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Performance Evaluation of Two Reactive Routing Protocols of MANET using Group Mobility Model

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Abstract

Mobile ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. Mobile ad-hoc network have the attributes such as wireless connection, continuously changing topology, distributed operation and ease of deployment. In this paper we have compared the performance of two reactive MANET routing protocol AODV and DSR by using Group mobility model. Both share similar On-Demand behavior, but the protocol's internal mechanism leads to significant performance difference. We have analyzed the performance of protocols by varying network load, mobility and type of traffic (CBR and TCP). Group Mobility model has been generated by IMPORTANT (Impact of Mobility Patterns on Routing in Ad-hoc NeTwork) tool. A detailed simulation has been carried out in NS2. The metrics used for performance analysis are Packet Delivery Fraction, Average end-to-end Delay, Routing Overhead and Normalized Routing Load. It has been observed that AODV gives better performance in CBR traffic and real time delivery of packet. Where as DSR gives better results in TCP traffic and under restricted bandwidth condition.

Keywords: *MANET, IMPORTANT, TCP, CBR, Group Mobility Model.*

1. Introduction

Mobile networks can be classified into infrastructure networks and Mobile Ad Hoc Networks (MANET) according to their dependence on fixed infrastructures [2]. In an infrastructure mobile network, mobile nodes have wired access points (or base stations) within their transmission range. In contrast, Mobile Ad Hoc networks are autonomously self-organized networks without support of infrastructure. In a Mobile Ad Hoc Network, nodes move arbitrarily, therefore the network may experience rapid and unpredictable topology changes. Routing paths in MANETs potentially contain multiple hops, and every node in MANET has the responsibility to act as a router [4]. Routing in MANET has been a challenging task ever since the wireless networks came into existence. The major reason for this is the constant change in network topology because of high degree of node mobility. A number of protocols have been developed to accomplish this task.

There are various mobility models such as Random Way Point, Reference Point Group Mobility Model (RPGM), Manhattan Mobility Model, Freeway Mobility Model, Gauss Markov Mobility Model etc that have been proposed for evaluation [8, 15].

Several performance evaluation of MANET routing protocols using CBR traffic have been done by considering various parameters such as mobility, network load and pause time. Biradar, S. R. et. al. [13] have analyzed the AODV and DSR protocol using Group Mobility Model and CBR traffic sources. Biradar, S. R. et. al. [13] investigated that DSR performs better in high mobility and average delay is better in case of AODV for increased number of groups. Also Rathy, R.K. et. al. [10] investigated AODV and DSR routing protocols under Random Way Point Mobility Model with TCP and CBR traffic sources. They concluded that AODV outperforms DSR in high load and/or high mobility situations.

In this paper we have investigated the performance of AODV and DSR On-Demand (reactive) routing protocol for performance comparison in the scenario of Group Mobility Model such as military battlefield. For this scenario, we have used Reference Point Group Mobility (RPGM) Model. The purpose of this work is to understand there working mechanism and investigate that which routing protocol gives better performance in which situation or traffic when the Group Mobility Model is used for node movement.

The rest of the paper is organized as follows. The next section discusses about the Reference Point Group Mobility (RPGM) Model. In section 3, we have given the brief introduction of AODV and DSR routing protocol. Section 4 and 5 deals with the simulation setup and results obtained on the execution of simulation. Finally, conclusion is drawn in section 6.

2. Reference Point Group Mobility (RPGM) Model

Group mobility can be used in military battlefield communication. Here, each group has a logical center (group leader) that determines the group's motion behavior. Initially, each member of the group is uniformly distributed in the neighborhood of the group leader. Subsequently, at every instant, each node has a speed and direction that is derived by randomly deviating from that of the group leader [7].

Applications: Group mobility can be used in military battlefield communications where the commander and soldiers form a logical group. More applications of RPGM Model are mentioned in [16].

Given below is topography showing the movement of nodes for Random Point Group Mobility Model in our simulation. The scenario contains fifty nodes with four groups.

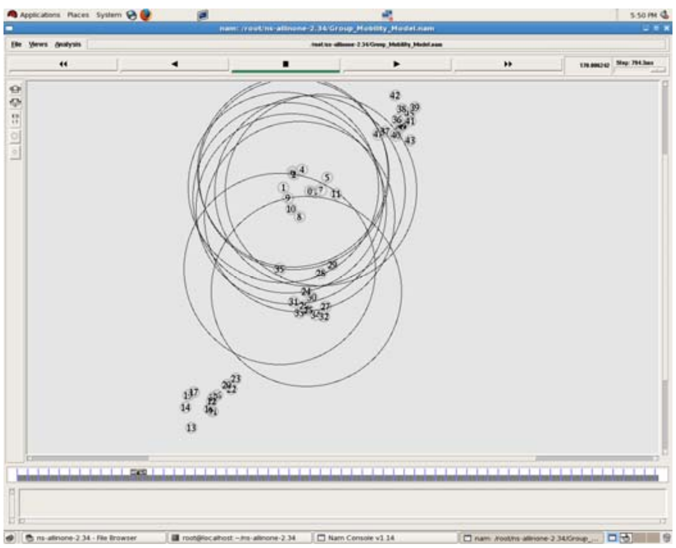


Figure 1: Movement of nodes for Group Mobility Model

Important Characteristics:

Each node deviates from its velocity (both speed and direction) randomly from that of the leader. The movement in group mobility can be characterized as follows:

(1) $|V_{member}(t)| = |V_{leader}(t)|$ + random () * SDR * max_ speed

(2) $|\theta_{member}(t)| = |\theta_{leader}(t)|$ + random () * ADR * max_ angle

Where 0 <= SDR, ADR <= 1. SDR is the Speed Deviation Ratio and ADR is the Angle Deviation Ratio.

SDR and ADR are used to control the deviation of the velocity (magnitude and direction) of group members from that of the leader. Since the group leader mainly decides the mobility of group members, group mobility pattern is expected to have high spatial dependence for small values of SDR and ADR.

3. Description of Routing Protocol

3.1 Ad-Hoc on Demand Distance Vector (AODV)

The Ad-hoc On-demand Distance Vector routing protocol [1,3,14] enables multihop routing between the participating mobile nodes wishing to establish and maintain an ad-hoc network. AODV is a reactive protocol based upon the distance vector algorithm.

The algorithm uses different types of messages to discover and maintain links. Whenever a node wants to try and find a route to another node it broadcasts a Route Request (RREQ) to all its neighbors. The RREQ propagates through the network until it reaches the destination or the node with a fresh enough route to the destination. Then the route is made available by uncasing a RREP back to the source.

The algorithm uses hello messages (a special RREP) that are broadcasted periodically to the immediate neighbors. These hello messages are local advertisements for the continued presence of the node, and neighbors using routes through the broadcasting node will continue to mark the routes as valid. If hello messages stop coming from a particular node, the neighbor can assume that the node has moved away and mark that link to the node as broken and notify the affected set of nodes by sending a link failure notification (a special RREP) to that set of nodes.

3.2 Dynamic Source Routing (DSR)

DSR is a reactive routing protocol i.e. determines the proper route only when packet needs to be forwarded [4,9,11]. For restricting the bandwidth, the process to find a path is only executed when a path is required by a node (On-Demand Routing). In DSR the sender (source, initiator) determines the whole path from the source to the destination node (Source-Routing) and deposits the addresses of the intermediate nodes of the route in the packets. Compared to other reactive routing protocols like ABR or SSA, DSR is beacon-less which means that there are no hello-messages used between the nodes to notify their neighbors about their presence. DSR was developed for MANETs with a small diameter between 5 and 10 hops and the nodes should only move around at a moderate speed. DSR is based on the Link-State-

Algorithms which mean that each node is capable to save the best way to a destination. Also if a change appears in the network topology, then the whole network will get this information by flooding. The DSR protocol is composed of two main mechanisms that work together to allow discovery and maintenance of source routes in MANET.

Route Discovery: When a source node S wishes to send a packet to the destination node D, it obtains a route to D. This is called Route Discovery. Route Discovery is used only when S attempts to send a packet to D and has no information of a route to D.
Route Maintenance: When there is a change in the network topology, the existing routes can no longer be used. In such a scenario, the source S can use an alternative route to the destination D, if it knows one, or invoke Route Discovery. This is called Route Maintenance.

4. Simulation Setup

We have used Network Simulator (NS)-2 in our evaluation. The NS-2 is a discrete event driven simulator [5,6] developed at UC Berkeley. We have used Red Hat Linux environment with version NS-2.34 of network simulator. NS-2 is suitable for designing new protocols, comparing different protocols and traffic evaluations. It is an object oriented simulation written in C++, with an OTcl interpreter as a frontend. NS uses two languages because simulator got to deal with two things: i) detailed simulation of protocols which require a system programming language which can efficiently manipulate bytes, packet headers and implement algorithms, ii) research involving slightly varying parameters or quickly exploring a number of scenarios.
The movement of nodes in the Group Mobility model is generated by a software called Mobility Generator which is based on a frame work called Important (Impact of Mobility Patterns on Routing in Ad-hoc NeTwork, from University of Southern California)[7,17,18].In the scenario we have considered four group with twelve node and one group leader in each.

Table 1: Simulation Parameters

Parameters	***Value***
Routing Protocols	*AODV DSR*
MAC Layer	*802.11*
Packet Size	*512 bytes*
Terrain Size	*1000m * 1000m*
Nodes	*50*
Mobility Model	*Group Mobility Model*
No. of Groups	*4*
Data Traffic	*CBR, TCP*
No. of Source	*10, 40*
Simulation Time	*900 sec.*
Maximum Speed	*0-60 m/sec (interval of 10)*

We have used four traffic patterns with varying number of sources for each type of traffic (TCP and CBR). The source-destination pair may be in same group or in different group. The goal of our simulation is to evaluate the performance differences of these two on-demand routing protocols. The type of traffic (CBR and TCP) and the maximum number of sources are generated by inbuilt tool of NS2 [6]. The parameters used for carrying out simulation are summarized in the table 1.

4.1 Performance Metrics

RFC2501 [12] describe a number of quantitative metrics that can be used for evaluating the performance of MANET routing protocols. We have used the following metrics for evaluating the performance of two on-demand reactive routing protocols (AODV & DSR):

4.1.1 Packet Delivery Fraction

It is the ratio of data packets delivered to the destination to those generated by the sources. It is calculated by dividing the number of packet received by destination through the number packet originated from source.

$$PDF = (Pr/Ps)*100$$

Where Pr is total Packet received & Ps is the total Packet sent.

4.1.2 Routing Overhead

It is the total number of control or routing (RTR) packets generated by routing protocol during the simulation. All packets sent or forwarded at network layer is consider routing overhead.

$$\text{Overhead} = \text{Number of RTR packets}$$

4.1.3 Normalized Routing Load

Number of routing packets "transmitted" per data packet "delivered" at destination. Each hop-wise transmission of a routing is counted as one transmission. It is the sum of all control packet sent by all node in network to discover and maintain route.

NRL = Routing Packet/Received Packets

4.1.3 Average End-to-End Delay (second)

This includes all possible delay caused by buffering during route discovery latency, queuing at the interface queue, retransmission delay at the MAC, propagation and transfer time. It is defined as the time taken for a data packet to be transmitted across an MANET from source to destination.

$$D = (Tr - Ts)$$

Where Tr is receive Time and Ts is sent Time.

5. Result and Discussion

Packet delivery ratio:
In case of CBR traffic both protocols delivers almost all originated data packets (around 99-100%) when mobility is low and number of sources is also low (10). But the packet delivery fraction starts degrading gradually when there is increase in number of sources (40) and with the increase in speed of nodes. DSR perform better when number of sources is low, but when network load increases, packet delivery ratio decreasing. AODV perform equally under all assumed load condition in CBR traffic (fig. 2). But in case of TCP traffic, DSR performs better irrespective of network load and speed (fig. 3).

Routing Overhead:
For CBR traffic, DSR protocol have significantly low routing overhead than AODV (fig. 4) when the mobility is increased. We have investigated that, when number of sources is low (10), the performance of DSR and AODV is similar regardless of mobility.

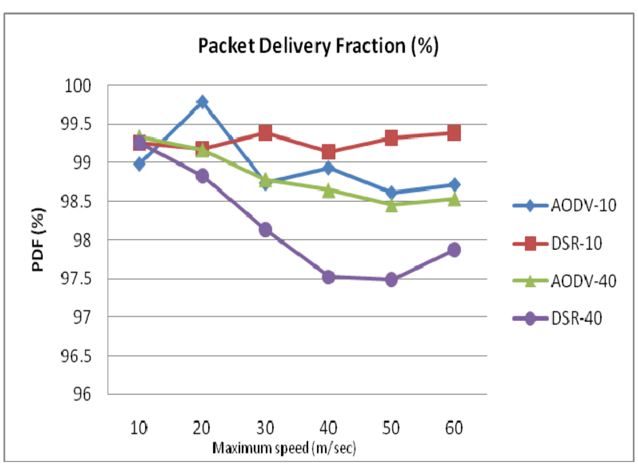
Figure 2: Fraction Delivery Fraction vs. Speed

But with large number of sources (40), DSR starts outperforming AODV for high mobility scenario. Further, DSR always have a lower routing overhead than AODV. In DSR route replies contribute to large fraction of routing overhead. Also in case of TCP traffic DSR performs better than AODV (fig. 5).

Normalized Routing Load:
In case of CBR traffic, with low number of sources (10) and low mobility, DSR performs better. But when the mobility increases, AODV perform better than DSR. But when number of sources is high (say 40), DSR perform better than AODV as shown in Figure 6. In case of TCP traffic, at low network load (10) both (AODV & DSR) gives almost similar performance. But when number of sources is high say 40 AODV perform better than DSR as shown in figure 7.

Average end-to-end Delay:
In CBR traffic, average end–end delay of DSR is comparable to AODV when number of sources is low (10), but with the increase in network load (say 40), delay in DSR is too much higher than AODV (fig. 8). But in case of TCP traffic, AODV perform better in all condition (fig. 9). Over all in case of real time packet delivery, AODV is better choice. DSR produce more delay due to route caching. Average end-end delay in case of TCP traffic is at least three times more than CBR traffic.

CBR Traffic Sources



TCP Traffic Sources

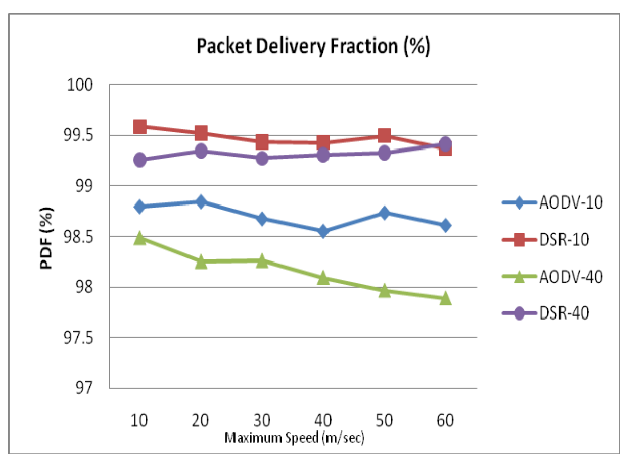


Figure 3: Fraction Delivery Fraction vs. Speed

CBR Traffic Sources

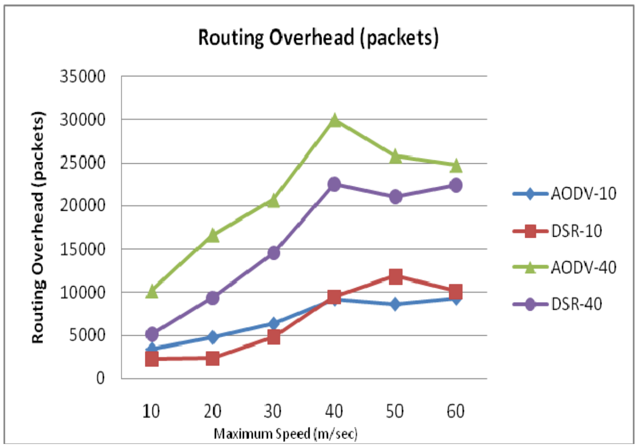


Figure 4: Routing Overhead vs. Speed

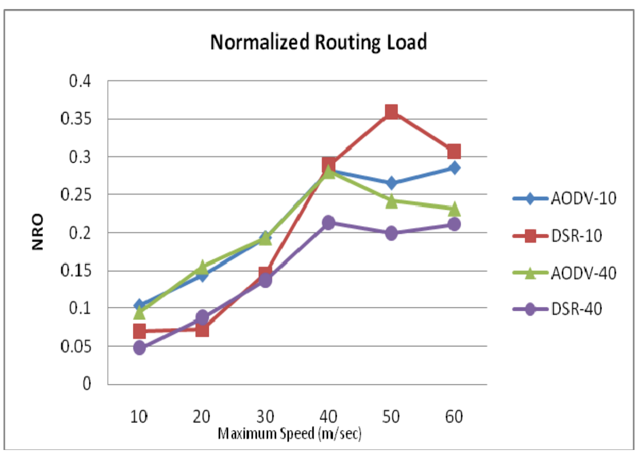


Figure 6: Normalized Routing Load vs. Speed

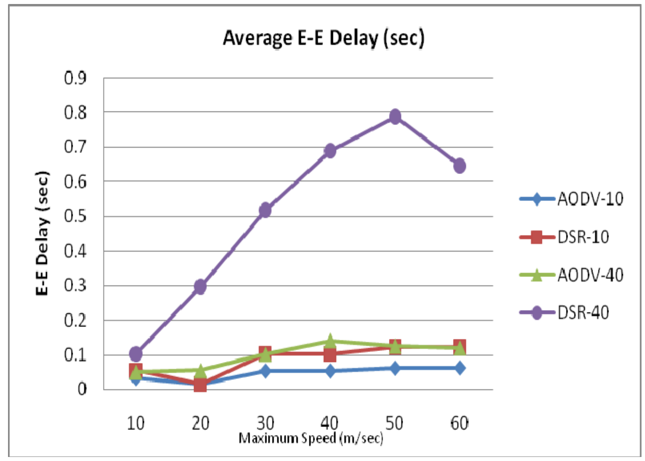


Figure 8: Average End-End Delay vs. Speed

TCP Traffic Sources

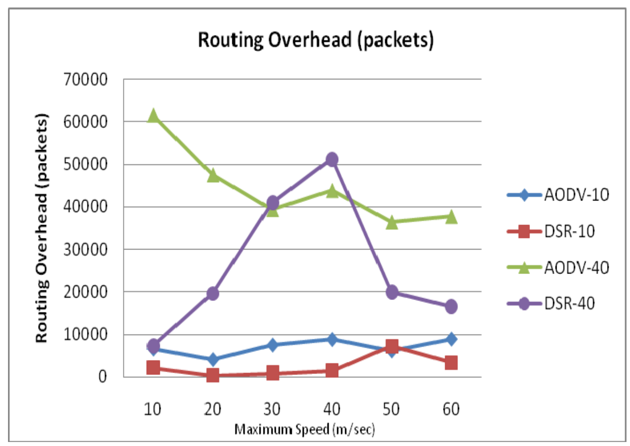


Figure 5: Routing Overhead vs. Speed

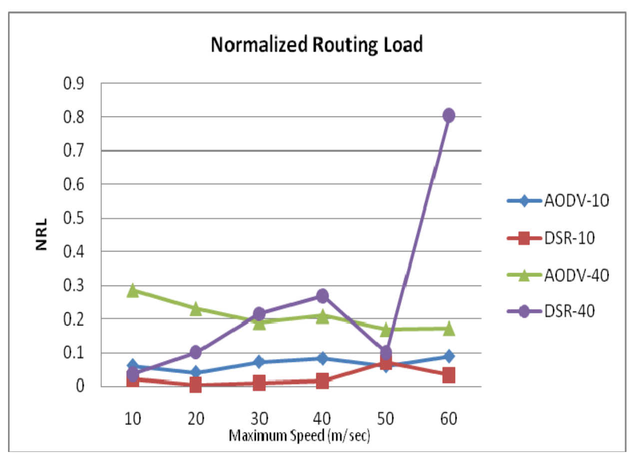


Figure 7: Normalized Routing Load vs. Speed

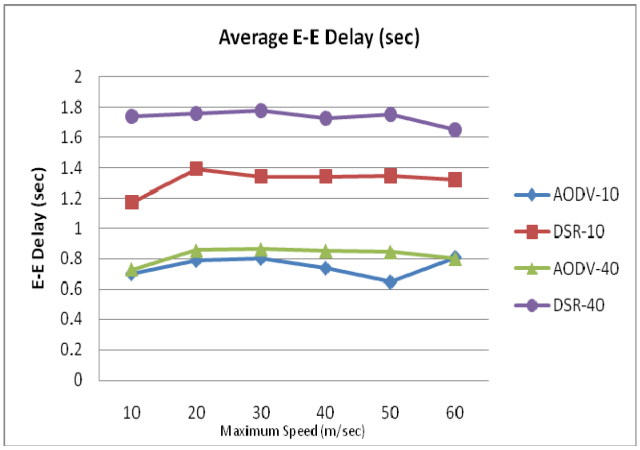


Figure 9: Average End-End Delay vs. Speed

6. Conclusions

From the figure 2 to 9, we conclude that in Group mobility model with CBR traffic sources AODV perform better. But in case of TCP traffic, DSR perform better in stressful situation (high load or high mobility). DSR routing load is always less than AODV in all type of traffic. Average end-to-end delay of AODV is less than DSR in both type of traffic. Over all the performance of AODV is better than DSR in CBR traffic and real time delivery of data. But DSR perform better in TCP traffic under restriction of bandwidth condition.

In this paper, two routing protocol are used and their performance have been analyzed under Group mobility model with respect to four performance metrics. This paper can be enhanced by analyzing the other MANET routing protocols under different mobility model and different type of traffic sources with respect to other performance metrics.

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