Routing Principles in Wireless Mesh Networks

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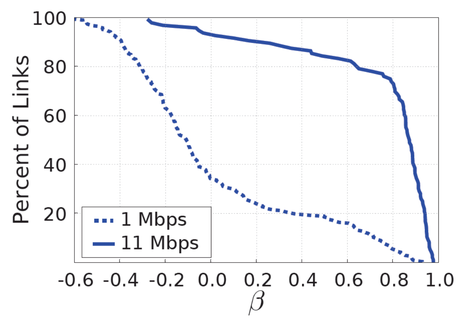
The Problems

Wireless routing is hard
Link dynamics are common, resulting in:
1.Online/frequent link and route quality assessment
2.Stale states
3.Uncontrolled churn
4.Loops

Burstiness
Short term dynamics
Measures temporal correlation of packet reception

Example Challenge

802.11 links can be bursty on the time scale of 500ms. This wreaks havoc on delivery and beacon-based estimation. Link state protocols suffer.



$$\beta = \frac{KW(Independent) - KW(Empirical)}{KW(Independent)}$$

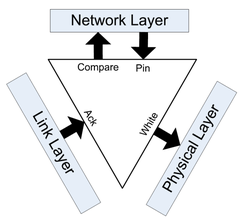
Three Principles

Abstracting the design principles from protocol implementation experiences

1. **Use cross-layer information to estimate link costs**
2. **Use data path to actively validate routing topology**
3. **Adapt beacon rates based on routing topology consistency**

Hybrid Link Estimation

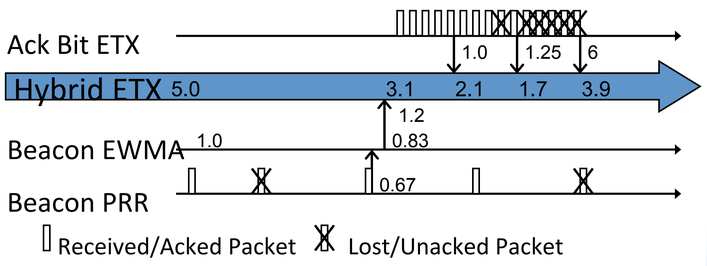
Estimate link cost by actively measuring the data path.



Use network layer for hints on what links are most useful.

Beacons discover neighbors.

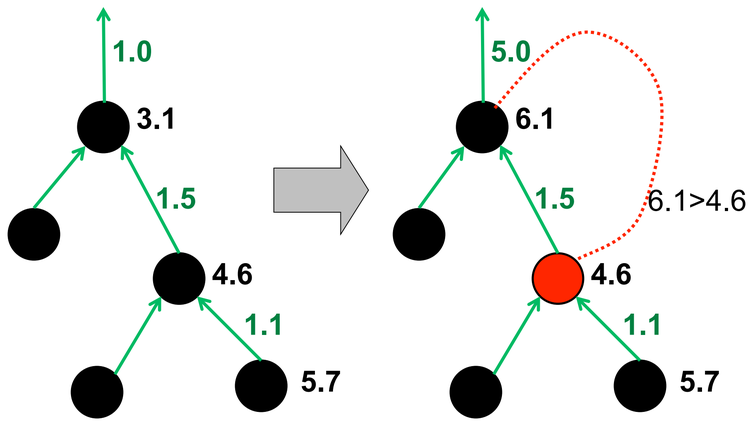
Merge data path and control path estimates using EWMA.



Data Path Validation

Data path estimates lead to very rapid changes in cost and route (e.g., 10 packet times). This dynamism causes routing loops.

Use the data path to quickly detect possible loops (cost does not monotonically decrease along route).

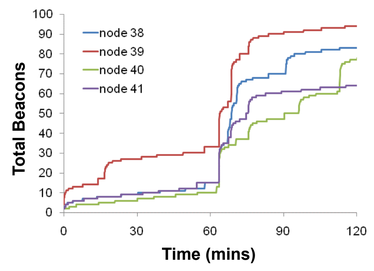


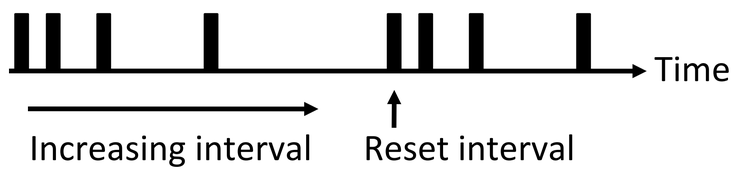
Adaptive Beaconing

Beacons seed routing tables and tell neighbors of a node's cost.

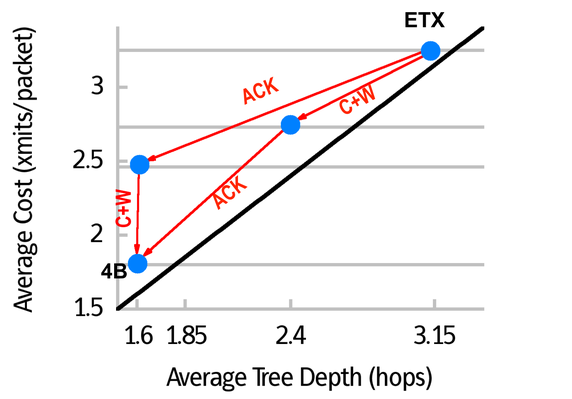
A node only needs to send beacons when stale information leads to routing errors or neighbors need candidates.

Use an exponential timer: reset on
1. Data path detection,
2. "pull" bit, or
3. large decrease.



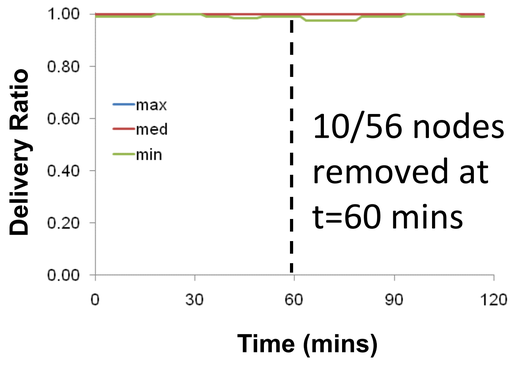


Experimental results



Link metric that uses all information significantly more efficient than ETX due to lower cost and shorter paths.

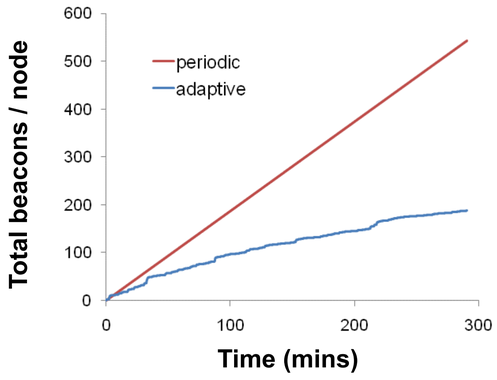
Use multiple information sources



No disruption in packet delivery.

Quick repair of topology triggered by data-path validation of broken links.

Detect disruption and inconsistencies quickly using data-path validation



Fewer beacons sent using adaptive beacons than with periodic beacons.

Use adaptive "Trickle" timers to reduce overhead and save energy

Results consistent across 12 testbeds, 7 hardware platforms, and 6 link layers