International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Validation of Ant Colony Optimization Algorithm for Longevity Maximization in Wireless Sensor Network

Laxmi Narendra Pawar[1], H. M. Baradkar[2]

[1]EXTC Department, JCOET College, Yavatmal, SGBAU University, Maharashtra, India

[2]Professor, EXTC department, JCOET College, yavatmal, SGBAU University, Maharashtra, India

Abstract: ***The lifetime of wireless sensor networks can be maximize using effective transmission strategy. An optimal distance based transmission strategy put forward to satisfy such a maximization aim on the basis of ant colony optimization. In wireless sensor network for high energy efficiency and a good energy balancing a local optimal distance acquirement scheme is presented by introducing two concepts, most energy efficient distance and most energy balancing distance. Also, two obtain energy depletion minimization for sensor nodes with maximum energy consumption along the network; a global optimal distance acquirement scheme is presented by working out a network lifetime evaluation method. At the end, our feeding significantly by using the simulation gives the solutions.***

Keywords: Network longevity maximization, high energy efficiency, wireless sensor network, good energy balancing

1. Introduction

For wide range of military and civilian applications [1] , [2] wireless sensor networks have attracted worldwide attention .The sensor nodes get power from the batteries in the wireless sensor networks. The limited and precious resources [3] energy is used chiefly in data transmission. Further, between a single sink and multiple nodes data transmission is generally performed. Highly non-uniform energy depletion between nodes of different locations results because of many to one communication manner. Many times the nodes which are closer to the sink used to consume their energy faster than the other nodes and the remaining would deplete their energy faster and results in the phenomenon of energy hole[4],[5]. Dis-jointing of network and shorting of the longevity of network cause because of premature depletion of the nodal energy where the energy is depleted more fastly is called hot spot [6], [7]. Thus, another important concept is energy balancing in data transmission. Thus, to obtain network longevity maximization how to design suitable and effective transmission strategy in such network place a vital role.

In the field of the data transmission of wireless sensor network, the concentric corona model has attracted the great concern. The authors in [4] claimed that nodes should forward the data to adjacent inner corona and each and every corona in the network must have same width, in [4] they discussed such a network model. A method that alternating between multi -hop transmission with fixed transmission distance and single –hop communication directly to the sink periodically in advanced in [8]. An optimal transmission distance for multi-hop communication was achieved using single-hop transmission and multi-hop transmission where also studied in [9]. The optimal ratio of number of data cycles operated in the single-hop transmission and multi-hop transmission nodes over the network lifetime was obtained in such a hybrid of single-hop transmission and multi-hop transmission was studied in [9]. Also, to obtain balanced energy usage in the network a hybrid of single-hop transmission and multi-hop transmission schemes was advanced in [10]. [11] Put in forward a mixed transmission algorithm, that includes flat and hierarchical multi-hop routing. Furthermore, mixed transmission schemes that include single-hop and multi-hop were obtained in [12]-[14].

Ant colony optimization [15] has been successfully applied to a large number of combinatorial optimization problems for examples data transmission in wireless sensor networks. Ant colony optimization [15] has obtained the popularity in the recent years as swarm intelligence methods. Authors in [16] define forward ant and backward ants. In this ant selects a path according to the actual energy level of nodes and the distance travelled by forward ant and such an algorithm is defined as energy efficient ant based routing algorithm. In another algorithm which was presented in [17] in this ant select the path according to the energy level of the nodes and the total numbers of the nodes visited by the ants and such a algorithm is defined as a dynamic and reliable routing protocol based on the ant colony algorithm. To reduce energy consumption a particular ant colony based routing algorithm was presented in [18]. In such routing algorithm the energy consumption throughout the path and the distance to the sink are used by the ant to choose paths. In order to maximize the network longevity another energy aware ant colony algorithm was presented in [19]. In this type of routing algorithm, the next higher mode of routing is selected according to distance to sink, the path of average energy and residual energy of mode. In [20] authors define as ant colony optimization based transmission scheme in which for longevity maximization of wireless sensor network energy balancing and energy efficiency have simply considered .

Although, the above mentioned transmission strategies have number of limitations and which are given as follows:

Low energy efficiency and poor energy balancing will be the result of single-hop transmission and multi-hop communication with fixed transmission distance respectively, because high amount of energy consumption is happened as an output of long transmission distance in single-hop and with the fixed transmission distance in multi-hop, we will have too much traffic load around the sink. Further, the hybrid transmission that includes part of single-hop and multi-hop is still no much better.

There are some passive methods such as considering the residual energy of nodes and such type of methods are far away from the network longevity maximization. The network longevity maximization can be significantly increased by using only a proactive method with both good energy balancing and high energy efficiency.

The energy balancing and energy efficiency have significant impact on it of relationship between node location and transmission distance. But, ant colony optimization based transmission methods which are present currently has not been sufficiently considered the importance of this relationship.

In this paper, the problem of network longevity maximization we investigate and to resolve such problems we take proactive methods. Further, on the basis of ant colony optimization we put forward the optimum distance based transmission strategy to obtain our goal.

We present performance improvisation for longevity maximization of wireless sensor network to achieve our goal on the basis of ant colony optimization. For both high energy efficiency and good energy balancing in wireless sensor networks , we present a "local optimal transmission distance acquirement scheme" by introducing two concepts , "most energy efficient distance " and most energy balancing distance " and this scheme contributes to network longevity maximization. To achieve energy depletion maximization for nodes with maximal energy consumption throughout the network, we proposed a "global optimal transmission distance acquirement scheme" by designing a network longevity maximization approach. And thus, this scheme further helps to extend the network longevity.

2. The Proposed Transmission Strategy

As shown in the fig.1, we consider a wireless sensor network where nodes are evenly deployed on a disk with a radius R centered at the sink. M disjoint concentric coronas divide this disk. An arbitrary wedge subtended by an angle Θ is also considered. This is partitioned into M sectors, which are denoted as Ω_1 , Ω_2 ,....... Ω_M by its intersection with M concentric coronas. Suppose each node generate the particular bits of data per second and having the initial uniform energy. This type of sector division can be called as a clustering technique which has some advantages such as more robustness and more scalability [21], [22]. Such a sector division can also be regarded as an effective method of achieving the load balancing with non-uniform clustering manner and this is because of different sizes of sector distribution

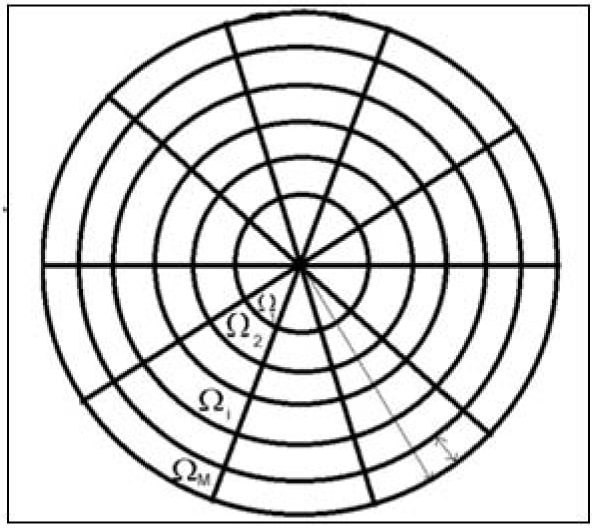

Figure 1: Network model

To seek an optimal transmission distance for nodes of each sector is our goal. There is an ant on the every sector initially; here the search is performed by the ant colony optimization. As shown in the fig.2, according to the specific probability, every ant moves from a sector to another towards the sink.

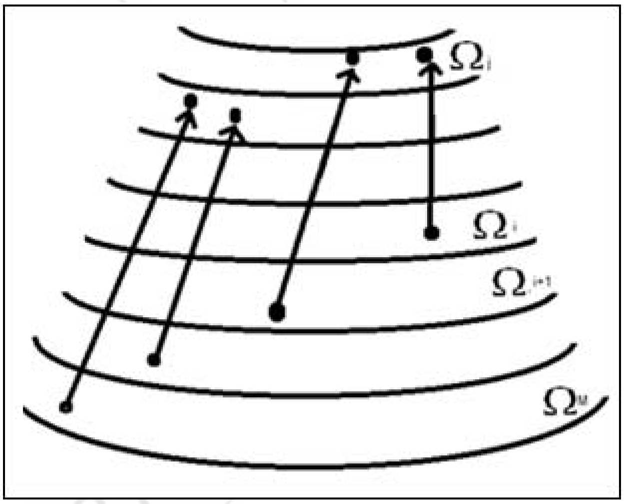

Figure 2: The moving mode

In order of the largest to the smallest number of the sector, these ants move one after another. Generally, every ant moves after the ant of the adjacent outer sector has completed its trip, the ant on the most outer sector moves firstly. When any ant moves only one hop, it has finished its full work. A corresponding path is created by an ant when it moves from Ω_i to sector Ω_j towards the sink and whose distance is„d‟. „d‟ is the transmission distance of the nodes in sector Ω_i , path is transmission route of this sector. Thus, the routing abstraction is the moving of ant. The solution that is the transmission distance of the nodes for all sectors have been obtained when all the ants completed their task of moving. The best solution is updated and reserved after several iterations. The sector Ω_i is named a direct source sector of Ω_j , if an ant moves from sector Ω_i to sector Ω_j towards the sink. Both sector Ω_i and sector Ω_{i+1} are the direct source sectors of the sector Ω_j as both of the ants of the sector Ω_i and sector Ω_{i+1} moves to sector Ω_j as shown is fig.2. Owing to the in-order moving, the ant on the sector Ω_i

must has visited all the direct source sectors of the sector Ω_i when it wants to choose the candidate sector Ω_j and must be informed about the total amount of its received data. When any ant starts to move, the ant must be aware of the total volume of the data required to be delivered by sector and all the ants in its outer sector have finished their trips. Thus, great convenience for data calculation can bring by this moving manner.

3. Related Concepts

3.1. The most energy efficient distance and the most energy balancing distance

In multi-hop transmission manner, to minimize the total energy usage along the transmission path, an optimal transmission distance at each hop has been found in [25]. Intervening relay nodes divides the D into X hops and this distance D is the data link between a data transmitter and a receiver .It is proved that for the number of the hops X and the given distance D, the total energy usage along the path can be obtain the minimum when the each hop shares the equal d=D/X transmission distance„d". Thus the distance„d" is called as most energy balancing distance, if nodes in the every sector consume equal amount of energy. To search for the optimal solutions, ant colony optimization utilizes the transition probability. Domain knowledge and search experiences these are the two important factor which are used to accelerate the search process in this algorithm. Domain knowledge is expressed by the heuristic information and search experiences are expressed by the pheromone intensity.

Local optimum transmission distance acquirement scheme based on the high energy efficient distance and the good energy balancing

The heuristic desirability and the pheromone intensity are related to a few considerations, including the transmission range and the data volume, etc. in the optimal distance based transmission strategy. It is simple to know that, the better effect of high energy efficiency is obtained when the transmission distance is closer to most energy efficient distance. Similarly, the stronger ability of good energy balancing is obtained when the transmission distance is closer to the most energy balancing distance. The heuristic value of the path is larger when„d" is nearer to d_{MEED}. Likewise, the heuristic value of the path is larger when„d" is nearer to d_{MEBD}. Hence, to select the path that can obtain both good energy balancing and high energy efficiency, the definition of heuristic value in our transmission strategy guides the ant. Thus, the degrees of good energy balancing and high energy efficiency are distinctly reflected in the definition of heuristic value which generally contributes to the network longevity maximization. This concept is known as local optimal distance acquirement scheme as in the ant colony optimization the heuristic factor is local value of any path. This scheme contributes to obtain network longevity maximization.

3.2. Global optimum transmission distance acquirement scheme based on the network longevity maximization

It is known that the network longevity is maximum when the maximal per node average energy consumption is smaller. The pheromone intensity on every path is updated after all ants finish their trips in our transmission strategy. So, to select an efficient path with minimal value of the maximal per node average energy consumption of different sectors, such pheromone updating rule can guide ants and according obtain network longevity maximization. This approach is named global optimal transmission distance acquirement scheme and this is because the pheromone updating is a global process in ant colony optimization. This scheme further gives the realization of network longevity maximization.

4. Comparison of Energy Usage

The distribution of energy usage between sensors having varying distances from the sink in different transmission strategies with K=8 and K=10 is shown in fig.3

With the distance to the sink rising from 20m to 180m the energy usage of single –hop communication increases significantly from about $1.2*10^{-3}$ J to about $9.2*10^{-3}$ J as shown in fig.3 . The reason for this is that square or quadruple of the transmission distance is proportional to transmission power. And as there is a long transmission distance between a sensor and sink in single –hop transmission, it is far away from high energy efficiency.

With the increase of distance to the sink, it can be seen from the figure that consumption of energy slowly drops in multi-hop and energy aware ant colony algorithm. The reason for this is that no enough load balancing measures have been taken in these two transmission strategies and also there is more traffic load close to the sink. The energy usage of the optimal distance based transmission strategy and hybrid vary little in this figure for whatever the distance to the sink is. This shows their good balancing ability of energy consumption. To achieve the load balancing hybrid adopts the single-hop and multi-hop. Multi-hop suffers from the larger traffic to be delivered for the nodes near to the sink while the single needs t5he less energy depletion due to the less transmission distance. On the other hand, because of the long transmission distance t6he single-hop is suffer from the larger energy consumption when nodes far from the sink while the multi-hop has the less traffic to be forwarded for the nodes far from the sink . Optimal distance based transmission strategy uses the most energy balanced distance to balance the energy expenditure and in the heuristic value of the ant colony algorithm this most energy balancing distance is a key factor.

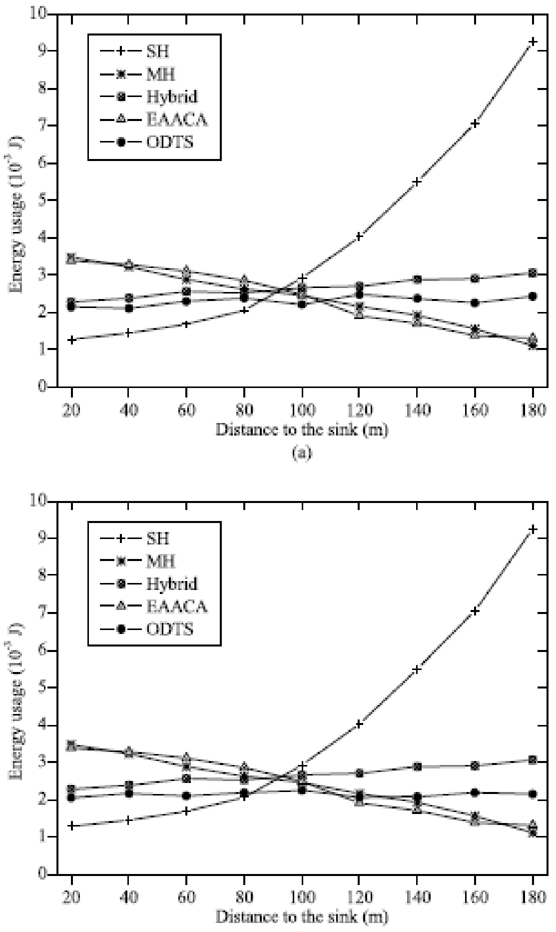

Figure 3: Distance of the energy usage among nodes located at the various distance from the sink (a) K=8 (b) K=10

Optimal distance based transmission strategy needs less energy usage than that of hybrid and this can be seen from the figure. This take places because of two reasons one is network longevity maximization mechanism by which the maximum per node energy consumption of the different section has been controlled and limited and in such a network energy expenditure has been decreased.

5. Comparison of Network Lifetime

Comparison of network lifetime achievable in different transmission strategies for different network radii is shown in fig.4. It is shown from the figure that as the network radius increases the network lifespan decreases. This is generally causes because of increase in the traffic load with the extension of the network. There is more traffic load if the network range is larger point.

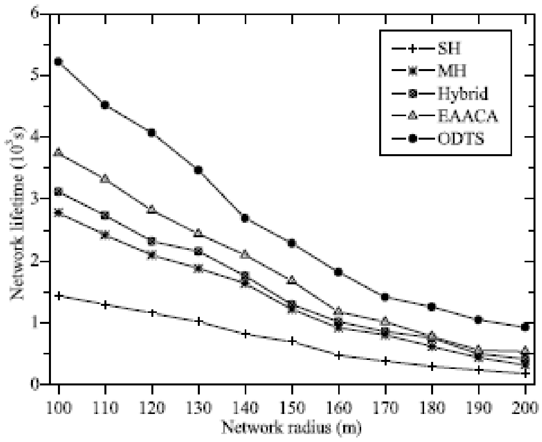

Figure 4: Network lifetime for various network radius

Further, in the comparison with the other transmission strategies the network lifetime obtained by the single –hop is lowest. IT is easy to know that all node and transmits the data directly to the sink then this will result in long distance communication which will decreases the network lifespan. The network lifespan is determined by the energy consumption of the nodes on the outer most sectors generally.

From the figure we can see that network longevity obtained by optimal distance based transmission strategy is generally longer than that achieved by other transmission strategies optimal distance transmission strategies achieve network longevity nearly five times that of single-hop. This generally obtains from two optimal transmission distance acquirement mechanism. One is local optimal transmission distance acquirement scheme which gives the transmission rage close to the most efficient distance d_{MEED} and the most balanced distance d_{MEBD} to obtain high energy efficiency and good energy balancing respectively. The other is global optimal transmission distance acquirement scheme, which is based on the fact that network longevity is determined by the maximum energy consuming nodes. The pheromone updating rule is defined by maximum per node average energy consumption of different sectors. Therefore, the selection of such a path with the less value of the maximum per node average energy consumption is done and in this way the network longevity is increased.

6. Conclusion

In this paper, the problem of network longevity maximization in the wireless sensor networks is investigated, and on the basis of the ant colony optimization an optimal-distance based transmission strategy is proposed. In this transmission strategy Some proactive measures have been taken , in which an optimal transmission-distance acquirement mechanism is designed for both good energy balancing and high energy efficiency, and another optimal transmission-distance acquirement scheme is given to obtain energy depletion minimization for nodes with maximal energy consumption along the network. Furthermore, in order to validate the effectiveness and superiority of our findings, simulations are used.

References

[1] N. A. Pantazis, S. A. Nikolidakis, and D. D. Vergados, "Energy-efficient routing protocols in wireless sensor networks: A survey," *IEEE Commun. Surv. Tuts.*, vol. 15, no. 2, pp. 551–591, May 2013.

[2] T. E. Cheng and R. Bajcsy, "Congestion control and fairness for many-to-one routing in sensor networks," in *Proc. 2nd ACM Conf. Embedded Netw. Sensor Syst.*, 2004, pp. 148–161.

[3] M. Magno, D. Boyle, D. Brunelli, E. Popovici, and L. Benini, "Ensuring survivability of resource-intensive sensor networks through ultra-low power overlays," *IEEE Trans. Ind. Informat.*, vol. 10, no. 2, pp. 946–956, May 2014.

[4] S. Olariu and I. Stojmenovic, "Design guidelines for maximizing lifetime and avoiding energy holes in sensor networks with uniform distribution and uniform reporting," in *Proc. 25th IEEE INFOCOM*, Apr. 2006, pp. 1–12.

[5] X. Wu, G. Chen, and S. K. Das, "Avoiding energy holes in wireless sensor networks with nonuniform node distribution," *IEEE Trans. Parallel Distrib. Syst.*, vol. 19, no. 5, pp. 710–720, May 2008.

[6] A. Liu, Z. Liu, M. Nurudeen, X. Jin, and Z. Chen, "An elaborate chronological and spatial analysis of energy hole for wireless sensor networks," *Comput. Standards Inter.*, vol. 35, no. 1, pp. 132–149, Jan. 2013.

[7] C.-F. Wang, J.-D. Shih, B.-H. Pan, and T.-Y. Wu, "A network lifetime enhancement method for sink relocation and its analysis in wireless sensor networks," *IEEE Sensors J.*, vol. 14, no. 6, pp. 1932–1943, Jun. 2014.

[8] M. Perillo, Z. Cheng, and W. Heinzelman, "On the problem of unbalanced load distribution in wireless sensor networks," in *Proc. IEEE Global Telecommun. Conf. Workshops*, Nov./Dec. 2004, pp. 74–79.

[9] V. Mhatre and C. Rosenberg, "Design guidelines for wireless sensor networks: Communication, clustering and aggregation," *Ad Hoc Netw.*, vol. 2, no. 1, pp. 45–63, Jan. 2004.

[10] A. Jarry, P. Leone, O. Powell, and J. Rolim, "An optimal data propagation algorithm for maximizing the lifetime of sensor network"

[11] A. E. A. A. Abdulla, H. Nishiyama, J. Yang, N. Ansari, and N. Kato, "HYMN: A novel hybrid multi-hop routing algorithm to improve the longevity of WSNs," *IEEE Trans. Wireless Commun.*, vol. 11, no. 7

[12] C. Efthymiou, S. Nikoletseas, and J. Rolim, "Energy balanced data propagation in wireless sensor networks," in *Proc. 18th Int. Parallel Distrib. Process. Symp.*, Apr. 2004.

[13] O. Powell, P. Leone, and J. Rolim, "Energy optimal data propagation in wireless sensor networks," *J. Parallel Distrib. Comput.*, vol. 67

[14] H. Zhang and H. Shen, "Balancing energy consumption to maximize network lifetime in data-gathering sensor networks," *IEEE Trans. Parallel Distrib. Syst.*, vol. 20, no. 10, pp. 1526–1539, Oct. 2009.

[15] M. Dorigo and T. Stutzle, *Ant Colony Optimization*. Cambridge, MA, USA: MIT Press, 2004.

[16] T. Camilo, C. Carreto, J. S. Silva, and F. Boavida, "An energy-efficient ant-based routing algorithm for wireless sensor networks," in *Ant Colony Optimization and Swarm Intelligence* (Lecture Notes in Computer Science), vol. 4150, M. Dorigo, L. M. Gambardella, M. Birattari, A. Martinoli, R. Poli, and T. Stützle, Eds. Berlin, Germany: Springer-Verlag, 2006, pp. 49–59.

[17] S. Okdem and D. Karaboga, "Routing in wireless sensor networks using ant colony optimization," in *Proc. 1st NASA/ESA Conf. Adapt. Hardw. Syst.*, Jun. 2006, pp. 401–404.

[18] J.-F. Yan, Y. Gao, and L. Yang, "Ant colony optimization for wireless sensor networks routing," in *Proc. Int. Conf. Mach. Learn. Cybern. (ICMLC)*, Jul. 2011, pp. 400–403.

[19] D. Cheng, Y. Xun, T. Zhou, and W. Li, "An energy aware ant colony algorithm for the routing of wireless sensor networks," in *Intelligent Computing and Information Science* (Communications in Computer and Information Science), vol. 134. Berlin, Germany: Springer-Verlag, 2011, pp. 395–401.

[20] X. Liu, "A transmission scheme for wireless sensor networks using ant colony optimization with unconventional characteristics," *IEEE Commun. Lett.*, vol. 18, no. 7, pp. 1214–1217, Jul. 2014.

[21] X. Liu, "A survey on clustering routing protocols in wireless sensor networks," *Sensors*, vol. 12, no. 8, pp. 11113–11153, Aug. 2012.

[22] X. Liu and J. Shi, "Clustering routing algorithms in wireless sensor networks: An overview," *KSII Trans. Internet, Inf. Syst.*, vol. 6, no. 7, pp. 1735–1755, Jul. 2012.

[23] S. Soro and W. B. Heinzelman, "Prolonging the lifetime of wireless sensor networks via unequal clustering," in *Proc. 5th IEEE Int. Workshop Algorithms Wireless, Mobile, Ad Hoc Sensor Netw. (WMAN)*, Denver, CO, USA, Apr. 2005,

[24] C. Li, M. Ye, G. Chen, and J. Wu, "An energy-efficient unequal clustering mechanism for wireless sensor networks," in *Proc. IEEE Int. Conf. Mobile Adhoc Sensor Syst. Conf.*, Washington, DC, USA, Nov. 2005, pp. 604–608.

Author Profile

Ms. Laxmi Narendra Pawar is PG Scholar, Electronics and Telecommunication Engg. Department, JCOET, Yavatmal, Maharashtra ,India