Performance Evaluation of Optimized Link State Routing Protocol over TCP Traffic in Mobile Ad-Hoc Networks

Alaa Eldin A. Y. Abdalla[1], Mohamed A. A. Elmaleeh[2], Mohamed H. M. Nerma[3]

Abstract—Mobile Ad-Hoc Network (MANET) is a wireless network without infrastructure. Optimized Link State Routing protocol (OLSR) is a proactive MANET routing protocol used in (MANET). In this paper, the performance of OLSR protocol is evaluated by considering the three routing aspects: scalability, network load and mobility. File Transfer Protocol (FTP) and Transmission Control Protocol (TCP) traffics are used over the designed network. The performance metrics delay, routing overhead, and throughput are used in the performance analysis. OPNET Modeler 14.5 is used as a simulator. The simulation results show that by increasing the number of nodes the OLSR floods the network with a high amount of routing traffic. It is found that the variations in the number of nodes and the network speed do not significantly affect the performance of OLSR in terms of end-to-end delay and throughput. This is because OLSR builds and maintains consistent paths resulting in low delay and high throughput.

Index Terms—OLSR, TCP, FTP, RWP, MANET, delay, throughput.

1 INTRODUCTION

MOBILE Ad-Hoc Network (MANET) is a wireless system that comprises mobile nodes. Nodes in the network can be fixed or mobile. Mobile nodes include laptop, mobile phone, MP3 player, home computer or personal digital assistant. Nodes may be located on ships, airplanes, land, etc. in order to use in communication systems [1].

1.1 Routing Protocols

Routing protocols are usually engaged to determine the routes following a set of rules that enables two or more devices to communicate with each other. In an ad hoc network routes are enabled in between the nodes using multi-hop, as the propagation range of the wireless radio is limited. These protocols are categorized into three groups as Reactive, Proactive and Hybrid based on the updated time of the routing information [2].

1.2 Proactive Routing Protocols

A proactive routing protocol is also called “table-driven” routing protocol. Using a proactive routing protocol, nodes in a mobile ad hoc network continuously evaluate routes to all reachable nodes and attempt to maintain consistent, up-to-date routing information. Therefore, a source node can get a routing path immediately if it needs one. In proactive routing protocols, all nodes need to maintain a consistent view of the

network topology. When a network topology change occurs, respective updates must be propagated throughout the network to notify the change. Using proactive routing algorithms, mobile nodes proactively update the network state and maintain a route regardless of whether data traffic exists or not, and the overhead to maintain up-to-date network topology information is high [2].

1.3 Reactive Routing Protocols

Reactive routing protocols for mobile ad hoc networks are also called “on-demand” routing protocols. In a reactive routing protocol, routing paths are searched only when needed. A route discovery operation invokes a route-determination procedure. The discovery procedure terminates when either a route has been found or no route is available after examination for all route permutations [2].

1.4 Hybrid Routing Protocols

Hybrid routing protocols are proposed to combine the merits of both proactive and reactive routing protocols and overcome their shortcomings. Normally, hybrid routing protocols for mobile ad hoc networks exploit hierarchical network architectures [2].

1.5 Optimized Link State Routing Protocols

Optimized Link State Routing Protocols (OLSR) is a proactive routing protocol for mobile ad hoc networks. The protocol inherits the stability of a link state algorithm and has the advantage of having routes immediately available when needed due to its proactive nature. OLSR is an optimization over the classical link state protocol, tailored for mobile ad hoc networks. OLSR minimizes the overhead from flooding of control traffic by using only selected nodes, called multi-point relays.

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(MPRs), to retransmit control messages. This technique significantly reduces the number of retransmissions required to flood a message to all nodes in the network. Secondly, OLSR requires only partial link state to be flooded in order to provide shortest path routes [3]. OLSR is modularized into a "core" of functionality, which is always required for the protocol to operate and a set of auxiliary functions. The core specifies, in its own right, a protocol able to provide routing in a stand-alone MANET. Each auxiliary function provides additional functionality, which may be applicable in specific scenarios, e.g., in case a node is providing connectivity between the MANET and another routing domain [3].

### 1.6 Transmission Routing Protocol

Transmission Control Protocol (TCP) is a Transport Layer Protocol and originally designed for wired network in 1981. The basic responsibility of TCP is to provide reliable transfer of data between the nodes i.e. to ensure that the data is reached the destination correctly without any loss or damage. The data is transmitted in the form of continuous stream of octets. The mechanism is adopted to assign a sequence number to each octet of data and receiver responds with positive acknowledgement to ensure that the data is received correctly [4].

### 1.7 Random Way Point Mobility Model

The random waypoint model is by far the most widely used model in the literature. The random way point (RWP) assumes a fixed number of nodes in a fixed size rectangle. The simulation starts with the nodes uniformly distributed in the rectangle. Each node chooses a random destination and chooses a random speed distributed uniformly in the interval \([v_{\text{min}}; v_{\text{max}}]\). Once it arrives at the destination, it pauses for a random time uniformly distributed in \([P_{\text{min}}; P_{\text{max}}]\), then it chooses a new speed and destination and repeats the process [5].

### 1.8 End to End Delay

The packet end-to-end delay is the average time that the packets take to traverse the network. This is the time from the generation of the packet by the sender up to their reception at the destination’s application layer and is expressed in seconds [6].

### 1.9 Routing Overhead

It is defined as the total number of routing packets transmitted over the network, expressed in bits per second or packets per second [6].

### 1.10 Throughput

The ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet is referred to as throughput. It is expressed in bits per second or packets per second [6].

#### 2 Design Implementation

The components used for designing of the network are mobile station (MANET) and fixed station (wireless Server), application configuration which decides the type of application running in the network, profile configuration to configure the type of profile on the network. Mobility configuration will decide the mobility model of every node which is selected as random waypoint for this simulation. Attributes of workstation will set the OLSR protocol used for the simulation. Simulation parameters used in this work are listed in Table 1.

#### 2.1 Wireless Parameters

Default wireless network parameters were used for the simulation except the data rate that was increased to 11Mbps. The default TCP and FTP parameters were used over the network designed network.

#### 2.2 OLSR Parameters

The defaults parameters of OLSR used over the network designed are listed in Table 2.

#### 2.3 Mobility Configuration

RWP is used as mobility model. The mobility and wireless network parameters were identical for all nodes in each scenario. All nodes were configured to move randomly within the defined wireless domain. The speed of each mobile node was defined by a constant 10 m/s for low mobility or 28 m/s for high mobility. The pause time is set to the constant 300.

### Table 1: Simulation Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>1000x1000 m²</td>
</tr>
<tr>
<td>Network size (no. of nodes)</td>
<td>5, 20, 50</td>
</tr>
<tr>
<td>Data rate</td>
<td>11 Mbps</td>
</tr>
<tr>
<td>Mobility model</td>
<td>Random waypoint</td>
</tr>
<tr>
<td>File size</td>
<td>1000 and 50000 bytes</td>
</tr>
<tr>
<td>Data type</td>
<td>FTP</td>
</tr>
<tr>
<td>Mobility speed</td>
<td>10 and 28 (m/s)</td>
</tr>
<tr>
<td>Simulation time</td>
<td>3,600 seconds</td>
</tr>
<tr>
<td>Address mode</td>
<td>IPv4</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

3.1 Impact of Scalability on OLSR Protocol Performance

Figure 1 shows the delay obtained for 5, 20 and 50 nodes respectively. It is observed that the OLSR delay increases as the number of nodes increases. This is because OLSR divides the nodes into MPR set and MPR selector set. It is clear that the OLSR protocol has a constant lower delay which means that routes in the network are always ready whenever the application layer has traffic to transmit.

The OLSR does not use much time in route discovery mechanism since the routes are available beforehand in the OLSR when the data transmission is needed, thereby resulting in a lower end-to-end delay. The consistency in the delay in OLSR is due to constant paths it maintains owing to its proactive nature. Even with a higher density of the network, the performance is not found to be degraded and a constant lower delay is noticed. This is because OLSR has the advantage of utilizing the MPR nodes to enable forwarding of the control messages to other nodes. Thus it eventually helps to minimize the network overhead.

3.2 Routing Overhead

Figure 2 shows the routing traffic sent in bits/sec for 5, 20 and 50 nodes respectively. The OLSR protocol sends a higher amount of routing traffic into the network because of its proactive nature and as such constantly floods the network with control and routing traffic to continuously update its routing tables. The consistency in the routing overhead in OLSR is due to the constant paths it maintains owing to its proactive nature. Increasing the number of nodes has clear influence of increasing the amount of routing traffic injected into the network.

3.3 Throughput

Figure 3 shows the throughput in bits/sec for 5, 20 and 50 nodes respectively. OLSR has the maximum throughput in every scenario regardless of high routing overhead and delay. OLSR has a consistent throughput since it has consistent routing overhead and delay.

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TABLE 2

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness</td>
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</tr>
<tr>
<td>Hello interval (seconds)</td>
<td>2.0</td>
</tr>
<tr>
<td>TC interval (seconds)</td>
<td>5.0</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>
<tr>
<td>Address mode</td>
<td>IPv4</td>
</tr>
</tbody>
</table>

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![Fig. 1. Delay for 5, 20 and 50 sources at speed of 10 m/s.](image1.png)

![Fig. 2. Routing Overhead obtained for 5, 20 and 50 sources at speed 10 m/s.](image2.png)

![Fig. 3. Throughput in bits/sec for 5, 20 and 50 nodes respectively.](image3.png)
3.4 Impact of Traffic Load on OLSR Protocol Performance

Figure 4 shows the delay for the low and high load traffic. The OLSR protocol shows in both cases have similar and consistent behavior with approximately same delay.

3.5 Impact of Node Mobility on OLSR Protocol Performance

Figure 5 shows the throughput for low and high load traffics. OLSR has a high throughput in both scenarios. The highest throughput achieved with high network load.

Figure 6 shows the delay for low and high mobility. The OLSR protocol presents low delay while varying the nodes speeds; this result is typical to OLSR protocol performance on varying the nodes speed.
3.6 Throughput

Figure 7 shows the throughput for low and high mobility. The OLSR protocol significantly presents high throughput for both scenarios.

4 Conclusion

In this paper the performance analysis of MANET routing protocol OLSR is performed by focusing on scalability, network load and mobility. The delay, routing overhead and throughput performance metrics were used to analyze the performance of the protocol. The network is designed using the FTP and TCP as an application and transport layer protocols.

Based on simulation results and focusing on scalability, OLSR protocol outperforms in both throughput and packet end-to-end delay it is found that the OLSR protocol has a higher routing overhead. It is therefore well suited for high capacity networks. The high routing traffic in OLSR is used to discover and maintain routes. It found to be un unsuitable for low capacity networks.

In the case of traffic load the OLSR protocol performance is almost similar while considering the throughput and delay. In case of mobility the OLSR protocol performance is not affected even at a higher nodes speed.

References


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