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IMPACT OF MOBILITY MODELS ON PERFORMANCE OF DSR

Rashmi Popli* & Ritu Saluja**

Mobile ad-hoc networks are composed by a set of mobile hosts (also called mobiles) communicating with each other via radio transceivers. In order to communicate with destinations which are located outside of their transmission ranges or hidden by obstacles, communicating mobiles rely on other mobiles which cooperate to forward messages to their destinations. To this purpose the network layer of the mobiles provides services of message delivery by running suitable routing algorithms. However, mobility and failures may give rise to network disconnections impairing service dependability. Due to mobility of nodes, the network topology varies with time. There are various mobility models which affects the performance of various protocols. In this paper, we have studied the effects of various mobility models on the performance of Dynamic Source Routing (DSR-Reactive Protocol) .For experiment purposes; we have considered four mobility scenarios: Random Waypoint, Group Mobility, Freeway model and Manhattan model.

1. Introduction

A mobile ad-hoc network (MANET) is a collection of nodes, which have the possibility to connect on a wireless medium and form an arbitrary and dynamic network with wireless links. That means that links between the nodes can change during time, new nodes can join the network, and other nodes can leave it.

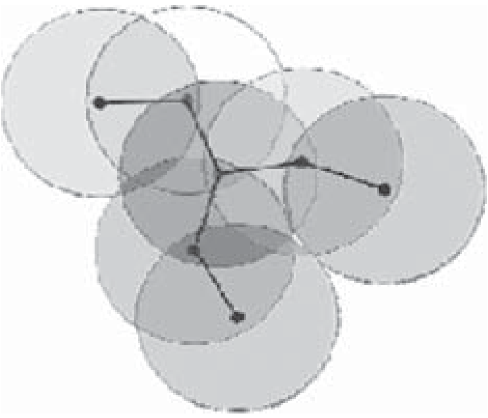

Figure 1: Multihop Ad-hoc Networks

A MANET is expected to be of larger size than the radio range of the wireless antennas, because of this fact it could be necessary to route the traffic through a multi-hop path to give two nodes the ability to communicate. There are neither fixed routers nor fixed locations for the routers as in cellular networks - also known as infrastructure networks. Cellular networks consist of a wired backbone, which connects the base-stations. The mobile nodes can only communicate over a one-hop wireless link to the base-station; multi-hop wireless links are not possible [1]. By contrast, a MANET has no permanent infrastructure at all.

II. Classification of Ad-Hoc Routing Protocols

Ad-Hoc routing protocols can be classified based on different criteria; however, the different classes of protocols are not mutually exclusive. So that, depending on the routing mechanisms employed by a given protocol, it may fall under more than one class. Routing protocols for Ad-Hoc networking can be classified into four categories viz. based on the routing information update mechanism, the use of temporal information for routing, routing topology, and utilization of specific resources. The mechanism of updating routing information is an essential part of any routing protocol. So that, this criterion is very important for classifying the routing protocols for ad- hoc wireless networks [2]. According to this criterion, there are three classes of routing protocols, they are summarized as follows:

Table-driven Routing Protocols

Based on the periodically exchanging of routing information between the different nodes, each node builds its own routing table which it can use to find a path to a destination. Examples of the protocols of this class are, Destination Sequenced Distance Vector routing protocol (DSDV), Wireless Routing Protocol (WRP), Cluster-Head Gateway Switch Routing protocol and Source Tree Adaptive Routing protocol (STAR).

On-Demand Routing Protocols

The nodes do not exchange any routing information. A source node obtains a path to a specific destination only

* Lecturer, YMCA Institute of Engineering, Faridabad. *E-mail: rashmimukhija@gmail.com.*

** Lecturer, Manav Rachna College of Engineering, Faridabad. *E-mail: saluja.ritu@gmail.com*

when it needs to send some data to it. Examples of the protocols of this class are, Dynamic Source Routing protocol (DSR), Ad Hoc On-Demand Distance-Vector Routing protocol (AODV), and Temporally Ordered Routing Protocol (TORA).

Hybrid Routing Protocols

Nodes are grouped into zones based on their geographical locations or distances form each other. Inside a single zone, routing is done based using table-driven mechanisms while an on-demand routing is applied for routing beyond the zone boundaries. ZRP is an example of Hybrid Routing Protocol.

III. MOBILITY MODELS

Mobility models are needed in the design of strategies for location updating and paging, radio resource management (e.g., dynamic channel allocation schemes), and technical network planning and design (e.g., cell and location area layout and network dimensioning). The purpose of mobility models is to describe typical terminal movement so that the analysis for these purposes can be made. Thus, the movement pattern of users plays an important role in performance analysis of mobile and wireless networks, especially in third-generation mobile communications, since terminal mobility has a great influence in most UMTS communication aspects involving either performance or traffic generation as a result of handover.

In order to thoroughly simulate a new protocol for an ad hoc network, it is imperative to use a mobility model that accurately represents the mobile nodes (MNs) that will eventually utilize the given protocol. Only in this type of scenario is it possible to determine whether or not the proposed protocol will be useful when implemented. Traces are those mobility patterns that are observed in real life systems. Synthetic models attempt to realistically represent the behaviors of MNs without the use of traces.

Random Waypoint (RW) Model

The Random Waypoint Model was first proposed by Johnson and Maltz. Soon, it became a 'benchmark' mobility model to evaluate the MANET routing protocols, because of its simplicity and wide availability. To generate the node trace of the Random Waypoint model the setdest tool from the CMU Monarch group may be used. This tool is included in the widely used network simulator ns-2.

The Random Waypoint model is most commonly used mobility model in research community. In the current network simulator (ns-2) distribution, the implementation of this mobility model is as follows: at every instant, a node randomly chooses a destination and moves towards it with a velocity chosen uniformly randomly from [0,V_max],

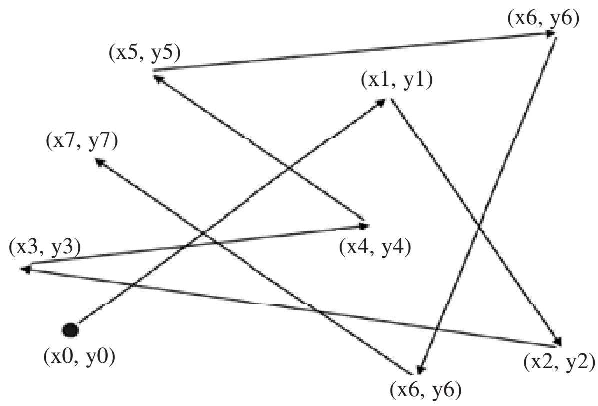

Figure 2: Example of Node Movement in the Random Waypoint Model

where V_max is the maximum allowable velocity for every mobile node [3].

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 again until the simulation ends. In our framework, the RW model acts as the 'baseline' mobility model to evaluate the protocols in Ad Hoc Network.

Reference Point Group Mobility (RPGM) Model

The Reference Point Group Mobility (RPGM) Model is a typical group mobility model. In RPGM model, each node in a group has two components in its movement vector: the individual component and the group component. The individual component is based on the Random Waypoint (RWP) model. A node randomly picks a destination within the group scope and moves towards that destination at a fixed speed. Once the node reaches the destination, it selects another destination randomly and moves towards it after a pause time.

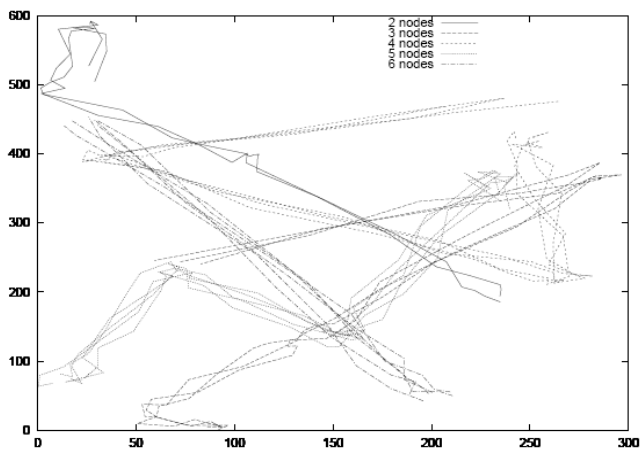

Figure 3: Traveling Pattern of Five Groups using the RPGM Model

This behavior is repeated for the duration of the simulation. The group component of mobility is shared by all nodes in the same group and is also based on the random waypoint model. In this case, however, the destination is an arbitrary place in the entire system. Because the RPGM model is based on RWP model, it still cannot overcome the shortcomings caused by the characteristics of the RWP model, such as non-uniform network density, and it is not adequate to simulate the group movement in reality, such as group split and mergence, etc.

Freeway Mobility (FW) Model

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. In this model we use maps. There are several freeways on the map and each freeway has lanes in both directions.

The differences between Random Waypoint and Freeway are the following:

(1) Each mobile node is restricted to its lane on the freeway.

(2) The velocity of mobile node is temporally dependent on its previous velocity.

Formally, vec{*V*_{*i*}}(*t*+1) = vec{*V*_{*i*}}(*t*) + random() * vec{*a*_{*i*}}(*t*)

(3) If two mobile nodes on the same freeway lane are within the Safety Distance (SD), the velocity of the following node cannot exceed the velocity of preceding node.

Formally, for all {*i*}, for all {*j*}, for all{*t*}, if D_{*i*, *j*}(*t*) < Safety_Distance, then

vec{V_{i}}(t) < vec{V_{j}}(t), if j is ahead of i in its lane.

Due to the above relationships, the Freeway mobility pattern is expected to have spatial dependence and high temporal dependence. It also imposes strict geographic restrictions on the node movement by not allowing a node to change its lane.

Manhattan Mobility (MH) Model

We introduce the Manhattan model to emulate the movement pattern of mobile nodes on streets defined by maps. It can be useful in modeling movement in an urban area where a pervasive computing service between portable devices is provided. 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. Except the above difference, the inter-node and intra-node relationships involved in the Manhattan model are very similar to the Freeway model.

Thus, the Manhattan mobility model is also expected to have high spatial dependence and high temporal dependence [4]. It too imposes geographic restrictions on node mobility. However, it differs from the Freeway model in giving a node some freedom to change its direction.

DYNAMIC SOURCE ROUTING PROTOCOL

DSR is a widely used on-demand ad-hoc network routing strategy that uses route caches. DSR floods route requests to find a route that is needed [5].

DSR Route Discovery

The header of the packet, which originates from a source node S to a destination node D, contains the source route, which gives the sequence of hops that the packet should traverse. A suitable source route is found normally when searching the Route Cache of routes obtained previously but if no route is found then the Route Discovery protocol is initiated to find a new route to D. Here S is the initiator and D the target. Node A transmits a ROUTE REQUEST message, which is received by all the nodes in the transmission range of A. Each ROUTE REQUEST message identifies the initiator and target of the Route Discovery and also contains a unique request ID, determined by the initiator of the REQUEST. Each ROUTE REQUEST also contains a record listing the address of each intermediate node through which this particular copy of the ROUTE REQUEST message has been forwarded. The initiator of the Route Discovery initializes the route record to an empty list. When the target node receives the ROUTE REQUEST message, it returns a ROUTE REPLY message to the ROUTE Discovery initiator with a copy of the accumulated route record from the ROUTE REQUEST. This route is cached in the Route Cache when the initiator receives the ROUTE REPLY and is used in sending subsequent packets to this destination. When the target node finds a ROUTE REQUEST message from the same initiator bearing the same request ID or if it finds its own address is already listed in the route record of the ROUTE REQUEST message, it discards the REQUEST. If the target node does not find the ROUTE REQUEST message from the initiator, then it appends its address to the route record in the ROUTE REQUEST message and propagates it by transmitting it as a local broadcast packet.

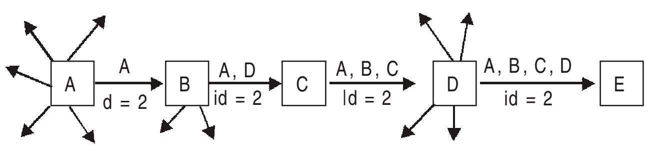

Figure 4: Node A is the Initiator and Node E is the Target

When Route Discovery is initiated the copy of the original packet is saved in a local buffer called Send Buffer [9]. The Send Buffer contains copies of each packet that cannot be transmitted by the sending node. The packets are kept until a source route is available or a timeout or Send Buffer overflow occurs. As long as when a packet with a source route is forwarded, each node in the source route makes sure that the packet has been received by the next hop in the source route. The confirmation of receipt will be received only by re-transmitting the packet for a number of times. a packet is in the Send Buffer, the node should initiate new Route Discovery until time out occurs or overflow of Buffer occurs. An exponential Back off algorithm is designed to limit the rate at which new ROUTE Discoveries may be initiated by any node for the same target.

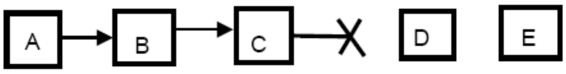

Figure 5: Node C is Unable to Forward a Packet from A to E over the Next Node D

Node A is the originator of a packet to the desired destination E. The packet has a source route through intermediate nodes B, C and D. Node A is responsible for receipt of the packet at B, node B at C, node C at D and node D at E. Node B confirms receipt of packet at C by overhearing C transmit the packet to forward it to D. The confirmation of acknowledgement is done by passive acknowledgements or as link-layer mechanisms such as option in MAC protocol [6]. The node receiving the packet can return a DSR specific software acknowledgement if neither of the acknowledgements is available. This is done by setting up a bit in the packet's header and then requesting a DSR specific software acknowledgement by the node transmitting the packet. When a node is unable to deliver a packet to the next node then the node sends a ROUTE ERROR message to the original sender of the packet. The broken link is then removed from the cache by the originator of the packet and retransmissions to the same destination are done by upper layer protocols like TCP.

V. SCENARIO DESCRIPTION

The performance simulation environment used is based on NS-2, a network simulator that provides support for simulating multi-hop wireless networks complete with physical and IEEE 802.11 MAC layer models. The main interest of the project was to test the ability of DSR in different mobility models. The performance evaluation, as well as the design and development of routing protocols for MANETs, requires additional parameters which is addressed in RFC developed by Internet Engineering Task Force (IETF)[7]. The movement was controlled as per the specifications of the respective models. If a node crosses the boundary of the area it is re-inserted at the beginning position in a randomly chosen lane. DSR performance is tested in terms of data rate (Bytes per second) by varying the node speed. We have tested the throughput in DSR by using all the four mobility models. Trace was UDP type trace.

Nodes in the simulation move according to all the four types of mobility models. The movement scenario files we used for each simulation are characterized by a pause time. Each node begins the simulation by remaining stationary for pause time seconds. It then selects a random destination in the 500 * 500 m space and moves to that destination at a speed distributed uniformly between 0 and some maximum speed.

We ran our simulations with movement patterns generated for five different speeds: 0, 10, 20, 30, 40, 50, meters per seconds. Standard 802.11 MAC layer was used and transmission range in each simulation was 500 meter. All the nodes in simulation had omni-directional antennas. No motion in z-direction was allowed thus whole topology was two-dimensional.

VI. SIMULATION RESULTS

We have calculated Throughput as a function of node speed. Actually throughput (bytes/second) is the total number of delivered data packets divided by the total duration of simulation time. We analyze the throughput of the protocol in terms of number of bytes delivered per one second by using all the four mobility models. The results of our simulations are as in Figures 6,7,8,9 which show the performance of DSR varies with the different mobility models.

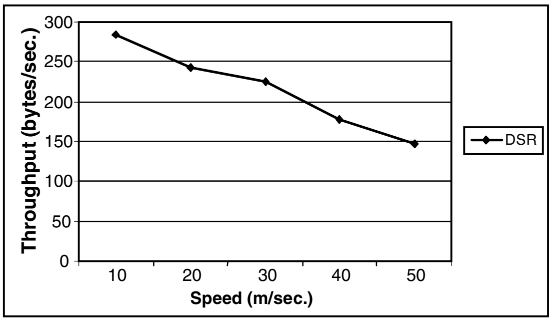

Figure 6: Variation in Throughput with Increase in Mobility for Random Way Point Mobility Model

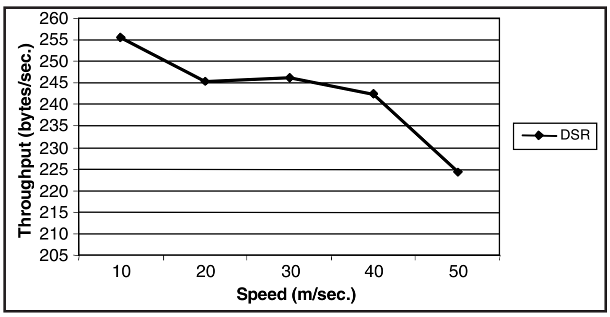

Figure 7: Variation in UDP throughput with increase in mobility for Random Point Group Mobility model

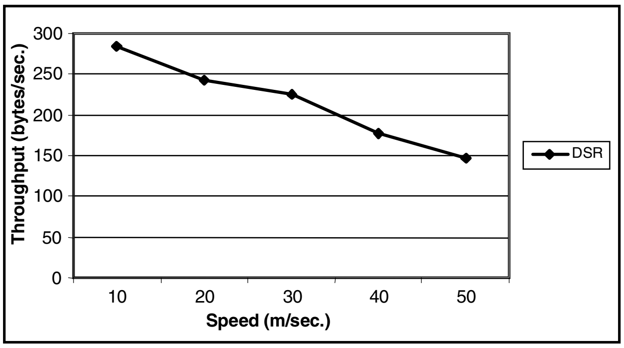

Figure 8: Variation in throughput with Increase in Mobility for Freeway Mobility (FW) Model

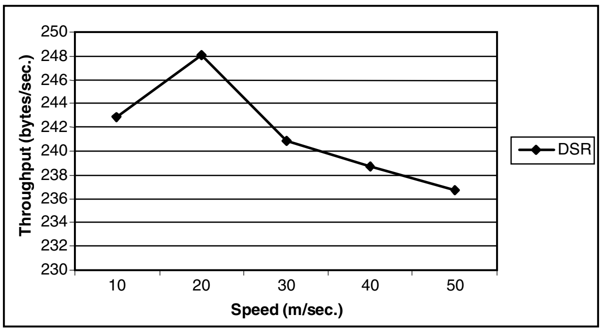

Figure 9: Variation in Throughput with Increase in Mobility for Manhattan Mobility (MH) Model

According to our graphs if we analyze the performance of DSR in different mobility models and different mobility scenarios then we find that in Freeway mobility model the performance of DSR is best in low mobility scenarios as compared to all the other three mobility models. But when the speed is increased then throughput decreases drastically. While in case of other mobility models like Random way point, Random Group or Manhattan model this curve of throughput goes down slowly.

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