Effects of Interference on Wireless Mesh Networks: Pathologies and a Preliminary Solution

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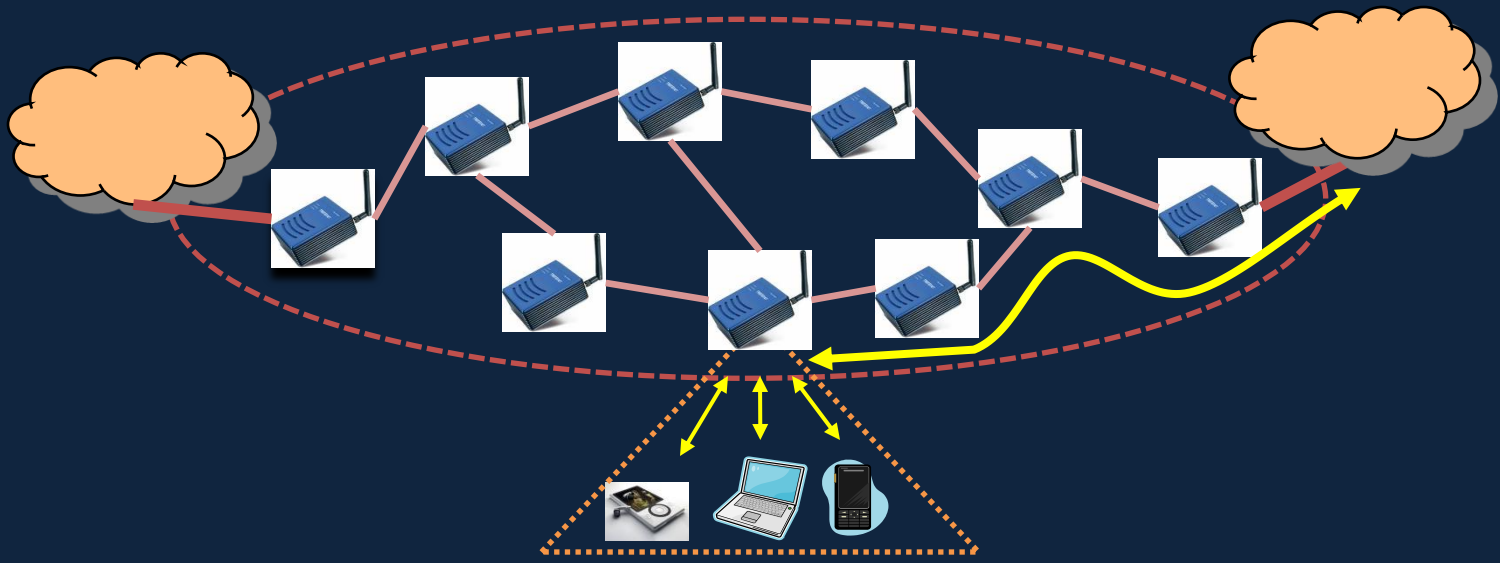
Wireless Mesh Networks



Can enable ubiquitous and cheap broadband access

Witnessing significant research and deployment

But early performance reports are disappointing

- Anecdotal evidence suggests that routing is one contributor

This work

- Empirically investigate performance issues in current routing method for wireless meshes
  - Find fundamental pathologies that stem from interference
- Develop a routing methodology that systematically accounts for interference
  - This paper is our first step

Routing and interference modeling in wireless mesh networks

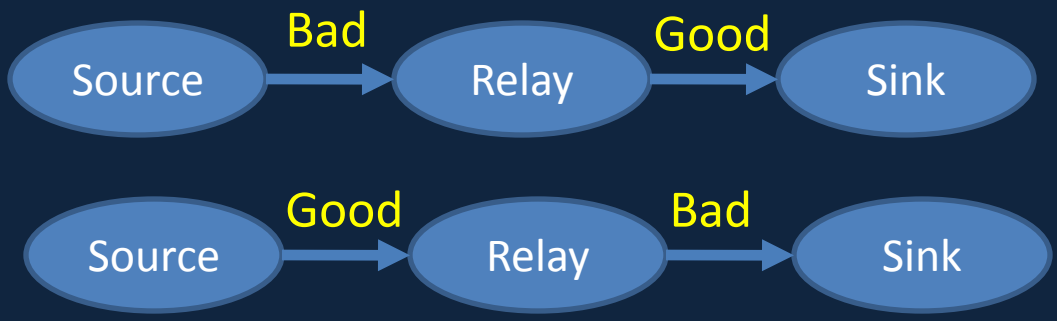
Routing

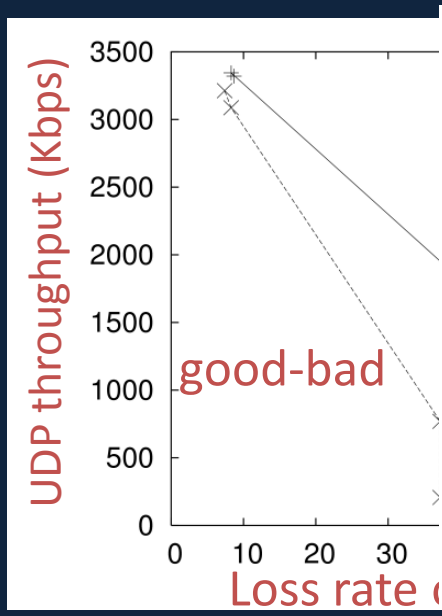
- Measure “link” cost and use least cost paths
- Account for interference in rudimentary ways
- Nodes can send as much as the MAC layer allows

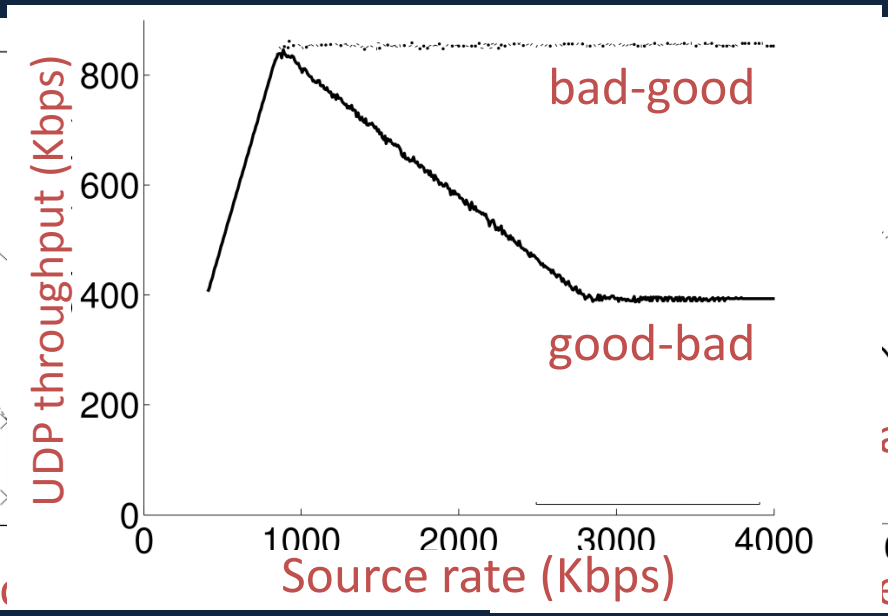
Analytic interference models

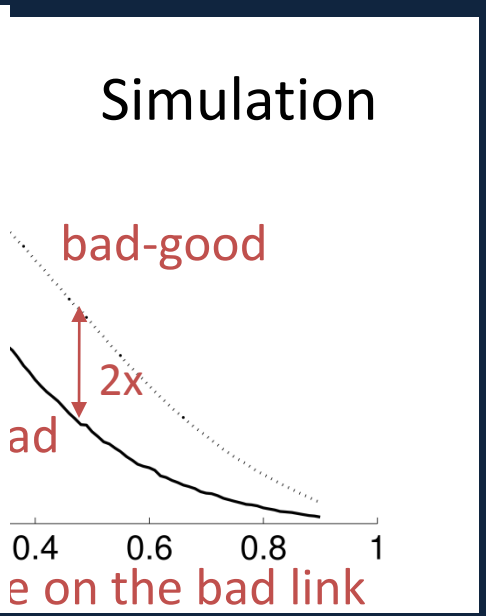
- Usually compute asymptotic bounds
- Do not usually prescribe routing
- Make simplistic assumptions about topology, traffic

Pathology 1: Severe performance degradation in the absence of rate feedback









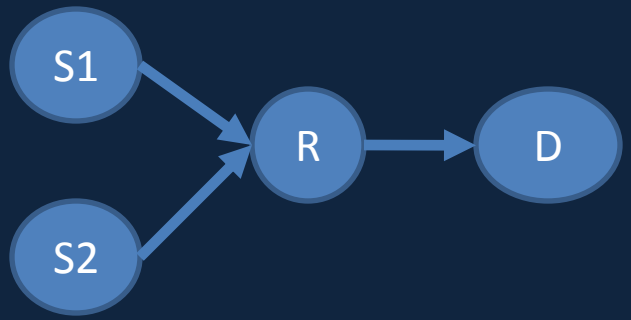
More on Pathology 1

Hard to eliminate in the general case without systematically accounting for interference

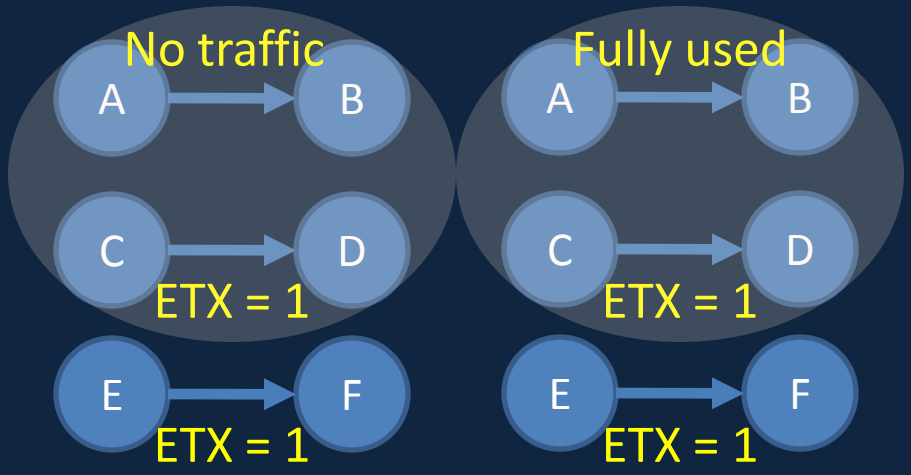
- Changing MAC allocation, RTS/CTS, or TCP's congestion response don't suffice

Occurs in any topology in which the bottleneck is downstream

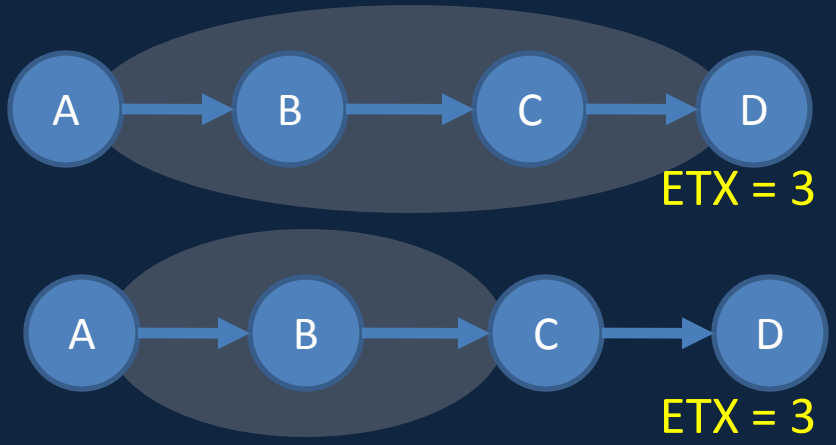
- Even if all links are reliable



Pathology 2: Poor path selection due to inaccurate quality estimation



Cost measurements ignore sender-side interference



Adding link costs to get path cost is a simplistic view of intra-flow interference

Our approach to routing

Goal: assign routing paths and rates to flows while systematically capturing the effects of interference

Divide the problem into two parts

1. Estimate flow rates that can be supported by a given set routing paths
2. Search over the space of routing patterns

Model-based flow rate computation

Input: topology, flow demands, routing paths

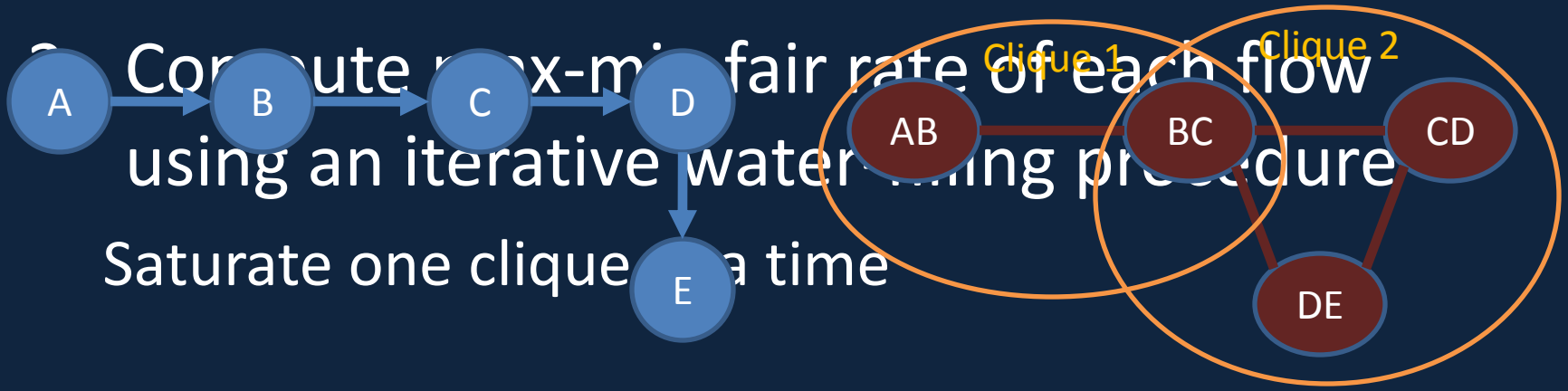
Output: sending rate of each flow

1. Capture interference dependencies using an approximate *Conflict Graph*

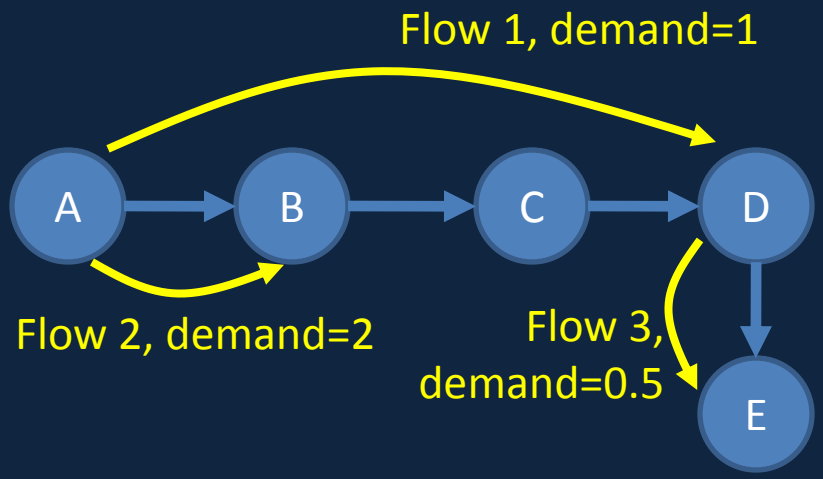
   Cliques contain links that cannot send together

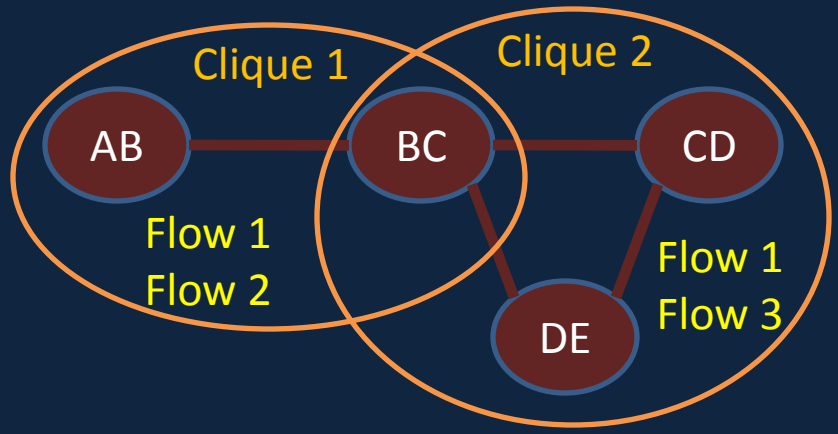
2. Compute max-min fair rate of each flow using an iterative water-filling procedure

   Saturate one clique at a time



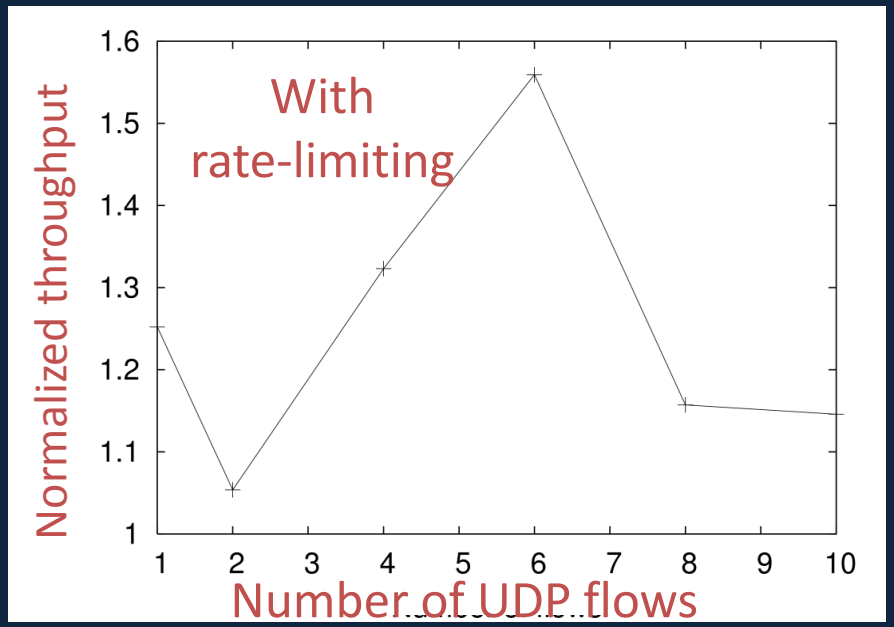
A (simplified) example



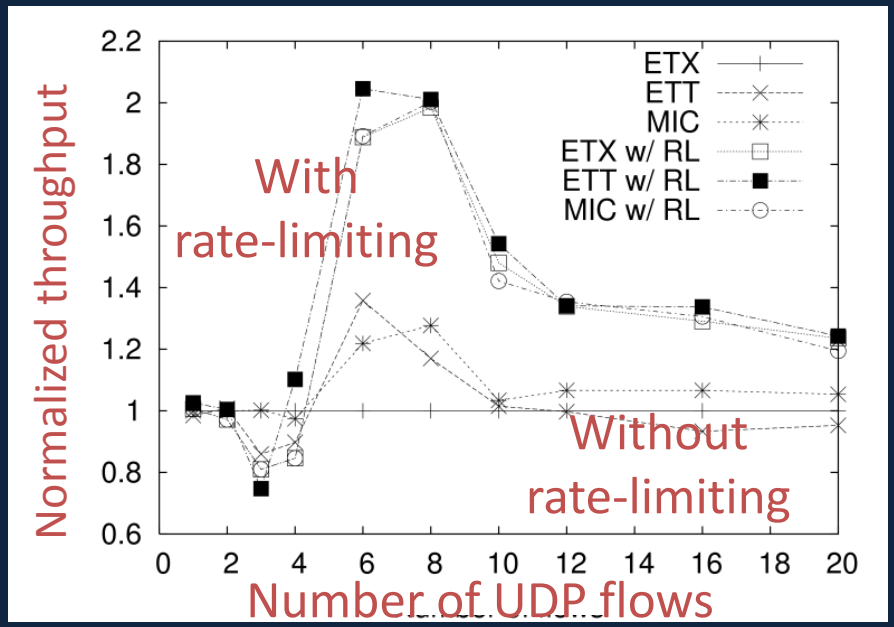


	Flow demand unmet (met)			Clique capacity unused (used)	
	Flow 1	Flow 2	Flow 3	Clique 1	Clique 2
	1 (0)	2 (0)	0.5 (0)	1 (0)	1 (0)
α_1 = 33%	0.67 (0.33)	1.33 (0.67)	0.33 (0.17)	0 (1)	0.5 (0.5)
α_2 = 100%			0 (0.5)		0.17 (0.83)

Throughput improvement when flows are limited to the computed rates



Testbed
(21 nodes)



Simulation
(25-node random topology)

Conclusions

Current wireless mesh routing protocols perform poorly in the face of interference

We propose a new model-based approach that systematically accounts for interference

- Our flow rate computation method improves throughput by 50-100% in some cases

- Future work: search over routing patterns to further improve performance