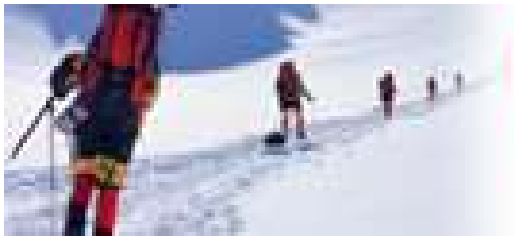


Data Communications and Networking Fourth Edition

Forouzan

# Chapter 22

# Network Layer: Delivery, Forwarding, and Routing

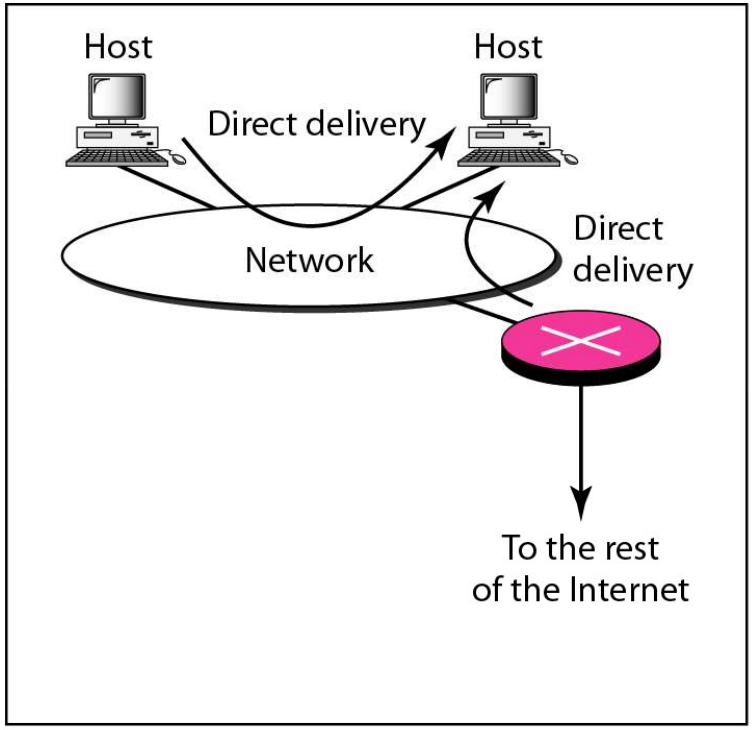
# 22-1 DELIVERY

***The network layer supervises the handling of the packets by the underlying physical networks. We define this handling as the delivery of a packet.***

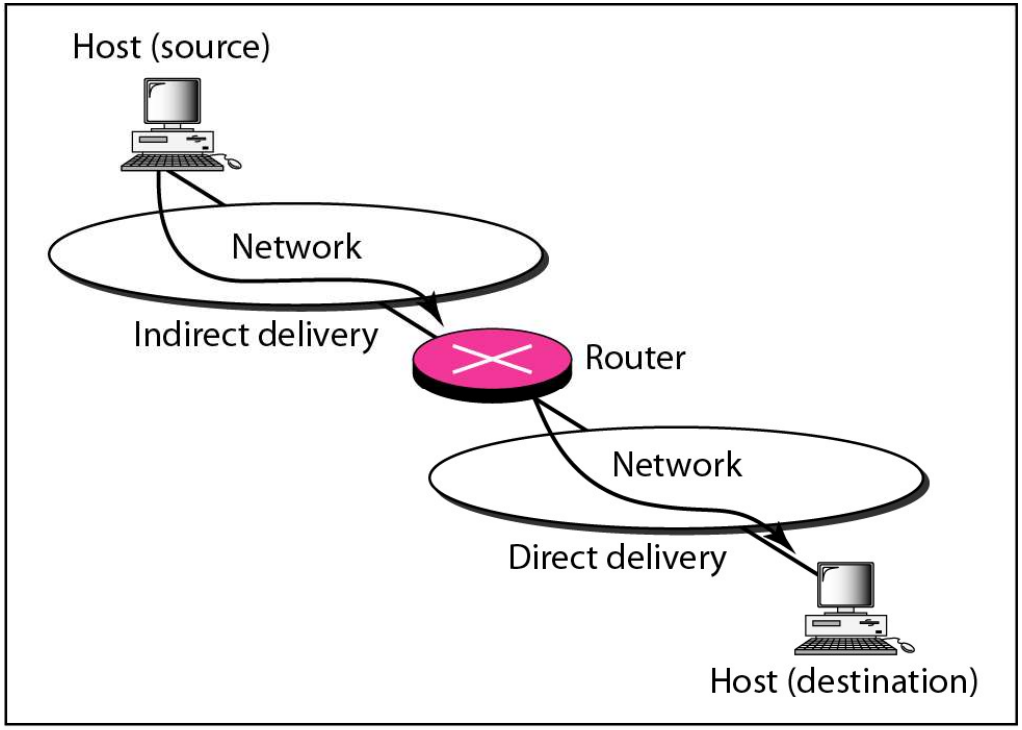
***Topics discussed in this section:***

**Direct Versus Indirect Delivery**

# Figure 22.1 *Direct and indirect delivery*




a. Direct delivery




b. Indirect and direct delivery

## Figure 22.2 *Route method versus next-hop method*

a. Routing tables based on route

| Destination | Route |
|---|---|
| Host B | R1, R2, host B |

Routing table for host A

| Destination | Route |
|---|---|
| Host B | R2, host B |

Routing table for R1

| Destination | Route |
|---|---|
| Host B | Host B |

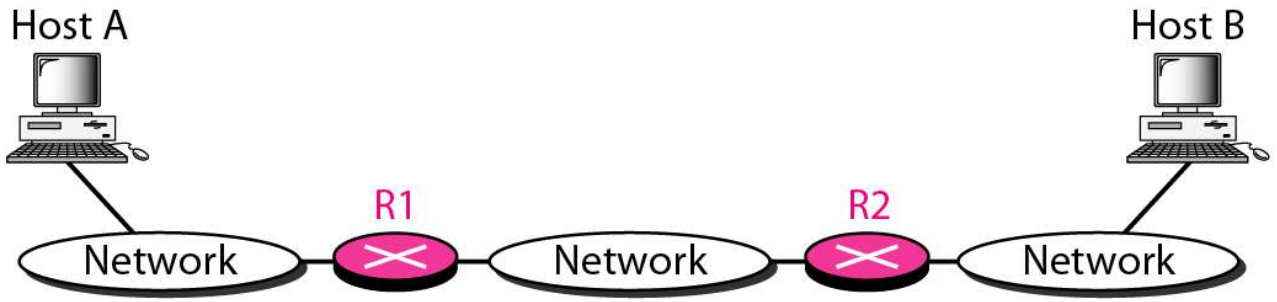
Routing table for R2

b. Routing tables based on next hop

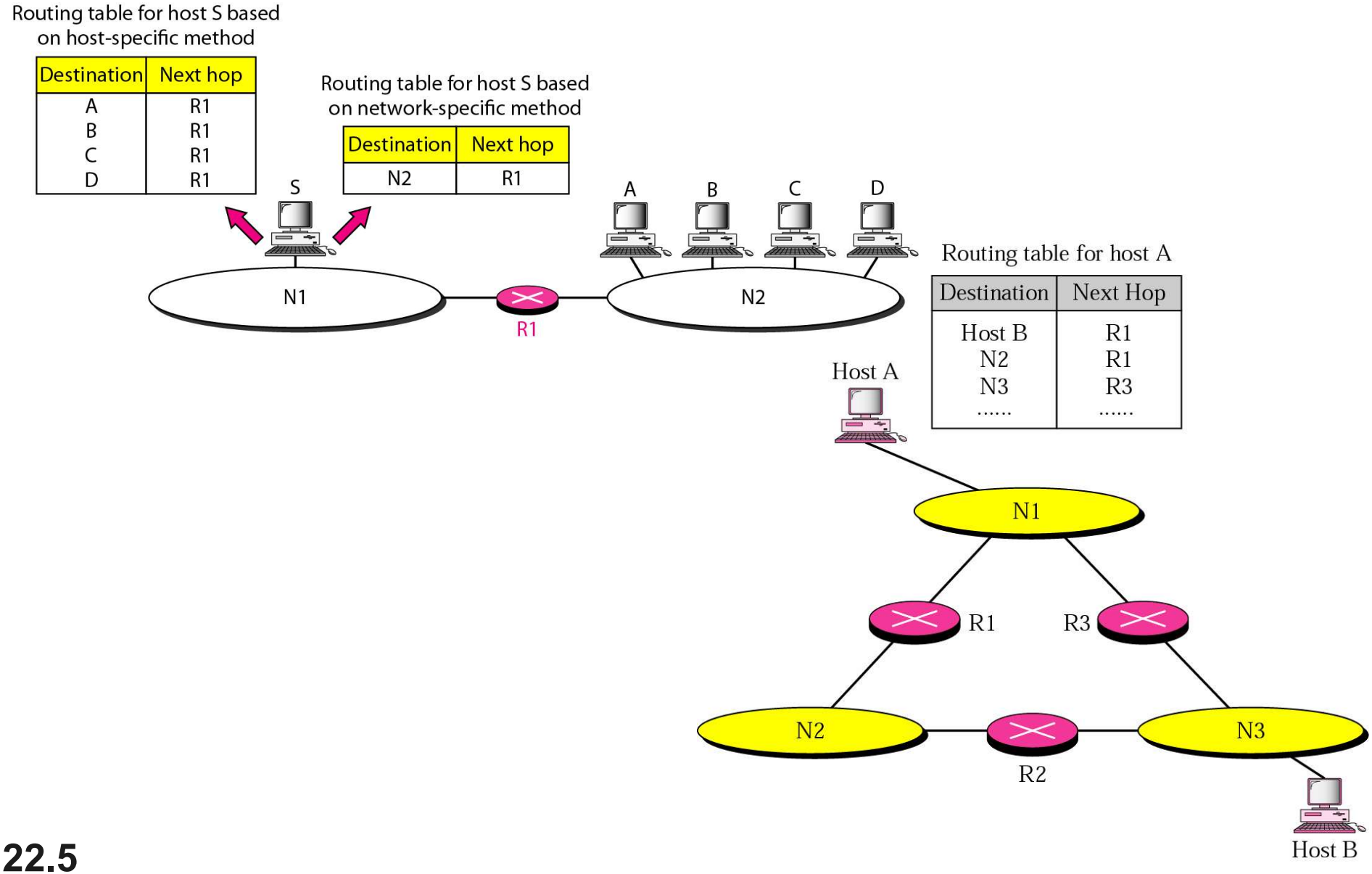
| Destination | Next hop |
|---|---|
| Host B | R1 |

| Destination | Next hop |
|---|---|
| Host B | R2 |

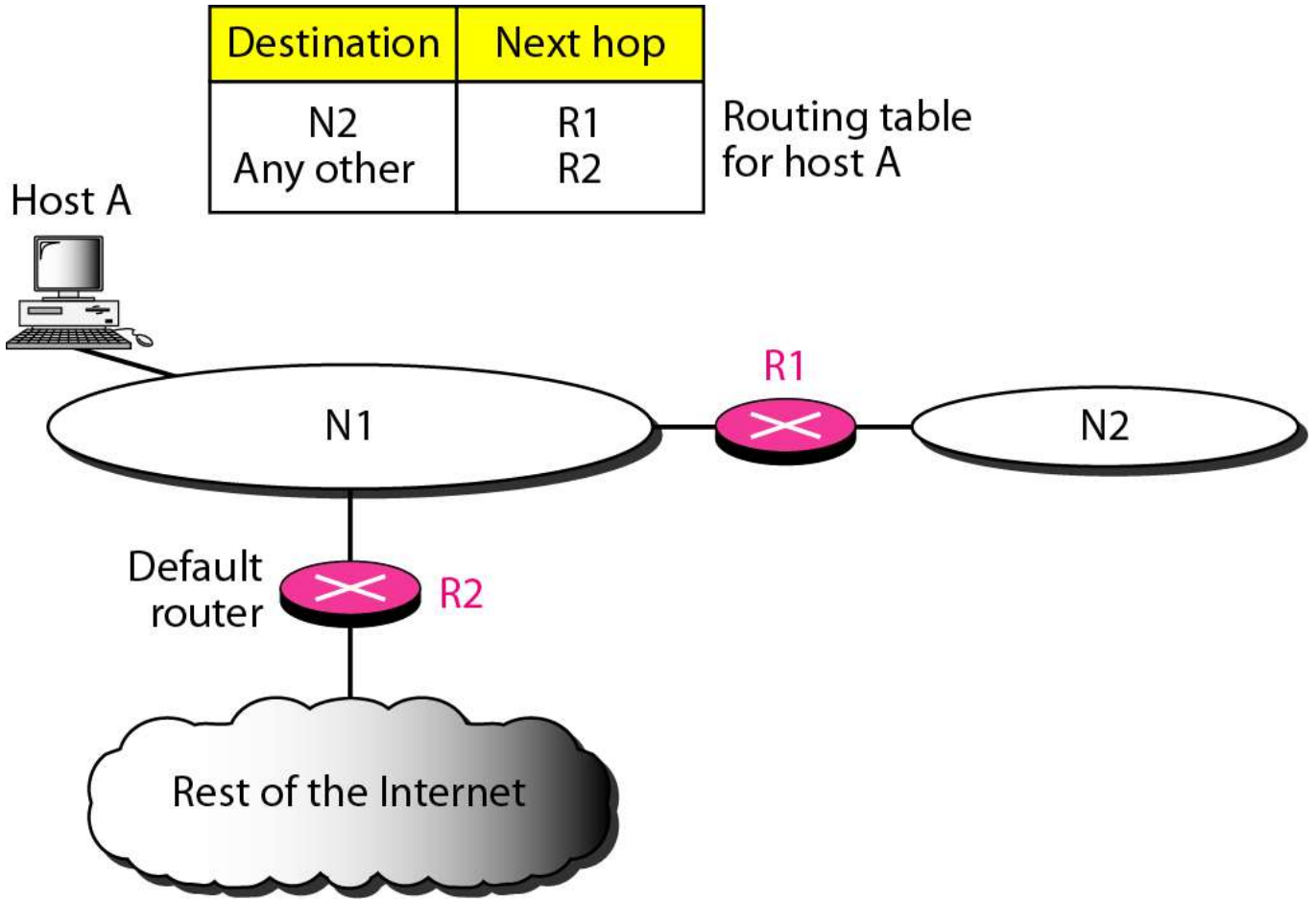
| Destination | Next hop |
|---|---|
| Host B | --- |



# Figure 22.3 *Host-specific versus network-specific method*



## Figure 22.4 *Default method*



# 22-2 FORWARDING

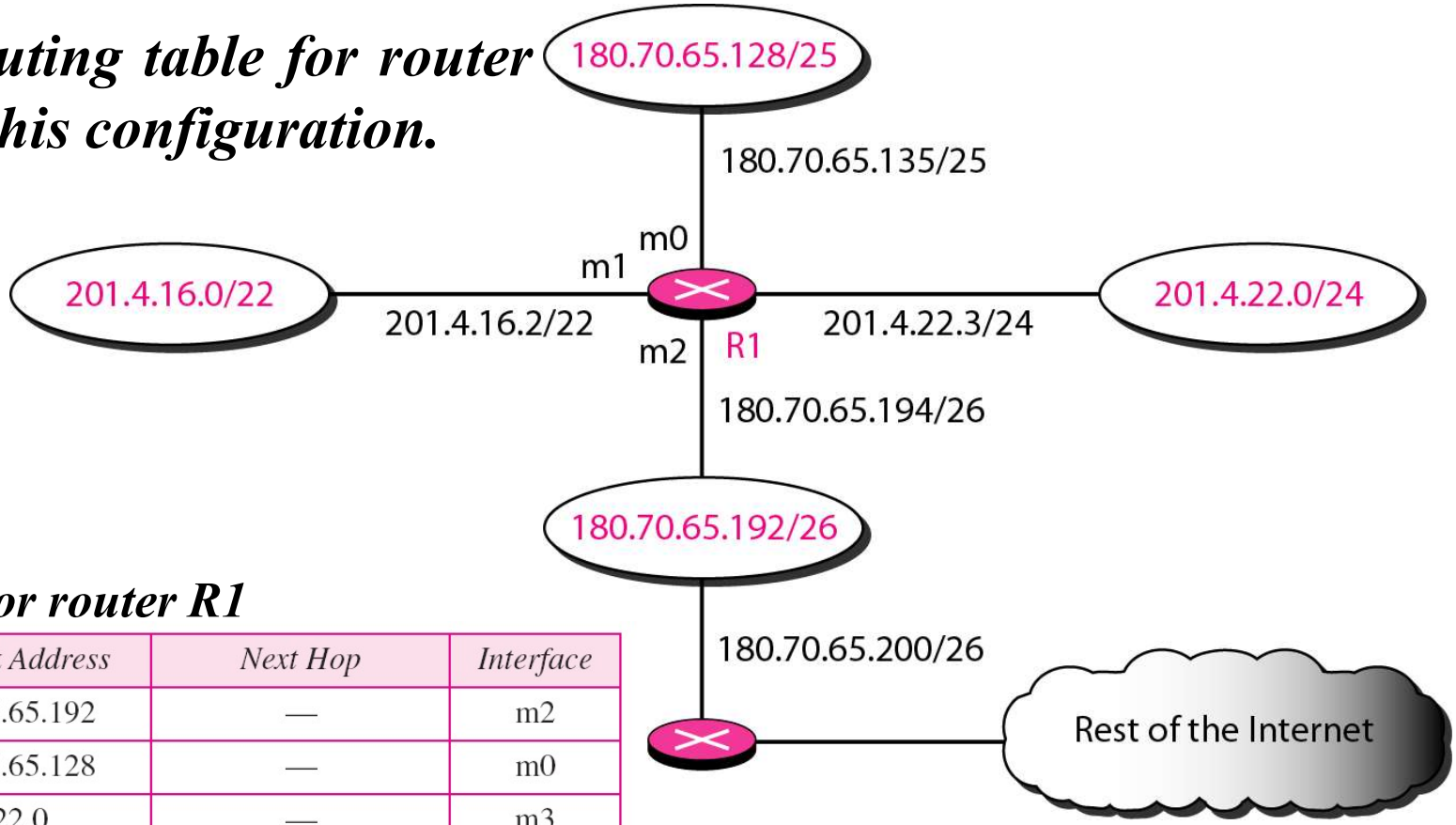
***Forwarding means to place the packet in its route to its destination. Forwarding requires a host or a router to have a routing table. When a host has a packet to send or when a router has received a packet to be forwarded, it looks at this table to find the route to the final destination.***

***Topics discussed in this section:***

**Forwarding Techniques**
**Forwarding Process**
**Routing Table**

## Figure 22.6 *Configuration for Example 22.1*

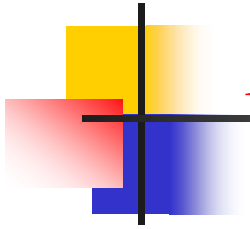
***Make a routing table for router R1, using this configuration.***




## *Solution*

***Routing table for router R1***

| *Mask* | *Network Address* | *Next Hop* | *Interface* |
|---|---|---|---|
| /26 | 180.70.65.192 | — | m2 |
| /25 | 180.70.65.128 | — | m0 |
| /24 | 201.4.22.0 | — | m3 |
| /22 | 201.4.16.0 | .... | m1 |
| Any | Any | 180.70.65.200 | m2 |



# Example 22.2

*Show the forwarding process if a packet arrives at R1 in Figure 22.6 with the destination address 180.70.65.140.*

## Solution

*The router performs the following steps:*

1. *The first mask (/26) is applied to the destination address. The result is 180.70.65.128, which does not match the corresponding network address.*
2. *The second mask (/25) is applied to the destination address. The result is 180.70.65.128, which matches the corresponding network address. The next-hop address and the interface number m0 is passed to ARP for further processing.*

# 22-3 UNICAST ROUTING PROTOCOLS

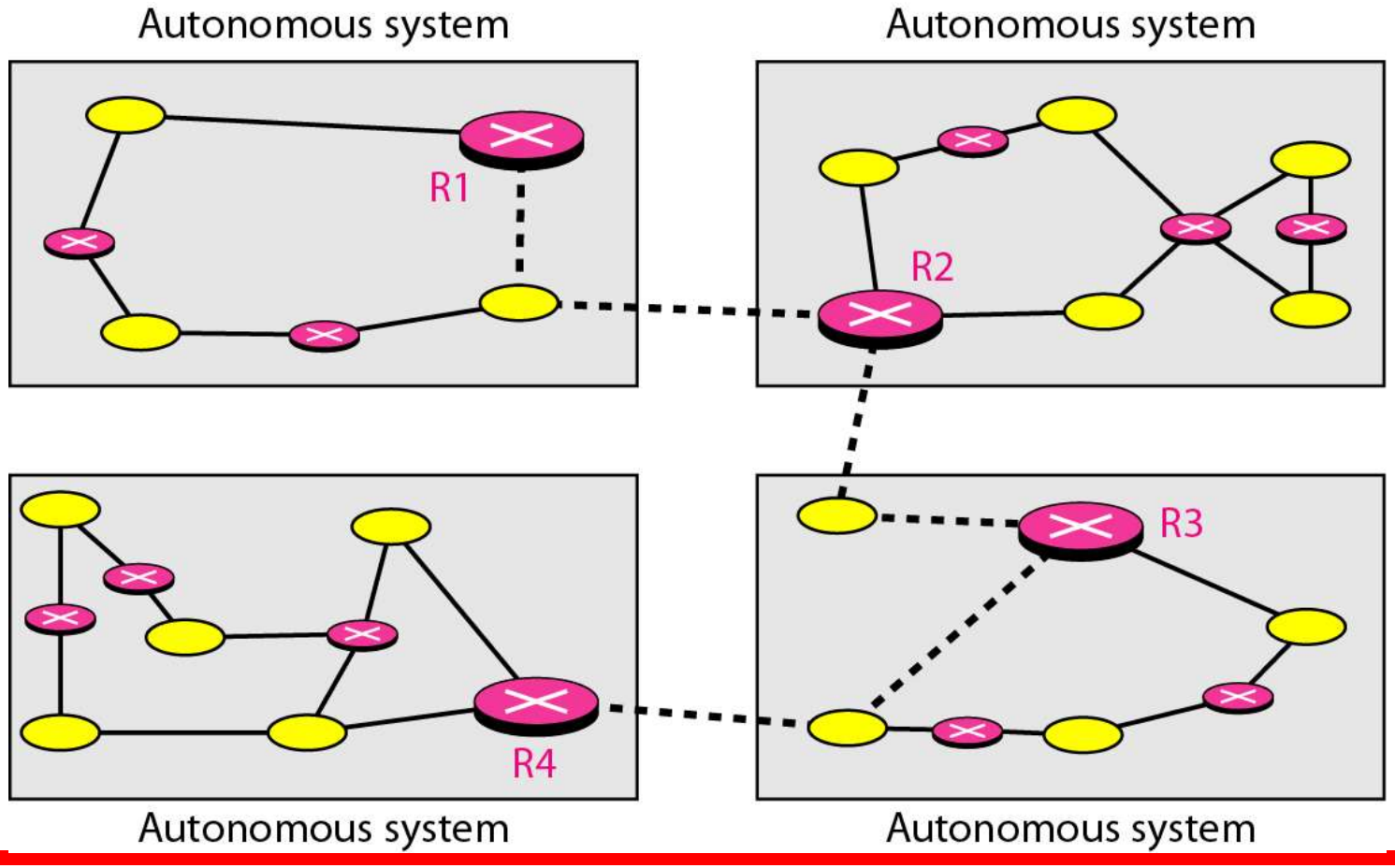
*A routing table can be either static or dynamic. A static table is one with manual entries. A dynamic table is one that is updated automatically when there is a change somewhere in the Internet. A routing protocol is a combination of rules and procedures that lets routers in the Internet inform each other of changes.*

***Topics discussed in this section:***

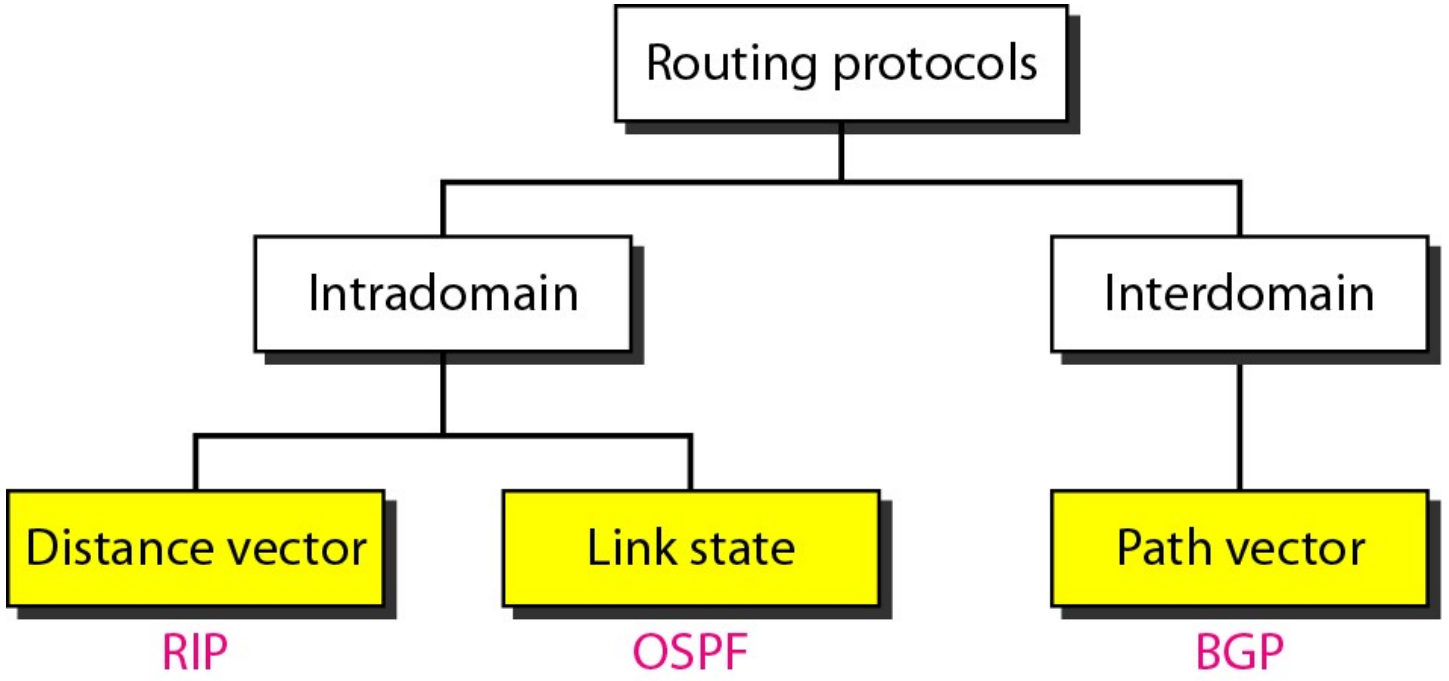
**Optimization**
**Intra- and Inter-Domain Routing**
**Distance Vector Routing and RIP (Routing Info Protocol)**
**Link State Routing and OSPF**
**Path Vector Routing and BGP**

## Figure 22.12 *Autonomous systems (Intra- and Interdomain Routing)*

**Routing inside an autonomous system is referred to as intradomain routing.**
**Routing between autonomous systems is referred to as interdomain routing.**



## Figure 22.13 *Popular routing protocols*

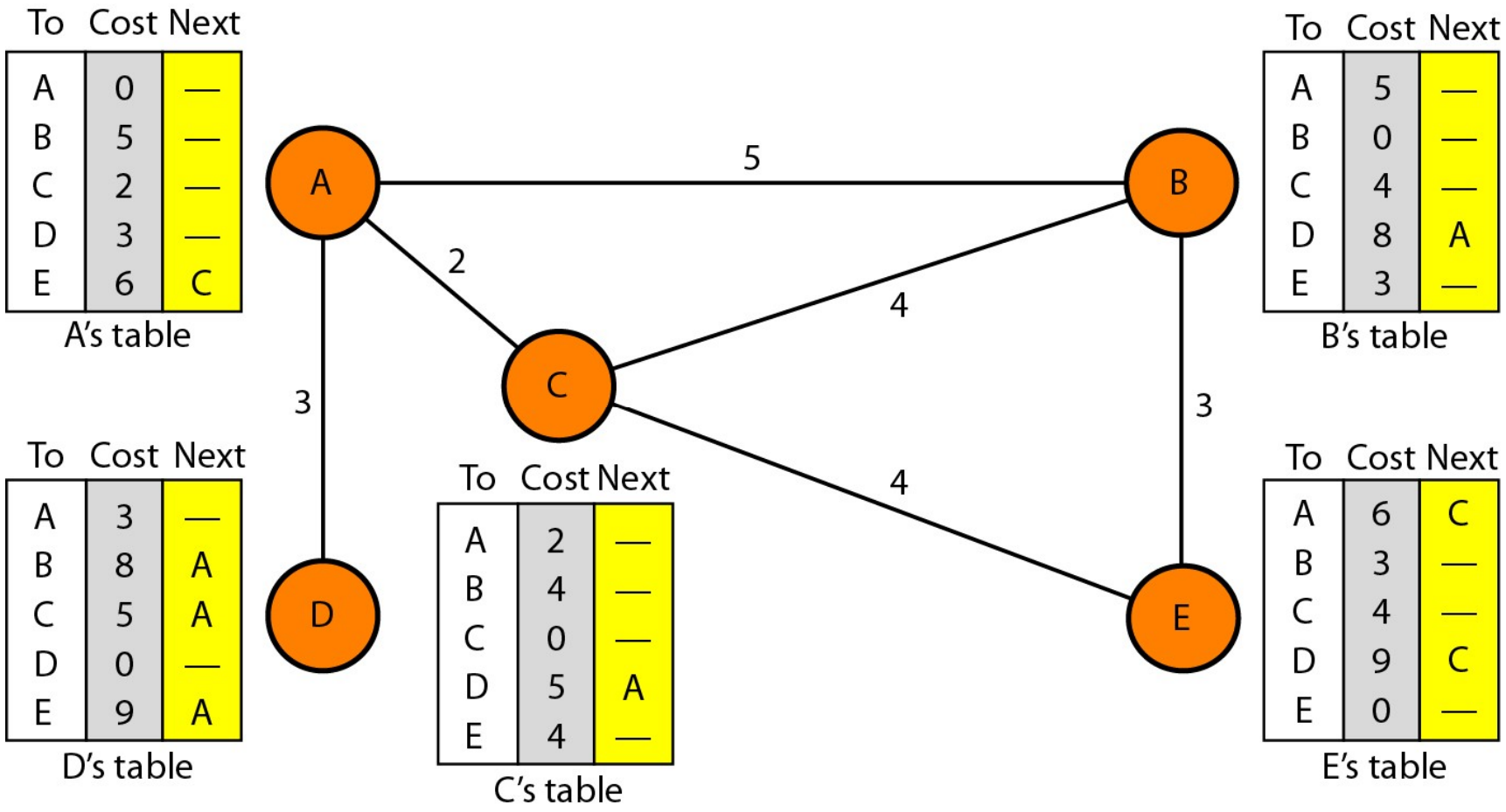



**Routing Information Protocol (RIP)**

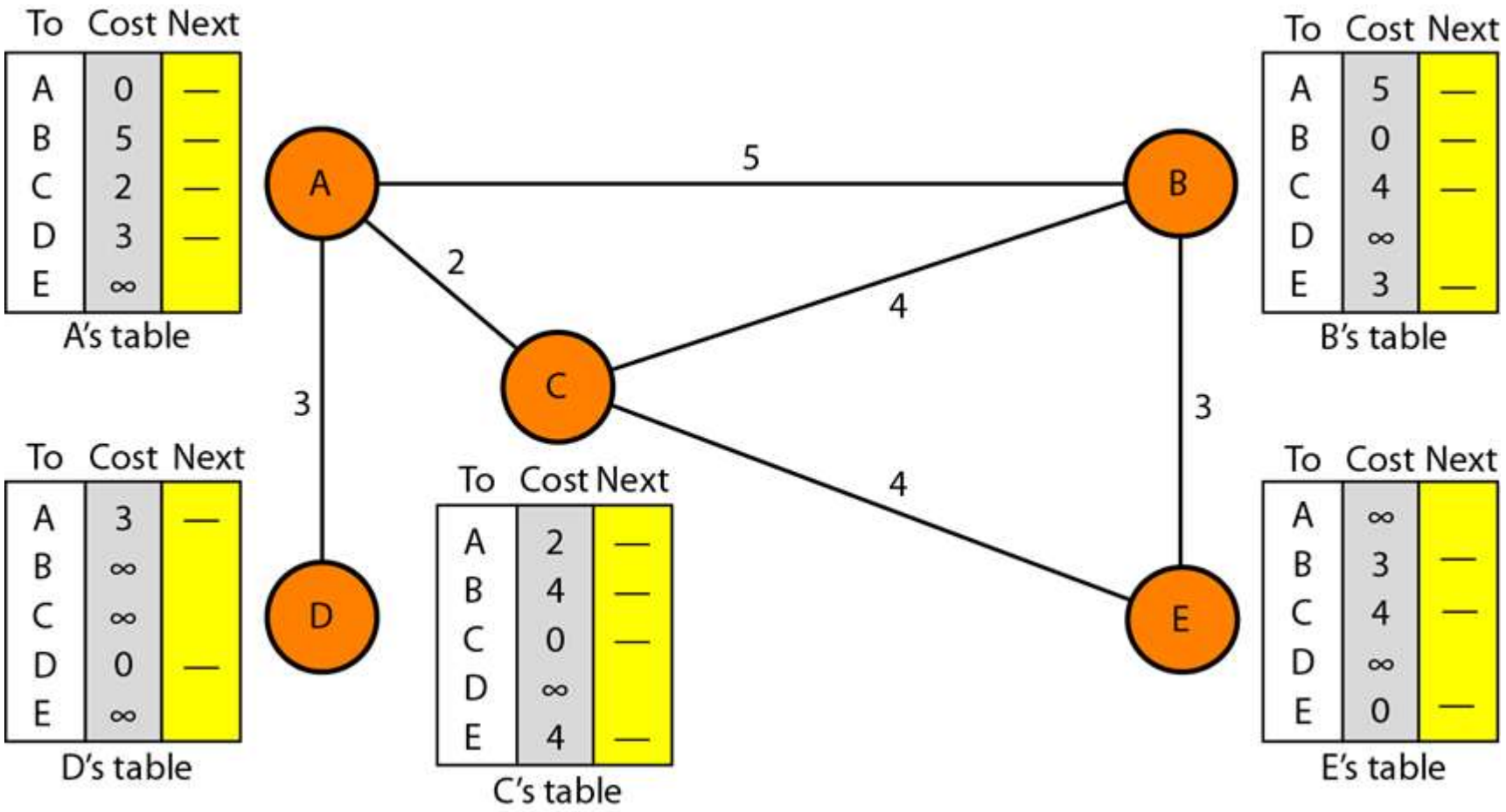
**Open Shortest Path First (OSPF)**

**Border Gateway Protocol (BGP)**

## Figure 22.14 *Distance vector routing tables*

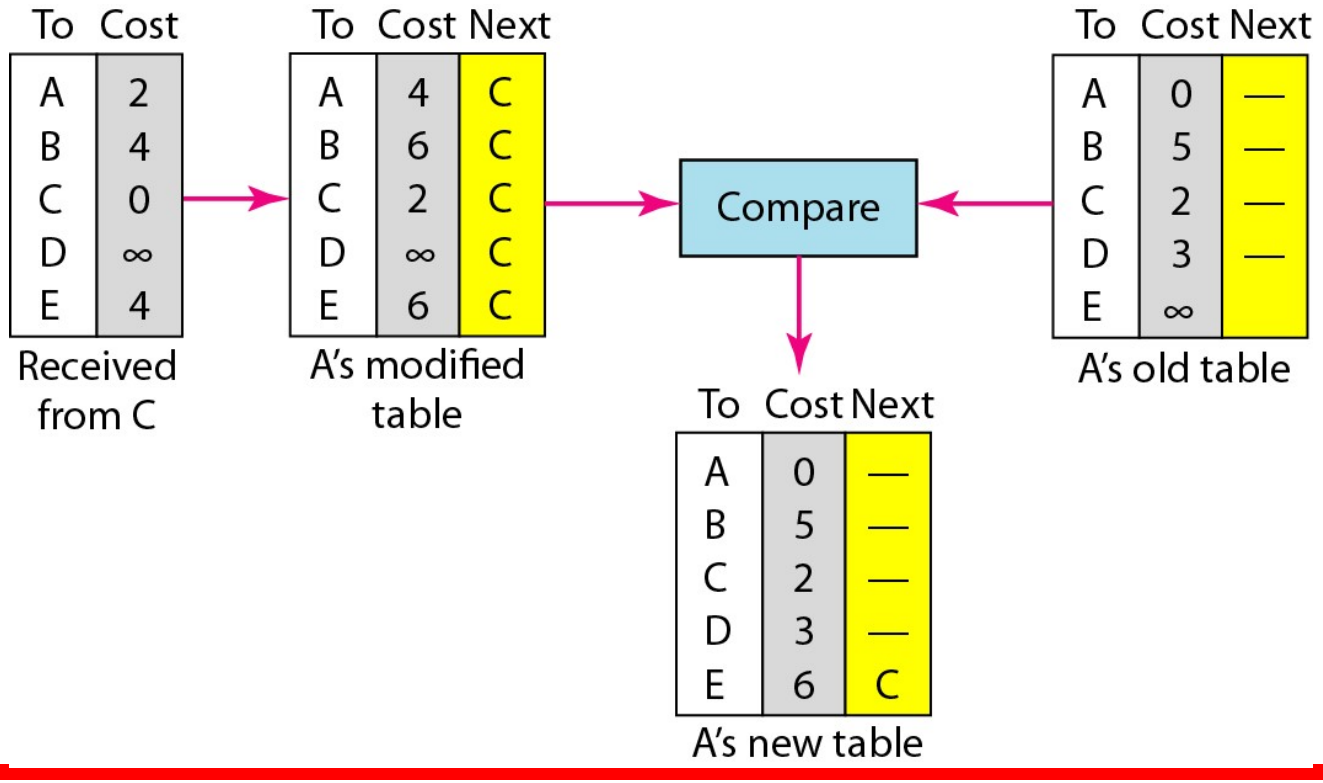


## Figure 22.15 *Initialization of tables in distance vector routing*

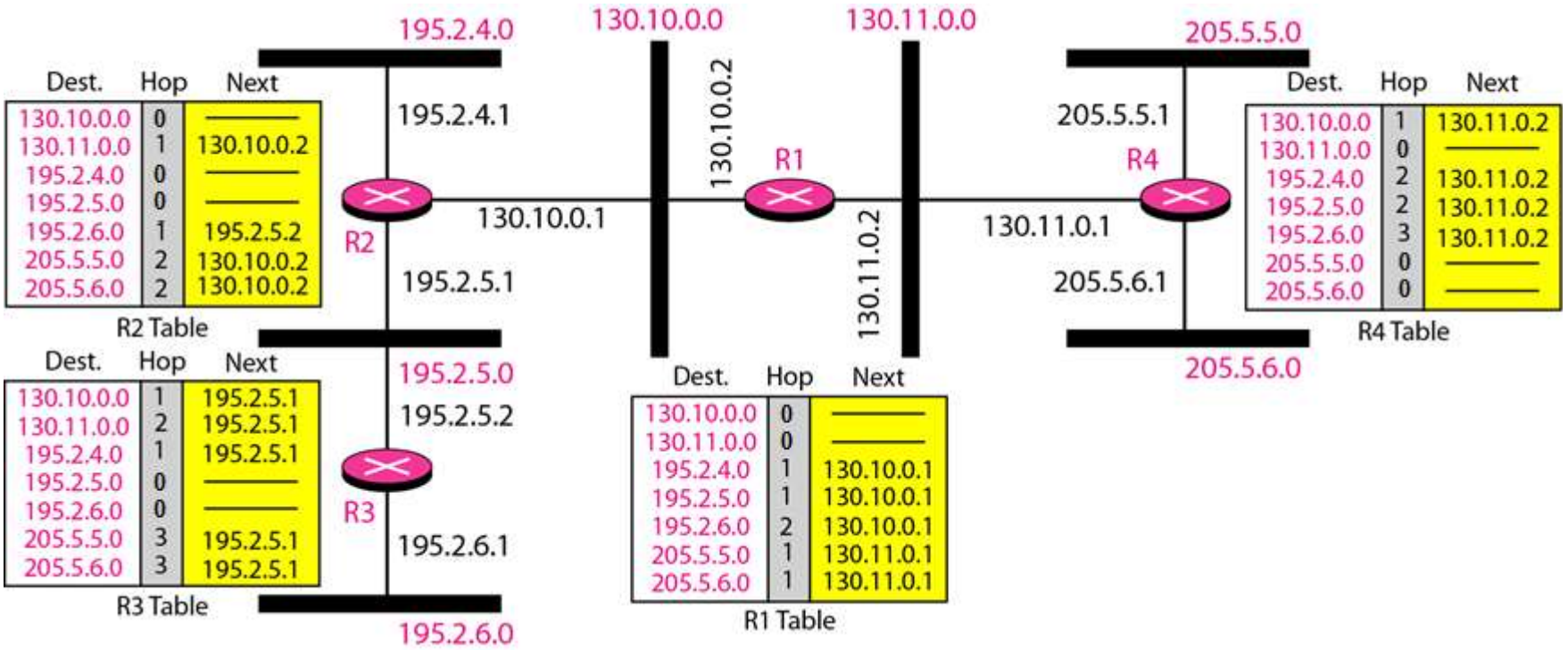


## Figure 22.16 *Updating in distance vector routing*

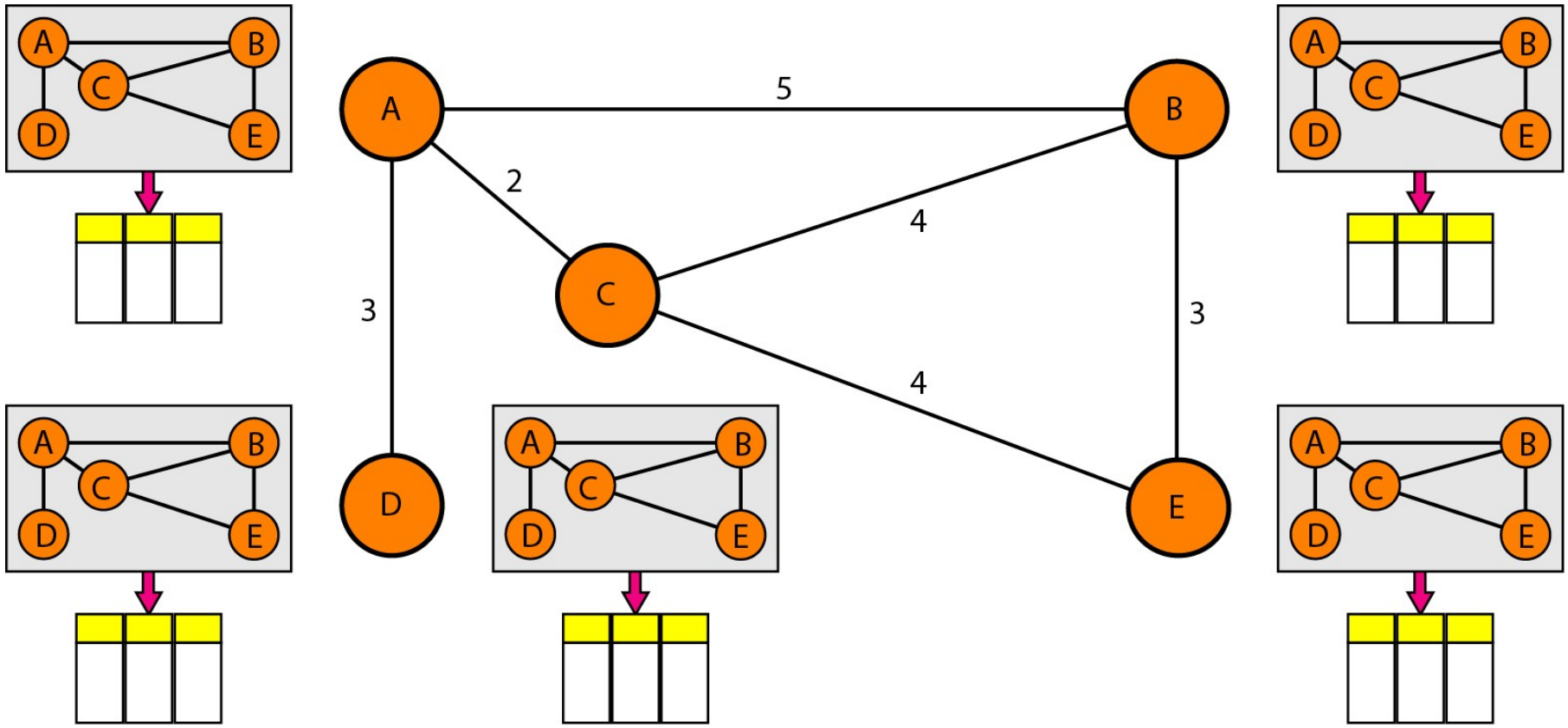
**In distance vector routing, each node shares its routing table with its immediate neighbors periodically and when there is a change.**



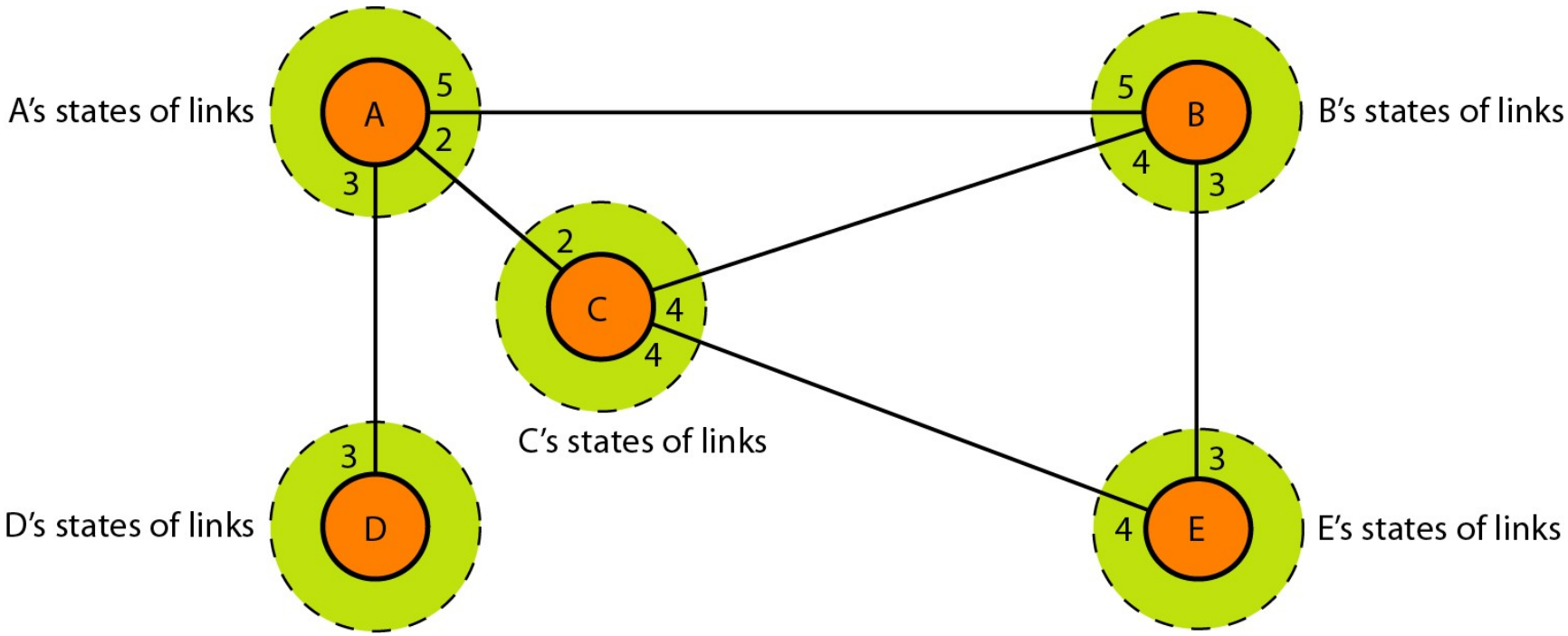
## Figure 22.19 *Example of a domain using RIP*



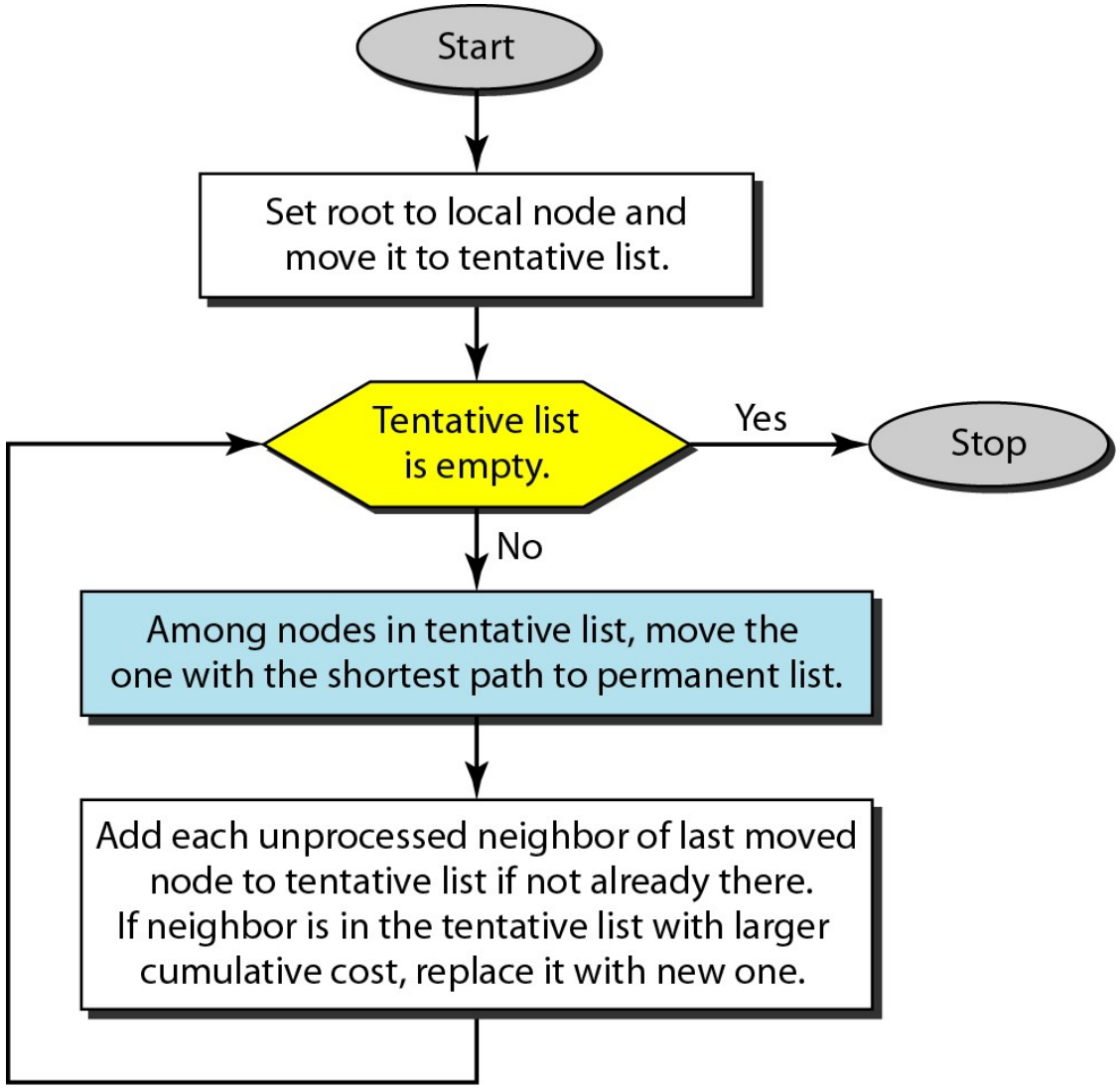
## Figure 22.20 *Concept of link state routing*



## Figure 22.21 *Link state knowledge*



## Figure 22.22 *Dijkstra algorithm*



# Figure 22.23 *Example of formation of shortest path tree*

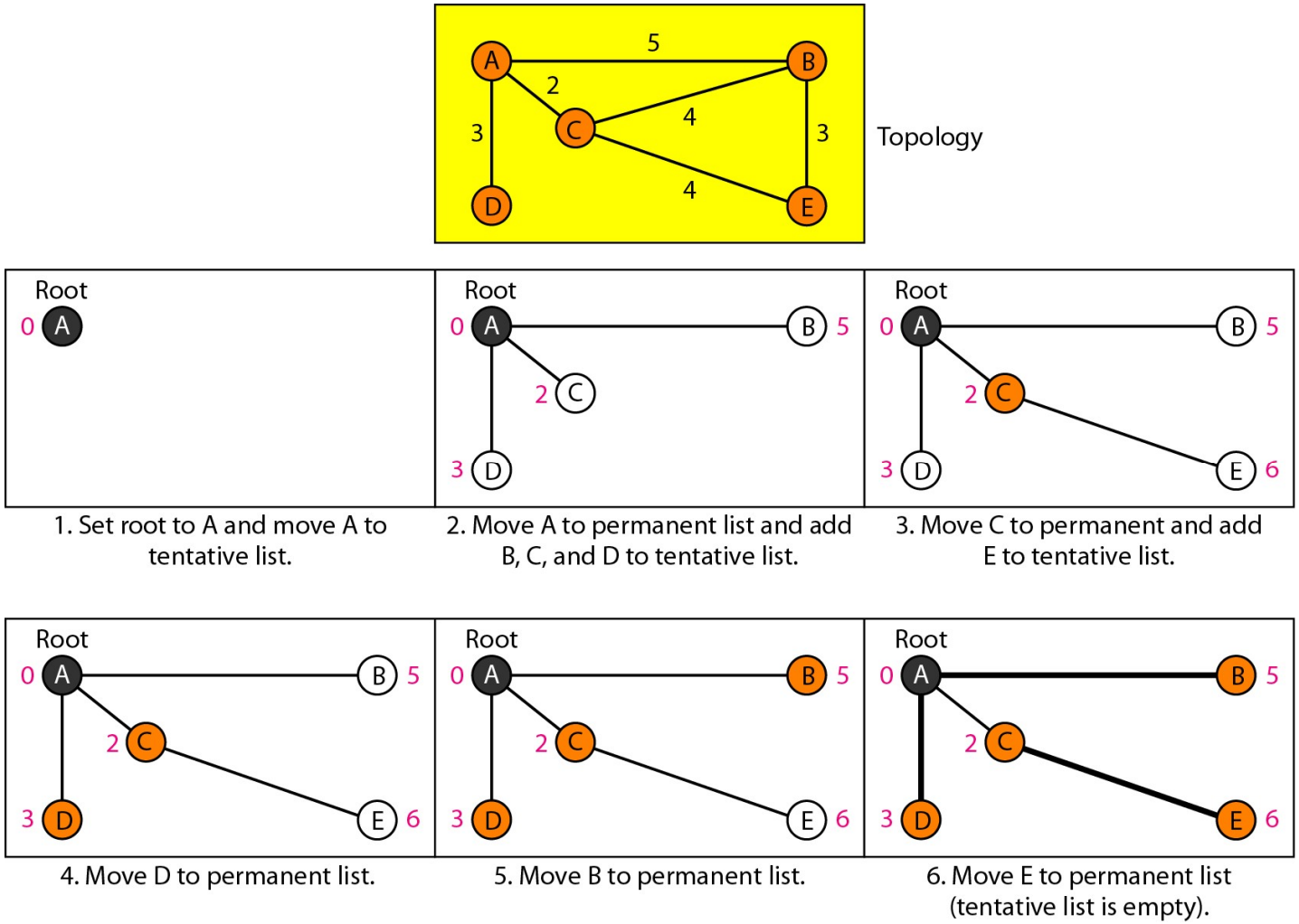
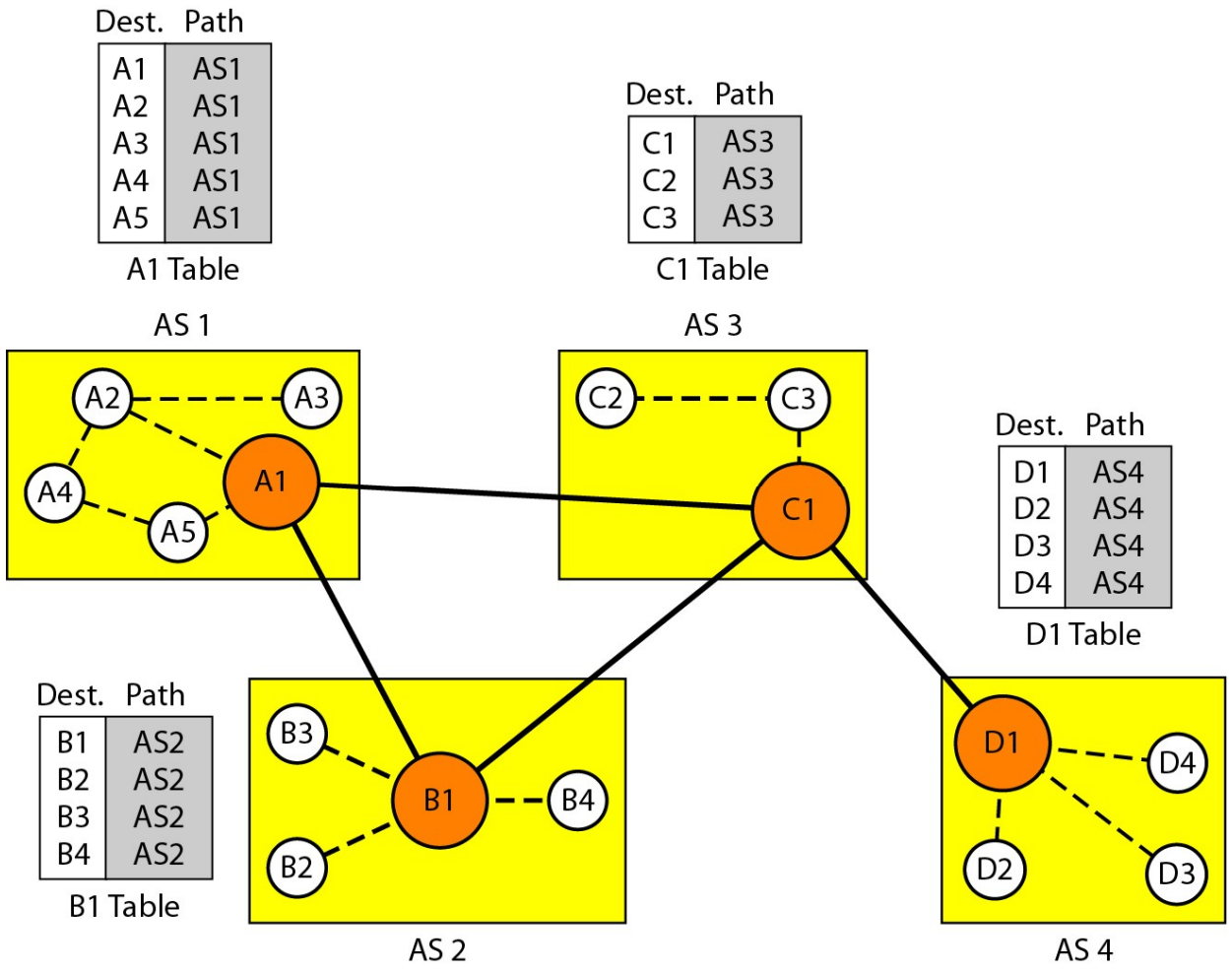


**Table 22.2** *Routing table for node A*

| *Node* | *Cost* | *Next Router* |
|---|---|---|
| A | 0 | — |
| B | 5 | — |
| C | 2 | — |
| D | 3 | — |
| E | 6 | C |

## Figure 22.30 *Initial routing tables in path vector routing*



## Figure 22.31 *Stabilized tables for three autonomous systems*