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Simulation of Reactive Routing Protocols in Mobile Ad Hoc Network : A Comparative Study

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Abstract*— MANET describes distributed, wireless, mobile and multi-hop networks that operate without the benefit of any existing infrastructure except for the nodes themselves. A MANET network cloud is composed of autonomous, potentially mobile and wireless nodes that may be connected at the edges to the fixed, wired internet. Our simulative study on MANET routing protocols and mobility models aims to determine the performance of current MANET routing protocols with respect to various mobility models implemented in ns-2. Routing is a challenging issue in MANET. To the best of our knowledge, no published work is available in the present literature, which compares distinct criteria as we have done to evaluate the performance of the considered routing protocols. Therefore focus in this paper is to compare the performance of two routing protocols DSR and AODV for CBR traffic by varying no. of nodes and mobility in terms of three metrics viz. packet delivery ratio (pdf), end to end delay, and Normalized routing Load(NRL). The simulation is carried out on NS2. The effort allows a fair comparison of the capabilities and limitations of different types of mobility patterns and their suitability for contemporary MANET routing protocols.

***Keywords*— AODV, DSR, Mobile ad hoc network, NS-2.34, RPGM and RWP**

I. Introduction and Related Work

Wireless and mobile ad hoc networks [1, 2] turn out to be the first option for a wide range of applications such as military, rescue, environmental, home automation, health, and security. The Recent Research and survey shows that demand of wireless portable devices such as mobile phones, laptops and PDAs is increasing in everyday life. It leads to the possibility of spontaneous or ad hoc wireless communication. Within the last few years there has been a surge of interest in mobile ad hoc networks (MANET)[3]. The reason of their popularity is because of the ease of deployment, infrastructure less, topology and their dynamic nature. Ad hoc networks [1] are typically built from low cost wireless devices such as notebook or handheld devices. Sometimes these devices have limited power and transmission range.

Two variations of mobile wireless network are: infrastructure network and infrastructure less network. Infrastructure network has bridges, known as base stations [3].These networks communicate with the nearest base station which lies within the range. The other variation is infrastructures less network, which are also called as Mobile ad hoc network (MANET). An ad hoc network [1] is a collection of mobile nodes forming a temporary network without the aid of any centralized administration or standard support services regularly available on conventional networks. Mobile Ad hoc networks (MANETs) are of much interest to both the research community and the military because of the potential to establish a communication network in any situation that involves emergencies. Examples are military deployment in hostile environment, search-and-rescue operations and several types of police and military operations. The advantages of such network are flexibility, rapid deployment, robustness, and inherent support for mobility.

A MANET is a collection of wireless mobile nodes forming a temporary network without using any centralized access point, infrastructure and centralized supervision. MANET is defined as a collection of mobile platforms or nodes where each node is free to move about arbitrarily. Due to node mobility, the network topology may change rapidly and unpredictably over time. Each node logically consists of a router that may have multiple hosts. The dynamic nature of MANET topology imposes the use of efficient routing protocols that ensure the delivery of packets safely to their destinations with acceptable delays. In spite of the problems of MANETs, MANETs have a tremendous potential to be used in various real-world situations such as battle field scenarios, rescue operations and vehicular networks, where setting up a traditional network infrastructure would be implausible [3]. Routing is the act of moving information across an internetwork from a source to a sink. Along the way, at least an intermediate node typically is encountered. The routing protocol has two main functions, First is the selection of routes for different source-destination pairs and the delivery of messages to their appropriate destination. The second function is the conceptually straightforward using a variety of protocols and data structures (routing tables).

Over the last few years, a number of routing protocols have been anticipated and enhanced to well route data packets among two nodes in MANETs [3]. It is not clear how those different protocols perform under different environments like that a protocol may be the best in one network configuration but the worst in another.
The main aim of this paper is :

• Describing the detailed understanding of ad hoc routing protocols.
• Implementing the Mobility models
• Analyze and compare the performance of routing protocols under different mobility models.

The purpose of this research is to provide understanding of how mobility affects routing in ad hoc networks and how to quantise those effects.

The rest of the paper is organized as follows. In section 2, we first present an entity model named Random Way Point mobility model (RWP) [4] and general group mobility model, called Reference Point Group Mobility model(RPGM)[5]. Section 3 briefly discusses the MANET routing protocols description and the functionality of the two familiar reactive routing protocols AODV and DSR. Section 4 shows the simulation results and performance comparison of the two above said routing protocols. Finally, Section 5 concluded with the comparisons of the overall performance of two reactive routing protocols AODV and DSR based on metrics like packet delivery ratio(%), the average end-to-end delay(ms) and Normalized routing load.

II. MOBILITY MODELS

A mobility model [6] should attempt to emulate the movements of real mobile nodes. To evaluate the performance of a protocol for an ad hoc network, it is required to test the protocol under realistic environments, especially including the movement of the mobile nodes in a network. Mobility models are based on setting out different parameters related to node movement. In the literature, there is a lot of mobility models used, mostly in simulations.

Random way point mobility model

The random way point model [4] is the simplest model but still the most widely used model to evaluate the performance of MANETs. The random way point model includes pause time between changes in direction and/or speed[7]. As a Mobile Node begins to move, it stays in one location for a certain period of time i.e. pause time. Once the pause time is elapsed, the Mobile node randomly chooses the next destination in the simulation area and selects a random speed uniformly distributed between [minspeed, maxspeed] and travels with a speed *v* which is uniformly chosen between the interval (0, *Vmax)*. Then, the MN continues its journey toward the newly selected destination at the chosen speed. As the mobile node arrives at the destination, it stays again for the specified pause time before continuing the process. The Random Waypoint Mobility Model is very widely used in simulation studies of MANET. As described in the performance measures in mobile ad hoc networks are affected by the mobility model used.

Reference Point Group Mobility Model

Reference Point Group Mobility (RPGM)[5] Model described as another way to simulate group behavior, The RPGM Group mobility may be used in rescue operations and military battlefield applications, where the commander and soldiers form a logical group. In reference point group mobility model, simulate group behavior, where each node belongs to a group where every node follows a logical centre (group leader) that determines the group's motion behavior. The nodes in a group are randomly distributed around a reference point. Each node use their own mobility model and are then combined to the reference point, which directs them in the direction of group. The movement of a group leader determines the movement of the members of that group. This generic description of group mobility can be used to create diversity of models for different types of mobility applications.

III. DESCRIPTION OF ROUTING PROTOCOLS

A lot of mobile ad hoc network routing protocols [8] have been proposed in the last four decade. These protocols can be classified into three main categories [9, 10] according to their functionality:

1. Proactive protocols
2. Reactive protocols and
3. Hybrid protocols

Proactive protocols

In proactive routing protocols the routes to all the destinations (or parts of the network) are determined at the time of start up and maintained by a periodic route update process. The protocols in proactive approach maintain consistent routing information about each node to other node in the form of a table.

Reactive Protocols

Reactive routing protocols establish routes only when they are needed [9, 10]. When a source node requires a route to a destination node, then it initiates a route discovery process by flooding the entire network with a route request (RREQ) packet. Once a route has been established by receiving a route reply (RREP) packet at the source node, different form of route maintenance procedure is used to maintain it, until either the destination becomes inaccessible or the route is no longer desired. These protocols use less bandwidth for maintaining the routing tables at every node.

Hybrid Protocols

When a network is large, the nodes are usually organized into a hierarchy. Hybrid routing protocols [8] attempts to combine the best features of proactive and reactive algorithms. It often consists of the two classical routing protocols: proactive and reactive. Hybrid protocols divide the network into areas called zones which could be overlapping or non-overlapping depending on the zone creation and management algorithm employed by a particular hybrid protocol.

AODV (Ad-hoc On-Demand Distance Vector Routing)

AODV [11] is an 'on demand routing protocol' with small delay. It is a destination based reactive protocol that means that routes are only established when needed to reduce traffic overhead. AODV is essentially a combination of DSR [12] and DSDV. It borrows the concept of basic on demand mechanism of route discovery and route maintenance from DSR, plus the use of sequence no, hop by hop routing, , and periodic beacons from DSDV. AODV supports Unicast, Broadcast and Multicast without any further protocols. This protocol inherits the feature of route discovery from DSR. However, AODV resolves the problem of large headers found in DSR. The Count-To-Infinity and loop problem is solved with sequence numbers and the registration of the costs. AODV maintains routing tables on the nodes instead of including a header in the data packet. The source node initiates the route discovery process in the same way as in DSR. An intermediate node may reply with a route reply (RREP) only if it knows a more recent path than the one known by the sender node to the destination. A destination sequence number is used to indicate how recent the path is as follows. A new route request generated by the sender node is tagged with a higher sequence number and an intermediate node that knows the route to the destination with a smaller sequence number cannot send the route reply(RREP) message. Forward links are setup when these RREP travels back along the path taken by RREQ. So the routing table entries are used to forward the data packet and the route is not included in the packet header.

DSR (Dynamic Source Routing)

The Dynamic Source Routing (DSR) [12, 13] is a reactive routing protocol which is specifically designed for use in multi hop wireless Ad hoc networks. It finds the routes when necessary and maintains them. DSR uses source routing and caching [12] where the sender node includes the complete hop-by-hop route to the destination node in the packet header and routes are stored in a route cache. The DSR is composed of two main mechanisms to allow the discovery and maintenance of source routes in the ad hoc networks. Route Discovery is a mechanism by which a source node sends a packet to a destination node, and obtains a source route to destination. Route Maintenance is a mechanism by which a node sends a packet to a destination is able to detect, if the network topology has changed. DSR uses more memory while reducing the route discovery delay in the system. When a node wants to communicate with another node to which it does not know the route, it initiates a route discovery with a flooding request of route request (RREQ) packets. Each node receiving the RREQ packets retransmits it unless it is the target node or it knows the route to the destination from its cache. Such a node replies to the RREQ message with a route reply (RREP) packet. The RREP packet takes the traverse path back to the source node established by the RREQ packet. This route is stored in the source node cache for future communication. If any link of the route is broken, the source node is informed by a route error (RERR) packet and this route is discarded from cache. Intermediate nodes store the source route in their cache for possible future use.

IV. SIMULATION AND ANALYSIS

The objective of this paper is to study and analyze the performance of two routing protocols for mobile ad hoc network. The network simulations have been carried out using an open-source network simulation tool call Network Simulator version 2 (NS-2.34)[14]. Routing protocols are Ad-Hoc on-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR). The simulation environment will be conducted with the LINUX operating system. We have generated mobility scenarios for Random waypoint and reference point group Model using the BONNMOTION tool and have converted generated scripts to the supported ns2 format so that they can be integrated into TCL scripts. We use traffic and mobility models similar to those previously reported using the same simulator [14]. Traffic sources are continuous bit-rate (CBR). The used data packets are 512 bytes.

Simulation Parameters

The main interest of this paper was to test the ability of different routing protocols to react on network topology changes (for node speed, no. of nodes and so on). Furthermore the focus was set on different network sizes (varying number of nodes) and different mobility (varying speed). The performance of AODV and DSR is evaluated by varying the node speed, number of nodes and keeping the other parameters such as transmission rate, pause time, simulation duration constant.

Performance Metrics

While analyzed the AODV and DSR protocols, we focused on three performance metrics [15] for evaluation which are Packet Delivery Fraction (PDF), Average End-to-End Delay and Normalized Routing Load (NRL).

Packet delivery fraction

Packet delivery fraction (PDF) is the ratio of number of received data packets successfully at the destinations over the number of data packets sent by the CBR sources.

Average End to end delay

It is the average time from the transmission of a data packet at a source node until packet delivery to a destination which includes all possible delays caused by buffering during route discovery, retransmission delay, propagation, queuing at the interface queue and transfer times of data packets.

$$D = (Tr - Ts)$$

Where Tr is the receive Time and Ts is sent Time.

Normalized Routing Load

The normalized routing load (NRL) it is the ratio of all routing control packets send by all nodes to number of received data packets at the destination nodes. Number of routing packets "transmitted" per data packet "delivered" at destination. It is the sum of all control packet sent by all node in network to discover and maintain route.

NRL = Routing Packet/Received Packets

Simulation Results

This chapter describes the simulation results obtained for packet delivery fraction, delay and normalized routing load. PDF and NRL are deducing through scalar values obtained in each application scenario simulation results. These simulations are using two mobility models that will be tested on different routing protocols scheme.

(i) Effect of varying number of nodes

A desirable property of a protocol is to have stable behavior regardless of the number of nodes in the network. The number of nodes was varied from 25 to 100 and the effect on PDF, AED and NRL was studied. The results can be found in figures 1, 2 and 3. A small number of nodes in a large simulation area will result in low connectivity due to the large distances between nodes.

The packet delivery fraction decreases as the number of nodes in the network increases. This is due to the fact that as the no. of nodes increases, the congestion in the network also increases and hence the number of lost packets due to retransmission also increases.

The Fig.1 inferred that In RWP model when we have less no of nodes aodv outperforms DSR by about 8% as we increases the nodes and the network become dense then DSR exceeds AODV by about 10 to 15%. While in RPGM, AODV outperforms DSR by 48%. All the four protocols decrease with increasing number of nodes. DSR shows better performance in Random way Point than DSR in RPGM by approx.48%. The protocols in RWP model performs better than RPGM

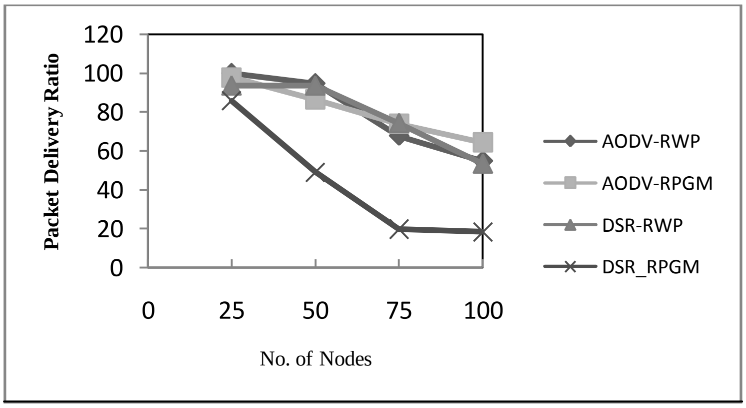

Figure 1 PDF vs. No. of Nodes

Fig 2 shows the measurements of delay at different speeds. In RWP model AODV has lesser delay approx. 15% than DSR. The DSR shows higher delay than aodv for less no of nodes by about 20% . Again in RPGM DSR shows higher delay than AODV by about 55% approx. RPGM found to be the best mobility model resulting in lowest delay for all the protocols. The DSR protocol is affected most bythe mobility model.

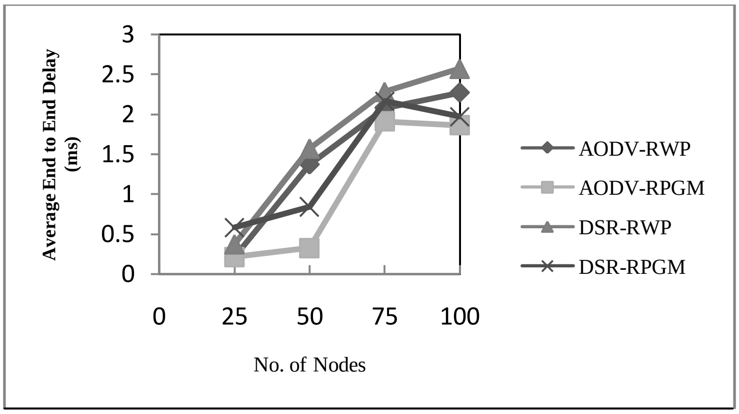

Figure 2 AED vs. No. of Nodes

Figure 3 represent NRL for AODV and DSR protocols in terms of CBR application type. It can be observed from the figures that mobility model has significant impact on the routing load. In RWP model AODV protocol has higher graph values in the plot with increasing number of nodes which implies that an AODV protocol performs worst in terms of NRL.

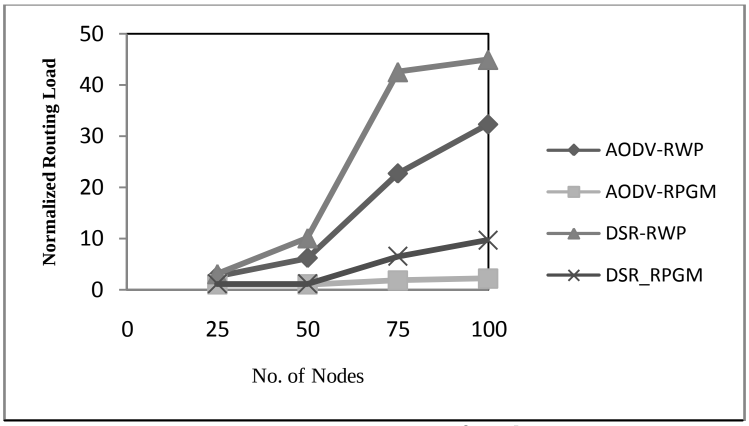

Figure 3 NRL vs. No. of Nodes

In RPGM, AODV has the lowest normalized routing load which is almost independent from the no. of nodes in the network because AODV scales well when the no nodes increases. DSR shows 40% better performance than AODV. In case of lower number of nodes for AODV protocol graph lines have similar NRL but with an increase in the number of nodes, AODV protocol starts outperforming. Routing load is found to be lowest under RPGM. DSR protocol, which causes the highest overhead, is most inconsistent also.

(ii) Effect of varying Node Mobility

In this set of simulations, we vary nodes' mobility. We start with a mobility scenario in which the nodes have a low velocity of 5 m/sec (18 Km/h). We then increase nodes velocity up to 20 m/sec (72 Km/h). We keep a constant number of 20 connections.

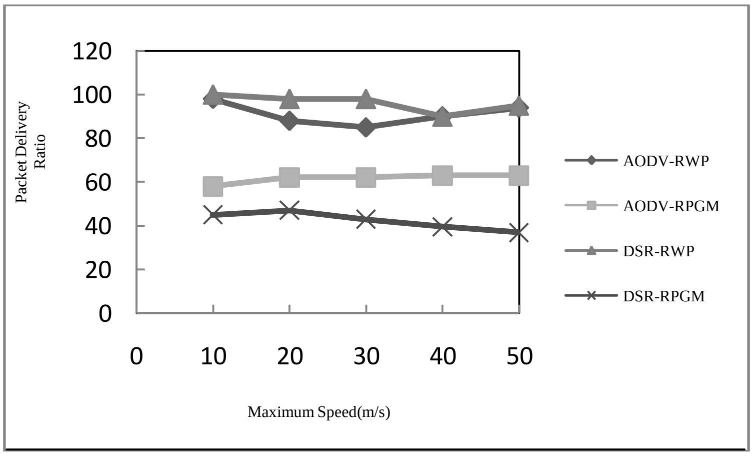

Figure 4 PDF vs. Maximum Speed

Figure 4 summarizes the packet delivery ratio (PDR). In RWP, DSR outperforms AODV by 5% while in RPGM, AODV exceeds DSR by 30%. On comparing the protocols we found that DSR in RWP model perform better than other protocols.

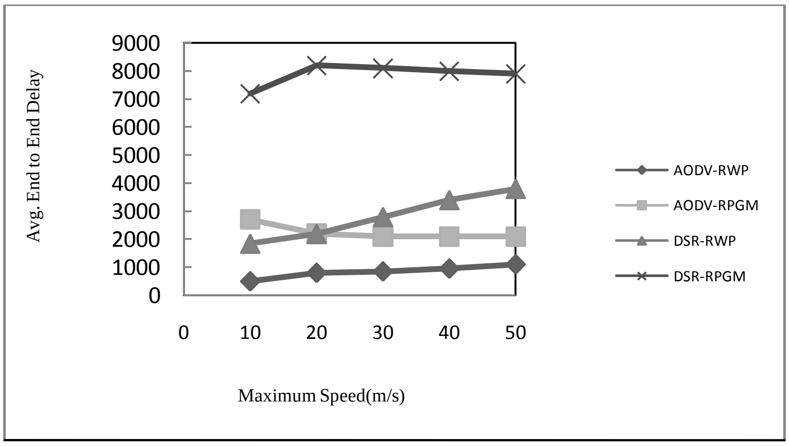

Figure 5 AED vs. Maximum Speed

The delay value of DSR protocol is highest than all the other routing protocols in both application types which means that DSR protocol is severely effected in terms of end to end delay.

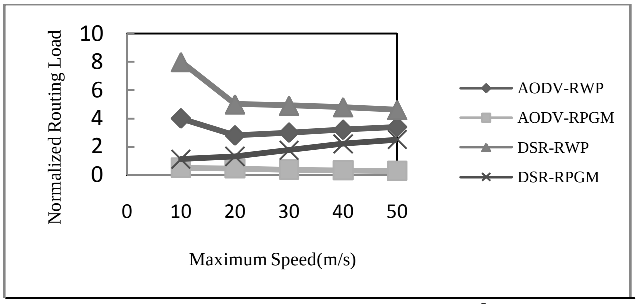

Fig.6 NRL vs. Maximum Speed

According to the definition of NRL it is evident that when NRL is least MANET routing protocol have better performance. The above figure depicts that DSR acts better in terms of NRL.

V. CONCLUSION

Two mobility models (RPGM and RWP) have been evaluated with special reference to performance concerned to routing protocols AODV and DSR. The earlier research on mobility models and comparison of the performance of protocols using NS-2.34 simulator has been done which clearly indicate the significant impact on node mobility pattern on routing performance. We can conclude that in low mobility and low load scenarios, both the protocols react in a similar way, while with mobility or load increasing DSR outperforms AODV routing protocol. Poor performances of DSR routing protocol, when mobility or load are increased, DSR always has a lower routing load than AODV. Due to aggressive caching, DSR will most often find a route in its cache and therefore rarely initiate a route discovery process unlike AODV. AODV performance depended on the mobility models that were used in the simulations. However, there are many other challenges to be faced in routing protocols design. A central challenge is the development of the dynamic routing protocol that can efficiently find routes between two communication nodes.

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