Lecture 4: Routing

Two main functions of a routing algorithm:

- Selection of routes for various origin-destination pairs
- Delivery of messages to their correct destination once the routes are selected

Shortest Path Algorithm

Many practical routing algorithms are based on the notion of a *shortest path* between two nodes. Here, each communication link is assigned a positive number called its *length.* A link can have a difference length in each direction. For an origin node and a destination node, each path (i.e., a sequence of links) has a length equal to the sum of the lengths of its links. A shortest path routing algorithm routes each packet along a minimum length (or shortest) path between the origin and destination nodes.

The Bellman-Ford Algorithm

Problem: Suppose that node 1 is the *destination* node and consider the problem of finding a shortest path from every node to node 1.

Assumption: There exists at least one path from every node to the destination.

Denote $d_{ij} = \infty$ if (i,j), i.e., the link from node i to node j, is not an arc of the connection graph.

A shortest walk from a given node i to node 1, subject to the constraint that the walk contains at most h arcs and goes through node 1 only once, is referred to as *a shortest ($\leq h$) walk* and its length is denoted by D_i^h.

Description

At step 0, each node has an estimate of its length to the destination: $D_i^0 = \infty, i \neq 1$

By convention, we take

$$D_1^h = 0, \text{ for all } h$$

Each node broadcasts to its neighbors its length estimation to the destination.

At step h, since node i needs one of its neighbors to relay its traffic to the destination, it updates

$$D_i^h = \min_j \ [d_{ij} + D_j^{h-1}], \text{ for all } i \neq 1$$

If the network contains N nodes. Then the algorithm terminates with at most N iterations.

Advantage: the algorithm can be executed at each node i in parallel with every other node. In each iteration, a node only communicates with its neighbors.

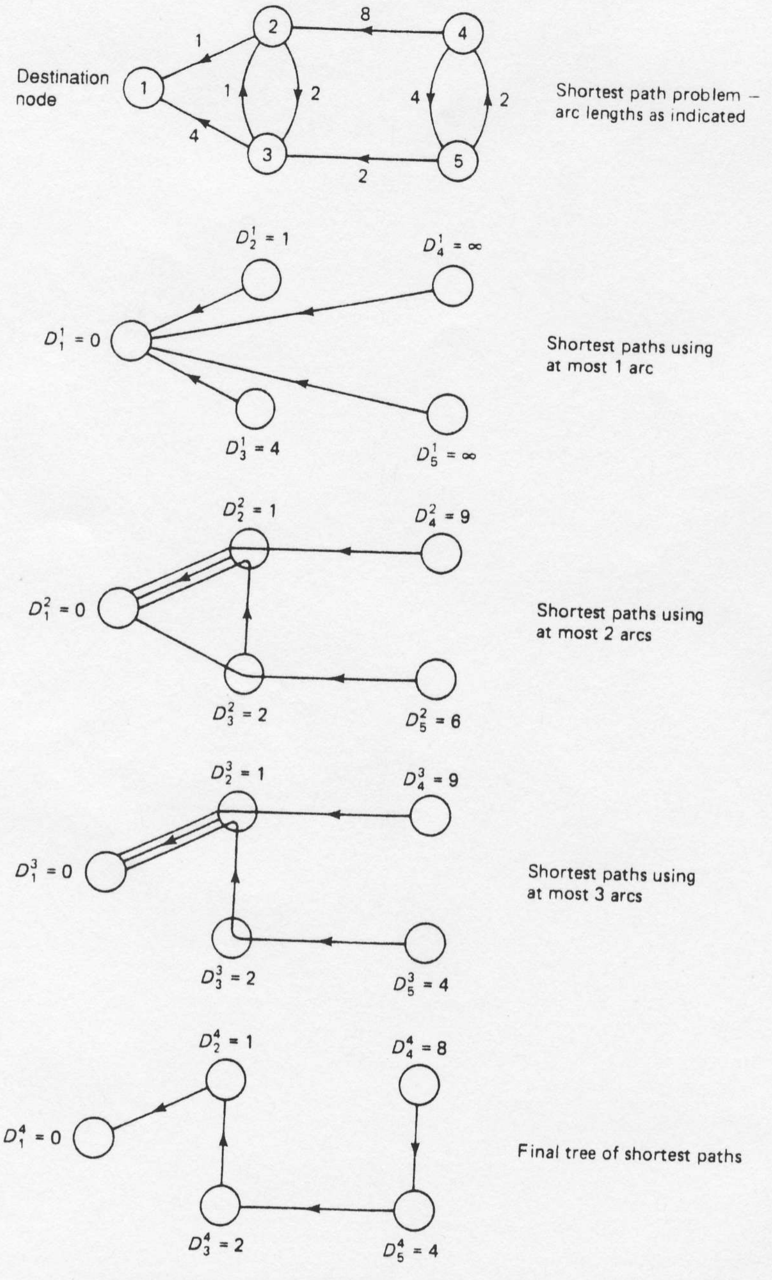


Figure 5.31 Successive iterations of the Bellman–Ford method. In this example, the shortest ($\leq h$) walks are paths because all arc lengths are positive and therefore all cycles have positive length. The shortest paths are found after $N - 1$ iterations, which is equal to 4 in this example.

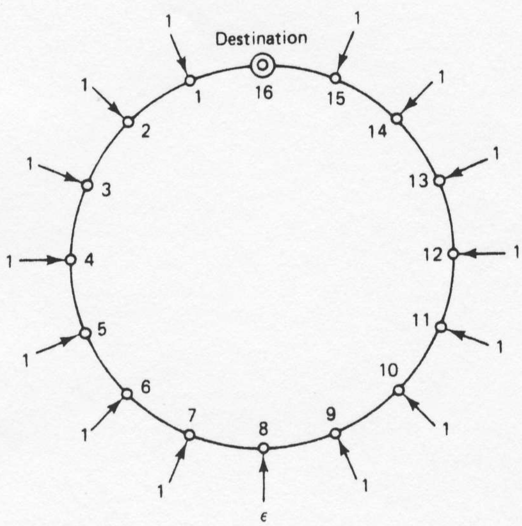
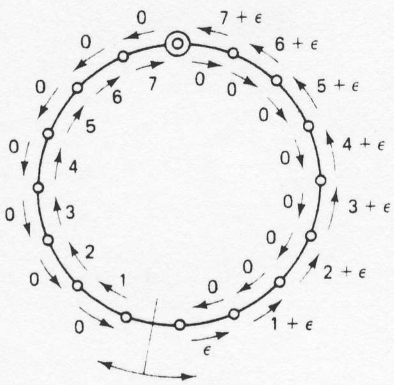
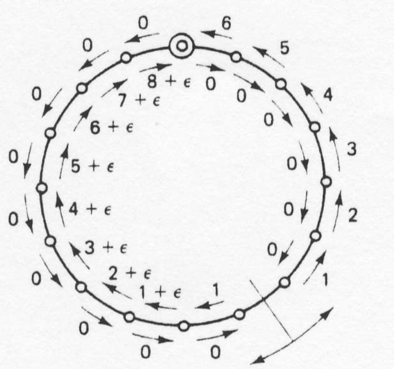


Figure 5.38 Sixteen-node ring network of Example 5.4. Node 16 is the only destination.

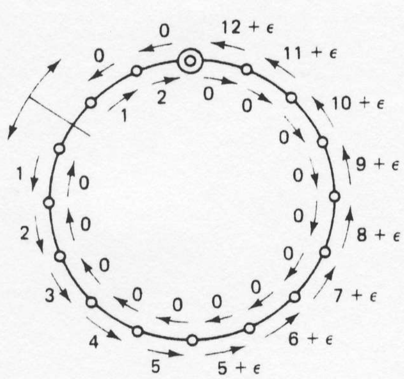
Route oscillation



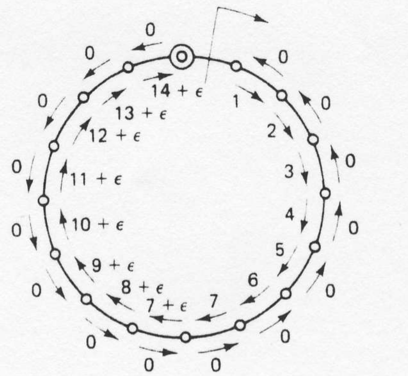
1st Routing



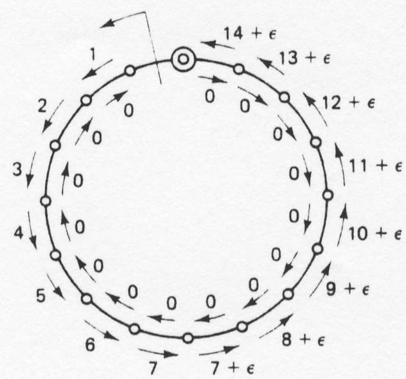
2nd Routing



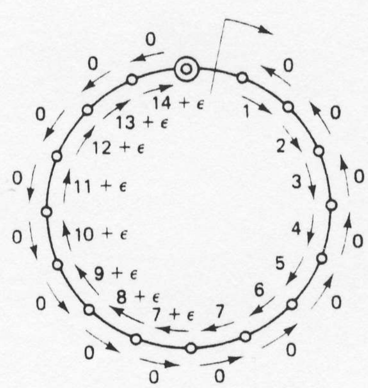
3rd Routing



4th Routing

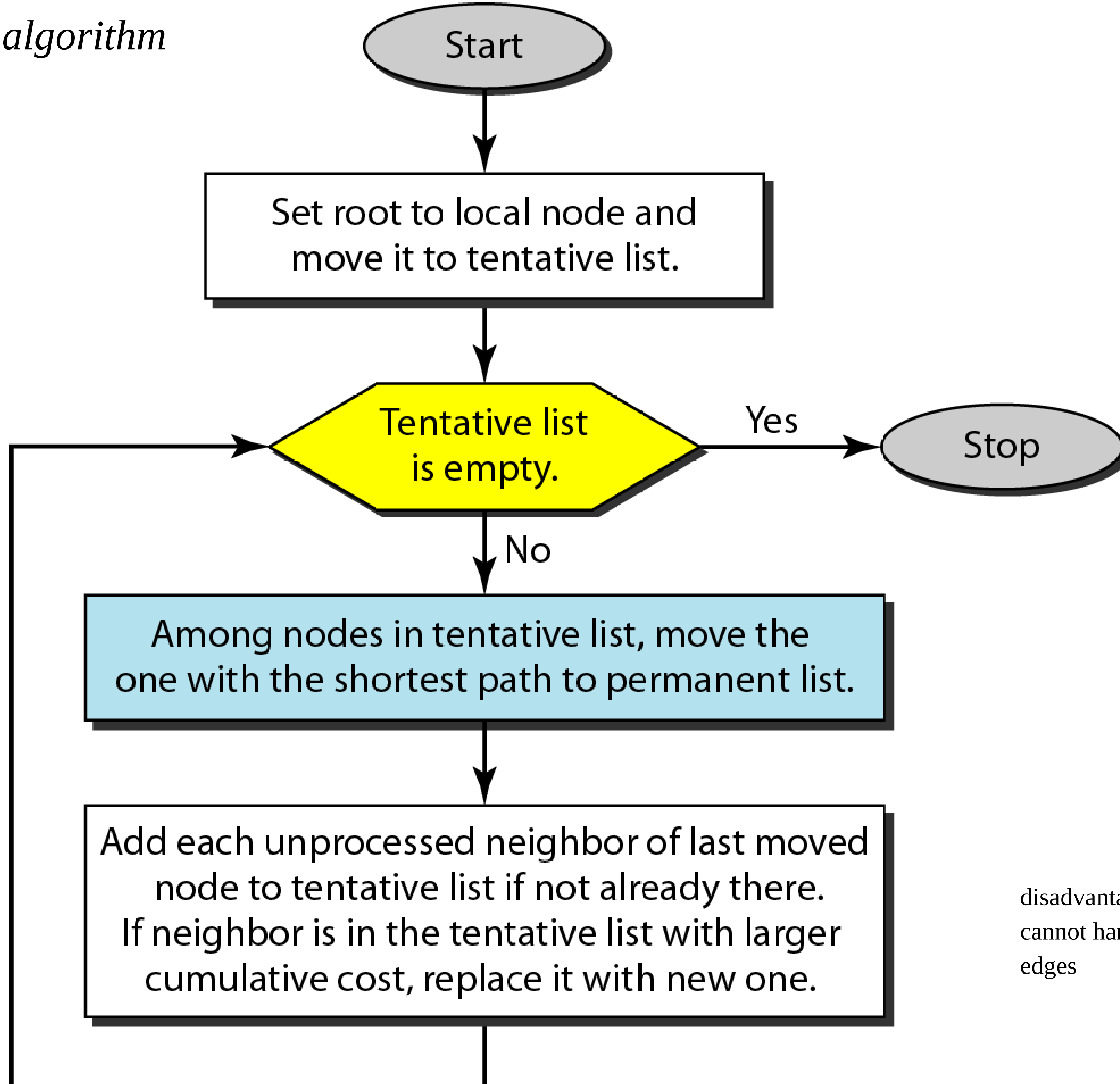


5th Routing

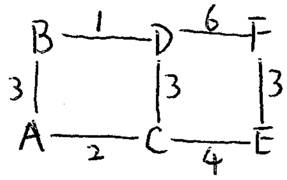


6th Routing

Dijkstra algorithm

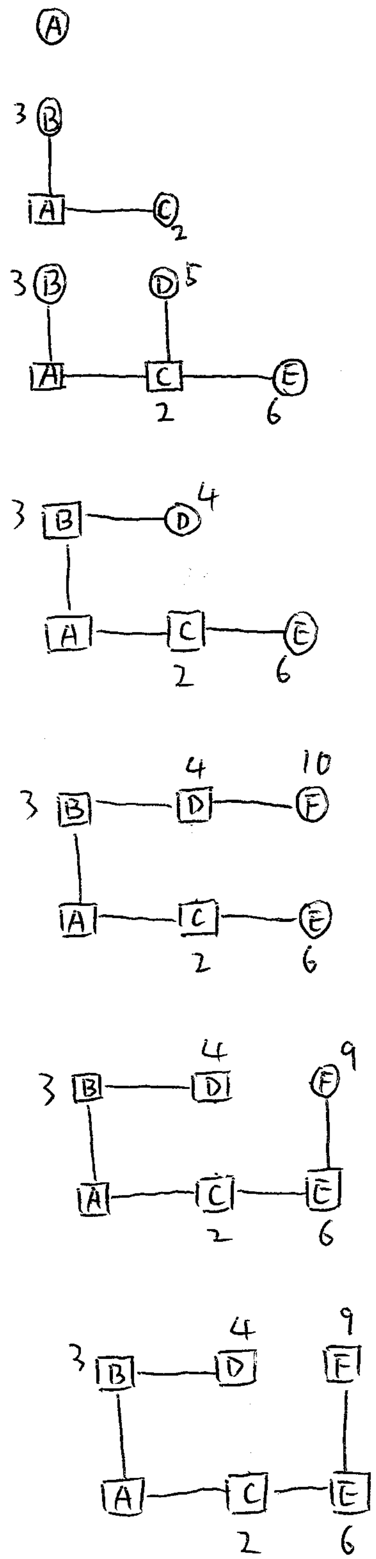


disadvantages: more time, cannot handle negative edges



O: tentative

□: permanent



Routing table at A:

node	cost	Next node
A	0	—
B	3	—
C	2	—
D	4	B
E	6	C
F	9	C