# PERFORMANCE ANALYSIS OF VARIOUS MANET ROUTING PROTOCOLS USING OPNET SIMULATOR

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**ABSTRACT-** This paper provides a various mobile ad hoc network routing protocols namely AODV,DSR, OLSR and TORA and its performance in OPNET modeller. The mobile nodes were randomly placed in the network to give the possibility of multi hop routes from a node to the server. The protocols were simulated under varying conditions like node mobility, node density and with FTP traffic. The performance analysis of above mentioned routing protocols is determined with respect to routing overhead, throughput, end-to-end delay and packet delivery ratio. The performance of the routing protocol depends on various factors such as network load and mobility effects. In this paper, the performance of AODV, DSR, OLSR and TORA ad hoc routing protocols were evaluated in OPNET under varying network load and mobile speeds.

**Keywords**: MANET, AODV, DSR, OLSR, TORA, OPNET

## I. INTRODUCTION

An ad hoc mobile network is a network which is a collection of randomly located wireless mobile nodes without the help of existing infrastructure network or centralized administration [1]. Due to the dynamic nature of nodes in the mobile ad hoc network, the network topology changes frequently which results in difficulty and complexity to routing among the mobile nodes within the network. These factors make the routing protocols vital in establishing communications among mobile nodes. In recent years, a lot of routing protocols and algorithms have been proposed and their performance under various traffic conditions and network environments studied and compared. The MANET provides a set of standard protocols which is robust and scalable to provide fast commercialization of mobile ad hoc networks in increasing network applications.

In general, ad hoc network routing protocols may be divided into two different categories. These are Proactive routing protocols and Reactive on-demand routing protocols[1]. Proactive routing protocols maintain up-to-date routing information between every pair of nodes in the network by sending, proactively, route updates at fixed time intervals. In proactive protocol, routing information is usually maintained in tables, the protocols are sometimes referred to as table-driven protocols. On the other hand, reactive on-demand routing protocols, , a route can be established to a destination only when there is a need, in general it is initiated by the source node through route discovery process within the network. Once a route has been established, it is maintained by the node until either the destination becomes inaccessible along every path from the source or has expired or until the route is no longer used.

Proactive protocols includes Destination-Sequenced Distance-Vector (DSDV) protocol, Cluster head Gateway Switch Routing (CGSR) protocol, Wireless Routing Protocol (WRP), Global State Routing (GSR), Optimized Link State Routing Protocol (OLSR), Fisheye State Routing (FSR) Protocol, Landmark Routing(LANMAR) Protocol, and Hierarchical State Routing (HSR).

Reactive routing protocols consist of Dynamic Source Routing (DSR), Ad-hoc on-Demand Distance Vector (AODV), Temporally Ordered Routing Algorithm (TORA), Associativity Based Routing (ABR), and Signal Stability Routing (SSR).

This paper is organized as follows: Section 1 dealt with the review the workings of the AODV, DSR, OLSR and TORA MANET routing protocols. Section2 provides the Performance metrics for evaluation. Section 3 gives simulation results and conclusions are given in Section 4.

## II. Review of Routing Protocol

### Optimized Link State Routing (OLSR)

Optimized Link State Routing (OLSR) [2] protocol gives the stability of link state algorithm. In general, in a pure link state protocol, all the links with neighbour nodes are affirmed and are flooded in the entire network. But, OLSR is an optimized version of a pure link state protocol only designed for MANET. This protocol performs hop-by-hop routing that means, every node in the network uses its most recent information to route a packet. Therefore, even when a node is moving, the packets can be effectively delivered to it, if its speed is such that its movements could be followed in its neighbourhood. In this routing, the optimization is done mainly in two ways. Firstly, OLSR reduces the size of the control packets for a particular node by intimating only a subset of links with the node‵s neighbours who are its multipoint relay selectors, instead of all links network. Secondly, it reduces flooding of the control traffic by only using the selected nodes, called multipoint relays (MPR) to spread information in the network. Since only multipoint relays of a node can retransmit its broadcast messages, it considerably reduces the number of retransmissions in a flooding or broadcast procedure. Figure 1.1 shows a sample network structure used in OLSR.OLSR protocol relies on the selection of multipoint relay nodes. Each node calculates the routes to all known destinations through these nodes. These MPRs are selected among the one hop neighbourhood of a node using the bidirectional links, and they are used to reduce the amount of broadcast traffic in the network.

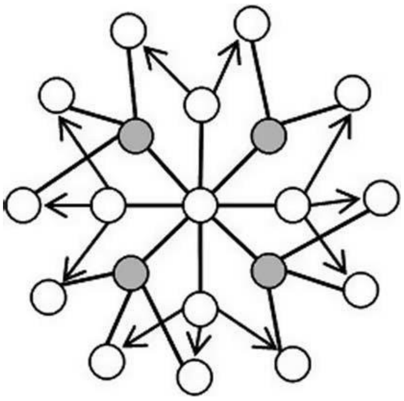
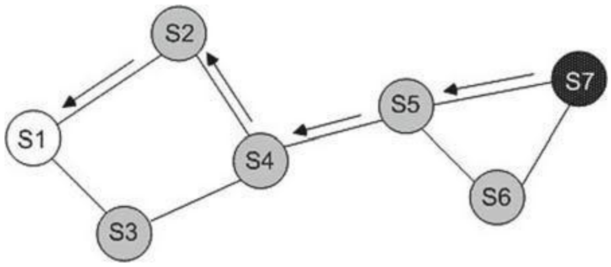


Fig. 1.1 Multipoint Relays (MPRs) are in gray colour. The transmitting node is shown at the center of the sample structure

### Ad Hoc On-Demand Distance Vector Routing(AODV)

Ad Hoc On-Demand Distance Vector Routing [3] is a reactive type routing protocol. It reduces the number of broadcasts by creating routes based on need. When any source node wants to send a packet to a destination, it starts the process and it broadcasts a route request (RREQ) packet. The neighbouring nodes sequentially broadcast the packet to their neighbours and the process continues until the packet reaches the destination. During the forwarding process of the route request, intermediate nodes trace the address of the neighbour from which is the first copy of the broadcast packet is received. This record is saved in their route tables, which helps for establishing a reverse path. If extra copies of the same RREQ are received later, these packets are discarded. By using the reverse path the reply message is sent. For route maintenance phase, when a source node leaves, it re-initiates a route discovery procedure. If any intermediate node moves within a particular route, the neighbour of the drifted node can identify the link failure and gives a link failure announcement to its upstream neighbour. This procedure prolonged until the failure notification attains the source node. Based on the received information, the source may decide to re-initiate the route discovery phase. Figure 1.2 shows an example of AODV protocol operation details. In this Figure, S1 is the source node and S7 is the destination node. The source node initiates the route request and the route is created based on need. Route reply is sent using the reverse path from the destination node.

(a)

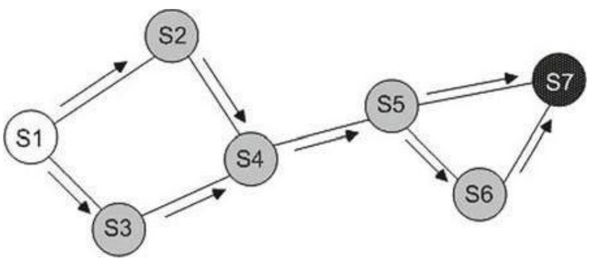


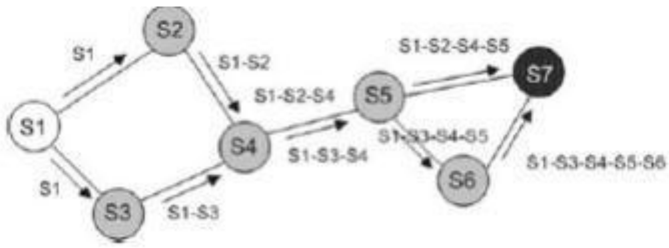

(b)

Figure 1.2 AODV protocol (a) Source node broadcasting the route request packet. (b) Route reply is sent by the destination using the reverse path

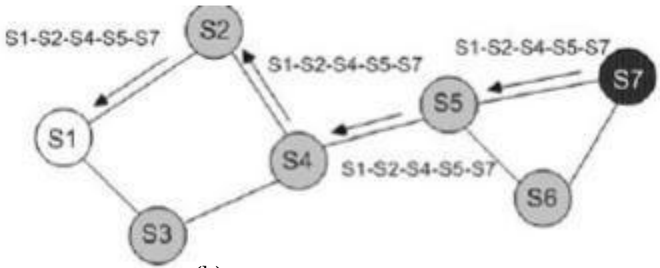
### Dynamic Source Routing (DSR)

Dynamic Source Routing [4] allows nodes in the MANET to dynamically cover a source route across multiple network hops to any destination. In DSR protocol, the mobile nodes are required to preserve route caches or the known routes. Update the route cache, when any new route is known for a particular entry in the route cache. Routing in DSR is done by using two phases. One route discovery phase another route maintenance phase. When a source node desires to send
a message packet to a destination, it first consults its route cache to determine whether it already knows about any route to the destination or not. If already there is a route entry for that destination, the source node uses that to send the packet. Otherwise, it initiates a route request broadcast process. This route request includes the source address, destination address and a unique identification number. Every intermediate node verifies whether it knows about the destination or not. If the intermediate node does not know about the destination, it forwards the packet another time and finally this reaches the destination. A node processes the route request packet as long as it has not previously processed the packet and its address is absent in the route record of the packet. Destination or any of the intermediate nodes generate the route reply when it knows about how to reach the destination. Figure 1.3 shows the operational method of the dynamic source routing protocol. In Figure, the route discovery procedure is shown where S1 is the source node and S7 is the destination node.



**(a)**




(b)

Fig. 1.3 (a) Route Discovery (b) Using route record to send the route reply

In this example, the destination gets the request through two ways. It chooses one path based on the route records in the incoming request packet and accordingly sends a route reply using the reverse path to the source node. At each hop, the best route with minimum hop is stored. In this example, the route record status at each hop showed to reach the destination from the source node. Here, finally the chosen route is S1-S2-S4-S5-S7.

**Temporarily Ordered Routing Algorithm (TORA)**

Temporally Ordered Routing Algorithm (TORA) [5] is also a another type of a reactive routing protocol which is some improvements in proactive type in which a link between nodes is formed by creating a Directed Acyclic Graph (DAG) of the route to the destination node from the source node. In route discovery phase, it applies a link reversal model. A route discovery query is broadcasted and throughout the entire network it is propagated until it ends the destination or a node that has information regarding how to reach the destination. TORA provides a parameter, named as height. Height is a distance of the responding node‘s distance up to the mandatory destination node. In route discovery process, this parameter is return back to the querying node. As the query reply propagates backside, each intermediate node updates its information in the TORA table with the route and its height to the destination. Then, the source node selects the best route by using height parameter toward the destination. This protocol has an important property is that it frequently chooses the most appropriate route, rather than the shortest route. For all these, TORA tries to minimize the routing traffic overhead.

## III. PERFORMANCE METRICS FOR EVALUATION

In this paper, four performance metrics are used to determine the overall network performance. These metrics are namely routing overhead, packet delivery ratio, packet end-to-end delay and network throughput [9].

### 1. Routing Overhead

As the network grows, various routing protocols perform differently. The amount of routing traffic increases as the network grows. This parameter measures the scalability of the protocol, and thus the network. It is defined as the total number of routing control packets transmitted over the network, which is expressed in bits per second or packets per second. Some sources of routing overhead in a network are cited in [6] as the number of neighbours to the node and the number of hops from the source to the destination. Other causes of routing overhead are network congestion and route error packets.

### 2 Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the ratio between the number of packets generated at the sources to the number of packets received by the destination. This metric reflects the network throughput. Thus, this metric is useful to measure any degradation in network throughput. A high packet delivery ratio is desired in a network.

### 3. Packet End-to-End Delay

The packet end-to-end delay is the time from the generation of the packet by the sender up to their reception at the destination. It is expressed in seconds. This metric includes not only the delays of data propagation and transfer, but also all possible delays caused by buffering, queuing and retransmitting data packets[10].It represents the reliability the routing protocol.

### 4.Throughput

It is defined as the ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet is referred to as throughput [7]. It is expressed in bits per second or packets per second. Frequent topology changes, unreliable communication, limited bandwidth and limited energy these factors that affect the throughput in MANETs [7]. A high value of throughput network is desirable.

## SIMULATION RESULTS

In this paper, the AODV,DSR, OLSR and TORA were analysed with the help of Opnet Modeller. This paper aims at modelling the behaviour of the routing protocols under varying network loads and speeds. Global discrete event statistics (DES) on each protocol and wireless LAN[8] were collected. Therefore average statistics of the throughput, delay, packet delivery ratio and routing overhead for various node size like 10, 20, 50 mobile nodes for the entire MANET were examined using Opnet Simulator. Main characteristics of the scenarios maintained are depicted in the Table 1.1.

Table 1.1 : Simulation Model

| Statistics | Value |
|---|---|
| Scenario Size | 1 X 1 Km |
| Simulation Time | 1 h |
| Nodes | 10,20,50 |
| 802.11 data rate | 11 Mbps |
| Mobility Model | Random Waypoint |
| Application type | FTP |
| Transmission Power | 0.005W |
| Pause time | 300s |

Routing overhead, packet end-to-end delay and the throughput of the network were analysed. Global statistics for the entire network were collected and average values were given. Global statistics for TORA was unable to collect with higher traffic sources, i.e. 50 nodes. Because of TORA protocol took more computer memory usage during the simulations. AODV,DSR,TORA and OLSR protocols were simulated with various scenarios is a combination of 10, 20 and 50 mobile nodes moving at constant speeds of 10 m/s and 30 m/s.

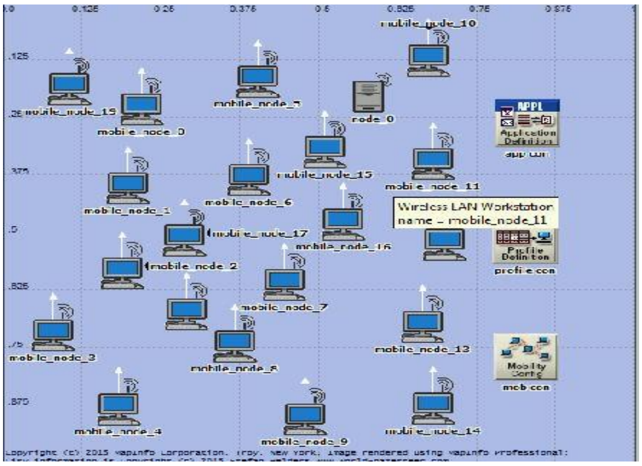


**Figure 3.1 : Opnet simulation setup**

**Routing Overhead**

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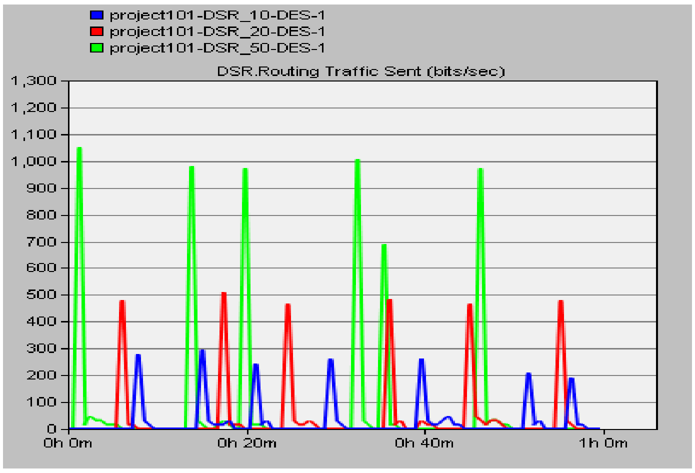


**Figure 3.2 : Routing overhead in AODV and DSR for 10,20 and 50 nodes**

In both DSR and AODV high mobility implies that there are frequent link breakages.

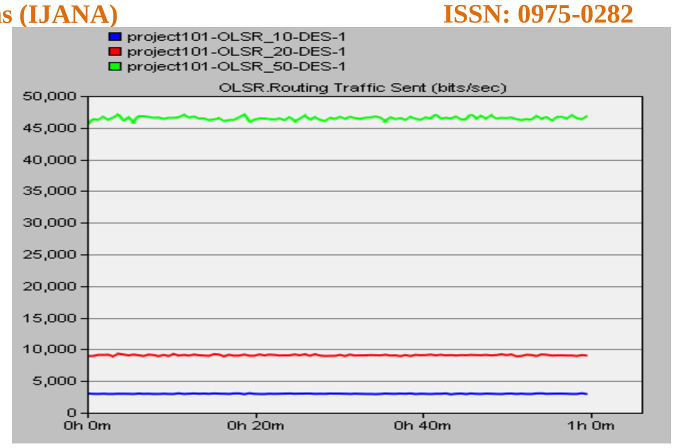


**Figure 3.3: Routing overhead in OLSR and TORA for 10, 20 and 50 nodes**

In OLSR, the increasing the mobility has no effects on the amount of routing traffic injected into the network. In TORA networks with large traffic sources, it performs better at higher than at lower mobility.

It was observed that OLSR sends the highest amount of routing traffic into the network followed by TORA, AODV and DSR. In DSR with the least amount of routing traffic sent. So, in routing overhead, DSR outperforms AODV, TORA and OLSR as it sends the least amount of routing traffic into the network

**Packet End-to-End Delay**

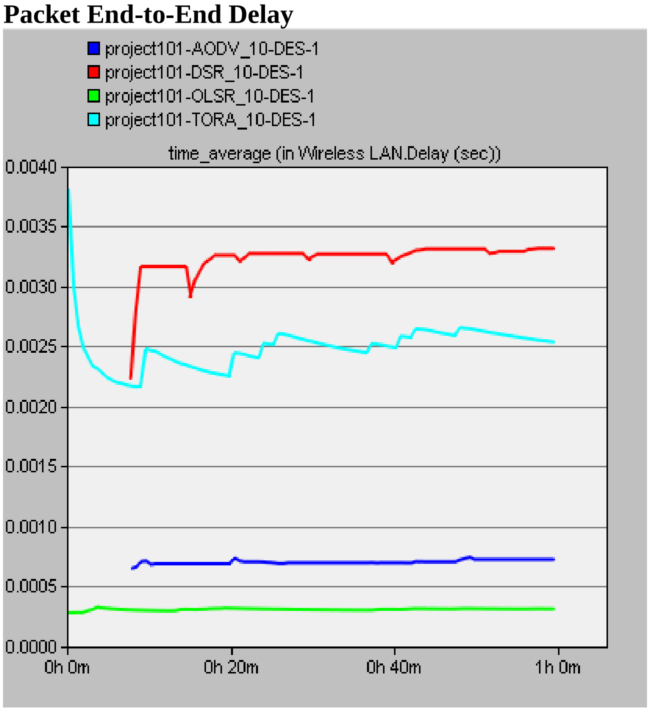


**Figure 3.4 : End-to-end delay –10 sources at 10m/s , 20 sources at 30m/s**

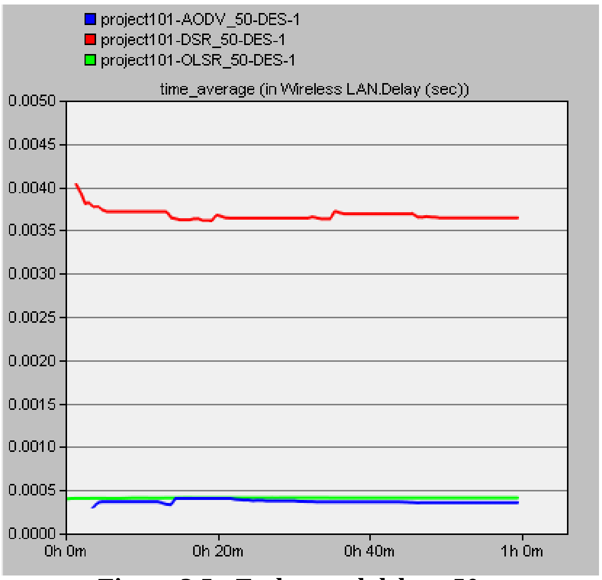


**Figure 3.5 : End-to-end delay –50 sources at 30m/s**

It was observed that OLSR having very low delay under light and medium load conditions. When heavy load condition AODV had low delay and mobility did not have an effect on the delay. DSR had a higher end-to-end delay as the network density is larger.

**Packet Delivery Ratio**

TORA delivered more number of packets with low speed and low number of traffic sources. When the number of sources increased, it was degraded from highest to lowest. TORA had the least packet delivery ratio when the nodes had a speed of 30 m/s with low number of traffic source. This increased as the number of nodes increased to 20.

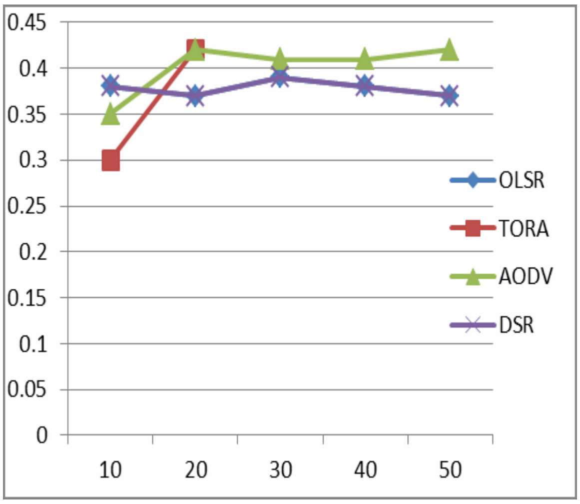


**Figure 3.6: Packet delivery ratios at 10 m/s**

At low speeds, AODV outperformed both DSR and OLSR in the networks with 5 and 20 traffic sources. When the traffic sources increased to 50, the packet delivery ratio for AODV degraded significantly and was comparable to that of DSR. OLSR at this stage outperformed all the other protocols. AODV outperformed OLSR and DSR in the larger network when the nodes were moving at 30 m/s. In the smaller network i,e less number of nodes, DSR and OLSR outperformed comparing AODV.

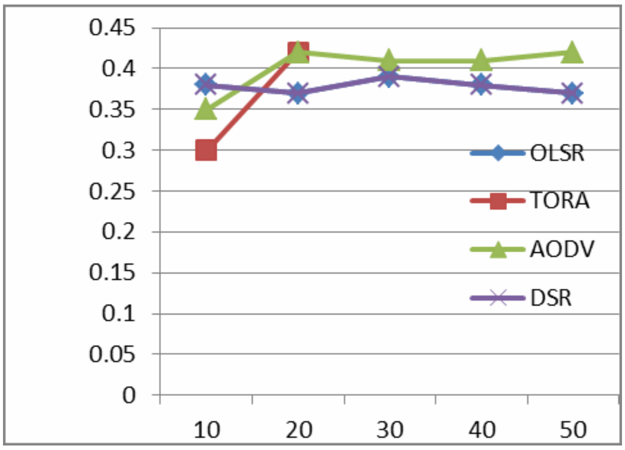


**Figure 3.7: Packet delivery ratios at 30 m/s**

**Throughput**

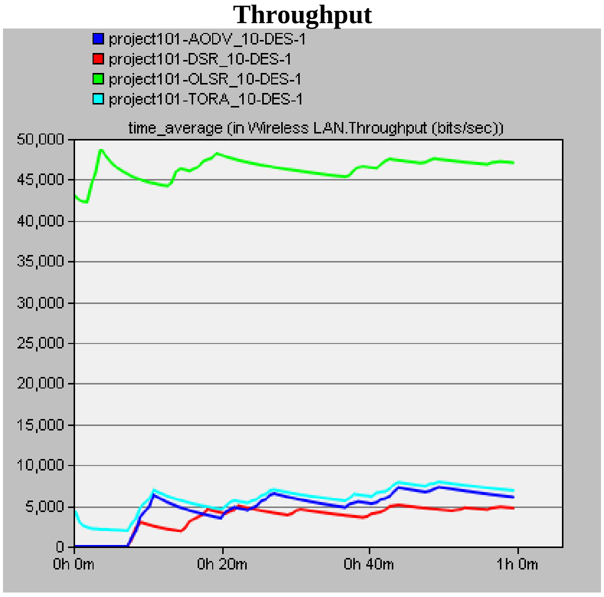


**Figure 3.8: Throughput –10 sources at 10m/s , 20 sources at 30m/s**

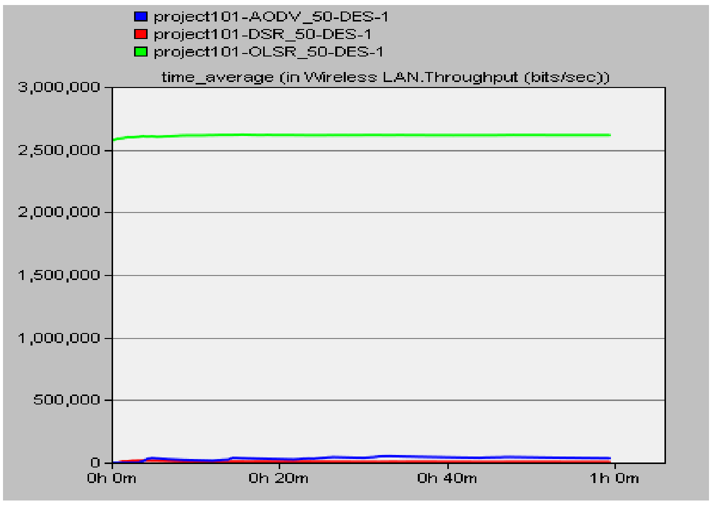


**Figure 3.9: Throughput –50 sources at 30m/s**

From the results, DSR and AODV provides better throughput than OLSR in smaller as well as larger networks both in low and high-speed scenarios. The throughput performance of TORA at large network load cannot be obtained because no data available.

## IV. CONCLUSIONS

In this paper, four different ad hoc routing protocols AODV, DSR, OLSR and TORA deployed over MANET were examined using FTP traffic analyzing the behaviour with respect to their routing overhead, throughput and packet end-to-end delay. From the above analysis, it is concluded that AODV had low delay when heavy load condition. Throughput of DSR and AODV is better as compared to OLSR. In routing overhead DSR performs well than AODV, TORA and OLSR.

From this analysis, it is concluded that among the considered protocols, there is no single one with an overall superior performance. One protocol was superior in terms of routing overhead whilst others were superior in terms of packet end-to-end delay, packet delivery ratio, or throughput. The choice of a particular routing protocol will depend on the intended use of the network.

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