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Distance Aware Location Based Optimization for AODV in Mobile Ad HOC Networks

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ABSTRACT

An Ad hoc network is a decentralized and mobile in nature due to which network topology changes dynamically. Therefore, MANET faces new challenges of routings. This research work is based on one of reactive routing protocol called Ad hoc On-demand Distance Vector (AODV). AODV uses flooding technique for route discovery process which results in generation of huge number of route request (RREQ) packets. This flaw of AODV has been already controlled by a technique called GeoAODV. This research work proposed an enhancement of GeoAODV called DG-AODV (Distance based GeoAODV), which further decreases the number of route request messages within the area defined by flooding angle. This paper also focuses on the comparative study of DG-AODV with AODV and GeoAODV. This comparative study shows that DG-AODV's packet delivery ratio increases, and route discovery time decreases in comparison with other two routing protocols.

KEYWORDS—*Wireless; Mobile Ad Hoc Networks; AODV; routing; Optimization; Location Based Protocol; Packet Delivery Ratio; Route Request Message*

I. INTRODUCTION

Ad hoc network is collection of wireless mobile devices (nodes) that communicate with each other over multi-hop wireless links, without any stationary infrastructure or centralized management [1] and [2]. Categorically, Mobile ad hoc networks' routing protocols can be classified into three classes that are: Reactive / On demand routing [3], [4], Table driven [5] routing and Hybrid routing protocols [6]. Proactive routing has its own advantages which include the availability of possible routes to nodes at any given time but at the expense of routing overhead and may encounter route staleness issues. These type of protocols may not be suitable for highly mobile environments where the topology of the network is constantly changing due to the mobility of the nodes [7].

When the network topology changes with the dynamics of the node mobility, it causes Ad-hoc On Demand Distance vector protocol (AODV) to flood more Route discovery messages in order to establish routes to unknown destinations. To overcome the flaws of AODV different optimization techniques has been already proposed one of them, on which this research work focuses is GeoAODV [8]. It overcomes the effect of RREQ by restricting the flooding to a certain region. Unnecessary RREQs messages are not flooded in GeoAODV. This approach improves performance of the route discovery phase of the Ad-Hoc On-Demand Distance Vector (AODV) routing protocol [5,9]. Different optimized versions of GeoAODV have also been proposed such as GeoRotate [10] which operates similarly to GeoAODV, except that it computes the request zone based on the location of the previous hop, instead of the source node. This modification re- orients the cone-shape search area towards the destination node, excluding nodes that are less likely to be part of the path towards the destination.

Even though simulation results show that GeoAODV generates less control packets than AODV, there is still a possibility to reduce Route Requests by applying appropriate procedures. This work focuses on an enhancement of GeoAODV called DG-AODV (Distance aware GeoAODV). DG-AODV works similar to GeoAODV with an additional calculation on each node to compute and compare relative distance between intermediate nodes. This approach further decreases route requests as the nodes that do not satisfy the criterion discard RREQs and do not further broadcast it. The proposed technique only broadcasts route request if distance between current-to-next node is less than previous-to-next node and distance between previous-to-current node is less than previous-to-next node. These computations cause unnecessary control packets to be discarded at current node if the criterion is not met. The process of route discovery is further elaborated in the next section. This paper has been divided as follows:

Section II discusses about related work, section III discusses motivation, in section IV Proposed algorithm has been discussed. Section V discusses about simulation environment and last section VI discusses about result and analysis.

II. RELATED WORK

As reactive routing protocols induce less routing overhead than proactive routing as it has already been explained in [9], [11], [12] and [13]. AODV has its share of flaws, and different optimization techniques have already been proposed to improve its

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performance. As an example, for Scalable routing in Vehicular ad hoc Networks, an optimization called “AODV Extension using Ant Colony Optimization" [14] has been proposed that avoids the delay of communication that occurs due to frequent disconnection in routing. This approach provides an efficient way of route maintenance. Another problem related to AODV is Link breakage and to overcome this effect, Primitive AODV has been proposed in which uses some threshold value to minimize the effect. This Paper focuses on one of problems associated with AODV, which is the generation of large number of RREQ messages. An optimization technique called GeoAODV addresses this issue in [10].

A. ***AODV***

AODV starts the route discovery process whenever a route to new destination is needed. Source/ originator node broadcastsa Route Request (RREQ), and route will be obtained when RREQ reaches either the destination itself or an intermediate node with a 'fresh enough' route to the destination and then it unicastsa route reply (RREP) to originator of RREQ. AODV relies on routing table entries to propagate a RREP back to the source and, subsequently, to route data packets to the destination.

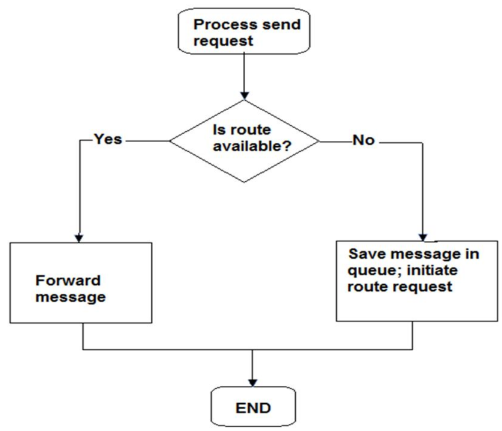

Fig. 1. AODV Process at Originator Node

Fig. 2. AODV Process at Intermediate Node

To handle the case in which route to destination node does not exist or case in which RREP message is lost, the source node rebroadcasts the RREQ message if no RREP is received by source after a time out. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops [15]. There is another type of message in AODV called RERR (Route error) to handle link breakage. Fig. 1 and Fig. 2 show the process diagrams of AODV for route establishment.

B. GEOAODV

GeoAODV has been explained in detail in [16]. It uses location information to limit the number of nodes participating in route discovery and performs selective flooding within the area that is expected to have path to the destination.

GeoAODV uses Global Positioning System to find the coordinates of the node; it distributes node's coordinates to network. In general, data retrieved by Global positioning system is in the form of a vector that contains information regarding three dimensions and the time. In this research work, two dimensional coordinates have been used in order to simplify the tested scenario. This reflects to the fact that all the communicating nodes exist on common plane. Thus, GeoAODV keeps track of and distributes the last known node position in the form of x and y coordinates only [16].

The main point that differentiates GeoAODV form AODV is Request zone, which is set using flooding angle. Generally, the information regarding last knownlocation of the destination plays a vital role in the calculation of forwarding angle. But the said angle is set to maximum value i.e. 360° if the location of destination is unavailable. This reflects the fact that the searching region is the whole network and GEOAODV acts regular AODV in this scenario. When the process of route discovery is initiated, the source /originator node broadcasts the RREQ messages to its neighbors but this time only to those neighbors that satisfy the criteria of search region (on the basis of forwarding angle). Doing so reduces unnecessary broadcasting of RREQ message hence eliminating unwanted load on the network. A node can determine its presence in search area using flooding angle value. When there is no RREP message obtained from destination, it increases flooding angle until destination nodes is found. In this case either node will find destination or value of flooding angle will be maximized to 360°, which is same as AODV. In GeoAODV, RREQ message contains additional information of source, destination coordinates and flooding angle.

The mechanism of searching best possible route used by GeoAODV can be further explained by the help of Fig. 3. When Source generates an RREQ message with the flooding angle value A1 in order to determine a route to Destination, node N1 will be the sole node to forward the RREQ as N1 the only node that lies within the search area defined by Forwarding Angle while N2, N3 and N4 will discard RREQ message as they do not satisfy the criteria. If the route to destination is not found by using previous forwarding angle, the angle is increased (A2) and the source node regenerates RREQ as a reattempt to search for a valid route to the destination node.

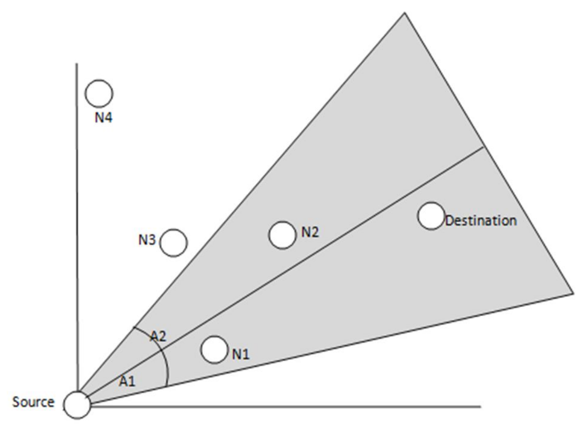

Fig. 3. Route Discovery Process illustration for GEOAODV

The RREQ message with flooding angle A2 may arrive at nodes N1, N2, and N3, however only nodes N1 and N2 will forward the message because they are inside of the search region defined by angle A2. The route request message will be discarded by the node N3 as it does not lie within the region specified by using forwarding angle. Overall process of route discovery for GeoAODV at intermediate nodes is explained in Fig. 4

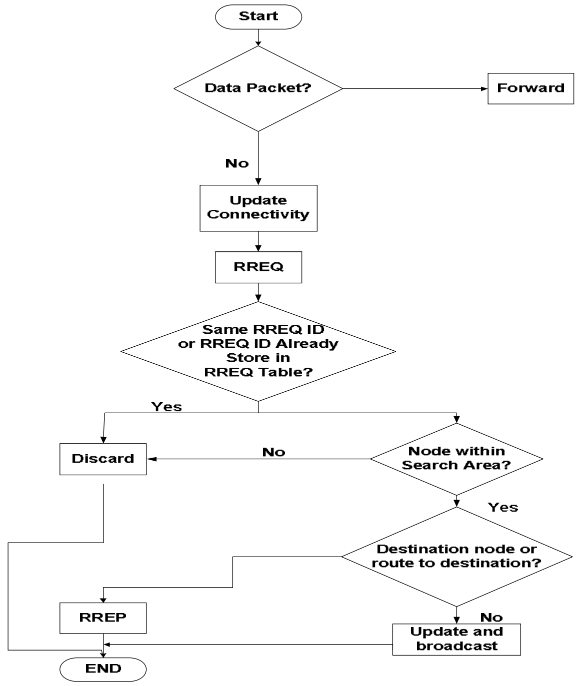

Fig. 4. GEOAODV Process at Intermediate Node

III. MOTIVATION

In this paper quality of service parameters are of prime focus and therefore, the problems related to it are highlighted. The main flaw of AODV protocol is during route discovery process as it causes generation of large number of RREQs messages and its number exceeds the sum of number of RREPL and RRER messages. So this affects a number of parameters that have a direct impact on the performance of a network. For example, increase in route discovery time and routing traffic and decrease in Packet delivery ratio. This also decreases the performance of AODV protocol. To overcome this flaw of AODV, different techniques has been proposed to decrease the number of RREQs such as GeoAODV [16] and its optimized versions that include GeoRotate [10] etc. But despite of these optimized versions, there is still some room to improve the performance of AODV. The work done in [10, 16] is based on restricting the number of RREQs to a certain region . So this paper proposed another optimized technique based on distance computations which further restricts the number of generated RREQs.

IV. PROPOSED ALGORITHM: DG-AODV

GeoAODV being an enhancement of AODV performs well in eliminating the unnecessary overhead associated with broadcasting of route request messages. But despite of such large reduction in number of control messages, there are still ways through which we can further reduce number of route request messages. Control messages within a search region defined by flooding angle can be further decreased by using a Distance technique. The objective of this paper is to enhance working of GeoAODV, through some extra calculation on each node. DG-AODV is based on the principles used in GeoAODV, but in addition it involves the calculation of distance between the nodes and their comparison at every intermediate node. Additional computations induces further processing at the nodes but ultimately results in efficiently reducing the amount of RREQs generated during route discovery process. These calculations are elaborated further in the next subsection.

A. Route Discovery Process: DG-AODV

As DG-AODV is based primarily on AODV, its route discovery process is initiated when source node wants to send data packets to a destination node. As in Fig. 5, source node broadcasts RREQ message to its neighbor node N5. Hence N5 receives RREQ message from source, and checks if it lies within search region or not. As N5 lies within search region, it will subsequently check for distance calculation. As in this case, N5 fulfills both conditions i.e. Distance between N5 to Destination is less than distance between Source to Destination and distance between Sources to N5 is less than Destination-Source. Therefore, N5 node broadcasts RREQ message to its neighboring nodes and these neighbor nodes recomputed and revalidate the mentioned criteria to check if RREQ is supposed to be either discarded or broadcasted again.

The nodes N1 and N2 receive RREQ message from N5, and check if they are within search region or not. As N1 and N2 both are within search region, they will check for distance calculation. N1 fulfills both conditions i.e. Distance between N1 to Destination is less than distance between N5 to Destination and also distance between Source to N1 is less than Destination to Source. On the other hand, N2 does not even fulfill first condition hence only N1 will further broadcast RREQ to Destination.

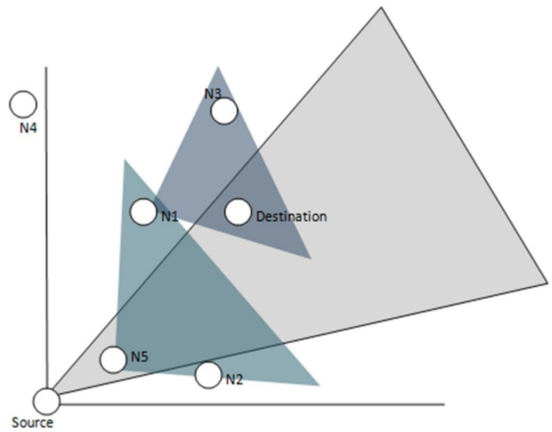

Fig. 5. Route Discovery Process for DG-AODV

When N3 receives RREQ message from N1, it will not broadcast RREQ to destination or to neighboring nodes because it does not fulfill the second condition i.e. Distance between N3 to Source is not less than Source-Destination. The process of route discovery and RREQ forwarding in DG-AODV is elaborated in Fig. 6.

Fig. 6. DG-AODV Process at Intermediate Node

V. SIMULATION ENVIRONMENT AND PARAMETERS

OPNET v.14.5 [17] has been used for simulating the research work in this paper. Performance of DG-AODV has been compared with AODV and GeoAODV in order to study the impact of introducing additional search criteria that facilitates the elimination of unwanted Route Requests with the purpose of reducing the overall control overhead associated with AODV. The simulation environment created for this comparative analysis included 100 client nodes that supported IEEE 802.11 WLAN standard for multi hop communication between them. The parameters used for configuration of the simulation environment are detailed in the subsequent subsection.

A. Configuration Parameters

As stated earlier, the environment set up for comparative analysis supported 100 clients and various scenarios were created to observe the impact of DG-AODV with 10, 20, 30, 40 and 50 communication nodes. The Simulation setup involved following parameters:

- A 1500 x 1500 subnet area (Topology Size) was used and campus network with total of 100 mobile nodes was deployed which places all nodes at random positions.
- Raw Packet Generator was used with the parameters specified in Table I. Every scenario had different number of source and destination nodes while destinations for every source were assigned randomly.
-

TABLE I. SIMULATION PARAMETERS

Parameter type	**Parameters Configuration**	
	Parameters Name	***Value***
Generic	Channel data rate	11 Mbps
	Simulation Kernel	Optimized (debug Mode)
	Simulation Time	400 seconds
	Seeds	128
	Operational mode	802.11b
Mobility Parameters	Mobility Model	Random Waypoint
	Speed	Uniform(1,10)
	Start Time	Normal(100,5)
	Pause Time	Constant(0)
	Stop Time	End of Simulation
Traffic Parameters	Traffic Type	MANET Raw Packet generation
	Start Time	100
	Packet Inter-arrival Time	Exponential(1)
	Packet Size	Exponential(1024) in bits
	Destination IP (v. 4.0) address	Randomly assigned
	Stop Time	End of Simulation

B. METRICS USED FOR PERFORMANCE ANALYSIS

- Total Route Request Sent
  The main purpose of implementing DG-AODV is to reduce the total number of Route Requests (RREQs) generated while establishing valid routes to the destination. Therefore, the total number of RREQ messages sent by all nodes in the network during route discovery is taken as the prime evaluation metric.
- Route Discovery Time
  It is time when RREQ message was sent to find path to destination, until RREP is received with a route to that destination. When unnecessary RREQs are eliminated, these results in reduced route discovery time as well.
- Packet Delivery Ratio
  Ratio of data packets received to those generated by the sources has also been observed for AODV, GeoAODV and DG-AODV.

VI. RESULTS AND ANALYSIS

*A. **Route Request Messages***

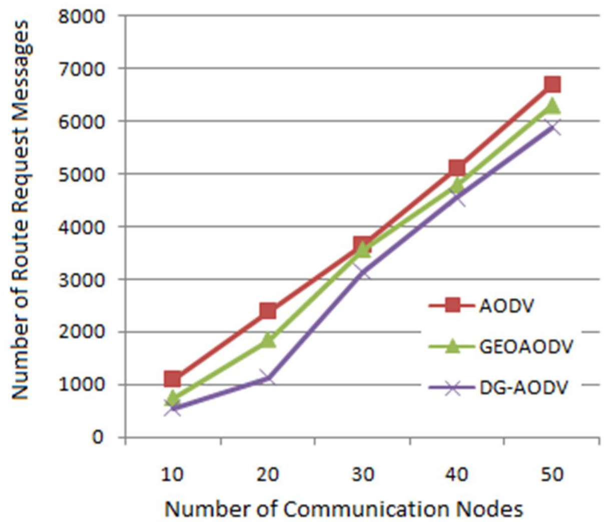

Fig. 7. Route Request messages count for AODV, GeoAODV, DG-AODV

From Fig. 8 it is clear that DG-AODV outperforms other AODV and GeoAODV as it generates less number of RREQ messages as compared with other two routing techniques. This reduction in number of route request packets is due to additional processing (i.e. distance calculation) at intermediate nodes which discard unnecessary RREQ packets, by further limiting the broadcasting of RREQ messages in GeoAODV's search region. The difference in number of RREQ packets generated in case of GeoAODV and AODV is sufficient to support the concept as described in [16], but on the other hand, RREQ messages generated as a result of DG-AODV are far less in number as compared to others. It can also be seen from

In Fig. 8, results show that when communication nodes are 10, GeoAODV generates approximately 33% less RREQ messages than AODV, and DG-AODV generates 50% less RREQ messages than AODV. Therefore, there is huge difference of RREQ messages in DG-AODV technique and AODV. But this difference decreases as number of communication nodes increase. At 40 nodes, number of RREQs of GeoAODV is 7% less than AODV and number of RREQ generated by DG-AODV are 11% less than AODV. Hence, this difference keeps on decreasing as communication nodes keeps on increasing, and at certain point this difference will be very minute so that it can be ignored. Hence, it may be notices that DG-AODV is well suited for the environment having fewer number of communicating nodes (smaller networks).

B. Route Discovery Time

Fig. 8 shows that route discovery time of DG-AODV is less than AODV and GeoAODV. This decrease in route discovery time of DG-AODV is due to less number of RREQs generated than other two techniques. Large number of RREQ messages causes increase in processing time at each node, which ultimately cause increase in route discovery time of network. So decreasing number of RREQ messages cause decrease in processing time at each node and hence decrease in route discovery time. As GeoAODV is an enhancement of AODV, it also has less route discovery time than AODV, but more than DG-AODV, due to same reason described above.

From Fig. 8, it can be seen that DG-AODV has less route discovery time than AODV, because it generates 50 % less RREQ than AODV, but difference in route discovery time of GeoAODV and DG-AODV is small. This is due to RREQ message difference between DG-AODV and GeoAODV at 10 node is not high (i.e. 17 %) than difference of DG-AODV and AODV at same nodes. This difference in route discovery time of DG-AODV with other two techniques is decreasing as communication nodes are increasing, but still at 50 nodes DG-AODV has less route discovery time than GeoAODV, and AODV. At 50 node route discovery time of GeoAODV is just equal to discovery time of AODV. This is due to decrease in difference of RREQ messages between them.

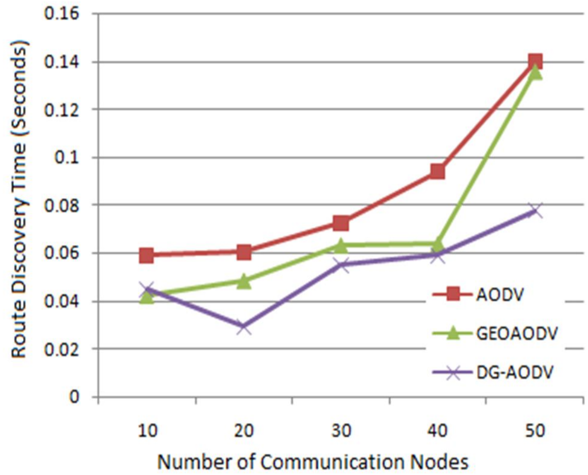

Fig. 8. Route Discovery Time (in seconds) for AODV, GeoAODV, DG-AODV

C. *Packet Delivery Ratio*

Fig. 9 show that DG-AODV has high packet delivery ratio (PDR). This ratio increases due to route discovery time, faster the node discover route for data transmission to destination, less will be chances for node to move another position. Change in position of node causes packet to be dropped because route from source to destination node can be broken due to change in position of any node in route. Hence, less number of RREQ messages cause small route discovery time, which increases PDR. This is the reason that PDR of DG-AODV is higher than PDR of AODV and GeoAODV.

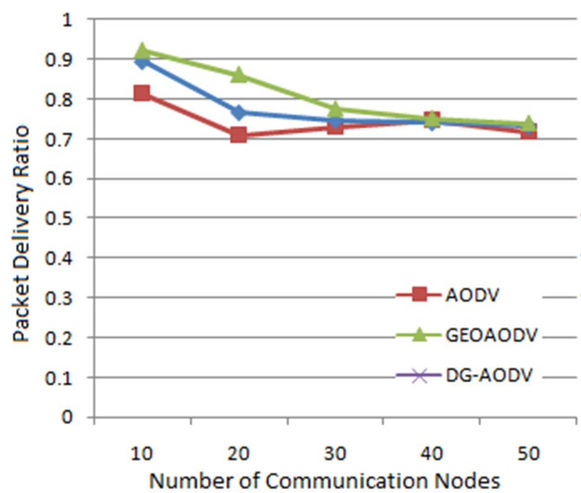

Fig. 9. Packet Delivery Ratio (PDR) for AODV, GeoAODV, DG-AODV

At first there is much difference between the values of PDR of DG-AODV and other two techniques (i.e. PDR value of DG-AODV is higher than both techniques).But this difference decreases as number of communication nodes are increasing. Because increase in number of communication nodes cause small difference in number of RREQ packets, which also decreases difference of route discovery time and hence in PDR of Distance technique come closer to PDR of AODV and GeoAODV.

V. Conclusions and Future Work

In this work, DG-AODV; an enhancement of GeoAODV has been proposed which uses additional procedures on intermediate nodes to reduce number of RREQ messages. Due to this reduction, performance of AODV has further been optimized. This can be evident from increase in value of packet delivery ratio and decrease in route discovery time and hence it provides a valuable enhancement in AODV. A detailed review of the obtained results is evident from the fig. 10 and fig. 11.

The bar chart in Fig. 10 reflects the results obtained for Packet Delivery Ratio and it clearly shows a significant improvement of DG-AODV over GeoAODV and AODV. Moreover, reduced amount of generated Route Request messages (RREQs) is evident from Fig. 11. For ten communication nodes, DG-AODV generates 49% less RREQ messages than AODV while 25% less RREQ messages are generated than GeoAODV. Similarly for twenty nodes, 52% reduction is observed when compared to original AODV while around 38% improved is estimated in comparison with GeoAODV. These statistics show that DG-AODV is quite an efficient technique in order to reduce the amount of unwanted RREQ messages which in turn improves the overall network performance. The algorithm proposed in this paper is more effective especially when the number of nodes is less than 30. In such scenarios, the improvement is more prominent. For example, in Fig. 11where the communication nodes are 10 or 20, DG-AODV generates around third of the route request messages for the similar network traffic. Moreover, Fig. 10 shows that PDR for DG-AODV is around 0.93 as compared to AODV (0.85) while for GeoAODV, PDR is 0.89.

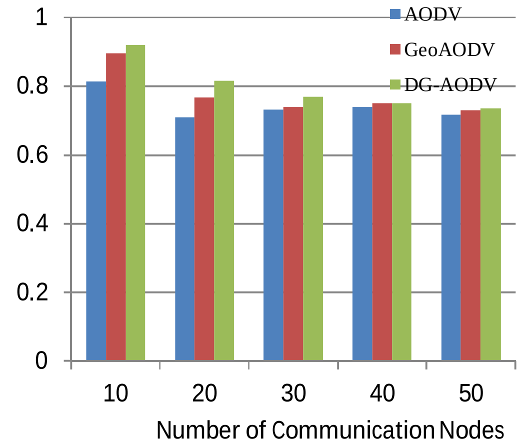

Fig. 10. Bar chart for Packet Delivery Ratio Comparison

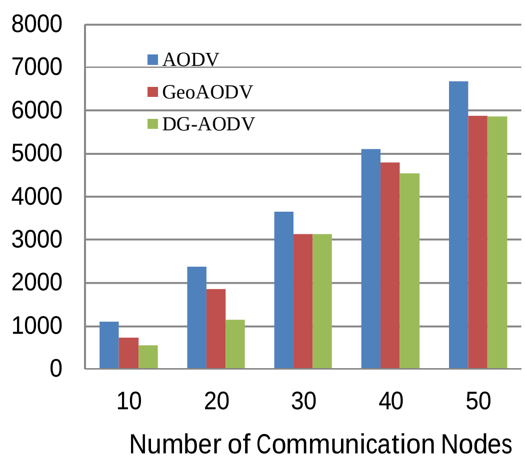

Fig. 11. Bar chart for Route Request Comparison

In the future, authors of this paper plan to extend this technique and make it more beneficial for larger networks along with focusing on the modification of processes at source node which generate RREQs in order to compute the expected location of destination nodes on the basis of its known location and mobility patterns. It may be accomplished by making the source node as a reference point and setting its coordinates to null momentarily and destination coordinates must be set in accordance with this new reference (i.e. subtracting actual source node coordinate from destination coordinates) ,if coordinates are known. Therefore, based on the distance between source and destination node and the expected direction of its mobility, quadrant of source node may be predicted. On the basis of quadrant information, the flooding angle will be set and hence there will be no need to further increase of flooding angle.

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REFERENCES

[1] C.E. Perkins, E.M. Royer and S.R.Das, “Performance comparison of two on-demand routing protocols for ad hoc networks,” *In Proc. of 19th annual joint conference of the ieee computer and communications societies*., 2000, pp. 3-12.

[2] M. Gupta, S. Kaushik. (May-June, 2012). ” Performance Comparison Study of AODV, OLSR and TORA Routing Protocols for MANETS,” *International Journal Of Computational Engineering Research* . Vol. 2(3), pp. 704-711.

[3] C.E. Perkins and P. Bhagwat, “Highly Dynamic Destination Sequenced Distance-Vector Routing (DSDV) for Mobile Computers,” *In SIGCOMM 94 Proc. of the conference on Communications architectures, protocols and applicationsComp*., New York., OCT 1994 , pp. 234–44.

[4] D. Johnson, D. Maltz, Y. Hu, and J. Jetcheva.(2001, mar). *The dynamic source routing protocol for mobile ad hoc networks*. Available : http://www.ietf.org/internet drafts/draft-ietf-manet-dsr-05.txt.

[5] C.E. Perkins and E.M. Royer, “Ad-Hoc On Demand Distance Vector Routing,” *Proc. of the 2nd IEEE Workshop on Mobile Computing Systems and Applications (WMCSA).*, New Orleans, LA, February 1999, pp. 90-100.

[6] M. Abolhasan, T. Wysocki and E. Dutkiewicz. (2004). “A review of routing protocols for mobile ad hoc networks".Available:http://www.sciencedirect.com/science/article/pii/S157087050300043X

[7] N. Javaid, M. Yousaf, A. Ahmad, A. Naveed and K. Djouani ,"Evaluating impact of mobility on wireless routing protocols," *Wireless Technology and Applications (ISWTA), 2011 IEEE Symposium on* .,Langkawi. 2011, pp. 84-89.

[8] V. Hnatyshin, R. Cocco, M. Ahmed and D. Urbano, "Dynamically Adjusting the Request Zone in GeoAODV Protocol," In Proc. of OPNETWORK 2012 International Conference, Washington, DC, August 2012.

[9] P. Johansson, T. Larsson, N. Hedman, B. Milczarek, and M. Degermark, “Routing protocols for mobile ad-hoc networks -a comparative performance analysis,” *In Proc. of the 1999 Mobile Computing Conference (MobiComm 1999)*, 1999.

[10] R. Cocco, V. Hnatyshin, M. Ahmed and D. Urbano, "Improving Geographical AODV Protocol by Dynamically Adjusting the Request Zone," *presented at 35th IEEE Sarnoff Symposium*, Newark, NJ, May 2012.

[11] J. Broch, D. Maltz, D. Johnson, Y. Hu, and J. Jetcheva. “A performance comparison of multi-hop wireless ad hoc network routing protocols”. *Proc. of the International Conference on Mobile Computing and Networking (MobiCom’98*), Oct. 1998.

[12] S.J. Lee, M. Gerla, and C.K. Toh.(jul,1999) . “A Simulation Study of Table Driven and On-Demand Routing Protocols for Mobile Ad Hoc Networks,”*IEEE Network*, pp.48-54.

[13] D.A. Maltz, J. Broch, J. Jetcheva, and D. B. Johnson.(Aug,1999). “The Effects of On-Demand Behavior in Routing Protocols for Multi-Hop Wireless Ad Hoc Networks,”. *IEEE Journal on Selected Areas in Communications, special issue on mobile and wireless network* .vol.17(8), pp.1439-1453.

[14] R.K.Chauhan , A. Dahiya .(Feb,2012).” AODV Extension using Ant Colony Optimization for Scalable Routing in VANETs ,” *Journal of Emerging Trends in Computing and Information Sciences ©2009-2012 CIS Journal*,. Vol.3(2).

[15] E. M. Royer and C. E. Perkins, "An Implementation Study of the AODV Routing Protocol," Proc. of the IEEE Wireless Communications and Networking Conference, Chicago, IL, Sept 2000.

[16] V. Hnatyshin and H. Asenov, "Design and Implementation of an OPNET model for simulating GeoAODV MANET routing protocol ," Proc. of the OPNETWORK 2010 International Conference, Session: Wireless Ad Hoc and Wireless Personal Area Networks, Washington DC, August 2010.

[17] OPNET Modeler ver. 16.0. OPNET Technologies, Inc®, www.opnet.com last visited 3/20/2013