Comparison of Protocols in MANET for Efficiency Evaluation of Mobility Models (Random Way Model)

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ABSTRACT
A mobile ad hoc network (MANET) is a network consisting of a set of wireless mobile nodes that communicate with each other without centralized control or established infrastructure. Every node in MANET moves arbitrarily making the multi-hop network topology to change randomly at unpredictable times. The MANETs technique is being used widely in variety of applications. The most challenging factor in MANET is routing. In this review paper, we study the comparision of protocols in MANET for efficiency evaluation of mobility models (Random Way Model) like Ad hoc on demand Distance Vector (AODV), Dynamic Source Routing (DSR) and proactive routing protocol Destination Sequenced Distance Vector (DSDV). We study the effect of high mobility on the efficiency evaluation of these routing protocols with respect to Average End-to-End Delay (AEL), Normalized Routing Load (NRL), Packet Delivery Fraction (PDF) and Throughput. This helps to analysize the Random Way Model (RWM) on qualitative and quantitative metrics criteria. The results show that AODV shows better performance than DSDV, DSR. This imposes different design constraints and requirement on routing protocols for MANET. We have analyzed the efficiency of protocols by varying network load, mobility and type of traffic (CBR and TCP). 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.

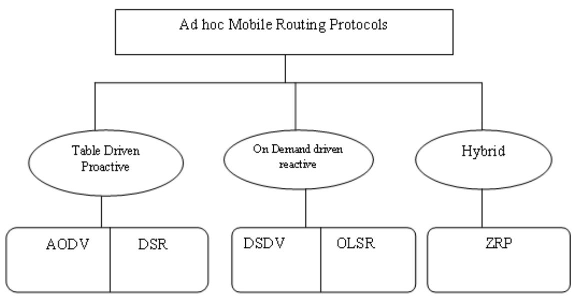
General Terms

CBR and TCP, TCP traffic, Restricted bandwidth, Qualitative and quantitative metrics

Keywords
MANET, AODV, DSR, DSDV, RWM, AEL, NRL, PDF, CBR, TCP.

1. INTRODUCTION
In MANET, nodes must be self-organized and creates a wireless ad hoc network in order to communicate and exchange messages with other nodes. This paper provides an analysis, overlook and performance evaluation of reactive and proactive routing protocols which are suitable for high speed wireless communications. The evaluation is conducted in two phases. In the first phase, comparison of the protocols based on qualitative metrics is done to locate those that may fit the evaluation criteria. In the second phase, evaluation of the selected protocols is done from the first phase based on quantitative metrics in a mobility model. Here, the objectives are as follows: i) To compare protocols based on qualitative metrics that most efficient. ii) To evaluate the selected protocols through extensive simulations under the same network parameters. It provides reliable and efficient networking services in a rapidly changing network load, mobility and type of traffic (CBR and TCP) networks and tactical scenarios. In such a environment, conventional links, networks, and transport protocols fail to operate properly. Hence, a significant fraction of the packets can be received in error or can be lost. Routing paths in MANETs contains multiple hops, and every node in MANET acts as a router. 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. Here, we have compared protocols in MANET for efficiency evaluation of mobility models (Random Way Model) for Ad hoc on demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Destination Sequenced Distance Vector (DSDV) on qualitative and quantitative metrics criteria. Biradar, S. R. et. al. [1] 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. [2] 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 done the comparision of AODV, DSR and DSDV for efficiency evaluation of mobility models in Random Way Model. The purpose of this work is to understand there working efficiency and performance of various routing protocols in various situation / traffic.

2. RELATED WORK
The main objective of ad hoc routing protocols is how to deliver data packets among nodes efficiently without predetermined topology or centralized control. All the MANET routing protocols are divided in three categories:



Types of MANET Routing Protocols

Here, we have done the comparision of AODV, DSR and DSDV for efficiency evaluation of mobility models (Random Way Model).

3. ROUTING PROTOCOLS
Routing protocols are broadly classified into three types such as Proactive, Reactive and Hybrid protocols.

3.1 Pro-active Routing (Table-driven)
The information from each node to every node in the network maintains up-to-date information by table driven routing protocols. These protocols require each node to maintain one or more tables to store routing information and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view. The areas where they differ are the number of necessary routing-related tables and the methods by which changes in network structure are broadcast. The main disadvantage of table driven implementation algorithm is-

I. Requirement for maintenance of a large amount of data at every node.

II. Slow reaction on restructuring and failures

3.1.1 Destination Sequenced Distance Vector (DSDV*)*
The Destination-Sequenced Distance-Vector Routing protocol (DSDV) presented in [8] is a table-driven algorithm based on the classical Bellman- Ford routing mechanism. The improvements made to the Bellman-Ford algorithm include freedom from loops in routing tables [9]. Every mobile node in the network maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded. Each entry is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops. Routing table updates are periodically transmitted throughout the network in order to maintain table consistency [10]. To help alleviate the potentially large amount of network traffic that such updates can generate, route updates can employ two possible types of packets. The first is known as a "full dump." This type of packet carries all available routing information and can require multiple network protocol data units (NPDUs). During periods of occasional movement, these packets are transmitted infrequently. Smaller "incremental" packets are used to relay only that information which has changed since the last full dump. Each of these broadcasts should fit into a standard size NPDU, thereby decreasing the amount of traffic generated. The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets. New route broadcasts contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast [8]. The route labeled with the most recent sequence number is always used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize (shorten) the path. Mobiles also keep track of the settling time of routes, or the weighted average time that routes to a destination will fluctuate, before the route with the best metric is received [8]. By delaying the broadcast of a routing update by the length of the settling time, mobiles can reduce network traffic and optimize routes by eliminating those broadcasts that would occur if a better route was discovered in the very near future.

3.2 Reactive Routing (On-demand)
A different approach from table-driven routing is source-initiated on-demand routing. This type of routing creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. Once a route has been established, it is maintained by some form of route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired.

3.2.1 Ad hoc On Demand Distance Vector (AODV)
AODV is an improvement on DSDV because it minimizes the number of required broadcasts by creating routes on an on-demand basis, as opposed to maintaining a complete list of routes, as in the DSDV algorithm. When a source node wants to send a message to some destination node and does not already have a valid route to that destination, it initiates a path discovery process to discover the other node. It transmit a route request (RREQ) packet 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. AODV utilizes destination sequence numbers to make certain that all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number, as well as a broadcast ID. The broadcast ID is incremented for every RREQ the node initiates, and together with the nodes IP address, uniquely identifies a RREQ. Along with its own sequence number and the broadcast ID, the source node includes in the RREQ the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ.

3.2.2 Dynamic Source Routing (DSR)
The Dynamic Source Routing (DSR) protocol presented in [11] [8] is an on demand routing protocol that is based on the concept of source routing. Mobile nodes are required to maintain route caches that contain the source routes of which the mobile is aware. Entries in the route cache are continually updated as new routes are learned. DSR also has the capability to handle unidirectional links. Since DSR discovers routes on-demand, it may have poor performance in terms of control overhead in networks with high mobility and heavy traffic loads. Scalability is said to be another disadvantage of DSR. In DSR, when a mobile (source) needs a route to another mobile (destination), it initiates a route discovery process which is based on flooding. The source originates a RREQ packet that is flooded over the network. The RREQ packet contains a list of hops which is collected by the route request packet as it is propagated through the network. Once the RREQ reaches either the destination or a node that knows a route to the destination, it responds with a RREP along the reverse of the route collected by the RREQ [7]. This means that the source may receive several RREP messages corresponding, in general, to different routes to the destination. DSR selects one of these routes, and it maintains the other routes in a cache. The routes in the cache can be used as substitutes to speed up the route discovery if the selected route gets disconnected. To avoid that RREQ packets

travel forever in the network, nodes, that have already processed a RREQ, discard any further RREQ bearing the same identifier.

3.3 Hybrid Protocols

ZRP [10][11] is a hybrid routing method, where the proactive and reactive behavior is mixed for ad hoc mobile networks. Purely proactive and purely reactive protocols perform well in a limited region of this range. For example, reactive routing protocols are well suited for networks where the call-to mobility ratio is relatively low. Proactive routing protocols, on the other hand, are well suited for networks where this ratio is relatively high

4. Random Waypoint

The Random way point mobility model includes pauses between changes in direction and/or speed. A mobile node begins by staying in one location for a certain period of time (i.e. pause). Once this time expires, the mobile node chooses a random destination in the simulation area and a speed that is uniformly distributed between [min-speed, max-speed]. The mobile node then travels toward the newly chosen destination at the selected speed. Upon arrival, the mobile node pauses for a specified period of time starting the process again. The random waypoint model is a commonly used mobility model in the simulation of ad hoc networks. This fact impairs the accuracy of the current simulation methodology of ad hoc networks and makes it impossible to relate simulation-based performance results to corresponding analytical results. To overcome these problems, it is presented a detailed analytical study of the spatial node distribution generated by random waypoint mobility. The movement trace of a mobile node using the Random Waypoint model is shown in figure 1.

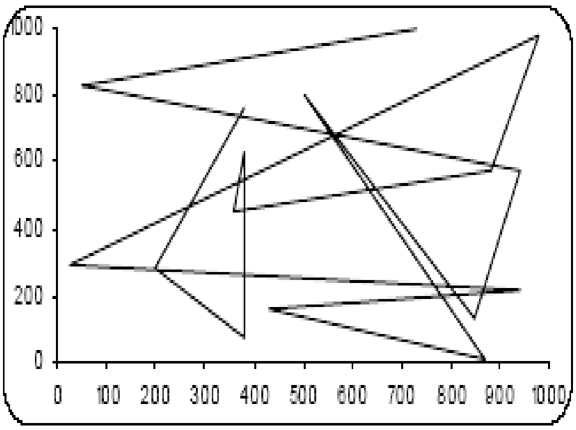


Fig. 1. Node movements in random waypoint.

5. SIMULATION SETUP

We have used the data of Network Simulator (NS)-2 in our evaluation in Red Hat Linux environment with version NS-2.34. NS-2 is suitable for designing new protocols, comparing different protocols, efficiency evaluation 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 has to deal with two things: Detailed simulation of protocols which require a system programming language which can efficiently manipulate bytes, packet headers and implement algorithms, Research involving slightly varying parameters or quickly exploring a number of generated scenarios by software called Mobility Generator which is based on a frame. In the scenario, we have considered four groups with twelve node and one group leader in each.

S.No.	Parameter	Value
1	Terrain Size	1200 X 1200 meters
2	Mobility Model	Random Waypoint
3	[Min, Max] speeds	($0\ ms^{-1}$, $20\ ms^{-1}$)
4	MAC Protocol	CSMA
5	Routing Protocol	AODV
6	Nominal traffic type	Constant Bit Rate (CBR), 12 connections
7	Number of Nodes	50

Table 1: Simulation Parameters

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 [4]. The parameters used for carrying out simulation are summarized in the table 1.

5.1 Performance Metrics

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)

5.1.1 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.

5.1.2 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. Overhead = Number of RTR packets.

5.1.3 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.

5.1.4 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.

6. RESULT AND DISCUSSION

6.1 Packet delivery ratio:

In CBR traffic both protocols delivers almost all originated data packets (around 98-100%) 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).

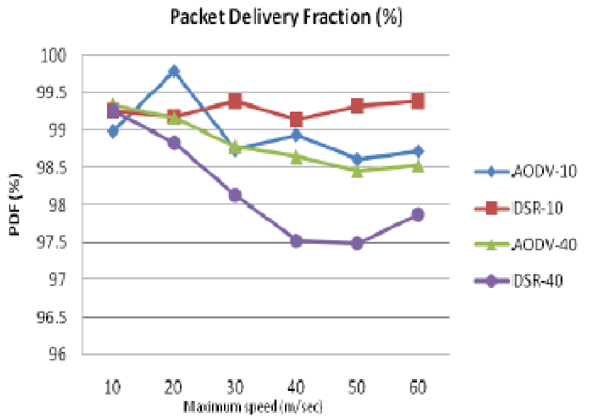


Fig 2: CBR Fraction Delivery Fraction vs. Speed [12]

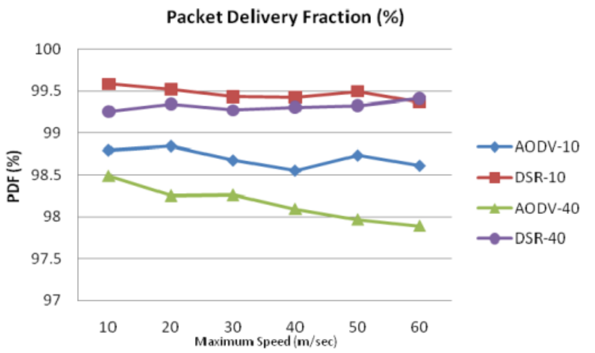


Fig 3: TCP Fraction Delivery Fraction vs. Speed [12]

6.2 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. 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).

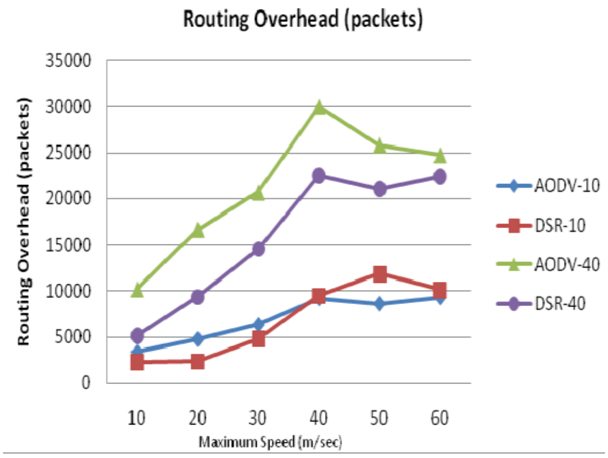


Fig 4: CBR Routing Overhead vs. Speed [12]

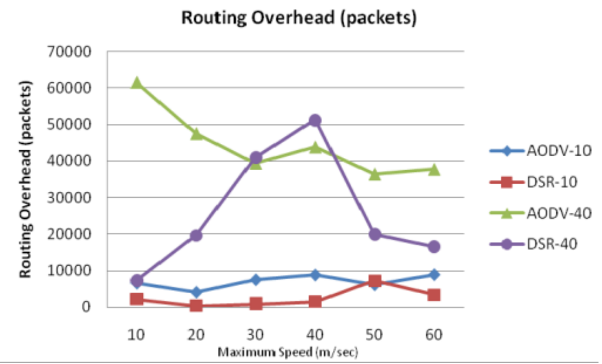


Fig 5: TCP Routing Overhead vs. Speed [12]

6.3 Normalized Routing Load:

In 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 (Fig 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 (Fig. 7).

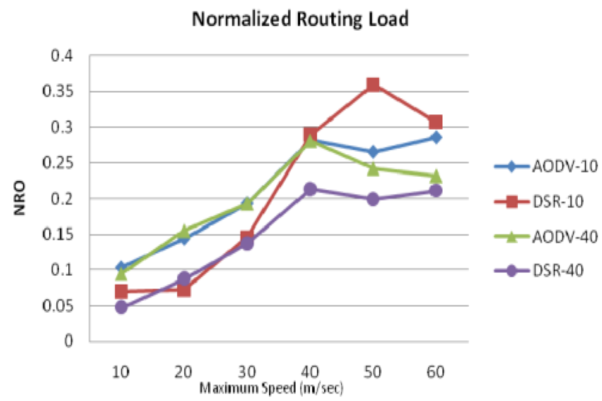


Fig 6: CBR Normalized Routing Load vs. Speed [12]

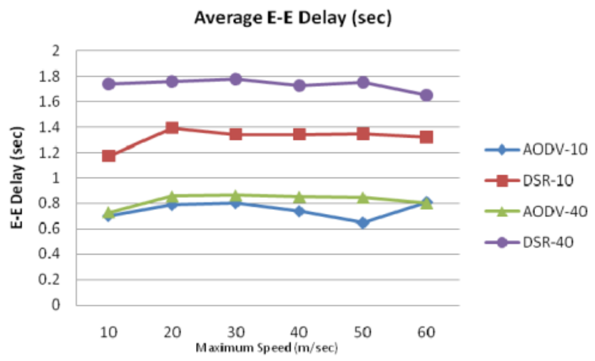


Fig 7: TCP Normalized Routing Load vs. Speed [12]

6.4 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. 6). But in TCP traffic, AODV perform better in all condition (fig. 8). 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.

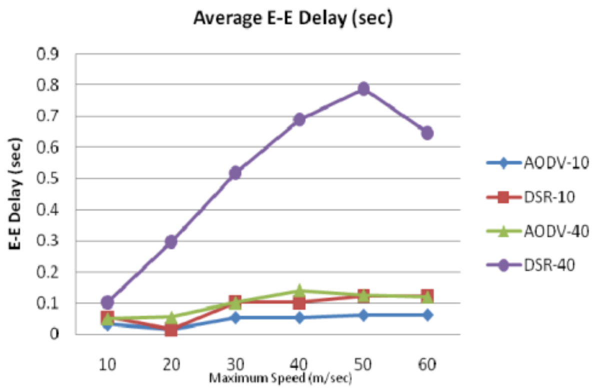


Fig 8: Average End-End Delay vs. Speed [12]

7. Conclusions:

During the comparative study it was reported that in case of MANETs with CBR traffic sources AODV has better result but, in case of TCP traffic, DSR perform better in high load or high mobility. The routing load in DSR is always less than AODV in both type of traffic. The average end-to-end delay of AODV is less than DSR in both type of traffic. Overall the performance of AODV is better than DSR in CBR traffic. But DSR perform better in TCP traffic under limited bandwidth condition. The performance of MANET Routing protocols like DSDV, AODV and DSR was analyzed qualitatively and then using NS-2 simulations. In networks with a small number of nodes and low mobility, AODV did not suggest a good solution as a routing protocol. However, AODV had better performance in all networks with higher mobility and a greater number of nodes.

8. ACKNOWLEDGMENTS

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