Reviewing Routing Operations

Medium-Sized Routed Network Construction

Why Routing

- Routes Data Packets
- Selects Best path to Deliver Data
- Provides Path Selection

Routing Table Entries

- Directly connected: Router attaches to this network
- Static routing: Entered manually by a system administrator
- Dynamic routing: Learned by exchange of routing information
- Default route: Statically or dynamically learned; used when no explicit route to network is known

Static vs. Dynamic Routes

Static Route

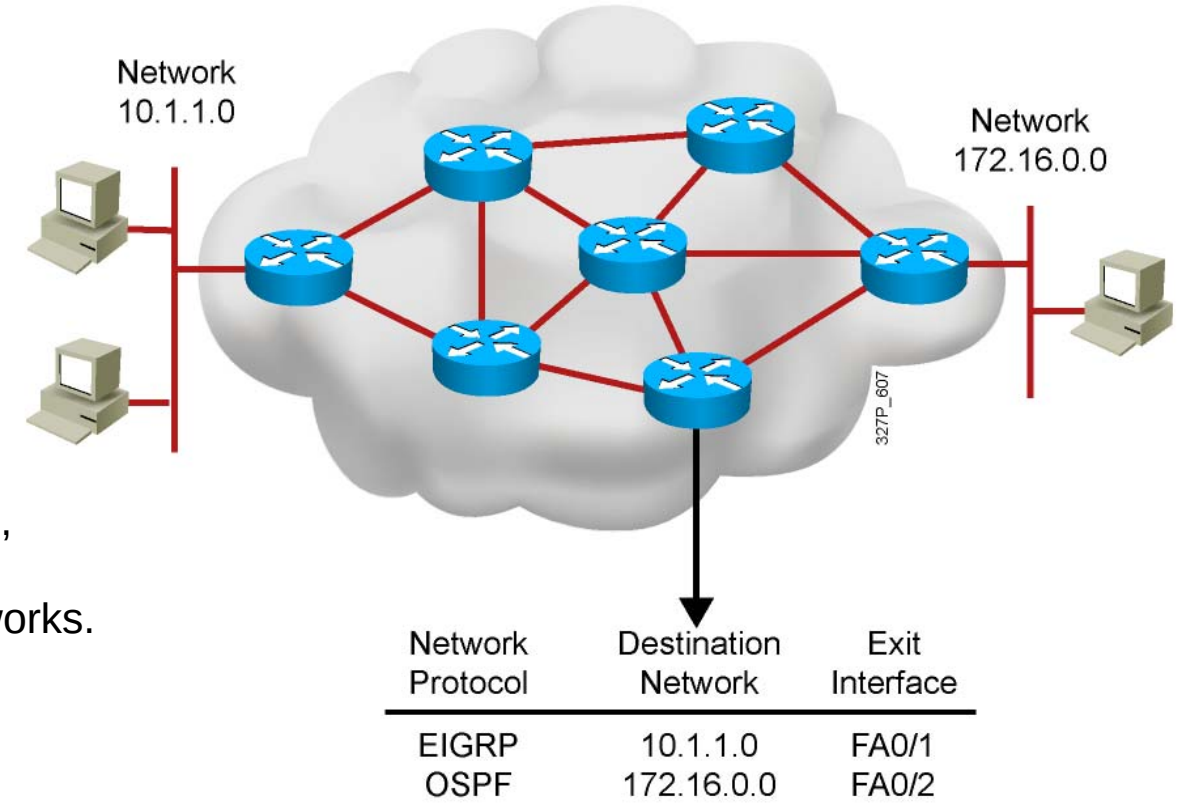
- Uses a route that a network administrator enters into the router manually

Dynamic Route

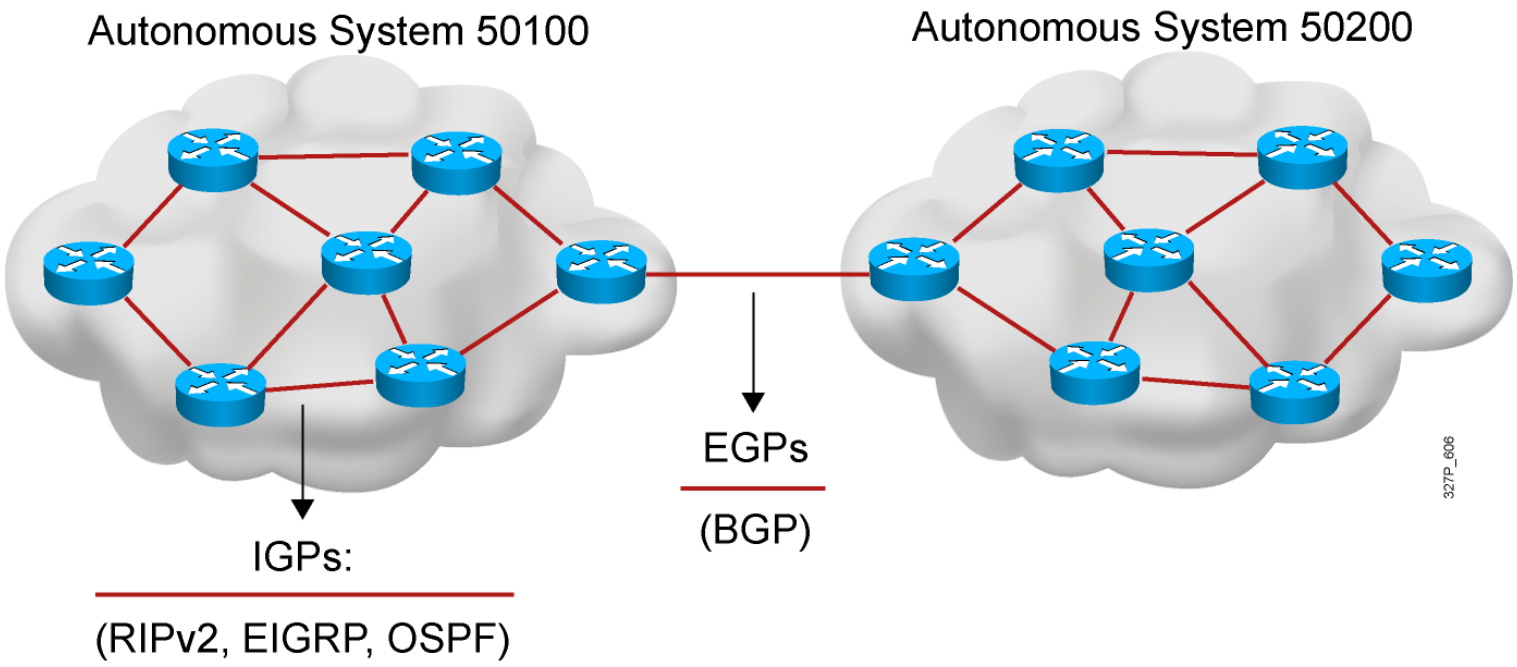
- Uses a route that a network routing protocol adjusts automatically for topology or traffic changes

What Is a Dynamic Routing Protocol?

- Routing protocols are used between routers to determine paths to remote networks and maintain those networks in the routing tables.
- After the path is determined, a router can route a routed protocol to the learned networks.



Autonomous Systems: Interior and Exterior Routing Protocols



- An autonomous system is a collection of networks within a common administrative domain.
- Interior gateway protocols operate within an autonomous system.
- Exterior gateway protocols connect different autonomous systems.

Classful Routing

- Classful routing protocols do not include the subnet mask with the network in the routing advertisement.
- Within the same network, consistency of the subnet masks is assumed, one subnet mask for the entire network.
- Examples of classful routing protocols include:
  - RIPv1
  - IGRP

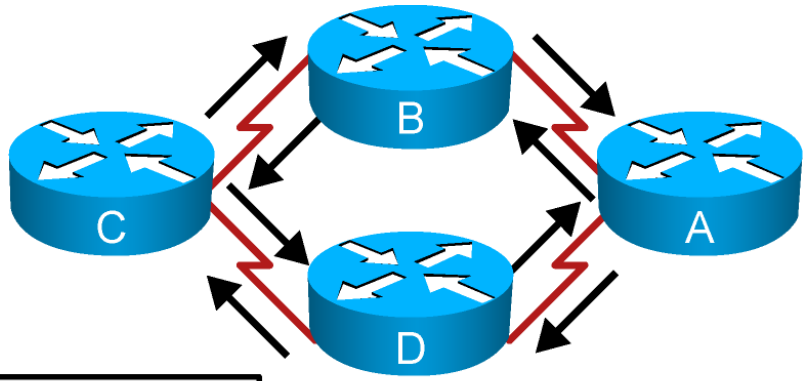
Note: Classful routing protocols are legacy routing protocols typically used to address compatibility issues. RIP version 1 and Interior Gateway Routing Protocol (IGRP) are introduced to provide examples.

Classless Routing

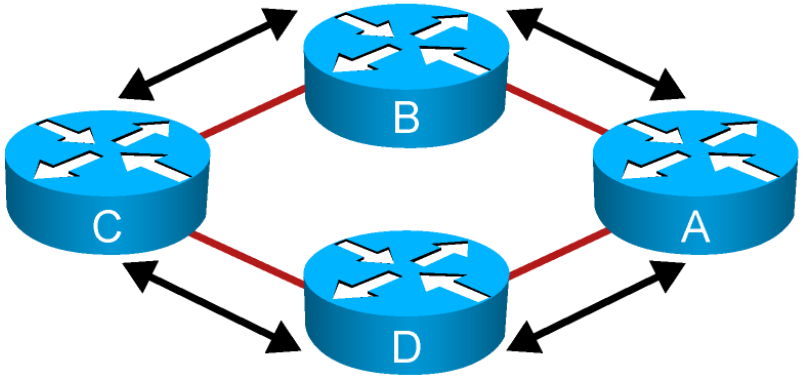
- Classless routing protocols include the subnet mask with the network in the advertisement.
- Classless routing protocols support VLSM (Variable Length Subnet Mask); one network can have multiple masks.
- Examples of classless routing protocols include:
  - RIPv2
  - OSPF
- RIPv2 acts classful by default.
  - The no auto-summary command forces this protocol to behave as if they are classless.

Classes of Routing Protocols

Distance Vector



Advanced Distance Vector



Link-State

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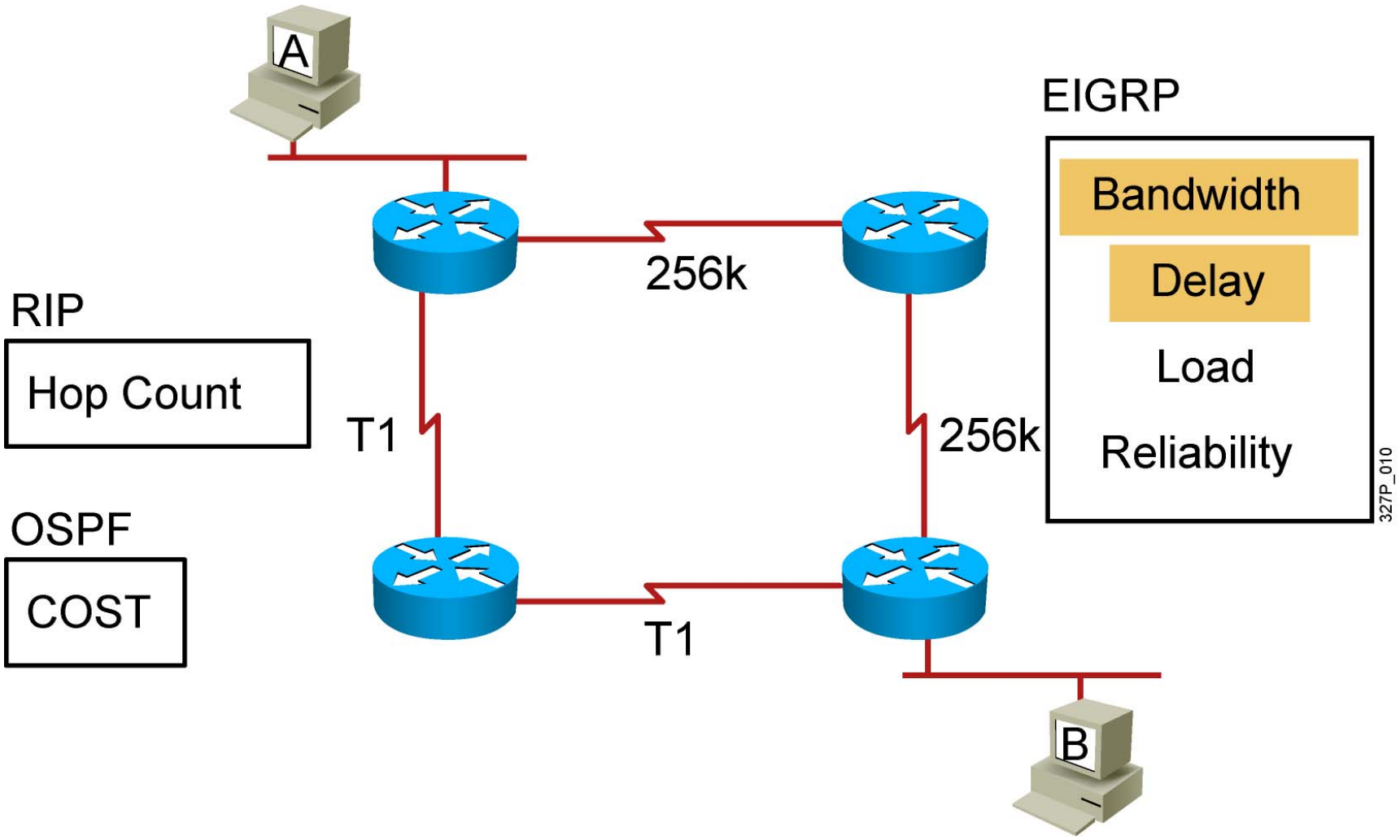
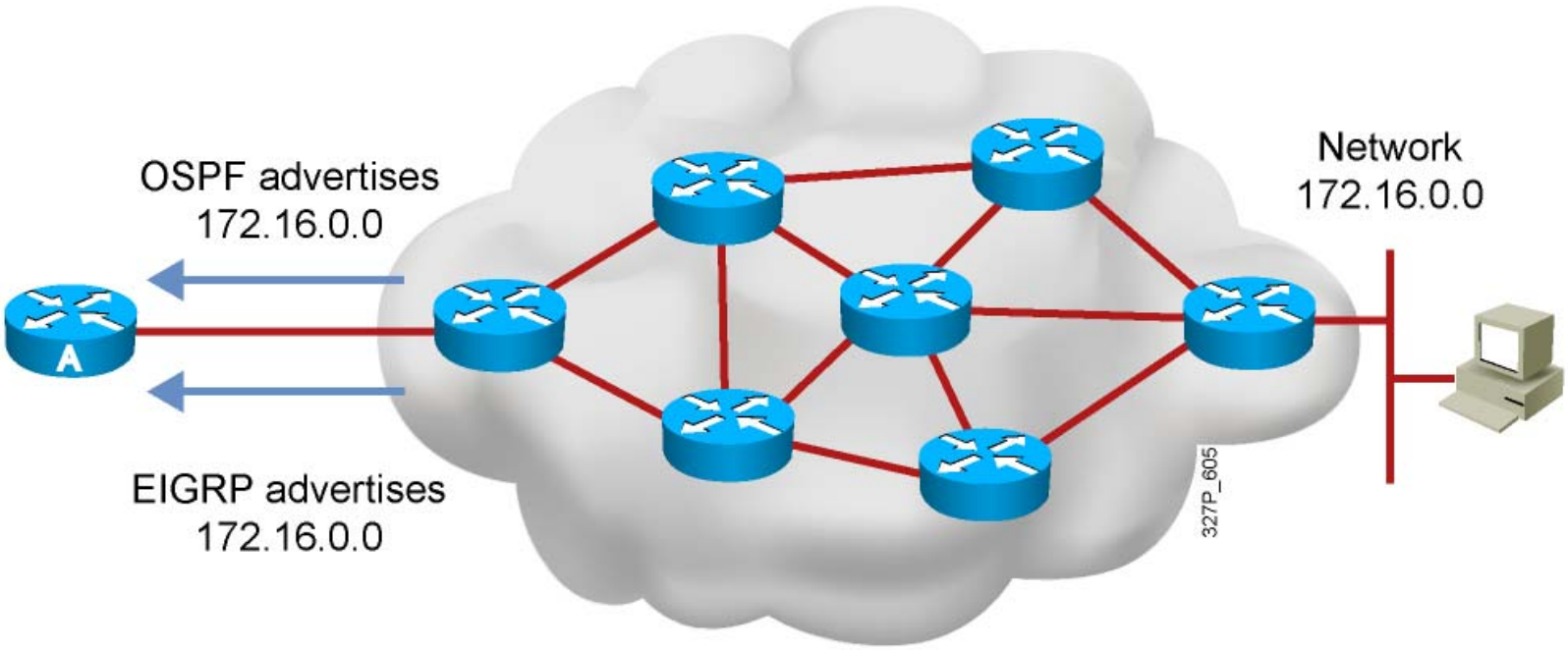
Selecting the Best Route Using Metrics



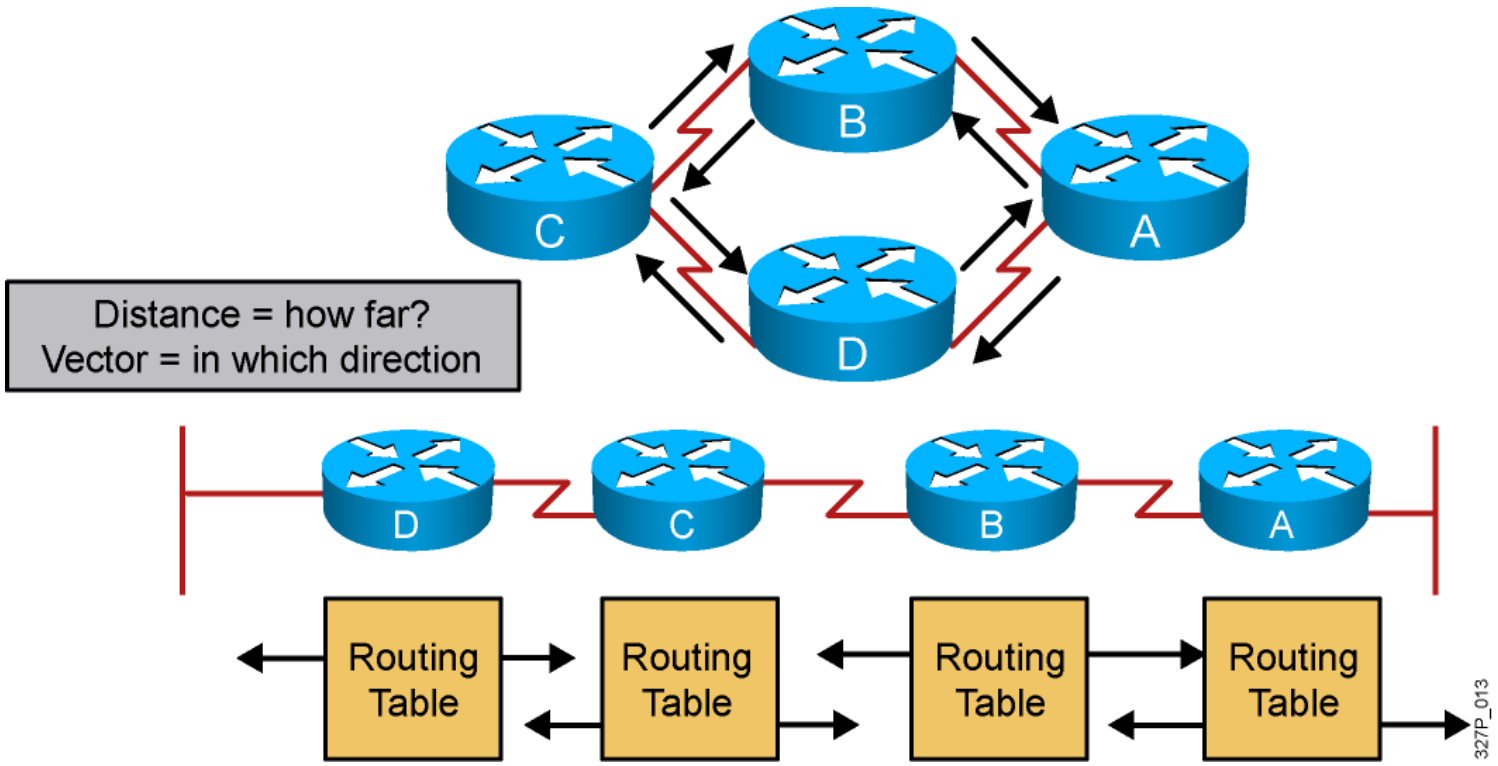
Administrative Distance: Ranking Routing Sources



Routers choose the routing source with the best administrative distance:

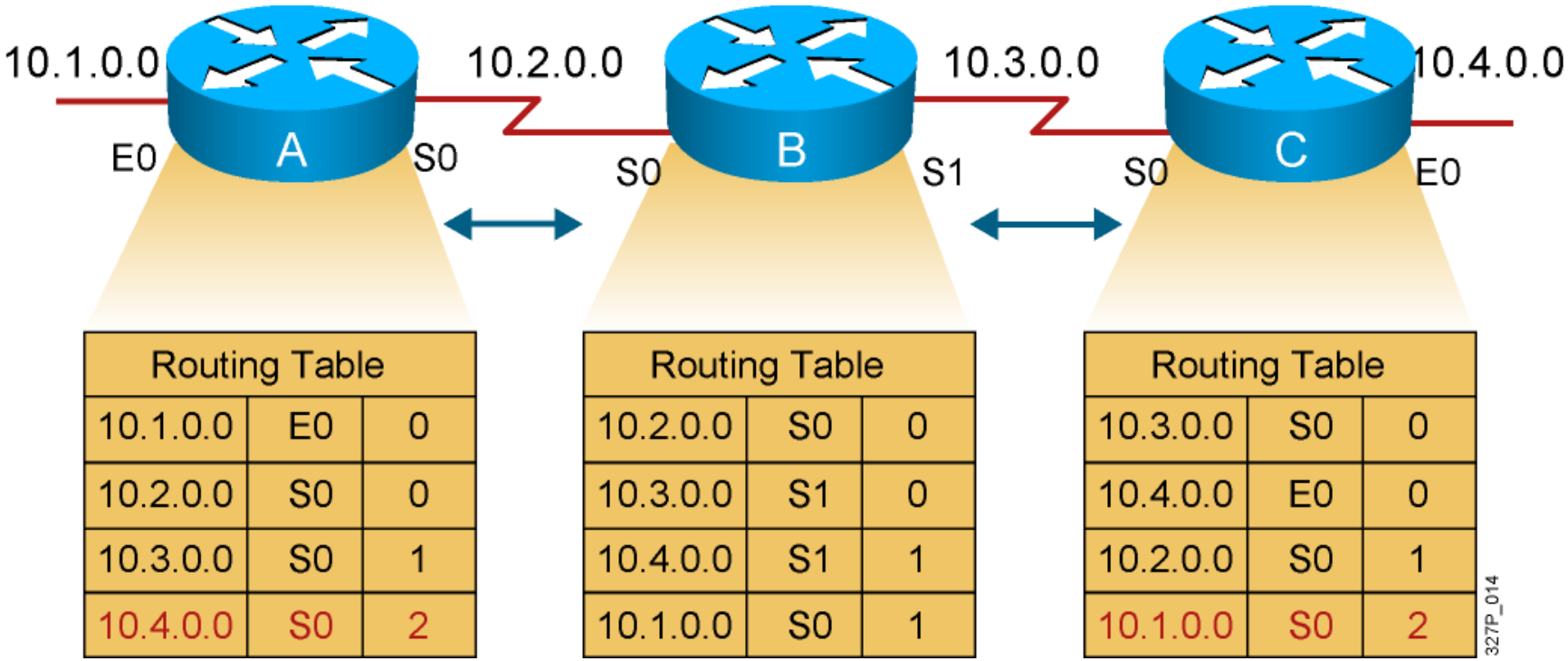
- OSPF has an administrative distance of 110.
- EIGRP has an administrative distance of 90.

Distance Vector Routing Protocols



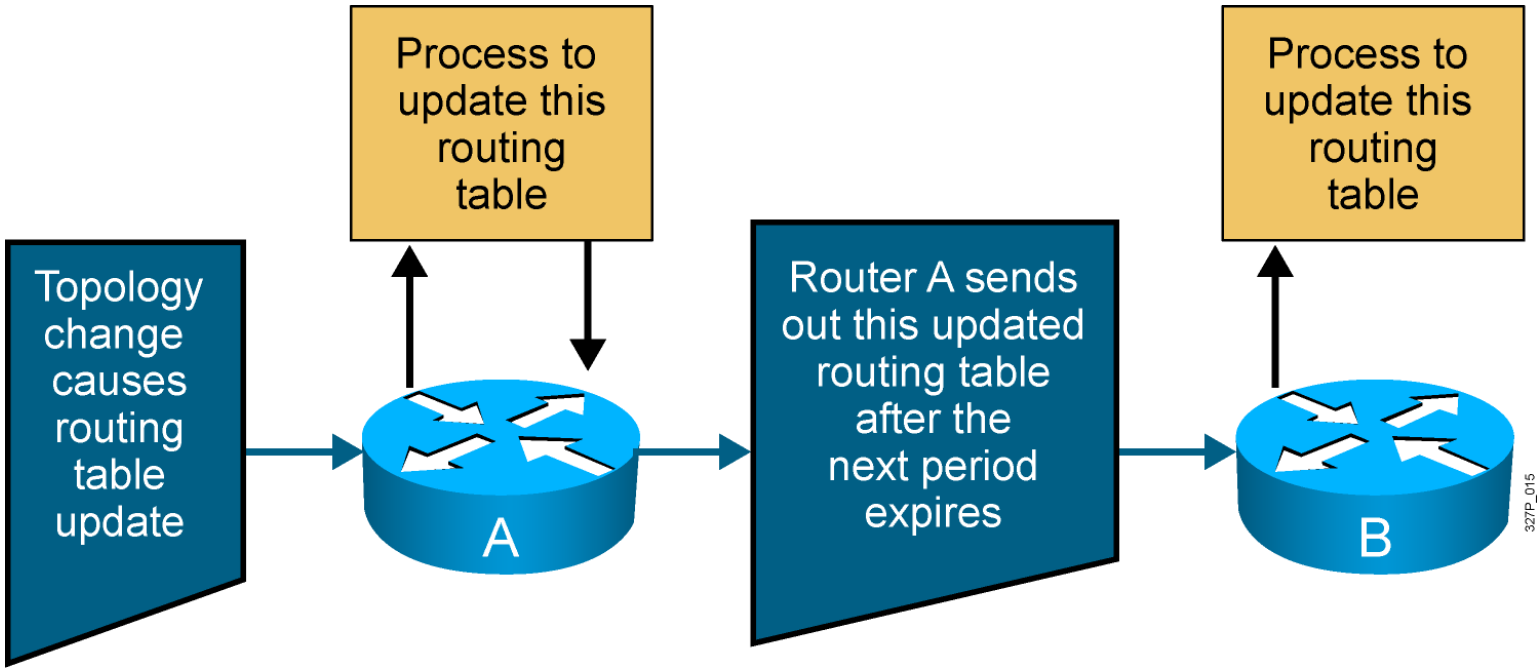
Routers pass periodic copies of their routing table to neighboring routers and accumulate distance vectors.

Sources of Information and Discovering Routes



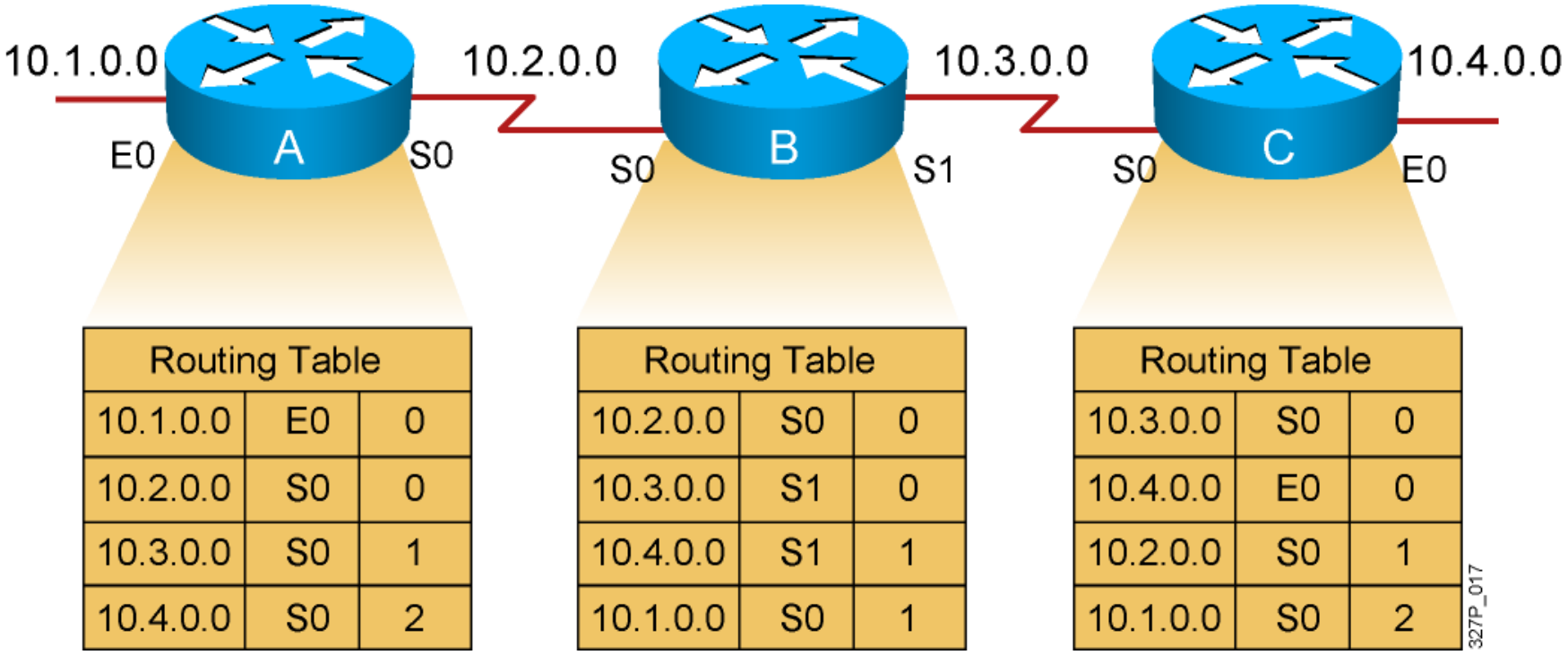
Routers discover the best path to destinations from each neighbor.

Maintaining Routing Information



Updates proceed step by step from router to router.

Inconsistent Routing Entries: Counting to Infinity and Routing Loops



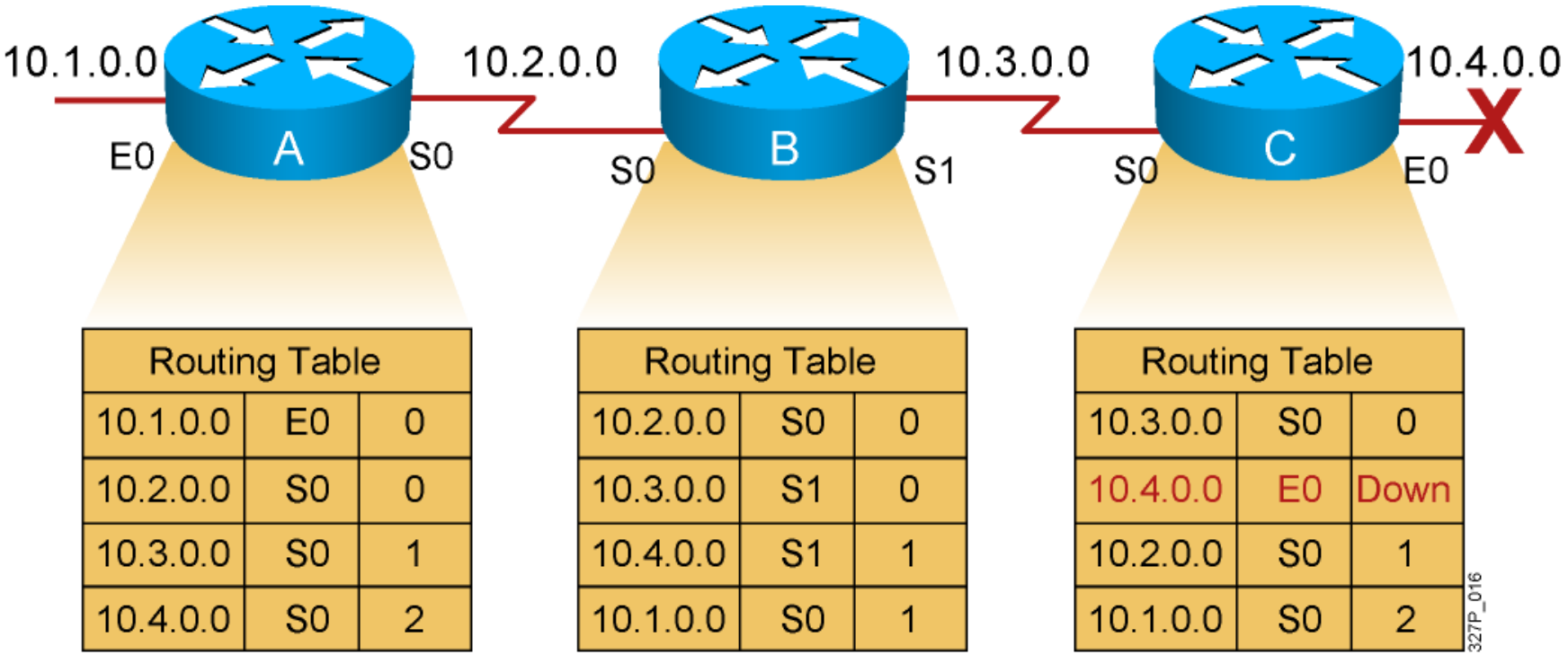
Routing Table		
10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	2

Routing Table		
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	1
10.1.0.0	S0	1

Routing Table		
10.3.0.0	S0	0
10.4.0.0	E0	0
10.2.0.0	S0	1
10.1.0.0	S0	2

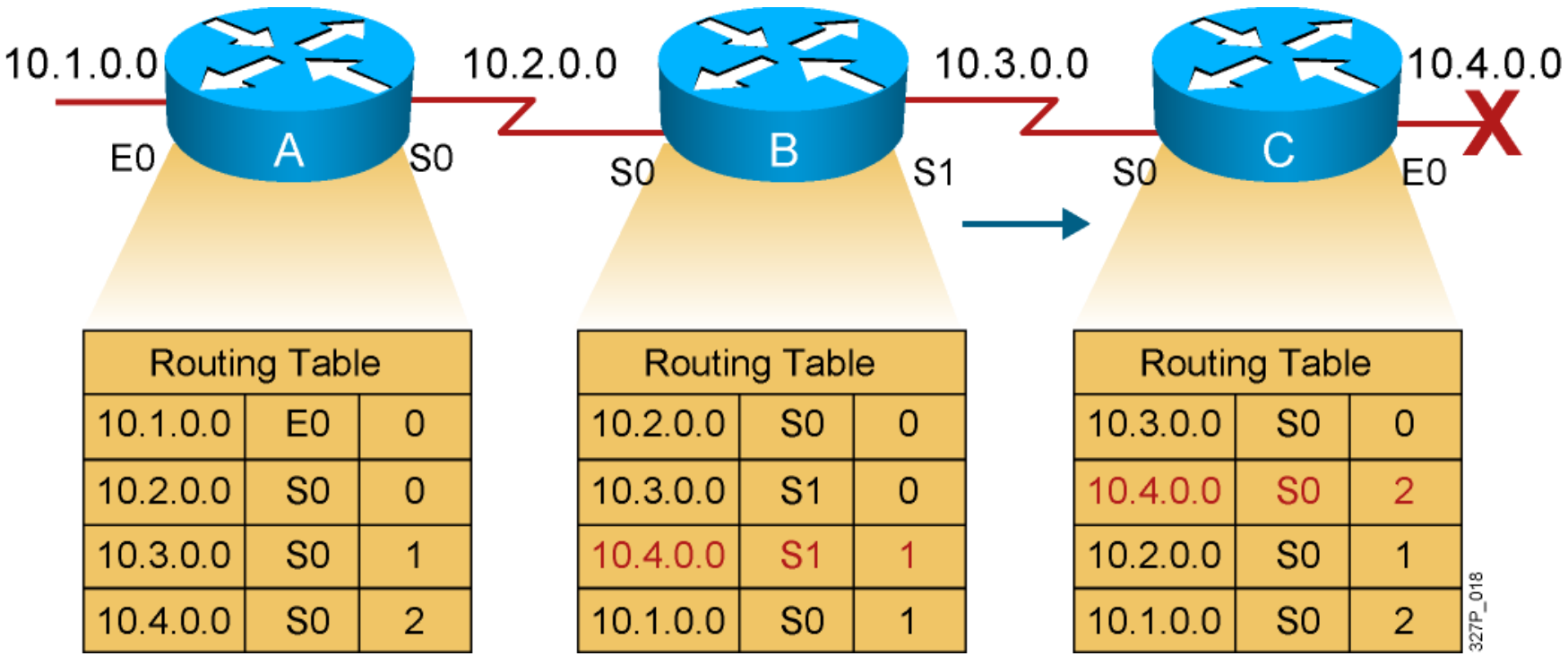
Each node maintains the distance from itself to each possible destination network.

Counting to Infinity



Slow convergence produces inconsistent routing.

Counting to Infinity (Cont.)



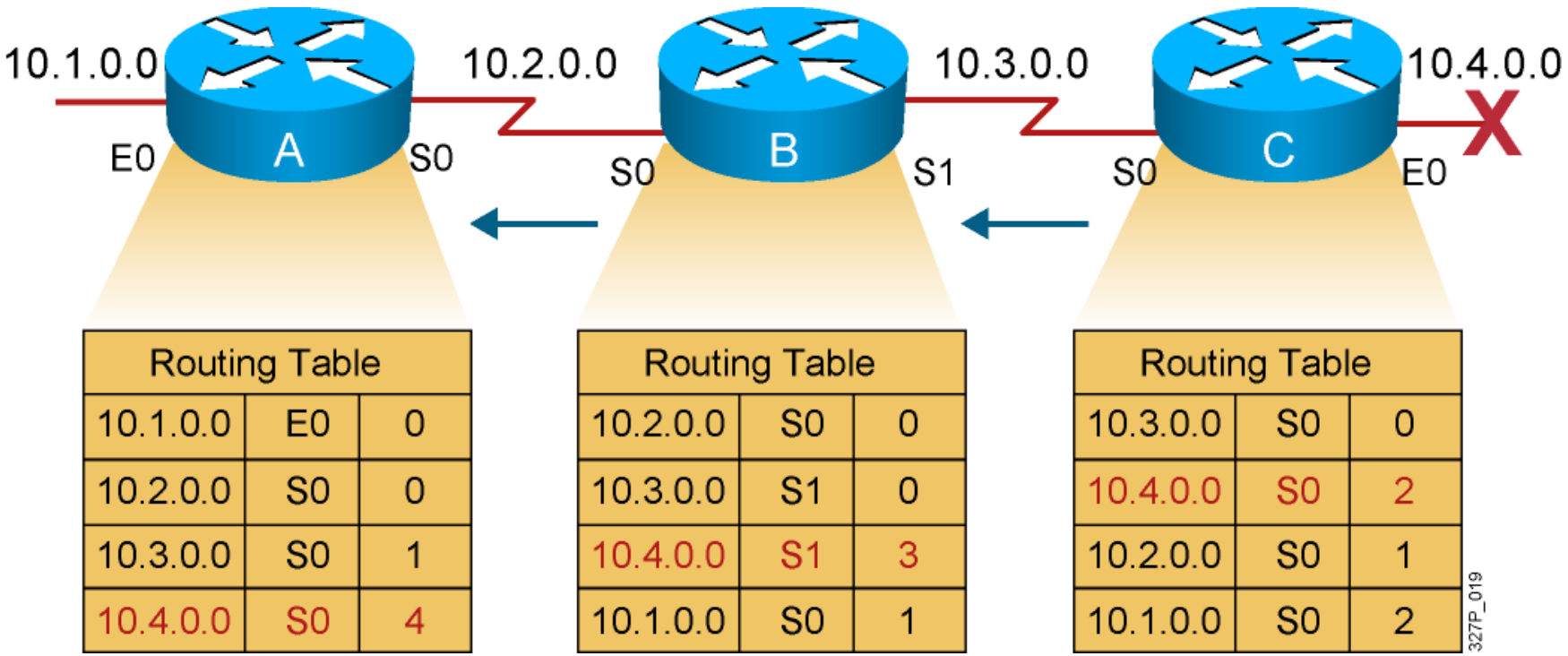
Routing Table		
10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	2

Routing Table		
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	1
10.1.0.0	S0	1

Routing Table		
10.3.0.0	S0	0
10.4.0.0	S0	2
10.2.0.0	S0	1
10.1.0.0	S0	2

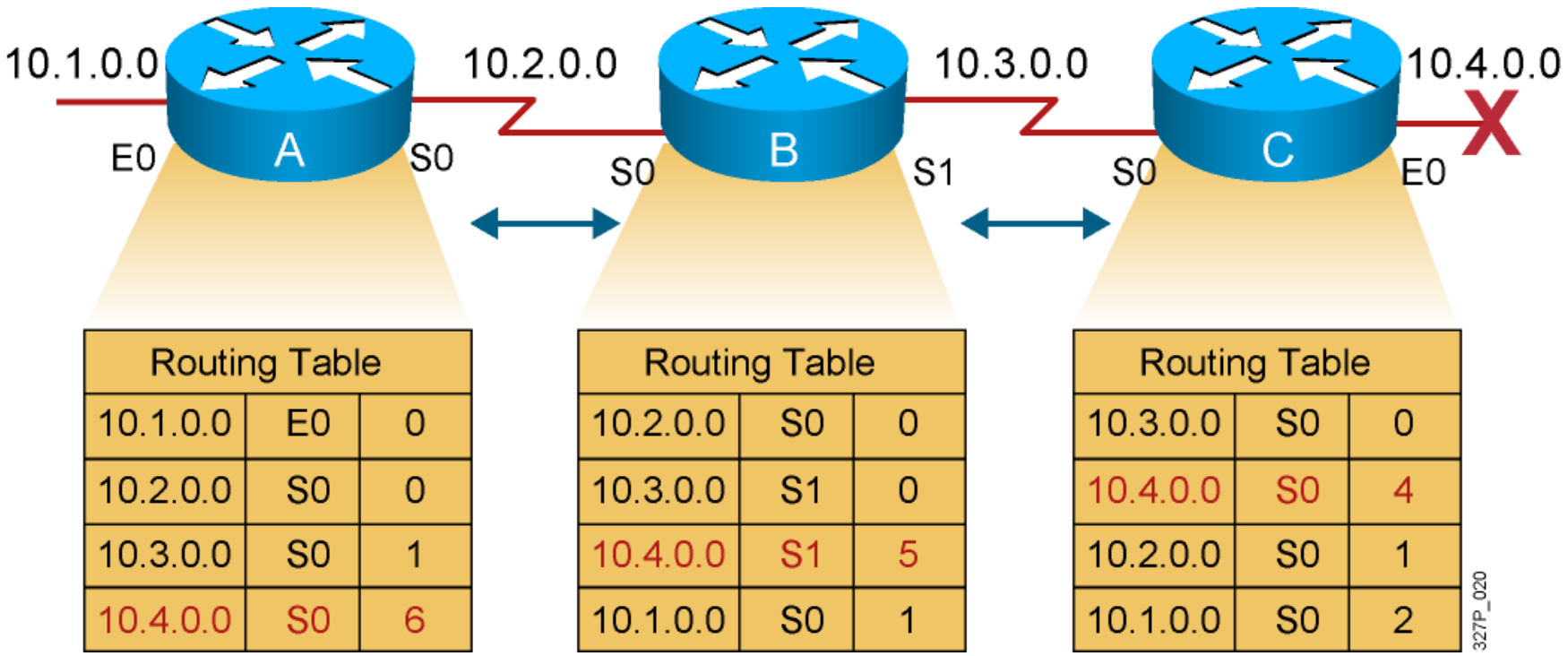
Router C concludes that the best path to network 10.4.0.0 is through router B.

Counting to Infinity (Cont.)



Router A updates its table to reflect the new but erroneous hop count.

Counting to Infinity (Cont.)



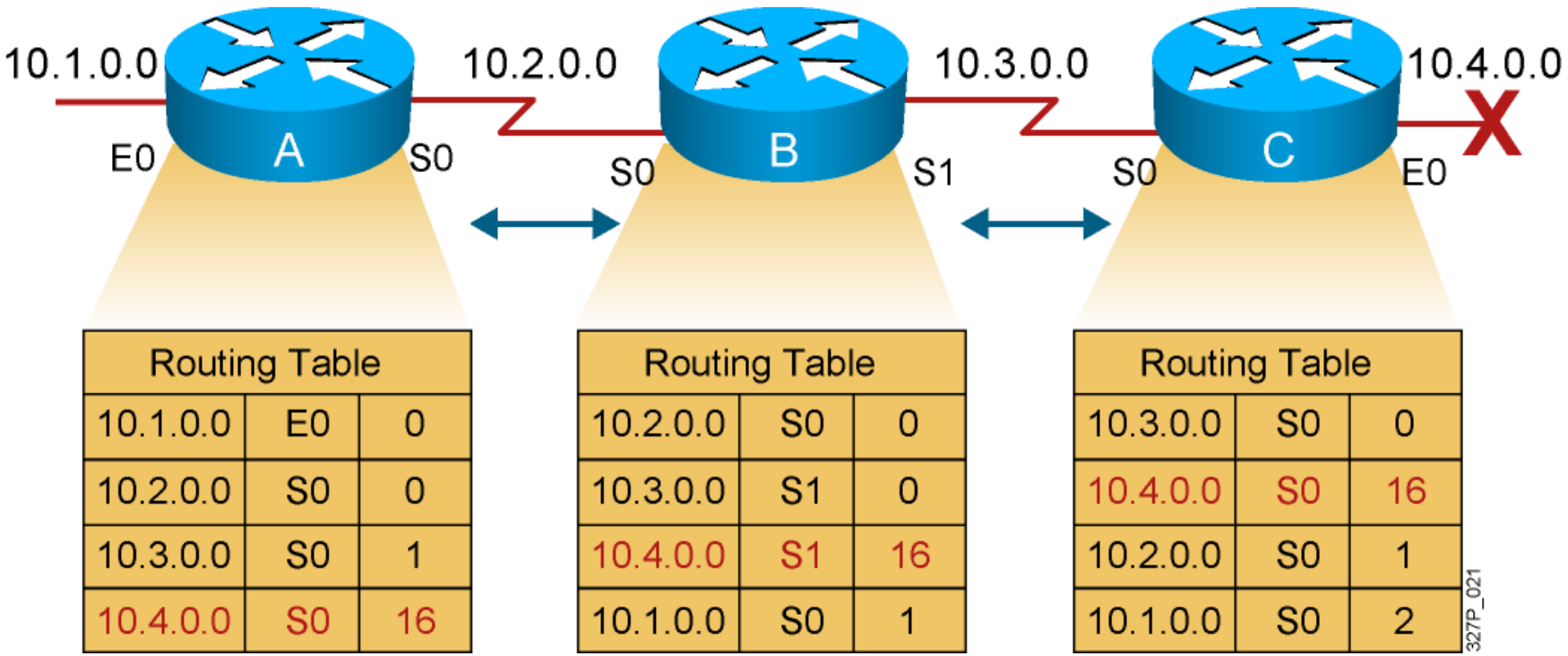
Routing Table		
10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	6

Routing Table		
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	5
10.1.0.0	S0	1

Routing Table		
10.3.0.0	S0	0
10.4.0.0	S0	4
10.2.0.0	S0	1
10.1.0.0	S0	2

The hop count for network 10.4.0.0 counts to infinity.

Solution to Counting to Infinity: Defining a Maximum



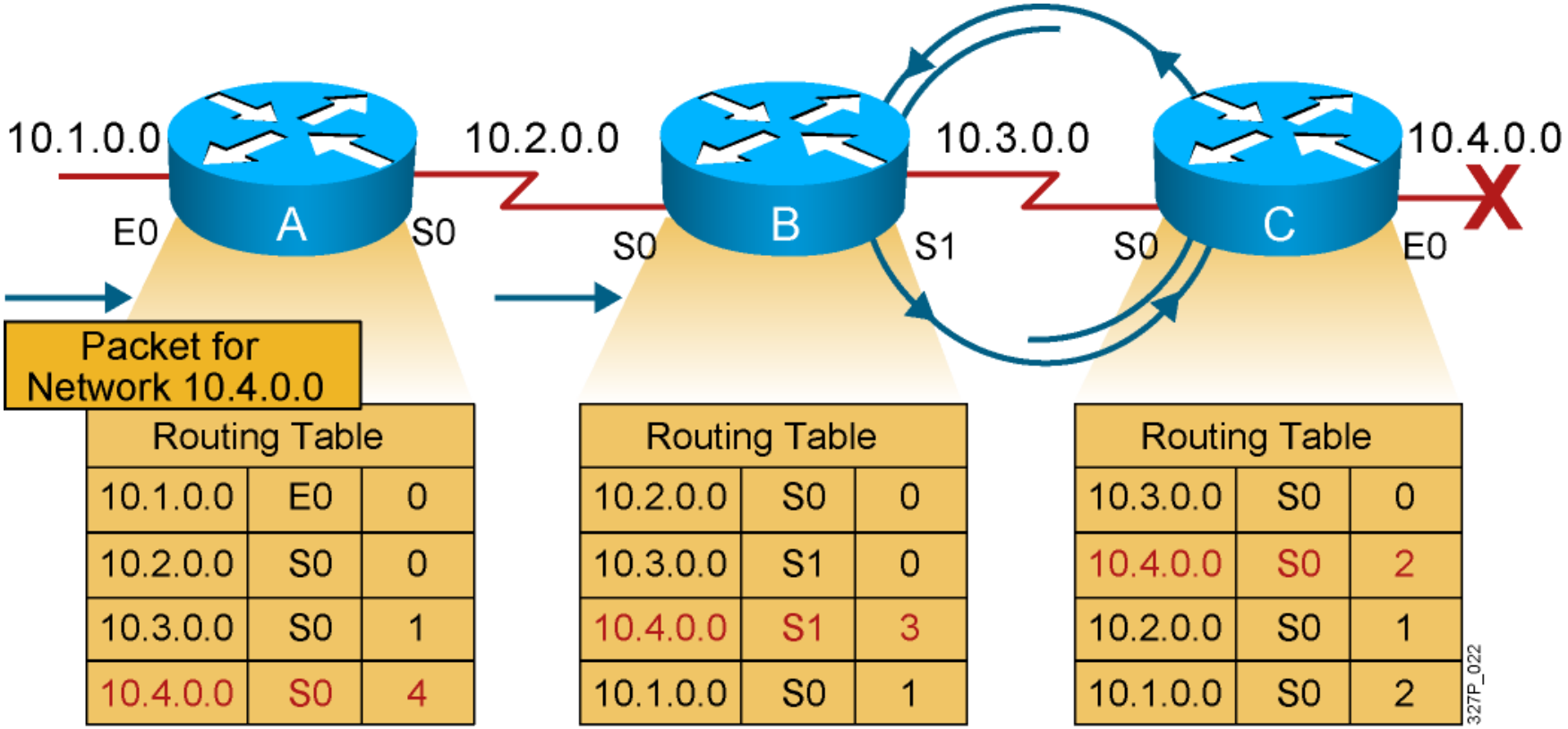
Routing Table		
10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	16

Routing Table		
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	16
10.1.0.0	S0	1

Routing Table		
10.3.0.0	S0	0
10.4.0.0	S0	16
10.2.0.0	S0	1
10.1.0.0	S0	2

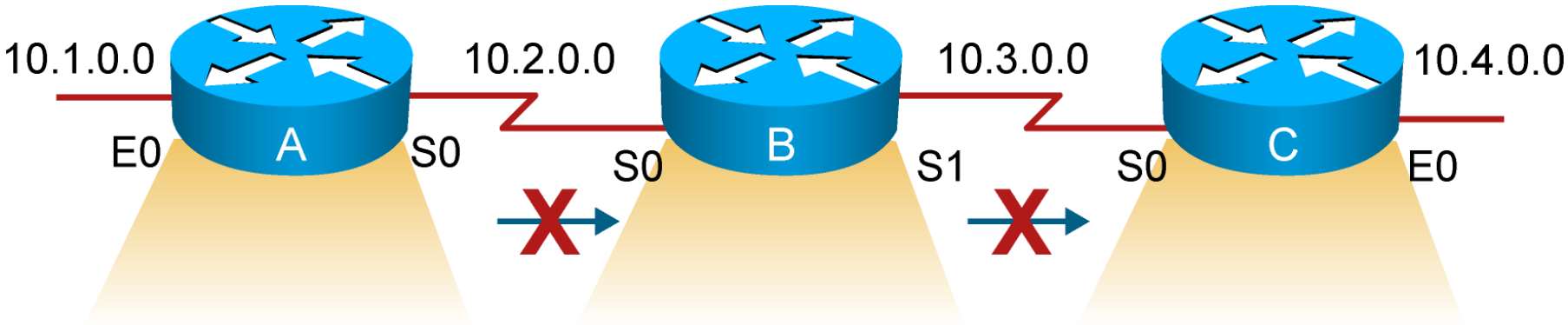
A limit is set on the number of hops to prevent infinite loops.

Routing Loops



Packets for network 10.4.0.0 bounce (loop) between routers B and C.

Solution to Routing Loops: Split Horizon



Routing Table		
10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	2

Routing Table		
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	1
10.1.0.0	S0	1

Routing Table		
10.3.0.0	S0	0
10.4.0.0	E0	0
10.2.0.0	S0	1
10.1.0.0	S0	2

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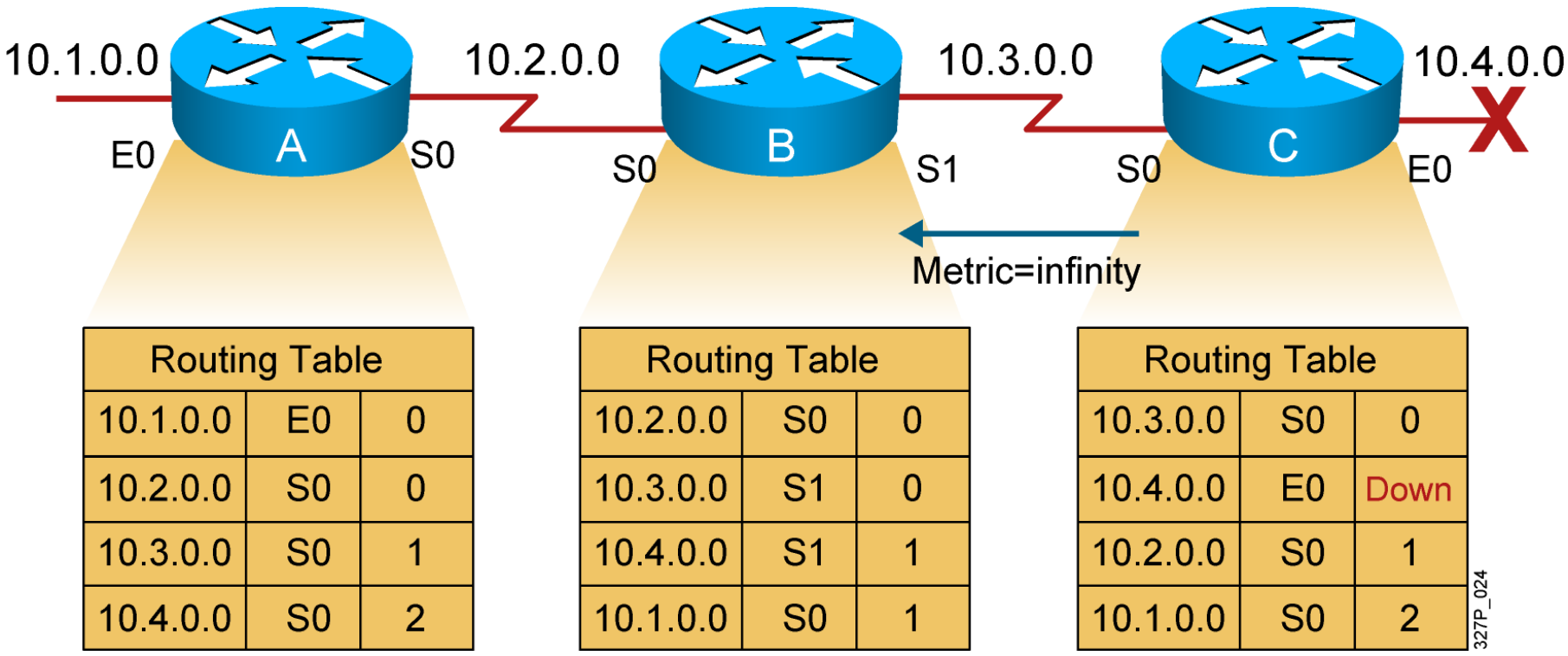
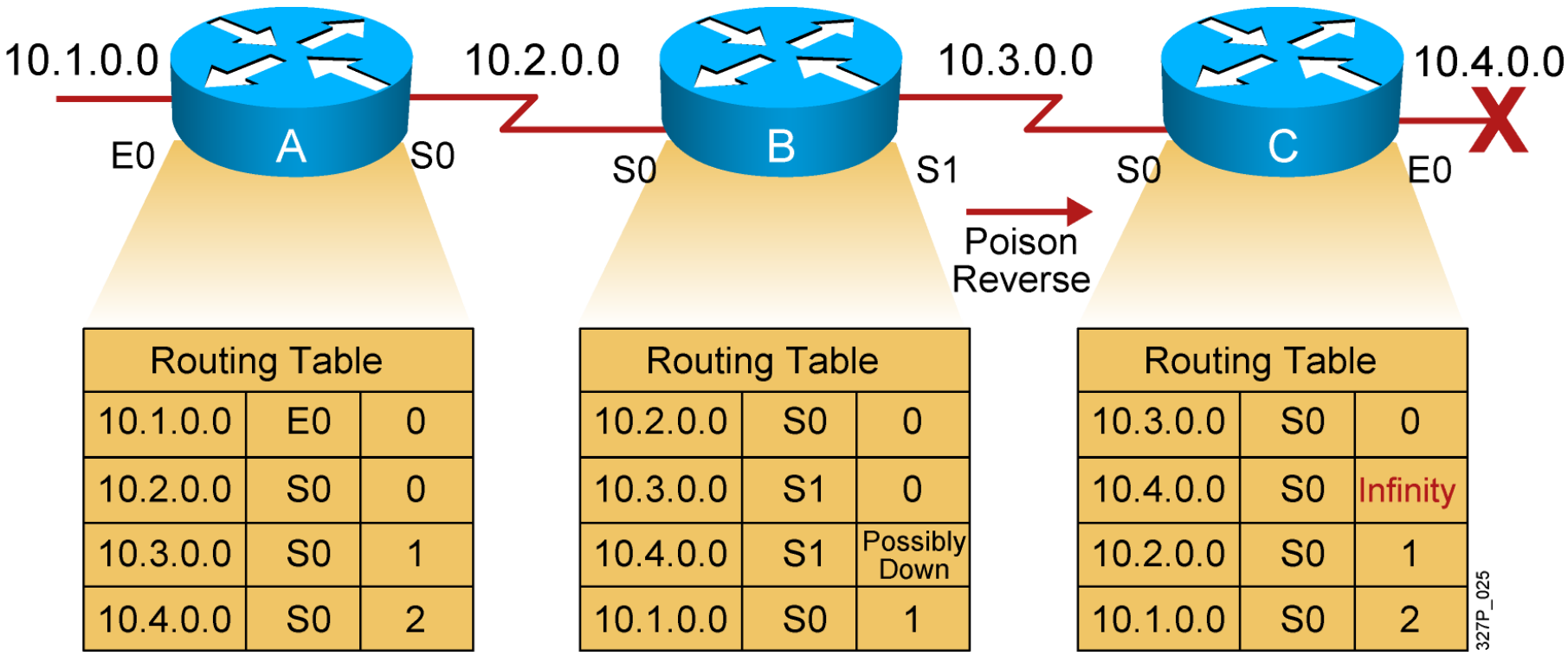
It is never useful to send information about a route back in the direction from which the original information came.

Solution to Routing Loops: Route Poisoning and Poison Reverse



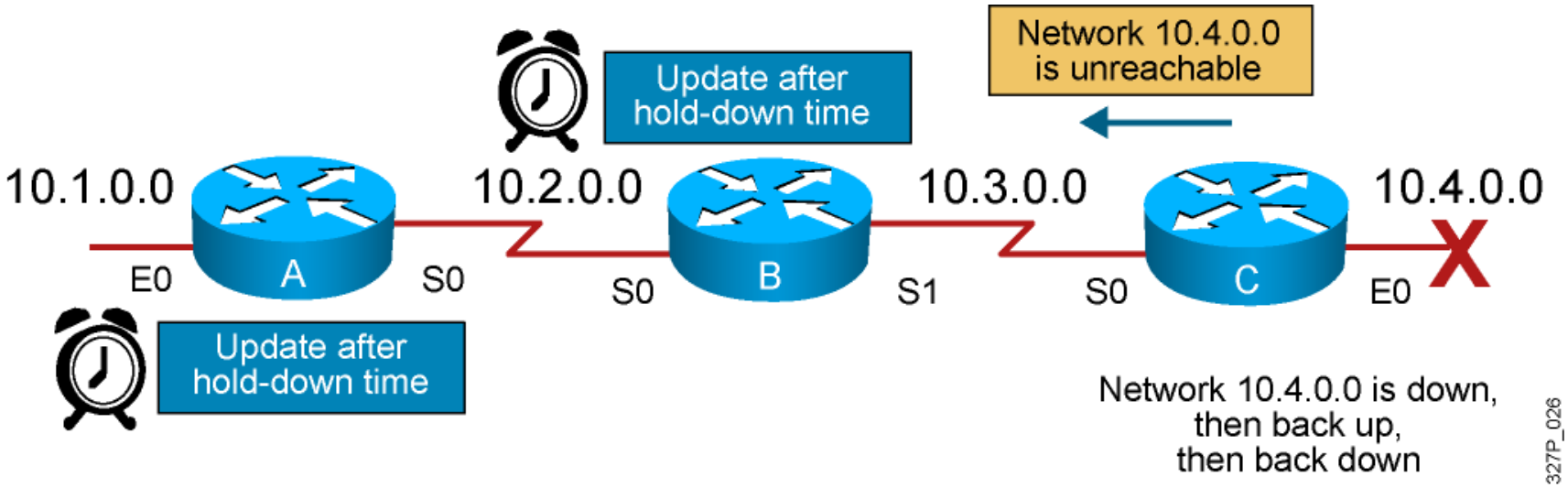
Routers advertise the distance of routes that have gone down to infinity.

Solution to Routing Loops: Route Poisoning and Poison Reverse (Cont.)



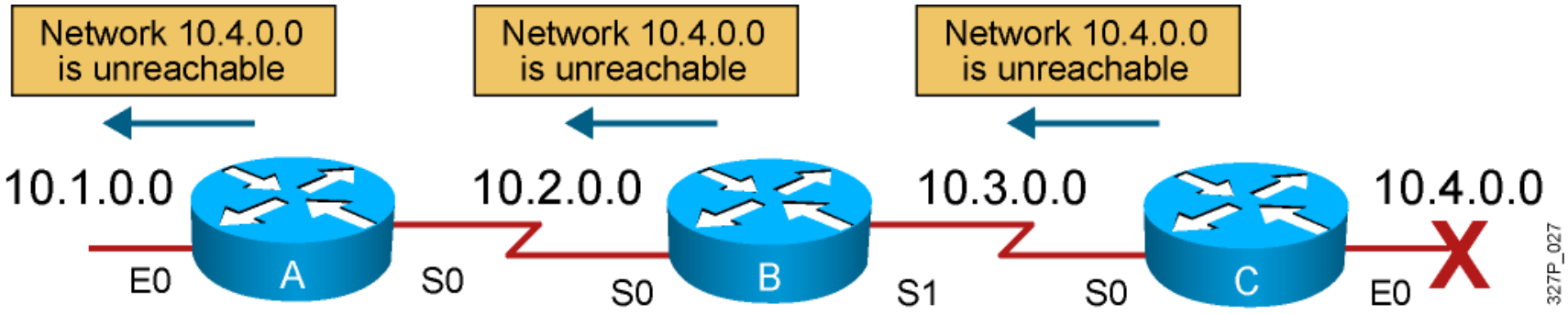
Poison reverse overrides split horizon.

Solution to Routing Loops: Hold-Down Timers



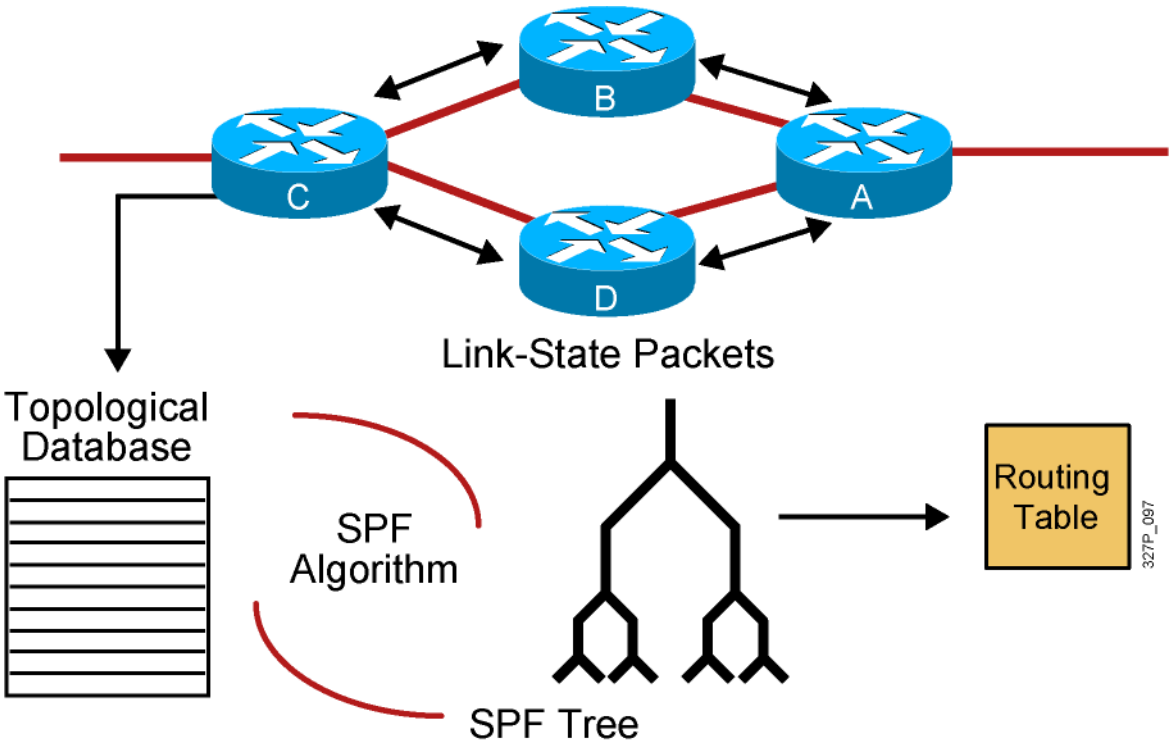
The router keeps an entry for the “possibly down” state in the network, allowing time for other routers to recompute for this topology change.

Triggered Updates



The router sends updates when a change in its routing table occurs.

Link-State Routing Protocols

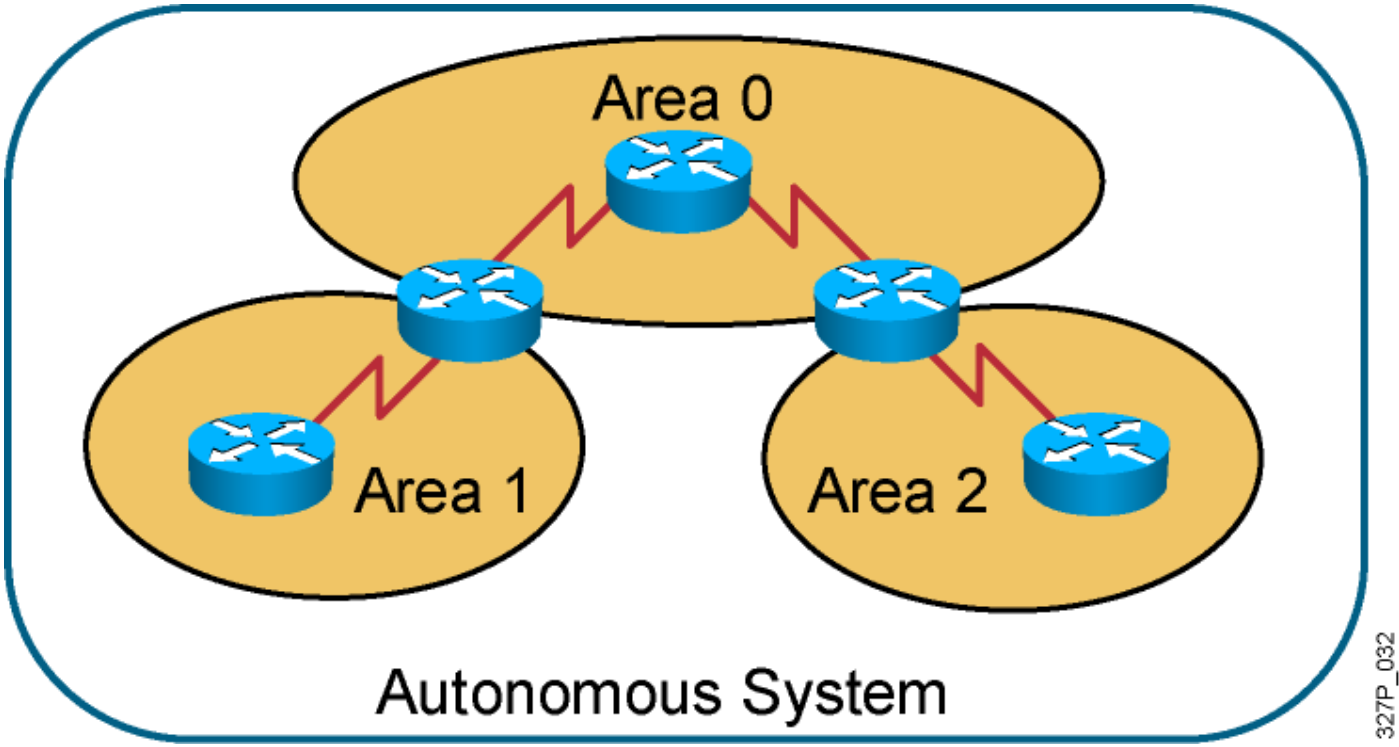


After an initial flood of LSAs, link-state routers pass small, event-triggered link-state updates to all other routers.

OSPF

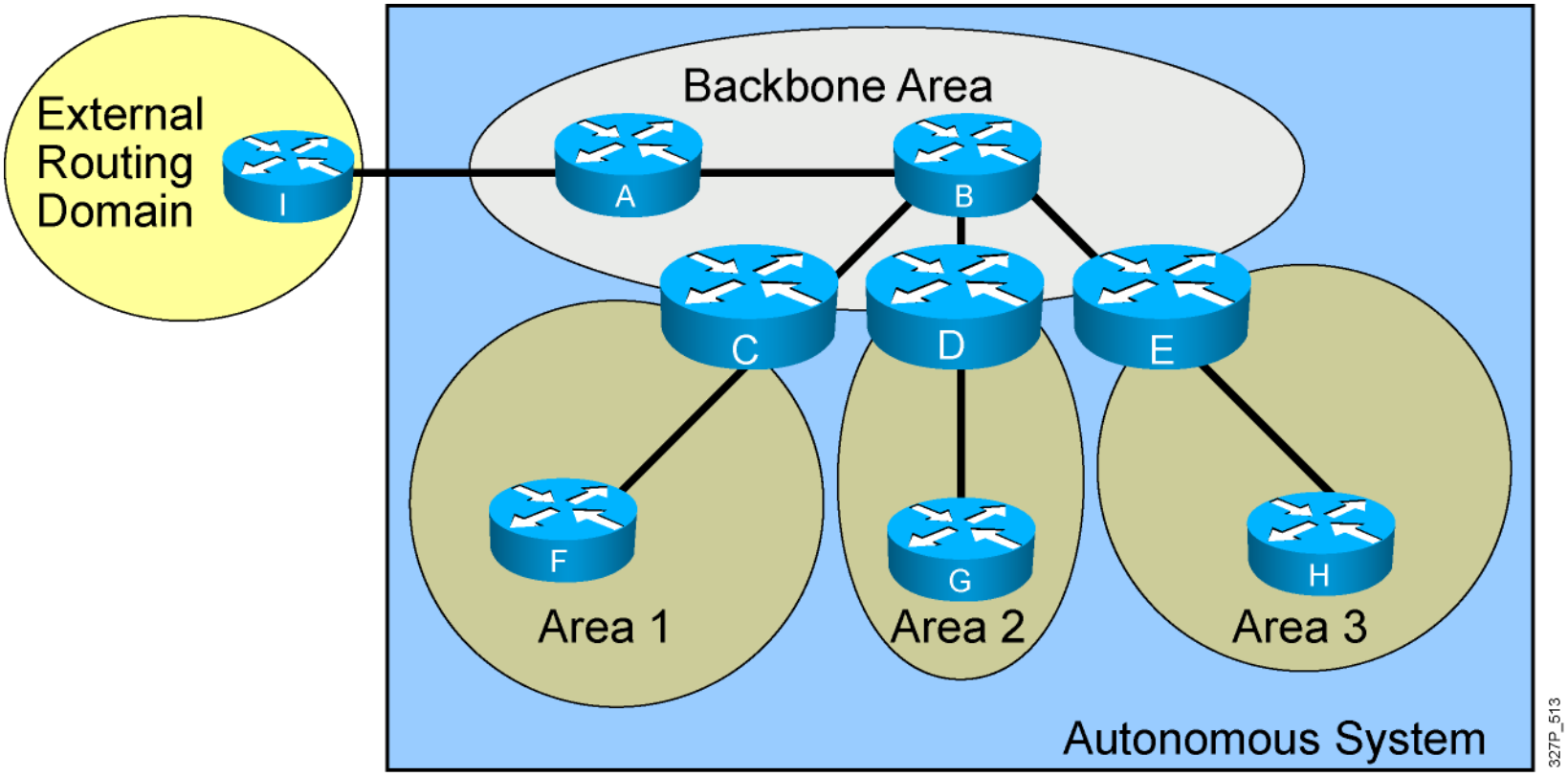
- Creates a neighbor relationship by exchanging hello packets
- Propagates LSAs (Link State Advertisements) rather than routing table updates
  - Link: Router interface
  - State: Description of an interface and its relationship to neighboring routers
- Floods LSAs to all OSPF routers in the area, not just directly connected routers
- Pieces together all the LSAs generated by the OSPF routers to create the OSPF link-state database
- Uses the SPF algorithm to calculate the shortest path to each destination and places it in the routing table

OSPF Hierarchical Routing



- Consists of areas and autonomous systems
- Minimizes routing update traffic

OSPF Hierarchy Example



- Minimizes routing table entries
- Localizes the impact of a topology change within an area

Benefits and Drawbacks of Link-State Routing

- Benefits of link-state routing:
  - Fast convergence:
    - Changes are reported immediately by the affected source
  - Robustness against routing loops:
    - Routers know the topology
    - Link-state packets are sequenced and acknowledged
  - Hierarchical network design enables optimization of resources.

- Drawbacks of link-state routing:
  - Significant demands for resources:
    - Memory (three tables: adjacency, topology, forwarding)
  - Requires very strict network design
  - Configuration can be complex when tuning various parameters and when design is complex

Summary

- Dynamic routing requires administrators to configure either a distance vector or link-state routing protocol.
- Distance vector routing protocols incorporate solutions such as split horizon, route poisoning, and hold-down timers to prevent routing loops.
- Link-state routing protocols scale to large network infrastructures better than distance vector routing protocols, but they require more planning to implement.