This problem set has four questions, some with multiple parts. Answer them as clearly and concisely as possible. Turn in your solutions during class on May 9, 2008.

1 Routing Implementation Details

A. In a link-state routing protocol, each node sends a “HELLO” message to all its neighbors every HELLO_INTERVAL seconds. Why shouldn’t a node remove the entry for a neighbor (link) from its local link state if it doesn’t hear from that neighbor within HELLO_INTERVAL of the last HELLO message?

B. Why do network gurus generally recommend that distance vector routing protocols not be used on networks with large diameter?

2 Routing Protocol Bandwidth

Anette Worker wants to compare the bandwidth consumed by distance vector routing advertisements and link-state advertisements in her network, which has has n nodes and m links. Each node address is 4 bytes long and each cost is a 2-byte integer. Each advertisement (in both distance vector and link-state routing) contains a 4-byte sequence number, followed by the rest of the advertisement. It is sent by a node once every T seconds. Ignore the bandwidth consumed by HELLO messages and by the address of the node making the advertisement.

A. What is the bandwidth (in bytes per second) consumed by the routing advertisements in a distance-vector protocol?

B. What is the bandwidth (in bytes per second) consumed by the routing advertisements in a link-state protocol?

C. Is there any connected network where the bandwidth consumed by distance vector exceeds that of link state routing with the aforementioned parameters? (Hint: Any connected network with n nodes must have at least n – 1 links.)

3 Distance Vector Protocol Puzzle

Deb Hugger is spending her summer helping to run an Internet data center. After a particularly painful power outage, Deb is curious about the order in which the electric company restored power to the nodes. Deb’s network topology shown on the next page:
All nodes except S lose power. The nodes power up in some order in quick succession, within 25 seconds. 5 seconds after a node’s power is restored, it sends out an advertisement along all its links to neighbors that are live. Each node sends a distance vector route advertisement (with its current routing table) every 45 seconds. A route advertisement sent to a live neighbor is never lost.

30 seconds after the first node’s power is restored, Deb finds that A’s routing table is:

<table>
<thead>
<tr>
<th>Destination</th>
<th>Cost</th>
<th>Next-hop node</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>B</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>E</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>E</td>
</tr>
</tbody>
</table>

Draw a timeline of events that correctly account for the information in the table. Include in your timeline the following two types of events:

1. Power-up of a node.
2. Distance vector advertisement.

Label each event with a possible time, and describe briefly how you arrived at your timeline.

### 4 Two Algorithms Aren’t Better than One

Alice and Bob are responsible for implementing Dijkstra’s algorithm at the nodes in a network running a link-state protocol. On her nodes, Alice implements a minimum-cost algorithm. On his nodes, Bob implements a “shortest number of hops” algorithm. They connect the network together, some nodes running Alice’s code and some running Bob’s.

They find that a routing loop occurs when they start the routing protocol up. Give an example of a network topology with 4 or more nodes in which a routing loop occurs when some nodes run one algorithm and some run the other. There are no failures.

(Note: A routing loop occurs when a group of \( k \geq 1 \) distinct nodes, \( n_0, n_1, n_2, \ldots, n_{k-1} \) have routes such that \( n_i \)'s next-hop (route) to a destination is \( n_{i+1 \mod k} \).)