CS 716: Introduction to communication networks

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Routing - Clicker Question

1. How does a router know which path to forward a packet on?

   A) It broadcasts an ARP request to find the destination.

   B) The route is given in the IP header of the packet.

   C) It constructs a routing table and does a lookup to find route.

   D) It forwards the packet to the default gateway.

- Choose one of the options below.

1. All of the above	2. A), C) and D)
3. C) and D)	4. C) only

Routing Questions

- How does a router know which path to forward a packet on?
  - Need to construct and lookup routing tables
- How does a router know whether its link with its neighbour is up or down?
  - Need to exchange periodic “keep-alive” messages.
- How does a router know whether a distant link is up or down?
  - Need to propagate “link-state” information.

Routing

- Routing is the mechanism of forwarding messages towards the destination node based on its address.

- Routers decide routes for packets, based on destination address and topology.
- Routers need to learn global information and compute routes to various networks.

- Exchange information with other routers to learn network topology.
- Maintain a table of available routes and their conditions.
- Use table along with path algorithms to determine the best route for a packet.

Routing methods

- Static routing: Default routes are specified at boot time

- Dynamic methods:
- Source-based: Specify route at source (DSR)

- Distance-vector routing: Set up next-hops to destinations looking at neighbors' routing tables (RIP)

- Link-state routing: Get map of network in terms of link states and calculate best route (but specify only the next-hop) (OSPF)

Distance vector routing

- “Vector” of distances to each possible destination at each router

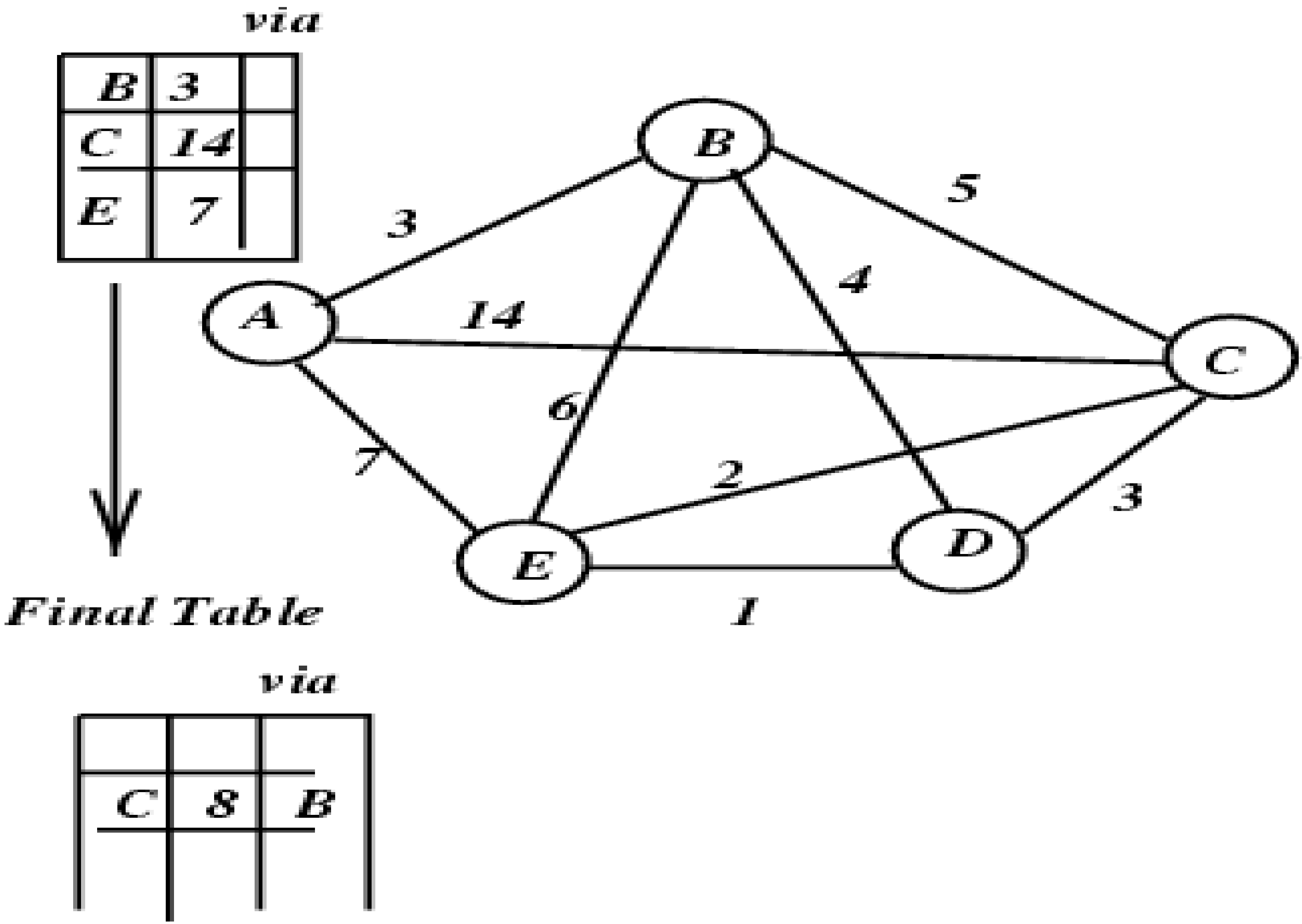
- How to find distances?
  - Distance to local network is 0
  - Look in neighbors’ distance vectors, and add link cost to reach the neighbor
  - Find minimum distance to destination

DV: Bellman-Ford algorithm

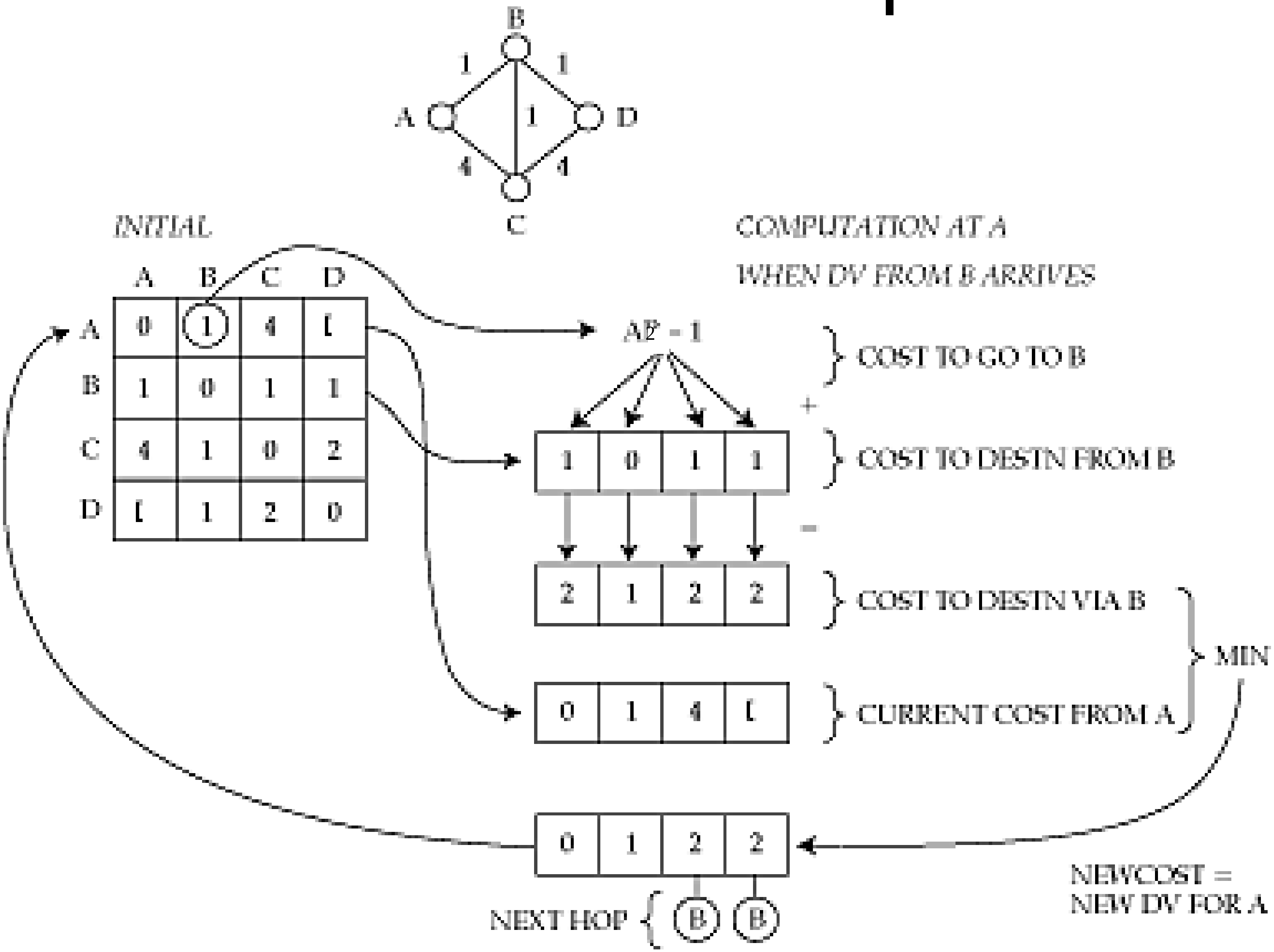
Iteration at each node:

1. *wait* for (change in local link cost or message from neighbor)
2. *recompute* distance table
3. if least cost path to any destination has changed, *notify* neighbors

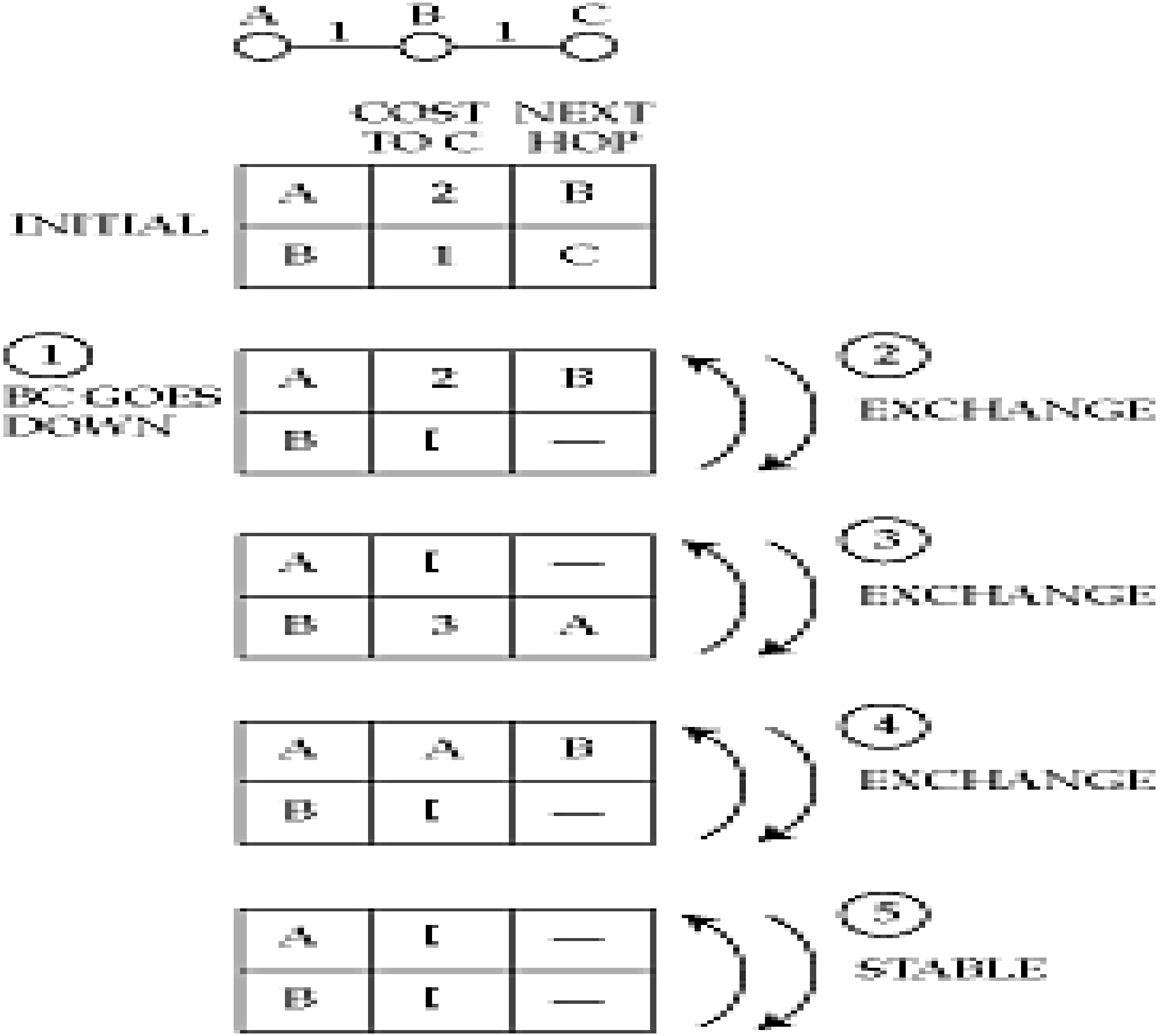
DV Example: RIP



DV: Another example



DV problem: Count to infinity



Count to Infinity problem

- Configuration A->B->C.
- If C fails, B needs to update and thinks there is a route through A
- A needs to update and thinks there is a route thru B

- No clear solution, except to set “infinity” to be small (eg 16 in RIP)

- Split-horizon: If A’s route to C is thru B, then A advertises C’s route (only to B) as infinity

Dealing with the problem

- Path vector
  - DV carries path to reach each destination

- Split horizon
  - never tell neighbor cost to X if neighbor is next hop to X

- Triggered updates
  - exchange routes on change, instead of on timer; faster count up to infinity

RIP information

- Distance vector
  - Cost metric is hop count; Infinity = 16
- RIPv1 defined in RFC 1058
  - uses UDP at port 520
- trigger for sending of distance vectors
  - 30-second intervals; 180s Refresh Timeout
  - routing table update; split horizon
  - format can carry upto 25 routes (512 bytes)
- RIPv2 defined in RFC 1388
  - uses IP multicasting (224.0.0.9); VLSM etc

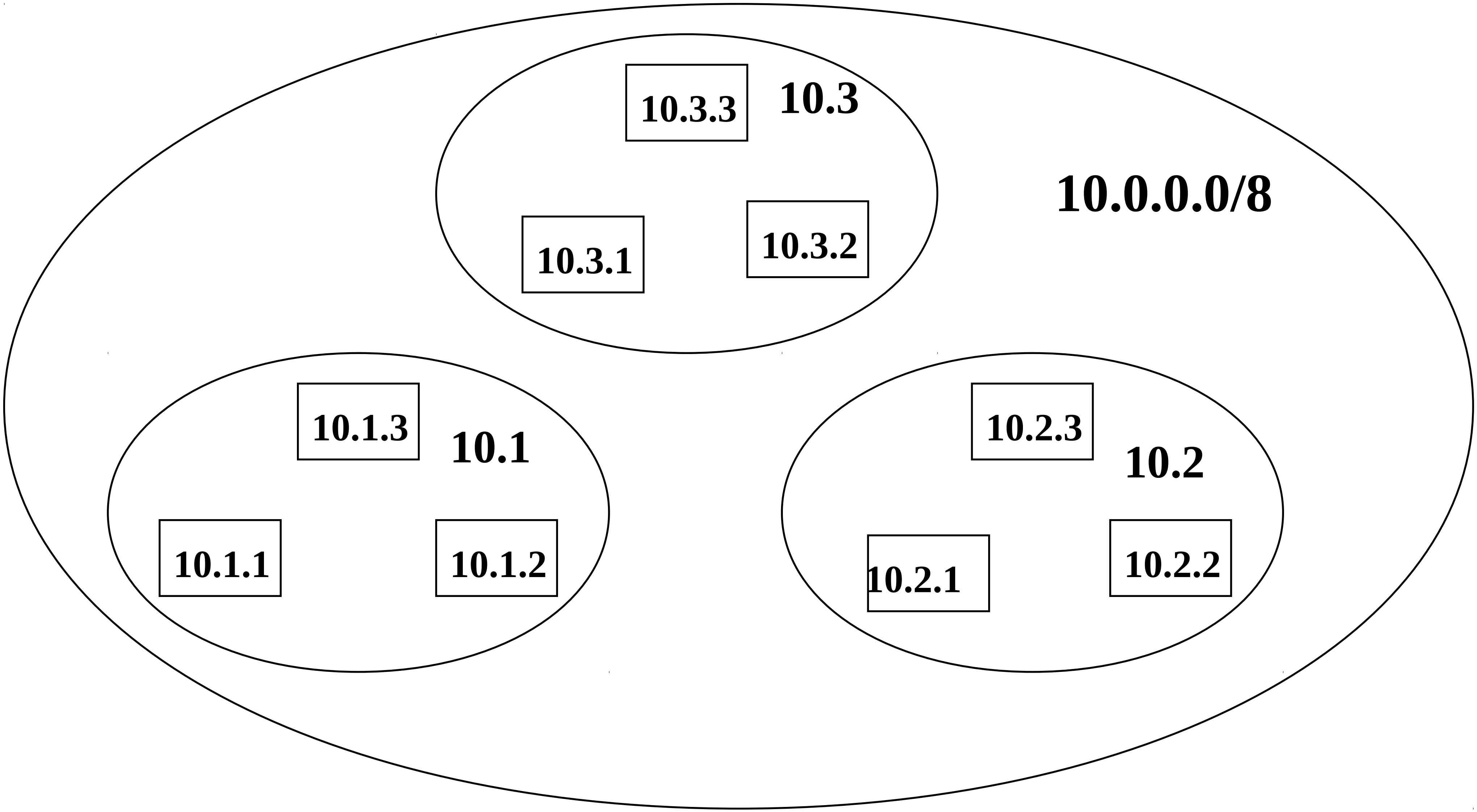
Hierarchical routing

- Technique used to build large networks

- Minimizes use of network resources
  - router memory
  - router computing resources
  - link bandwidth

- Flat routing: linear increase in routing table size
- Hierarchical: logarithmic increase in routing table size

Hierarchical routing: example



Hierarchical routing example

- Consider a router in 10.1.1
  - assume 16 entries in each level (16 routes within 10.1.1)
  - with flat routing, 9*16 = 144 entries/router

- With 3 level hierarchy, a router in 10.1.1
  - has 16 entries for the routes in 10.1.1.*
  - One entry each for 10.1.2.*, 10.1.3.* and 10.1.*.* (default)
  - for a total of 19 entries.

- Marked reduction in routing table size

Routing issues

- Simplicity and Performance:
  - Size of the routing table should be kept small
  - Minimize number of control messages exchanged

- Correctness and Robustness:
  - Packet should be eventually delivered to the destination
  - Must be flexible to cope with changes in the topology and failures
  - No formation of routing loops or frequent toggling of routes

- Fairness and Optimality:
  - Every node should have a fair chance while transmitting packets
  - Balancing between minimizing mean packet delay v/s maximizing total network throughput