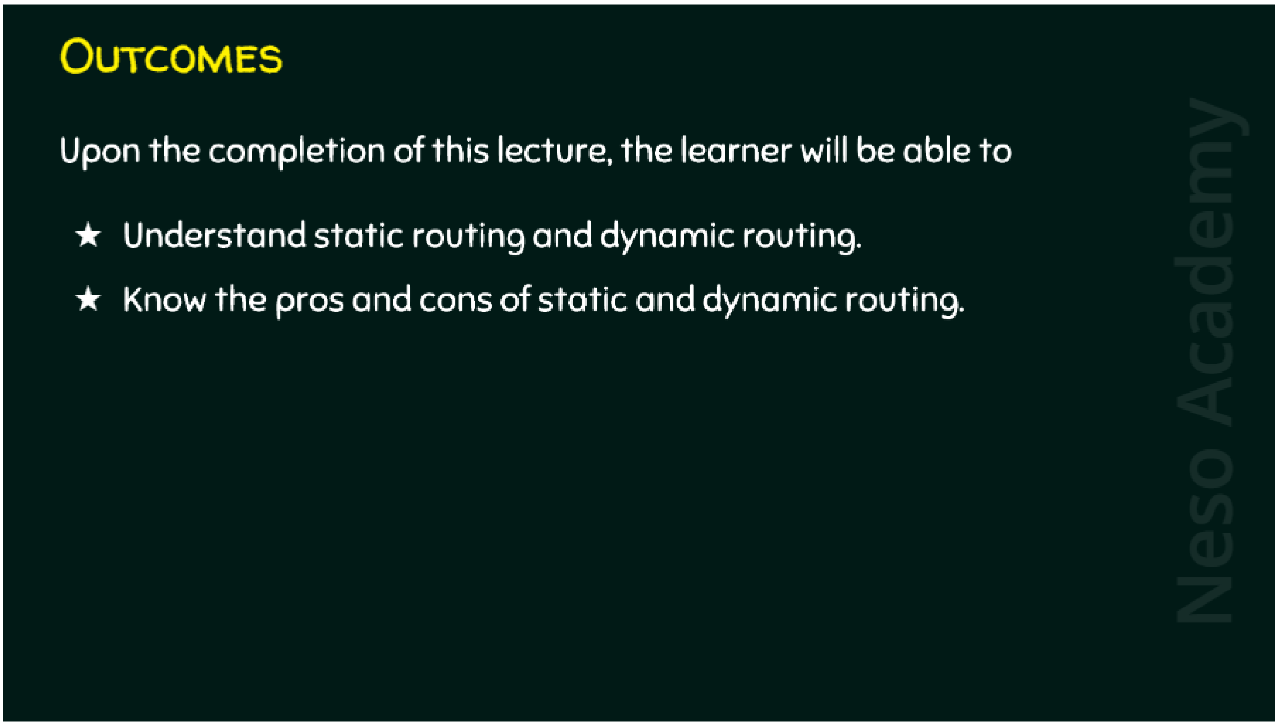
Routing Protocols | Neso Academy

nesoacademy.org/cs/06-computer-networks/ppts/05-routingprotocols

RoutingProtocolsNeso AcademyCHAPTER - 5



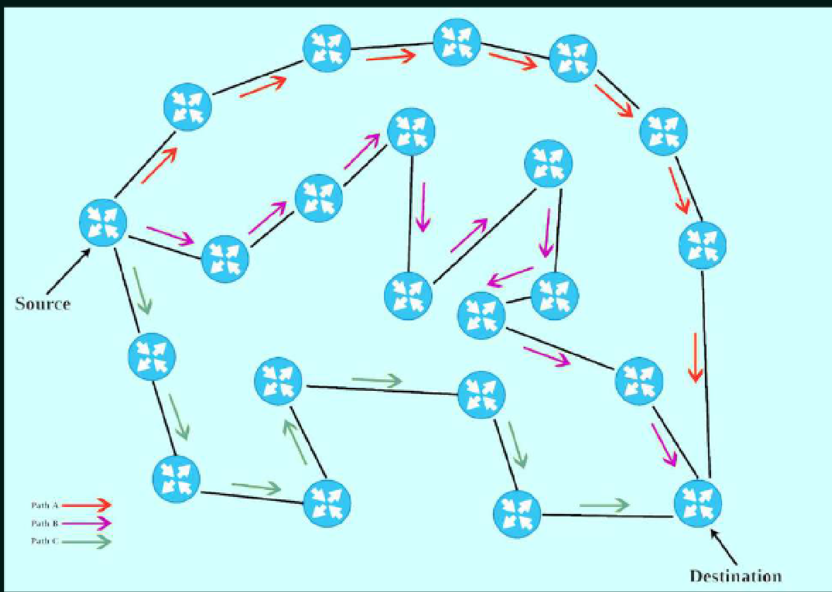
Outcomes★★Neso Academy

Various methods to build a routing table

★ Static Routing
★ Dynamic Routing

Various methods to build a routing table★★Neso Academy

Routing



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Static Routing

- ★ A static routing table is created, maintained, and updated by a network administrator, manually.
- ★ A static route to every network must be configured on every router for full connectivity.
- ★ This provides a granular level of control over routing, but quickly becomes impractical on large networks.
- ★ Routers will not share static routes with each other, thus reducing CPU/RAM overhead and saving bandwidth.
- ★ However, static routing is not fault-tolerant, as any change to the routing infrastructure (such as a link going down, or a new network added) requires manual intervention.
- ★ Routers operating in a purely static environment cannot seamlessly choose a better route if a link becomes unavailable.

Static Routing★★★★★★Neso Academy

Dynamic Routing

- ★ A dynamic routing table is created, maintained, and updated by a routing protocol running on the router.
- ★ The choice of the "best route" is in the hands of the routing protocol, and not the network administrator.
- ★ Examples of routing protocols: RIP (Routing Information Protocol), OSPF (Open Shortest Path First), and EIGRP (Enhanced Interior Gateway Routing Protocol).
- ★ Routers do share dynamic routing information with each other, which increases CPU, RAM, and bandwidth usage.
- ★ However, routing protocols are capable of dynamically choosing a different (or better) path when there is a change to the routing infrastructure.

Dynamic Routing★★★★★Neso Academy

Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand the need for dynamic routing protocols.

Outcomes★Neso Academy

Dynamic Routing Protocols

A static approach has several shortcomings:

★ It does not deal with node or link failures

★ It does not consider the addition of new nodes or links

★ It implies that edge costs cannot change

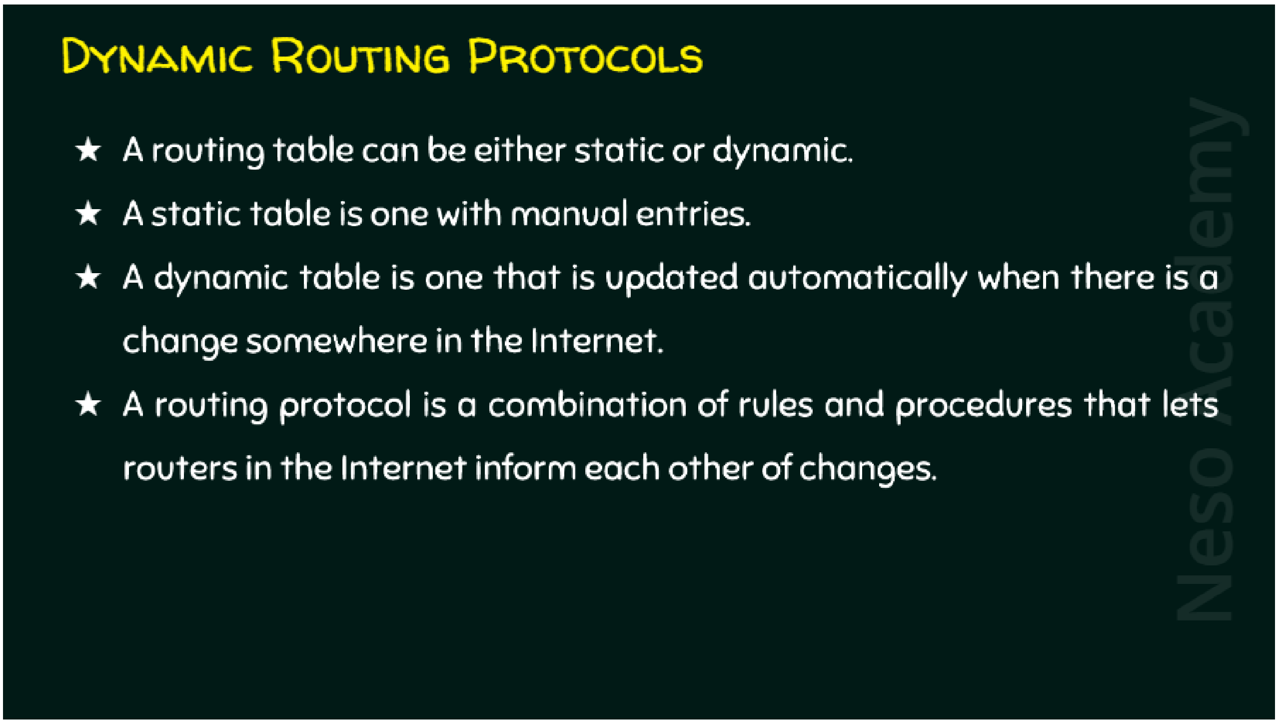
What is the solution?

★ Need a distributed and dynamic protocol

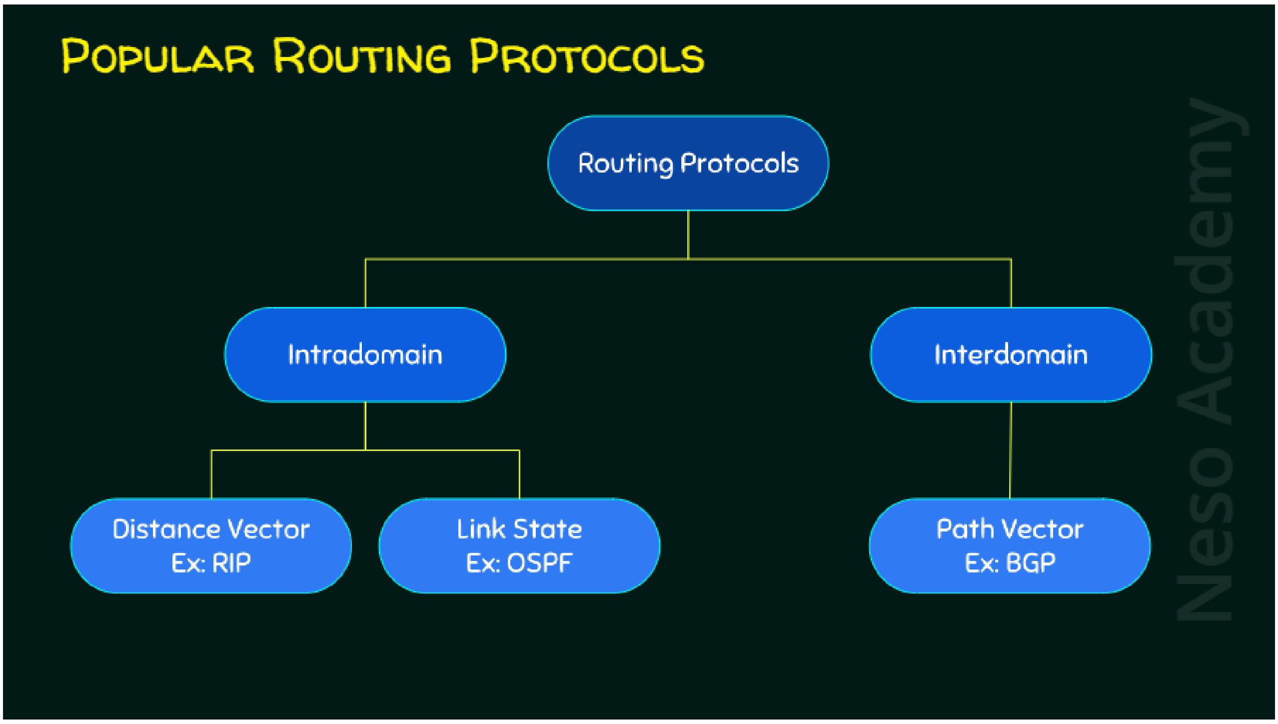
★ Two main classes of protocols

1. Distance Vector
2. Link State

Dynamic Routing Protocols★★★★★Neso Academy

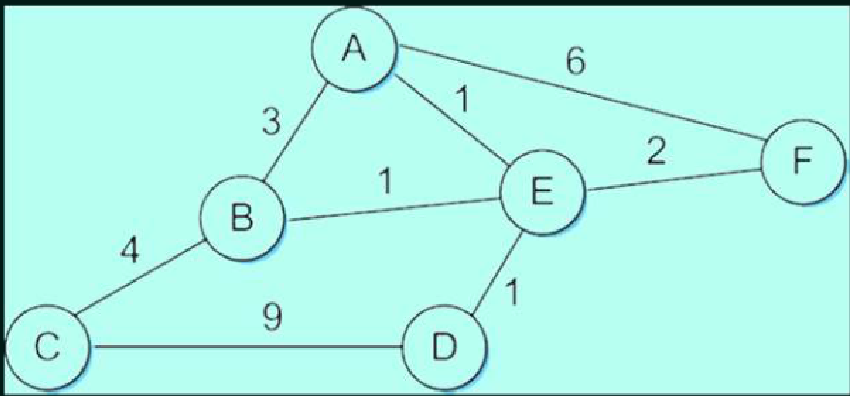


Dynamic Routing Protocols★★★★Neso Academy



Popular Routing ProtocolsNeso Academy

Network as a graph



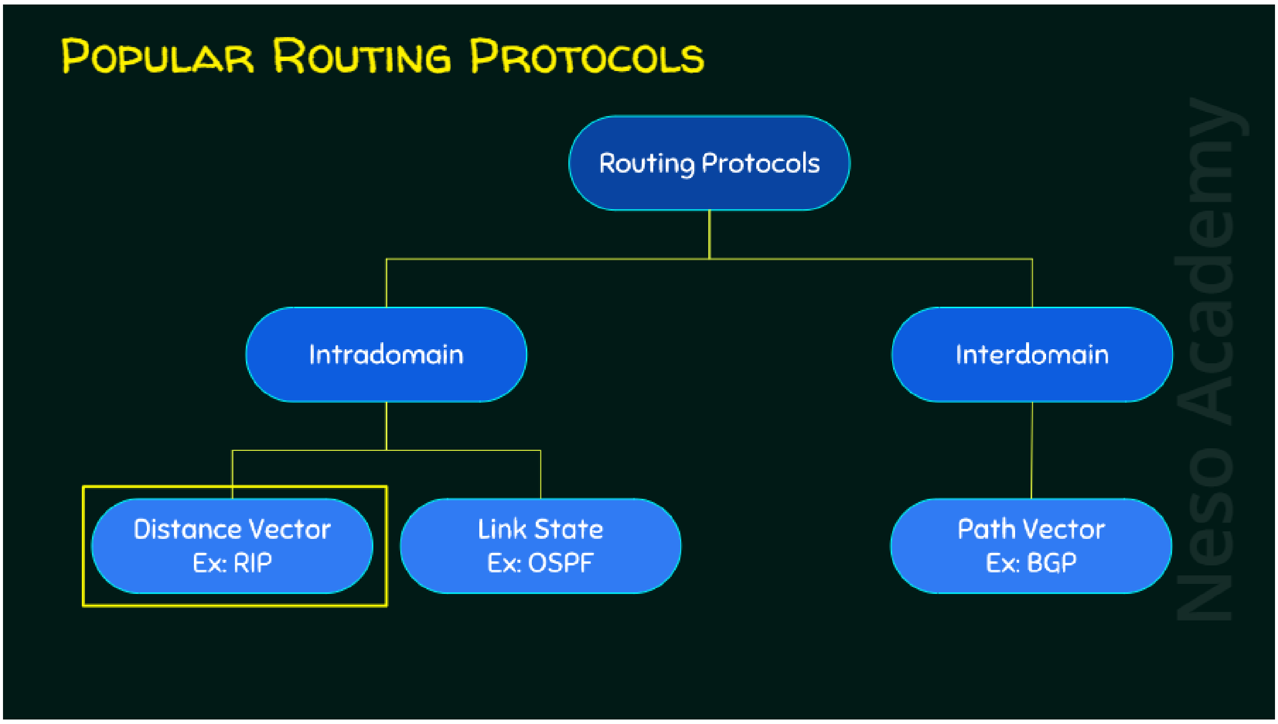
Network as a graphNeso Academy

Outcomes

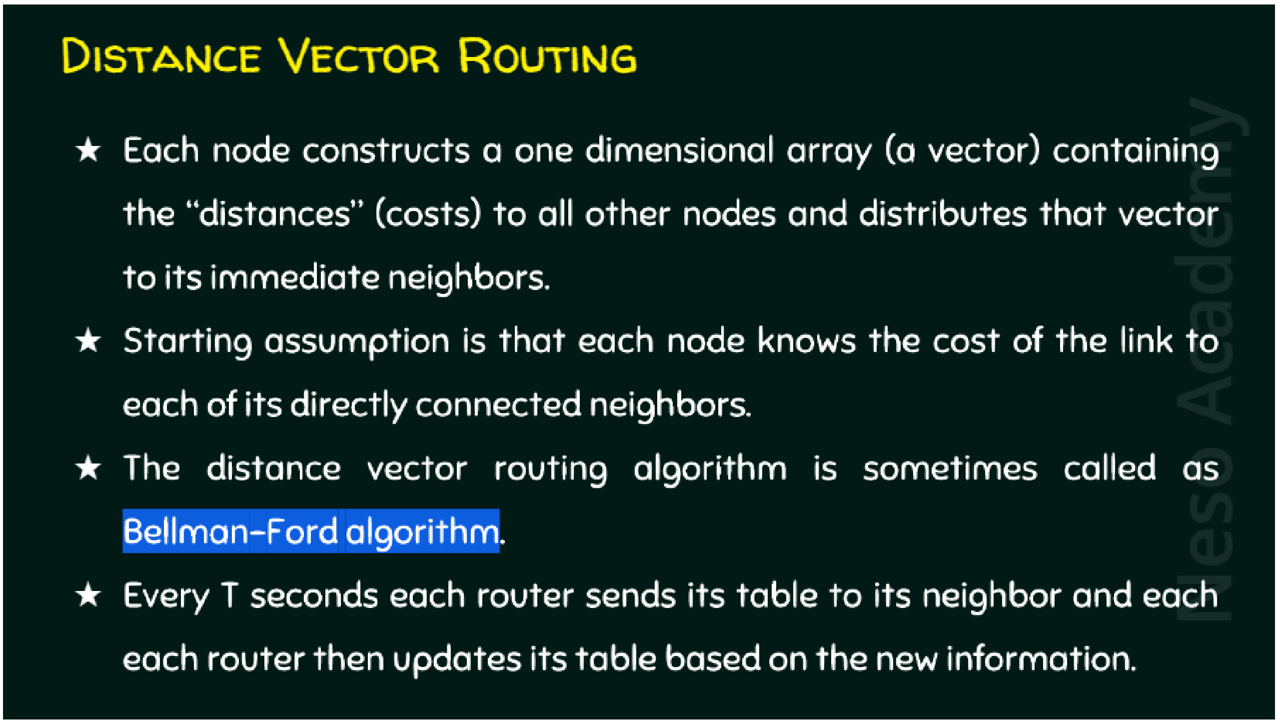
Upon the completion of this lecture, the learner will be able to

★ Understand Distance Vector Routing (DVR).

Outcomes★Neso Academy



Popular Routing ProtocolsNeso Academy



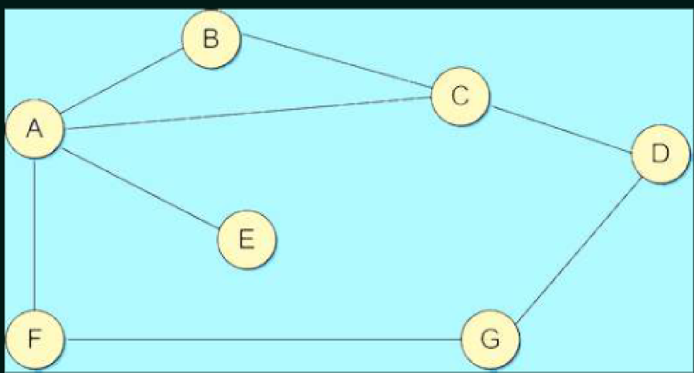
Distance Vector Routing★★★★Neso Academy

Distance Vector Routing

- ★ Problems include fast response to good new and slow response to bad news.
- ★ Also too many messages to update.

Distance Vector Routing★★Neso Academy

Example



Routing Table Entries: (Destination, Distance/Cost, Next Hop)
Node A: (B,1,B), (C,1,C), (F,1,F), (E,1,E), (D,2,C) etc.,

ExampleNeso Academy

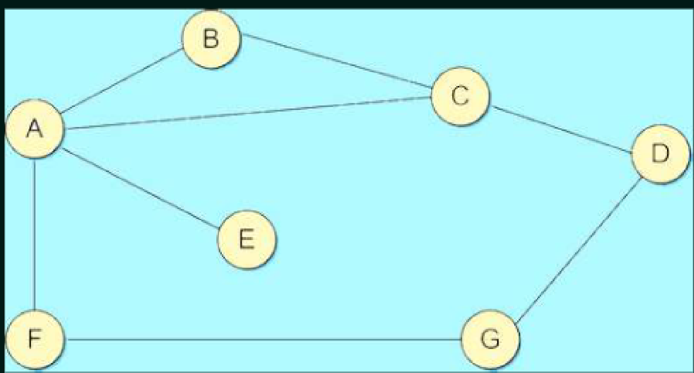
Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand the working of Distance Vector Routing (DVR).

Outcomes★Neso Academy

Example

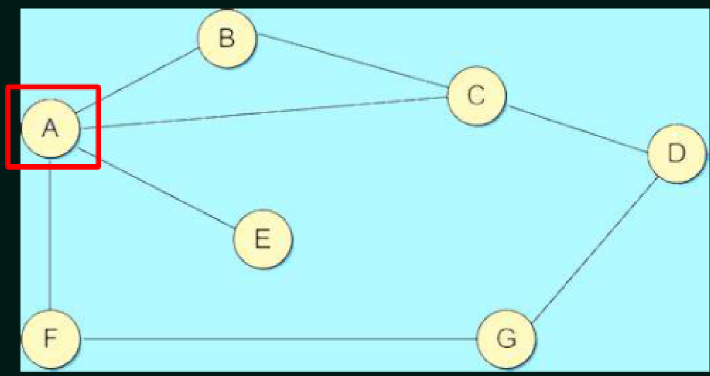


Routing Table Entries: (Destination, Distance/Cost, Next Hop)
Node A: (B,1,B), (C,1,C), (F,1,F), (E,1,E), (D,2,C) etc.,

ExampleNeso Academy

Initial Routing table of A

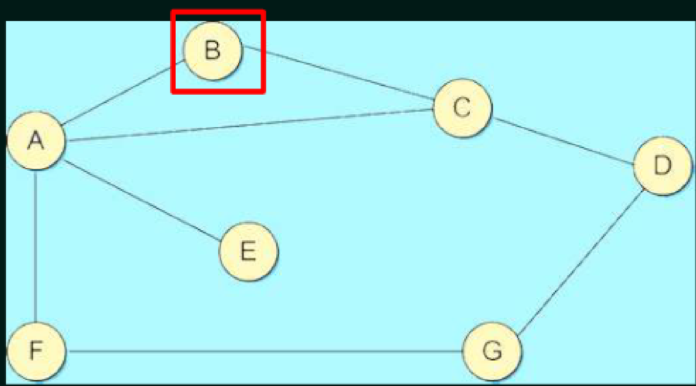
Destination	Cost	Next Hop
A	0	-
B	1	B
C	1	C
D	∞	-
E	1	E
F	1	F
G	∞	-



Initial Routing table of A∞∞Neso Academy

Initial Routing table of B

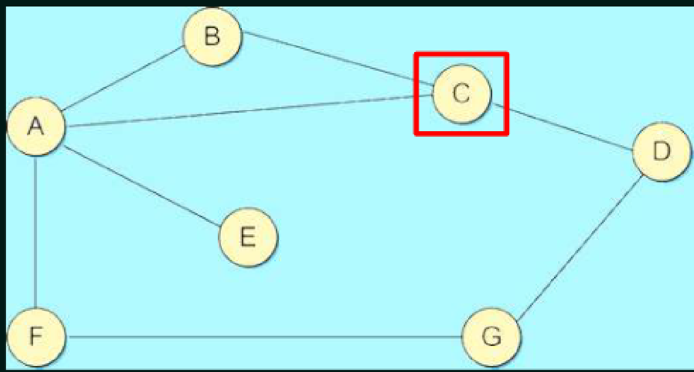
Destination	Cost	Next Hop
A	1	A
B	0	-
C	1	C
D	∞	-
E	∞	-
F	∞	-
G	∞	-



Initial Routing table of B∞∞∞∞Neso Academy

Initial Routing table of C

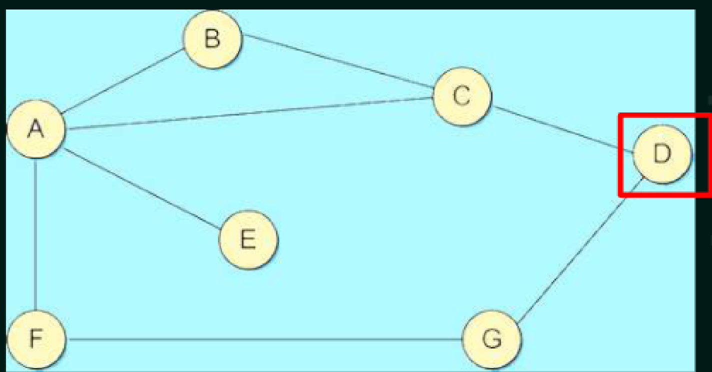
Destination	Cost	Next Hop
A	1	A
B	1	B
C	0	-
D	1	D
E	∞	-
F	∞	-
G	∞	-



Initial Routing table of C∞∞∞Neso Academy

Initial Routing table of D

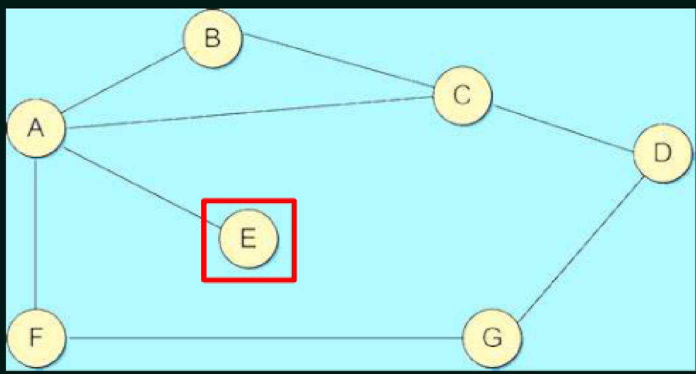
Destination	Cost	Next Hop
A	∞	-
B	∞	-
C	1	C
D	0	-
E	∞	-
F	∞	-
G	1	G



Initial Routing table of D∞∞∞∞Neso Academy

Initial Routing table of E

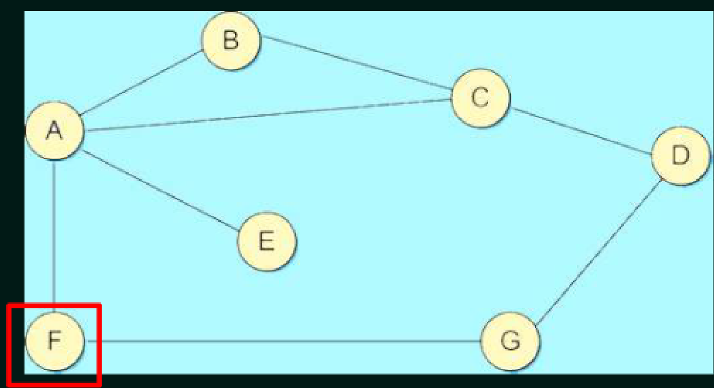
Destination	Cost	Next Hop
A	1	A
B	∞	-
C	∞	-
D	∞	-
E	0	-
F	∞	-
G	∞	-



Initial Routing table of E∞∞∞∞∞Neso Academy

Initial Routing table of F

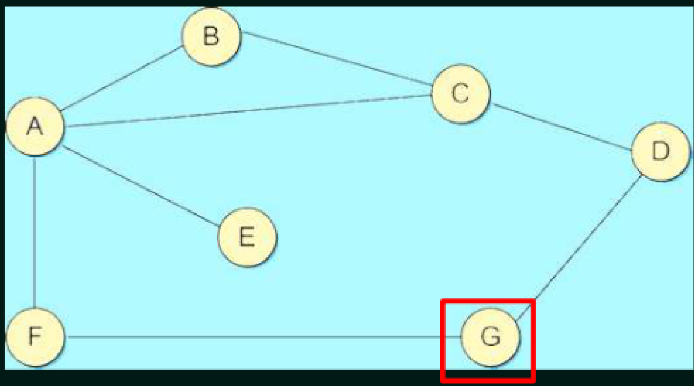
Destination	Cost	Next Hop
A	1	A
B	∞	-
C	∞	-
D	∞	-
E	∞	-
F	0	-
G	1	G



Initial Routing table of F∞∞∞∞Neso Academy

Initial Routing table of G

Destination	Cost	Next Hop
A	∞	-
B	∞	-
C	∞	-
D	1	1
E	∞	-
F	1	1
G	0	-



Initial Routing table of G∞∞∞∞Neso Academy

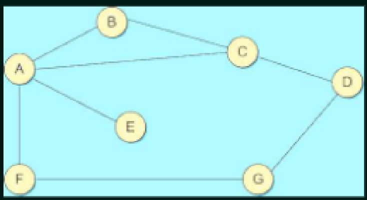
Initial distance stored at each node

Information stored at Node	Distance to reach node						
	A	B	C	D	E	F	G
A	0	1	1	∞	1	1	∞
B	1	0	1	∞	∞	∞	∞
C	1	1	0	1	∞	∞	∞
D	∞	∞	1	0	∞	∞	1
E	1	∞	∞	∞	0	∞	∞
F	1	∞	∞	∞	∞	0	1
G	∞	∞	∞	1	∞	1	0

......to be continued

Initial distance stored at each node∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞Neso Academy

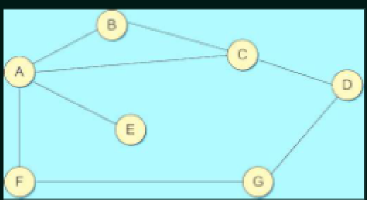
INITIAL DISTANCE STORED AT EACH NODE



Information stored at Node	Distance to reach node						
	A	B	C	D	E	F	G
A				∞			∞
B				∞	∞	∞	∞
C					∞	∞	∞
D	∞	∞			∞	∞	
E		∞	∞	∞		∞	∞
F		∞	∞	∞	∞		
G	∞	∞	∞		∞		

Initial distance stored at each node∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞Neso Academy

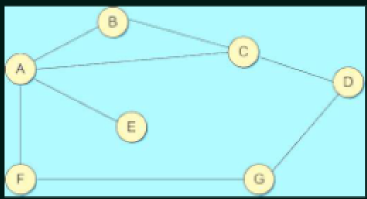
INITIAL ROUTING TABLE OF NODE A



Destination	Cost	Next Hop
B		
C		
D		
E		
F		
G		

Initial routing table of node ANeso Academy

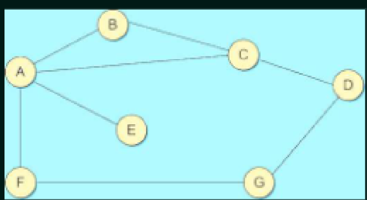
Final routing table of node A



Destination	Cost	Next Hop
B		
C		
D		
E		
F		
G		

Final routing table of node ANeso Academy

Final distance stored at each node



Information stored at Node	Distance to reach node						
	A	B	C	D	E	F	G
A				∞			∞
B				∞	∞	∞	∞
C					∞	∞	∞
D	∞	∞			∞	∞	
E		∞	∞	∞		∞	∞
F		∞	∞	∞	∞		
G	∞	∞	∞		∞		

Final distance stored at each node∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞Neso Academy

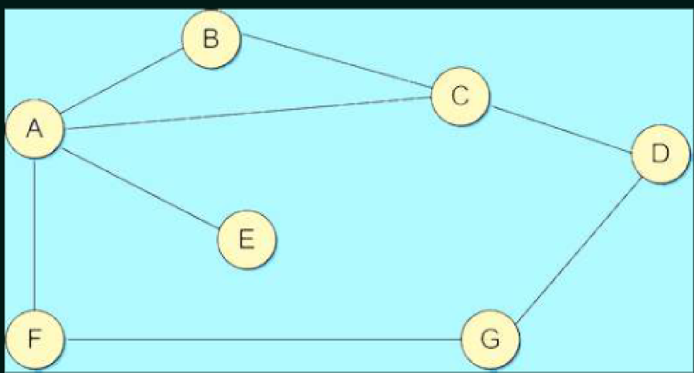
Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand the working of Distance Vector Routing (DVR).

Outcomes★Neso Academy

Example



Routing Table Entries: (Destination, Distance/Cost, Next Hop)
Node A: (B,1,B), (C,1,C), (F,1,F), (E,1,E), (D,2,C) etc.,

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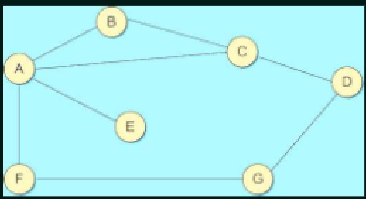
Initial distance stored at each node



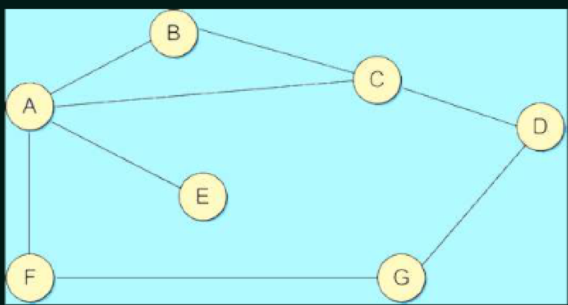
Information stored at Node	Distance to reach node						
	A	B	C	D	E	F	G
A	0	1	1	∞	1	1	∞
B	1	0	1	∞	∞	∞	∞
C	1	1	0	1	∞	∞	∞
D	∞	∞	1	0	∞	∞	1
E	1	∞	∞	∞	0	∞	∞
F	1	∞	∞	∞	∞	0	1
G	∞	∞	∞	1	∞	1	0

Initial distance stored at each node∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞∞Neso Academy

Example

A

A	0
B	1
C	1
D	∞
E	1
F	1
G	∞



B

A	1
B	0
C	1
D	∞
E	∞
F	∞
G	∞

C

A	1
B	1
C	0
D	1
E	∞
F	∞
G	∞

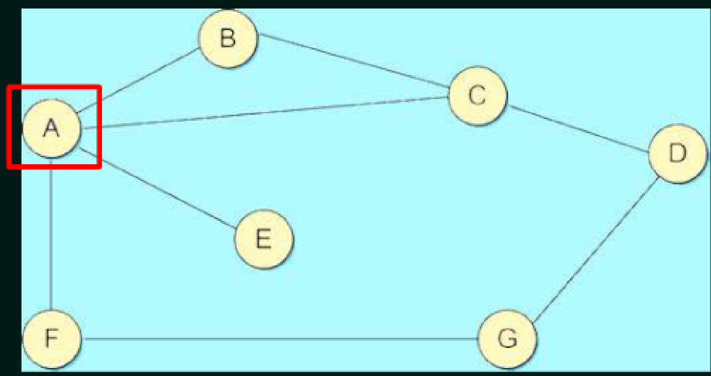
E

A	1
B	∞
C	∞
D	∞
E	0
F	∞
G	∞

Example∞∞∞∞∞E∞∞∞B∞∞∞∞CA∞∞Neso Academy

Final Routing table of A

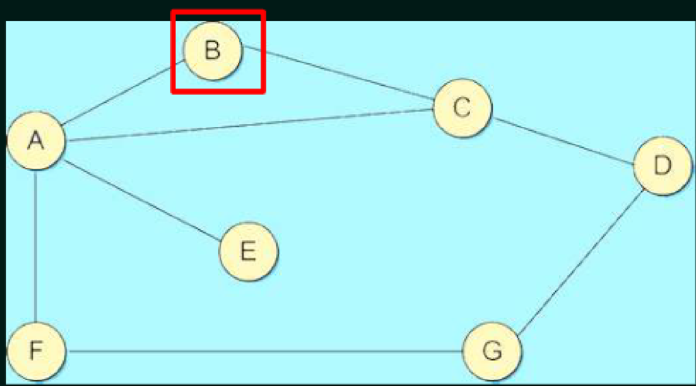
Destination	Cost	Next Hop
A	0	-
B	1	B
C	1	C
D	2	C
E	1	E
F	1	F
G	2	F



Final Routing table of ANeso Academy

Final Routing table of B

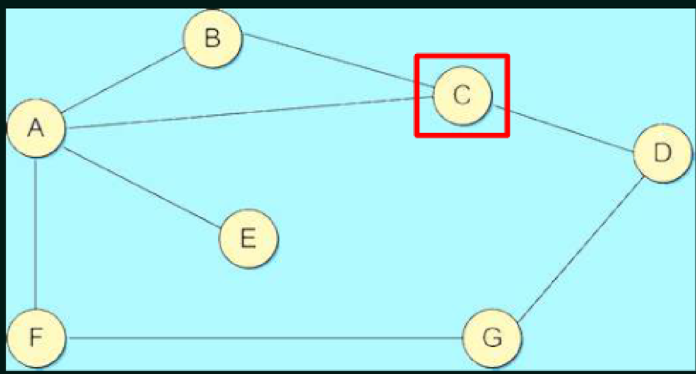
Destination	Cost	Next Hop
A	1	A
B	0	-
C	1	C
D	2	C
E	2	A
F	2	F
G	3	F



Final Routing table of BNeso Academy

Initial Routing table of C

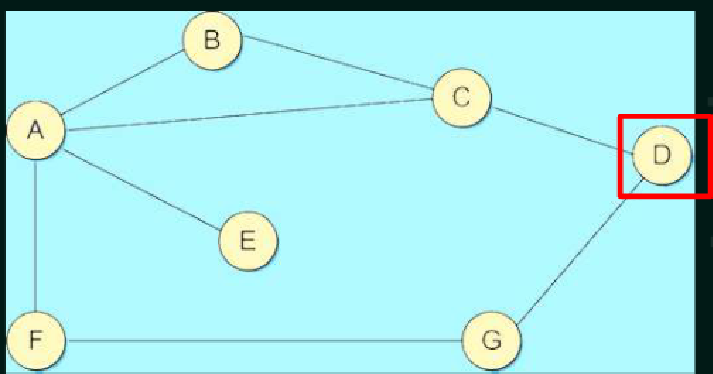
Destination	Cost	Next Hop
A	1	A
B	1	B
C	0	-
D	1	D
E	2	A
F	2	A
G	2	D



Initial Routing table of CNeso Academy

Initial Routing table of D

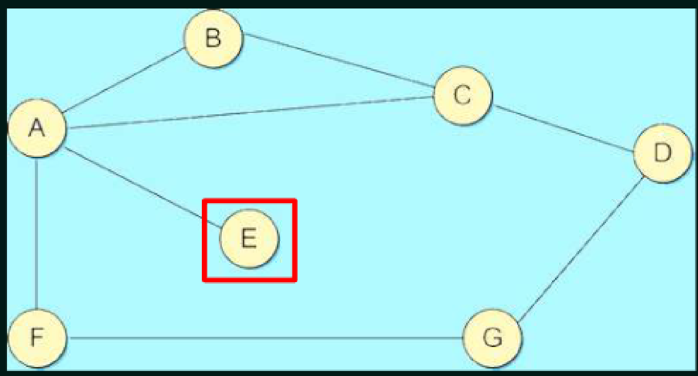
Destination	Cost	Next Hop
A	2	C
B	2	C
C	1	C
D	0	-
E	3	C
F	2	G
G	1	G



Initial Routing table of DNeso Academy

Initial Routing table of E

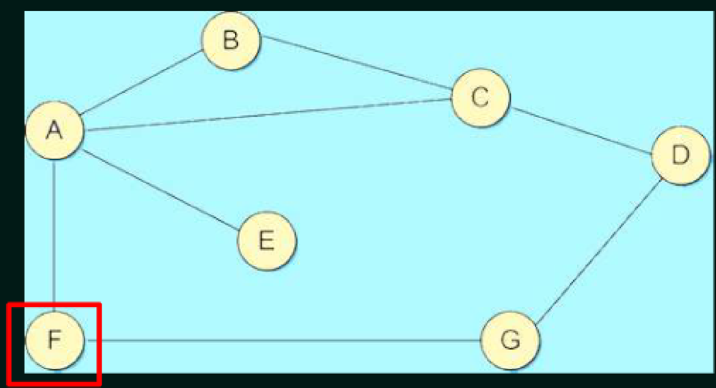
Destination	Cost	Next Hop
A	1	A
B	2	A
C	2	A
D	3	A
E	0	-
F	2	A
G	3	A



Initial Routing table of ENeso Academy

Initial Routing table of F

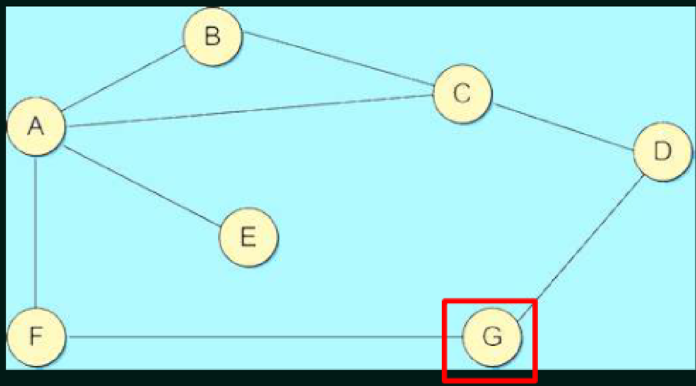
Destination	Cost	Next Hop
A	1	A
B	2	A
C	2	A
D	2	G
E	2	A
F	0	-
G	1	G



Initial Routing table of FNeso Academy

Initial Routing table of G

Destination	Cost	Next Hop
A	2	F
B	3	F
C	2	D
D	1	1
E	3	F
F	1	1
G	0	-

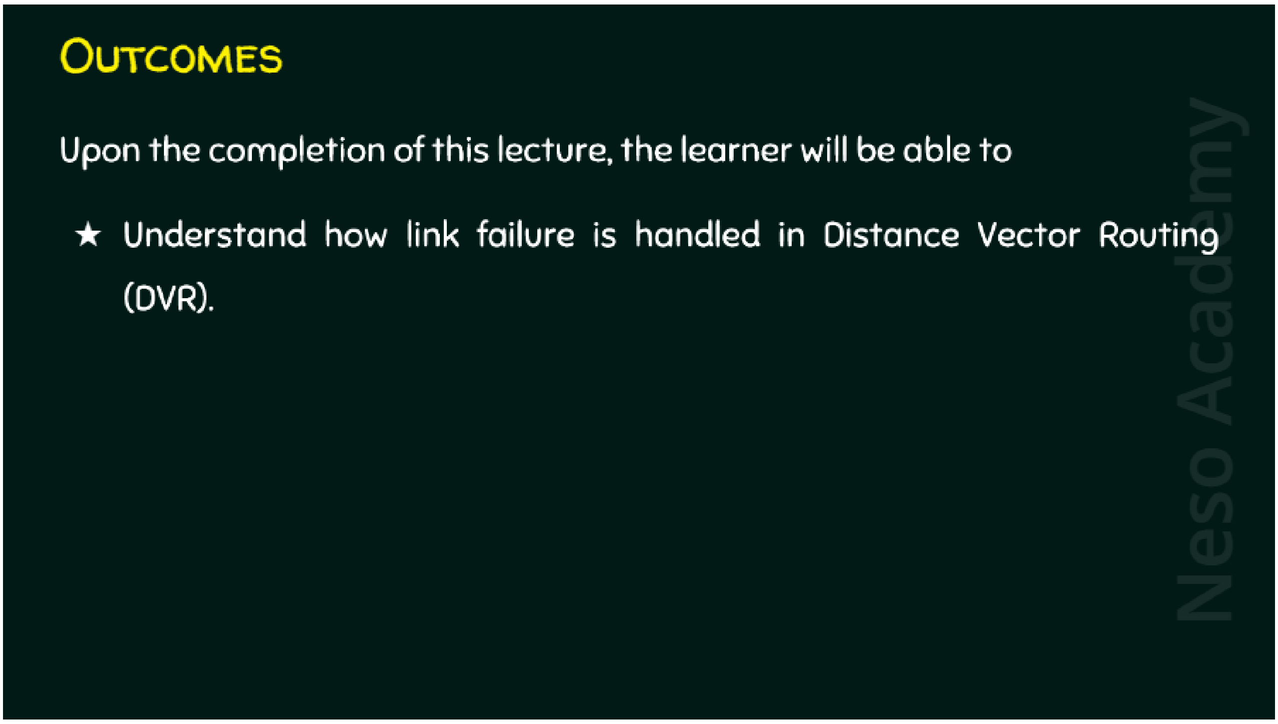


Initial Routing table of GNeso Academy

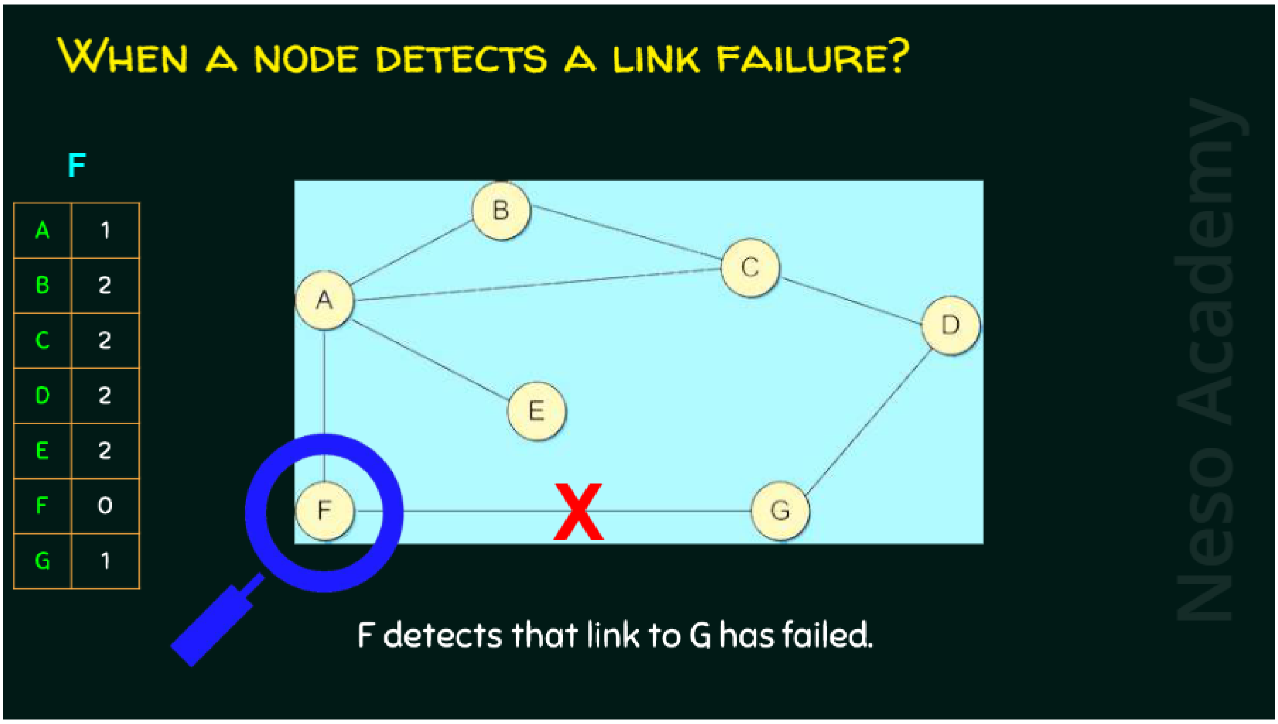
Final distance stored at each node

Information stored at Node	Distance to reach node						
	A	B	C	D	E	F	G
A	0	1	1	2	1	1	2
B	1	0	1	2	2	2	3
C	1	1	0	1	2	2	2
D	2	2	1	0	3	2	1
E	1	2	2	3	0	2	3
F	1	2	2	2	2	0	1
G	2	3	2	1	3	1	0

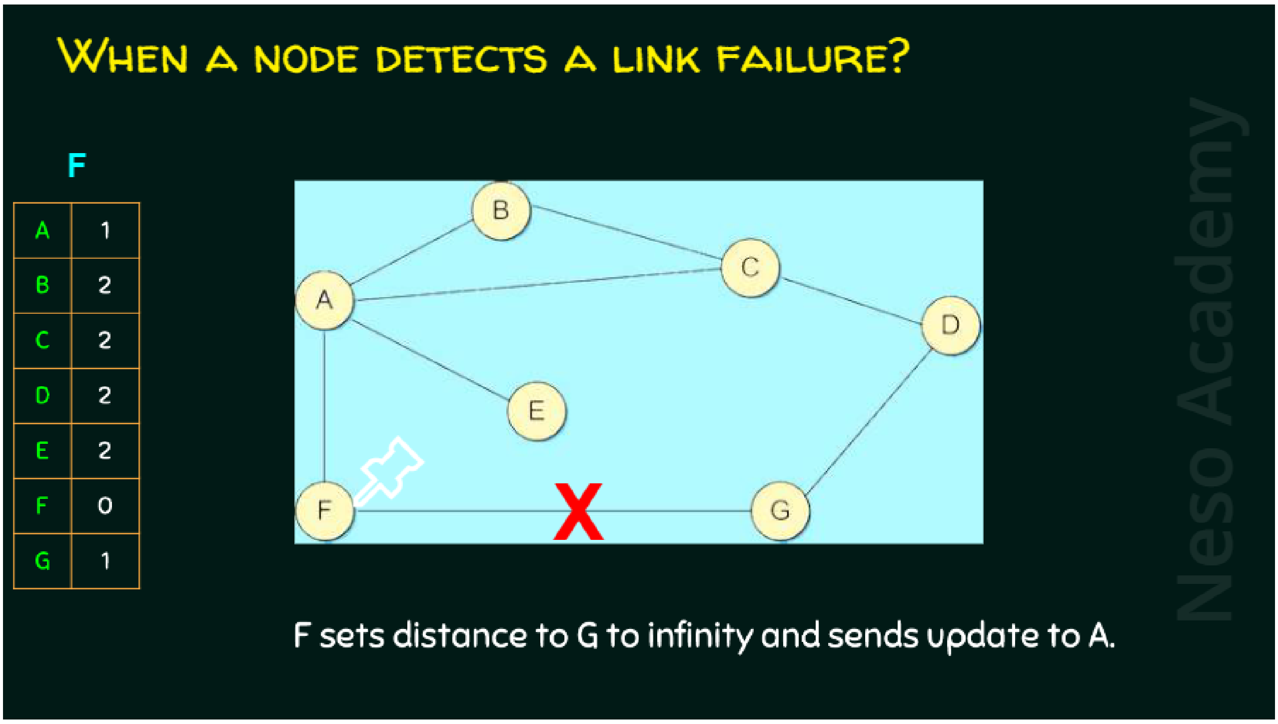
Final distance stored at each nodeNeso Academy



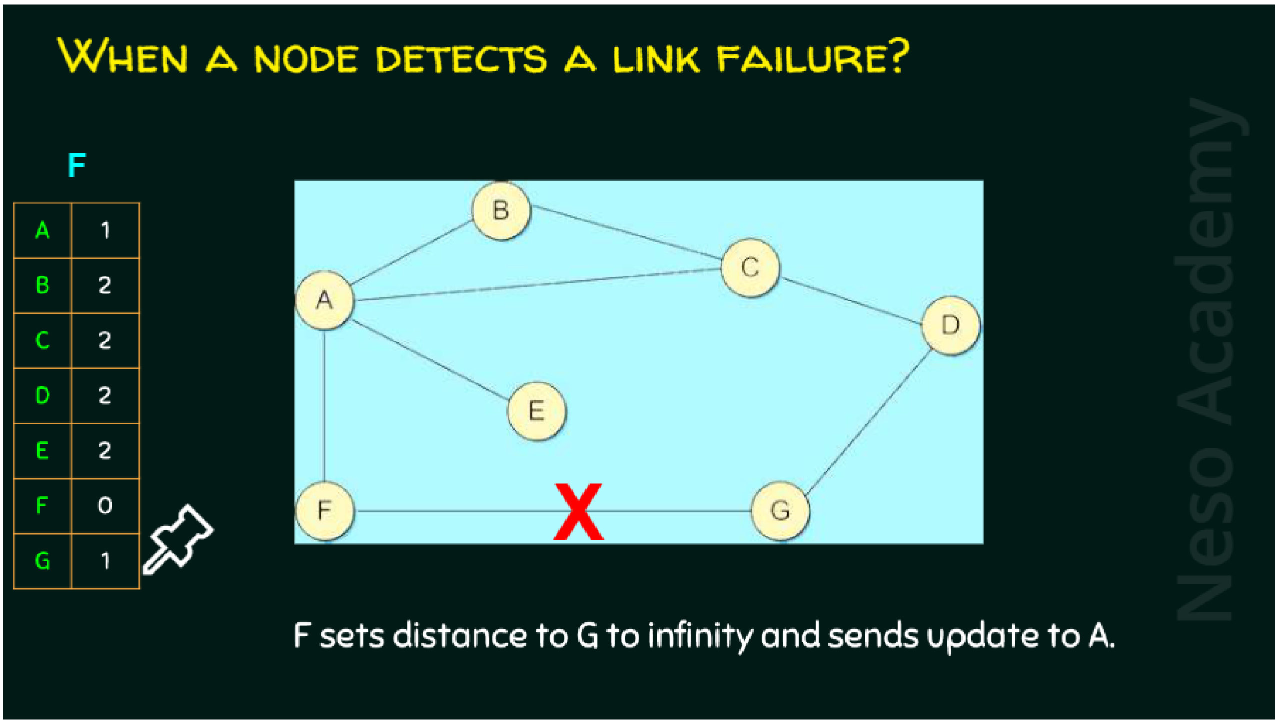
Outcomes★Neso Academy



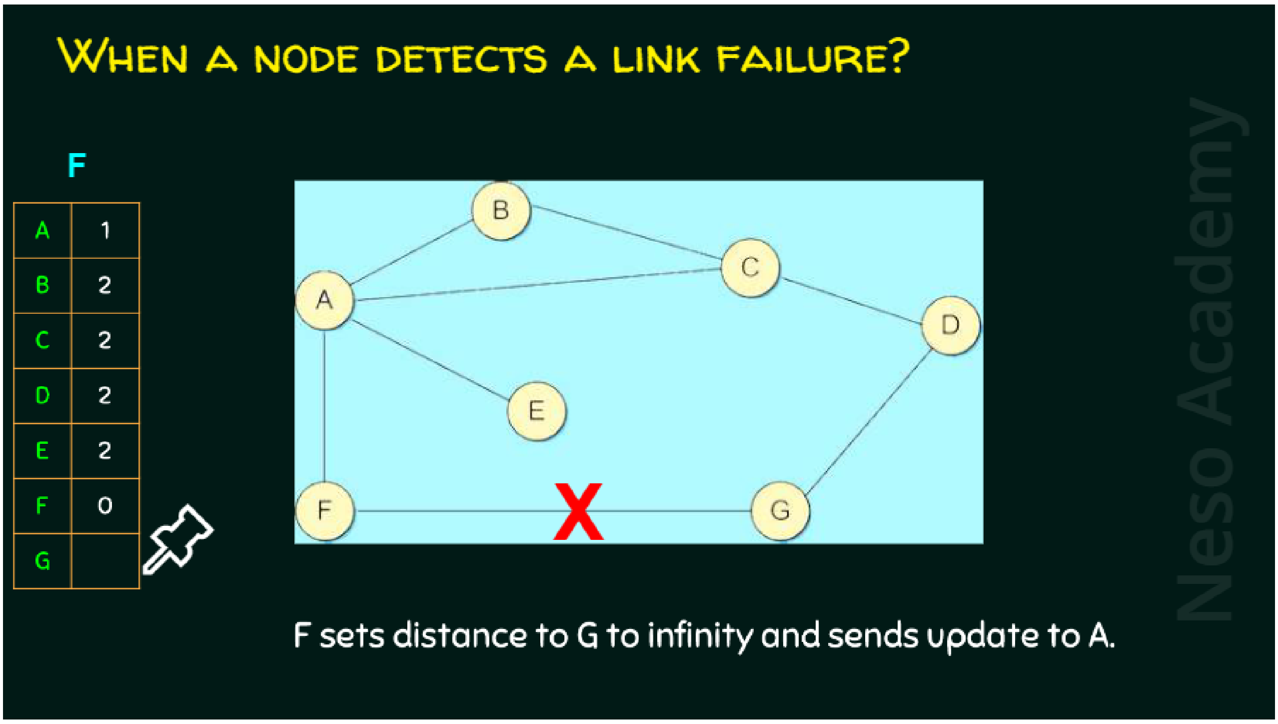
When a node detects a link failure?XFNeso Academy



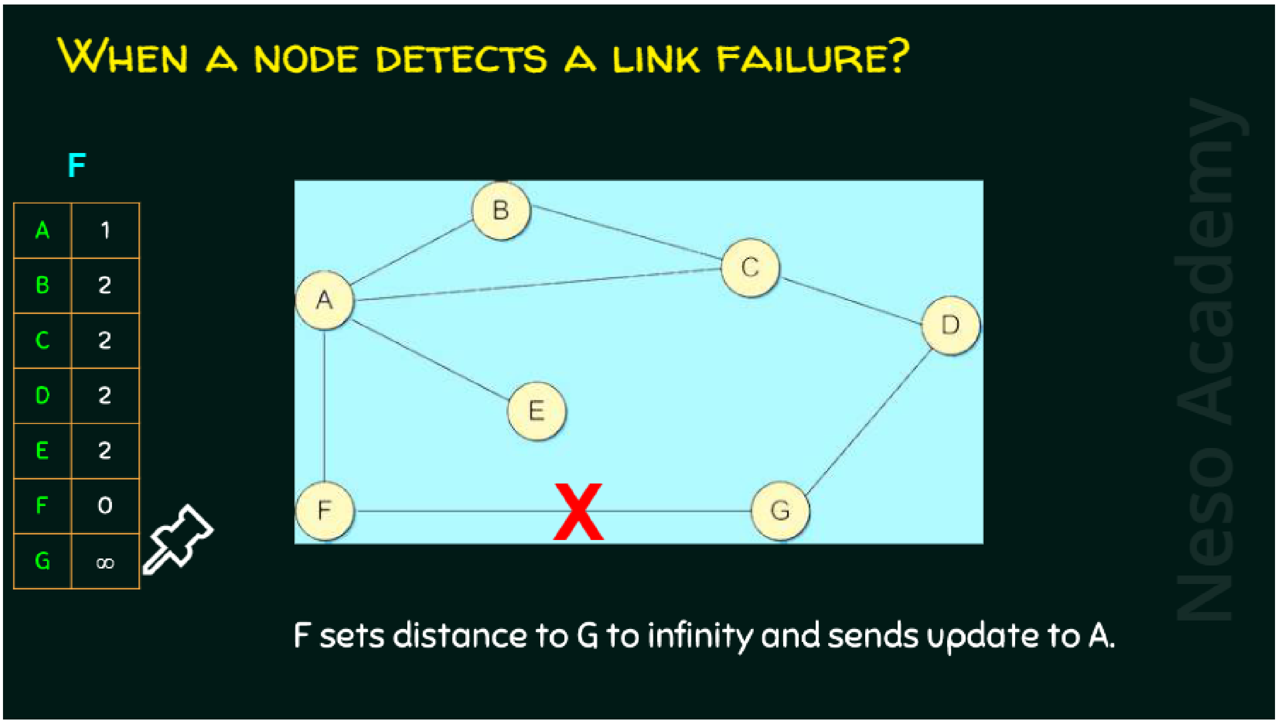
When a node detects a link failure?X📌FNeso Academy



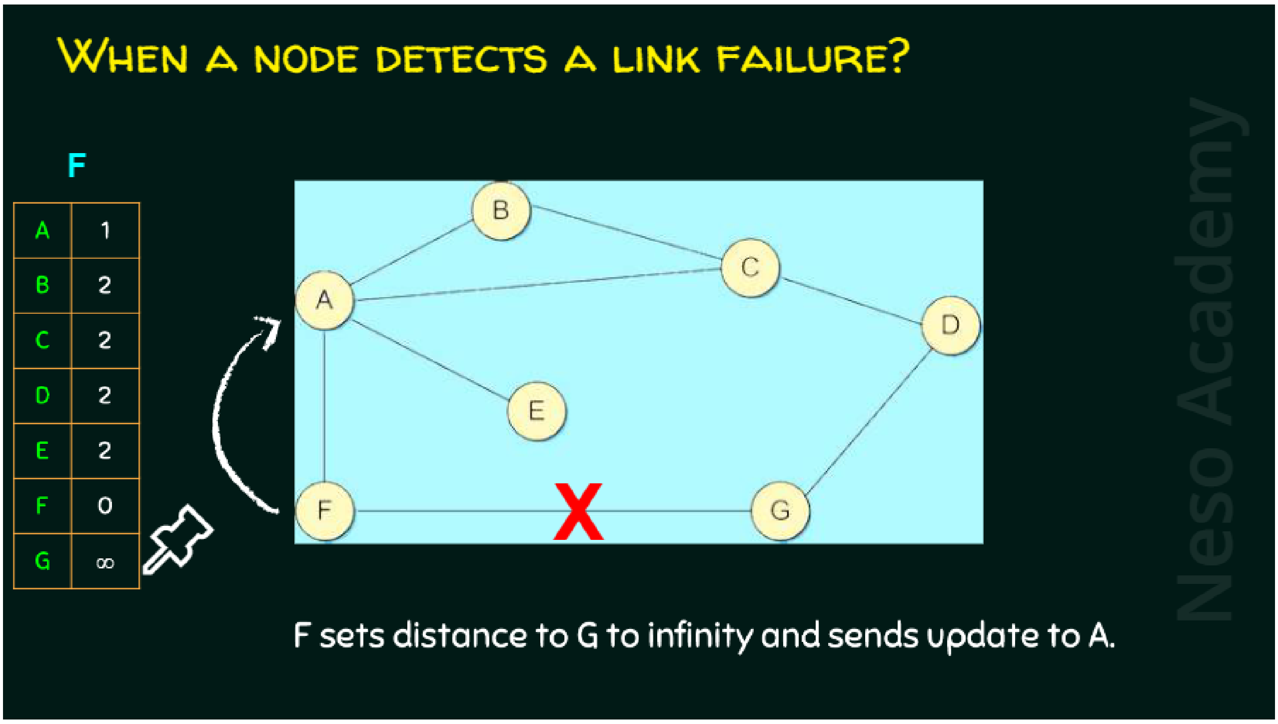
When a node detects a link failure?X📌FNeso Academy



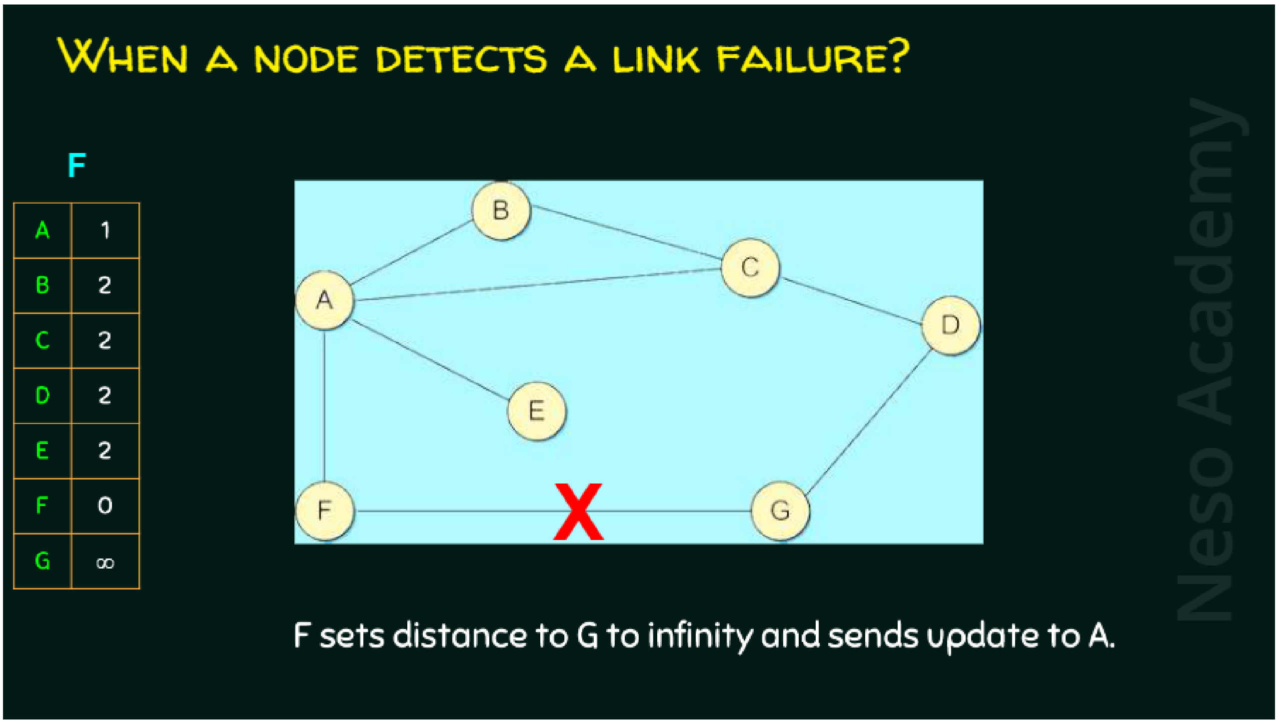
When a node detects a link failure?X📌FNeso Academy



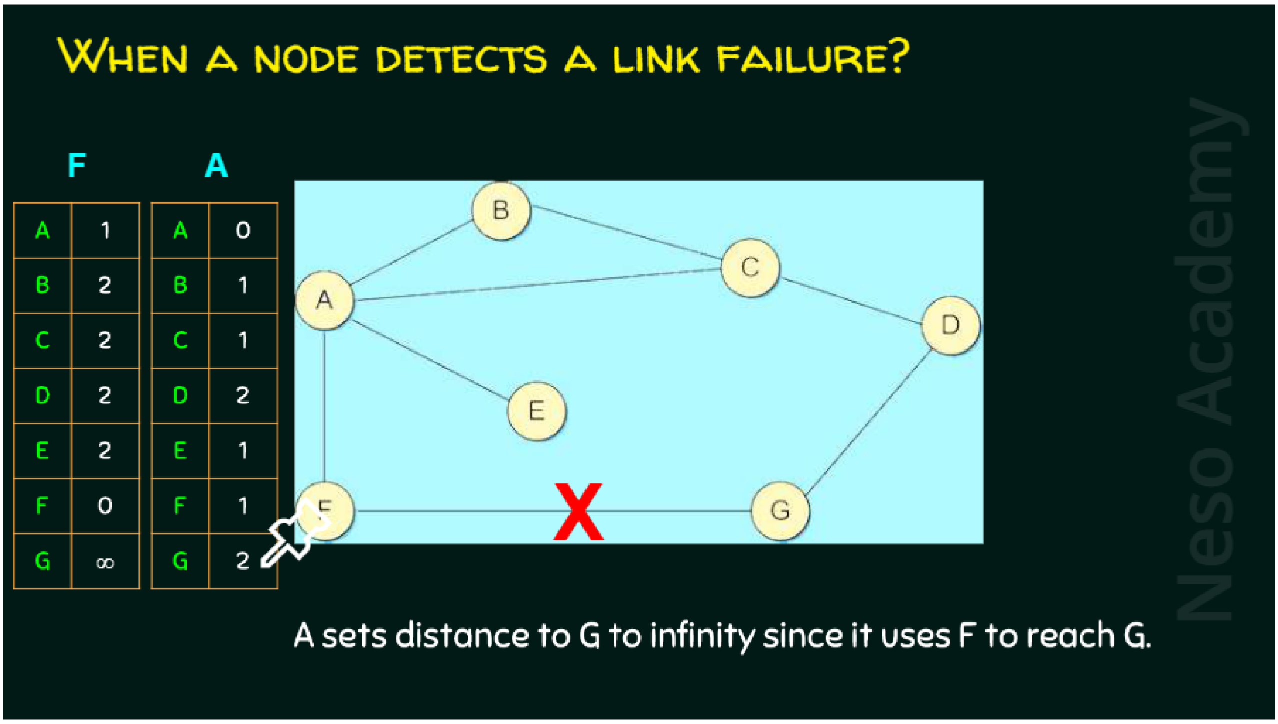
When a node detects a link failure?X📌F∞Neso Academy



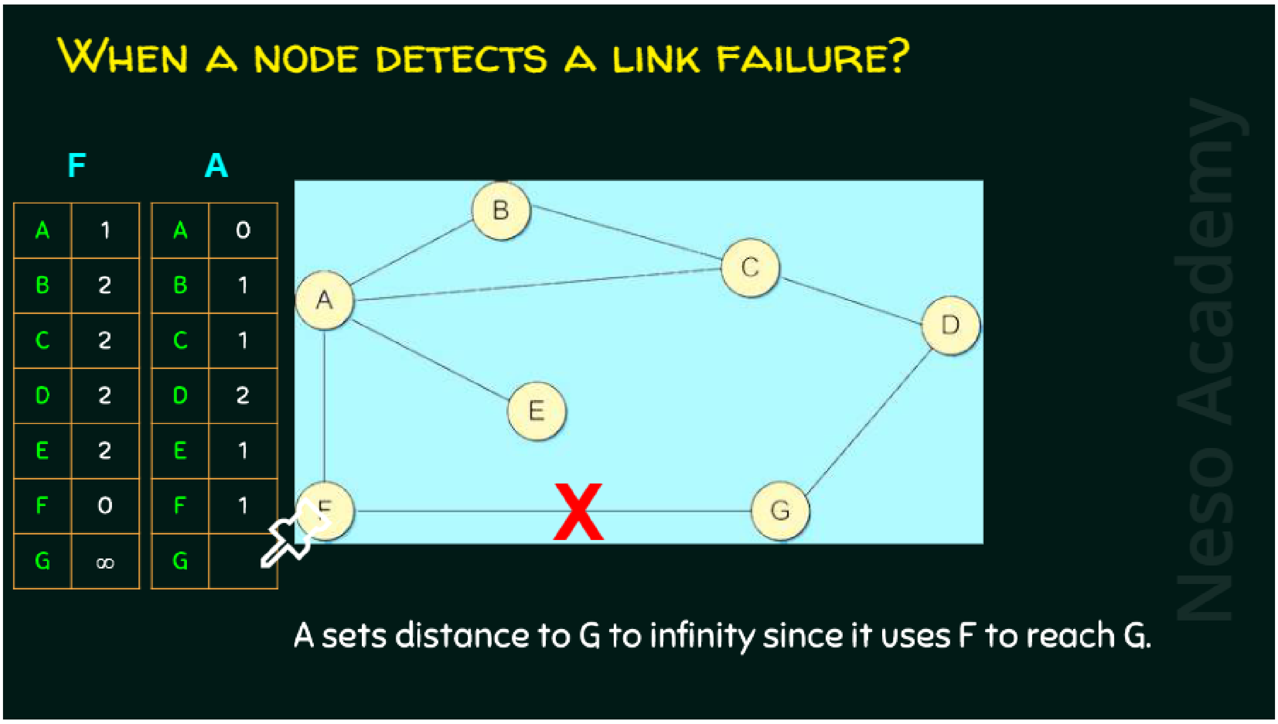
When a node detects a link failure?X📌F∞Neso Academy



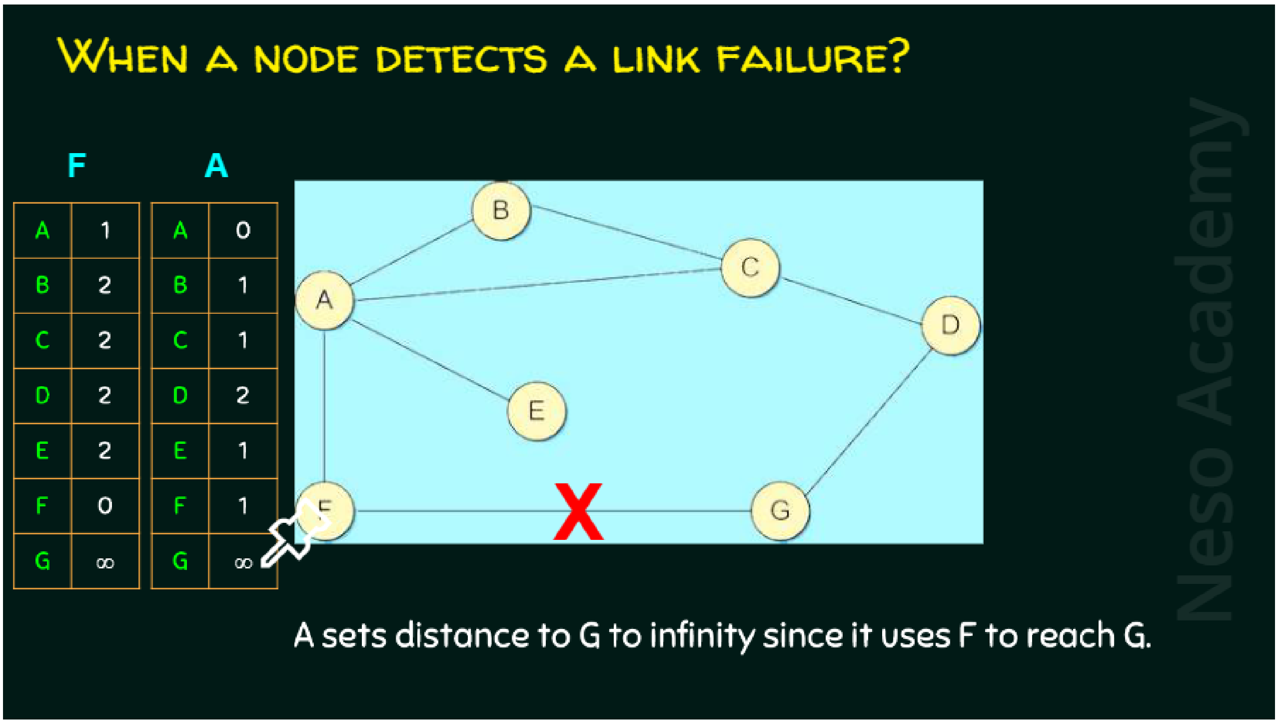
When a node detects a link failure?XF∞Neso Academy



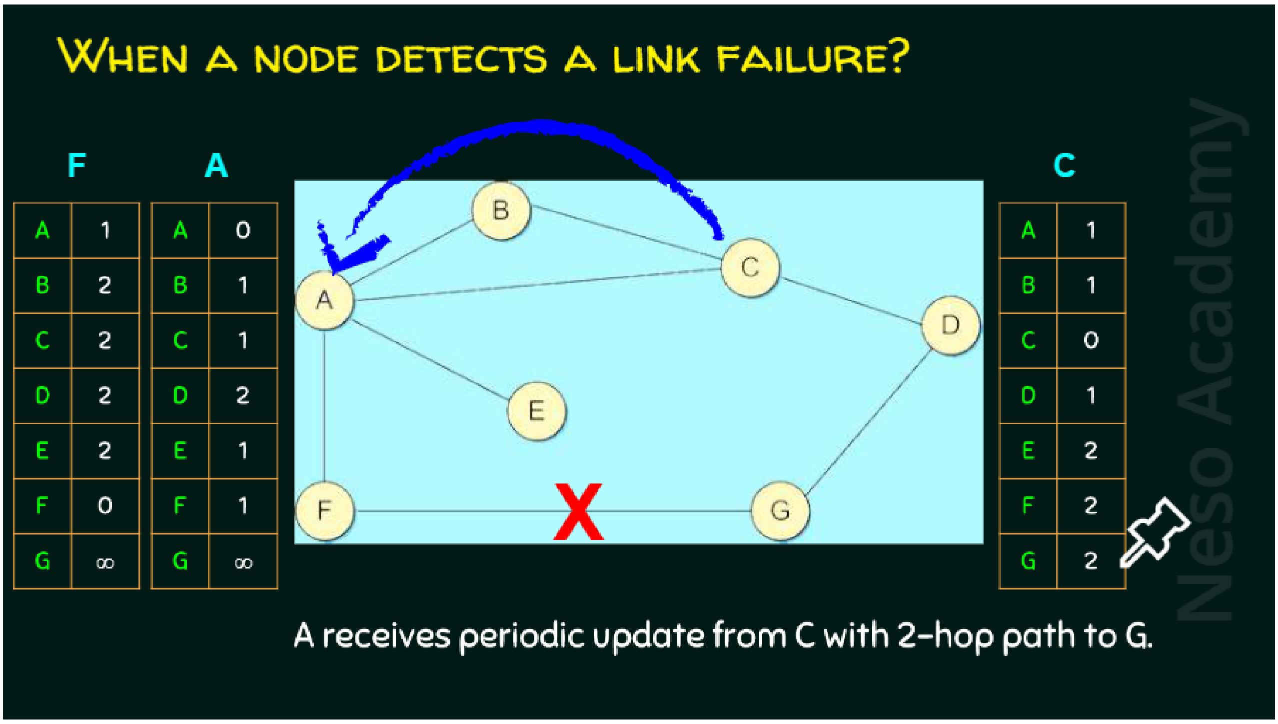
When a node detects a link failure?XF∞A📌Neso Academy



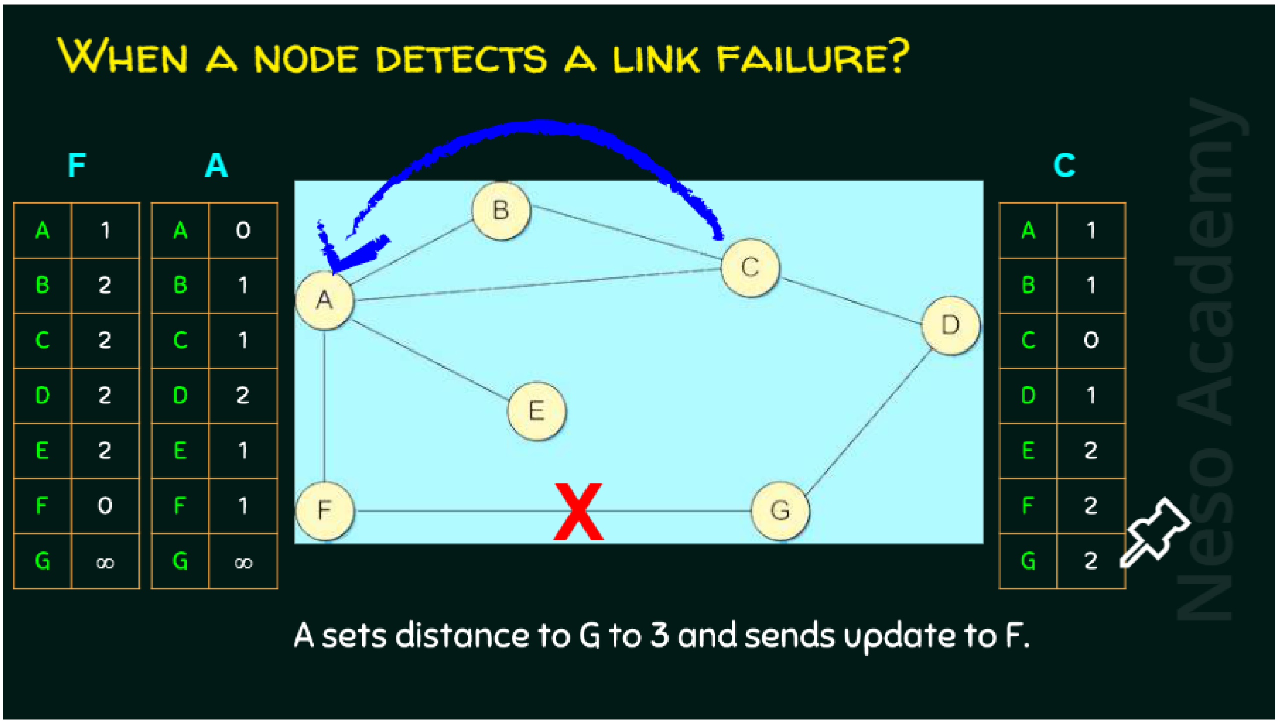
When a node detects a link failure?XF∞A📌Neso Academy



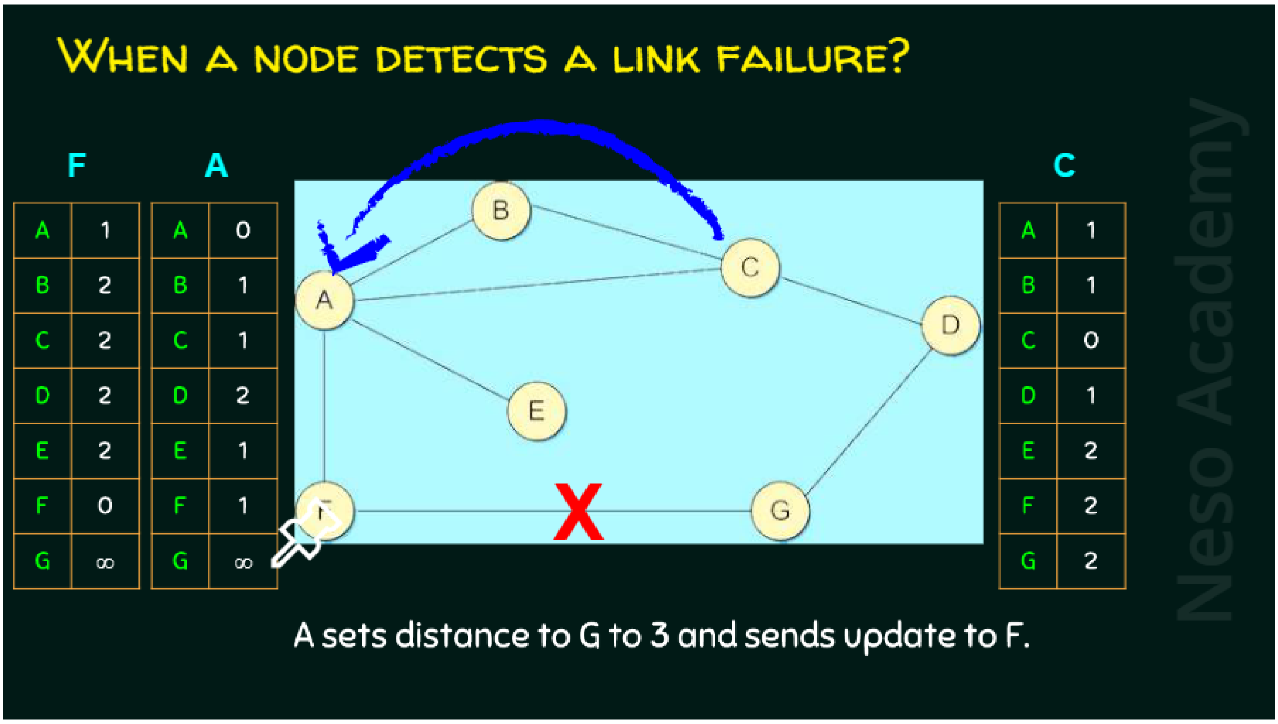
When a node detects a link failure?XF∞A∞📌Neso Academy



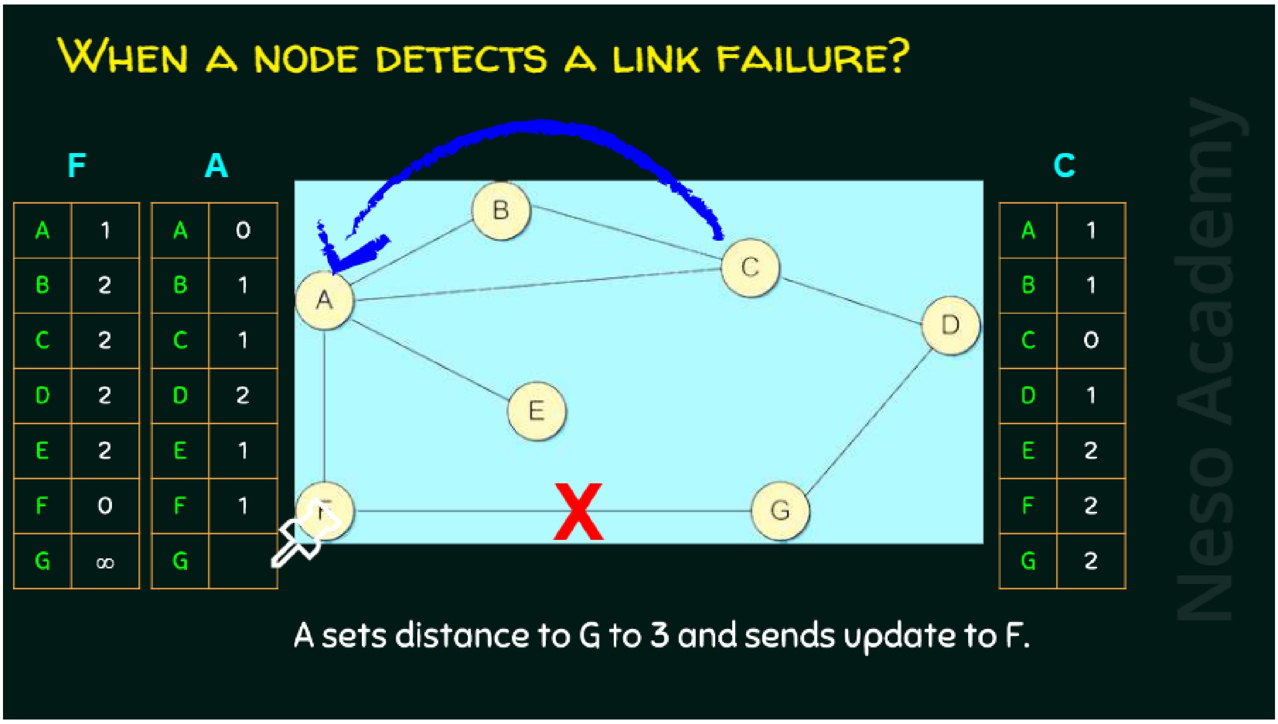
When a node detects a link failure?XF∞A∞C📌Neso Academy



When a node detects a link failure?XF∞A∞C 📌 Neso Academy



When a node detects a link failure?XF∞A∞C 📌 Neso Academy



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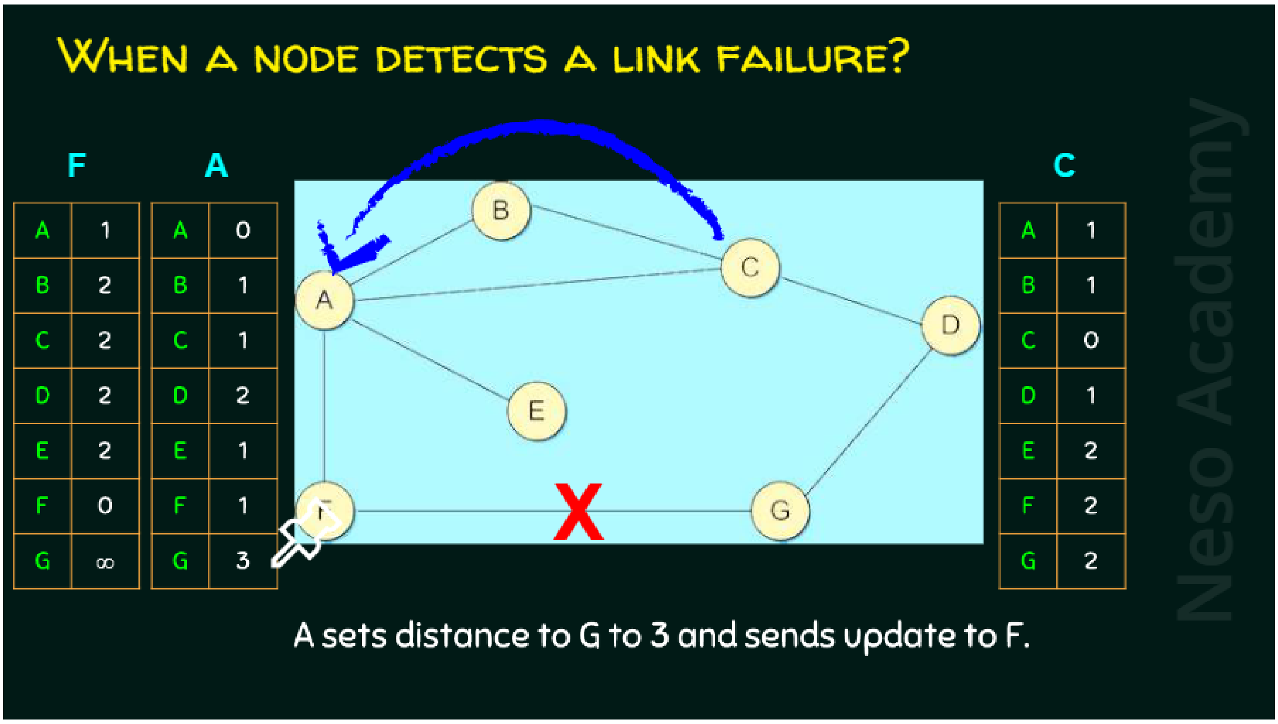

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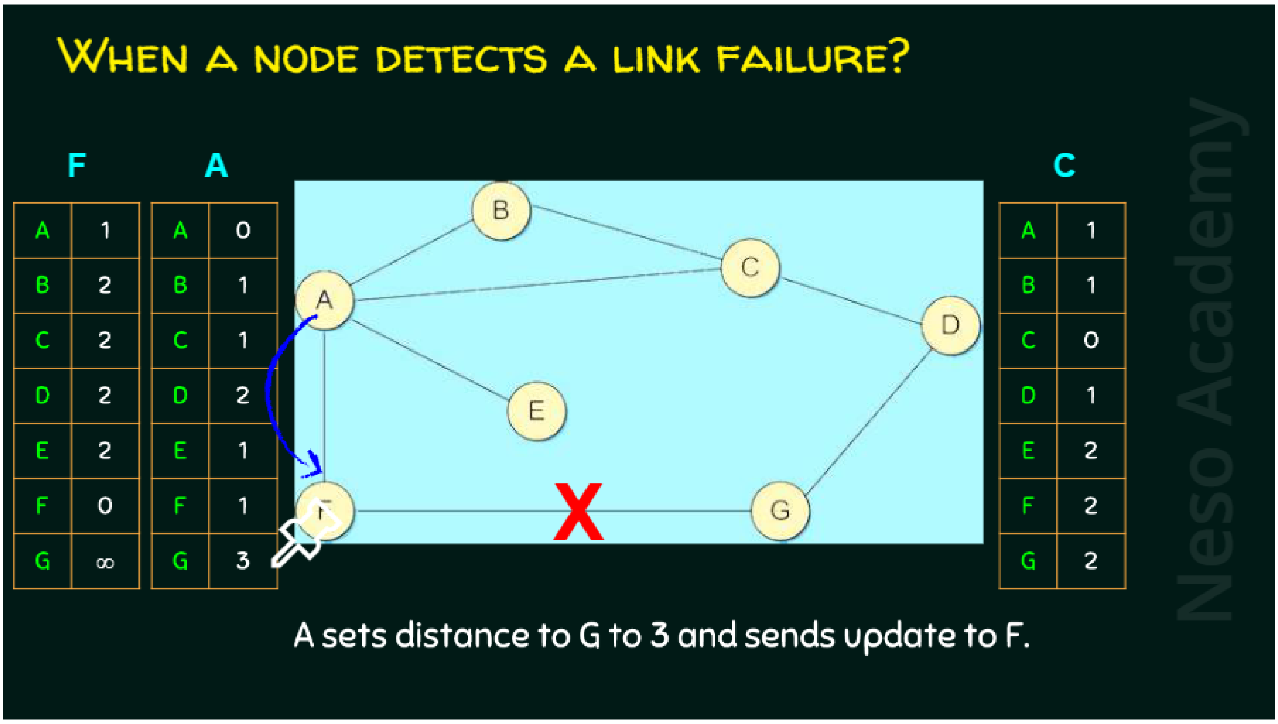

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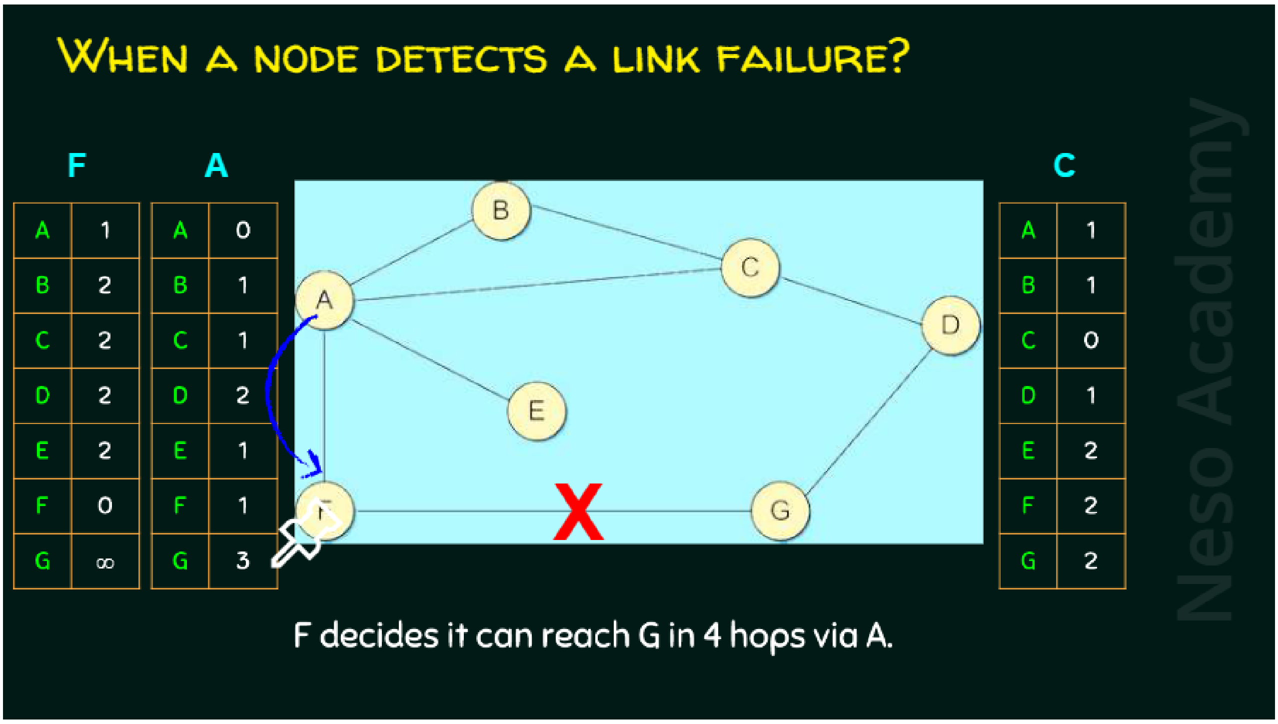
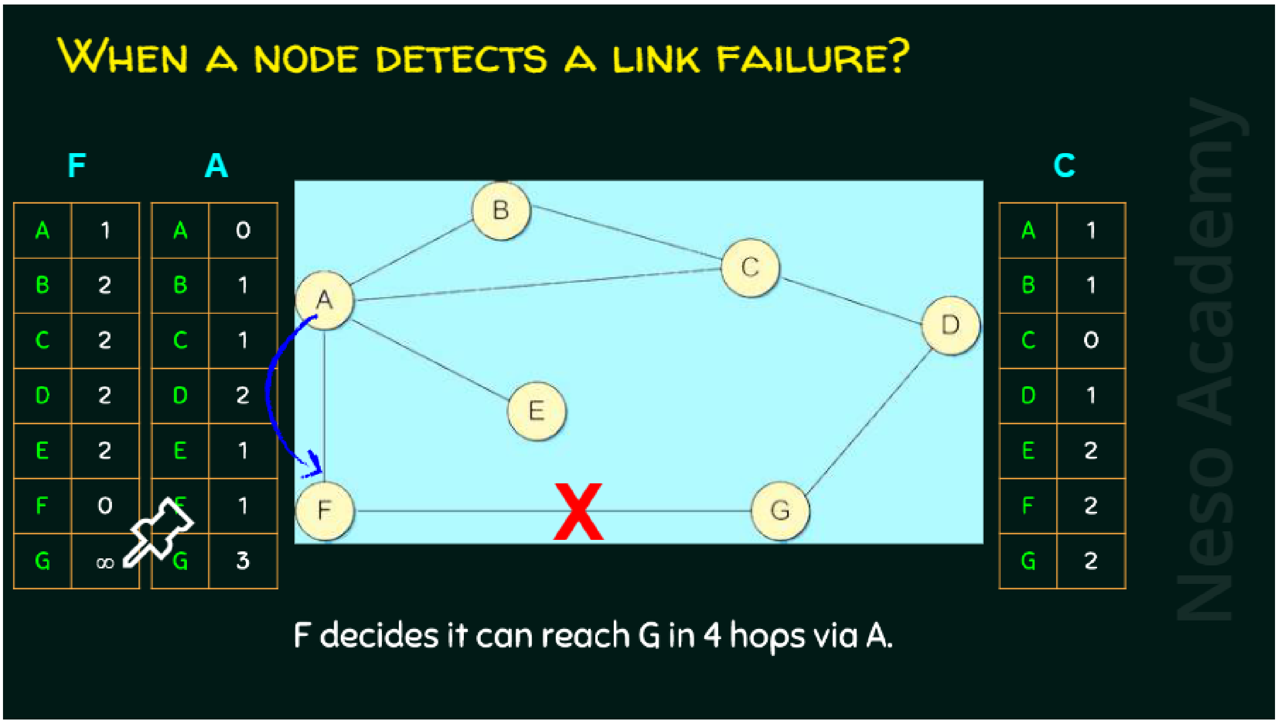
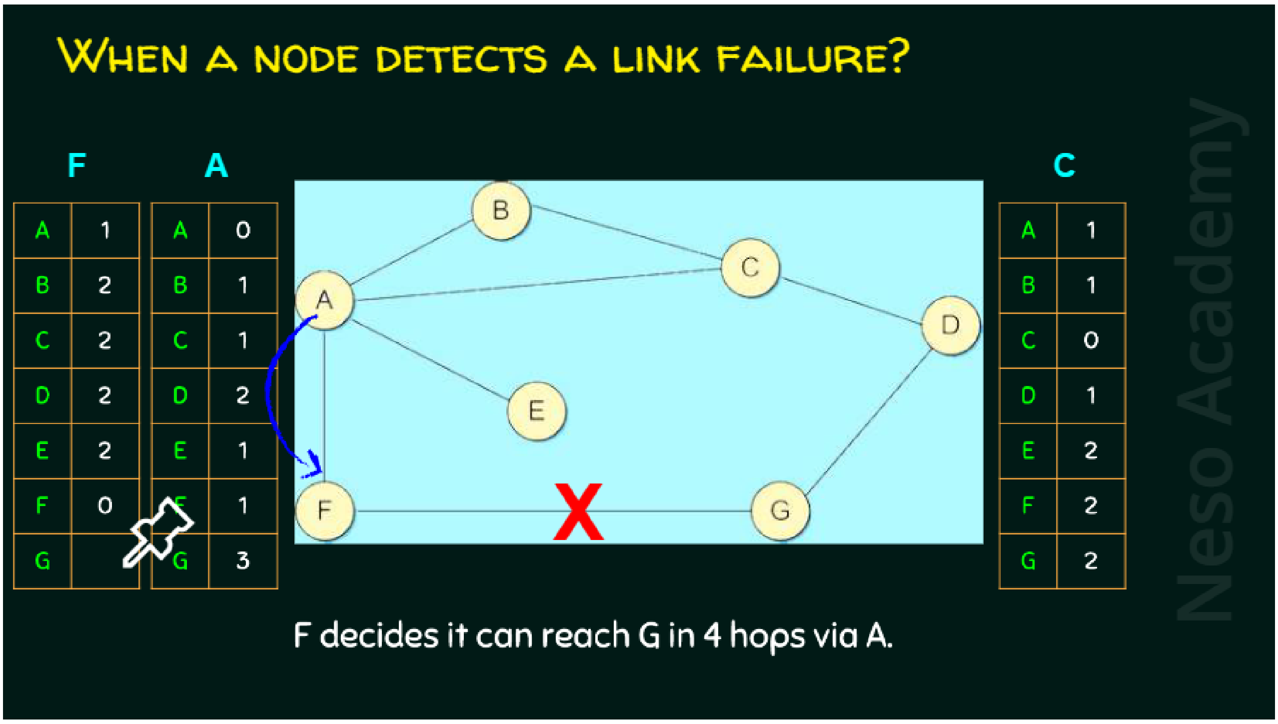


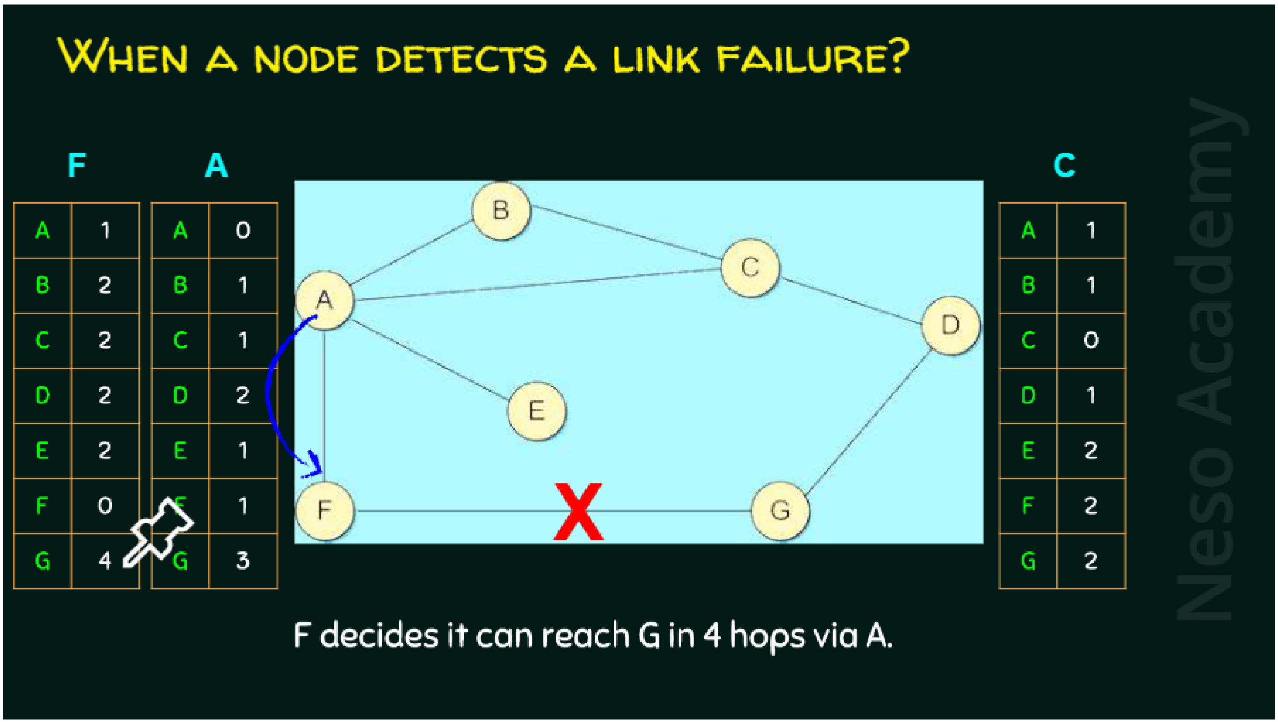
When a node detects a link failure?XF∞AC📌Neso Academy



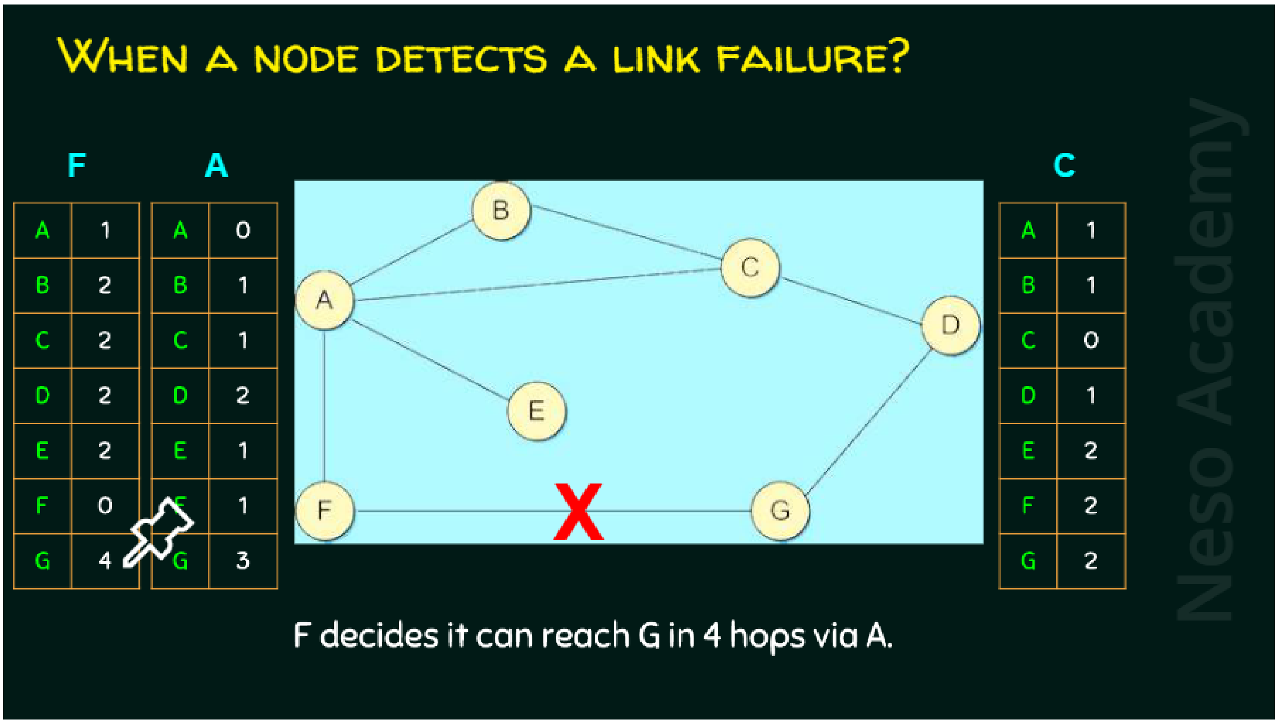
When a node detects a link failure?XF∞AC📌Neso Academy



When a node detects a link failure?XFAC📌Neso Academy



When a node detects a link failure?XFAC 📌 Neso Academy



When a node detects a link failure?XFAC 📌 Neso Academy

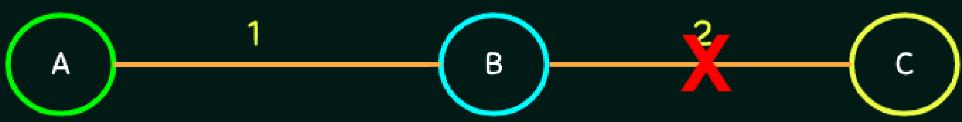
Outcomes

Upon the completion of this lecture, the learner will be able to

- ★ Understand Count-to-infinity problem.
- ★ Know the solutions for Count-to-infinity problem.

Outcomes★★Neso Academy

Count-to-infinity Problem

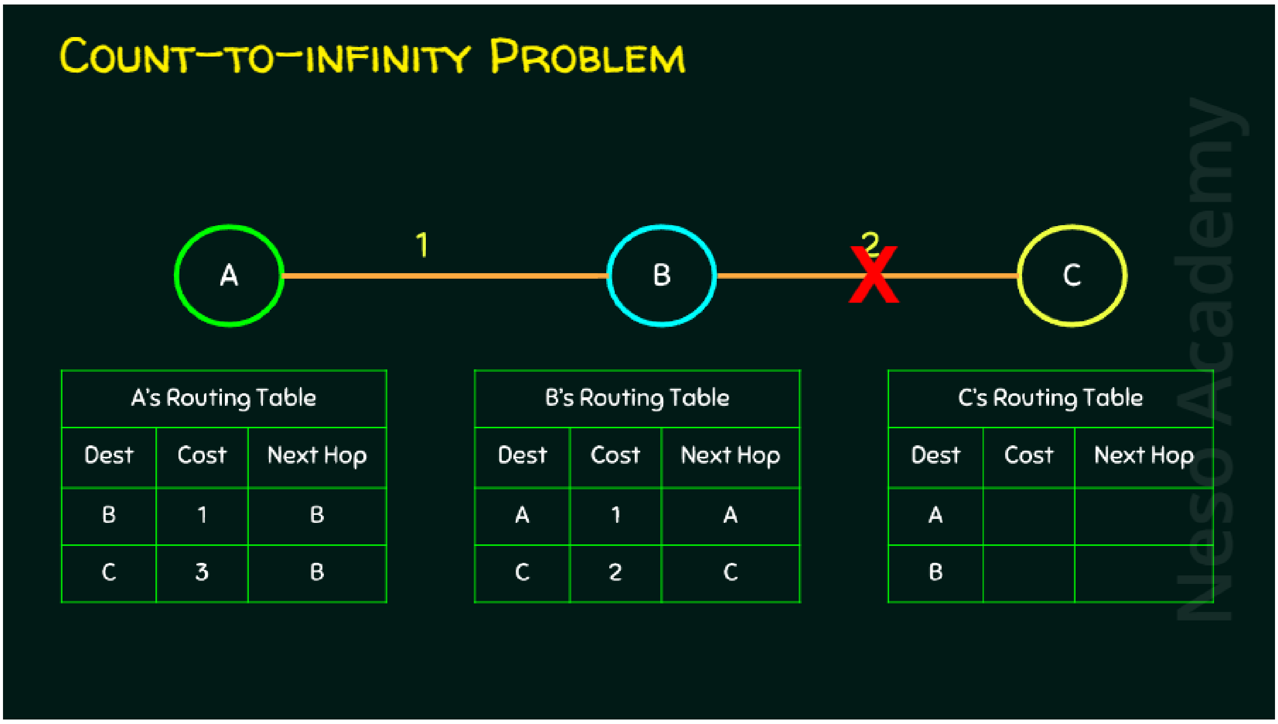


A's Routing Table		
Dest	Cost	Next Hop
B	1	B
C	3	B

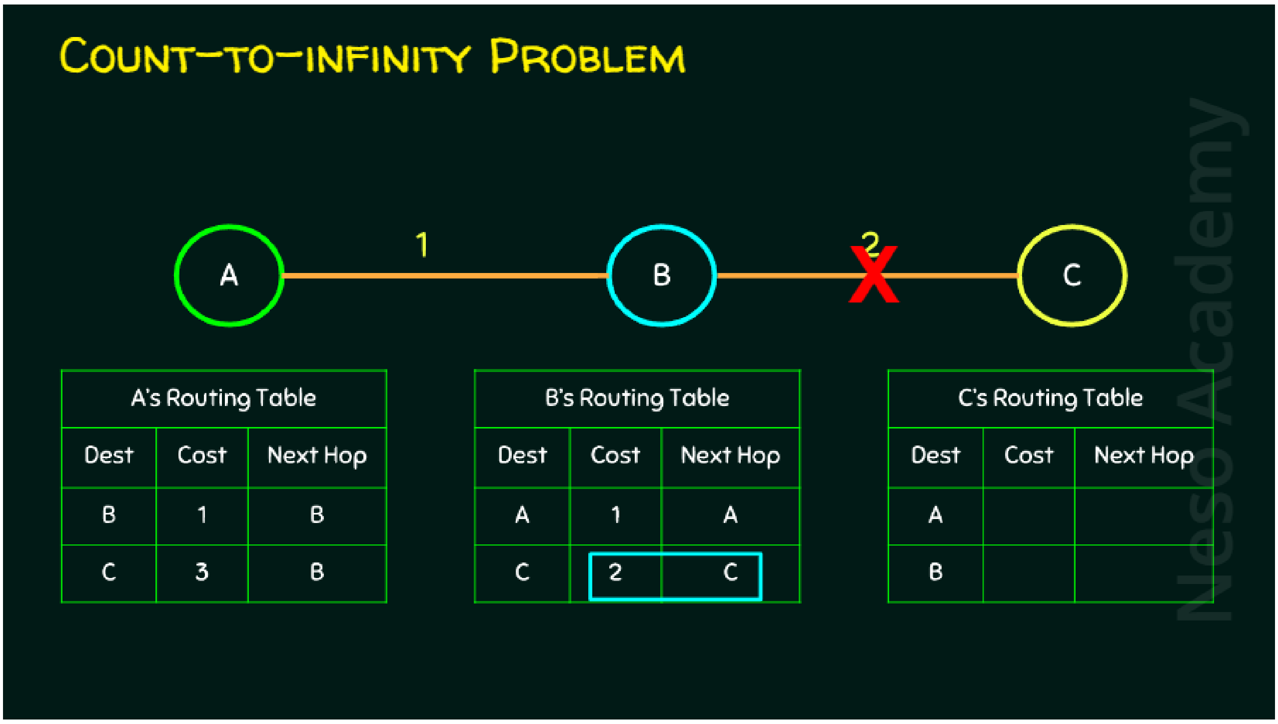
B's Routing Table		
Dest	Cost	Next Hop
A	1	A
C	2	C

C's Routing Table		
Dest	Cost	Next Hop
A	3	B
B	2	B

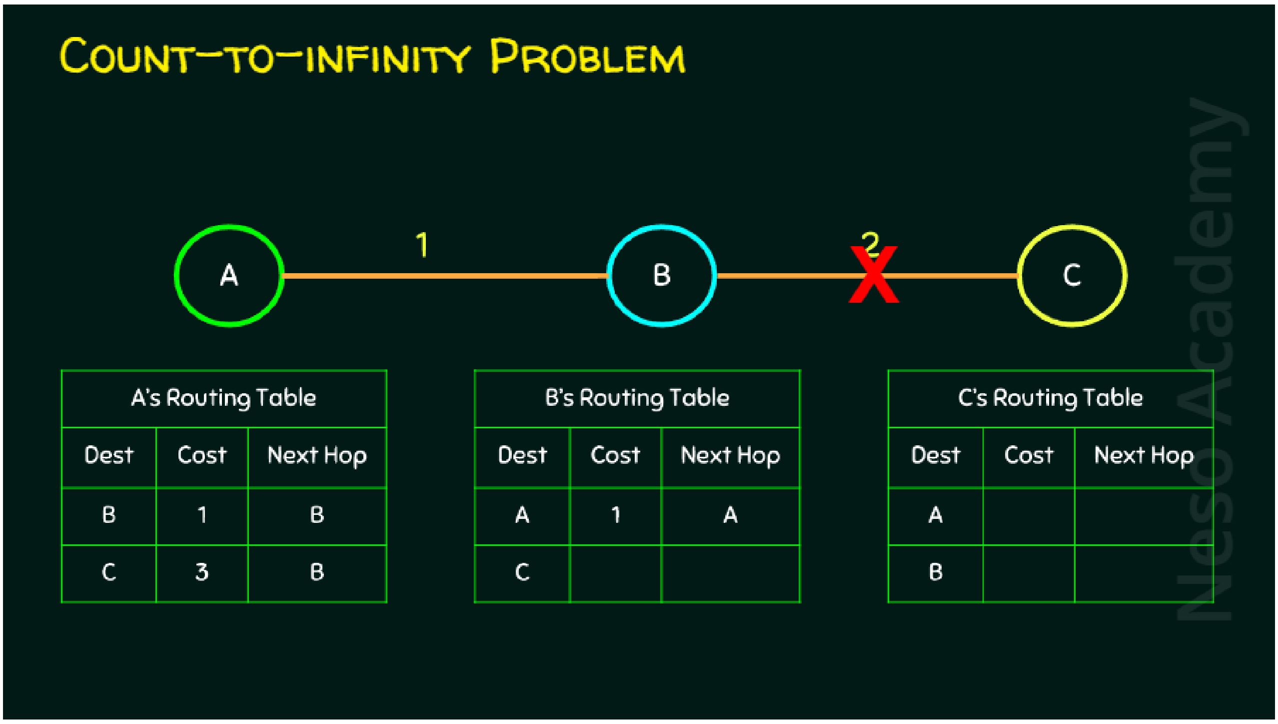
Count-to-infinity ProblemXNeso Academy



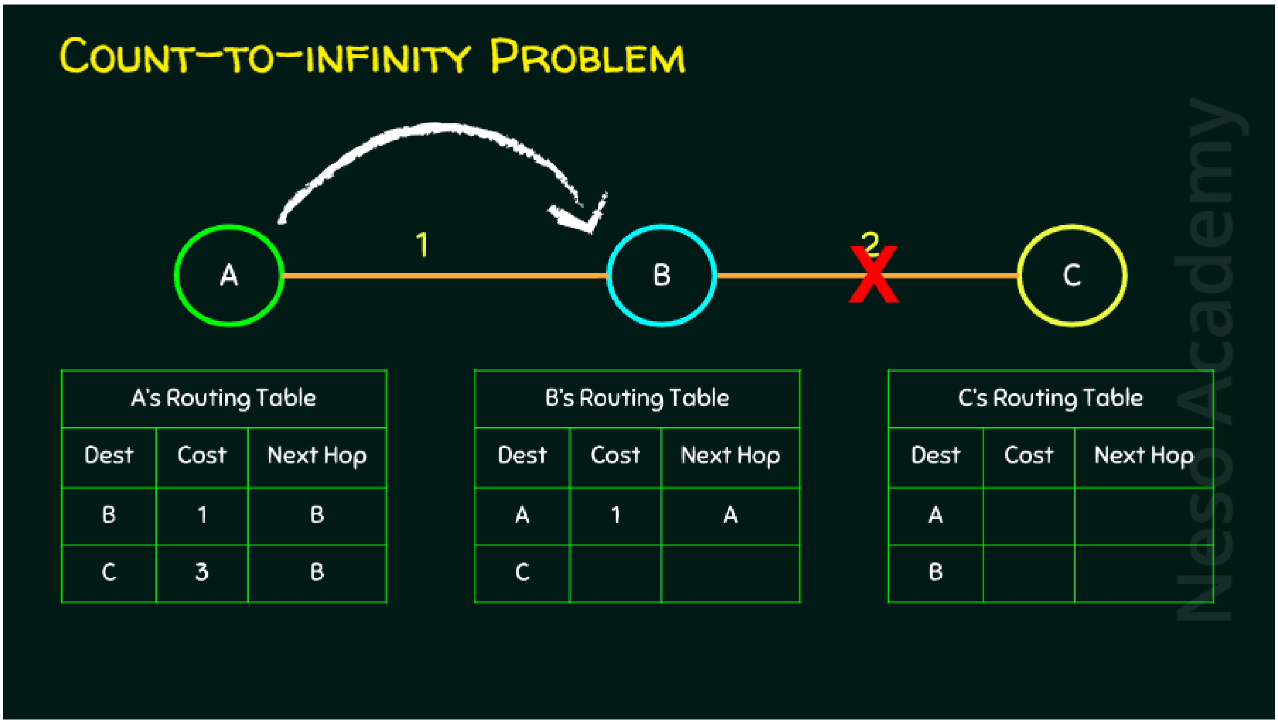
Count-to-infinity ProblemXNeso Academy



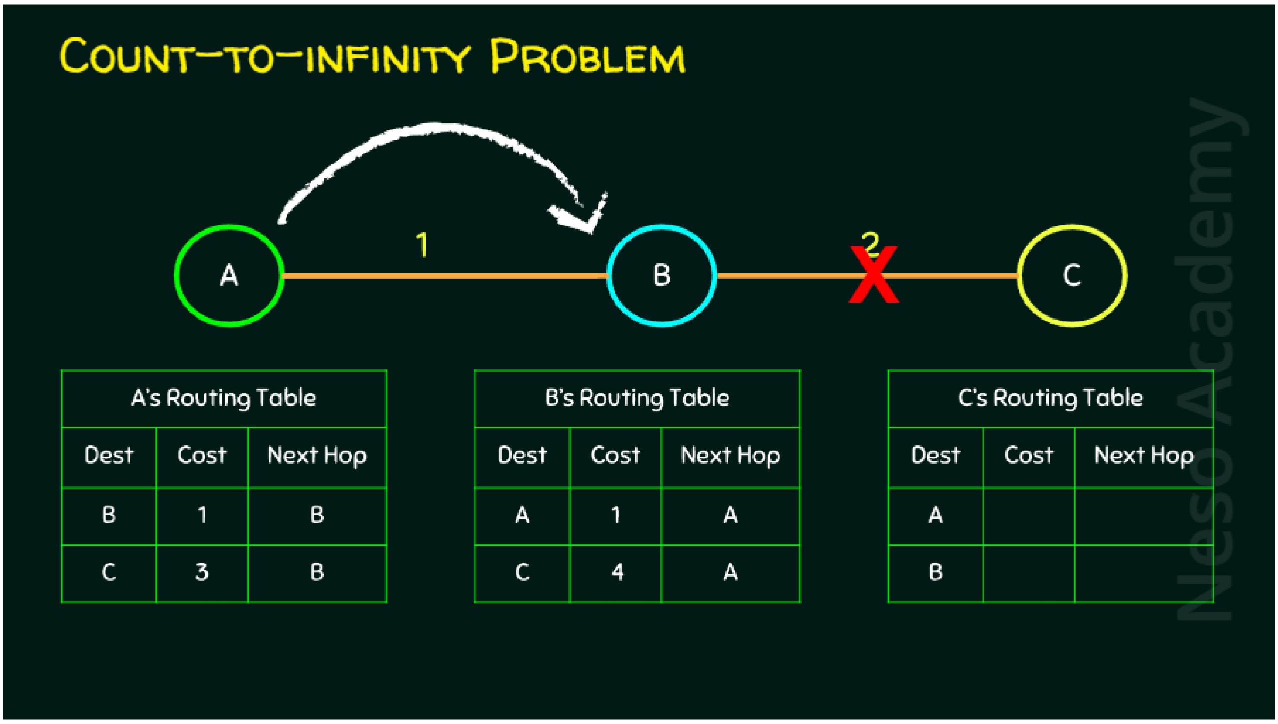
Count-to-infinity ProblemXNeso Academy



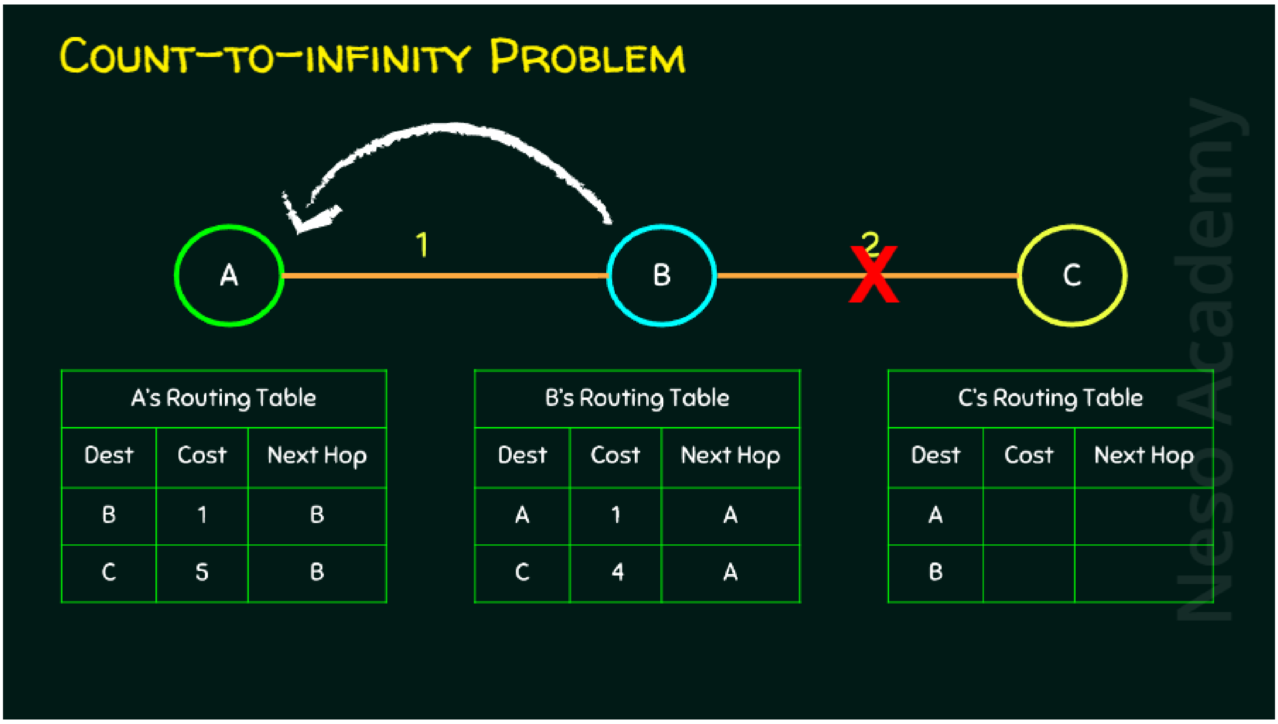
Count-to-infinity ProblemXNeso Academy



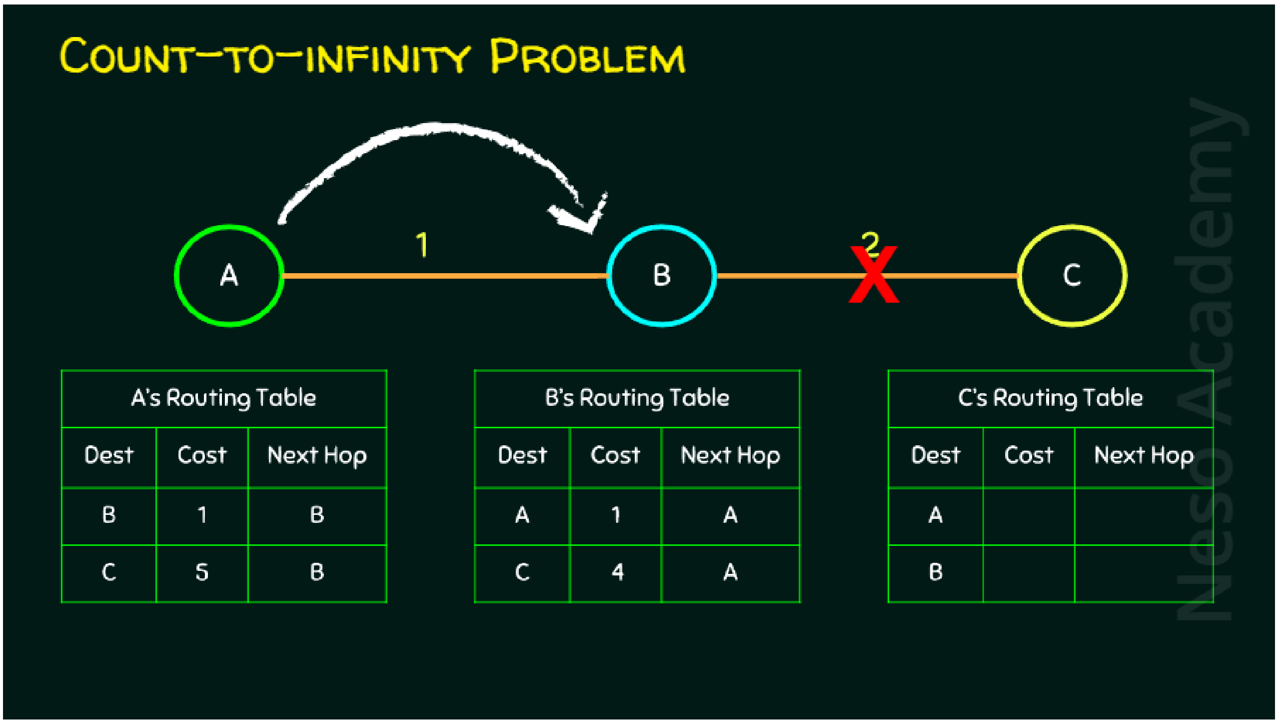
Count-to-infinity ProblemXNeso Academy



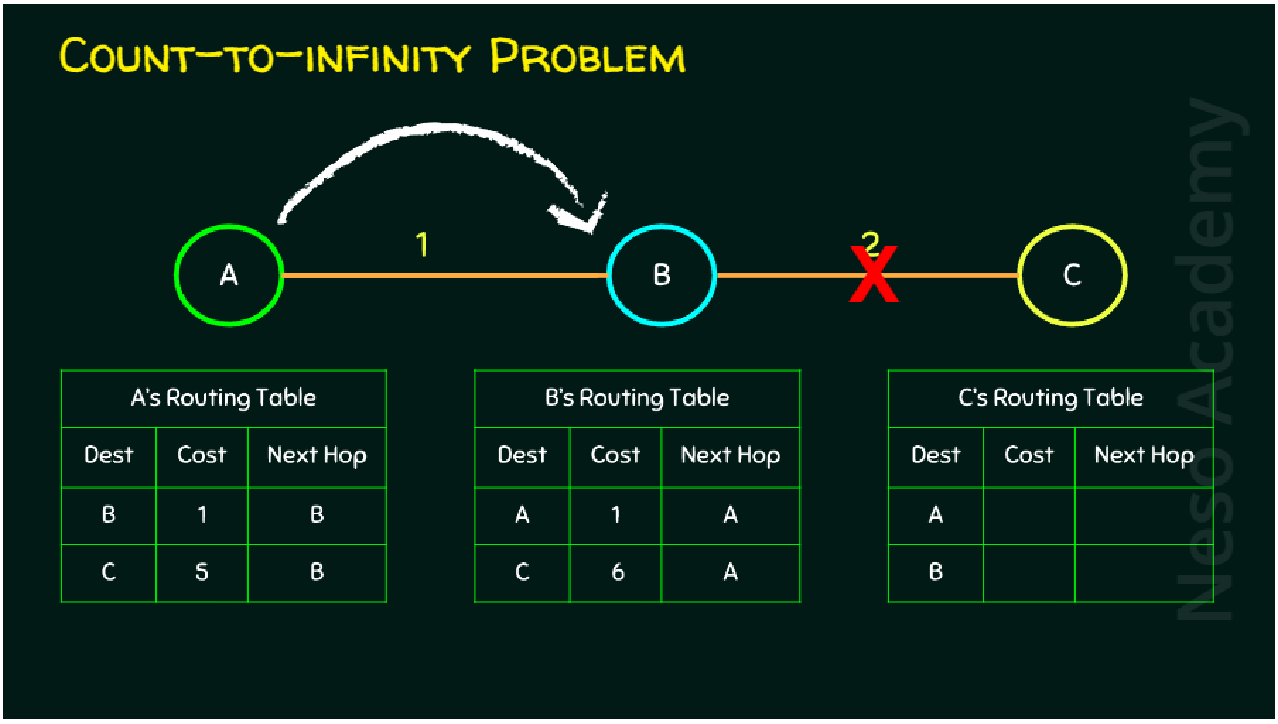
Count-to-infinity ProblemXNeso Academy



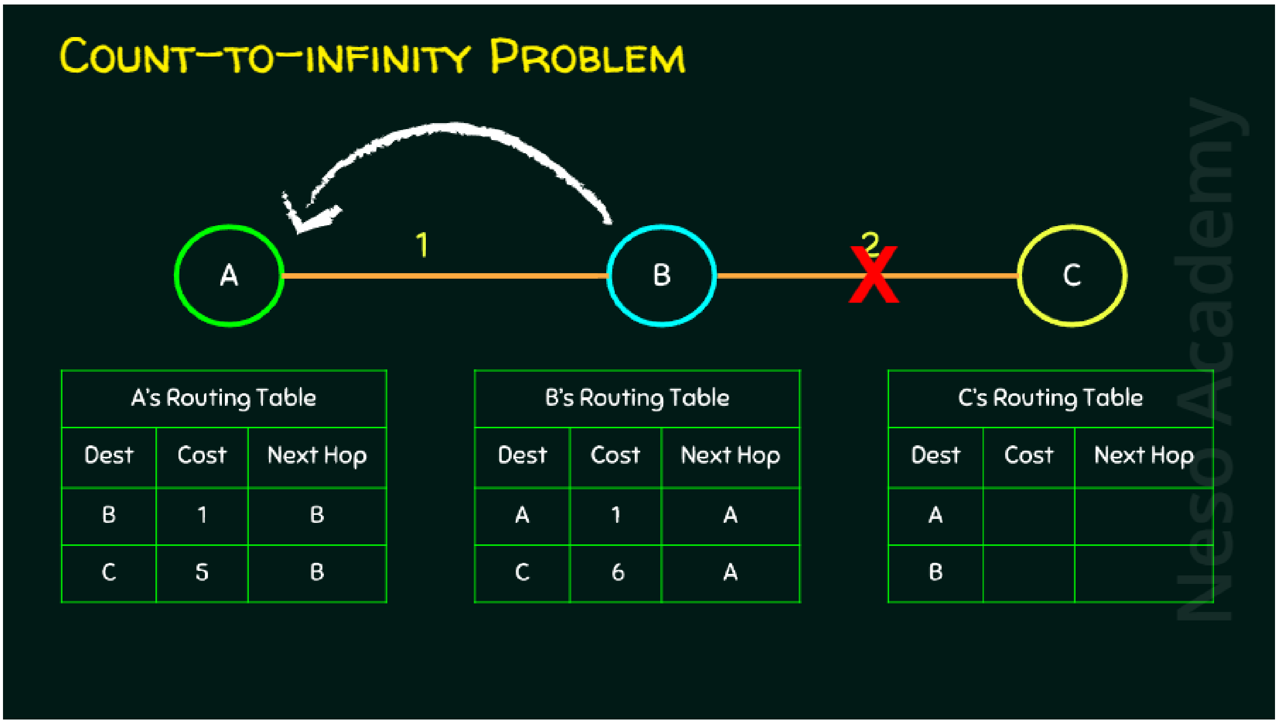
Count-to-infinity ProblemXNeso Academy



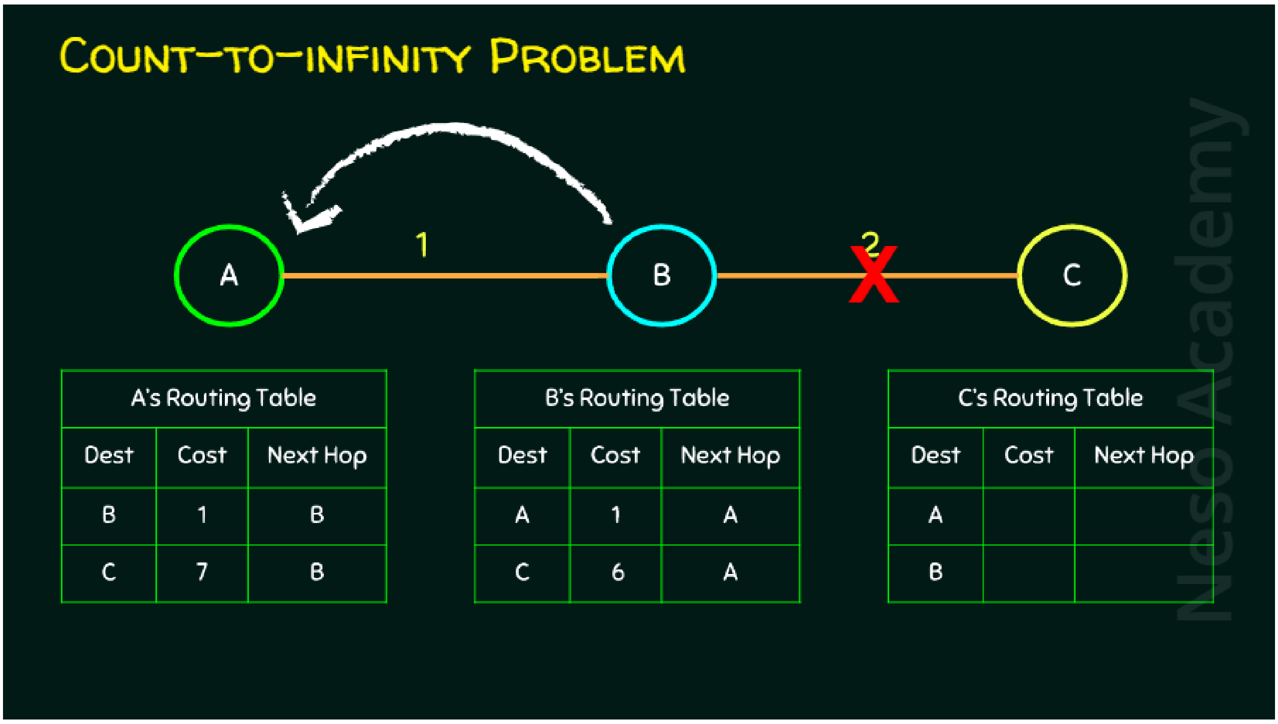
Count-to-infinity ProblemXNeso Academy



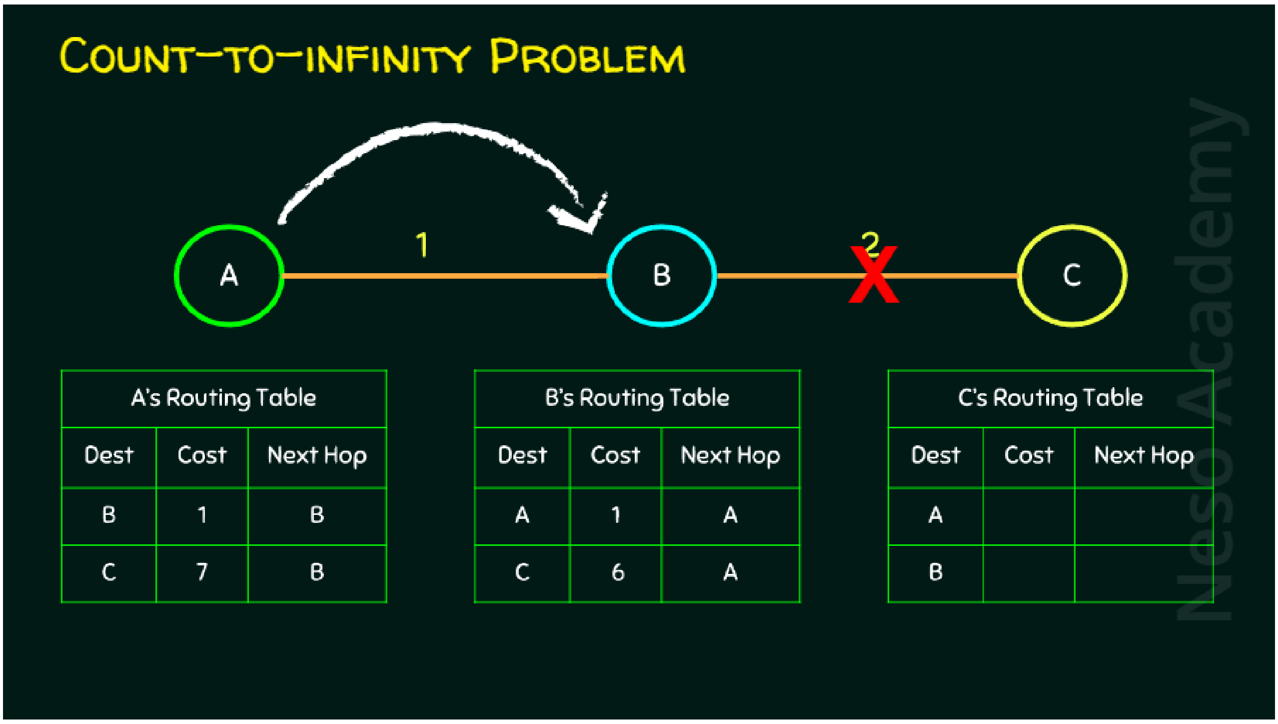
Count-to-infinity ProblemXNeso Academy



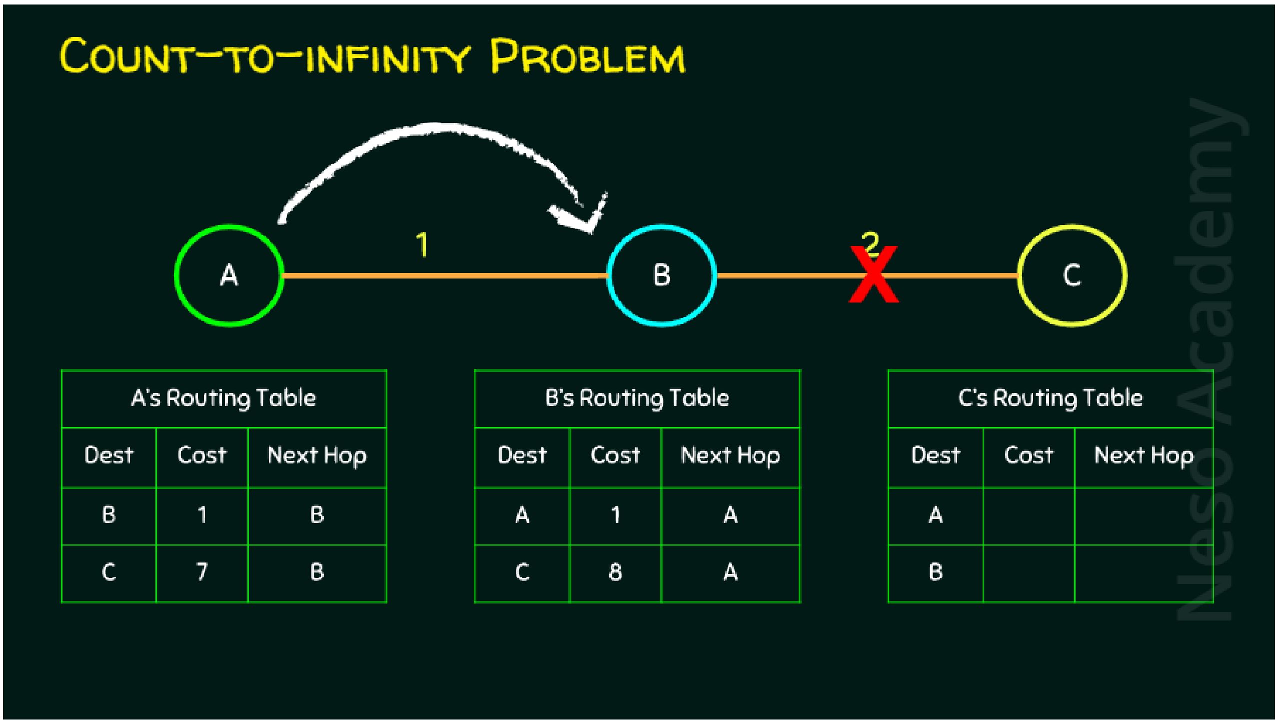
Count-to-infinity ProblemXNeso Academy



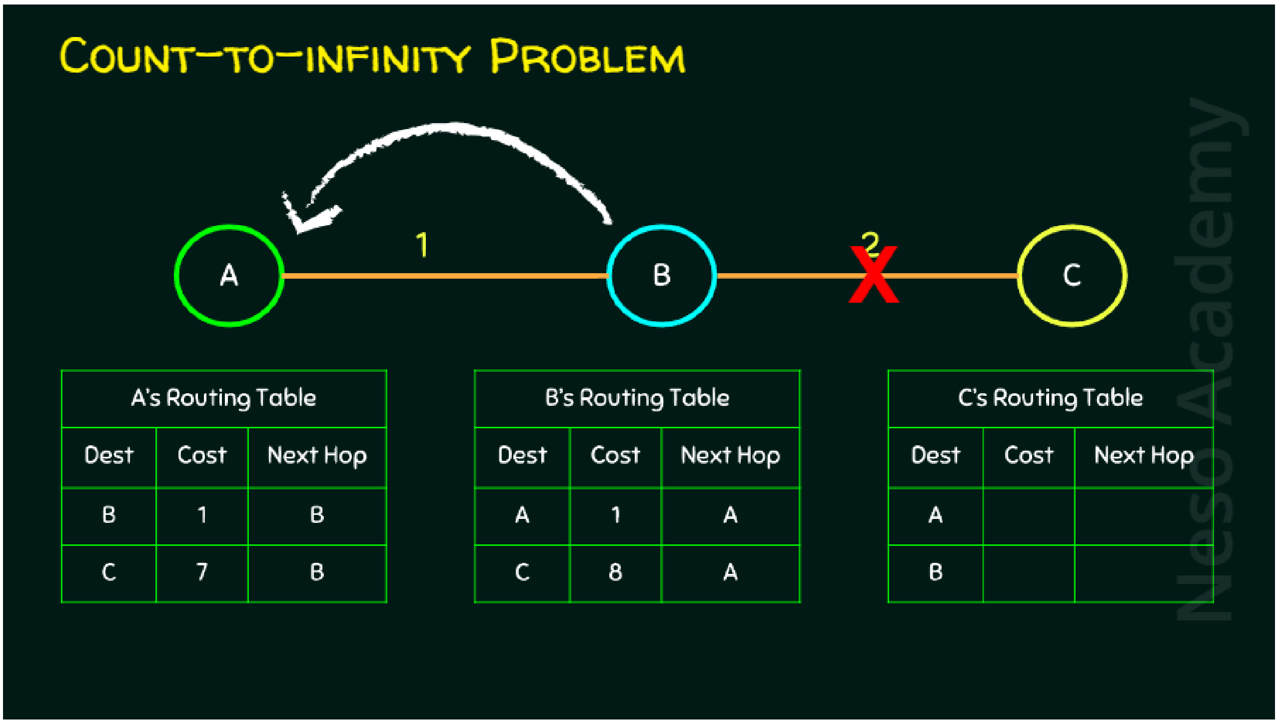
Count-to-infinity ProblemXNeso Academy



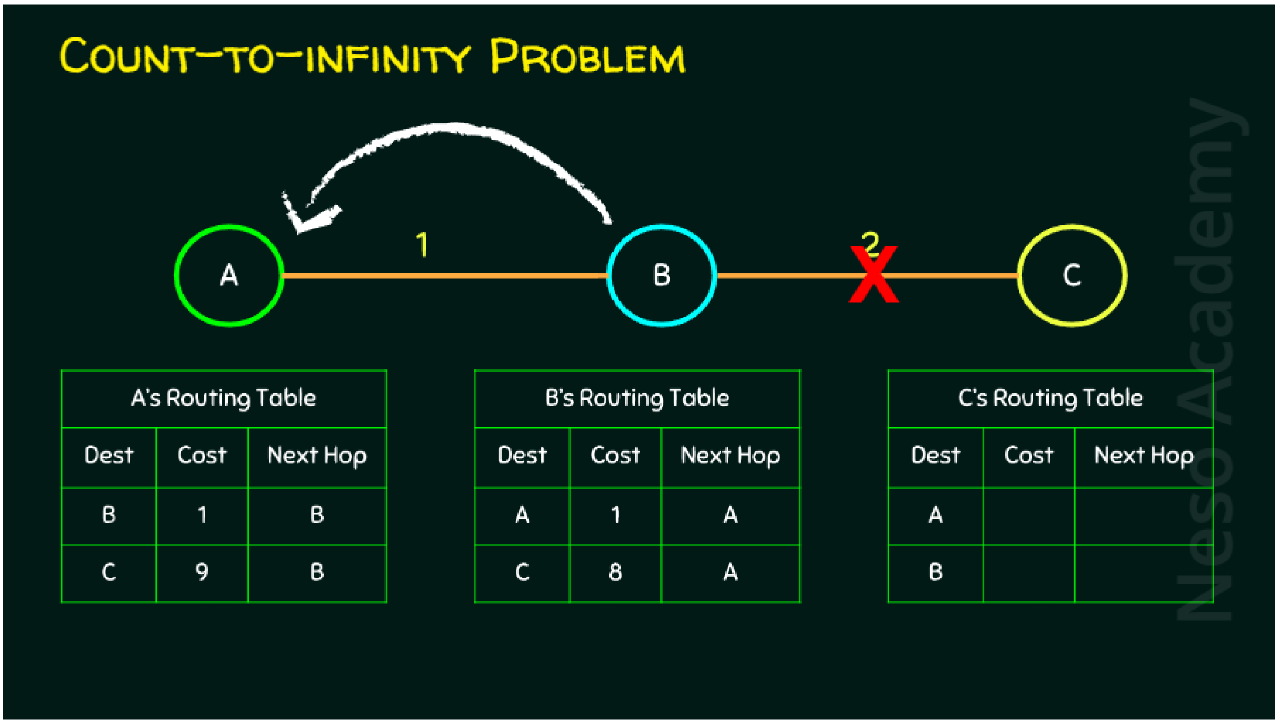
Count-to-infinity ProblemXNeso Academy



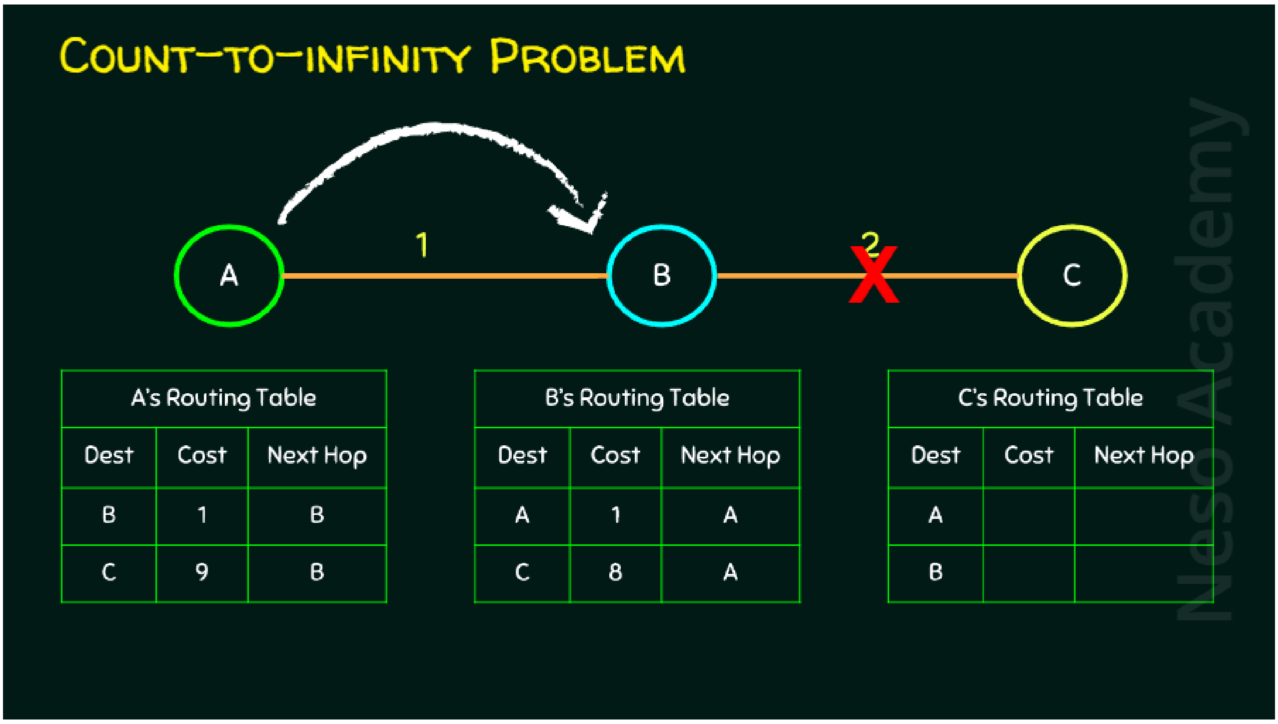
Count-to-infinity ProblemXNeso Academy



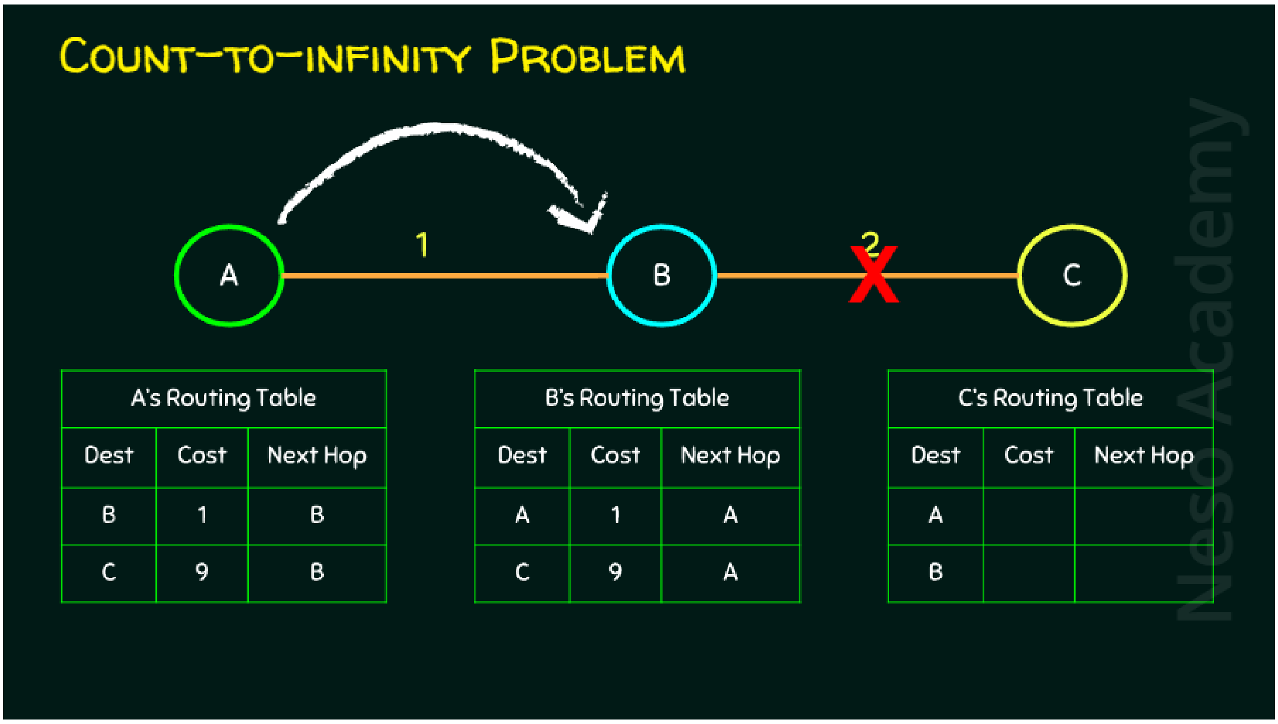
Count-to-infinity ProblemXNeso Academy



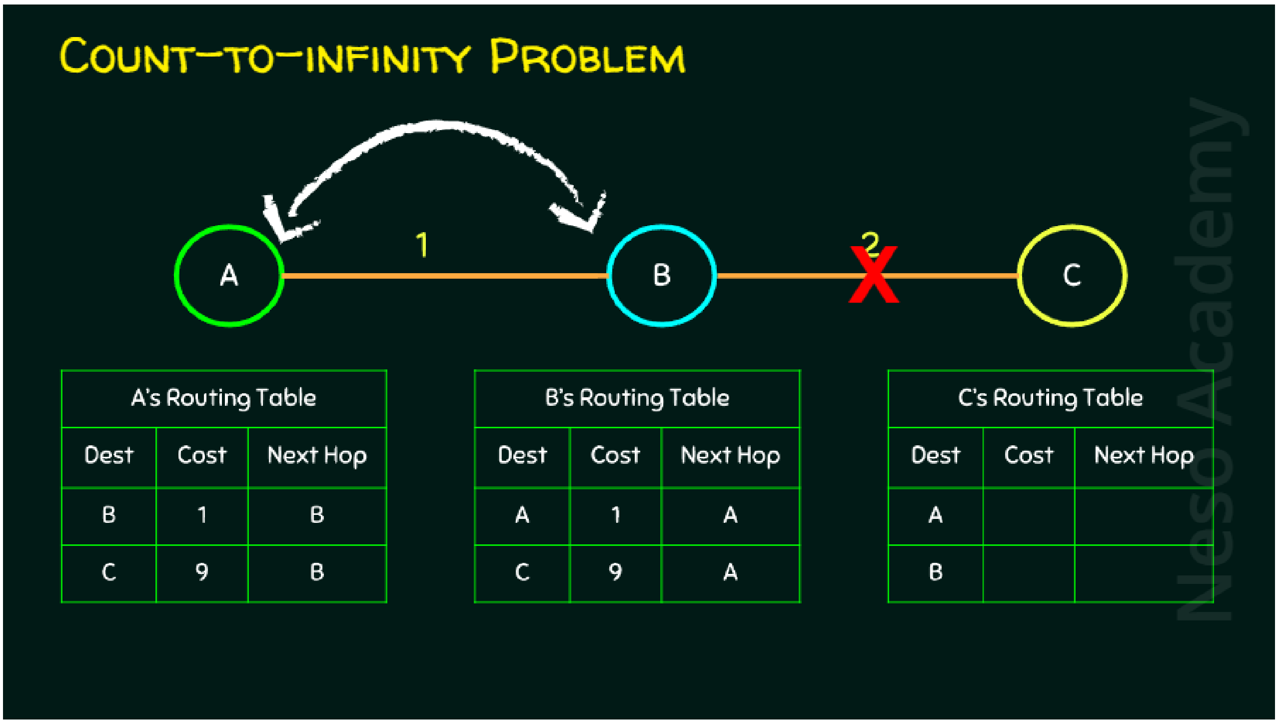
Count-to-infinity ProblemXNeso Academy



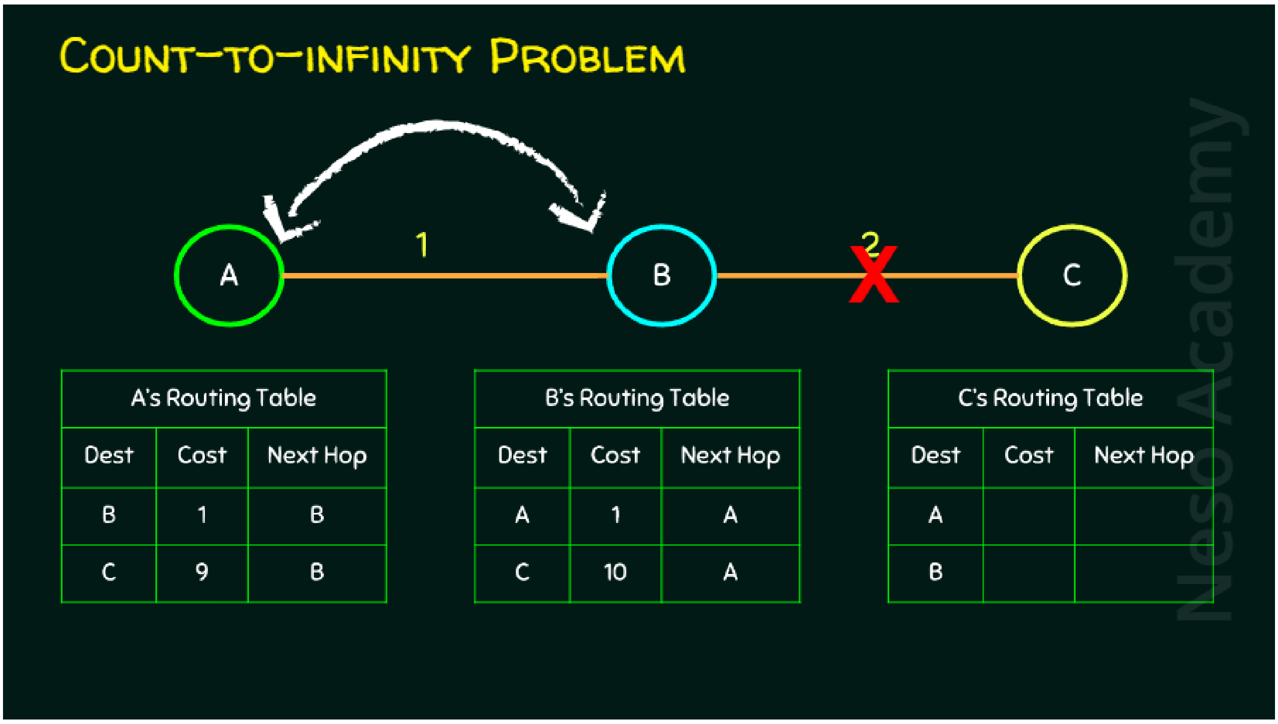
Count-to-infinity ProblemXNeso Academy



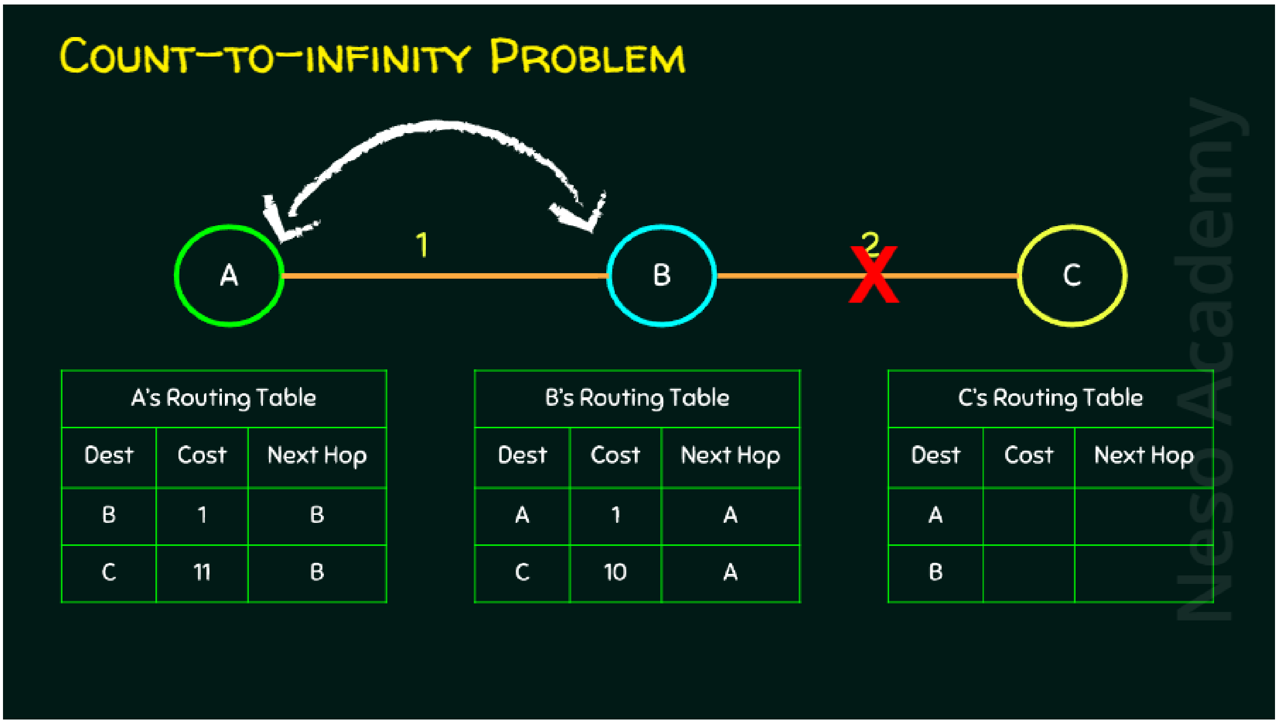
Count-to-infinity ProblemXNeso Academy



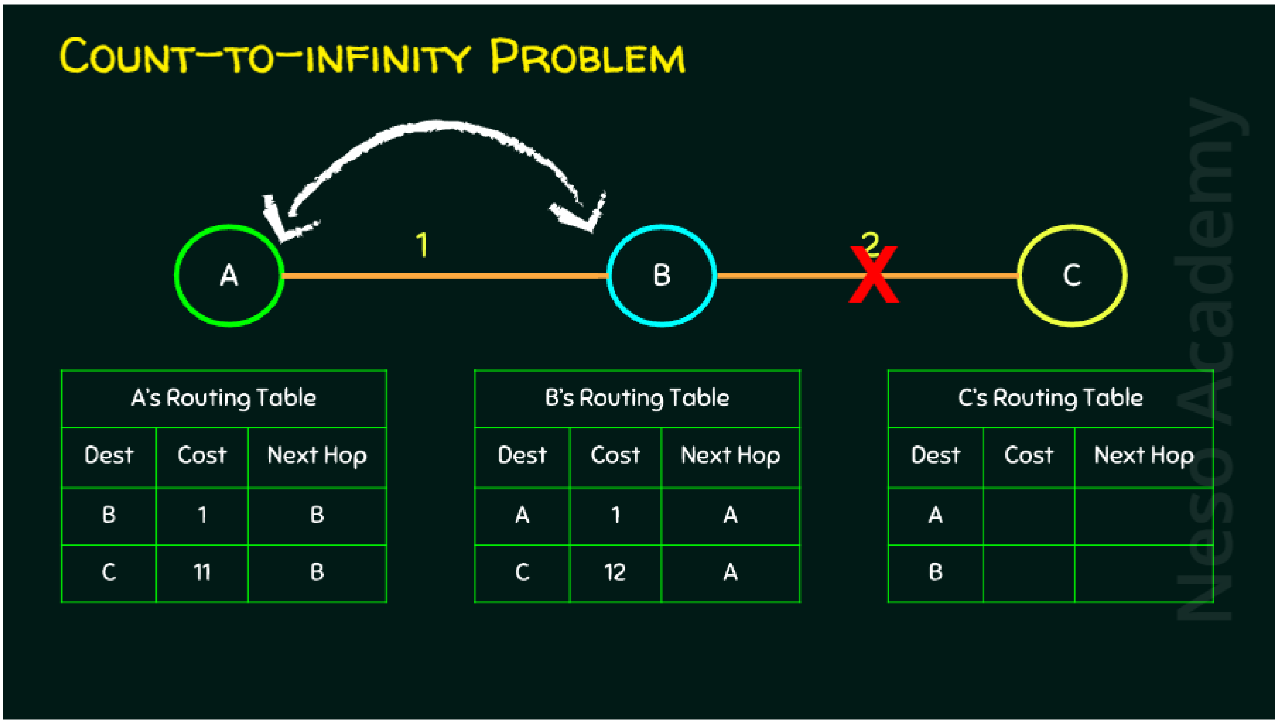
Count-to-infinity ProblemXNeso Academy



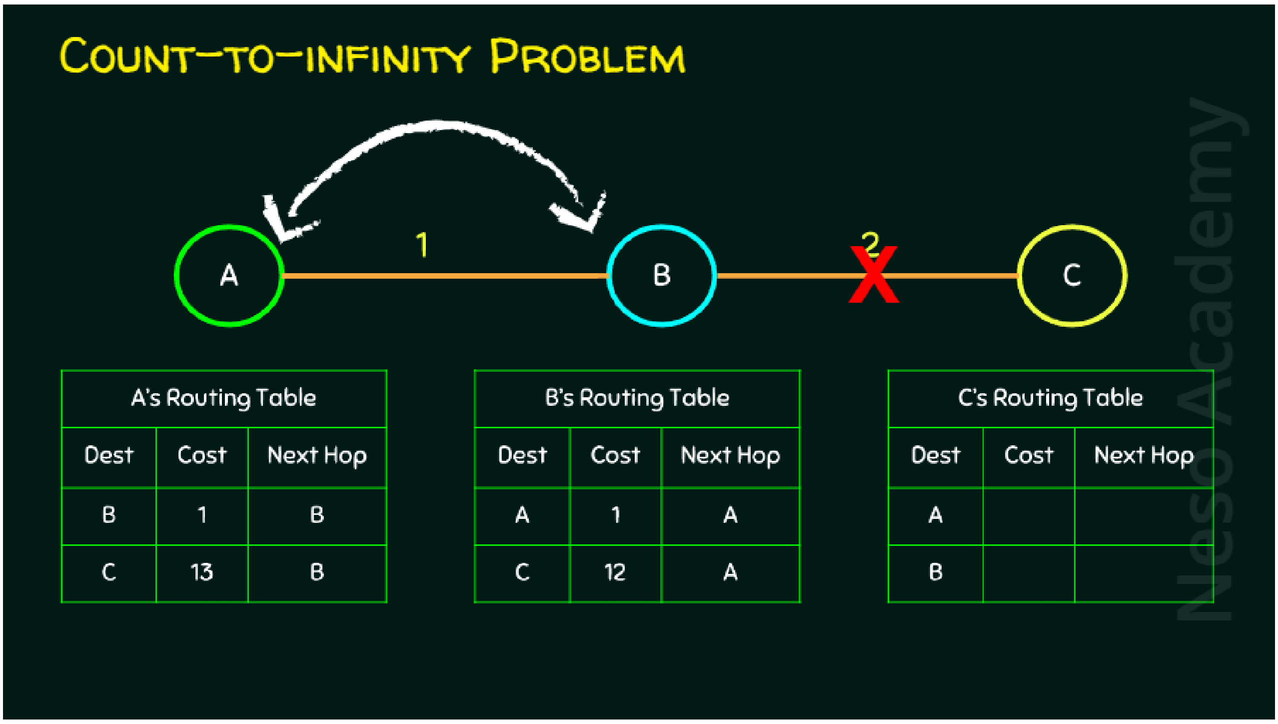
Count-to-infinity ProblemXNeso Academy



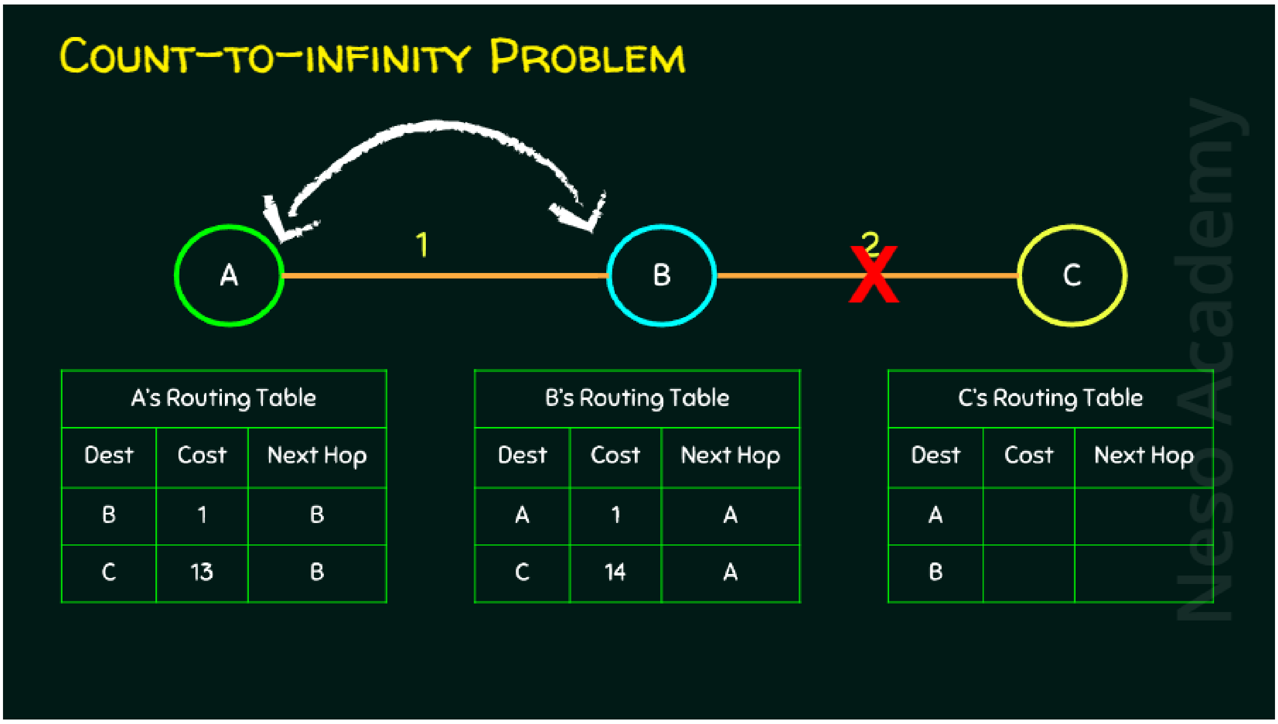
Count-to-infinity ProblemXNeso Academy



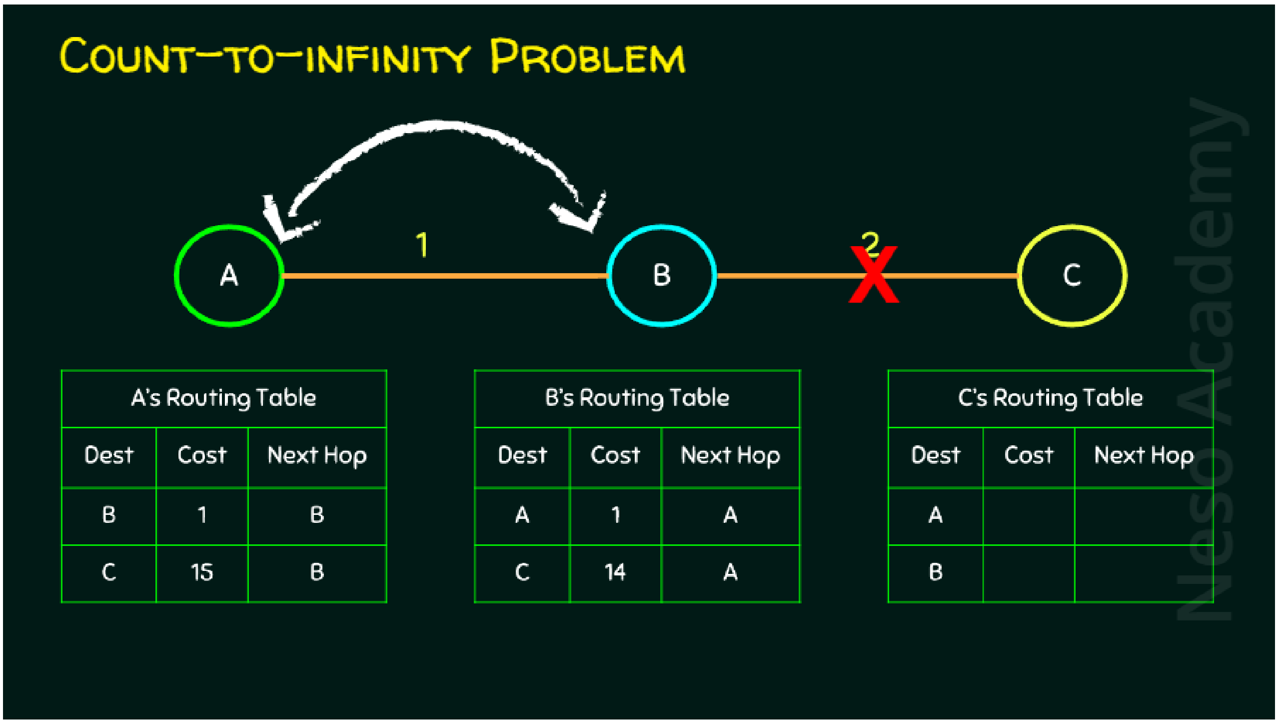
Count-to-infinity ProblemXNeso Academy



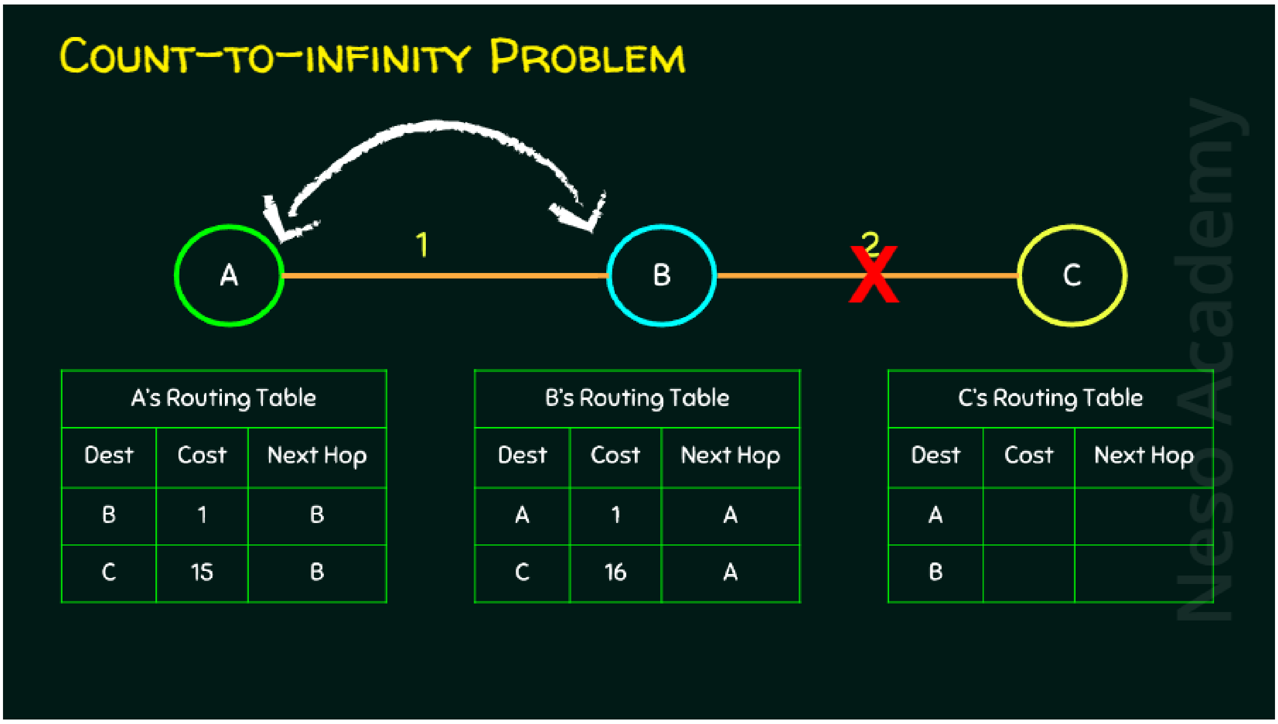
Count-to-infinity ProblemXNeso Academy



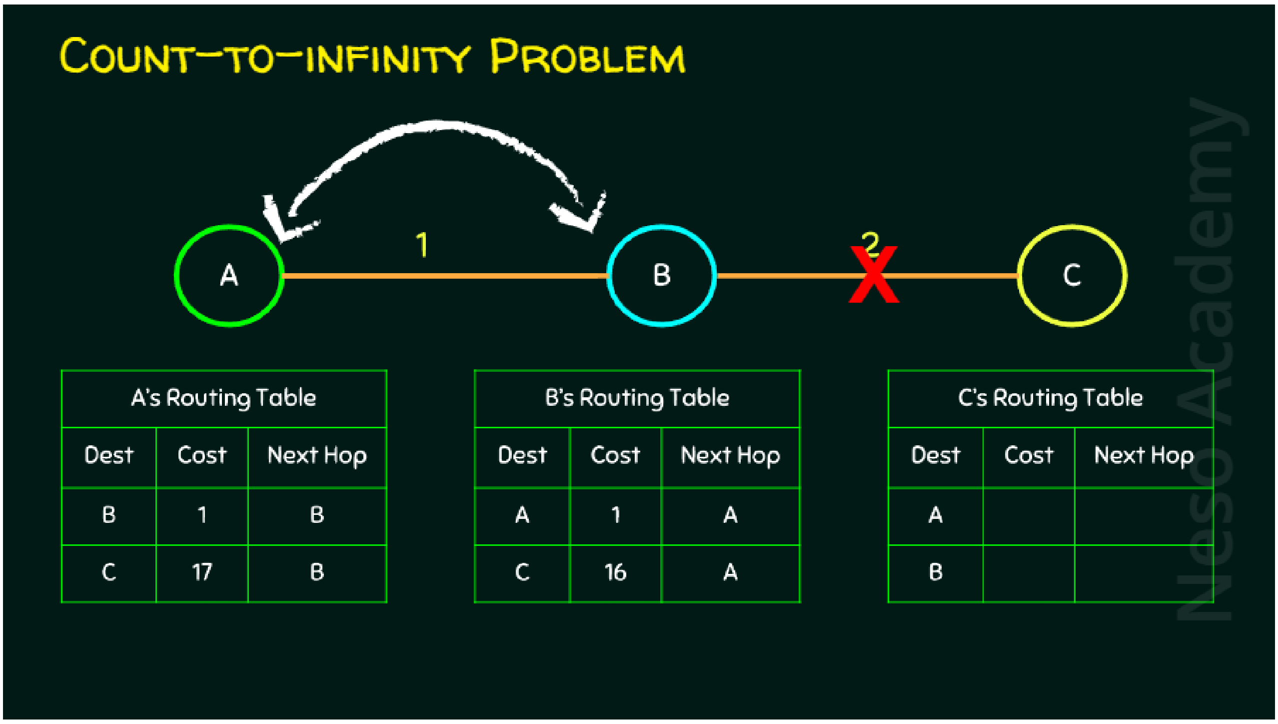
Count-to-infinity ProblemXNeso Academy



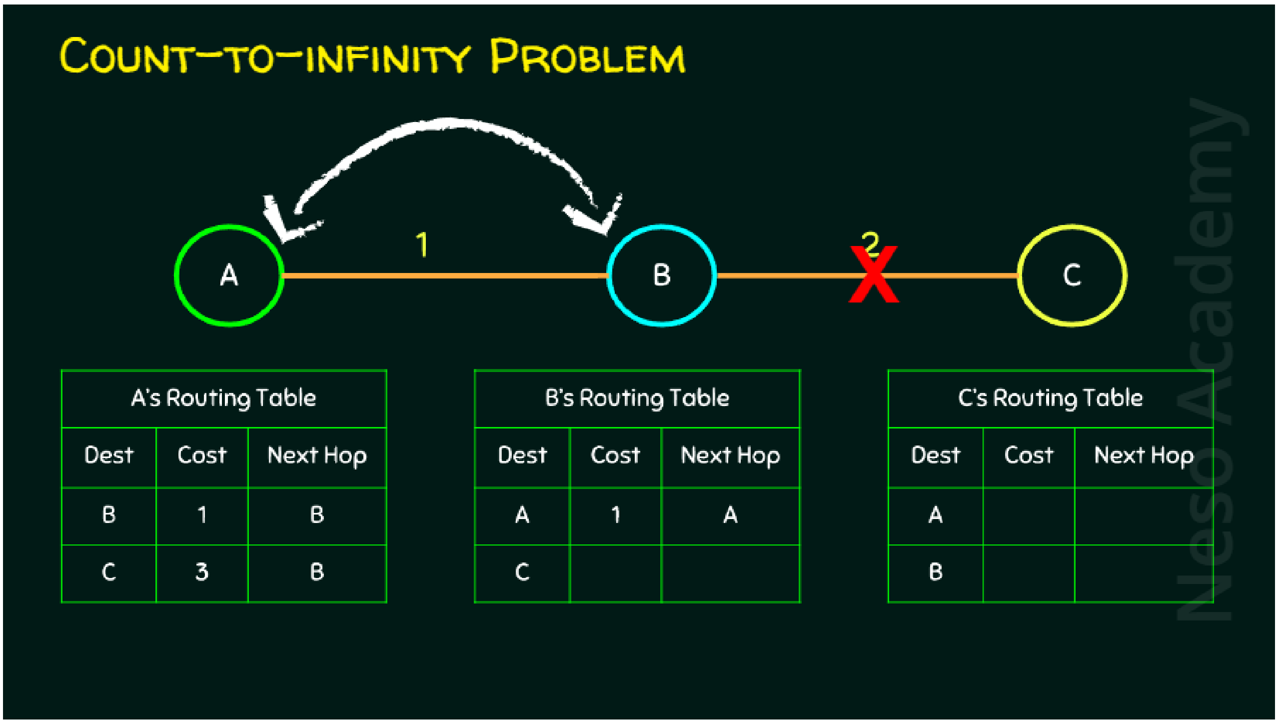
Count-to-infinity ProblemXNeso Academy



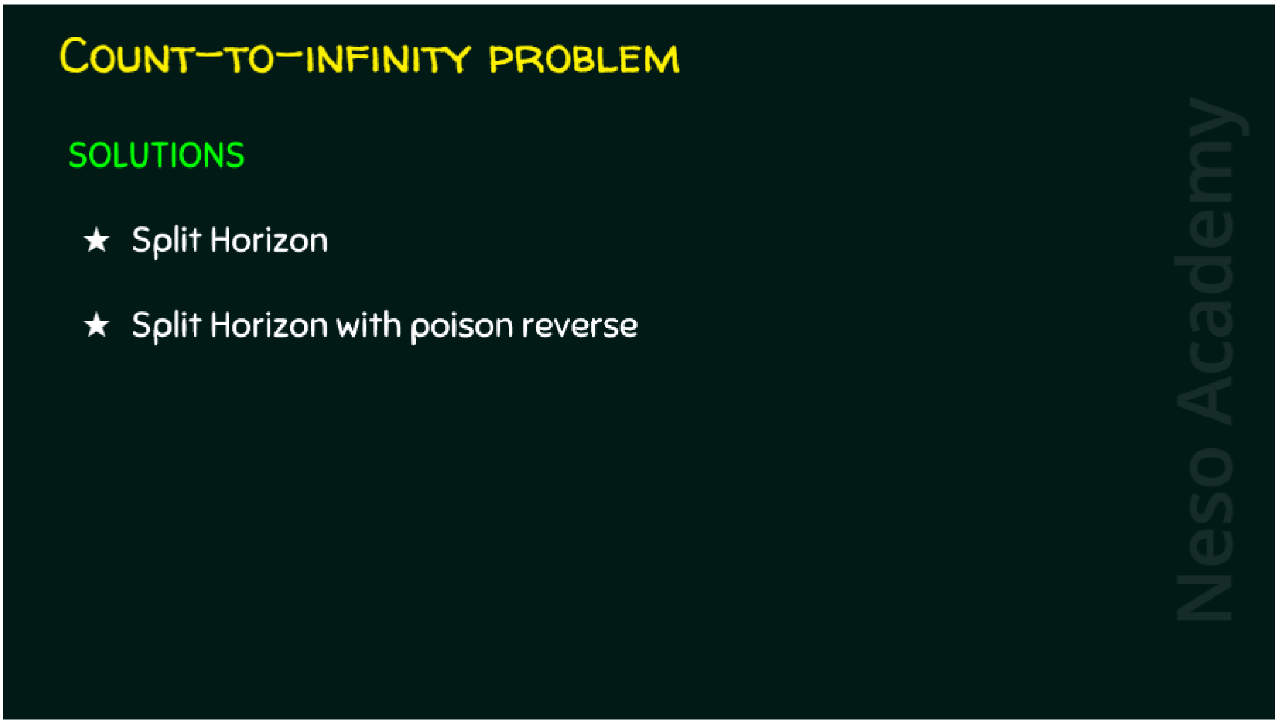
Count-to-infinity ProblemXNeso Academy



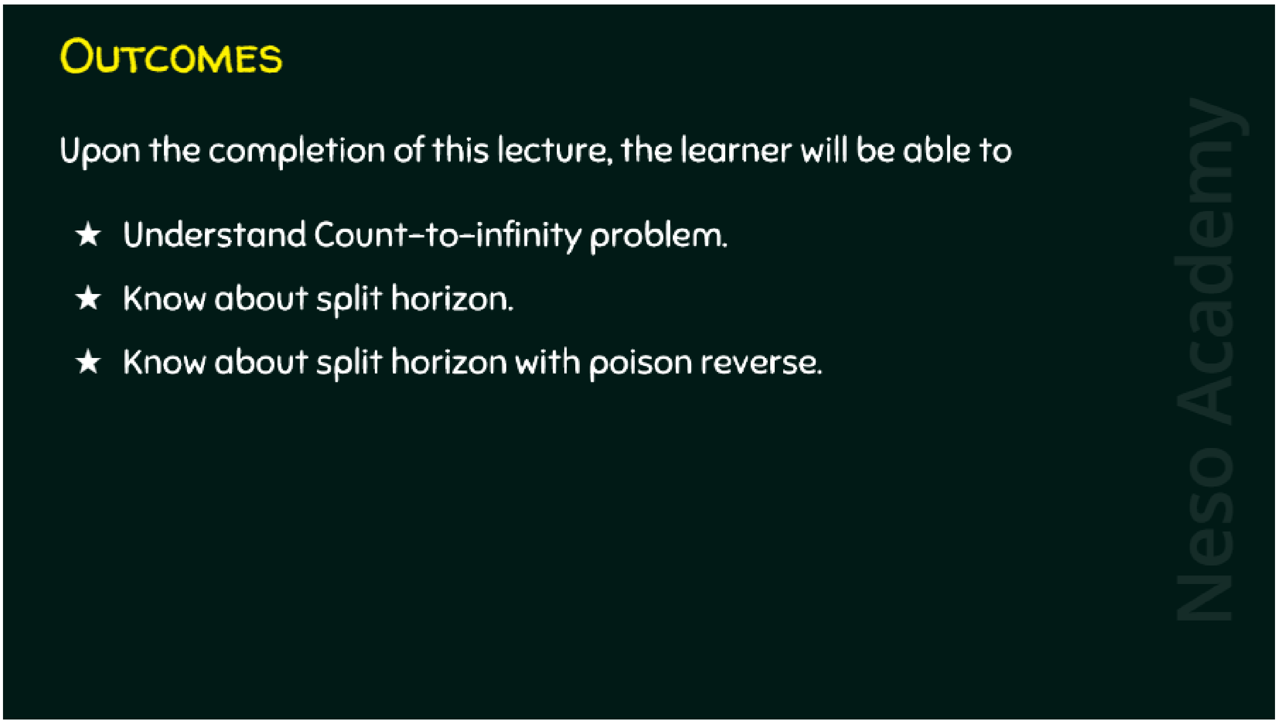
Count-to-infinity ProblemXNeso Academy



Count-to-infinity ProblemXNeso Academy

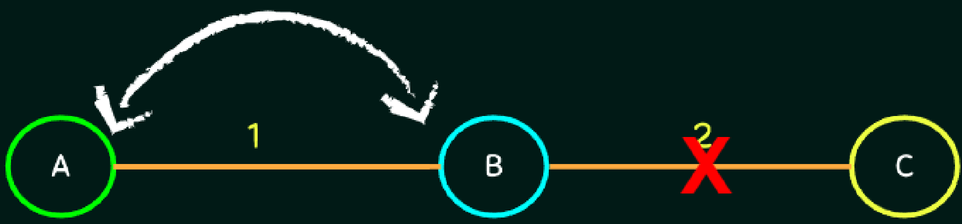


Count-to-infinity problem★★Neso Academy



Outcomes★★★Neso Academy

Count-to-infinity Problem



A's Routing Table		
Dest	Cost	Next Hop
B	1	B
C	17	B

B's Routing Table		
Dest	Cost	Next Hop
A	1	A
C	16	A

C's Routing Table		
Dest	Cost	Next Hop
A		
B		

Count-to-infinity ProblemXNeso Academy

Count-to-infinity Problem

SOLUTIONS

- ★ Split Horizon
- ★ Split Horizon with poison reverse

Count-to-infinity Problem★★Neso Academy

Split horizon

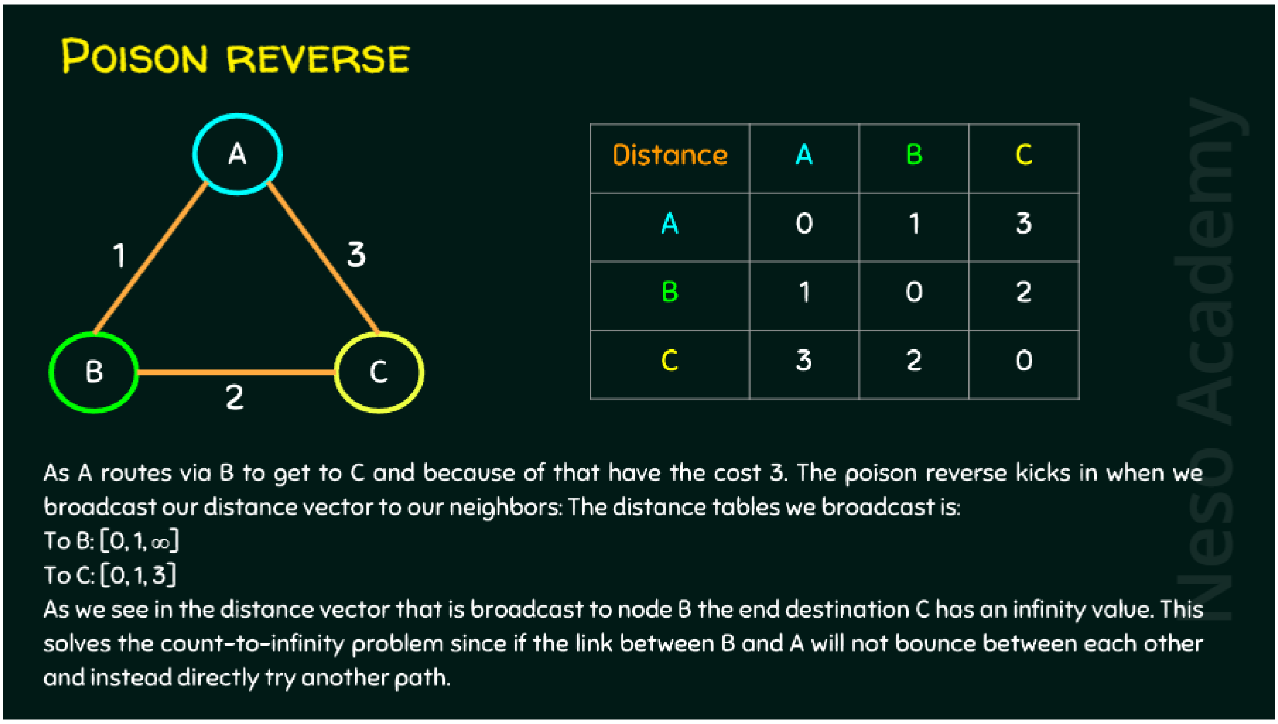
- ★ In computer networking, split-horizon route advertisement is a method of preventing routing loops in distance-vector routing protocols by prohibiting a router from advertising a route back onto the interface from which it was learned.
- ★ In other words, it is a method of preventing a routing loop in a network.
- ★ The basic principle is simple: Information about the routing for a particular packet is never sent back in the direction from which it was received.
- ★ With the split-horizon rule in place, this particular loop scenario cannot happen, improving convergence time in complex, highly-redundant environments.

Split horizon★★★★Neso Academy

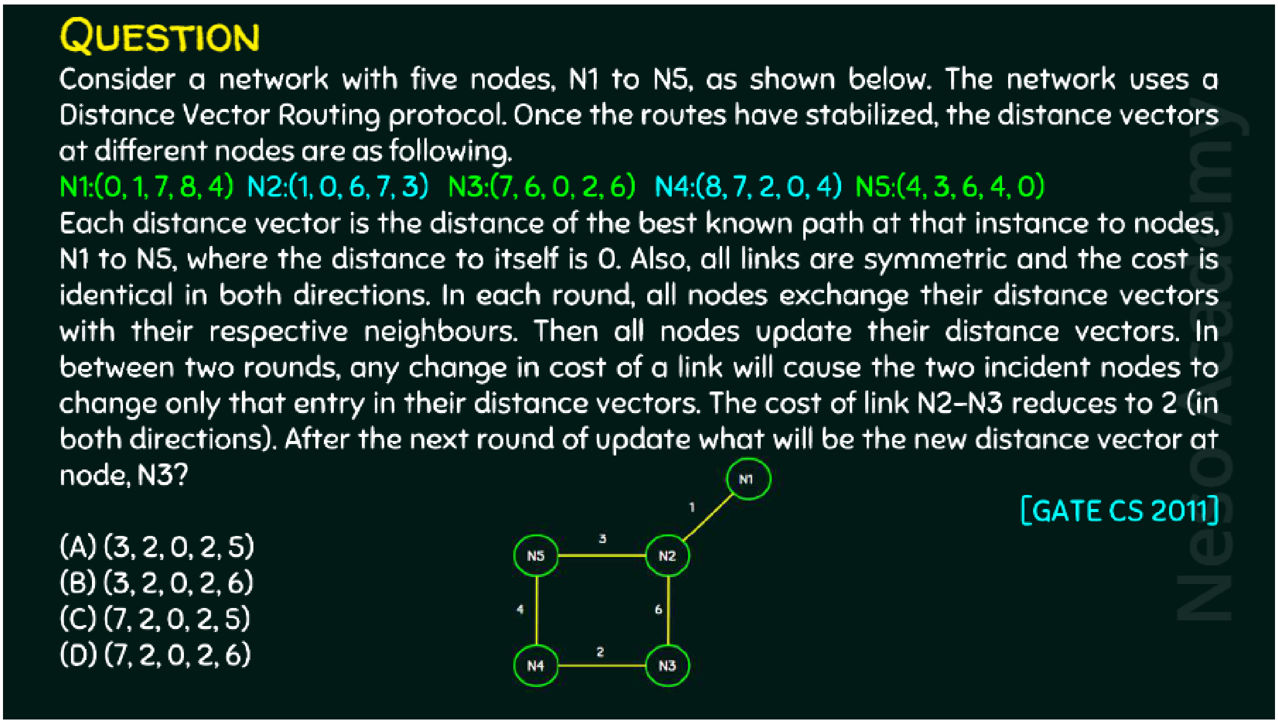
Poison reverse

- ★ Poison Reverse is an implemented algorithm that is often used within distance-vector routing.
- ★ The use of poison reverse is to solve the count-to-infinity problem.
- ★ Practically, poison reverse can be thought of as the reverse of split horizon.
- ★ With poison reverse, route advertisements that would be suppressed by split horizon are instead advertised with a distance of infinity.

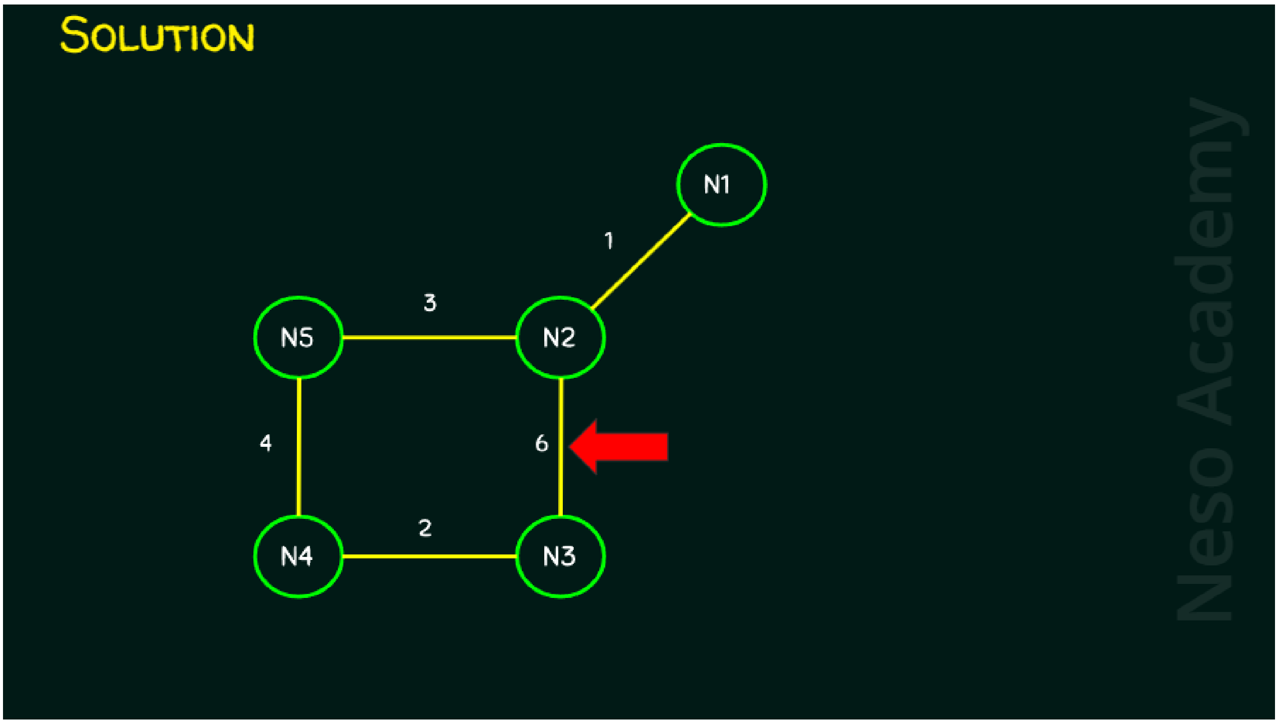
Poison reverse★★★★Neso Academy



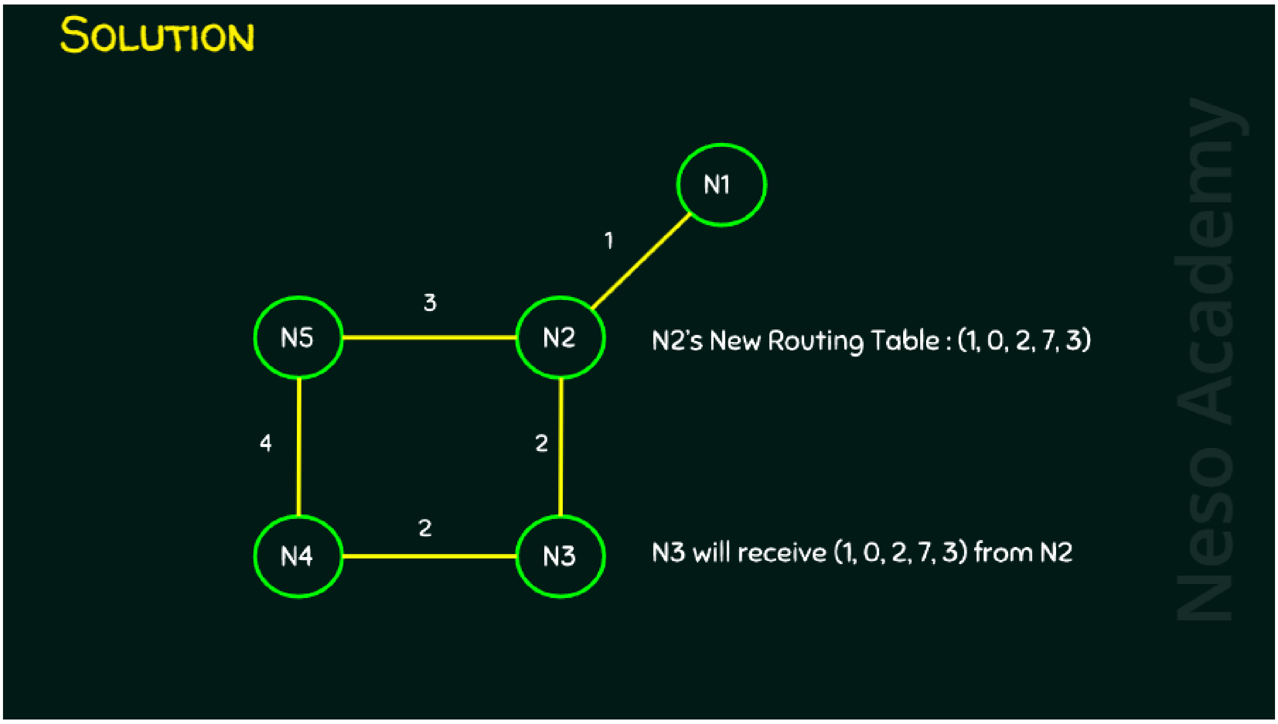
Poison reverse∞Neso Academy



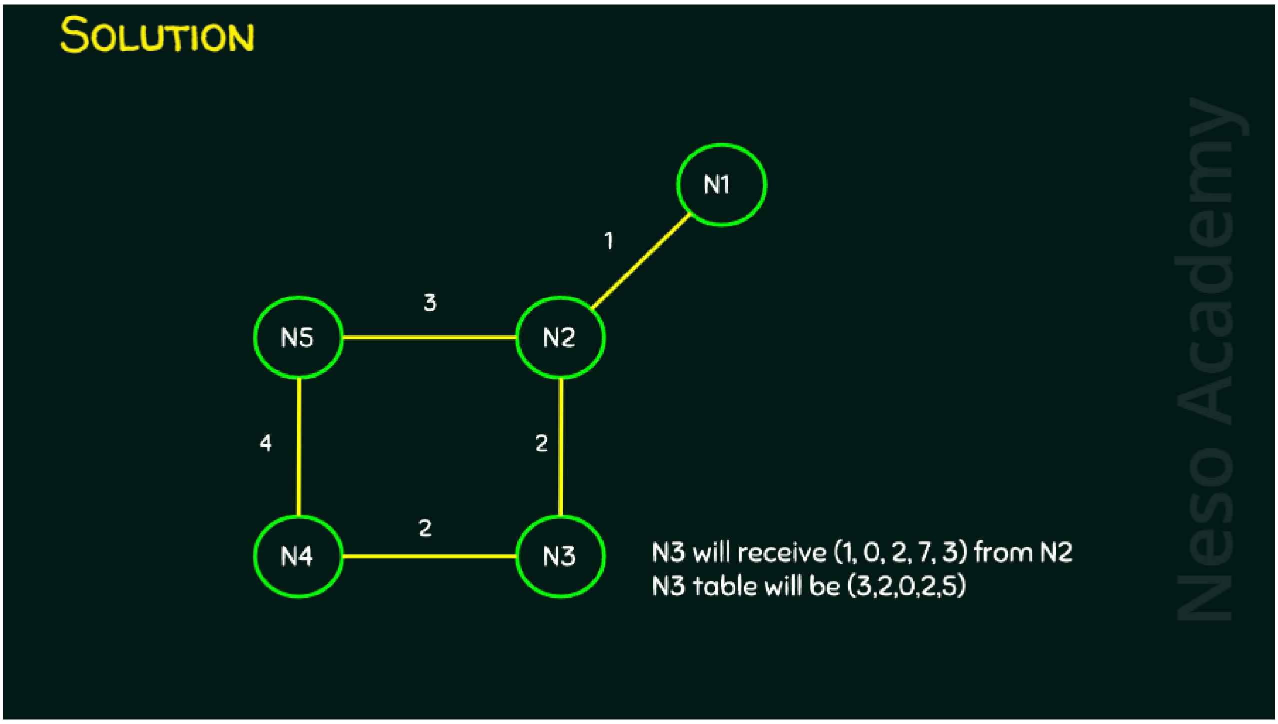
QuestionNeso Academy



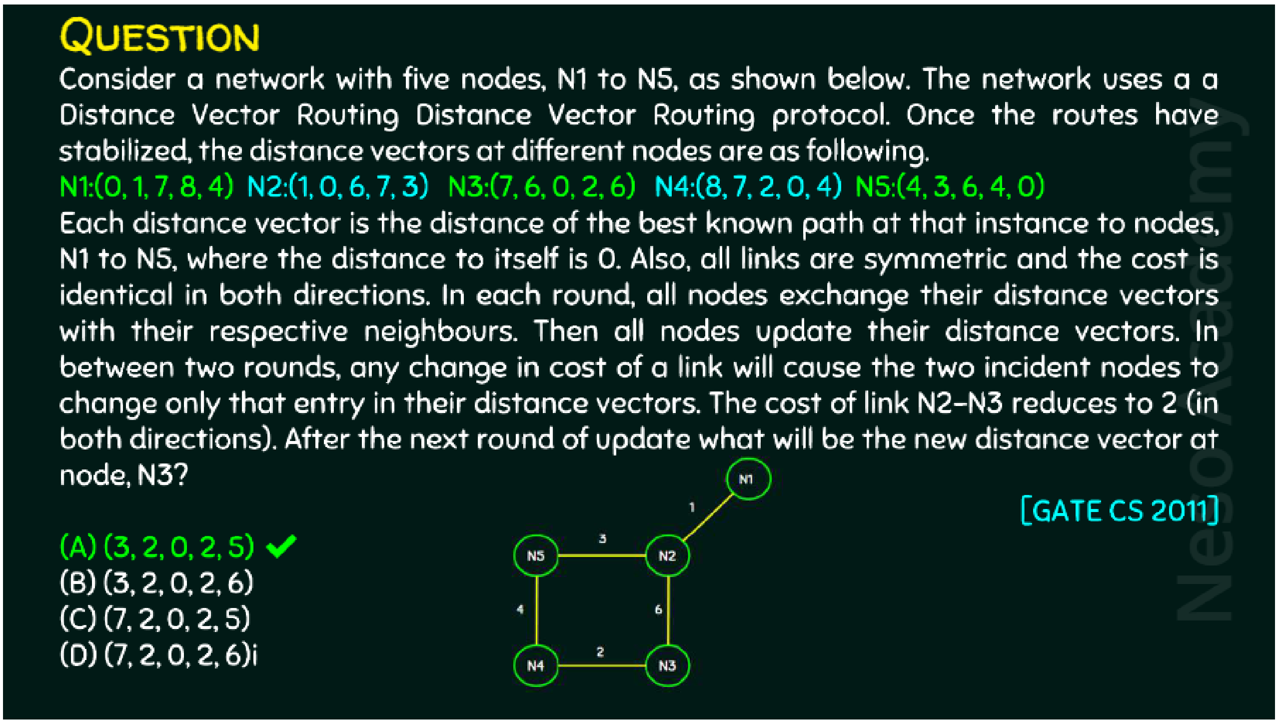
SolutionNeso Academy



SolutionNeso Academy



SolutionNeso Academy



Question✓Neso Academy

QUESTION

After the update in the previous question, the link N1–N2 goes down. N2 will reflect this change immediately in its distance vector as cost, ∞. After the NEXT ROUND of update, what will be cost to N1 in the distance vector of N3?

[GATE CS 2011]

(A) 3
(B) 9
(C) 10
(D) ∞

Question∞∞Neso Academy

QUESTION

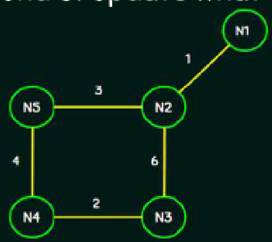
Consider a network with five nodes, N1 to N5, as shown below. The network uses a Distance Vector Routing protocol. Once the routes have stabilized, the distance vectors at different nodes are as following.

N1:(0, 1, 7, 8, 4) N2:(1, 0, 6, 7, 3) N3:(7, 6, 0, 2, 6) N4:(8, 7, 2, 0, 4) N5:(4, 3, 6, 4, 0)

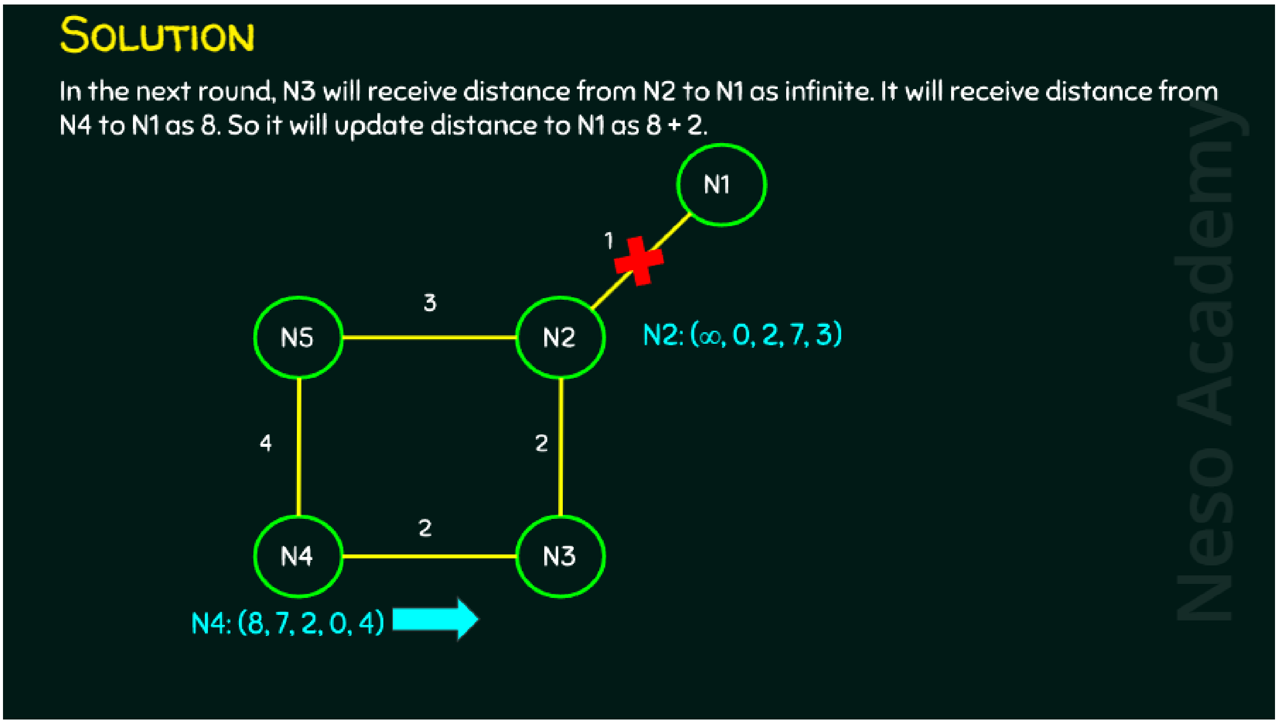
Each distance vector is the distance of the best known path at that instance to nodes, N1 to N5, where the distance to itself is 0. Also, all links are symmetric and the cost is identical in both directions. In each round, all nodes exchange their distance vectors with their respective neighbours. Then all nodes update their distance vectors. In between two rounds, any change in cost of a link will cause the two incident nodes to change only that entry in their distance vectors. The cost of link N2–N3 reduces to 2 (in both directions). After the next round of update what will be the new distance vector at node, N3?

[GATE CS 2011]

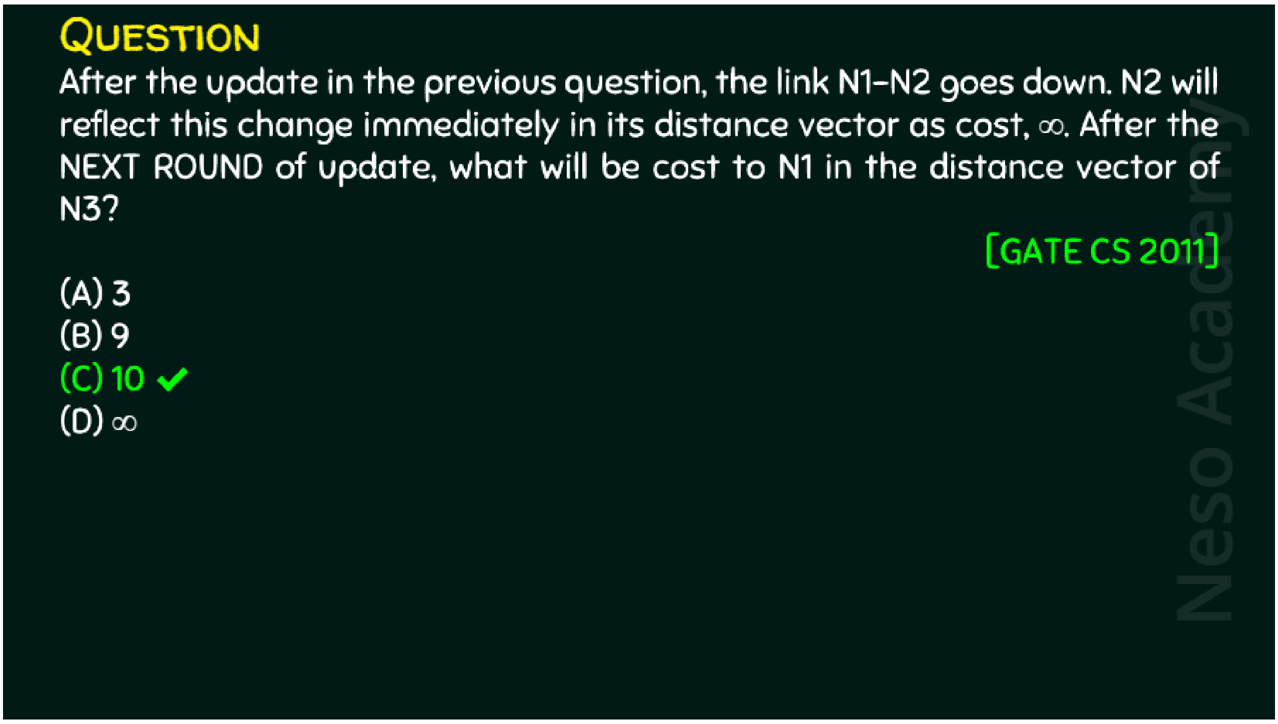
(A) (3, 2, 0, 2, 5)
(B) (3, 2, 0, 2, 6)
(C) (7, 2, 0, 2, 5)
(D) (7, 2, 0, 2, 6)



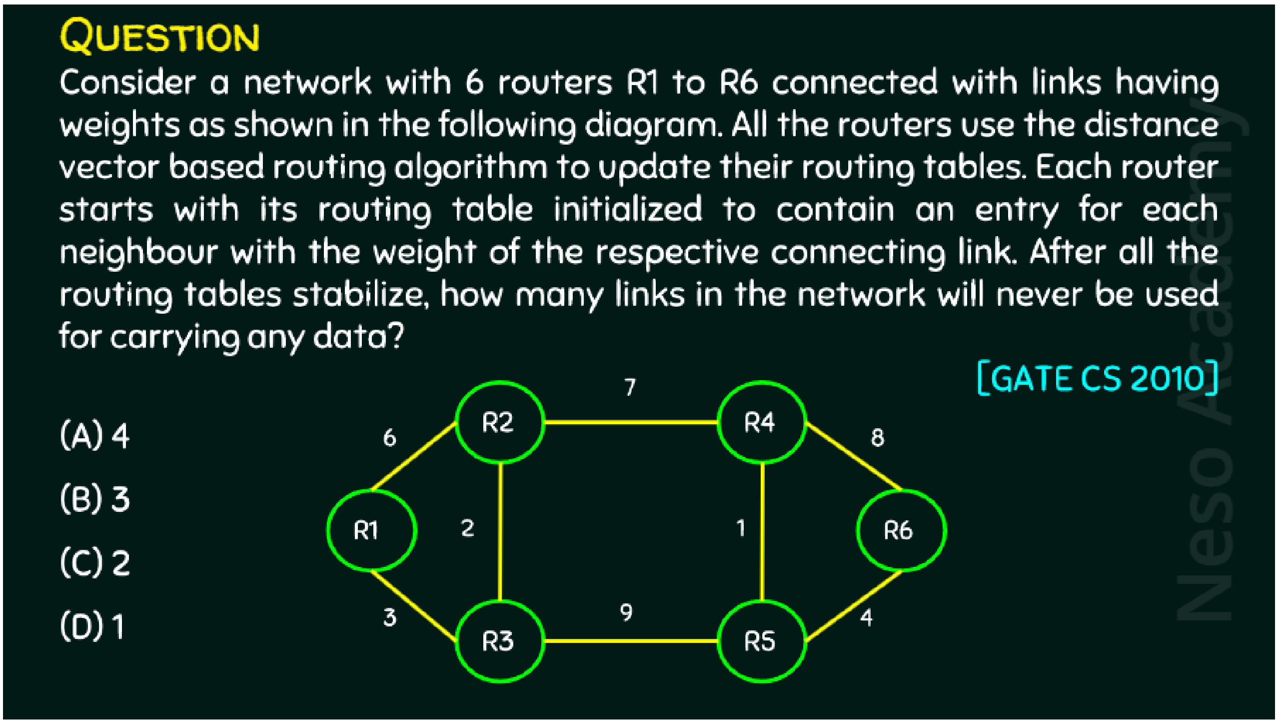
QuestionNeso Academy



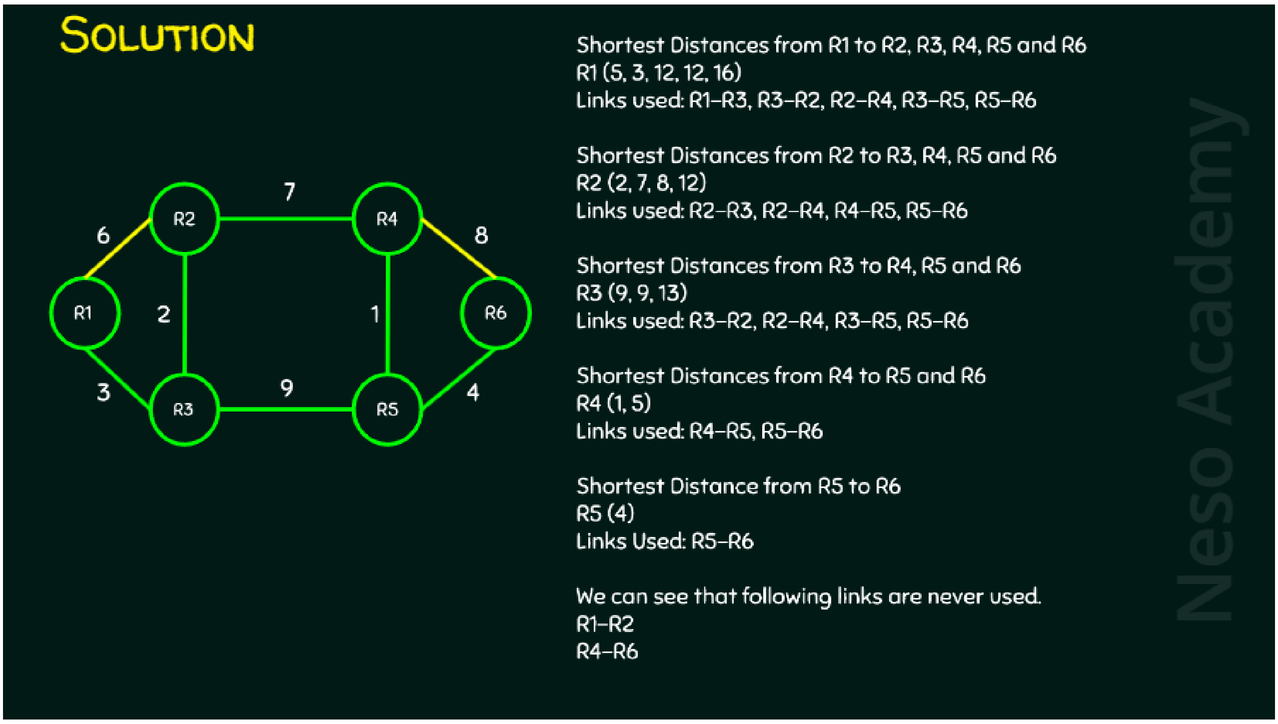
Solution∞Neso Academy



Question∞✓∞Neso Academy



QuestionNeso Academy



SolutionNeso Academy

QUESTION

Consider a network with 6 routers R1 to R6 connected with links having weights as shown in the following diagram. All the routers use the distance vector based routing algorithm to update their routing tables. Each router starts with its routing table initialized to contain an entry for each neighbour with the weight of the respective connecting link. After all the routers stabilize, how many links in the network will never be used for carrying any data?

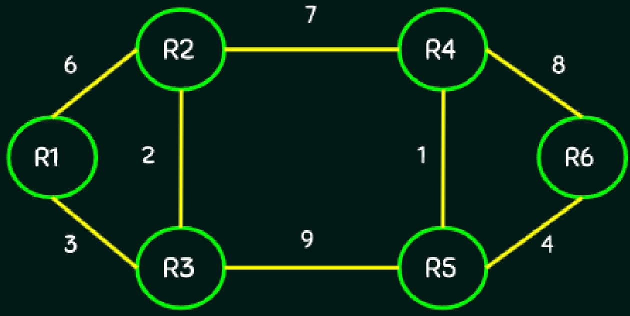
[GATE CS 2010]

(A) 4

(B) 3

(C) 2 ✓

(D) 1



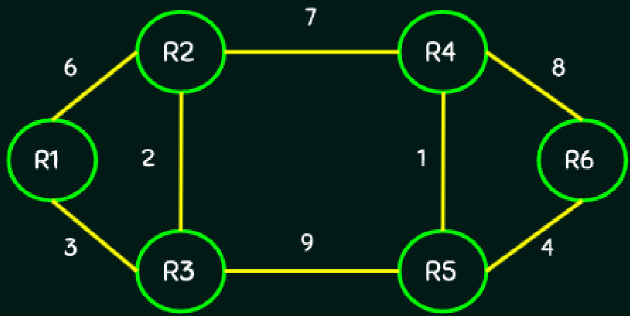
Question✓Neso Academy

QUESTION

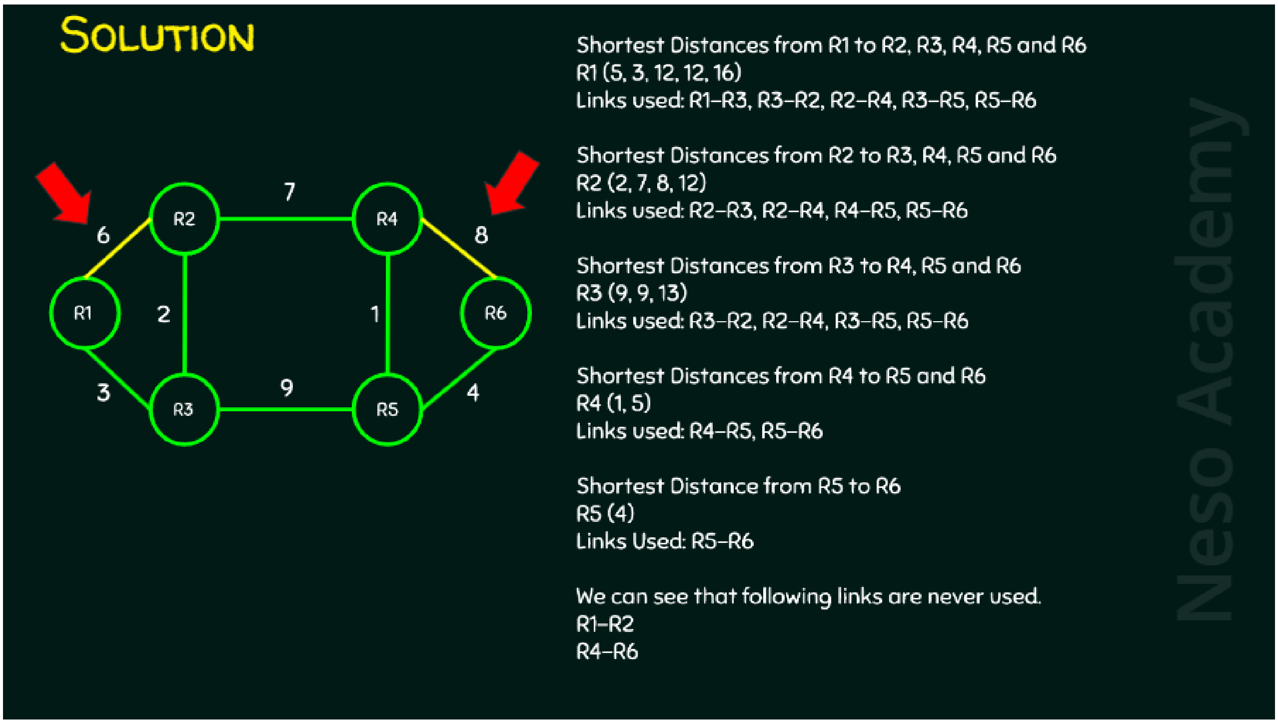
Consider a network with 6 routers R1 to R6 connected with links having weights as shown in the following diagram.
Suppose the weights of all unused links in the previous question are changed to 2 and the distance vector algorithm is used again until all routing tables stabilize. How many links will now remain unused?

[GATE CS 2010]

(A) 0
(B) 1
(C) 2
(D) 3



QuestionNeso Academy



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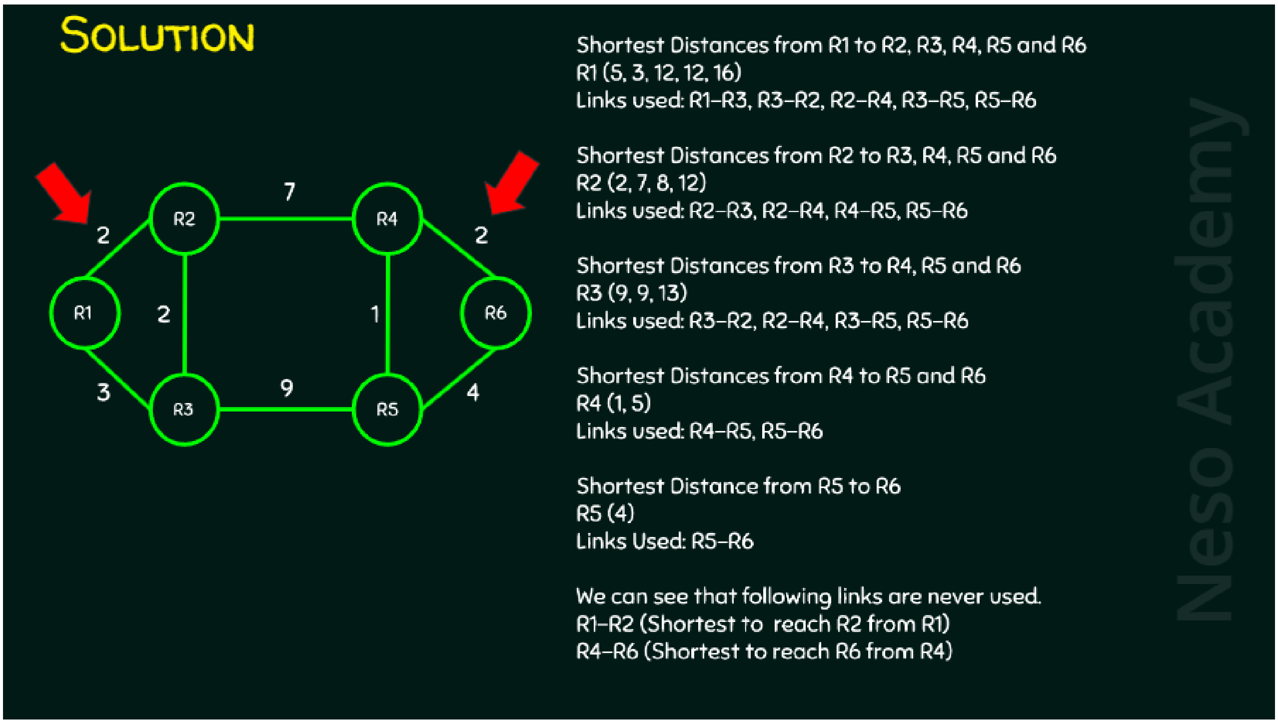


SolutionNeso Academy

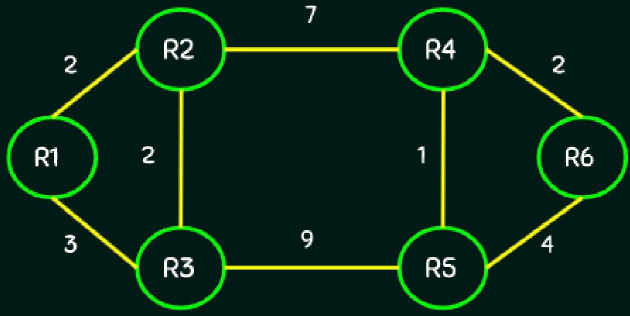
Question

Consider a network with 6 routers R1 to R6 connected with links having weights as shown in the following diagram.

Suppose the weights of all unused links in the previous question are changed to 2 and the distance vector algorithm is used again until all routing tables stabilize. How many links will now remain unused?

[GATE CS 2010]

(A) 0 ✔
(B) 1
(C) 2
(D) 3



Question✓Neso Academy

Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand the various RIP versions.

★ Compare RIPv1, RIPv2 and RIPng.

Outcomes★★Neso Academy

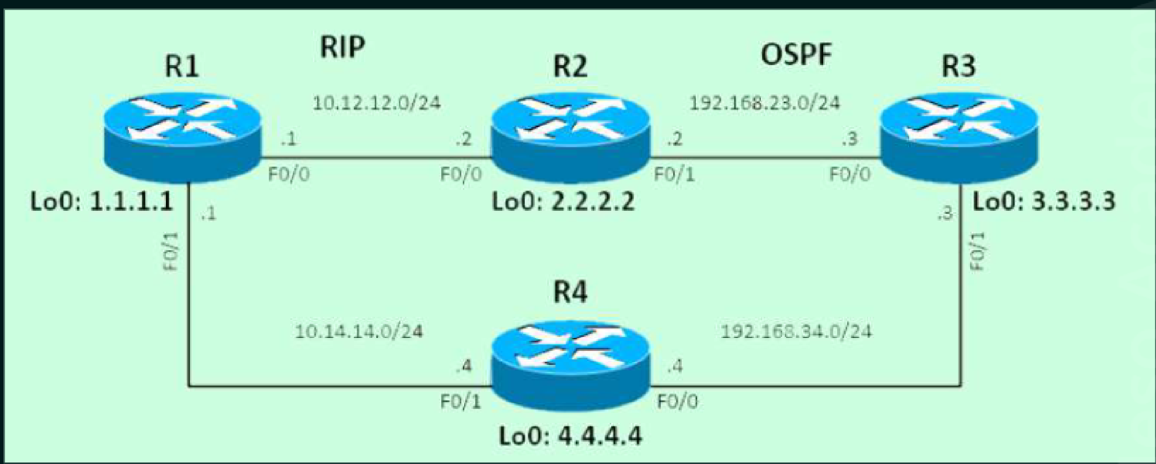
RIP Messages

RIP defined two types of messages:

- ★ Request Message: Asking a neighbouring RIPv1 enabled router to send its routing table.
- ★ Response Message: Carries the routing table of a router.

RIP Messages★★Neso Academy

RIP Messages



RIP MessagesNeso Academy

RIP Versions

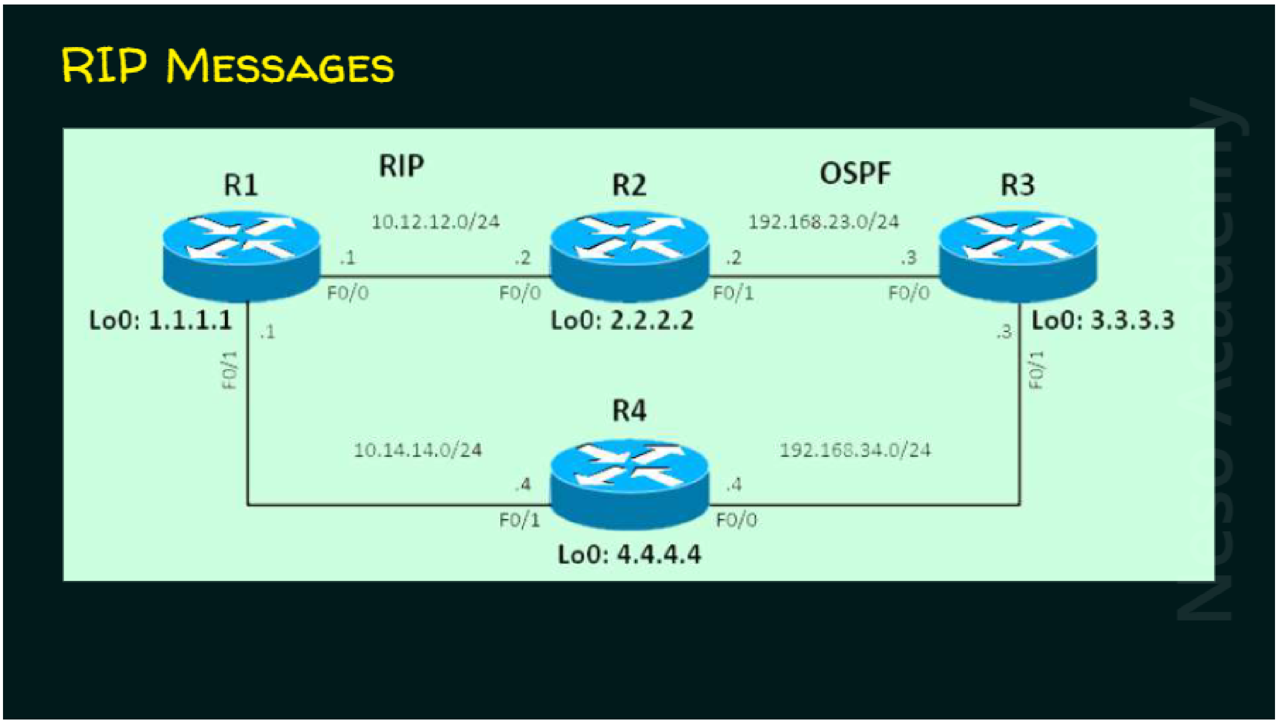
- ★ RIPv1
- ★ RIPv2
- ★ RIPng

RIP Versions★★★Neso Academy

RIPv1

- ★ When starting up, and every 30 seconds thereafter, a router with RIPv1 implementation broadcasts to 255.255.255.255 a request message through every RIPv1 enabled interface.
- ★ RIPv1 enabled routers not only request the routing tables of other routers every 30 seconds, they also listen to incoming requests from neighbouring routers and send their own routing table in turn.
- ★ RIPv1 uses classful routing.
- ★ 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. There is also no support for router authentication, making RIP vulnerable to various attacks.

RIPv1★★★★★Neso Academy



RIP MessagesNeso Academy

RIPv2

★ It included the ability to carry subnet information, thus supporting Classless Inter-Domain Routing (CIDR).

★ To maintain backward compatibility, the hop count limit of 15 remained.

★ In an effort to avoid unnecessary load on hosts that do not participate in routing, RIPv2 multicasts the entire routing table to all adjacent routers at the address 224.0.0.9, as opposed to RIPv1 which uses broadcast.

★ Unicast addressing is still allowed for special applications.

★ In RIPv2, MD5 authentication was introduced.

★ Route tags were also added in RIPv2. This functionality allows a distinction between routes learned from the RIP protocol and routes learned from other protocols.

RIPv2★★★★★★Neso Academy

RIPng

- ★ NG = Next Generation.
- ★ It is an extension of RIPv2 for support of IPv6, the next generation Internet Protocol.
- ★ The main differences between RIPv2 and RIPng are:
  - ○ Support of IPv6 networking.
  - ○ While RIPv2 supports authentication, RIPng does not. IPv6 routers were, at the time, supposed to use IPsec for authentication.
  - ○ RIPv2 encodes the next-hop into each route entry, 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.

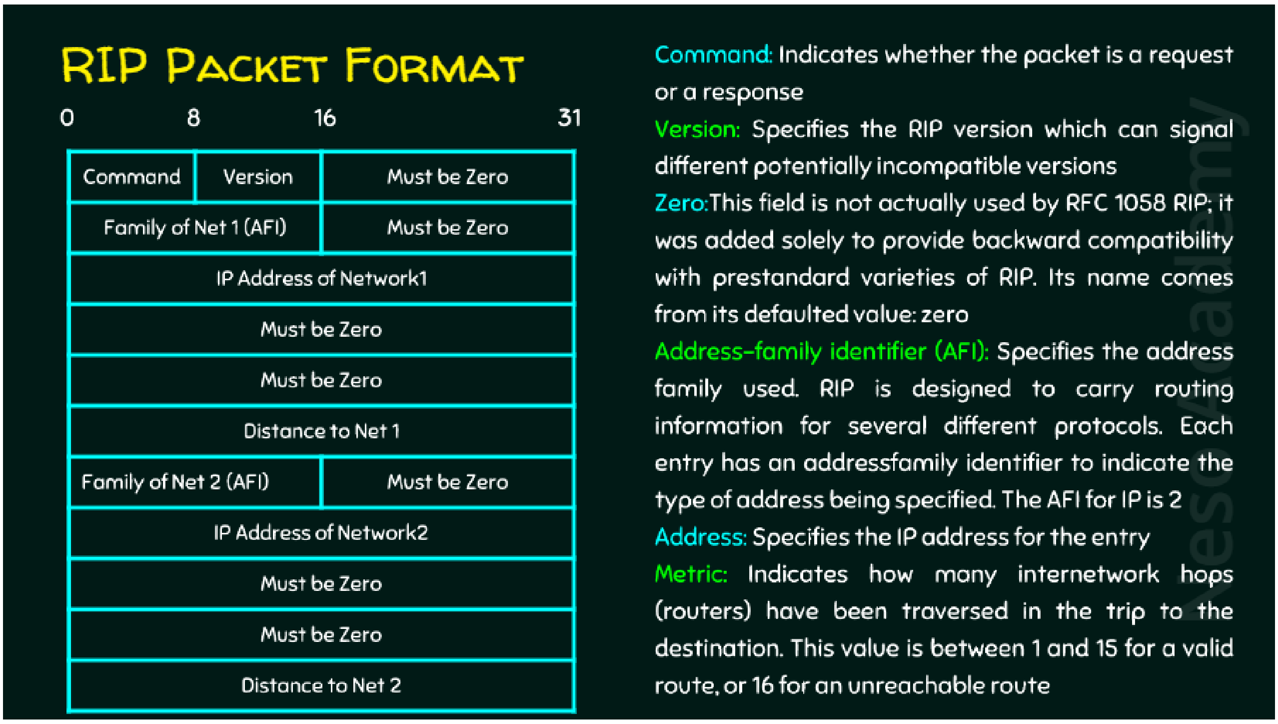
RIPng★★★○○○○Neso Academy

Outcomes

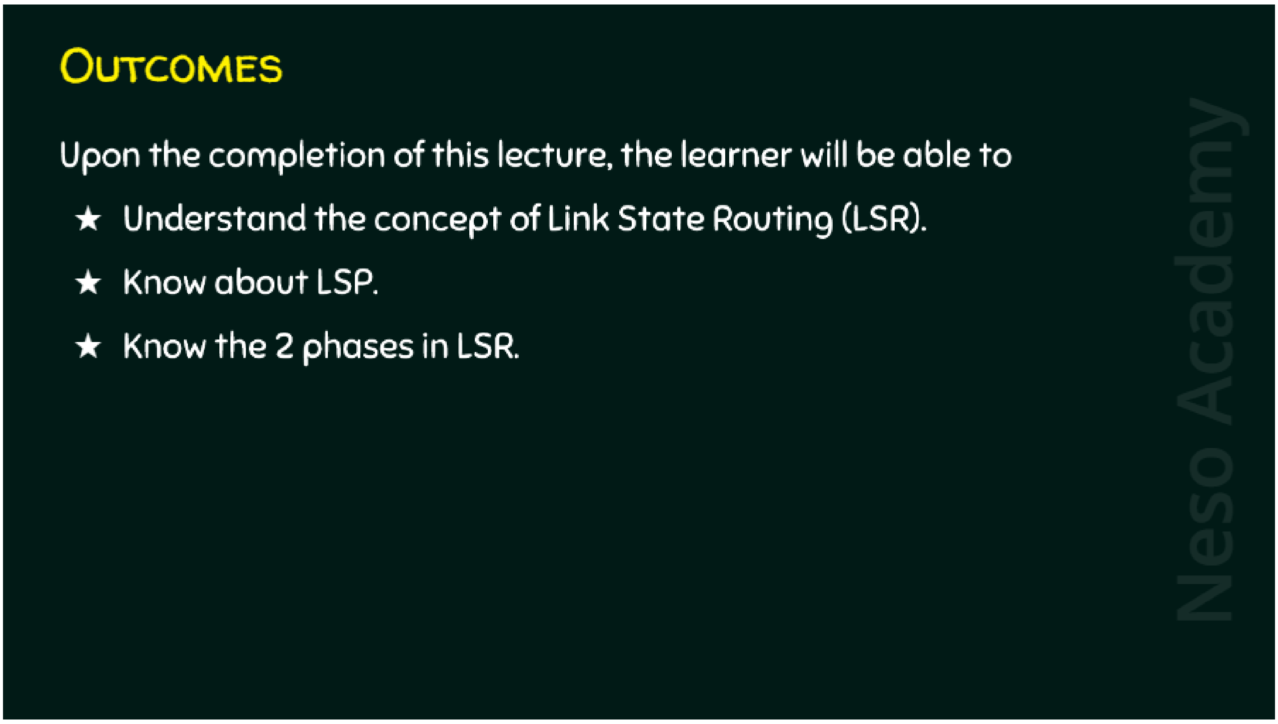
Upon the completion of this lecture, the learner will be able to

- ★ Understand the RIP packet format.
- ★ Know various fields in RIP packet format.

Outcomes★★Neso Academy



RIP Packet FormatNeso Academy



Outcomes★★★Neso Academy

Link State Routing

- ★ Link + State.
- ★ LSR has a different philosophy from that of DVR.
- ★ In LSR, each node has the entire topology.

Link State Routing★★★Neso Academy

Link State Routing

- ★ Link + State.
- ★ LSR has a different philosophy from that of DVR.
- ★ In LSR, each node has the entire topology.

Link State	Distance Vector
Complete Topology	Local Topology
Flooding	Exchange
Global	Decentralized
"Tell the world about neighbours"	"Tell the neighbours about the world"

Link State Routing★★★Neso Academy

Link State Routing

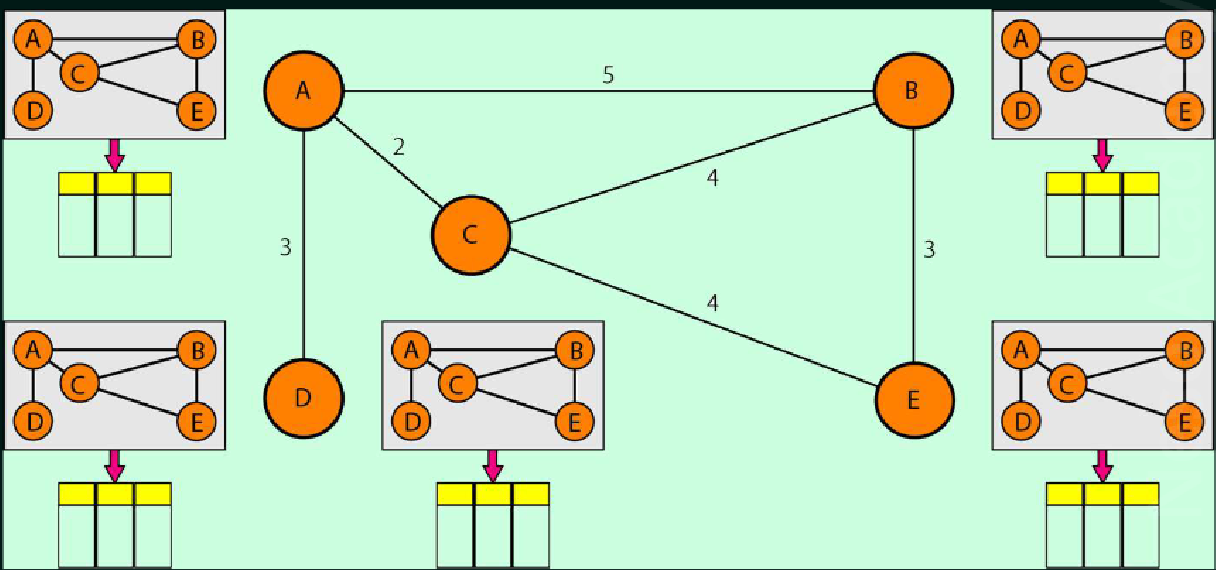
A link state packet can carry a large amount of information.

Link State Packet contains...

- ★ ID of the node that created the LSP
- ★ Cost of link to each directly connected neighbor
- ★ Sequence number (SEQNO)
- ★ Time-To-Live (TTL) for this packet

Link State Routing★★★★Neso Academy

Link State Routing



Link State RoutingNeso Academy

Link State Routing

Strategy: Send to all nodes (not just neighbors) information about directly connected links (not entire routing table).

Idea: LSR in Two Phases

Phase 1: Reliable flooding

Initial State: Each node knows the cost to its neighbors.

Final State: Each node knows the entire network topology.

Phase 2: Route Calculation

Each node uses Dijkstra's Algorithm on the graph to calculate optimal routes to all nodes.

Link State RoutingNeso Academy

Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand reliable flooding in LSR.

★ Know the fields of LSP and its the features.

Outcomes★★Neso Academy

Link State Routing

Link State Packet (LSP)

★ ID of the node that created the LSP
★ Cost of link to each directly connected neighbor
★ Sequence number (SEQNO)
★ Time-To-Live (TTL) for this packet

LSPs are generated on two occasions:

1. Triggered
2. Periodic

Link State Routing★★★★Neso Academy

Link State Routing

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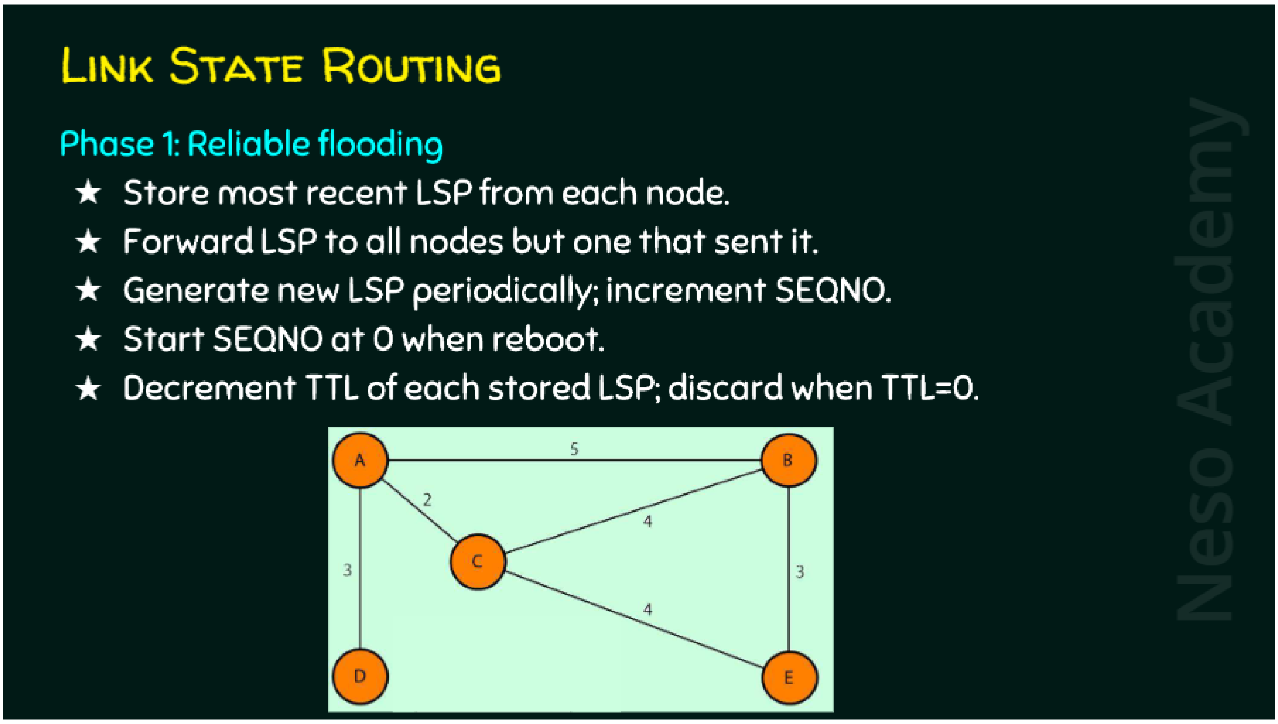
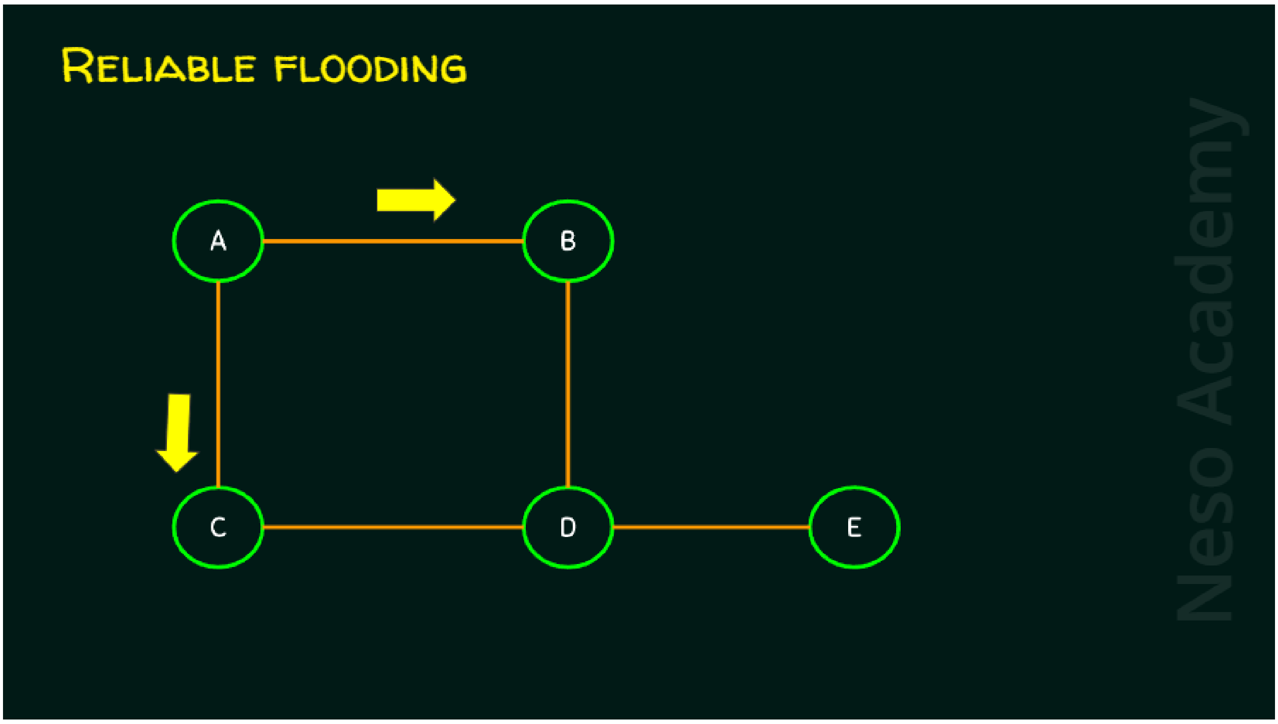
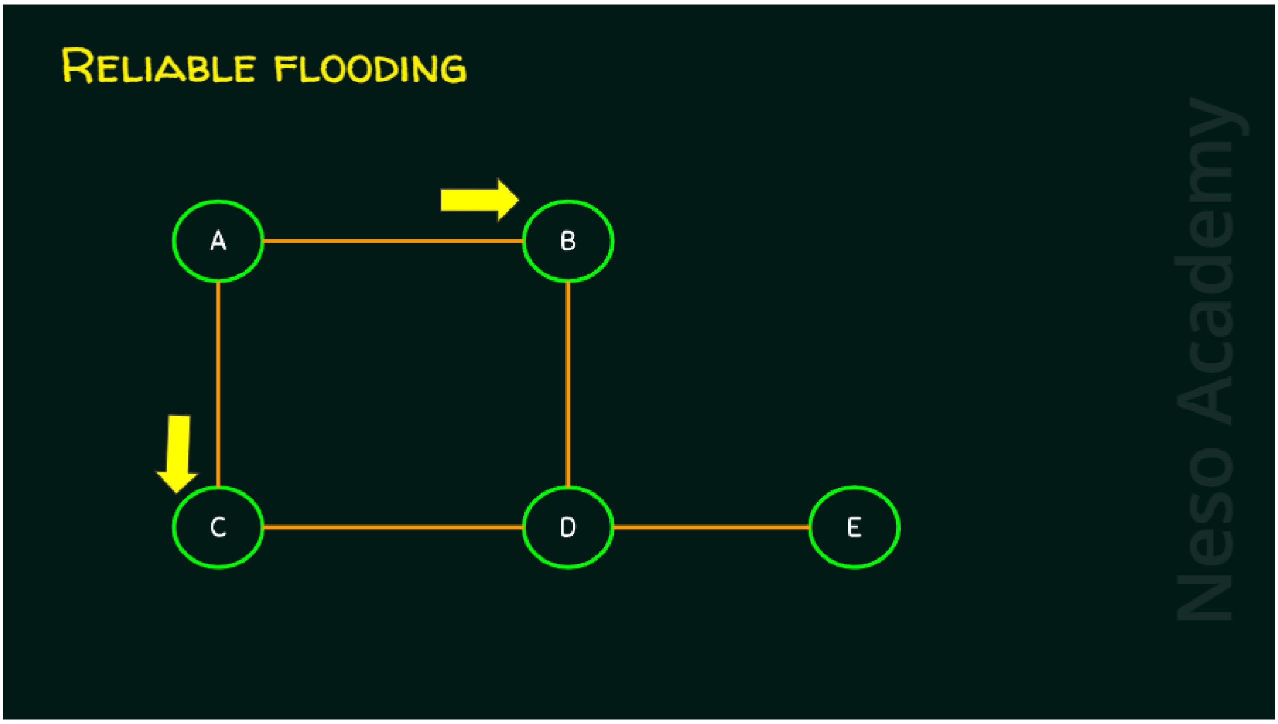
Link State RoutingNeso Academy



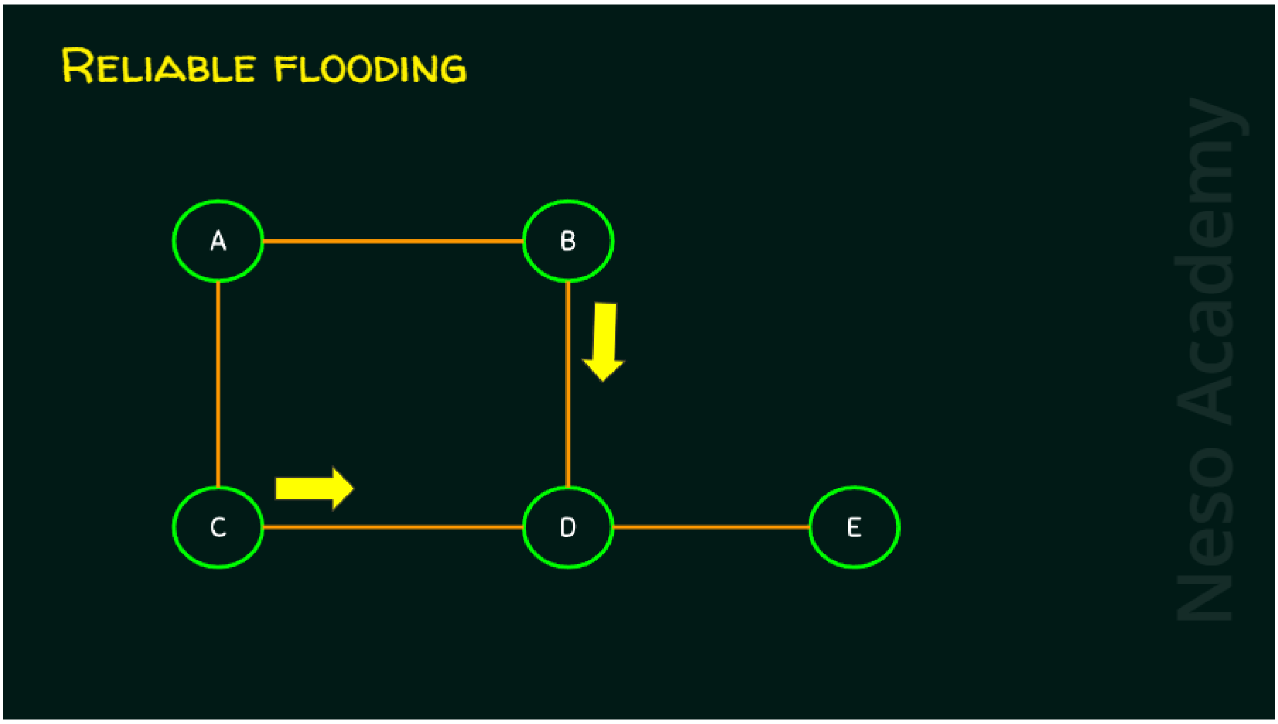
Link State Routing★★★★★Neso Academy



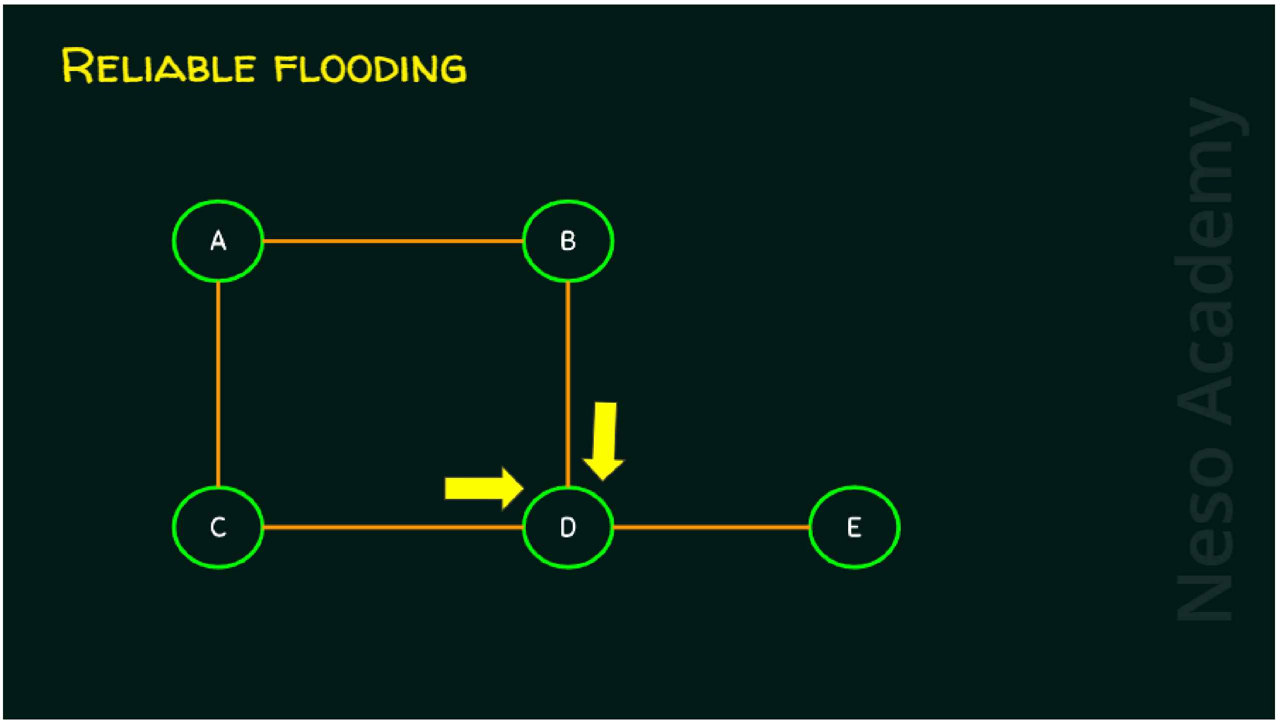
Reliable floodingNeso Academy



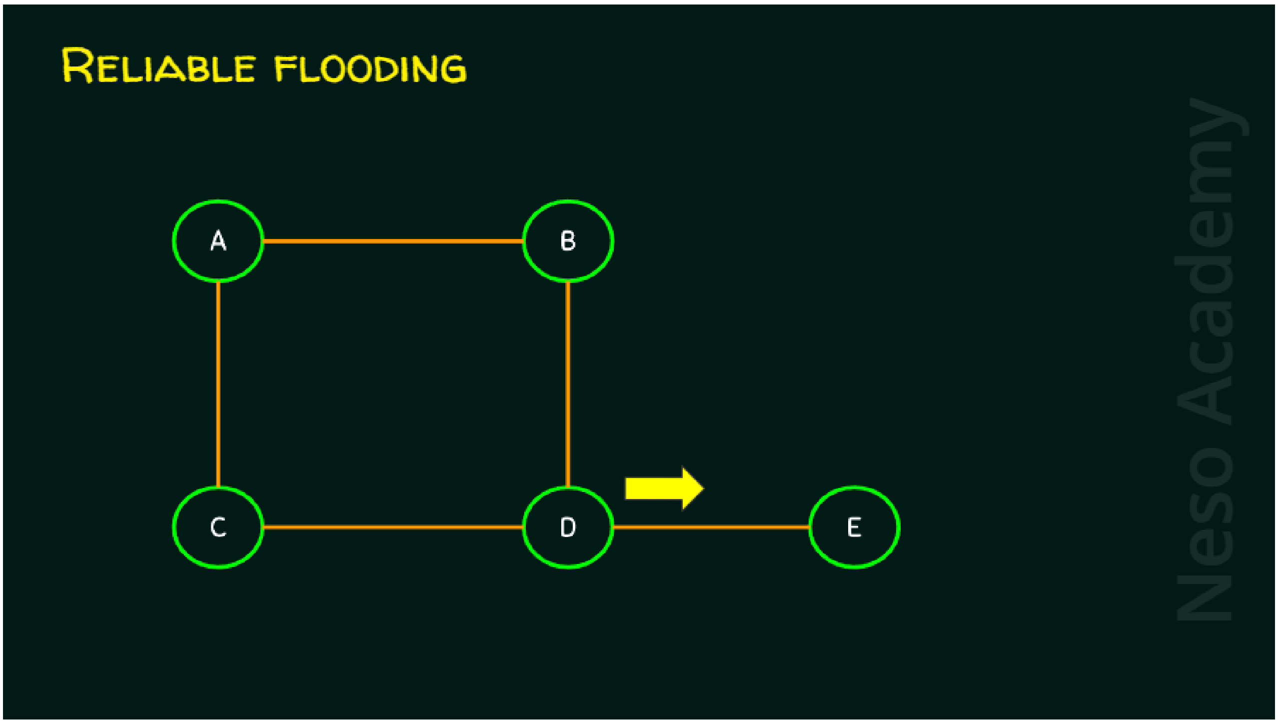
Reliable floodingNeso Academy



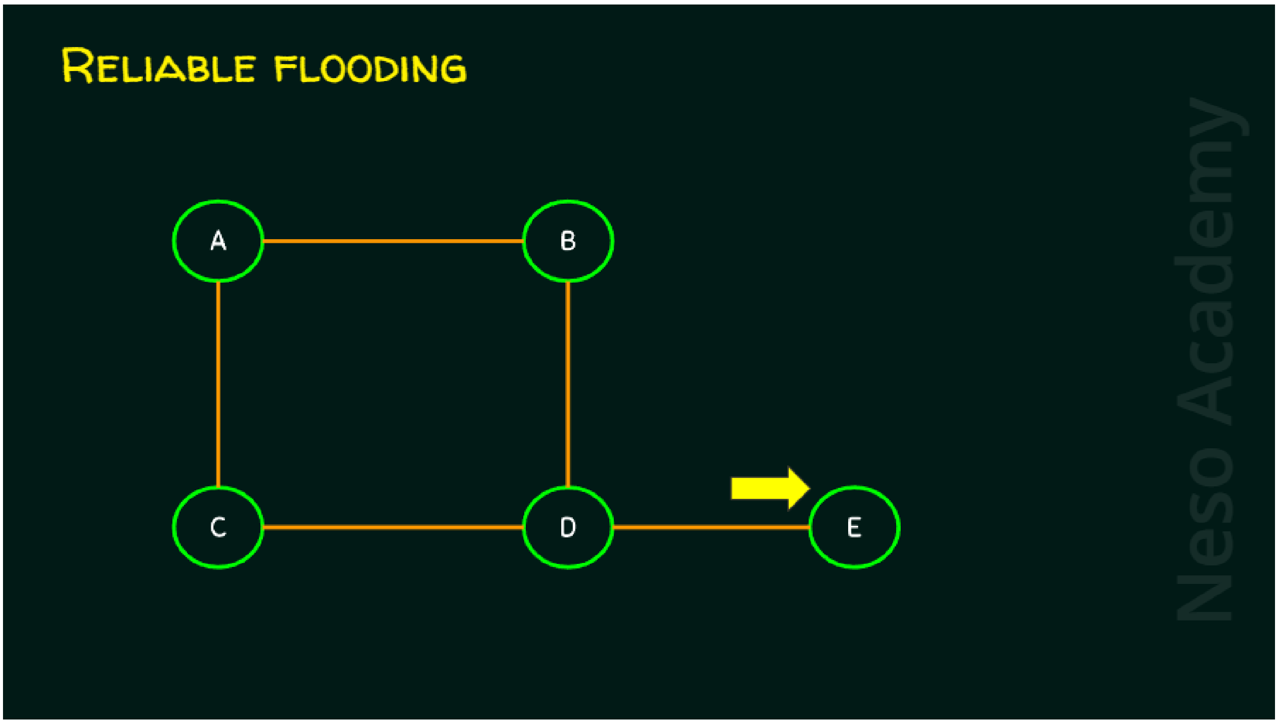
Reliable floodingNeso Academy



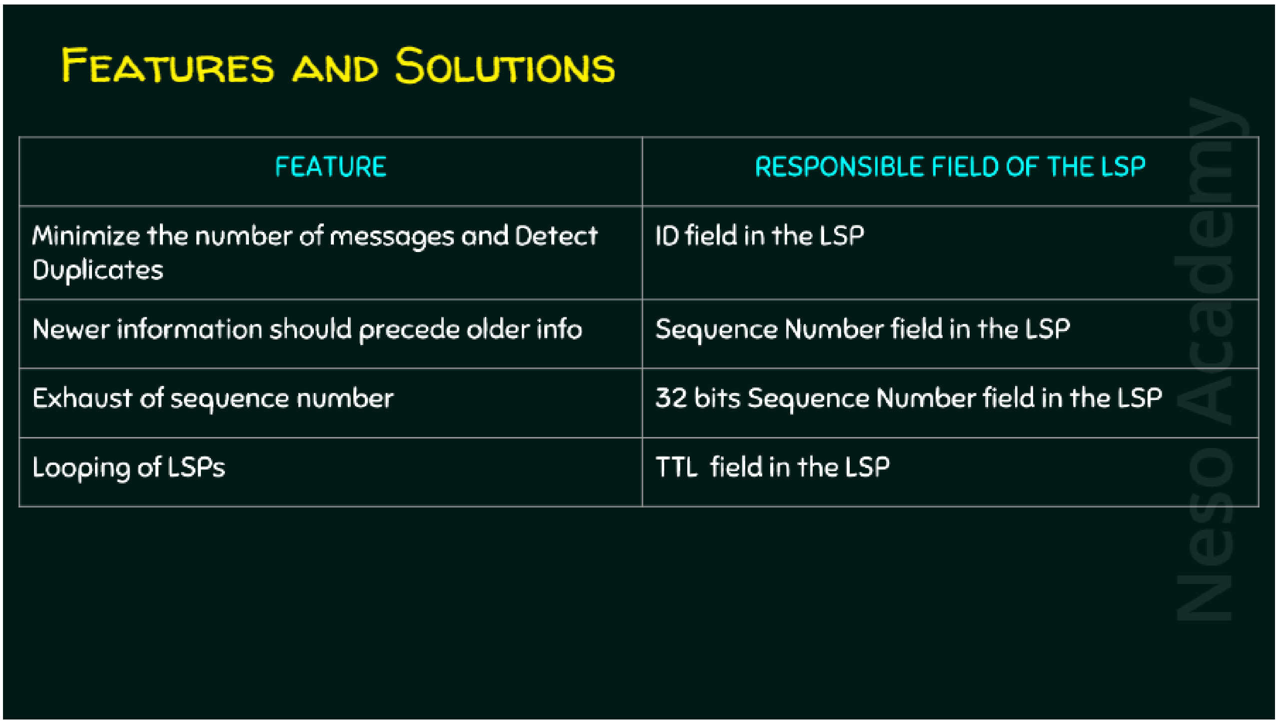
Reliable floodingNeso Academy



Reliable floodingNeso Academy



Reliable floodingNeso Academy



FEATURES AND SOLUTIONS

FEATURE	RESPONSIBLE FIELD OF THE LSP
Minimize the number of messages and Detect Duplicates	ID field in the LSP
Newer information should precede older info	Sequence Number field in the LSP
Exhaust of sequence number	32 bits Sequence Number field in the LSP
Looping of LSPs	TTL field in the LSP

Features and SolutionsNeso Academy

Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand the difference between LSR and DVR.

Outcomes★Neso Academy

LSR vs DVR

Features	Link State Routing	Distance Vector Routing
Topology	Complete Topology	Local Topology
Communication Type	Flooding	Exchange
Convergence	Fast	Slow
Routing Loops	Less prone	Highly Prone
Algorithm	Dijkstra's Algorithm	Bellman Ford Algorithm
Metric	Cost	Hop count
Updates	Triggered, Partial	Frequent, Periodic
Scalability	Highly scalable	Limited
Protocols	OSPF, IS-IS	RIP, IGRP

LSR vs DVRNeso Academy

Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand Dijkstra's Algorithm.

Outcomes★Neso Academy

Link State Routing

Strategy: Send to all nodes (not just neighbors) information about directly connected links (not entire routing table).

Idea: LSR in Two Phases

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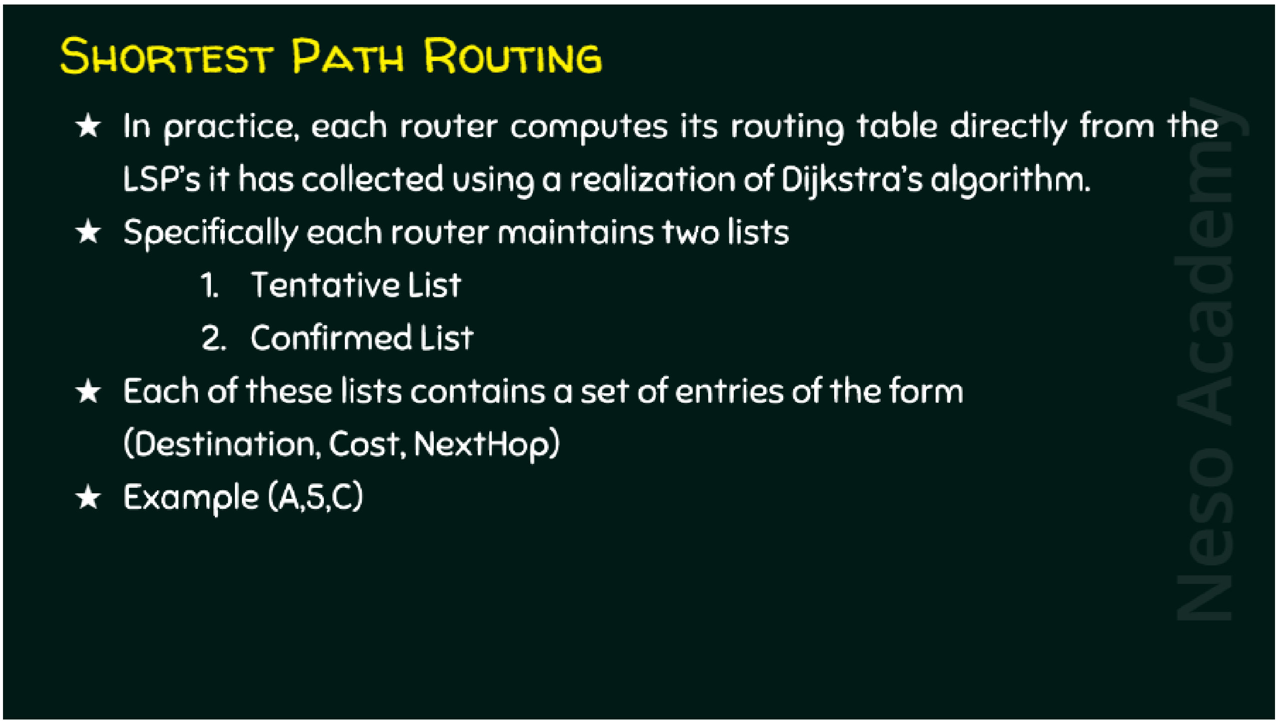
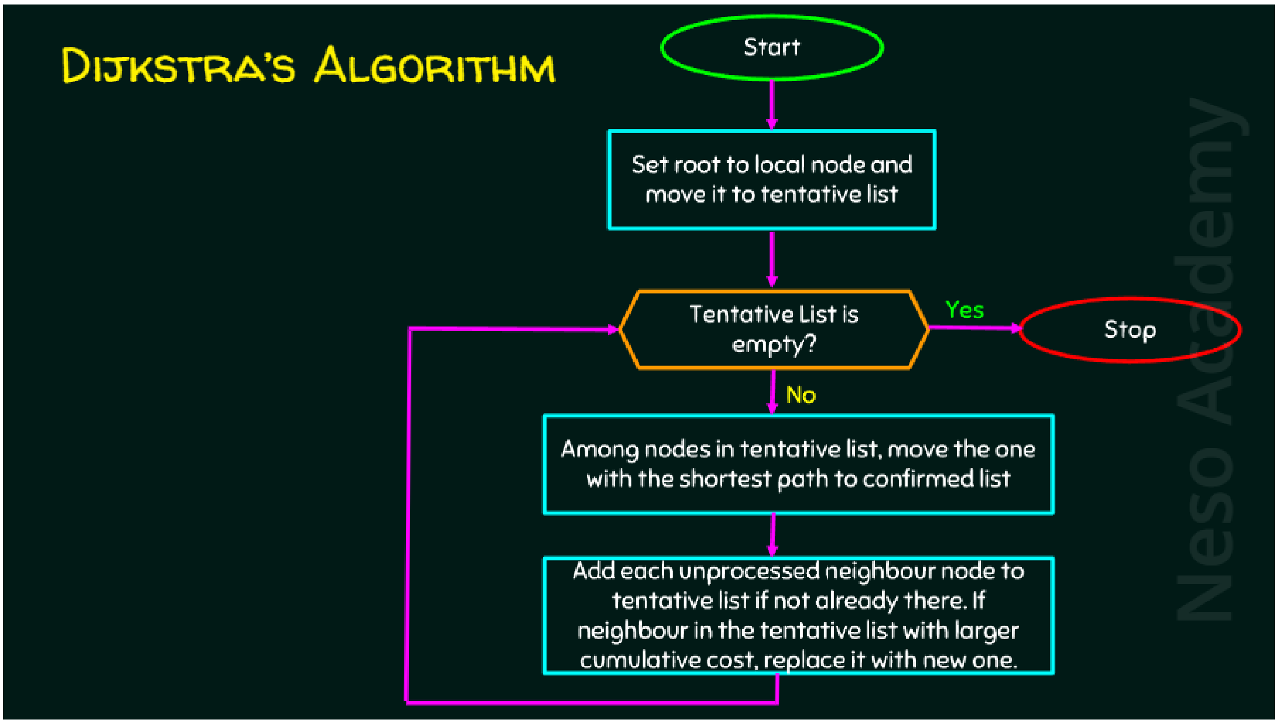


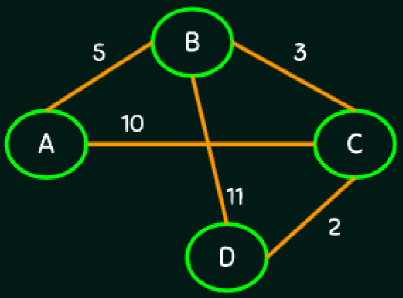
Shortest Path Routing★★★★Neso Academy



Dijkstra's AlgorithmNeso Academy

QUESTION

Find the shortest path routing for the following graph



Step	Confirmed	Tentative
1	(D,0,–)	
2	(D,0,–)	(B,11,B) (C,2,C)
3	(D,0,–) (C,2,C)	(B,11,B)
4	(D,0,–) (C,2,C)	(B,5,C) (A,12,C)
5	(D,0,–) (C,2,C) (B,5,C)	(A,12,C)
6	(D,0,–) (C,2,C) (B,5,C)	(A,10,C)
7	(D,0,–) (C,2,C) (B,5,C) (A,10,C)	

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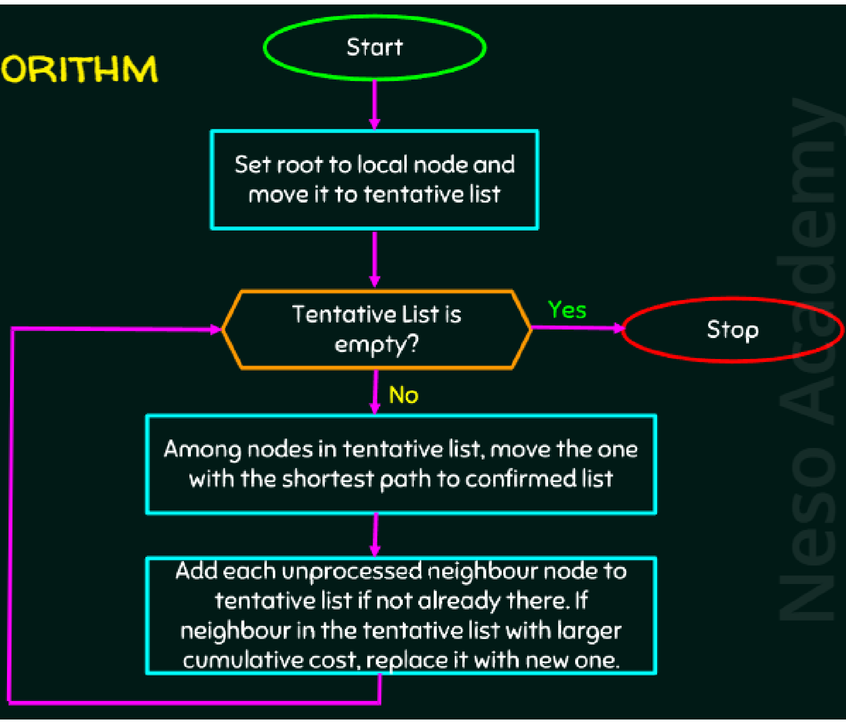
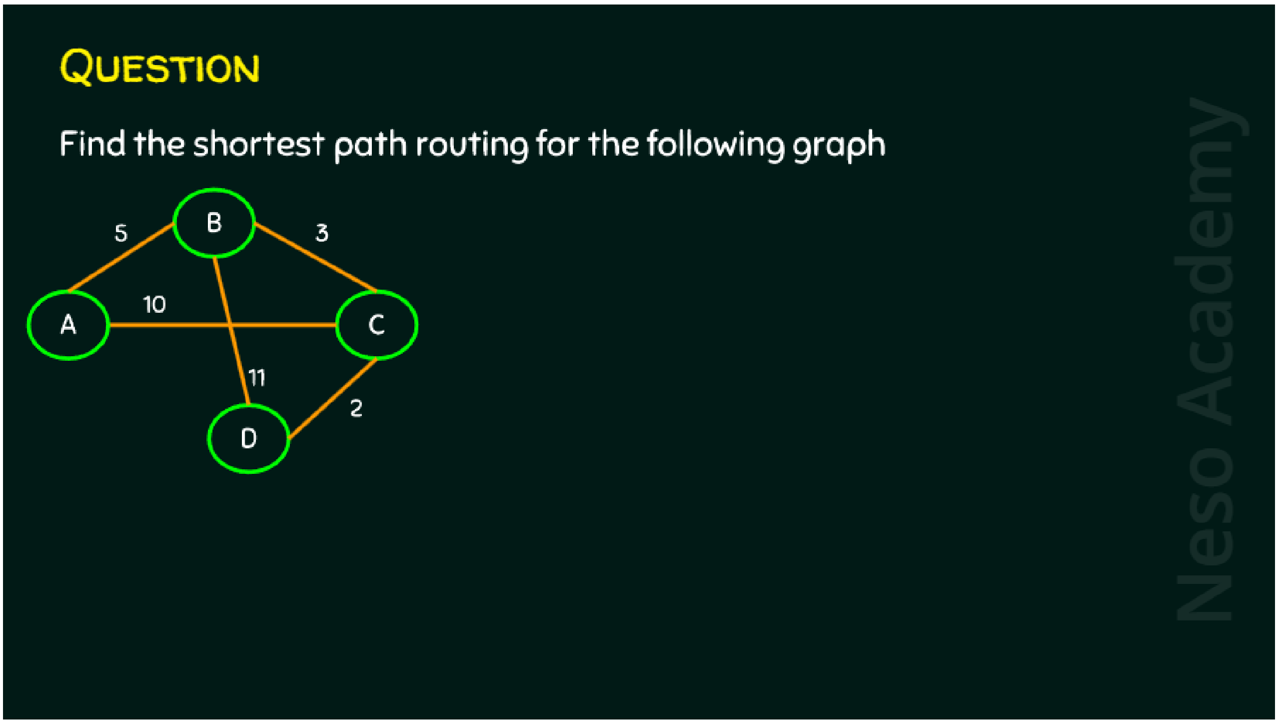
DIJKSTRA'S ALGORITHM



Dijkstra's AlgorithmNeso Academy



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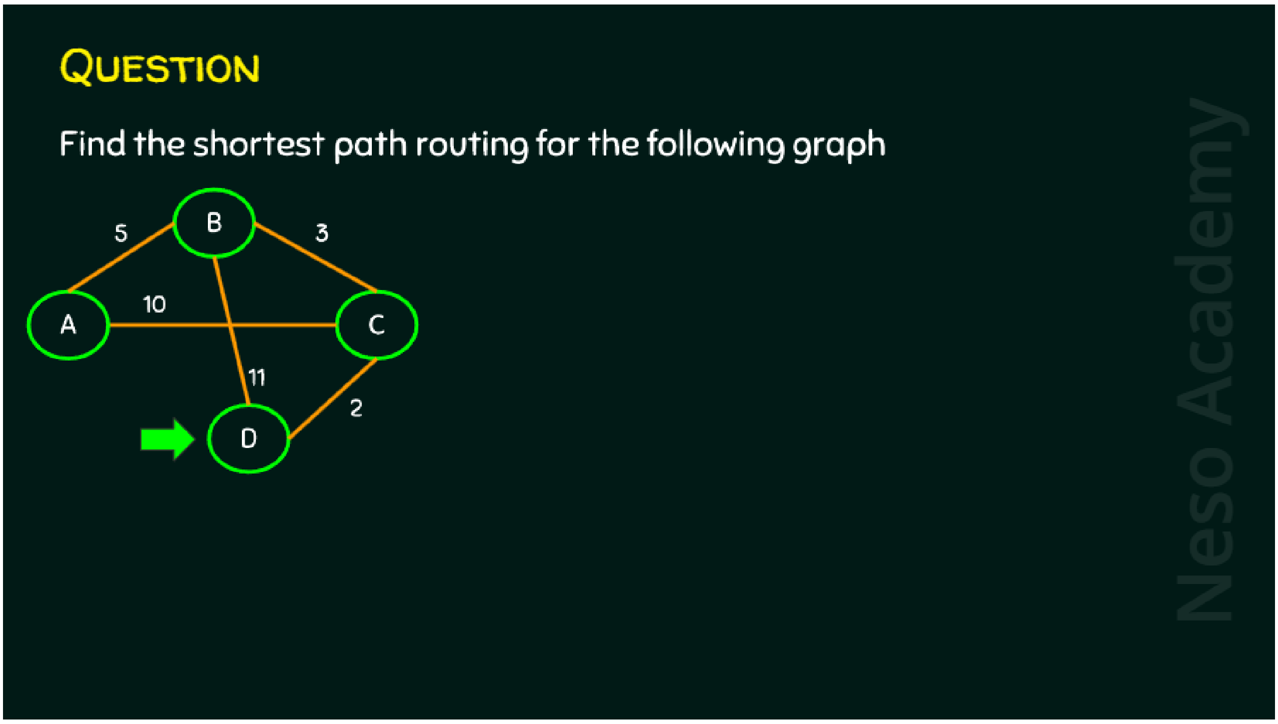

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QUESTION

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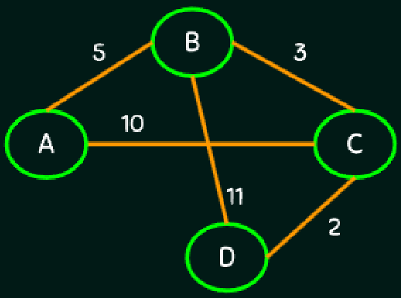

Step	Confirmed	Tentative
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2	(D,0,–)	(B,11,B) (C,2,C)
3	(D,0,–) (C,2,C)	(B,11,B)
4	(D,0,–) (C,2,C)	(B,5,C) (A,12,C)
5	(D,0,–) (C,2,C) (B,5,C)	(A,12,C)
6	(D,0,–) (C,2,C) (B,5,C)	(A,10,C)
7	(D,0,–) (C,2,C) (B,5,C) (A,10,C)	

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QUESTION

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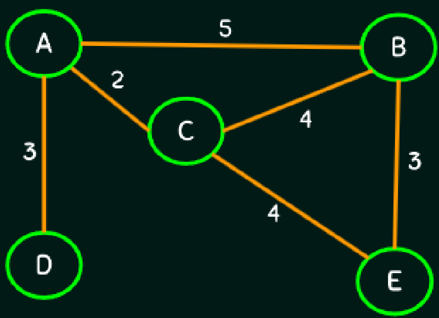

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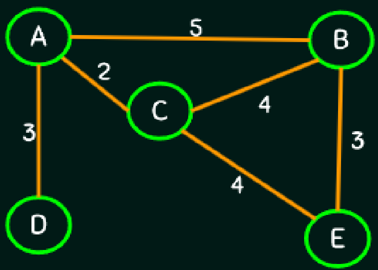
Question

Find the shortest path routing for the following graph



Step	Confirmed	Tentative
1	(A,0,–)	
2	(A,0,–)	
3	(A,0,–) (C,2,C)	(B,6,C)
4	(A,0,–) (C,2,C) (D,3,D)	
5	(A,0,–) (C,2,C) (D,3,D) (B,5,B)	(E,8,B)
6	(A,0,–) (C,2,C) (D,3,D) (B,5,B) (E,6,B)	

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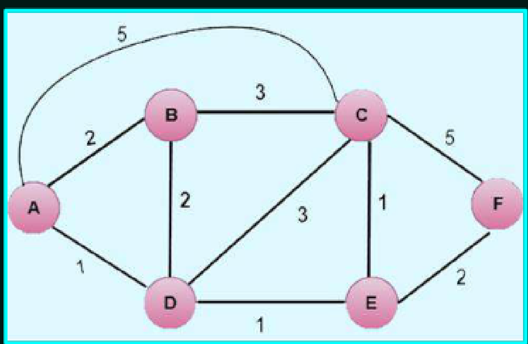
Homework

Find the shortest path routing for the following graph



HomeworkNeso Academy

QUESTION

Two popular routing algorithms are Distance Vector (DV) and Link State (LS) routing. Which of the following are true?

(S1) Count to infinity is a problem only with DV and not LS routing (True)

(S2) In LS, the shortest path algorithm is run only at one node (False)

(S3) In DV, the shortest path algorithm is run only at one node (False)

(S4) DV requires lesser number of network messages than LS (True)

[GATE IT 2008]

(A) S1, S2 and S4 only

(B) S1, S3 and S4 only

(C) S2 and S3 only

(D) S1 and S4 only ✔

Question✓Neso Academy

QUESTION

Consider the following three statements about link state and distance vector routing protocols, for a large network with 500 network nodes and 4000 links.

[S1] The computational overhead in link state protocols is higher than in distance vector protocols. [True]

[S2] A distance vector protocol (with split horizon) avoids persistent routing loops, but not a link state protocol. [False]

[S3] After a topology change, a link state protocol will converge faster than a distance vector protocol. [True]

Which one of the following is correct about S1, S2, and S3 ?

[GATE CS 2008]

(A) S1, S2, and S3 are all true.

(B) S1, S2, and S3 are all false.

(C) S1 and S2 are true, but S3 is false.

(D) S1 and S3 are true, but S2 is false. ✔

Question✓Neso Academy

Outcomes

Upon the completion of this lecture, the learner will be able to

★ Understand the theoretical aspects of OSPF.

★ Know about Autonomous System (AS).

★ Know about the use of hello packets.

Outcomes★★★Neso Academy

OSPF

★ Open Shortest Path First (OSPF) is a routing protocol for IP networks.

★ It uses a link state routing (LSR) algorithm and falls into the group of interior gateway protocols (IGPs), operating within a single Autonomous System (AS).

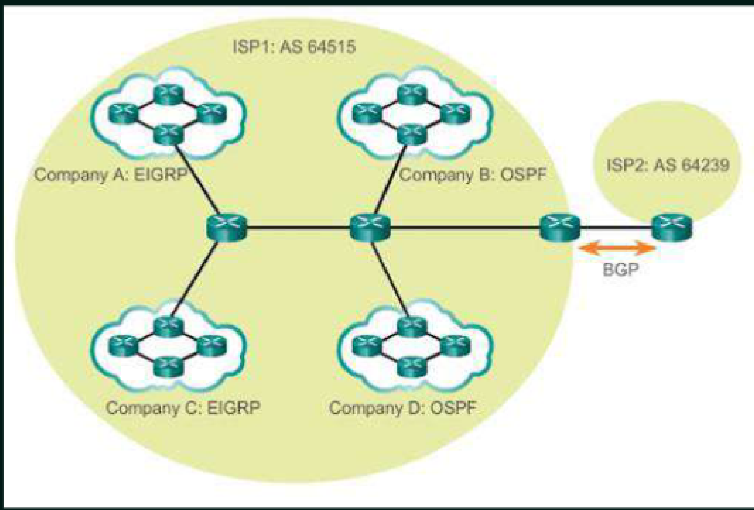
★ RIP uses hop count as metric whereas OSPF uses cost as the metric.

★ OSPF was developed so that the shortest path through a network was calculated based on the cost of the route.

★ The link cost is calculated by taking bandwidth, delay and load into account .

OSPF★★★★★Neso Academy

Autonomous System



Autonomous SystemNeso Academy

OSPF

- ★ Therefore OSPF undertakes route cost calculation on the basis of link-cost parameters, which can be weighted by the administrator.
- ★ OSPF is reliable even for large and complex networks.
- ★ As a link-state routing protocol, OSPF maintains link-state databases.
- ★ The state of a given route in the network is the cost, and OSPF algorithm allows every router to calculate the cost of the routes to any given reachable destination.

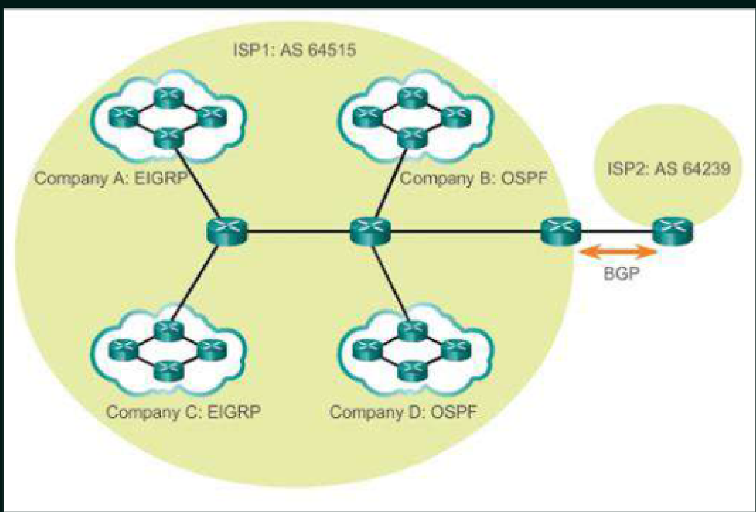
OSPF★★★★Neso Academy

OSPF Hello Procedure

- ★ A router interface with OSPF will then advertise its link cost to neighboring routers through multicast, known as the hello procedure.
- ★ All routers with OSPF implementation keep sending hello packets, and thus changes in the cost of their links become known to neighboring routers.

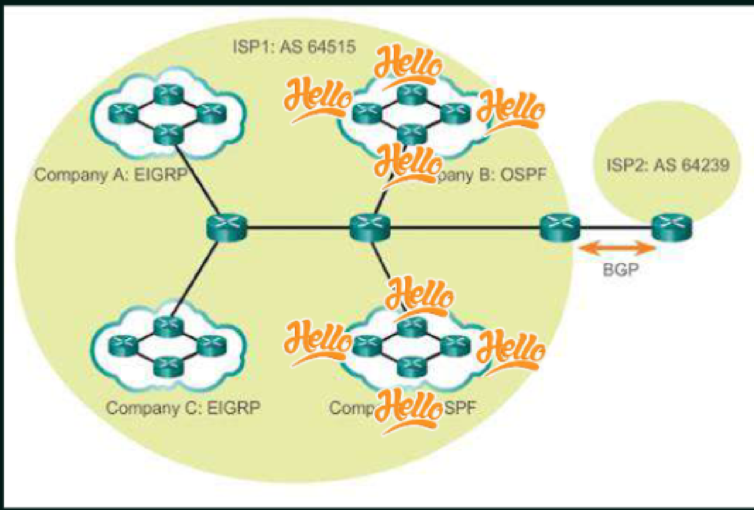
OSPF Hello Procedure★★Neso Academy

OSPF Hello Procedure



OSPF Hello ProcedureNeso Academy

OSPF Hello Procedure

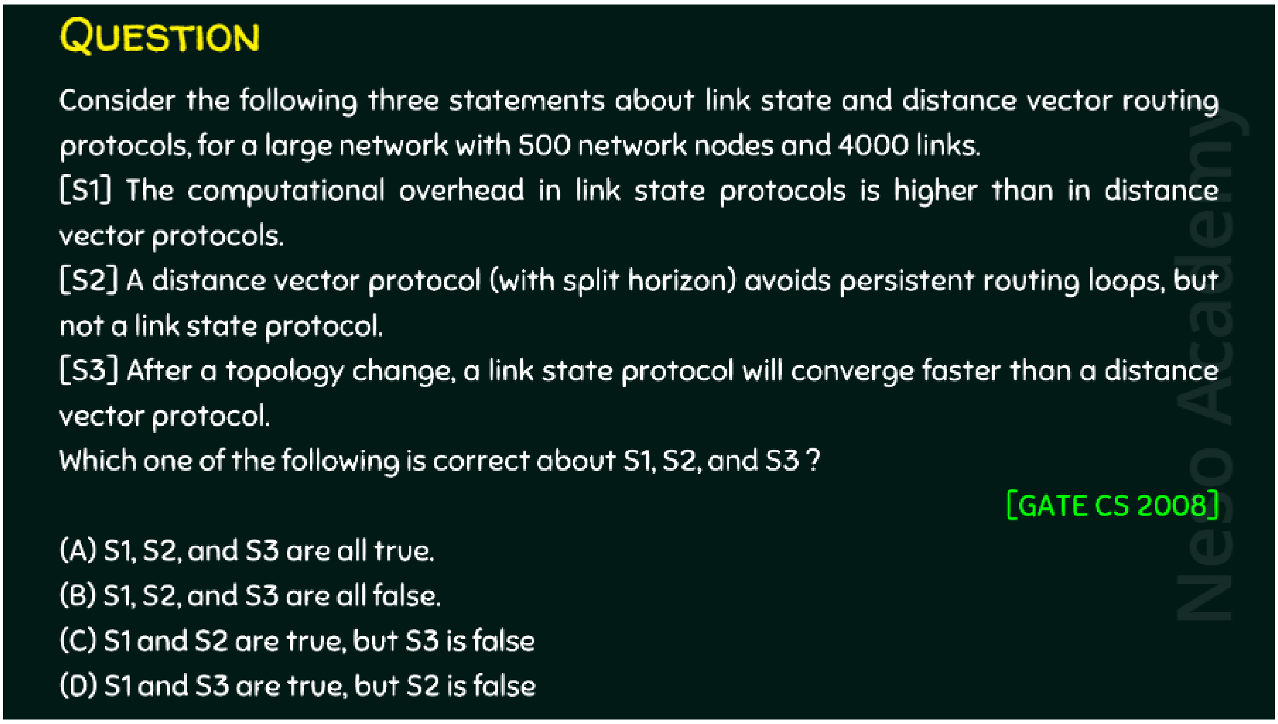


OSPF Hello ProcedureNeso Academy

OSPF

- ★ The information about the cost of a link, that is the speed of a point to point connection between two routers, is then cascaded through the network because OSPF routers advertise the information they receive from one neighboring router to all other neighboring routers.
- ★ This process of flooding link state information through the network is known as synchronization.
- ★ Based on this information, all routers with OSPF implementation continuously update their link state databases with information about the network topology and adjust their routing tables.

OSPF★★★Neso Academy



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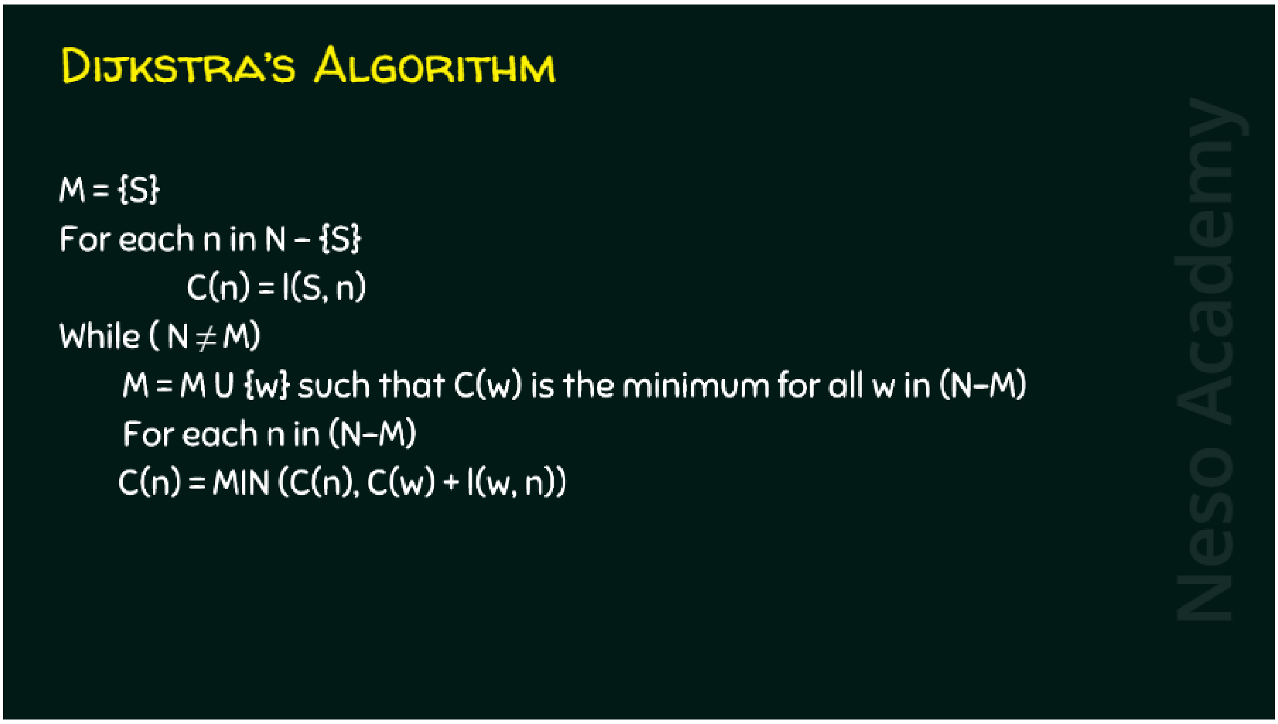
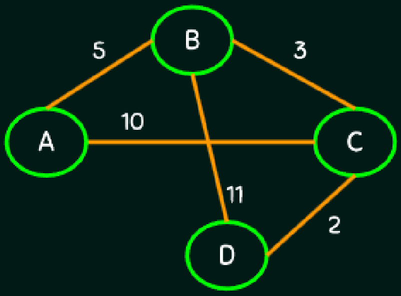


Dijkstra's Algorithm≠Neso Academy

Question

Find the shortest path routing for the following graph



Step	Confirmed	Tentative
1	(D,0,–)	
2	(D,0,–)	(B,11,B) (C,2,C)
3	(D,0,–) (C,2,C)	(B,11,B)
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Outcomes

Upon the completion of this lecture, the learner will be able to

- ★ Understand OSPF areas.
- ★ Understand OSPF neighborship and OSPF adjacency.

Outcomes★★Neso Academy

OSPF

- ★ An OSPF network can be structured, or subdivided, into routing areas to simplify administration and optimize traffic and resource utilization.
- ★ Areas are identified by 32-bit numbers, expressed either simply in decimal, or often in the same dot-decimal notation used for IPv4 addresses.
- ★ By convention, area 0 (zero), or 0.0.0.0, represents the core or backbone area of an OSPF network.
- ★ While the identifications of other areas may be chosen at will; administrators often select the IP address of a main router in an area as the area identifier.

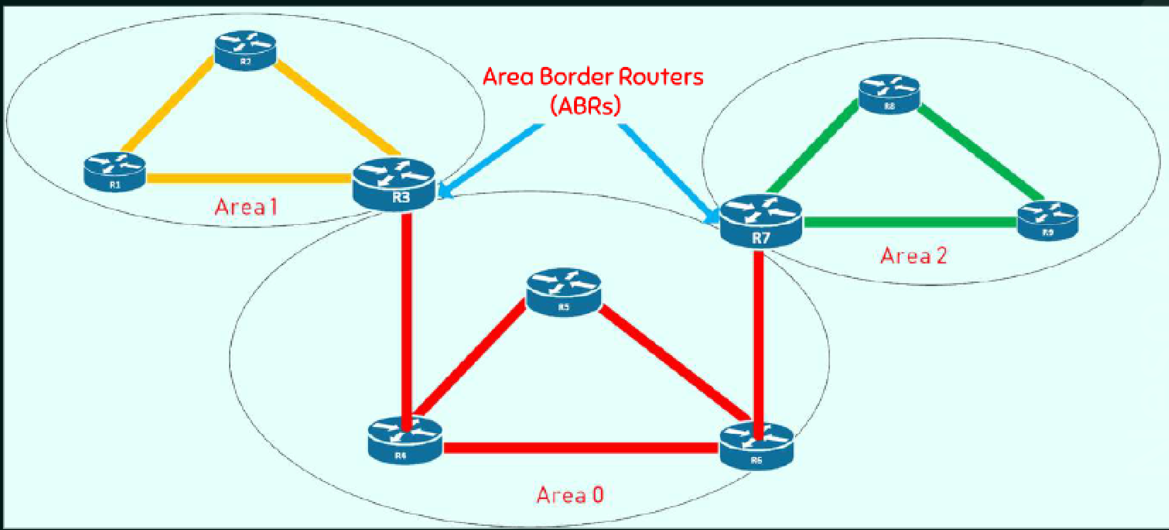
OSPF★★★★Neso Academy

OSPF

- ★ Each additional area must have a connection to the OSPF backbone area. Such connections are maintained by an interconnecting router, known as an area border router (ABR).
- ★ An ABR maintains separate link-state databases for each area it serves and maintains summarized routes for all areas in the network.
- ★ OSPF detects changes in the topology, such as link failures, and converges on a new loop-free routing structure within seconds
- ★ OSPF supports complex networks with multiple routers, including backup routers, to balance traffic load on multiple links to other subnets.

OSPF★★★★Neso Academy

OSPF



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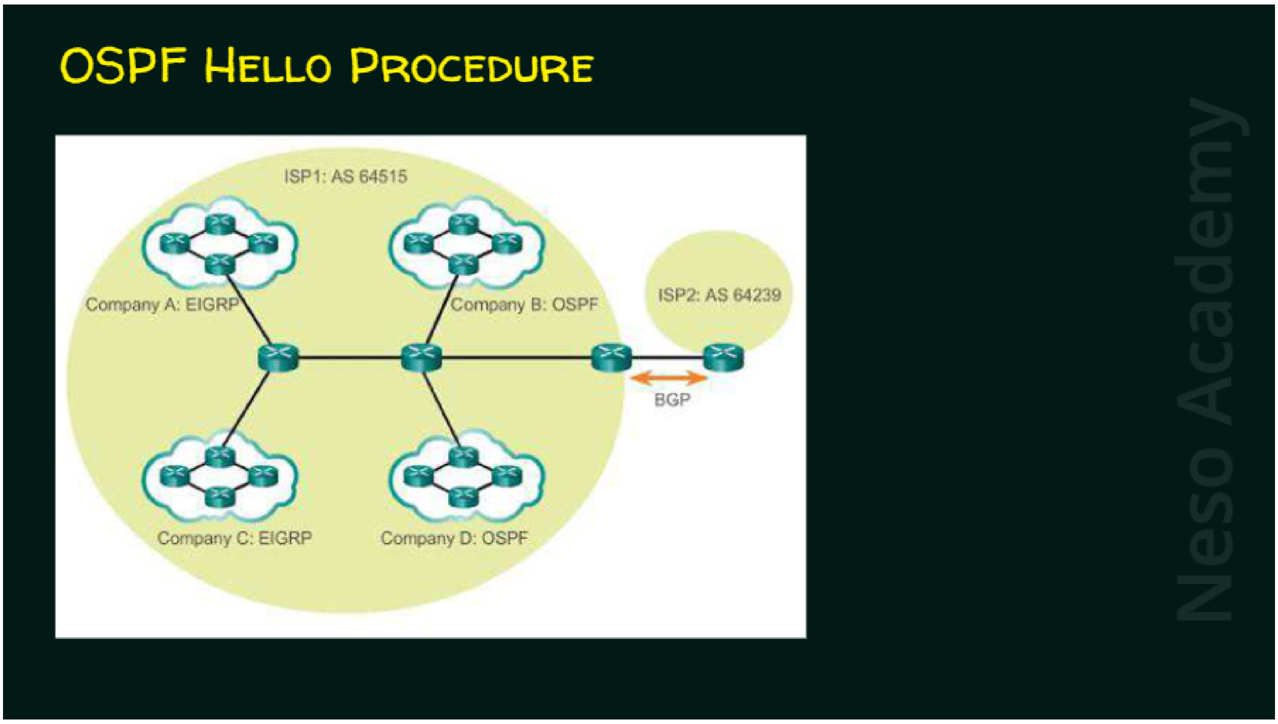
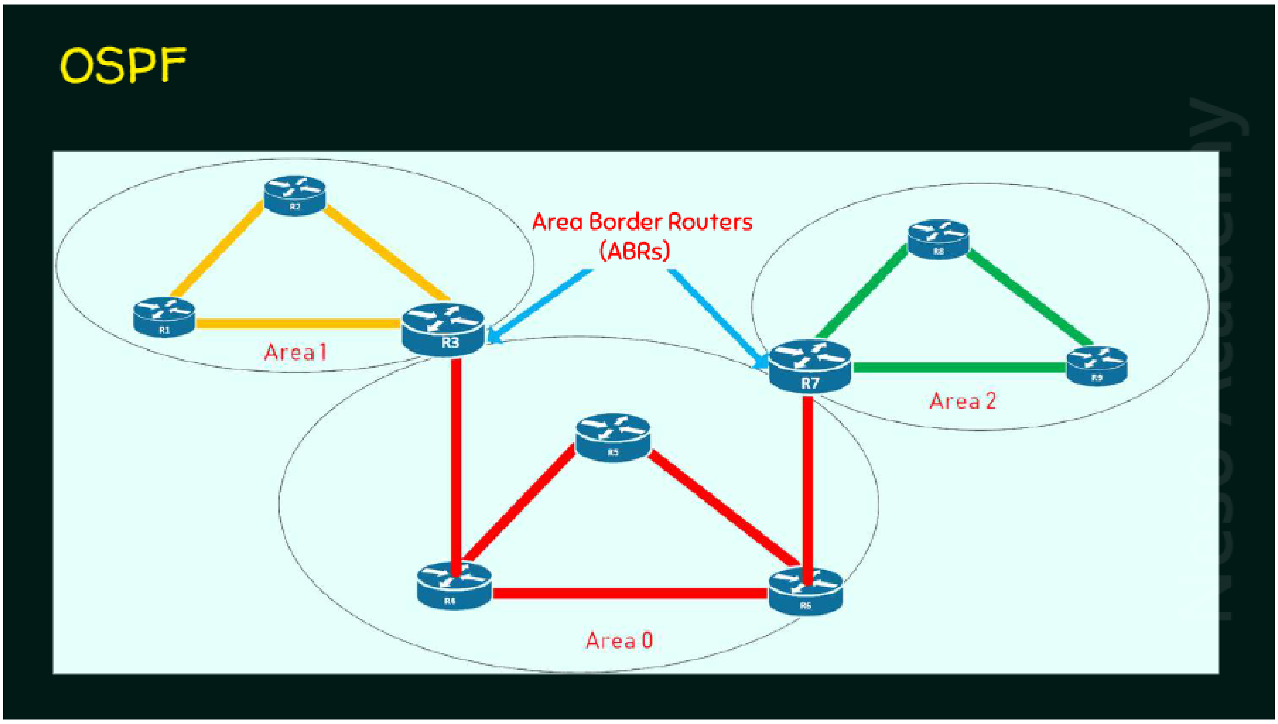
OSPF

- ★ As a link-state routing protocol, OSPF establishes and maintains neighbor relationships for exchanging routing updates with other routers.
- ★ The neighbor relationship table is called an adjacency database.
- ★ Two OSPF routers are neighbors if they are members of the same subnet and share the same area ID, subnet mask, timers and authentication.
- ★ In essence, OSPF neighborship is a relationship between two routers that allow them to see and understand each other but nothing more.

OSPF★★★★Neso Academy



OSPF Hello ProcedureNeso Academy



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OSPF

- ★ OSPF neighbors do not exchange any routing information – the only packets they exchange are Hello packets.
- ★ OSPF adjacencies are formed between selected neighbors and allow them to exchange routing information.
- ★ Two routers must first be neighbors and only then, can they become adjacent.
- ★ Two routers become adjacent if at least one of them is Designated Router or Backup Designated Router (on multiaccess type networks), or they are interconnected by a point-to-point or point-to-multipoint network type.

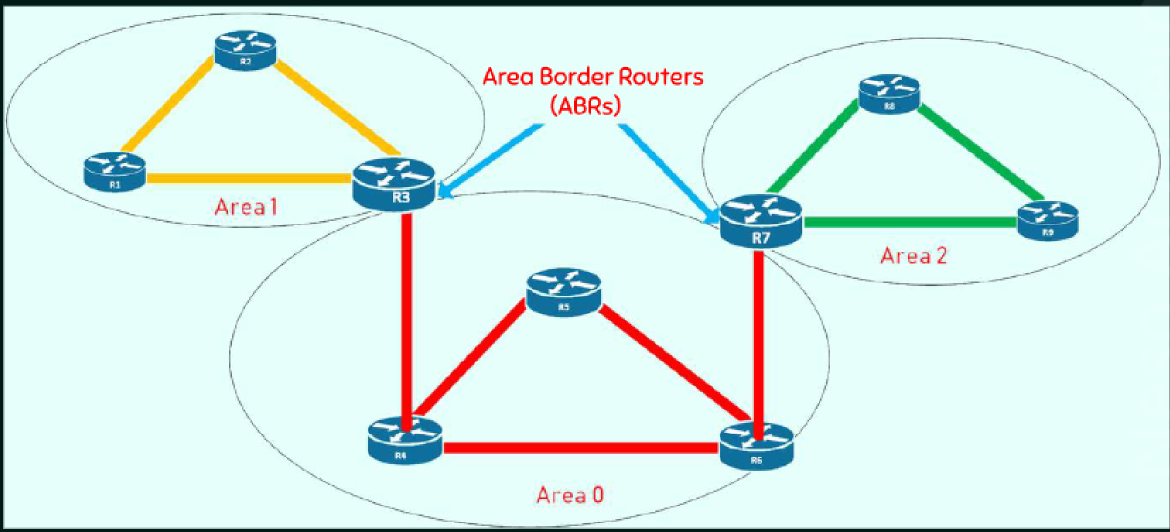
OSPF★★★★Neso Academy

OSPF

- ★ For forming a neighbor relationship between, the interfaces used to form the relationship must be in the same OSPF area.

OSPF★Neso Academy

OSPF



OSPFNeso Academy

Outcomes

Upon the completion of this lecture, the learner will be able to

★ Know various states in OSPF.

★ Understand the OSPF states.

Outcomes★★Neso Academy

OSPF

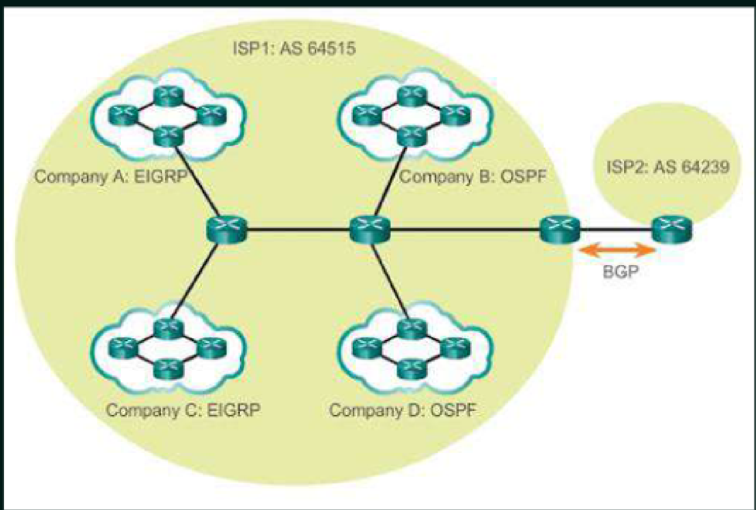
★ Each OSPF router within a network communicates with other neighboring routers on each connecting interface to establish the states of all adjacencies.

★ Every such communication sequence is a separate conversation identified by the pair of router IDs of the communicating neighbors.

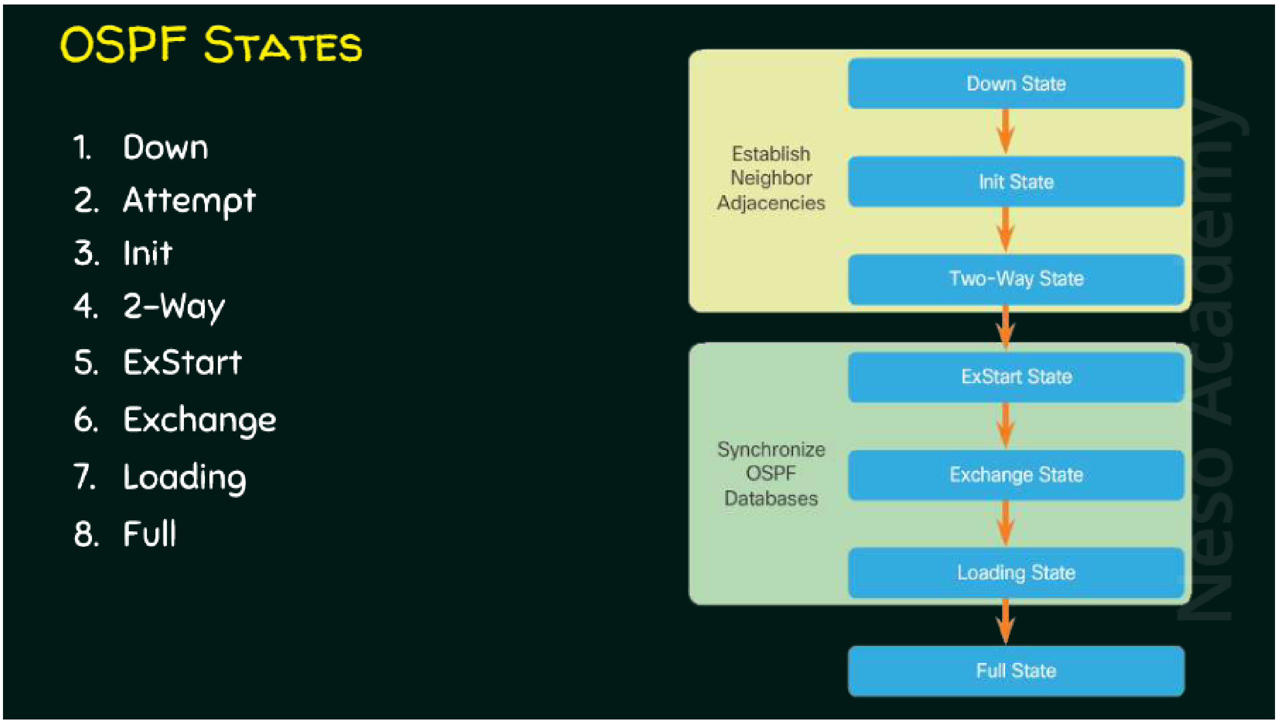
★ During its course, each router conversation transitions through a maximum of eight conditions defined by a state machine.

OSPF★★★Neso Academy

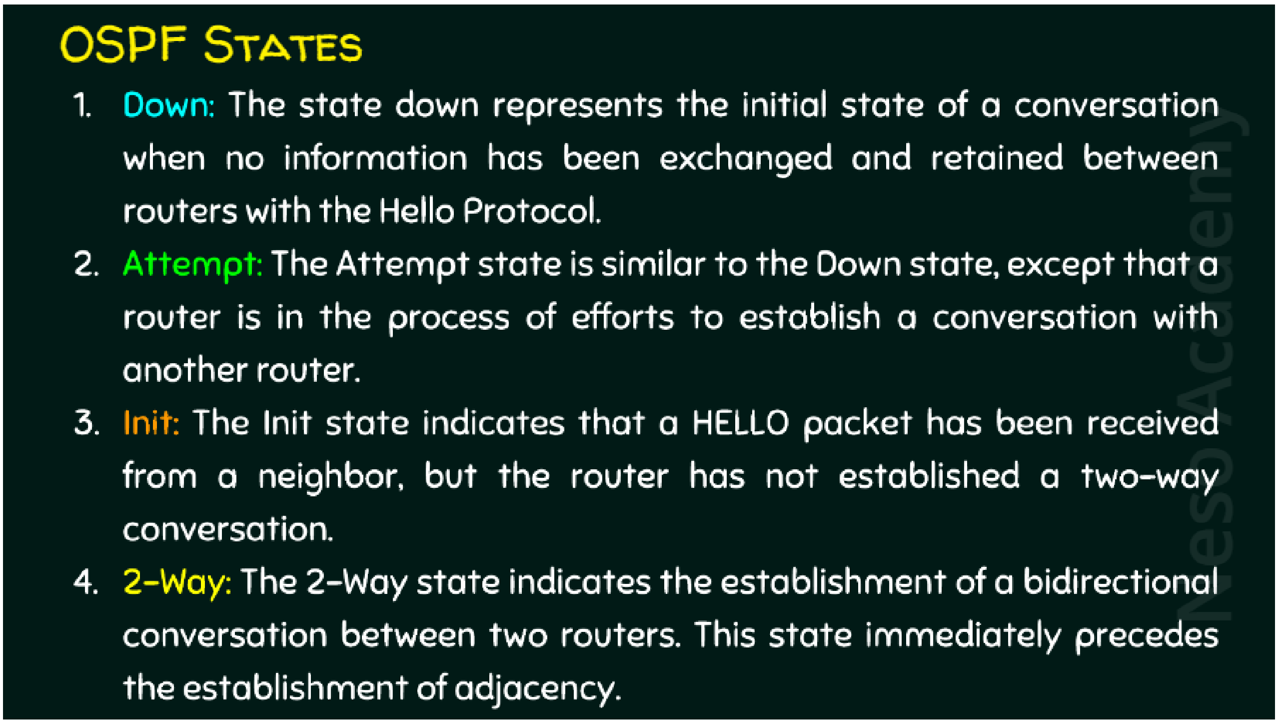
OSPF



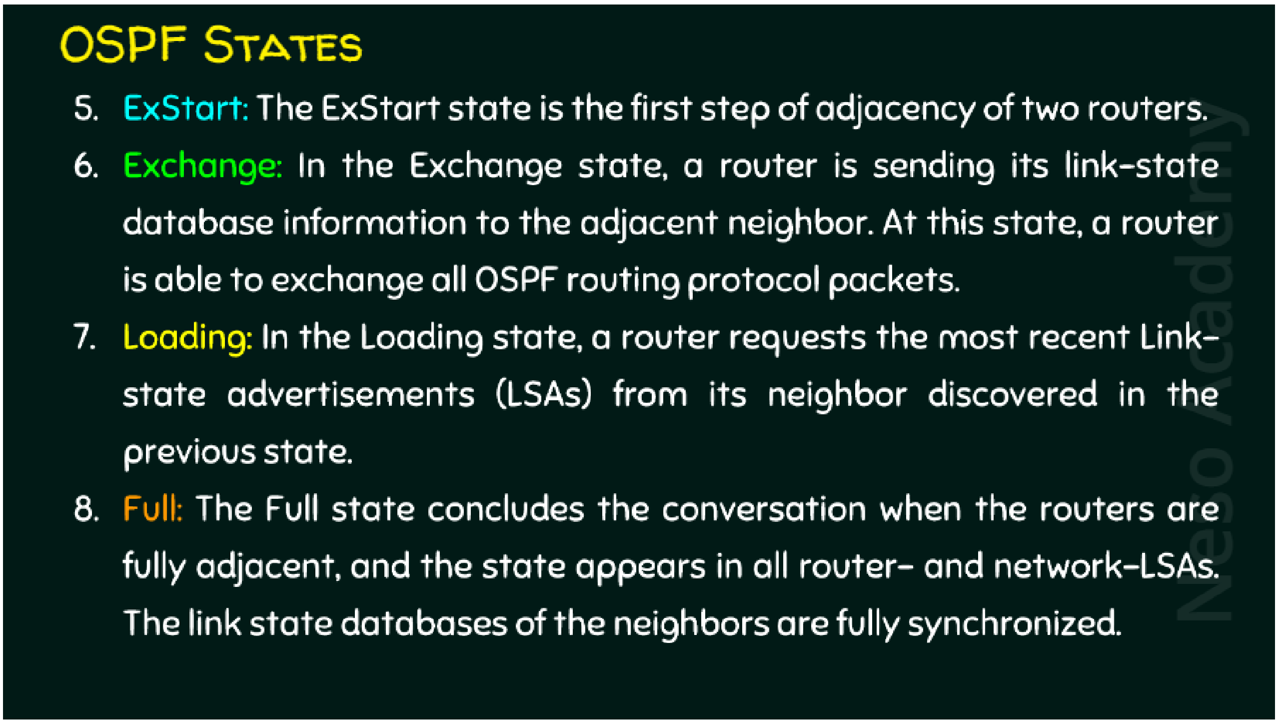
OSPFNeso Academy



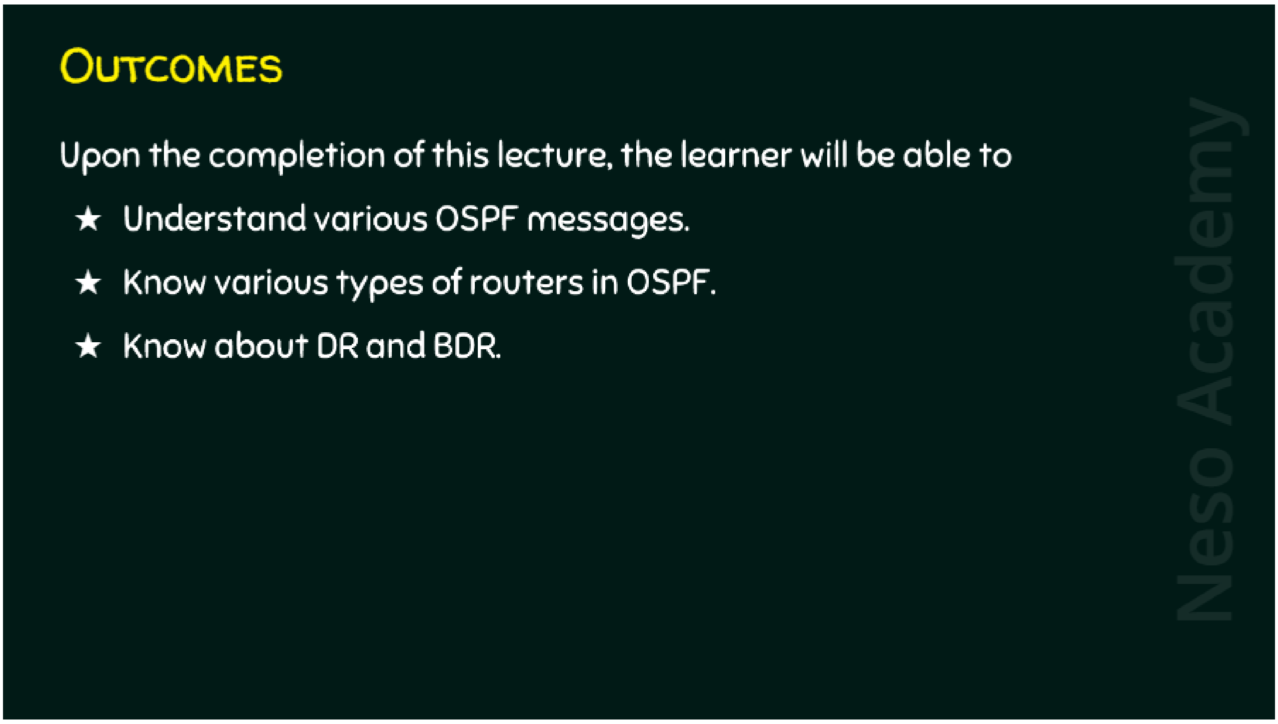
OSPF StatesNeso Academy



OSPF StatesNeso Academy



OSPF StatesNeso Academy



Outcomes★★★Neso Academy

OSPF Messages

OSPF defines five different message types, for various types of communication:

Type 1	Hello	Neighbors
Type 2	Database Description (DBD)	Adjacencies
Type 3	Link State Request (LSR)	
Type 4	Link State Update (LSU)	Reliable Update
Type 5	Link State Acknowledgment (LSAck)	

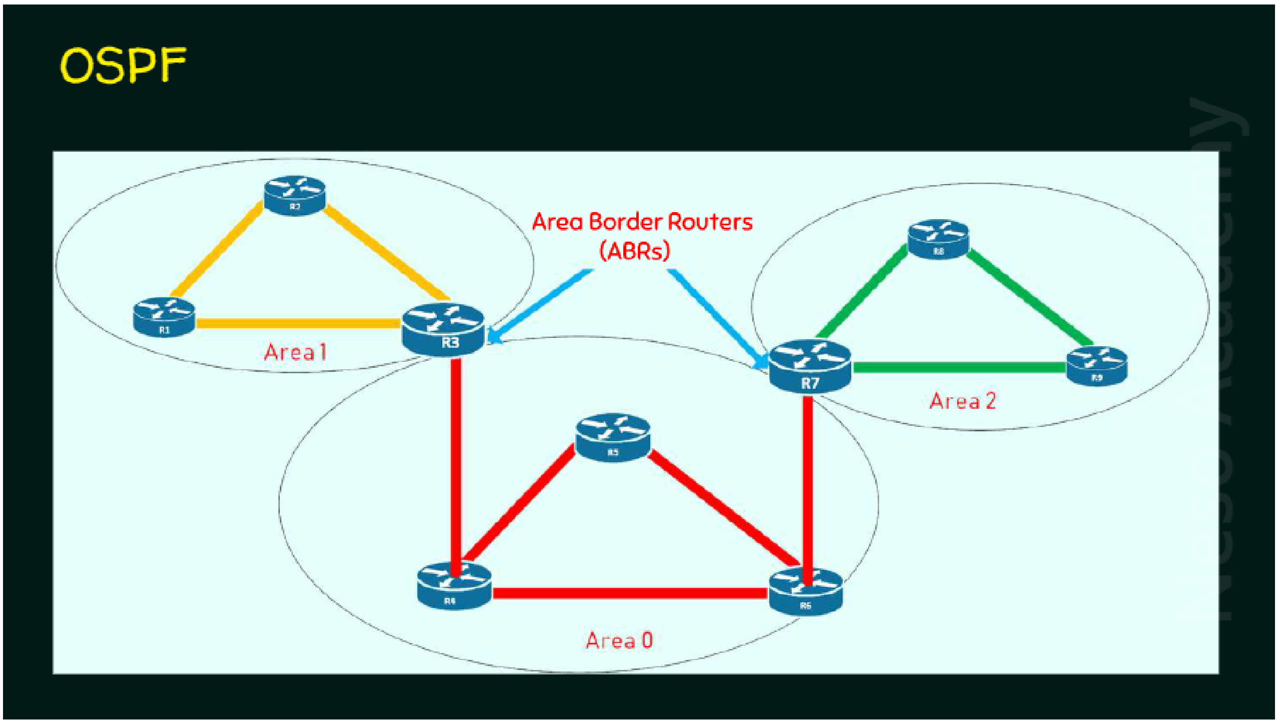
OSPF MessagesNeso Academy

OSPF Router Types

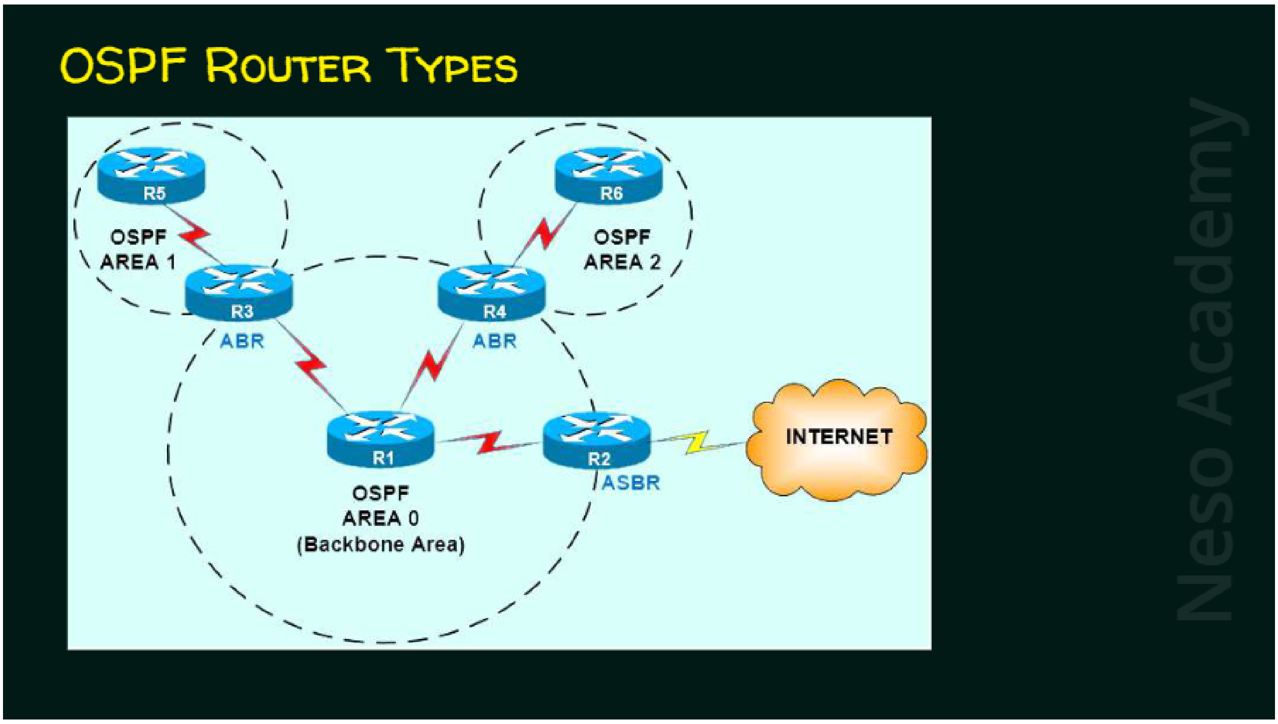
OSPF defines the following overlapping categories of routers:

- ★ Internal Router (IR) : An internal router has all its interfaces belonging to the same area.
- ★ Area Border Router (ABR): An area border router is a router that connects one or more areas to the main backbone network. It is considered a member of all areas it is connected to.
- ★ Backbone Router (BR): A backbone router has an interface to the backbone area. Backbone routers may also be area routers, but do not have to be.
- ★ Autonomous System Boundary Router (ASBR): An ASBR connects One AS with another or the internet.

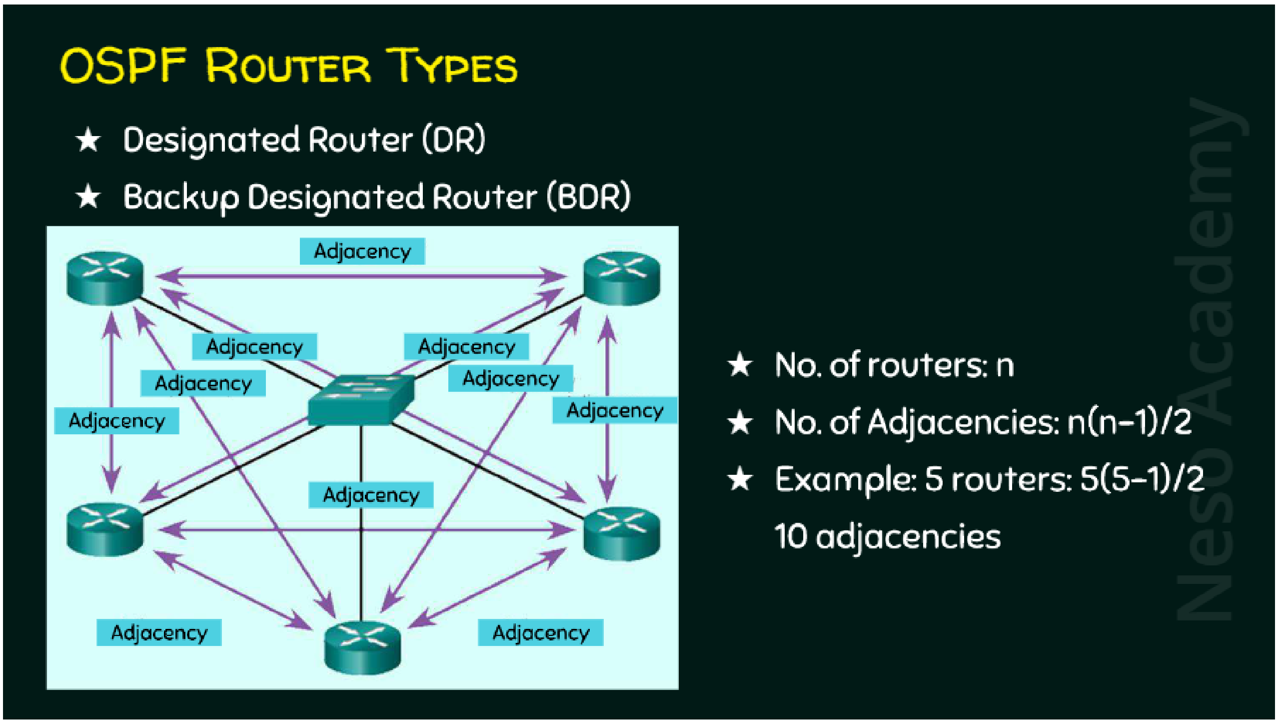
OSPF Router Types★★★★Neso Academy



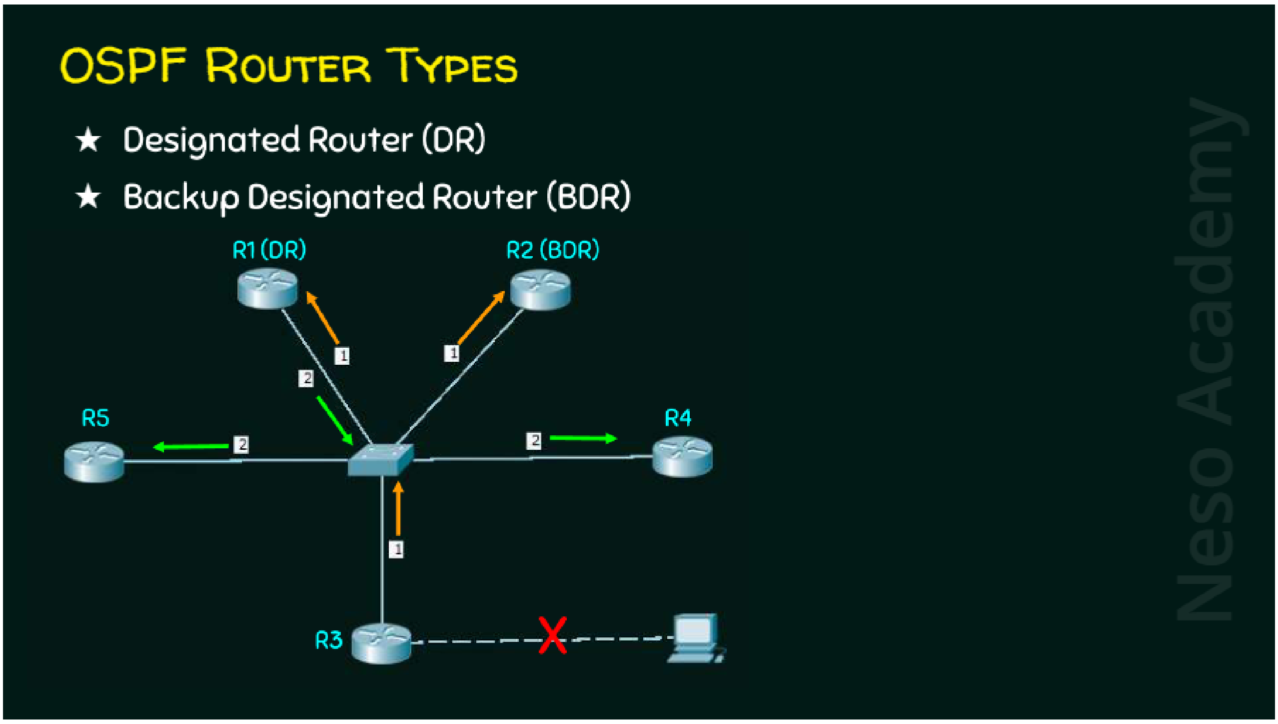
OSPFNeso Academy



OSPF Router TypesNeso Academy



OSPF Router Types★★★★★Neso Academy



OSPF Router Types★★Neso Academy

DR and BDR

★ Based on the network type, OSPF router can elect one router to be a Designated Router (DR) and one router to be a Backup Designated Router (BDR).

★ For example, on multiaccess broadcast networks (such as LANs) routers defaults to elect a DR and BDR. DR and BDR serve as the central point for exchanging OSPF routing information.

★ Each non-DR or non-BDR router will exchange routing information only with the DR and BDR, instead of exchanging updates with every router on the network segment.

★ DR will then distribute topology information to every other router inside the same area, which greatly reduces OSPF traffic.

★ If DR fails, BDR takes over its role of redistributing routing information.

DR and BDR★★★★★Neso Academy

DR and BDR

On LANs, DR and BDR have to be elected.

Rules for electing DR and BDR:

1. Router with the highest OSPF priority will become a DR. By default, all routers have a priority of 1.
2. If there is a tie, a router with the highest router ID wins the election. The router with the second highest OSPF priority or router ID will become a BDR.

DR and BDRNeso Academy

Outcomes

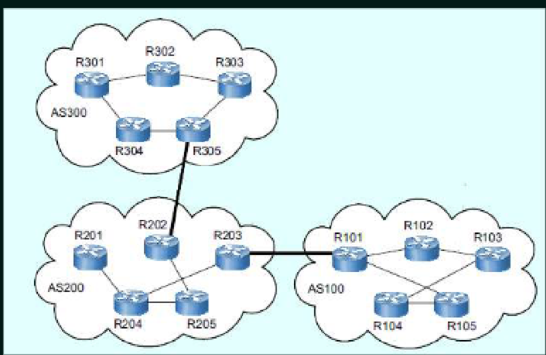
Upon the completion of this lecture, the learner will be able to

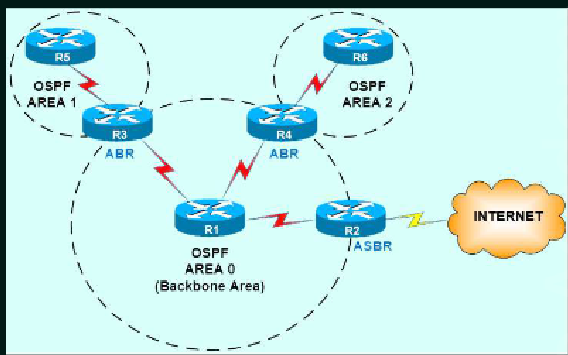
★ Understand various OSPF message types.

★ See all 5 OSPF message types captured using Wireshark.

Outcomes★★Neso Academy

OSPF





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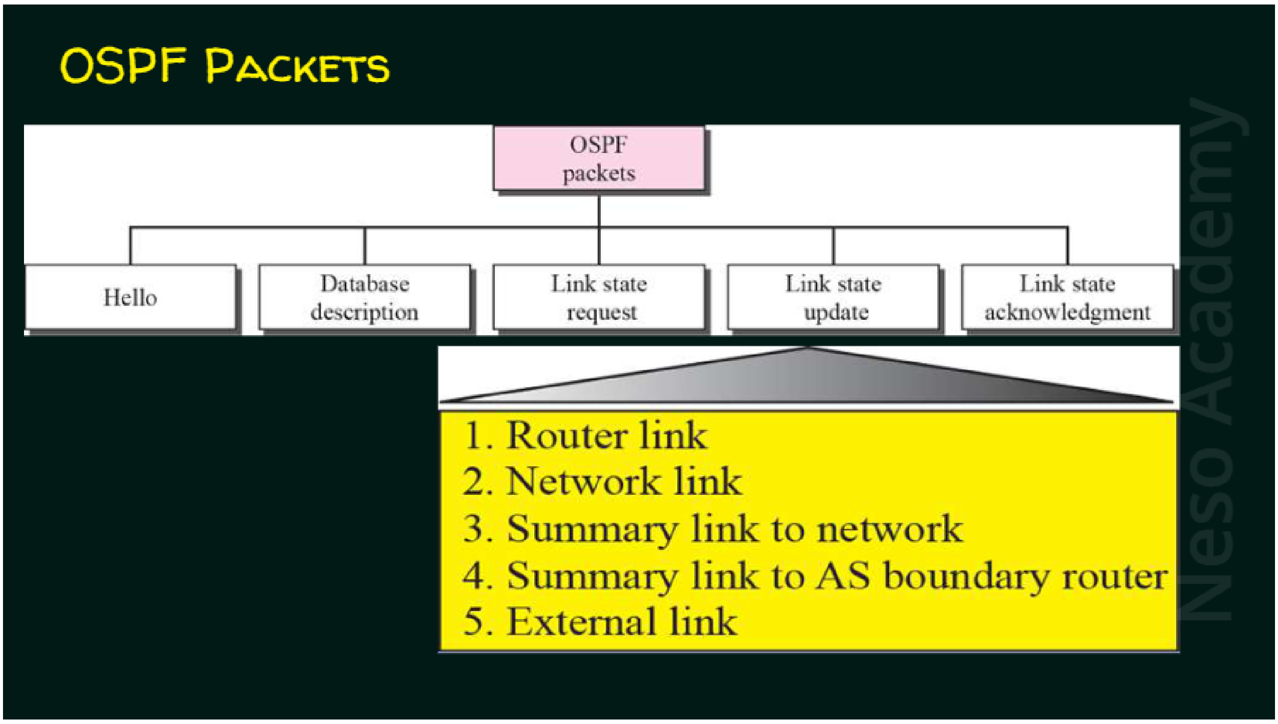
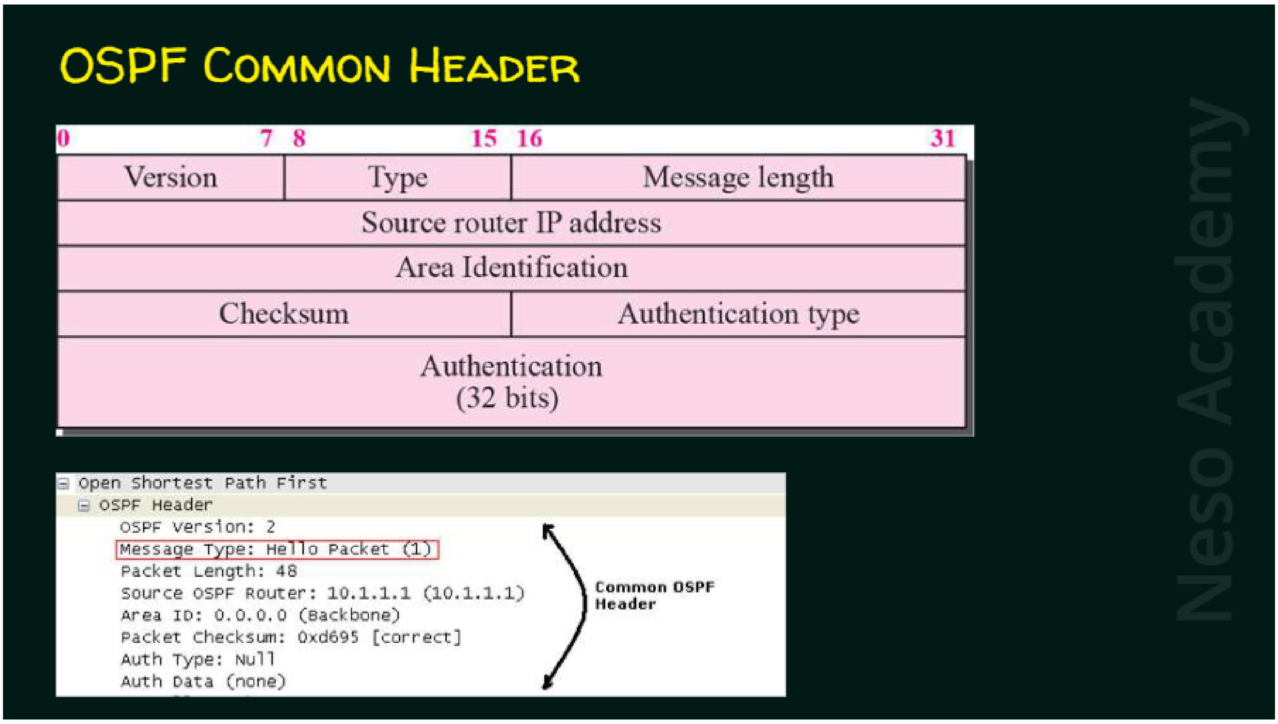
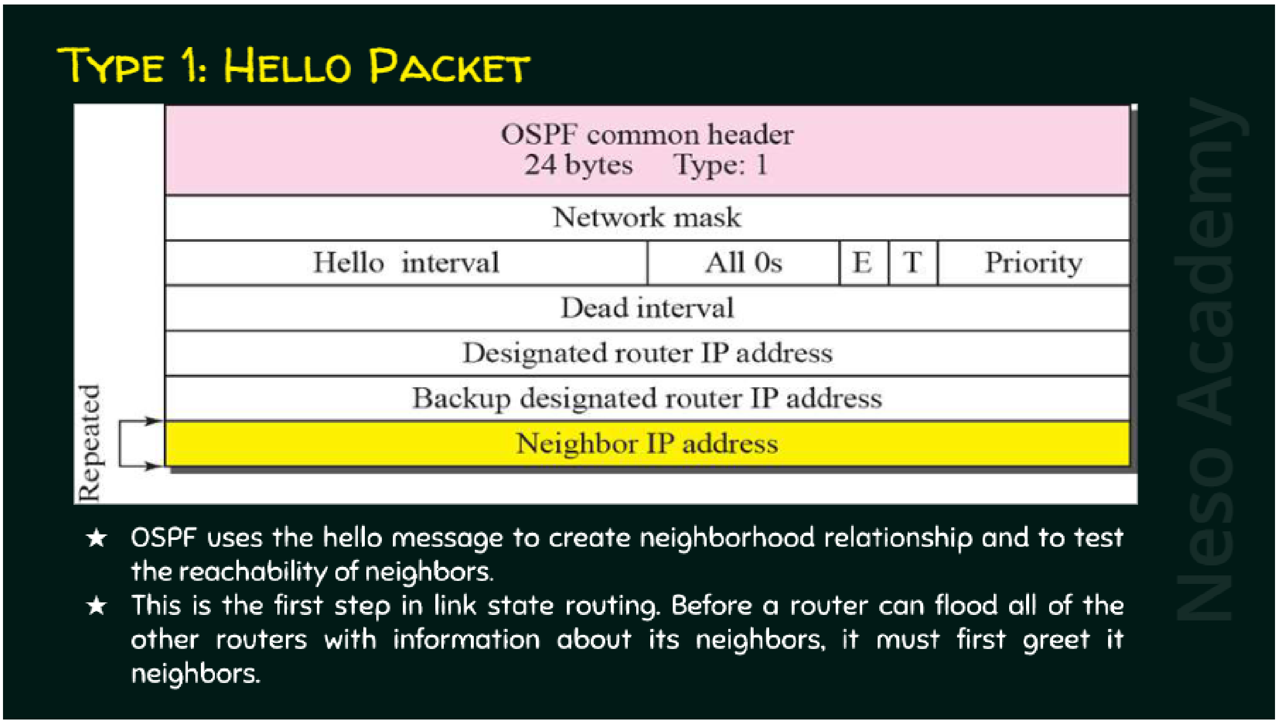


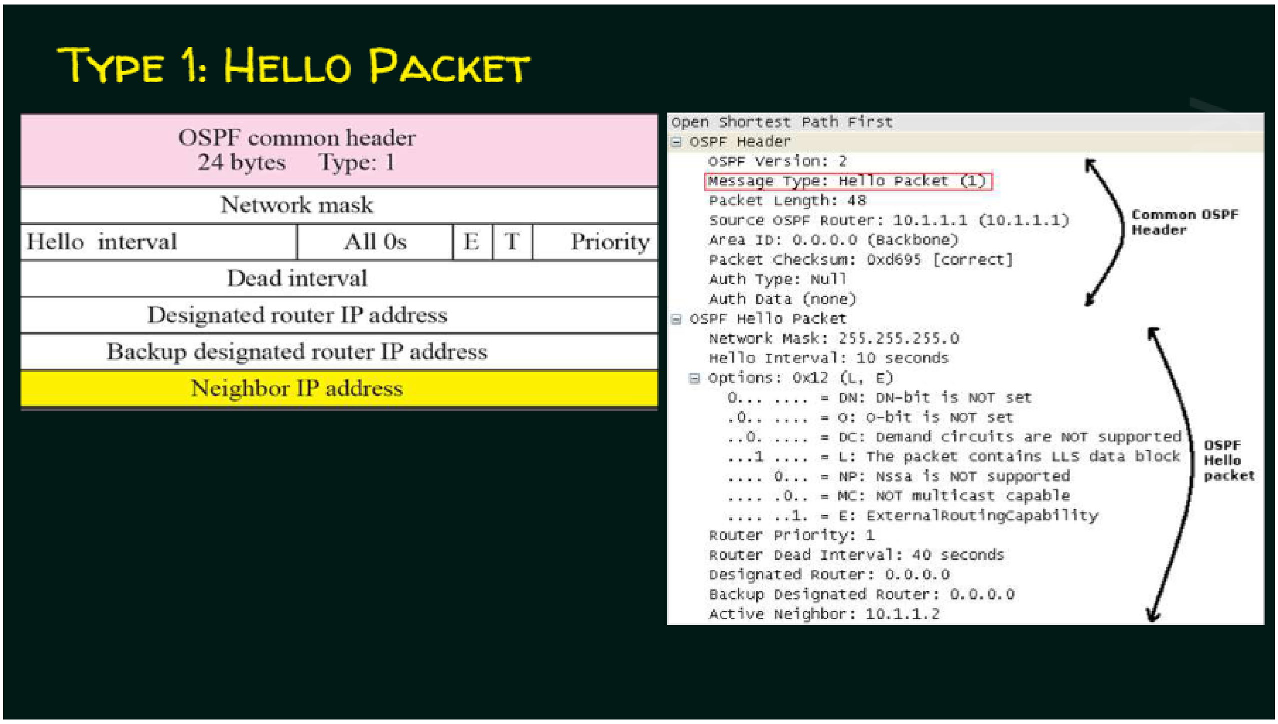
OSPF PacketsNeso Academy



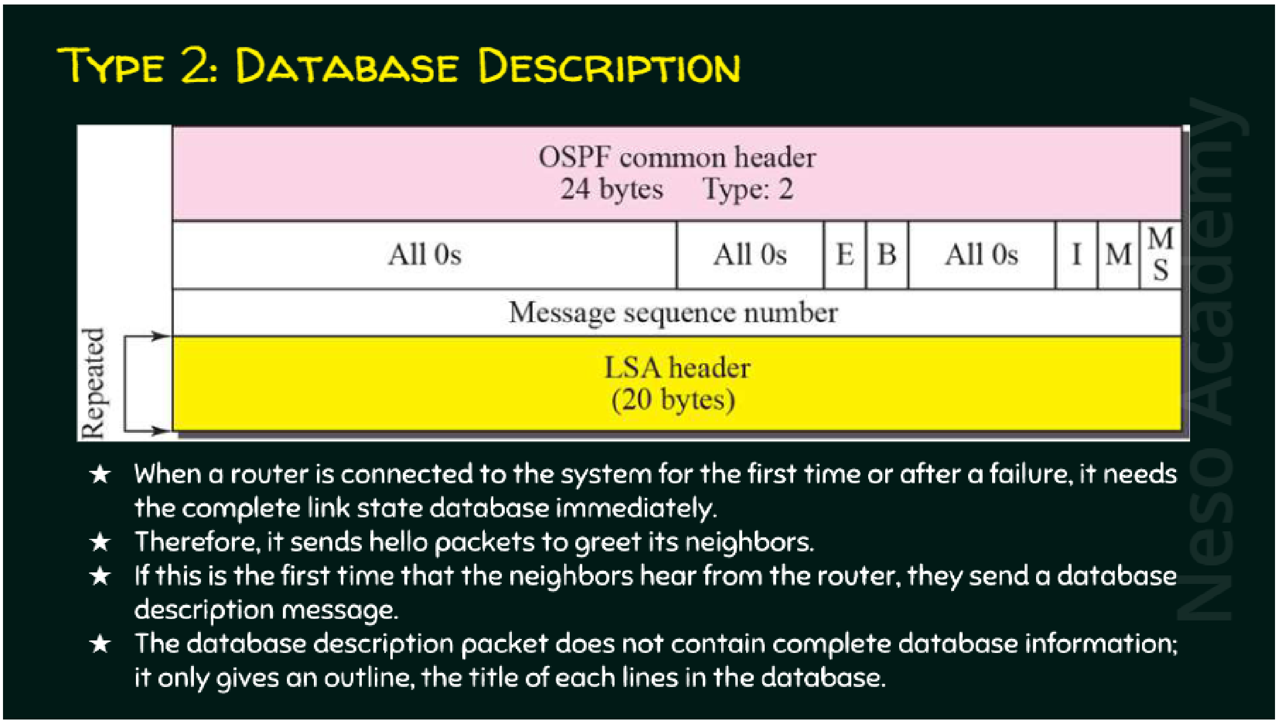
OSPF Common HeaderNeso Academy



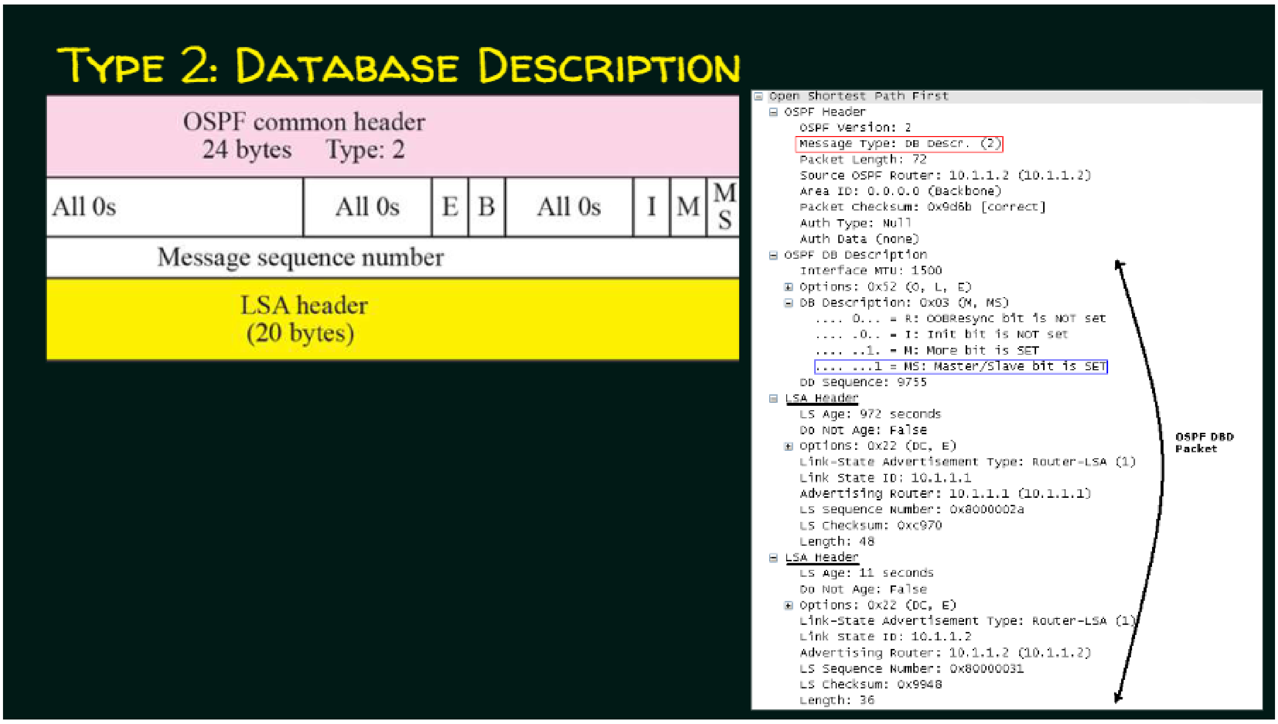
Type 1: Hello Packet★★Neso Academy



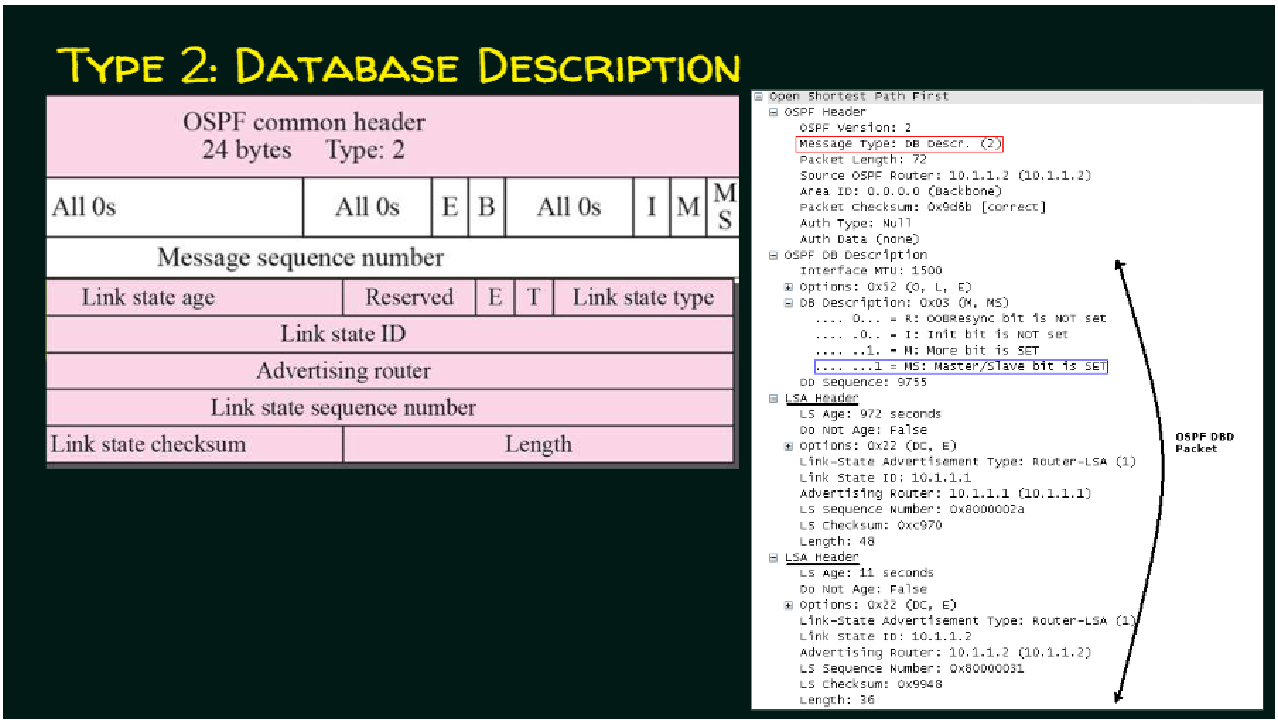
Type 1: Hello PacketNeso Academy



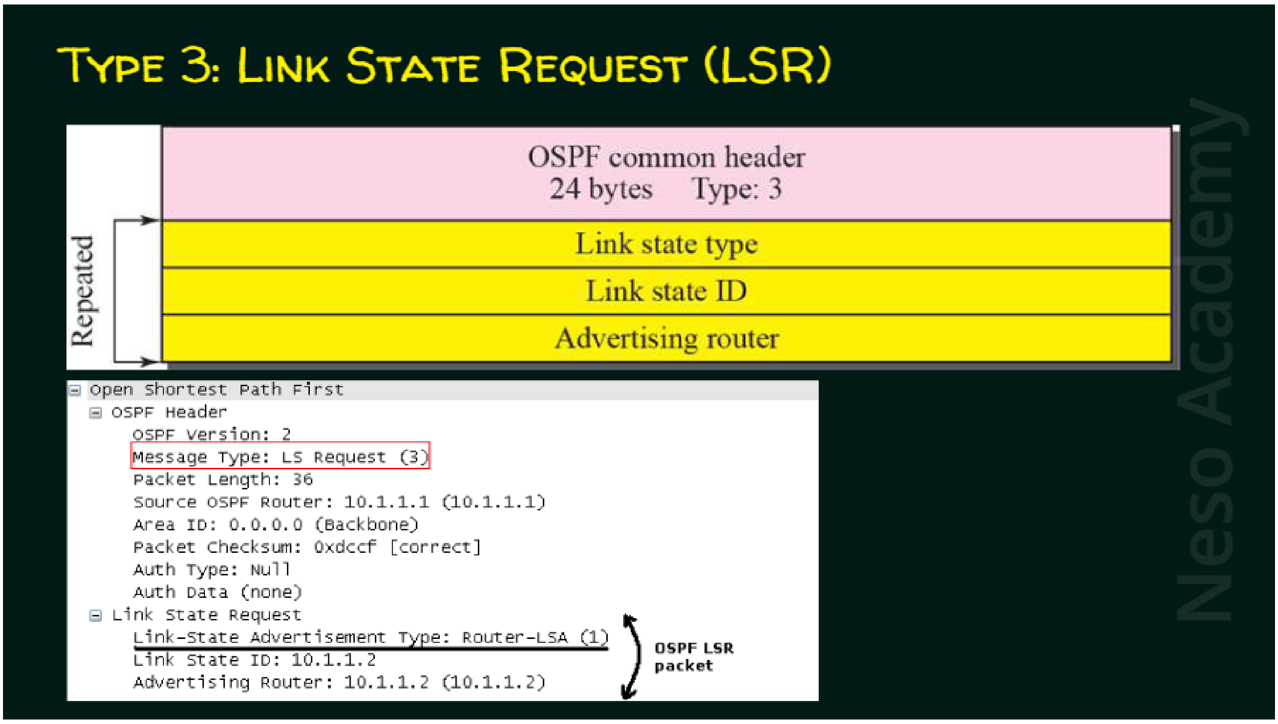
Type 2: Database Description★★★★Neso Academy



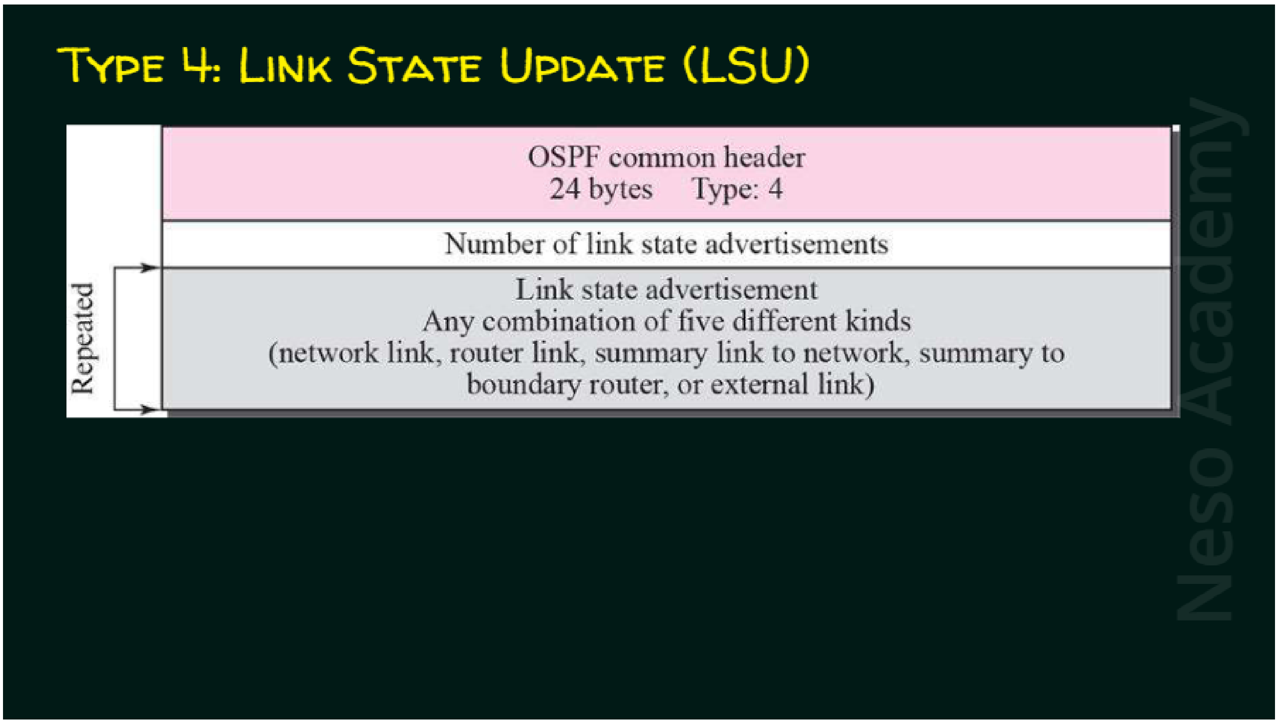
Type 2: Database DescriptionNeso Academy



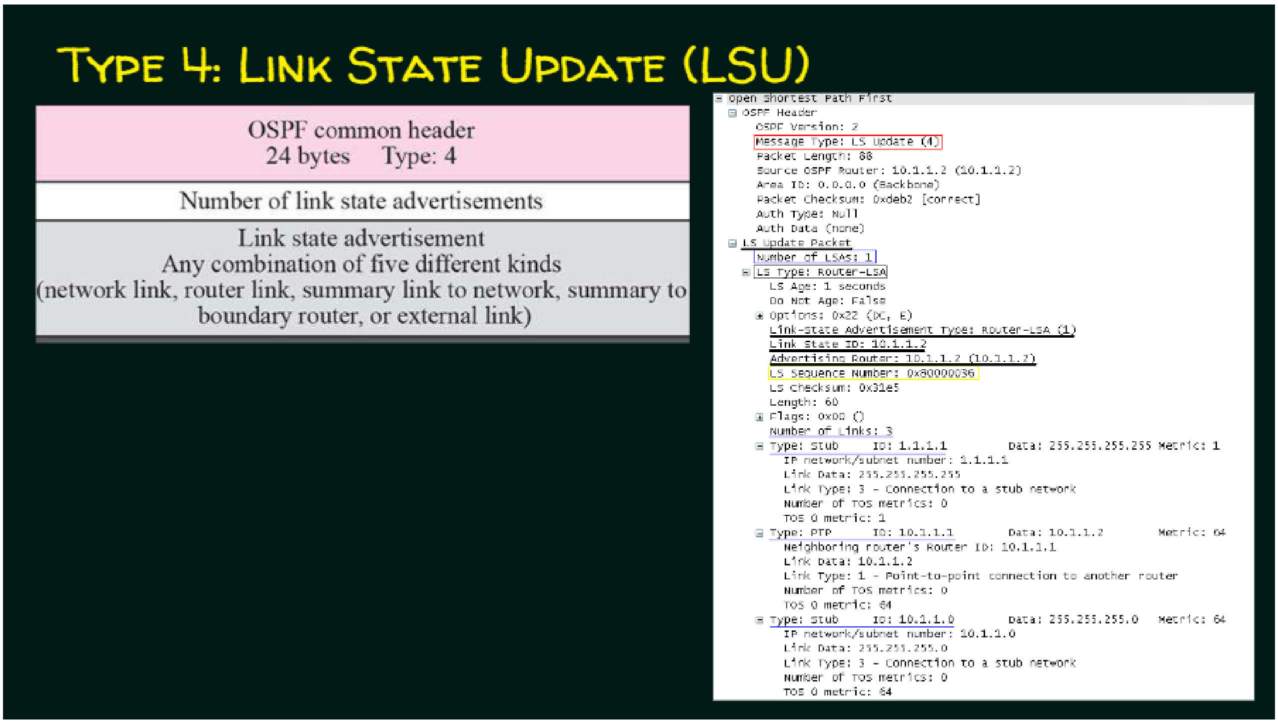
Type 2: Database DescriptionNeso Academy



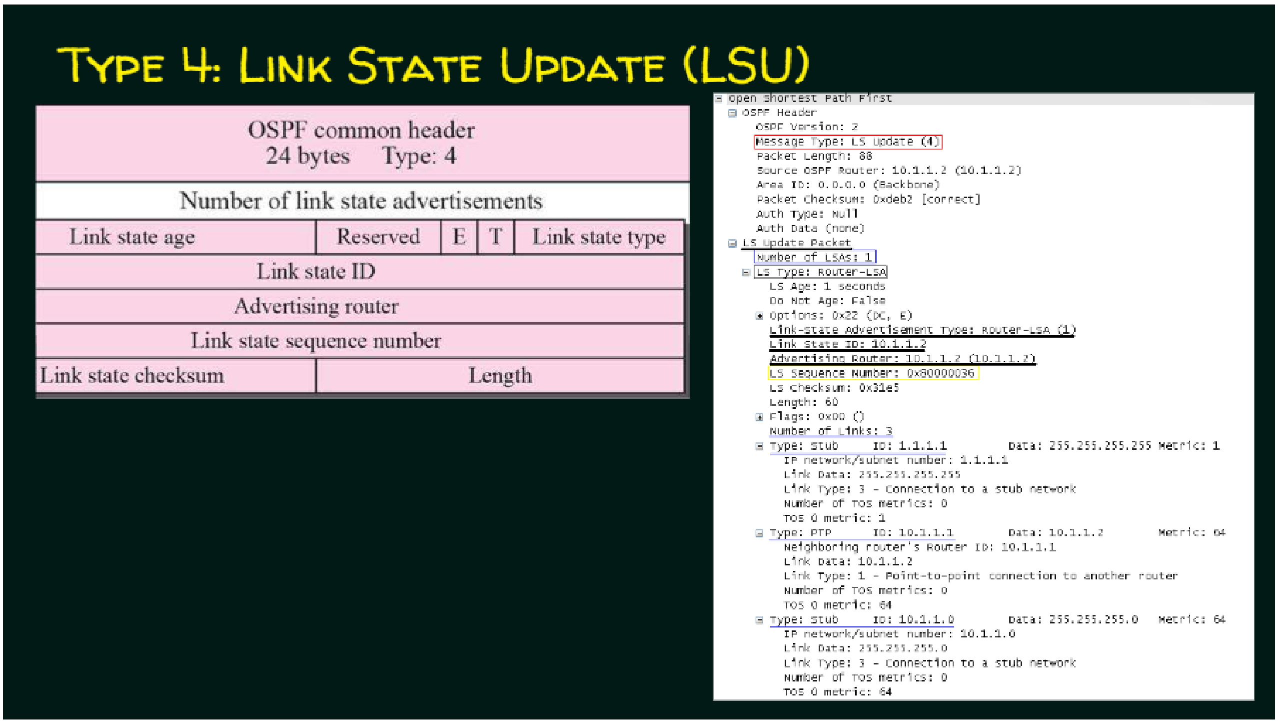
Type 3: Link State Request (LSR)Neso Academy



Type 4: Link State Update (LSU)Neso Academy

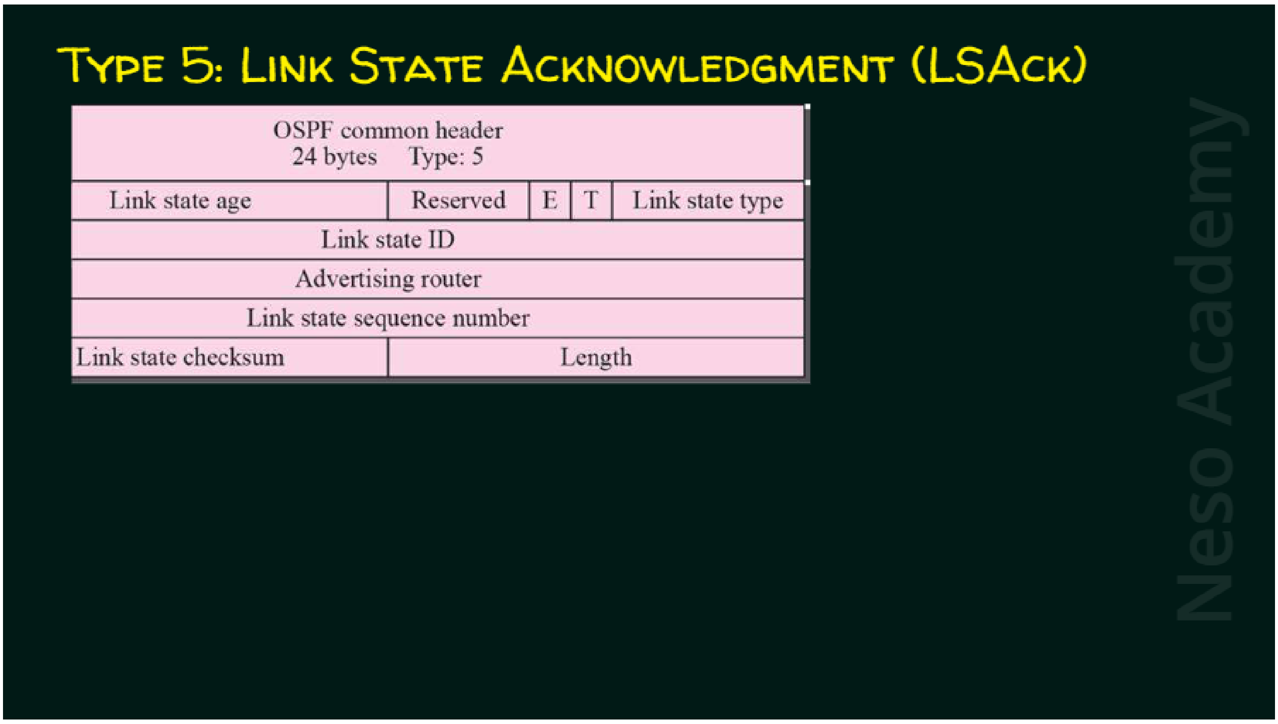


Type 4: Link State Update (LSU)Neso Academy

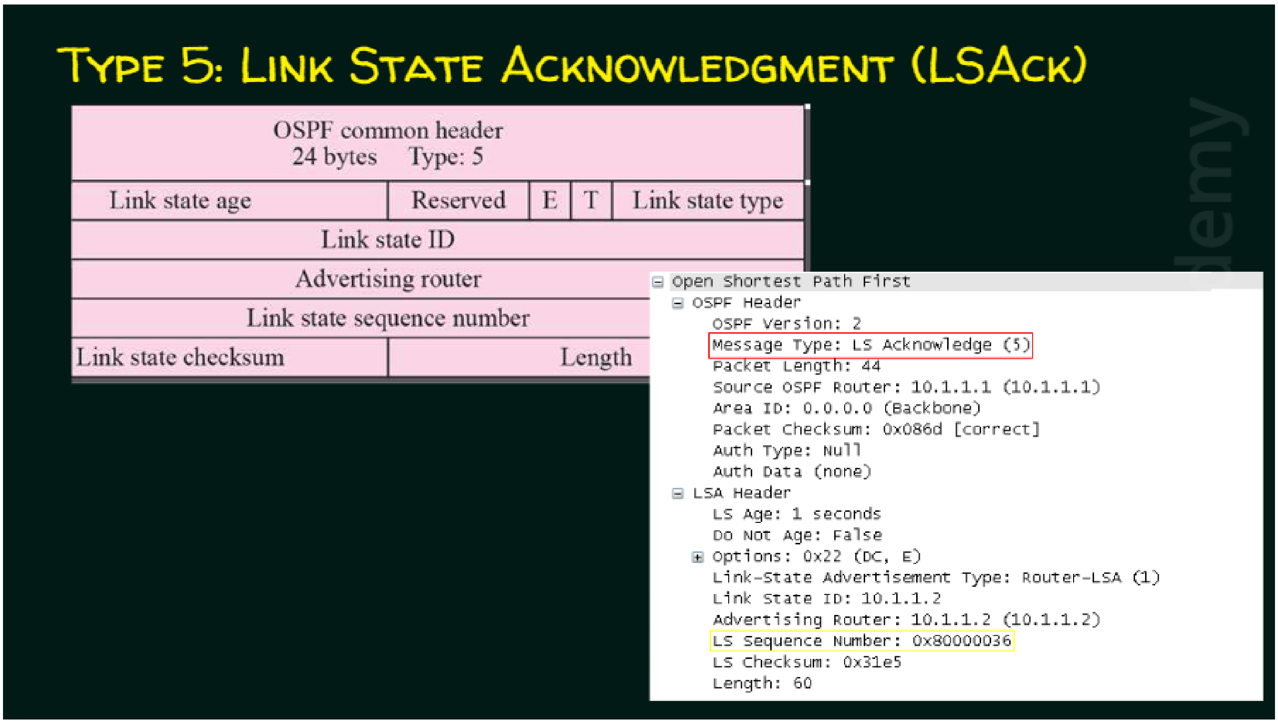


Type 4: Link State Update (LSU)Neso Academy

Type 5: Link State Acknowledgment (LSAck)Neso Academy



Type 5: Link State Acknowledgment (LSAck)Neso Academy



Type 5: Link State Acknowledgment (LSAck)Neso Academy

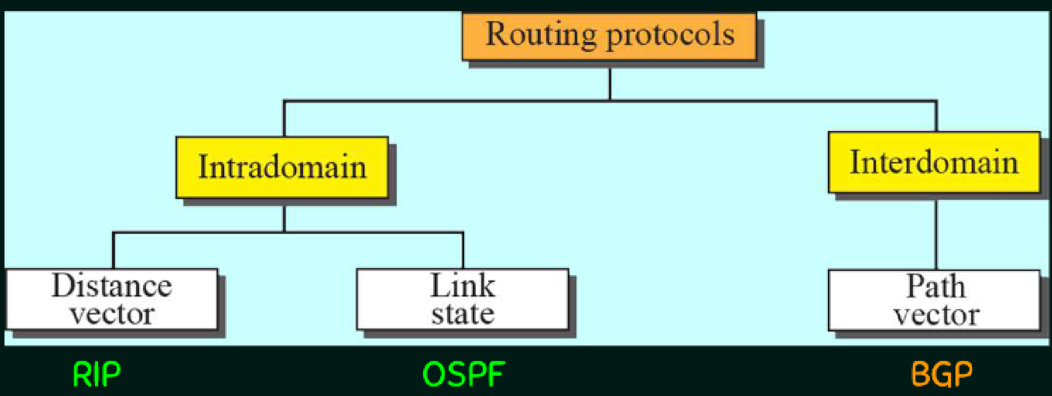
Outcomes

Upon the completion of this lecture, the learner will be able to

- ★ Understand the basics of BGP.
- ★ Understand the operation of BGP.

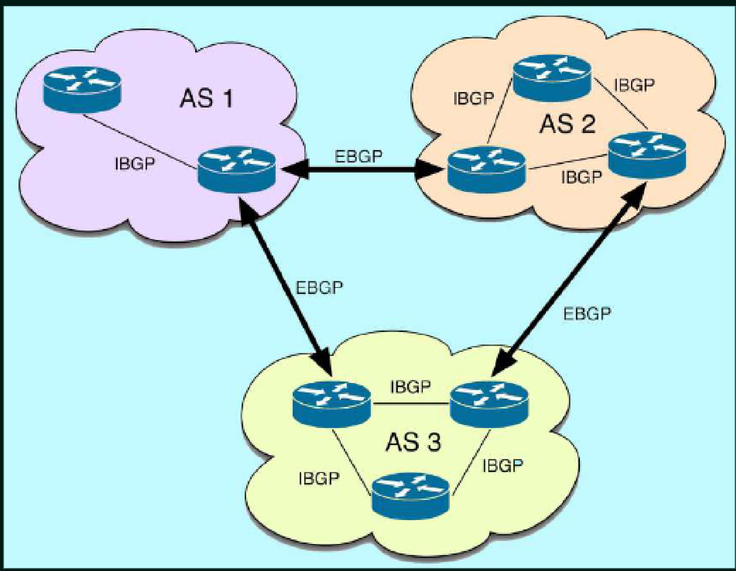
Outcomes★★Neso Academy

Routing protocols



Routing protocolsNeso Academy

BGP



BGPNeso Academy

BGP

★ Border Gateway Protocol (BGP) is a standardized exterior gateway protocol designed to exchange routing and reachability information among autonomous systems (AS) on the Internet

★ BGP is classified as a path-vector routing protocol and it makes routing decisions based on paths, network policies, or rule-sets configured by a network administrator.

★ BGP used for routing within an autonomous system is called Interior Border Gateway Protocol or Internal BGP (iBGP).

★ In contrast, the Internet application of the protocol is called Exterior Border Gateway Protocol or External BGP (eBGP).

BGP★★★★Neso Academy

BGP

★ The current version of BGP is version 4.

★ The major enhancement was the support for Classless Inter-Domain Routing (CIDR) and use of route aggregation to decrease the size of routing tables.

BGP★★Neso Academy

Operation of BGP

★ BGP neighbors, called peers, are established by manual configuration among routers to create a TCP session on port 179.

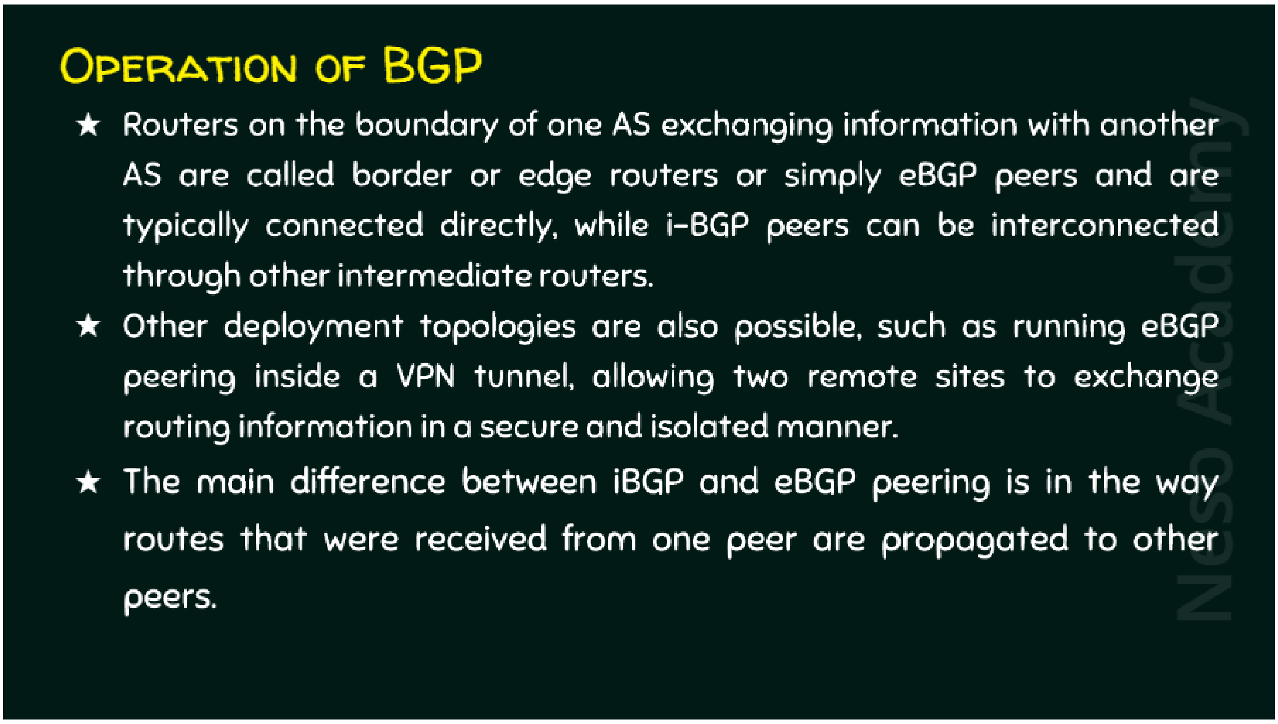
★ A BGP speaker sends 19-byte keep-alive messages every 60 seconds to maintain the connection.

★ Among routing protocols, BGP is unique in using TCP as its transport protocol and is the slowest routing protocol in the world.

★ When BGP runs between two peers in the same autonomous system (AS), it is referred to as Internal BGP (i-BGP or Interior Border Gateway Protocol).

★ When it runs between different autonomous systems, it is called External BGP (eBGP or Exterior Border Gateway Protocol).

Operation of BGP★★★★★Neso Academy



Operation of BGP★★★Neso Academy