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Performance Comparison of Routing Protocols Based on Different Models in Mobile Adhoc Network

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Abstract- The main characteristics of Mobile Adhoc NETwork (MANET) are no infrastructure, no centralized administration and self-configuring networks. The primary motivation of MANET deployment is to increase portability, flexibility and mobility but, mobility causes an unpredictable change in topology and makes routing more difficult. Efficient dynamic routing is a research challenge in such networks. In this paper we have evaluated the performance of three protocols namely AODV (Adhoc On demand Distance Vector routing), DSR (Dynamic Source Routing) reactive routing protocol and DSDV(Destination Sequenced Distance Vector) routing which is a proactive routing protocol on the basis of packet delivery ratio and normalized routing overhead using NS-2 simulator. Four different models are created by changing few parameters of traffic generator file and scenario file like pause time, speed of mobile nodes, network size and number of maximum connections and the results demonstrate that the difference in the mechanism of routing protocols lead to specific performance variation. The selection of an efficient routing protocol thus depends on different parameters of the MANET.

Index Terms- AODV; DSDV; DSR; MANET; ns2

I. Introduction

Mobile Adhoc Networks is an autonomous system of mobile nodes connected by multi-hop wireless links without centralized infrastructure support. A central challenge in such networks is the development of dynamic routing protocol that can efficiently find routes between two communicating nodes and is able to keep up with the high degree of node mobility that often changes the network topology drastically and unpredictably. The routing protocols can be broadly classified into on-demand routing protocols (reactive) and table-driven routing protocols (proactive). The most popular on demand routing algorithms are Adhoc On-Demand Distance Vector routing [1] and Dynamic Source Routing [3]. Destination Sequenced Distance Vector [2] routing is a table-driven routing algorithm. To determine the advantage of these protocols many researchers have made investigations comparing the performance of these protocols under various conditions and constraints [4][5][7][10].

The rest of the paper is organized as follows. In Section II related works on the research already done in the field of protocol comparison is discussed. In Section III, we present brief overview of routing protocols used. Section IV gives a description of simulation environment and the performance metrics evaluated. The simulation results obtained are discussed in Section V. Finally, Section VI concludes this paper.

II. Related Work

A number of protocols are implemented and tested for MANETS in order to fulfill the major requirements of routing including, enhancement of the bandwidth utilization, loop-free routing, minimum route acquisition delay, higher packet delivery ratio, lesser overheads per packet, minimum consumption of energy and others.

In the beginning, protocol comparison of DSDV, AODV and DSR was carried out by Per Johansson et.al. [7]. The simulations were made on random scenarios including varied mobility and varied load. Results were presented as a function of a novel mobility metric designed to reflect the relative speeds of the nodes in a scenario. In most simulations the reactive protocols (AODV and DSR) performed significantly better than DSDV. The performance comparison of two reactive routing protocols AODV and DSR was presented by S.R Das et.al. [5] using varying network load, mobility and network size. The simulation results show that DSR outperforms AODV when there are less number of nodes and low mobility but AODV outperforms DSR in more stressful situation.

The various types of mobility models were identified and evaluated by Tracy Camp et al. [6] and it is seen that the mobility of a node will also affect the overall performance of the routing protocols. The performance of the routing protocols OLSR, AODV and DSR was examined by considering the metrics of packet delivery ratio, control traffic overhead and route length by using NS-2 simulator [11] [12] . Mobile Adhoc protocols possess qualitative properties (distributed operation, loop freedom, demand based routing & security) and quantitative properties (end-to end delay, route discovery time, throughput, control packet overhead and packet delivery ratio). Most of the routing protocols are qualitatively enabled but lot of simulation studies were carried out in the paper by B. Mohammed [9] to review the quantitative properties of routing protocols. In our study we have compared two quantitative properties(packet delivery ratio and normalized routing overhead) of AODV,DSR and DSDV routing protocols when run over different models constructed by taking four different scenarios including varied mobility in terms of pause time and speed of nodes ,varied traffic connection and varied network size.

III. ROUTING PROTOCOLS

Adhoc On-demand Distance Vector (AODV) routing protocol

AODV [1] works on an on-demand basis that is, route is found from source node to destination only when there is a demand to transmit a data packet .It uses table driven routing framework and destination sequence numbers. AODV supports only one route for each destination and it deals with route table management. The path discovery and route maintenance process can be explained as follows:

Path Discovery Process in AODV: A RREQ packet is broadcasted to initiate path discovery. The RREQ contains the following fields:
<source_addr,source_sequence_#,broadcast_id,dest_addr,destination_sequence_#,hop_cnt>.
Each neighbor re-broadcasts it to its own neighbor after increasing the hop_cnt. An intermediate node can receive multiple copies of same RREQ broadcast from various neighbors. The pair <source_addr,broadcast_id > uniquely identifies a RREQ. An RREQ with same source address and broadcast_id is discarded .The intermediate node records the address of the neighbor from which it receives the first copy of the RREQ to automatically build the reverse path. Source_seq_# is used to maintain “freshness” information about the reverse route to the source. The desination_seq_# is the latest sequence number received in the past by the source for any route towards the destination. RREP contains the following information:
<source_addr, dest_addr, dest_sequence_#, hop_cnt, lifetime>
If an intermediate node has route entry for desired destination in its routing table, it compares its destination sequence number to the destination sequence number in the RREQ. If RREQ’s sequence number is greater than intermediate node must not use its recorded route and re-broadcast the RREQ. If it has a route with sequence number greater or equal to that contained in RREQ it uncast a RREP back to its neighbor from which it received the RREQ. In the event that there is no corresponding entry for that destination, an entry is created. Lifetime is the time in milliseconds for which nodes receiving the RREP consider the route to be valid.

Route Maintenance in AODV: If a source node moves during an active session, it can reinitiate route discovery procedure to the destination. If an intermediate node moves, its upstream neighbor notices the move and sends RERR (route error) packet giving link failure notification message. Optionally a mobile node may perform local connectivity maintenance by periodically broadcasting HELLO messages.

Dynamic Source Routing (DSR)

DSR [3] is an on-demand routing protocol based on source routing. In source routing the sender knows complete hop-by-hop route to the destination. Each packet carries list of all nodes in the path in its header which makes packet routing trivially loop-free. The routes are stored in a route cache. DSR is composed of two processes: *Route Discovery and Route Maintenance.*

Route Discovery in DSR: If a node in an adhoc network wishes to send a data packet to a destination for which it does not already know the route, it initiates a route discovery by flooding the network with RREQ packets. Each node receiving a RREQ, rebroadcasts it, until it is the destination node or it has a route to the destination in its route cache. The sending node even saves a copy of the original packet in a local buffer called Send Buffer where each packet is stamped with time and discarded after this timeout period. While the packet remains in the Send Buffer, the node should occasionally initiate a new Route Discovery for the destination. A RREQ packet is replied by a RREP packet which routes itself back to the source by traversing the RREQ path backwards. The propagation of RREQ and RREP in DSR is shown in Fig. 1 and Fig. 2 respectively. In response to single route discovery, a node may learn and cache multiple routes to any destination. So, if the currently used route fails or breaks, there is no need to perform a new Route Discovery.

Route Maintenance in DSR: The mechanism by which a node sending a packet along a specified route to some destination detects if that route is broken is called Route Maintenance. Route Maintenance is used to handle route breaks. When a node encounters a fatal transmission problem at its data link layer, it removes the route from its route cache and generates a route error message. The route error message is sent to each node that has sent a packet routed over the broken link. When a node receives a route error message, it removes the hop in error from its route cache.

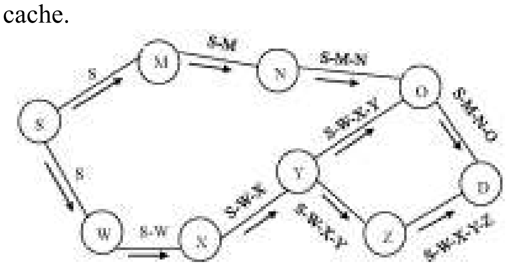


Figure 1: Propagation of Route Request

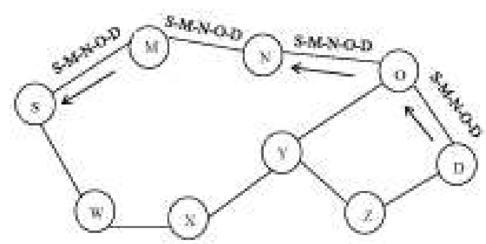


Figure 2: Propagation of Route Reply

Destination Sequenced Distance Vector (DSDV) Routing Protocol

DSDV [2] is a Proactive (table-driven) routing protocol based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements. Packets are transmitted between the stations of the network by using routing tables which are stored at each station of the network. Each routing table, at each of the stations, lists all available destinations, and the number of hops to each. Each route table entry is tagged with a sequence number which is originated by the destination station. Each station periodically transmits updates, and transmits updates immediately when significant new information is available. The DSDV protocol requires each mobile station to advertise, to each of its current neighbors, its own routing table. The data broadcast by each mobile computer will contain its new sequence number and the following information for each new route: destination’s address, number of hops required to reach the destination and sequence number of the information received regarding that destination, as originally stamped by the destination.

Routes with more recent sequence numbers are always preferred as the basis for making forwarding decisions. Of the paths with the same sequence number, those with the smallest metric will be used. Mobile Hosts cause broken links as they move from place to place, the broken link may be detected by the layer-2 protocol, or it may instead be inferred if no broadcasts have been received for a while from a former neighbor. A broken link is described by a metric of ∞ (i.e., any value greater than the maximum allowed metric). When a link to a next hop has broken, any route through that next hop is immediately assigned an infinite metric and assigned an updated sequence number.

IV. SIMULATION AND PERFORMANCE METRICS

A. Simulation Environment

The simulations were performed using the Network Simulator 2 (ns-2) [8], which allows node mobility, thereby providing for simulation of mobile ad hoc networks. In ns-2 protocols used in ad hoc networks have been supported. Node movement is modeled by the random waypoint mobility model [13] in which the nodes move from one waypoint to another randomly. A specific speed and duration is chosen for every transition. After the stipulated transition duration ends the node may pause for a specific duration of time (pause time) before starting its transition towards the next waypoint. We have compared the routing protocols by generating different network scenarios modeled as Pause-time model (pause time is varied in the scenario generator file), Nodes model (number of nodes in the network are varied both in the scenario and traffic generator file), Speed model (speed of mobile nodes is varied in scenario file) and Flow model (number of maximum connections in the network are varied in the traffic generator file). The Simulation Environment for different models is given in Table I

B. Performance Metrics

The performance metrics considered for comparisons and evaluations are

Packet Delivery Ratio: The Packet Delivery Ratio (PDR) is defined as the ratio between payload packets delivered to the destination and those generated by the source nodes. This number presents the effectiveness of the protocol and it is generally denoted as percentage. It measures the loss rate and characterizes both the correctness and efficiency of ad hoc routing protocols. A high packet delivery ratio is desired in any network.

$$Packet\ Delivery\ Ratio\ (\%) = \frac{P_r}{P_s} * 100$$

P_r = total packets received
P_s = total packets sent

Normalized Routing Overhead: The number of routing packets "transmitted" per data packet "delivered" at the destination is known as normalized routing overhead. This metric provides an indication of the extra bandwidth consumed by overhead to deliver data traffic.

$$Normalized\ Routing\ Overhead = \frac{number\ of\ routing\ packets}{number\ of\ transmitted\ data\ packets}$$

Table 1: Simulation Environment for Different Models

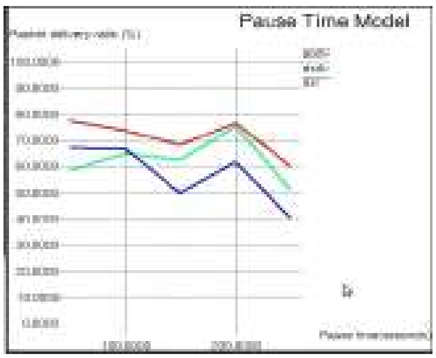
Simulation Parameters	Models			
	Pause Time Model	Nodes Model	Speed Model	Flow Model
Simulation time(s)	300	300	300	300
Simulation area	1000m x 600m	1000m x 600m	1000m x 600m	1000m x 600m
Channel BW (Mb/s)	2	2	2	2
MAC Layer	IEEE 802.11	IEEE 802.11	IEEE 802.11	IEEE 802.11
No. of nodes	25	Varied (5,10,15, 20,25)	10	25
Node transmission range (m)	250	250	250	250
Pause time(s)	Varied(50,100,150,200,250)	100s	100s	100s
Node speed(m/s)	10	10	Varied(5,10,15,20,25)	10m/s
Traffic type	CBR	CBR	CBR	CBR
Data packet size (byte)	512	512	512	512
Data rate (pkts/s)	4	4	4	4
Max connections	25	equal to no. of nodes (5,10,15, 20,25)	10	Varied(5, 10,15,20, 25 nodes)

V. RESULTS AND DISCUSSIONS

In this section results are evaluated by comparing three protocols AODV, DSR and DSDV using four different models by varying the pause time (pause time model), number of nodes(nodes model), number of connections (flow model) and speed of node movement(speed model). The performance parameters compared include Packet Delivery Ratio (PDR) and Normalized Routing Overhead.

A. Pause Time Model

In this model the pause time governing mobility of nodes in the network is varied from 50s to 250s in slots of 50s. Lower pause time means high node's random movement. If pause time is increased then movement of nodes is decreased. Fig. 3(a) shows the result for Packet Delivery Ratio for pause time model.PDR value of AODV is higher than all other protocols because of its on demand nature. Only when nodes want to send data connection is established therefore always selecting fresh and active route made it possible to deliver large number of data packets even in a situation of high mobility when routes break frequently. DSDV has lowest PDR value for low pause time, because of lack of alternate routes and presence of stale routes in routing table that leads to packet drop when nodes are moving at higher rate. In higher mobility scenario DSR has poor PDR than the other reactive routing protocol, AODV.



(a) Packet Delivery Ratio vs. Pause Time

(b) Normalized Routing Overhead vs. Pause Time

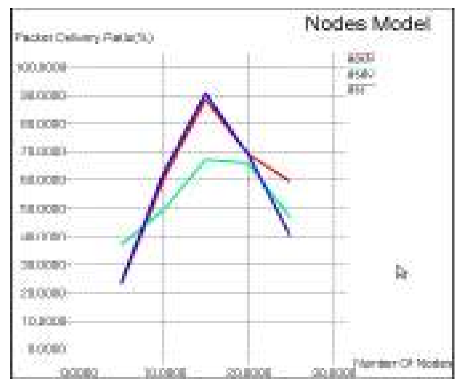
Figure 3: Packet Delivery Ratio (PDR) and Normalized routing overhead in Pause Time Model

Fig. 3(b) shows the normalized routing overhead for AODV, DSR and DSDV for this model. Although fast routes discovery of AODV leads to better delivery fraction it increases routing overhead. As compared to DSDV, routing overhead of AODV is higher in high mobility. Routing overhead of proactive protocol (DSDV) is comparatively low or stable than AODV, because of periodic updates of DSDV. DSR almost always has a lower routing load than AODV because of the aggressive caching strategy used by DSR so that it is more likely to find a route in the cache, and hence resorts to route discovery less frequently than AODV. The major contribution to AODV's routing overhead is from RREQ's, while RREP's constitute a large fraction of DSR's routing overhead.

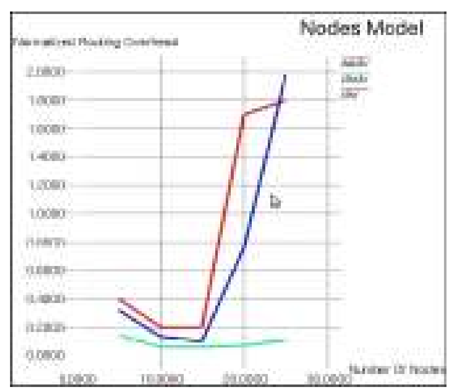
B. Nodes Model

In this model, the number of nodes in the network varies from 5 nodes to 25 nodes and traffic flow is between all the nodes in the network. Fig. 4(a) shows the result of packet delivery ratio and Fig. 4(b) shows Normalized routing overheads for this model. If number of nodes is low in case of PDR the performance of DSR and AODV is similar but as the number of nodes increase AODV starts outperforming DSR. DSDV being proactive routing protocol is suitable for limited number of nodes with low mobility due to the storage of routing information in the routing table at each node.

The routing overhead of AODV and DSR rise steeply if number of nodes are increased because they are reactive routing protocols and find routes only when desired,so as the number of sources increase, the overhead increases. DSDV, shows consistent overhead over the increasing number of sources. DSR has less overhead as compared to AODV because it uses source routing mechanism



(a) Packet Delivery Ratio vs. Number of Nodes



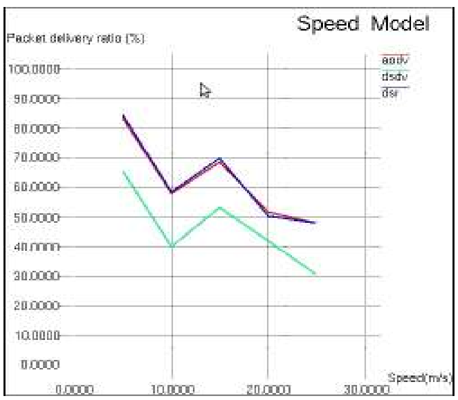
(b) Normalized Routing Overhead vs. Number of Nodes

Figure 4: Packet Delivery Ratio (PDR) and Normalized routing overhead in Nodes Model

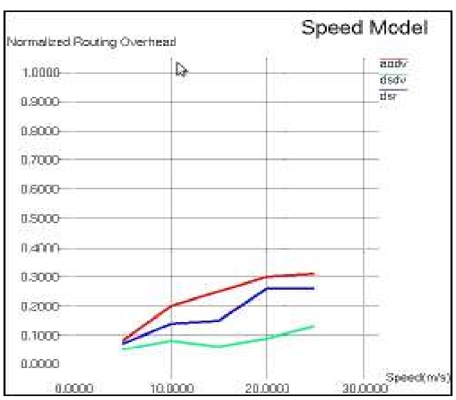
C. Speed Model

In this model the speed of node movement is varied between 5m/s to 25 m/s in a network of 10 nodes. Fig. 5(a) shows the packet delivery ratio as the speed of nodes is increased. AODV and DSR show equivalent performance but the PDR decreases with increase in speed of node movement. On the other hand, packets delivery fraction of DSDV is found lower than AODV and DSR, when nodes are moving at high speed .This is because the chance to select stale route (in high mobility) increases which causes packets to be dropped.

The Normalized Routing Overhead of the three protocols is compared in Fig. 5(b). As compared to DSDV routing overhead of AODV is higher and increased as speed is increased. In the presence of high mobility, link failures can happen very frequently which trigger new route discoveries in AODV since it has at most one route per destination in its routing table. The reaction of DSR to link failures in comparison is mild and causes route discovery less often. The reason is the abundance of cached routes at each node. But with high mobility, the chance of the caches being stale is quite high in DSR. Eventually when a route discovery is initiated, the large number of replies received in response which adds to overheads in DSR. Routing overhead of DSDV is comparatively low or stable than AODV. DSDV is showing lowest routing overheads as it is proactive routing protocol.



(a) Packet Delivery Ratio vs. Node Speed



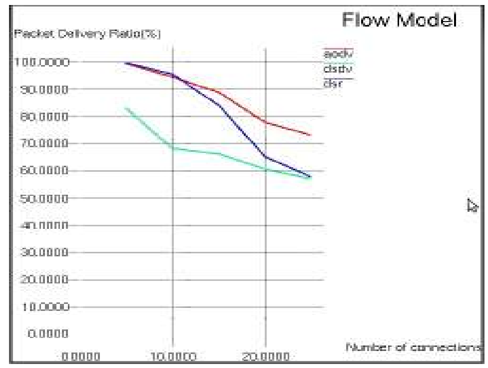
(b) Normalized Routing Overhead vs. Node Speed

Figure 5: Packet Delivery Ratio (PDR) and Normalized routing overhead in Speed Model

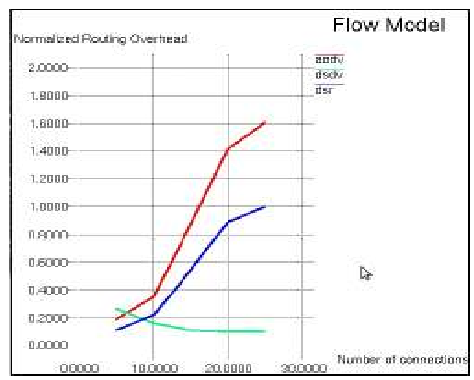
D. Flow Model

In this model the number of connection in the network is varied from 5 nodes to 25 nodes in slots of 5.The comparison of Packet delivery ratio of AODV, DSR and DSDV for variable traffic connections is shown in Fig. 6(a).The PDR for DSR and AODV are similar with 5 and 10 sources. However, with increasing number of connections, AODV outperforms DSR. As number of CBR sources increase DSDV maintained its packets delivery (an average of 65%) continuously till the end of simulation while DSR started dropping packets rapidly. So in the Flow model AODV shows the best delivery ratio and DSDV shows the worst performance.

The Normalized Routing Overhead of AODV, DSR and DSDV are shown in Fig. 6(b). Always choosing active routes requires AODV to initiate route discovery process most frequently therefore routing overhead of AODV is higher than DSDV. The low routing load of DSDV is because of local periodic messages which keep routing table update. As the number of connections are increased the routing overheads of AODV and DSR are increased because of its reactive nature.



(a) Packet Delivery Ratio vs. number of connections



(b) Normalized Routing Overhead vs. number of connections

Figure 6: Packet Delivery Ratio (PDR) and Normalized routing overhead in Flow Model

VI. CONCLUSION AND FUTURE OUTLOOK

In this paper, the performance of three MANET Routing protocols such as DSDV, AODV and DSR was analyzed using NS-2 Simulator. The comprehensive simulation results of packet delivery ratio and normalized routing overhead are evaluated by varying pause time, network size, speed of mobile nodes and number of connections. DSDV is a proactive routing protocol and suitable for limited number of nodes with low mobility due to the storage of routing information in the routing table at each node. Comparing DSR with AODV protocol, overheads in DSR is less since DSR protocol uses source routing and route cache.

Hence, DSR is preferable for moderate traffic with moderate mobility. AODV has better packet delivery ratio in more stressful situations where there is high mobility and large network size but it performs badly in terms of normalized routing overhead. If the results are compared in terms of Packet Delivery Ratio then AODV is the best protocol but, if routing overheads are considered DSDV shows minimum overheads. Overall DSR presents a good tradeoff and can be considered a good selection. It is also true that any of the single protocol does not supersede the other one. Their performance depends upon the different network scenarios. In future the performance comparison of the routing protocols will be done over different MAC Protocols like CSMA and ETDMA that would impact the relative performance of routing protocols considered in different network scenarios.

REFERENCES

[1] C. Perkins, E. Belding-Royer and S. Das. "Ad hoc on-demand distance vector (AODV) routing protocol", July 2003. IETF Internet RFC 3561.

[2] Charles E. Perkins and Pravin Bhagwat, "Highly dynamic Destination-Sequenced Distance-Vector routing (DSDV) for mobile computers", Proc. of the SIGCOMM '94 Conference on Communications Architectures, Protocols and Applications, pages 234–244, August 1994.

[3] David B. Johnson, David A. Maltz, Josh Broch. "Dynamic Source Routing for Multihop wireless ad hoc networks", In Ad Hoc Networking, edited by Charles E. Perkins, chapter 5, pp 139-172. Addison-Wesley, 2001.

[4] S.R. Das, R. Castaneda, J. Yan, and R. Sengupta. "Comparative performance evaluation of routing protocols for mobile, ad hoc networks", In 7th Int. Conf. on Computer Communications and Networks (IC3N), pp. 153–161, October 1998.

[5] S. R. Das, C. E. Perkins, and E. M. Royer. Performance Comparison of Two On-demand Routing Protocols for Ad Hoc Networks. Proceedings of the IEEE Conference on Computer Communications (INFOCOM), pp. 3-12, Tel Aviv, Israel, March 2000.

[6] Tracy Camp, Jeff Boleng and Vanessa Davies, " A Survey of Mobility Models for Ad Hoc Networks Research", Wireless Communication & Mobile Computing (WCMC): Special issue on Mobile Ad Hoc Networking:Research, Trends and Applications, vol. 2, no. 5, pp. 483-502, 2002.

[7] P. Johansson, T. Larsson, N. Hedman, B. Mielczarek, and M. Degermark, "Scenario-based Performance Analysis of Routing Protocols for Mobile Ad-hoc Networks". Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom), pp. 195-206, Seattle, WA, August 1999.

[8] Network Simulator-2 (NS-2) http://www.isi.edu/nsnam/ns/.

[9] Mohammed Bouhorma, H.Bentaouit and A.Boudhir, "Performance comparison of Ad hoc Routing protocols AODV and DSR", Proceedings of the IEEE Conference on Multimedia Computing and Systems, pp. 511-514 IEEE, April 2009.

[10] Yasser Kamal Hassan, Mohamed Hashim Abd El-Aziz, and Ahmed Safwat Abd El-Radi, "Performance Evaluation of Mobility Speed over MANET Routing Protocols", in International Journal of Network Security, Vol.11, No.3, pp. 128-138, Nov. 2010.

[11] Saiful Azadm, Arafatur Rahman and Farhat Anwar, "A Performance comparison of Proactive and Reactive Routing protocols of Mobile Ad hoc Networks(MANET)", in Journal of Engineering and Applied Sciences, 2007.

[12] Wang Lin-zhu, FANG Ya-qin and SHAN Min, "Performance comparison of Two Routing Protocols for Ad Hoc Networks", Proceedings of WASE International conference on Information Engineering,Vol.1, pp.260-262, July2009.

[13] Esa Hyytiä and Jorma Virtamo, "Random waypoint model in cellularNetworks", published online in Springer Science and Business Media,June,2006.

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