Routing

Routing

- Routing: **Packet *forwarding* . moving packets between ports**
  - Look up destination address in forwarding table
  - Find *out-port* or (*out-port*, *MAC addr)* pair
- ***Routing* is process of populating forwarding table**
  - Routers exchange messages about nets they can reach
  - Goal: Find optimal route for every destination, or maybe good route, or maybe just any route (depending on scale)
  - Routing table : static or dynamic - Routing Protocols

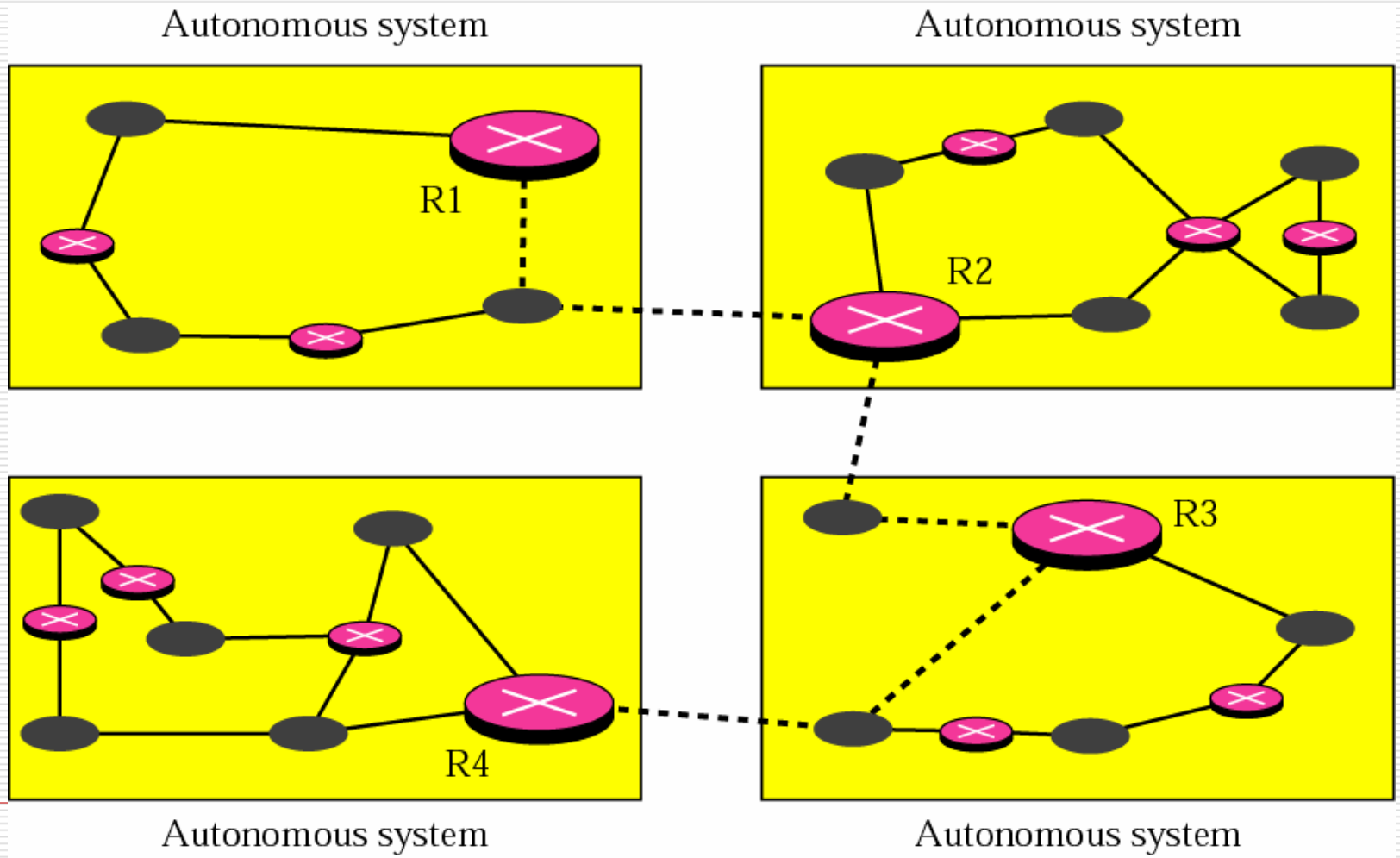
Unicast / Multicast

- Unicast Routing: Router forwards the received pkt. through only one of its ports.
- Multicast Routing: Router forwards the received pkt. through several of its ports.
- Metrics : Cost assigned for passing through a network.
- Router chooses route with shortest metric -Can be based on latency, b/w, utilization, queue length etc.
- Autonomous Systems (AS) : Group of networks and routers under the authority of single administration.

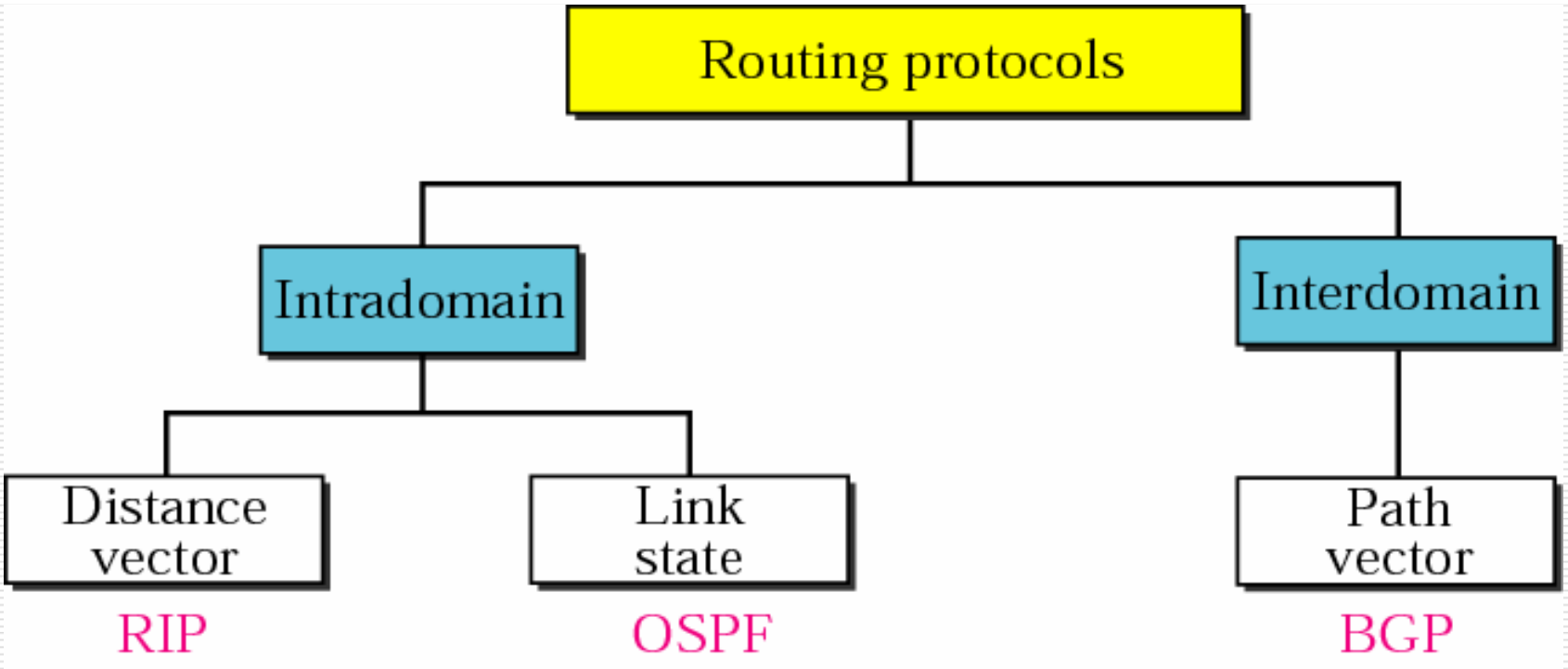
Routing

- ***Intra*-domain vs. *Inter*-domain routing**
  - Intra: All routers under same administrative control
  - Intra: Scale to »100 networks
  - Inter: Decentralized, scale to Internet
- Routing inside an autonomous system is referred to as intra-domain routing. Routing between autonomous systems is referred to as inter-domain routing.

Autonomous Systems



Routing Protocols



RIP

- Interior routing protocol , based on distance vector routing. Uses Bellman-Ford algorithm

- Distance Vector Routing :
  - In distance vector routing, the least cost route between any two nodes is the route with minimum distance. In this protocol each node maintains a vector (table) of minimum distances to every node

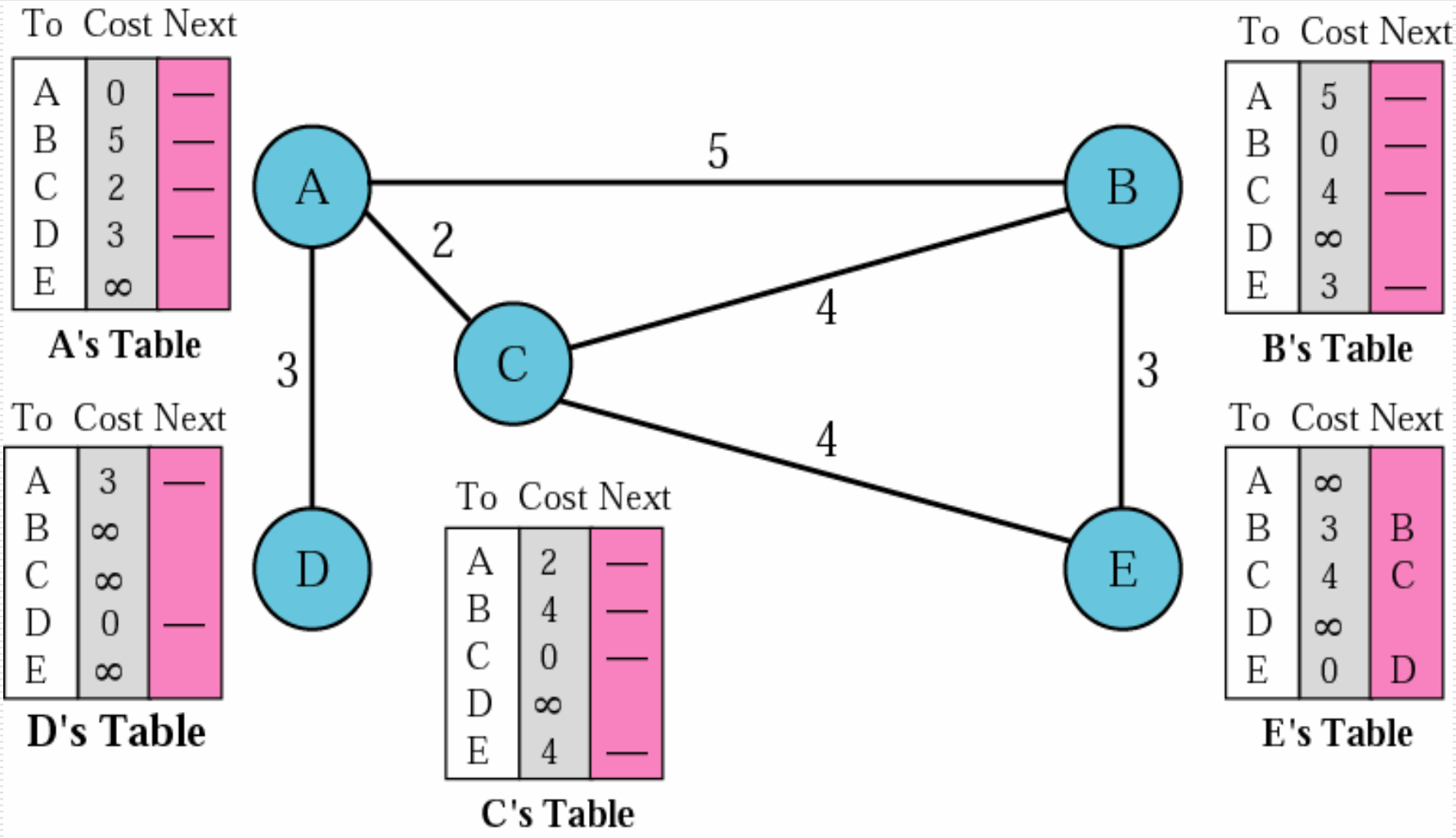
Distance Vector Routing

- Each router periodically shares its knowledge about the entire internet with its neighbors.
  - Share knowledge about entire AS.
  - Sharing only with neighbors.
  - Sharing at regular intervals.
- Routing Table :
  - Has one entry for each destination network of which the router is aware.
  - Dest. Nw addr | shortest dist. | Nxt router |

A distance vector routing table

Destination	Hop Count	Next Router	Other information
163.5.0.0	7	172.6.23.4	
197.5.13.0	5	176.3.6.17	
189.45.0.0	4	200.5.1.6	
115.0.0.0	6	131.4.7.19	

Distance vector routing tables



Distance vector routing

- Every node sends a message to its directly connected neighbors containing its personal list of distance. (for example, **A** sends its information to its neighbors **B,C** and **D**.)
- If any of the recipients of the information from **A** find that **A** is advertising a path shorter than the one they currently know about, they update their list to give the new path length and note that they should send packets for that destination through **A**.

Distance vector routing

- After every node has exchanged a few updates with its directly connected neighbors, all nodes will know the least-cost path to all the other nodes.
- In addition to updating their list of distances when they receive updates, the nodes need to keep track of which node told them about the path that they used to calculate the cost, so that they can create their forwarding table.
- (for example, **B** knows that it was **A** who said " I can reach **E** in one hop" and so **B** puts an entry in its table that says " To reach **E**, use the link to **A**.)

RIP Updating Algorithm

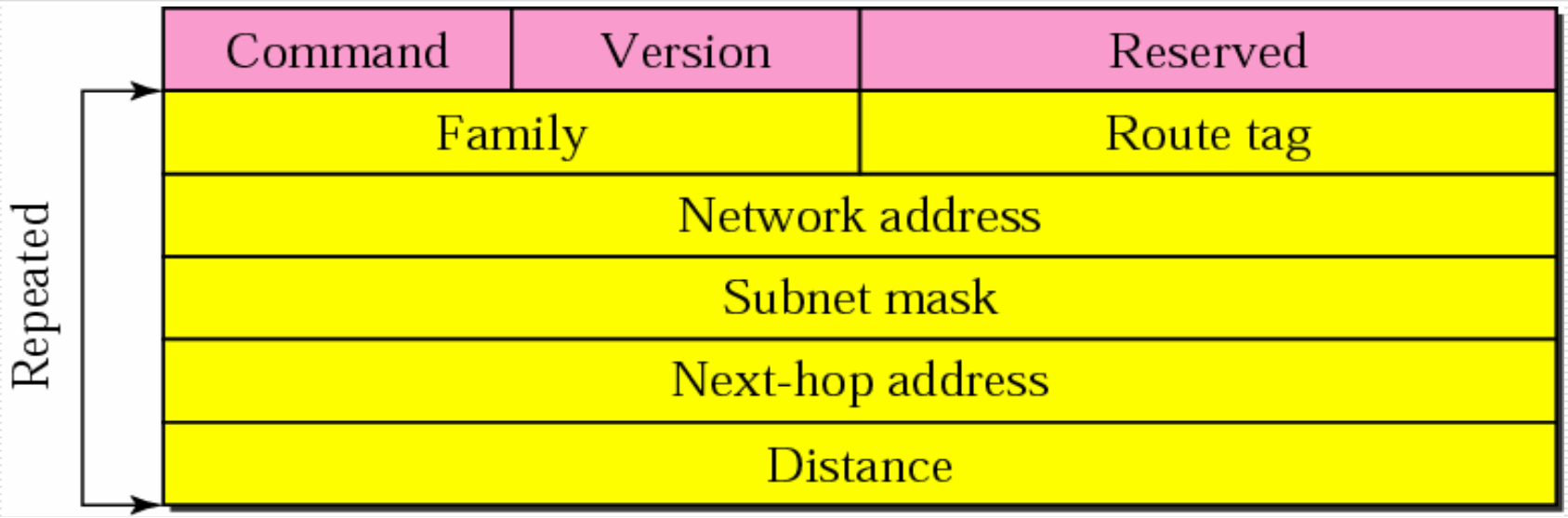
Receive: a response RIP message

1. Add one hop to the hop count for each advertised destination.
2. Repeat the following steps for each advertised destination:
   - If (destination not in the routing table)
     - Add the advertised information to the table.
   2. Else
   - If (next-hop field is the same)
     - Replace entry in the table with the advertised one.
   2. Else
   - If (advertised hop count smaller than one in the table)
     - Replace entry in the routing table.
3. Return.

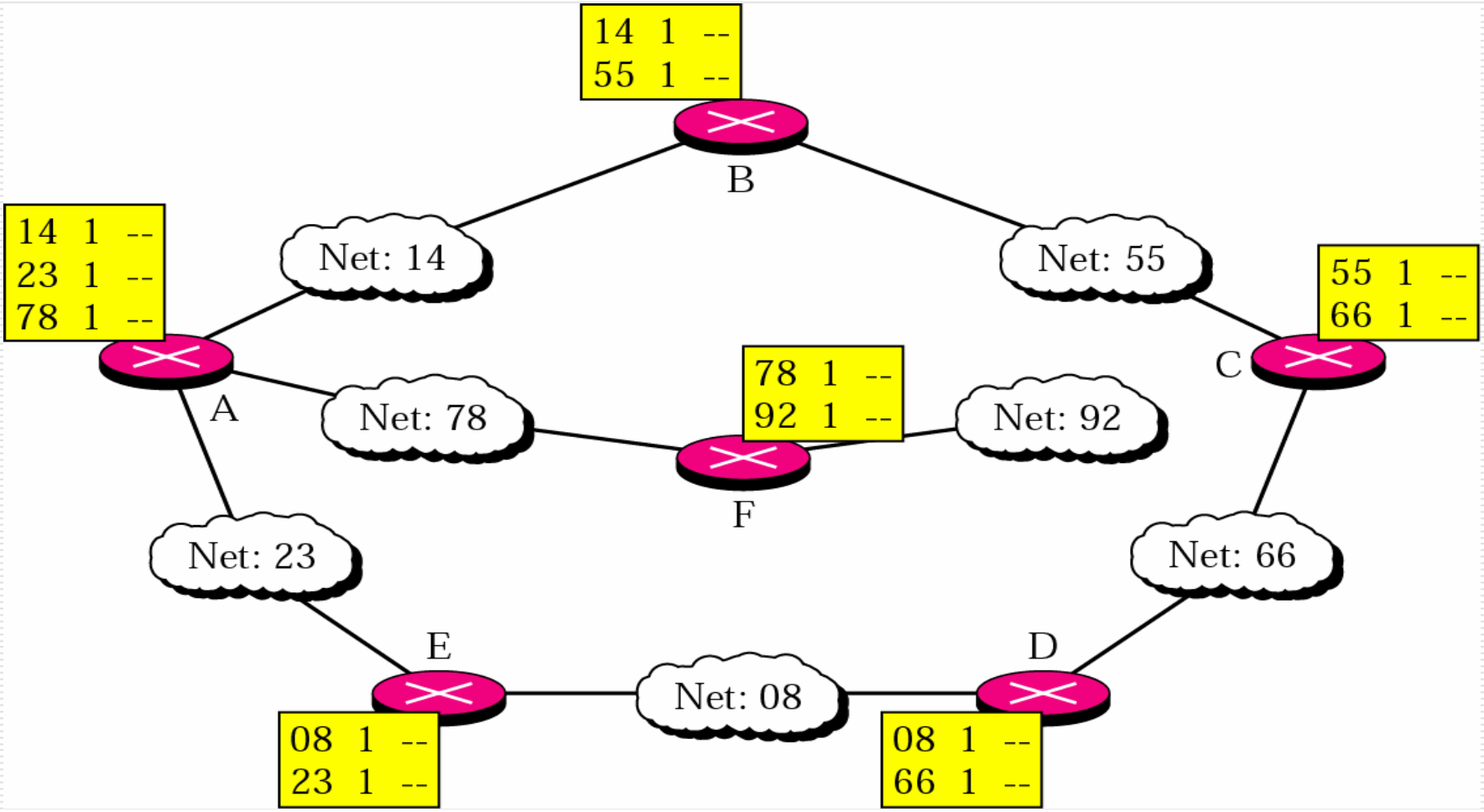
Distance Vector -RIP

- Advertisements sent in UDP packets, periodically repeated using well-known port 520.
- Distance vectors: exchanged every 30 sec via Response Message (also called **advertisement**)
- Each advertisement: route to up to 25 destination net
- If no advertisement heard after 180 sec - neighbor/link declared dead -routes via neighbor invalidated
  - link failure info quickly propagates to entire net

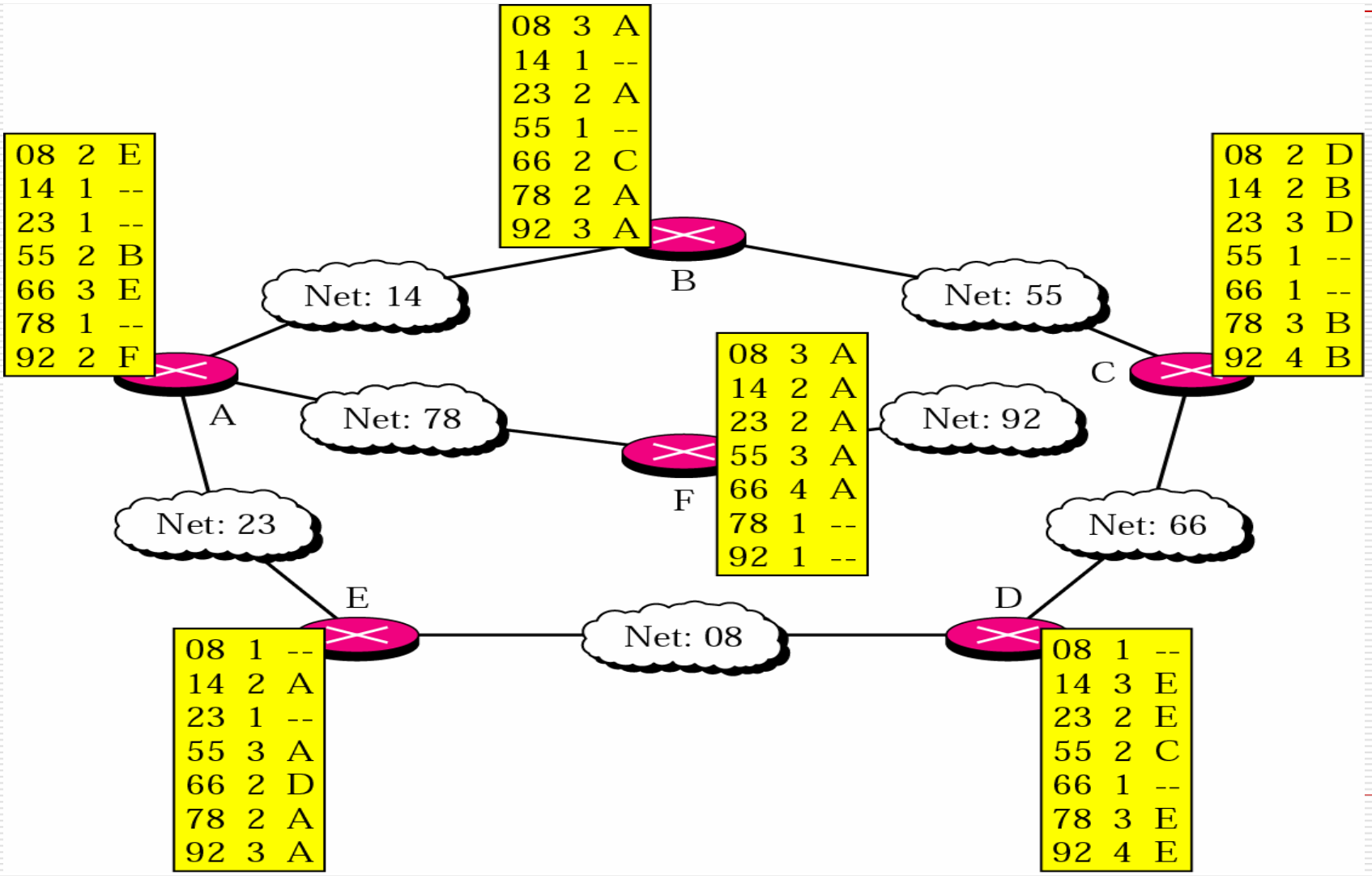
RIP version 2 format



Initial routing tables in a small autonomous system



Final routing tables



Features of Distance Vector

- ☐ Distributed
- ☐ Adapts to traffic changes and link failures
- ☐ Useful for small subnets -easy to install
- ☒ Count to infinity

Link State Routing

In link state routing, if each node in the domain has the entire topology of the domain, the node can use Dijkstra's algorithm to build a routing table.

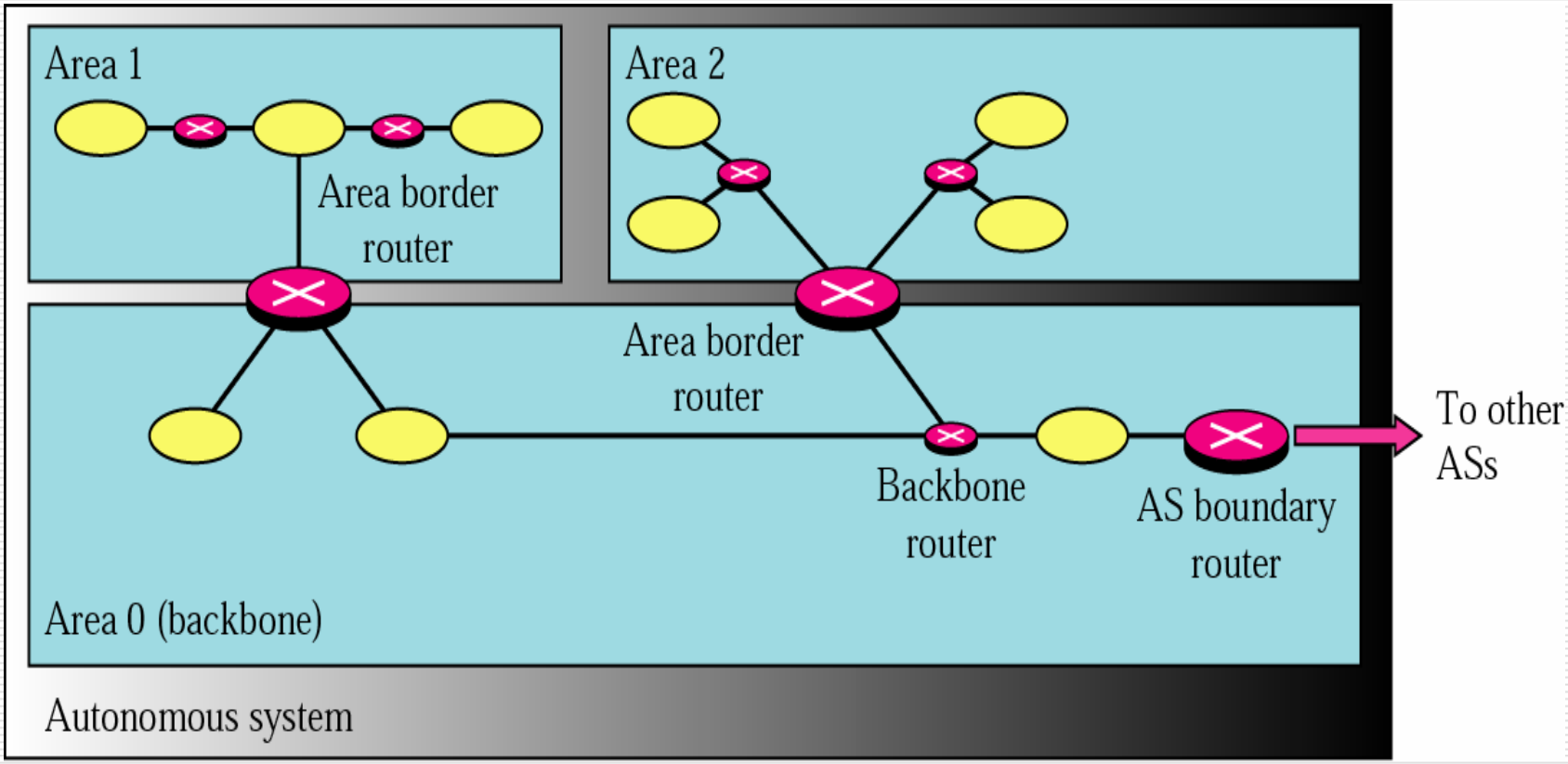
- Link state information is flooded to all nodes

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.

- Autonomous system boundary routers
- AS into Areas : Collection of NWs, hosts and routers within an AS
- Area border routers
- Backbone- routers
- Metric: Link costs - based on a type of service

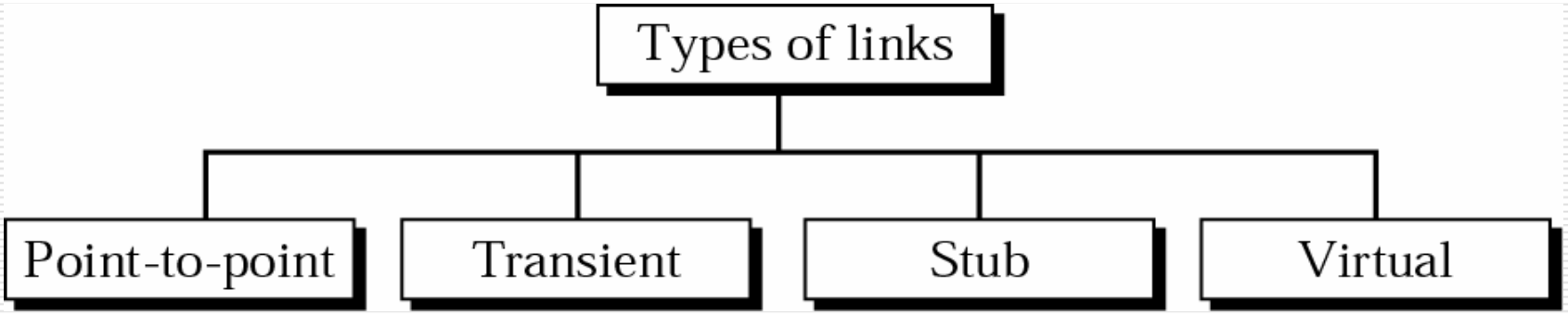
Areas in an autonomous system



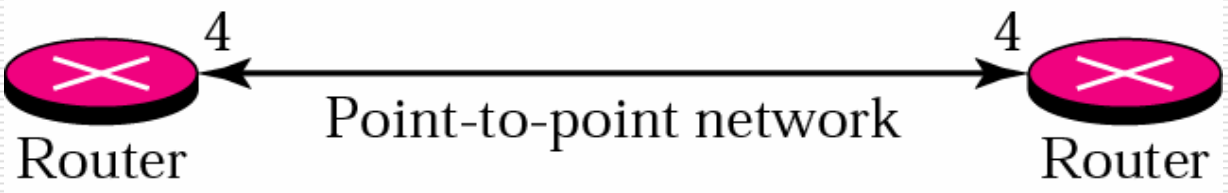
Link State Routing

- Each router periodically shares its knowledge about its neighborhood with every router in the area.
  - Share knowledge neighborhood.
  - Sharing with every other router
  - Sharing when there is a change.

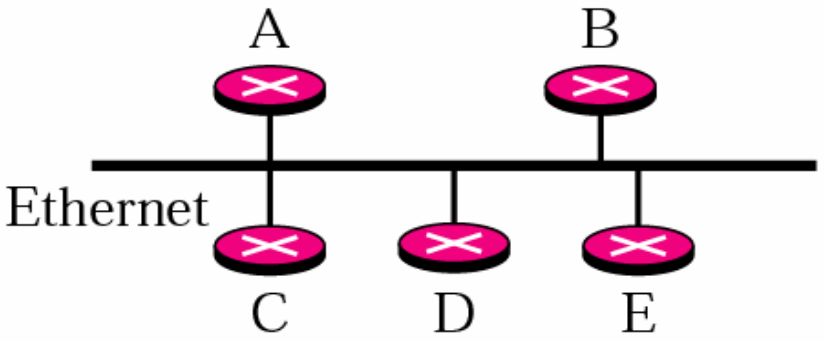
Types of Links



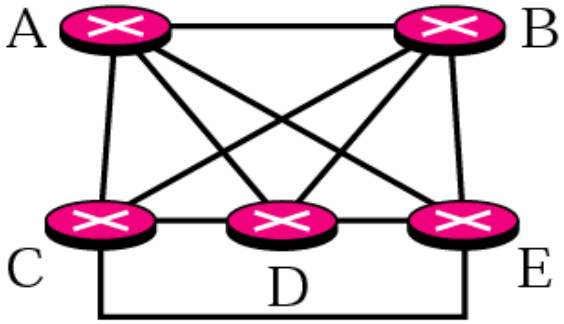
Point-to-point link



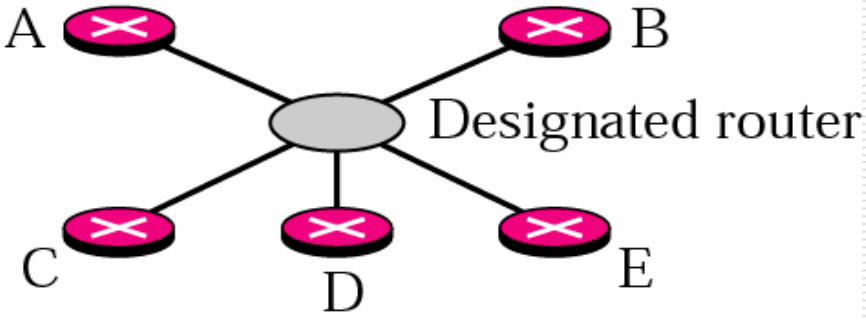
Transient link



a. Transient network

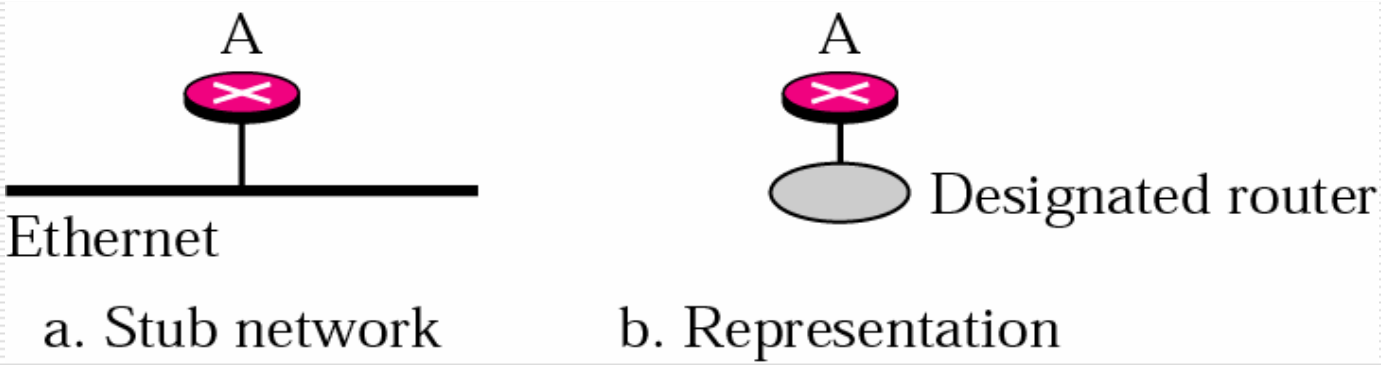


b. Unrealistic representation



c. Realistic representation

Stub link

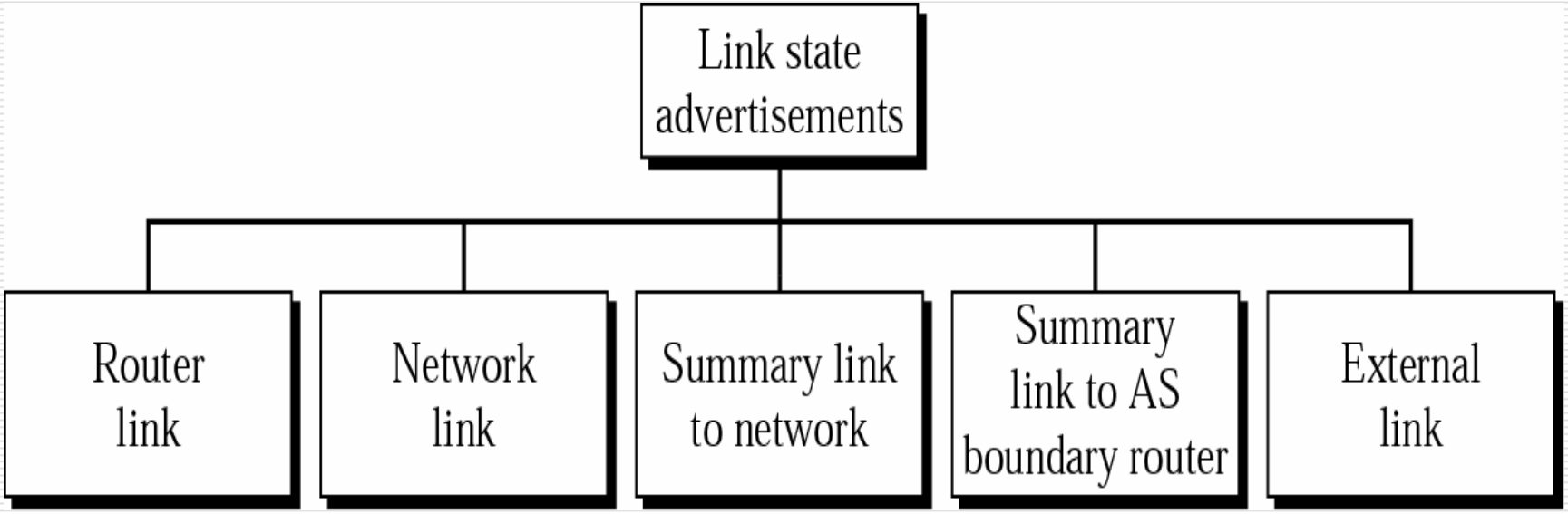


a. Stub network b. Representation

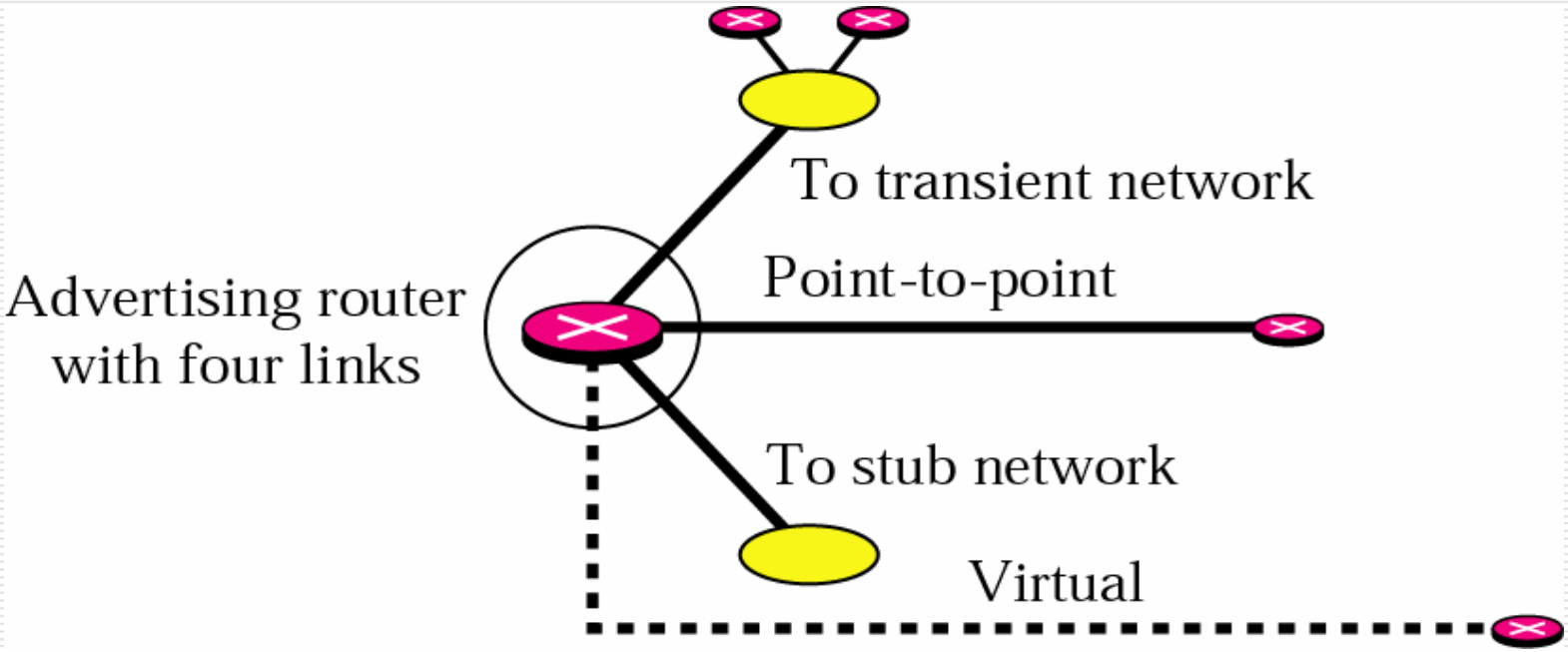
Types of LSAs

Each router generates *link state advertisements (LSAs)* which are distributed to all routers

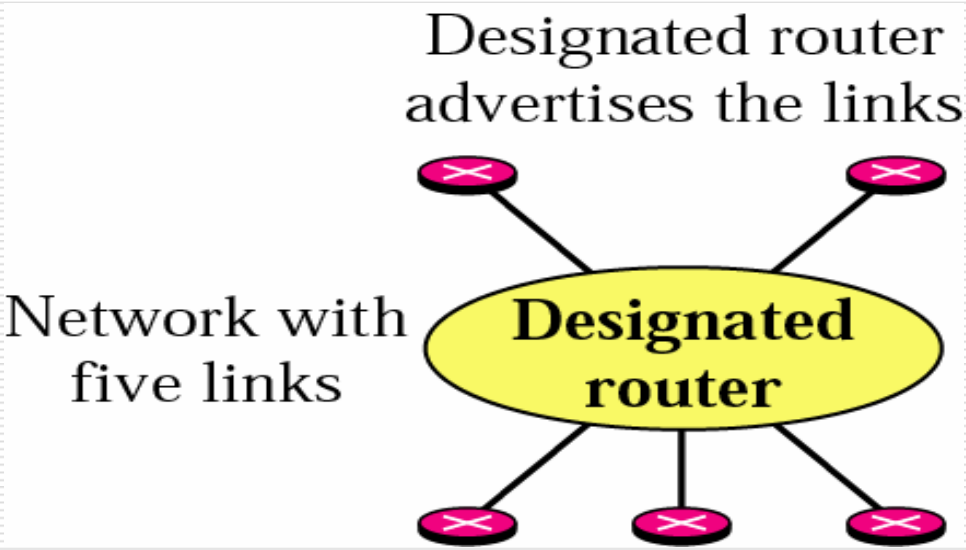
LSA = (link id, state of the link, cost, neighbors of the link)



Router link


To transient network
Point-to-point
Advertising router
with four links
To stub network
Virtual

Network link



Features of OSPF

- Provides authentication of routing messages
- Enables load balancing by allowing traffic to be split evenly across routes with equal cost
- Type-of-Service routing allows to setup different routes dependent on the TOS field
- Supports subnetting
- Supports multicasting
- Allows hierarchical routing