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Performance Evaluation of Reactive and Proactive Routing Protocols based on Mobility and Offered Load

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***Abstract*— An ad hoc network is a collection of nodes forming a temporary network without the use of any additional infrastructure and no centralized control. In recent years, a variety of new routing protocols targeted but little performance information on each protocol. The goal of this paper is to compare between well known MANETs routing protocols such as DSR, OLSR, AODV and DSDV using Network Simulator (NS2) over CBR traffic with respect to four important routing performance metrics such as Packet Delivery Ratio (PDR), average end-to end delay, average throughput, and normalized routing load(NRL). The simulation study involved considering the effect of mobility and offered load on four routing protocols performance.**

Keywords— **MANET, Routing Protocol, Reactive, Proactive, NS2**

I. INTRODUCTION

The need to provide network systems that can connect various terminal-controlled peripherals such as laptops, personal digital assistants (PDA), sensors, tablets and others wireless data communication devices in locations without any fixed network infrastructure has led to increase proliferation in research on ad hoc network technology field [1].

A wireless ad hoc network is a collection of mobile nodes or terminals that communicate with each other by forming a multi-hop radio network and maintaining wireless link connectivity depending on routing manner that are used. The nodes 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 stand-alone fashion, or may be connected to the Internet [2] [3]. The most appealing thing about MANET is flexibility of communication anytime and anywhere. Each node in ad hoc network works as router which is free to move arbitrary and each of these nodes is responsible for forwarding packets for each others, that's required routing protocol responsible for making routing decisions and be adaptive with such dynamic topology. Designing of routing protocol in ad hoc is considered one of the most important aspects and is a quite challenging task; because it should deals with different issues effectively such as mobility, energy, frequently change in network topology, security and etc [4].

Data communication in a MANET differs from that of wired networks in different aspects. The wireless communication medium does not have a foreseeable behaviour as in a wired channel. On the contrary, the wireless communication medium has variable and unpredictable characteristics. The signal strength and propagation delay may vary with respect to time and environment where the mobile nodes are. Unlike a wired network, the wireless medium is a broadcast medium; that is, all nodes in the transmission range of a transmitting device can receive a message [5].

II. ROUTING PROTOCOL IN MANETS

Routing is the mechanism by which user traffic is directed and transported through the network from the source node to the destination node. Routing is one of the most important aspects in Ad Hoc networks because Ad Hoc network topologies are frequently change and multi-hop communication is required. In Ad Hoc networks, source and destination nodes might be separated or destination is not in the source power range, thus packets from the source to the destination need to be forwarded by multiple nodes. So routing has two main functions, selection of routes for various source-destination pairs, forwarding and delivery of packet to correct destination. The forwarding and processing packets are depending on routing strategy such as flooding, source routing and so on [5].

There is a large number of routing protocols that have been proposed [2]-[5], each having their own pros and cons, routing protocols in ad hoc fall in two categories called proactive and reactive protocols.

Proactive routing protocols maintain the routing information of all the participating nodes and update their routing information frequently irrespective of the routing requests. Unlike the proactive protocols: reactive protocols do not update their routing information frequently and will not maintain the network topology information, it establishes the route only when it is required. Next we will describe four routing protocols that will be used in our evaluation study.

A. Ad hoc On-Demand Distance Vector (AODV)

AODV is a reactive protocol that builds routes between two nodes only if a communication between these two nodes is desired [6].

Mobile nodes in the Ad Hoc network are dynamic and they use multi-hop routing by using Ad Hoc On-Demand Distance Vector algorithm. Mobile nodes respond to any change in the network topology and link failures in necessary times. In case of the link failures the respective defective nodes are notified with the message, and then the affected nodes will revoke the routes using the lost link. This will help AODV to avoid the Bellman-Ford "counting to infinity" problem. AODV uses three types of control message that are Route Request (RREQ), Route Replies (RREP) and Route Error (RERR) for finding the route from source to destination [5] [6].

The Route Request-packet is broadcasted by an origin node if it doesn't have a route to a destination node to which it desires to send a data packet. This packet is relayed in broadcast by all neighboring nodes receiving it and forwarded further through the network until it reaches a node that knows the requested destination, possibly the destination itself. This node then generates a Route Reply-packet as a positive reply which is forwarded in unicast back on the reverse path that was created while forwarding the Route Request. These two packets are used by the source, the destination and all intermediate nodes on the route to create appropriate route table entries. The Route Error-packet is only sent if an intermediate node on the route cannot relay a data packet for a specific node.

In addition, AODV uses Destination Sequence Numbers (DSN) for every route entry [6]. Destination Sequence Number is created by the destination; this DSN and the respective route information have to be included by the nodes while finding the routes to destination nodes. Routes with the greatest DSN are preferred in selecting the route to destination.

B. Dynamic Source Routing (DSR)

DSR is also a reactive routing protocol [7]. It is known as simple and efficient, specially designed for the multi-hop mobile Ad Hoc network. DSR protocol plays a key role in determining and maintaining all the routing automatically as the number of hops needed changes at anytime and the mobile nodes involved may leave or join the network. DSR protocol involves two major mechanisms called route discovery and route maintenance that work together to establish and maintain the routing process [2]. Route discovery is the mechanism by which a source node S wishing to send a packet to a destination node D obtains a source route to D. Route discovery is used only when S attempts to send a packet to D and does not already know a route to D. in Route maintenance mechanism is used to repair broken route while using a source route to D, for example, if the network topology has changed such that it can no longer use its route to D because a link along the route no longer works. When Route maintenance indicates a source route is broken, S can attempt to use any other route it happens to know to D, or can invoke route discovery again to find a new route for subsequent packets to D. Route maintenance for this route is used only when S is actually sending packets to D.

C. Optimized Link State Routing (OLSR)

OLSR is a table driven protocol [8]. It usually stores and updates its routes so when a route is needed. OLSR exchanges the topology information always with other nodes. Few nodes are selected as MPRs (Multi point relays). MPRs are responsible for transmission of broadcast messages during flooding and generating link state information. MPRs technique used in OLSR protocol will reduce the message overhead and even minimize the number of control messages flooded in the network [2]. Nodes maintain the information of neighbours and MPR's, by sending and receiving HELLO messages from its neighbours. Each node with a nonempty MPR selector set periodically generates a Topology Control message (TC message) [2]. This TC message is diffused to all nodes in the network at least every TC Interval. A TC message contains the list of neighbours that have selected the sender node as a multipoint relay. The information diffused in the network by these TC messages will help each node to build its topology table. Based on this information, the routing table is calculated.

D. Destination Sequence Distance (DSDV)

DSDV is proactive routing protocol [9], it operation is based on distance vector algorithm, it uses routing table by which each node maintain table that tagged with sequence number, generated by destination. The Routing table of each node maintained consistent by periodic exchange a routing information between nodes, Packets are transmitted periodically and incrementally as changes are detected. DSDV prevent occurrence of loops, DSDV adds an even sequence number to each routing table entry of the standard distance vector routing protocol and includes it in each routing update being sent [5]. Nodes detecting broken links to a neighbour create new entries with an "infinite" metric and the next odd sequence number after the even sequence number in its corresponding routing table entry. When a node receives a route update, for each entry in the route update, it accepts the entry if it has a higher sequence number, or if it has an equal sequence number and a lower metric than the route entry currently in the node's route table for this destination.

III. Related Work

In this section, we will investigate the works that issued relating to MANET routing protocols. A series of works have been published related to this issue. We will present some of these publishing papers.

Aleksandr [10] focused on two routing protocol called Ad hoc On-Demand Distance Vector and Optimized Link State Routing Protocol. Their study show that The AODV protocol will perform better in the networks with

static traffic with the number of source and destination pairs is relatively small for each host, also the OLSR protocol is more efficient in networks with high density and highly sporadic traffic.

Nadia et al [11] compared the performance of three routing protocols called ad hoc on demand distance vector protocol; optimized link state routing protocol and temporary ordered routing algorithm protocol in OPNET [12] under ftp traffic. The simulation results shows that optimized link state routing protocol is a very effective, efficient route discovery protocol for MANETs.

P. Manickam et al [13] compared the performance of the three MANET Routing protocols (DSDV, AODV and DSR) using NS2 Simulator, the simulation result shows that AODV performs better in case of packet delivery ratio but it performs badly in terms of average End-to-End delay and throughput, however, DSR is preferable and outperforms AODV for moderate traffic with moderate mobility, in addition suitable for limited number of nodes with low mobility due to the storage of routing information in the routing table at each node.

Ashish Shrestha [14] presented a performance comparison of the three MANET routing protocols (AODV, OLSR, TORA) using OPNET in term of mobility and scalability. The simulation results show that AODV and OLSR experienced higher packet delay and network load compared to TORA. However, AODV showed better efficiency to deal with high congestion and it scaled better by successfully delivering packets over heavily trafficked network compared to OLSR and TORA.

Akshai Aggarwal [15] studied the performance of three routing protocols AODV, DSR and DSDV using NS2, with varying mobility and number of nodes scenarios. The simulation results shows that AODV performs better in a network with a larger number of nodes whereas DSR performed better when the number of nodes is small, however Normalized routing load (NRL) for AODV increased at a higher rate compared to that in DSDV & DSR with increasing number of nodes in networks. In this paper, we will compare the performance of MANET routing protocols using NS2 in term mobility and offered load.

IV. Performance Metrics

In this paper, we consider following four performance metrics to compare the four routing protocols, the performance metrics are calculated from trace file by using AWK language [16]:

A. Average End-to-End Delay

The average end-to-end delay measures the average delay for a data packet when travelling from a source node to a destination node. It considers route discovery delay, different interfacing delay, queuing delay, propagation delay and transmission delay of data packets.

B. Packet Delivery Ratio (PDR)

PDR is the ratio of the data packets received successfully by the destination to the data packets sent by the sources.

C. Average Throughput

Throughput is defined as the total amount of data a receiver R actually receives from the sender S divided by the time it takes for R to get the last packet.

D. Normalized Routing Load (NRL)

This is the ratio of the number of protocol control packets transmitted to the number of data packets received.

V. Simulation Setup

The evaluation of routing protocols is implemented with the network simulation version 2 (NS2) which is a discrete event simulator and the topology is created by the shell script tool called setdest [16]. The speed and initial position of nodes is generated randomly and the nodes are placed within a (600×600) m area. The node mobility speed is between (1 m/s) and (12 m/s) generated by uniform distribution and the simulation time is 100s. A Constant bit rate (CBR) traffic source is used and the source-destination pairs are spread randomly over the network. Only 512 byte data packet size is used. Radio propagation range for each node is 250 m and channel capacity is (2 Mbit/s). The number of source-destination pairs is chosen randomly in all scenarios. All simulation parameters are configured by Tool Command Language (TCL) [17] and are shown in Table (1).

TABLE (1) Simulation Parameters

Parameter	**Value**
Routing protocol	DSDV, DSR, OLSR, AODV
Number of nodes	25
Transport layer	UDP
MAC layer	802.11b
Traffic type	Constant bit rate (CBR)
Range of transmission	250 m
Offered load	100, 200,300,400,500 Kbps
Mobility model	Random way point
Simulation time	90 sec
Data Packet Size	512Bytes
Antenna type	Omni directional antenna
Antenna height	1.5 m
Frequency	2.4 GHZ
Propagation Model	Two Ray Ground

VI. Simulation Results

In this section, the performance comparison of four MANET routing protocols (AODV, DSR, DSDV, and OLSR) is taken into account in term of mobility and offered load. In the mobility scenario, we will consider a mobility effect on the performance of protocols, the scenario is built which consist of 25 mobile nodes move randomly with a speed changed from (1-12) m/sec over (600X600) m network size, the source and destination nodes are chosen to transmit a rate equal to 100 kbps. Considering figure (1), it shows that average end to end delay increases linearly as mobility increased, and proactive protocols (DSDV, OLSR) give lesser end to

end delay than reactive protocols (DSR, AODV). In terms of PDR and average throughput in mobility scenario, reactive protocols gives better performance than proactive protocols where DSR and AODV PDR equals to 100% as mobility (<=5 m/sec), and it degrades to 98% as mobility reaches to 12 m/sec as shown in figures (2 and 3). In addition, reactive protocols give better performance than proactive protocols (OLSR, DSDV) with respect to NRL as depicted in figure (4) because proactive protocols depends on periodic exchange of control message to build its own routing tables as compared to reactive protocols which doesn't depend on periodic exchange of control packets, it only send control packet when route to destination is required.

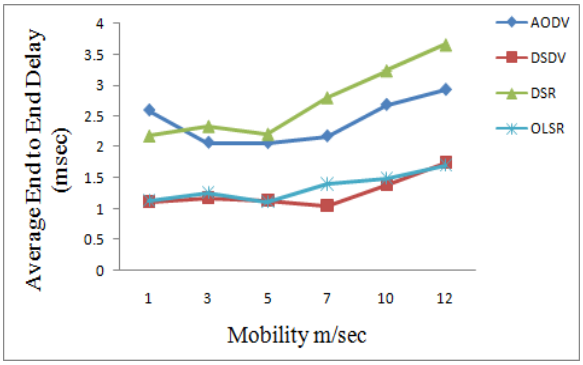

Figure (1) Average end-to-end delay versus mobility

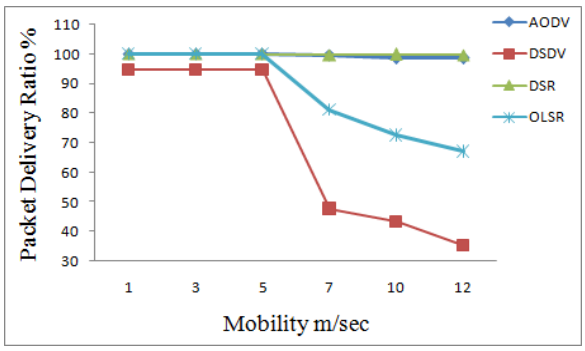

Figure (2) Packet delivery ratio versus mobility

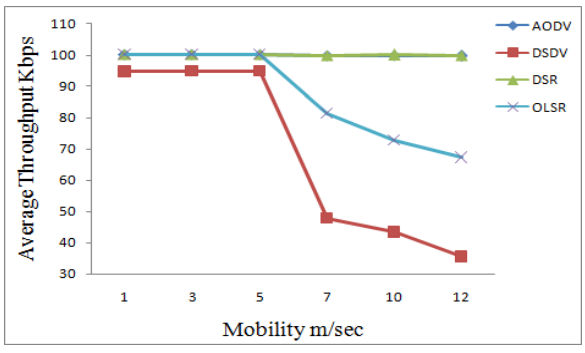

Figure (3) Average throughput versus mobility

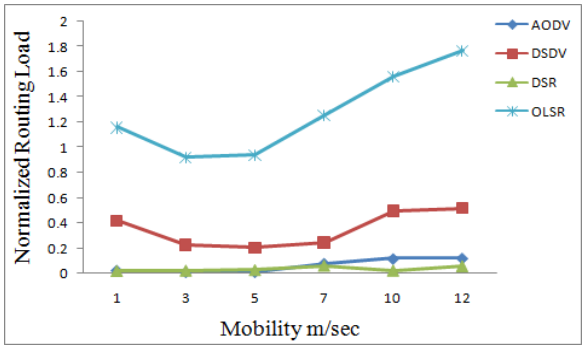

Figure (4) Normalized routing load versus mobility

In offered load scenario, The simulation scenario considers the effect of offered load on performance of protocols, also the network area (600X600) m is built consisting of 25 mobile nodes with the offered load is changed between (100-500 Kbps), a random waypoint mobility model is used with node speed varied between (1-10) m/sec.

Figures (5, 6, 7, and 8) show the effect of changing offered load versus performance metrics such as packet delivery ratio, normalized routing load, average end to end delay and average throughput respectively.

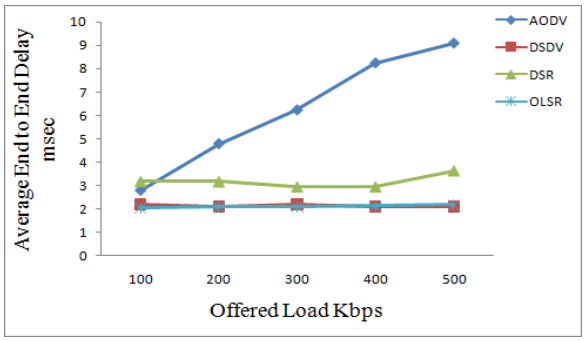

Figure (5) Average end to end delay versus offered load

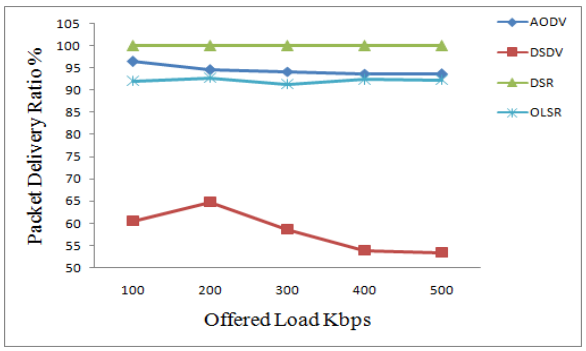

Figure (6) Packet Delivery ratio versus offered load

As offered load increased, AODV gives higher delay followed by DSR and finally proactive protocols which give minimum delay. In term of PDR, DSR outperforms all other protocols, followed by AODV, OLSR and DSDV which gives minimum PDR value as shown in figure (6). In term of average throughput, all protocols give increased in throughput as offered load increased

except DSDV which gives minimum throughput as shown in figure (7). The normalized routing load versus offered load is shown in figure (8), where OLSR protocol gives higher NRL followed by DSDV, AODV, and DSR. Proactive protocols give higher NRL because it depends on periodic exchange of control packets.

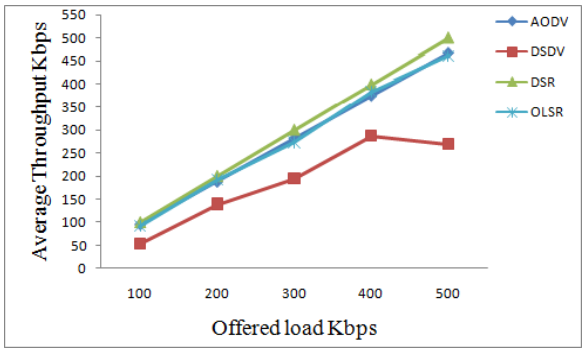

Figure (7) Average throughput versus offered load

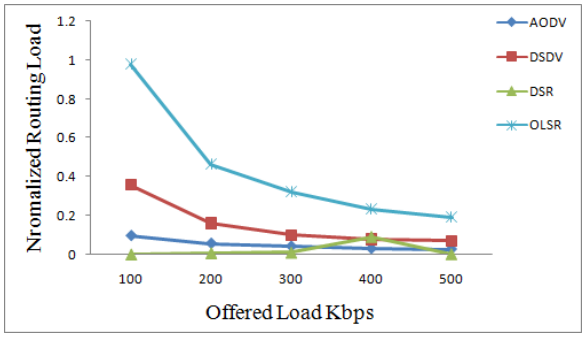

Figure (8) Normalized routing load versus offered load

VII. CONCLUSIONS

In this paper, a performance comparison of reactive (DSR, AODV) and proactive (OLSR, DSDV) routing protocols for MANET is presented as a function of mobility and offered load. Network topology is built in NS2 which consists of 25 mobile node, and the performance of routing protocols is evaluated with four performance metrics such as packet delivery ratio, average throughput, average end to end delay, and normalized routing load. According to our simulation results, DSR shows better performance than AODV, DSDV and OLSR in term of PDR in mobility and offered load scenarios. Also in both scenarios reactive protocols give approximately the same performance with respect to average throughput, and it's better than proactive protocols. with respect to NRL, reactive protocols give lower NRL value as compared with proactive, because proactive protocols depends on periodic exchange of control message to build it own routing tables. However, the proactive protocols achieve minimum end to end delay, because it previously has route to each node in network that store node ID in routing table.

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