Routing Protocols

Distance Vector Routing

- Initially A believes B is one hop away and D is unreachable.
- A sends its beliefs to its direct neighbors.
- B learns from A that it can reach E at a cost of 2 by going through A. B modifies its record.
- In the next cycle B passes on this information to C. For C the cost to go to E via B is 3.
- By now C has found a way to go to E via A at the cost of 2. So C rejects the path through B.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
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<td>1</td>
<td>X</td>
<td>1</td>
<td>1</td>
<td>X</td>
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<tr>
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<td>1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C</td>
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<td>1</td>
<td>X</td>
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<td>X</td>
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<td>F</td>
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<td>X</td>
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<td>G</td>
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<td>X</td>
<td>X</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Final Vector Routing

Per-Node Perspective

- As far as one is concerned:
- Each node maintains a table with three columns.
  - Destination, Cost, Next Hop.
- Each node periodically sends update with a list of pairs:
  - Destination, Cost.
- Whenever, a node receives an update from a neighbor that includes a route that is better than one of its current route, it changes the route in its forwarding table.
- A Node sends update:
  - periodically (in few seconds or in several minutes).
  - Triggered update, when a node changes its routing table entry.

Besides the cost every node also keeps track of the next hop.
Quiz

Quiz: 205: A graph has 20 nodes and a speaker node has 3 immediate neighbors. In Distance Vector Protocol this speaker node will send information about how many nodes?

Example of Update

• F knows [G=1], and A knows [G=2 via F]
• F detects that its link to G has failed.
• F advertises [G=x]
• A updates [G=x]
• C advertises [G=2]
• A notes [G=3 via C]
• F notes [G=4 via A]

Finally the network stabilizes.
Problem!

- A knows \([E=1]\), and B knows \([E=2\text{ via A}]\)
- A detects that its link to E has failed.
- A advertises \([E=x]\)
- But B and C advertises \([E=2]\), based on who is fast..
- B hears \([E=2]\), updates \([E=3\text{ via C}]\), and advertizes to A
- A thinks \([E=4\text{ via B}]\) and advertises to C
- C thinks \([E=5\text{ via A}]\)

The cycle will continue until the distance is too large!

Count to Infinity Problem
(Propagation of good news)

\[
\begin{array}{cccccc}
& A & B & C & D & E \\
A & \text{inf.} & \text{inf.} & \text{inf.} & \text{inf.} & \text{initial state} \\
1 & \text{inf.} & \text{inf.} & \text{inf.} & \text{after exchange 1} \\
1 & 2 & \text{inf.} & \text{inf.} & \text{after exchange 2} \\
1 & 2 & 3 & \text{inf.} & \text{after exchange 3} \\
1 & 2 & 3 & 4 & \text{after exchange 4} \\
\end{array}
\]

Suppose initially A to B link was down so every body knows distance to A is infinity. Now the link comes up.
Good news propagates fast!
Count to Infinity Problem
(propagation of bad news!)

\[
\begin{array}{cccccc}
A & B & C & D & E \\
\hline
1 & 2 & 3 & 4 & \text{initial state} \\
3 & 2 & 3 & 4 & \text{after exchange 1} \\
3 & 4 & 3 & 4 & \text{after exchange 2} \\
5 & 4 & 5 & 4 & \text{after exchange 3} \\
5 & 6 & 5 & 6 & \text{after exchange 4} \\
\end{array}
\]

\begin{tabular}{cccccc}
Inf. & Inf. & Inf. & Inf. & In many steps \\
\end{tabular}

Suppose initially A to B was up. So every body knows distance to A. Now the link is down. But every body gets wrong information from neighbor. Bad news propagates in many steps.

Split-Horizon Technique

- Initially A and B both has distance to D=2.
- Now D to C disconnects.
- Using split-horizon both A and B tells C that they cannot reach D.
- C concludes it cannot reach D and reports that to A and B.
- But B says to A that it can reach to D by Hop 3. So A concludes it has a path to D with 4 hop via B!
- This is however count-to-infinity problem!
Link State Routing

- The problem with distance vector routing was the nodes were advertising paths which they were not sure about!
- They were advertising only to their neighbors.
- In link state, nodes advertise only the information about which they are sure.
- But they advertise to everyone.

Reliable Advertising

- Update packet link-state packet (LSP) contains
  - the ID of the creator node.
  - The list of directly connected neighbors.
  - A sequence number
  - a time to live (TTL).
- The first two items are for routing calculation.
- Sequence number is used to determine the most up-to-date information.
- TTL is used to make sure, LSP do not circulate for ever.
Link State Routing Example

COMPUTER COMMUNICATION NETWORK

A seq B seq C seq D seq E seq F seq
age age age age age age

Link State Routing Example

COMPUTER COMMUNICATION NETWORK

A seq B seq C seq D seq E seq F seq
age age age age age age
Link State Packet Buffer

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SEQ</th>
<th>AGE</th>
<th>A</th>
<th>C</th>
<th>F</th>
<th>DATA</th>
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</thead>
<tbody>
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<tr>
<td>F</td>
<td>21</td>
<td>60</td>
<td>1</td>
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<td>0</td>
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<tr>
<td>E</td>
<td>21</td>
<td>59</td>
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<tr>
<td>C</td>
<td>20</td>
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<td>D</td>
<td>21</td>
<td>59</td>
<td>1</td>
<td>0</td>
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Hierarchical Routing

Full Table for 1A

<table>
<thead>
<tr>
<th>Dest</th>
<th>Line</th>
<th>Hops</th>
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</thead>
<tbody>
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<tr>
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<td></td>
</tr>
<tr>
<td>1C</td>
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<tr>
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<tr>
<td>5E</td>
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</tbody>
</table>

Source: javed@kent.edu
Hierarchical Routing

Network Layer

- There are other network layer issues such as congestion control and quality of service.

- We will return to them later.