Exploring the Behavior of Mobile Ad Hoc Network Routing Protocols with Reference to Speed and Terrain Range

Asha Ambhaikar and Lokesh Kumar Sharma

***Abstract* — a mobile ad hoc network is a collection of autonomous mobile nodes that communicate with each other over wireless links. Such networks are expected to play increasingly important role in future civilian and military settings, being useful for providing communication support where no fixed infrastructure exists or the deployment of a fixed infrastructure is not economically profitable and movement of communicating parties is possible. However, since there is no stationary infrastructure such as base stations, mobile hosts need to operate as routers in order to maintain the information about the network connectivity. Therefore, a number of routing protocols have been proposed for ad hoc wireless networks. In this paper, we study and compare the performance of the following routing protocols AODV, DSR, and DSDV. For experimental purposes, we have considered three terrain area 900m x 700m, 1100 x 600m and 1400m x 900m and illustrate the performance of the routing protocol across two different parameters Average Throughput and Number of Dropped Packets. Our simulation result shows that both AODV and DSR are performing better as compared to DSDV. Performance of DSR is better among AODV, DSR and DSDV in case of average throughput and number of dropped packets for increasing speed with varying terrain range.**

***Index Terms-* AODV, DSR, DSDV, Random way point model, Attraction point.**

I. 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. 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. 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. By contrast, a MANET has no permanent infrastructure at all. All mobile nodes act as mobile routers. A MANET is highly dynamic. Links and participants are often changing and the quality of the links as well. Hence, a routing protocol for ad hoc networks runs on every host and is therefore subject to the limit of the resources at each mobile host. A good routing protocol should minimize the computing load on the host as well as the traffic overhead on the network. Traditional routing protocols based on the link-state or distance-vector algorithms are aimed at finding optimal routes to every host in the network, and topological changes of network can only be reflected through the propagation of periodic updates. These protocols are not suitable for ad hoc networks [2].

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II. AD HOC ROUTING PROTOCOLS

Ad hoc routing protocols can be characterized into two categories: proactive and reactive (On-demand) [3]. Among the tested protocols in this work, only DSDV is proactive and the other two (DSR, AODV) are reactive. Proactive protocols update route information periodically, while reactive ones establish routes only when needed.

A. DESTINATION-SEQUENCED DISTANCE VECTOR ROUTING (DSDV)

The Destination Sequenced Distance Vector Protocol (DSDV) is a proactive, distance vector protocol which uses the Bellman-Ford algorithm. Compared to RIP one more attribute is added to the routing table. The sequence number as new attribute guarantees loop-freedom. It makes it possible for the

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mobile to distinguish stale routes from new ones and that is how it prevents loops. DSDV can only handle bidirectional links. The routing table in each node consists of a list of all available nodes, their metric, the next hop to destination and a sequence number generated by the destination node. The routing table is used to transmit packets through the ad hoc network. In order to keep the routing table consistent with the dynamically changing topology of an ad hoc network the nodes have to update the routing table periodically or when there is a significant change in the network. Therefore mobile nodes advertise their routing information by broadcasting a routing table update packet. The metric of an update packet starts with metric one for one hop neighbors and is incremented by each forwarding node and additionally the original node tags the update packet with a sequence number. The receiving nodes update their routing tables if the sequence number of the update is greater than the current one or it is equal and the metric is smaller than the current metric. Delaying the advertisement of routes until best routes have been found may minimize fluctuations of the routing table. On the other hand the spreading of the routing information has to be frequent and quick enough to guarantee the consistency of the routing tables in a dynamic network. There exist two types of update packets. One is the full dump which contains the entire routing table and must be periodically exchanged. The other is an incremental update which only consists of the information changed since the last full dump [4].

B. AD HOC ON-DEMAND DISTANCE VECTOR ROUTING (AODV)

AODV is an on-demand protocol, which initiate route request only when needed. When a source node needs a route to certain destination, it broadcasts a route request packet (RREQ) to its neighbors. Each receiving neighbor checks its routing table to see if it has a route to the destination. If it doesn’t have a route to this destination, it will re-broadcast the RREQ packet and let it propagate to other neighbors. If the receiving node is the destination or has the route to the destination, a route reply (RREP) packet will be sent back to the source node. Routing entries for the destination node are created in each intermediate node on the way RREP packet propagates back. A hello message is a local advertisement for the continued presence of the node. Neighbors that are using routes through the broadcasting node will continue to mark the routes as valid. If hello messages from a particular node stop coming, the neighbor can assume that the node has moved away. When that happens, the neighbor will mark the link to the node as broken and may trigger a notification to some of its neighbors telling that the link is broken. In AODV, each router maintains route table entries with the destination IP address, destination sequence number, hop count, next hop ID and lifetime. Data traffic is routed according to the information provided by these entries [5].

C. DYNAMIC SOURCE ROUTING (DSR)

The Dynamic Source Routing protocol (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self organizing and self-configuring, without the need for any existing network infrastructure or administration. DSR has been implemented by numerous groups, and deployed on several test beds. Networks using the DSR protocol have been connected to the Internet. DSR can interoperate with Mobile IP, and nodes using Mobile IP and DSR have seamlessly. Migrated between WLANs, cellular data services, and DSR mobile ad hoc networks. The protocol is composed of the two main mechanisms of “Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. All aspects of the protocol operate entirely on-demand, allowing the routing packet overhead of DSR to scale automatically to only that needed to react to changes in the routes currently in use. The protocol allows multiple routes to any destination and allows each sender to select and control the routes used in routing its packets, for example for use in load balancing or for increased robustness. Other advantages of the DSR protocol include easily guaranteed loop-free routing, support for use in networks containing unidirectional links, use of only "soft state" in routing, and very rapid recovery when routes in the network change. The DSR protocol is designed mainly for mobile ad hoc networks of up to about two hundred nodes, and is designed to work well with even very high rates of mobility [6][13].

III. RANDOM WAYPOINT MOBILITY MODEL

The random way point mobility model is simple and is widely used to evaluate the performance of MANETs. The random way point mobility model contains pause time between changes in direction and/or speed. Once a Mobile Node begins to move, it stays in one location for a specified pause time. After the specified pause time is elapsed, the MN randomly

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selects the next destination in the simulation area and chooses a speed uniformly distributed between the minimum speed and maximum speed and travels with speed v whose value is uniformly chosen in the interval (0, Vmax). Vmax is some parameter that can be set to reflect the degree of mobility. Then, the MN continues its journey toward the newly selected destination at the chosen speed. As soon as the MN arrives at the destination, it stays again for the indicated pause time before repeating the process. The traveling pattern of a mobile node using the random waypoint mobility model starts at a randomly chosen point or position [7][8].

IV. THE TRAFFIC AND MOBILITY MODELS

Continuous bit rate (CBR) traffic sources are used. The source-destination pairs are spread randomly over the network. The mobility model uses the random waypoint model in a rectangular field with three different field configurations as: 900 m x 700 m, 1100 m x 600 m, 1400 m x 900 m field with 4 packet/s network load whereas network size is constant at 100 nodes. Here, each packet starts its journey from a random location to a random destination with a randomly chosen speed. Once the destination is reached, another random destination is targeted after a pause. The pause time, which affects the Relative speeds of the mobile hosts, is kept constant at 5 s. Simulations are run for 100 simulated seconds. Maximum speed is varied at 5, 10, 20, 30, 40 m/s.

V. SIMULATION SETUP

Table I. Evaluation with varying Mobility Parameter Value

Simulation Time	100 s
No. of Nodes	100
Pause time	5s
Environnent Size	900m x 700m, 1100m x 600m, 1400m x 900m
Traffic Type	Constant Bit Rate
Maximum Speed	5, 10, 20, 30, 40 m/s.
Network load	4 packets/s
Attraction Point	X Co-ordinate :-150 Y Co-ordinate :-100 Intensity: -1.5 Standard Deviation: - 20

Simulation has been carried out by Network Simulator 2.27 (ns-2 [9]). In our simulation, we have used network load at the rate of 4 packets/s taken uniform 100 nodes with constant pause time 5s. In this simulation we wanted to investigate how the protocol behaves with different considered terrain areas and mobility. Details parameters are given on Table I.

VI. PERFORMANCE METRICS

Following important metrics are evaluated-

- **Speed (m/s)**:- Speed with which nodes move from source to destination.
- **Average Throughput (Kbps):-** The data transferred by all connections in bits/second as an average throughout the entire length of the simulation.
- **Drop Packet: -** Packets that doesn’t reach to its destination due to invalid route.
- **Attraction Point: -** An attraction point is a destination of interest to multiple people. It is defined by using four tuples x-coordinate, y-coordinate, intensity and standard deviation where the coordinates give the attraction point's position; the intensity levels weight the attraction points. A point with an intensity x times as high as another point's will also attract a node with a probability which is x times as high and the last parameter is the standard deviation that is used to determine the nodes distances to the attraction point on each of the two dimensions.

VII. RESULTS AND ANALYSIS

The simulation results bring out some important characteristic between the routing protocols for different terrain range with one attraction point. Following analysis for average throughput(Kbps) and number of dropped packets has been observed from simulation results obtained for varying speed 5,10,20,30,40 and terrain range of 900mx700m 1100mx600m, 1400mx900m network size of 100 nodes .

A. AVERAGE THROUGHPUT (KBPS)

As can be observed in Fig.1a, Fig.2a and Fig. 3a, the higher the speed, average throughput decreases. Fig.1a shows the average throughput in terrain range 900m x 700m where throughput is decreasing with increasing speed. For speed 5, 10, 20 DSR is slightly performing better than AODV but in case of 30, 40 speed AODV is performing well. DSDV has lowest throughput and with increasing speed, it changes drastically. Fig. 2a shows the average throughput in terrain range 1100m x 600m where DSR and AODV performing better than DSDV. There is a little

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difference in the throughput of AODV and DSR. For 5, 10, 20 speeds AODV are better and for 30, 40 speeds DSR are better. Fig. 3a shows the average throughput in terrain range 1400m x 900m DSDV performance is greatly degraded for higher speed of 20, 30 & 40. DSR is only performing better for speed 20 otherwise AODV is better. Network throughput decreases when the speed increases, the reason is that link outage becomes more frequent causing a higher packet drop probability. All of the protocols have higher throughput when the nodes move at low speeds, i.e., at speed 5m/s all protocols achieve best throughput. DSR and AODV perform well in all cases, delivering an. average of above 98% of the data packets. However, DSDV throughput degrades to 75% as the speed and terrain range increases, since a stale routing table entry causes data packets to be forwarded over a broken link. DSDV maintains only one route per destination, so each packet that the MAC layer is unable to deliver is dropped due to the lack of alternate routes. When the speed as well as terrain area increases, all the routing protocols suffer a decrease in throughput. Higher speeds cause frequent link changes and connection failures. Overall performance of DSR and AODV is better than DSDV but performance DSR is best, since DSR has already has a route for certain destination; AODV would have to send specific request for destination, the packet would in meanwhile stay in buffer until a valid route is found. This will take some time and therefore increase delay and decreased throughput. At higher speed, DSDV exhibits the highest drop in throughput, which is due to packets being dropped along outdated routes.

B. Dropped Packets

As can be observed in Fig.1b, Fig.2b and Fig. 3b the higher the speed and larger terrain range, number of dropped packet increases. Fig. 1b shows the number of dropped packet in terrain range 900m x 700m where it is increasing with increasing speed. For speed 5, 10, 20 DSR is slightly performing better than AODV but in case of 30, 40 speed AODV is performing well. DSDV has largest number of dropped packets with increasing speed. Fig. 2b shows the number of dropped packets in terrain range 1100m x 600m where DSR and AODV performing better than DSDV. DSR is performing best for simulation area 1100m x 600m for 10, 20, 30, 40 speeds except for 5s where AODV is better. Fig. 3b shows the number of dropped packets in terrain range 1400m x 900m, DSR is only performing better for speed 10, 20 otherwise AODV is better. It is clear that numbers of packets dropped are minimum for reactive protocols AODV and DSR than proactive protocol DSDV but comparatively DSR showing best performance. Dropped packet problem is much more complicated in mobile ad hoc networks, because wireless links are subject to transmission errors and the network topology changes dynamically. It may be due to transmission errors, no route to the destination, broken links, congestions, etc. The effects of these causes are tightly associated with the network context (e.g., host mobility, number of connections, traffic load, etc.). A packet may be dropped at the source if a route to the destination is not available, or the buffer that stores pending packets is full. It may also be dropped at an intermediate host if the link to the next hop has broken. Dropped Packet is highest in DSDV because all of the dropped packets are lost as stale routing table entry directed them to be forwarded over broken link. In contrast, on-demand protocols, AODV and DSR build routing information as and when they are created make them more adaptive and result in better performance. When speed increases, the number of dropped packet increases. The main reason for dropping packets are that the protocol is sending packets on a broken route that it think is valid and that packet in the buffer are dropped because of congestion and timeouts.

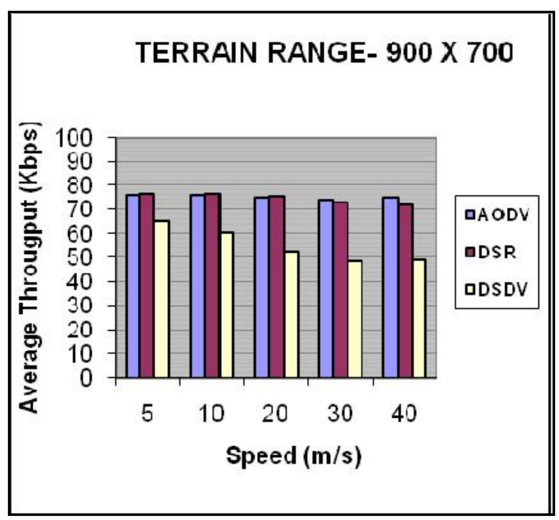

Fig. 1a. Average throughput in terrain range 900m x 700m

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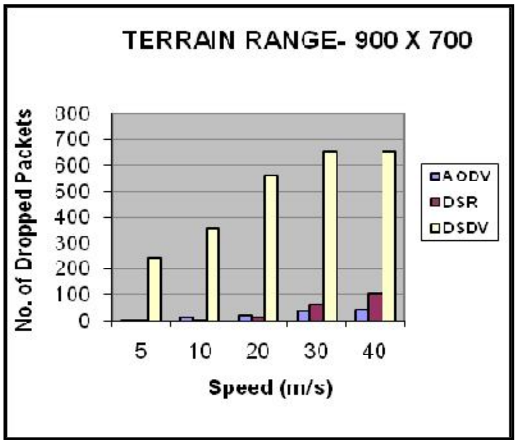

Fig. 1b. Number of dropped packet in terrain range 900m x 700m

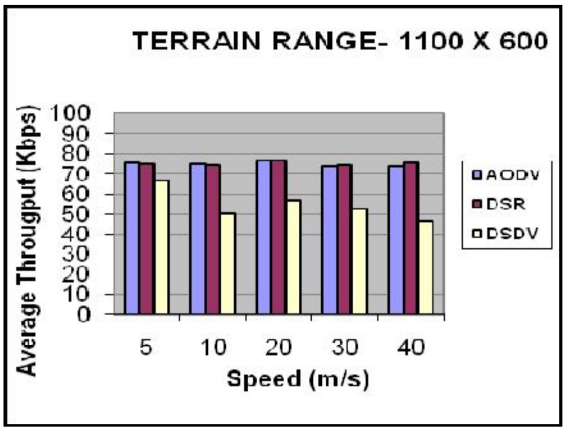

Fig. 2a. Average throughput in terrain range 1100m x 600m

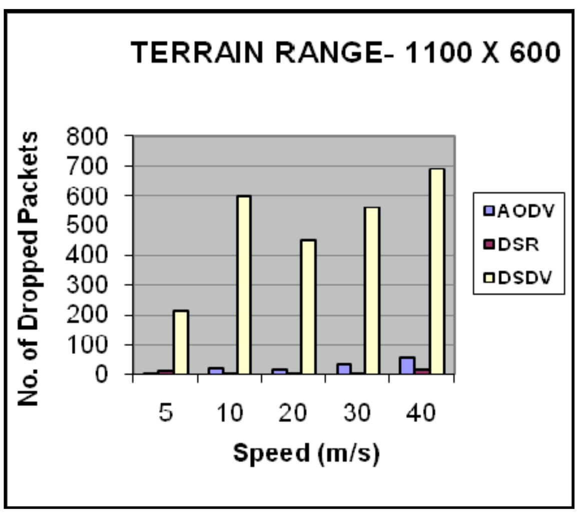

Fig. 2b. Number of dropped packet in terrain range 1100m x 600m

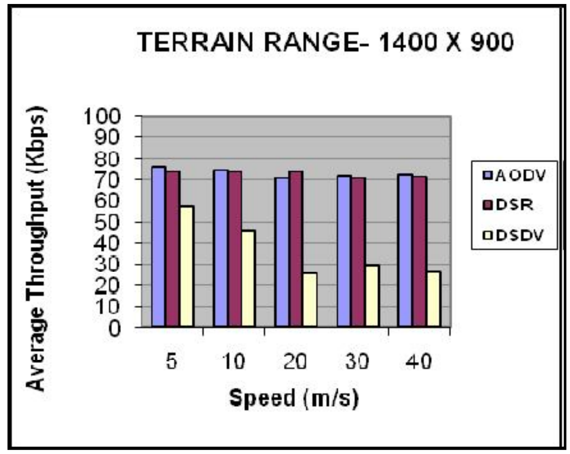

Fig. 3a. Average throughput in terrain range 1400m x 900m

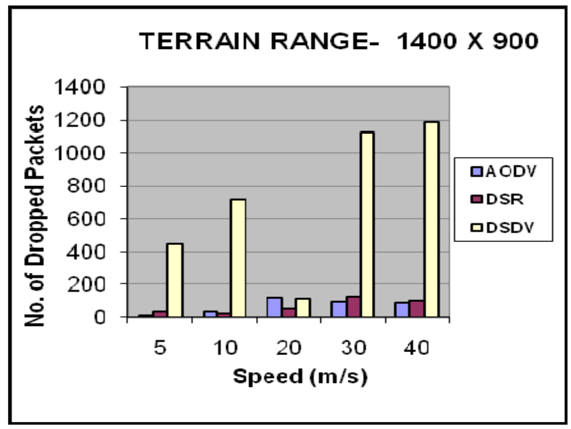

Fig. 3b. Number of dropped packet in terrain range 1400m x 900m

VIII. Conclusion and Future Work

Performance of DSR, AODV and DSDV under three different terrain ranges with one attraction point at varying speed has been compared. The significance of speed and terrain area to the average throughput and number of dropped packets has been examined. The impacts of host mobility, communication request, traffic load, traffic type for DSR, AODV and DSDV routing protocols have been studied. When the speed increases, all the routing protocols suffer a decrease in throughput. Higher speeds cause frequent link changes and connection failures. Overall performance of DSR and AODV is better than DSDV. Each of them shows different characteristics In general, observation such as average throughput and number of dropped packets, DSR and AODV performing better but DSR performing best whereas DSDV being proactive protocol showing worst performance for both

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parameters. Source route caching helped DSR to significantly improve its performance. DSDV protocols exhibit higher number of dropped packets with increased speed and AODV transmits periodically broadcast message that generate routing packets and thus decreased throughput. It is also observed that with increase terrain range and increased speed the average throughput as well as number of dropped packets is also increasing. Number of MANET routing protocols have been introduced all of which typically perform well in some performance metrics while significant weakness in other performance metric. But it is still needful to evaluate the protocols having different performance parameters with various scenarios and different attraction point. The further study will include additional analysis of same protocols with different performance metrics for more evaluation of performance of these protocols including different terrain range with attraction points.

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