**PAPER PRESENTATION**

**ON**

**IMPACT OF MOBILITY ON THE PERFORMANCE**

**OF**

**MULTICAST ROUTING PROTOCOLS IN MANET**

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***ABSTRACT:***

The advent of ubiquitous computing and the proliferation of portable computing devices have raised the

importance of mobile ad-hoc network. A major challenge lies in adapting multicast communication into

such environments where mobility and link failures are inevitable. The purpose of this paper is to study

impact of mobility models in performance of multicast routing protocols in MANET. In this work, three

widely used mobility models such as Random Way Point, Reference Point Group and Manhattan mobility

models and three popular multicast routing protocols such as On-Demand Multicast Routing Protocol,

Multicast Ad hoc On-demand Distance Vector Routing protocol and Adaptive Demand driven Multicast

Routing protocol have been chosen and implemented in NS2. Several experiments have been carried out

to study the relative strengths, weakness and applicability of multicast protocols to these mobility models.

***KEYWORDS***

*Mobile Ad hoc Network, multicast routing, mobility models, ODMRP, MAODV, ADMR.*

**1. INTRODUCTION**

Mobile ad hoc networks (MANETs) are self-organizing networks that do not require a fixed

infrastructure. Two nodes communicate directly if they are in the transmission range of each other.

Otherwise, they reach via a multi-hop route. Each MANET node must therefore be able to function

as a router to forward data packets on behalf of other nodes [1]. Because of their unique

benefits and versatilities, MANETs have a wide range of applications such as collaborative,

distributed mobile computing (e.g., sensors, conferences), disaster relief (e.g., flood, earthquake),

war front activities and communication between automobiles on highways. Most of these applications

demand multicast or group communication.

Each of these applications can potentially involve in different scenarios with different mobility

patterns, traffic rates dependent on the environment and the nature of the interactions among the

participants. In order to thoroughly study the protocols for these applications, it is imperative to

use the mobility models that accurately represent the mobile nodes which utilize the protocols.

In this paper, it is proposed to analyze the performances of widely used multicast routing

protocols namely Multicast Ad hoc On-demand Distance Vector (MAODV) routing protocol [2,

3], On-Demand Multicast Routing Protocol (ODMRP) [4, 5] and Adaptive Demand driven

Multicast Routing protocol (ADMR) [6] against three different mobility model that characterize

the realistic behaviours such as Random Waypoint, Reference Point Group and Manhattan

mobility models.

Rest of the paper is organized as follows: Section 2 reviews the related work. Section 3

summarizes the Mobility Models that are considered in this paper. Section 4 explains the

multicast protocols while Section 5 explains the experimental scenarios and methodology.

Section 6 deals with experimental results. Finally, concluding remarks are given in section 7.

**2. RELATED WORK**

An extensive literature survey has been done to analyze the performance of routing protocols for

various mobility models. Few researchers have carried out experiments to study the

performance of unicast routing protocols such as DSR, DSDV, AODV and TORA in mobile

environments [7]. Most of the initial research was using Random Waypoint as the underlying

mobility model and CBR traffic consisting of randomly chosen source destination pairs. The

protocols were mainly evaluated for packet delivery ratio and routing overhead. It was inferred

that, the on-demand protocols such as DSR and AODV performed better than table driven ones

such as DSDV at high mobility rates [7], while DSDV performed quite well at low mobility

rates.

A comparison study of the two on-demand routing protocols namely DSR and AODV [2] was

prepared with the packet delivery ratio and end to end delay metrics. It is inferred that DSR

outperforms AODV in less demanding situations, while AODV outperforms DSR at heavy

traffic load and high mobility. Another work proposed a framework to analyze the impact of

mobility pattern on unicast routing performance of mobile ad hoc network [3], considering the

Freeway mobility, Manhattan and RPGM mobility model.

The impacts of different mobility models on the performance of mobile IP multicast protocols

are evaluated for two mobility metrics such as number of link changes and multicast agent

density [8]. In [9], the authors have studied the effect of the different mobile node movement

pattern in random-based mobility model group (Random Waypoint Mobility Model, Random

Walk Mobility Model and Random Direction Mobility Model) on the performance of a unicast

routing protocol AODV. The impact of different mobility models on mesh based Multicast

Routing Protocols were analysed and presented in [10] by considering ODMRP and ADMR

protocol under different mobility scenarios. A framework to analyse the impact of mobility

model for unicast routing and on-demand routing is proposed in the literature [11, 12].

However, in the literature very few attempts were made to evaluate multicast routing protocols.

The existing works do not capture the variety of mobility patterns likely to be exhibited by ad

hoc applications and have not considered both tree based and mesh based multicast routing

protocols for their study. Thus, in this work, we intend to study the performance of both tree and

mesh based multicast routing protocol with three different mobility models.

**3. MOBILITY MODELS**

There are many mobility models proposed for use in MANET [13]. Out of the several mobility

models [8], in this work, we consider three mobility models that are designed to capture a wide

range of mobility patterns for ad-hoc applications. These models are briefly described in the

following sections.

**3.1. Random Waypoint Model**

The Random Waypoint Mobility Model [8, 13] is a widely used mobility model, which imitate

the natural entities move in extremely unpredictable direction and speed. In this model the

Mobile Nodes (MN) includes pause times between changes in direction and/or speed. An MN

begins by staying in one location for a certain period of time and then it move to another

location by choosing a random destination and a speed that is uniformly distributed between

minimum speed and maximum speed. Upon arrival, the MN pauses for a specified time period

before starting the process again. In this model, the Mobile nodes are initially distributed

randomly around the simulation area. This initial random distribution of Mobile nodes is not

representative of the manner in which nodes distribute themselves when moving. The figure 1

shows the nodes moving in a simulation area with random speeds.



Figure 1. Travelling pattern of an MN using the Random Waypoint Mobility Model

**3.2. Reference Point Group Model**

Reference Point Group Mobility (RPGM) model [8] [13] [14], is a group mobility model which

represents the random motion of a group of mobile nodes as well as the random motion of each

individual node within the group [10]. Group movements are based upon the path travelled by a

logical centre for the group. The logical centre for the group is used to calculate group motion

via a group motion vector. The motion of the group centre completely characterizes the

movement of its corresponding group of mobile nodes, including their direction and speed.

Individual mobile nodes randomly move about their own pre-defined reference points, whose

movements depend on the group movement. This mobility model is prevalent in many ad hoc

applications which demand group communications.

**3.3. Manhattan Model**

The random way point and RPGM models are the random mobility models where the movement

of mobile nodes are freely moving at any direction. In some mobile applications, the movement

of mobile nodes follows the mobility pattern similar to the road maps. Thus Manhattan model

[13] is also considered in this work. In the Manhattan model, the mobile nodes emulate the

movement of nodes that are similar to the movement pattern on the streets defined by maps. In

this model maps are used for the movement patterns. The map is composed of a number of

horizontal and vertical streets. Each street has two lanes for each direction (North and South

direction for vertical streets, East and West for horizontal 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. The figure 2

shows the map used for Manhattan mobility model.



Figure 2. Map used in Manhattan Mobility Model

**4. MULTICAST ROUTING PROTOCOLS**

Multicasting is an effective way to provide group communication and it is very challenging in

ad hoc networks due to the dynamic nature of the network topology. In this section, popularly

used one tree based and two mesh based multicast routing protocols in mobile ad hoc network

environment is described.

**4.1. MAODV**

MAODV protocol [2,3] is an extension of the AODV unicast protocol. This protocol discovers

the multicast routes on demand using a broadcast route discovery mechanism employing the

route request (RREQ) and route reply (RREP) messages. A mobile node originates an RREQ

message when it wishes to join a multicast group, or has data to send to a multicast group but

does not have a route to that group. Only a member of the desired multicast group may respond

to a join RREQ. If the RREQ is not a join request, any node with a fresh enough route (based on

group sequence number) to the multicast group may respond. If an intermediate node receives a

join RREQ for a multicast group of which it is not a member, or it receives a RREQ and does

not have a route to that group, it rebroadcasts the RREQ to its neighbors. As the RREQ is

broadcast across the network, nodes set up pointers to establish the reverse route in their route

tables. A node receiving an RREQ first updates its route table to record the sequence number

and the next hop information for the source node. This reverse route entry may later be used to

relay a response back to the source. For join RREQs, an additional entry is added to the

multicast route table and is not activated unless the route is selected to be part of the multicast

tree. If a node receives a join RREQ for a multicast group, it may reply if it is a member of the

multicast group’s tree and its recorded sequence number for the multicast group is at least as

great as that contained in the RREQ. The responding node updates its route and multicast route

tables by placing the requesting node’s next hop information in the tables and then unicasts an

RREP back to the source. As nodes along the path to the source receive the RREP, they add

both a route table and a multicast route table entry for the node from which they received the

RREP thereby creating the forward path. When a source node broadcasts an RREQ for a

multicast group, it often receives more than one reply. The source node keeps the received

route with the greatest sequence number and shortest hop count to the nearest member of the

multicast tree for a specified period of time, and disregards other routes. At the end of this

period, it enables the selected next hop in its multicast route table, and unicasts an activation

message (MACT) to this selected next hop. The next hop, on receiving this message, enables the

entry for the source node in its multicast routing table. If this node is a member of the multicast

tree, it does not propagate the message any further. However, if this node is not a member of the

multicast tree, it would have received one or more RREPs from its neighbors. It keeps the best

next hop for its route to the multicast group, unicasts MACT to that next hop, and enables the

corresponding entry in its multicast route table. This process continues until the node that

originated the chosen RREP (member of tree) is reached. The first member of the multicast

group becomes the leader for that group, which also becomes responsible for maintaining the

multicast group sequence number and broadcasting this number to the multicast group. This

update is done through a Group Hello message.

If a member terminates its membership with the group, the multicast tree requires pruning.

Links in the tree are monitored to detect link breakages, and the node that is farther from the

multicast group leader (downstream of the break) takes the responsibility to repair the broken

link. If the tree cannot be reconnected, a new leader for the disconnected downstream node is

chosen as follows. If the node that initiated the route rebuilding is a multicast group member, it

becomes the new multicast group leader. On the other hand, if it was not a group member and

has only one next hop for the tree, it prunes itself from the tree by sending its next hop a prune

message. This continues until a group member is reached. Once separate partitions reconnect, a

node eventually receives a Group Hello message for the multicast group that contains group

leader information different from the information it already has. If this node is a member of the

multicast group and if it is a member of the partition whose group leader has the lower IP

address, it can initiate reconnection of the multicast tree.

**4.2. ODMRP**

A mesh-based demand-driven multicast protocol namely On-Demand Multicast Routing

Protocol (ODMRP) [4, 5] which is, similar to Distance Vector Multicast Routing Protocol in

wired network is considered. In this protocol, a source periodically builds a multicast tree for a

group by flooding the control packet throughout the network. Nodes that are members of the

group respond to the flood and join the tree. This is done by the source periodically flooding a

JOIN QUERY message throughout the network. Each node receiving this message stores the

previous hop from which it received the message. When a group member receives the JOIN

QUERY, it responds by sending a JOIN REPLY to the source, following the previous hop

stored at each node. Nodes that forward a JOIN REPLY create soft forwarding state for the

group, which must be renewed by subsequent JOIN REPLY messages. If the node is already an

established forwarding member for that group, then it suppresses any further JOIN REPLY

forwarding in order to reduce channel overhead. The basic trade-off in ODMRP is between

throughput and overhead. A source can increase throughput by sending more frequent JOIN

QUERY messages. Each message rebuilds the multicast mesh, repairing any breaks that have

occurred since the last query, thus increasing the chance for subsequent packets to be delivered

correctly. However, because each query is flooded, increasing the query rate also increases the

overhead of the protocol.

**4.3. ADMR**

The second protocol we consider is ADMR [6]. ADMR creates source specific multicast trees,

using an on-demand mechanism that only creates a tree if there is at least one source and one

receiver active for the group. Sources periodically send a network-wide flood, but only at a very

low rate in order to recover from network partitions. In addition, forwarding nodes in the

multicast tree may monitor the packet forwarding rate to determine when the tree has broken or

the source has become silent. If a link has broken, a node can initiate a repair on its own, and if

the source has stopped sending, then any forwarding state is silently removed. Receivers also

monitor the packet reception rate and can re-join the multicast tree if intermediate nodes have

been unable to reconnect the tree.

To join a multicast group, an ADMR receiver floods a MULTICAST SOLICITATION message

throughout the network. When a source receives this message, it responds by sending a unicast

KEEP-ALIVE message to that receiver, confirming that the receiver can join that source. The

receiver responds to the KEEP-ALIVE by sending a RECEIVER JOIN along the reverse path.

In addition to the receiver’s join mechanism, a source periodically sends a network-wide flood

of a RECEIVER DISCOVERY message. Receivers that get this message respond to it with a

RECEIVER JOIN if they are not already connected to the multicast tree. Each node begins a

repair process if it misses a defined threshold of consecutive packets. Receivers do a repair by

broadcasting a new MULTICAST SOLICITATION message. Nodes on the multicast tree send

a REPAIR NOTIFICATION message down its subtree to cancel the repair of downstream

nodes. The most upstream node transmits a hop-limited flood of a RECONNECT message. Any

forwarder receiving this message forwards the RECONNECT up the multicast tree to the

source. The source in return responds to the RECONNECT by sending a RECONNECT

REPLY as a unicast message that follows the path of the RECONNECT back to the repairing

node. Nodes on the multicast tree also maintain their forwarding state. They expect to receive

either PASSIVE ACKNOWLEDGEMENT (if a downstream node forwards the packet) or an

EXPLICIT ACKNOWLEDGMENT if it is a last hop router in the tree. If defined thresholds of

consecutive acknowledgments are missed then the forwarding node expire its state.

In all the above three protocols the overhead increases due to dynamic behavior of the node

mobility resulting in link breakages.

**5. IMPLEMENTATION**

There are three techniques to evaluate the performance namely analytical modeling, simulation

and measurement. In this work, simulation technique had been chosen because it is the most

suitable technique to get more details that can be incorporated and less assumption is required

compared to analytical modeling [15]. The performance evaluations of the protocols due to

mobility have been carried out by implementing the protocols in NS2 simulator [16]. The

implementation scenario is depicted in the Figure 3. The NS2 requires the mobility model and

traffic pattern as an input. The mobility models have been generated using Java and the resultant

file is converted into NS2 format. The traffic file is generated from the NS2 “cbrgen” tool [16].

The routing protocols are implemented using C++ and is set as parameter to NS2.



The simulation outputs the trace files which are then analyzed using Perl. After extracting the

various values from the trace file, the results were obtained. The results were averaged over

several runs with the same simulation environment. The results and discussions are given in the

subsequent section.

**6. SIMULATION RESULTS AND PERFORMANCE COMPARISON**

Our simulation models a dynamic mobile ad hoc network of 50 mobile nodes moved in an area

of 1000m by 700m rectangular area. Each node has a uniform transmission range of 150m. The

simulation has been run for each of the three mobility model with 10 multicast sessions and 10

nodes in each group. The multicast source and receiver nodes are selected at random. Multiple

runs are conducted for different scenarios and the collected data is averaged over these runs.

The mobility scenario generator produced the Random Waypoint, RPGM and Manhattan

mobility patterns as required by the NS-2. Each run of the simulator accepts the scenario files

that describe the exact motion of each node together with exact time at which each change in

motion is to occur. We generated scenario files with varying node speeds. For all these

scenarios MAODV, ODMRP and ADMR routing protocols were used for testing the

performance variation due to mobility. The metrics used to measure the performance of routing

protocols are **Mobility** **Models** **Performance** **Metrics** Random Waypoint, RPGM and Manhattan Mobility models **Trace**

**Analysis** PDRRouting Overhead **Results Routing Protocol** ODMR PAMDRMAODV **SimulationEnvironment**

***Packet delivery ratio:*** The ratio of the number of packets originated by the application layer

CBR sources to the number of packets successfully delivered to their CBR sink at the final

destination.

***Normalized routing overhead***: It is the number of control packets transmitted per data packet

received at the destination.

**6.1. Packet Delivery Ratio**

Out of the three routing protocols, it is observed that MAODV performs better than the other

two protocols in term of packet delivery ratio which is shown in Figures 4, 5 and 6. Figures 7,

8 and 9 shows that the packet delivery ratios in Random Way Point model for the three

protocols do not have sudden change when the speed of the mobile node increases. Thus

Random Waypoint mobility model performs fairly well in all the three protocols.

MAODV has the highest packet delivery ratio when compared to ODMRP and ADMR. In

MAODV there is significant decrease in the packet delivery ratio when the speed of the mobile

node increases. It is obvious that when the mobile node moves with greater speed there are

more chances for link breakage and result in less packet delivery ratio.

The throughput of ODMRP protocol depends purely on the mobility model and not much based

on the speed of the mobile nodes. RPGM mobility model gives the better packet delivery ratio

for ODMRP and the Manhattan model gives the worst packet delivery ratio because of the

lower reachability. This ordering from the best to worst is roughly predicted by link changes.

ADMR is able to maintain high throughput for nearly all mobility models even as the speed

increases. This is due to two mechanisms followed in the protocol. First, the forwarding nodes

are able to initiate local repair mechanism of the multicast tree when the packet loss is

occurring due to link breakage. Secondly, the receivers that are experiencing high packet loss

can request the protocol to switch to flooding in order to control the packet loss.

**6.2. Routing Overhead**

From the figure 10 to figure 15, we observe that MAODV has the highest routing overhead

when compared to ODMRP and ADMR among all the three mobility models. Generally, the

routing overhead increases with the speed of the mobile nodes. RPGM model gives minimum

overhead as it supports the group movement and hence ensures more reachability.



MAODV has the highest routing overhead for RPGM model than the other two models. This

is because in group mobility model the link failures between different groups leads to changes

with respect to the connection pattern. Hence the dynamic tree construction requires more

control packets. ODMRP has the least routing overhead for RPGM model as it the mesh based

routing protocol and it provides more than one path between two different nodes. ADMR has

the minimum routing overhead compared to MADOV protocol over all the mobility models as

it uses flooding at higher speeds.



**7. CONCLUSION**

In this paper, we analyzed the impact of mobility pattern on multicast routing performance of

mobile ad hoc networks. We observe that in addition to the strengths and weaknesses of the

individual multicast routing protocols, the mobility patterns does also have influence on the

performance of the routing protocols. The connectivity of the mobile nodes, route setup and

repair time are the major factors that affect protocol performance. This conclusion is consistent

with the observation of the previous such studies on unicast routing protocols. There is no clear

winner among the protocols in our case, since different mobility patterns seem to give different

performance rankings of the protocols. This work can be further explored to study the impact of

mobility on the performance of other multicast routing protocols. Several other parameters such

as traffic patterns, node density and initial placement pattern of nodes may affect the routing

performance and hence this work can be extended to investigate them further.