ISSN: 2454-4248
182 – 186

Efficient Routing for Maximizing Lifetime using Nature Inspired Algorithm in Wireless Sensor Network

Sumbul
Dept. of ECE
I.K Gujral Punjab Technical University
Jalandhar, India
syedsumbulali@gmail.com

Dr. Avtar Singh Buttar*(Author)*
Head of Dept. of ECE
I.K Gujral Punjab Technical University
Jalandhar, India
danshavtar@rediffmail.com

***Abstract*—** Recent advancements in semiconductors and material science technologies give rise to the Wireless Sensor Network (WSN). Latest advances in remote interchanges and hardware have empowered the improvement of minimal effort, low-control, multifunctional sensor nodes that are little in measure and impart untethered in short distances. Nature Inspired Algorithms have been successfully implemented in WSN to address various challenges of it. It provides adaptive mechanisms that exhibit intelligent behavior of nature in complex and dynamic environments in WSNs. Wireless Sensor Network is energy limited. The purpose of the research is to form efficient routes using an algorithm which is inspired by foraging behavior of ants that enhances network lifetime by reducing node's energy consumption by selecting the optimal route. The process of establishing paths from a source to a sink across one or more relays is called routing and the route is formed based on the probabilistic rule of Ant Colony Optimization (ACO). The proposed algorithm includes the route discovery and route maintenance process. Our proposed algorithm, obtain more balanced transmission among the nodes and reduce the energy consumption of the routing and therefore extends the network lifetime.

***Keywords*-** *Wireless Sensor Network (WSN); Nature Inspired Algorithm; Ant Colony Optimization(ACO); routing*

*****

I. INTRODUCTION

Communication plays a very important role in our life since the existence of the human era, whether it is verbal, non verbal, wired, wireless etc. In 18th century wired communication came into existence where electric telephone wire was used in 1870. In 1878, commercial telephone service started in New Haven. Due to so many limitations of wire there was a need of communication system which should be mobile in nature and much more flexible than wired system. In 1901, wireless communication system emerged as a new technology in which transfer of information is done without the use of electric wires over a distance.

The recent advancements in semiconductors and material science technologies Microelectromechanical System (MEMS) give rise to the Wireless Sensor Network (WSN). Latest advances in remote interchanges and hardware have empowered the improvement of minimal effort, low-control, multifunctional sensor nodes that are little in measure and impart untethered in short separations. These minor sensor nodes, which comprise of detecting, information handling and conveying parts, use the possibility of sensor systems. Detecting is a strategy used to accumulate data about a physical question or process, including the event of occasions (i.e., changes in state, for example, a drop in temperature or weight). A protest performing such a detecting assignment is known as a sensor. At the point when numerous sensors helpfully screen extensive physical conditions, they frame a Wireless sensor Network (WSN) [1][2].

.

II. WIRELESS SENSOR NETWORKS

Sensors interface the physical with the advanced world by catching and uncovering true wonders and changing over these into a frame that can be handled, put away and followed up on. Incorporated into various gadgets, machines and situations sensors give an enormous societal advantage. Information gathered by sensor nodes in a WSN is ordinarily engendered toward a base station that connections the WSN with different systems where the information can be pictured, broke down and followed up on. Remote sensor systems comprise of little nodes with detecting, calculation and remote correspondences capacities. An extensive number of these sensors can be arranged in numerous applications that require unattended operations, subsequently creating a remote sensor organize [3]. For example, WSNs have profound effects on military and civil applications such as target field imaging, intrusion detection, weather monitoring, security surveillance, distributed computing, detecting ambient conditions such as temperature, movement, sound, light, or the presence of certain objects, inventory control and disaster management. WSN can be used in devices such as laptops, PDAs or mobile phones to very tiny and simple sensing devices. WSN nodes are deployed in specific areas for specific task for a long period of time, so they are battery powered.

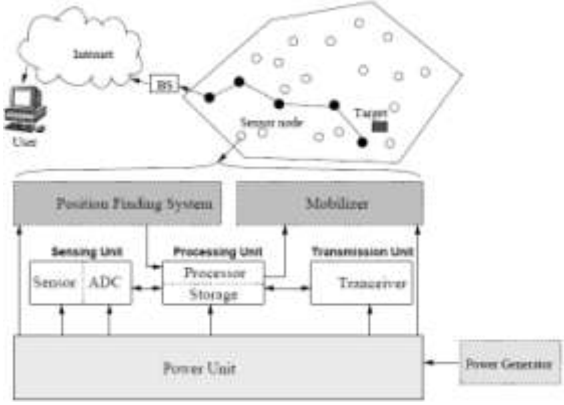

Figure 1. Components of Wireless Sensor Networks.

ISSN: 2454-4248
182 – 186

III. ROUTING AND COMPUTATIONAL INTELLIGENCE TECHNIQUES

A. *Routing Protocols in WSN*

The process of establishing paths from a source to a sink across one or more relays is called routing. Routing Protocols are responsible for identifying or discovering routes from source to sink [3]. With respect to Network Organization most routing protocols fit into one of three classes namely flat based, hierarchical-based and location based. With respect to Route Discovery there lies two types of protocols namely Reactive Protocol and Proactive Protocol. Based on Protocol Operation there are various protocols namely Negotiation Based, Multipath Based, Query Based, QoS Based and Coherent Based.

B. *Computational Intelligence in WSN*

Computational Intelligence (CI) has been successfully used in recent years to address various challenges in WSN such as data aggregation, energy aware routing, security, optimal deployment and localization. It provides adaptive mechanisms that exhibit intelligent behavior in complex and dynamic environments in WSNs [5]. Different techniques are proposed by different researchers few are as follows, Ant Colony Optimization (ACO)[6-11], Artificial Neural Network [12], Genetic Algorithm[13], Particle Swarm Optimization [14]

IV. PROPOSED SYSYTEM

Sensor nodes are firmly obliged in terms of energy, handling, and capacity limits. In this way, they require cautious asset administration. The proposed technique is the enhancement of lifetime in WSN using ACO.

In the proposed technique, the inverse of the distance of next node to hop from the source as well as from the base station is taken. So, that the average of inverse of the distance gives the better estimation of the next node to hop as well as the residual energy of the nodes lying in its communication range. The deposition of pheromone is done by modifying one or multiple pheromone matrices. To avoid loops each ant needs to memorize the nodes it has visited already. This is done by storing a list of visited nodes in each ant packet at each time an ant arrives at the next node. To limit energy utilization of WSN, ACO is used to make the route efficiently and hence this optimum route consumes less energy and enhances the network lifetime.

A. *Energy Calculation*

Efficient use of energy is one of the design challenges of WSN. Energy utilization is computed by the first order radio model.

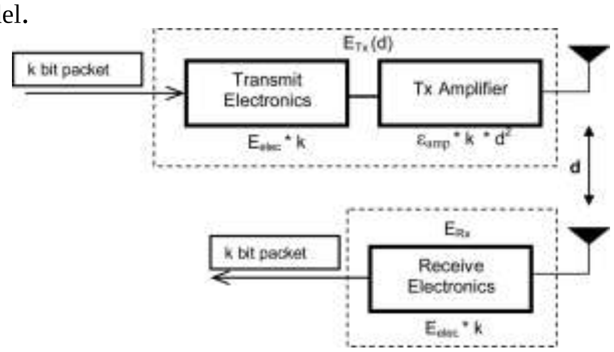

Figure 2. First Order Radio Model.

Most of the energy is consumed in sensing activities in the network, processing the data, communicating with other nodes and transmission of collected information to the base station. In the areas where nodes are densely deployed, there is probability of transmitting duplicate data to the base station which causes to reduction in energy efficiency as a lot of energy is wasted in transmitting same information again and again. Every node transmits information to the following node while the accepting node aggregates the received information with its own particular information and afterward transmits the aggregated information to base station. The energy consumption of transmitting a k- bit packet at a distance d can be expressed as follows as per first order radio model.

$$E_{TX} = \begin{cases} k \cdot E_{elec} + k \cdot E_{fs} \cdot d^2 & \text{if } d \le d_0 \\ k \cdot E_{elec} + k \cdot E_{mp} \cdot d^4 & \text{if } d > d_0 \end{cases} \quad (1)$$

If d>do, distance parameter becomes 4 times of the original distance

If d<=do, distance parameter becomes 2 times of the original distance.

B. *Mathematical Model*

Distance between node to node and node to Base Station (BS) is calculated using Euclidean Distance formula which is described below:

ds(i,j)=sqrt((X(i) - X(j))^2 + (Y(i) - Y(j))^2) (2)

where i,j are node numbers

When the distance between node to node and node to base station is calculated using this Euclidean formula then inverse of this distance is done. Inverse of the distance is taken in order to calculate the energy, as more the distance between the nodes and to the base station, more will be the energy required to transmit the data and vice-versa.

Probabilistic Rule provided by the ACO based algorithm is used. Pheromone value is updated which is built by the solution in each iteration by itself by all the 'k' ants.

$$p_{ij}^k = \begin{cases} \dfrac{[\tau_i]^\alpha [\eta_i]^\beta}{\sum_{l \in N_i^k} [\tau_l]^\alpha [\eta_l]^\beta} & \text{When } j \in N_i^k \\ 0 & \text{Else} \end{cases} \quad (3)$$

ŋij = (1/dij) is a heuristic value that is known a priory (dij is the distance between the nodes i and j). α and β are parameters that define the relative influence of pheromone and heuristic information.

Pheromone update is formally denoted as:

$$Ʈ_{ij}(t+1) = (1-\rho)Ʈ_{ij}(t) + \Sigma_{k=1}^{m} \Delta Ʈ_{ij}^{k}(t) \quad (4)$$

Where ρ is the evaporation rate which value lies between 0 to 1 i.e., ρ ϵ (0,1].

ΔƮij is the quantity of the pheromone laid on node i,j by ant k.

$$\Delta Ʈij = \begin{cases} \frac{Q}{L_k}, & \text{ifant k use node (i,j)} \\ 0, & \text{otherwise} \end{cases} \quad (5)$$

Where Q is a constant and is the length of the tour constructed by the ant k. Pheromone updation is done to increase the associated value of that good solution and decreases those values which are associated with the bad solutions.

C. Flowchart

Proposed system depends on nature inspired algorithms to increase most extreme lifetime of system by efficient routing. Energy of every node is computed and the procedure proceeds till the framework is not dead or energy of every node is not equivalent to zero.

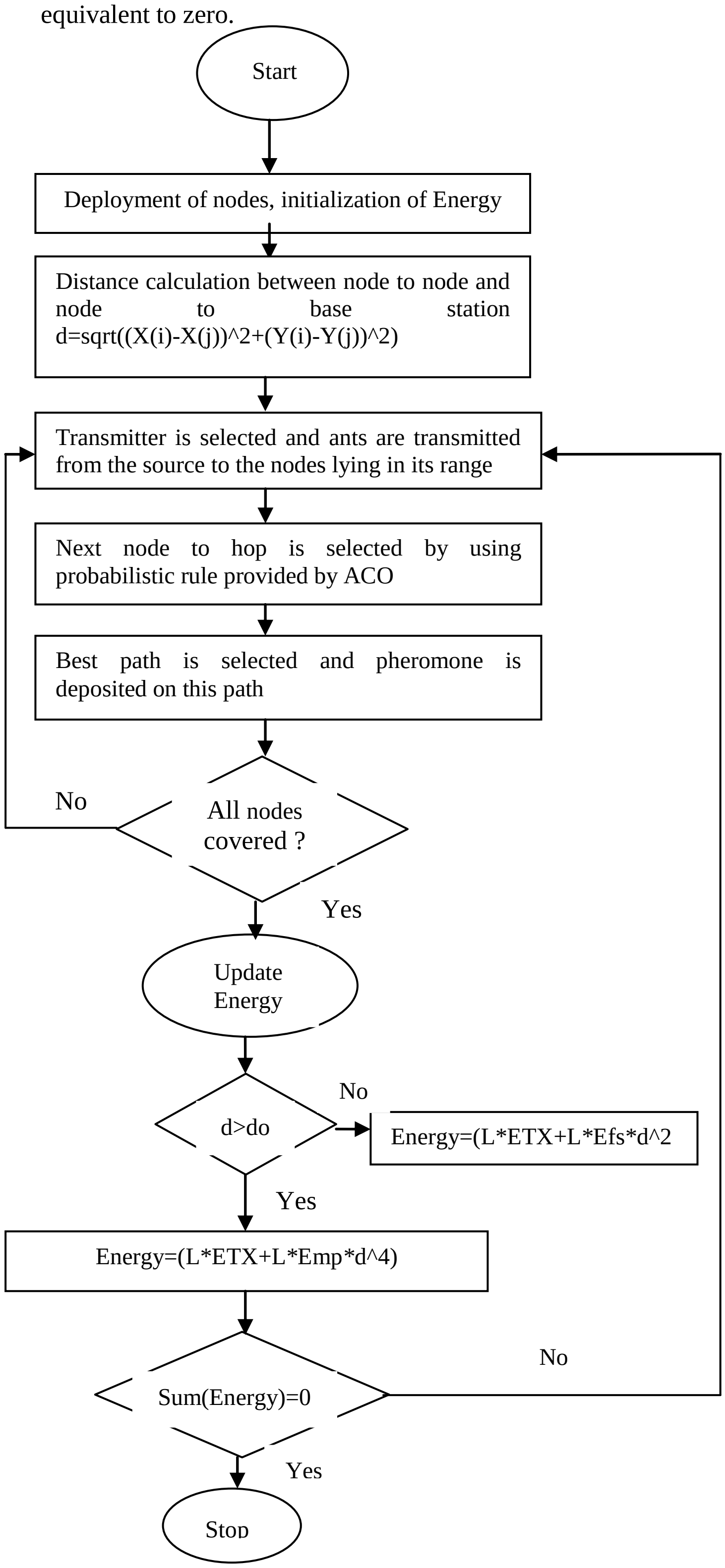

Figure 3. Flowchart of proposed work.

V. Performance Analysis

Simulation setup incorporates parameters for sensor field with region in which nodes are deployed, base station area, beginning energy of every node and no. of bits to be transmitted. At first we plot a system of 100 nodes sent haphazardly in 100×100 m^2 region with every node having starting energy 0.05 J. The base station situated at (50,100) m. Energy consumption is calculated using first order radio model. Initial pheromone which is default pheromone value is 0.01 for all the nodes.

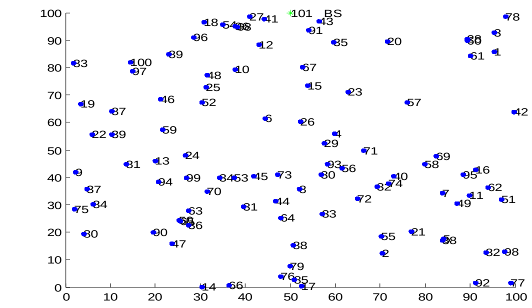

Figure 4. Deployment of sensor nodes.

The following stem plot shows the initial energy of all nodes which is 0.05J at the beginning.

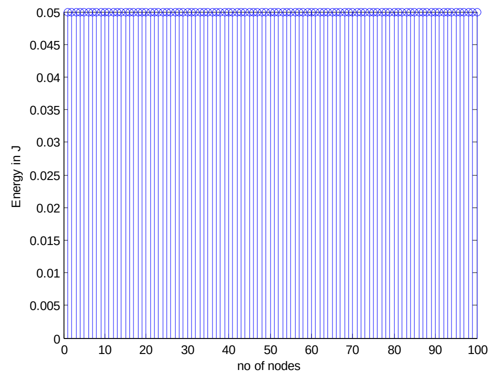

Figure 5. Stem plot of initial energy of nodes.

The average distance gives the better estimation of the next node to hop as well as the residual energy of the nodes. The deposition of pheromone is done by modifying one or multiple pheromone matrices. To avoid loops each ant needs to memorize the nodes it has visited already. Route is formed on the basis of probabilistic rule.

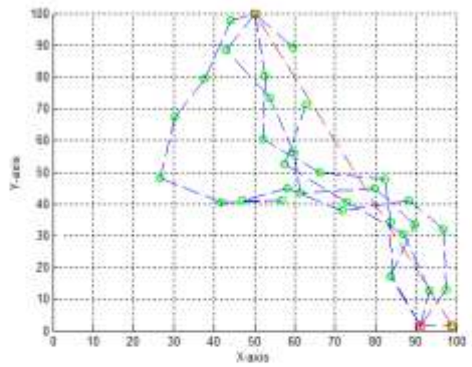

Figure 6. Formation of first best route.

The above route formation process will continues until all nodes does not took participation in route formation process.

This whole process is known as round and the best path is represented by the red lines.

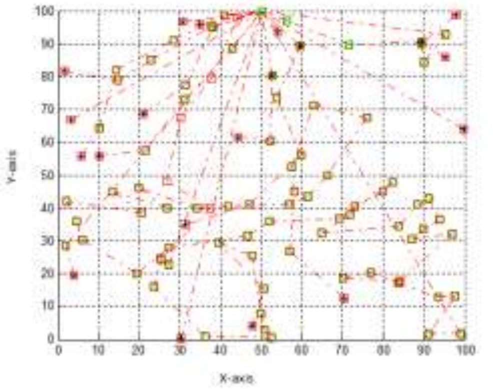

Figure 7. Final topology after 1st round.

After completion of one round we ascertain the aggregate every one of the energies of 100 nodes and checked whether the sum of energies of nodes is zero or not. In the event that entirety of energies is not equivalent to zero the entire procedure proceeds until the point when the energy of every node is not equivalent to zero.

Energy of nodes also deplete while sending the data from node to node and then to the base station. In route formation data is sent from one node to another. While doing so, the data is aggregated from one node to another along with the data of the node it is sending. The stem plot of energies after completing 100 rounds is as follows

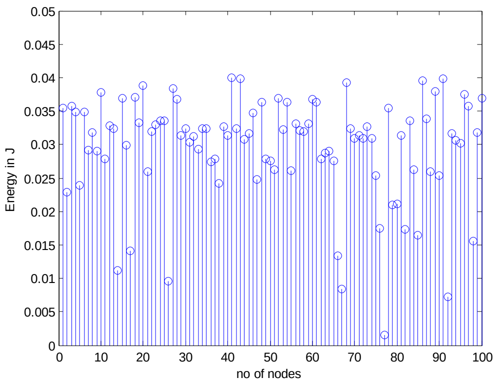

Figure 8. Stem plot of energy after 100th round.

No. of rounds are directly proportional to the lifetime of a network. As the rounds increases the lifetime of network also increases.

Lifetime of Wireless Sensor Network is defined as the time spanning from the instant when the network starts functioning properly.The time (number of rounds) of network disconnection due to the failure of one or more sensor nodes.

When node transmits and receives the data packets it looses some amount of energy due to which the initial energy of nodes starts depleting. After transmitting and receiving data packets the remained energy of the sensor nodes is termed as the Residual Energy. So, residual energy is the current energy of the nodes after transmitting and receiving data packets.

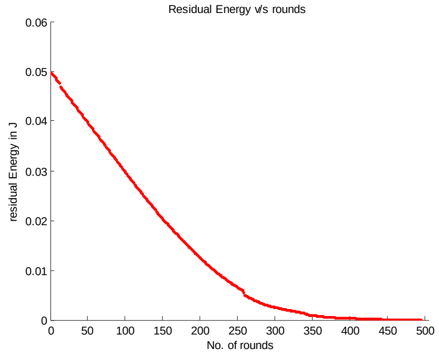

Figure 9. Graph of residual energy v/s number of rounds.

At the point when energy of every node is zero the framework is dead. At the point when the proposed strategy is simulated for 100 nodes, the network made due for longer time, in our proposed technique our system becomes dead after completing 495 rounds.

Simulation results are given for the proposed routing technique based on foraging behavior of ant colony optimization along with the results of average energy consumption in different cases

TABLE I. AVERAGE ENERGY CONSUMPTION FOR DIFFERENT SCENARIO

No. of nodes	Average Energy Consumption(in J)
100	0.0101
150	0.0158
200	0.0223
250	0.0281
300	0.0333

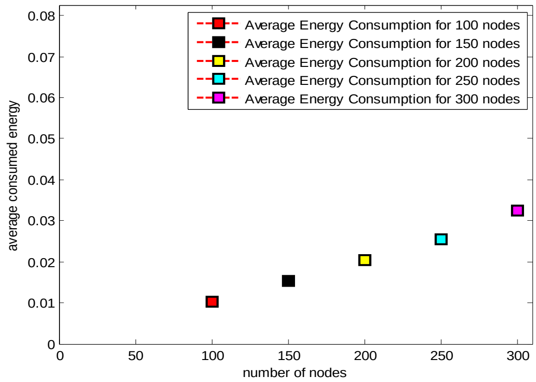

Figure 10. Plot of average energy consumption.

So, the proposed technique is energy efficient and hence, the lifetime of WSN is improved with the execution of proposed approach.

VI. CONCLUSION AND FUTURE SCOPE

As expressed earlier, the most recent applications request greatest lifetime of network with the goal of longer lifetime and more information can be exchanged to the BS. Unfortunately, a large portion of energy is devoured in information transmission, gathering and collection forms. To tackle the issue, existing techniques were presented in Wireless Sensor Network. The path toward setting up courses from a source to a sink through one or more relay is called routing. In routing the

ISSN: 2454-4248
182 – 186

nodes aggregate information starting with one node then onto the next and transmit it to the base station. The emphasis is laid on energy efficient routing techniques for WSN based on foraging conduct of ants. It intended to propose a routing procedure based on the nature inspired algorithm keeping in mind the end goal to maximize the lifetime of the network. Simulation demonstrated the execution of the proposed work. The algorithm makes the framework energy efficient and furthermore improves the lifetime of the network by shaping efficient and optimum routes.

With the achievement in enhancing the lifetime of WSN, in any case, some exploration work still needs to be done.

- Hybridization of atleast two existing techniques can bring about diminished intricacy.
- Different parameters can be thought about like quality of service, load balancing, reliability of connection among sensor nodes to further improve the lifetime of network.
- Loss Rate ought to be least so that the network lifetime comes out to be more efficient.

References

[1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "A survey on sensor networks," *IEEE Communications Magazine*, vol. 40, no. 8, pp. 102–114, Aug. 2002.

[2] J. N. Al-Karaki and A. E. Kamal, "Routing techniques in wireless sensor networks: A survey," *IEEE Wireless Communications*, vol. 11, no. 6, pp. 6–28, Dec. 2004.

[3] W. Dargie and C. Poellabauer "Fundamental of Wireless Sensor Networks: Theory and Practice", John Wiley & Sons, 2010.

[4] A. W. Ali and Parmanand, "Energy Efficiency in routing protocol and data collection approaches for WSN: A Survey", *IEEE/International Conference on Computing, Communication and Automation (ICCCA2015)*, pp. 540-545, Greater Noida, India, 15-16 May, 2015.

[5] R. V. Kulkarni, A. Forster and G. K. Venayagamoorthy, "Computational intelligence in wireless sensor networks: A survey," *IEEE Communications Surveys & Tutorials*, vol. 13, no. 1, pp. 68–96, 2011.

[6] M. Dorigo, V. Maniezzo and A. Colorni, "Ant system: Optimization by a colony of cooperating agents," *IEEE Transactions on Systems, Man and Cybernetics*, Part B (Cybernetics), vol. 26, no. 1, pp. 29–41, 1996.

[7] M. Dorigo and C. Blum, "Ant colony optimization theory: A survey," *Theoretical Computer Science*, vol. 344, no. 2-3, pp. 243–278, Nov. 2005.

[8] J.-H. Ho, H.-C. Shih, B.-Y. Liao and S.-C. Chu, "A ladder diffusion algorithm using ant colony optimization for wireless sensor networks," *Information Sciences*, vol. 192, pp. 204–212, Jun. 2012.

[9] A. E. Ghazi, B. Ahiod and A. Ouaarab, "Improved Ant Colony Optimization Routing Protocol for Wireless Sensor Networks," *Networked Systems*, vol. 8593, pp. 246-256, Aug. 2014.

[10] A. Mohajerani and D. Gharavian, "An ant colony optimization based routing algorithm for extending network lifetime in wireless sensor network", *Wireless Networks*, vol.22, no. 8, pp. 2637-2647, 2016.

[11] M. Dorigo, T. Stutzle, "Ant Colony Optimization," Bradford Book, 2004.

[12] B. Yegnanarayana, "Artificial neural networks," PHI Learning Pvt. Ltd., 2004.

[13] L. Schmitt "Theory of genetic algorithms," *Theoretical Computer Science*, vol. 259, no. 1-2, pp. 1-61, May 2001.

[14] R. Eberhart and Y. Shi, "Particle swarm optimization: developments, applications and resources," *IEEE Proceedings of the 2001 congress on evolutionary computation*, vol. 1. , pp. 81-86 Piscataway, NJ, USA, 2001.

[15] J. Zhu, H. Zhao and J. Xu, "An Energy Balanced Reliable Routing Metric In WSNs", *Wireless Sensor Networks*, vol. 1, no. 1, pp. 22, 2009.