Performance Analysis of MANET Routing Protocols AODV, OLSR and TORA under the different Traffics (CBR and VBR)

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***Abstract*—** A mobile ad hoc network (MANET) consists of mobile wireless nodes. The communication between these mobile nodes is carried out without any centralized control. MANET is a self organized and self configurable network where the mobile nodes move arbitrarily. The main classes of MANET routing protocols are Proactive, Reactive and Hybrid. In this paper we compare performance of Proactive routing protocol by focusing on Optimized Link State Routing (OLSR) and Reactive Routing Protocol by focusing on Ad Hoc On Demand Distance Vector (AODV) and Temporally Ordered Routing Algorithm (TORA). In this paper our simulation tool is OPNET modeller. The performance of these routing protocols is analysed by three metrics: delay, network load and throughput. This paper presents a performance analysis of three Mobile Ad Hoc Network (MANET) routing protocols – AODV, OLSR and TORA under the two mobility models i.e. Random Way Point and Random Walk Mobility Model. Each routing protocol was configured into two network scenarios with the default and modified parameters in order to achieve better transmission characteristics. The final evaluation is presented at the end of this paper.

***Keywords*—** MANET, AODV, OLSR, TORA, OPNET Simulator, Mobility Models

I. INTRODUCTION

MANET stands for Mobile Ad hoc Network. It is a decentralized autonomous wireless system which consists of free nodes. Nodes communicate with each other without the use of predefined infrastructure. In this network nodes will generate both user and application traffic and carry out network control and routing duties. Mobile Ad hoc Networks have the attributes like wireless connection, different types of topology, distributed operation and some communication protocol. The primary challenge in building a MANET [4][5] is equipping each device to continuously maintain the information required to route traffic. MANET routing protocols are traditionally divided into three categories which are Proactive Routing Protocols, Reactive Routing Protocols, Hybrid. Proactive Routing Protocols [6][7] are also called table driven routing protocols and it constantly maintain the updated topology of the network. Each node in this protocol maintains individual routing table which contains routing information of every node in the network. Reactive Routing Protocol is also called on-demand routing protocol. Reactive protocols do not initiate route discovery by themselves, until they are requested. Hybrid Routing Protocols can be derived from the two previous ones, containing the advantages of both the protocols. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding.

II. AD-HOC ROUTING PROTOCOLS

This section describes the main features of three protocols AODV (Ad hoc On-demand Distance Vector) [1] and OLSR (Optimized Link State Routing) [2],Temporally Ordered Routing Protocols Algorithm (TORA) [3] deeply studied using OPNET14.5 .

An ad-hoc routing protocol is a convention, or standard, that it improves the scalability of wireless networks compared to infrastructure based wireless networks because of its decentralized nature. Ad-hoc networks are best suited due to minimal configuration and quick operation.

Figure 1: MANET

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

AODV [1] provides a good compromise between proactive and reactive routing protocols. AODV uses a distributed approach which means that a source node is not required to maintain a complete sequence of intermediate nodes to reach the destination [10]. It is also an improvement from DSR by addressing the issue of high messaging overhead and large header packets in maintaining routing tables at nodes, so that packets do not have to store much routing information in the headers. AODV uses a routing table in each node and keeps one to two fresh routes. The incorporated features of AODV include features of DSDV, like the use of hop by hop routing, periodic beacon messaging and sequence numbering. A periodic beacon message is used to identify neighbouring nodes. The sequence numbering guarantees a loop free routing and fresh route to destination. AODV has the advantage of minimizing routing table size and broadcast process as routes are created on demand [9]. The two mechanisms; route discovery and route maintenance of AODV are like those of DSR .AODV is an on-demand routing protocol. The AODV [9] algorithm gives an easy way to get change in the link situation. For example if a link fails notifications are sent only to the affected nodes in the network. This notification cancels all the routes through this affected node. It builds unicast routes from source to destination and that's why the network usage is least. Since the routes are build on demand so the network traffic is minimum. AODV does not allow keeping extra routing which is not in use [10]. If two nodes wish to establish a connection in an ad hoc network then AODV is responsible to enable them to build a multihop route. AODV uses Destination Sequence Numbers (DSN) to avoid counting to infinity that is why it is loop free. This is the characteristic of this algorithm. When a node send request to a destination, it sends its DSNs together with all routing information. It also selects the most favorable route based on the sequence number [10]. There are three AODV messages i.e. Route Request (RREQs), Route Replies (RREPs), and Route Errors (RERRs) when the source node wants to create a new route to the destination, the requesting node broadcast an RREQ message in the network [9]. The RREQ message is broadcasted from source node A to the destination node B. The RREQ message is shown by the black line from source node A to many directions. The source node A broadcasts the RREQ message in the neighbour nodes. When the neighbour nodes receive the RREQ message it creates a reverse route to the source node A. This neighbour node is the next hop to the source node A. The hop count of the RREQ is incremented by one. The neighbour node will check if it has an active route to the destination or not. If it has a route so it will forward a RREP to the source node A. If it does not have an active route to the destination it will broadcast the RREQ message in the network again with an incremented hop count value. The procedure for finding the destination node B. The RREQ message is flooded in the network in searching for finding the destination node B. The intermediate nodes can reply to the RREQ message only if they have the destination sequence number (DSN) equal to or greater than the number contained in the packet header of RREQ.

The intermediate nodes forward the RREQ message to the neighbour nodes and record the address of these nodes in their routing cache. The destination node B replies with RREP message denoted by the dotted orange line, the shortest path from destination B to source A. The RREP reached to the originator of the request. This route is only available by unicasting a RREP back to the source. The nodes receiving these messages are cached from originator of the RREQ to all the nodes.

When a link is failed an RERR message is generated. RERR message contains information about nodes that are not reachable. The IP addresses of all the nodes which are as their next hop to the destination.

B. OLSR (Optimized Link State Routing)

The OLSR [2][8] protocol is an optimised pure state link algorithm. It is designed to reduce retransmission duplicates and with a proactive nature the routes are always available when needed. It uses hop by hop mechanics when forwarding packets. It is a proactive routing protocol and is also called as table driven protocol because it permanently stores and updates its routing table. OLSR [6][7] keeps track of routing table in order to provide a route if needed. OLSR can be implemented in any ad hoc network. Due to its nature OLSR is called as proactive routing protocol. All the nodes in the network do not broadcast the route packets. Just Multipoint Relay (MPR) nodes broadcast route packets. These MPR nodes can be selected in the neighbor of source node. Each node in the network keeps a list of MPR nodes.

This MPR selector is obtained from HELLO packets sending between in neighbor nodes. These routes are built before any source node intends to send a message to a specified destination. Each and every node in the network keeps a routing table. This is the reason that the routing overhead for OLSR [8] is minimum than other reactive routing protocols and it provide a shortest route to the destination in the network. There is no need to build the new routes, as the existing in use route does not increase enough routing overhead. It reduces the route discovery delay.

C. TORA (Temporally Ordered Routing Algorithm)

TORA is a routing algorithm. It is mainly used in MANETs to enhance scalability. TORA is an adaptive routing protocol. It is therefore used in multi-hop networks. A destination node and a source node are set. TORA establishes scaled routes between the source and the destination using the Directed Acyclic Graph (DAG) built in the destination node. This algorithm does not use 'shortest path' theory, it is considered secondary. TORA builds optimized routes using four messages. Its starts with a Query message followed by an Update message then clear message and finally Optimizations message. This operation is performed by each node to send various parameters between the source and destination node. The parameters include time to break the link (t), the originator id (oid), Reflection indication bit (r), frequency sequence (d) and the nodes id (i). The first three parameters are called the reference level and last two are offset for the respective reference level. Links built in TORA are referred to as 'heights', and the flow is from high to low. At the beginning, the height of all the nodes is set to NULL i.e. (-,-,-,-,i) and that of the destination is set to (0,0,0,0,dest). The heights are adjusted whenever there is a change in the topology. A node that needs a route to a destination sends a query message with its route required flag. A query packet has a node id of the intended destination. When a query packet reaches a node with information about the destination node, a response known as an Update is sent on the reverse path. The update message sets the height value of the neighbouring nodes to the node sending the update. It also contains a destination field that shows the intended destination.

III. EXPERIMENTAL SET UP

We carried out simulations on Opnet [3] simulator. The simulation parameters are summarized in table 1.

Table 1. Simulation parameters

Parameter	**Value**
Simulator	Opnet 14.5
Area	3.5×3.5 Km
Wireless MAC	802.11
Number Of Nodes	50
Mobility Model	Random Walk, Random Waypoint Mobility
Data Rate	11 Mbps
Routing Protocols	AODV,OLSR and TORA
Simulation Time	5 minutes
Traffic	CBR, VBR, TCP

Figure 2. shows a sample network created with 50 Nodes, one static FTP server, application configuration and profile configuration for the network in which FTP has been chosen as an application. Figure 2 depicts a network with 50 fixed nodes whose behaviour has to be analysed nodes in the network with respect to time to determine the effecting features of each protocol.

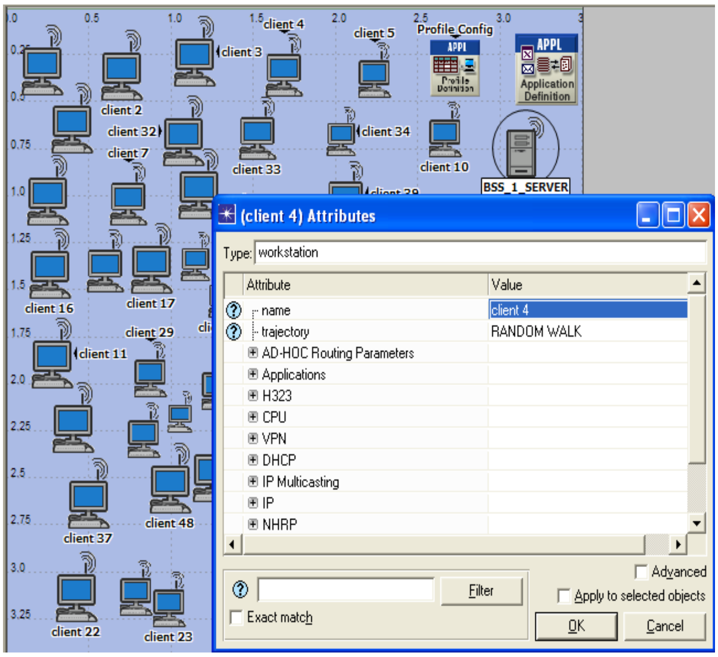

Figure 2. Network created with 50 nodes

IV. PERFORMANCE PARAMETERS

OPNET modeler 14.5[6][7] is used to investigate the performance of routing protocols AODV, OLSR and TORA with varying network sizes, data rates, and network load. We evaluate three parameters in our study on overall network performance. These different types of parameter show the different nature of these Protocols, the parameters are throughput, delay and network load.

A. *Throughput*

Throughput is defined as the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput [9]. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec).

B. *Delay*

The packet end-to-end delay is the time of generation of a packet by the source up to the destination reception. So this is the time that a packet takes to go across the network. This time is expressed in sec. Hence all the delays in the network are called packet end-to-end delay [11], like buffer queues and transmission time. Sometimes this delay can be called as latency; it has the same meaning as delay.

$$d_{end\text{-}end} = N[d_{trans} + d_{prop} + d_{proc}]$$

Where

$d_{end\text{-}dend}$ = End to end delay

d_{trans} = Transmission delay

d_{prop} = Propagating delay

d_{proc} = Processing delay

Suppose if there are n number of nodes, then the total delay can be calculated by taking the average of all the packets, source destination pairs and network configuration.

C. *Network Load*

Network load represents the total load in bit/sec submitted to wireless LAN layers by all higher layers in all WLAN nodes of the network [10]. When there is more traffic coming on the network, and it is difficult for the network to handle all this traffic so it is called the network load.

V. RESULTS

We carried out simulations on Opnet simulator14.5. The results show differences in performance between considered routing protocols, which are the consequence of various mechanisms on which protocols are based. We carried out our simulations with 50 nodes.

Figures 3,4,5,6,7 and 8 depicts the throughput, delay and network load of this network with respect to total simulation time which is taken as 5 minutes for which the simulation was run.

In this simulation, the networks is set to 50 nodes, the traffic type is TCP, CBR and VBR, the data transmission rate is 11 Mbps and the simulation time is 5 minutes.

A. *Throughput*

In this figure, it shows that OLSR protocol outperforms both AODV and TORA protocol in 50 nodes simulation setup and is able to handle both Constant and variable traffic perfectly. Overall we observe OLSR gives better throughput than other two.

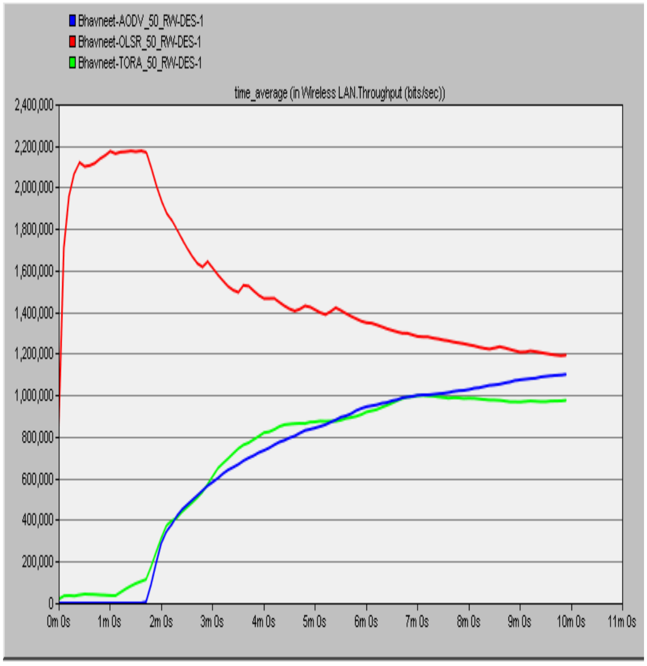

Figure 3. Throughput (50 Nodes Random Walk)

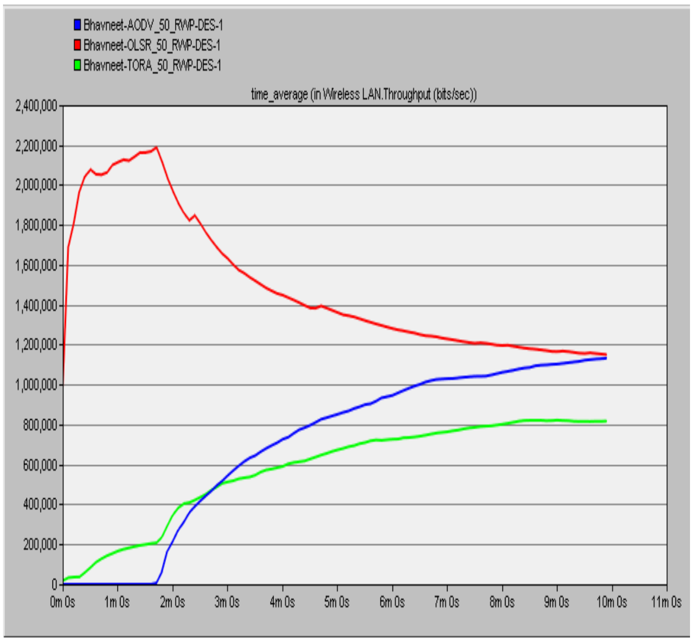

Figure 4. Throughput (50 Nodes Random Way Point)

Thus we see that Random Way Point model gives slightly better throughput for AODV and OLSR and Random Walk for TORA.

B. *Delay*

In Fig.5, we see that again OLSR outperforms both AODV and TORA in terms of end to end delay experienced in the network. AODV protocol under both Random Way Point and Random Walk Mobility Model experiences high delay.

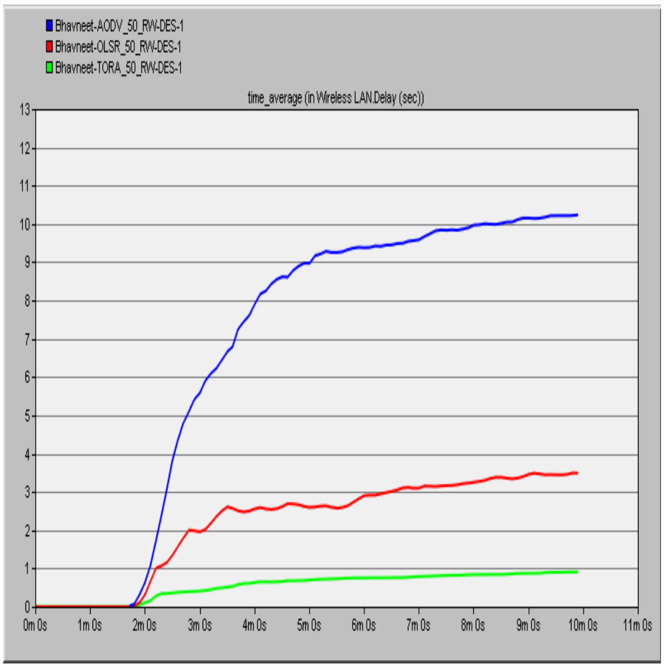

Figure 5. Delay (50 Nodes Random Walk)

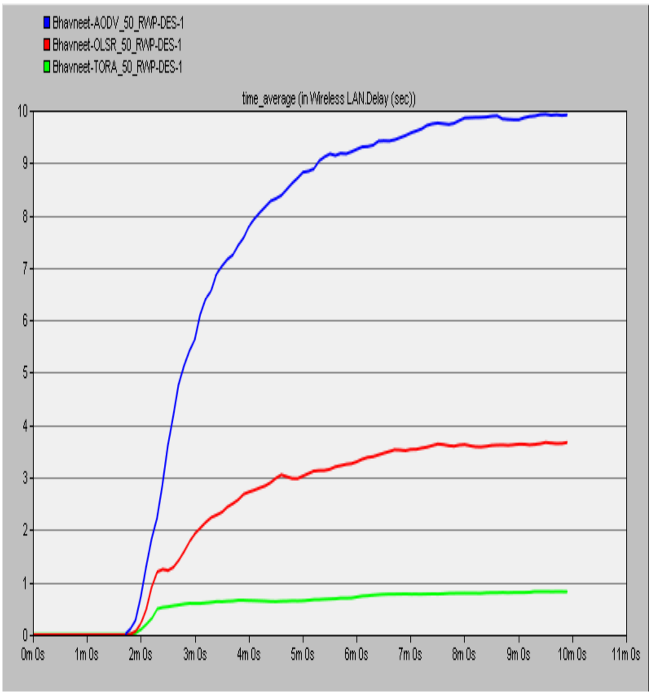

Figure 6. Delay (50 Nodes Random Way Point)

C. *Network Load*

According to simulation, as we can see in Fig. 7, Network load AODV has the best performance with regardless of Network size and mobility. That stable behaviour of AODV is a desirable property of a protocol as it indicates that it can scale well in networks in which the mobility changes over time.

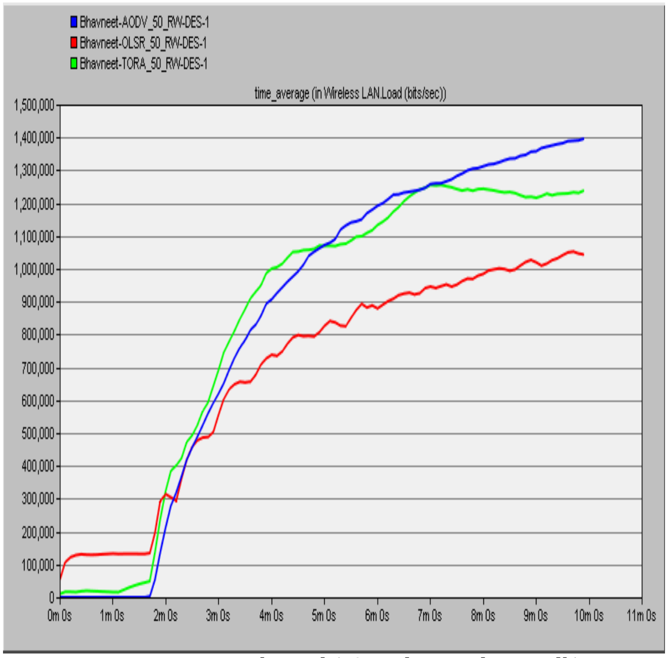

Figure 7. Network Load (50 Nodes Random Walk)

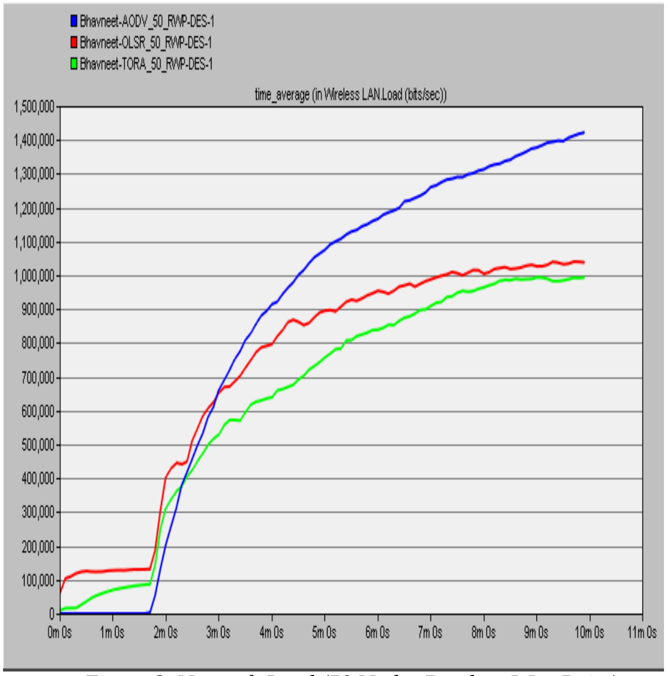

Figure 8. Network Load (50 Nodes Random Way Point)

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VI. CONCLUSION

We have evaluated the three performance measures i.e. Network Load, End-to-end delay and Throughput with different mobility models (Random Walk model and Random Waypoint Mobility model) and TCP, CBR and VBR as traffic type while taking 50 nodes. From the extensive simulation results, in this paper we found that OLSR shows the best performance in terms of throughput, load. Moreover, Random Way Point Model outperforms Random Walk Model for all three routing protocols i.e. AODV, OLSR and TORA At the end we came to the point from our simulation and analytical study that the performance of routing protocols vary with network and selection of accurate routing protocols according to the network, ultimately influence the efficiency of that network in magnificent way.

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