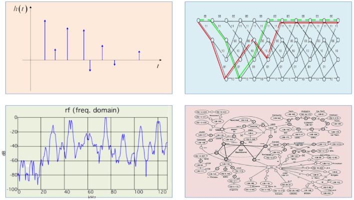
Routing Algorithms: Dealing With Failures

6.02 Fall 2013 Lecture 21



INTRODUCTION TO EECS II

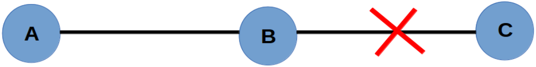
DIGITAL COMMUNICATION SYSTEMS

Today's Plan

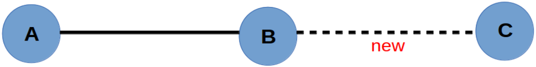
- Network Dynamics and Failures
- Analysis of Dijkstra Algorithm (Static/Ideal)
- Consequences of Incomplete LSA Flooding
- Dealing With Loopy Forwarding
- Analysis of Distance-Vector Algorithms (Static/Ideal)
- Count-To-Infinity
- Split-Horizon and Path-Vector Routing

Network Dynamics And Failures

Link Failure:



Link Recovery:



Probabilistic Nature of Packet Delivery:

$$\mathbf{P}(\text{delivery}) = p$$

Dijkstra's Shortest Path Algorithm: Complexity

Parameters:

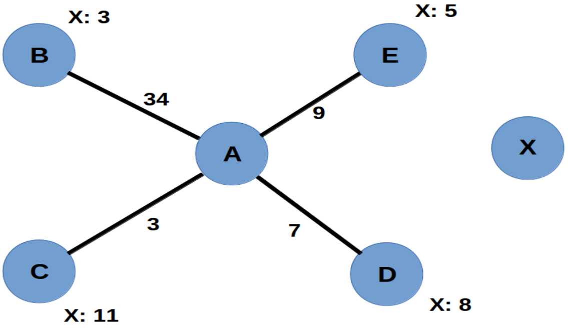
- **N**: number of nodes
- **L**: number of links

Complexity:

- finding **u** (minimal cost node):
  N times: **O(log N)** each time, total **O(N log N)**
- updating **costs**:
  O(L), since each link appears twice

Correctness of Shortest Path Routing (Ideal)

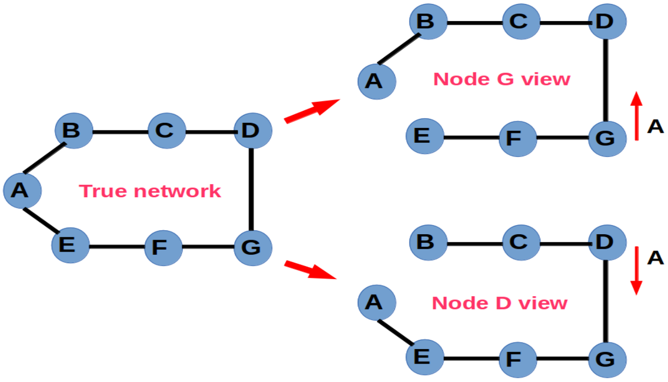
Shortest Path Routing:
forward to the neighbor with minimal total cost to destination



Distance to destination decreases monotonically at every step.

Consequences of Incomplete LSA Flooding

Node G does not get the LSA from A and E
Node D does not get the LSA from A and B



Dealing With Forwarding Loops

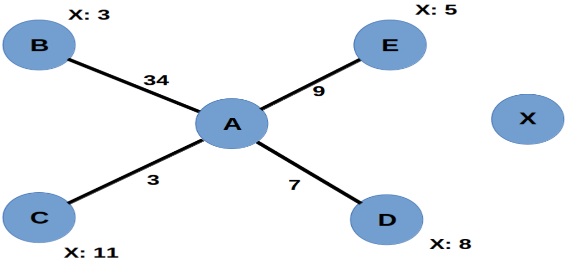
Eventually, in the LSA framework, we expect all nodes to have complete info about the network.

In the meanwhile, hop limit eliminates infinite loops:

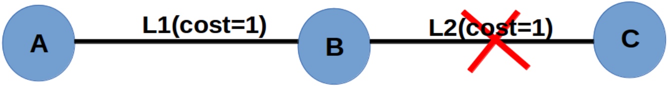
- **Passing every node, a package reduces its hop limit by 1**
- **A package with hop limit of zero is dropped**

Distance-Vector Algorithms

$$D^{+}(A,X) = \min_{\text{B is neignhor(A)}}\{C(A,B) + D(B,X)\}$$
$$R(A,X) = \arg\min_{\text{B is neignhor(A)}}\{C(A,B) + D(B,X)\}$$



Counting To Infinity



C: 2,L1

C: 1,L2

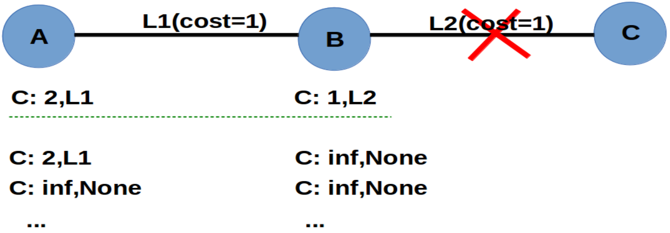
C: 2,L1
C: inf,None
C: 4,L1
C: inf,None
...

C: inf,None (3,L1 is even worse)
C: 3,L1
C: inf,None
C: 5,L1
...

A ghost of C is lurking in the links. . .

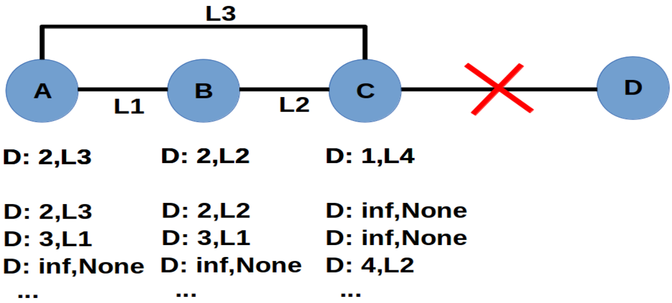
The "Split-Horizon" Fix

Do not advertise (advertize ∞) down the forward route



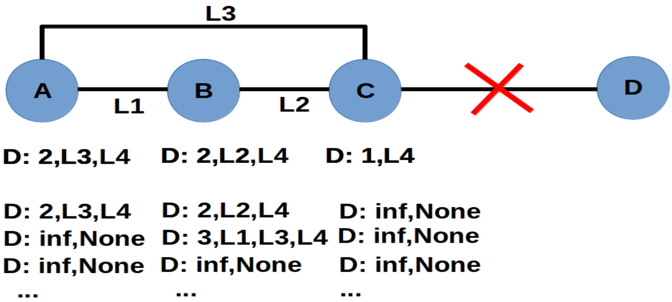
The "Split-Horizon" Fix Does Not Always Work

When Advertisements Are Not In Sync



The "Path-Vector" Fix

- Report not just the first forward, but the whole path
- Do not advertise (advertize ∞) down the path



Summary

- The network layer implements the glue that achieves connectivity
- Does addressing, forwarding, and routing
- Forwarding entails a routing table lookup; the table is built using routing protocol
- DV protocol: distributes route computation; each node advertises its best routes to neighbors
- Path-vector: include path, not just cost, in advertisement to avoid count-to-infinity