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Performance Evaluation of Manhattan Mobility Model in Mobile Ad-hoc Networks

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Abstract: Mobility model is the foundation of the simulation study of various routing protocols in Mobile Ad-hoc Network (MANET). 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. A high mobility of MANET nodes reduces the reliability of network communication. In dynamic networks, high mobility of the nodes makes it very difficult to predict the dynamic network topology and hence route/link failures. NS2 network simulator is used to implement MANET by using Destination-Sequenced Distance Vector (DSDV), Ad Hoc Demand Vector (AODV), and Dynamic Source Routing (DSR) by using mobility generator tool, Bonnmotion-3.0.1 in this paper. This paper compares mobility model on AODV, DSDV, and DSR routing protocols with QoS performance metrics throughput, packet delivery ratio, end to end delay, packet overhead and packet dropping rate.

Keywords: *MANET, AODV, DSDV, DSR, Manhattan..*

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1. INTRODUCTION

The ever-growing demand for connectivity among mobile devices, whether at a workplace, home or during a walk, has made mobile ad-hoc networks (MANETs) as a promising research area. A MANET is an autonomous system of mobile nodes consisting of router, switch and battery. The multi-hop relaying method is a key concept for MANETs [1]. Multi-hop relay techniques are used to relay data packets from intermediate nodes between any pair of source and destination resulting in faster transmission rates. However, mobility is the primary issue in MANETs as due to movement; a node can reach out of the transmission range of its preceding node, resulting in link failure. MANETs are designed to be self configured, self-organized and can find radio connectivity for irregular operation of a routing protocol with no support from fixed infrastructure. MANETs are popular because of less deployment time requirement, no need for fixed base station in contrast to other wireless networks [1]. Security issues are also there like attacks, session hijacking, eavesdropping, jamming, Denial of Service, etc. [2]. In section 2, 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.

2. MANET ROUTING PROTOCOLS AND MOBILITY MODELS

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.

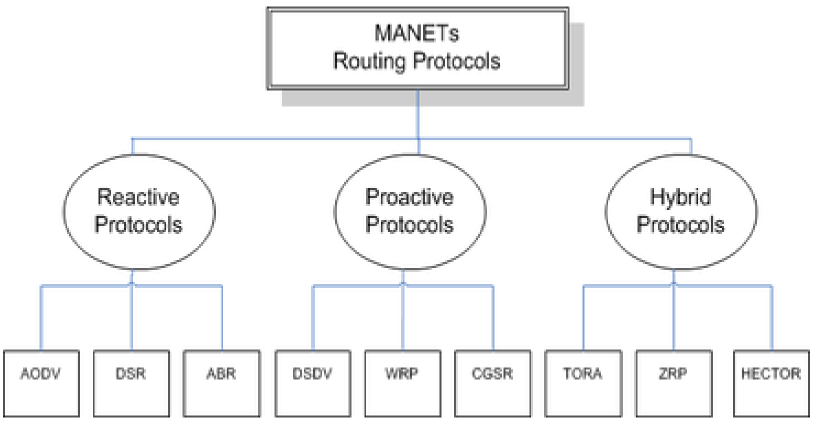

Figure 1: Proactive, Hybrid, and Reactive Routing Protocols in MANET

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. 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) [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 [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 [6].

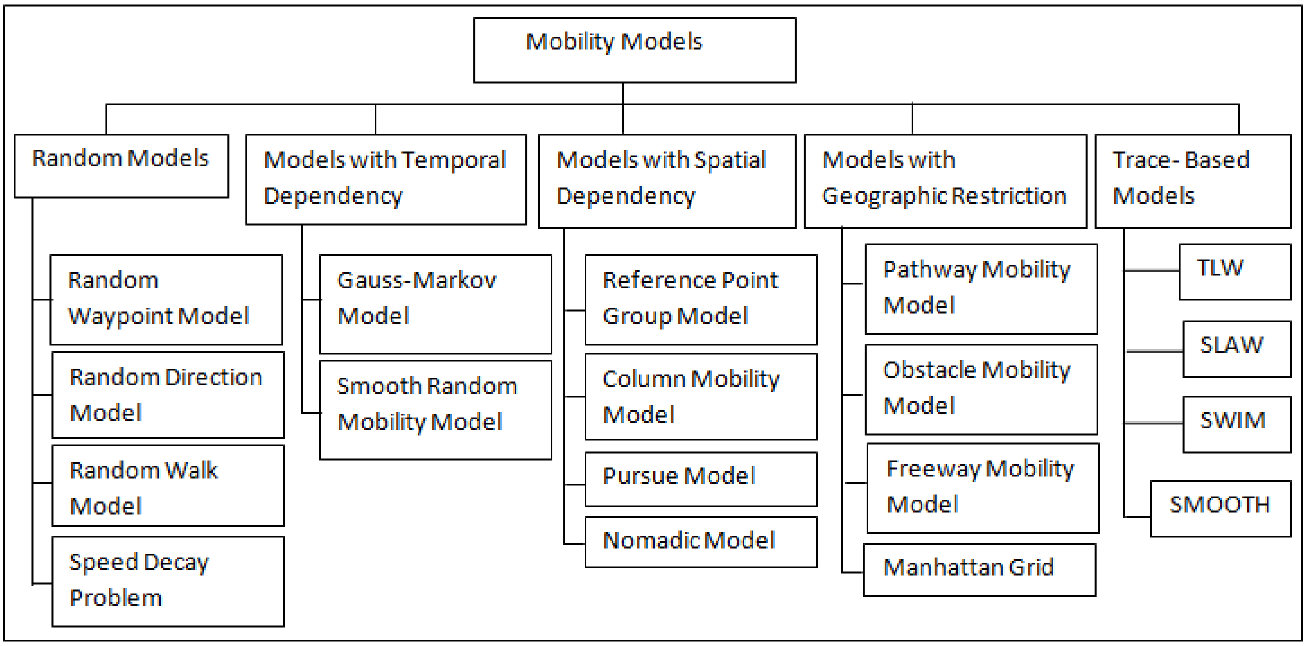

Figure 2: Classification of Mobility Models

We provide 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]. To implement the simulation, we are choosing Manhattan mobility model because of its extensive and live use.

Manhattan Model emulates the movement pattern of mobile nodes on streets. Under this model, the scenario is composed of some rows and columns in the form of streets. The displacement of nodes is to along with the grid of horizontal and vertical streets. At the intersection of horizontal and vertical streets, the mobile node can take turn left, right or go straight. The speed of mobile node is dependent on the direction of previous movements [9]. After a node initiates to move in the selected direction and touches the successive path intersection, the subsequent path in which the node will move is chosen probabilistically. If a node can stay in to move in the identical direction or can also change directions, then the node has 0.5 probability of staying in the identical direction, probability of 0.25 for fine turning to the east/north and 0.25 probability of fine turning to the west/south depending on the direction of the prior movement. If a node has only two alternatives like the situation when the node is in one of four bounding paths of the network, then the node has an equal probability of discovering either of the dualistic options. If a node reaches any of four concerns of the network, then the node has no other choice except to explore that option. Figure 3 shows the flow pattern of nodes in Manhattan mobility model.

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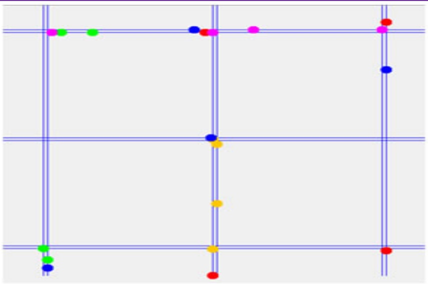

Figure 3: Movement of nodes in Manhattan Model

3. 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 Manhattan Mobility Model. 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	Manhattan	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):** The number of data packets received by a destination on total data packets sent by the source node is called as packet delivery ratio (PDR) [10] shown in figure 4.

$$\text{PDR} = \frac{\sum_{i=0}^{n-1} \text{Number of data packets received}}{\sum_{i=0}^{n-1} \text{Number of data packets sent}} \quad (1)$$

- **Average End-to-End Delay:** It indicates that the time taken for a packet to travel from the source node application layer of the destination node. It also includes the route discovery wait time that may be experienced by a node when a route is initially not available. This time includes establishment route, waiting in the Priority/CMU queue, the transferring time in the wireless channel [11] shown in figure 5.

$$\text{Delay} = \frac{\sum_{i=0}^{n-1}(\text{Receiving\_Time} - \text{Sending\_Time})}{\sum_{i=0}^{n-1} \text{Total\_Packets}} \quad (2)$$

- **Throughput:** It is defined as the ratio of total packets received to the simulation time [12] as shown in figure 6.

$$\text{Throughput} = \frac{\sum_{i=0}^{n-1} \text{Number of data packets received}}{\text{Simulation\_Time}} \quad (3)$$

- **Total Dropped Packets:** This is the number of packets lost due to incorrect or unavailable routes and MAC layer collisions shown in figure 7.

$$\text{Drop\_rate} = \sum_{i=0}^{n-1}(\text{Packets\_Sent} - \text{Packets\_Received}) \quad (4)$$

- **Packet Overhead:** It is the number of all nodes transmission packets including data and encoded packet [13] shown in figure 8.

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$$\text{Packet\_Overhead} = \sum_{i=0}^{n-1} \text{Data\_Packets} + \sum_{i=0}^{n-1} \text{Control\_Packets} \quad (5)$$

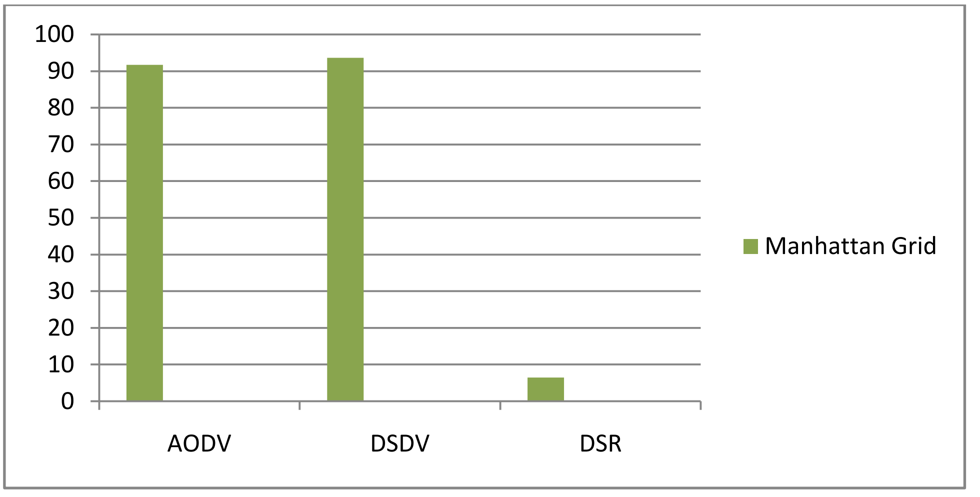

Figure 4: Packet Delivery Ratio

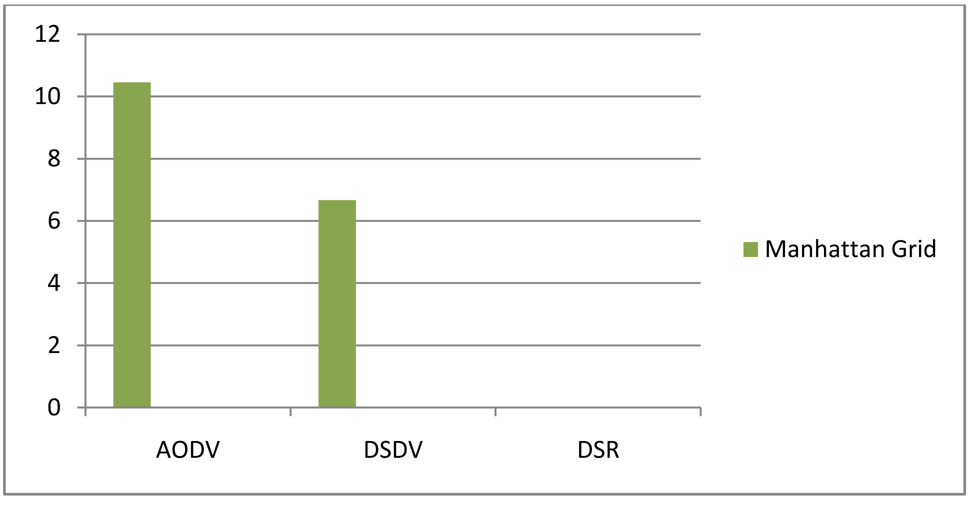

Figure 5: Average End-to-End Delay

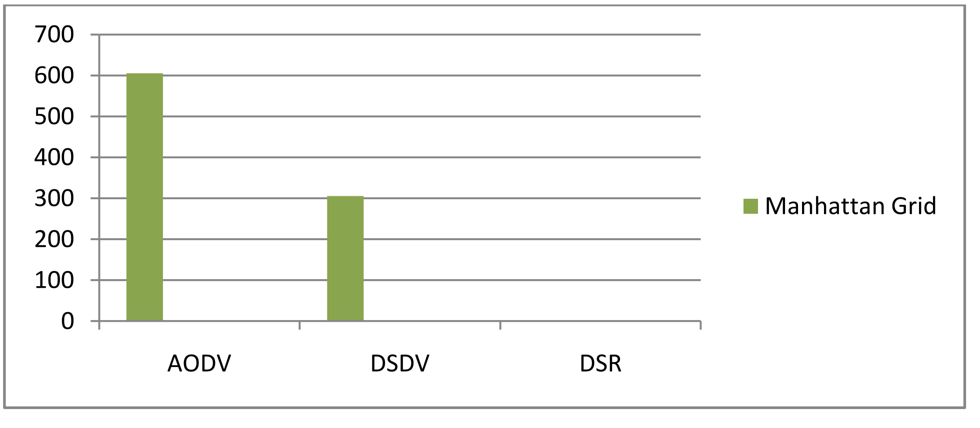

Figure 6: Throughput

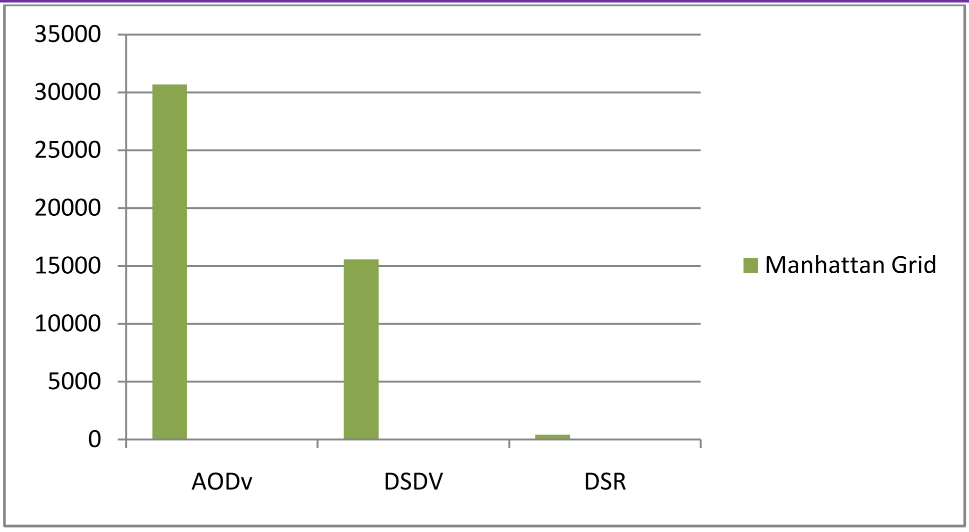

Figure 7: Packet Overhead

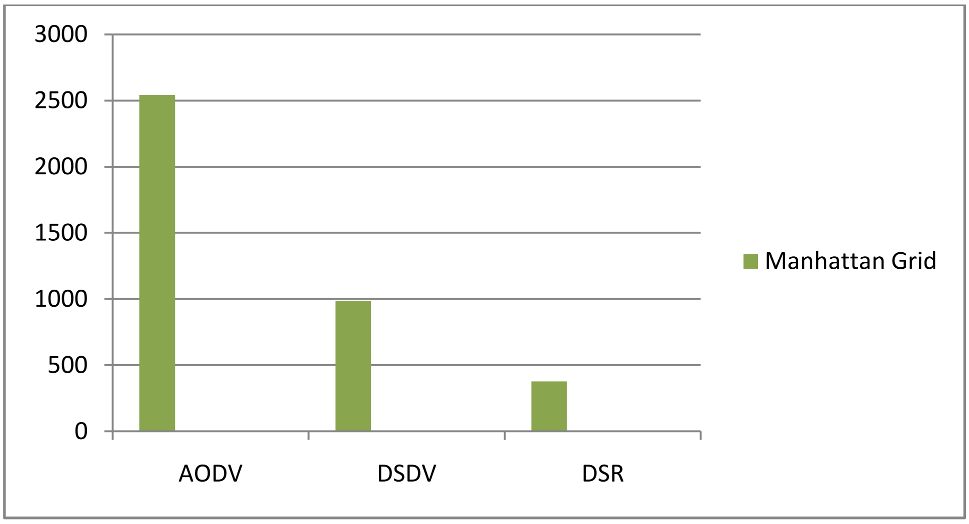

Figure 8: Average Packet Loss

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 mobility model 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 3, packet delivery ratio is increased for DSDV with Manhattan model. In performance metric Average End to End Delay, DSR has lesser delay than AODV, and DSDV. AODV provides more throughput and packet overhead. DSR is acting well in case of packet loss with the Manhattan mobility model.

4. CONCLUSION

We analyzed the behavior of MANET routing protocols under geographic restriction based mobility model. 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 RWP plays as a base mobility model to analyze the performance of routing protocols when there is no group movement but it has sharp movement when reaches to boundary line. The aim of this research to develop an understanding of the effect of temporal dependency based 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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