

Position-based Routing for Wireless Networks: A Re-analysis

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Concluding Remark

- Guaranteed Delivery may be 'over-rated' in some situations
 - Where non-routing elements are likely to be cause of packet loss
 - When the complexity of delivering the last x% has a negative effect on resources.

Context

- Large number of wireless nodes
- Limited resources
 - Traditional meaning: energy, space, computation
 - Alternative meaning: scale in a mobile env.
 - (Potentially) lack of infrastructure.
- Self-organising
 - Loose definition: no manual intervention.
- Mobility

Routing remains a challenge

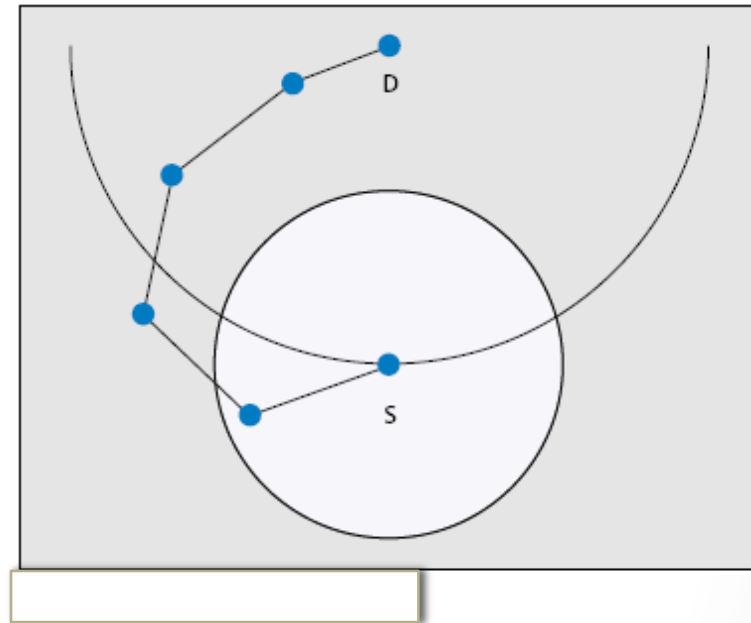
- Scale of routing tables
 - No aggregated or hierarchical naming
- Effect of shared medium:
 - Does routing setup and exchange impedes utilization?
 - (We generally assume that it does, though this is unclear.)
- Mobility and availability complicate matters.
- All challenges exacerbated if resources are limited.

Holy Grail: Position-based Routing

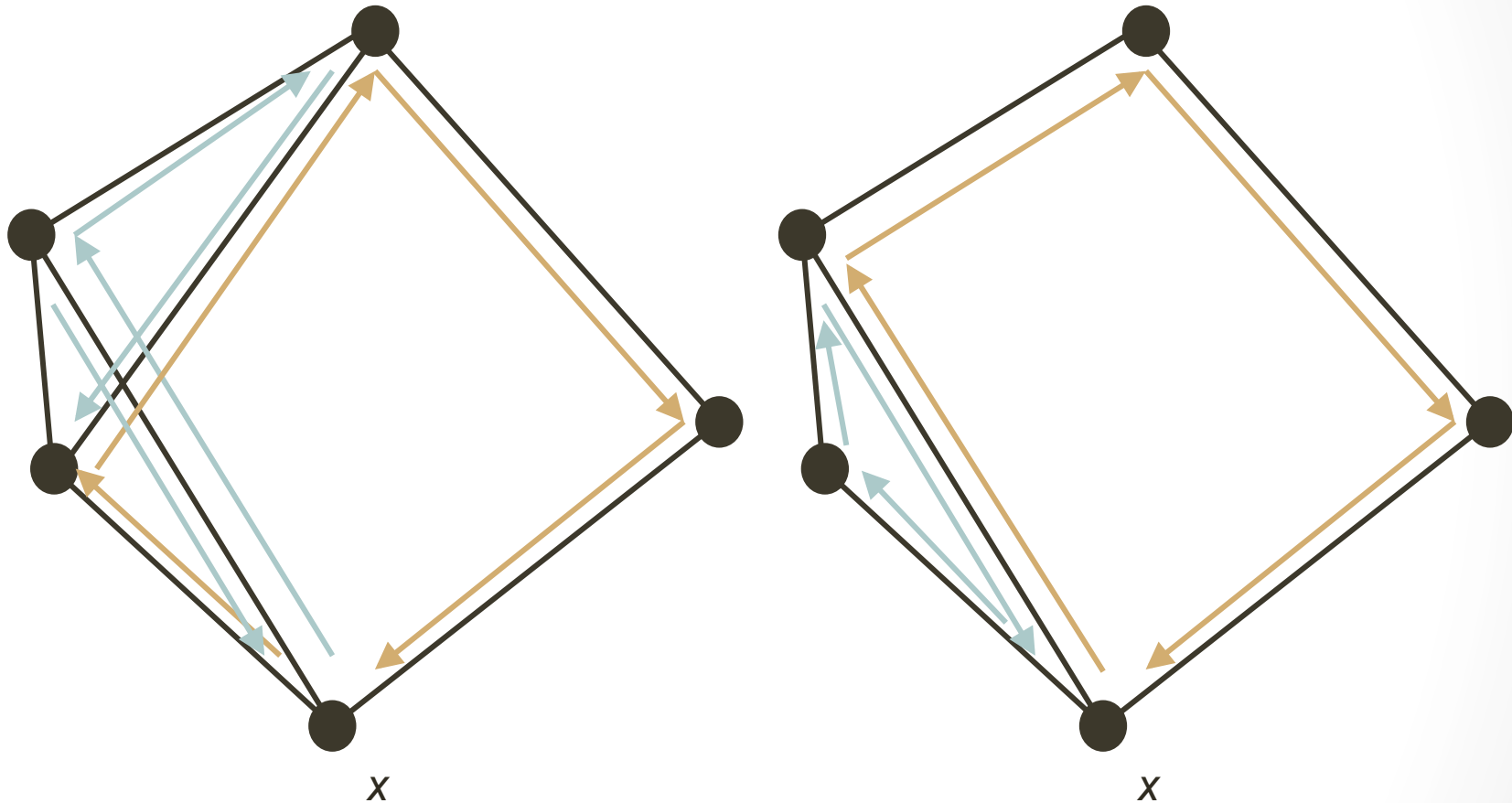
- Local decisions
 - no broadcast, or forwarding of routing info beyond 1-hop
- Fixed memory
 - Routing table consists of 1-hop neighbours
- Greedy forwarding:
 - Reduce distance to destination
- May be seen as an optimization problem
 - Any optimization may find a local minimum!
 - Some 'recovery' method is required.

Escape from Local Minima

- 'Left-hand rule' (LHR)
 - escape from a maze
- May take longer path
- Defeated by intersections.



Planarity as a Solution



Planar graph + left-hand traversals = unique faces!

Planarity in the Real World

- Localised protocols:
 - Connectivity only guaranteed under unit-disc model
 - Known to be unrealistic in practice.
 - eg. GPSR, GoAFR
- Cooperative protocols:
 - Work in arbitrary network graphs
 - Complex setup & high messaging complexity
 - May be 'over-solving' the problem
 - eg. GDSTR, (Lazy-)CLDP.
- Neither solution is ideal.

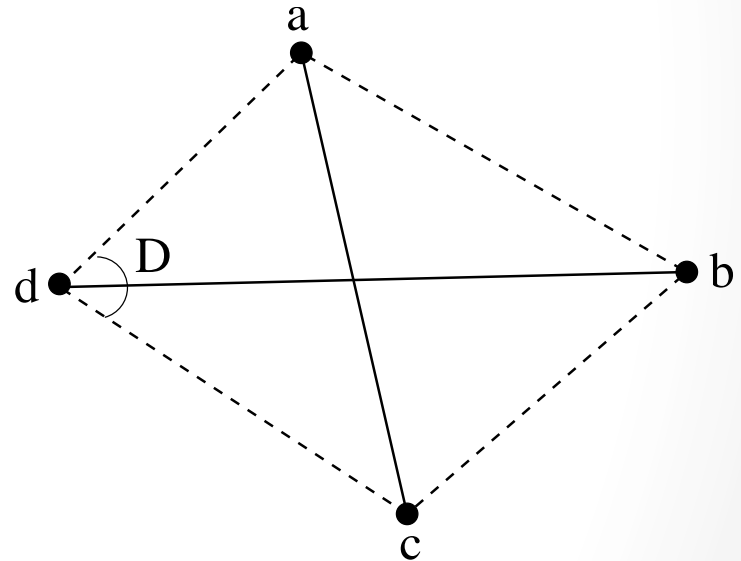
Challenging Theorem (2009):

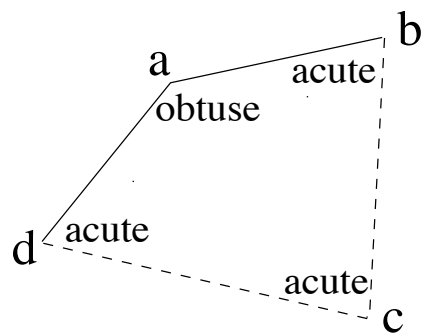
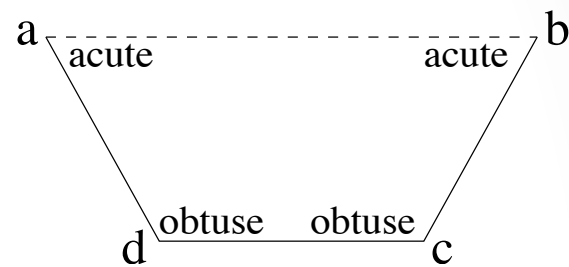
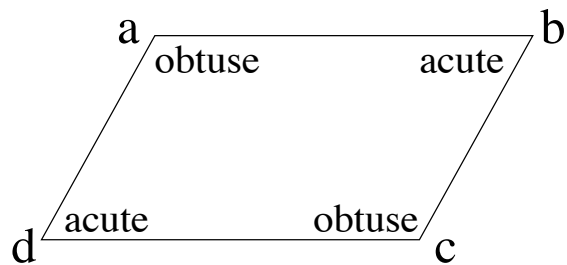
Given k hops of information in an arbitrary graph, there exists no deterministic local algorithm (that can guarantee delivery).

- Intuition: Given k hops, an offending configuration can always be constructed at $k+1$ hops.
- Two alternatives
 - Constrain the network graph (all prev work)
 - **Understand and attack the causes for failure in the graph.**

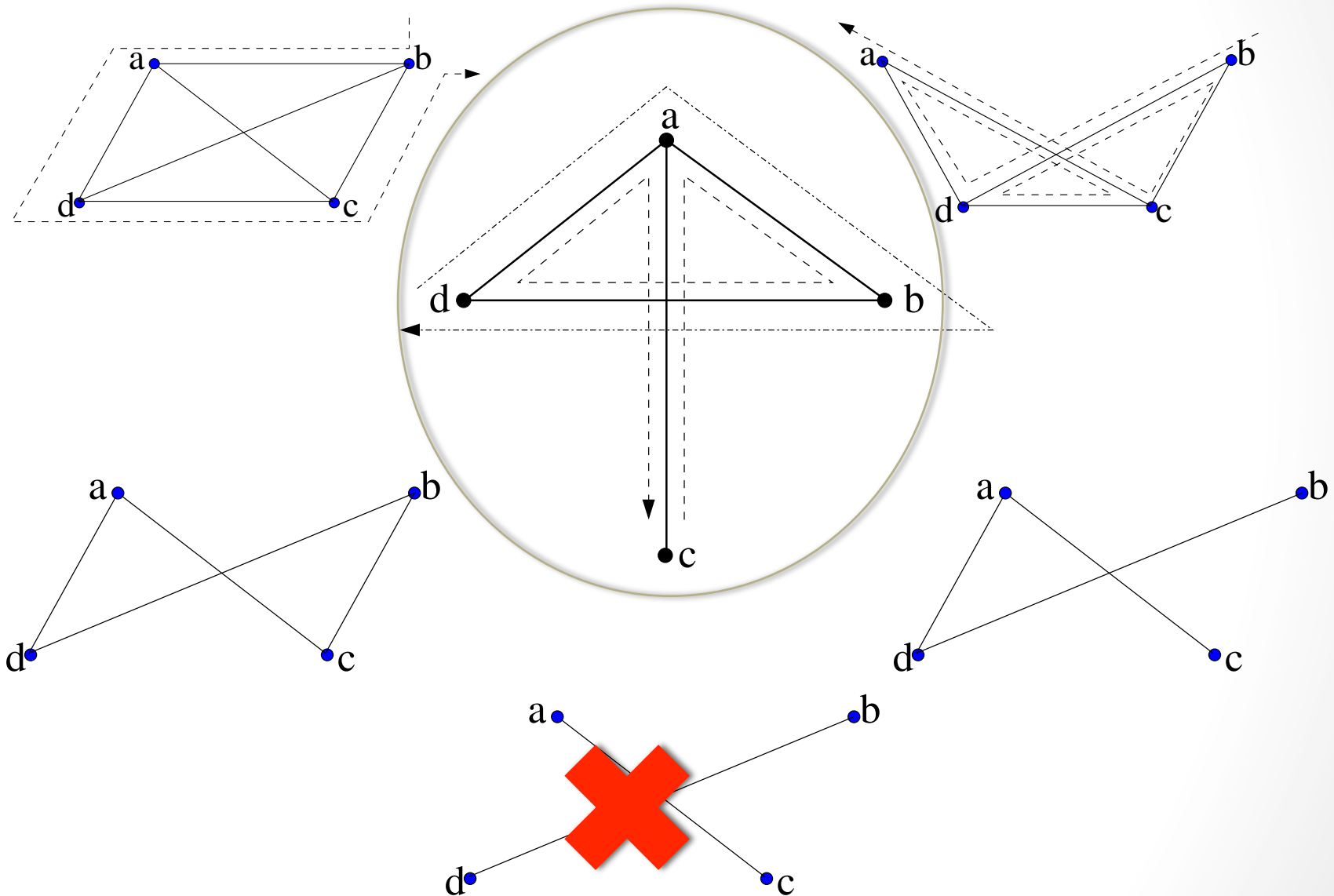
Back to First Principles

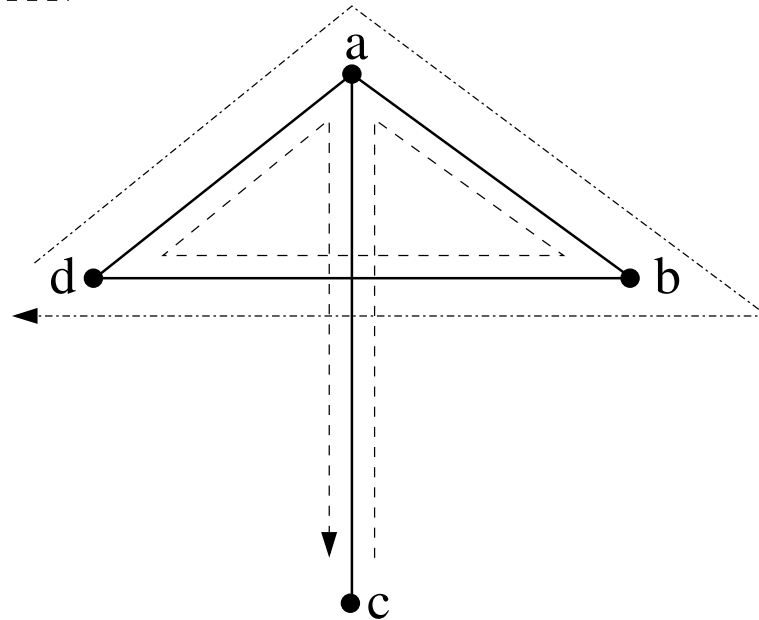
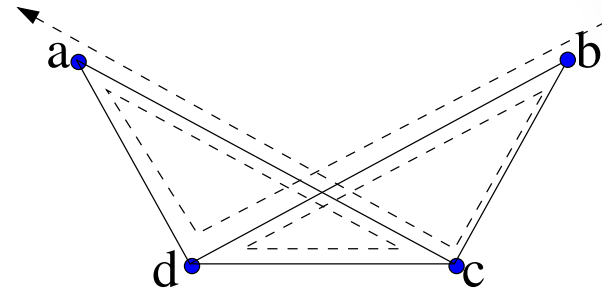
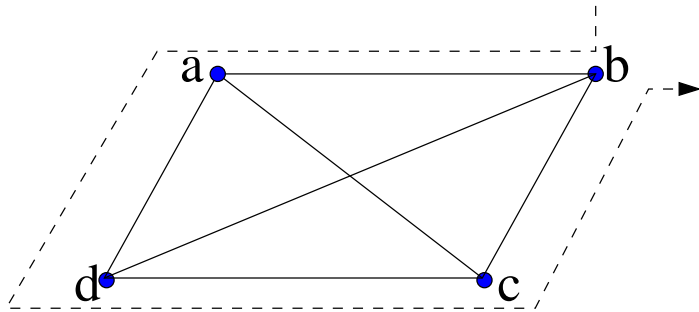
- Consider any intersection of two links.
- Initially, restrict to unit disc graph
- Ask: What sides of 4-gon may exist?





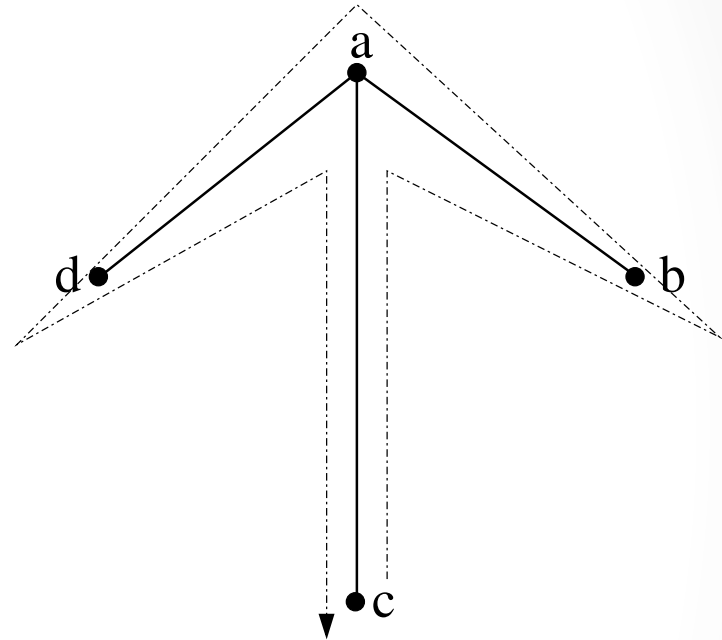
All Intersections Exist as One of Five





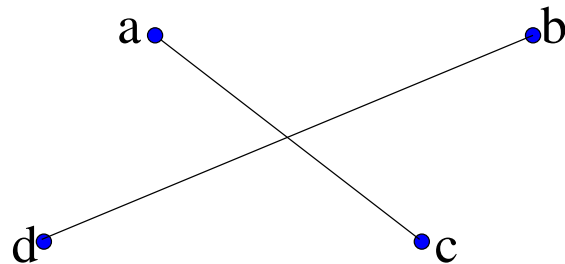
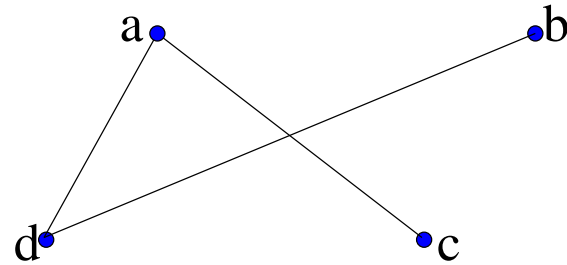
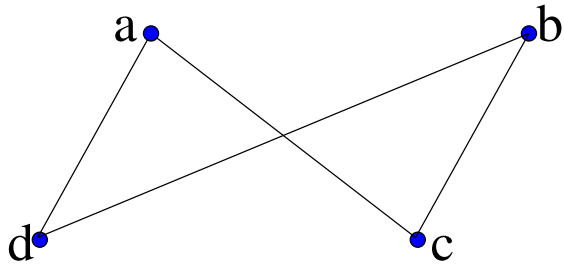
Three possible intersections in UDG

Only the 'umbrella' shape matters.



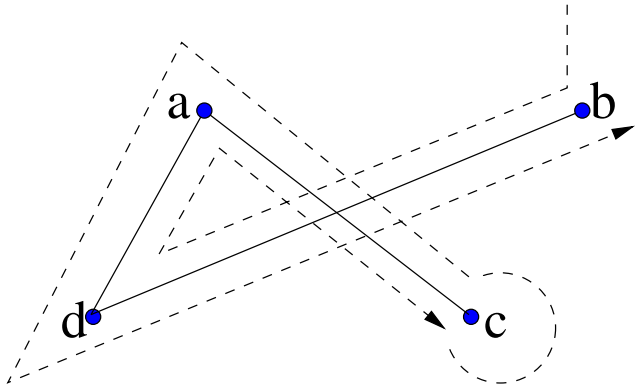
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Now Arbitrary Graphs

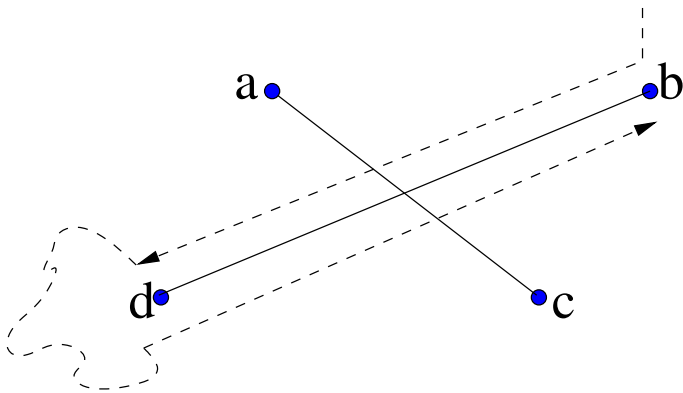


- 3 remaining configurations
- Last case reduces to one of remaining 5.

Intersections 4 and 5



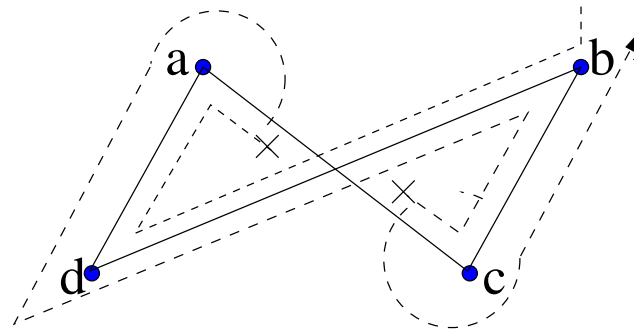
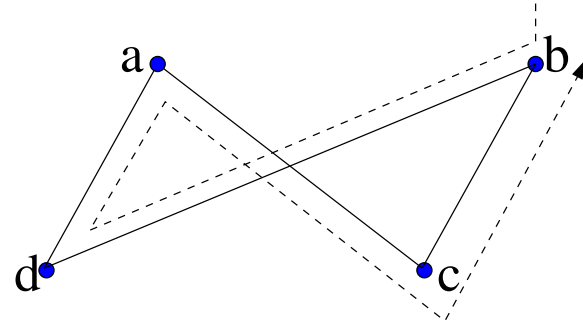
- 1-sided 4-gon is no issue



- 0-sided either
 - Two- separate networks,
 - Otherwise reduces to another config

Last one.

- Defeats LHR unless
 - allow packet to record its traversal,
 - Skip links that intersect.



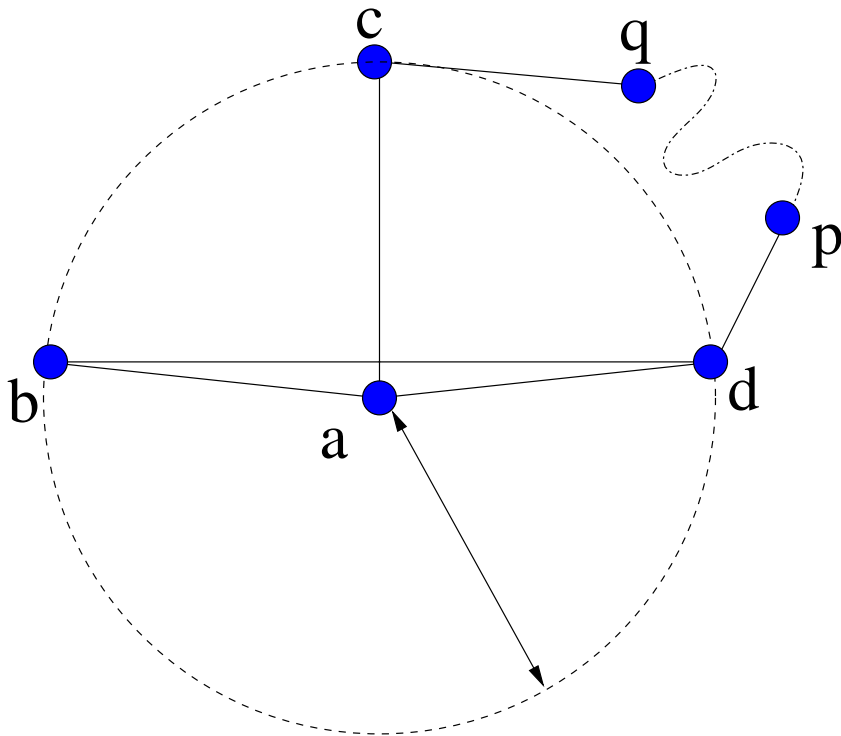
Back to Umbrella

- How frequently does it appear?
- Umbrella appearance, irrespective of constraints:

Network Size (Density)	Node Distribution	Ratio U/I
1500 (7.5)	uniform	0.013
	norm	0.013
	skew	0.011

- So, does it matter?

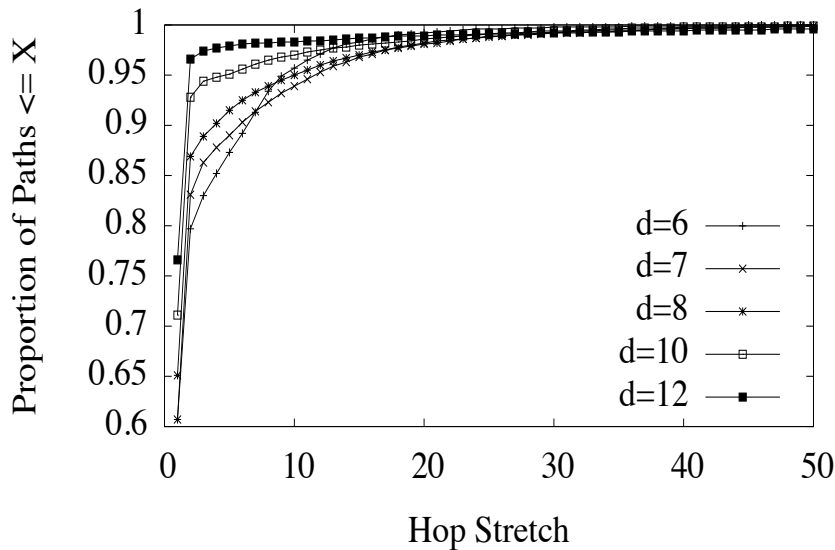
Additional constraints req'd



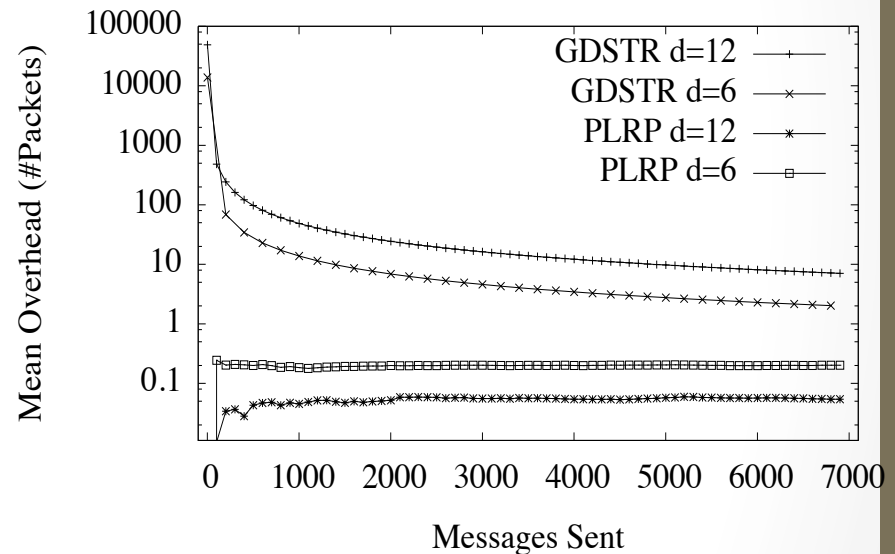
Only Umbrella Defeats LHR

- Only under strict conditions:
 1. Packet must be in recovery
 2. Umbrella must be encountered from 'outside'
 3. Must be no alternate path.

What happens if we ignore it?

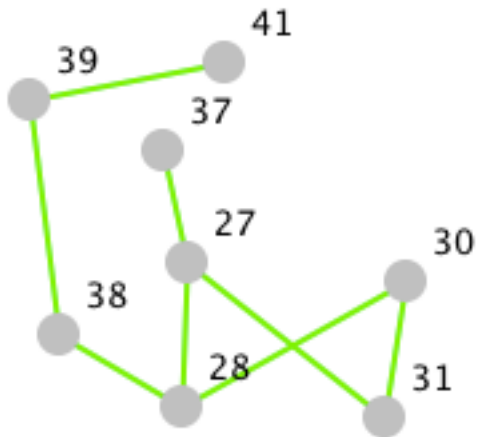


Hop stretch \sim LCLDP

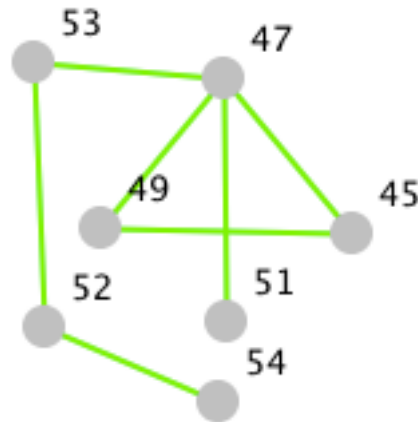


Message overhead

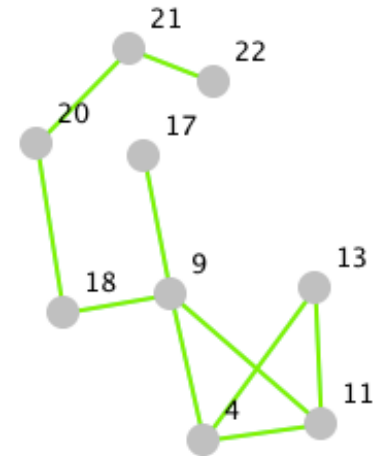
Worst cases never appear, so...



(a)



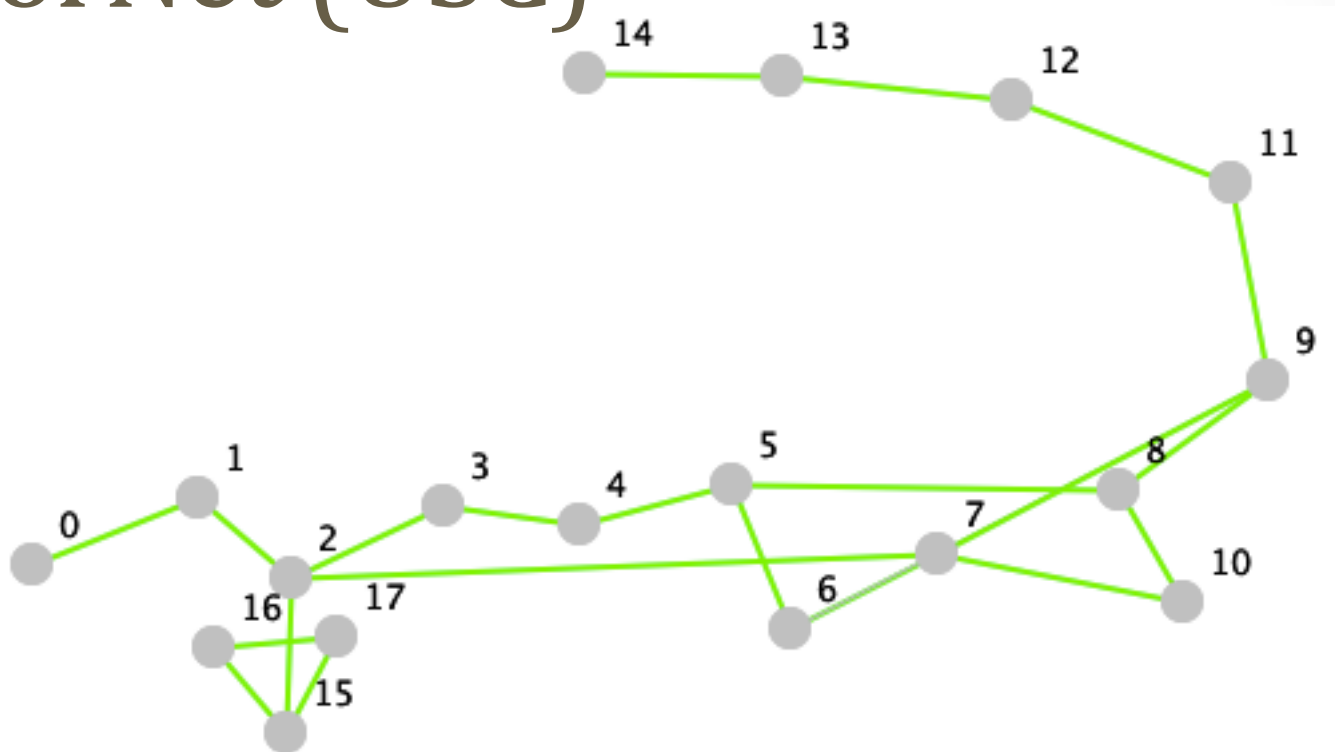
(b)



(c)

		Path Stretch				Message Overhead			
		GDSTR	CLDP	LCR	PLRP	GDSTR	CLDP	LCR	PLRP
(a)	37->41	5	9	7	7	624	245	0	0
(b)	51->54	4	6	6	11	792	227	227	6
(c)	17->22	5	10	15	15	774	298	0	8

TutorNet (USC)



		Path Stretch				Message Overhead			
		GDSTR	CLDP	LCLDP	PLRP	GDSTR	CLDP	LCR	PLRP
	3->14	9	8	8	29	1641	1082	1082	0

Remarks & Open Questions

- Always pays to understand root causes for failure
- Current solutions may be 'over-solving' the problem
 - Problem cases rarely appear
 - Their solutions are complex
- Future & Open Questions:
 - Trade-off between knowledge/setup & path stretch?
 - Do high setup & maintenance costs even matter?
 - Larger performance gain in dynamic/mobile networks?

In General

- Guaranteed Delivery may be 'over-rated' in some situations
 - Where non-routing elements are likely to be cause of packet loss
 - When the complexity of delivering the last x% has a negative effect on resources.