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# Traffic Pattern Based Performance Comparison of AODV, DSDV & OLSR MANET Routing Protocols using Freeway Mobility Model

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**Abstract:*Mobile ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. Mobile Ad-hoc networks are self-organizing and self-configuring multihop wireless networks where, the structure of the network changes dynamically. This is mainly due to the mobility of the nodes. In the current study we have compared the performance of three MANET routing protocols AODV as reactive, DSDV and OLSR as proactive by using Freeway Mobility Model. These share some similar behavior, but the protocols internal mechanism leads to significant performance difference. We have analyzed the performance of protocols by varying network load, mobility and type of traffic (CBR and TCP). Freeway Mobility model has been generated by IMPORTANT (*Impact of Mobility Patterns on Routing in Ad-hoc NeTwork) *tool. A detailed simulation has been carried out in NS2. The metrics used for performance analysis are Packet Delivery Fraction, Average end-to-end Delay, Packet Loss, Routing Overhead, Normalized Routing Load and throughput. It has been observed that AODV (reactive) protocol performs better in CBR traffic and in case of real time delivery of packets but at cost of higher routing overhead. But in TCP traffic, proactive routing protocol OLSR gives better result. Over all performance of routing protocols in TCP traffic is much better than CBR traffic.***

***Key words:MANET, AODV DSDV, OLSR, IMPORTANT, TCP, CBR, Freeway Mobility Model, Performance Metrics***

## 1. INTRODUCTION

Mobile networks can be classified into infrastructure networks and mobile ad hoc networks (MANET) according to their dependence on fixed infrastructures [2]. In an infrastructure mobile network, mobile nodes have wired access points (or base stations) within their transmission range. In contrast, mobile ad hoc networks are autonomously self-organized networks without infrastructure support. In a mobile ad hoc network, nodes move arbitrarily, therefore the network may experience rapid and unpredictable topology changes. Routing paths in MANETs potentially contain multiple hops, and every node in MANET has the responsibility to act as a router [4]. Routing in MANET has been a challenging task ever since the wireless networks came into existence. The major reason for this is the constant change in network topology because of high degree of node mobility. A number of protocols have been developed to accomplish this task.

There exists various mobility models such as random way point, reference point group mobility model (RPGM), Manhattan mobility model, freeway mobility model, Gauss Markov mobility model etc that have been proposed for evaluation [8, 15].

## 2. RELATED WORK

Several performance evaluation of MANET routing protocols using CBR traffic have been done by considering various parameters such as mobility, network load and pause time. G. Jayakumar and G. Gopinath et. al. [19] investigated performance of AODV and DSR using Manhattan Grid Mobility Model with CBR traffic sources. They investigated that AODV perform better than DSR. Nor Surayati Mohamad Usop, Azizol Abdula and Ahmad [20] investigated the performance of AODV, DSDV and DSR in Grid Environment using CBR traffic. They concluded that AODV and DSDV performed better than DSR. Biradar, S. R. et al.[13] have analyzed the AODV and DSR protocol using Group Mobility Model and CBR traffic sources. Biradar, S. R. et. al.[13] investigated that DSR performs better in high mobility and average delay is better in case of AODV for increased number of groups. Also Rathy, R.K. et. al.[10] investigated AODV and DSR routing protocols under Random Way Point Mobility Model with TCP and CBR traffic sources. They concluded that AODV outperforms DSR in high load and/or high mobility situations.

In this paper we have investigated the performance of AODV (reactive), DSDV and OLSR (proactive) routing protocol for performance comparison in the scenario of movement of nodes on Highway. For this scenario we have used Manhattan Grid (MH) mobility model. The purpose of this work is to understand the working mechanism of protocols, Freeway Mobility Model and which routing protocol gives better performance in which situation or traffic when the nodes move on highway.

The rest of the paper is organized as follows. In the next section we discuss the Freeway Mobility Model (MH). In section 4, we have given the brief introduction of AODV, DSDV and OLSR routing protocol. Section 5 and 6 deals the simulation setup and results obtained on the execution of simulation. Finally, we draw the conclusion in section 7.

## 3. FREEWAY (FW) MOBILITY MODEL

This model emulates the motion behavior of mobile nodes on a freeway [7]. It can be used in exchanging traffic status or tracking a vehicle on a freeway. Each mobile node is restricted to its lane on the freeway. The velocity of mobile node is temporally dependent on its previous velocity.

Following is an example of topography showing the movement of nodes for Freeway Mobility Model with twelve nodes.

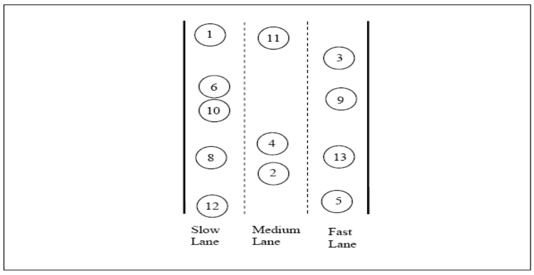


Figure 1: Movement of nodes for Freeway Mobility Model

Important Characteristics: In this model we use maps. There are several freeways on the map and each freeway has lanes in both directions. The differences between Random Waypoint and Freeway are the following:

(1) Each mobile node is restricted to its lane on the freeway.

(2) The velocity of mobile node is temporally dependent on its previous velocity. Formally,

$$|\vec{V_i}(t+1)| = |\vec{V_i}(t)| + random() * |\vec{a_i}(t)| \quad (1)$$

(3) If two mobile nodes on the same freeway lane are within the Safety Distance (SD), the velocity of the following node cannot exceed the velocity of preceding node. Formally,

$$\forall i, \forall j, \forall t, D_{ij,}(t), < SD \Rightarrow |\vec{V_i}(t)| < |\vec{V_j}(t)| \quad (2)$$

if j is ahead of i in its lane.

Due to the above relationships, the Freeway mobility pattern is expected to have spatial dependence and high temporal dependence. It also imposes strict geographic restrictions on the node movement by not allowing a node to change its lane.

## 4. DESCRIPTION OF ROUTING PROTOCOL

4.1 Ad-Hoc on Demand Distance Vector (AODV)

The Ad-hoc On-demand Distance Vector routing protocol [1,3,14] enables multihop routing between the participating mobile nodes wishing to establish and maintain an ad-hoc network. AODV is a reactive protocol based upon the distance vector algorithm.

The algorithm uses different messages to discover and maintain links. Whenever a node wants to try and find a route to another node it broadcasts a Route Request (RREQ) to all its neighbors. The RREQ propagates through the network until it reaches the destination or the node with a fresh enough route to the destination. Then the route is made available by uncasing a RREP back to the source.

The algorithm uses hello messages (a special RREP) that are broadcasted periodically to the immediate neighbors. These hello messages are local advertisements for the continued presence of the node, and neighbors using routes through the broadcasting node will continue to mark the routes as valid. If hello messages stop coming from a particular node, the neighbor can assume that the node has moved away and mark that link to the node as broken and notify the affected set of nodes by sending a link failure notification (a special RREP) to that set of nodes.

4.2 Destination Sequenced Distance Vector (DSDV)

This routing protocol was developed 1994 by C. Perkins and it is a proactive distance-vector protocol [4, 9, 15].

Destination-Sequenced Distance-Vector Routing protocol is a proactive table driven algorithm based on classic Bellman-Ford routing. In proactive protocols, all nodes learn the network topology before a forward request comes in. In DSDV protocol each node maintains routing information for all known destinations. The routing information is updated periodically. Each node maintains a table, which contains information for all available destinations, the next node to reach the destination, number of hops to reach the destination and sequence number. The nodes periodically send this table to all neighbors to maintain the topology, which adds to the network overhead. Each entry in the routing table is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, there by avoiding the formation of routing loops.

4.3 Optimized Link State Routing Protocol (OLSR)

Optimized Link state Routing protocol (OLSR) [4,11],is one of the proactive routing protocols for mobile ad hoc networks i.e. periodically the updated routing information is maintained.

Basically OLSR uses multipoint relays (MPRs), a node's one hop neighbor selected for forwarding packets, to reduce the control traffic overhead. OLSR performs better in a large and dense network. Its performance is also better in scenarios where the traffic is random and sporadic between a larger set of node. Following three kinds of control messages are used in OLSR

1) Hello messages are sent periodically to all neighboring node having node's identifier, list of node's neighbors, its MPRs and its neighbors whose bidirectional link have not been yet known.

2) Topology Control (TC) massages are periodically sent by a node having a set of bidirectional links between the node and a subset of node's neighbors. Its purpose is to spread the topological information about the entire network.

3) Multiple Interface Declaration (MID) messages, as indicated by name, are used to declare that a node is running OLSR on multiple interfaces. MPR is responsible for flooding the MID message throughout in the network.

## 5. SIMULATION SETUP

We have used Network Simulator (NS)-2 in our evaluation. The NS-2 is a discrete event driven simulator [5, 6] developed at UC Berkeley. We used Red Hat environment with version NS-2.34 of network simulator. NS-2 is suitable for designing new protocols, comparing different protocols and traffic evaluations. It is an object oriented simulation written in C++, with an OTcl interpreter as a frontend. NS uses two languages because simulator got to deal with two things: i) detailed simulation of protocols which require a system programming language which can efficiently manipulate bytes, packet headers and implement algorithms, ii) research involving slightly varying parameters or quickly exploring a number of scenarios.

The movement of nodes in the Freeway Mobility model is generated by a software called Mobility Generator which is based on a frame work called Important (Impact of Mobility Patterns on Routing in Ad-hoc NeTwork, from University of Southern California)[7,17,18]. In the scenario we have used two highways with three lanes each and having traffic in opposite direction.

Table 1: Simulation Parameters

| ***Parameters*** | ***Value*** |
|---|---|
| *Routing Protocols* | *AODV, DSDV, OLSR* |
| *MAC Layer* | *802.11* |
| *Packet Size* | *512 bytes* |
| *Terrain Size* | *1000m * 1000m* |
| *Nodes* | *50* |
| *Mobility Model* | *Freeway Mobility Model* |
| *No. of Highways* | *2* |
| *No. of Lanes* | *6 (3 on each highway)* |
| *Data Traffic* | *CBR, TCP* |
| *No. of Source* | *10, 40* |
| *Simulation Time* | *900 sec.* |
| *Maximum Speed* | *0-60 m/sec (interval of 10)* |

We have used four traffic patterns with varying number of sources (10 and 40) for each type of traffic (TCP and CBR). The source-destination pair may be same lane or in different lane. The goal of our simulation is to evaluate the performance differences of the three AODV, DSDV and OLSR routing protocols. The type of traffic (CBR and TCP) and the maximum number of sources are generated by inbuilt tool of NS2 [6]. The parameters used for carrying out simulation are summarized in the table 1.

5.1 **Performance Metrics:** RFC2501 [12] describe a number of quantitative metrics that can be used for evaluating the performance of MANET routing protocols. We have used the following metrics for evaluating the performance of routing protocols (AODV, DSDV & OLSR):

5.1.1 Packet delivery ratio:

It is the ratio of data packets delivered to the destination to those generated by the sources. It is calculated by dividing the number of packet received by destination through the number packet originated from source.

PDF = (Pr/Ps)*100

Where Pr is total Packet received & Ps is the total Packet sent.

5.1.2 Routing overhead:

It is the total number of control or routing (RTR) packets generated by routing protocol during the simulation. All packets sent or forwarded at network layer is consider routing overhead.

Overhead = number of RTR packets

5.1.3 Normalized routing overhead:

Number of routing packets "transmitted" per data packet "delivered" at destination. Each hop-wise transmission of a routing is counted as one transmission. It is the sum of all control packet sent by all node in network to discover and maintain route.

CBR Traffic Sources

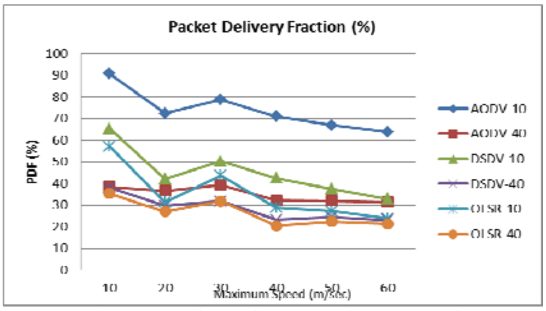


Figure 2: Packet Delivery Fraction vs. Speed

NRL = Routing Packet/Received Packets

5.14 Average End-to-End Delay (second):

This includes all possible delay caused by buffering during route discovery latency, queuing at the interface queue, retransmission delay at the MAC, propagation and transfer time. It is defined as the time taken for a data packet to be transmitted across an MANET from source to destination.

D = (Tr –Ts)

Where Tr is receive Time and Ts is sent Time

5.1.5 Packet Loss

It occurs when one or more packets fail to reach to their destination.

Packet Loss % = (1-Pr/Ps)*100

Where Pr is total number of Received Packets and Ps is total number of Sent Packets.

5.1.6 Throughput (packet/second)

It is the rate at which network send or receive data. It rated in term of bits or packets per seconds. It is the sum of data rates that are delivered to all nodes in MANET.

Throughput = Pr/Pf

Where Pr is the total number of Received Packets and Pf is the total number of Forwarded Packets.

## 6. Result and Discussion

TCP Traffic Sources

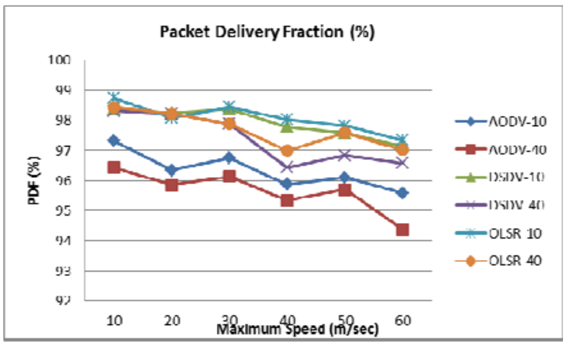

Figure 3: Packet Delivery Fraction vs. Speed

CBR Traffic Sources

TCP Traffic Sources

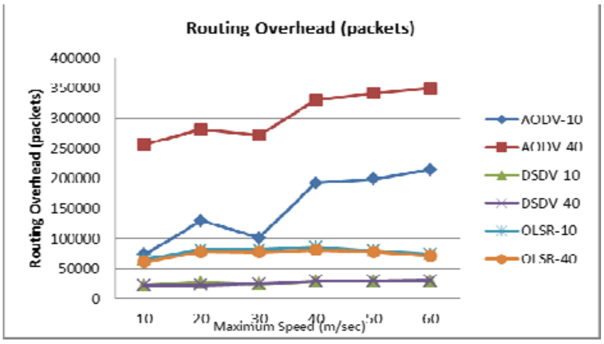


Figure 4: Routing Overhead vs Speed

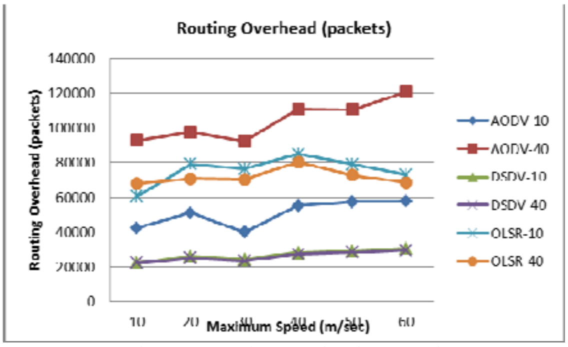


Figure 5: Routing Overhead vs Speed

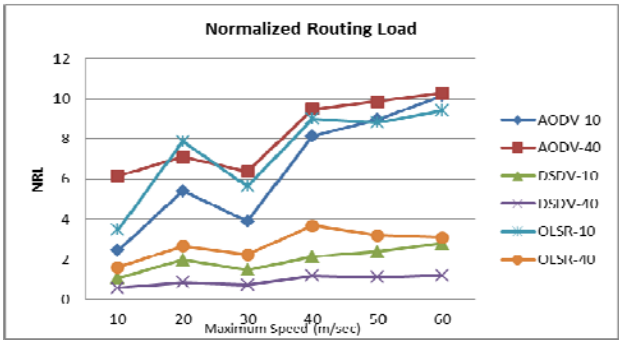


Figure 6: Normalized Routing Load vs Speed

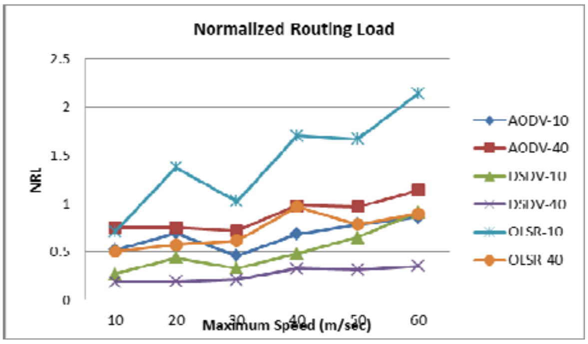


Figure 7: Normalized Routing Load vs Speed

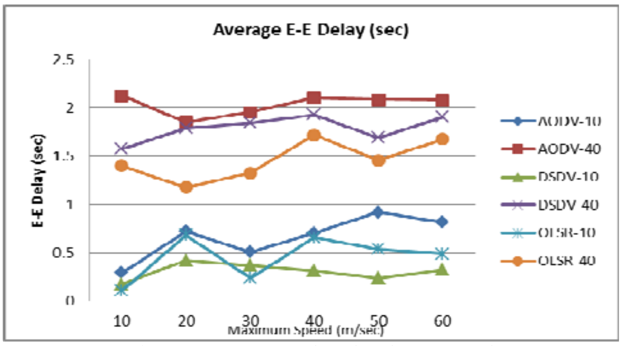


Figure 8: Average End-End-Delay vs Speed

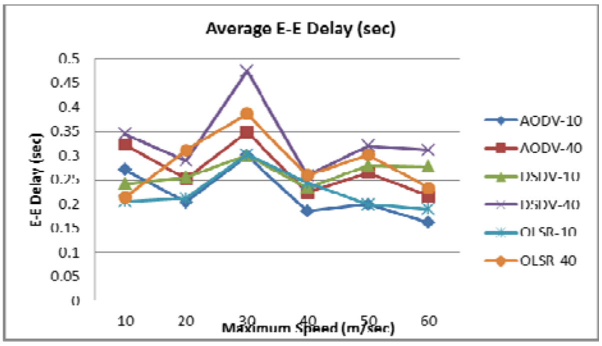


Figure 9: Average End-End-Delay vs Speed

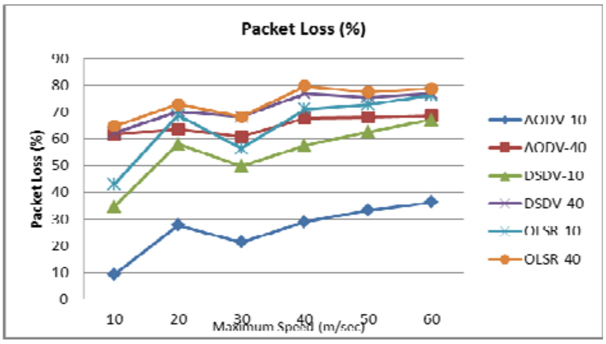


Figure 10: Pacet Loss Load vs Speed

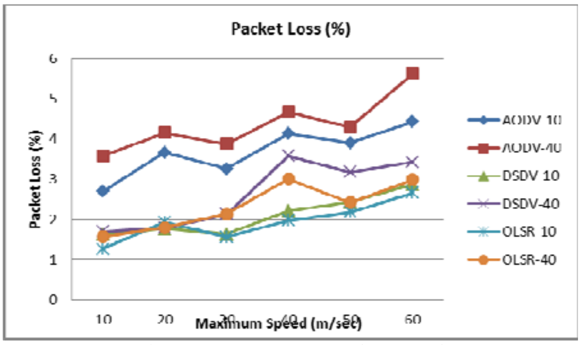


Figure 11: Pacet Loss Load vs Speed

CBR Traffic Sources

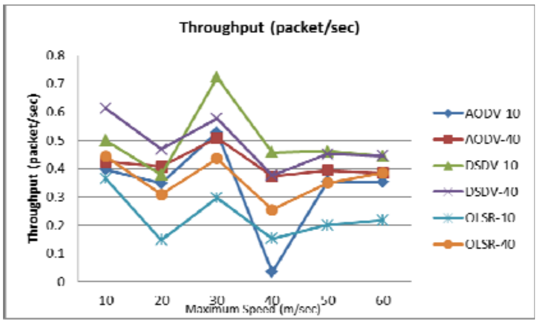


Figure 12: Throughput vs Speed

**Packet delivery ratio:**

In case of CBR traffic, AODV performs better than DSDV and OLSR in high or low network load at all speed. PDF of all the three routing protocols decreases when speed is increased. DSDV performs better than OLSR in low or high network load as shown in Figure 2. AODV deliver almost (60-90%) packet when network load is low say 10. In TCP traffic, OLSR and DSDV perform better than AODV in high or low network load. OLSR and DSDV deliver almost (96.5-98.5%) packet as compared to AODV around (94-97%). OLSR is better choice in TCP traffic as shown in Figure 3. Over all, the packet delivery fraction is around (94-99%) in TCP traffic which is better than CBR traffic around (20-90%) as shown in Figure 2 and 3.(low → high).

**Routing Overhead:**

Under CBR traffic and for high or low network load routing overhead of DSDV is low as compared to AODV and OLSR as shown in Figure 4. The routing overhead of AODV is high as compared to other two routing protocols and it increasing with speed in network load (high or low).

In TCP traffic also, DSDV gives better result than AODV and OLSR in all type of load as shown in Figure 5.DSDV is better choice in both type of traffic. Over all, the routing overhead in TCP traffic is low as compared to CBR traffic.

**Normalized Routing Overhead:**

In case of CBR traffic, DSDV performs better than AODV and OLSR in all network loads (high or low). AODV gives better result than OLSR when network load is low (10), but when network load is high say 40, OLSR performs better than AODV (Figure 6).

TCP Traffic Sources

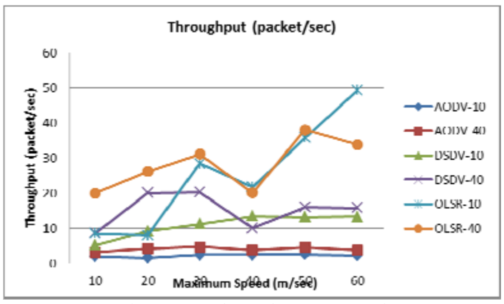


Figure 13: Throughput vs Speed

In TCP traffic also, DSDV gives better result than AODV and OLSR in all network load (high or low). AODV gives better result than OLSR when network load is low say 10, but when network load is high say 40, OLSR perform better than AODV (Figure 7). Over all, DSDV gives better performance for normalized routing load in both type of traffic. NRL in TCP traffic is low as compared to CBR traffic.

**Average end-to-end Delay:**

In CBR traffic, average delay of DSDV is low as compared to AODV and OLSR under low network load say 10, but when network load is high say 40, OLSR give better result than AODV and DSDV. Performance of AODV is low as compared to DSDV and OLSR in all type of load (high or low) as shown in Figure 8.

In case of TCP traffic, AODV gives better result than DSDV and OLSR in high or low network load and at all speed (Figure 5.12 (b)). Average delay of OLSR is less than DSDV as shown in Figure 9. Over all, the average delay in TCP traffic is low as compared to CBR traffic.

**Packet Loss**:

Figure 10 shows that in CBR traffic, packet loss is very less for AODV in high or low network load as compared to DSDV and OLSR. DSDV performs better than OLSR in all network load (high or low) at all speed. Packet loss is increase with speed as shown in Figure 10 and 11.

In case of TCP traffic, AODV produces high packet loss than other considered routing protocols. In the TCP application OLSR is better choice than AODV and DSDV (Figure 11). Over all, packet loss rate is low in TCP traffic as compared to CBR traffic.

**Throughput:**

In CBR traffic, DSDV throughput is better than AODV and OLSR for high as well as low network load as shown in Figure 12.

For TCP traffic, OLSR gives better throughput than AODV and DSDV as shown in Figure 13 for high or low network load. Over all, throughput in TCP traffic is much better than CBR traffic. In case of TCP traffic, the throughput of all protocols gives better result.

## 7. CONCLUSION

From Figure 2 to 13, we concluded that in Freeway Mobility Model with CBR traffic sources, AODV performs better than OLSR and DSDV, but at the cost of higher routing overhead and end-end delay. Routing overhead of DSDV is always less than AODV and OLSR. DSDV gives better throughput in CBR traffic.

In TCP traffic sources, OLSR gives better result than AODV and DSDV, but at higher routing overhead and end-end delay. Throughput of OLSR is also better in TCP traffic. Over all, above consider routing protocols performs better in TCP traffic as compared to CBR traffic.

In this paper, we have investigated the performance of only three routing protocol using CBR and TCP traffic under Freeway Mobility Model. Further study could be conducted on the other MANET routing protocols under different mobility model and using different types of traffic sources.

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