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

Niigata University

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July 2009

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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)”
Routing Loop Issue in Mobile Ad Hoc Networks

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Other comments..?

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end
Routing Loop Issue in Mobile Ad Hoc Networks

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

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Partial Network

2\textsuperscript{nd} shortest Route

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Mechanism of looping

Partial Network

[Diagram of a partial network with nodes labeled D, 1, 2, 3, 4, 5, and 6]

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Mechanism of looping

draft-speakman-manet-looping-issue-00

Shortest Route
Mechanism of looping

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no *in-node* LLN
- packets dropped
Mechanism of looping

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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

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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

Partial Network

link break
immediate or delayed action
Mechanism of looping

Partial Network

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link break
action - reroute
Mechanism of looping

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Partial Network

control message:
node 2 becomes aware of 4-6 link break
Mechanism of looping

draft-speakman-manet-looping-issue-00

Partial Network

node 2 becomes aware of 4-6 link break
control message:

node 2 chooses next best route
Result: Routing Loop
Partial Network

Mechanism of looping

draft-speakman-manet-looping-issue-00

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

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

**Table 4.1.**
Transient nature of loops

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

Transient nature of loops
Figure 5.5a. The average number of Symmetric Links.
Routing Performance

Figure 5.7a. The total number of Observed Loops.
Figure 5.9. The proportion of loops that are 2-way.
Figure 5.10a. The end-to-end Packet Delivery Ratio.

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

L. Speakman, Y. Owada & K. Mase
“An analysis of loop formation in OLSRv2 in ad-hoc networks and limiting its negative impact”
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.
General Performance

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

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

![Graph showing General Performance]

**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

General Performance

Packet Delivery Ratio

node density (nodes per km^2)

nOLSRv2
nOLSRv2-LLN
PD-Post

N/L-Dens
Figure 6.21a. The end-to-end Packet Delivery Ratio.
Draft proposal

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