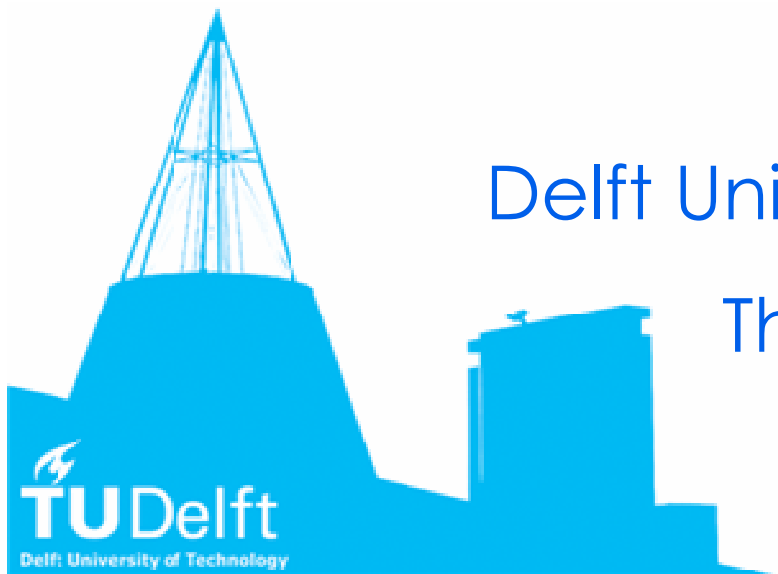


Virtual Ring Routing: Network routing inspired by DHTs

Muneeb Ali

Delft University of Technology

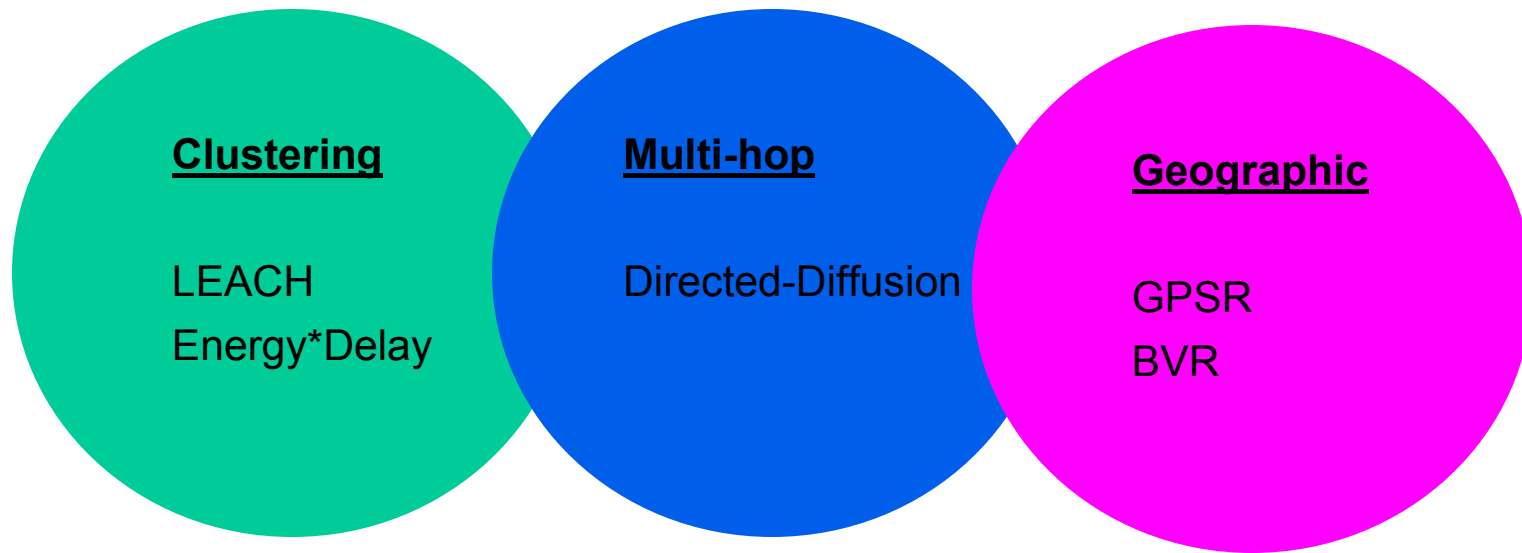
The Netherlands



¹Original paper presented at SIGCOMM'06 by
M. Caesar, M. Castro, E. Nightingale, G. O'Shea and A. Rowstron

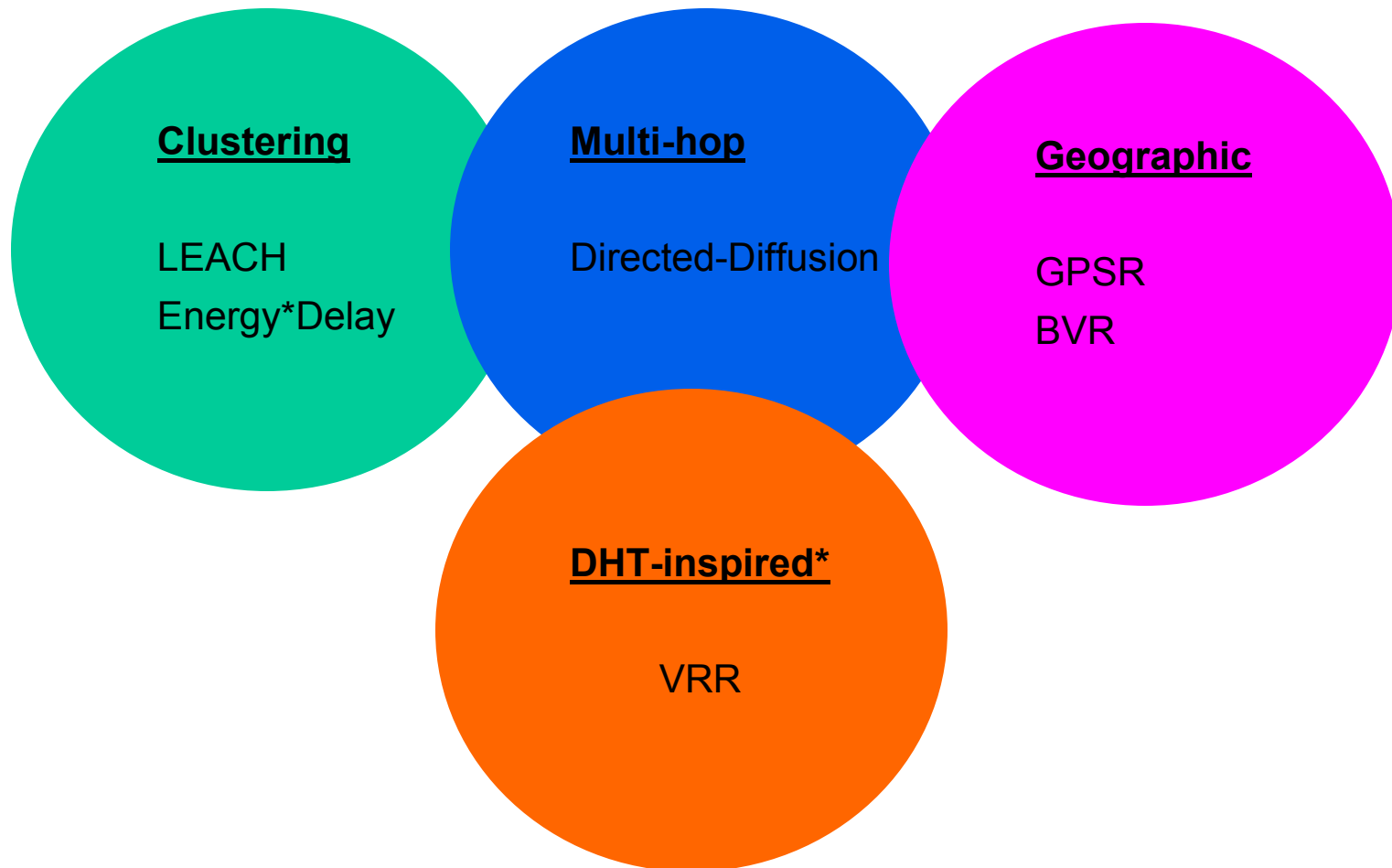
Big Picture

Sensornet Routing Protocols



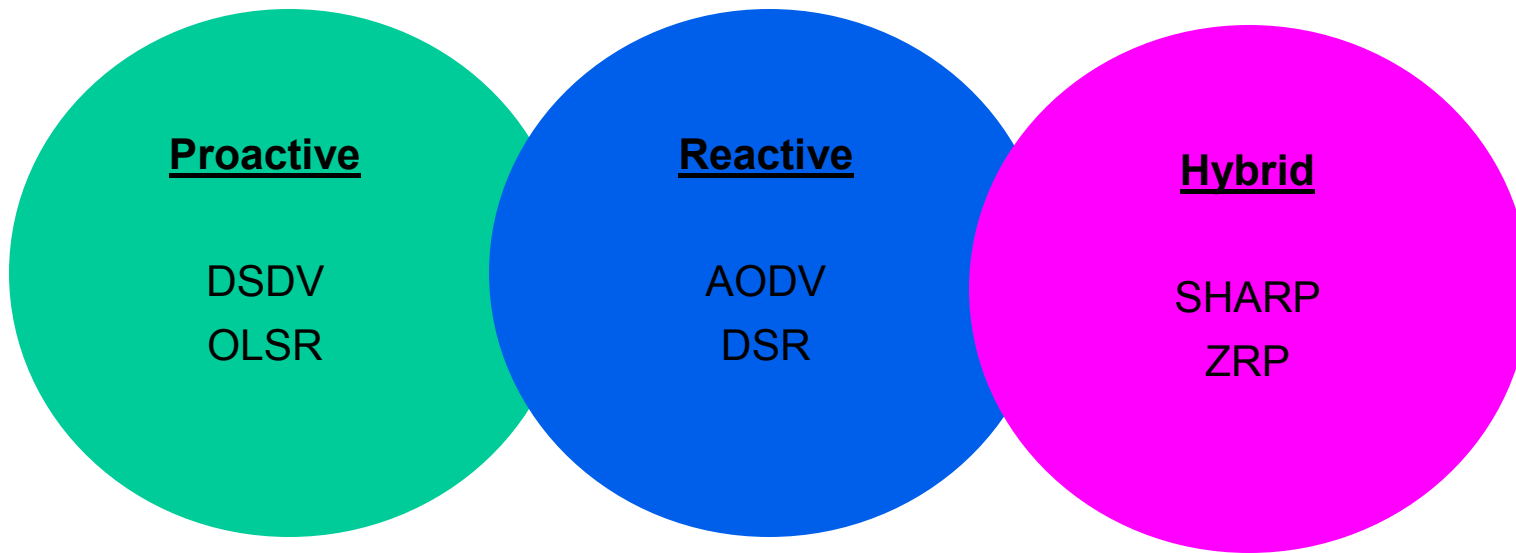
Big Picture

Sensornet Routing Protocols



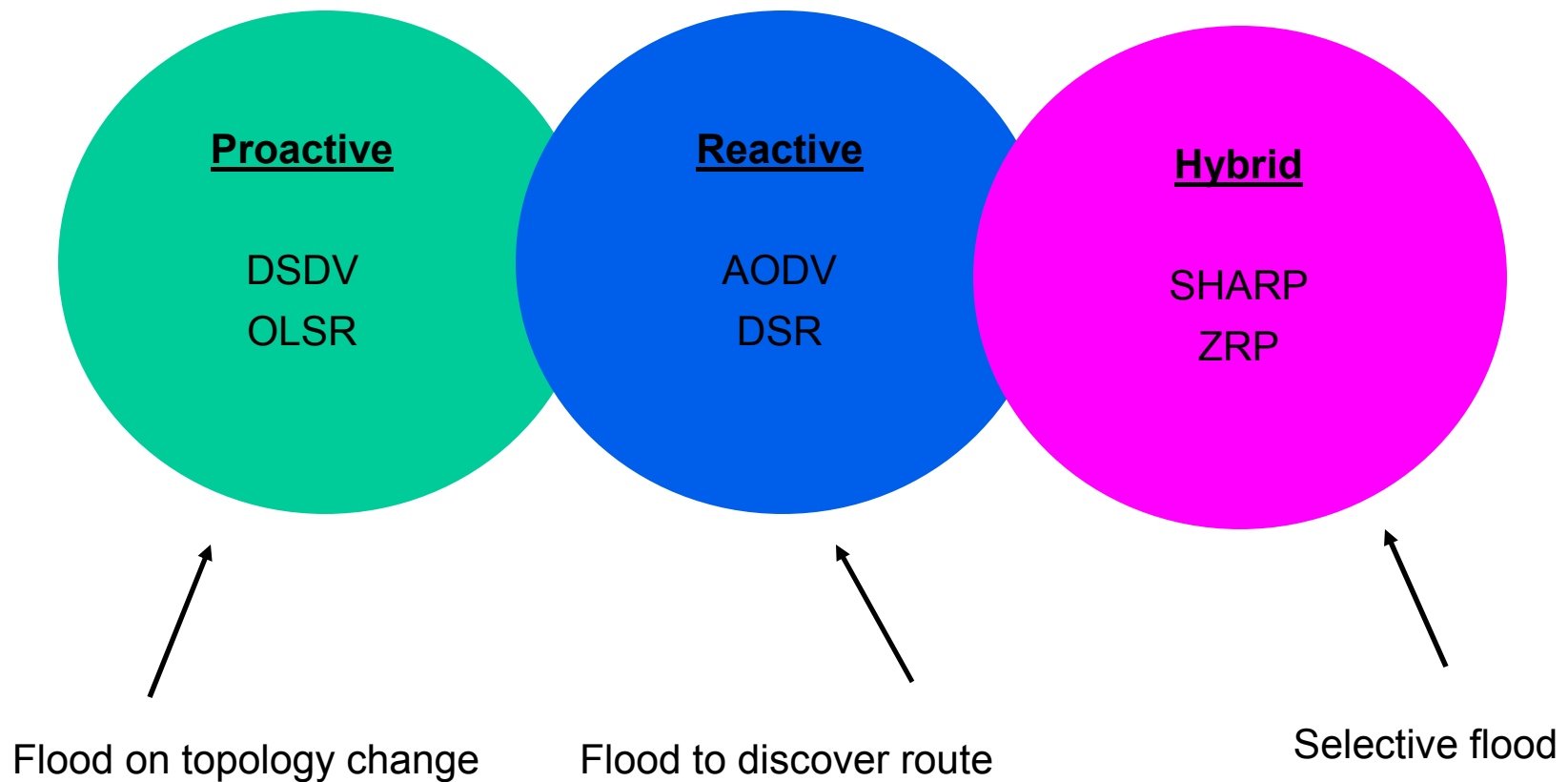
Big Picture

Ad-hoc Routing Protocols



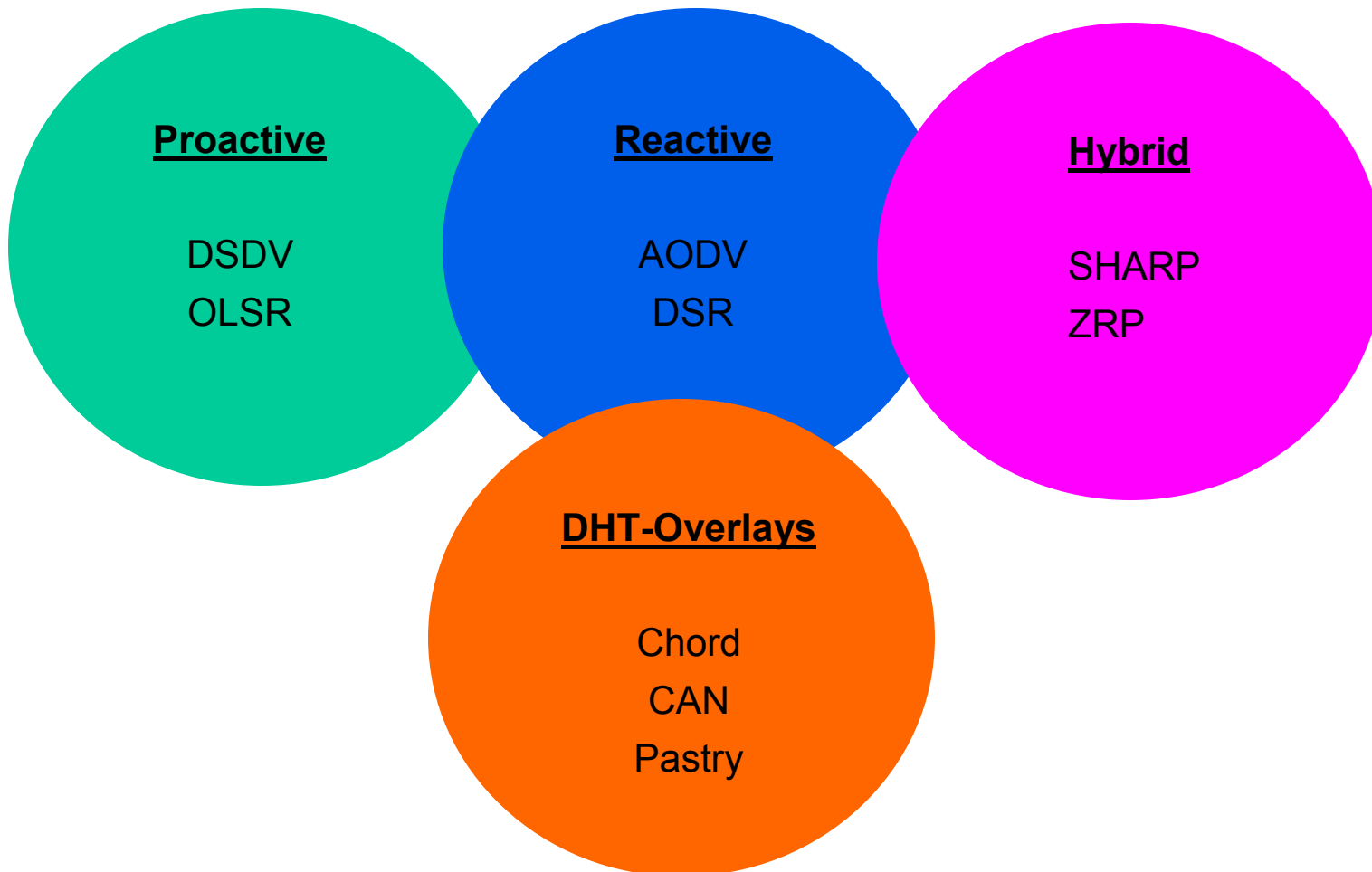
Big Picture

Ad-hoc Routing Protocols



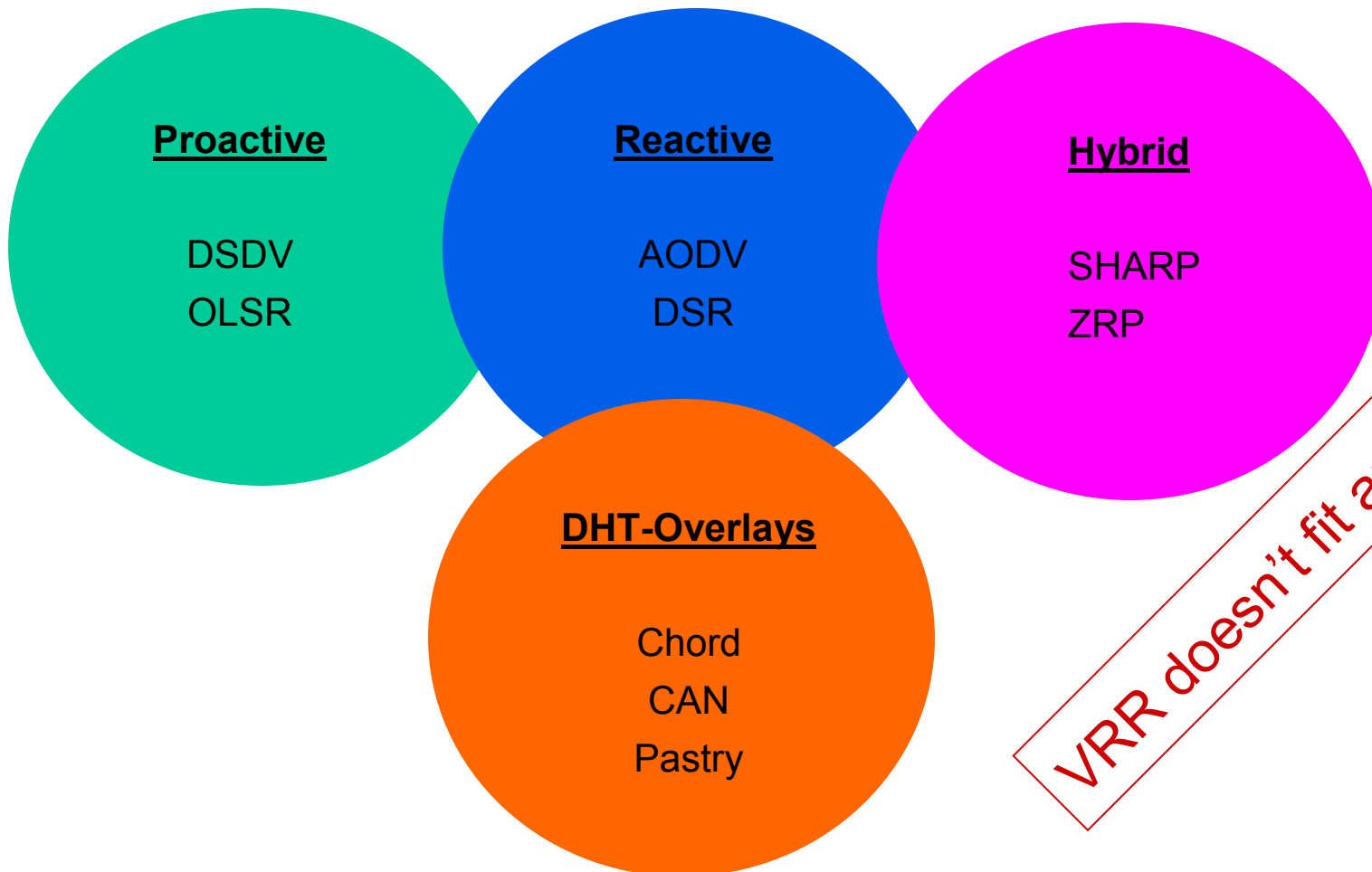
Big Picture

Ad-hoc Routing Protocols



Big Picture

Ad-hoc Routing Protocols



VRR doesn't fit anywhere!

VRR Overview

Flood (proactive or reactive)

Location-dependant address (geographic)

VRR Overview



Flood (proactive or reactive)



Location-dependant address (geographic)

VRR Overview

 Flood (proactive or reactive)

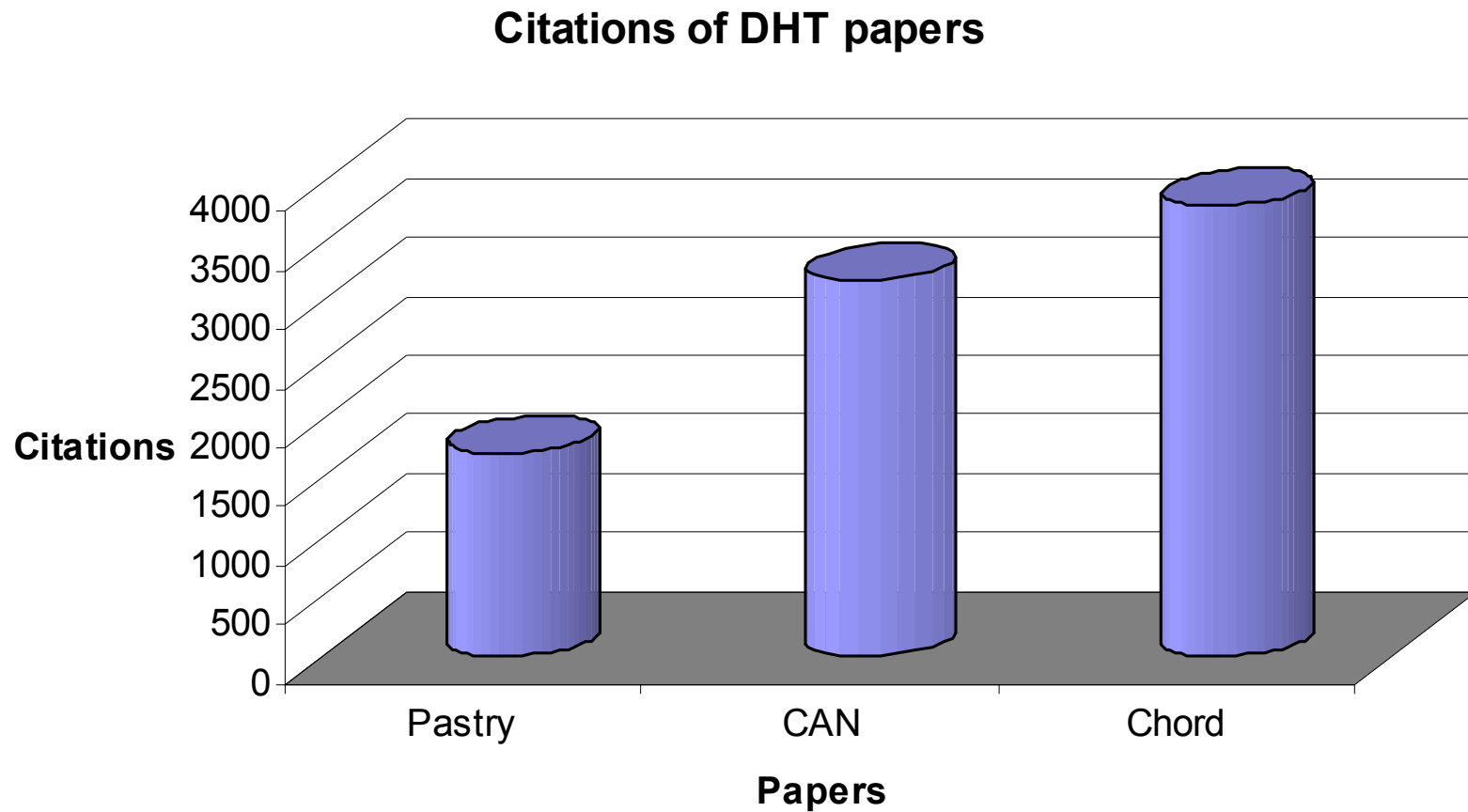
 Location-dependant address (geographic)

Unique point in design space

Inspired by DHT but implemented directly on top of link layer (no overlays)

Both point-to-point and DHT-like routing

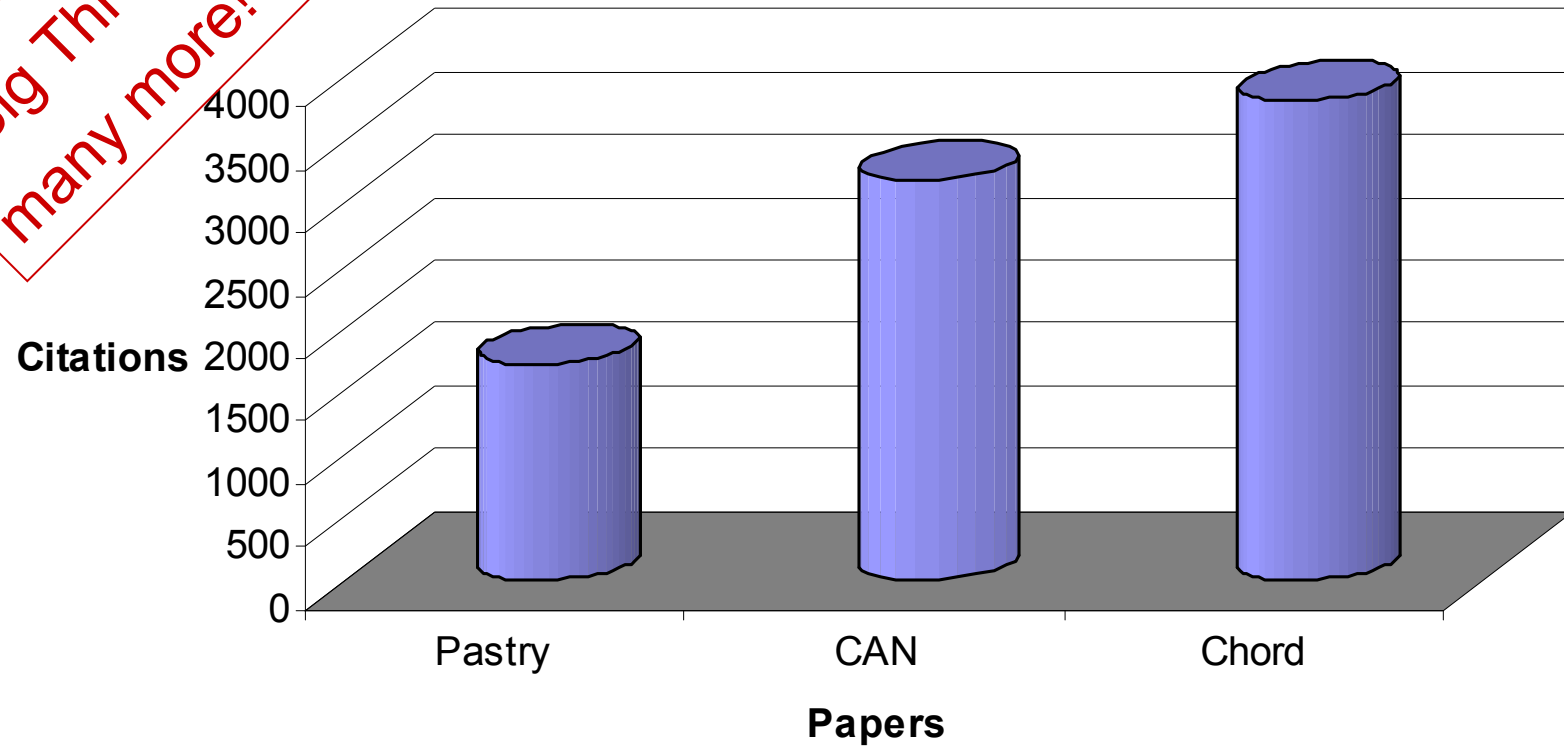
Distributed Hash Tables (DHTs)



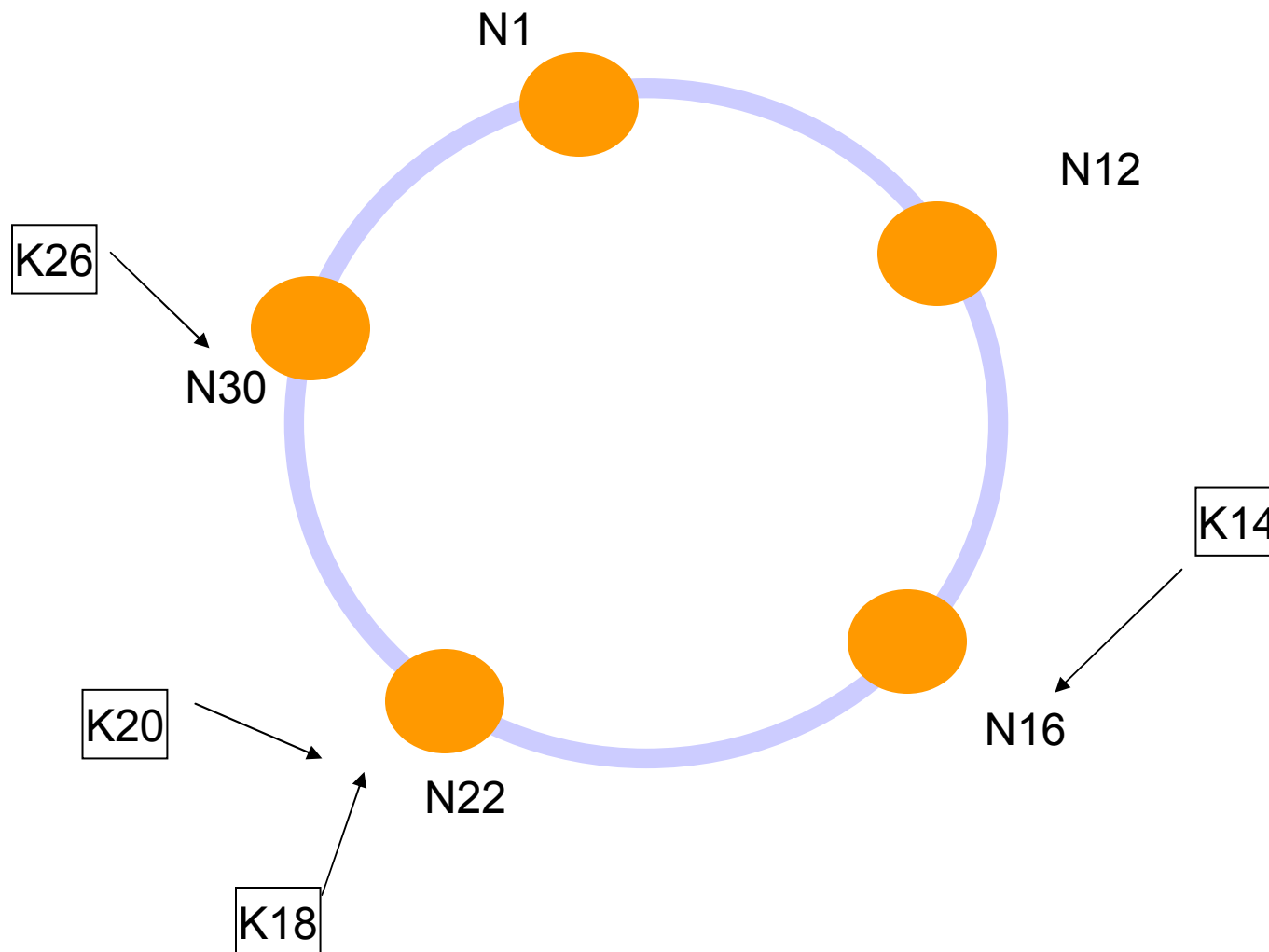
Distributed Hash Tables (DHTs)

These are the
"Big Three" ..
many more!

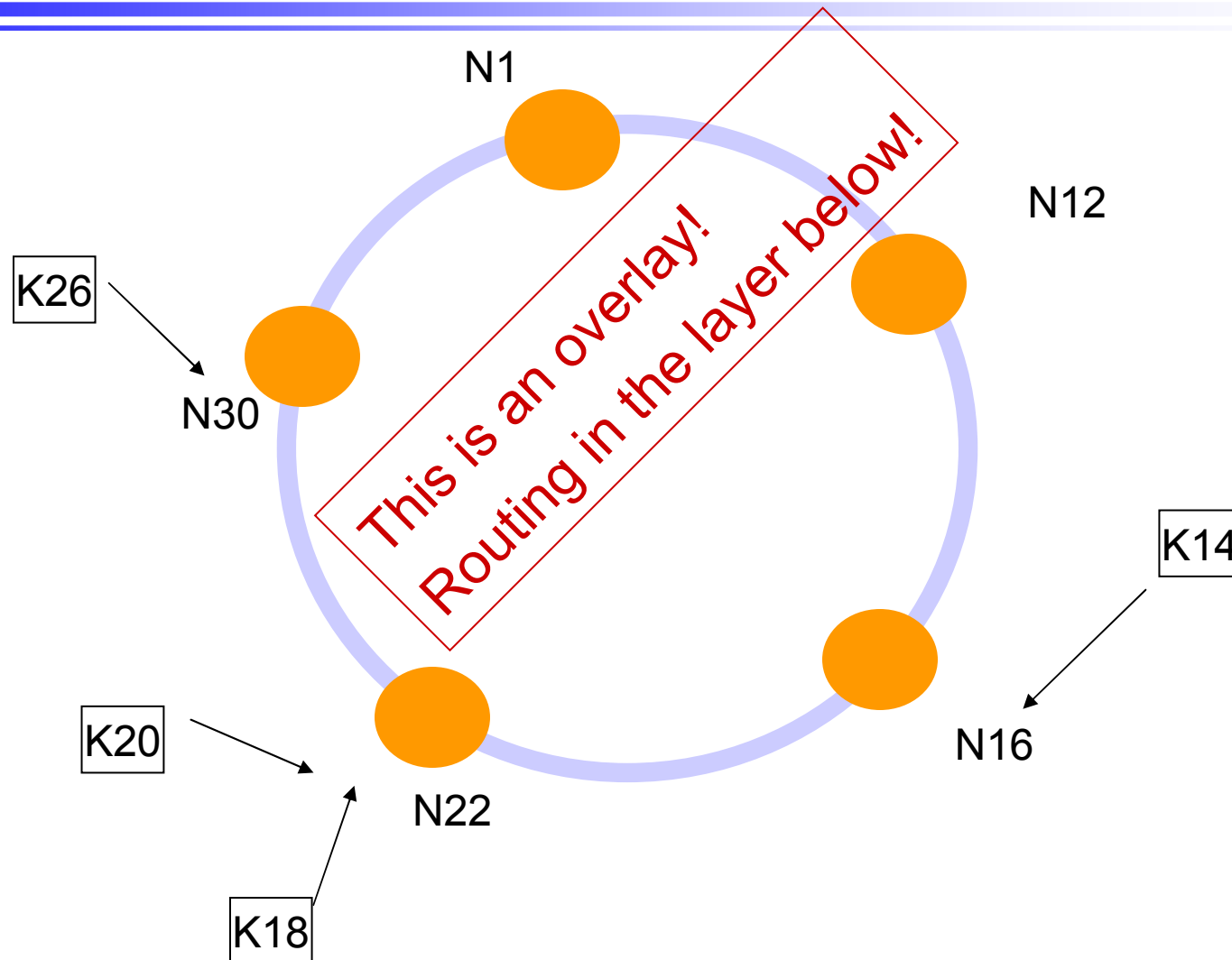
Citations of DHT papers



Background on DHT

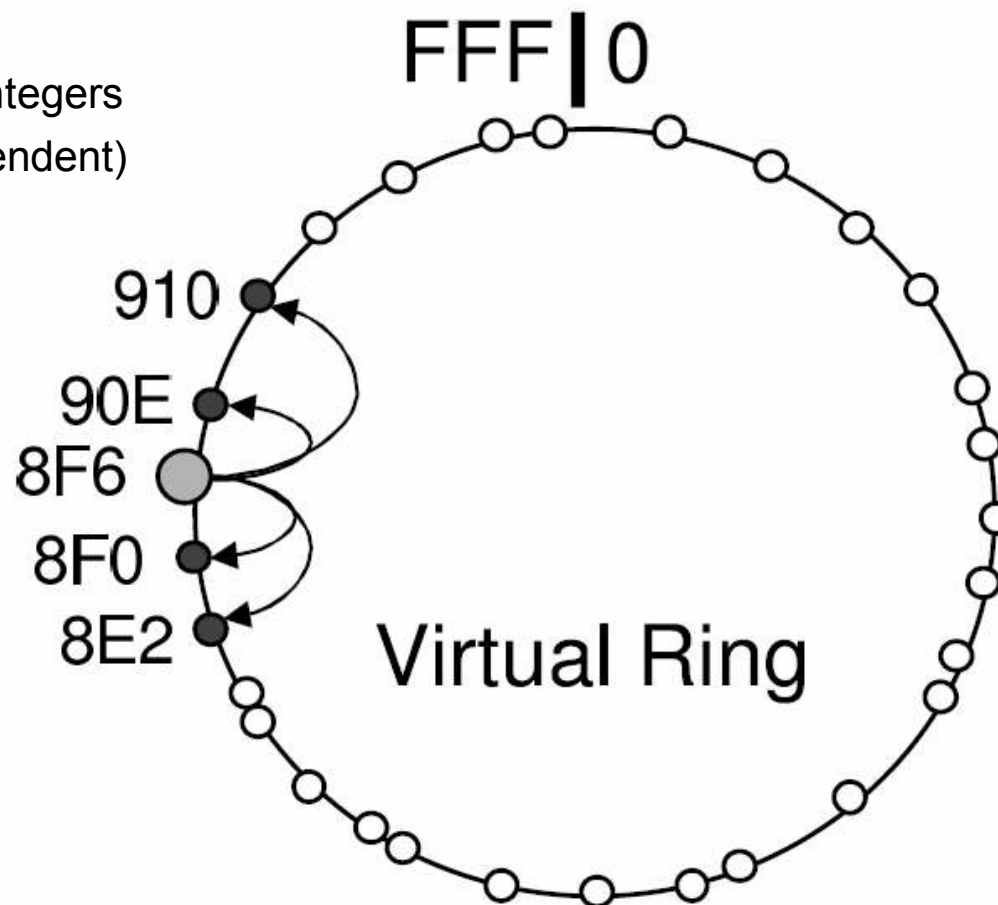


Background on DHT

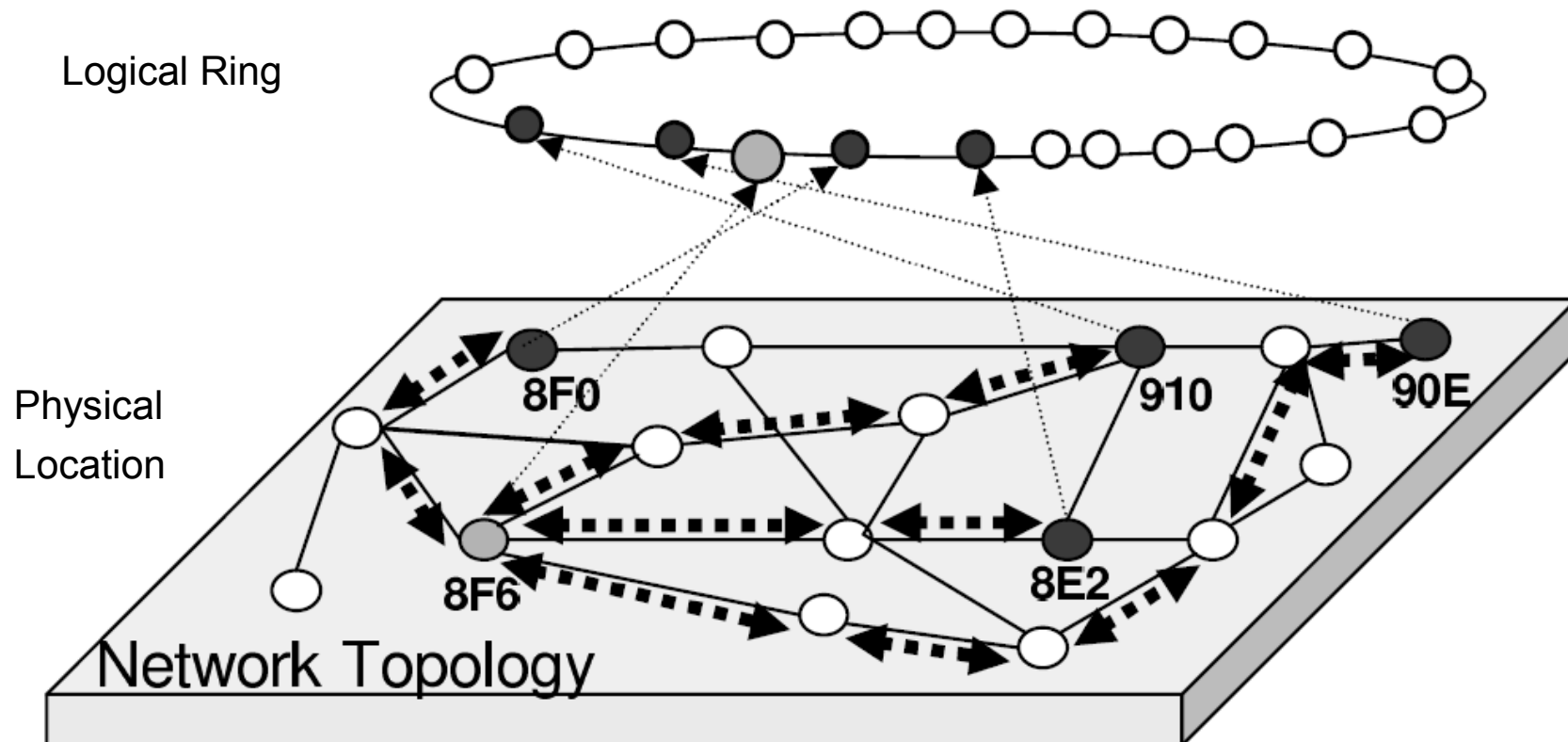


VRR Protocol

Node IDs are Integers
(location independent)



VRR Protocol



VRR Protocol

endpoint _A	endpoint _B	next _A	next _B	path id
8F0	8F6	20E	null	03
8E2	8F6	F01	null	2F
8F6	90E	null	7E2	1E
910	8F6	F01	null	2F
35F	37A	20E	7E2	12
A01	A10	F01	FC1	F0
8F6	20E	null	20E	FF
8F6	F01	null	F01	FF
8F6	7E2	null	7E2	FF
8F6	FC1	null	FC1	FF

VRR Protocol

Physical
Neighbors
“p-set”



endpoint _A	endpoint _B	next _A	next _B	path id
8F0	8F6	20E	null	03
8E2	8F6	F01	null	2F
8F6	90E	null	7E2	1E
910	8F6	F01	null	2F
35F	37A	20E	7E2	12
A01	A10	F01	FC1	F0
8F6	20E	null	20E	FF
8F6	F01	null	F01	FF
8F6	7E2	null	7E2	FF
8F6	FC1	null	FC1	FF

VRR Protocol

Virtual
Neighbors
“v-set”

endpoint _A	endpoint _B	next _A	next _B	path id
8F0	8F6	20E	null	03
8E2	8F6	F01	null	2F
8F6	90E	null	7E2	1E
910	8F6	F01	null	2F
35F	37A	20E	7E2	12
A01	A10	F01	FC1	F0
8F6	20E	null	20E	FF
8F6	F01	null	F01	FF
8F6	7E2	null	7E2	FF
8F6	FC1	null	FC1	FF

VRR Protocol

Routes
through
8F6 →

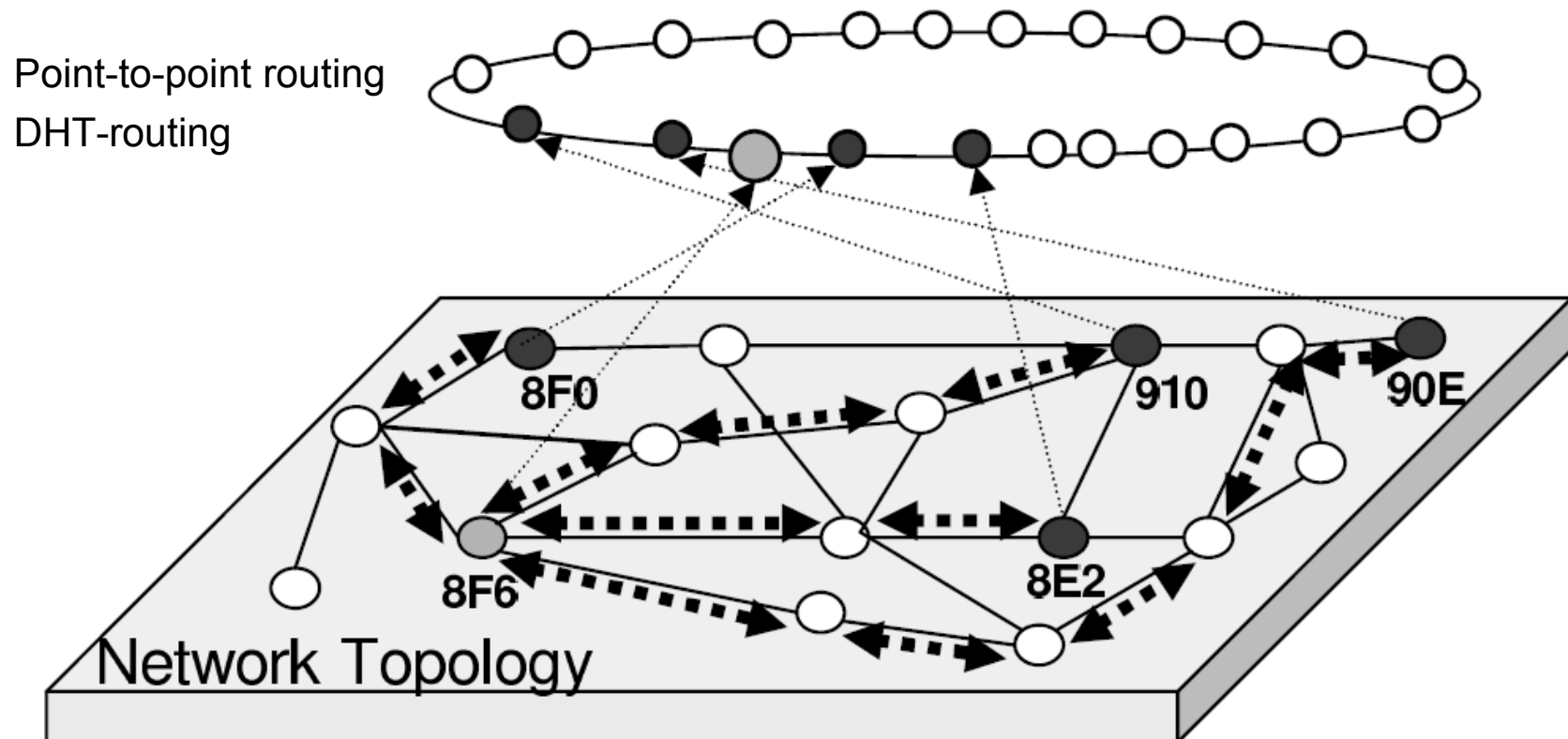
endpoint _A	endpoint _B	next _A	next _B	path id
8F0	8F6	20E	null	03
8E2	8F6	F01	null	2F
8F6	90E	null	7E2	1E
910	8F6	F01	null	2F
35F	37A	20E	7E2	12
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8F6	20E	null	20E	FF
8F6	F01	null	F01	FF
8F6	7E2	null	7E2	FF
8F6	FC1	null	FC1	FF

VRR Protocol

	endpoint _A	endpoint _B	next _A	next _B	path id
“v-set” Routes through 8F6	8F0	8F6	20E	null	03
	8E2	8F6	F01	null	2F
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“p-set”	A01	A10	F01	FC1	F0
	8F6	20E	null	20E	FF
	8F6	F01	null	F01	FF
	8F6	7E2	null	7E2	FF
	8F6	FC1	null	FC1	FF

Routing is done by simply sending the packet to the node with the closest ID

Putting the pieces together



Results (ad-hoc)

Simulation setup similar to CMU Monarch Project (ns-2)

802.11b links at 11Mbps

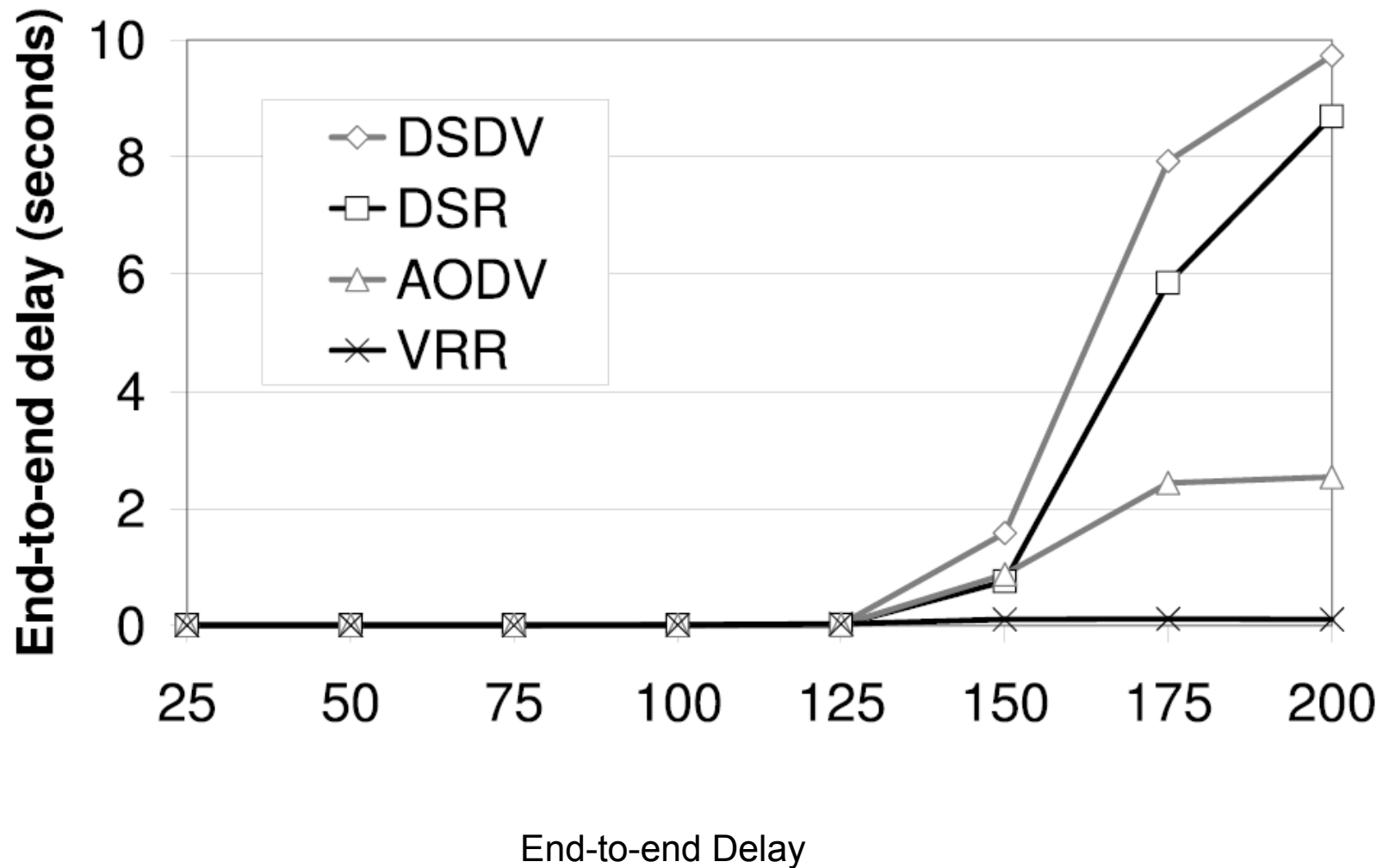
4-byte node identifier

V-set size = 4 (virtual neighbors)

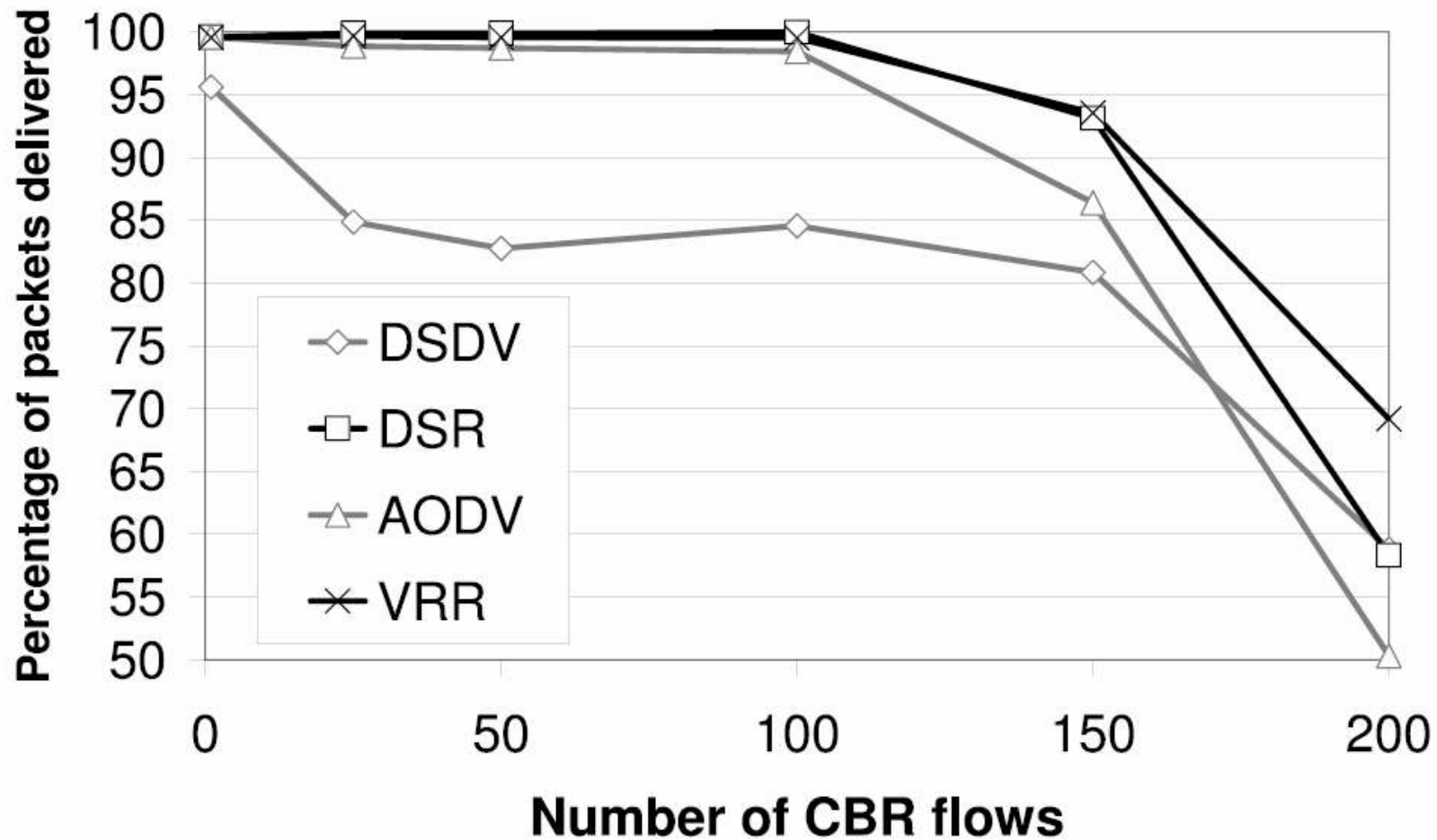
1500m x 300m plane

25 to 200 nodes

Results (ad-hoc)



Results (ad-hoc)



Packets delivered correctly

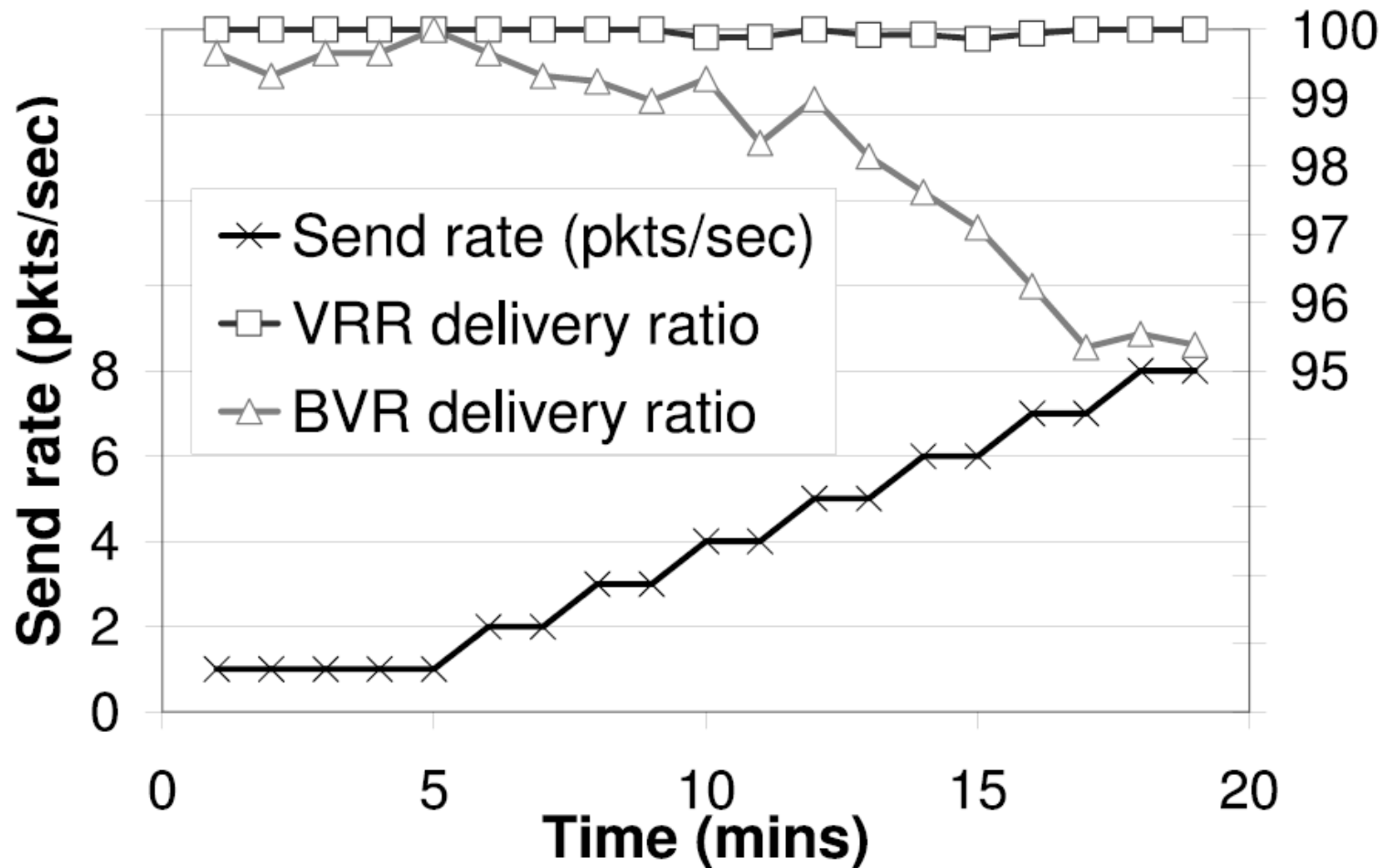
CBR = Constant Bit Rate UDP

Results (sensornets)

How does VRR perform in sensornets?

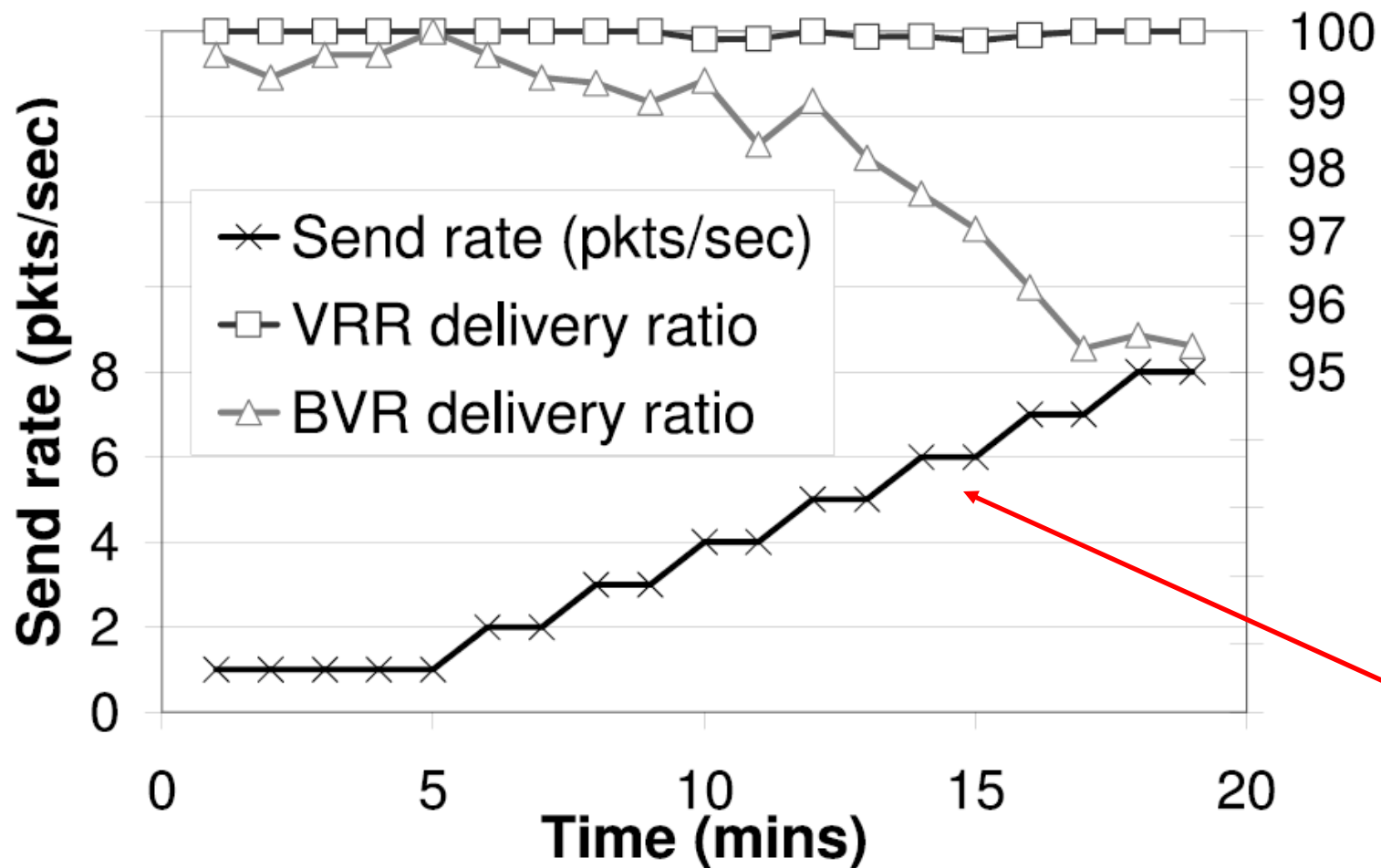
Real experiments on Mica2Dot (67-node setup)

Results (sensornets)



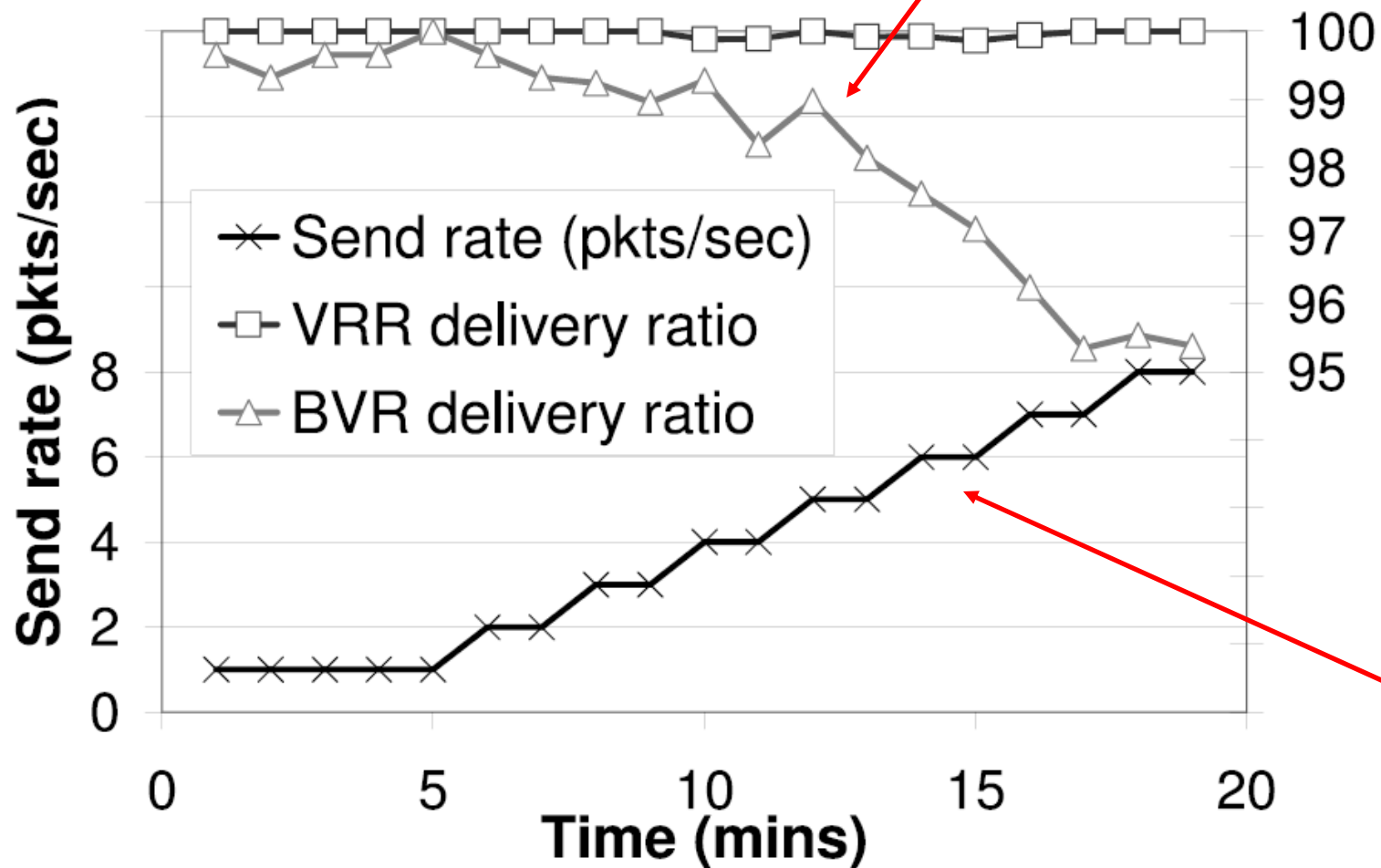
Delivery Rate (with varying packet rate)

Results (sensornets)



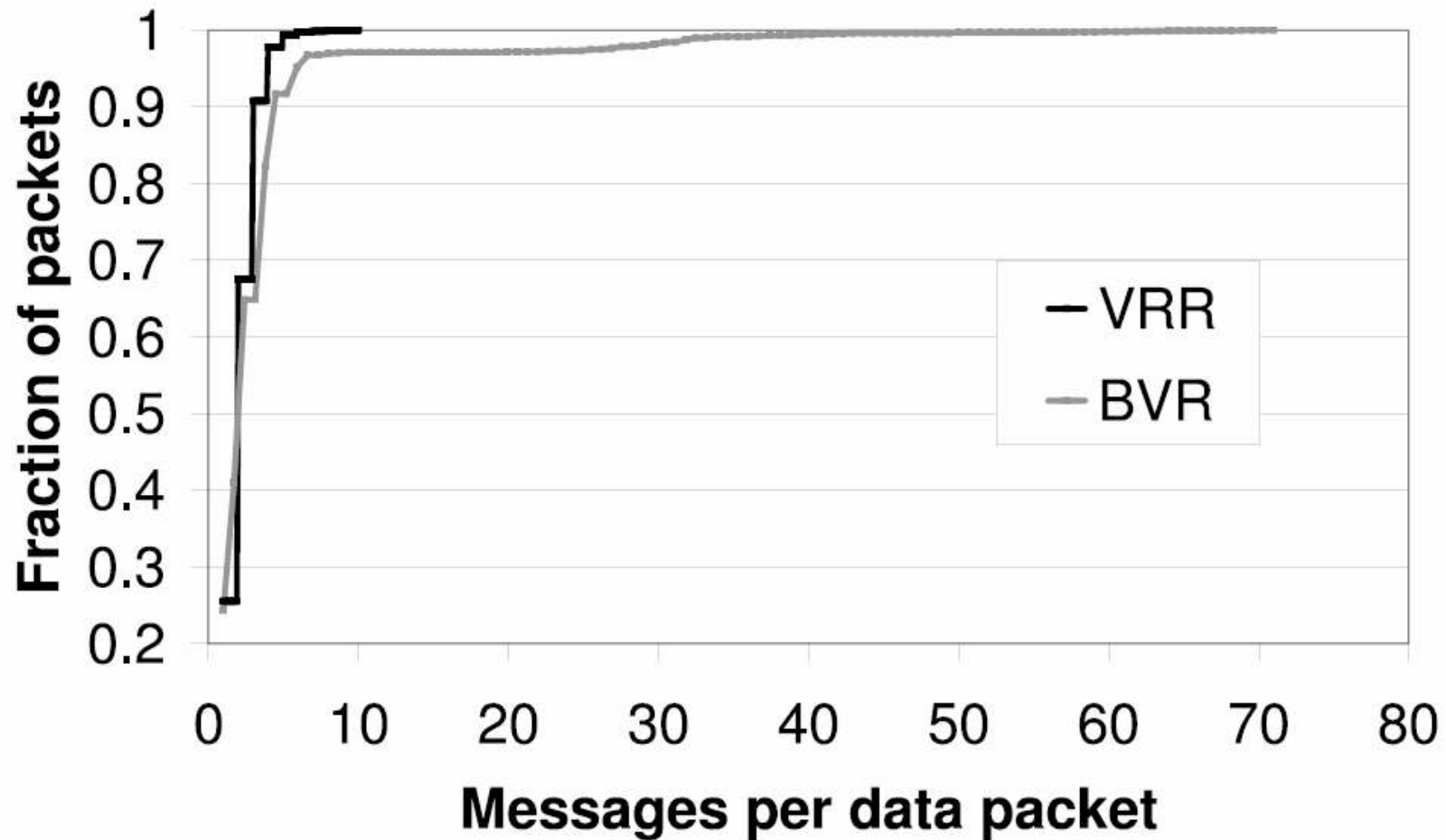
Delivery Rate (with varying packet rate)

Results (sensornets)



Delivery Rate (with varying packet rate)

Results (sensornets)

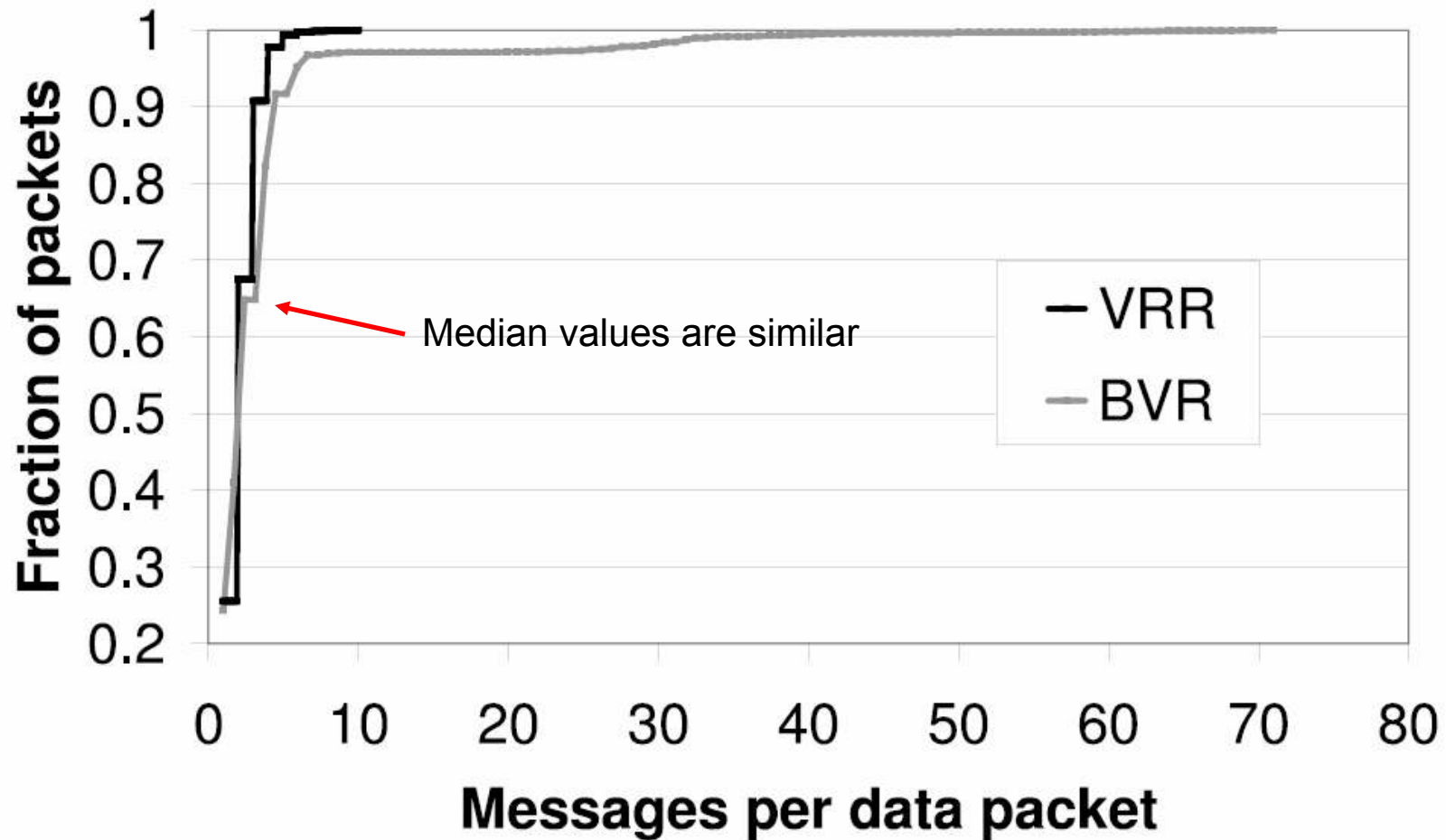


BVR – 32% of payload

VRR – 04% of payload

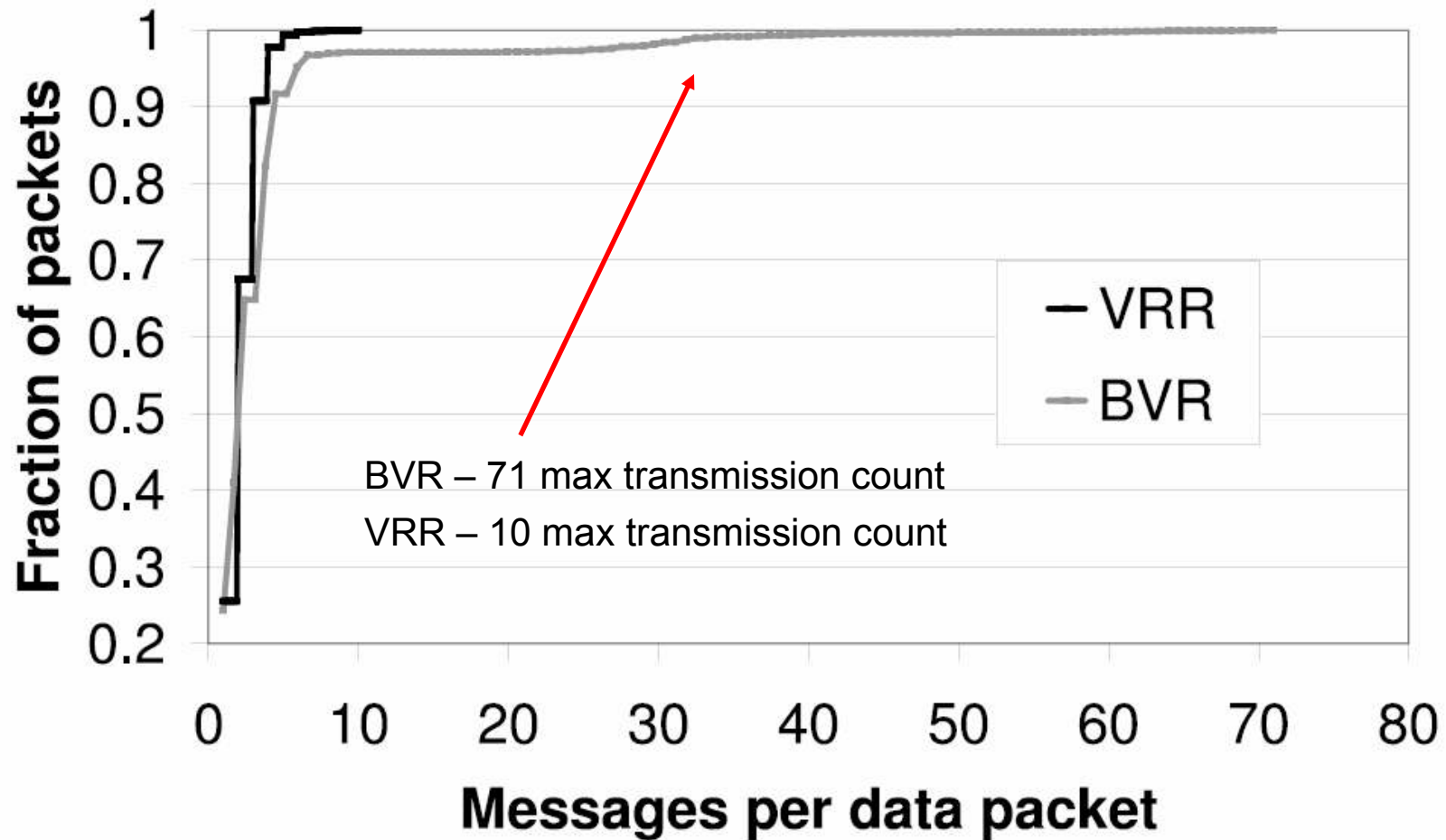
Message Overhead (per packet)

Results (sensornets)



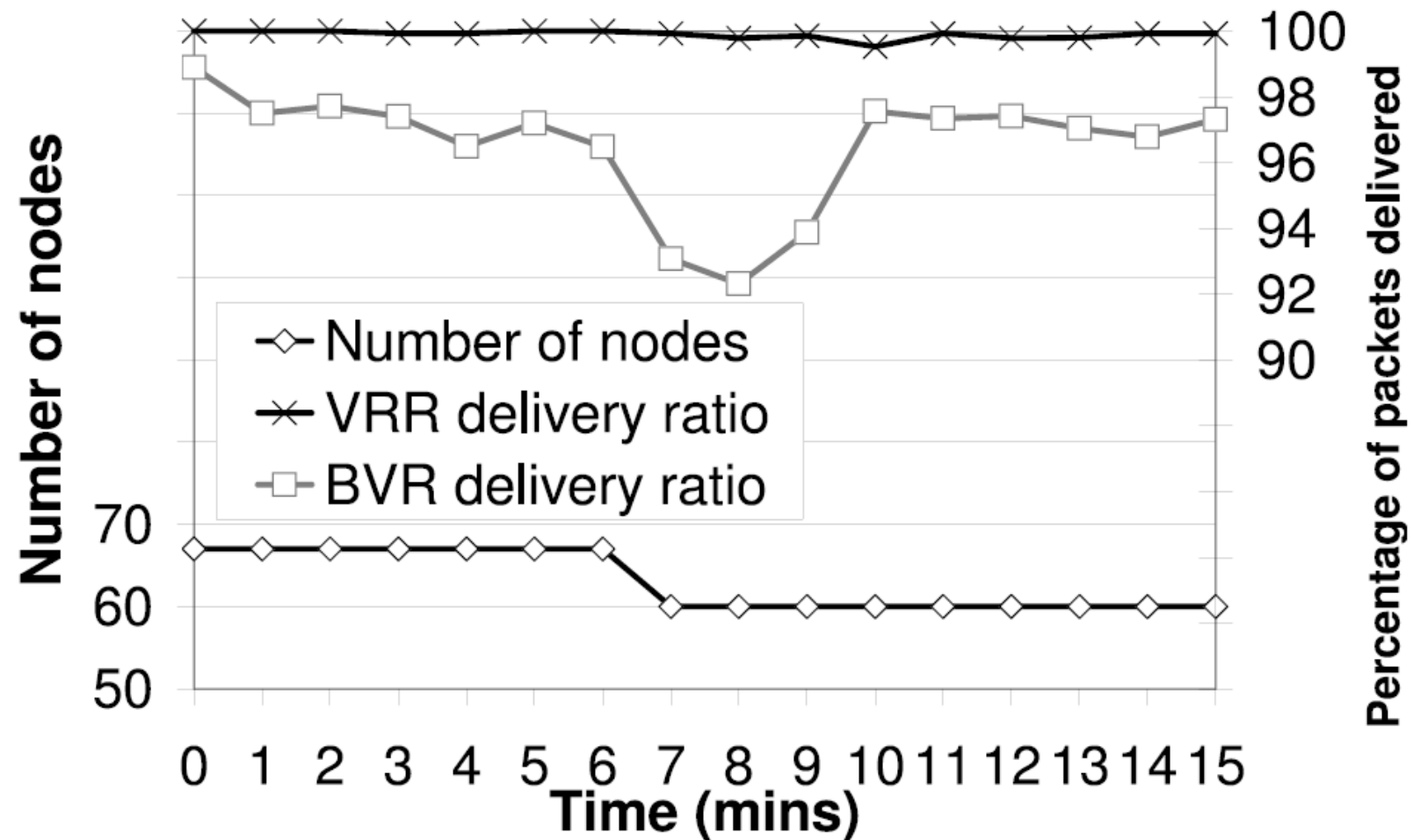
Message Overhead (per packet) shown as CDF

Results (sensornets)



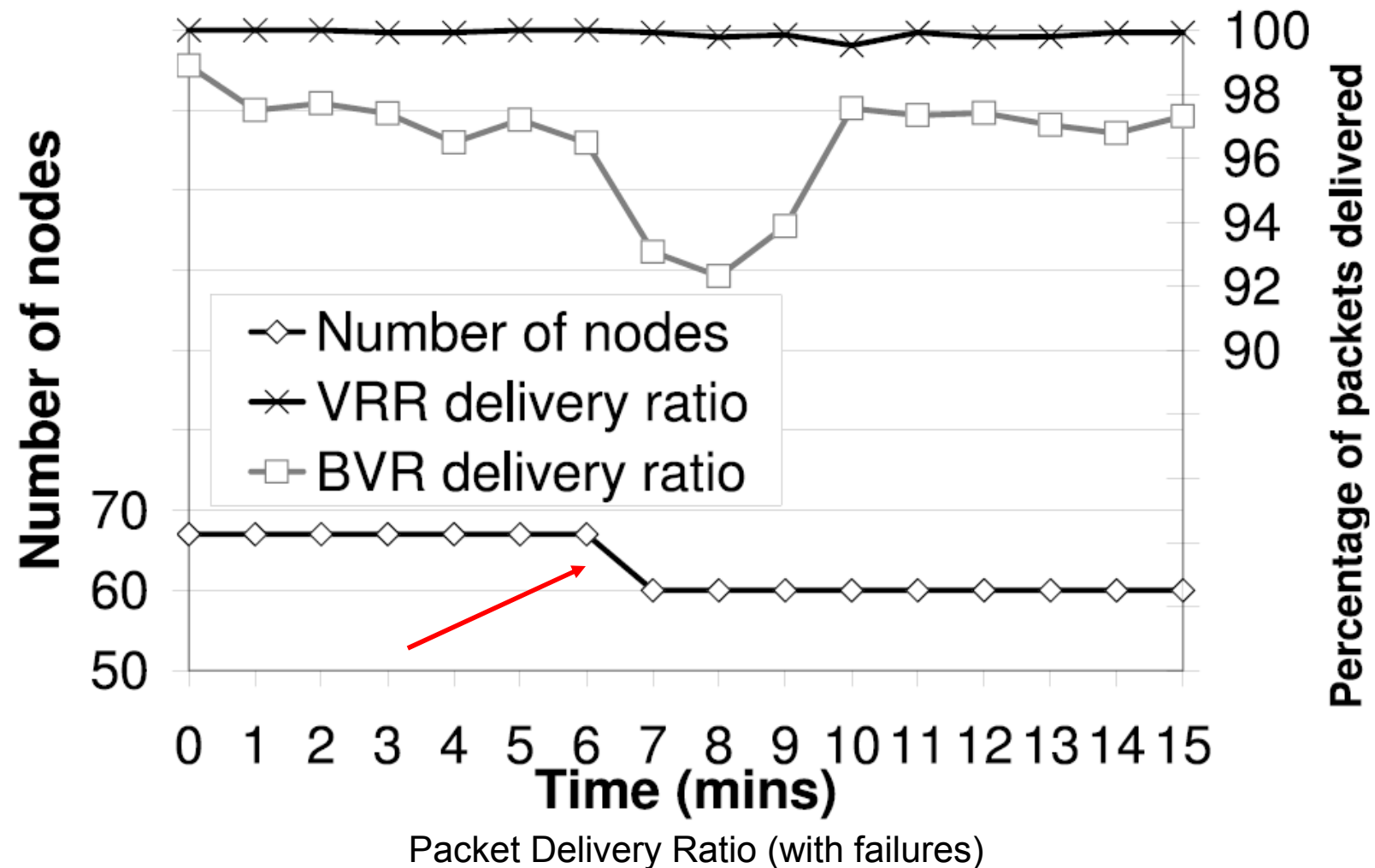
Message Overhead (per packet) shown as CDF

Results (sensornets)

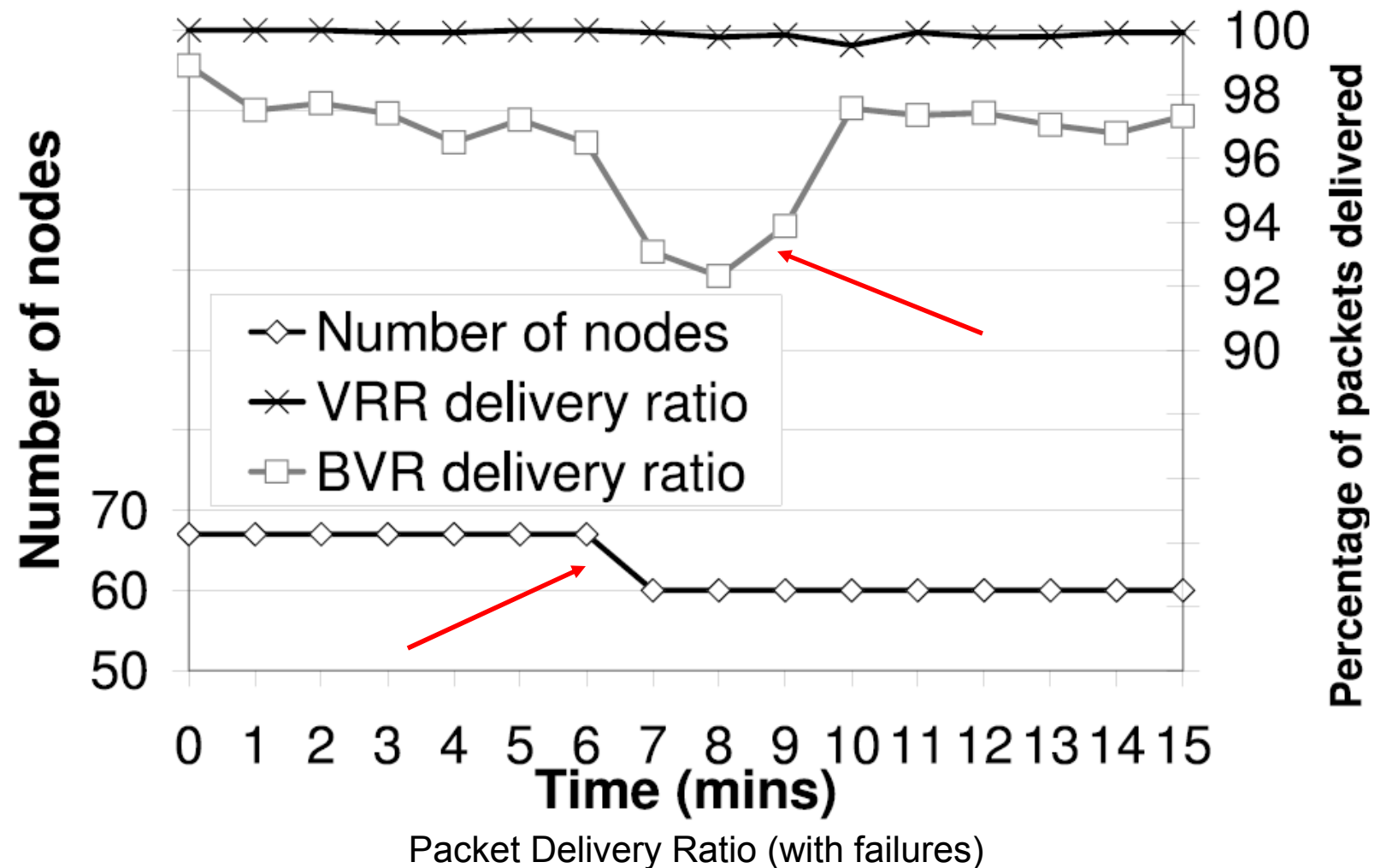


Packet Delivery Ratio (with failures)

Results (sensornets)



Results (sensornets)



Conclusions

- Provides both
 - Point-to-point routing (any pair of nodes)
 - DHT functionality
- Location independent identifiers
- Each node maintains small no. of paths (proactively)
- No flooding
- Robust performance across variety of
 - Networks (ad-hoc, sensornet)
 - Workloads

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 - Workloads

VRR Rocks!!
But ...
They should have cited my
CSN paper!!

Questions

Muneeb Ali

<http://ali.dritte.org>

Thank You !

