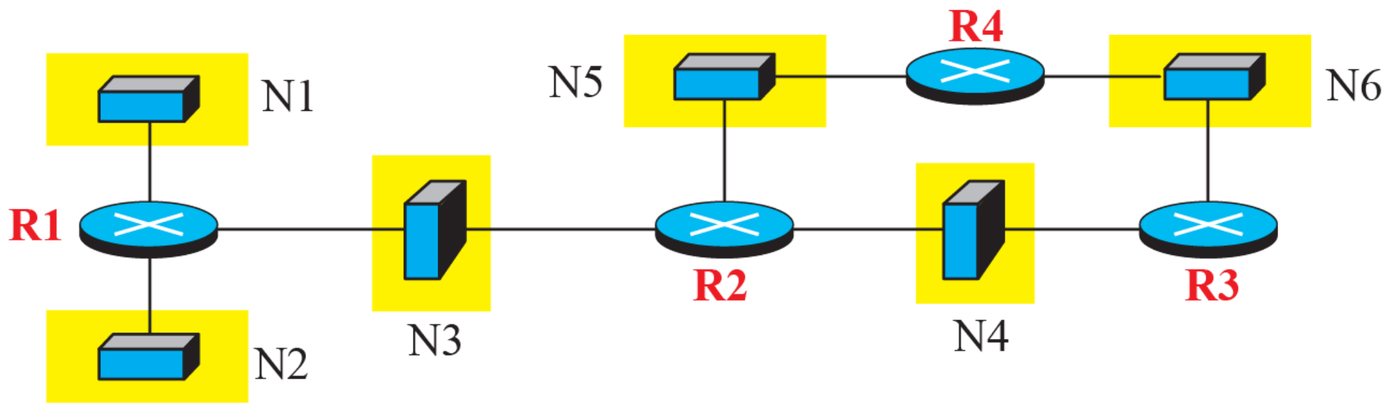


Fields

Com: Command, request (1), response (2)
Ver: Version, current version is 2
Family: Family of protocol, for TCP/IP value is 2
Tag: Information about autonomous system
Network address: Destination address
Subnet mask: Prefix length
Next-hop address: Address length
Distance: Number of hops to the destination

Figure shows a more realistic example of the operation of RIP in an autonomous system. First, the figure shows all forwarding tables after all routers have been booted. Then we show changes in some tables when some update messages have been exchanged. Finally, we show the stabilized forwarding tables when there is no more change.

Example of an autonomous system using RIP (Part I)



Legend

Des.: Destination network
N. R.: Next router
Cost: Cost in hops

R1

Des.	N. R.	Cost
N1	———	1
N2	———	1
N3	———	1

R2

Des.	N. R.	Cost
N3	———	1
N4	———	1
N5	———	1

R3

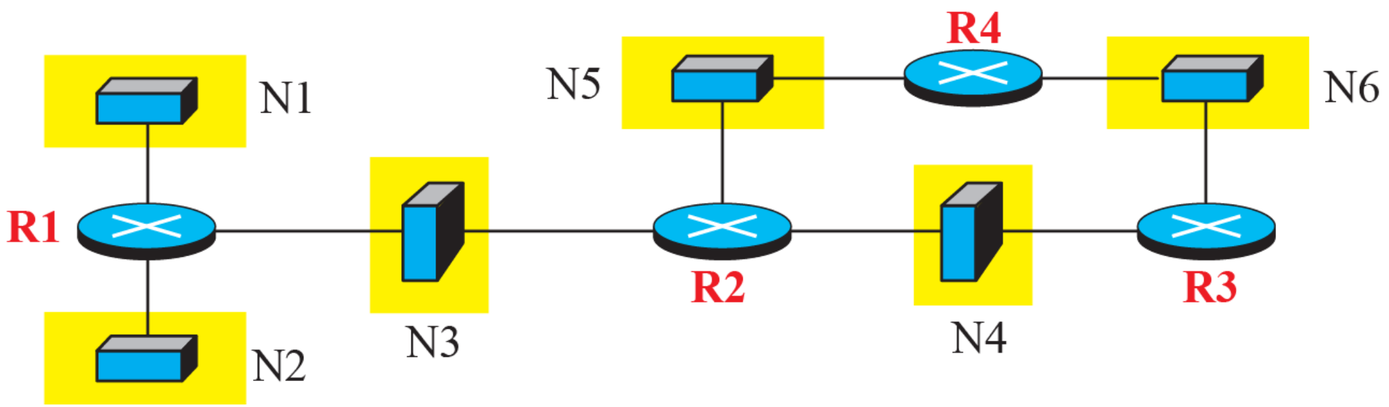
Des.	N. R.	Cost
N4	———	1
N6	———	1

R4

Des.	N. R.	Cost
N5	———	1
N6	———	1

Forwarding tables after all routers booted

Example of an autonomous system using RIP (Part II)



Legend

Des.: Destination network
N. R.: Next router
Cost: Cost in hops
: New route
: Old route

New R1

Des.	N. R.	Cost
N1	——	1
N2	——	1
N3	——	1
N4	R2	2
N5	R2	2

Old R1

Des.	N. R.	Cost
N1	——	1
N2	——	1
N3	——	1

R2 Seen by R1

Des.	N. R.	Cost
N3	R2	2
N4	R2	2
N5	R2	2

New R3

Des.	N. R.	Cost
N3	R2	2
N4	——	1
N5	R2	2
N6	——	1

Old R3

Des.	N. R.	Cost
N4	——	1
N6	——	1

R2 Seen by R3

Des.	N. R.	Cost
N3	R2	2
N4	R2	2
N5	R2	2

New R4

Des.	N. R.	Cost
N3	R2	2
N4	R2	2
N5	——	1
N6	——	1

Old R4

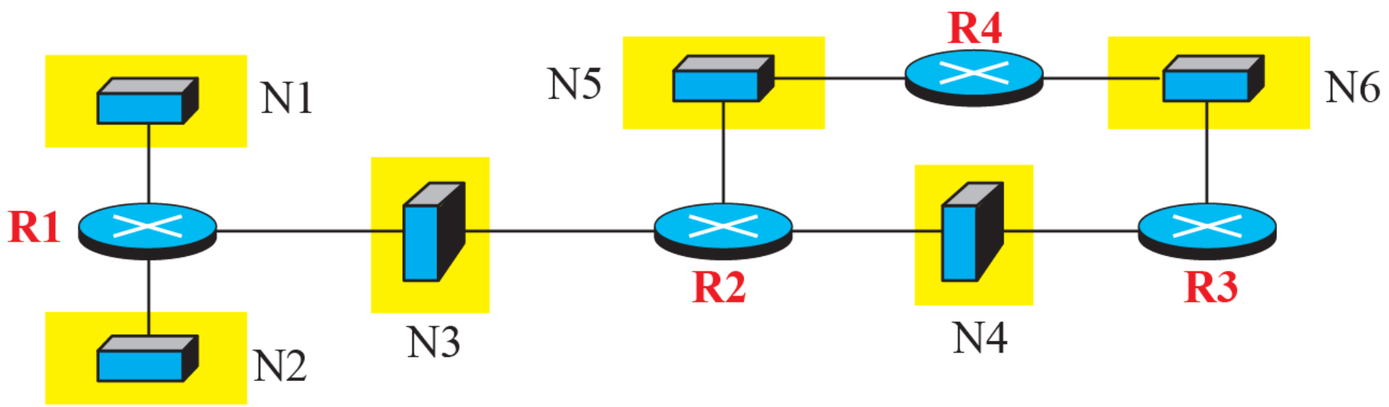
Des.	N. R.	Cost
N5	——	1
N6	——	1

R2 Seen by R4

Des.	N. R.	Cost
N3	R2	2
N4	R2	2
N5	R2	2

Changes in the forwarding tables of R1, R3, and R4 after they receive a copy of R2's table

Example of an autonomous system using RIP (Part III)



Legend

Des.: Destination network
N. R.: Next router
Cost: Cost in hops

Forwarding tables for all routers after they have been stablized

Final R1

Des.	N. R.	Cost
N1	———	1
N2	———	1
N3	———	1
N4	R2	2
N5	R2	2
N6	R2	3

Final R2

Des.	N. R.	Cost
N1	R1	2
N2	R1	2
N3	———	1
N4	———	1
N5	———	1
N6	R3	2

Final R3

Des.	N. R.	Cost
N1	R2	3
N2	R2	3
N3	R2	2
N4	———	1
N5	R2	2
N6	———	1

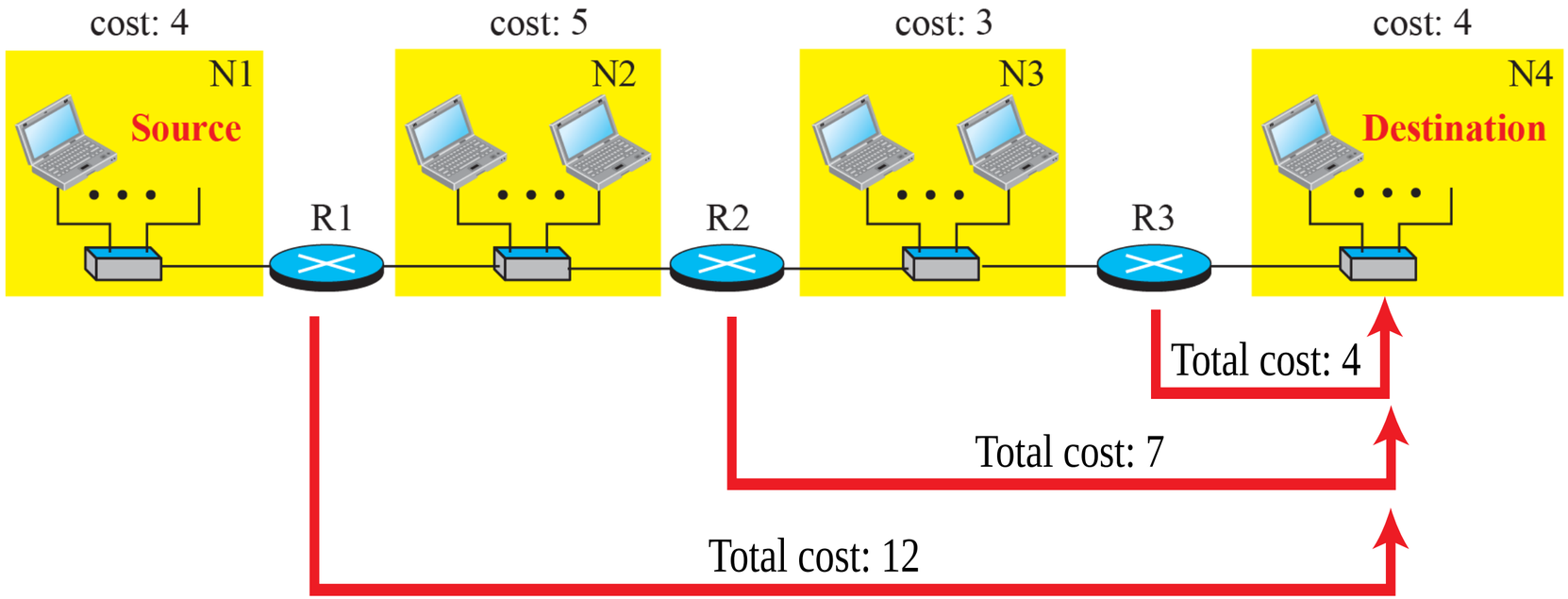
Final R4

Des.	N. R.	Cost
N1	R2	3
N2	R2	3
N3	R2	2
N4	R2	2
N5	———	1
N6	———	1

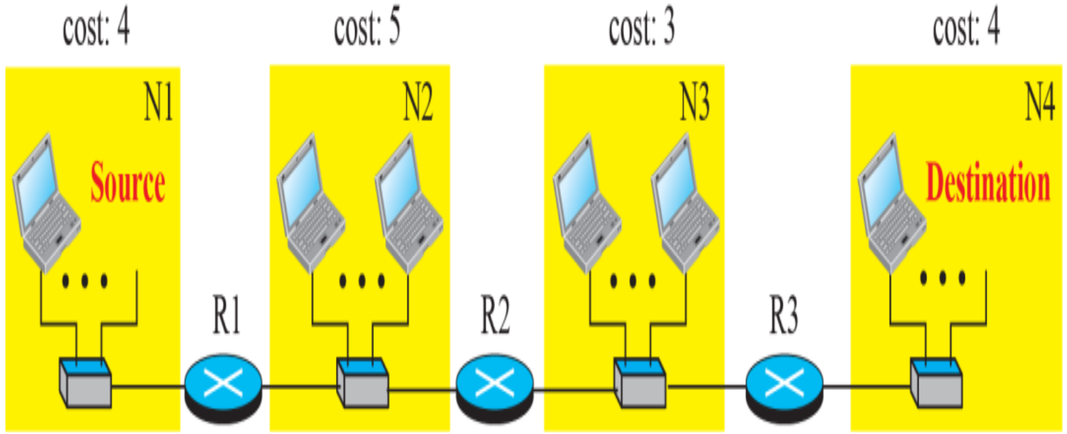
Open Shortest Path First

Open Shortest Path First (OSPF) is also an intradomain routing protocol like RIP, but it is based on the link-state routing protocol . OSPF is an open protocol, which means that the specification is a public document.

Metric in OSPF



Forwarding tables in OSPF



Forwarding table for R1

Destination network	Next router	Cost
N1	——	
N2	——	
N3	R2	
N4	R2	12

Forwarding table for R3

Destination network	Next router	Cost
N1	R2	12
N2	R2	8
N3	——	3
N4	——	4

Forwarding table for R2

Destination network	Next router	Cost
N1	R1	9
N2	——	5
N3	——	3
N4	R3	7

Areas in an autonomous system

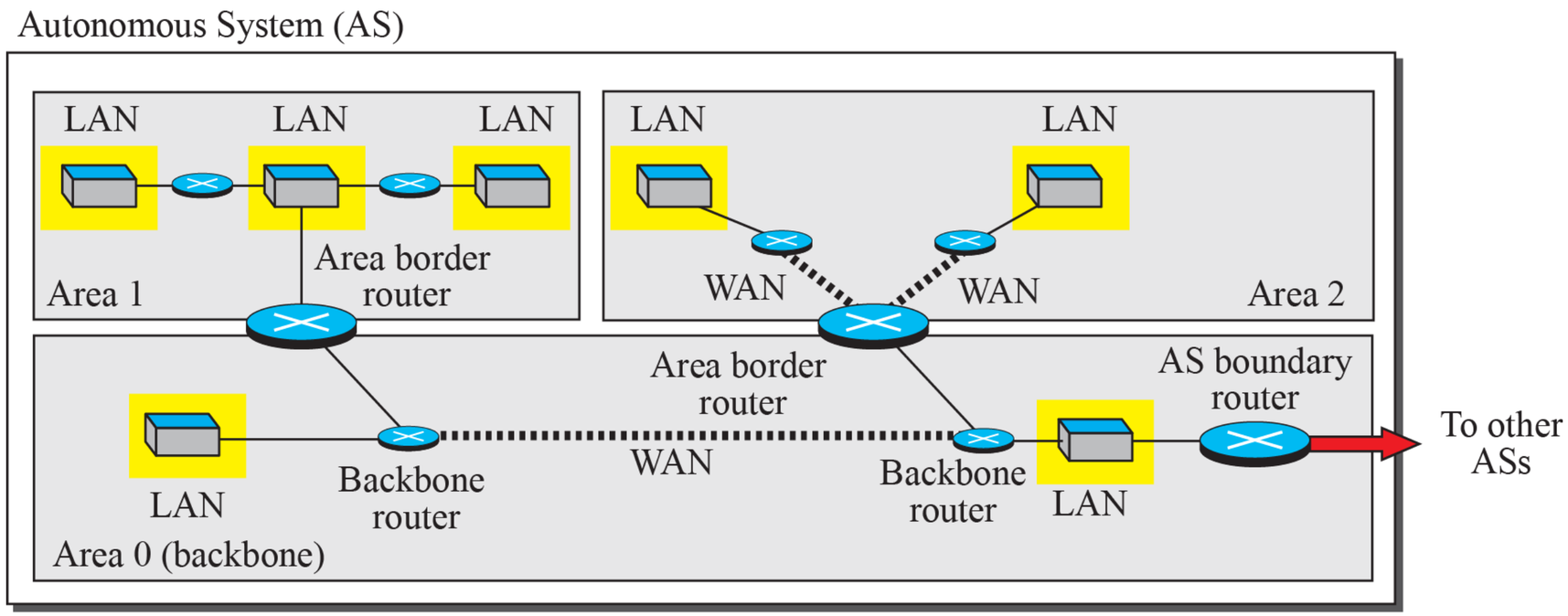
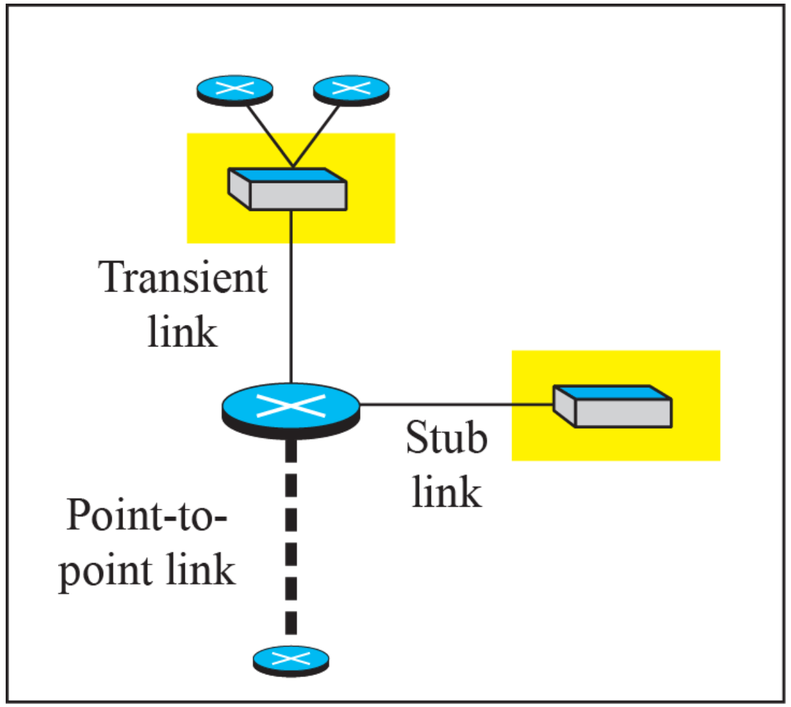
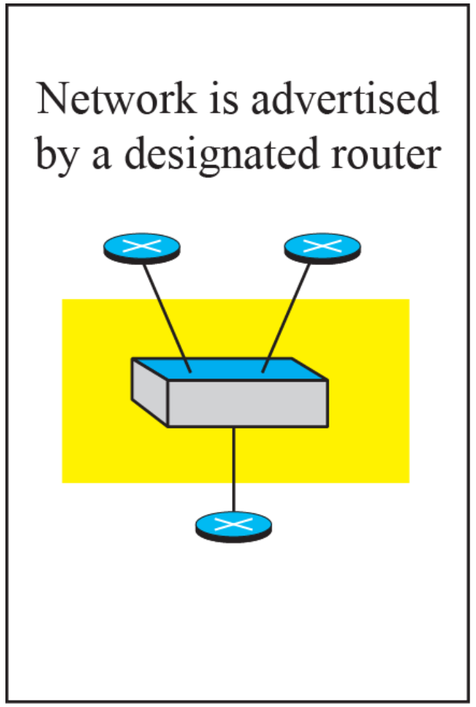


Figure 20.22: Five different LSPs (Part I)

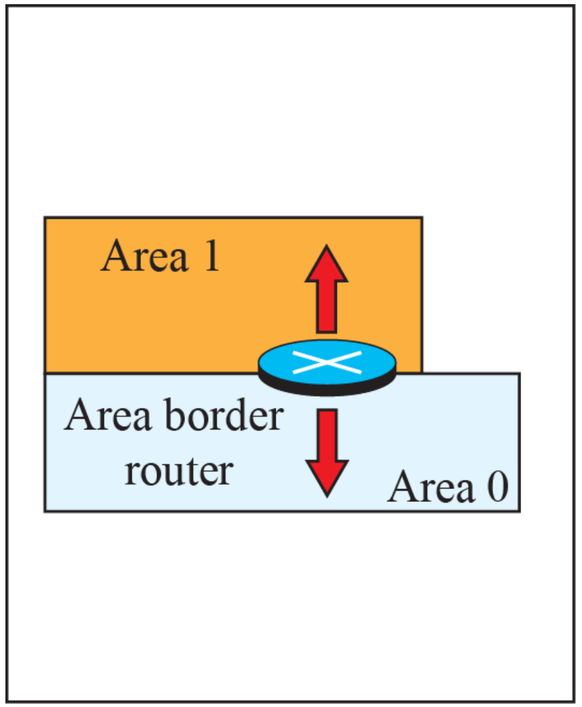


a. Router link

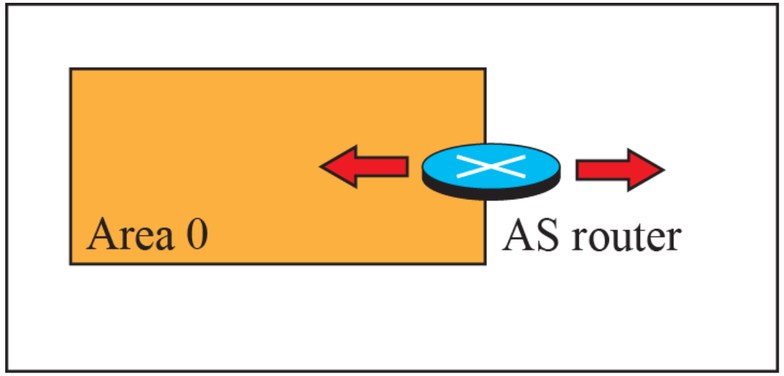


b. Network link

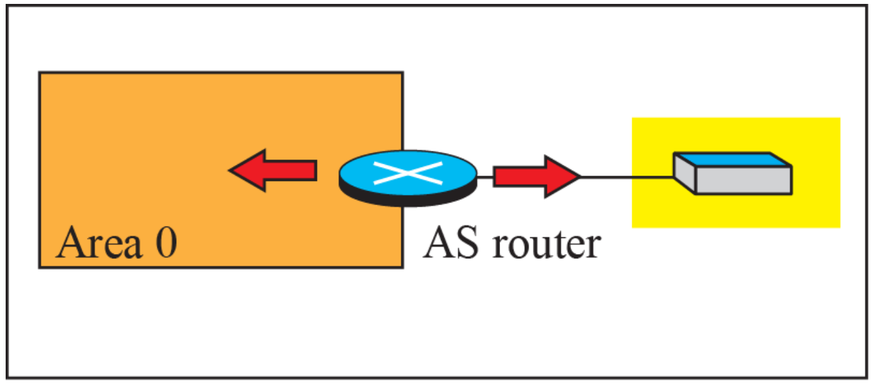
Figure 20.22: Five different LSPs (Part II)



c. Summary link to network

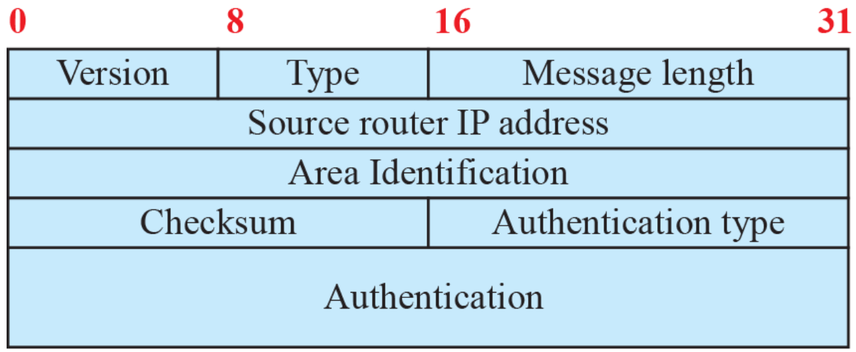


d. Summary link to AS



e. External link

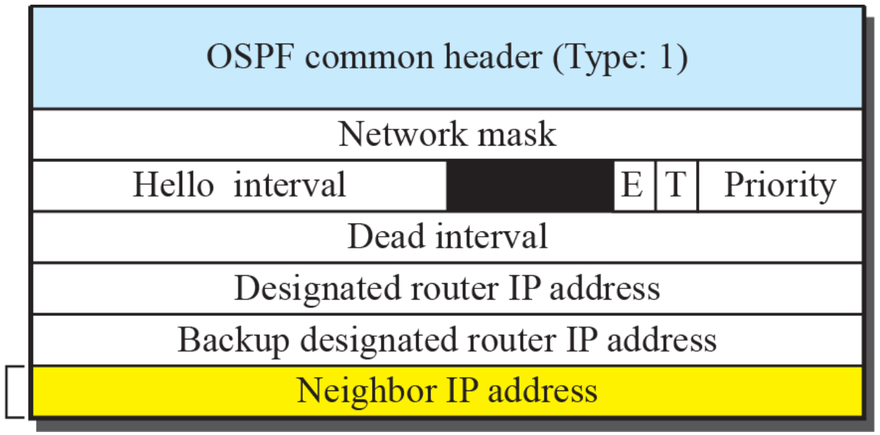
Figure 20.23: OSPF message formats (Part I)



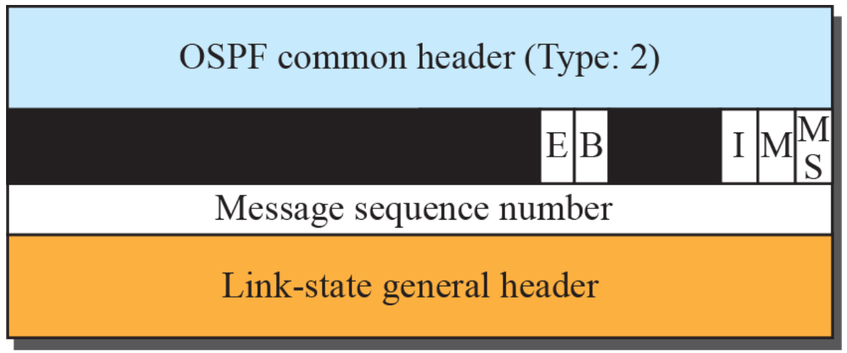
OSPF common header

Legend

E, T, B, I, M, MS: flags used by OSPF
Priority: used to define the designated router
Rep.: Repeated as required

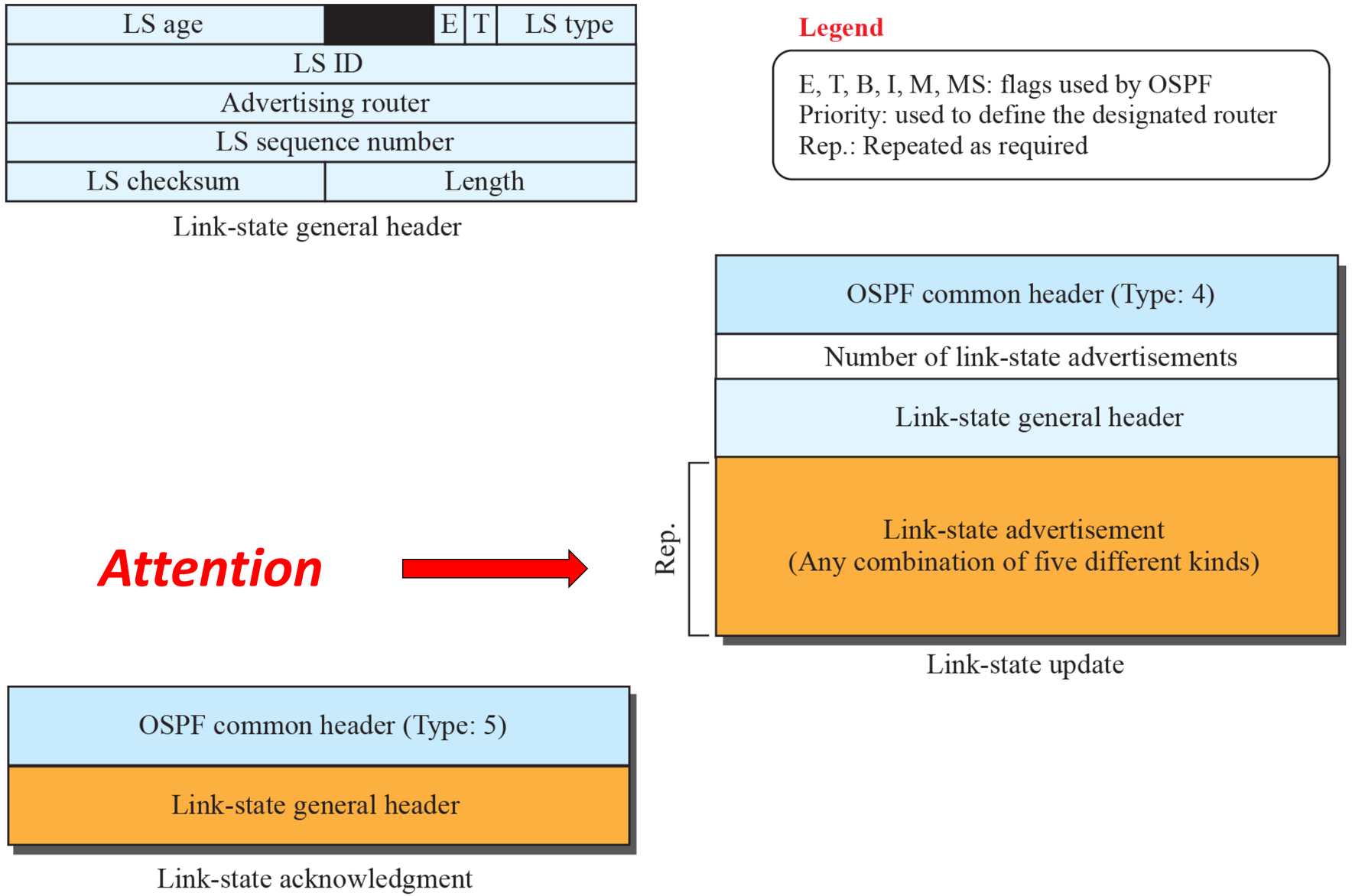


Attention



Database description

Figure 20.23: OSPF message formats (Part II)



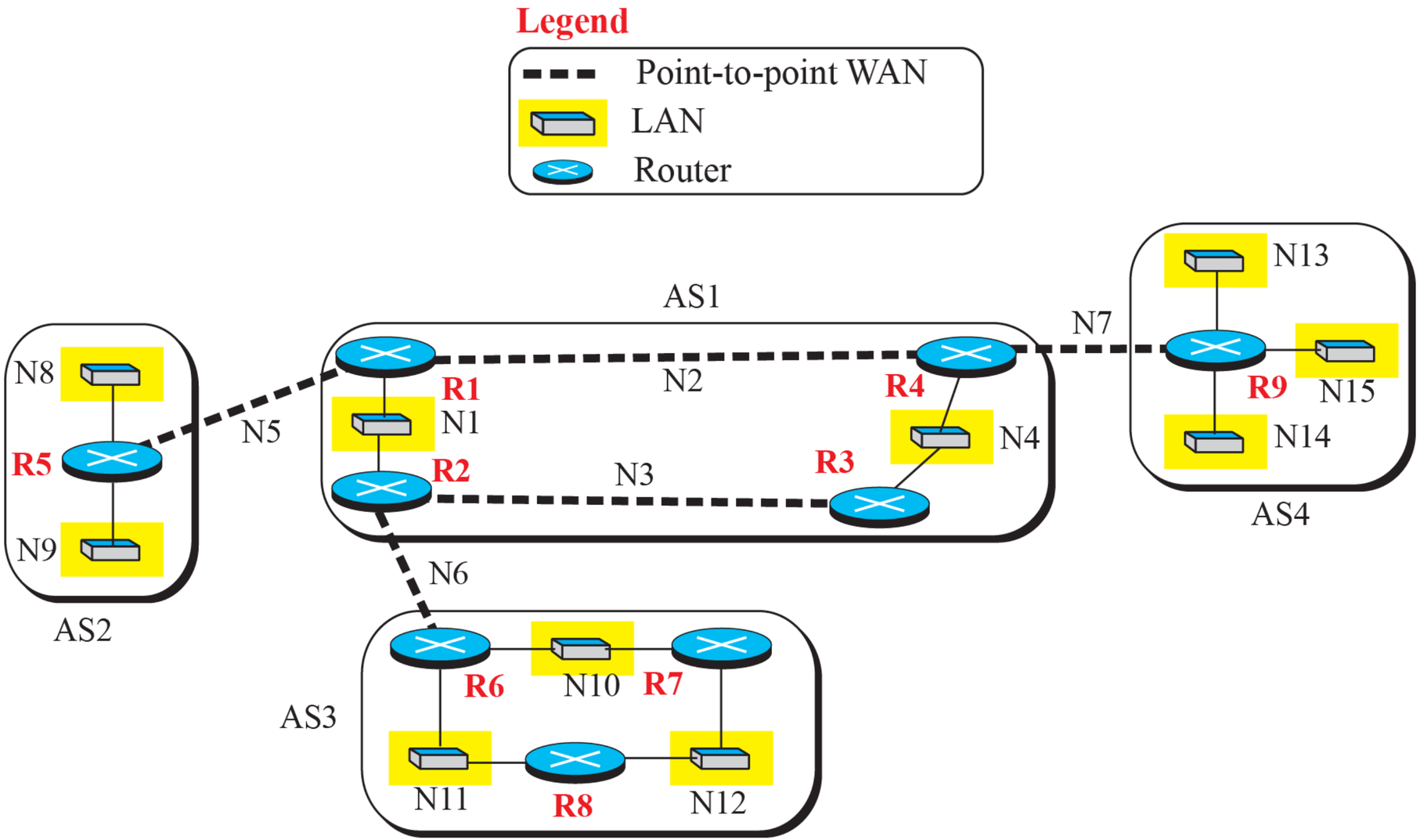
Border Gateway Protocol

- The Border Gateway Protocol version 4 (BGP4) is the only interdomain routing protocol used in the Internet today.
- BGP4 is based on the path-vector algorithm we described before, but it is tailored to provide information about the reachability of networks in the Internet.

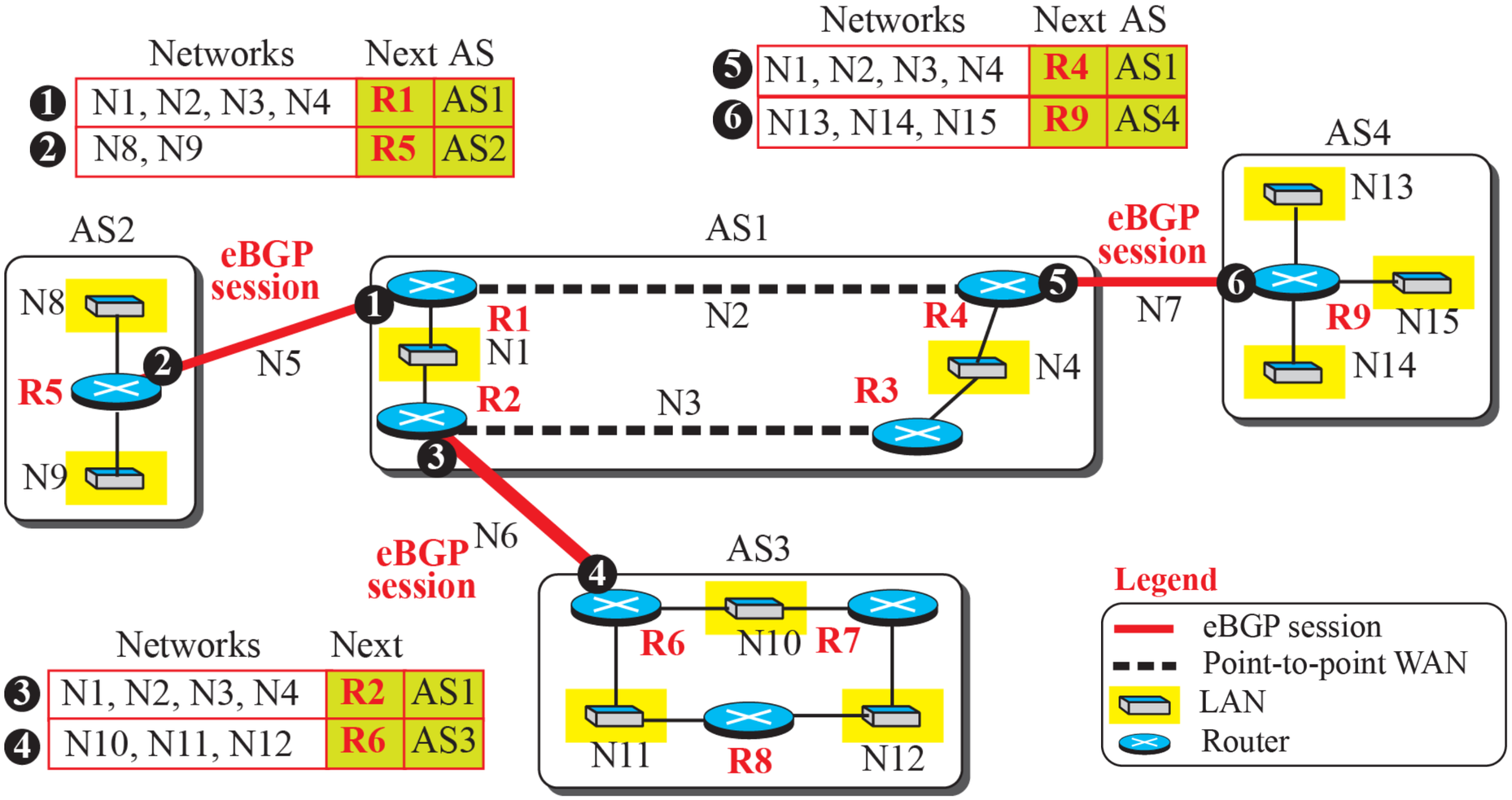
- BGP, and in particular BGP4, is a complex protocol. In this section, we introduce the basics of BGP and its relationship with intradomain routing protocols (RIP or OSPF).
- Figure shows an example of an internet with four autonomous systems. AS2, AS3, and AS4 are *stub autonomous systems; AS1 is a transient one.*
- *In our example,* data exchange between AS2, AS3, and AS4 should pass through AS1.

- To enable each router to route a packet to any network in the internet, we first install a variation of BGP4, called *external BGP (eBGP), on each border router (the* one at the edge of each AS which is connected to a router at another AS).
- We then install the second variation of BGP, called *internal BGP (iBGP), on all routers.*
- *This* means that the border routers will be running three routing protocols (intradomain,eBGP, and iBGP), but other routers are running two protocols (intradomain and iBGP).

A sample internet with four ASs



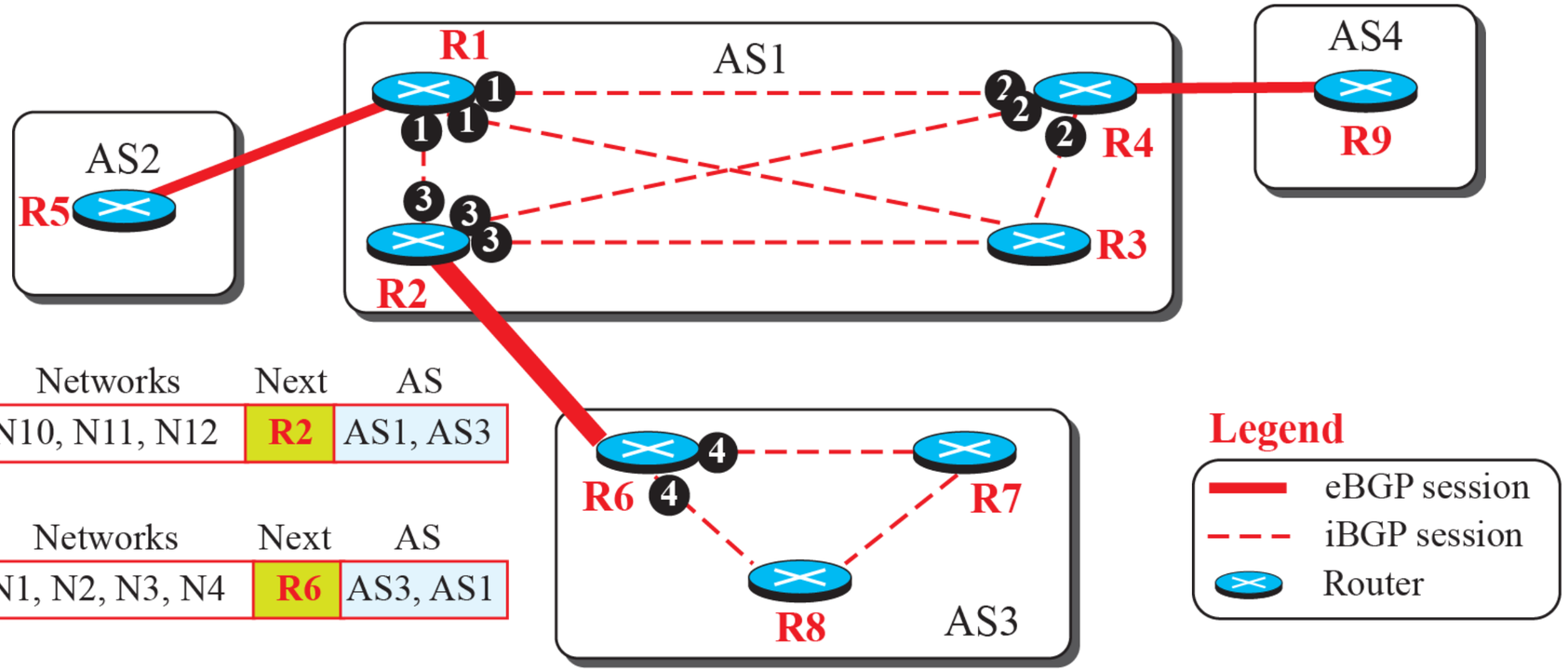
eBGP operation



Combination of eBGP and iBGP sessions in our internet

	Networks	Next	AS
1	N8, N9	R1	AS1, AS2

	Networks	Next	AS
2	N13, N14, N15	R4	AS1, AS4



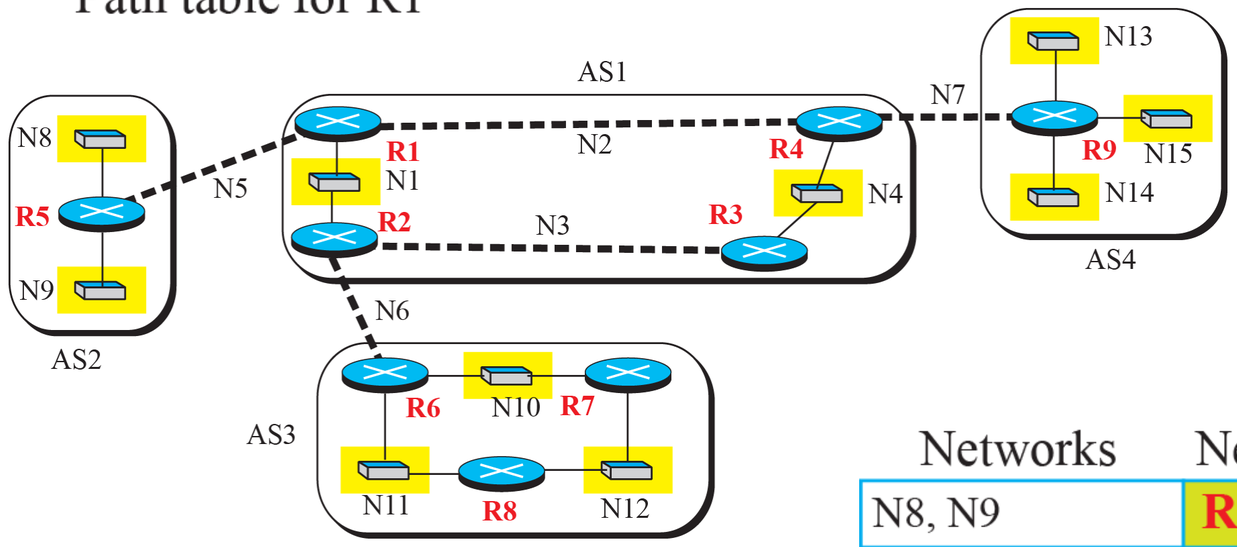
	Networks	Next	AS
3	N10, N11, N12	R2	AS1, AS3

	Networks	Next	AS
4	N1, N2, N3, N4	R6	AS3, AS1

Finalized BGP path tables (Part I)

Networks	Next	Path
N8, N9	R5	AS1, AS2
N10, N11, N12	R2	AS1, AS3
N13, N14, N15	R4	AS1, AS4

Path table for R1



Networks	Next	Path
N8, N9	R1	AS1, AS2
N10, N11, N12	R6	AS1, AS3
N13, N14, N15	R1	AS1, AS4

Path table for R2

Networks	Next	Path
N8, N9	R2	AS1, AS2
N10, N11, N12	R2	AS1, AS3
N13, N14, N15	R4	AS1, AS4

Path table for R3

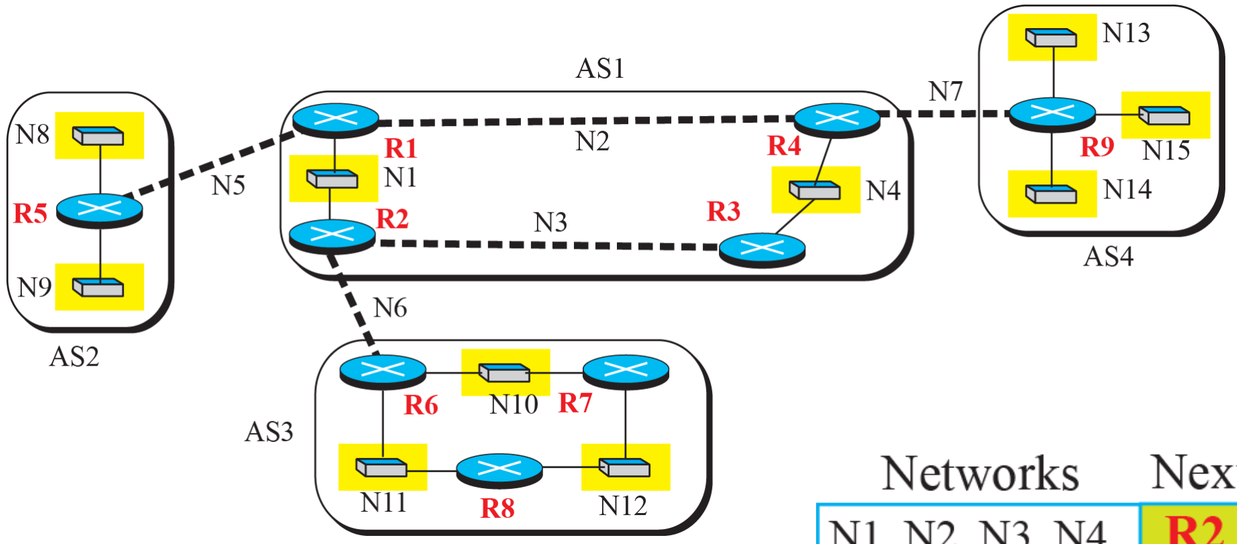
Finalized BGP path tables (Part II)

Networks	Next	Path
N1, N2, N3, N4	R1	AS2, AS1
N10, N11, N12	R1	AS2, AS1, AS3
N13, N14, N15	R1	AS2, AS1, AS4

Path table for R5

Networks	Next	Path
N8, N9	R1	AS1, AS2
N10, N11, N12	R1	AS1, AS3
N13, N14, N15	R9	AS1, AS4

Path table for R4



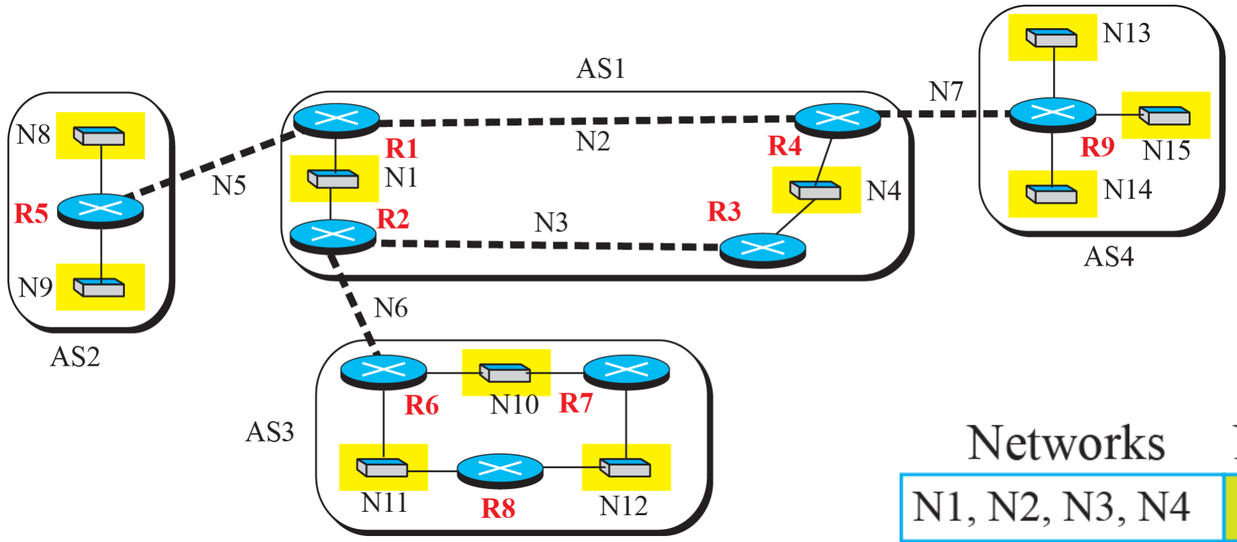
Networks	Next	Path
N1, N2, N3, N4	R2	AS3, AS1
N8, N9	R2	AS3, AS1, AS2
N13, N14, N15	R2	AS3, AS1, AS4

Path table for R6

Finalized BGP path tables (Part III)

Networks	Next	Path
N1, N2, N3, N4	R4	AS4, AS1
N8, N9	R4	AS4, AS1, AS2
N10, N11, N12	R4	AS4, AS1, AS3

Path table for R9



Networks	Next	Path
N1, N2, N3, N4	R6	AS3, AS1
N8, N9	R6	AS3, AS1, AS2
N13, N14, N15	R6	AS3, AS1, AS4

Path table for R8

Networks	Next	Path
N1, N2, N3, N4	R6	AS3, AS1
N8, N9	R6	AS3, AS1, AS2
N13, N14, N15	R6	AS3, AS1, AS4

Path table for R7

Forwarding tables after injection from BGP (Part I)

Des.	Next	Cost
N1	—	1
N4	R4	2
N8	R5	1
N9	R5	1
N10	R2	2
N11	R2	2
N12	R2	2
N13	R4	2
N14	R4	2
N15	R4	2

Table for R1

Des.	Next	Cost
N1	—	1
N4	R3	2
N8	R1	2
N9	R1	2
N10	R6	1
N11	R6	1
N12	R6	1
N13	R3	3
N14	R3	3
N15	R3	3

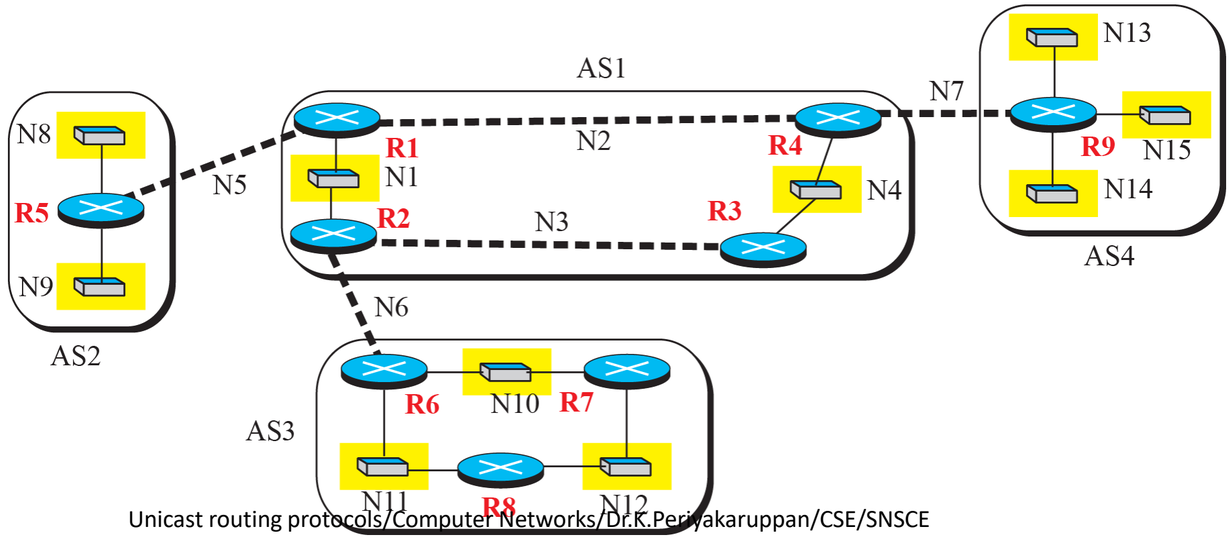
Table for R2

Des.	Next	Cost
N1	R2	2
N4	—	1
N8	R2	3
N9	R2	3
N10	R2	2
N11	R2	2
N12	R2	2
N13	R4	2
N14	R4	2
N15	R4	2

Table for R3

Des.	Next	Cost
N1	R1	2
N4	—	1
N8	R1	2
N9	R1	2
N10	R3	3
N11	R3	3
N12	R3	3
N13	R9	1
N14	R9	1
N15	R9	1

Table for R4



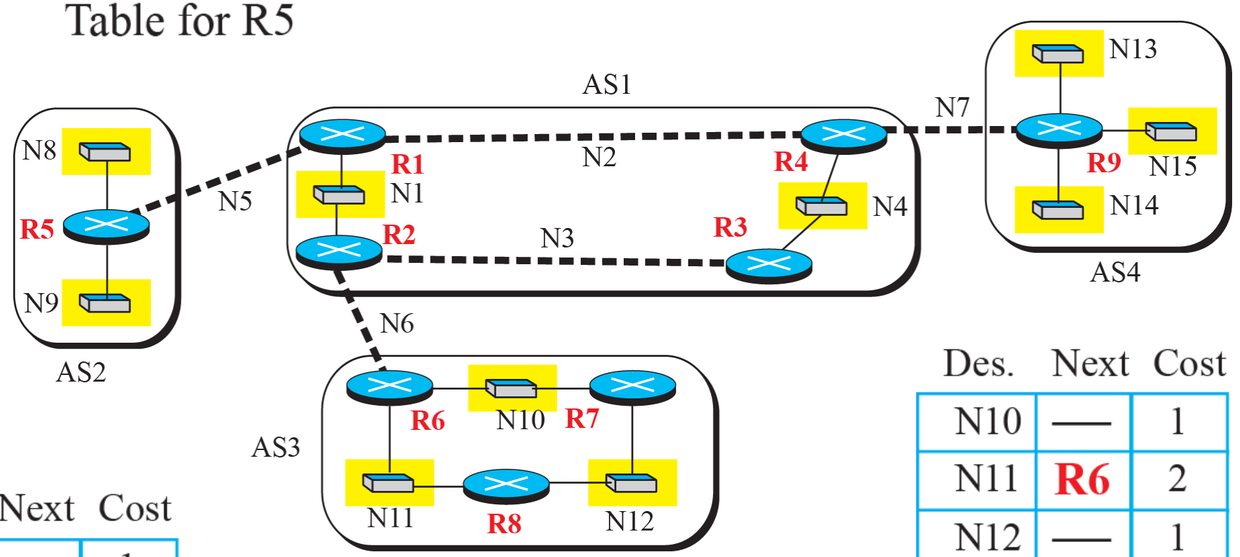
Forwarding tables after injection from BGP (Part II)

Des.	Next	Cost
N8	—	1
N9	—	1
0	**R1**	1

Table for R5

Des.	Next	Cost
N13	—	1
N14	—	1
N15	—	1
0	**R4**	1

Table for R9



Des.	Next	Cost
N10	—	1
N11	—	1
N12	**R7**	2
0	**R2**	1

Table for R6

Des.	Next	Cost
N10	**R6**	2
N11	—	1
N12	—	1
0	**R6**	2

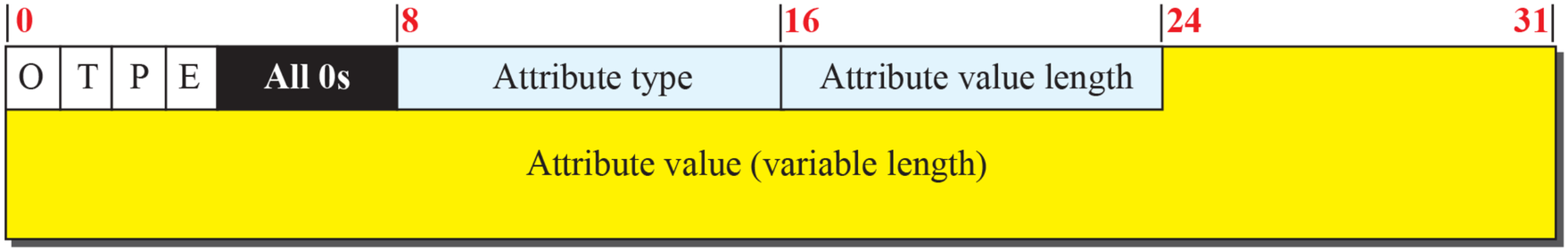
Table for R8

Des.	Next	Cost
N10	—	1
N11	**R6**	2
N12	—	1
0	**R6**	2

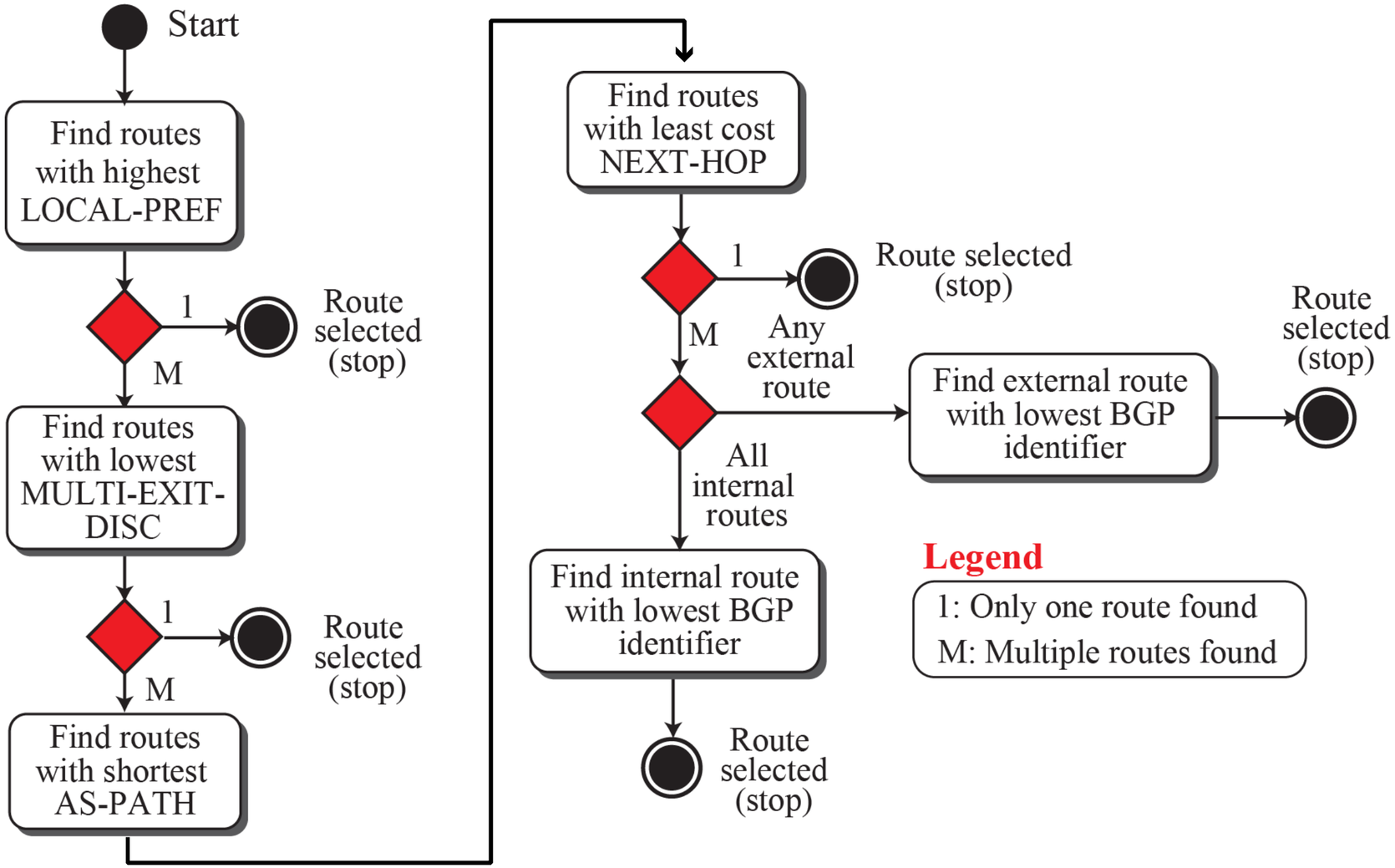
Table for R7

Format of path attribute

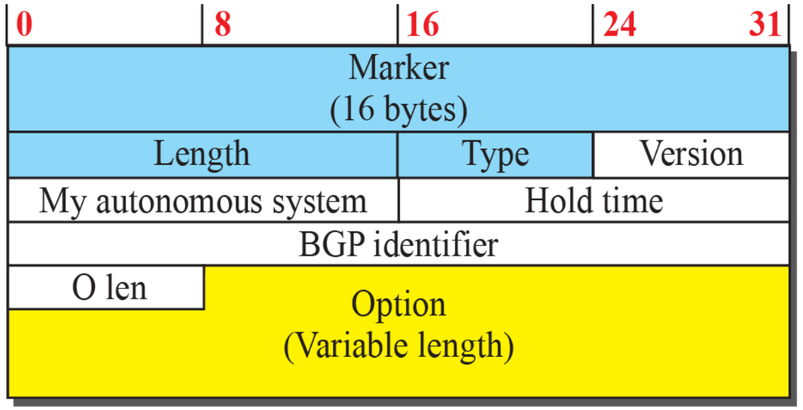
O: Optional bit (set if attribute is optional)
P: Partial bit (set if an optional attribute in lost in transit)
T: Transitive bit (set if attribute is transitive)
E: Extended bit (set if attribute length is two bytes)



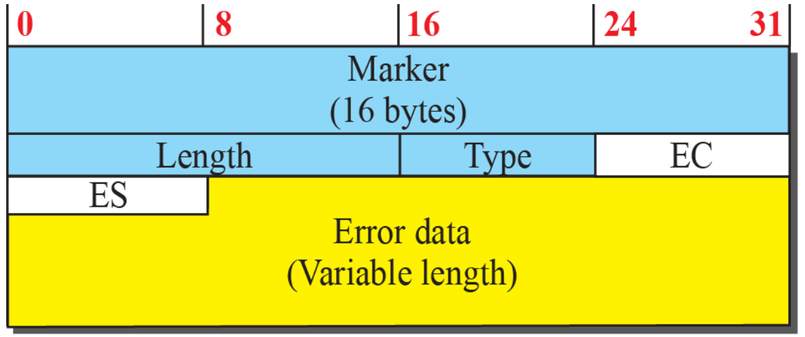
Flow diagram for route selection



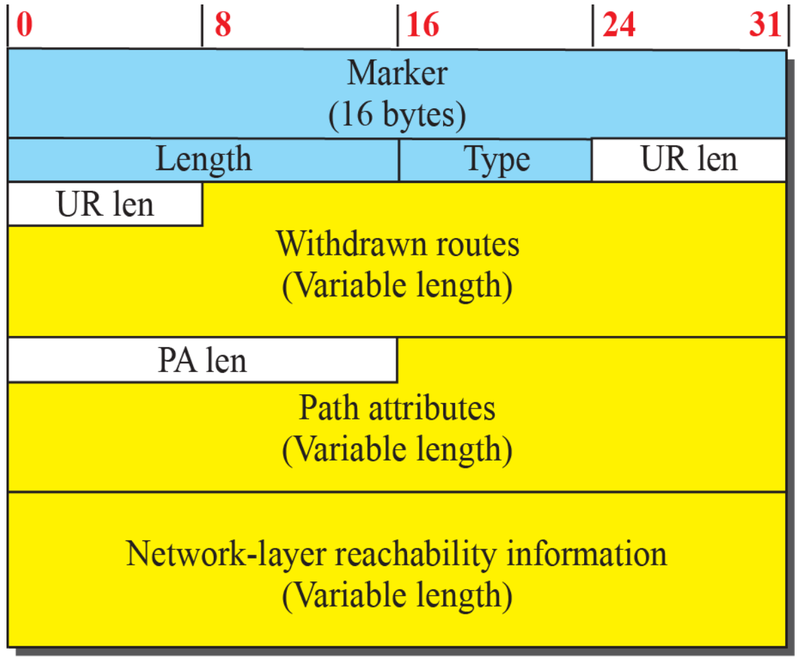
BGP messages



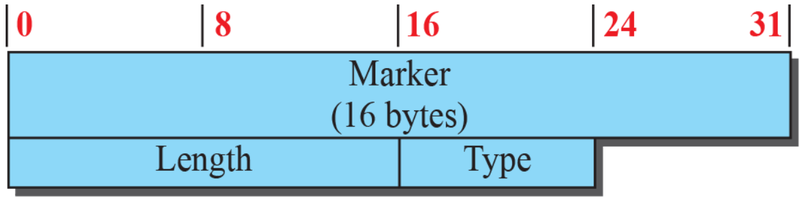
Open message (type 1)



Notification message (type 3)



Update message (type 2)



Keepalive message (type 4)

Fields in common header

Marker: Reserved for authentication
Length: Length of total message in bytes
Type: Type of message (1 to 4)

Abbreviations

O len: Option length
EC: Error code
ES: Error subcode
UR len: Unfeasible route length
PA len: Path attribute length

Assessment

a) List Unicast routing protocols.
 b) What is RIP?
c) What is Intra and inter domain routing protocols?
d) What is BGP?.

Reference

TEXT BOOKS

Behrouz A. Forouzan, Data Communications and Networking, Fifth Edition TMH, 2013.

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