Energy Aware Reliable Routing Protocol (EARRP) for Mobile Ad Hoc Networks Using Bee Foraging Behavior and Ant Colony Optimization

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Abstract

Energy aware reliable routing in mobile ad hoc networks is an astonishing task and in this paper we propose to design, develop such protocol which will be a good solution. For developing such protocol EARRP, two swarm intelligence techniques are involved namely ant colony optimization and bee colony foraging behavior. For optimization, we proposed adaptive solutions in order to estimate MAC overhead, link eminence and residual energy. After estimating the above said metrics, the fitness function is derived out. The performance metrics taken are overhead, delay, packet delivery ratio and total energy consumed by nodes. By simulation results the proposed EARRP outperforms AODV by reducing energy consumption, overhead and delay. Also EARRP gains better packet delivery ratio than that of AODV.

Keywords: ACO, Bee Foraging, Routing in MANET, Energy

1. Introduction

Wireless mobile ad hoc network is a distinct kind of network which has minimum or nullified backbone infrastructure. The characters such as flexibility and quickly deplorability of mobile ad hoc networks are due to this aspect. Yet, this property possesses major technological challenges which include issues of efficient routing, medium access, power management, security and quality of service (QoS). The nodes correspond over wireless links and so the nodes must be able to fight against the unpredictable character of wireless channels and interference from the additional transmitting nodes. Though the user required QoS in wireless ad hoc networks is achieved, these factors lead to a challenging problem in the direction of data throughput.

Either a direct link or a multi-hop route is used for the communication between source nodes and destination nodes. For this, it is necessary that all nodes should have some fundamental routing potential to make sure that packets are delivered to their relevant destinations. While implementing ad hoc networks, huge complications occur due to the frequent route changes, which is due to the mobility of the nodes and intrusion between nodes. Unequal transport layer and constrained amount of traffic is due to the high packet loss rates and recurrent topological changes in the network. The three well-known problems in ad hoc networks are the lack of reliable packet delivery due to the intrusion and movement of nodes, incomplete bandwidth due to the channel limitations and constrained node life span caused as a result of small battery size.

2. Related Works

Over the last few years, several routing protocols are proposed for mobile ad hoc networks [1]-[7], [12], [13]. A number of performance comparison studies [8]-[11] have revealed that the on-demand routing protocols perform better in terms of packet delivery and routing overhead than proactive routing schemes especially in the presence of node mobility. Proactive and hybrid schemes do not perform well in dynamic topologies because of the following two major factors: Slow detection of broken links and periodic exchange of route updates even when routes are not needed.

Wesam AlMobaideen [14] has presented a Stability-based Partially Disjoint AOMDV (SPDA) protocol which is a modification of the AOMDV protocol. His SPDA finds partially disjoint paths based on links stability. His idea is that accepting partially disjointed paths that are more stable than other maximally disjoint ones could increase paths lifetime. This in turn improves MANET performance in terms of delay, routing packets overhead, and the network throughput.

Kambiz Homayounfar [15] has described an algorithm that helps MANET routing in two ways. First, it provides a metric that by its nature warns of the possibility that links can break. This metric, which can be considered a link stability index, accumulates at each node to form a path stability index. Therefore, his algorithm enables intermediate nodes to balance stability of the route with end- to-end delay. His principle is that intermediate nodes must wait before they re-broadcast a request they just picked up from a neighbor. This waiting mechanism has, in turn, two advantages. First, in case a better link comes along, there is no need for re-broadcast. This reduces overhead of redundant broadcasts. Second, by using a simple waiting mechanism that depends on link stability, end-to-end delay reduces.

3. EARRP

EARRP is an on-demand unipath routing protocol. The proposed EARRP utilizes several unique characteristic feature of foraging behavior of bee colony optimization and establishes the link using ant colony optimization. Similar to the behavior of bees, EARRP uses an unusual bee packet which is send to the neighboring nodes within the transmission range from the sending node. The unusual bee packet gathers the vital data’s about the nearby neighboring nodes. Like the ant colony optimization, the pheromone trail is left when the forwarding ant moves towards the food source. Similar to the behavior of ants in real, the proposed EARRP triggers reliable node selection mechanism, which establishes the link (pheromone). In our proposed EARRP, the route request packets (RREQ) are assessed to be the forwarding ant agents (FAA). The FAA will find the reliable node and establishes the pheromone (link). The following ants (FA) are the data packets which follow the same path towards the destination. Due to the change in the network topology is considered as an obstacle which due to the mobility of the nodes, the FAA using the reliable node selection mechanism and start communicating the packets through the reliable node. After the link establishment the source node sends a command to put the neighboring nodes switch to sleep state, hence node remaining energy of such nodes will expand.

3.1 MAC Overhead Estimation

In mobile ad-hoc network, we consider IEEE 802.11 MAC with the distributed coordination function (DCF). It has the packet sequence as request-to-send (RTS), clear-to-send (CTS), and data, acknowledge (ACK). The amount of time between the receipt of one packet and the transmission of the next is called a short inter frame space (SIFS). Then the channel work due to MAC contention will be

$$Cw = tRTS + tCTS + 3tSIFS \qquad (1)$$

Where tRTS and tCTS are the time taken for RTS and CTS, respectively and tSIFS is the SIFS period. The MAC overhead MO can be represented as

$$MO = Cw + tac \qquad (2)$$

Where tac is the time taken due to access contention. The amount of MAC overhead is mainly dependent on two factors. They are medium access contention, and the number of packet collisions.

3.2 Eminence of Link Estimation

The eminence of link while doing optimization will be computed at the physical layer, which is used and accessed at the top layers for routing. This section describes about the estimation of eminence of link for the neighboring nodes. In the physical layer the measured link eminence value is reassigned towards the MAC layer. Along with, this value is stored in the routing/neighbor tables and is used for optimization when more than one node is inside the transmission range of the sending node. The link eminence is being used in order to benefit up the performance of the mobile ad hoc networks by optimizing routing decisions.

The IEEE 802.11 is fairly reliable MAC protocol. The link eminence has reached every exposed node; it assumes the fixed utmost transmission power. When a sending node transmits Request – To – Send (RTS) packet, it attaches its transmissions power. The receiving node measures the link eminence received for the free–space propagation model while receiving the RTS packet.

$$LE = (\lambda / 3.14 * [4 * Dist_{sr}]) * T_g * T_r \qquad (3)$$

Where λ is the wavelength of carrier, Distsr is distance between the sender node and the receiver node, Tg and Tr are unity gain of transmitting and receiving omni directional antennas, respectively.

3.3 Residual energy estimation

It is to be assumed that all nodes present in mobile ad-hoc network are equipped with a residual energy detection device and know their physical node location. The packet transmitting energy for a packet can be computed as

$$Energy_{tx} = \frac{DPsize \times PTE}{Bw} \qquad (4)$$

where $DPsize$ is the data packet size PTE is the packet transmitting power and Bw is the wireless link bandwidth. When a mobile node performs power control during packet transmission, the transmitting energy for one packet relative to the node distance is given as

$$PTE = c * dst^{\alpha} \tag{5}$$

Where k is the proportionality constant, dst is the distance between the two neighboring nodes, and α is a parameter that depends on the physical environment (generally between 2 and 4). The shorter distance between the transmitter and the receiver, the smaller amount of energy required. At each node, the total energy required is given by

$$TER = pkts \times (PTE + PPE) \tag{6}$$

where $pkts$ is the number of packets. The energy required for packet processing (PPE) is much smaller than that required for packet transmitting. The node remaining energy or the residual energy is the energy left after the packet transmission (i.e.) residual energy RE is given by

$$RE = IE - TER \tag{7}$$

Where RE is the residual energy, IE is the initial energy and TER is the total energy required.

3.4 Fitness function for ant colony optimization

The reliable node selection mechanism uses three estimated parameters using the equation (2), (3) & (7). They are MAC overhead, link eminence and residual energy. Only after estimating the aforesaid parameters the ant colony optimization finds reliable node which will be carried out using,

$$\mathrm{FF} = \min\left(\int_{i=1}^{i=nn} \mathrm{LE} * \left(1 / \mathrm{MO}\right) + \mathrm{RE} \right) \tag{8}$$

The node with the minimum weight value is selected and the pheromone (link) is established.

4. Simulation Model and Parameters

We use NS2 to simulate our proposed protocol in our simulation; the channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, 50 to 200 mobile nodes move in a 1000 meter x 1000 meter rectangular region for 100 seconds simulation time. We assume each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In our simulation, the speed is set as 5m/s. The simulated traffic is Constant Bit Rate (CBR).

The simulation settings and parameters are described in table 1.

Table1. Simulation settings and parameters

No. of Nodes	50, 75, 100, 125, and 150
Area Size	1000 X 1000 meters
MAC	802.11b
Radio Range	250 meters
Simulation Time	100 seconds
Traffic Source	CBR
Packet Size	512 KB
Mobility Model	Random Waypoint Model
Speed	5 m/s
Initial Energy	0.5 Joules

Performance metrics

Overhead, delivery ratio, delay and total energy consumption of nodes.

Result graphs

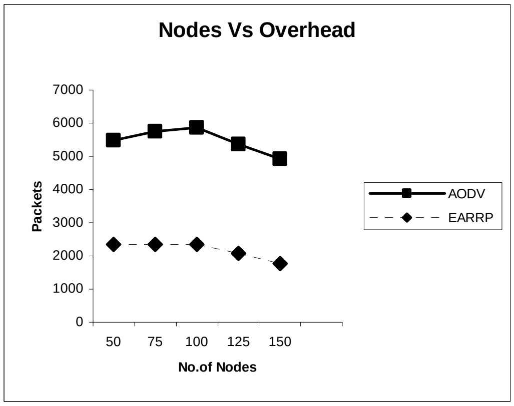

Fig.1 Number of Nodes Vs Overhead Packets

From the figure 1 it is clearly shown that the number of overhead packets is reduced in EARRP than AODV.

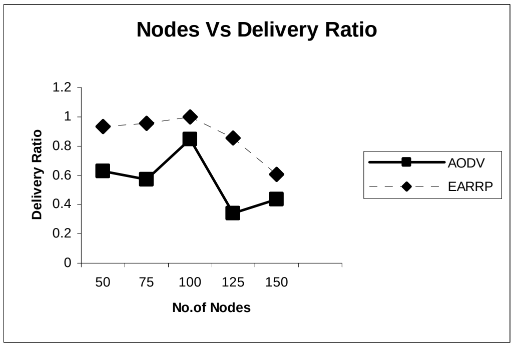

Fig. 2 Number of Nodes Vs Packet Delivery Ratio

From the figure 2 it is observed that the delivery ratio of packets is increased in EARRP than AODV.

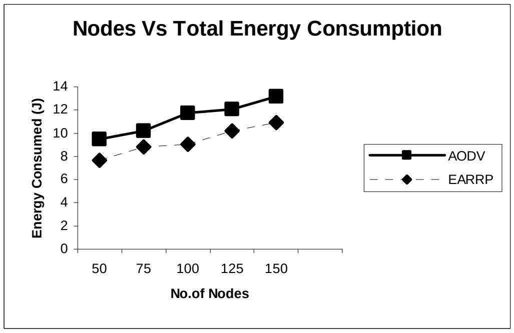

Fig.3 Number of Nodes Vs Total Energy Consumption of Nodes (J)

From the figure 3 , it is shown that the overall energy consumption of the nodes present in the ad hoc network is reduced in EARRP than AODV.

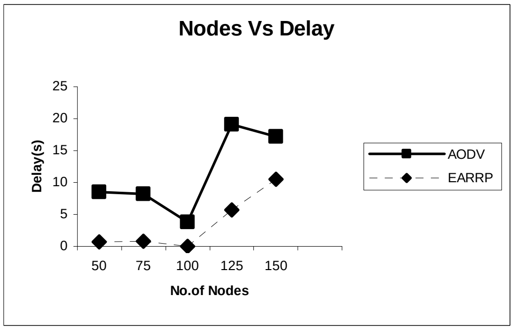

Fig.4 Number of Nodes Vs Delay (Sec)

From the figure 4, it is proved that the delay is reduced in EARRP than AODV.

5. Conclusions

This paper presented an energy aware reliable routing protocol for mobile ad-hoc networks. The proposed EARRP attains better delivery ratio. Also it reduces delay, overhead packets and energy consumption.

References

[1] Charles E.Perkins and Elizabeth M. Royer, "Ad-hoc On-Demand Distance Vector Routing", in proceedings of 2nd IEEE Workshop on Mobile Computing Systems and Applications, pp: 90- 100, 25- 29 Feb, New Orleans, LA, USA, 1999, Doi: 10.1109/MCSA.1999.749281.

[2] David B. Johnson and David A. Maltz, "Dynamic Source Routing in Ad Hoc Wireless Networks", in proceedings of International Series in Engineering and Computer Science, vol. 353, pp: 153- 181, 1996.

[3] Xiaobing Hou and David Tipper, "Impact of Failures on Routing in Mobile Ad Hoc Networks Using DSR", in proc. of IEEE Journal on Selected Areas in Communications, vol. 8, no. 9, pp. 1696-1708, Dec. 1990.

[4] Hossam Hassanein and Audrey Zhou, "Routing with Load Balancing in Wireless Ad hoc Networks", in proc. of 4th ACM International Workshop on Modeling, Analysis and Simulation of Wireless and Mobile Systems, pp: 89- 96, Rome, Italy, 2001.

[5] Ihab El Kabary, Amal Elnahas and Said Ghoniemy, "Weighted Critical Path Routing Protocol for Mobile Ad Hoc Networks", in proc. of International Conference on Wireless Information Networks and Systems, Portugal, 2006.

[6] Lei Chen and Wendi B. Heinzelman, "QoS-Aware Routing Based on Bandwidth Estimation for Mobile Ad Hoc Networks", in proceedings of IEEE Journal on Selected Areas in Communications, vol. 23, no. 3, March 2005.

[7] Kaixin Xu, Ken Tang, Rajive Bagrodia, Mario Gerla and Michael Bereschinsky, "Adaptive Bandwidth Management and QoS Provisioning in Large Scale Ad Hoc Networks", in proceedings of IEEE Conference on Military Communications, vol. 2, pp: 1018- 1023, 13- 16 October 2003, Doi: 10.1109/MILCOM.2003.1290305.

[8] Michael Gerharz, Christian de Waal and Matthias Frank and Paul James, "A Practical View on Quality-of-Service Support in Wireless Ad Hoc Networks", in Proc. of the 3rd IEEE Workshop on Applications and Services in Wireless Networks (ASWN), pp: 185-196, Berne, Switzerland, July 2003.

[9] Geetha Jayakumar and Gopinath Ganapathy, "Performance Comparison of Mobile Ad-hoc Network Routing Protocol", in proc. of International Journal on Computer Science and Network Security, vol. 7, no. 11, Nov. 2007.

[10] E. Ahvar and M. Fathy, "Performance Evaluation of Routing Protocols for High Density Ad Hoc Networks based on Energy Consumption by GlomoSim Simulator", in proceedings of World Academy on Science, Engineering and Technology, vol. 23, August 2007.

[11] Changling Liu and Jorg Kaiser, "A Survey of Mobile Ad Hoc network Routing Protocols", Technical Report, University of Magdeburg, October 2005

[12] Duc A. Tran and Harish Raghavendra, "Congestion Adaptive Routing in Mobile Ad Hoc Networks", IEEE

Transactions on Parallel and Distributed Systems, vol. 17, no. 11, November 2006.

[13] Jianbo Xue, Patrick Stuedi and Gustavo Alonso, "ASAP: An Adaptive QoS Protocol for Mobile Ad Hoc Networks", 14th IEEE proceedings on Personal, Indoor and Mobile Radio Communications, vol. 3, pp: 2616- 2620, 7-10 September 2003, Doi: 10.1109/PIMRC. 2003.1259201.

[14] Wesam AlMobaideen, “SPDA: Stability Based Partially Disjoint AOMDV”, European Journal of Scientific Research ISSN 1450-216X Vol.27 No.3 (2009), pp.342-348, 2009.

[15] Kambiz Homayounfar, “Cross-Layer MANET Routing Algorithm Based on Radio Link Stability”, Workshop on Mobile Communications, IEICE Tech. Rep, Vol.108, no. 447, AN2008-64, pp. 1-6, March 2009.

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