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An Analysis of Stable Mobility Model for TORA & OLSR Routing Protocols in MANET

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Abstract: A Mobile Ad-Hoc Network (MANET) is a self-configuring network of mobile nodes connected by wireless links to form an arbitrary topology without the use of existing infrastructure. In this paper, we have evaluated the performance of two routing protocols Temporally Ordered Routing Algorithm Protocol (TORA-Reactive Protocol) and Optimized Link State Routing Protocol (OLSR-Proactive Protocol) based upon different Mobility Models to analyse a Stable Mobility Model for MANET Routing Protocol. For experimental purposes, we have considered four mobility model scenarios: Random Waypoint, Reference Group Point Mobility, Freeway and Manhattan models. These four Mobility Models are selected to represent the possibility of practical application in the future. Performance comparison has been conducted across the varying Node Speed with fixed Network size. Experimental results illustrate that performance of the routing protocol varies across different mobility models.

Keywords: MANET, Throughput, End-to-End Delay, Packet Delivery Ratio, Routing overhead, Packet loss, TORA, OLSR, RWPM, RPGM, MGM, Freeway.

I. INTRODUCTION

A mobile ad-hoc network (MANET) is a self-configuring network of mobile nodes connected by wireless links, to form an arbitrary topology. The nodes are free to move randomly. Thus the network's wireless topology may be unpredictable and may change rapidly. Minimal configuration, quick deployment and absence of a central governing authority make ad hoc networks suitable for emergency situations like natural disasters, military conflicts, emergency medical situations etc. [1] [2].

Simulation studies of MANET routing protocols have mostly assumed random waypoint (RWPM) as a reference mobility model [3], [4]. In order to examine many different MANET applications there is a need to provide additional mobility models. Typical examples are modeling a movement in the city street environment, university campuses and the movement of groups of nodes, e.g. for specific military purposes. Recently, a performance comparison of AODV, DSR and TORA protocols based on the Manhattan grid (MGM), RWPM, RPGM model has been published [5]. A performance study of AODV, OLSR, DSR and TORA considering a probabilistic random walk and the boundless simulation area has been presented in [6]. A performance evaluation of TORA using scenario based RWPM mobility models has been presented in [7]. A comparative analysis of FSR and OLSR protocols, considering Random Waypoint, Reference group mobility, File Mobility models can be found in [8].

The objective of this work is to provide a systematic and comprehensive comparative analysis of the two typical representations of MANET routing protocols, OLSR (proactive routing protocol) and TORA (reactive routing protocol), with respect to the four mobility models. They include Random Waypoint mobility model, Reference Point Group mobility model, Freeway and Manhattan mobility model. Performance analysis and comparison encompass packet delivery fraction, end-to-end delay, throughput, and packet drop with respect to different node speeds and fixed network size. The analysis covers a wide range of MANET scenarios and aims to be useful in a variety of applications, for the purpose of network research, design and implementation.

II. OVERVIEW OF ROUTING PROTOCOLS

Considering procedures for route establishment and update, MANET routing protocols can be classified into three types: Proactive Protocols, Reactive Protocols and Hybrid Protocols.

Proactive or table-driven protocols attempt to maintain consistent up-to-date routing information from each node to every other node in the network. Each node maintains tables to store routing information, and any changes in network topology need to be reflected by propagating updates throughout the network.

Reactive or on demand protocols are based on source-initiated on-demand reactive routing. This type of routing creates routes only when a node requires a route to a destination. Then, it initiates a route discovery process, which ends when the route is found.

Hybrid protocols combine proactive and reactive schemes.

A. Temporally Ordered Routing Algorithm Protocol (TORA):

TORA protocol [9] belongs to the class of reactive protocols. The protocol is highly adaptive, efficient and it is used to establish the “temporal order” of topological change events which is used to structure the reaction to topological changes. The protocol is designed to minimize reaction to topological changes. The protocol is distributed in that nodes need only maintain information about adjacent nodes. The protocol is “source initiated” and quickly creates a set of routes to a given destination only when desired. The protocol accomplishes three functions through the use of three distinct control packets such as query (QRY), update (UPD) and clear (CLR). QRY packets are used for both creating and maintaining routes, and CLR packets are used for erasing routes.

B. Optimized Link State Routing Protocol (OLSR)

In OLSR [10], each node periodically constructs and maintains the set of neighbours that can be reached in 1-hop and 2-hops. Based on this, the dedicated MPR algorithm minimizes the number of active relays needed to cover all 2-hops neighbours. Such relays are called Multi-Point Relays (MPR). A node forwards a packet if and only if it has been elected as MPR by the sender node. In order to construct and maintain its routing tables, OLSR periodically transmit link state information over the MPR backbone. Upon convergence, an active route is created at each node to reach any destination node in the network.

III. MOBILITY MODELS DESCRIPTION

A. Random Waypoint Model (RWPM):

The Random Waypoint model is the most commonly used mobility model in research community. At every instant, a node randomly chooses a destination and moves towards it with a velocity chosen randomly from a uniform distribution [0, V_max], where V_max is the maximum allowable velocity for every mobile node [11].

After reaching the destination, the node stops for a duration defined by the 'pause time' parameter. After this duration, it again chooses a random destination and repeats the whole process until the simulation ends.

B. Reference Point Group Mobility Model (RPGM):

Reference point group mobility can be used in military battlefield communication. Here each group has a logical centre (group leader) that determines the group's motion behaviour. Initially each member of the group is uniformly distributed in the neighbourhood of the group leader. Subsequently, at each instant, every node has speed and direction that is derived by randomly deviating from that of the group leader [12].

C. Manhattan Grid Model (MGM):

In this model nodes move only on predefined paths. The arguments -u and -v set the number of blocks between the paths [13, 14] Maps are used in this model too. However, the map is composed of a number of horizontal and vertical streets. The mobile node is allowed to move along the grid of horizontal and vertical streets on the map. At an intersection of a horizontal and a vertical street, the mobile node can turn left, right or go straight with certain probability. It too imposes geographic restrictions on node mobility.

D. Freeway Model:

This model emulates the motion behaviour of mobile nodes on a freeway map and each freeway has lanes in both directions [14]. 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.

IV. PERFORMANCE METRICS

The Routing Protocols Performance is evaluated using four mobility models like RWPM, RPGM, Manhattan, and Freeway. The Routing Protocol Performance Metrics that evaluated are.

A. ***Throughput:*** Throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. The throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot.

$$Tp = (Tbr/St) * (8/1000)\ kbps$$

where
Tp = Throughput
Tbr = Total no of bytes received
St = Simulation time

B. ***Packet Delivery Fraction:*** Packet Delivery Ratio is the delivery ratio of the data packets which are generated by the CBR sources to the destination. The performance of the protocol is better if PDF value is higher which implies that how successful the packets have been delivered.

$$PDR = Ps / Pr$$

where
Ps = Packet sent
Pr = Packet received

C. ***End to End Delay:*** Average end-to-end delay is an average end-to-end delay of data packets. This delay can be caused by many reasons, like, latching during route discovery latency, queuing at interface queue, and retransmission delays at the MAC. End to end delay can be calculated by dividing the time difference between every CBR packet sent and received, in the total number of CBR packets received. For the better performance of the protocol end to end delay must be as low as possible.

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

where
$d_{end\text{-}end}$ = end-to-end delay
d_{trans} = transmission delay
d_{prop} = propagation delay
d_{proc} = processing delay
N = number of links

D. ***Packet Loss:*** Due to many reasons packets will be dropped while moving from source to the destination. Packet Loss is used to measure of the number of packets dropped by the routers It is defined as the difference between the number of packets sent by the source and received by the destination.

$$PL = Ps - Pr$$

where
Ps = Packet sent
Pr = Packet received

V. SIMULATION SETUP

This section of the paper gives simulation workflow and simulation environment setup to evaluate the effect of mobility on the performance of routing protocols. The routing protocol used for the simulation is available with NS-2 (version 2.35). Simulation Parameters are found in Table I.

Table I Simulation Parameters

Parameter	***Values***
Protocols	TORA, OLSR
Simulation Area	1100m x 1100m
Simulation Time	200 Sec
No of Nodes	40
Traffic type	CBR
MAC Protocol	MAC/802.11
Antenna	Omni Directional
Maximum Speed	1,10,20,30,40,50 m/Sec
Mobility Model	RWPM, RPGM, Freeway, MGM
Network Simulator	NS 2.35

Four mobility models RWPM, RPGM, Manhattan, and Freeway Models are used and the scenarios, movements for these Models were generated using a software called Mobility Generator [15] which is based on a framework called Important (Impact of Mobility Patterns On Routing in Ad-hoc Networks, from University of Southern California) which upon inputs of number of nodes, mobility model and scale (area) generates the TCL script for mobility. Background traffic, using TCL script is also employed along with the traffic, which we have monitored. Standard 802.11 MAC layer was used and transmission range in each simulation was 250 meters.

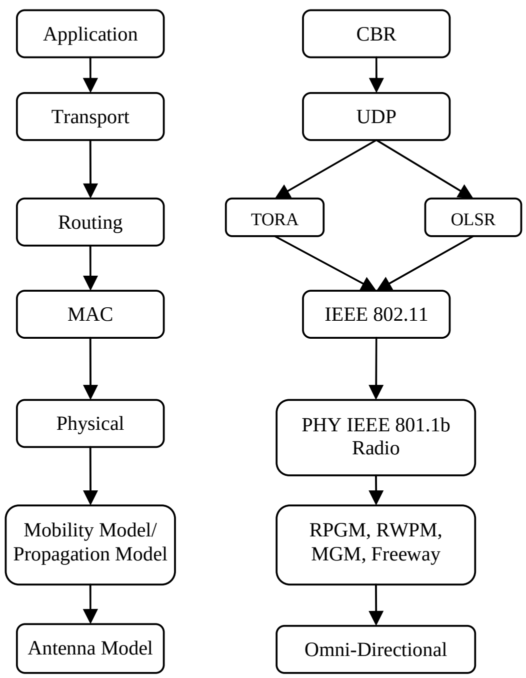

Figure. 1 Simulation Environment Setup

Fig. 1 shows the Simulation Environment setup. All the nodes in the simulation had Omni directional antennas. A standard CMUPri model for queue of buffer size 50 was used. The simulation had 40 nodes and runs for 200 secs. Flat 1100x1100 mtr scenario was created in all the mobility cases.

VI. PERFORMANCE EVALUATION

The objective of the analysis is to observe how the routing protocol performance gets affected with different mobility pattern in fixed network size of 40 nodes and varying node speed 1,10,20,30,40,50 (m/Sec) with 200s simulation time in mobile ad-hoc environment. A 'cbr' data packet application of size 512 bytes is taken. The simulation is carried out in the region of 1100m x 1100m in the present analysis.

We have evaluated the performance based on End-to-End delay, Throughput, Packet Delivery Ratio and Packet Loss as the metrics. These metrics describe nature of Ad hoc networks and formulate boundary conditions of Ad hoc networks but these properties do not directly related to performance. To measure external performance of a protocol, we consider end-to-end delay as metrics and to measure internal effectiveness of a protocol; we consider throughput, packet delivery ratio and packet loss as the metrics. All these metrics are most widely used for representing performance of routing protocols because higher data delivery, lower control overhead and lower delay are always desirable.

A. Analysis of TORA Performance Metrics with Different Mobility Models:

It has been observed that the Throughput for TORA protocol has different effects according to various Mobility models, but the throughput is constant for TORA in RPGM other than Freeway, MGM and RWPM models, In MGM the throughput is low as the node speed decreases and it keeps constant as the node speed increases shown in Fig. 2 (a).

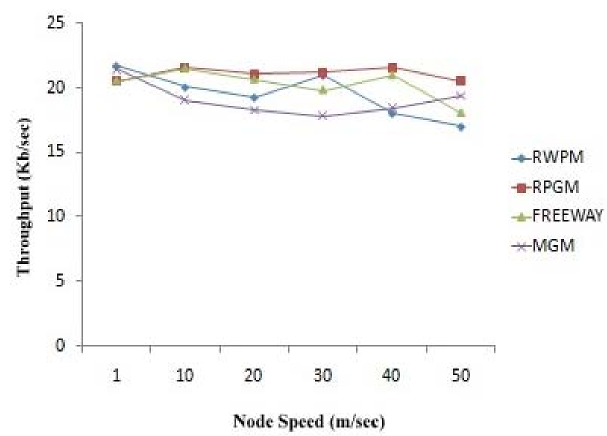

Figure. 2 (a) TORA – Node Speed (m/Sec) vs. Throughput (KB/Sec)

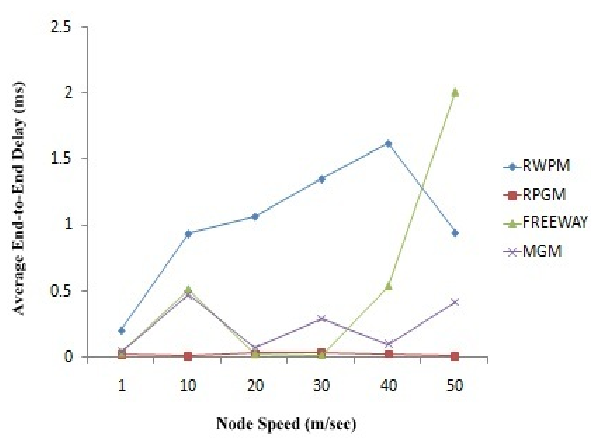

Figure. 2 (b) TORA – Node Speed (m/Sec) vs. Average End- to- End Delay (ms)

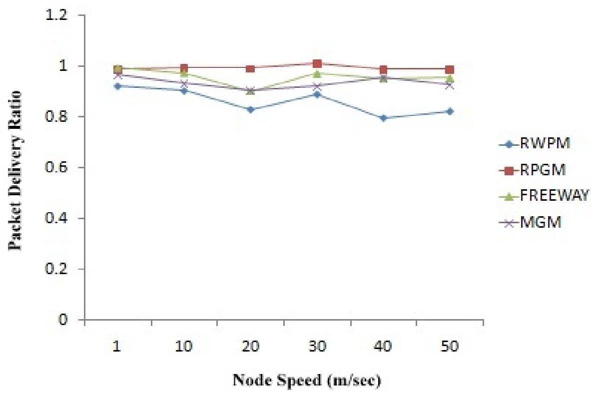

Figure. 2 (c) TORA – Node Speed (m/Sec) vs. PDR (%)

Considering the Average End-to-End Delay for TORA it has lower Delay for the RPGM than other models like RWPM, Freeway and Manhattan Model. It has been also observed that the delay increases in RWPM and Freeway model as the node speed increases. The delay is constant in the Manhattan mobility model as shown in Fig. 2 (b). The Packet Delivery Ratio for TORA is constant for RPGM other than RWPM, Freeway, and Manhattan Models; While RWPM has a low Packet Delivery ratio shown in Fig. 2 (c). Considering the Packet Drop in TORA RWPM has a high Packet Drop other than RPGM, Freeway and Manhattan Models, RPGM has a low Packet Drop, where Freeway and Manhattan Models have a constant drop in Packets as shown in Fig. 2 (d).

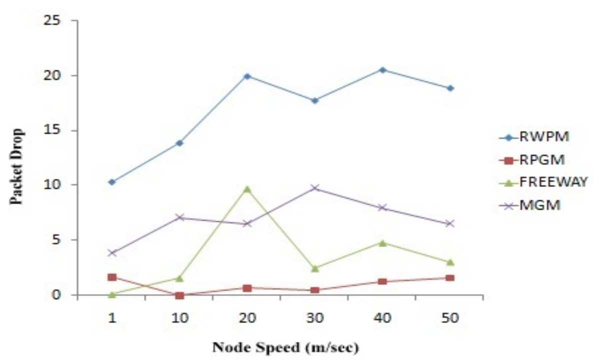

Figure. 2 (d) TORA – Node Speed (m/Sec) vs. Packet Drop (%)

From the above results it is clear that mobility models have varying characteristics depending upon Routing protocols. Mobility models behave randomly. Table II shows the Performance Comparison of TORA Protocol's Metrics with Mobility Models.

Table 2: TORA Performance vs. Mobility Models

	TORA			
	Throughput	End - End Delay	PDR	Packet Drop
RWPM	80.57 %	23.27 %	72.00 %	72.88 %
RPGM	83.65 %	0.61 %	82.55 %	3.88 %
MGM	76.23 %	8.71 %	77.91 %	18.46 %
FWM	82.42 %	21.26 %	79.80 %	13.42 %

The Overall comparison of TORA Performance Metrics and the Mobility Models clearly states that, Throughput for TORA is good with RPGM while it is bad with MGM Model; Average End to End Delay is low in RPGM while it is high in RWPM and freeway Model. PDR is good in RPGM and Bad in RWPM. Packet Drop is low in RPGM than RWPM, MGM, and Freeway Models. Finally it is clear that RPGM is Stable with the Performance Metrics of TORA Routing Protocol.

B. Analysis of OLSR Performance Metrics with Different Mobility Models:

It has been observed that throughput for OLSR increases in RPGM other than RWPM, Freeway Model and Manhattan Model, and the throughput decreases very low in RWPM and Manhattan Model as the node speed increases shown in Fig. 3 (a).Considering the Average End-to-End Delay for OLSR it has lower Delay for the RPGM than other models like RWPM, Freeway and Manhattan Model. Average End-to-End Delay increases drastically in Freeway and Manhattan models as the node speed increases shown in Fig. 3 (b).

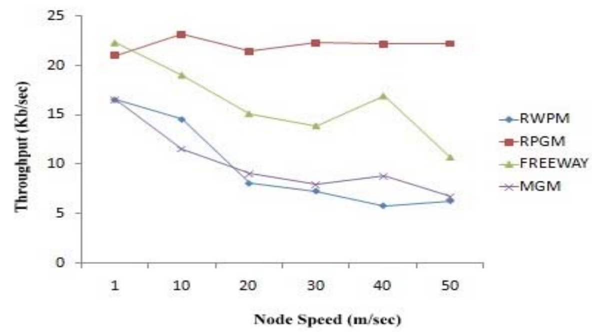

Figure. 3 (a) OLSR – Node Speed (m/Sec) vs. Throughput (KB/Sec)

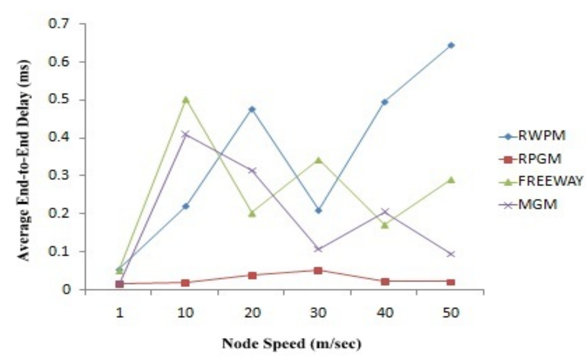

Fig. 3 (b) OLSR – Node Speed (m/Sec) vs. Average End-to- End Delay (ms)

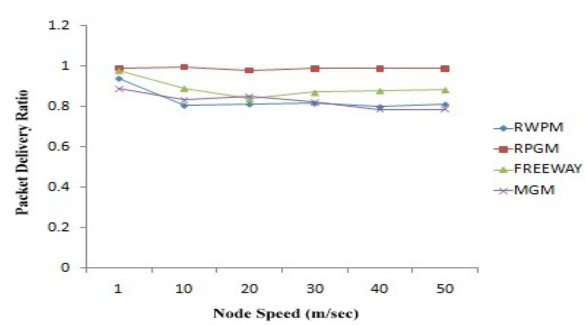

Figure. 3 (c) OLSR – Node Speed (m/Sec) vs. PDR (%)

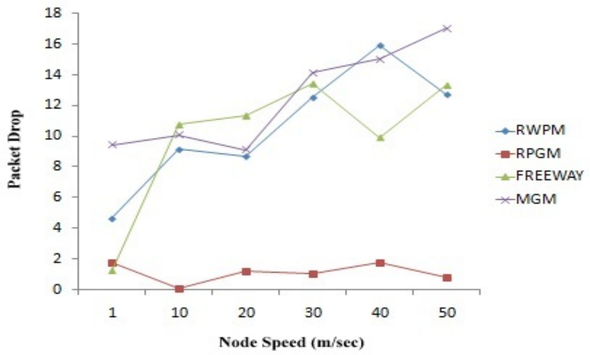

Figure. 3 (d) OLSR – Node Speed (m/Sec) vs. Packet Drop (%)

The Packet Delivery Ratio for OLSR is constant for RPGM other than RWPM, Freeway, and Manhattan Models, While in RWPM, Freeway, and Manhattan Models the Packet Delivery ratio decreases slightly as the node speed increases shown in Fig. 3 (c). Considering the Packet Drop in OLSR a low Packet Drop is observed in RPGM, where RWPM, Freeway and Manhattan Models have high drop in Packets. Manhattan Model has the high Packet drop while Freeway and Random waypoint model has High Drop in Packets as the node speed increases shown in Fig 3(d).

From the above results and Performance analysis of OLSR protocol it is stated that Mobility models has varying impact on the Routing Protocols. Table III shows Performance Comparison of OLSR Protocol's Metrics with Mobility Models.

Table 3: OLSR Performance vs. Mobility Models

	OLSR			
	Throughput	End - End Delay	PDR	Packet Drop
RWPM	71.25 %	10.66 %	38.80 %	64.57 %
RPGM	82.21 %	1.63 %	88.06 %	4.90 %
MGM	68.94 %	20.34 %	36.79 %	75.80 %
FWM	74.76 %	14.96 %	62.99 %	47.90 %

The Overall comparison of OLSR Performance Metrics and the Mobility Models clearly states that, Throughput for OLSR is good with RPGM while it is bad with MGM and RWPM; Average End to End Delay is low in RPGM while it is high in MGM and freeway Model. PDR is good in RPGM and Bad in RWPM and MGM. Packet Drop is low in RPGM while it is high in RWPM, MGM, and Freeway Models. Finally it is clear that RPGM is Stable with the Performance Metrics of OLSR Routing Protocol.

VII. CONCLUSION

This paper studied the performance of the two widely used MANET routing protocols (OLSR, TORA) with respect to Random Waypoint Mobility Model, Reference Point Group mobility model, Manhattan and Freeway model. We have developed a set of simulation scripts for the NS2 simulation environment merged with the Mobility Generator scenario generation tools. Simulation results indicate that the relative ranking of routing protocols may vary depending on mobility model. The relative ranking also depends on the node speed as the presence of the mobility implies frequent link failures and each routing protocol reacts differently during link failures.

The Reactive protocol TORA experiences the most Stable performance with all mobility models. This protocol performs best with Group Mobility model and Freeway Model. The Proactive protocol OLSR experiences the unstable performance with mobility models like Random Waypoint, Freeway and Manhattan models. This protocol performs best with entity models that have lower levels of randomness (Group Mobility Model). It has been observed that the both TORA and OLSR experience a good performance with the Reference Point Group Mobility Model. While TORA has high Throughput and Low End to End Delay comparing to OLSR Protocol. Packet Delivery Ratio for both TORA and OLSR is relatively same. Considering about the Packet Drop OLSR suffers a high Packet Drop comparing to TORA Protocol.

In Future Work we have planned to prove the Reliability of Protocols by varying the Network size and to compare the Performance of Multicast Routing Protocols like MAODV and ODMRP with varying node speeds and Different Mobility models.

VIII. ACKNOWLEDGEMENT

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