IETF 75 - MANET WG
Routing Loop Issue in Mobile Ad Hoc Networks

Niigata University

By:

Lee Speakman[1] and Kenichi Mase[2]

July 2009

1. Research Center for Natural Hazard and Disaster Recovery, Niigata University

2. Graduate School of Science & Technology, Niigata University

Overview

- Transient routing loops have been observed to form in Ad-hoc Networks running MANET proactive link-state routing protocols using hop count metric
- Looping packets observed using nOLSRv2* in the Niigata University Testbed and in simulation using Qualnet 4
- The authors propose an Informational draft for best practices / recommendations regarding looping issues

* nOLSRv2 is the Niigata University implementation of the OLSRv2 protocol for simulation and real-world.

Routing performance

- Comparison against simple Packet Discard technique on Loop Detection shows effect of looping packets on surrounding medium and traffic in OLSRv2
- Simple discard of looping packets may significantly improve performance by discarding those packets unlikely to reach the destination
- Negative effects of looping packets significant under certain environments;
  - higher network loads
  - lower node/link densities

Draft proposal

- Provide recommendations regarding looping issues in proactive link-state Mobile Ad hoc Networks to
  - reduce the likelihood of loop formation
    - Mesh & Mobile environments – different needs?
    - Link stability & responsiveness?
    - Instant link-change messaging recommendations?
  - deal with formed loops; correction and avoidance
  - other issues

draft-speakman-manet-looping-issue-00 (May 25, 2009) put forward for consideration

"Routing Loop Issue in Mobile Ad Hoc Networks (MANETs)"

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Other comments..?

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Supporting material follows…

draft-speakman-manet-looping-issue-00

Mechanism of looping

draft-speakman-manet-looping-issue-00

Partial Network

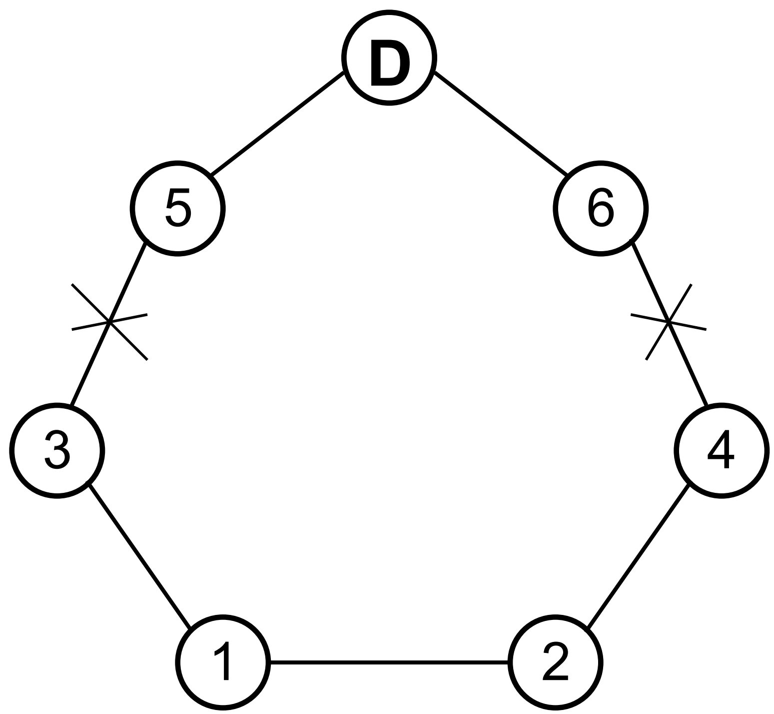
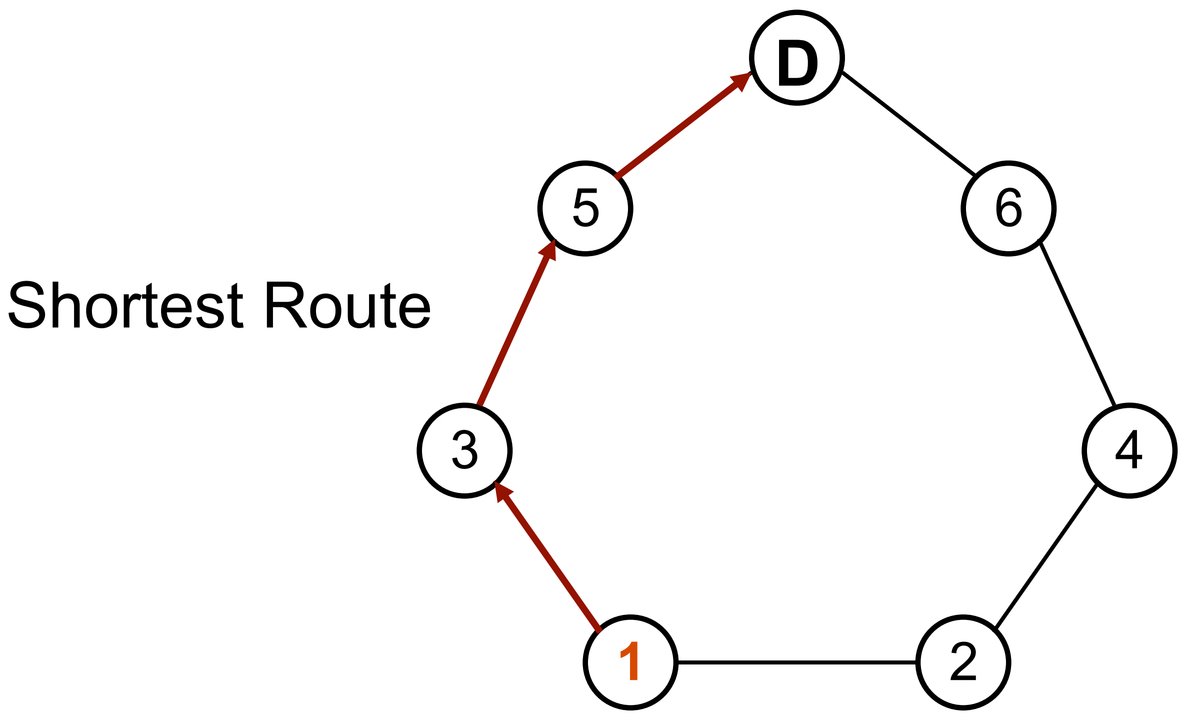


Figure 1. Partial network of nodes with routes to destination D considered to be part of a larger and denser network with other nodes and links not shown

Mechanism of looping

draft-speakman-manet-looping-issue-00

Partial Network



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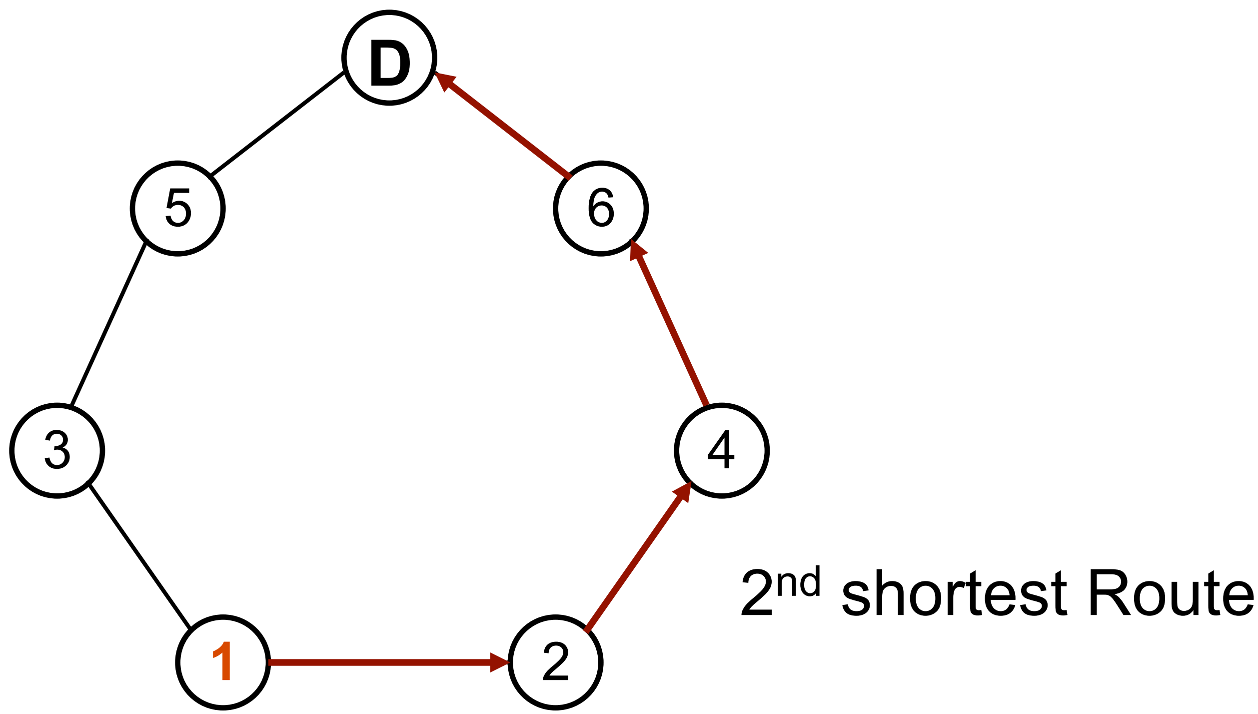

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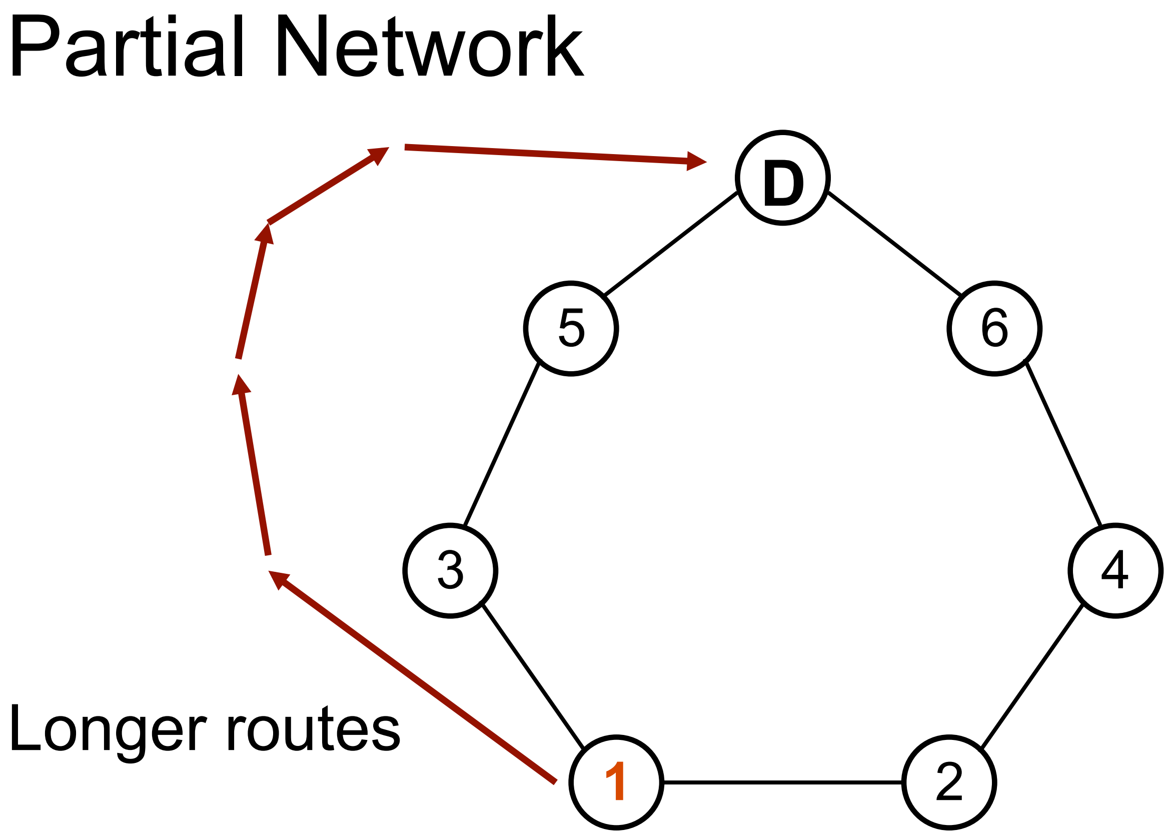

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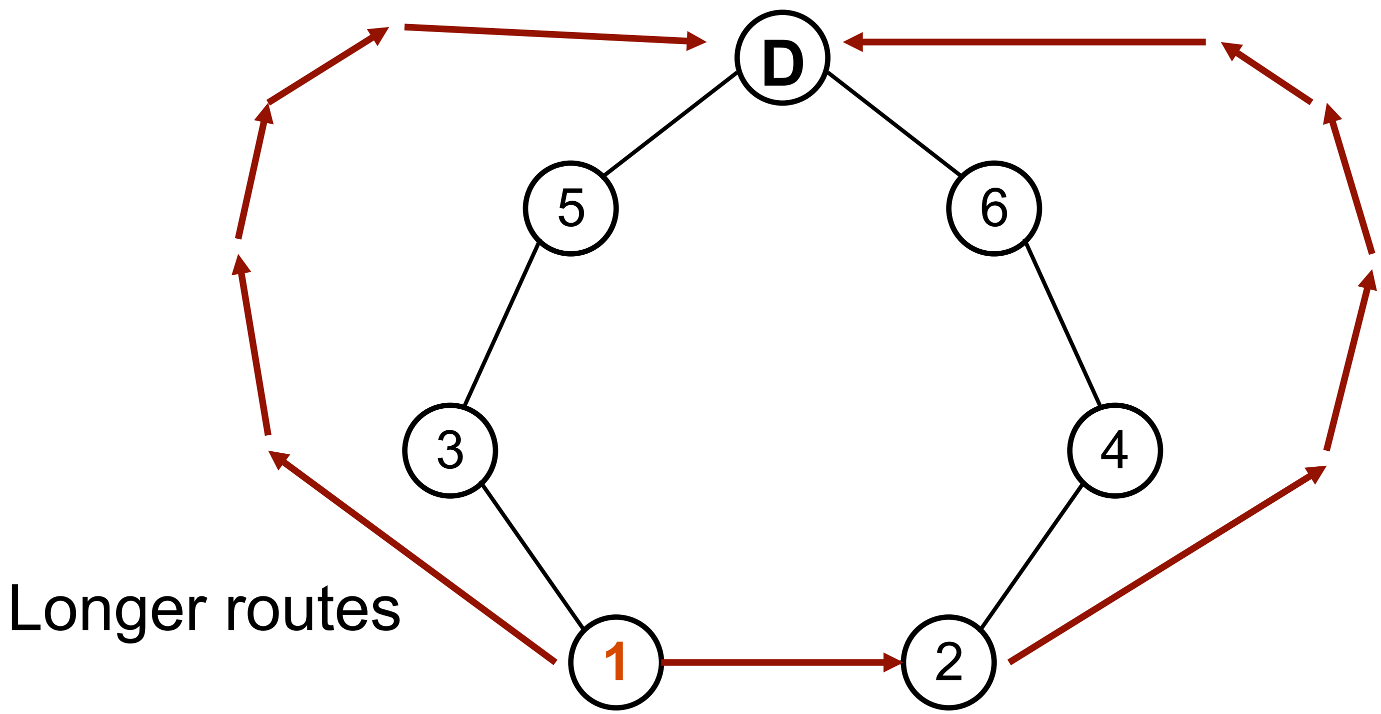

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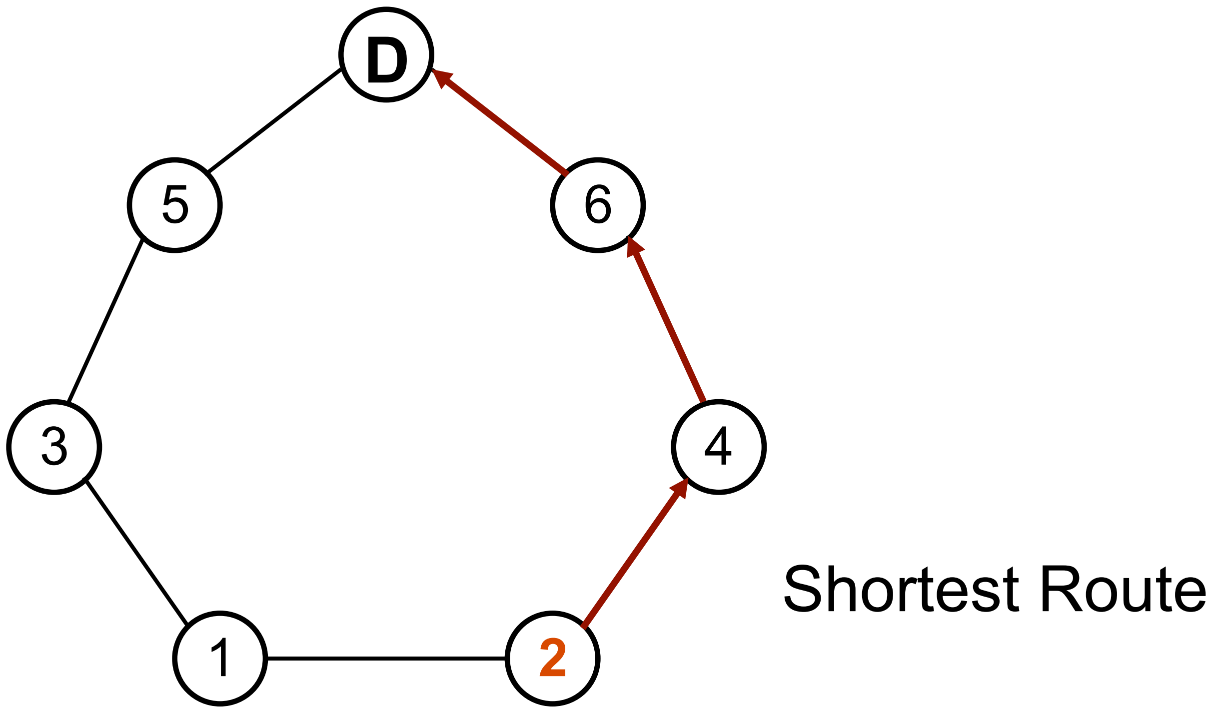

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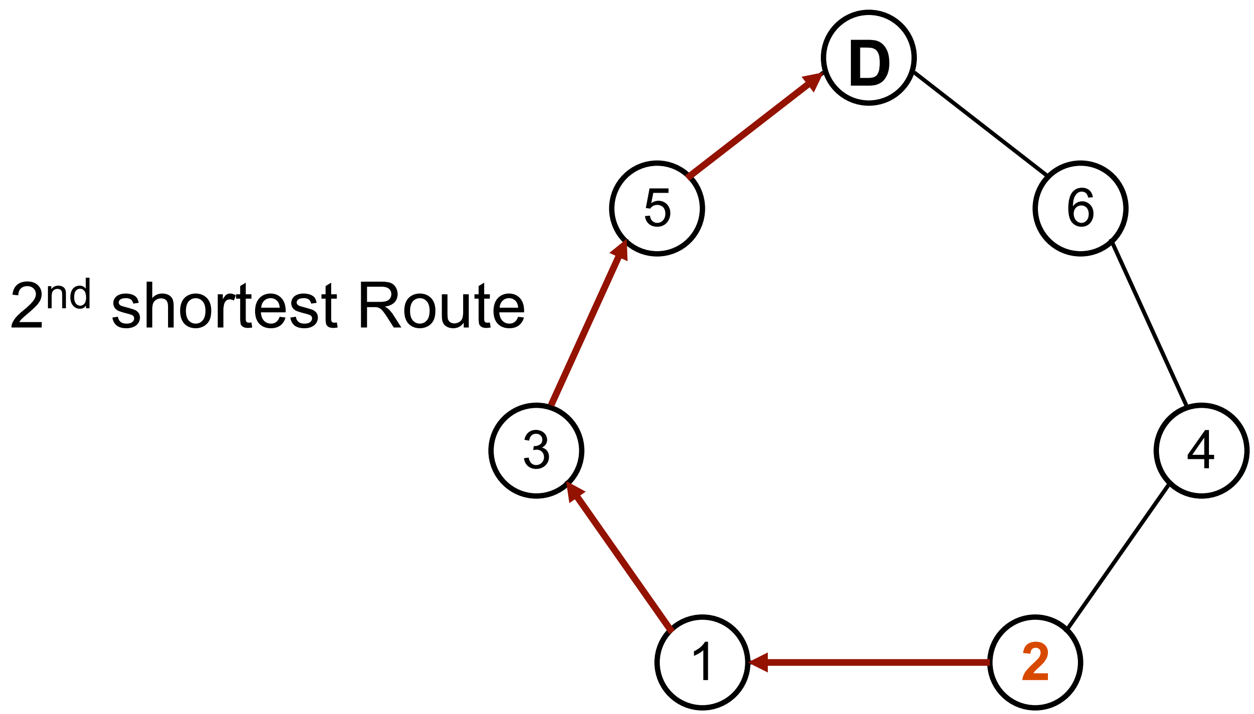

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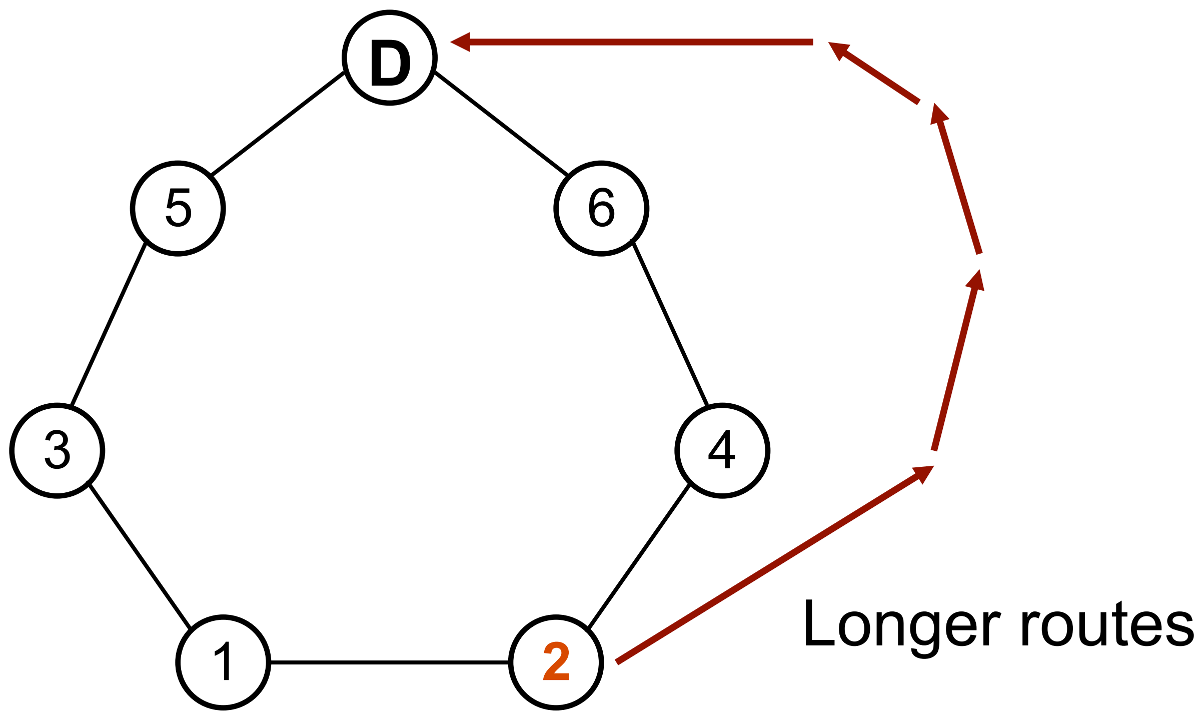

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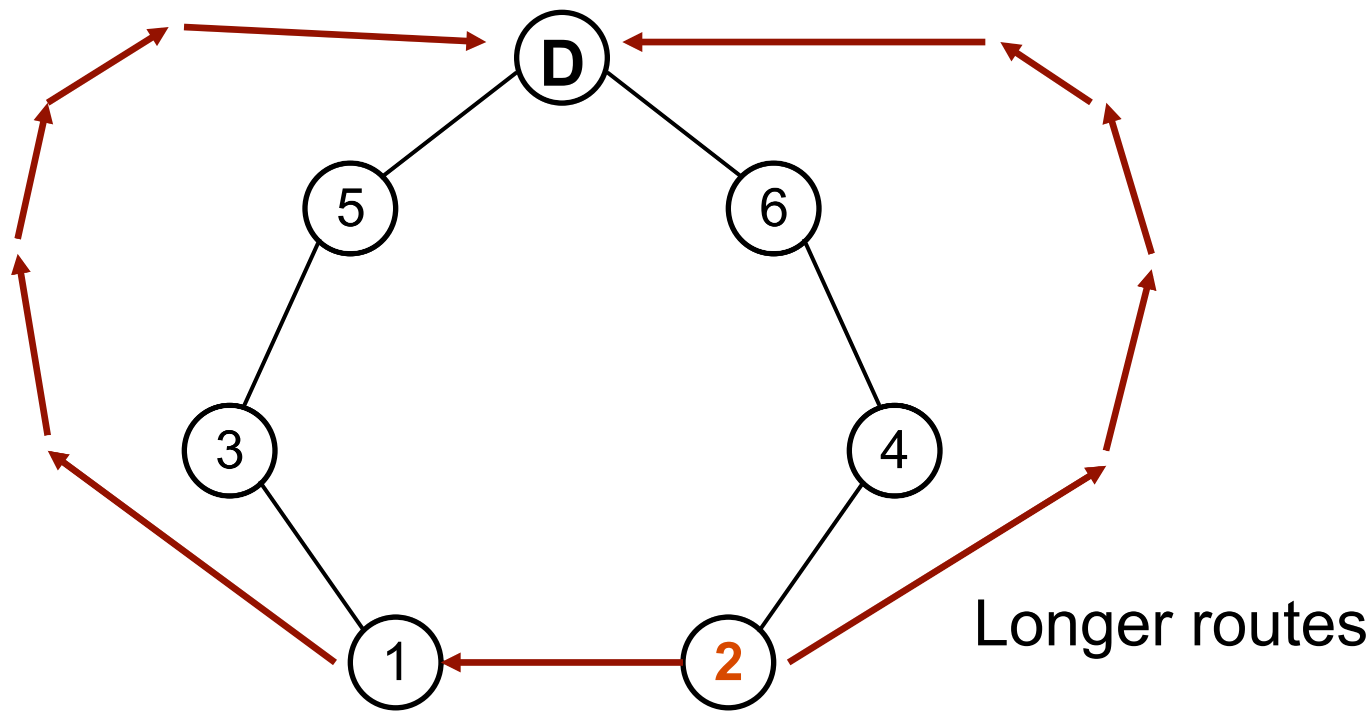

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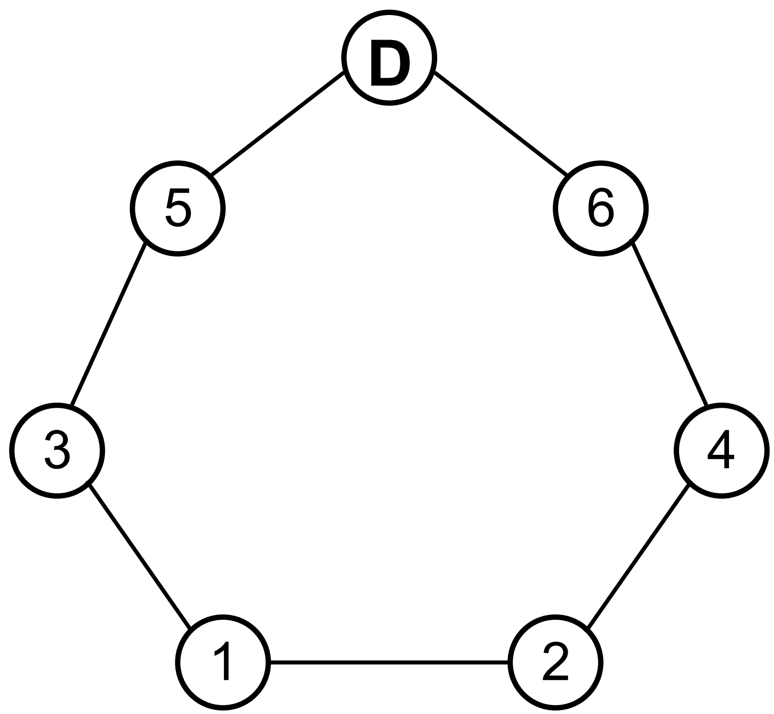

Mechanism of looping

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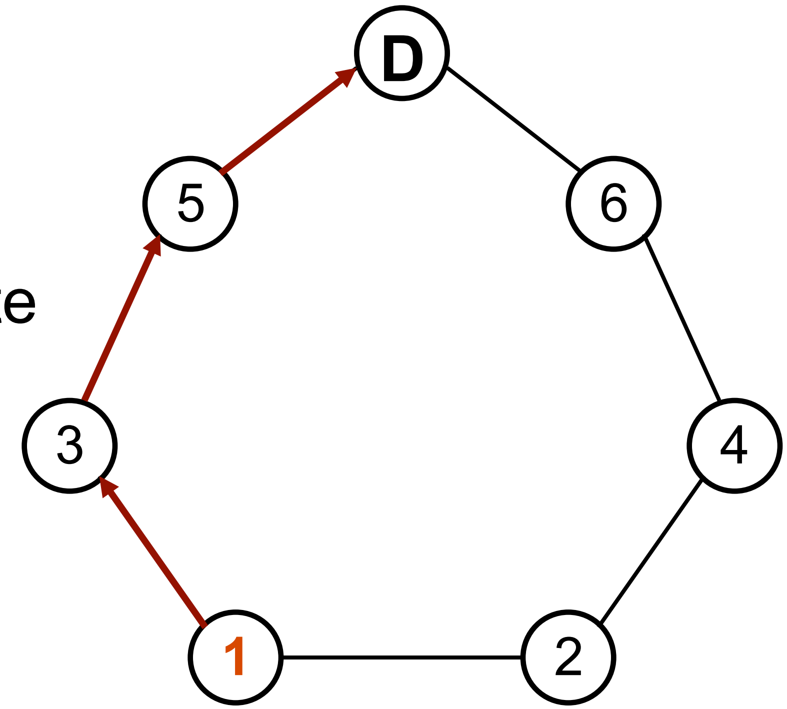
Shortest Route



Mechanism of looping

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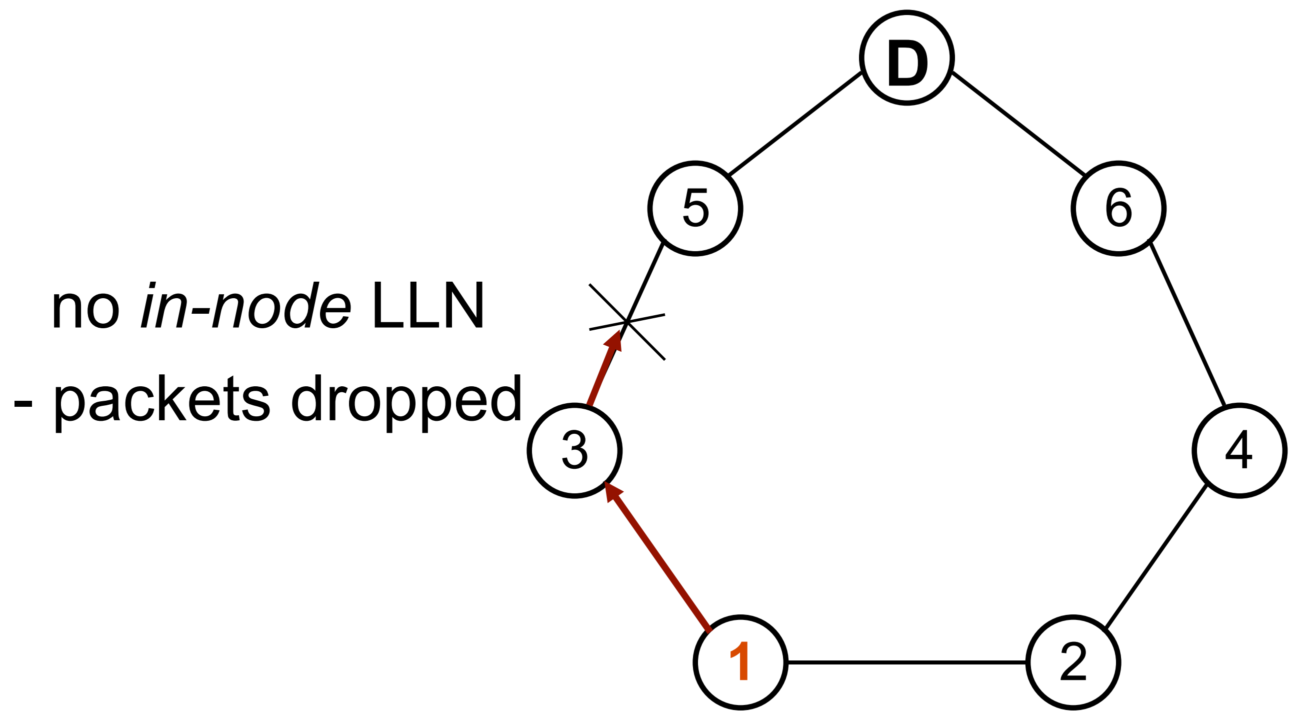
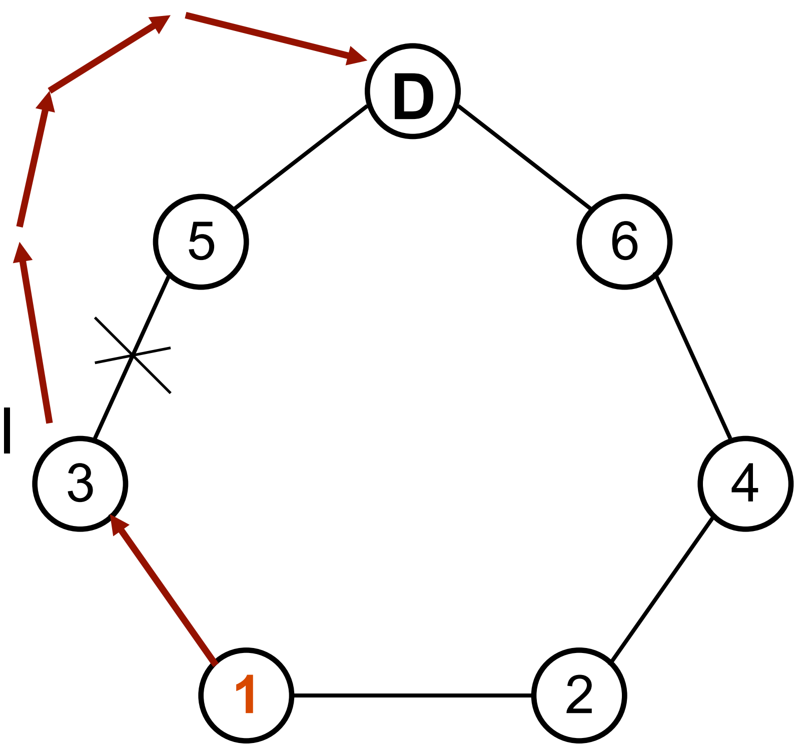


Mechanism of looping

draft-speakman-manet-looping-issue-00

in-node LLN

- routing protocol is notified immediately



Mechanism of looping

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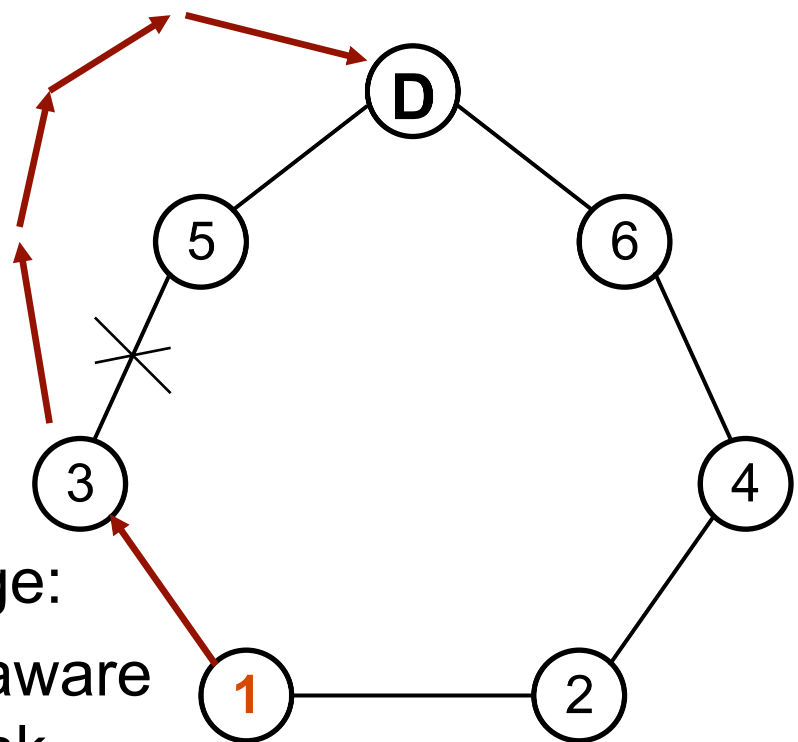


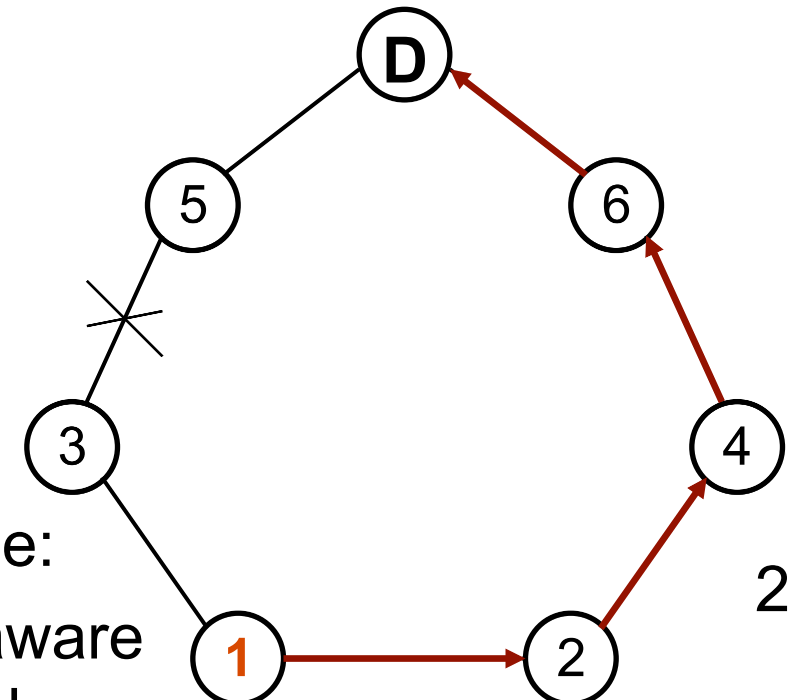
control message:

node 1 becomes aware of 3-5 link break

Mechanism of looping

draft-speakman-manet-looping-issue-00

Partial Network



control message:

node 1 becomes aware of 3-5 link break

2nd shortest Route

Mechanism of looping

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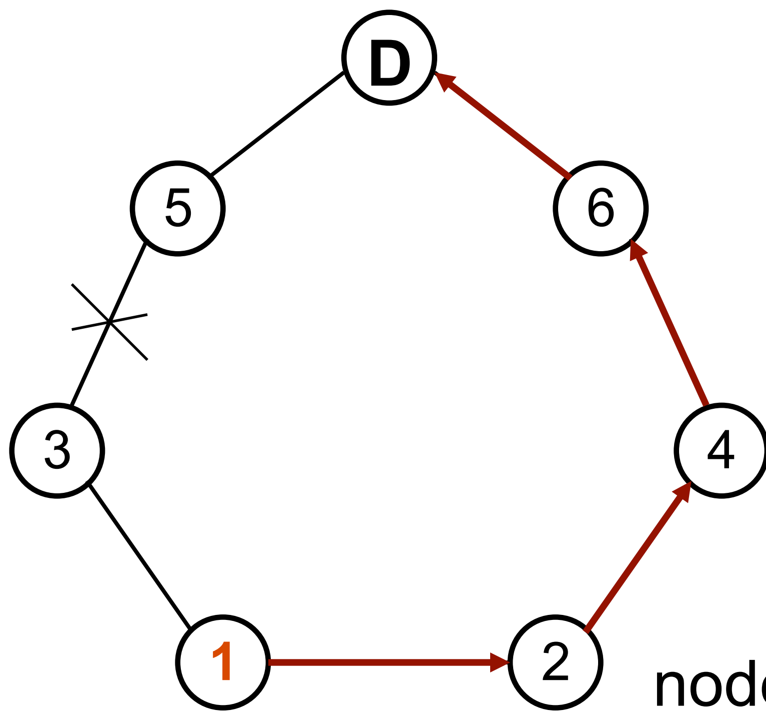
Partial Network



node 2 still unaware of 3-5 non-link

Mechanism of looping

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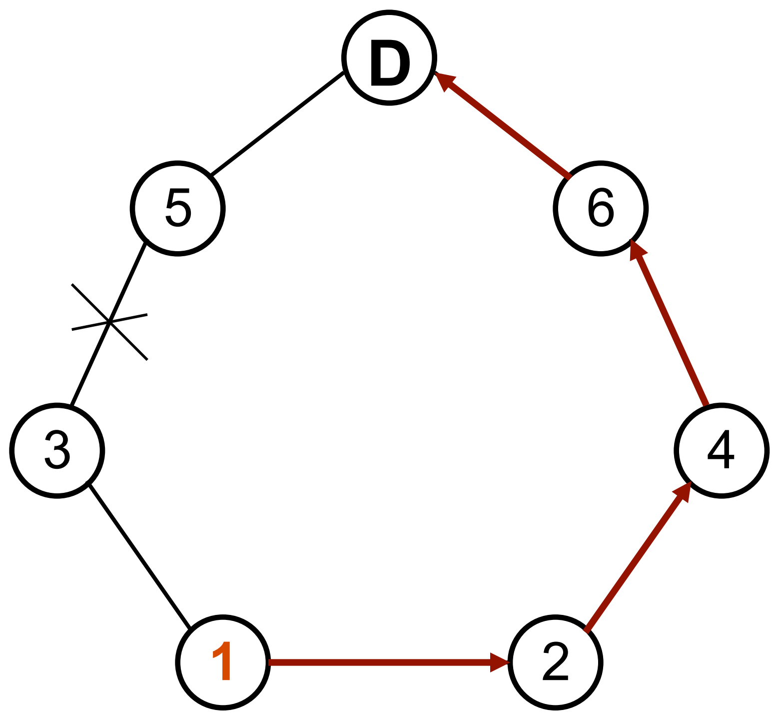
Partial Network



Mechanism of looping

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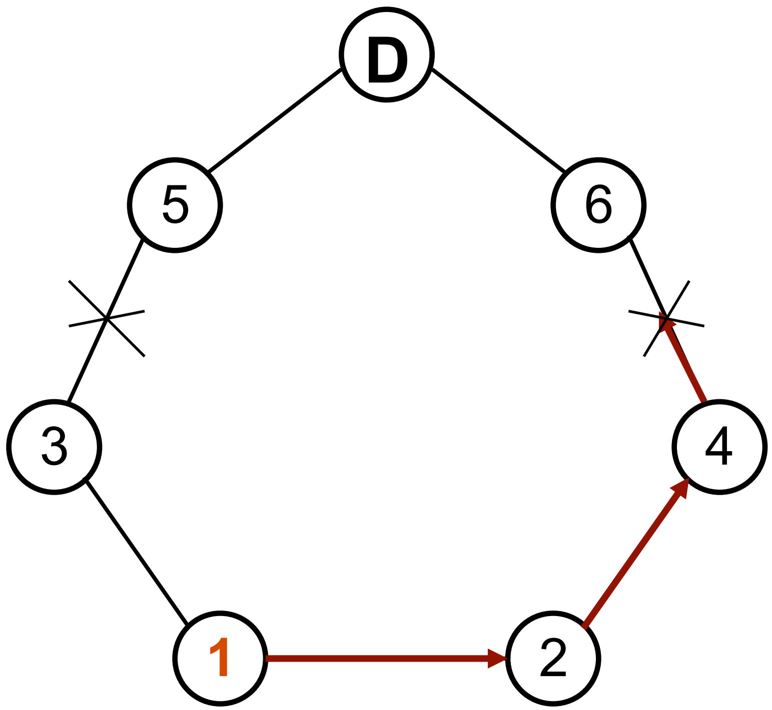
Partial Network



link break

immediate or delayed action

Mechanism of looping

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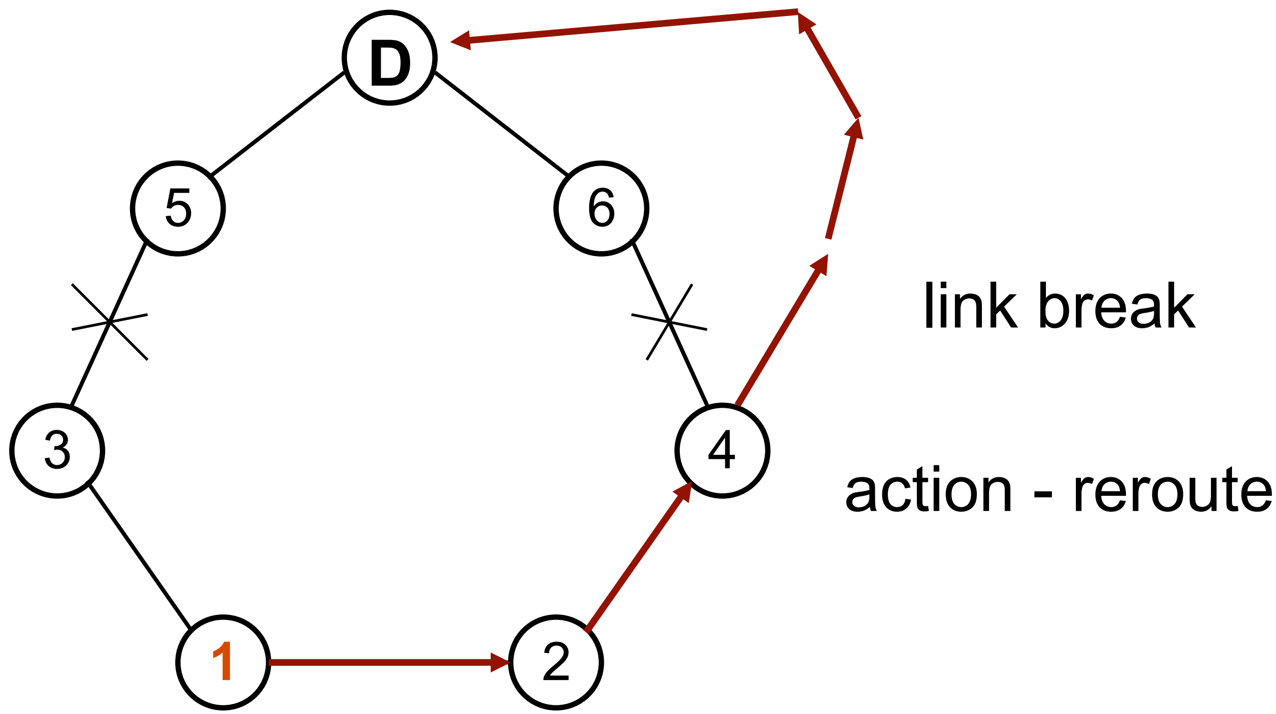
Partial Network



Mechanism of looping

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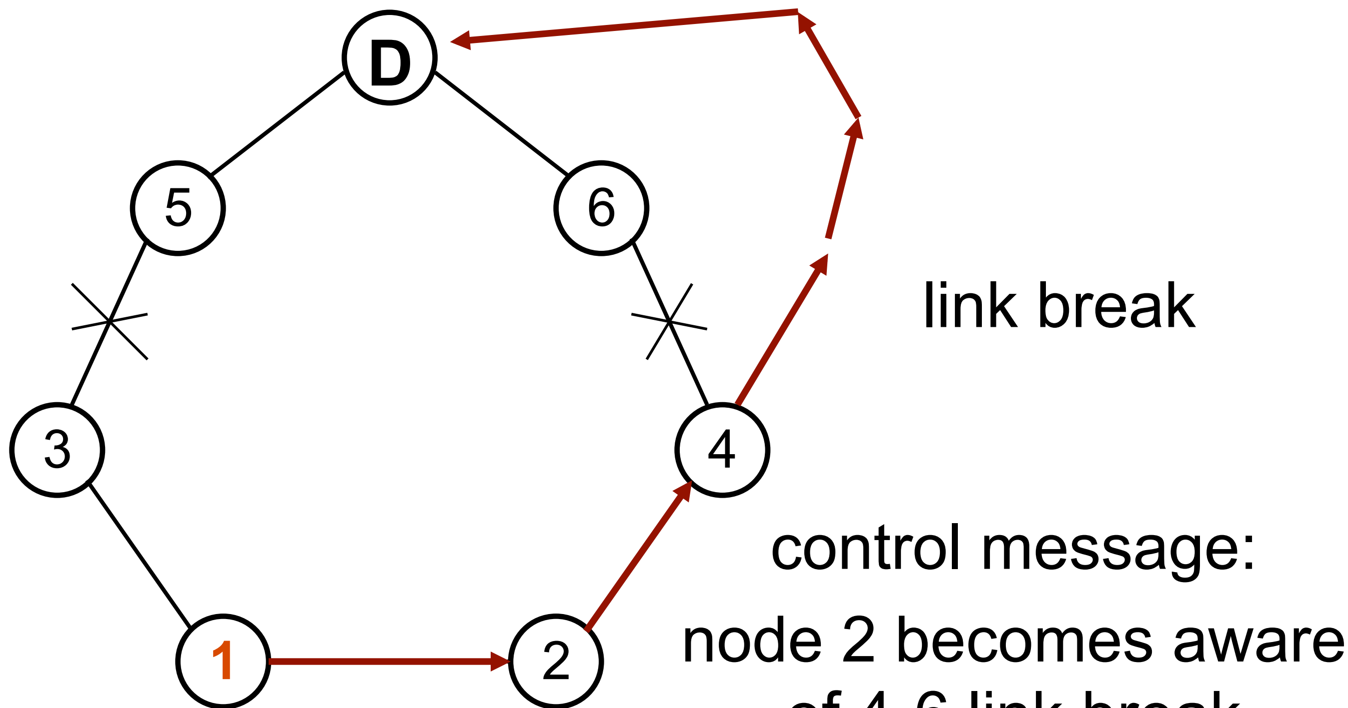

Mechanism of looping

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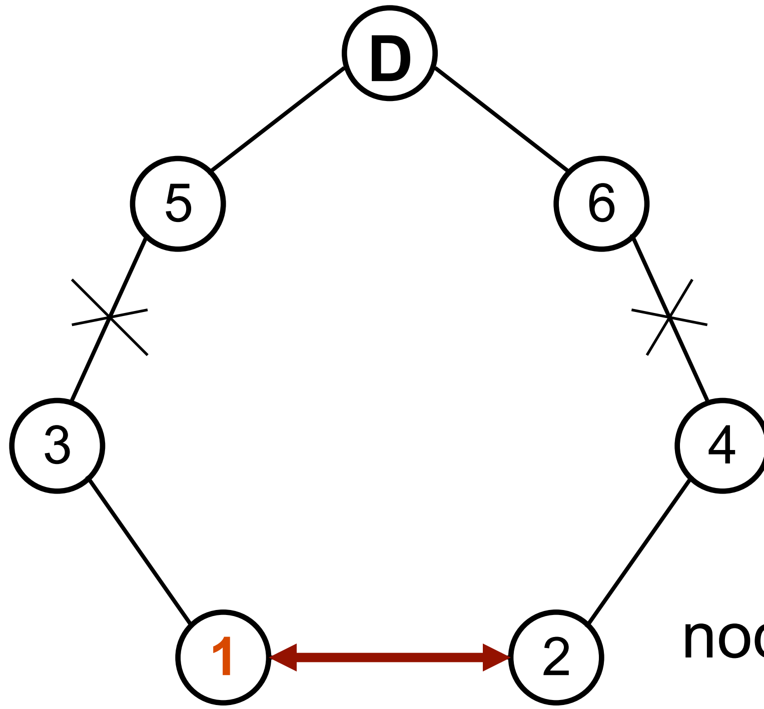

link break

control message:

node 2 becomes aware of 4-6 link break

node 2 chooses next best route

Result: Routing Loop

Mechanism of looping

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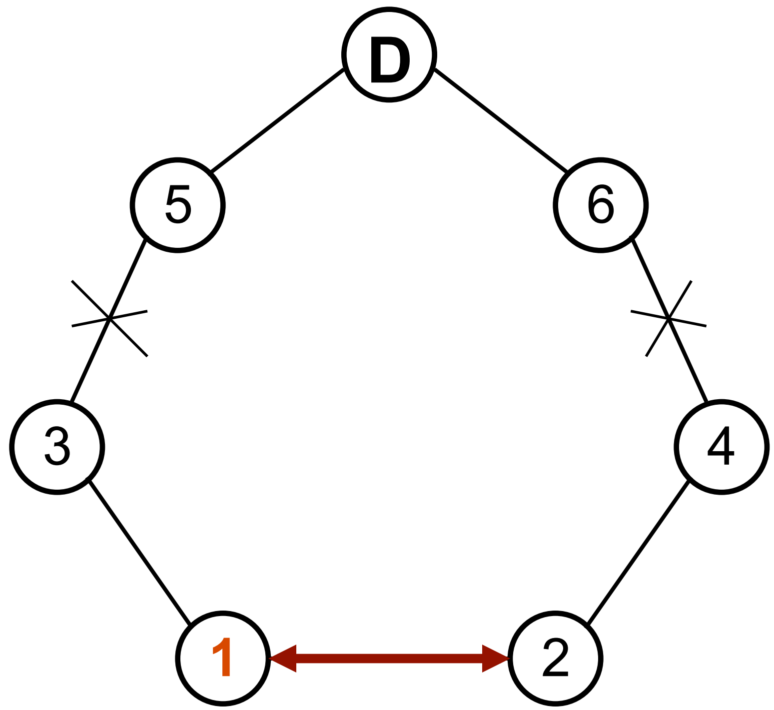
Partial Network



Instant Hello from either node 3 or node 4 (where an *in-node* LLN may have occurred) cannot solve the problem

Looping Issue

Looping packets observed using nOLSRv2* in the Niigata University Testbed and in simulation using Qualnet 4.

Current limitation with extensive data collection on testbed. Simulation results shown.

* nOLSRv2 is the Niigata University implementation of the OLSRv2 protocol for simulation and real-world.

Figure & Table numbers taken Dissertation Submitted to the Graduate School of Engineering and the Committee on Doctoral Program in Information Science and Technology of Niigata University.

Much more extensive results available on request.

Simulation Parameters

Parameter	**Values**
Simulation Suite	Qualnet 4.0
Routing Protocol	nOLSRv2 (Niigata OLSRv2)
Routing Parameters	Default value
Simulation area	1000m x 2000m
Node placement	Random (60 nodes unless specified)
Mobility	Random waypoint (max: 5m/s unless specified)
Applications	CBR (Constant Bit Rate) UDP
Application packet size	512 Bytes
Transmission Interval	0.25s
CBR start–end	120s–720s (±5s randomspread) (600s)
Transport protocol	UDP
Network protocol	IPv4
MAC protocol	IEEE 802.11
Propagation pathloss	Two-ray
PHY-Model&Data-Rate	PHY802.11b 2Mbps
TX-POWER	15.0dBm

Table 4.1.

Transient nature of loops

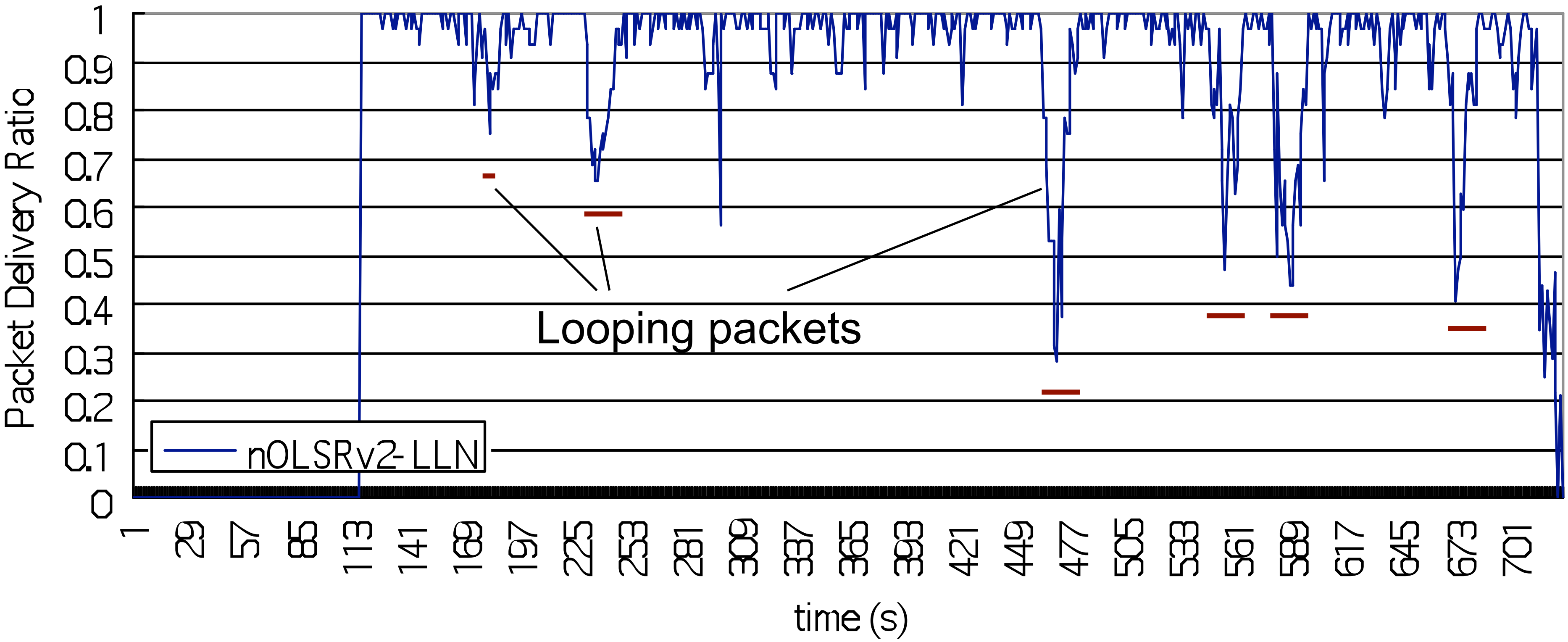


Figure 5.1a. PDR against time.

Transient nature of loops

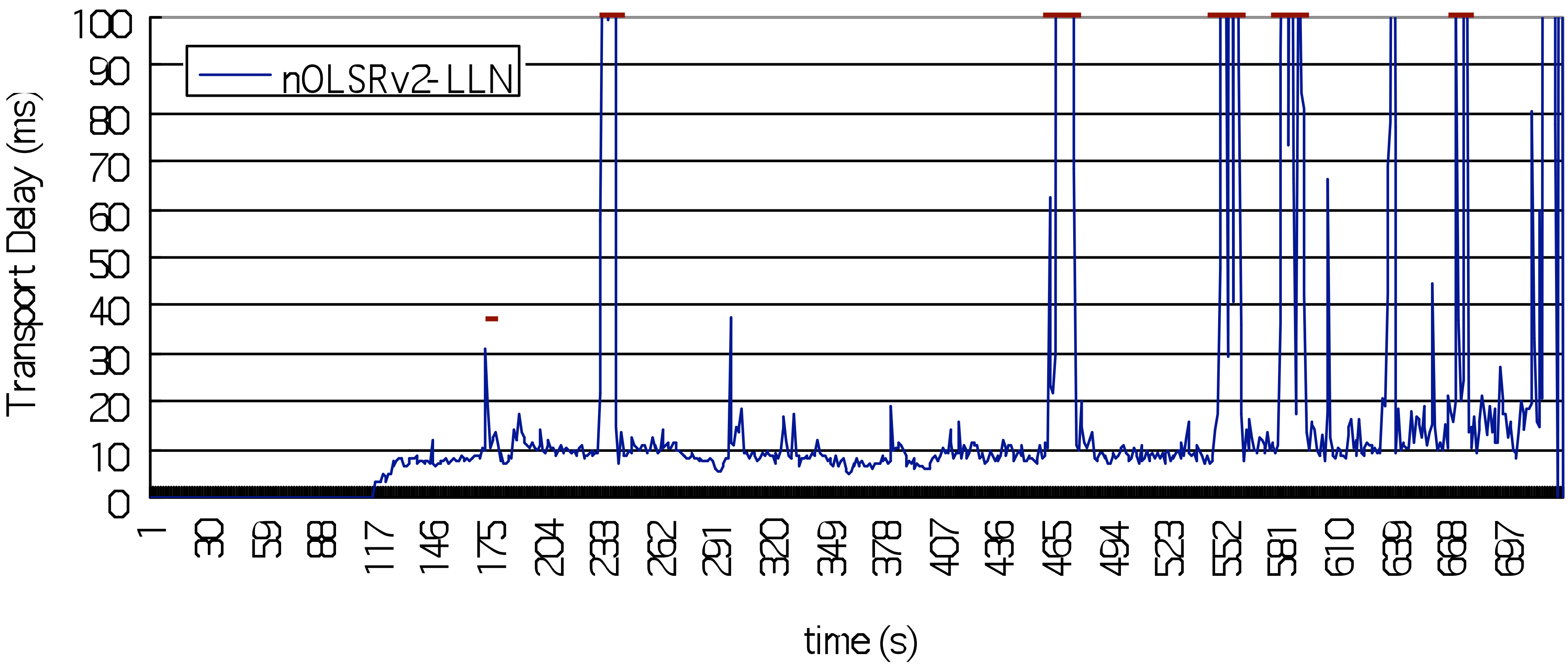


Figure 5.1b. End-to-end delay against time.

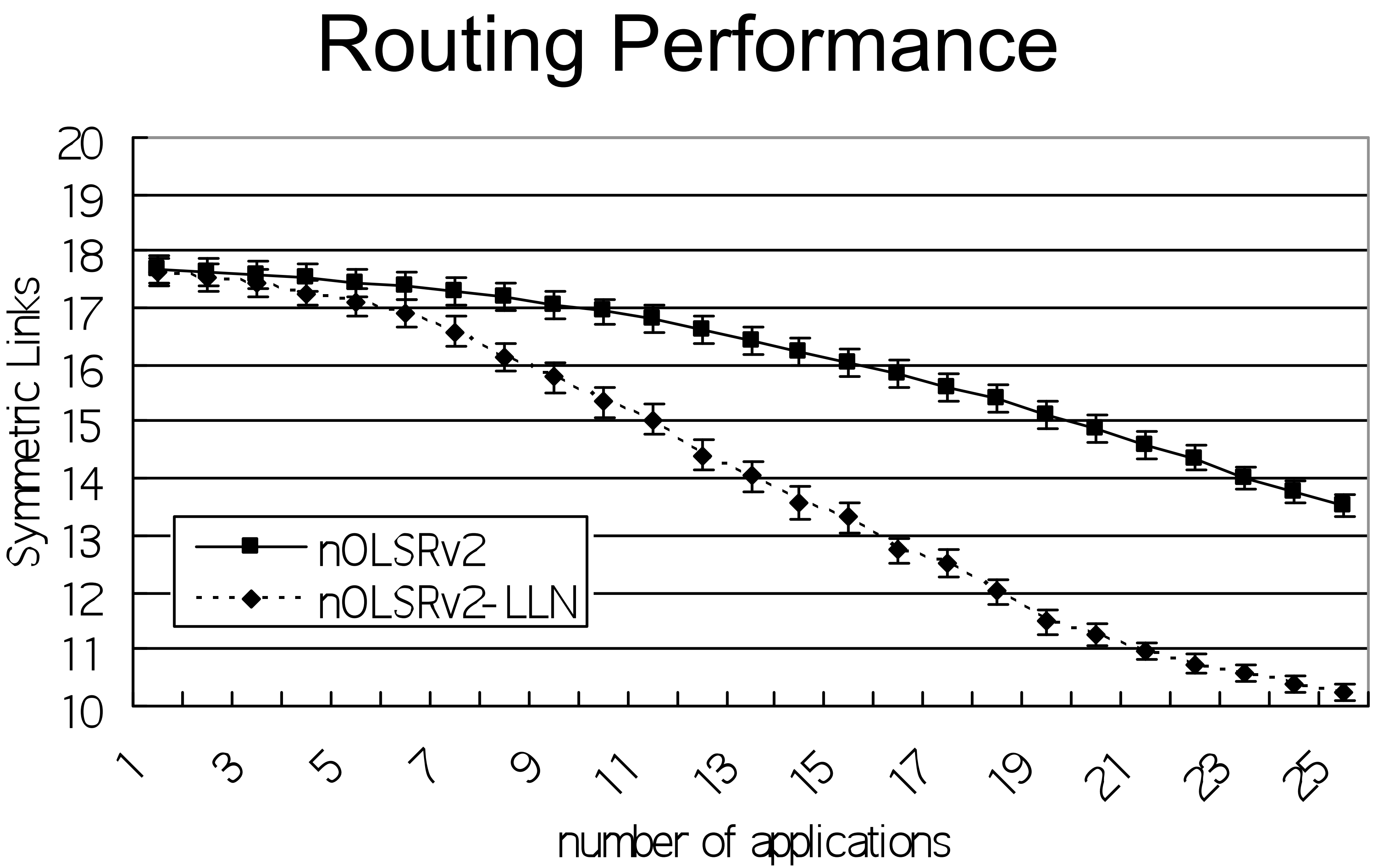


Figure 5.5a. The average number of Symmetric Links.

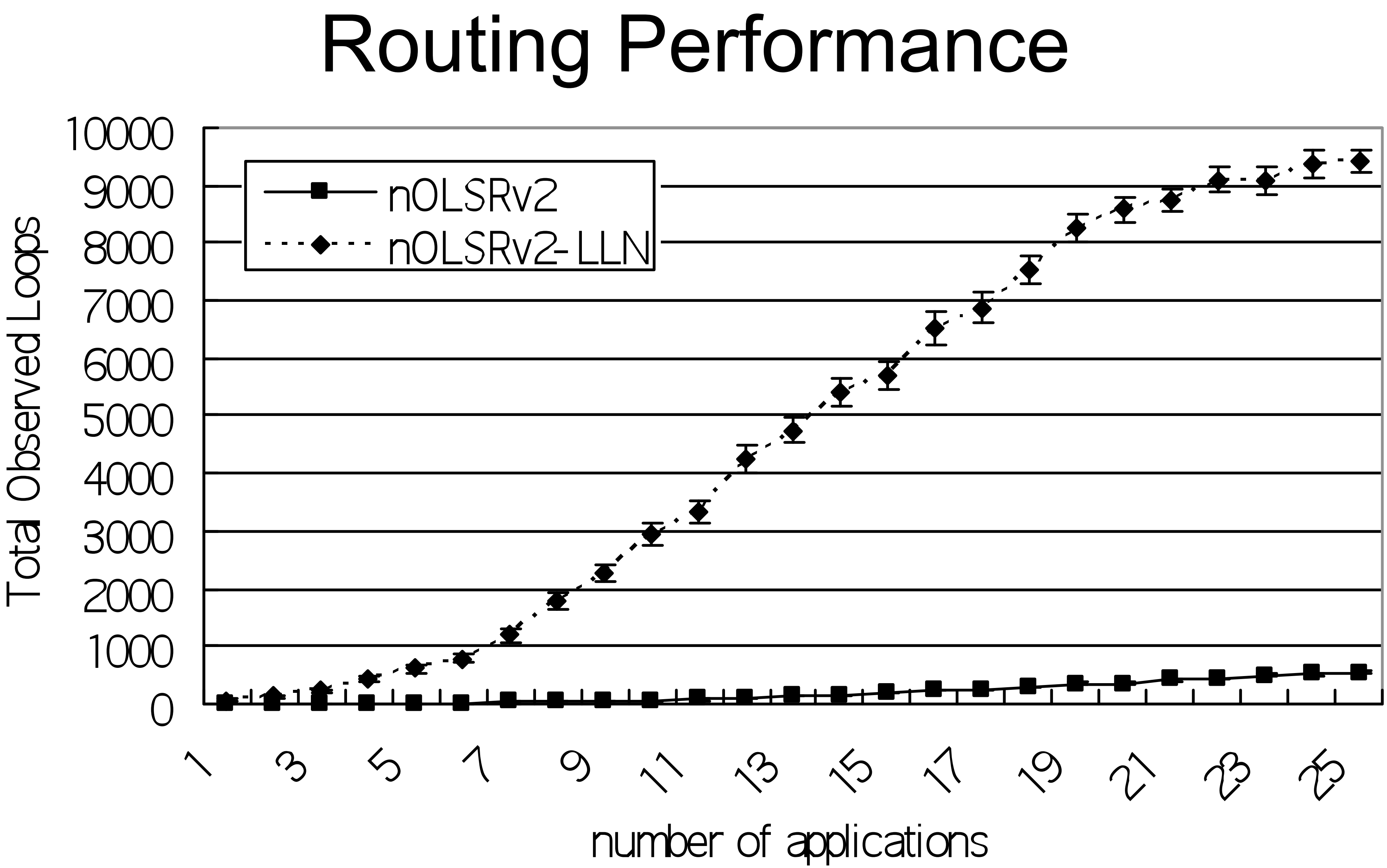


Figure 5.7a. The total number of Observed Loops.

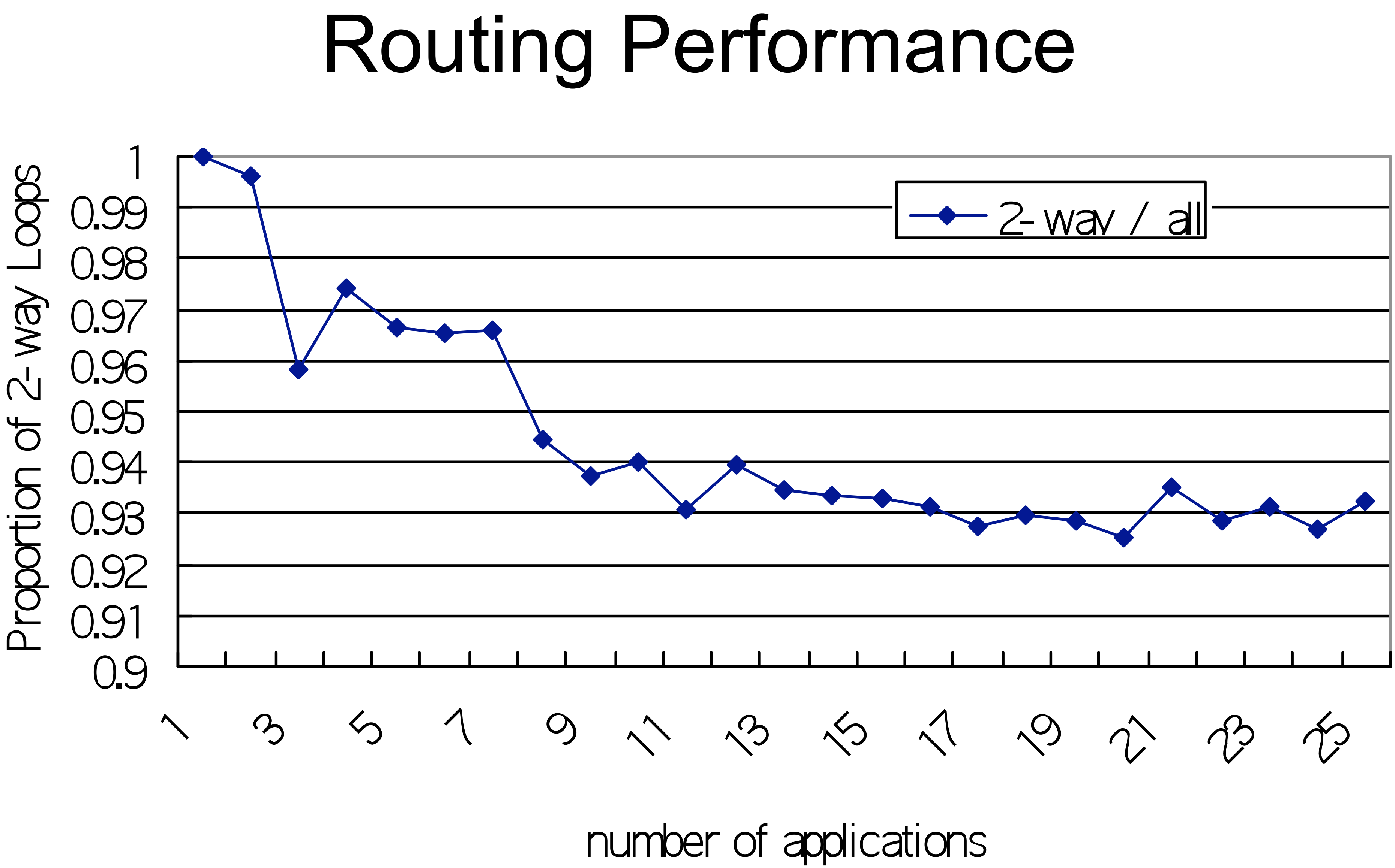


Figure 5.9. The proportion of loops that are 2-way.

(Similar to **Figure 2** in draft-speakman-manet-looping-issue-00)

General Performance

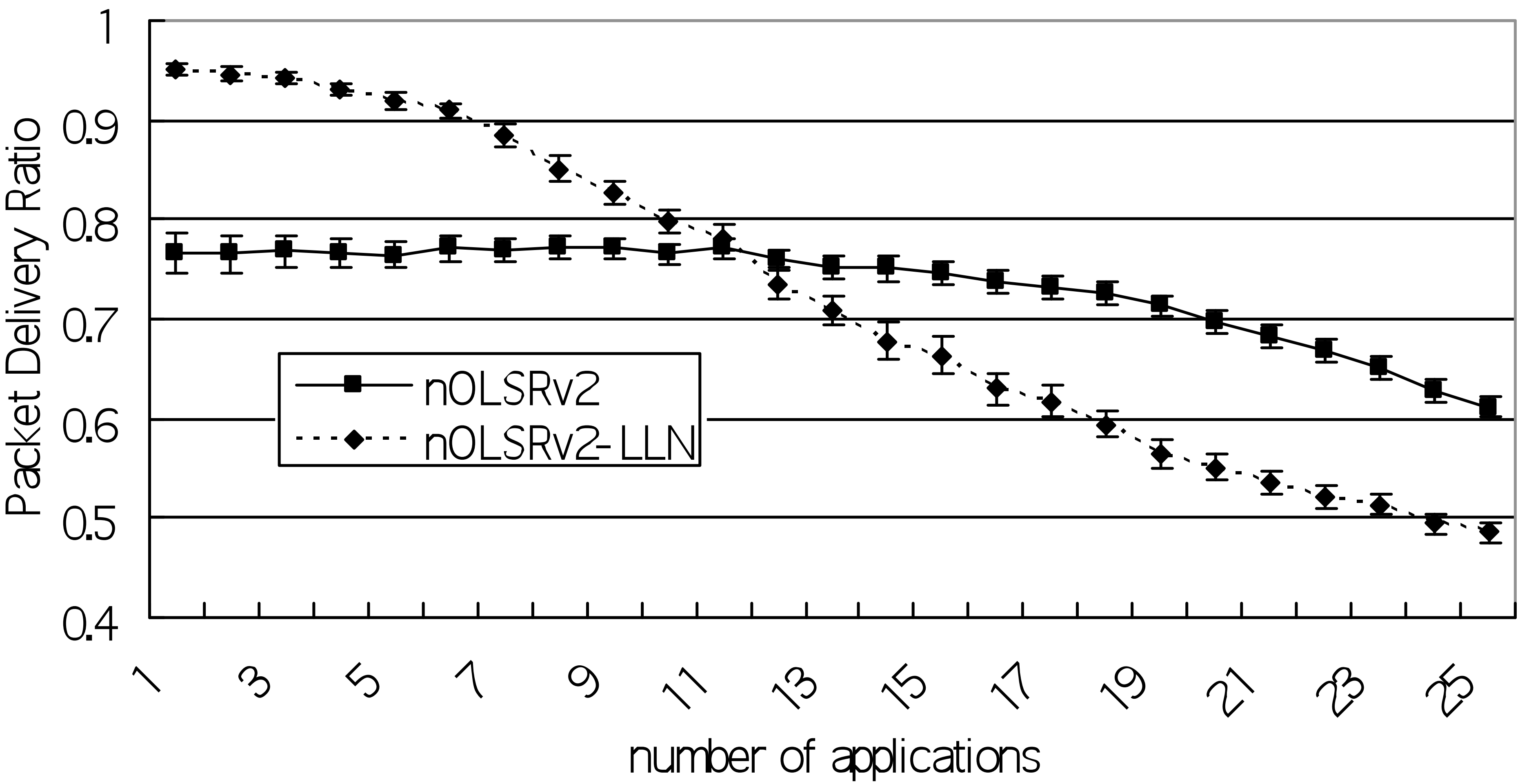


Figure 5.10a. The end-to-end Packet Delivery Ratio.

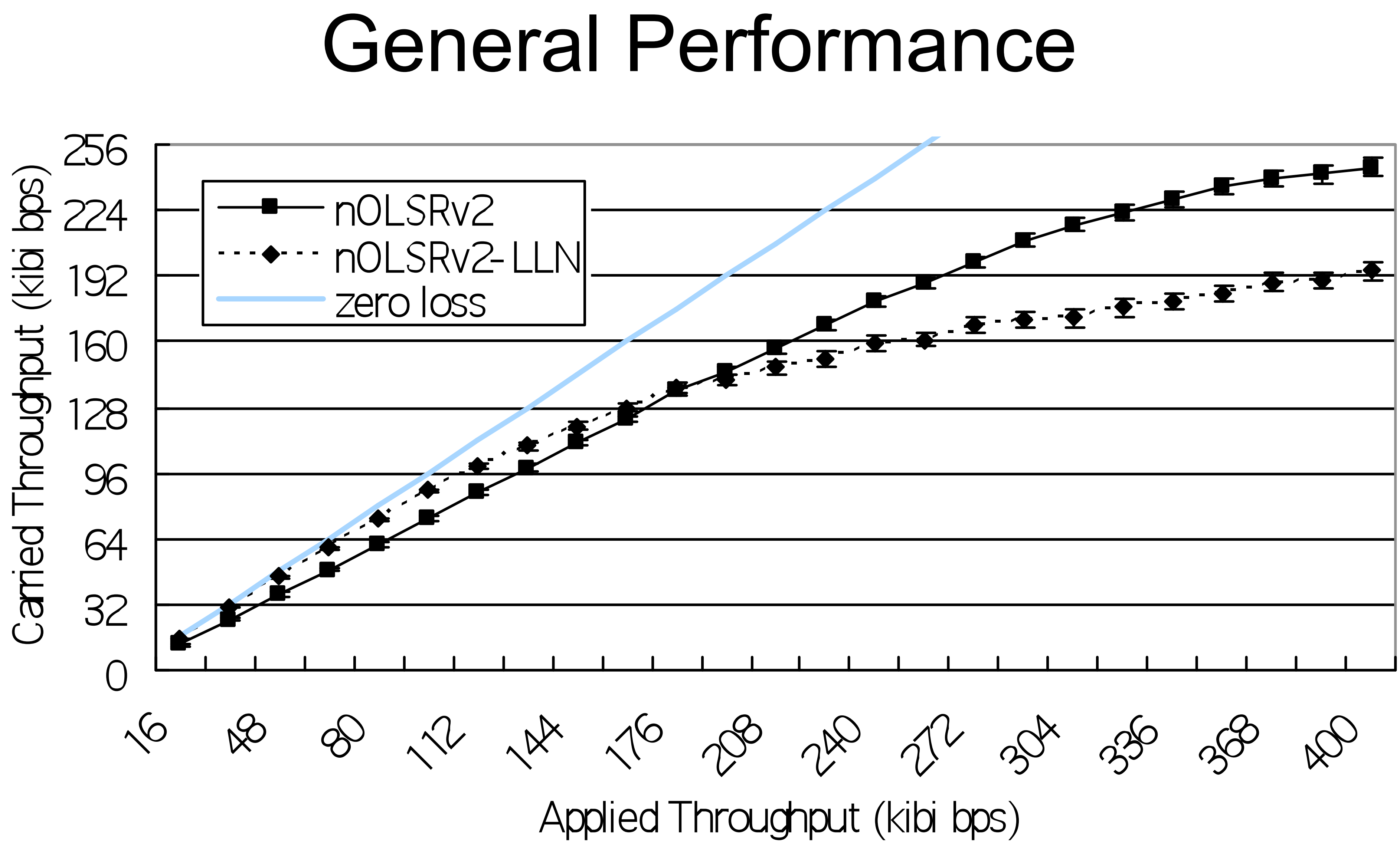


Figure 5.10b. Carried Throughput against applied throughput

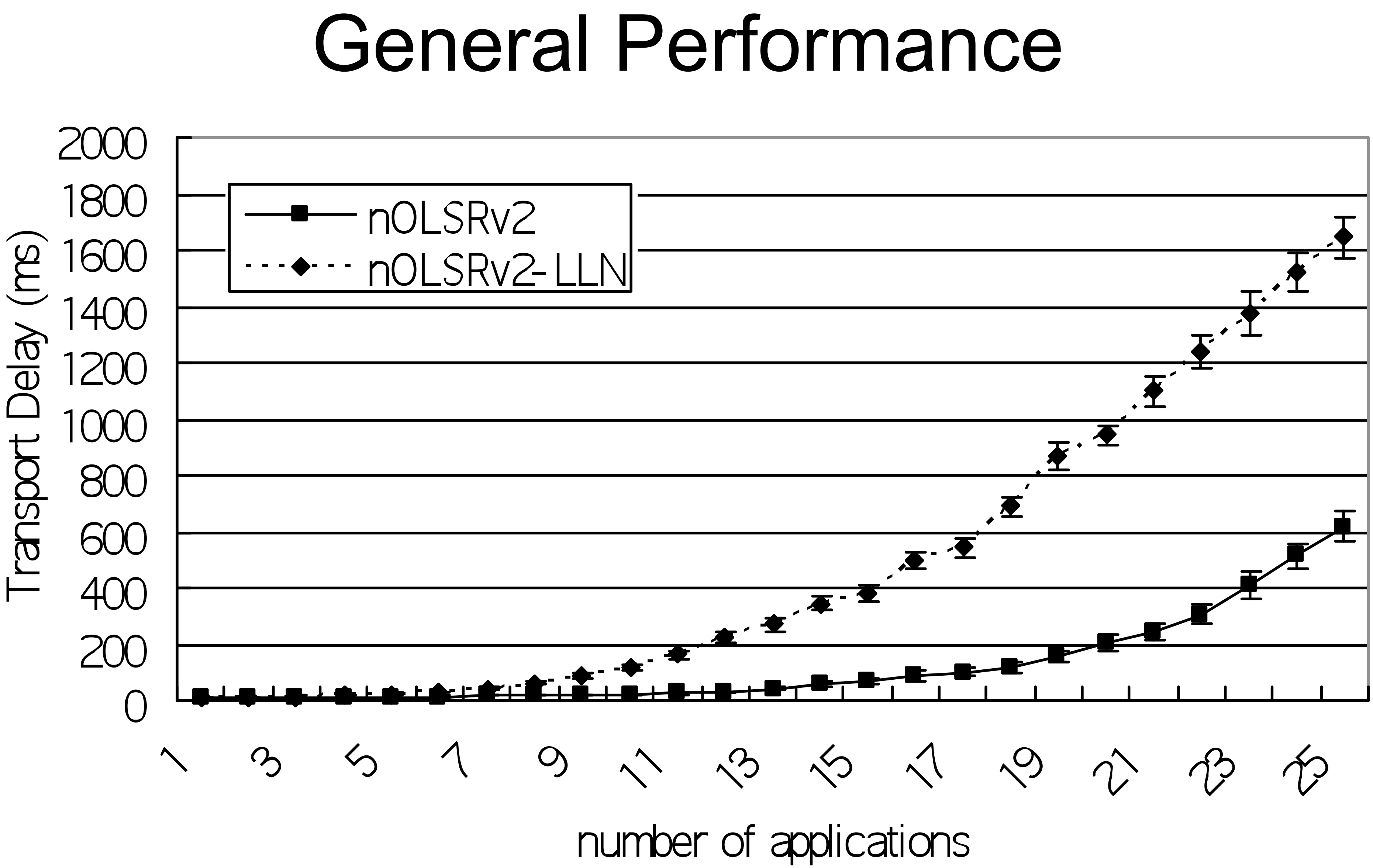


Figure 5.10c. The end-to-end delay in milliseconds.

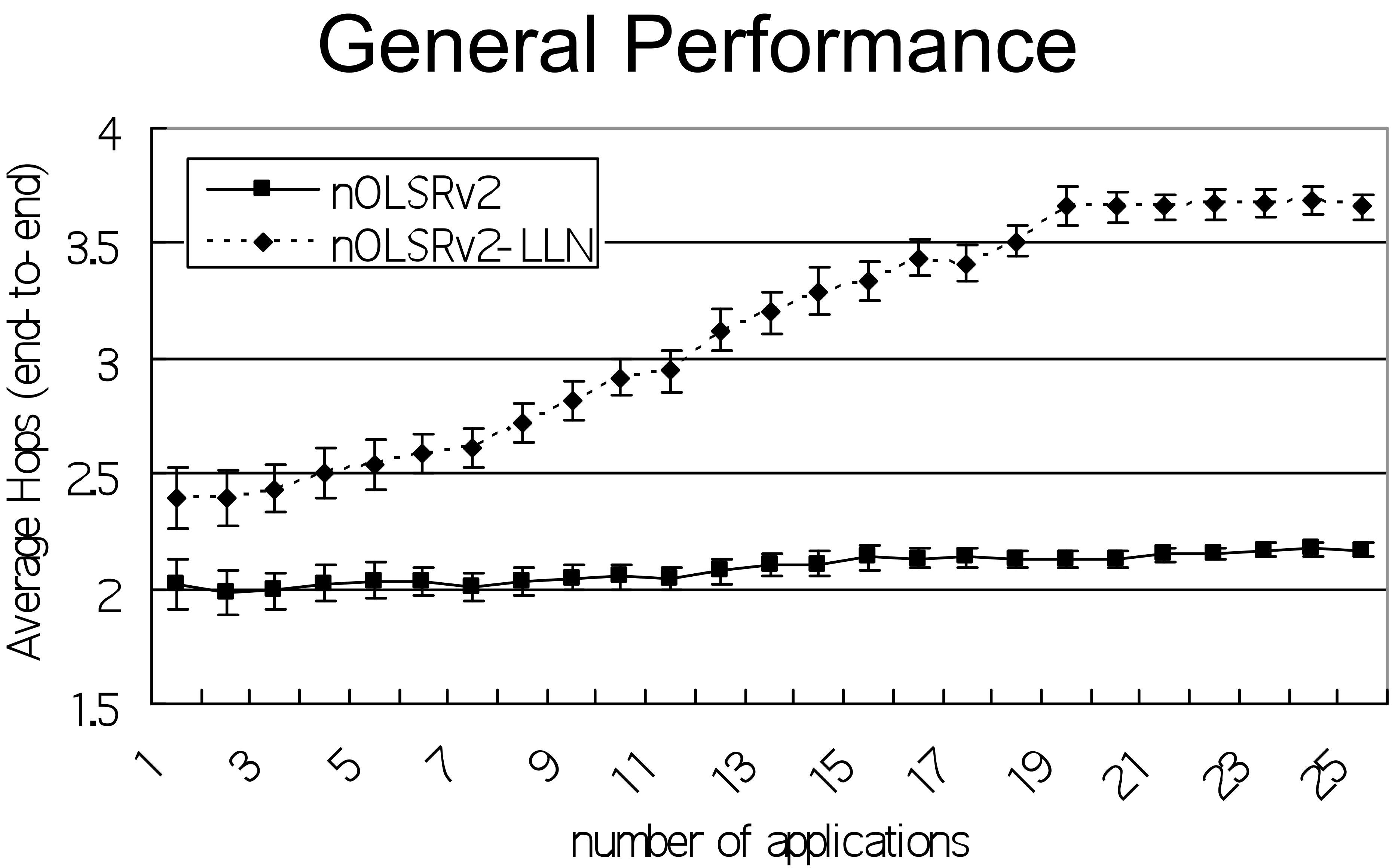


Figure 5.10d. The average number of hops taken end-to-end.

Routing Performance

Comparison of results with a Loop Detection (DPD-based) and Packet Discard mechanism

papers:

L. Speakman, Y. Owada & K. Mase

"Looping in OLSRv2 in Mobile Ad-hoc Networks, Loop Suppression and Loop Correction"

IEICE Trans. Commun. Vol. E92-B, No. 04, Apr. 2009.

L. Speakman, Y. Owada & K. Mase

"An analysis of loop formation in OLSRv2 in ad-hoc networks and limiting its negative impact"

IEEE Communications Society, 2008 CQR Workshop, Apr. 2008.

Routing Performance

Comparison against simple Packet Discard technique on Loop Detection

Method shows effect of looping packets on surrounding medium and traffic in OLSRv2

Simple discard of looping packets may significantly improve performance by discarding those packets unlikely to reach the destination

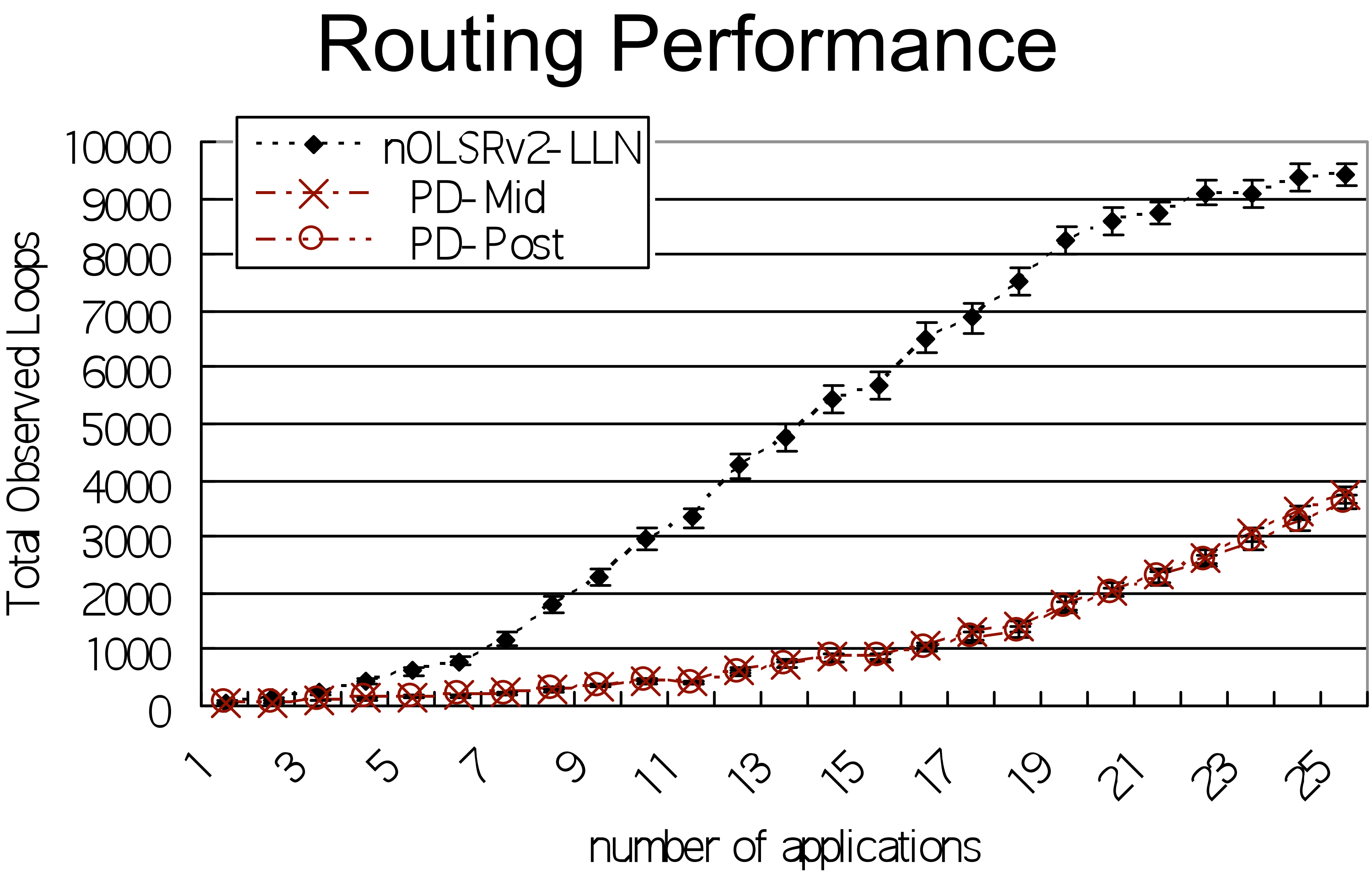


Figure 6.6a. The total number of Observed Loops.

(Same as **Figure 2** in draft-speakman-manet-looping-issue-00)

General Performance

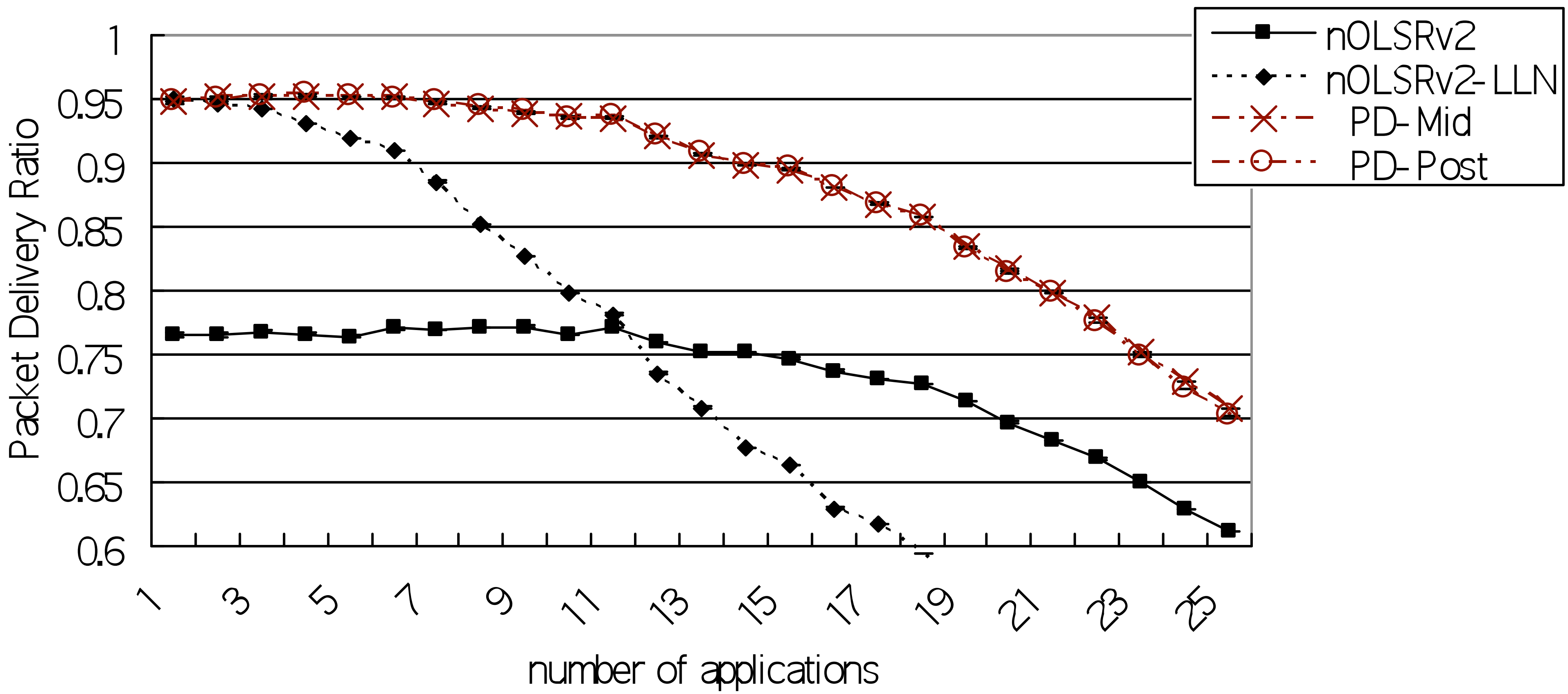


Figure 6.9a. The end-to-end Packet Delivery Ratio.

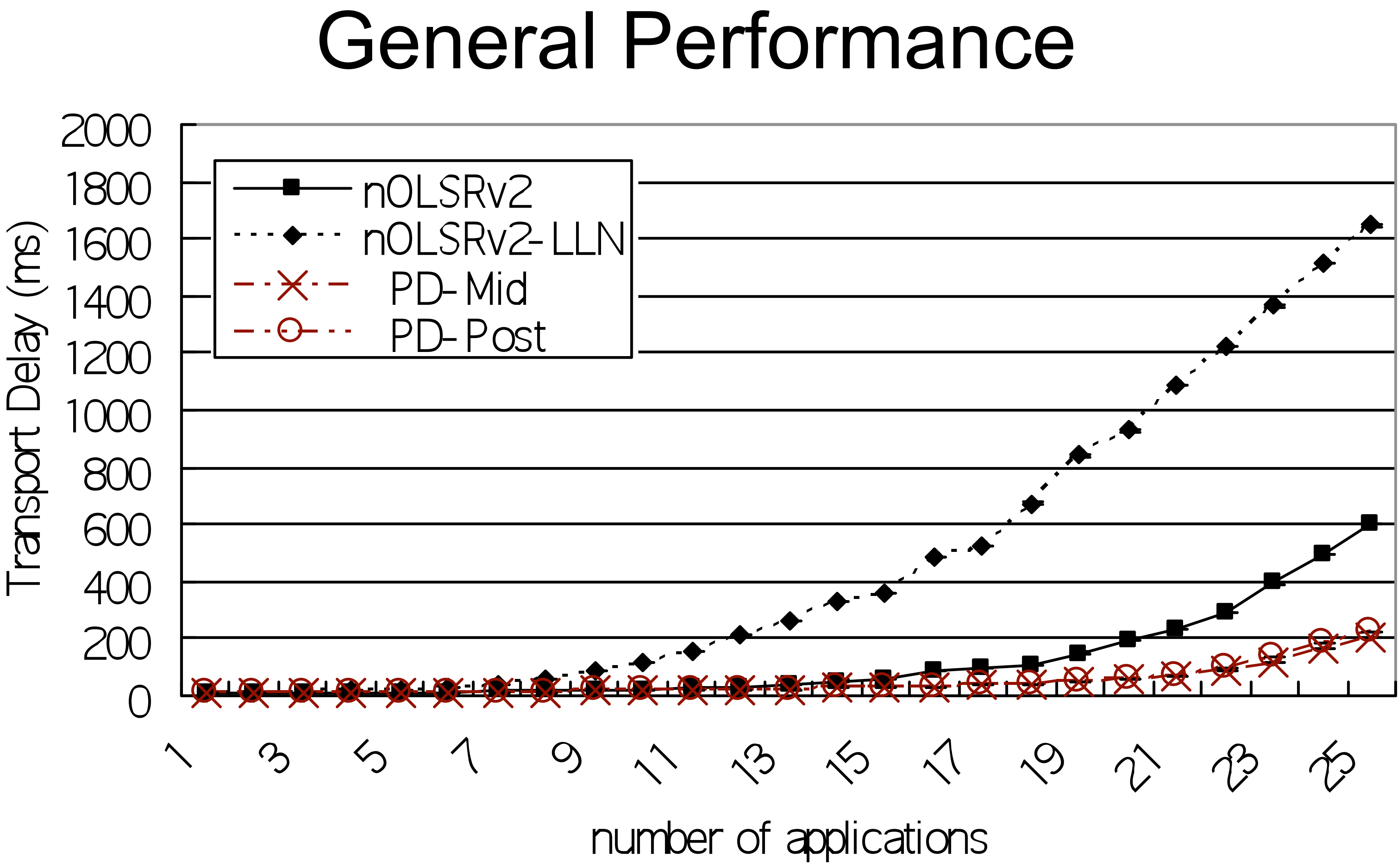


Figure 6.11a. The end-to-end delay in milliseconds.

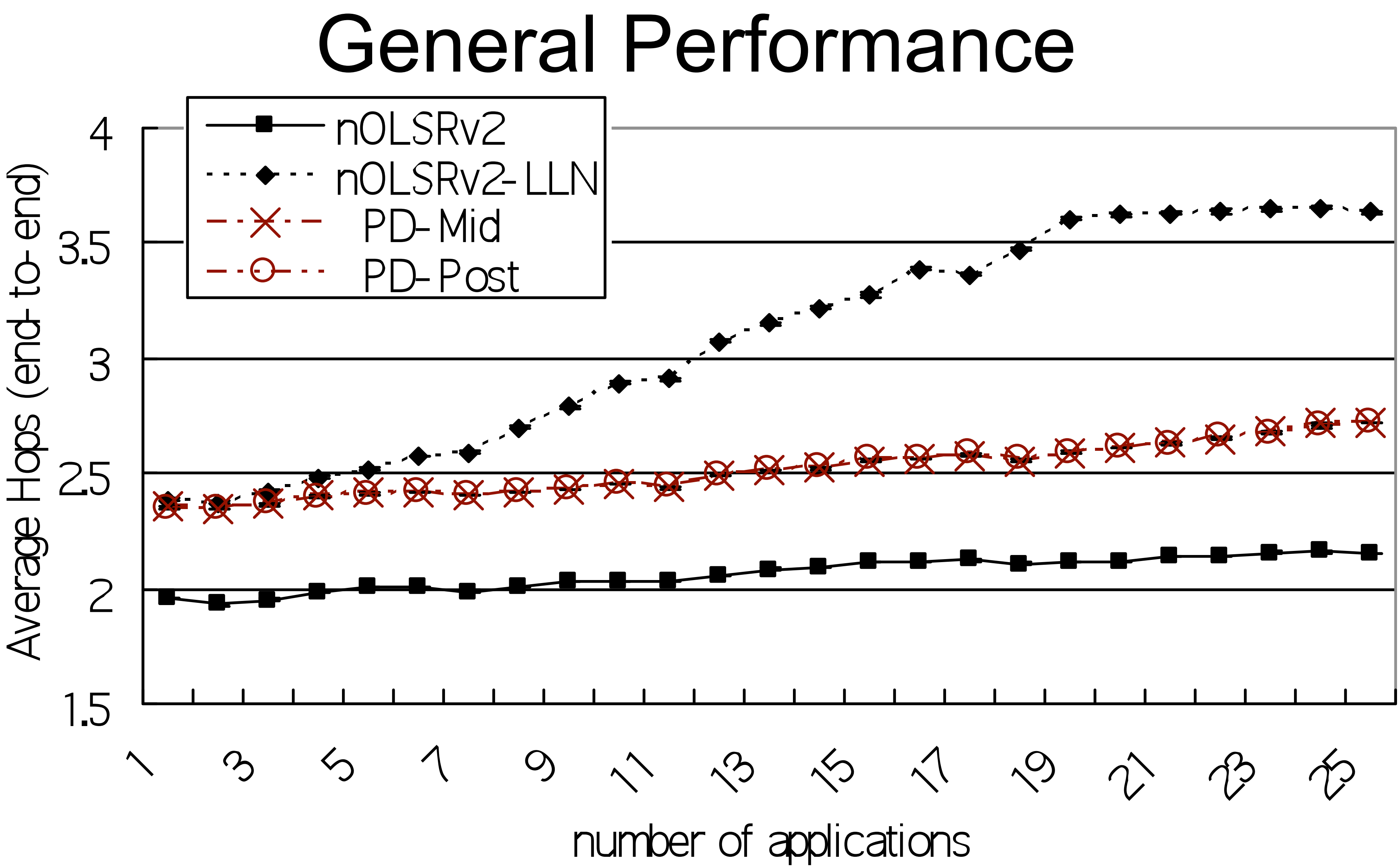


Figure 6.12a. The end-to-end delay in milliseconds.

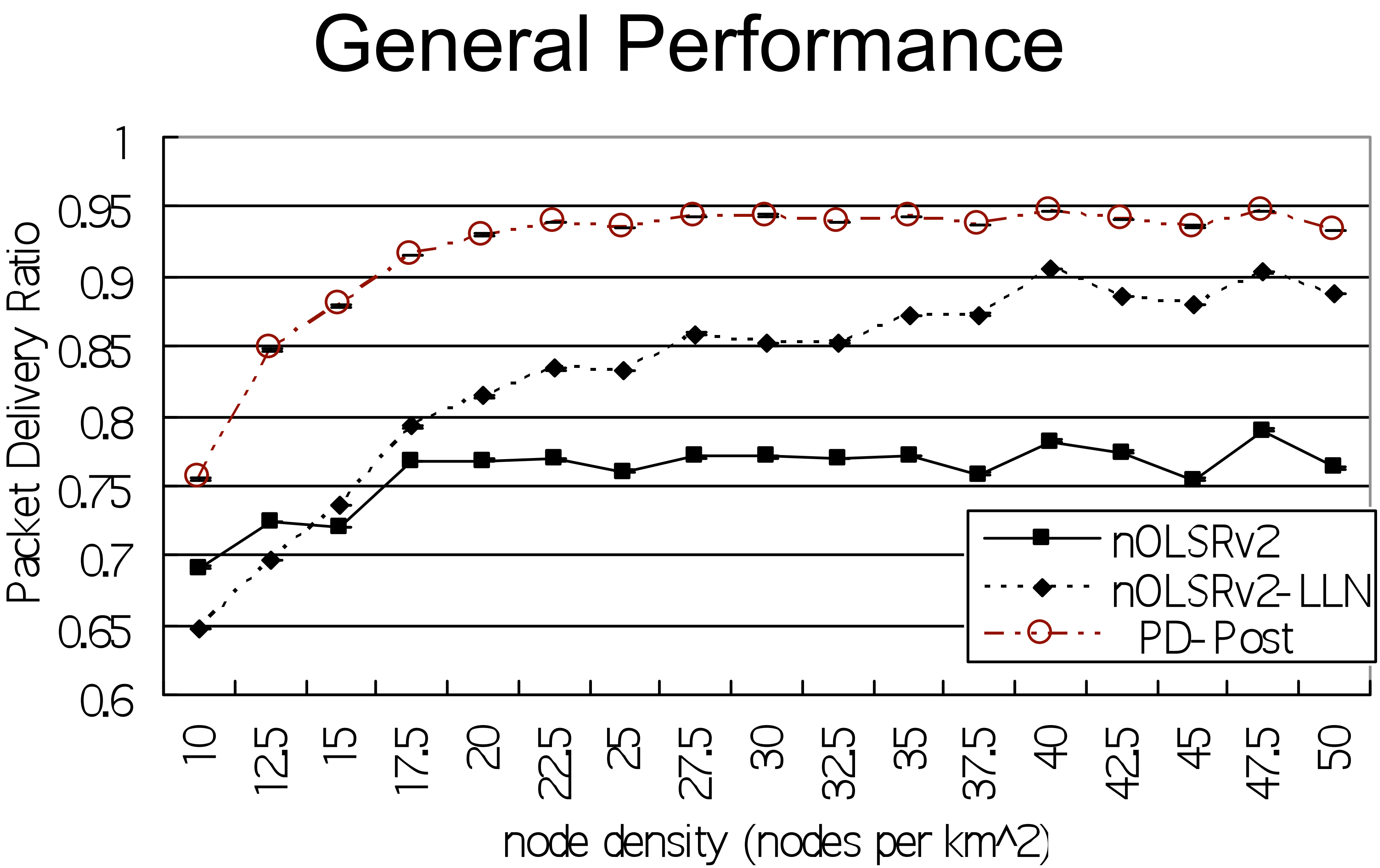


Figure 6.16a. The end-to-end Packet Delivery Ratio N/L-Dens

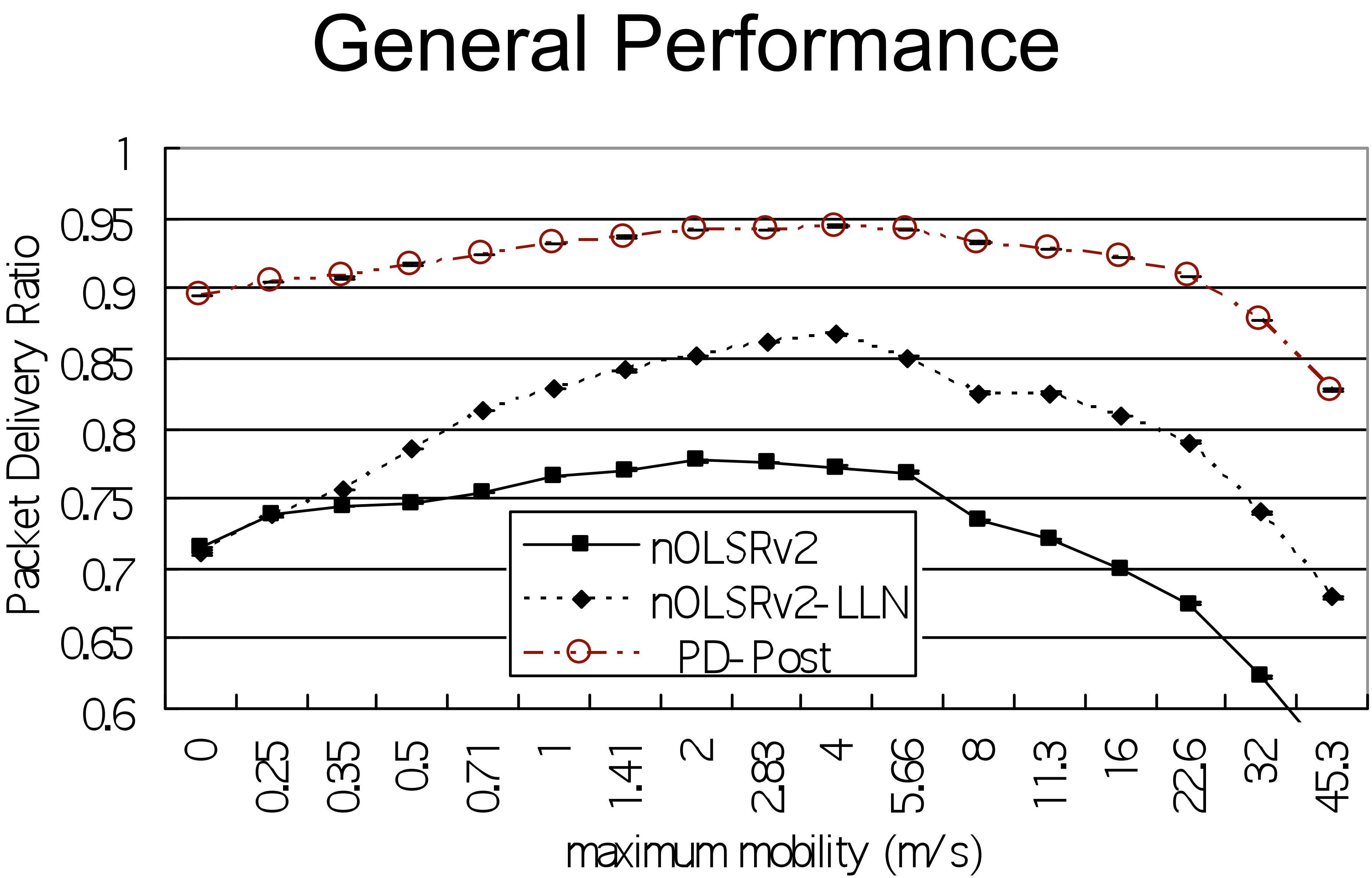


Figure 6.21a. The end-to-end Packet Delivery Ratio.

Mobil

Draft proposal

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