

Background

- Advanced Metering Infrastructure (AMI) based on unreliable wireless links
- Mesh topology
- Non-mobile nodes, but dynamic topology
- 802.11 / 802.15.4 link layer
- Problems with relying completely on the control-plane to update routes
 - Control plane may not yet have converged
 - High control overhead for fixing paths (reactive or proactive routing protocol)

Problem Statement

■ Reactive Protocols

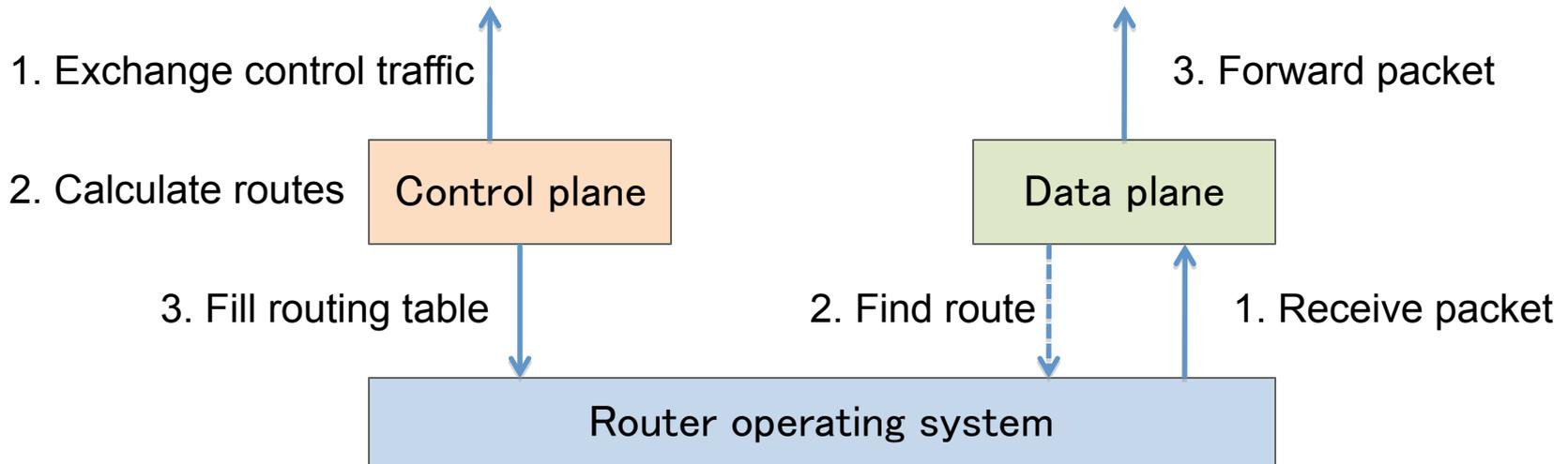
- If a link is unstable, RREQ may be required to repair the route
- The RREQ flood in the network in turn may lead to collisions and further packet loss
- Repeating this process, the network may become unstable

■ Proactive Protocols

- Invalid routes until protocol converges

Solution Approach

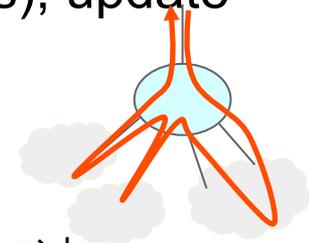
- Instead of increasing repair / route update frequency in the control plane, use data plane
 - Find alternate paths
 - Detect loops
 - Update / poison routes
- No pre-computed alternative routes in control place



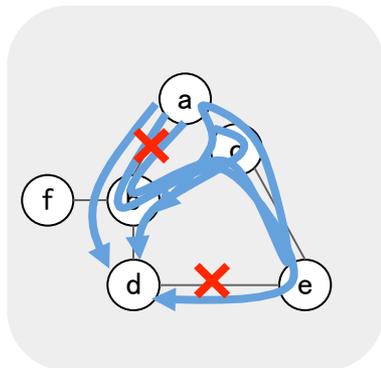
Mechanism

■ General idea:

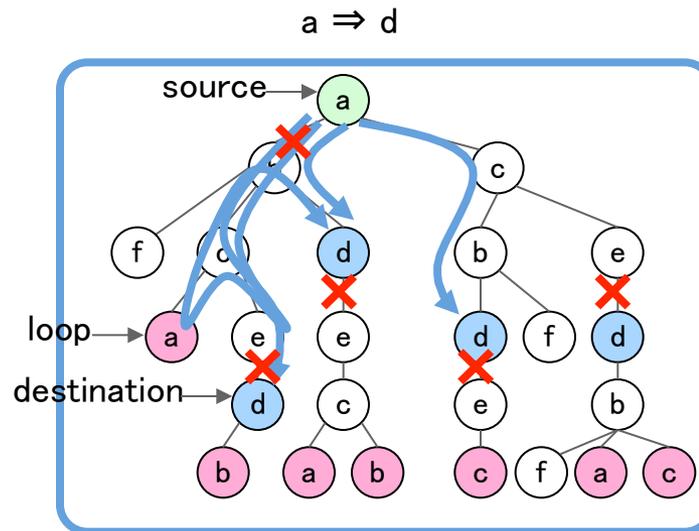
- If standard forwarding to next hop fails, try alternate neighbors in a DFS fashion
- When all neighbors unsuccessfully tried, return packet to parent
- When loop detected (detected by storing sequence numbers), update routing table (“poison route”)



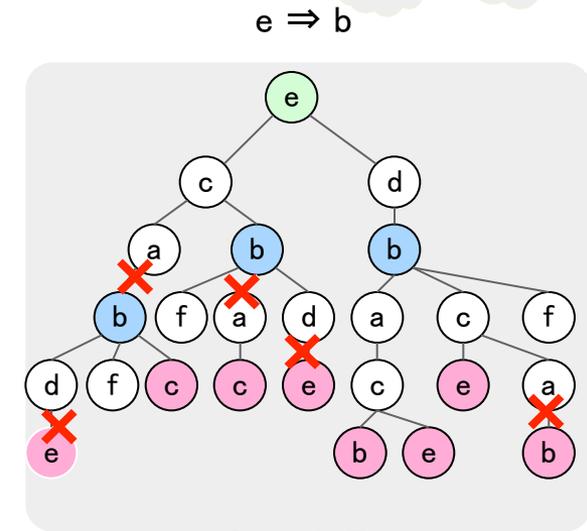
Example:



Network topology



Search Tree



Search Tree

Information Sets

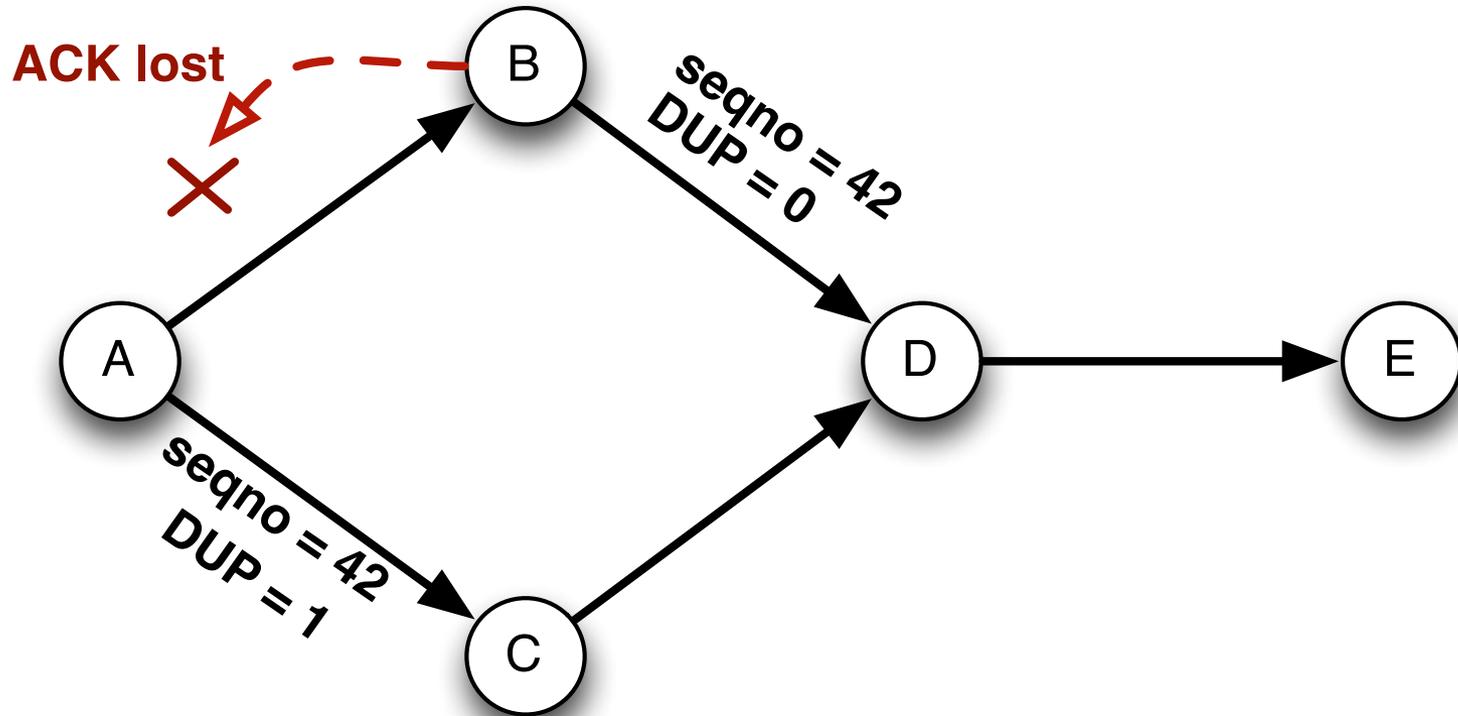
- $(P_orig_address, P_seq_number, P_prev_hop, P_next_hop_neighbor_list, P_time)$

- where

- $P_orig_address$ is the **Originator Address** of the received frame;
- P_seq_number is the **Sequence Number** of the received frame;
- P_prev_hop is the Source Address (i.e. the **previous hop**) of the frame;
- $P_next_hop_neighbor_list$ is a **list of next hops to which the frame has been sent previously**;
- P_time specifies when this Tuple expires.

- Access required to list of bidirectional neighbors

DUP Flag



Approach Advantages

- Fewer control traffic messages
- Fewer collisions when flooding the network
- Increased reliability of the network

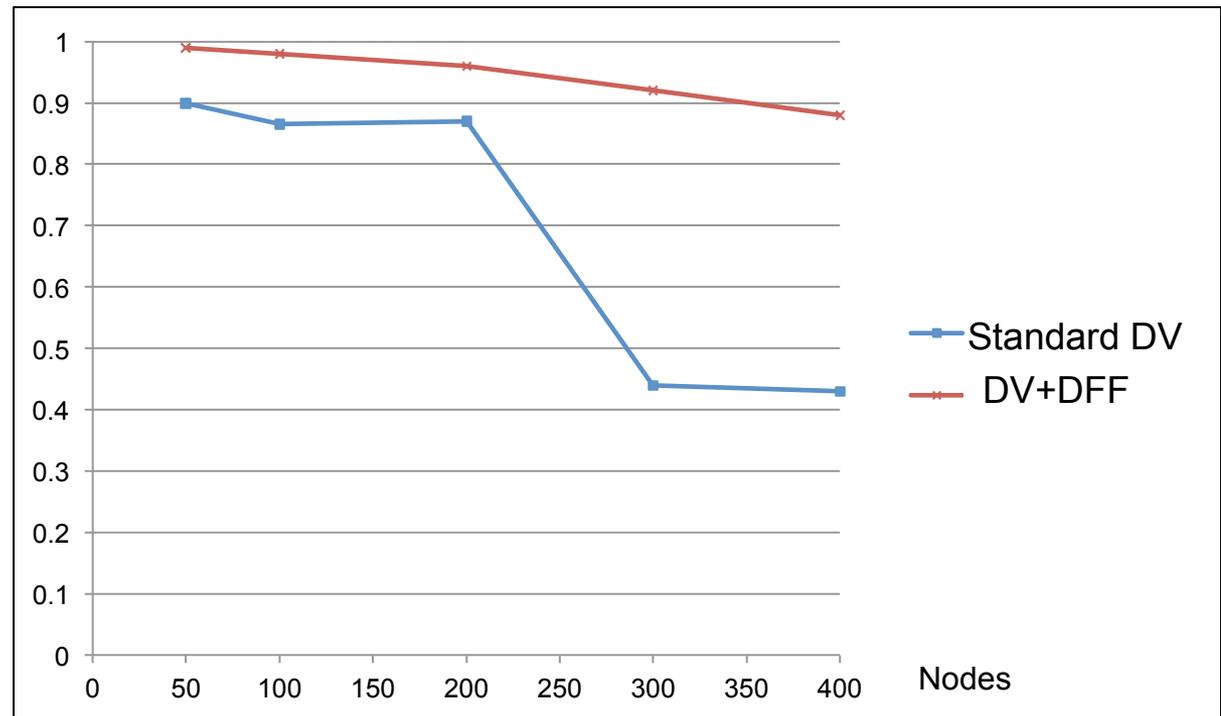


Figure: Delivery ratio (from network simulation, source: [3])

DFE Deployments

■ US

- Field test on-going at KCEC (AMI + Internet service)
- Full scale will be 2,100 nodes
- Press release
http://www.kitcarson.com/index.php?option=com_content&view=article&id=45&Itemid=1

■ Japan

- Large deployments

References



- [1] Depth-First Forwarding in Unreliable Networks
[Herberg, Cárdenas, Céspedes, Iwao. draft-dff-cardenas]
- [2] Dynamic Data Forwarding in Wireless Mesh Networks
[Iwao, et.al., IEEE SmartGridComm 2010]
- [3] Analysis of Data Forwarding Mechanisms in Unreliable Networks
[Céspedes, Cárdenas, Iwao. IEEE Innovative Smart Grid Technologies Conference 2012]