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Simulation based Performance Evaluation and Comparison of Proactive and Reactive Routing Protocols in Mobile Ad-hoc Networks

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***Abstract*— Mobile Ad-hoc Network (MANET) is a collection of wireless mobile nodes dynamically forming a temporary network without the aid of any established infrastructure or centralized administration. The mobility of nodes in MANETs results in frequent changes of network topology making routing in MANETs a challenging task. Routing protocols in MANET helps node to send and receive packets. Some studies have been reported in the literature to evaluate the performance of the proposed routing algorithms. However, since the publication of experimental standards for some routing protocols by IETF, little activity has been done to contrast the performance of reactive against proactive protocols. This paper evaluates the performance of reactive (AODV) and proactive (OLSR) routing protocols in MANETs based on Average end-to-end delay, Throughput and Traffic Received under FTP traffic with different network conditions using OPNET 14.5. Our results, contrarily to previously reported studies conducted on the same routing protocols, show the superiority of proactive over reactive protocols in routing such traffic.**

***Keywords*— MANET, Routing, AODV, OLSR.**

I. INTRODUCTION

As the importance of computers in our daily life increases, it also sets new demands for connectivity. Wired solutions have been around for a long time but there is increasing demand on working wireless solutions for connecting to the Internet, reading and sending E-mail messages, changing information in a meeting and so on. There are solutions to these needs, one being wireless local area network that is based on IEEE 802.11 standard. However, there is increasing need for connectivity in situations where there is no base station (i.e. backbone connection) available (for example two or more PDAs need to be connected). This is where ad-hoc networks step in.

A MANET is an autonomous system of mobile routers (and associated hosts) connected by wireless links - the union of which forms an arbitrary graph. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. The strength of the connection can change rapidly in time or even disappear completely. Nodes can appear, disappear and re-appear as the time goes on and all the time the network connections should work between the nodes that are part of it. The ad hoc network is a communication network without a pre-exist network infrastructure. In ad-hoc networks every communication terminal (or radio terminal RT) communicates with its partner to perform peer-to-peer communication. This collaboration between the RTs is very important in the ad-hoc networks. In ad-hoc networks all the communication network protocols should be distributed throughout the communication terminals (i.e. the communication terminals should be independent and highly cooperative).

II. RELATED WORK

Nadia et al. [2] evaluated QoS with MANET routing protocols. The paper focused on three main protocols AODV, OLSR and TORA. Their work focused on routing performance with lower network congestion and with fixed number of nodes. They argued that OLSR is the most favourite proactive protocol and AODV is the most effective on-demand protocol within their environment.

Maashri et al. [3] looked into analyzing performance of MANET routing protocols. Their study involved comparison of OLSR, DSR and AODV with self-similar traffic like CBR, Pareto, and Exponential. They argued that DSR performance was better for packet delivery ratio and OLSR performance degraded in situations where high mobility and network load exist. On the other hand, it was argued that AODV provides the most average performance amongst all.

Samir et al. [4] evaluated SPF, EXBF, DSDV, TORA, DSR and AODV with varying number of nodes and looked into scalability of the protocols. The work here focuses on scalability of the protocols by employing heavy congestion with Constant Bit Rate traffic of high load for FTP and video download. They investigated the performance of OLSR and AODV under high Constant Bit Rate traffic.

III. DESIRABLE PROPERTIES OF AD-HOC ROUTING PROTOCOLS

The properties [5] that are desirable in Ad-Hoc Routing protocols are:

A. Distributed operation

The protocol should be distributed. It should not be dependent on a centralized controlling node. This is the case even for stationary networks. The difference is that the nodes in an ad-hoc network can enter or leave the network very easily and because of mobility the network can be partitioned.

B. Loop free

To improve the overall performance, the routing protocol should guarantee that the routes supplied are loop free. This avoids any waste of bandwidth or CPU consumption.

C. Demand based operation

To minimize the control overhead in the network and thus not waste the network resources the protocol should be reactive. This means that the protocol should react only when needed and that the protocol should not periodically broadcast control information.

D. Unidirectional link support

The radio environment can cause the formation of unidirectional links. Utilization of these links and not only the bi-directional links improves the routing protocol performance.

E. Security

The radio environment is especially vulnerable to impersonation attacks so to ensure the wanted behavior of the routing protocol we need some sort of security measures. Authentication and encryption is the way to go and problem here lies within distributing the keys among the nodes in the ad-hoc network.

F. Power conservation

The nodes in the ad-hoc network can be laptops and thin clients such as PDA's that are limited in battery power and therefore uses some standby mode to save the power. It is therefore very important that the routing protocol has support for these sleep modes.

G. Multiple routes

To reduce the number of reactions to topological changes and congestion multiple routes can be used. If one route becomes invalid, it is possible that another stored route could still be valid and thus saving the routing protocol from initiating another route discovery procedure.

H. Quality of Service Support

Some sort of Quality of service is necessary to incorporate into the routing protocol. This helps to find what these networks will be used for. It could be for instance real time traffic support. It should be noted that none of the proposed protocols have all these properties, but it is necessary to remember that the protocols are still under development and are probably extended with more functionality.

IV. Classification of Routing Protocols

All routing in ad-hoc networks involves finding a path from the source to destination, and delivering packets to the destination nodes while nodes in the network move freely. Due to node mobility, a path established by source may not exist after some time. To deal with node mobility, nodes need to maintain routes in the network. Depending upon how nodes establish and maintain path, routing protocols are divided in to three categories:

A. Proactive Routing Protocols

These are also called table driven protocols. It maintains routing table using the routing information learnt from neighbors on periodic basis. Main characteristics of these protocols include: distributed, shortest-path protocols, maintain routes between every host pair at all times, based on Periodic updates of routing table and high routing overhead and consumes more bandwidth.

B. Reactive Routing Protocols

These are also called demand driven protocols that find path as and when required. They maintain information about the active routes only. They performs route discovery phase before data transmission by flooding route request packet and destination node reply with route reply packet. A separate route maintenance procedure is required in case of route failure. Main Characteristics of these routing protocols are: determine routes as and when required, less routing overhead, source initiated route discovery and more route discovery delay.

C. Hybrid Routing Protocols

In this various approaches of routing protocols are combined to form a single protocol. ZRP (Zone Routing Protocol), is one such protocol that combines the proactive and reactive approach. Main characteristics include: Combination of selected features of proactive and reactive protocols, Adaptive to network condition.

V. Overview of Routing Protocols

A. Ad-hoc On-demand Distance Vector (AODV) Routing Protocol

AODV [1], [6], [7] is a reactive routing protocol that minimizes the number of broadcasts by creating routes on-demand. Messages in network are of two types, routing messages and data messages. Routing messages are further divided into two types, path discovery message and path maintenance message. Path discovery includes RREQ (Route Request) and RREP (Route reply). Path maintenance includes RERR (Route error) and HELLO messages. To find a path to the destination, a RREQ packet is broadcasted by the source till it reaches an intermediate node that has recent route information about the destination or till it reaches the destination. When a node forwards a RREQ to its neighbors, it also records in its tables the node from which the first copy of the request came. This information is used to construct the reverse path for the RREP packet. AODV uses only symmetric links because the RREP follows the reverse path of the RREQ. If one of the intermediate nodes moves then the moved node's neighbor sends a link failure notification to its upstream neighbors and so on till it reaches the source upon which the source can reinitiate route discovery if needed. After having learned about the failure, the source node may reinitiate the route discovery protocol. Optionally a mobile node may perform local connectivity maintenance by periodically broadcasting hello messages.

The advantage of AODV is that it creates routes only on demand, which greatly reduces the periodic control message overhead associated with proactive routing protocols. The disadvantage is that there is route setup latency when a new route is needed, because AODV queues data packets while discovering new routes and the queued packets are sent out only when new routes are found. This situation causes throughput loss in high mobility scenarios, because the packets get dropped quickly due to unstable route selection.

B. Optimized Link State Routing (OLSR) Protocol

OLSR [1], [9] is an optimization of pure link state algorithm in ad-hoc network. The routes are always immediately available when needed due to its proactive nature. Hop by hop routing is used in forwarding packets. The use of Multipoint Relay selectors (MPR) in OLSR is the distinctive feature over other classical link state protocols. In OLSR, only nodes selected as MPRs forward control traffic, reducing the size of control message. MPRs advertise link state information for their MPR selectors periodically in their control messages. MPRs are also used to form a route from a given node to any destination in route calculation. Every node periodically broadcasts a list of its MPR selectors instead of the whole list of neighbours. In order to exchange the topological information, the Topology Control (TC) message is broadcasted throughout the network. Each node maintains the routing table in which routes for all available destination nodes are kept.

VI. Simulation and Performance Analysis

OPNET (Optimized Network Engineering Tool) Modeler 14.5 is used for the design and implementation of this work. OPNET provides virtual network communication environment and is prominent for the research studies, network modeling and engineering, R & D Operation and performance analysis. The parameters that have been used in the following experiments are summarized in Table I.

TABLE I
Main Characteristics of Scenario

Statistic	**Value**
Simulator	OPNET 14.5
Protocols Studied	AODV, OLSR
Scenario Size	1000m x 1000m
Number of Nodes	10, 100
Node Mobility (m/s)	10
Traffic Type	FTP
Node Movement Model	Random Waypoint Model
Transmit Power (W)	0.005
Simulation Time	3 minutes

All scenarios have been modeled and evaluated using OPNET 14.5. Fig. 1 shows a sample network created with 100 nodes, one static FTP server, application configuration for the network in which FTP (File Transfer Protocol has been chosen) as an application.

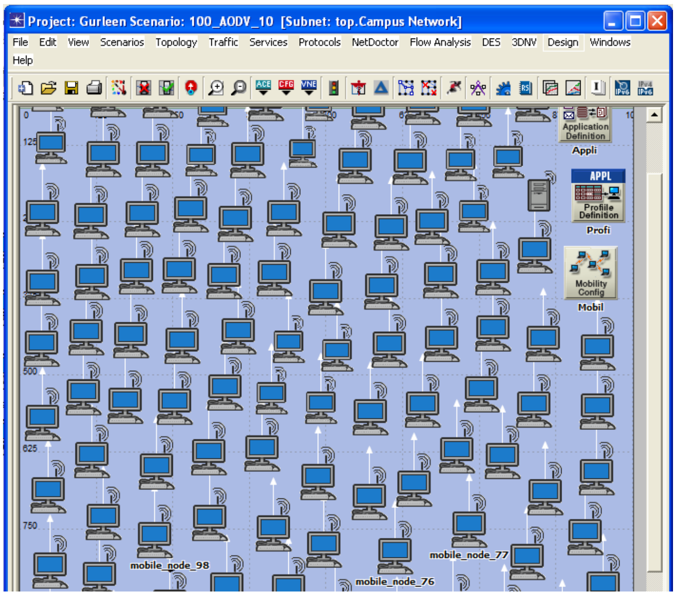

Fig. 1 MANET Scenario with 10 nodes

The performance metrics selected to make the performance differences are:

A. Average end to end delay

This metric represents average end-to-end delay and indicates how long it took for a packet to travel from the source to the application layer of the destination. It is measured in seconds.

B. Throughput

Throughput refers to how much data can be transferred from one location to another in a given amount of time. Unit of throughput is bits/sec or packets/sec. Throughput in aspect of MANET is affected due to topology change, bandwidth etc.

C. Routing Traffic Received

VII. Simulation Results

The simulation results are shown in the following section and comparison between the two protocols are performed by varying numbers of nodes on the basis of the above mentioned metrics.

A. Average end to end Delay

Average end to end delay of reactive protocol (AODV) is much higher than proactive protocol (OLSR). The values of delay vary from 0.020 to 0.0025 for AODV while in case of OLSR; it varies from 0.08 to 0.0005.

With the increasing number of nodes, average end to end of both OLSR and AODV. Now the value of AODV varies from 0.24 to 0.01 while it varies from 0.015 to 0.001 in case of OLSR. Hence OLSR proves to be a better candidate.

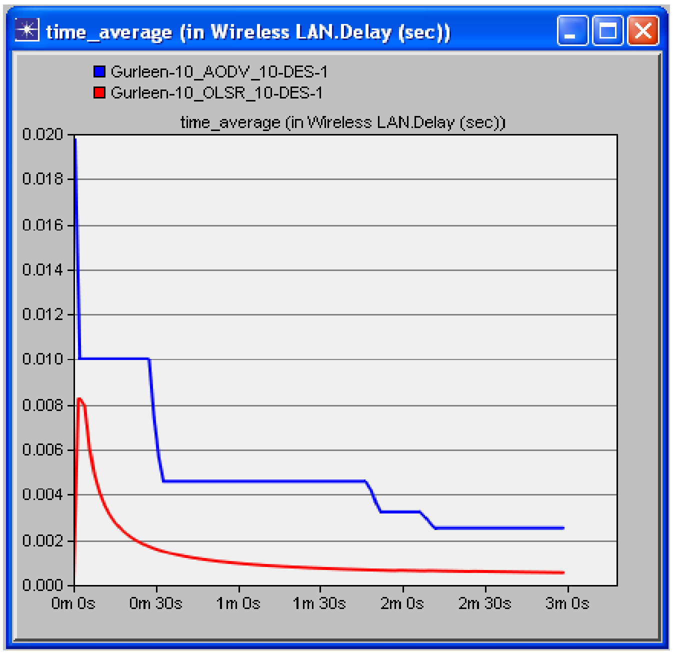

Fig. 2 Average end to end Delay for 10 nodes

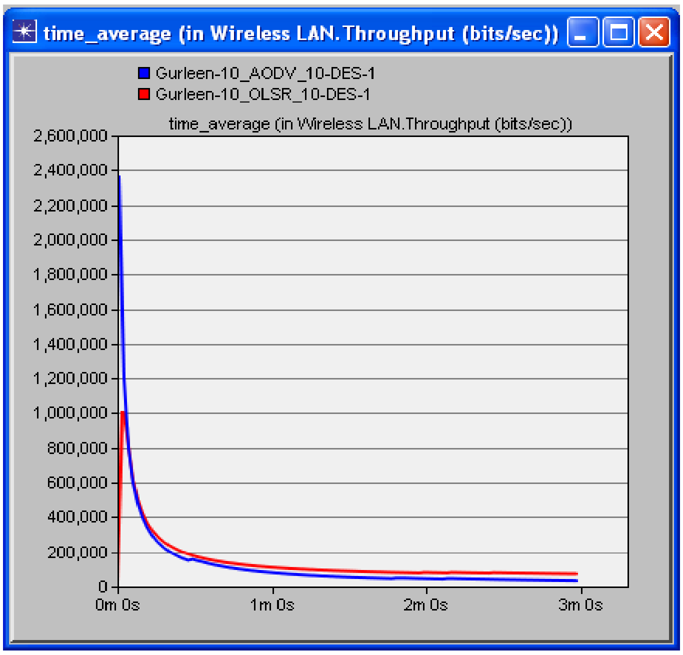

Fig. 4 Throughput for 10 nodes

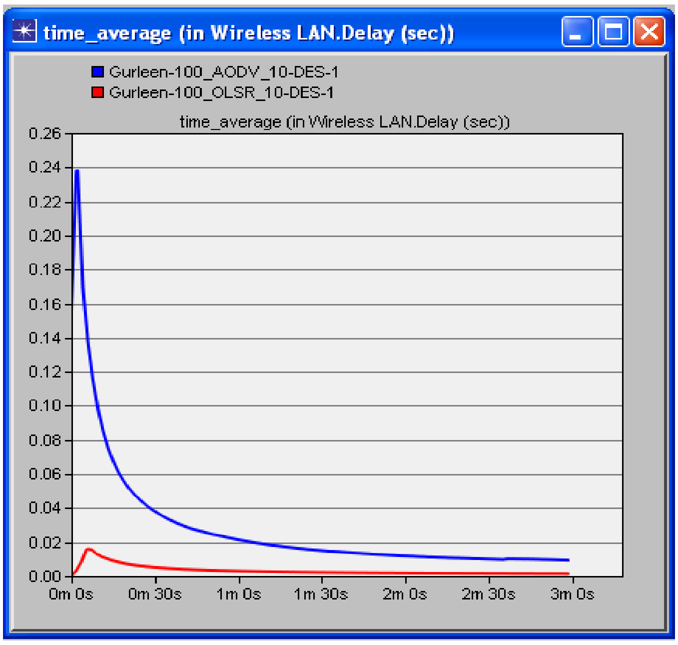

Fig. 3 Average end to end Delay for 100 nodes

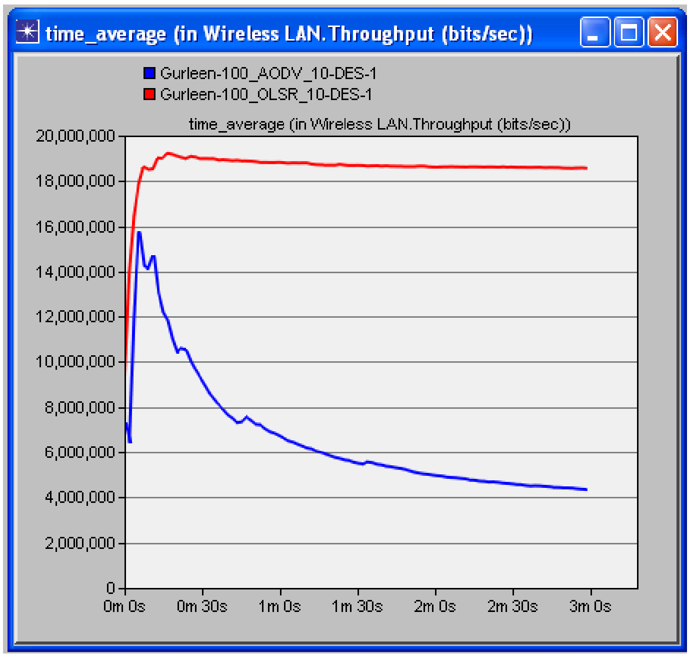

Fig. 5 Throughput for 100 nodes

B .Throughput

The throughput of AODV shows a very high peak in the first 5 seconds of simulation. After that the throughput of OLSR is more than that of AODV till the end of simulation.

When the number of nodes increases, OLSR outperforms AODV and the graph shows a significant improvement in the values of OLSR but the performance curve of AODV is downwards.

C. Routing Traffic Received

For 10 nodes, the traffic received by AODV shows a continuous decrease from 120 to 8. But the values for OLSR remain almost stable at 55 with the simulation time. Hence after 10 seconds of simulation, the packet receiving performance of OLSR is much more than that of AODV.

But with more number of nodes, the packet receiving performance of AODV is much more than that of OLSR. It varies from 30,000 to 10,000 for AODV while its stable at 5,000 for OLSR.

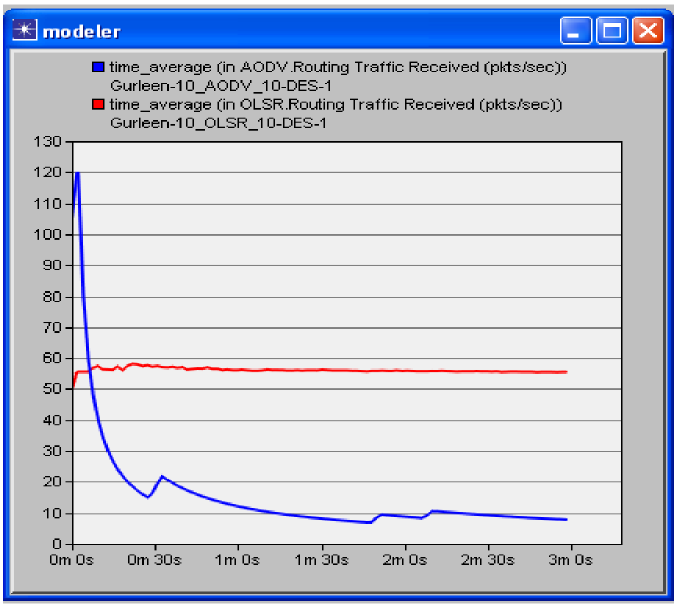

Fig.6 Traffic Received for 10 nodes

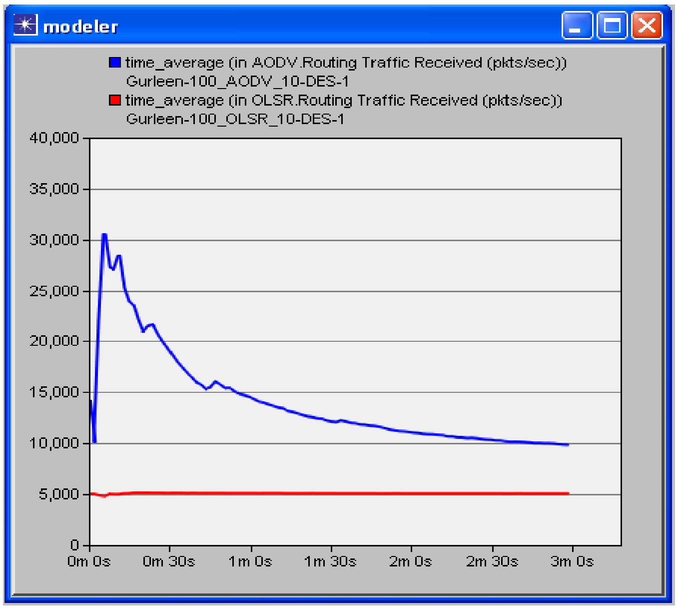

Fig. 7 Traffic Received for 100 nodes

VIII. Conclusions

In the paper, the performance difference is made between the proactive and reactive protocol for different number of nodes. In the paper, detailed analysis of the behavior of protocols based on some important metrics such as Average end-to-end Delay, Throughput and Traffic Received is performed. The network load is selected for small size like 10 nodes and large size 100 nodes.

The delay of OLSR is less than that of AODV. Also the throughput of OLSR is more than AODV. The traffic receiving performance of OLSR is also more than AODV in case of few numbers of nodes. But above of all, OLSR is showing the best performance over the others in almost every respect.

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