Comparative Analysis of Trace-Based Mobility Models in Mobile Ad-hoc Networks

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Abstract - The mobility and node density is the fundamental characteristic which differentiates MANETs from other wireless or wired network. A Mobile Ad-hoc Network (MANET) is a continuously self-configuring network without infrastructure, where every node functions as a transmitter, router, and data sink. The main aim to design MANET routing protocols to adaptively cater for dynamic changes in topology while maximizing packet delivery ratio and, throughput and minimizing delay, packet overhead, and minimum packet drop rate. NS2 network simulator is used to implement MANET by using Destination-Sequenced Distance Vector (DSDV), Ad Hoc On Demand Vector (AODV), and Dynamic Source Routing (DSR) by using mobility generator tool, Bonnmotion-3.0.1 in this paper. The effect of mobility and mobility models of nodes changing in MANET is investigated and compared some reactive and proactive routing protocols including AODV, DSR, and DSDV. The simulated study on Trace-based mobility models, SLAW and TLW aim to analyze the performance of current MANET routing protocols. This paper compares mobility models from their characteristics and QoS performance metrics throughput, packet delivery ratio, end to end delay, packet overhead and packet dropping rate.

Keywords: *MANET, Routing Protocols, SLAW, TLW.*

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a collection of wireless mobile nodes forming a self-configuring network without using any existing infrastructure. Rather than all the parameters, mobility and mobility models play a very substantial role in actuating the performance of routing protocols in MANET. Mobility models characterize the movement pattern of MANET nodes, and each routing protocols exhibits specific characteristics of these models. The performance of MANET routing protocols needs to be analyzed at node density, node speeds, traffic nodes, as well as network size to find the most adaptive and efficient routing protocol for dynamic MANET topologies. If the mobile node moves out of range during receiving and forwarding of packets, the mobility influences ongoing transmissions. Challenging issues in MANET includes limited bandwidth, energy constraints, high cost, and security. The desired challenges in MANET includes unreliability of wireless links between nodes, dynamic topologies, threats from malicious nodes inside the network, lacking firm boundaries, requiring centralized management facility, restricted power supply, and scalability [1]. Security issues are also there like attacks, session hijacking, eavesdropping, jamming, Denial of Service, etc. [2]. In section 2, related work of paper is discussed along with brief overview of MANET routing protocols and mobility models, Section 3 covers the result from performance metrics, and finally, in section 4, results are concluded.

II. RELATED WORK

MANET routing protocols are Internet Protocol (IP) based and may use unicast, multicast or hybrid approaches and may act as regular wired IP services rather than being regarded as an entirely separate entity. Figure 1 shows the classification of different routing protocols of MANET based on proactive, reactive and hybrid approaches.

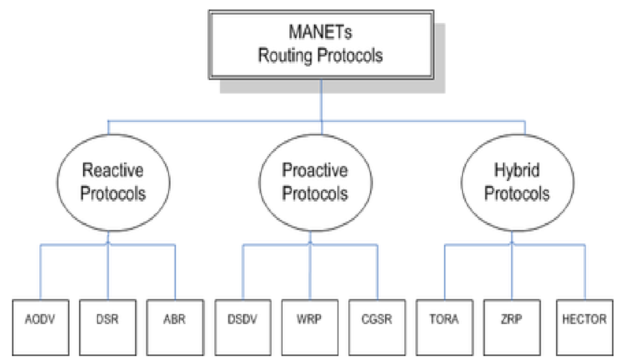

Fig.1: Proactive, Hybrid, and Reactive Routing Protocols in MANET

Ad-hoc On Demand Distance Vector (AODV) is a category of reactive protocol that requests for a route only when it needs and does not require that the mobile nodes maintain routes to destinations that are not communicating. AODV guarantees loop-free paths by using sequence numbers that indicate how new, or fresh, a route is. Each node has a routing table containing one route entry for each destination. Each route entry keeps track of some areas such as Destination IP Address, Destination sequence number, Next Hop, and Hop Count. Three control messages are broadcast by AODV on the network to establish a path from source to destination: Route Request (RREQ), Route Reply (RREP), and Route Error (RERR). By the use of sequence numbers, the nodes of origin are always able to find new valid paths [3]. A **Destination-Sequenced Distance-Vector Routing (DSDV)** follows a table-driven approach based on the Bellman-Ford algorithm [4]. It resolves the problem of looping. A sequence number is embedded in each packet. The sequence numbers are even if a link is present; else, an odd number is used. The destination generates the number, and the emitter needs to send out the next update with this. The routing information is distributed among nodes infrequently and smaller incremental updates more frequently [5]. **Dynamic Source Routing (DSR)** DSR establishes a path to the destination when a source node requests one. DSR uses the path of origin strategy. The originator must know the complete hop sequence to the destination before starting transmission. Each node maintains a route cache, where all routes it knows are stored. The route discovery process is initiated if the desired path cannot be found in the route cache. A node broadcasts the route request message only if its address is not present in the route record of the message to limit the number of route requests propagated. The sequence of hops is included in each packet's header. However, one significant advantage is that intermediate nodes can learn routes from the source routes in the packets they receive. The factors: time, bandwidth and energy are strong arguments for finding a way, is such a costly operation for using source routing. The routing of origin avoids the need for up-to-date routing information in the intermediate. Finally, it prevents routing loops quickly because the entire route is determined by a single node instead of making the decision hop-by-hop [6].

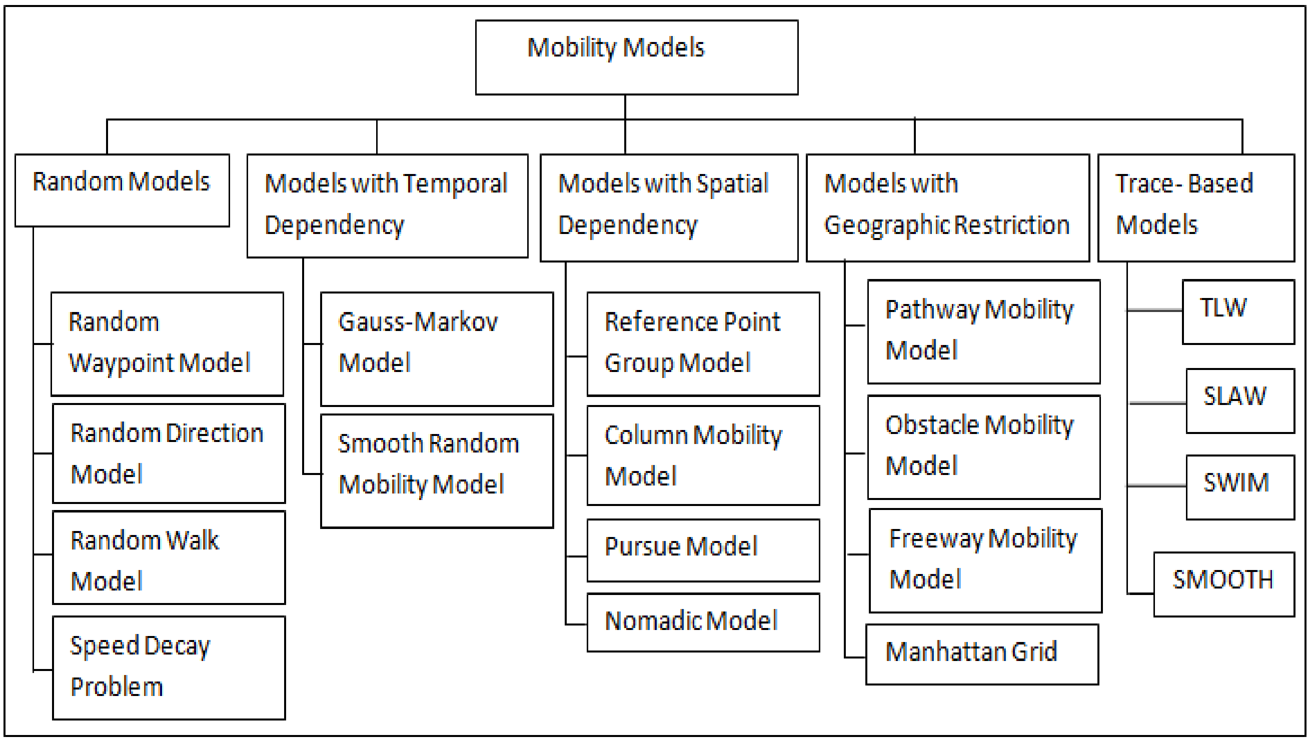

Fig.2: Classification of Mobility Models

A classification of various mobility models into several classes based on their specific movement characteristics in figure 2. For some movement patterns, the flow of the mobile node is likely to be affected by its change history, known as mobility with **temporal dependence**. The mobile nodes with **spatial dependency** are travel in a correlated manner. If the movements of nodes are bounded by streets, freeways or obstacles, this class deals with mobility models with **geographic restrictions** [7]. Mobility models that are based on real datasets are called **trace-based** mobility models. Movement traces collected from several indoor or outdoor sites. Traces are also available on CRAWDAD which is the largest repository for real datasets collected from diverse scenarios [8].

III. TRACE-BASED MOBILITY MODELS

Trace-Based mobility models are based on real datasets. The traces are collected from several indoor/outdoor sites are available on CRAWDAD. The CRAWDAD is the largest repository for real datasets. These datasets are collected from diverse scenarios. The traces can be classified via the scenarios for which they were collected. So, results obtained from the analysis of the dataset may not apply to another dataset. Traces can be collected by locations, and contact information.

A. TRUNCATED LEVY WALK (TLW)

The Truncated Levy Walk (TLW) mobility model uses traces generated on the basis of Global Positioning System (GPS) collected from five outdoor sites [9]. It includes Disney World, two campuses, a metro city scenario, and a state fair. To remove the noise that may be exist in the movement, the traces are already preprocesses. The traces are preprocessed to remove noise that may be present in the movement patterns. Initially, mobile nodes are in TLW are randomly distributed over the simulation area shown in figure 3. A mobile node makes power-law jumps in random directions. Then pauses for a specified time at every visited location as shown in figure 4.

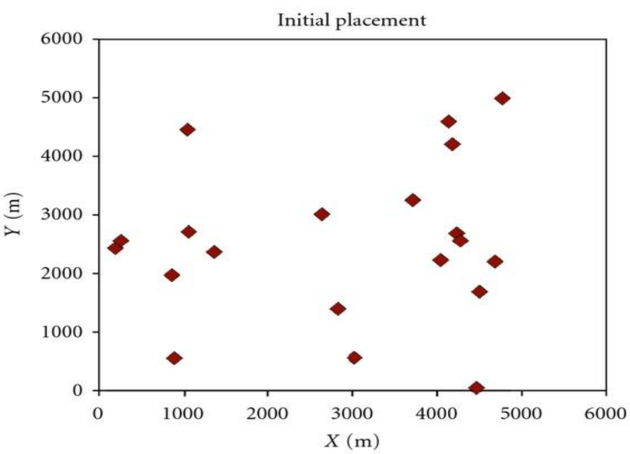

Fig.3: Initial Node Distribution in TLW

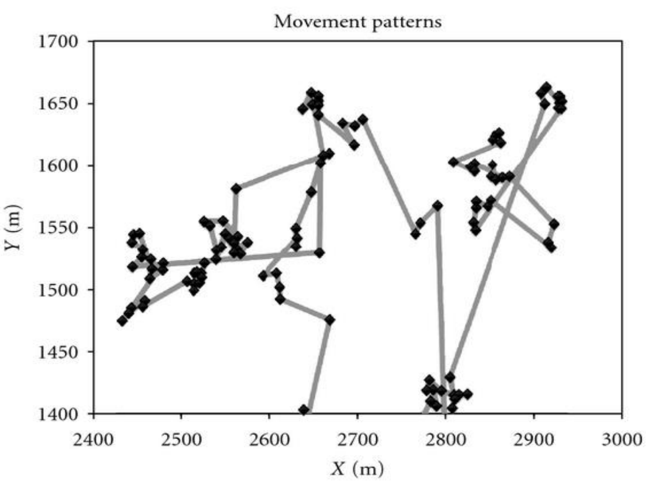

Fig.4: Movement Pattern of Mobile Node in TLW

B. SELF-SIMILAR LEAST ACTION WALK (SLAW):

The SLAW mobility model is based on the same set of traces used in the development of TLW. The locations are modeled as a self-similar process. If the aggregated processes are highly correlated then a process is called self-similar [10]. A Hurst parameter controlled the distribution of locations, which can be varied from 0.5 to 1. A mobile node may visit for the scenario with Hurst=0.75 for the initial distribution of locations. A Hurst is a well-defined parameter mathematically; it is hard to estimate its value. In a given data set, different Hurst values may be calculated with various Hurst estimators. The initial distribution of mobile nodes and their movement pattern are shown in figure 5 and figure 6 respectively.

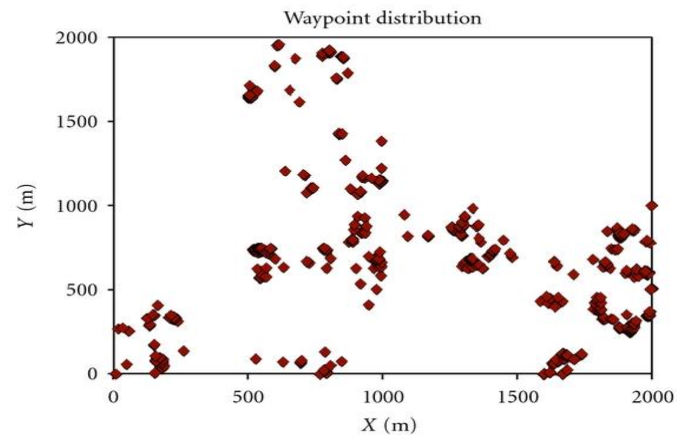

Fig.5: Initial distribution of nodes in SLAW

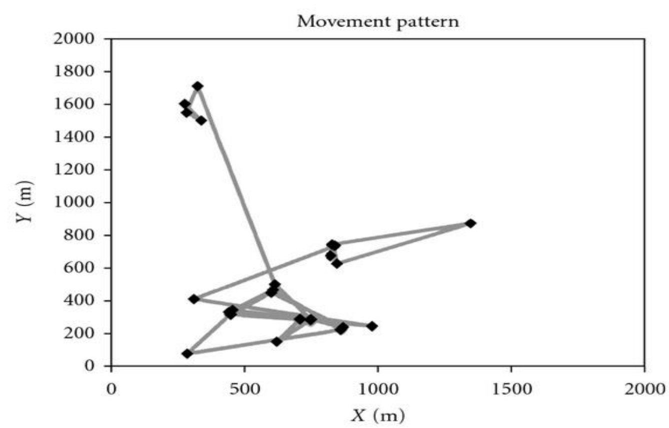

Fig.6: Movement pattern of mobile node in SLAW

IV. RESULTS AND DISCUSSION

Simulations have been performed in network simulator, NS2, to determine the performance of routing protocols. We evaluate three MANET routing protocols (AODV, DSDV, and DSR) against SLAW and TLW. Simulation parameters list is defined in Table 1.

Table 1: Simulation Parameters List

Parameters List		
Experiment Parameter	**Analysis Value**	**Description**
Simulator	NS2	Network Simulator
Mobility Generator	Bonnmotion-3.0.1	Mobility Generator Tool
Simulation Time	100 S	Simulation Duration
Terrain Dimension	X-2285, Y-1224	X, Y Dimension of motion
No. of mobile nodes	300	No. of nodes in a network
Mobility Speed	0-5 meter per second	Mobility of nodes
No. of Connection	92	Connections
Mobility Model	TLW, SLAW	Mobility direction
Routing Protocols	AODV, DSR, DSDV	Path-finding
MAC Protocol	802.11	Wireless Protocol

The comparison is performed by measuring the following QoS performance metrics:

Packet Delivery Ratio (PDR) is defined as the ratio of data packets delivered successfully to destination nodes and the total number of data packets generated for those destinations. PDR characterizes the packet loss rate, which limits the throughput of the network [11]. The higher the delivery ratio better is the performance of the routing protocol. PDR is determined as:

$$PDR= (P_r / P_s) \times 100$$

Where P_r and P_s are the value of packets received, and packets sent respectively. Figure 7 shows the fraction of the originated application data packets each protocol was able to deliver, as a function of nodes.

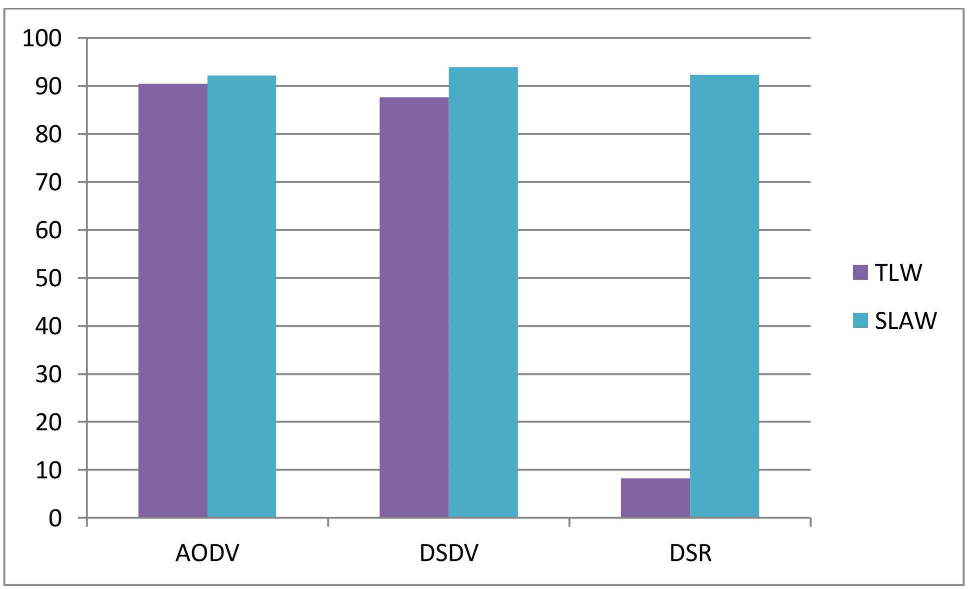

Fig.7: Packet Delivery Ratio

Average End-to-End Delay (D_{avg}) indicates that the time taken for a packet to travel from the source node application layer of the destination node [12]. It also includes the route discovery wait time that may be experienced by a node when a map is initially not available. The average end to end delay is computed as:

$$D_{avg} = \Sigma (t_r - t_s) / P_r$$

Where t_s is the packet send time, t_r is the packet receive time for the same packet at the destination, and P_r is the total packets received. The average delay increases for all routing protocols as shown in figure 8.

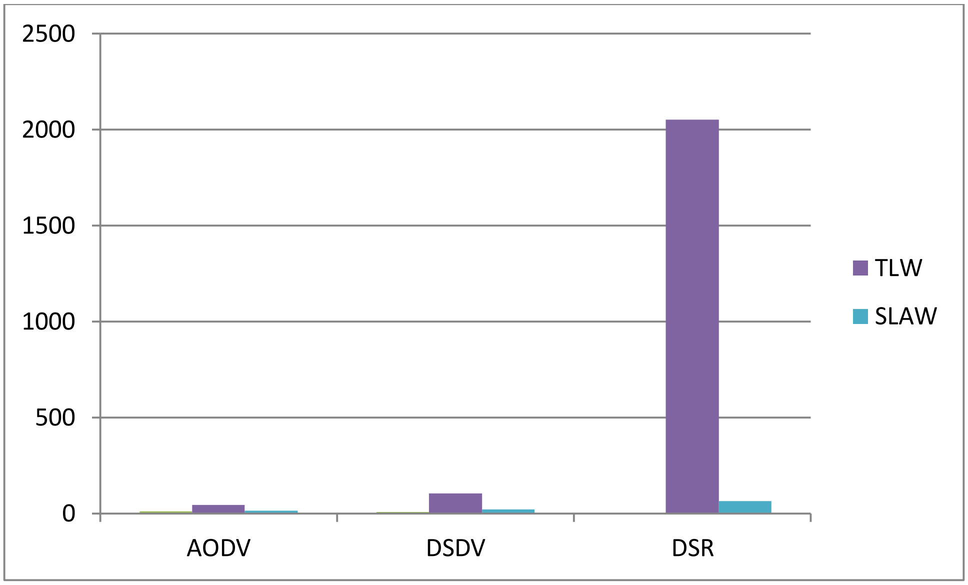

Fig.8: Average End-to-End Delay

Throughput: The average rate of successful message delivery over a communication channel [13] is called throughput. The average end to end throughput is shown in figure 9 which reflects the usage degree of the network resources for the conventional routing protocols.

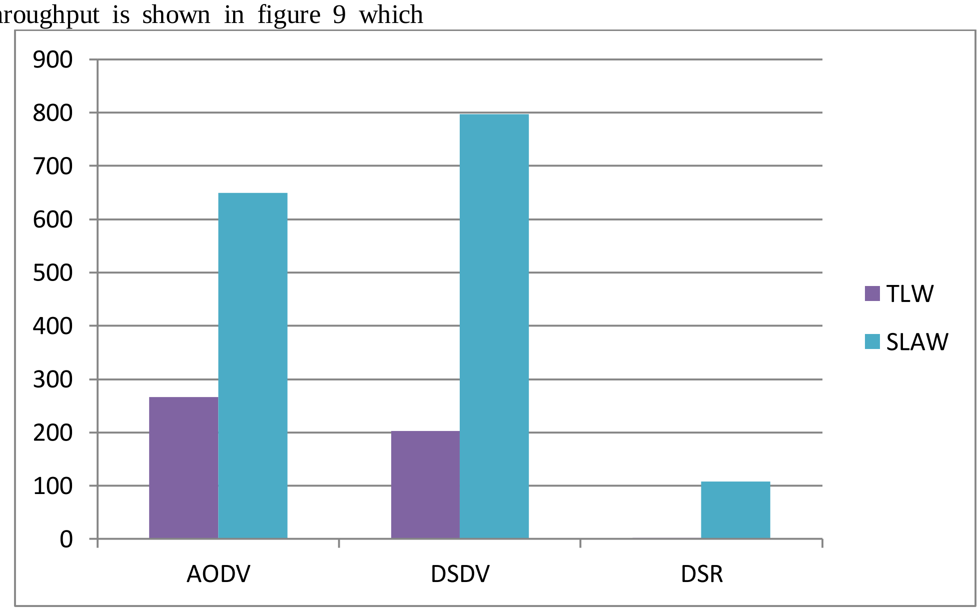

Fig.9: Throughput

Packet Overhead: It is the number of all nodes transmission packets including data and encoded packet. Figure 10 shows the packet overhead rate for RWP, Gauss-Markov and Manhattan models.

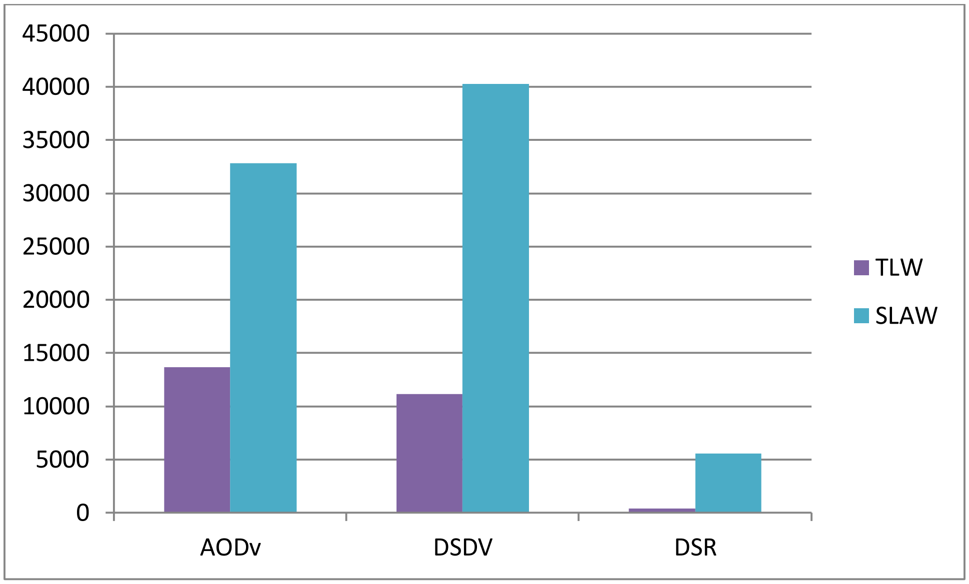

Fig.10: Packet Overhead

Average Packet Loss: The number of packets lost due to incorrect or unavailable routes and MAC layer collisions [14] is known as average packet loss. Figure 11 shows the relationship between the network size and the average packet dropped off the standardized protocols which indicate the degree of each protocol.

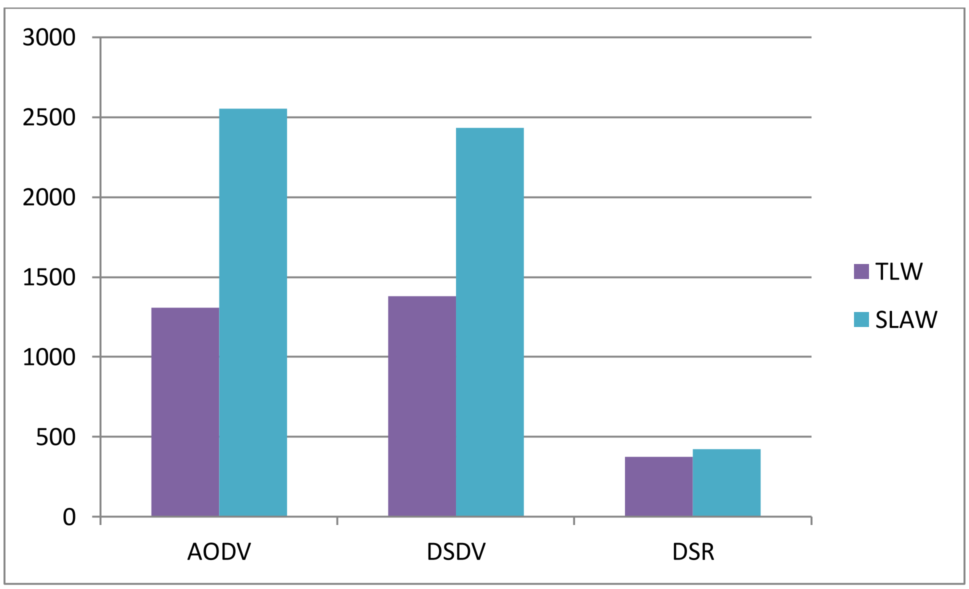

Fig.11: Average Packet Loss

The same parameters are used during simulation for each routing protocol to ensure the simulation produced accurate results. From the results, the objective of this project which is to evaluate the QoS performances for AODV, DSR, and DSDV MANET protocols over trace-based mobility models is fulfilled. The analysis has been done through simulation using commercial and highly reliable NS2 simulator over Bonnmotion-3.0.1 mobility tool. As a result shown in Figure 7, packet delivery ratio is increased for AODV, DSDV and DSR with SLAW than TLW. In performance metric Average End-to-End Delay, SLAW is providing less delay in DSR, AODV, and DSDV and more throughput value than TLW. TLW is creating fewer packets and lesser packet loss than SLAW

V. CONCLUSION

In this paper, we analyzed the behavior of MANET routing protocols under trace-based mobility models. The results of our extensive NS2 simulations clearly indicate the significant impact that node movement pattern has on routing performance. We observe that a change in mobility pattern has a different impact on all routing protocols. The aim of this research to develop an understanding of the effect of mobility over the routing performance. In future, we intend to study mobility models to determine the MANET protocol best suited to military mobile ad-hoc networks.

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VI. REFERENCES

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