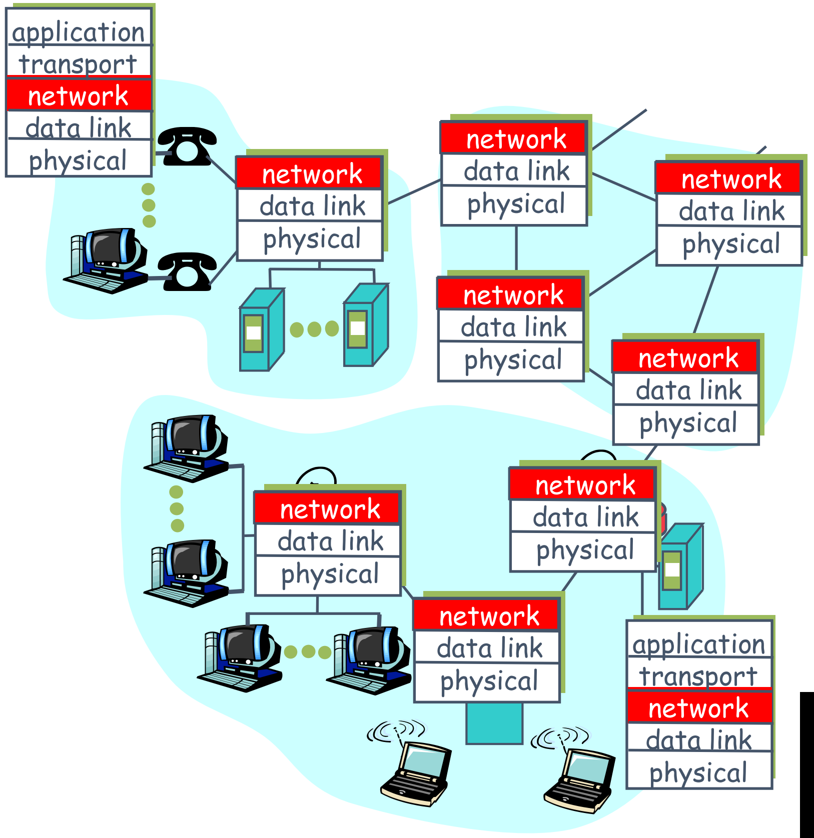
NETWORK LAYER : Fungsi Routing

Fungsi network layer

- Membawa paket dari host pengirim ke penerima
- Protokol network layer ada di setiap host dan router

Tiga fungsi utama:

1. *path determination:* menentukan rute yang ditempuh paket dari sumber ke tujuan (*Routing algorithms*)
2. *switching:* memindahkan paket dari input router ke output router
3. *call setup:* beberapa arsitektur jaringan mensyaratkan *router call setup* sepanjang jalur sebelum data dialirkan



Routing

Routing protocol

Goal: menentukan suatu jalur yang “baik” (router-router yang berurutan) melalui suatu jaringan dari source ke destination.

Graph abstraction untuk algoritma routing :

graph nodes (vertex) adalah routers

graph edges (arc) adalah link fisik

link cost: delay, biaya, atau level kongesti

- Jalur yang “baik” :
    - Biasanya berarti jalur dengan biaya yang minimum
    - Bisa jadi ada definisi lain

METRIC

Metric yang bisa digunakan :

Hop count

Bandwidth

Delay

Load

Reliability→ biasanya refers to BER

Maximum transmission unit

ROUTING PROTOCOL & ROUTED PROTOCOL

Routing Protocol

protokol untuk komunikasi antara router-router

mengijinkan router-router untuk sharing informasi tentang jaringan dan koneksi antar router → untuk membangun dan memperbaiki table routing

Contoh routing protokol:

- Routing Information Protocol (RIP)
- Interior Gateway Routing Protocol (IGRP)
- Enhanced Interior Gateway Routing Protocol (EIGRP)
- Open Shortest Path First (OSPF)

Routed Protocol

Protokol untuk mengatur paket data / trafik user

menyediakan informasi yang cukup dalam layer address jaringannya untuk melewatkan paket yang akan diteruskan dari satu host ke host yang lain berdasarkan alamatnya.

Contoh routed protocol:

- Internet Protocol (IP)
- Internetwork Packet Exchange (IPX)

KLASIFIKASI ALGORITMA ROUTING

STATIC OR DYNAMIC?

Static

informasi tabel routing dientrikan oleh administrator secara manual

cocok digunakan untuk jaringan skala kecil /router lokal

Dinamis

keuntungan : mudah dikelola, mampu beradaptasi dengan perubahan kondisi internetwork, route berdasarkan informasi router tetangga

Cocok untuk jaringan skala besar

Contoh : - RIP (algoritma distance vector)

- OSPF (alg link-state)

PROTOKOL ROUTING UNICAST

- Tabel routing dapat berupa statis atau dinamis.
- Tabel statis adalah tabel dengan entri manual. Tabel dinamis adalah tabel yang diperbarui secara otomatis ketika ada perubahan di suatu tempat di Internet.
- Protokol perutean adalah kombinasi dari aturan dan prosedur yang memungkinkan router di Internet saling menginformasikan perubahan.

Inter- and Intra-Domain Routing

Internet adalah kombinasi jaringan yang dihubungkan oleh router. Ketika datagram berpindah dari sumber ke tujuan, ia mungkin akan melewati banyak router hingga mencapai router yang terhubung ke jaringan tujuan.

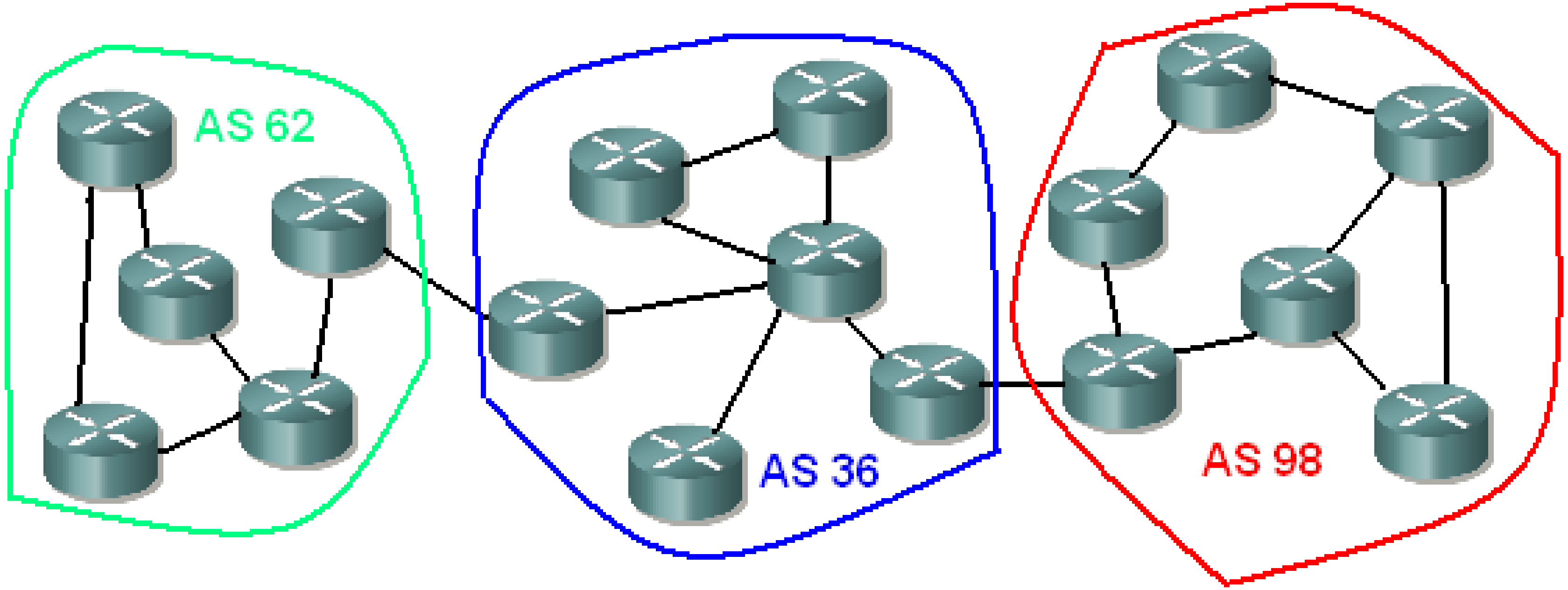
Saat ini, internet bisa sangat besar sehingga satu protokol routing tidak dapat menangani tugas memperbaharui tabel routing semua router. Untuk alasan ini, internet dibagi menjadi Autonomous System (AS). AS adalah sekelompok jaringan dan router di bawah wewenang administrasi tunggal. Routing di dalam AS disebut routing intra-domain. Routing antara sistem otonom disebut inter-domain routing.

Inter Domain :
BGP (antar AS)

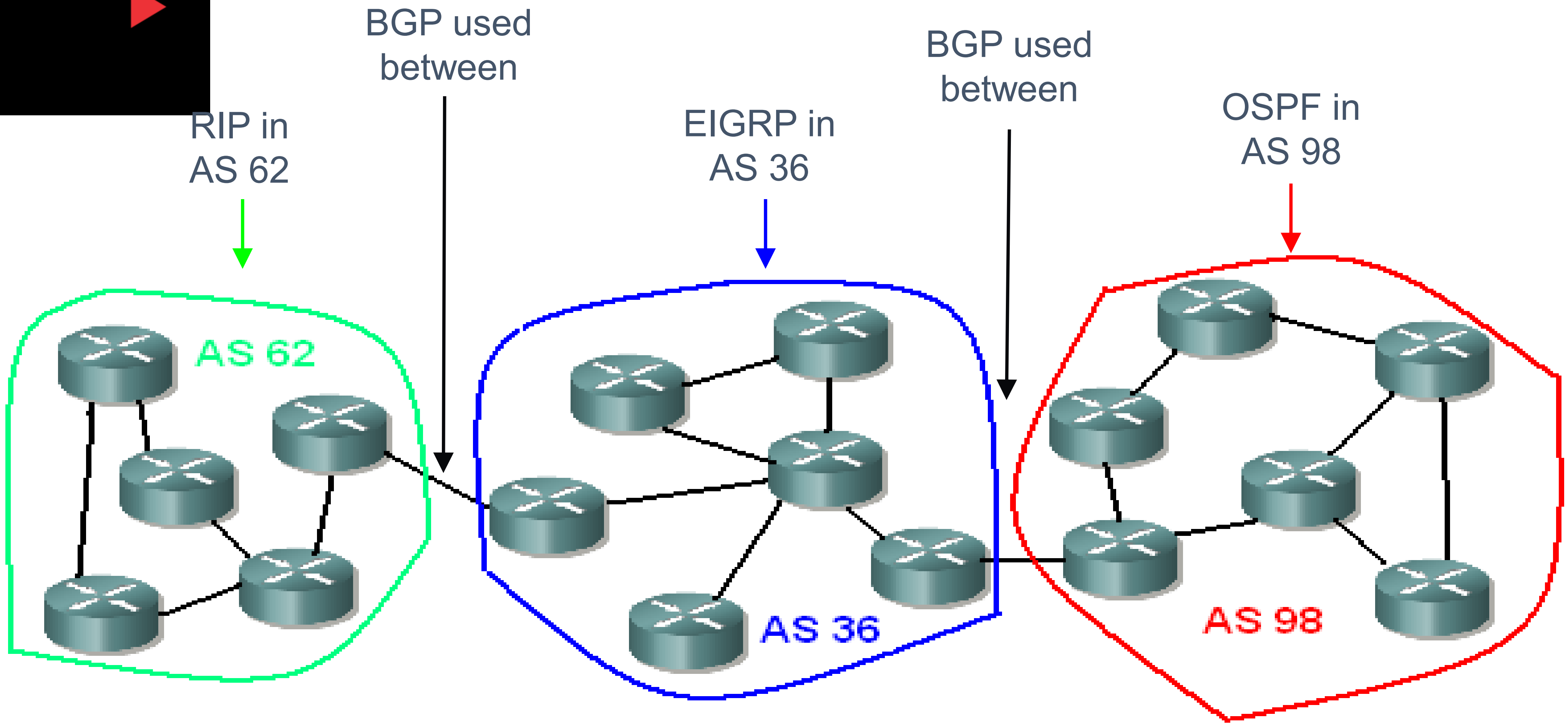
Intra Domain :
OSPF, RIP, IGRP (didalam AS)

Autonomous Sytems (AS)

Autonomous systems membagi internetwork global menjadi unit yang dapat dikelola



Intra- and Inter-Domain



RIP in AS 62

BGP used between

EIGRP in AS 36

BGP used between

OSPF in AS 98

Routing Algorithm classification

Global or decentralized information?

Global:

Semua routers mempunyai informasi yang lengkap mengenai topologi dan biaya link.

“link state” algorithms (OSPF dan IS-IS)

Decentralized:

router hanya mengetahui perangkat yang terhubung kepadanya secara fisik serta biayanya.

Proses komputasi yang iteratif dan pertukaran informasi dengan tetangganya.

“distance vector” algorithms (RIP, IGRP and EIGRP)

SINGLE PATH OR MULTIPATH

Single Path

mempelajari rute dan memilih sebuah rute terbaik

tidak dapat beradaptasi terhadap load balancing traffic

contoh : BGP

Multipath

mempelajari berbagai rute dan memilih lebih dari satu rute terbaik

Elemen Teknik Routing:

- Performansi: Hop, jarak, kecepatan, delay, cost
- Decision Time : paket, sesi
- Decision Place : terdistribusi, sentralisasi
- Informasi sumber : tidak ada, lokal, bertetangga, sepanjang rute, semua node
- Strategi : tetap, adaptif, acak, flooding
- Waktu update routing adaptif : kontinu, periodik, perubahan topologi, perubahan beban utama

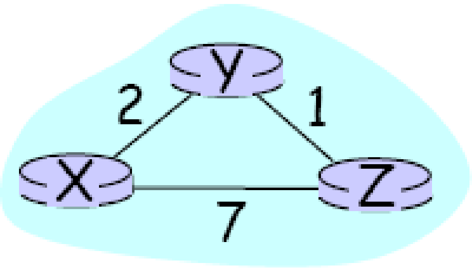
Load Balancing

```
R 192.168.6.0/24 [120/1] via 192.168.2.1, 00:00:24, Serial0/0/0
                 [120/1] via 192.168.4.1, 00:00:26, Serial0/0/1
```

- Routing table lists two routes to the same destination, with the same metric.
- Both routes were discovered by the same protocol.
- Both routes will be used.

Distance Vector

- Algoritma beroperasi dengan memaintain tabel routing dari setiap router . Tabel routing diupdate secara periodik.
- Pada lingkungan pure distance vector, update routing secara periodic melibatkan pengiriman routing table tetangga secara full.



		cost via	
	D^X	Y	Z
dest	Y	2	∞
	Z	∞	7

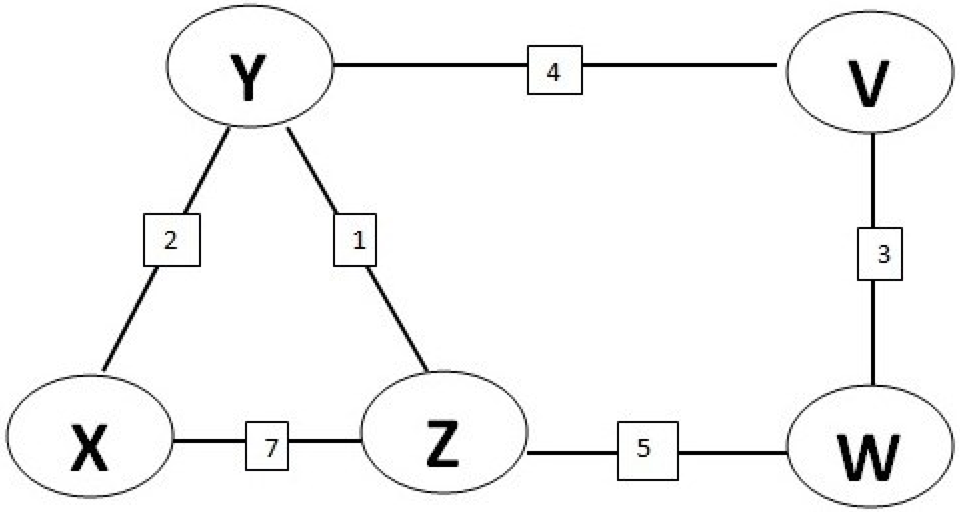
		cost via	
	D^Y	X	Z
dest	X	2	∞
	Z	∞	1

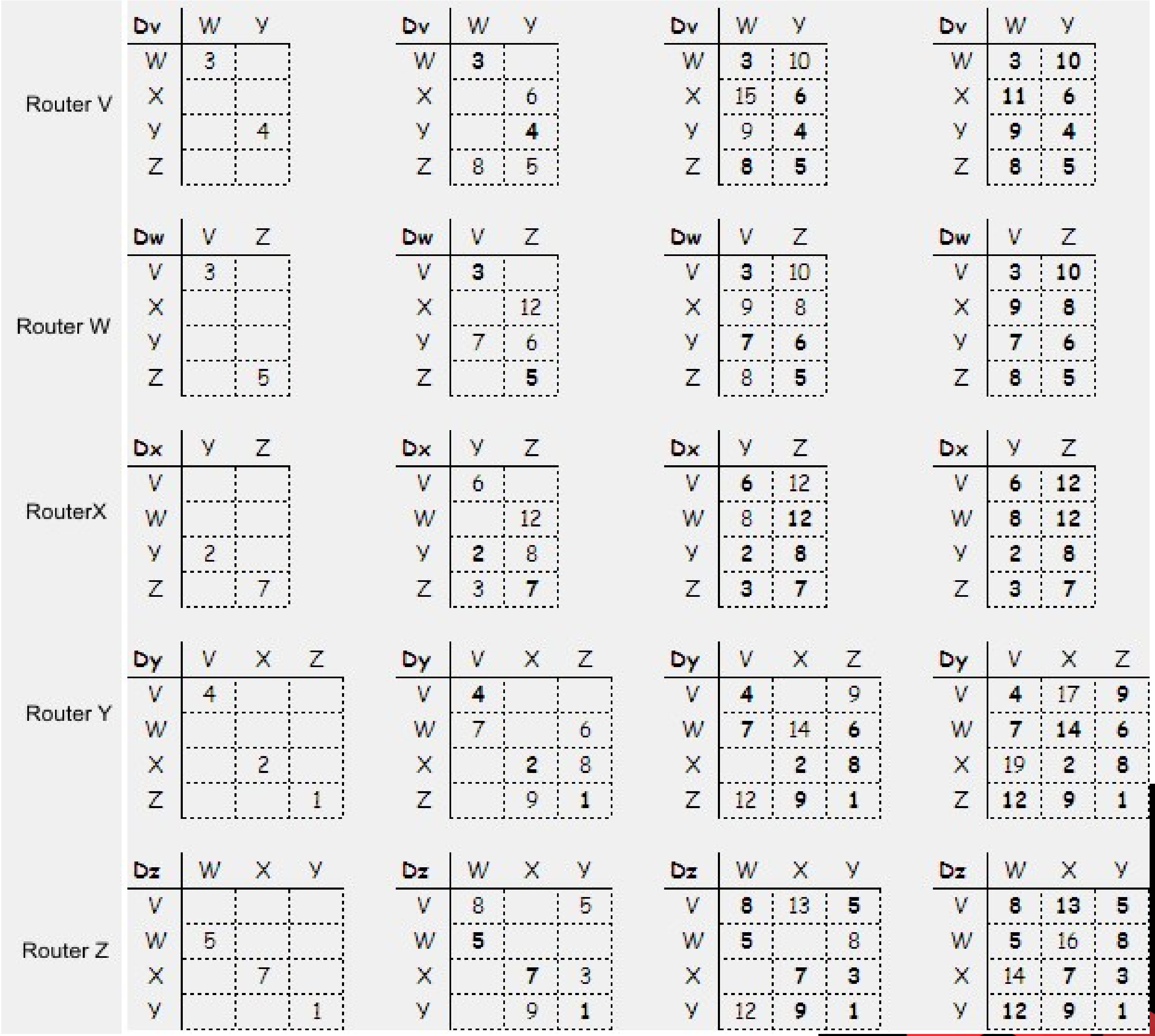
		cost via	
	D^Z	X	Y
dest	X	7	∞
	Y	∞	1

		cost via	
	D^X	Y	Z
dest	Y	2	8
	Z	3	7

$$D^X(Y,Z) = c(X,Z) + \min_w \{D^Z(Y,w)\}$$
$$= 7+1 = 8$$

$$D^X(Z,Y) = c(X,Y) + \min_w \{D^Y(Z,w)\}$$
$$= 2+1 = 3$$





Router V

Dv	W	Y
W	3	
X		
Y		4
Z		

Dv	W	Y
W	**3**	
X		6
Y		**4**
Z	8	5

Dv	W	Y
W	**3**	10
X	15	**6**
Y	9	**4**
Z	**8**	**5**

Dv	W	Y
W	**3**	**10**
X	**11**	**6**
Y	**9**	**4**
Z	**8**	**5**

Router W

Dw	V	Z
V	3	
X		
Y		
Z		5

Dw	V	Z
V	**3**	
X		12
Y	7	6
Z		**5**

Dw	V	Z
V	**3**	10
X	9	8
Y	**7**	**6**
Z	8	**5**

Dw	V	Z
V	**3**	**10**
X	**9**	**8**
Y	**7**	**6**
Z	**8**	**5**

RouterX

Dx	Y	Z
V		
W		
Y	2	
Z		7

Dx	Y	Z
V	6	
W		12
Y	**2**	8
Z	3	**7**

Dx	Y	Z
V	**6**	12
W	8	**12**
Y	**2**	**8**
Z	**3**	**7**

Dx	Y	Z
V	**6**	**12**
W	**8**	**12**
Y	**2**	**8**
Z	**3**	**7**

Router Y

Dy	V	X	Z
V	4		
W			
X		2	
Z			1

Dy	V	X	Z
V	**4**		
W	7		6
X		**2**	8
Z		9	**1**

Dy	V	X	Z
V	**4**		9
W	**7**	14	**6**
X		**2**	**8**
Z	12	**9**	**1**

Dy	V	X	Z
V	**4**	17	**9**
W	**7**	**14**	**6**
X	19	**2**	**8**
Z	**12**	**9**	**1**

Router Z

Dz	W	X	Y
V			
W	5		
X		7	
Y			1

Dz	W	X	Y
V	8		5
W	**5**		
X		**7**	3
Y		9	**1**

Dz	W	X	Y
V	**8**	13	**5**
W	**5**		8
X		**7**	**3**
Y	12	**9**	**1**

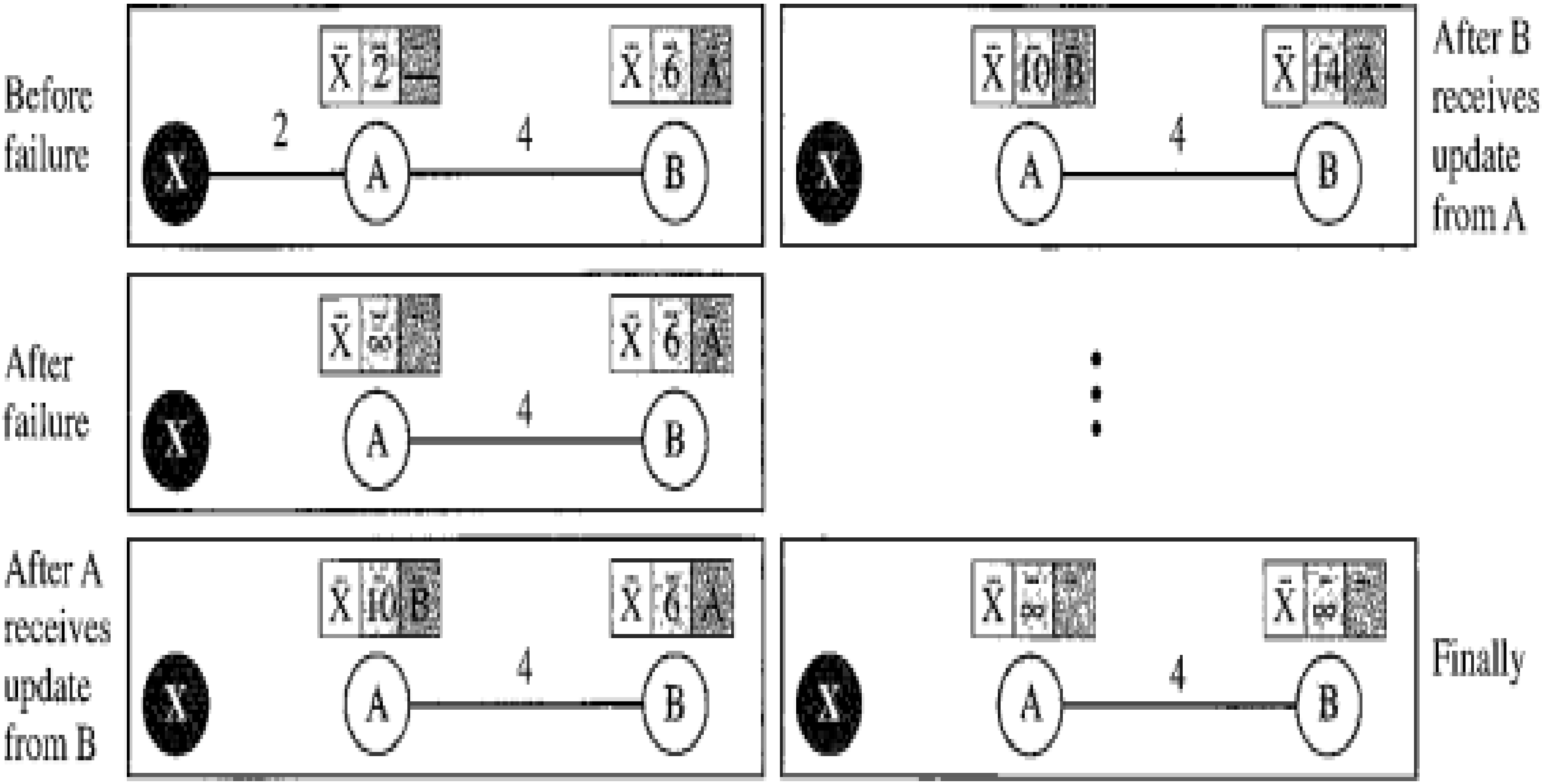
Dz	W	X	Y
V	**8**	**13**	**5**
W	**5**	16	**8**
X	14	**7**	**3**
Y	**12**	**9**	**1**

Algoritma Distance Vector

```
Pada semua node,X:
Inisialisasi
Untuk semua node bersebelahan v
   $D^X(*,v) = \infty$ {* berarti untuk semua baris}
   $D^X(v,v) = c(X,v)$
Untuk semua tujuan, y
   Kirim $min_w{}^XD$ (y,w) kesetiap tetangga
loop
    tunggu (sampai ada perubahan cost link ke tetangga V
     atau diterima update dari tetangga V)
    If (c(X,V) berubah dengan d)
      then untuk semua tujuan y:
           $D^X(y,V) = D^X(y,V) + d$
    Else if (diterima update dari V dengan tujuan Y)
      then untuk tujuan tunggal y:
           $D^X(Y,V) = c(X,V) +$ nilai baru
    IF ada nilai baru $min_wD^X(Y,w)$ untuk semua tujuan Y
      then kirim nilai baru $min_wD^X(Y,w)$ ke semua tetangga
terus menerus
```

Problem

Figure 22.17 *Two-node instability*



PROBLEM

- **Count-to-infinity** → Jika misal ruter A down. B tidak "mendengar" apapun dari A. Namun C "mengatakan" bahwa mengirim paket ke A bisa lewat C. dst...
  - Solusi → tetapkan nilai maximum

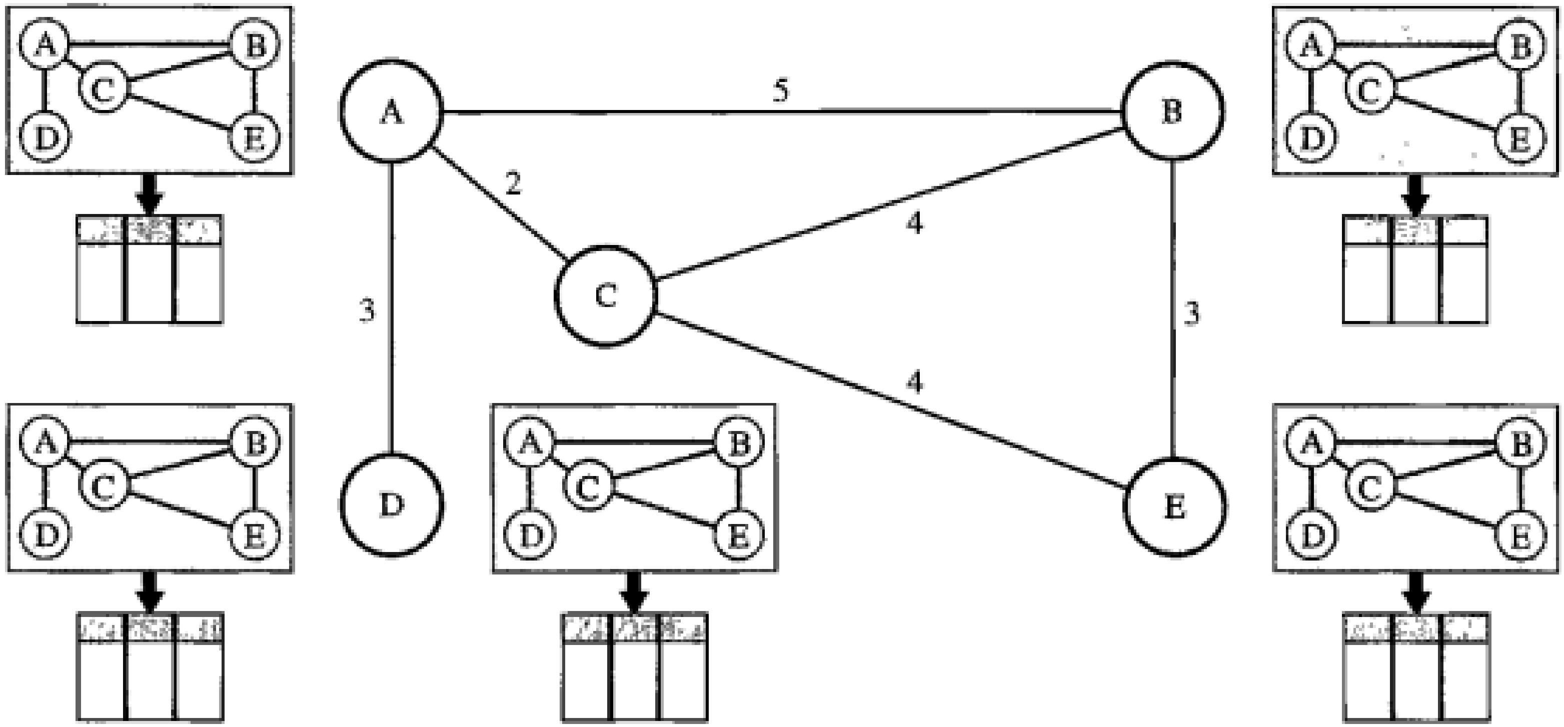
- **Routing loop** → solusi : split horizon (tidak mengirimkan informasi kembali ke pengirim) → Interface router tidak akan mengirimkan informasi update routing tabel kepada interface router yang telah mengirimkan update routing tabel yang sama. Artinya, tidak beguna memberikan informasi kepada pemberi informasi

- **Update message yang tidak perlu** → solusi : holddown timer (Metode yang digunakan untuk mengantisipasi keadaan network yang tidak stabil, yang disebabkan oleh penyebaran informasi update routing tabel yang belum tentu kevalidan nilainya. Dengan kata lain, hold down akan menjaga sebuah router dalam mengumumkan perubahan routing tabelnya sampai kondisi network stabil dan sebuah interface benar - benar sudah mendapatkan route terbaik

Link State

- Pada link state, router melakukan:
  - ✓ Mempelajari network address dari tetangga
  - ✓ Menghitung delay atau cost setiap tetangga
  - ✓ Membentuk paket utk menyebarkan informasi ruting yang baru dipelajari
  - ✓ Mengirim paket pada tiap router
  - ✓ Menghitung shortest path ke tiap router.
- Paket link state (link state advertisement – LSA)→ identitas sender, sequence number, age
- Link state mengumpulkan informasi dari seluruh router dalam jaringan atau dalam area tertentu dan kemudian setiap router menghitung path terbaiknya secara independen.
- Jika terjadi failure, dikirimkan LSA. Masing-masing router akan mengcopy LSA, mengupdate databasenya, dan memforward database tersebut ke tetangganya. LSA menyebabkan router melakukan perhitungan kembali best path nya.

Figure 22.20 *Concept of link state routing*

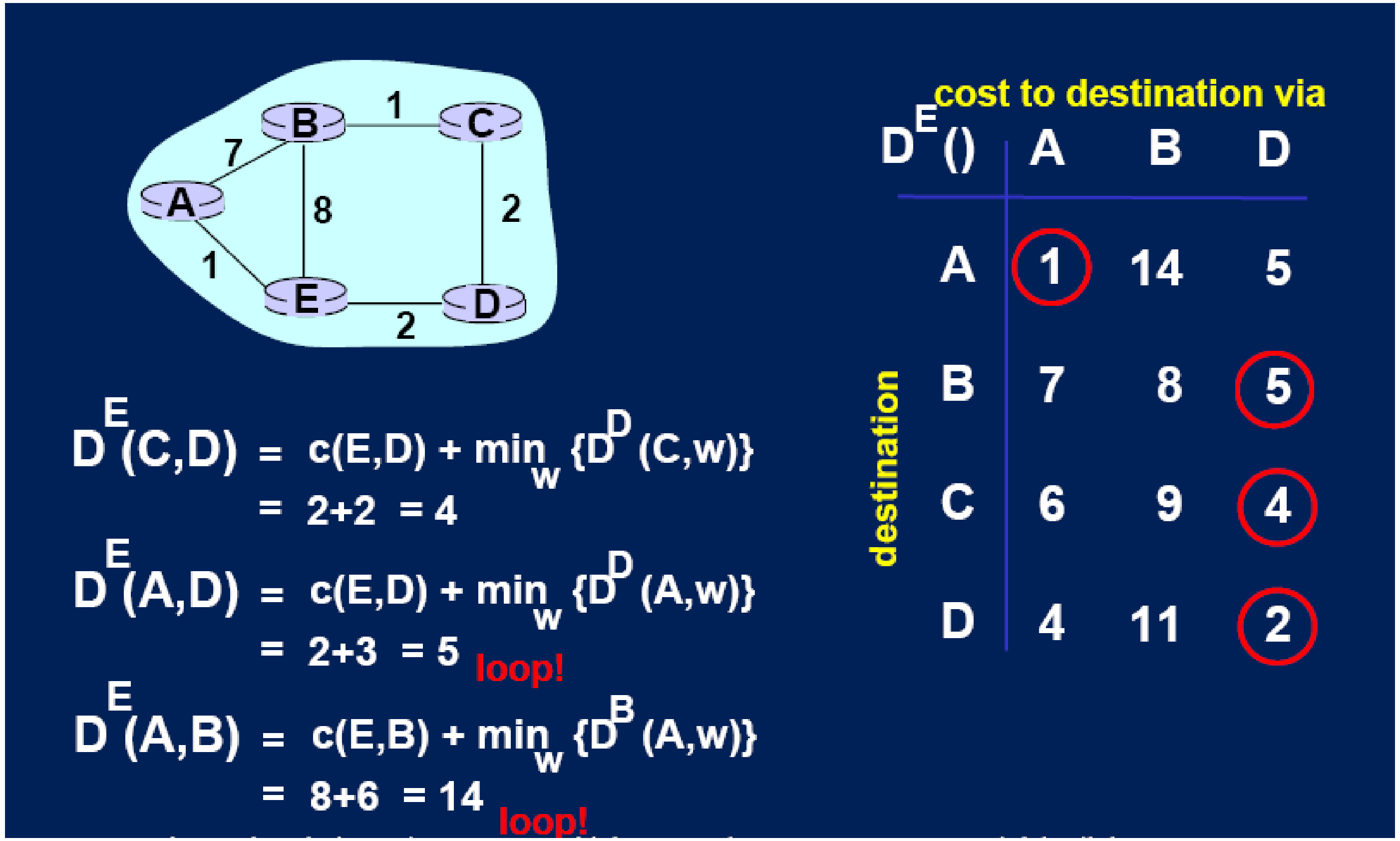


- Contoh link-state network hierarchi:
  - ✓ Area : grouping of contiguous network (jaringan yang berdekatan)
  - ✓ AS : sejumlah network dalam administrasi yang sama yang men-share strategi routing yang sama.
- Misal di OSPF : area backbone, area border router, nonbackbone internal router,
- Misal di IS-IS :router L2, L1/L2, L1

Link State Algorithm

$D^X(Y,Z)$ = jarak dari X ke Y, melalui Z sebagai hop selanjutnya

$= c(X,Z) + \min_w{}^Z\{D\ (Y,w)\}$



$$D^E(C,D) = c(E,D) + \min_w \{D^D(C,w)\}$$
$$= 2+2 = 4$$

$$D^E(A,D) = c(E,D) + \min_w \{D^D(A,w)\}$$
$$= 2+3 = 5$$

loop!

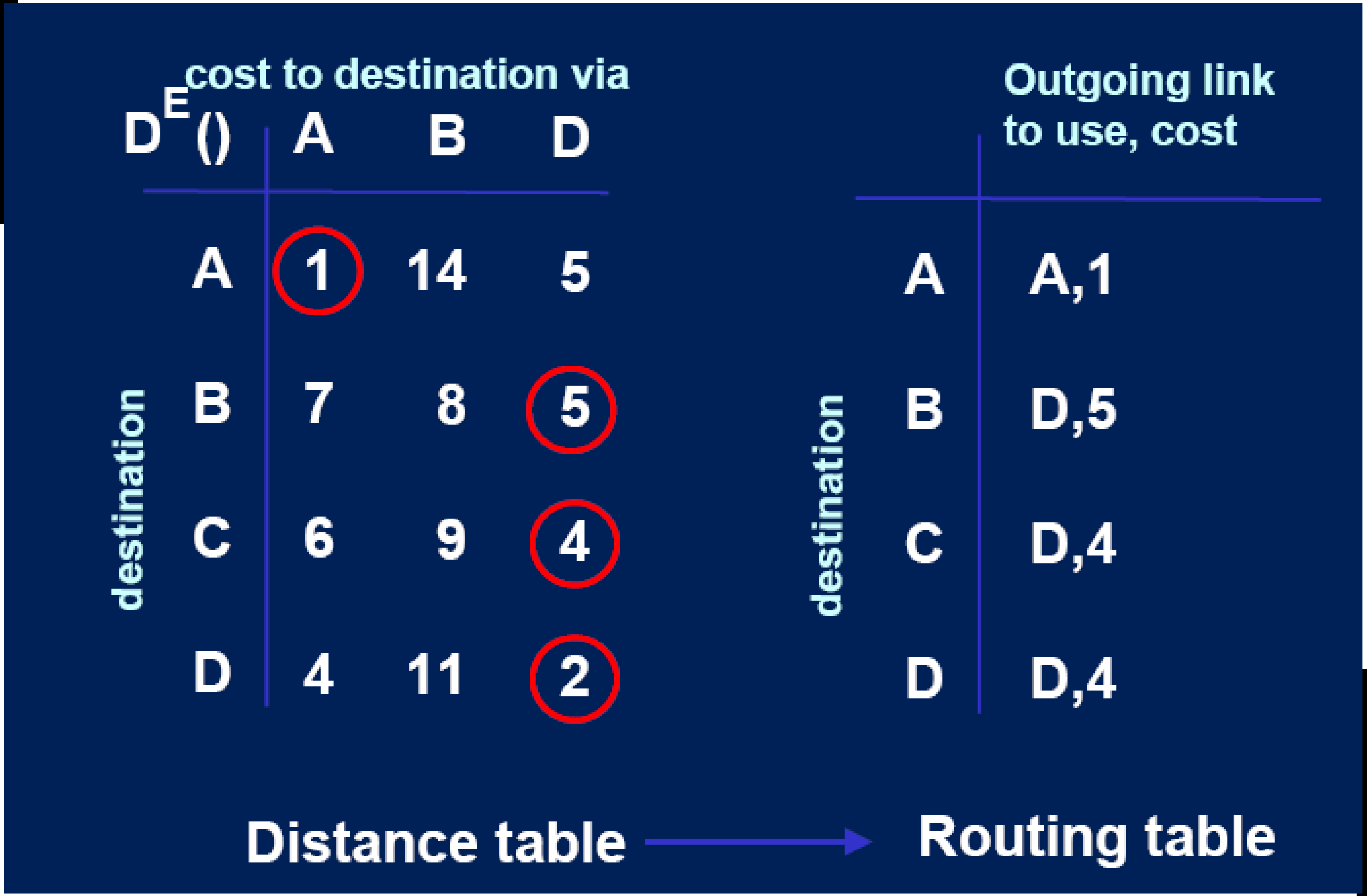
$$D^E(A,B) = c(E,B) + \min_w \{D^B(A,w)\}$$
$$= 8+6 = 14$$

loop!

cost to destination via

$D^E()$	A	B	D
A	1	14	5
B	7	8	5
C	6	9	4
D	4	11	2

destination



cost to destination via

destination

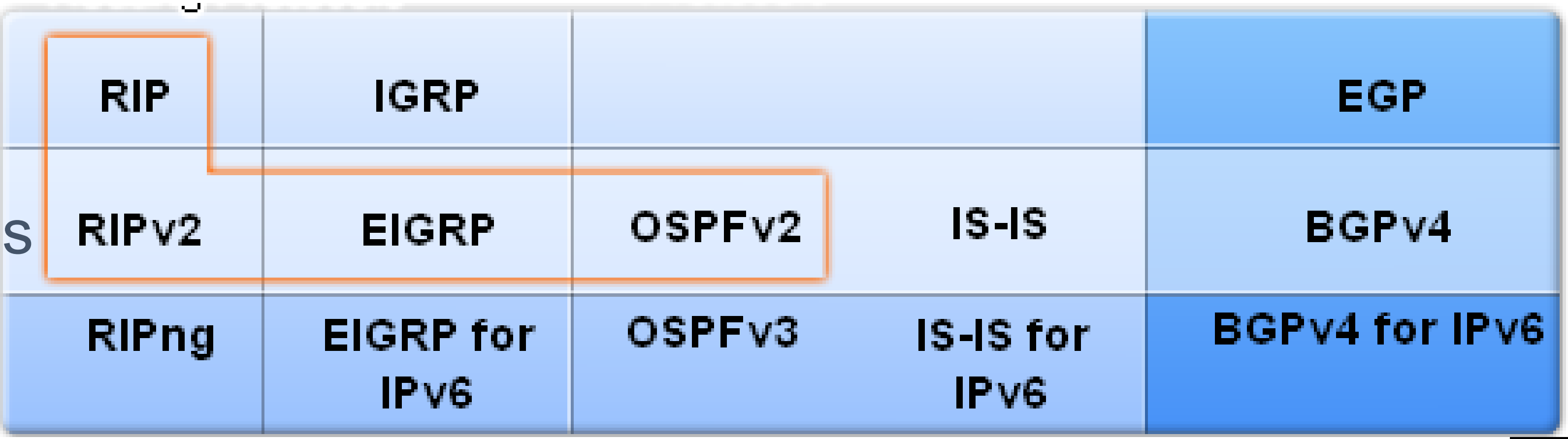
$D^E()$	A	B	D
A	1	14	5
B	7	8	5
C	6	9	4
D	4	11	2

destination

	Outgoing link to use, cost
A	A,1
B	D,5
C	D,4
D	D,4

Distance table → Routing table

Routing protocols



	Interior gateway protocols				Exterior gateway protocols
Classful	RIP	IGRP			EGP
Classless	RIPv2	EIGRP	OSPFv2	IS-IS	BGPv4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGPv4 for IPv6

Routing protocols

Interior gateway protocols

Exterior gateway protocols

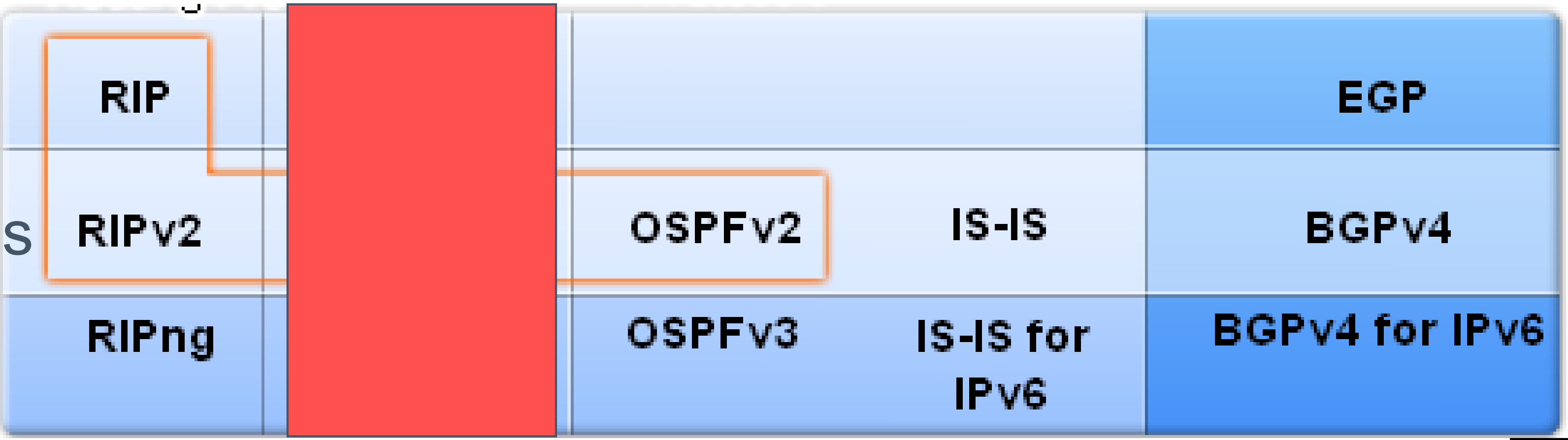
Classful	[redacted]	IGRP			EGP
Classles	[redacted]	EIGRP	OSPFv2	IS-IS	BGPv4
IPv6	[redacted]	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGPv4 for IPv6

Distance vector, open standard

Routing protocols

Interior gateway protocols

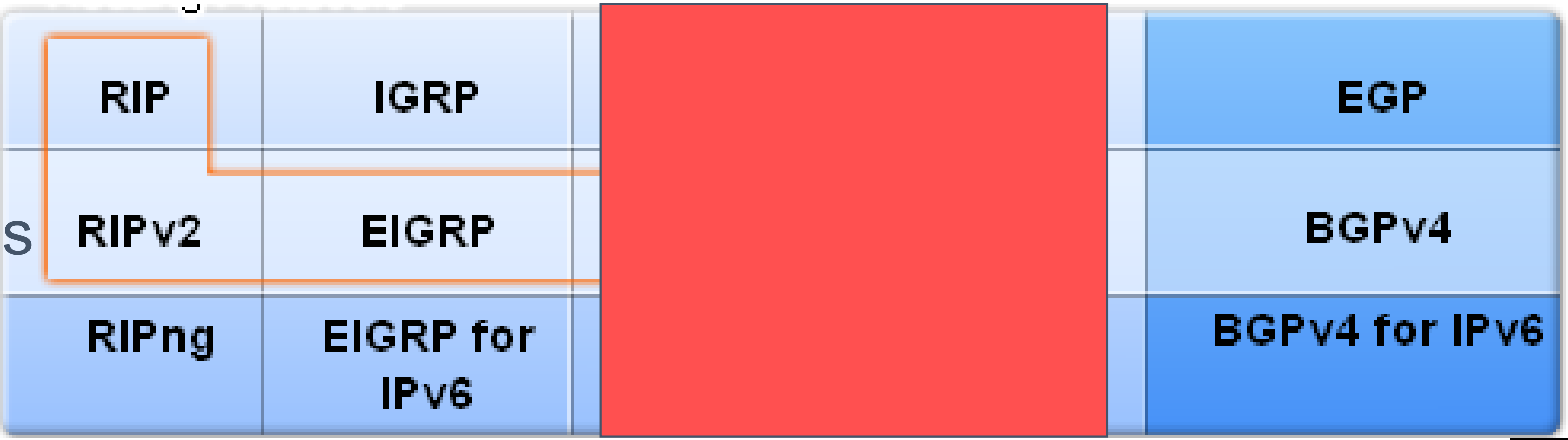
Exterior gateway protocols



Classful	RIP	[redacted]			EGP
Classless	RIPv2	[redacted]	OSPFv2	IS-IS	BGPv4
IPv6	RIPng	[redacted]	OSPFv3	IS-IS for IPv6	BGPv4 for IPv6

Distance vector, Cisco proprietary

Routing protocols



	Interior gateway protocols			Exterior gateway protocols
Classful	RIP	IGRP	[redacted]	EGP
Classless	RIPv2	EIGRP	[redacted]	BGPv4
IPv6	RIPng	EIGRP for IPv6	[redacted]	BGPv4 for IPv6
			Link state	

Link-state vs Distance-vector

- Distributed Database Model
- Advantages
  - More functionality due to distribution of original data
  - No dependency on intermediate routers
  - Easier to troubleshoot
  - Fast convergance : when the network changes, new routes are computed quickly
  - Less bandwidth consuming

- Distributed Processing Model
- Advantages
  - Less Complex
  - Easier to implement and to administer
  - Needs Less Memory

Administrative Distance

- Rute yang berbeda dapat ditemukan oleh protokol routing yang berbeda, atau satu rute bisa dinamis dan satu statis.
- Rute dengan jarak administrasi terendah yang digunakan.
- Jarak administratif adalah indikasi "kepercayaan" atau keinginan rute.

Administrative distances

- 0 directly connected
- 1 static route
- 90 route found using EIGRP
- 100 route found using IGRP
- 110 route found using OSPF
- 120 route found using RIP
- Maximum possible value is 255
- These are default values.

Administrative distance

```
D 192.168.6.0/24 [[redacted]/2172416] via 192.168.2.1, 00:00:24, Serial0/0
R 192.168.8.0/24 [[redacted]/1] via 192.168.3.1, 00:00:20, Serial0/1
```

- Two routing protocols running on a router linking two areas with the different protocols
- Administrative distances are the defaults for the routing protocols.
- D means EIGRP. Note the metric is not hop count.

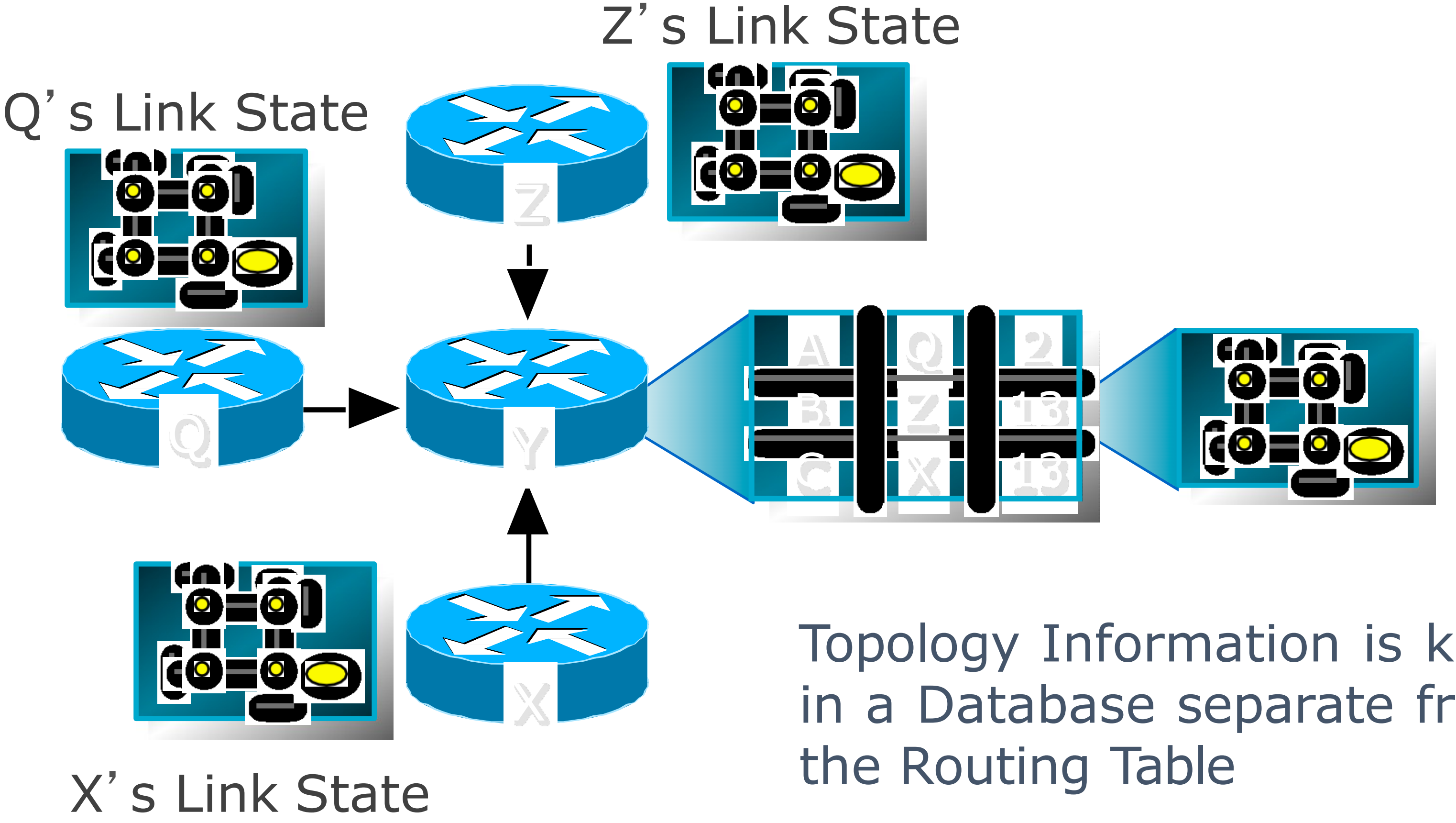
Open Shortest Path First (OSPF)

Sumber : APNIC Training
https://training.apnic.net/wp-content/uploads/sites/2/2016/11/eROU02_OSPF_Basics.pdf

OSPF

- Open Shortest Path First
- Link state or SPF technology
- Developed by OSPF working group of IETF (RFC 1247)
- OSPFv2 (IPv4) standard described in RFC2328
- OSPFv3 (IPv6) standard described in RFC2740
- Designed for:
  - TCP/IP environment
  - Fast convergence
  - Variable-length subnet masks
  - Discontiguous subnets
  - Incremental updates
  - Route authentication
- Runs on IP, Protocol 89

Link State Routing Protocol



Z’s Link State

Q’s Link State

X’s Link State

A	Q	2
B	Z	13
C	X	13

Topology Information is kept in a Database separate from the Routing Table

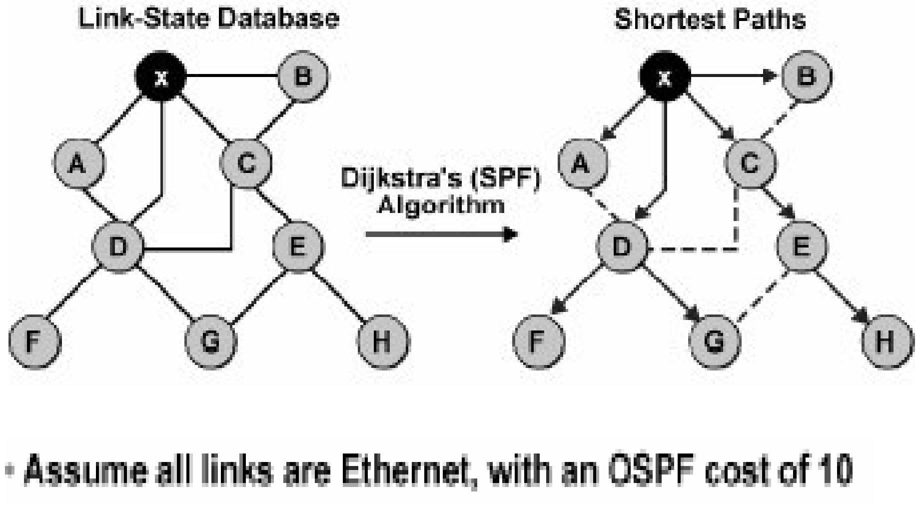
What is Link State Routing

- Do not send full routing table on periodic interval
- Maintain three tables to collect routing information
  - Neighbor table
  - Topology Table
  - Routing table
- Use Shortest Path First (SPF) algorithm to select best path from topology table
- Send very small periodic (Hello) message to maintain link condition
- Send triggered update instantly when network change occur

Link State Data Structure

- Neighbor Table
  - List of all recognized neighboring router to whom routing information will be interchanged
- Topology Table
  - Also called LSDB which maintain list of routers and their link information i.e network destination, prefix length, link cost etc
- Routing table
  - Also called forwarding table contain only the best path to forward data traffic

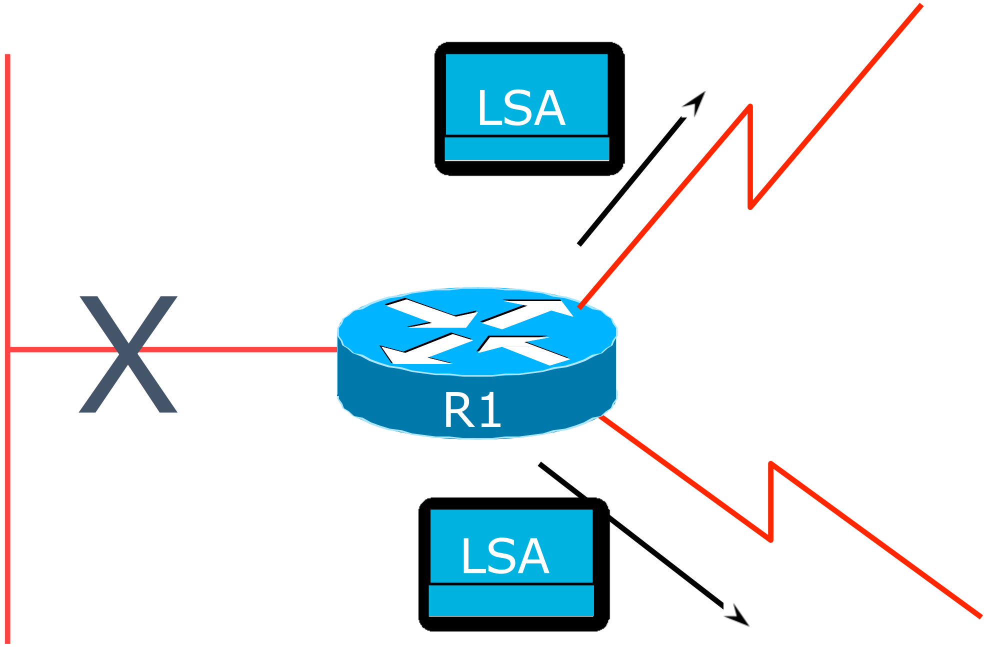
Shortest Path First (SPF) Tree



- Assume all links are Ethernet, with an OSPF cost of 10

- Every router in an OSPF network maintain an identical topology database
- Router place itself at the root of SPF tree when calculate the best path

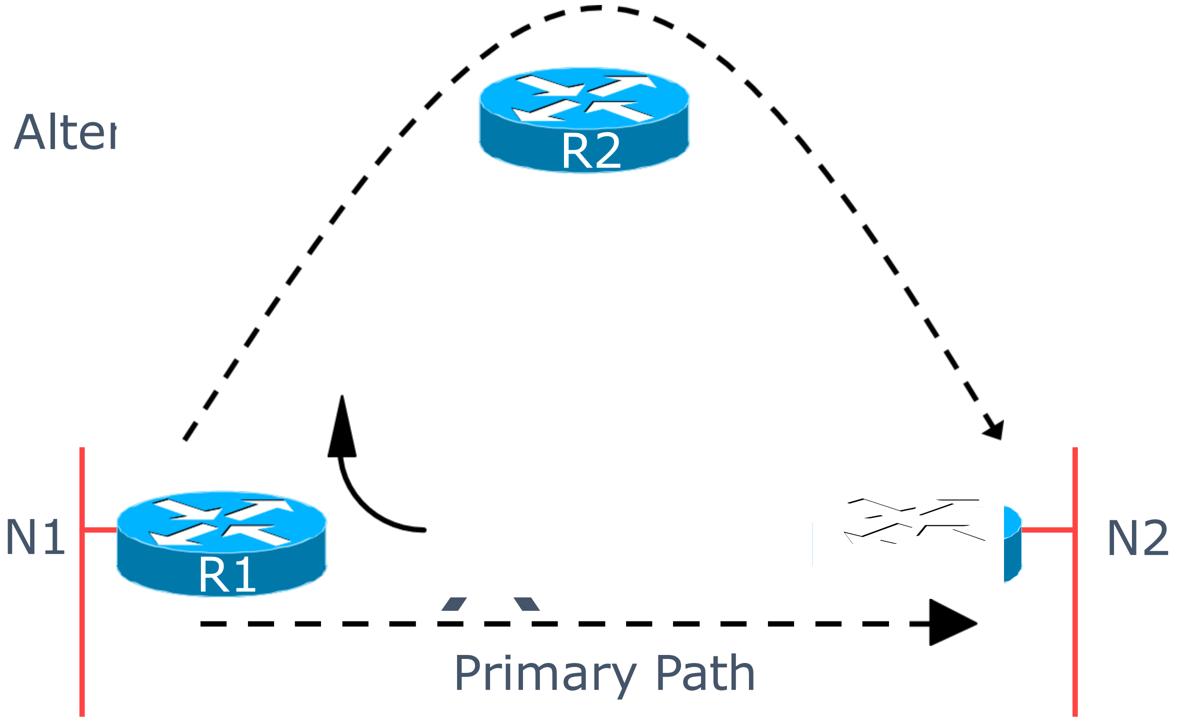
Low Bandwidth Utilisation



- Only changes propagated
- Uses multicast on multi-access broadcast networks

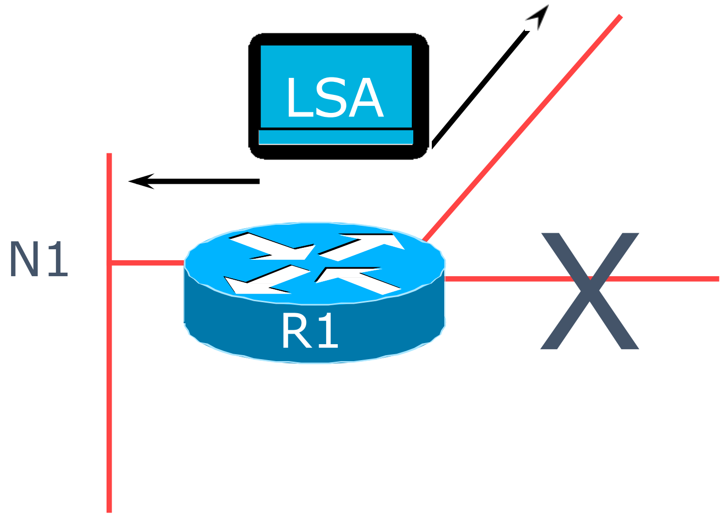
Fast Convergence

- Detection Plus LSA/SPF
  - Known as the Dijkstra Algorithm



Fast Convergence

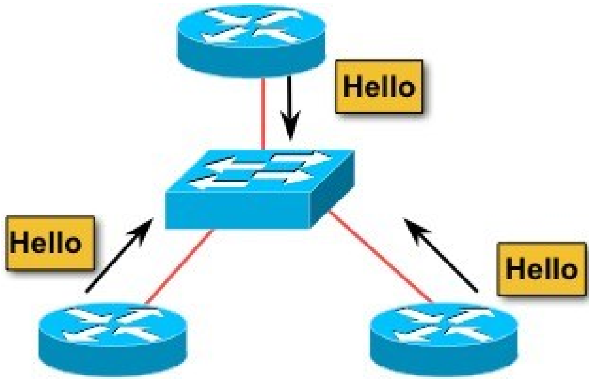
- Finding a new route
  - LSA flooded throughout area
  - Acknowledgement based
  - Topology database synchronised
  - Each router derives routing table to destination network



Basic OSPF Operation

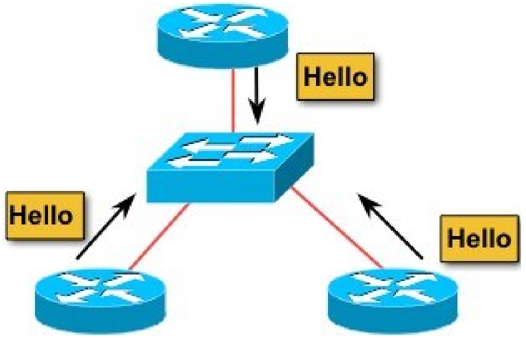
- Neighbor discovery
  - Send L3 multicast message (hello) to discover neighbors
- Exchanging topology table (LSDB)
  - Send L3 multicast message (DBD packets)
- Use SPF algorithm to select best path
  - Each router independently calculates best path from an identical topology database of an OSPF network or area
- Building up routing table
  - All the SPF selected best paths are installed in routing table for the traffic to be forwarded

OSPF Neighbor Discovery Process



- Use IP packet to send hello message. At start routers are at OSPF **Down State**
- Use multicast address 224.0.0.5/FF02::5 to make sure single IP packet will be forwarded to every router within OSPF network. Router now at OSPF **Init State**

OSPF Neighbor Discovery Process



- All neighboring router with OSPF enabled receive the hello packet
- Checks contents of the hello message and if certain information match it reply (Unicast) to that hello with sending its router ID in the neighbor list.
- This is OSPF **Two-way State**

Contents Of A Hello Packet

- Required information to build up adjacency:
  - Router ID of sending router
  - Hello and dead interval time *
  - List of neighbors
  - Network mask
  - Router priority
  - Area ID *
  - DR & BDR IP
  - Authentication information (If any) *

* Need to match to create neighbor relationship

Discovering Network Information

- After creating 2-way neighbor relationship neighboring routers will start exchanging network related information
- At this stage they will decide who will send network information first. Router with the highest router ID will start sending first. This stage is called OSPF **Exstart Stage**
- Then they will start exchanging link state database. This stage is **Exchange Stage**

Adding Network Information

- When router receive the LSDB it perform following action:
  - Acknowledge the receipt of DBD by sending Ack packet (LSAck)
  - Compare the information it received with the existing DB (if any)
  - If the new DB is more up to date the router send link state request (LSR) for detail information of that link. This is Loading Stage
- When all LSR have been satisfied and all routers has an identical LSDB this stage is OSPF **Full Stage**

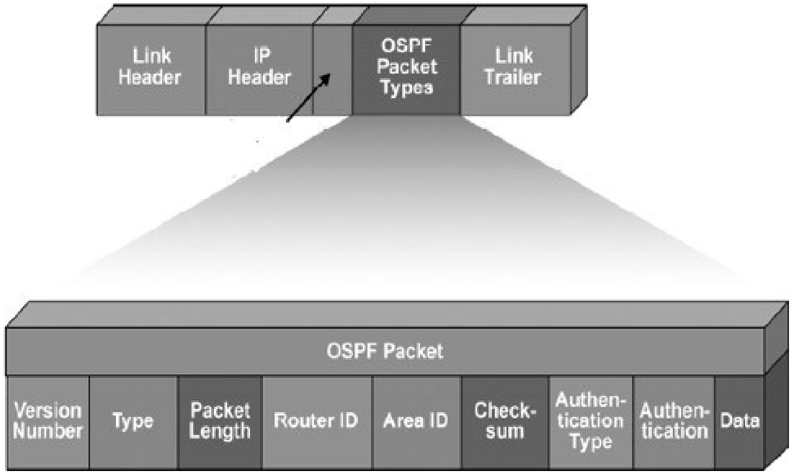
Maintaining Routing Information

- Send periodic updates (Hello) to all neighbors to make sure link with the neighbor is active. I.e 10 sec for LAN
- Send triggered (Instant) update if any network information changed
- Maintain link state sequence number to make sure all information are up-to-date
- Sequence number is 4-byte number that begins with 0x80000001 to 0x7fffffff

OSPF Packet Types

- OSPF use following five packet types to flow routing information between routers:
  - 1: hello [every 10 sec]
    - Hello Builds adjacencies between neighbors
  - 2: DBD [Database Descriptor Packet]
    - DBD for database synchronization between routers
  - 3: LSR [Link State Request Packet]
    - Requests specific link-state records from router to router
  - 4: LSU [Link State Update Packet]
    - Sends specifically requested link-state records
  - 5: LSAck [Link State Ack Packet]
    - Acknowledges the above packet types

Format of OSPF Packet



- All five OSPF packets encapsulated in IP payload (Not TCP)
- To ensure reliable deliver using IP packet OSPF use its own Ack packet (Type 5)

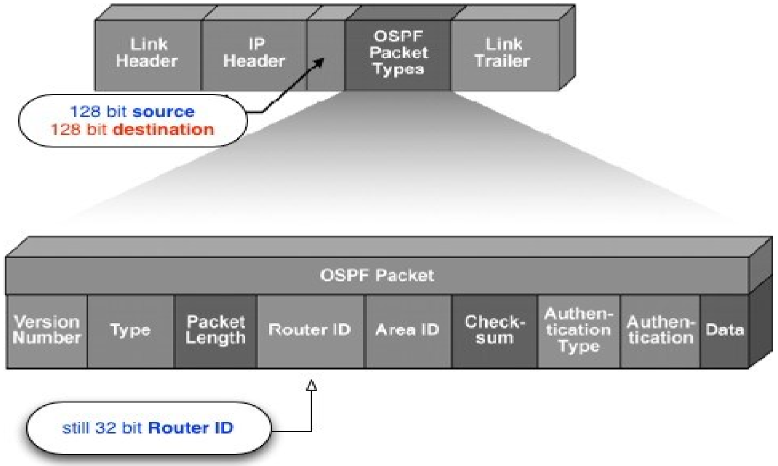
Format of OSPF Packet Header Field

- Version number
  - Either OSPF version 2 (IPv4) or version 3 (IPv6)
- Packet type
  - Differentiates the five OSPF packet types [Type 1 to Type 5]
- Packet length
  - Length of OSPF packet in bytes
- Router ID
  - Defines which router is the source of the packet [Not always source address of IP header]
- Area ID
  - Defines the area where the packet originated
- Checksum
  - Used for packet-header error-detection to ensure that the OSPF packet was not corrupted during transmission
- Authentication type
  - An option in OSPF that describes either clear-text passwords or encrypted Message Digest 5 (MD5) formats for router authentication

Content of OSPF Packet Data

- Data (for hello packet):
  - Contains a list of known neighbors
- Data (for DBD packet):
  - Contains a summary of the LSDB, which includes all known router IDs and their last sequence number, among a number of other fields
- Data (for LSR packet):
  - Contains the type of LSU needed and the router ID of the needed LSU
- Data (for LSU packet):
  - Contains the full LSA entry. Multiple LSA entries can fit in one OSPF update packet
- Data (for LSAck packet):
  - Is empty

Difference is OSPFv3 for IPv6



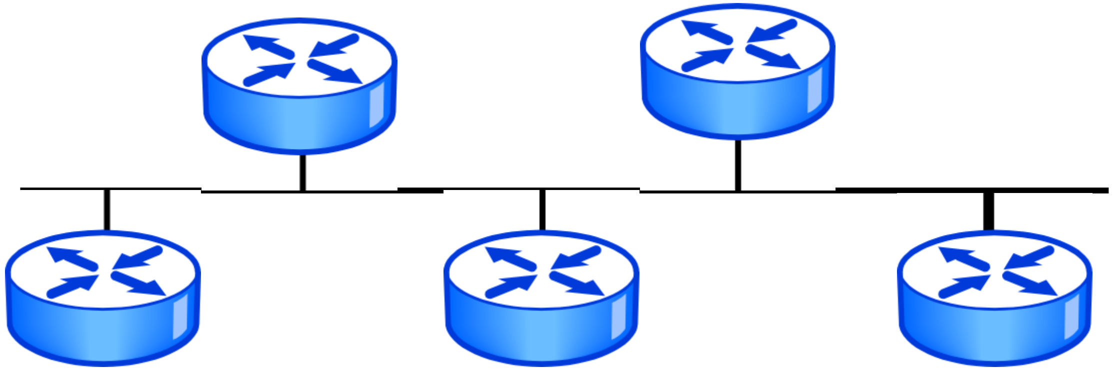
- OSPFv3 still use 32 bit number as router ID
- So OSPFv3 operation and packet types are same as OSPFv2
- Change will be in IP header where source address will be interface address and destination will be FF02::5 which is 128 bit address.
- Change will be in DBD [t2] and LSU packet [t4] to carry 128 bit prefix

OSPF Network Topology

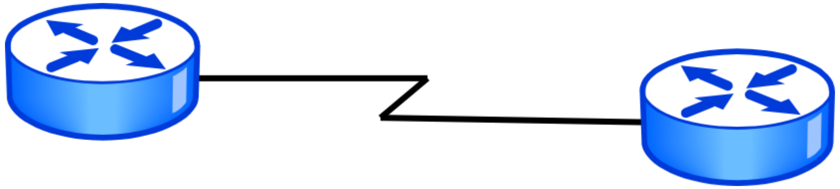
- OSPF network can made up of different types of network links
- Neighbor relationship behavior will also be different for each network type
- It is important for OSPF to be configured correctly based on its network types to be functioned properly
- Some network type create neighbor relationship automatically some need to create it manually

OSPF Network Topology

Broadcast Multi-access

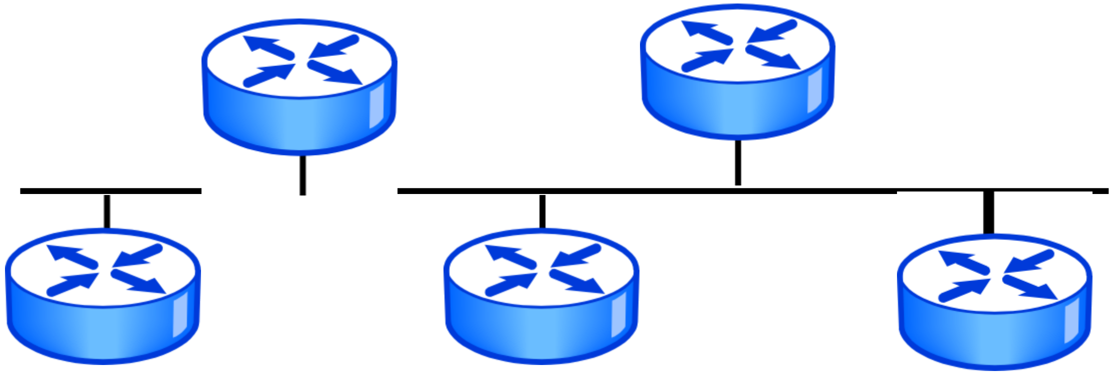


Point-to-Point



Non Broadcast Multi-access (NBMA)

Broadcast Multi-access Network



- Generally LAN type of technologies like Ethernet or Token Ring
- Neighbor relationship are created automatically
- DB/BDR election is required
- Default OSPF hello is 10 sec dead interval is 40 sec

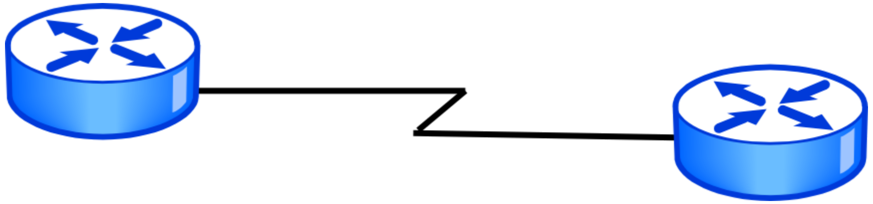
Broadcast Multi-access Network

- Broadcast network use flooding process to send routing update
- Broadcast network use DR/BDR concept to reduce routing update traffic in the LAN
- Packet sent to DR/BDR use 224.0.0.6/FF02::6 multicast address
- Packets from DR to all other routers use 224.0.0.5/FF02::5 multicast address
- All neighbor routers form full adjacencies relation with the DR and BDR only

DB/BDR Election Process

- Router with the highest priority value is the DR, Second highest is BDR
- In the event of tie router with the highest IP address on an interface become DR and second highest is BDR
- DR/BDR election can be manipulated by using router-ID command.
- In practice loopback IP address is used as router ID and the highest IP address will become DR, Second highest is BDR
- The DR/BDR election is non-preemptive
  - Generates network link advertisements
- Assists in database synchronization

Point-to-Point Network



- Usually a serial interface running either PPP or HDLC
- Neighbor relationship are created automatically
- No DR or BDR election required
- Default OSPF hello is 10 sec and dead interval is 40 sec

Non Broadcast Multi-access Network

- A single interface interconnects multiple sites like Frame Relay/ATM/X.25
- NBMA topologies support multiple routers, but without broadcasting capabilities
- OSPF neighbor relation need to create manually, DR/BDR will be elected
- Default OSPF hello is 30 sec and dead interval is 120 sec

Routing Information Protocol (RIP)

Sumber : Khasif Latif,
https://www.slideshare.net/kashiflatifface/routing-information-protocol?from_action=save

WHAT IS RIP…?

P (Routing Information Protocol) is a standard for exchange of routing information among gateways and hosts.

Hop Count:

Hop Count refers to the intermediate devices (like routers) through which data must pass between source and destination, rather than flowing directly over a single wire.

COUNT…

- RIP prevents routing loops by implementing a limit on the number of hops allowed in a path from the source to a destination.
- The maximum number of hops allowed for RIP is 15.
- This hop limit, however, also limits the size of networks that RIP can support.
- A hop count of 16 is considered an infinite distance and used to deprecate inaccessible, inoperable, or otherwise undesirable routes in the selection process.

COUNT…

- Originally each RIP router transmitted full updates every 30 seconds.
- In the early deployments, routing tables were small enough that the traffic was not significant.
- As networks grew in size, however, it became evident there could be a massive traffic burst every 30 seconds, even if the routers had been initialized at random times.
- RIP uses the User Datagram Protocol (UDP) as its transport protocol, and is assigned the reserved port number 520.

VERSIONS OF RIP

There are three versions of the Routing Information Protocol:

1. RIP version 1
2. RIP version 2
3. RIPng (RIP next generation)

RIP VERSION 1

- Version 1 is the most-deployed version, since it is compatible with all RIP-capable devices.
- The periodic routing updates do not carry subnet information, lacking support for variable length subnet masks (VLSM).
- This limitation makes it impossible to have different-sized subnets inside of the same network class.
- In other words, all subnets in a network class must have the same size. There is also no support for router authentication, making RIP vulnerable to various attacks.

RIP VERSION 2

- Developed in 1993
- Last standardized in 1998
- Ability to carry subnet information
- To maintain backward compatibility, the hop count limit of 15 remained.
- RIPv2 multicasts the entire routing table to all adjacent routers at the address 224.0.0.9, as opposed to RIPv1 which uses broadcast.
- Route tags were also added in RIP version 2.

RIPNG

Png (RIP next generation), is an extension of RIPv2 for pport of IPv6, the next generation Internet Protocol. The main differences between RIPv2 and RIPng are:

- Support of IPv6 networking.
- While RIPv2 supports RIPv1 updates authentication, RIPng does not
- RIPv2 allows attaching arbitrary tags to routes, RIPng does not;
- RIPv2 encodes the next-hop into each route entries, RIPng requires specific encoding of the next hop for a set of route entries.
- RIPng sends updates on UDP port 521 using the multicast group FF02::9.

LIMITATIONS

- Without using RMTI (Metric-based Topology Investigation), Hop count can not exceed 15, in the case that it exceeds this limitation, it will be considered invalid.
- Most RIP networks are flat. There is no concept of areas or boundaries in RIP networks.
- Variable Length Subnet Masks were not supported by RIP version 1.
- Without using RMTI, RIP has slow convergence and count to infinity problems.

IMPLEMENTATIONS

- **Cisco IOS**, software used in Cisco routers (supports version 1, version 2 and RIPng)
- **Cisco NX-OS** software used in Cisco Nexus data center switches (supports RIPv1 and RIPv2)
- **Junos** software used in Juniper routers, switches, and firewalls (supports RIPv1 and RIPv2)
- Routing and Remote Access, a **Windows Server** feature, contains RIP support
- **Quagga**, a free open source routing software suite based on GNU Zebra
- **BIRD**, a free open source routing software suite OpenBSD, includes a RIP implementation