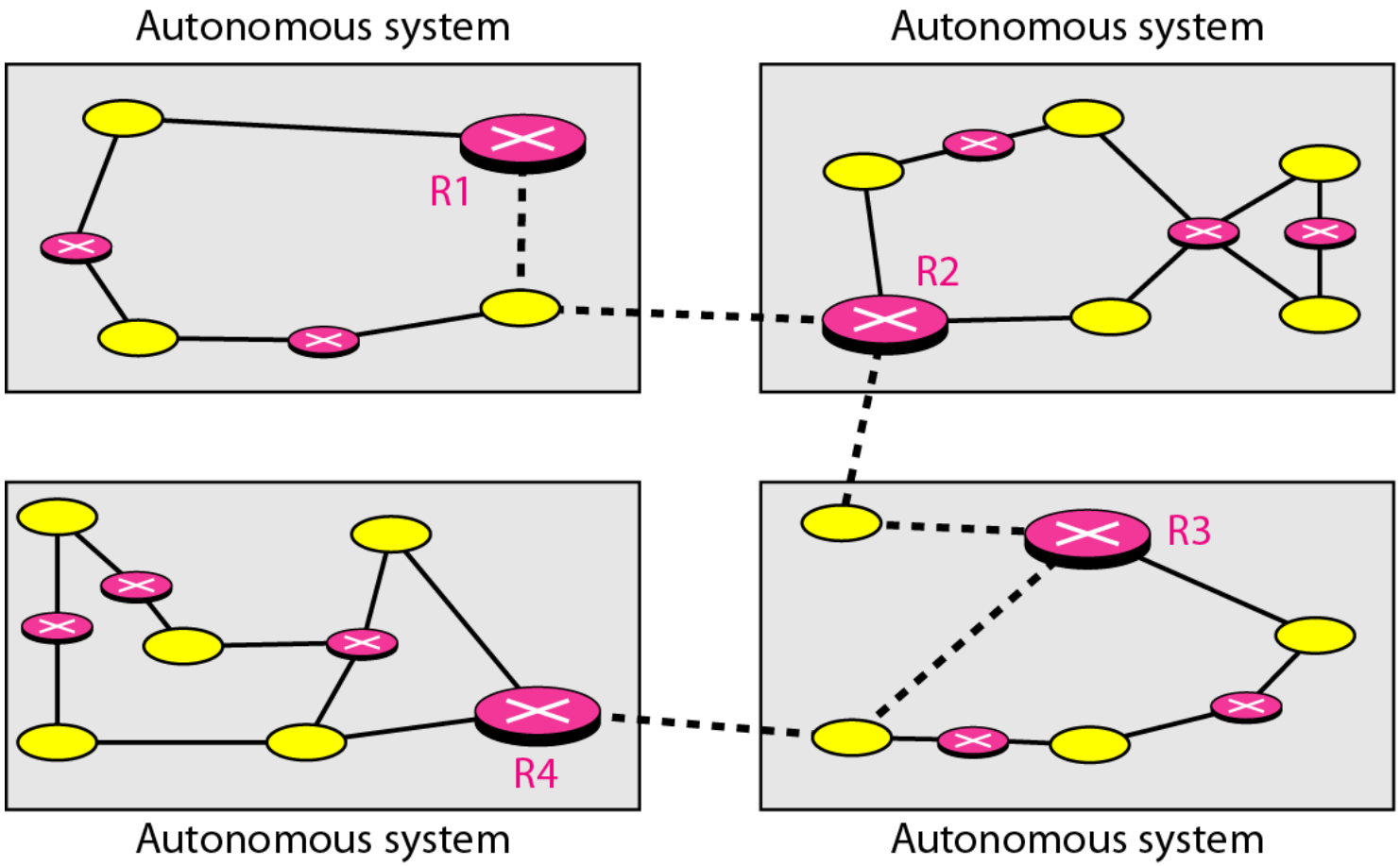
UNICAST ROUTING PROTOCOLS

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.

Figure 22.12 *Autonomous systems*



- When it receives a packet, to which network should it pass the packet?
- The decision is based on optimization: Which of the available pathways is the optimum pathway?

Poll

- decision of path selection is based on
- A. optimum pathway
- B. non-optimum pathway
- C. Random pathway

- One approach is to assign a cost for passing through a network. We call this cost a metric.
- However, the metric assigned to each network depends on the type of protocol.
- Some simple protocols, such as the Routing Information Protocol (RIP), treat all networks as equals. The cost of passing through a network is the same; it is one hop count.

- So if a packet passes through 10 networks to reach the destination, the total cost is 10 hop counts
- Another method can be type of service

Poll

- if a packet passes through 80 networks to reach the destination, the total cost is

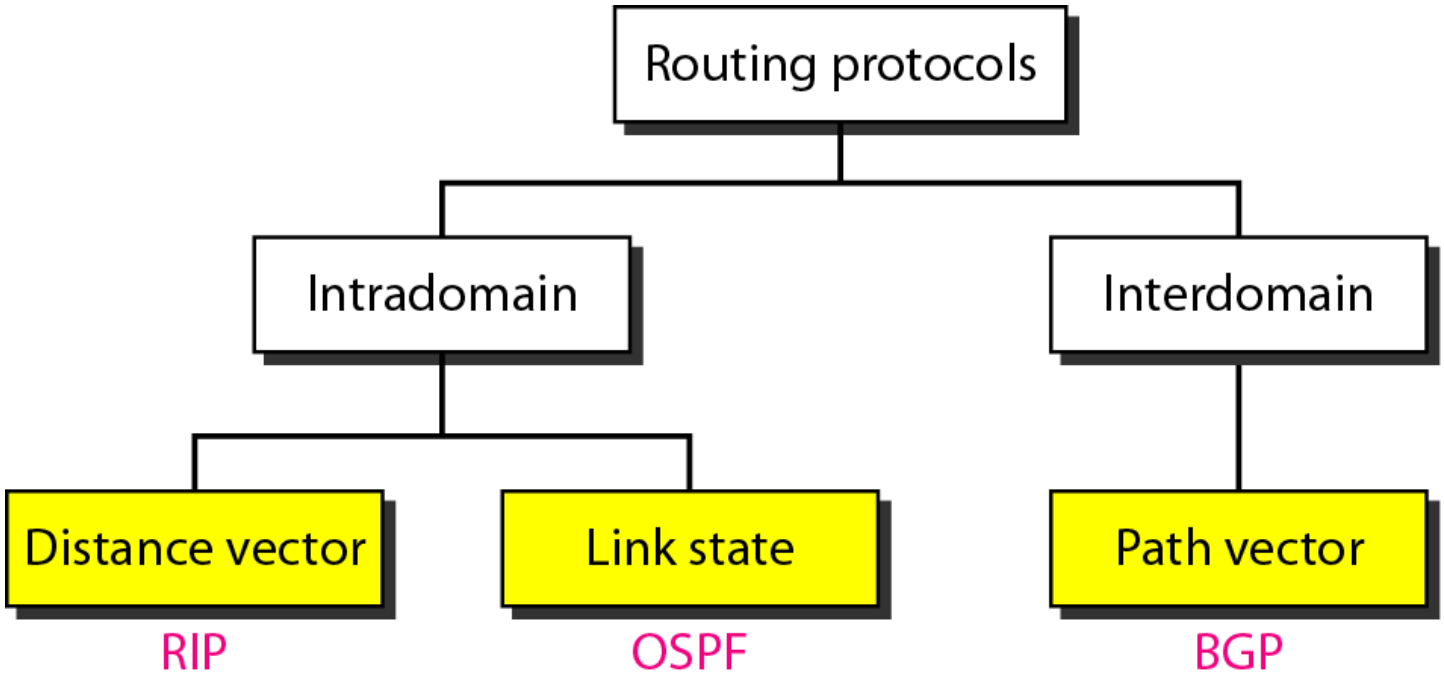
A. 80

B. 160

C. 8

D. 16

Figure 22.13 *Popular routing protocols*

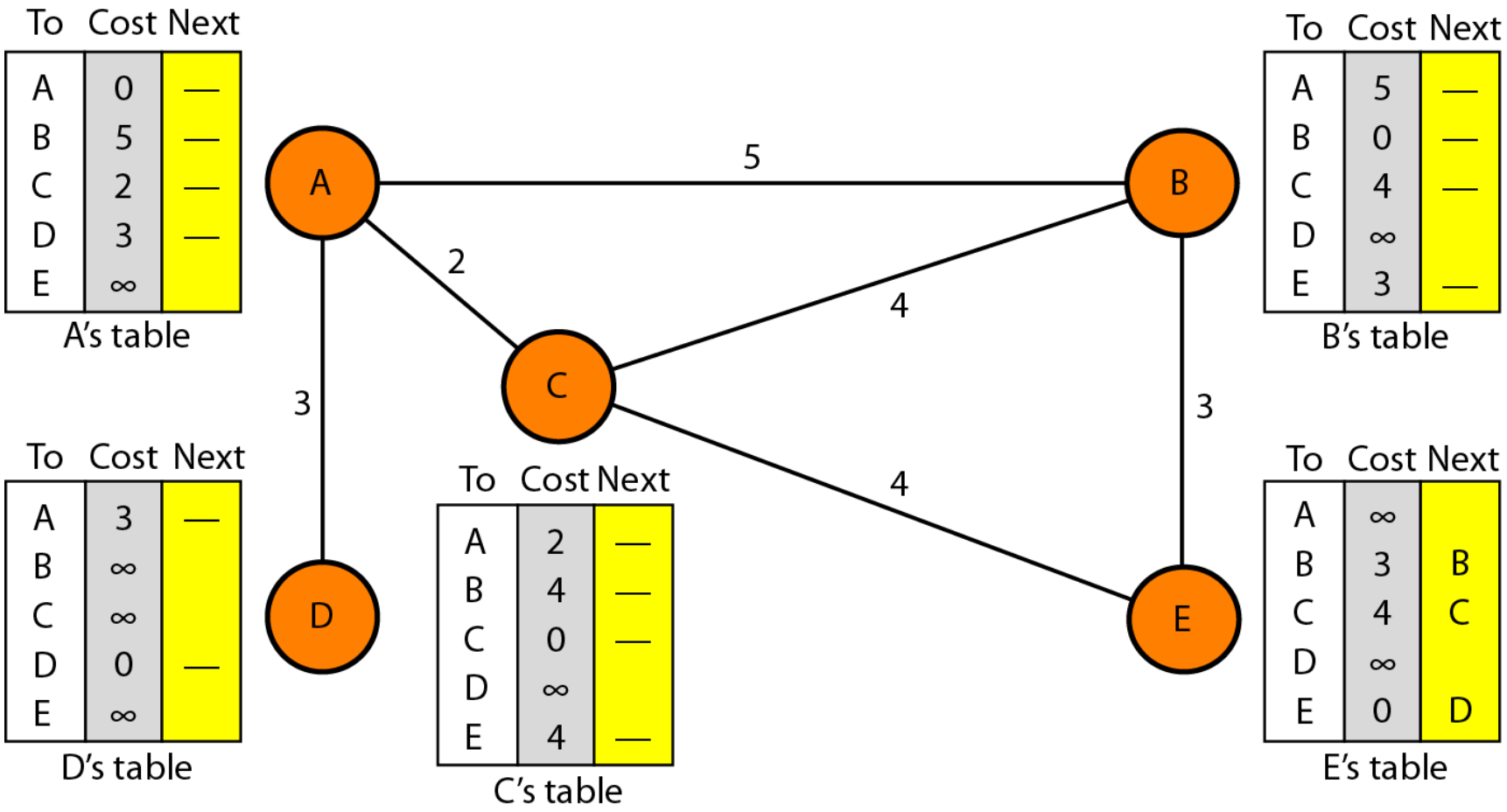


- In distance vector routing, the least-cost route between any two nodes is the route with minimum distance.

- In this protocol, as the name implies, each node maintains a vector (table) of minimum distances to every node.

- The table at each node also guides the packets to the desired node by showing the next stop in the route (next-hop routing).

Figure 22.15 *Initialization of tables in distance vector routing*



Note

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

Figure 22.16 *Updating in distance vector routing*

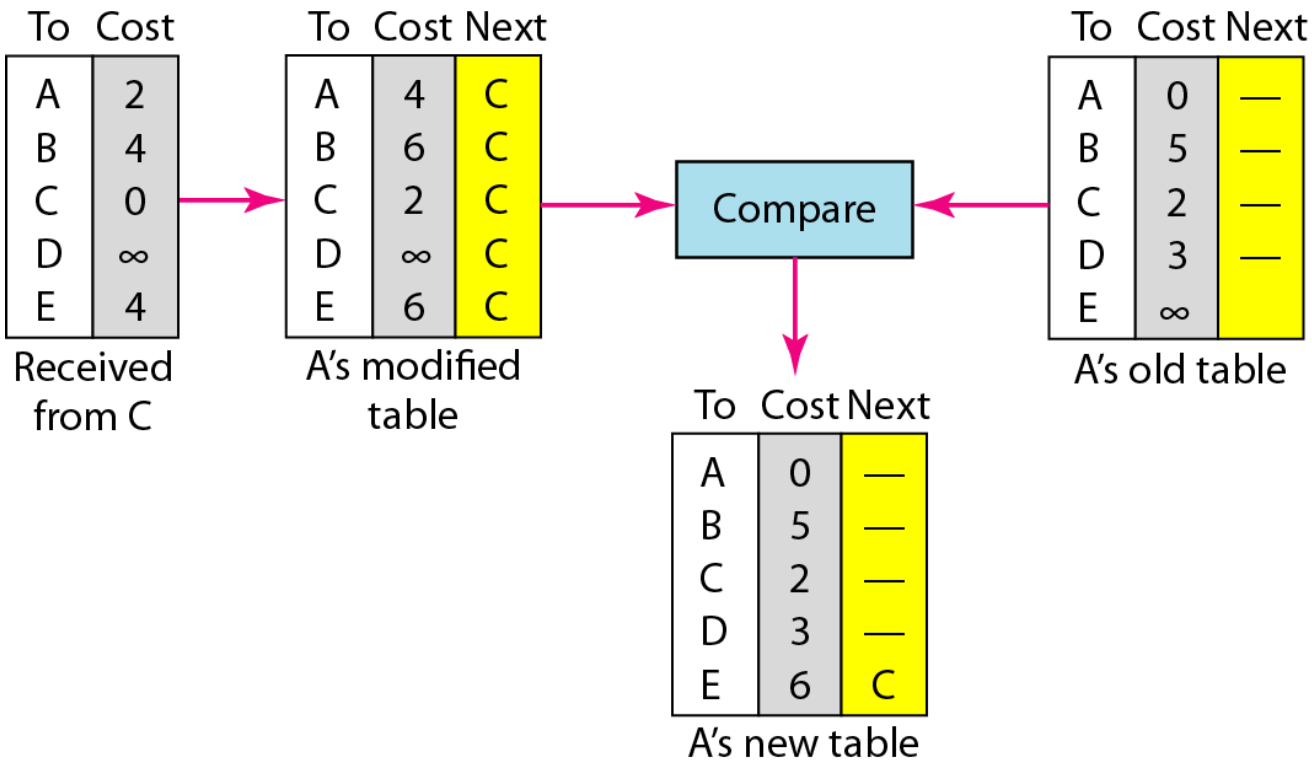
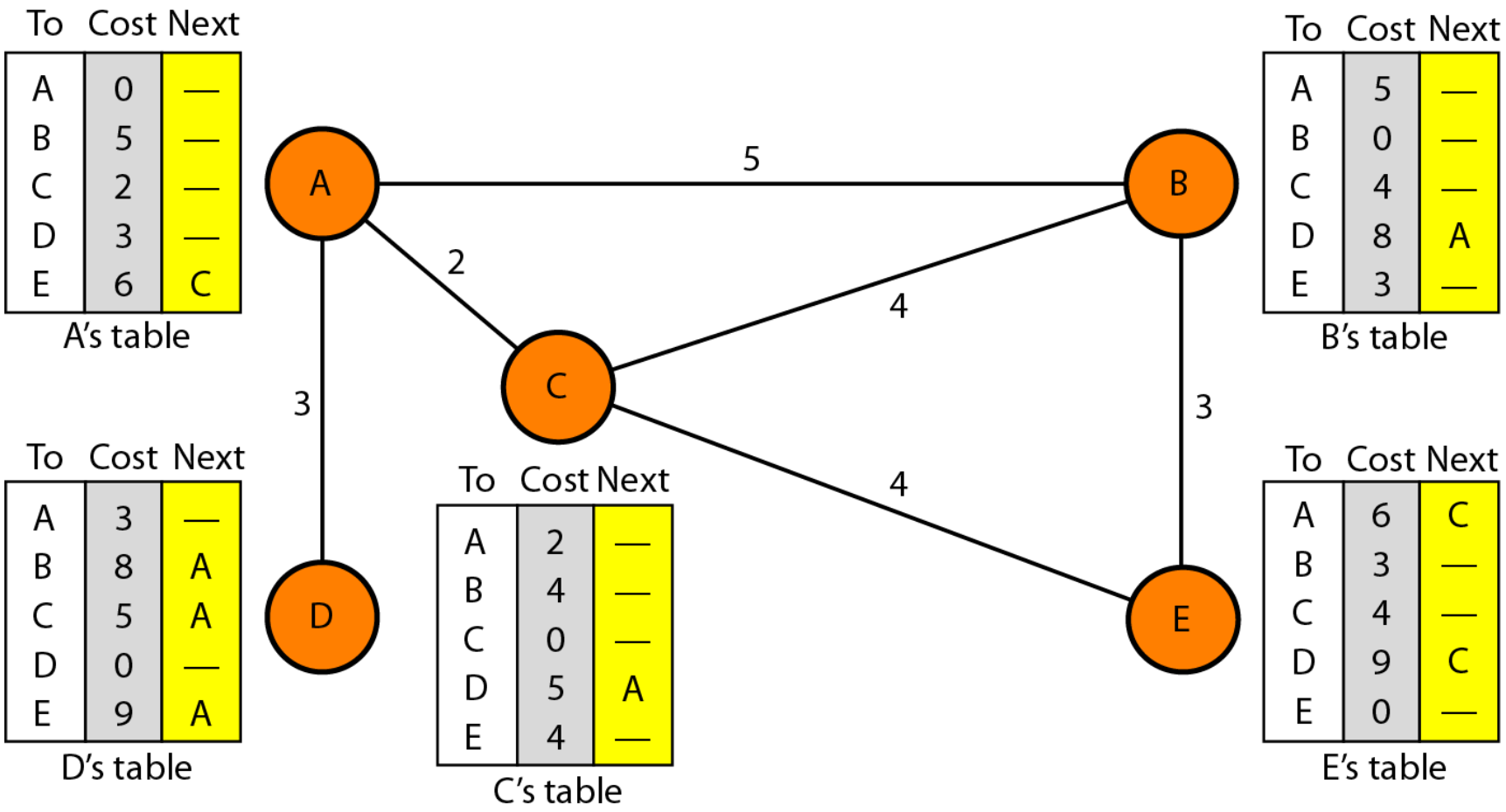


Figure 22.14 *Distance vector routing tables*



When does a node send its partial routing table (only two columns) to all its immediate neighbors?

Periodic Update: A node sends its routing table, normally every 30 s, in a periodic update. The period depends on the protocol that is using distance vector routing.

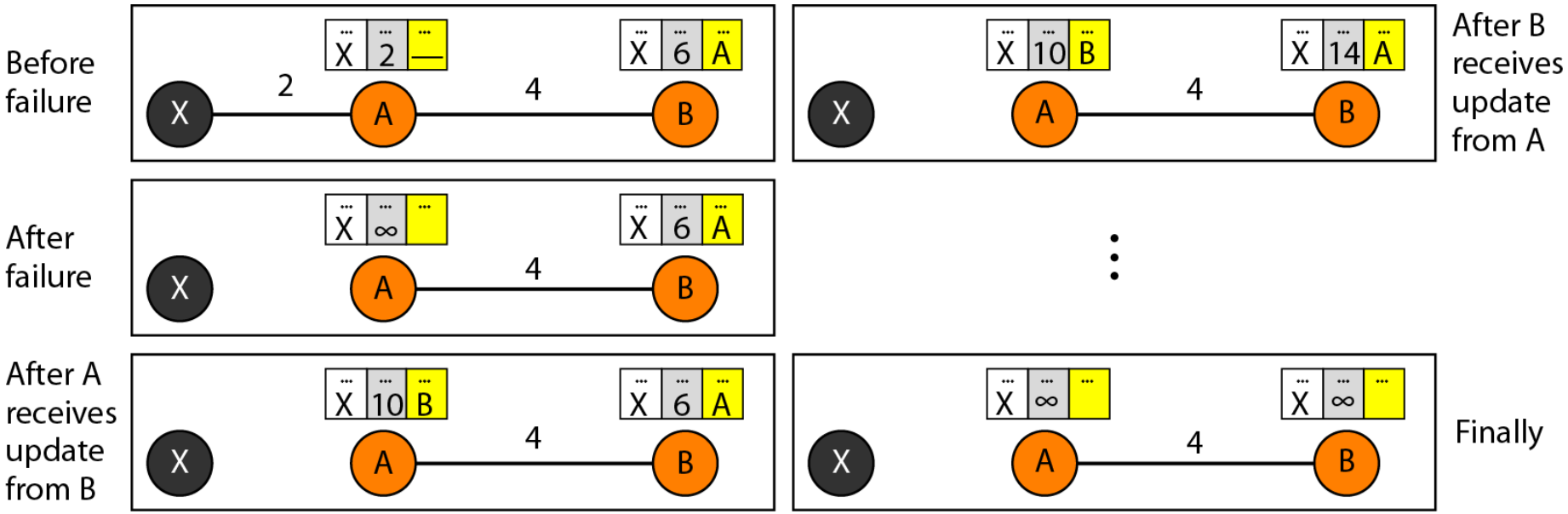
Triggered Update: A node sends its two-column routing table to its neighbors anytime there is a change in its routing table. This is called a triggered update.

The change can result from the following:

1. A node receives a table from a neighbor, resulting in changes in its own table after updating.

2. A node detects some failure in the neighboring links which results in a distance change to infinity.

Figure 22.17 *Two-node instability*



Defining Infinity

- The first obvious solution is to redefine infinity to a smaller number, such as 100.
- For our previous scenario, the system will be stable in less than 20 updates. As a matter of fact, most implementations of the distance vector protocol define the distance between each node to be I and define 16 as infinity.
- However, this means that the distance vector routing cannot be used in large systems.
- The size of the network, in each direction, can not exceed 15 hops.

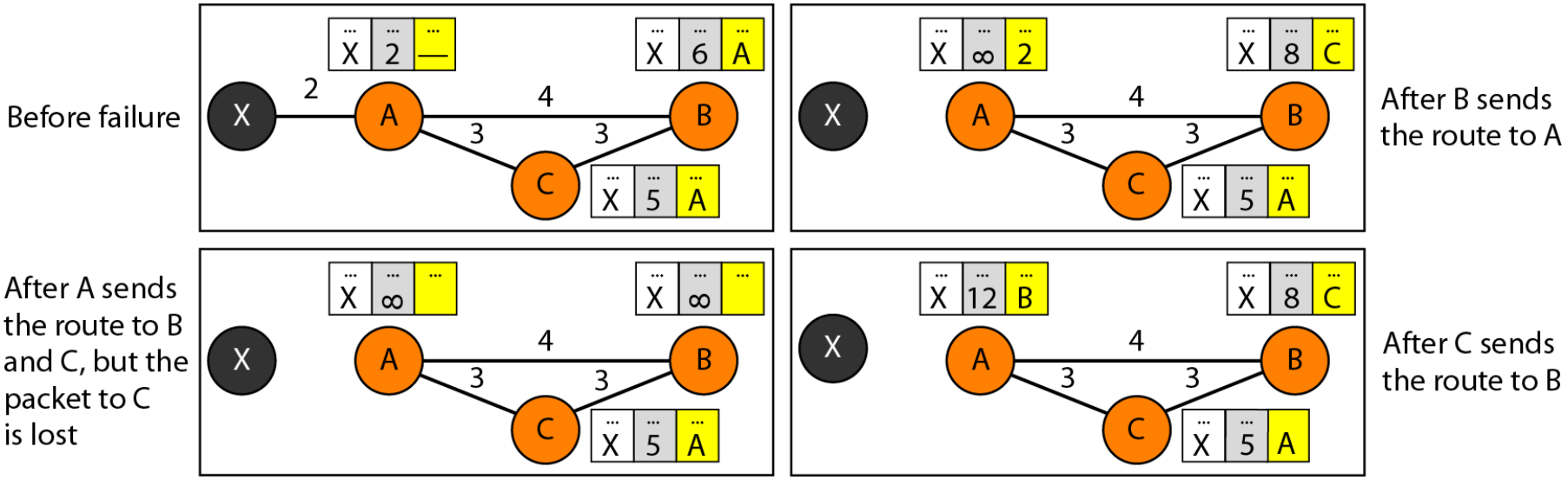
Split Horizon

- If node B thinks that the optimum route to reach X is via A, it does not need to advertise this piece of information to A; the information has come from A (A already knows).
- Taking information from node A, modifying it, and sending it back to node A creates the confusion.

Split Horizon and Poison Reverse

- Normally, the distance vector protocol uses a 3timer, and if there is no news about a route, the node deletes the route from its table.
- When node B in the previous scenario eliminates the route to X from its advertisement to A, node A cannot guess that this is due to the split horizon strategy (the source of information was A) or because B has not received any news about X recently.
- The split horizon strategy can be combined with the poison reverse strategy.
- Node B can still advertise the value for X, but if the source of information is A, it can replace the distance with infinity as a warning: "Do not use this value; what I know about this route comes from you."

Figure 22.18 *Three-node instability*



Routing Information Protocol (RIP)

It is an Intradomain routing protocol used inside an autonomous system. It is a very simple protocol based on distance vector routing.

RIP implements distance vector routing directly with ***some considerations***:

1. In an autonomous system, we are dealing with routers and networks (links). The routers have routing tables; networks do not.

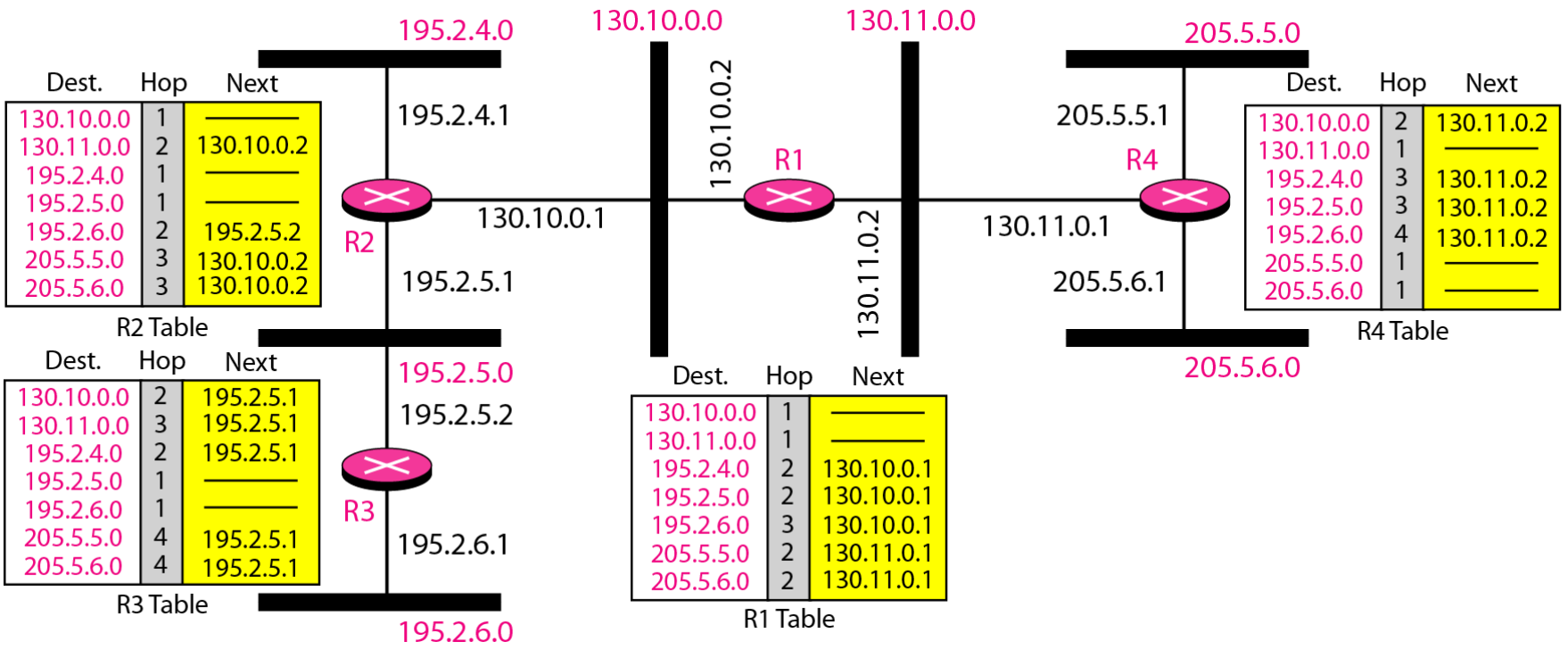
2. The destination in a routing table is a network, which means the first column defines a network address.

3. The metric used by RIP is very simple; the distance is defined as the number of links (networks) to reach the destination. For this reason, the metric in RIP is called a hop count.

4. Infinity is defined as 16, which means that any route in an autonomous system using RIP cannot have more than 15 hops.

5. The next-node column defines the address of the router to which the packet is to be sent to reach its destination.

Figure 22.19 *Example of a domain using RIP*



Link state routing

- In link state routing, each node in the domain has the entire topology of the domain
- List of nodes and links, how they are connected including cost (metric), and condition of the links (up or down)

Poll

- In link state routing, each node in the domain have information of entire

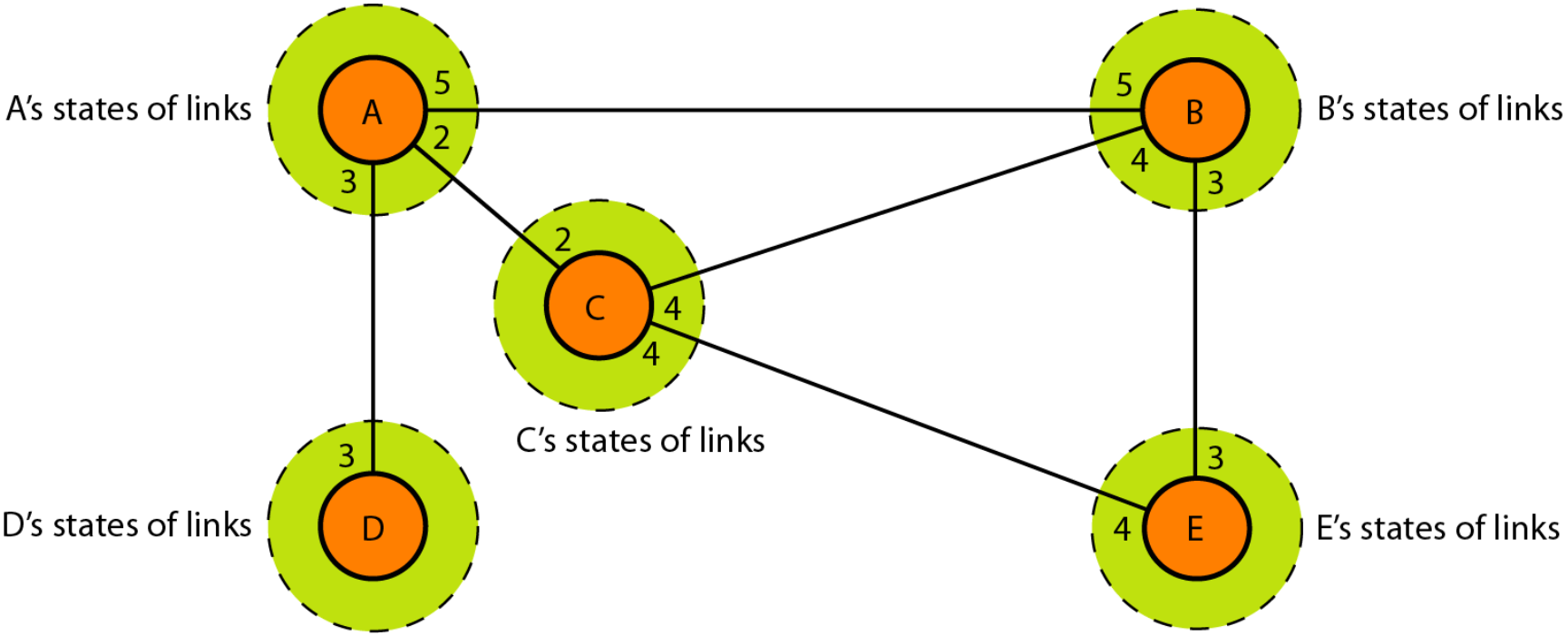
A. Topology

B. Adjacent node only

C. Next hop only

D. None of the above

Link state knowledge



Build routing table

In link state routing, four sets of actions are required to ensure that each node has the routing table showing the least-cost node to every other node.

1. Creation of the states of the links by each node, called the link state packet (LSP).
2. Dissemination of LSPs to every other router, called **flooding, in an efficient and** reliable way.
3. Formation of a shortest path tree for each node.
4. Calculation of a routing table based on the shortest path tree.

Creation of Link State Packet (LSP) -

- A link state packet can carry a large amount of information.
- For the moment, however, we assume that it carries a minimum amount of data:
  - node identity
  - list of links
  - sequence number,
  - age.
- The first two, node identity and the list of links, are needed to make the topology. The third, sequence number, facilitates flooding and distinguishes new LSPs from old ones.
- The fourth, age, prevents old LSPs from remaining in the domain for a long time

- LSPs are generated on two occasions:
  - *When there is a change in the topology of the domain*
  - On a periodic basis

Flooding of LSPs-

- The creating node sends a copy of the LSP out of each interface.
- A node that receives an LSP compares it with the copy it may already have.
- If the newly arrived LSP is older than the one it has, it discards the LSP. If it is newer, the node does the following:
- a. It discards the old LSP and keeps the new one.
- b. It sends a copy of it out of each interface except the one from which the packet arrived.

Figure 22.23 *Example of formation of shortest path tree*

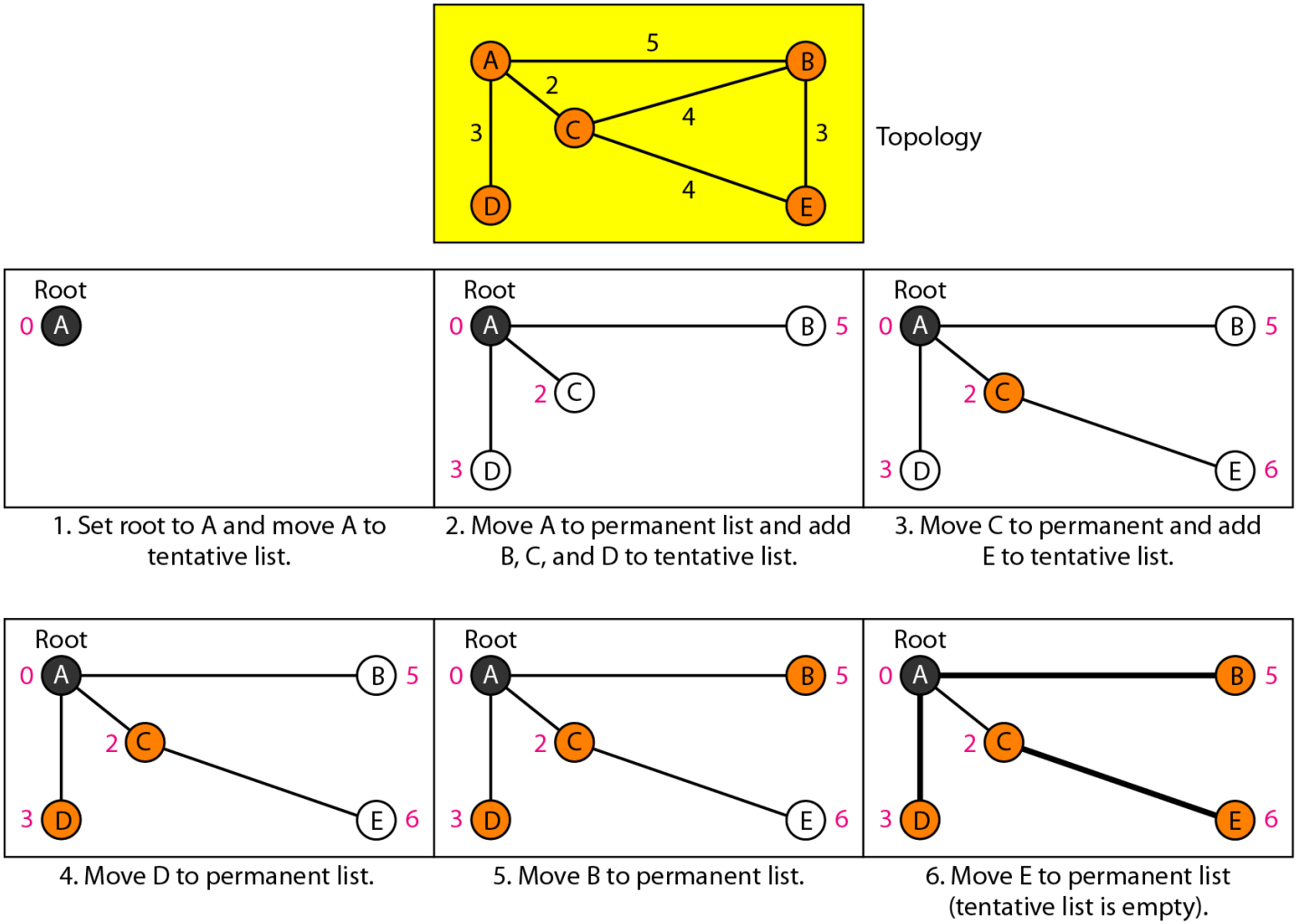


Figure 22.22 *Dijkstra algorithm*

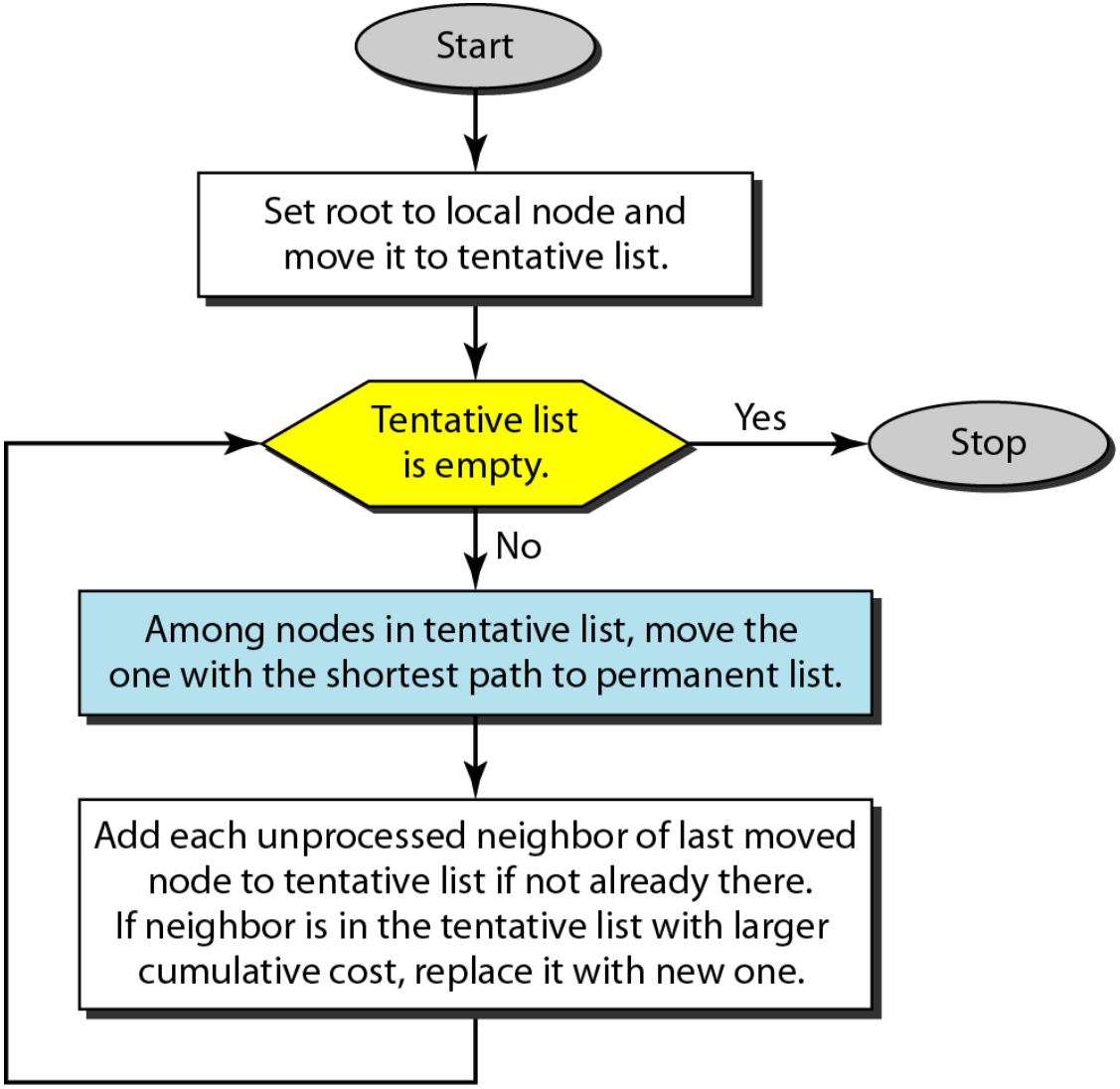


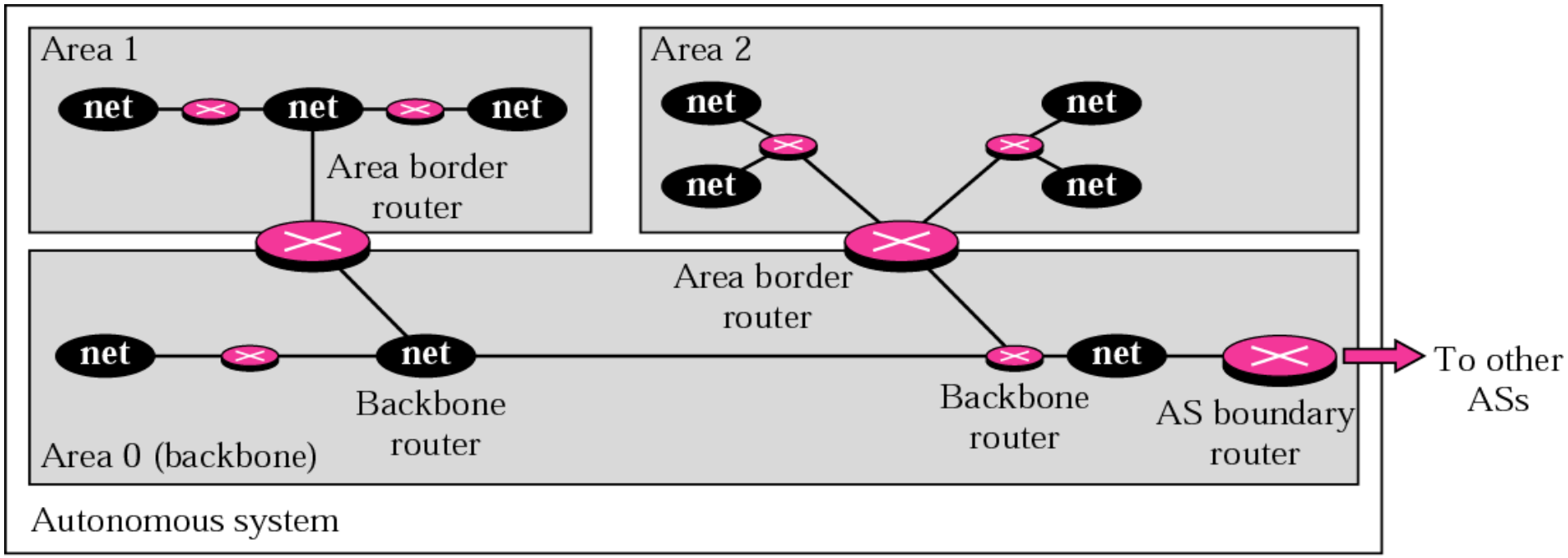
Table 22.2 *Routing table for node A*

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

OSPF

The Open Shortest Path First (OSPF) protocol is an intradomain routing protocol based on link state routing. Its domain is also an autonomous system.

Figure 14.19 *Areas in an autonomous system*



Metric in OSPF

- OSPF allows administrator to assign a cost called metric.
- The metric can be based on type of service- minimum delay, maximum throughput and so on.
- Therefore, a router can have multiple routing tables based on different type of service.

Figure 14.20 *Types of links*

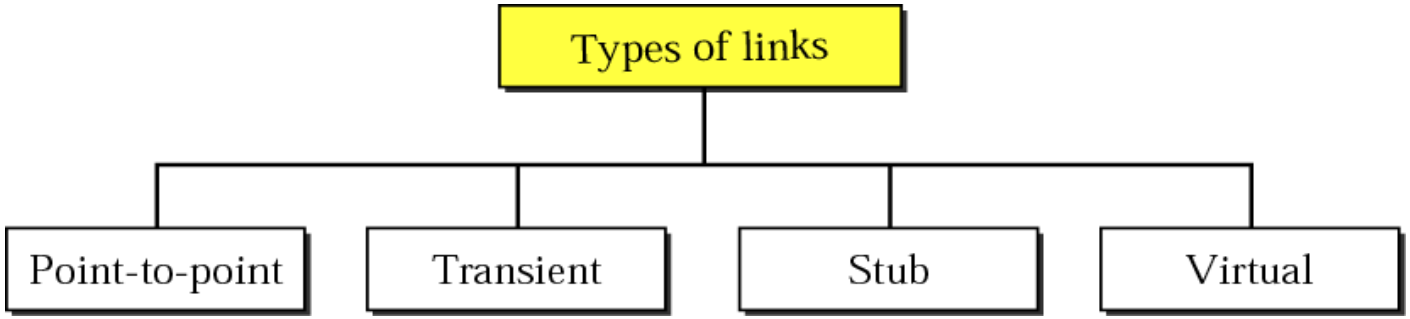


Figure 14.21 *Point-to-point link*

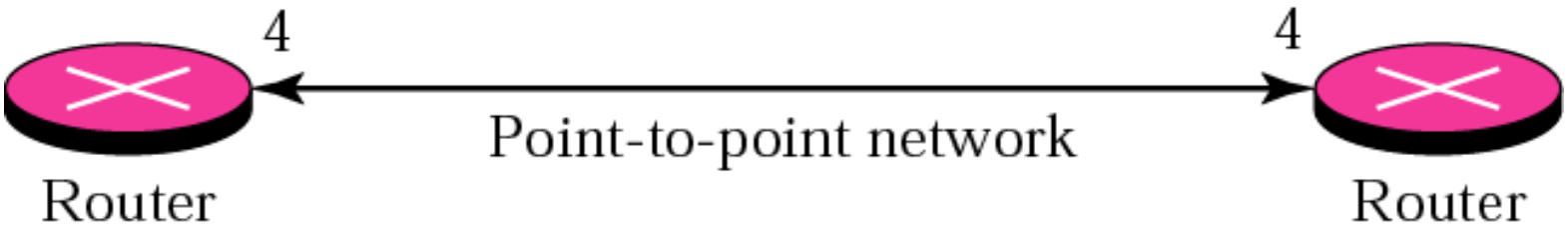
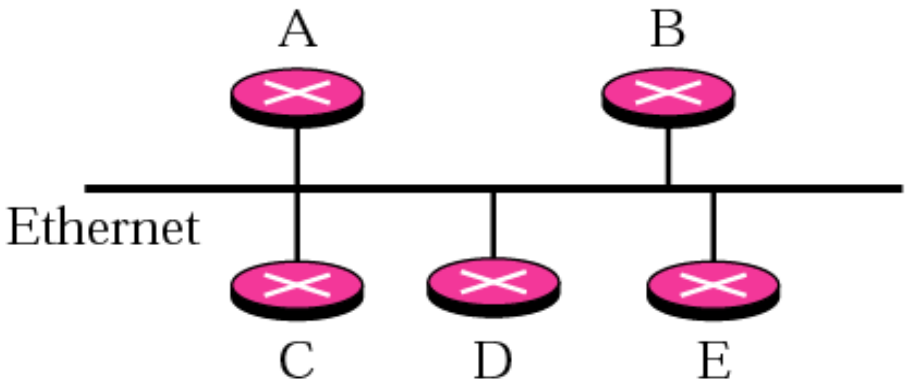
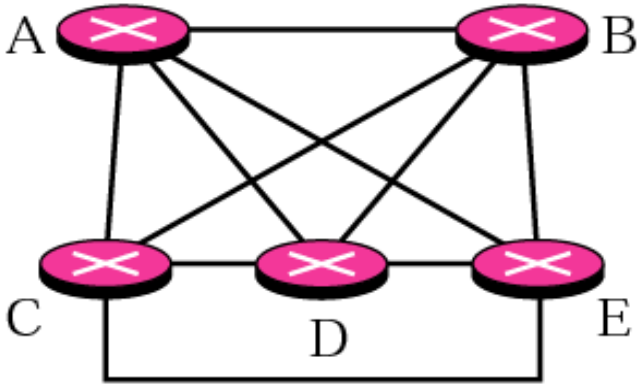


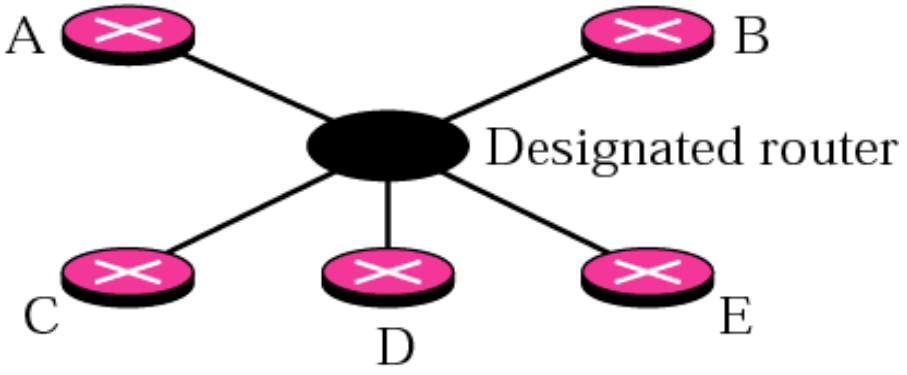
Figure 14.22 *Transient link*



a. Transient network

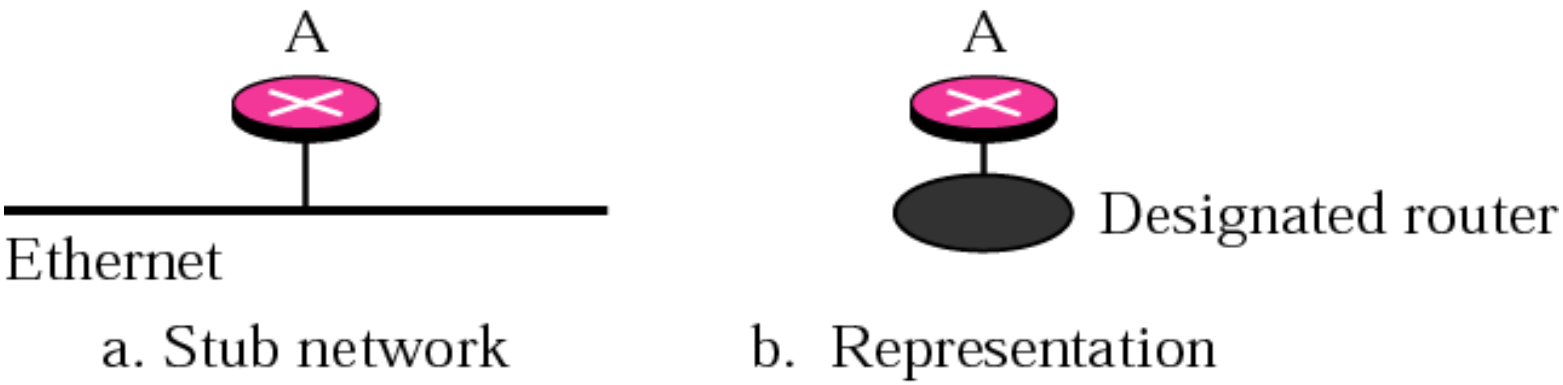


b. Unrealistic representation



c. Realistic representation

Figure 14.23 *Stub link*



a. Stub network b. Representation

PATH VECTOR ROUTING

Path vector routing is similar to distance vector routing. There is at least one node, called the speaker node, in each AS that creates a routing table and advertises it to speaker nodes in the neighboring ASs..

The topics discussed in this section include:

Initialization
Sharing
Updating

- Problem in distance vector is node instability.

- Problem in link state routing is heavy traffic due to flooding and extra resources required for generating routing tables.

Steps in path vector Routing

- Initialization
- Sharing
- Updating– Loop prevention, policy routing, optimum path.

Figure 14.48 *Initial routing tables in path vector routing*

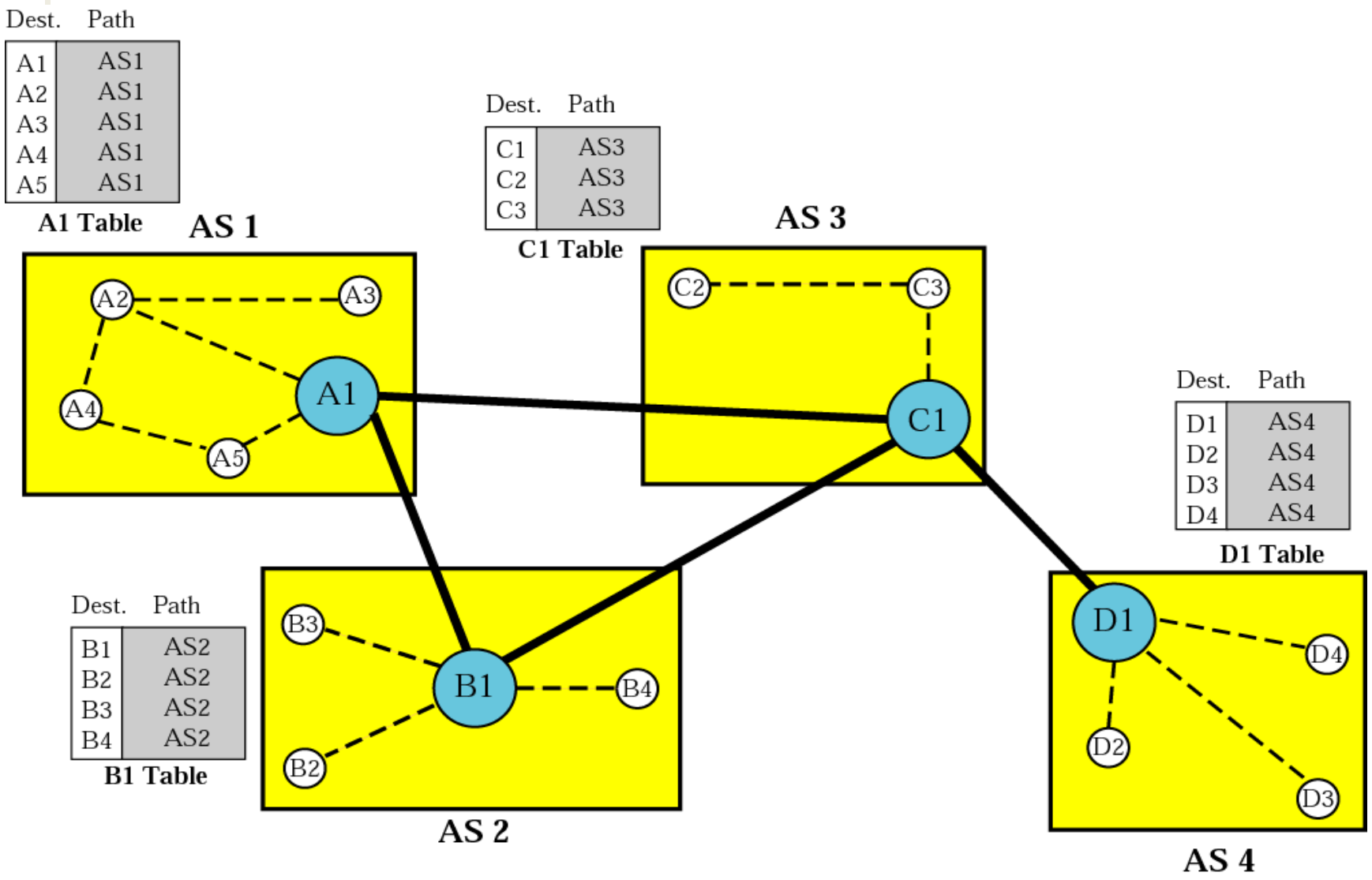


Figure 14.49 *Stabilized tables for four autonomous systems*

Dest.	Path
A1 ... A5	AS1
B1 ... B4	AS1-AS2 ... AS1-AS2
C1 ... C3	AS1-AS3 ... AS1-AS3
D1 ... D4	AS1-AS2-AS4 ... AS1-AS2-AS4

A1 Table

Dest.	Path
A1 ... A5	AS2-AS1
B1 ... B4	AS2 ... AS2
C1 ... C3	AS2-AS3 ... AS2-AS3
D1 ... D4	AS2-AS3-AS4 ... AS2-AS3-AS4

B1 Table

Dest.	Path
A1 ... A5	AS3-AS1
B1 ... B4	AS3-AS2 ... AS3-AS2
C1 ... C3	AS3 ... AS3
D1 ... D4	AS3-AS4 ... AS3-AS4

C1 Table

Dest.	Path
A1 ... A5	AS4-AS3-AS1
B1 ... B4	AS4-AS3-AS2 ... AS4-AS3-AS2
C1 ... C3	AS4-AS3 ... AS4-AS3
D1 ... D4	AS4 ... AS4

D1 Table

14.7 BGP

Border Gateway Protocol (BGP) is an interdomain routing protocol using path vector routing. It first appeared in 1989 and has gone through four versions.

The topics discussed in this section include:

Types of Autonomous Systems
Path Attributes
BGP Sessions
External and Internal BGP

Path Attributes

- Well Known attribute
  - Mandatory
  - Discretionary
- Optional attribute
  - Transitive
  - Non-transitive

BGP Sessions

- Using TCP connections—reliable
- Last for long time so it is called as semi permanent connections.

Figure 14.50 *Internal and external BGP sessions*