Performance Evaluation of AODV, DSR, OLSR, and GRP MANET Routing Protocols Using OPNET.

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Abstract—Routing is a critical issue in MANET and hence the focus of this paper along with the performance analysis of routing protocols. In this paper performance of four MANET routing protocols (AODV, DSR, OLSR and GRP) are compared. To evaluate and validate the feasibility of the study, simulation experiments were carried out. For these experiments, the four protocols were tested under different scenarios and circumstances using a simulation tool called OPNET. The performance of these routing protocols is analyzed based on two performance metrics: delay and throughput. The simulation results have shown that on average under heavy FTP traffic condition, overall OLSR outperforms the other three with respect to these under two scenarios (20 and 80 mobile nodes) that have been created in OPNET.

Keywords: MANET, AODV, DSR, OLSR, GRP, OPNET, FTP.

I. INTRODUCTION

The emergence of wireless networks has gone a long way in solving the growing service demands. The focus of research and development has almost shifted from wired networks to wireless networks. The limitations of wireless network techniques such as high error rate, power restrictions, bandwidth and other constraints has not deterred the growth of wireless networks. [1]. Mobile Ad-hoc network (MANET) is the most demanding field in the area of wireless networks.

MANET has mobile devices or users which are generally known as nodes each one of which is equipped with radio transmitter and receiver [2]. MANET is a temporary network of wireless mobile nodes which has no fixed infrastructure. There are no dedicated routers, servers, access points, base stations and cables [15]. The mobile nodes which are within each other’s transmission range can communicate with each other directly otherwise, the nodes in between them forward the packets for them from source to destination. Every node acts as a router to forward the packets to other nodes whenever required [3]. One of the main areas of research has been routing technology which will route packets from source to destination, which the focus of this paper.

Mobile ad-hoc network is infrastructure less networks having nodes which can act as a transmitter, router or receiver. MANETs have a dynamic topology where nodes are mobile. To monitor the working of the nodes and nature in which they behave while sending, receiving or forwarding data is classified by a set of rules known as routing protocols [14].

The routing protocols cannot be included under one category or one classification, therefore, the known characteristics should be listed and the MANET routing protocols classified according to these attributes [13].

In this paper, four major MANET routing protocols (AODV, DSR, OLSR and GRP) have been evaluated based on FTP (High load) traffic as application by increasing the number of nodes in different scenarios to assess the performance of each protocol. The performance is analyzed by means of delay and throughput by using OPNET Modeler 14.0. The first two protocols are selected from Proactive category namely OLSR, GRP and the second are selected from Reactive category namely AODV, DSR.

OPNET provides several MANET routing protocol models that are integrated with the IP and wireless LAN models. In addition, a MANET framework is available for rapid development of new MANET protocol models. OPNET support the following routing protocols (AODV, DSR, OLSR, OPSFv3, TORA and GRP).
II. SIMULATION ENVIRONMENT

OPNET modeler v14.0 has been used as a simulation tool to implement these set of experiments. Two major scenarios have been created, one for 20 nodes and the second one for 80 nodes to assess the performance of these four routing protocols with different number of users with heavy FTP traffic at both scenarios. In addition, the delay and throughput are the key metrics given in these experiments. Fig 1 shows the simulation environment.

Fig. 1 Simulation Environment

In the experiment, the simulation time was set to 3600 second for each scenario. The required results were collected based on the selected metrics (Delay and Throughput). DES (global discrete event statistics) are collected on each scenario. Table I summarizes the simulation environment settings. In this simulation the Random waypoint mobility was used as a model for the simulation. Random mobility used shows more behavior good mobility and it was a simple in use [12]. 100 m/s used as a constant speed for mobile nodes movement till reach the destination, 200 second used as a pause time and after that it will research and chosen a new destination randomly. Table II shows the simulation parameters.

TABLE I

<table>
<thead>
<tr>
<th>Simulation Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Nodes</td>
<td>20 and 80.</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>1 hour (3600 (sec)).</td>
</tr>
<tr>
<td>Simulation Area</td>
<td>1000 x 1000 (m x m).</td>
</tr>
<tr>
<td>Routing Protocols</td>
<td>AODV, DSR, OLSR, GRP.</td>
</tr>
<tr>
<td>Mobility Model</td>
<td>Random waypoint.</td>
</tr>
<tr>
<td>Data Rate</td>
<td>11 mbps.</td>
</tr>
<tr>
<td>Application</td>
<td>FTP (High load).</td>
</tr>
<tr>
<td>Simulation Metrics</td>
<td>Delay and throughput</td>
</tr>
</tbody>
</table>

III. PERFORMANCE METRICS

According to [3,4,7,9,10], it is possible to evaluate the performance of the MANET protocols with respect to several quality attributes, both performance-related attributes and more general quality attributes, such as scalability. The following performance-related metrics have been identified as important for MANET protocols. These performance metrics will show the efficiency of the MANET protocols. The performance is analyzed by means of delay and throughput by using OPNET Modeler 14.0.

Delay (sec): It is the ratio of time difference between every packet sent and received to the total time difference over the total number of packets received. Throughput (bit/sec) the ratio of total data reaches a receiver from the sender is known as Throughput. The time it takes by the receiver to receive the last message is called as throughput [11]. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). Throughput can be mathematically expressed as in equation I.

\[
\text{Throughput} = \frac{\text{Number of delivered packet} \times \text{Packet size} \times \text{a}}{\text{total duration of simulation}}
\]

Fig. 2 Throughput Calculation Equation

IV. SIMULATION SCENARIOS

Various environmental scenarios, identified in Table II, will be used to measure the efficiency of the fourth routing protocols.

TABLE II EVALUATION SCENARIOS

<table>
<thead>
<tr>
<th>Nodes Num.</th>
<th>Traffic Setting (FTP Heavy Traffic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A (20 Nodes)</td>
<td></td>
</tr>
<tr>
<td>Scenario B (80 Nodes)</td>
<td></td>
</tr>
</tbody>
</table>

Scenario A investigates how these four MANET routing protocols behave under a heavy FTP traffic with respect to the delay and the throughput and 20 nodes.

Scenario B investigates how these four protocols perform under a heavy FTP traffic and 80 nodes with respect to the delay and throughputs.
V. EXPERIMENT RESULT

The results have been divided into two sets based on the above scenarios as presented in Table II. The graphs of results are presented in a two-dimensional Cartesian plane where the x-axis represents the temporal progression of the simulation and the y-axis represents the relevant performance metric. Fig. 3 & Fig. 4 show the delay for the 20 and 80 nodes scenarios respectively.

Fig 3 shows that AODV has a lowest delay during simulation time (ST). AODV here has a delay but less than DSR, whereas GRP and OLSR have least delay also they are so closed together. Finally, it has been found that OLSR is the best during delay from the beginning of the simulation at 5 mins, after that it can be seen that GRP and OLSR has the same values fortunately.

As seen in Fig. 3, OLSR has a least delay while AODV has almost similar characteristic to OLSR but it is larger than OLSR in value average, whereas GRP has a medium delay also DSR has a highest delay compared to all routing protocols. This concludes that OLSR has a lowest delay and is performing better comparing to other routing protocols.

Under the 20 nodes scenario and with regard to the throughput metric, the OLSR clearly has a highest throughput as seen in Fig. 5, Whereas DSR has the lowest, while AODV and GRP have a medium throughput. This result shows clearly that the OLSR outperforms the other protocols.

Fig 6 shows clearly that OLSR has a highest throughput again under 80 nodes, so it is the best from others routing protocols, followed by AODV then GRP and last and least throughput is DSR during this scenario.
VI. RESULTS ANALYSIS

According to the obtained results, it was able to answer the question "which routing protocol is performing best?", as seen from the above graphs and below table that, OLSR is the best at all scenario during delay and throughput in 20 and 80 scenarios. The four experiments gave results with similar patterns and characteristics. The graphs of results are presented in a two-dimensional Cartesian plane where the x-axis represents the temporal progression of the simulation and the y-axis represents the relevant performance metric.

As seen from the graph (Fig. 4), the OLSR protocol in general perform slightly better at reducing the delay for transmitting data packet than the other protocols. This reduction in the delay due to working mechanism of the OLSR over the others [10], which lead to a speed up of the content delivery process, which will reflect overall in reducing the delivery time as indicated by the graph and this is due to the fact that OLSR uses the concept of Multipoint Relays (MPR) to reduce the possible overhead in the network. Table III shows the obtained result in numerical means, which shows clearly that OLSR protocol is given high throughputs and less delay over the other protocols.

<table>
<thead>
<tr>
<th>Nod.</th>
<th>Metrics</th>
<th>AODV</th>
<th>DSR</th>
<th>OLSR</th>
<th>GRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Delay (sec)</td>
<td>0.00206</td>
<td>0.00647</td>
<td>0.00135</td>
<td>0.00434</td>
</tr>
<tr>
<td></td>
<td>Throughput (bit/sec)</td>
<td>301,146</td>
<td>214,124</td>
<td>456,106</td>
<td>299,136</td>
</tr>
<tr>
<td>80</td>
<td>Delay (sec)</td>
<td>0.00213</td>
<td>0.004267</td>
<td>0.00298</td>
<td>0.00198</td>
</tr>
<tr>
<td></td>
<td>Throughput (bit/sec)</td>
<td>462,198</td>
<td>265,894</td>
<td>1,658,467</td>
<td>345,319</td>
</tr>
</tbody>
</table>

 VII. CONCLUSION

This paper presents an evaluation study of four major MANET routing protocols. It is necessary to provide the network operators and mobile applications developers such a study to help them to decide which MANET routing protocols can help to enhance the end-user experience. In addition, routing protocols have an important effect on the overall performance of the mobile applications that using MANET as a business network [16]. The simulation results have indicated that OLSR in general performed better than the other three protocols (AODV, GRP, and DSR) with respect to delay and throughputs under heavy FTP traffic. In other words, OLSR can be considered is the best among the other in terms of bandwidth utilization which required for cutting-edge mobile applications that required high throughput and less delay. Furthermore, the results support the intuitive expectations of OLSR behaviour as has been proven in [10].

REFERENCE