Performance evaluation of routing protocols under different mobility models over MANETs

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Abstract

A Mobile Ad hoc Network (MANET) is a collection of mobile wireless nodes that can dynamically form a network without necessarily using any pre-existing infrastructure. Due to the potential ease of deployment, it is widely used in civilian & military applications. Its multihop connectivity allows the transmission range to be extended infinitely. While its intriguing features enable MANETs to be installed in many situations where traditional networks are unavailable, destroyed or impossible, they pose several problems which arise due to the shared nature of the wireless medium, limited transmission range of wireless devices, node mobility and energy constraints etc. Mobility models define the movement of mobile nodes with respect to location, velocity and acceleration in MANET. Transmissions of Packets between the mobile devices are controlled by Routing Protocols. Performance of routing protocol is affected by mobility rate as well as mobility model used in the simulation. Mobility Models that are used commonly are either non realistic (Random Waypoint) or Semi-realistic (Reference Point Group, Manhattan and Freeway mobility). In this paper, we have used routing protocols from reactive, proactive and hybrid categories to make comparison. The performance routing protocols is observed in non realistic as well as semi-realistic mobility model. The aim of this paper, is to determine the performance measures like throughput, packet delivery ratio, Average end-to-end delay, and Routing overhead of MANET’s Routing - AODV, DSDV, OLSR and ZRP with varying scalability and offered load under different mobility models. The impact of network density on the performance of these said routing protocols under Random Way Point, Random Point Group mobility, Manhattan and Freeway mobility models is observed under NS2 simulator.

Keywords: MANETS, AODV, ZRP, NS-2, PDR,, CBR traffic.

1. INTRODUCTION

Wireless communication is an application of science and technology that has become vital for modern existence. For the home user, wireless has become popular due to the ease of installation and location freedom. From the early radio and telephone to current devices such as mobile phones and laptops, accessing the global network has become the most essential and indispensable part of every one’s lifestyle. Wireless communication is an ever-developing field and the future holds many possibilities in this area. Future devices can be developed to support communication with higher data rates and more security. Dominant means of supporting such communication capabilities is through the use of wireless LANs. As the deployment of wireless LANs increases around the globe, it is important to understand the different technologies and select the most appropriate one.

1.1 Wired vs. Wireless Networks

Computer networks for the home and small business can be built either using wired or wireless technology. Wired Ethernet has been the traditional choice in homes but Wi-Fi wireless technologies are gaining ground fast. Both wired and wireless networks have their own advantages and disadvantages.

1.2 Wireless Networks

A wireless network connects computers without the need of physical wire connections. The lack of a physical connection means that users are able to roam or work wherever they wish and still have access to the computer network. There are three main types of wireless network:

- Wide Area Networks (WAN)
- Local Area Networks (LAN)
- Personal Area Networks (PAN)

Wireless LANs can be broadly classified as (Fig 1 (a & b)):

- Ad hoc Wireless LAN
- Wireless LAN with infrastructure

In ad hoc networks, several wireless nodes join together to establish a peer-to-peer communication. Each client communicates directly with the other clients within the network. Ad hoc mode is designed such that only the clients within the transmission range (within the same cell) of each other can communicate. If a client in an ad hoc network wishes to communicate outside its cell, a member of the cell must operate as a gateway and perform routing. They typically require no administration. Networked nodes share their resources without a central server.
1.3 Mobile Ad-hoc Network
An ad-hoc wireless network is a collection of wireless nodes that self-organize in a network without the help of any existing infrastructure. Some or possibly all of these nodes are mobile. Ad-hoc networks can be classified into three categories based on applications: Mobile Ad-hoc Networks (MANETs), Wireless Mesh Networks (WMNs), Wireless Sensor Networks (WSN). An ad-hoc wireless network is a collection of two or more devices equipped with wireless communications and networking capability. Such devices can communicate with another node that is immediately within their radio range or one that is outside their radio range. For the latter scenario, an intermediate node is used to relay or forward the packet from the source toward the destination. An ad-hoc wireless network is self-organizing and adaptive. This means that a formed network can be deformed on the fly without the need of any system administration. The term “ad-hoc” tends to imply “can be mobile, standalone, or networked.” Ad-hoc nodes or devices should be able to detect the presence of other such devices and to perform the necessary handshaking to allow the sharing of information and services. A mobile ad-hoc network is self-created and self-organized by a set of mobile nodes called hosts. The nodes are interconnected by single-hop or multiple hop wireless connection, and each node may serve as a packet level router for other nodes in the mobile ad hoc network [25, 27].

Mobile ad hoc networks consist of wireless hosts that communicate with each other in the absence of a fixed infrastructure. Routes between two hosts in MANET may consist of hops through other hosts in the network. The task of finding and maintaining routes in MANET is nontrivial since host mobility causes frequent unpredictable topological changes. A number of MANET protocols for achieving efficient routing have been recently proposed. They differ in the approach used for searching a new route and/or modifying a known route, when hosts move. It is assumed that each node is aware of the geographic location of all other nodes in MANET. Of course, for this work all nodes must be able to see all the other nodes of the network, to be able to establish communication with them. When a node goes out of range, it just looses connection with the rest of ad-hoc network. The vision of mobile ad hoc networking is to support robust and efficient operation mobile wireless networks by incorporating routing functionality into mobile nodes [25].

2. MOBILITY MODELS
Mobility is anything that causes a change in the topology, able to move or be moved freely or easily. A mobility generation tool called “setdest” is developed by CMU for generating random movements of nodes in the wireless network of NS-2 is used to generate mobility model and USC mobility generator tool for generating mobility model for Random Point Group Mobility (RPGM), Manhattan (MHM) and Freeway (FWM) model for varying scalability and offered load Scenarios. There are many mobility models proposed. We are going to use the following four mobility model for our research [2].

2.1 Random Way Point Mobility (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. 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.
2.2 Random Point Group Mobility (RPGM)
The group mobility model we proposed here is called Random Point Group Mobility (RPGM) model. Each group has a logical “center”. The center’s motion defines the entire group’s motion behavior, including location, speed, direction, acceleration etc. Thus, the group trajectory is determined by providing a path for the center. Usually, nodes are uniformly distributed within the geographic scope of a group [2].

2.3 Manhattan Model (MHM)
The Manhattan model can be useful in modeling movement in an urban area. The scenario is composed of a number of horizontal and vertical streets. Given below is example topography showing the movement of nodes for Manhattan Mobility Model with seventeen nodes. The map defines the roads along the nodes can move [2].

2.4 Freeway mobility model (FWM)
This model emulates the motion behavior of mobile nodes on a freeway. 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. In this model we use maps. There are several freeways on the map and each freeway has lanes in both directions.

3. SURVEY OF MOBILITY MODELS
3.1 Routing protocols in MANETs
A Routing Protocol is a protocol that specifies how routers communicate with each other to disseminate information that allows them to select routes between any two nodes on a network. Typically, each router has a priori knowledge only of its immediate neighbors. A routing protocol shares this information so that routers have knowledge of the network topology.
at large. The specific characteristics of routing protocols include the manner in which they either prevent routing loops from forming or break routing loops if they do form, and the manner in which they determine preferred routes from a sequence of hop costs and other preference factors. There are many protocols already have developed for MANET environments [6,18,14]. All these protocols can be classified in different ways. Based on the network structure the routing protocols can be classified as flat routing, hierarchical routing and geographic position assisted routing. Flat Routing protocols can be divided into proactive, reactive and hybrid protocols, depending on the routing topology [6,12].

Proactive protocol
With a proactive protocol, each node maintains one or more tables containing routing information to every node in the network. All nodes update these tables so as to maintain a consistent and up-to-date view of the network. When the network topology changes, the nodes propagate update messages throughout the network to update the tables. These protocols differ in the method by which the topology change information is distributed across the network, and the number of routing tables that are required [12].

Reactive protocol
Reactive protocols do not maintain up-to-date routing tables at the nodes; instead the routes are created as and when required. When a source wants to send to a destination, it invokes a route discovery mechanism to find a suitable path to the destination. The route remains valid until the destination is unreachable or until the route is no longer needed. These protocols differ in the way route discovery and route maintenance is done [12].

Hybrid Routing Protocol
Hybrid routing protocols are a new generation of protocol, which are both proactive and reactive in nature. These protocols are designed to increase scalability by allowing nodes with close proximity to work together to form some sort of a backbone to reduce the route discovery overheads. This is mostly achieved by proactively maintaining routes to nearby nodes and determining routes to far away nodes using a route discovery strategy. Most hybrid protocols proposed to date are zone-based, which means that the network is partitioned or seen as a number of zones by each node, other group of nodes into trees or clusters [4,5].

Comparative Study of Routing Protocols for Mobile Ad-hoc Networks
Thomas Heide Clausen et al described [14] the Optimized Link State Routing Protocol (OLSR), a proactive routing protocol for Mobile Ad-hoc Network (MANET). This paper evaluated its performance through exhaustive simulations using the Network Simulator 2 (ns2), and compare with other ad-hoc protocols, specifically the Ad-hoc On-Demand Distance Vector (AODV) routing protocol and the Dynamic Source Routing (DSR) protocol. they studied the protocols under varying conditions (node mobility, network density) and with varying traffic (TCP, UDP, different number of connections/streams) to provide a qualitative assessment of the applicability of the protocols in different scenarios.

Investigation of MANET routing protocols for mobility and scalability
Ashish Shrestha et al. analyzed the performance of AODV, OLSR and TORA using OPNET modeler 14.5. The protocols were tested using the same parameters with high CBR traffic flow and random mobility. Performance of protocols with respect to scalability has also analyzed. Results showed that, AODV and OLSR experienced higher packet delay and network load compared to TORA. This was due to the localization mechanism employed in TORA. On the other hand, when segment delay is considered both OLSR and AODV performed very reliably and established quick connection between nodes without any further delay. TORA showed high end-to-end delay due to formation of temporary loops within the network [1]. Throughput was considered as the main factor because it is the actual rate of data received successfully by nodes in comparison to the claimed bandwidth. TORA again performed worst among the three analyzed protocols, delivering much lower throughput than AODV and OLSR. AODV and OLSR performed pretty well showing average performance throughout the simulation which is equivalent to result generated by other researchers.

Analysis of Reactive Routing Protocols for Mobile Ad-Hoc Networks
Yogesh Chaba et al. analyzed the reactive routing protocols for MANETs. Route is determined when needed and traffic volume control is lower than global routing and can be further improved using GPS. LAR storage, communication and time complexity depends on the number of nodes, routes and diameter of network. Network scalability depends on the level of traffic and the levels of multi hoping which may be up to few hundred nodes but point-point may scale higher [10].

Zone Base Routing Protocol for high mobility MANETs
Hongyan Du proposed a Zone-Based routings protocol, where the network area was divided into fixed none-overlapping square zones. As we know that Zone routing protocol is a hybrid protocol. It combines the advantages of both proactive and reactive routing protocols. This paper used a source routing, which reduces the routing overhead. Mobility factor is defined and can be collected by each node itself according to the statistic data and is considered in zone head selection and route determination. A more stable path has been discovered which leads to lower probability of link breakage, and reach higher throughput for the network [8].

Performance Evaluation of ZRP on MANETs Using QUALNET Simulator Version 5.0
M.N. SreeRangaRaju et al. proposed an algorithm to provide improved quality of service via hybrid routing protocol-Zone Routing Protocol (ZRP). In this paper considered two reactive routing protocols Dynamic Source Routing (DSR)
and Ad hoc On Demand Distance Vector (AODV) as reference for analyzing ZRP by considering route acquisition delay and quick route reconfiguration during link failure. These parameters viz., route acquisition delay and quick route reconfiguration have their impact on increase in end to end delay, this automatically decreases the number of packets received thus the throughput. In this paper used well known network simulator QualNet version 5.0 to compare QoS parameters viz., throughput, number of bytes received, number of packets received, average end-to-end delay and the time at which first packet is been received for DSR, AODV and ZRP [18].

4. SIMULATION METHODOLOGY
There are several environmental factors affect the performance, stability and accuracy. These factors can be listed as Degree of Connectivity among Nodes, Degree of Mobility, Number and Duration of Data Flows. The MANETs routing protocol are categorized in accordance with network size and location base services: flat routing protocols, hierarchical routing protocols and location based routing protocols.

4.1 Simulation And Results
In this, proposed work four routing protocols: AODV, DSDV, OLSR and ZRP are to be compared to evaluate their performance in accordance with the various mobility models namely – Random way point model, Random point Group model, Manhattan and free way mobility model. TCP has been considered as transport protocol and CBR as traffic generator. Protocol evaluations are based on the simulation using ns2.

There are several network simulation softwares like NS2, NS3, Glomosim, Opnet, Omnet++ and Qualnet available to evaluate the performance of routing protocols. Each one is having its own advantages and disadvantages. we are going to use NS2 [19] for my study which suits me.

NS2 is one of the most popular open source network simulators. The original NS is a discrete event simulator targeted at networking research. The current NS project is supported through DARPA. The current second version NS2 is widely used in academic research and it has a lot of packages contributed by different non-benefit groups. First and foremost, NS2 is an object-oriented, discrete event driven network simulator which was originally developed at University of California-Berkely [19].

Table I: Salient Simulation Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Mobility Models</td>
<td>Random Way Point, Random point Group Mobility, Manhattan and freeway models</td>
</tr>
<tr>
<td>Radio Propagation Model</td>
<td>Two Ray Ground Model</td>
</tr>
<tr>
<td>MANET Routing Protocols</td>
<td>AODV, DSDV, OLSR, ZRP</td>
</tr>
<tr>
<td>Nominal Traffic Type</td>
<td>FTP</td>
</tr>
<tr>
<td>No. of Nodes</td>
<td>40, 60, 80, 100</td>
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<tr>
<td>Simulation Time</td>
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<tr>
<td>Data Rate</td>
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<td>Terrain Area</td>
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<td>Packet Size</td>
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<tr>
<td>MAC Method</td>
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<tr>
<td>Antenna</td>
<td>Omni-Antenna</td>
</tr>
</tbody>
</table>

4.2 Network Scenarios
In the ad hoc network, we have simulated the following two different scenarios:
1. Network density with Random Way Mobility.
2. Network density with Random Point Group Mobility.
3. Network density with Manhattan Mobility.
4. Network density with Freeway Mobility.

There are many parameters which can be used to evaluate the performance of routing protocols. Performance metrics are considered as follows:

Average End to End Delay:
Average end to end delay is the time a data packet takes in traversing from the time it is sent by the source node till the point it is received at the destination node. This metric is a measure of how efficient the underlying routing algorithm is, because primarily the delay depends upon optimality of path chosen, the delay experienced at the interface queues and delay caused by the retransmissions at the physical layer due to collisions.
Figure 5: Average Delay with respect to nodes density in RWPM Mobility Model.

Fig. 5, Shows effect of Mobility on Average end to end delay on all the four under Random Way Point Mobility model when we increase the network density it affects more to the AODV in terms of End to End Delay of DSDV. Delay is increasing more in AODV. DSDV and ZRP has the less end to end delay in RWPM Model.

Figure 6: Average Delay with respect to nodes density in RPGM Mobility Model.

Graph Shows effect of Mobility on Average end to end delay on all the four under Random Point Group Mobility model when we increase the network density it does not have much effect on OLSR and AODV in terms of End to End Delay within this limit. Delay variations are more in DSDV. AODV and OLSR has the less end to end delay in RPGM model.

Figure 7: Average Delay with respect to nodes density in MHM Mobility Model.

Graph Shows effect of Mobility on Average end to end delay on all the four under Manhattan Mobility model when we increase the network density it does not have much effect on DSDV and AODV in terms of End to End Delay within this limit. Delay variations are more in ZRP. AODV and DSDV has the less end to end delay in MHM model.
Figure 8: Average Delay with respect to nodes density in FWM Mobility Model.

Graph Shows effect of Mobility on Average end to end delay on all the four under Random Point Group Mobility model when we increase the network density it does not have much effect on OLSR in terms of End to End Delay within this limit. Delay variations are more in ZRP. DSDV and OLSR has the less end to end delay in RPGM model.

Routing Overhead :
The total number of routing packets transmitted during the simulation. For packets sent over multiple hops, each transmission of the packet (each hop) counts as one transmission. Routing packets are those that are originated by the routing protocol and do not also include user data.

Figure 9: Routing Overhead with respect to nodes density in RWPM Mobility Model.

In this mobility model, ZRP generate the highest routing overhead. AODV is just above the ZRP in terms of generating routing overhead. DSDV has lowest routing overhead among all.

Figure 10: Routing Overhead with respect to nodes density in RPGM Mobility Model.
Here ZRP generate very large routing overhead as compared to other mentioned protocols. AODV and DSDV perform almost equal in terms of routing overhead.

![Routing Overhead with respect to nodes density in MHM Mobility Model.](image1)

Figure 11: Routing Overhead with respect to nodes density in MHM Mobility Model.

Here ZRP generate very large routing overhead as compared to other mentioned protocols. OLSR and DSDV perform almost equal in terms of routing overhead.

![Routing Overhead with respect to nodes density in FWM Mobility Model.](image2)

Figure 12: Routing Overhead with respect to nodes density in FWM Mobility Model.

Here ZRP generate very large routing overhead as compared to other mentioned protocols. DSDV and OLSR perform almost equal in terms of routing overhead.

5. CONCLUSION AND FUTURE WORK

Simulation results shows the effect of various network density on to compare the performance of four protocols AODV (reactive), DSDV(proactive), OLSR (proactive) and ZRP (hybrid) under the FTP traffic in Random Way Point Mobility and Random Point Group, Manhattan and freeway Mobility Models under varying network density. This comparison shows that the DSDV protocol performed the best in Random Way Point Mobility model and this type of scenario with average delay and routing load. OLSR performs almost similar to DSDV in terms of different performance metrics. In Group Mobility Model scenario when we compared, DSDV is good in average delay, routing load ratio than AODV and ZRP. But overall result shows that DSDV is good in Random way point mobility model scenario. But ZRP gives poor performance when we increase the network density. When we increase the network density all the protocols are affected in accordance with mobility models. Similarly DSDV show better results for considered scenarios under Manhattan and freeway mobility.

We can extend this work by evaluating the performance by considering other scenarios like other traffic generators, congestion control algorithms, packet interarrival duration etc.

REFERENCES


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