ISSN No. 0976-5697

Volume 3, No. 1, Jan-Feb 2012

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

Robust Ant Based Routing Protocol for MANET

Srinivas Sethi*
Computer Science Engineering and Application
IGIT Sarang Odisha, India
igitsethi@gmail.com

Siba K. Udgata
Department of Computer & Information Sciences
University of Hyderabad Hyderabad, India
udgatacs@uohyd.ernet.in

Abstract: Routing is one of the challenging issues in mobile ad hoc network (MANET) where the routing problem deals with methods to transport a packet across a network from source node to destination node. In this paper, we focuses on improve packet delivery ratio (PDR), better End-to-End Delay and control the overhead using the third party route reply, self local route repair with Link Expire Time (LET). This is based on AODV and inspired by the ant-colony optimization (ACO) used to solve complex optimization problems and utilizes a collection of mobile agents as “ants” to perform optimal routing activities.

Keywords: MANET; Routing Protocol; Antnet; ACO; Ant;

I. INTRODUCTION

MANET is an infrastructure less wireless communication network of a set of mobile nodes, placed together in an ad hoc manner with the limited resources like bandwidth, processing power, limited battery power etc. Due to its dynamic nature, a primary challenge of MANET is to design of effective routing algorithm that can adapt its behavior to frequent and rapid changes in the ad hoc network. Proactive, reactive and hybrid routing protocols are three different types of routing protocols can be used for MANET [1].

Ant Colony Optimization (ACO)[2][3] is an example of Swarm Intelligence (SI) based on the study of ant colony behavior, which can be applied to a wide range of different optimization problems. This protocol gathers routing information through the repetitive sampling of possible paths using artificial ant packets. The communications between ants are indirect in which they sense and follow a chemical substance called pheromone. Ants follow only the trail which exudes the strongest scent indicating the best-possible route from the colony’s nest to the food source [4].

Based on the local information in the network, it deposits a substantial amount of pheromones on the trail and this information implicitly ranks the path it has traversed. A route with higher pheromone concentration indicates a route of better quality. The ant-based solutions for wireless ad hoc routing are more appealing as they easily fit into the dynamic nature of MANET. It provides adaptivity, robustness and even efficiency which are prime requisites in such dynamic environment.

We investigate the issue of adaptive routing in MANET and combines ideas from ACO routing with techniques from dynamic programming, third party route reply, self local route repair with LET and reactive properties of AODV in Ant-R routing protocol.

The rest of the paper is organized as; section II discusses related works. Section III describes the new proposed routing protocol. Simulation environment is discussed in section IV followed by performance evaluation parameters in section V. Section VI discusses results of routing protocol followed by conclusions in section VII.

II. RELATED WORKS

Network topology information can be collected and updated in a distributed and autonomous way via the local interaction among ant-like agents. The authors in [5] study analysis of various SI inspired routing algorithms for MANETs.

AntNet [6] is a meta-heuristic ant based routing protocol in which, forward ants and backward ants are used as route request and route reply respectively. At regular intervals, forward ants are launched towards randomly selected destination and the backward ants are generated after the forward ants reach at the destination point. Then it utilizes useful information gathered by the forward ants. The backward ants use the route information from the forward ant and update the pheromone values in the node’s routing tables. The amount of pheromones deposit is depending on the trip time of the forward ants. The main disadvantage of AntNet is very slow in terms of end-to-end delay and the performance of AntNet routing degrades as network size or link density is increased [7]. It is robust to changes in the topology of network and convergence to a good solution as well. “Modified-AntNet”[8], is extension of AntNet in which information exchange with neighboring nodes is facilitated by helping ants.

AntHocNet [9] is a meta-heuristic ant based hybrid routing protocol for MANET, which is designed on the Ant Colony Optimization (ACO) framework with proactive and reactive approach. In a reactive path setup phase, multiple paths are set up between the source and destination of a data session. Ants proactively test existing paths and explore new ones during the course of the communication session.

ARA [10] is an ant based routing protocol on AntNet and routes are maintained primarily by data packets as they flow through the network. The path to the destination is reinforced by increasing the pheromone value in the routing table and this brings higher benefit as flooding of periodic ants is being reduced. ARA implements a pheromone decay

© 2010, IJARCS All Rights Reserved

mechanism where its value in the routing table decreases over time. An attempt is made to send the packet over an alternate route in case of a route failure; otherwise, it is returned to the previous hop expecting that there exists an alternate route in the network. As data packets increase, the pheromone of a routing path increases and at the same time the pheromones of other alternate routes evaporate, making the whole data traffic network will quickly converge to a particular route. ARA has no updating mechanism to adapt the changes in a dynamic network such as MANET.

AODV[11] [12] is an reactive, destination based loop free routing protocol in which, table driven routing framework and destination sequence numbers are used. When an active link becomes break down, AODV initiates a new route discovery process which incurs additional delay and network flooding.

In this paper, we used and implemented the third party route reply [13], self repair[14] time to live (TTL) [15] based local route repair [16] with Life Expire Time (LET) [17] concept to improve the performance of proposed routing protocol in terms of Overhead, end-to-end delay and packet delivery ratio (PDR). AODV is used to compares with proposed routing protocol Ant-R.

III. DESCRIBSTION OF PROPOSED PROTOCOL

A. Background:

The proposed routing protocol is based on meta-heuristic swarm intelligence whose working principle is inspired by social insect behavior. It is a purely on-demand or reactive routing scheme and it sends update ants only to existing active destinations. Further it uses the third party route reply in route discovery to make the scalable, local route repair with LET and third party route reply in route maintenance for efficient robust and optimize of proposed routing protocol.

Source and destination are treated as first and second party respectively; whereas, intermediate node can be treated as third party. There is no need to forward the message to continue traveling in search for the destination if the intermediate nodes have information of destination. Any visited intermediate node that have a route in its routing table to the same destination can generate a route reply. As a result the performance of proposed routing protocol is improved in terms of different performance evaluation parameters like PDR, end-to-end delay and overhead.

LET determines the link expire time between the sender and itself. So, the node decides the link between them is about to break. If so, it initiates a route repair procedure for every affected destination. This procedure is to find a new sub-path towards the destination avoiding that link besides any other unstable links.

The local repair of link breaks in active route increase scalability efficiency of routing protocol. For short route local repair may not have any significant performance advantages, but for large network with longer routes it is likely that link break will occur so frequently that it is difficult to keep up with all the necessary repairs for the source node. If the broken link is closer to the destination node than source node, attempt a local repair; otherwise, bring down the route.

Based on self repair it improved by adopting intermediate nodes instead of the source to repair a route to destination. If data is flowing and a link break is detected by the intermediate node it does not send a route error (RERR) to the source. It sends a Route Repair (RR) message back to the pre-hop node. After sending RR message to pre-hope node, it tends to broadcast route request (RREQ) to repair the break route. If node cannot repair the route within TTL, it sends back a Route Repair Fail (RRF) message to pre-hop node and at the same time the node sends the data packets, which store in the cache, back to pre-hop node. Otherwise, the node repairs the route in time; it sends back a Route Repair OK (RROK) message to pre-hop node which has received a RR message.

B. Protocol Design:

Now we discuss the adaptation of the ant colony optimization meta-heuristic for MANET and describe the Ant-R. Two different packets like data packets and control packets are used in network. In ant routing, data packets use the information stored at routing tables for traveling from the source to the destination node. Two different control packets like forward ant (FANT) and a backward ant (BANT) are used to update the routing tables and distribute information about the traffic load in the network. Apart from the above, the neighbor control packets are used to maintain a list of available nodes to which packets can be forwarded. The HELLO messages from each node are broadcasted periodically to all its neighbors to check if the ant has arrived or not. The time when the ant has been generated is called Birth-Time and Arrival-Time at the final destination is used to calculate the trip time.

In the route discovery phase FANT and BANT are used to create a new routes. A FANT is used to establish the pheromone track to the source node and gathers information about the state of network. In contrast, a BANT is used to establish the pheromone track to the destination node and it uses the collected information to adapt the routing tables on their path as well. Nodes are able to distinguish duplicate packets on the basis of the sequence number and the source address of the FANT as well. The source node would initiate a route discovery mechanism when a path to destination needs to be established. It would disseminate FANT to all its one-hop neighbors.

A node creates a record in its routing table with destination address, next hop address, and pheromone value after receiving a FANT for the first time. The node interprets the source address of the FANT as destination address of BANT. The address of the previous node treated as the next hop. It computes the pheromone value depending on the number of hops the FANT needs to reach the node. If the node is not destination then check the route table and it tries to locate the route to destination. This is implementation of third party route reply. It sends the reply by creating BANT if it locates the route to the destination node. The destination node extracts the information of the FANT when the FANT reaches the destination node, and then destroys it. Subsequently, it creates a BANT and sends it to the source node. The path is established when the sender receives the BANT from the destination node and data packets can be sent. Ant-R ensures

© 2010, IJARCS All Rights Reserved

that routing paths are free from loops, and does not require extra overhead.

Subsequent data packets are used to maintain the path once the FANT and BANT have established the pheromone tracks for the source and destination nodes. When a node relays a data packet toward the destination node, it increases the pheromone value of the entry to strengthen the route to the destinations by the data packets and the evaporation process of the pheromone values is performed as no data packet are relay towards the destination node.

Another important concern is a handling the failure of the route which is mainly due to dynamic nature of MANET by node mobility. Ant-R recognizes route failures through a link expire time (LET) of nodes in the network. The LET can be calculated when receiving a HELLO message from one node to another node. So, the node decides the link is about to break and initiates the route repair process. This procedure is initiated before link break. The node searches for an alternative link through TTL based self local route repair using LET. The TTL value is used so that only the most recent whereabouts of the destination will be searched. It sends the packet via this alternate path, if the alternate path is established. If the packet does not reach the destination, the source has to initiate a new route discovery phase. By using LET and self local repair it avoid the link break from source to destination. It also controls the overhead by using self local repair.

IV. SIMULATION ENVIORNMENT

We use Network Simulator 2 (NS2) [18] under linux platform for exhaustive simulation using the parameters as per Table-1 for different mobility rate and number of nodes of AODV and Ant-R. The nodes mobility speed is varied as per Table-1 and according to the random waypoint mobility model. The mobility model of node describes the movement pattern of mobile nodes and each node is responsible for computing its own position and velocity. Constant Bit Rate (CBT) is used to transfer data packets.

Table-1. Parameter values of AODV and Ant-R for simulation

S.No	Parameters	Values
1	Area size	500x500 m
2	Transmission range	250 m.
3	Number of Nodes	50, 100, 150, 200,250, 300 Nos.
4	Simulation time	900 s.
5	Nodes Mobility	1,5,10,15,20 m/s
6	Pause times	10 s.
7	Data rate	1 Kbps.
8	No. of experiments	5 times.

V. PERFORMANCE EVALUATION PARAMETERS

The packet delivery ratio (PDR), overhead, (end-to-end) delay, which are the standard parameters used for evaluating the performance of routing protocols are chosen and compare with existing routing protocol AODV. These three performance metrics are the most common benchmark to measure the overall performance of the network routing protocol. These are defined and discussed in the followings:

The packet delivery ratio is defined as the percentage of the ratio between the number of packets sent by constant bit rate sources and the number of received packets by the sink or destination. It describes average percentage of the data packets which reach at the destination. This performance evaluation parameter measures the delivery reliability, efficiency and the throughput of the protocol.

$$PDR = \frac{\sum \text{Number of packets delivered at destination}}{\sum \text{number of sent packets at sources}} * 100$$

Average End-to-end Delay is the average overall delay for a packet to traverse from a source to a destination. This is important as today many applications like IP telephony need a small latency to deliver usable results.

Overhead is the number of routing packets transmitted for delivered the data packets. For packets transmitted over multiple hops, each transmission over one hop, counts as one transmission and we can also estimate how many transmitted routing messages are used. Sending more routing packets increases the probability of packet collision and can delay data packets in the queues.

In this paper exhaustive simulation experiments are carried out at different mobility rates, Network density in terms of number of nodes for comparison among Ant-R with AODV.

VI. RESULT AND DISCUSSION

In this paper, we are trying to make the protocol more robust by using third party route reply and self local route repair with LET. At the same time we are also trying to improve the PDR which denotes the efficiency, reliability and effectiveness of proposed routing protocol.

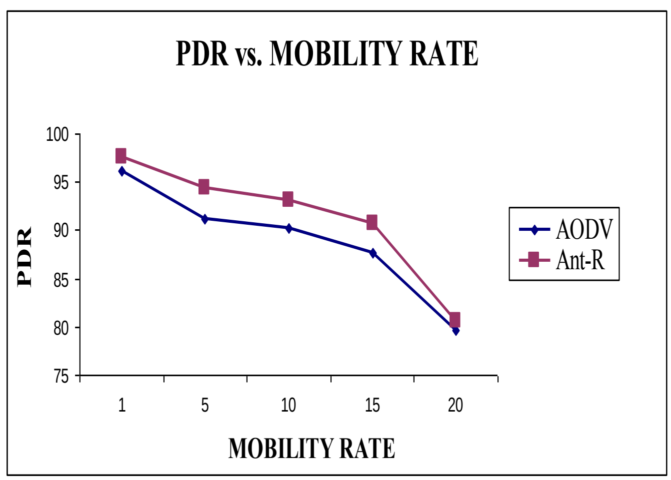

Fig.-1: PDR vs. Mobility Rate at 50 nodes

© 2010, IJARCS All Rights Reserved

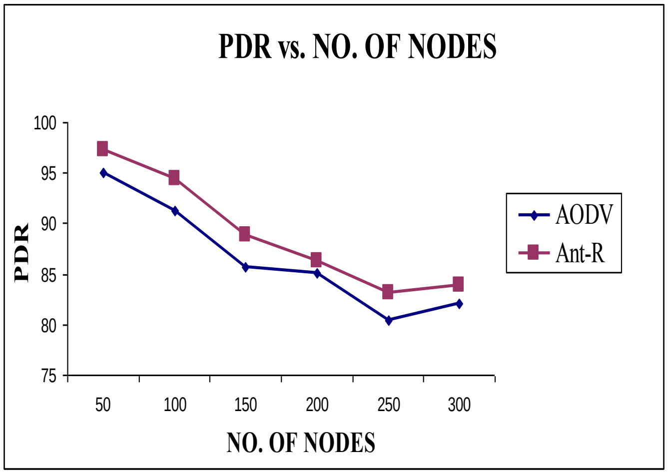

Fig.-2: PDR vs. No. of Nodes at 5 m/s

Fig.-1 shows, the PDR of Ant-R is more than other AODV in respect all mobility rate. Similarly from Fig.-2 it is observed that PDR of Ant-R is more than AODV in the network in respect to various node sizes. It shows improved reliability, effectiveness and efficiency of Ant-R in comparison to AODV.

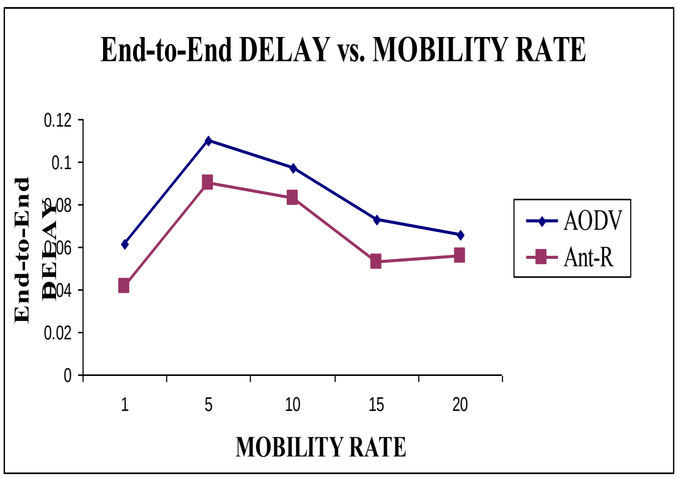

Fig.-3: End-to-End Delay vs. Mobility Rate at 50 nodes

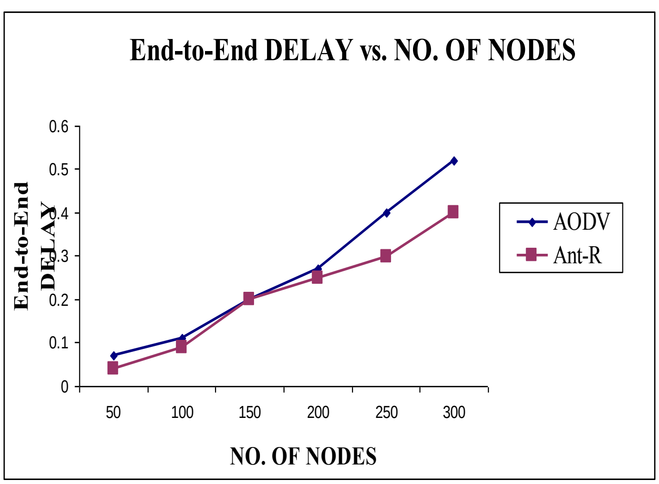

Fig.-4: End-to-End Delay vs. No. of Nodes at 5 m/s

In real time application, End-to-End Delay is one of the important parameter to measure performance of proposed routing protocol. So, from Fig.-3; it is observed that, End-to-End Delay for Ant-R is less than AODV for all mobility rates. Similarly End-to-End Delay for Ant-R is less than AODV for various node sizes as Fig.-4.

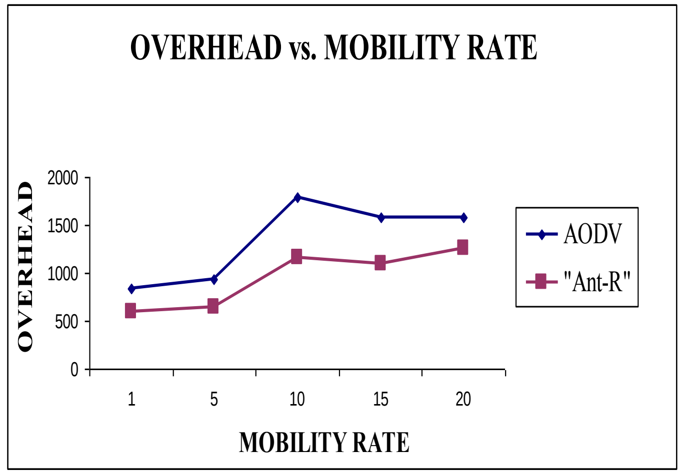

Fig.5: Overhead vs. Mobility Rate at 50 nodes

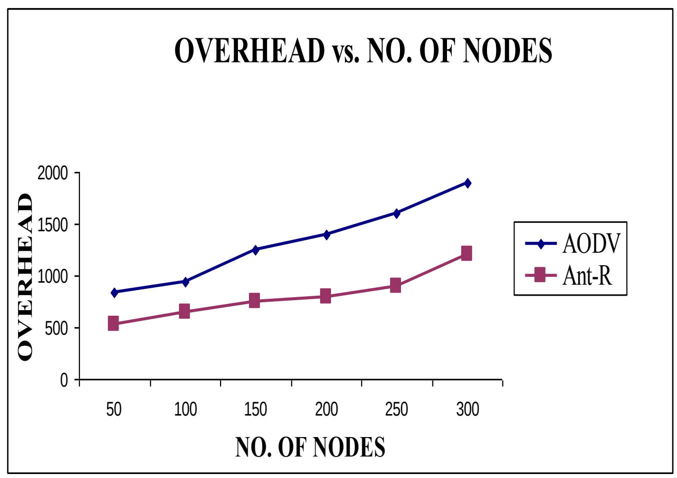

Fig.6: Overhead vs. No. of Nodes at 5 m/s

The overhead of Ant-R is controlled by using third party route reply and local repair in the network. From Fig.-5, it is observed that the total overhead of proposed Ant-R is better than AODV for various mobility rates. Fig.-6, shows the total overhead of proposed routing protocol Ant-R is better than AODV for various node sizes.

From the above results, it is observed that, the performance of Ant-R is better than AODV for all possible combination of mobility rates and node sizes. This shows that the proposed routing protocol Ant-R outperforms on AODV.

VII. CONCLUSION

In this paper, a new ant based routing protocol for MANET environment is proposed. The proposed algorithm improves

© 2010, IJARCS All Rights Reserved

the efficiency, effectiveness and reliability; particularly it is more robust. The efficiency of proposed routing protocol Ant-R is shown to better than AODV. The proposed routing protocol uses third party route reply and self local route repair with LET along with principles of ant colony to improve the performance of proposed routing protocol. It is enabled optimal path routing, fast route discovery and robust route maintenance with better PDR, overhead and end-to-end delay.

VIII. REFERENCES

[1] M. Abolhasan T. Wysocki, and E. Dutkiewicz "A Review of Routing Protocol for Mobile Ad hoc Networks", Elsevier Ad Hoc Nwtworks Journal, Vol. 2, No.1, pp. 1-22, January 2004

[2] .Dorigo M., & Gambardella, L.M., "Ant colony system: a cooperative learning approach to the traveling salesman problem". IEEE Transactions on Evolutionary Computation, 1(1), 53-66.,1997

[3] Flynn, J. "British Telecom: Notes from the Ant Colony". Business Week, p. B27. ,1997

[4] Beckers, R. Deneubourg, J.L., & Goss, S. "Trails and U-turns in the selection shortest path by the ant. ", Journal of Theoretical Biology", 159, 397-415,1992

[5] Jin Wang and Sungyoung Lee, "A Performance Comparison of Swarm Intelligence Inspired Routing Algorithms for MANETs", ICCSA 2009, Part II, LNCS 5593, 2009, pp. 432–442.

[6] Caro, G.D. & Dorigo, M. "Ant Colonies for Adaptive Routing in Packet-Switche Communications Networks", Paper presented at the Proceedings 5 Parallel Problem Solving from Nature, Amsterdam. , 1998.

[7] S.S. Dhillon, P. Van Mieghem, "Performance Analysis of the AntNet Algorithm", International Journal of Computer Networks, Elsevier, pp: 2104-2125, 2007

[8] Azadeh Soltani, M.R. Akbarzadeh-T, M. Naghibzadeh, "Helping ants for adaptive network routing", Journal of the Franklin Institute, Elsevier, pp:389-403,2006

[9] Gianni Di Caro_, Frederick Ducatelle, Luca Maria Gambardella. "AntHocNet: An Ant-Based Hybrid Routing Protocol for Mobile Ad Hoc Networks", Springer-Verlag Berlin Heidelberg 2004, PPSN VIII, LNCS 3242, pp. 461–470.(2004).

[10] Gunes, M., Sorges, U. & Buouazizi, I. "ARA-The Ant-Colony Based Routing Algorithm for MANETs.", Paper presented at the meeting of the International Workshop on Ad Hoc Networking (IWAHN), Vancouver, Canada, 2002

[11] C.E. Perkins and E.M. Royer, "Ad-Hoc On-Demand Distance Vector Routing", Proc. Workshop Mobile Computing Systems and Applications (WMCSA '99), Feb. 1999. pp. 197-211, Apr. 1997.

[12] C.E. Perkins, E.M. Belding-Royer, and I.D. Chakeres, "Ad Hoc On Demand Distance Vector (AODV) Routing", IETF Internet draft, Oct. 2003.

http://www.ietf.org/internet-drafts/draft-ietf-manet-aodv13.txt

[13] David Gan Chye Ong, "Ant Intelligence Routing Algorithm for Mobile Ad Hoc Networks", Ph. D thesis of Malaysia University of Science and Technology, 2004.

http://library.must.edu.my/v3/Catalog-Databases/MUSTTheses/2004/MIT/PDF/DavidGanChyeOng.pdf

[14] Jing Feng, Huaibei Zhou, "A Self-Repair Algorithm for Ad Hoc On-Demand Distance Vector Routing", IEEE

[15] Ziping Liu and Bidyut Gupta, "A Modified Shared-tree Multicast Routing Protocol in Ad Hoc Network", Journal of Computing and Information Technology (CIT), Vol. 13, No. 3, 2005, pp. 177–193.

[16] Sung-Ju Lee, Elizabeth M. Belding-Royer, and Charles E. Perkins, "Scalability Study of the Ad hoc On-Demand Distance Vector Routing Protocol", International Journal of Network Management, Volume 13 , Issue 2 (March/April 2003), pp:97 - 114

[17] W. Su, S. Lee, and M. Gerla, "Mobility predjction and routing in ad hoc wireless networks", Internntionul Journal of Network Management, Wilq& Sons, 2000.

[18] NS-2 Manual, 2009.

http://www.isi.edu/nsnam/ns/nsdocumentation.htm

© 2010, IJARCS All Rights Reserved