Optimizing Cost Matrix to Enhance the Network Metrics of WSN using Ant Colony Optimization Approach

Sandeep Kaur(student)
Electronics department
Guru Nanak Dev University
Amritsar, India

Ravinder Singh Sawhney(Sr. lecturer)
Electronics department
Guru Nanak Dev University
Amritsar, India

***Abstract*— in this research work, we followed a meta-heuristic technique to conserve the battery life of a cluster of nodes being used in a WSN. In wireless sensor networks, all the nodes need not to be powered all the time and each node has a limited battery life. Hence the conservation of battery life is a vital issue. The proposed solution is based on Ant Colony Optimization (ACO)-a meta-heuristic approach by calculating the cost value using MATLAB version R2011b due to the ease of implementation of node deployment and network setup in it. Simulation was completed by varying the value of W1, W2 and W3.According to the condition W1+W2+W3=1.The maximum value that can be assigned is 0.8 is only assigned to W1 parameter for the battery life and minimum value assigned to any parameter is 0.1. The cost value is mapped with metrics packet delivery ratio, end to end delay, normalized routing load and drop ratio.**

Keywords- MANET; cost value; packet delivery ratio; End-to-end delay; normalized routing load; drop ratio.

I. Introduction

Due the latest developments in field of MANETs researchers focus has shifted towards designing the energy efficient MANETs. The reasons are that devices in MANETs are typically small in size so size and amount of battery is limited. In wireless mobile networks more energy is consumed for data communication than in internal processing. So there is need to conserve the energy in order to enhance the network lifetime. A lot of research have been done in order to find the solution for this problem in recent years some of which are data compression and in-network aggregation[2-10] and reducing the data overhead[1-10].

II. LITERATURE REVIEW

Ant colony optimization (ACO) is an optimization technique inspired by the exploratory behavior of ants while finding food [3-4]. The routing algorithm based on ants was developed by G. Di Carlo and M. Dorigo [5] and M. Gunes, U. Sorges and I. Bouazizi in [6] and further discussed in [7]. In this paper, ANT colony optimization (ACO) based meta-heuristic is used for cluster head selection. The node having the minimum cost value is elected as the cluster head. The main purpose of the paper is to enrich the performance of routing parameters for mobile ad hoc networks using AntHocNet [8-9] routing algorithm. N. N. Joshi and R. D. Joshi proposed (ELAR1-VAR) controls the transmission power of a node according to the distance between the nodes. It also includes energy information on route request packet and selects the energy efficient path to route data packets [12]. M. H. Mamoun [10], proposed a new hybrid routing protocol for MANETS called location aided hybrid protocol aimed to optimize bandwidth usage of MANETS by reducing the routing overhead but also extend the battery life of mobile devices by reducing the required number of operations for route determination with fuzzy logic [10].R. S. Sawhney and Harminder kaur proposed scheme to reduce the routing overhead considering the various node parameters for selection of cluster head [1].

III. Proposed routing algorithm

Our proposed algorithm belongs to the class of hybrid protocols which focuses on conservation of battery life. The hybrid protocols selecting the path with the minimum cost, where the cost takes into account the residual energy of each visited node (and possibly its neighbors) and the energy consumption of a packet on this path. These protocols avoid the problems encountered by the proactive and on-demand by weighing the factors used in the cost computation [11]. To achieve this only one mobile node i.e. cluster head was elected to communicate while rest cluster members are kept at sleep mode. Cost value is calculated considering the parameters battery (W1), density (W2) and direction (W3).

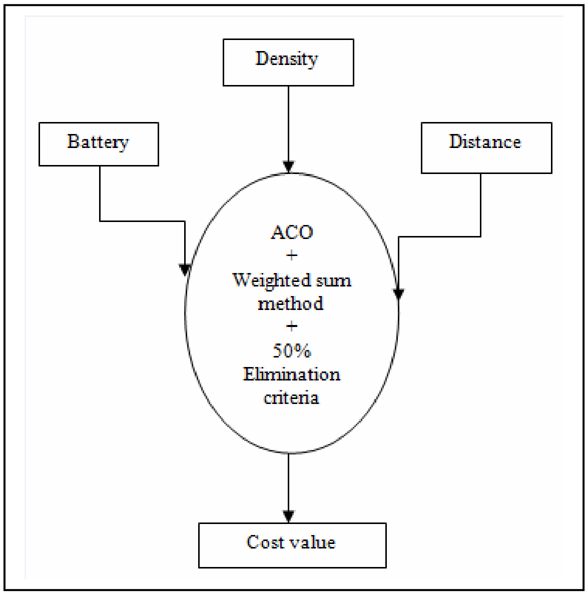


Figure 1: ACO system used to obtain cost value

A. *Assumptions*

When the simulations were run, then there were three cases:

a) If there was no node in the cluster i.e. cluster is empty.
b) If there was only one node in cluster, then that node itself acts as cluster head which means communication should be continued till single node was present in the cluster.
c) If there was more than one node in the cluster, then by using ant colony optimization(ACO) cluster head was elected as explained below:

Initialize weight coefficients W1, W2 and W3 for battery, density and distance respectively such that

W1+W2+W3=1

In our simulation we are assign W2=.2(fixed) while W1 is assigned value in range 0.70 to 0.45 in decreasing order and W3 is assigned value in range 0.1 to 0.35 in increasing order.

B. *Cluster head selection*

Perform these steps for each and every cluster

Step 1. During simulation, search space was considered equivalent to the current nodes in the simulation area.
In this search space

For j=1: ants (even)

A dummy variable was created to take random values from search space. This dummy variable was stored in ants_loco_p.

Step 2.Euclidian distance between the nodes in the search space and values stored in ants_loco_p were calculated by using the distance formula,

$$D=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$$

Here GPS system has been used and it means mobile nodes know their relative position in terms of X-Y co-ordinates with respect to each other.

Step 3. If Euclidian distance □ grid distance/2
It means a particular node was able to act as cluster head and hence calculate distance from the base station. Because a node present in the centre of cluster covers equally all other nodes present within that particular cluster during routing.

Step 4. Calculate the cost value for each ant with weighted sum method. Then individuals were sorted in ascending order according to the cost value.

For k=1: iterations
For j=1: ants
W1_p=ants_loco_p (j, a)/ (battery*w1*100);

W2_p=ants_loco_p (j, b)/ (density*w2*100);

W1_p=ants_loco_p (j, c)/ (distance*w3*100);

Food_value=W1_p+W2_p+W3_p;
Cost_value=1-food_value
If
The cost value was better than ants_loco_p_{best} in history
Set new cost value as the best i.e. ants_loco_p_{best}
End if
End for
End for

Step 5.Choose the ant having minimum cost value as $g_{\_best}$
For each ant i
Repeat step 4 to calculate cost value
If (ants_loco_c (j, k) □ ants_loco_p (j, k))
Ants_loco_p (j, :)=ants_loco_c (j, :);
End if
End for
Ants_loco_p= sortrows (ants_loco_p(j,:));

Step 6. Apply 50% elimination criteria, where best 50% ants replace the other.

For j=1: ants/2
Best=ants_loco_p (j, :);
Ants_loco_p (end+1,:) = best;
End

Step 7.Out of the above best nodes, the node with minimum cost was elected as a cluster head.

Step 8. As the cluster head was elected; it collects data from all other nodes present in the particular cluster and passes to the base station [1].

IV. SIMULATION STEPS

MATLAB software version R2011b is used for AntHocNet algorithm simulations due to its ease of node deployment and network set up. MATLAB's built in functions provide excellent tools for linear algebra computations, data analysis, signal processing, optimization etc. and many other types of scientific computations. With the help of MATLAB critical analysis of results is achieved by deploying wireless mobile nodes with random uniform distribution.

A. Methodology

1. A service area of dimensions 600 m ×600 m is chosen for MANET infrastructure.

a) The service area is further divided into cells.
b) Each cell has a set of mobile nodes.
c) Each mobile node communicates with each other.
d) Each mobile node is moving randomly in some direction with some mobility rate.

2. If the distance between two cluster heads is less than the transmission range than the packet is assumed to be delivered else the control packet is incremented.
3. Here CBR (Constant Bit Rate) is chosen as the traffic type. Table 1 briefly mentions the various simulation parameters and figure 1 shows the simulation scenario in MATLAB.

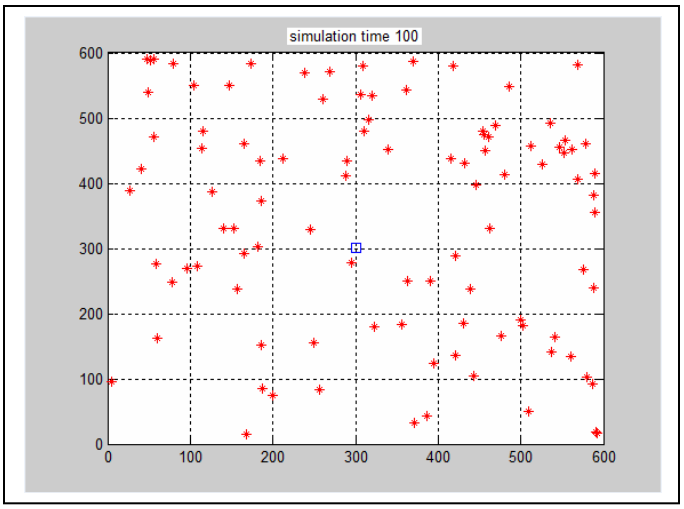


Figure 2: Simulation Scenario

TABLE1. LIST OF SIMULATION PARAMETERS

S.No.	Parameter	Value
1	Geographical Area	600 ×600 m^2
2	Number of Mobile nodes	100
3	Routing algorithm	AntHocNet
4	Mobility model	Random waypoint
5	MAC layer Protocol	IEEE 802.11 DCF protocol
6	Packets Size	512 bytes
7	Traffic load	4 UDP Packets/Second
8	Traffic Type	CBR
9	Performance parameter	Packet delivery ratio, End-to-end delay, normalized routing load and drop ratio.

1. Packet Delivery Ratio:
It is the ratio of the number of packets which are successfully received and the total number of packets transmitted.

2. Average End-To-End Delay:
This is the cumulative statistical measure of the delays experienced by the packets travelling between source and destination.

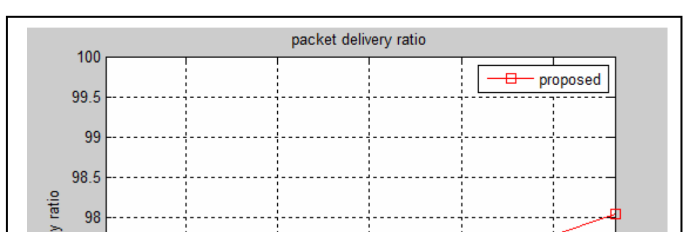
3. Normalized routing load:
It is the number of control packets per data packets transmitted in network.

4. Drop Ratio:
Packet drop ratio is calculated by subtract to the number of data packets sent to source and number of data packets received destination through the number of packets originated by the application layer of the source.

V. RESULTS AND DISSCUSSSION

A. Packet Delivery Ratio:

Packet delivery ratio is measured with respect to the cost value. The packet delivery ratio increases with increase in the cost value. Cost value is calculated from W1, W2 and W3. Packet delivery ratio reaches its maximum at cost value of .8838 (where W1=.45, W2=.20 andW3=.35)



.

Figure 2: Packet delivery ratio vs. cost value

B. End-to-End delay

End-to-end delay is measured with respect to the cost value. It is investigated that the end to end delay decreases with the cost value and reaches its minimum at cost value of 0.8838 as shown in figure 3.

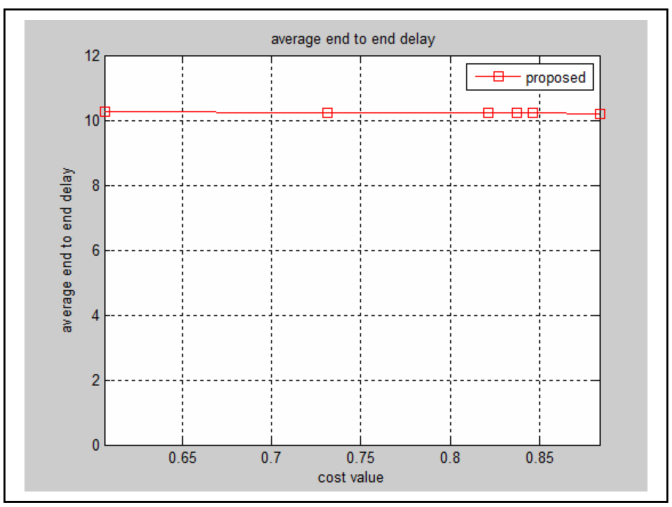


Figure 3: End-to-End delay vs. cost value

C. Normalized routing load:

Normalized routing load is measured with respect to the cost value. As demonstrated in figure 4: Normalized routing load decreases with increase in the cost value and reaches its maximum at 0.8838.

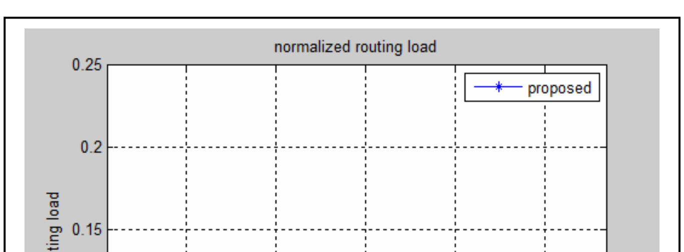


Figure 4: Normalized routing load vs. cost value

D. Drop ratio

The figure 5 demonstrates the graph between drop ratio and the cost value. It is investigated that the value of drop ratio is minimum at cost value of 0.8838.

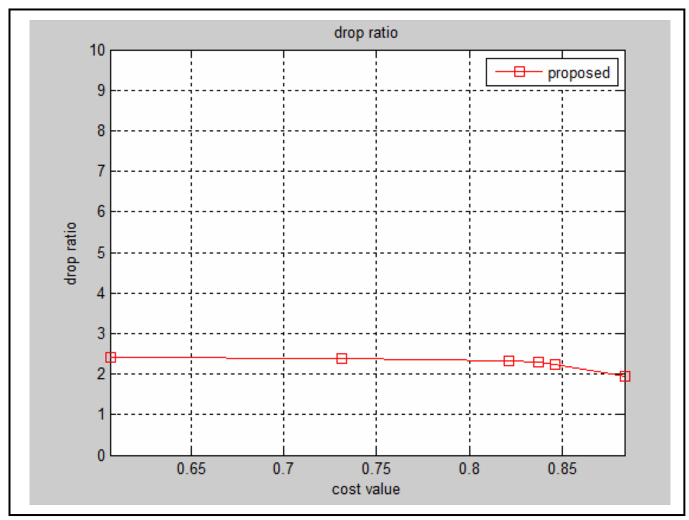


Figure 5: Drop ratio vs. cost value

VI. CONCLUSION

Energy consumption is an important issue for networking devices. It is one of the most important performance metrics for mobile ad-hoc networks. While it focuses on how the battery life can be prolonged. The efforts have to be made to improve the energy consumption so that network should remain alive for a longer time. Simulated results validate that the performance is best at cost value of 0.8838 (W1=0.45, W2=0.20 and W3=0.35).i.e. the value of w1 and w3 should be balanced so as to achieve best results.

As the packet delivery ratio remains above 97% for all the cost value there is a slight variation. End to end delay remain nearly stable around 10. Normalized routing load is in the range 0.0249 to 0.0201 and drop ratio has a slight variation in the range 2.4100 to 1.9500. As our aim is to minimize the battery requirement or in other words maximize the battery life, so the cost value of 0.6060 (W1=0.7, W2=0.2 and W3=0.1) i.e. weight factor for battery W1 is given highest priority so as to prolong the network lifetime.

REFERENCES

[1] Harminder Kaur and R. S. Sawhney, "Reducing Routing Overhead Using Ant Colony Optimization In Wireless Mobile Networks", In International Conference On Telecommunications And Networks, pp 620-624, August 2013.

[2] Harminder Kaur, R. S. Sawhney and R. Vohra, "Multi hope routing in wireless mobile networks using Ant Colony Optimization", in International Journal of Computer Applications (IJCA), Volume 69– No.26, may 2013.

[3]M. Dorigo, G. Di Caro, and L. M. Gambardella. "Ant algorithms for discrete optimization", Artificial Life 1999; volume- 5(2), pp: 137–172.

[4]T. Stutzle & M. Dorigo,"An Experimental Study of the Simple Ant Colony", 2002.

[5]G. Di Caro, M Dorigo, "AntNet: distributed stigmergetic control for communications networks",Journal of Artificial Intelligence, Res. 9, pp: 317–365 (1998).

[6] M. Gunes¸, U. Sorges and I. Bouazizi, "ARA – The Ant-Colony Based Routing Algorithm for MANETs", Parallel proceeding workshops proceedings international conference, page(s):79-85, 2002.

[7] D. Subramanian, P. Druschel and J. Chen, "Ants and Reinforcement Learning: A Case Study in Routing in Dynamic Networks", May 2003.

[8] G.A. Di Caro, F. Ducatelle and L.M., Gambardella, "AntHocNet: an ant-based hybrid routing algorithm for mobile ad hoc networks", In Proceedings of PPSNVIII, volume 3242 of LNCS, pages 461–470 Springer, 2004. (Best paper award).

[9] G.A. Di Caro, F.Ducatelle, and L.M. Gambardella, "Swarm intelligence for routing in mobile ad hoc networks" , In Proceedings of the IEEE Swarm Intelligence Symposium, pages 76–83, Pasadena, USA, June 2005. IEEE Press.

[10] M. H. Muamoun, "Location aided hybrid routing algorithm for MANETS", in international journal of engineering & technology IJET-IJENS, Vol-11 (1), 2011.

[11] A. Meshram and M .A. Rizvi, "Issues And Challenges of Energy Consumption in MANET Protocols" in ISSN 2319-4529, S e p t e m b e r 2 0, 2 0 1 3.

[12] N. N. Joshi and R. D. Joshi, "Energy Conservation in MANET using variable range location aided routing protocol", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 5, October 2011.

AUTHOR'S PROFILE

Name: Miss. Sandeep kaur
Position: Student
Email: sandeepkaur1390@gmail.com
Area of interest: Networking

Name: Dr. Ravinder singh sawhney
Position: Senior lecturer
Email: sawhney_gndu@hotmail.com
Area of interest: Nanotechnology and Networking
Number of publications: 35
Have teaching experience of 15 years