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Performance Evaluation of MANET Routing Protocols with Scalability for FTP Delay Traffic Using OPNET Modeler

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Abstract – Mobile ad hoc network is a collection of wireless nodes that can dynamically be set up anywhere and anytime to exchange information without using any pre-existing network infrastructure. It is a self organized and self configurable network where the mobile nodes move randomly. In MANET mobile nodes can receive and forward packets as a router and each node operates not only as an end system, but also as a router to forward packets. The nodes are free to move i.e. the nodes are mobile. These nodes change position frequently. So there is no fixed infrastructure, which results in addition and exclusion of any number of nodes from the network for relatively small networks routing protocols may be sufficient. However, in larger networks either hierarchical or geographic routing protocols are needed. In this Thesis three routing protocols AODV (Ad- Hoc On-Demand Distance Vector), OLSR (Optimized Link State Routing Protocol) and DSR (Dynamic Source Routing Protocol) are compared. Most of the previous research on MANET routing protocols have focused on simulation study by varying various parameters, such as network size, pause times etc. The performance of these routing protocols is analyzed with Scalability for FTP in terms of their Delay Traffic and their results are shown in graphical forms. The comparison analysis will be carrying out about these protocols and in the last the conclusion will be presented, that which routing protocol is the best one for mobile ad -hoc networks.

Keywords - Mobile Ad-hoc Network, Performance Analysis, Routing Protocols, AODV, DSR, OLSR, OPNET MODELER 14.5.

I. INTRODUCTION

MANET is a dynamic distributed system [1], in which wireless devices with limited energy can move arbitrary. In this network, nodes communicate without any fixed infrastructure. MANET is a self-configurable network and nodes are free to move randomly, so topology may change and this event is unpredictable [6]. According to these characteristics, routing is a critical issue and we should choose an efficient routing protocol to makes the MANET reliable [10].

The most popular routing protocols [1] in MANET are AODV (reactive), DSR (reactive), OLSR (proactive) and GRP (hybrid). Reactive protocols find the routes when they are needed. Proactive protocols are table driven protocols and find routes before they need it. And finally hybrid routing protocols offer an efficient framework that can simultaneously draw on the strengths of proactive and reactive routing protocols.

In this paper, we focus on four MANET routing protocols, AODV, OLSR, DSR and GRP. We consider four parameters to evaluate the performance of these routing protocols: End-to-end delay, network load, throughput and media access delay. The organization of the paper is as follows. We explain routing protocols in section 2, related works are discussed in section 3, section 4 explains the experiment and performance analysis, our simulation result presented in section 4 and finally section 5 concludes the paper.

II. ROUTING PROTOCOLS IN MANETS

Three routing protocols are considered in this paper, namely; DSR, AODV and OLSR. Below is a brief description of each protocol:

A. DSR – Dynamic Source Routing (DSR)

DSR is a reactive routing protocol that discovers and maintains routes between nodes. In the route discovery, DSR floods Route Request Packet to the network. Each node that receives this packet, first add its address to it and then forwards the packet to the next node. When the targeted node or a node that has route to the destination receives the Route Request, it returns a Route Reply to the sender and a route is established. Each time a packet follows an established route, each node has to ensure that the link is reliable between itself and the next node. In the Route maintenance, DSR provides three successive steps: link layer acknowledgment, passive acknowledgment and network layer acknowledgment. When a route is broken and one node detects the failure, it sends a Route Error packet to the original sender [1, 5].

B. Optimized Link State Routing (OLSR)

OLSR is a table driven protocol. It usually stores and updates its routes so when a route is needed, it present the route immediately without any initial delay. In OLSR, some candidate nodes called multipoint relays (MPRs) are selected and responsible to forward broadcast packets during the flooding process. This technique reduces the overhead of packet transmission compared to flooding mechanism [1]. OLSR performs hop-by-hop routing, where each node uses its

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most recent routing information to route packets. MPR's is made in a way that it covers all nodes that are two hops away (i.e. neighbors of the neighbors). A node senses and selects its MPR's with control messages called HELLO messages. Hello messages are used to ensure a bidirectional link with the neighbor. HELLO messages are sent at a certain interval. Nodes broadcast "TC" or Topology control messages to determine it's MPRs [11].

C. Ad Hoc on-Demand Distance Vector Routing (AODV)

AODV provides on-demand route discovery in MANET. Whenever the nodes need to send data to the destination, if the source node doesn't have routing information in its table, route discovery process begins to find the routes from source to destination. Route discovery begins with broadcasting a route request (RREQ) packet by the source node to its neighbors. RREQ packet comprises broadcast ID, two sequence numbers, the addresses of source and destination and hop count. The intermediary nodes which receive the RREQ packet could do two steps: If it isn't the destination node then it'll rebroadcast the RREQ packet to its neighbors. Otherwise it'll be the destination node and then it will send a unicast replay message, route replay (RREP), directly to the source from which it was received the RREQ packet. A copied RREQ will be ignored. Each node has a sequence number. When a node wants to initiate route discovery process, it includes its sequence number and the most fresh sequence number it has for destination. The intermediate node that receive the RREQ packet, replay to the RREQ packet only when the sequence number of its path is larger than or identical to the sequence number comprised in the RREQ packet. A reverse path from the intermediate node to the source forms with storing the node's address from which initial copy of RREQ. There is an associated lifetime value for every entry in the routing table. Suppose that some routes are not applied within their lifetime period, so these routes are expired and should be dropped from the table. But if routes are used, the lifetime period is updated so those routes are not expired. When a source node wants to send data to some destination, first it searches the routing table; if it can find it, it will use it. Otherwise, it must start a route discovery to find a route [1]. It is also Route Error (RERR) message that used to notify the other nodes about some failures in other nodes or links [9].

III. RELATED WORKS

1. Behavioural study of MANET Routing Protocols [2]

Amandeep Makkar et al, in their paper, "Behavioural study of MANET Routing Protocols" presented a behavioral study of different MANET routing protocols i.e. Optimized Link State Routing (OLSR), Destination Sequenced Distance vector (DSDV), Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV) and Temporally Ordered Routing Protocol (TORA) protocols, have been carried out to identify which protocol is most suitable for efficient routing over Mobile Ad hoc NETwork (MANET). This paper provides an overview of these routing protocols and then makes their comparative analysis so to analyze their performance, which is important for identifying which protocol is best suitable for MANET and how the performance of that protocol can be further improved.

2. On MANET Routing protocols for Mobility and Scalability[4]

Ashish Shrestha and Firat tekiner, in their paper "On MANET Routing protocols for Mobility and Scalability", presented a performance comparison of the reactive and proactive MANET routing protocols, namely AODV, DSR, TORA and OLSR in a varying network sizes with increasing area and nodes size. The main issue of MANET is the breakage of link at certain moment and re-generation of link at certain state as it consists of routers which are mobile in nature. Therefore performance comparison is done by using the simulator OPNET Modeler 14.5, to investigate the mobility and scalability of the routing protocols. Throughput was considered as the main factor for comparison because it is the actual rate of data received successfully by nodes in comparison to the claimed bandwidth. AODV and OLSR performed pretty well showing average performance throughout the simulation.

3. Performance Evaluation of Routing Protocols in MANET with different traffic loads [8]

Laxmi Shrivastava et al, in their paper "Performance Evaluation of Routing Protocols in MANET with different traffic loads" described, as the network size changes, the control overhead and traffic loads will automatically change. The performance of the routing protocols in MANETs degrades with increasing traffic load. This paper present observations regarding the performance comparison of reactive and proactive protocols for varying traffic load in mobile ad hoc networks (MANETs). The general observation from simulation (NS-2) is that DSR has performed well compared to AODV and DSDV in the situation of heavy traffic load.

4. Scalability of Routing in MANET [10]

Prashant Singh and D.K. Lobiyal in their paper "Scalability of Routing in MANET" described that because of the multihop nature of the ad hoc networks, the scalability of MANETs is directly related to the routing protocol. The scalability is subject to the fundamental limitation imposed by the multi-hop nature of MANETs. In this paper, simulations are conducted to investigate scalability of DSR, AODV, and LAR routing protocols using prediction based link availability model. This also proves that whether link prediction model also adds up to the scalability of routing protocol. From simulation results (GloMoSim), it is clear that performance of routing is improved due to link prediction model and the protocols are scalable with the model.

5. Scalability Improved DSR Protocol for MANETs [9]

M. Tamilarasi et al, in their paper, "Scalability Improved DSR Protocol for MANETs" described a technique to improve the performance of the DSR protocol. As reactive Dynamic Source Routing (DSR) Protocol is a commonly applied protocol in Mobile Ad hoc networks, when the network size is increased, it is observed that the overhead is also getting

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increased due to the source routing nature of DSR and this in turn reduces the efficiency of DSR protocol. In order to improve the scalability of DSR, in this paper, a modification is proposed for DSR. In Modified Dynamic Source Routing (MDSR) protocol, the number of RREPs are limited to only one. This reduces the overhead by restricying the multiple RREPs. Simulation results (GloMoSim) show that the modified DSR (MDSR) has less overhead and delay compared to conventional DSR irrespective of network size.

6. Scalability study of ad-hoc wireless mobile network routing protocol in sparse and dense networks [7]

Hean Kuan Ong et al, in their paper "Scalability study of ad-hoc wireless mobile network routing protocol in sparse and dense networks" presented a the detailed study of scalability of the ad hoc routing protocols towards sparse networks, dense networks and combination of sparse and dense networks. Two different categories of ad-hoc wireless networks is used to evaluate how scalable they are for various scenarios. By using Network Simulator (ns-2), simulation of two selected routing protocols DSDV and AODV is conducted to analyze the various factors that cause the routing performance to degrade in large-scale networks. The result shows that data delivery ratio decreases as the network size increases. The scalability reduces in sparse network even though there is less overhead.

7. Analysis of Scalability in MANET's Protocols [11]

Roxana Zoican, in his paper "Analysis of Scalability in MANET's Protocols" presented an architectural framework for a service discovery protocol for MANETs, which is based on the homogenous and dynamic deployment of cooperating directories within the network. In modern applications, group communication is more important. Multicasting provides necessary services for group communication in such type of applications. With the increasing number of nodes, scalability issue in multicasting of Mobile Ad hoc Network is still an open problem. This paper analyzed a scalable service discovery protocol aimed at MANETs, composed of up to a hundred of nodes, and further supporting bridging with other networks, either ad hoc or infrastructure-based. The solution was evaluated through simulation, which shows the efficiency of the analyzed protocol.

8. A Coding-Based Routing for Scalable MANET [5]

Bo Ryu et al, in their paper "A Coding-Based Routing for Scalable MANET" presented a special approach for routing in the MANETs which can increase the scalability of the network in terms of number of nodes and number of hops. The drawbacks of the traditional routing protocols are also described. Then the comparison is made between the traditional protocols and the protocols whose basic principle depend upon the new approach proposed. It is claimed that the new protocols are likely to be inherently scalable, robust and efficient. Preliminary simulation results show considerable performance gain over legacy MANET routing approach.

9. Towards Scalable MANETs [6]

E. Baccelli and J. Schiller, in their paper "Towards Scalable MANETs" described, in the near-future, self-organized networking is becoming an important component in the Internet architecture. A big challenge concerning the integration of this new component is the accomplishment of scalable and efficient mobile ad hoc routing. This paper overviews considerations relative to the design of such MANET protocols inside the framework provided by the IETF, stating the need for new hybrid protocols and architecture which offer a gradual transition from "traditional" MANET routing towards scalable MANET routing integrated in the Internet. This paper also proposes a DHT-OLSR protocol, based on OLSR, enhanced with dynamic clustering and distributed hash table routing. The protocol uses key-based unicast routing to scale to very large MANET topologies.

IV. EXPERIMENT DESIGN AND PERFORMANCE ANALYSIS

In this paper, we have nine different scenarios in OPNET modeler 14.5. In each scenario, we apply a various routing protocol. Comparisons have been made between AODV, DSR and OLSR protocols. Table 1 shows the simulation Parameters of scenarios containing 20 mobile nodes, 40 mobile nodes and 100 mobile nodes operating at Data Rate 11Mbps. Each scenario was run for 2.3 minutes. We considered there parameters for the evaluation; Network delay, network load and Network throughput. In each figure from Fig. 2 to Fig. 6, the horizontal axis shows the simulation time in hour and minute format, and the vertical axis represent one of the five parameters (delay, network load, throughput, media access delay and load).

Attribute	Value
Maximum Simulation Time	150 sec
Interface Type	Wireless(ad-hoc)
Mobility Model	Random Way Point
Data Rate(bps)	11Mbps
Transmit Power(W)	0.020
Buffer Size(bits)	1024000
No. of Nodes	20,40,100
Pause Time	200 sec
Protocols	DSR, AODV, OLSR
Traffic Generation Application	FTP

Table1. Simulation Parameters

V. SIMULATION RESULTS

A. Delay 20 nodes:

Fig. 1 show that overall Delay for 20 nodes in OLSR is the Minimum, in AODV is less than DSR and in DSR, we have the Maximum Delay.

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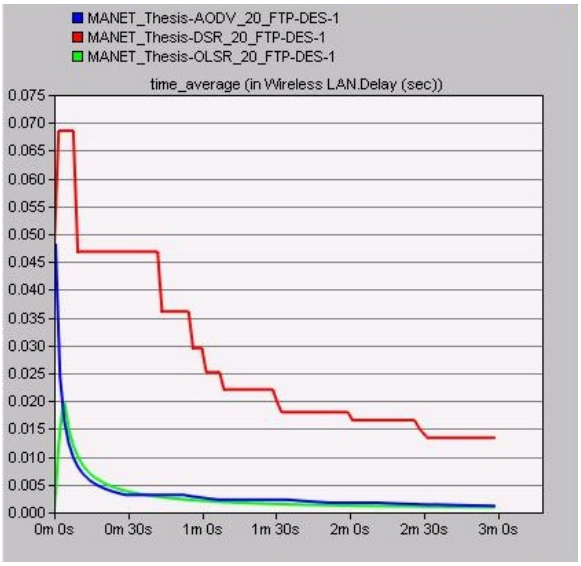

Figure 1. Delay comparison in three routing protocols

B. Delay for 40 nodes:

Fig. 2 show that overall Delay for 40 nodes in OLSR is the Minimum, in AODV is less than DSR and in DSR, we have the Maximum Delay.

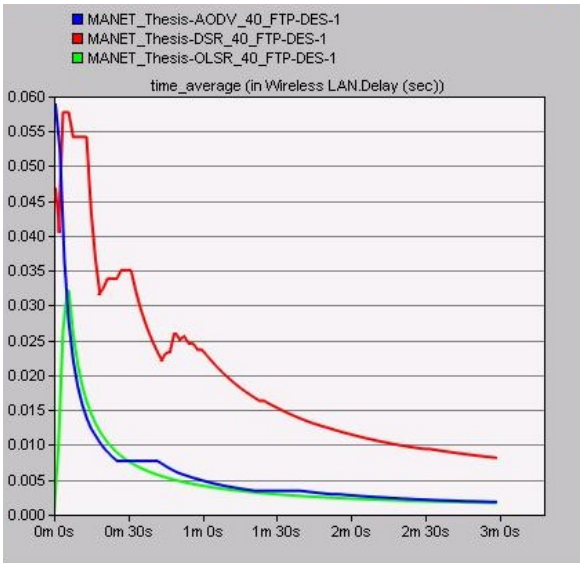

Figure 2. Delay comparison in three routing protocols

C. Delay for 100 nodes:

Fig. 3 show that overall Delay for 20 nodes in OLSR is the Minimum, in AODV is less than DSR and in DSR, we have the Maximum Delay.

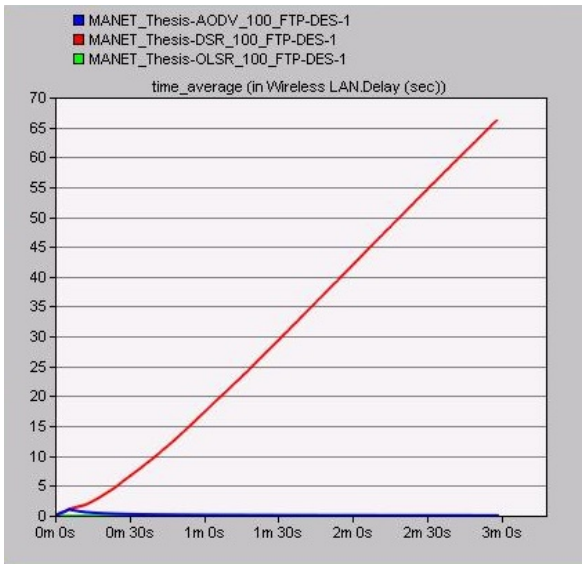

Figure 3. Delay comparison in three routing protocols

D. Overall Delay evaluation:

We can also present performance metrics with KIVIAT diagram. This diagram helps us in quick identification of performance evaluation. We consider the obtained value of three MANET Routing Protocols; AODV, OLSR and DSR. According to Fig. 4, we can conclude that OLSR and AODV perform better than DSR, because of their values in this diagram.

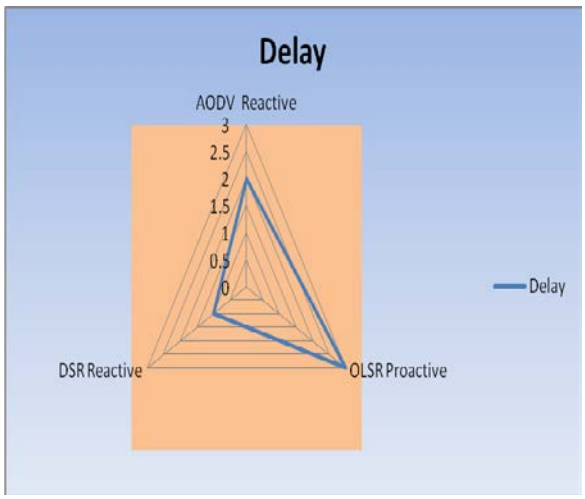

Figure 4. KIVIAT diagram with "Delay" for AODV, OLSR and DSR routing protocols comparison

VI. CONCLUSION

In this paper, Scalable performance of AODV, OLSR, and DSR were evaluated, using OPNET modeler 14.5. We summarized the results in table 2. Numbers used in this table show the best to worst choice in selecting routing protocols. Number "3" represents the best protocol, and number "1" shows the worst one.

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TABLE 2. COMPARISION BETWEEN MANET ROUTING PROTOCOLS

Routing Protocol	Reactive/ Proactive	Delay Number
AODV	Reactive	2
OLSR	Proactive	3
DSR	Reactive	1

From the above table, we can see that, DSR is the worst choice when we consider Delay. Best and Average values belong to OLSR and AODV. In summary, we can say that OLSR perform better than others and DSR is the worst routing protocol here.

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