Performance Analysis of Routing Protocols for Wireless Ad-Hoc Networks

Sukhchandan Lally
Ljiljana Trajković

Communication Networks Laboratory
http://www.ensc.sfu.ca/~ljilja/cnl
School of Engineering Science
Simon Fraser University, Vancouver, British Columbia
Canada
Roadmap

- Ad-Hoc Routing Protocols
- Ad-Hoc On-Demand Distance Vector (AODV) Algorithm
- Dynamic Source Routing (DSR) Algorithm
- Optimized Link State Routing (OLSR) Algorithm
- OPNET Simulated Network Topologies
- Simulation Scenarios
- Simulation Results
- Conclusion
- References
Ad-Hoc Routing Protocols

- Ad-hoc routing protocols control routing packets between computing devices in a mobile ad-hoc network.
- Mobile Ad-hoc Network (MANET) routing protocols can be classified as unicast, multicast, and broadcast.
- The unicast routing protocols can be classified as reactive (on-demand) and proactive (table-driven) based on the method of acquiring information.
Ad-Hoc On Demand Distance Vector Algorithm

- AODV is a reactive routing protocol that is suitable for dynamic self-starting and ad-hoc networks
- AODV defines Route Request (RREQ), Route Reply (RREP), and Route Error (RERR) message types

### AODV Parameters

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route Discovery Parameters</td>
<td>Default</td>
</tr>
<tr>
<td>Active Route Timeout (seconds)</td>
<td>3</td>
</tr>
<tr>
<td>Hello Interval (seconds)</td>
<td>uniform (2, 2.1), uniform (10, 10.1)</td>
</tr>
<tr>
<td>Allowed Hello Loss</td>
<td>2</td>
</tr>
<tr>
<td>Net Diameter</td>
<td>16</td>
</tr>
</tbody>
</table>
Dynamic Source Routing Algorithm

- DSR is an on-demand routing protocol based on the concept of source routing.
- Each routed packet carries in its header a complete and ordered list of nodes.
- The protocol consists of two major phases: route discovery and route maintenance.
- The route maintenance mechanism uses RERR packets and acknowledgments.

DSR Parameters

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route Cache Parameters</td>
<td>(...)</td>
</tr>
<tr>
<td>Max Cached Routes</td>
<td>Infinity</td>
</tr>
<tr>
<td>Route Expired Timer (seconds)</td>
<td>60 300</td>
</tr>
<tr>
<td>Route Cache Export</td>
<td>Do Not Export</td>
</tr>
<tr>
<td>Send Buffer Parameters</td>
<td>Default</td>
</tr>
<tr>
<td>Request Discovery Parameters</td>
<td>(...)</td>
</tr>
<tr>
<td>Request Table Size (nodes)</td>
<td>16</td>
</tr>
<tr>
<td>Maximum Request Table Identifier</td>
<td>16</td>
</tr>
<tr>
<td>Maximum Request Retransmission</td>
<td>16</td>
</tr>
</tbody>
</table>
Optimized Link State Routing Algorithm

- OLSR is a proactive routing protocol
- OLSR does not require reliable control message delivery and can sustain reasonable loss of control messages
- OLSR uses Topology Control (TC) messages to provide sufficient link state information

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness Default</td>
<td></td>
</tr>
<tr>
<td>Hello Interval (seconds)</td>
<td>2, 10, 2, 10</td>
</tr>
<tr>
<td>TC Interval (seconds)</td>
<td>5, 5, 25, 25</td>
</tr>
<tr>
<td>Neighbor Hold Time (seconds)</td>
<td>6.0</td>
</tr>
<tr>
<td>Topology Hold Time (seconds)</td>
<td>15.0</td>
</tr>
<tr>
<td>Duplicate Message Hold Time (seconds)</td>
<td>30.0</td>
</tr>
</tbody>
</table>
OPNET Simulated Network Topologies

- OPNET models for an ad-hoc network in a highly dynamic environment with UDP and TCP connection scenarios were created.
- The routing protocol and mobility differ in each scenario.
- Each scenario consists of 16 wireless local area network (WLAN) nodes.
OPNET Simulated Network Topologies

- Each node covers an area of approximately 675 m
- Each node can only see its neighboring nodes because the distance between neighboring nodes is approximately 500 m

TCP connection scenario
Simulation Scenarios

- Simulation tool: OPNET Modeler 16.0.A
- The first scenario: a static scenario used to compare its performance with other scenarios
- The second scenario: some nodes move with very low speed comparable to human walk (1 m/s)
- The third scenario: included are high-speed nodes that move with maximum speed equal to the speed of cars in a city (50 km/h)
- For each scenario, we consider two types of connections (UDP and TCP) and three ad-hoc routing protocols
OPNET Model of UDP Connection

- UDP connection scenarios: a two-hour interval of the Matrix III movie trace was streamed
- We created 24 simulation scenarios for UDP connection
- The faster the nodes find a route, the faster they may send the video, which causes smaller end-to-end delay
- AODV routing protocol with hello message interval of 2 s has better route discovery time as compared to other scenarios
- DSR routing protocol with route expiry timer of 300 s has better route discovery time
- OLSR is a proactive routing protocol and has a route to the destination before it begins sending data
Average route discovery time in the UDP connection scenarios: AODV and DSR
The OLSR routing protocol with hello message interval of 2 s and topology control message interval of 5 s performs better in finding a route to the destination and in dealing with the node movement.
OPNET Model of TCP Connection

- TCP connection scenarios consist of six client nodes that download 50 kbytes of data.
- In the scenarios with the DSR routing protocol, we used two route expiry timers: 60 s and 300 s.
Average wireless delay in the TCP connection ad-hoc network for OLSR
Simulation Results: Route Discovery Time

- Large delays occur if the route discovery operation fails to find a route to the destination.
- In the static UDP scenario, the route discovery phase in AODV is approximately 10 times faster than the route discovery phase of DSR.
- The route discovery phase in AODV routing protocol is independent of the network topology.
- The DSR route discovery time is higher in scenarios that include movements.
- Unlike AODV, route discovery phase in DSR depends on network topology.
Average route discovery time (s) in UDP connection ad-hoc network scenarios: AODV and DSR cases.

Average route discovery time (s) in TCP connection ad-hoc network scenarios: AODV and DSR cases.
Simulation Results: End-to-End Delay/Download Response Time

- The end-to-end delay in the static network for all three routing protocols is less than approximately 0.5 s for most simulation scenarios.
- AODV end-to-end delay is almost constant for all mobilities.
- The OLSR has the smallest delay in all mobility scenarios as it discovers routes before attempting to send any data.
- DSR has the smallest download response time.
Average packet end-to-end delay (s) in all UDP connection ad-hoc network

Average download response time (s) in TCP connection ad-hoc network scenarios
Simulation Results: Routing Traffic Overhead

- OLSR has much larger routing traffic overhead in comparison to AODV and DSR.
- The protocol sends approximately 5,500 bps and receives approximately 14,000 bps of routing traffic.

Average routing traffic sent and received in the static ad-hoc network in UDP connection.
Simulation Results: Routing Traffic Overhead

- There is a slight increase in routing traffic sent and received in case of static UDP connection network

Average routing traffic sent (top) and received (bottom) in the less dynamic ad-hoc network in UDP connection scenarios
Simulation Results: Routing Traffic Overhead

- The DSR sends more routing traffic in presence of highly dynamic nodes and in video streaming scenario.

Average routing traffic sent and received in the highly dynamic ad-hoc network in UDP connection scenarios.
- DSR routing traffic in video streaming scenario increases as nodes movement increases.
- DSR has consistent results in file downloading and it generates the least amount of routing traffic compared to AODV and OLSR.
- OLSR generates a very large amount of traffic sent and received.

Average routing traffic sent and received in a static ad-hoc network in TCP connection scenarios
Average routing traffic sent and received in a less dynamic ad-hoc network in TCP connection scenarios

Average routing traffic sent and received in a highly dynamic ad-hoc network in TCP connection scenarios
Conclusions

- AODV is the most flexible routing protocol in the presence of movement
- DSR does not perform well in presence of movement
- DSR suffers from less flexibility in presence of movement
- In case of TCP connection scenarios, DSR shows good performance in download response time and has low routing traffic overhead
- OLSR routing protocol maintains the demand for end-to-end delay value less than 20 ms
- In case of TCP connection scenarios, OLSR does not perform well
- In the presence of movement, DSR and OLSR impose large routing traffic overhead
References

References


