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PERFORMANCE INVESTIGATION OF ROUTING PROTOCOLS OF MOBILE AD-HOC NETWORKS USING CBR AND TCP TRAFFIC

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Abstract: In this paper we have investigated performance of two reactive MANET routing protocol Ad Hoc On-demand Distance Vector Routing protocol (AODV) and the Dynamic Source Routing protocol (DSR) by using 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 mobility and type of traffic (CBR and TCP). A detailed simulation has been carried out in NS2. The metrics used for performance analysis are Packet Delivery Fraction, Average end-to-end Delay. It has been observed that AODV gives better performance in CBR traffic and real time delivery of packet. As a result, more data packets can be received by the destinations in inter-group communications. Hence, the *packet delivery ratio* is increased as the speed increases. Where as DSR gives better results in TCP traffic and under restricted bandwidth condition. The simulation results reflect that group partitions have a significant impact to the performance of network routing protocols.

Keywords: TCP, CBR, AODV, DSR

INTRODUCTION

Mobility models are used in simulation studies to describe the dynamic behaviors of mobile devices in the real world for analyzing and evaluating the performance of ad hoc network protocols under various scenarios [1]. Mobility models play a significant role in the development of MANETs. Most existing mobility models, such as the Random Waypoint Mobility model [2] and the Random Walk Mobility model [3], are designed to simulate the movement of each individual, which are referred to as entity mobility models [4]. However, with the emergence of group-oriented applications, several group mobility models have been recently proposed. The applications requiring group mobility can be found in various scenarios, which include military operations, searching, and rescue in disaster recovery, visiting an exhibition hall, and firefighters operating in a building.

The common characteristic of the above applications is that mobile nodes can be organized in the unit of groups, which could be further partitioned into many subgroups or merged with other groups. However, among all the existing group mobility models, none of them can simulate the inherent group operations, *i.e.*, partitions and group mergers, which are very common in most practical group mobility, related scenarios. In addition, some group mobility models can only be applied to specific scenarios with the restrictions in the aspects of, e.g., fixed group membership, fixed velocity, and predefined paths for group's movement. By considering these restrictions, most of existing models are unable to describe the behaviors of group mobility realistically.

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.

LITERATURE REVIEW

In this section, we will review some of the mobility models for MANETs first. Following that, review of the network routing protocols in MANETs will be presented.

Review on Mobility Models in MANETs

Mobility models in MANETs are generally classified into two categories, namely entity mobility models and group mobility

models. Entity mobility models are used to describe the mobility of each individual's mobility while group mobility models mimic the movement of groups in MANETs.
Several group mobility models are designed for MANETs, although they may not be as widely used as entity mobility models. Reference Point Group Mobility (RPGM) model [10] is a generic group mobility model.
In this model, the movement path of a group is predefined by a series of points, which are referred to as "reference points". Each group has a group leader, which serves as the logical center of the group. Every mobile node follows the movement of the logical center with a random deviation in its position to that of the logical center. It is compulsory to predefine group membership and group leaders before running a simulation, which are not allowed to change during the simulation.

Review on Network Routing Protocols

In ad hoc networks, routing protocols are typically categorized into two classes, table-driven routing protocols and on-demand routing protocols [11,12]. The two classes of routing protocols are differentiated by the mechanisms, which they use to maintain and update routes in ad hoc networks [6,13-15]. In table-driven routing protocols, when a source has a packet to send, the routing information will be available immediately from its routing table which is updated periodically by advertisements, e.g. hello messages. However, in on-demand routing protocols, the source, which wants to send a packet, has to trigger a route discovery process if it can not find any fresh enough route from its routing table or the routes in its routing table are no longer available, and thus the routing information is updated by request. Both table-driven and on-demand routing protocols use more control overhead than the traditional static networks. In dynamic network environments such as MANETs, fast change of network topology will result in massive routing overhead generated to update routing tables of each mobile node, especially for the nodes using table-driven routing protocols. Table driven routing protocols are not adaptive to fast changes of network topology.

On the other hand, on-demand routing protocols only need to update their routing information when they have packets to deliver. Hence, on-demand routing protocols generally outperform table-driven routing protocols in dynamic network environment. Thus, we choose two well-known on-demand routing protocols, *i.e.* AODV and DSR, for the study of the impact of group partitions and mergers on the network performance in this work.

Next, we will review these two routing protocols. "AODV minimizes the number of required broadcasts by creating routes on a demand basis" [8,14]. In AODV, when a source node desires to send a packet but does not have a valid path to the destination, it initiates a route discovery process to locate the destination by broadcasting a route request (RREQ) message to its neighbors, which then forward the request to their neighbors and so on, until either the destination or an intermediate node with a "fresh enough" route to the destination is located.

Each node that forwards the RREQ creates a reverse route for itself back to the source node. The routing table is updated with the address of the neighbor from which the first copy of the broadcast message is received; thereby the reverse routes are established. Other additional copies of the same RREQ arrived later are discarded.
The destination or any intermediate node with a "fresh enough" route to the destination responds by unicasting a route reply (RREP) packet back to the neighbor from which it first received the RREQ. The RREP is routed back along the reverse path hop-by-hop. The intermediate nodes update their route tables with the node from which the RREP is received as forward route entries. If an intermediate node moves, its upstream neighbors notices it and sends a link failure notification message to all its upstream neighbors to inform them of deletion of that route. The link failure notification message is relayed to the source, which will choose to re-initiate a new route discovery process or discard. DSR is a source-routed on-demand routing protocol [9]. In DSR, a node maintains route cache containing the source routes that it is aware of and updates entries in the route cache when it learns about new routes. The protocol consists of two major phases: route discovery and route maintenance. The route discovery phase is initiated by broadcasting a route request (RREQ) when the source node does not find a route to the destination in its route cache or if the route has expired. This RREQ contains the address of the destination, along with the source nodes' address and a unique identification number. To limit the number of RREQs propagated, a node processes the RREQ only if it has not already seen it before. Each node receiving the RREQ checks whether it knows of a route to the destination. If it does not, it adds its own address to the route record of the packet and then forwards the packet along its outgoing links. A route reply (RREP) is generated when either the destination or an intermediate node with current information about the destination receives the RREQ. In the route maintenance phase, each node transmitting the packet is responsible for confirming that the packet has been received by the next hop along the source route. Hello message is used to maintain the local connectivity of a node. By periodically broadcasting a hello message, a node may determine whether the next hop is within communication range. If no hello message is received, the node returns a route error (RRER) message to the original sender of the packet which can send the packet using another existing route or perform a new route discovery and remove the expired route information from its routing table.

Both AODV and DSR protocols employ a route discovery procedure. However, they have several important distinctions between each other. The most notable of these is that DSR uses more overhead in route constructions and route maintenance since each packet in DSR keeps much more routing information than that of AODV, whereas in AODV packets only contain the destination and source address. DSR is intended for networks in which the mobile nodes move at a moderate speed and the network is relatively small [9,16].
Additionally, DSR allows nodes to keep multiple routes to a destination in their route cache [12,17]. When a link on a route is broken, the source node can check its route cache for another route. However, DSR does not contain any mechanism to validate route entries when it faces with a choice of multiple routes. This leads to stale route entries, particular at high mobility environment. On the other hand, AODV allows nodes to keep only one route entry to each destination in the cache.

The route discovery process will be reinitiated if the route in the route table of the source node is invalid.

INTRODUCTION TO ROUTING PROTOCOL

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.

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.

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. Simulations are summarized in the table 1.

PERFORMANCE METRICS

MANET routing protocols can be evaluated by a number of quantitative metrics described by RFC2501 [7]. We have used the following metrics for evaluating the performance of the two routing protocols (AODV & DSR).

Packet Delivery Fraction

It is the ratio of the number of packets received by the destination to the number of data packets generated by the source.

Minimum Delay

It is defined as the minimum time taken for a data packet to be transmitted across a MANET from source to destination.

Maximum Delay

It is defined as the maximum time taken for a data packet to be transmitted across a MANET from a source to destination.

Average end-to-end delay

It is defined as the average time taken by the data packets to propagate from source to destination across a MANET. This includes all possible delays caused by buffering during routing discovery latency, queuing at the interface queue, and retransmission delays at the MAC, propagation and transfer times.

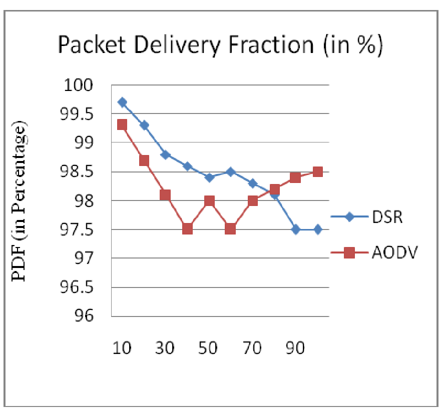
Throughput

It is the rate of successfully transmitted data packets per second in the network during the simulation.

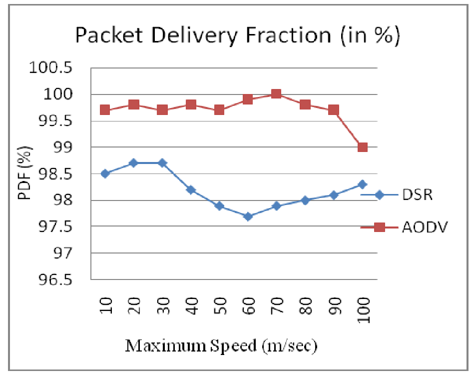
RESULT AND DISCUSSION

Packet delivery ratio

In case of CBR traffic both protocols deliver almost all originated data packets (around 97-100%) when mobility is low and number of sources is also low. 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. But in case of TCP traffic, DSR performs better irrespective of network load and speed.



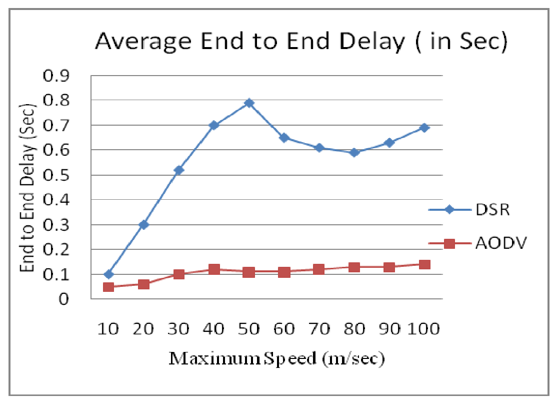
CBR Traffic Sources



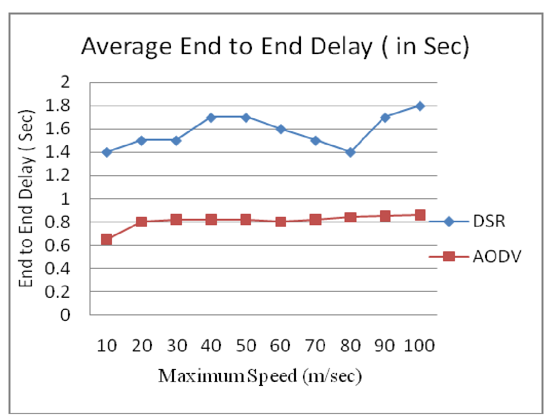
TCP Traffic Sources

Average end-to-end Delay

In CBR traffic, average end–end delay of DSR is comparable to AODV when number of sources is low. But in case of TCP traffic, AODV performs better in all condition. 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

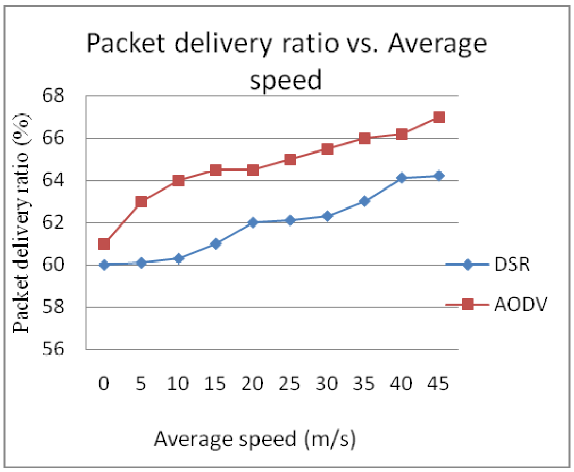


TCP Traffic Sources

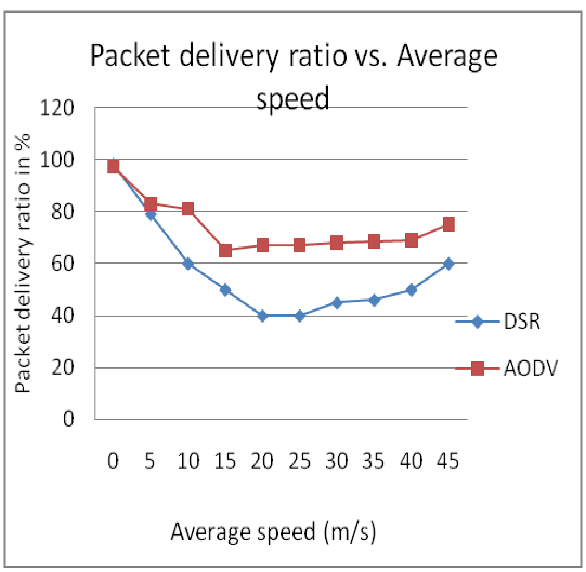
Below figures presents the results which show how the *packet delivery ratio* varies with mobility speeds. As illustrated in figures, the trends of *packet delivery ratio* for both AODV and

DSR increase as the average speed increases when group partition is disabled. The growth is 2% to 3% for both of AODV and DSR. Since 50% source-destination pairs are placed in different groups respectively for inter-group communications, they may not be connected initially if the sources cannot find routes to their destinations, which may be due to the long distance beyond the transmission range or the lack of intermediate nodes between each other. When the network topology changes as nodes move faster, those previously disconnected source-destination pairs, which are placed in different groups, would possibly get connected.

As a result, more data packets can be received by the destinations in inter-group communications. Hence, the *packet delivery ratio* is increased as the speed increases. On the contrary, the performance of *packet deliver ratio* for both DSR and AODV falls dramatically under



Packet delivery ratio vs. Average speed (m/s)—Group partition disabled



Packet delivery ratio vs. Average speed (m/s) — Group partition enabled.

CONCLUSIONS

As a conclusion, in this paper, two routing protocol of MANET are used and their performance have been analyzed under mobility model with respect to 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.

We conclude that in mobility model with CBR traffic sources AODV perform better. But in case of TCP traffic, DSR performs better in stressful situation. 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.

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