Indian Journal of Science and Technology, Vol 9(33), DOI: 10.17485/ijst/2016/v9i33/95830, September 2016
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Fire Fly Optimization Algorithm based Clustering by Preventing Residual Nodes in Mobile Wireless Sensor Networks

Ramandeep Kaur*, Anupam Mittal and Ruchi Aggarwal

Department of Computer Science and Engineering, Chandigarh University, Gharuan - 140413, Punjab, India;
rimmiramandeep@gmail.com, anupam.cgc@gmail.com, ruchi1705143@gmail.com

Abstract

This paper regarding the use of the natural phenomenon's based optimization techniques to resolve the problem of non-clustered nodes. **Objectives:** This research minimizes energy consumption. Its objective is to provide efficient clustering for avoidance of residual nodes and prevents occurrence of dead nodes with usage of mobile nodes. **Methods:** In this research paper firstly deploy number of mobile nodes in specified region with usage of MATLAB environment. For grouping of these nodes LEACH protocol uses for clustering. During clustering with LEACH some nodes residual and not become part of any cluster. Firefly Optimization used for prevention of residual nodes and efficient clustering. It uses distance and light intensity parameters for clustering. GSA algorithm used for finding best path for data transmission with less energy consumption. **Findings:** In this research paper shows efficient clustering of nodes with prevention of residual nodes. In existing LEACH protocol some static nodes are residual and not become part of any cluster. These nodes send data directly to base station and consume large amount of energy. These individual nodes die early due to maximum energy consumption. But in this research mobile nodes are used and occurrence of dead nodes prevented on basis of distance and light intensity parameters. Nodes which are at minimum distance are brighter than farthest nodes. Minimum distance nodes join nearest cluster and prevent formation of remaining nodes. **Improvements:** In this paper results shown that it performs better in terms of network lifetime, energy consumption, end to end delay and throughput and number of dead nodes.

Keywords: Cluster Formation, Firefly Optimization, Routing, Wireless Sensor Networks

1. Introduction

Mobile Wireless sensor network is collection of sensor nodes that can change their position and interact with physical environment. Mobile wireless sensor networks an infrastructure less network which includes sensing, processing, and communication elements as sending and receiving data. Mobile wireless sensors used in many applications such as physical monitoring, target tracking, military and environment monitoring. Wireless sensor network in which nodes are stationary and cover only specific area in which nodes deployed. Energy and memory for data storage are limited in wireless sensor networks. Mobile Wireless Sensor Networks (MWSNs) in which nodes can leave or join connection of network at any time. Main difference is from WSNs is change of position at any time. Advantage for using MWSNs is less energy consumption for data transmission[1]. Mobile nodes can communicate to each other when these are eligible in specified range area. MWSNs have reduced energy consumption and enhance network coverage with network lifetime improvement. For less energy consumption clustering algorithm is used in which number of nodes grouped in one cluster. In each cluster on basis of energy Cluster Head (CH) is selected. All grouped nodes send data to cluster head. CH sends data directly to base station with usage of multiple dynamic paths. It prevents delays, consume less energy and increase delivery ratio[2]. Several protocols have been proposed for clustering. In this paper uses a LEACH (Low Energy Adaptive

*Author for correspondence

Clustering Hierarchy) protocol for clustering. It is hierarchical routing based protocol. It uses TDMA based MAC protocol for consuming less energy[3]. During clustering in MWSNs some of nodes are residual and not become part of any cluster. Such nodes send data directly to base station. For prevention of these residual nodes Fire Fly Optimization (FFO) used for clustering. Routing is major factor for data transmission. In this research uses a Gravitational Search Algorithm (GSA) for finding best hop for data transmission.

1.1 Routing Protocols

There are various techniques used for clustering in wireless sensor networks as a load balanced clustering algorithm which manages the traffic load between different size clusters. In this algorithm nodes grouped in a way that gateway controls the overall load of nodes in a specified network. There is not cluster head selected for routing[4]. Optimized Energy Efficient Routing Protocol (OEERP) maximize the lifetime of networks. OEERP works in three phases. In cluster formation cluster formed on basis of energy and it changes in every round. When some nodes are residual during cluster formation phase these nodes send data directly to base station. During re-clustering residual nodes eliminated and CH changes with uniform battery drain. Nodes not depend on beacon based transmission for long time to reach base station[5].

MH-PEGASIS algorithm proposed that increase the lifetime of network and minimizes energy consumption. Routing in single hop when cluster head at large distance from base station there is consume large amount of energy. Multihop PEGASIS consume less memory and it provides efficiently routing between cluster heads. It uses inter clusters Multihop routing to reach a base station[6].

Low Energy Adaptive Clustering Hierarchy –Mobile (LEACH) is enhanced cluster based routing protocol that select clusters on basis of residual energy of nodes, lowest mobility and least distance from base station. It mainly consists of five phases as initialization phase, cluster formation phase, CH selection phase, data transmission and re- clustering of nodes. It is energy efficient routing protocol that enhances the network lifetime[7]. Low-energy adaptive clustering hierarchy (O-LEACH) is a popular clustering protocol. This protocol select cluster heads and performs data aggregation processes on the clusters on the basis of residual energy. This algorithm has better stability than LEACH. This algorithm works on static nodes and dynamic nodes[8].

1.2 Optimization Techniques

Ant bee colony optimization and Ant colony optimization (ABCACO) techniques maximize the lifetime of networks. Wireless sensor network WSNCABC uses hierarchical clustering. It operates iteratively and decrease the distance between cluster head and base station. It gives better performance as lifetime of networks, scalability as compare to existing algorithms[9].

A novel centralized PSO protocol for Hierarchical Clustering (PSO-HC) in WSNs. For maximize the network lifetime by minimizing the number of active CHs and to maximize the network scalability by using two-hop communication between the sensor nodes and their respective CHs. PSO-HC outperforms in terms of average consumed energy and throughput[10]. PSO algorithm minimizes intra cluster distance between sensor nodes and consumes less energy[11].

Ant Colony optimization used for network routing. In this routing is on basis of ant's behavior, ants find shortest path from food to nest. An ant lays pheromones on ground while moving from source to destination. Other ants follow same path on basis of pheromones. With usage of ACO optimization reduce overhead on clusters with usage of optimal path for data transmission. But ACO applicable only where source and destination predefined. Pheromones value calculated on basis of number of hops to reach the nodes[12].

E-OEERP protocol which prevents individual node formation in clustering and improves the overall network lifetime and compared with traditional protocols such as LEECH, OEERP, DRINA, and BCDCP. E-OEERP uses Particle Swarm Optimization algorithm for elimination of individual nodes formation. Gravitational Search Algorithm (GSA) is used for constructing an optimal routing path to transmit the sensed data to the base station on basis of distance and force between the sensors nodes and it find the next best hop for data transmission[13]. Rest of this paper is organized as: Section II and Section III describes proposed methodology and describes results and interpretations, and Section IV describes Conclusion and future work.

2. Problem Formulation

Energy consumption and network lifetime main challenges in Mobile wireless sensor networks due to Multihop communication. To prevent formation of residual nodes that is not being part of any cluster. These nodes may die

if remain individual node for long time period because these individual nodes send data directly to base station. Data lost due to occurrence of dead nodes.

3. Proposed Methodology

In this section describes proposed methodology in which firstly deploy number of mobile nodes and perform clustering with LEACH protocol. Proposed methodology as shown in Figure 1 in which Fire Fly Optimization (FFO) algorithm applied for energy efficient clustering. FFO based routing protocol uses LEACH protocol. During clustering some nodes are residual not become part of any cluster. These Residual nodes prevented using FFO with distance calculation between nodes. On basis of distance residual nodes included in nearest cluster. Large distance paths also consume large amount of energy. GSA algorithm used to find optimal path from one node to another for data transmission.

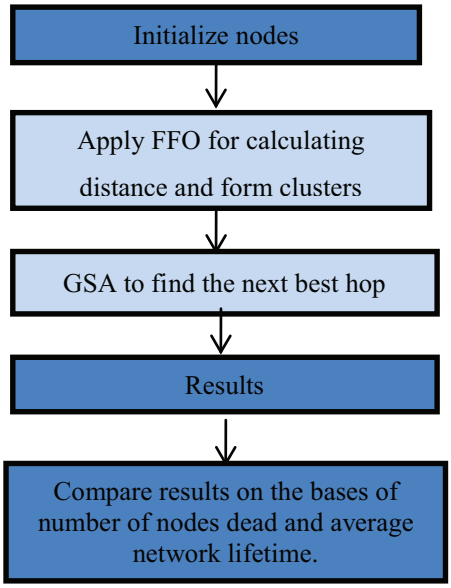

Figure 1. Proposed methodology.

3.1 Fire Fly Optimization

FFO algorithm is Meta-heuristic algorithms proposed by Dr. Xin She yang at Cambridge University in 2007. It is on the basis of flashing behavior of fireflies[14]. It finds the particle position. Firefly optimization mainly depends upon these methods:

1. All fireflies are unisex. These attract to each other on the basis of flash light.

2. Attractiveness of fireflies on basis of light directly proportional to its brightness. If there is not found brighter light of fireflies than firefly move randomly.

3. If distance between fireflies increases means light intensity decreases.

4. Objective function related to brightness of firefly.

According to inverse square law intensity of light I decrease as distance r between fireflies increases. Intensity (I) inversely proportional to radius as:

$$I \alpha 1/r2 \quad (1)$$

5. Firefly algorithm mainly depends on light intensity and attractiveness. According to inverse square law

$$I(r) = I_s/r^2 \quad (2)$$

where, I_s Intensity of source and r radius (distance between fireflies). But there is fixed light absorption γ

$$I=I_0 e^{-\gamma r2} \quad (3)$$

I_0 Initial intensity. Firefly's attractiveness β is proportional to the light intensity seen by different fireflies which can be defined as:

$$\beta= \beta_0 e^{-\gamma r2} \quad (4)$$

where, β_0 is attractiveness when radius=0

Light intensity changes with changes in distance as r changes[15].

3.1.1 Clustering using Firefly Algorithm

Each node distance calculated on basis of brightness. Each cluster adds nodes on basis of distance from CH form a new cluster and prevent residual nodes. Distance between nodes calculated as:

$$\text{Distance} = (X_1-X_2)^2(Y_1-Y_2)^2\text{^}0.5 \quad (5)$$

In Firefly algorithm, clustering energy of sensor nodes considered as light intensity of fireflies. Sensor which is brighter considered as with maximum energy. Light intensity fireflies move towards brighter intensity fireflies. Similarly, in clustering less energy nodes move towards higher energy nodes. Fireflies move from one location to another location with attraction toward brighter firefly[16].

The Firefly algorithm improve network lifetime and the throughput of the network with selection of CH on basis of residual energy and nodes in cluster coverage selected on basis of distance[17] as shown in Figure 2.

3.2 Gravitational Search Algorithm (GSA)

GSA algorithm used in routing for finding optimal path[18]. It finds next best hop for data transmission from source to destination. It sends nearest path identification message to all its neighbors. Nearest Path identification message

collect information about the neighbor nodes location, light intensity. Neighbor nodes send same request to its own neighbors for collecting information about nodes location. This process repeated until it reaches to base station.

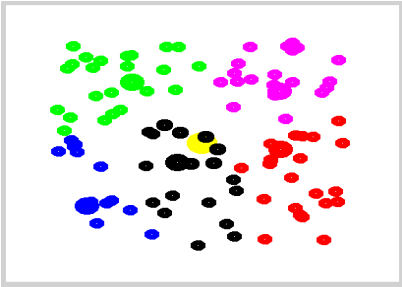

Figure 2. Cluster formation using Fire Fly algorithm.

GSA based on the Gravitational algorithm of Newton[19]. According to Newton's law of Gravity "Every substance attracts other substance with force F which directly proportional to product of masses and inversely proportional to distance between them" It is stated as:

$$F=G.\ [M_1M_{2/}R^2] \quad (6)$$

where,

F= Force of particles

G= Gravitational constant ($G=6.8*10^{-11}\ m^3kg^{-1}s^{-2}$)

M_1 and M_2 masses of particles

R= Radius (distance between particles)

Law of Motion describes relationship between particles mass m, acceleration a, Force F applied as shown in Figure 3.

a=F/M

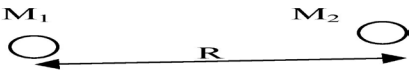

Figure 3. Newton's law of gravity.

Acceleration is minimum for large size particles and maximum for small size particles. GSA combines both these laws. According to GSA algorithm every particle attracts to another particle with gravitational force.

Gravitational Search Algorithm is used in the Cluster Formation Phase and Path Establishment Phase for routing the data from nodes to base station. On basis of range or distance parameters it selects clusters and route data[20]. When clusters are formed with Firefly algorithm, all clusters nodes start transmission of data to their respective cluster head. Cluster head collect data from nodes and transfer to base station for less energy consumption. All clusters calculate shortest routing path with searching next best hop with usage of GSA algorithm as shown in Figure 4.

Force of attraction greater in nearest nodes rather than farthest node. Greater force and minimum distance indicates better transmission with less energy consumption. In various clusters distance different from each other. GSA finds the location of nodes in wireless sensor networks[21].

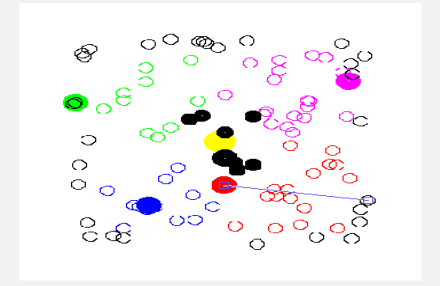

Figure 4. Calculation of force between CHs.

LEACH protocol used with FFO and GSA algorithm as:

1. In first method initialize nodes with LEACH protocol.

2. Distance calculated on basis of brightness of sensor nodes. Form a cluster on basis of distance between nodes with FFO and prevention of residual nodes with cover the region on basis of distance.

3. Apply GSA algorithm to find best route information.

4. Evaluate results and compare with LEACH protocol for clustering in mobile wireless sensor networks.

4. Simulation Environment

The simulation of the proposed methodology is being done in MATLAB. This technique uses LEACH protocol with FFO and GSA algorithm for simulation in MATLAB. Deployment area with 100 nodes deployed randomly for the simulation of LEACH protocol. In this simulates the previous clustering algorithm with LEACH protocol in which residual nodes arises. Residual nodes prevented with re-clustering the nodes with the firefly algorithm. In this implementation uses five clusters where the data sending is happening form all nodes with one node at a time. The strategy is repeated with the firefly algorithm for the calculation of cluster on the base of brightness. Simulation parameters shown in Table 1.

There are some assumptions for simulation

1. Every node is considered as firefly and every node consist of its own battery.

2. All nodes have same energy during initialization phase and nodes deployed randomly in search space.

3. When nodes move and during transmission energy consumed.

Table 1. Network parameters

Parameter	Value
Number of Nodes	100
Network Size	400*400
Initial Energy of Nodes	100 mJ (Milijoules)
Radius of Cluster	12
Number of clusters	5
Nodes movement	Mobility
Base Station position	200*200

4.1 Results Interpretations

Results are evaluated with simulation of LEACH protocol in which residual nodes arises due to coverage problem. In which colored nodes represent clusters and blank nodes represent residual nodes due to coverage problem as shown in Figure 5. In proposed hybrid approach LEACH protocol uses with usage of FFO for clustering. During reclustering residual nodes join nearest clusters on basis of distance calculation with firefly algorithm as in Figure 2. Residual nodes prevented with reclustering on basis of distance calculation as brightness feature calculation of light intensity.

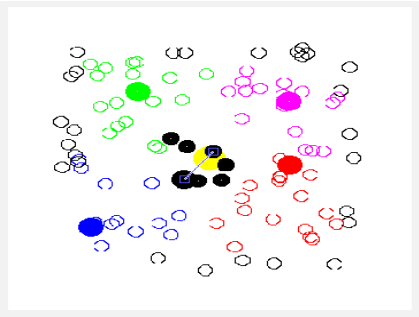

Figure 5. Cluster formation using LEACH protocol.

4.2 Performance Analysis

Various parameters are analyzed and compared with existing and new approach like energy consumption, throughput, number of dead nodes, Network Lifetime, end to end delay.

4.2.1 Energy Consumption

Energy Consumption of node measured on basis of transmission. The energy comparison also shows the energy consumed comparison between LEACH and LEACH + FFA. LEACH+FFA+GSA performs better consuming less energy because the cluster is now better so the energy consumed is less as shown in Figure 6.

It can be calculated as

E_p previous energy, E_c current energy, E_r residual energy

$E_r=E_p-E_c$

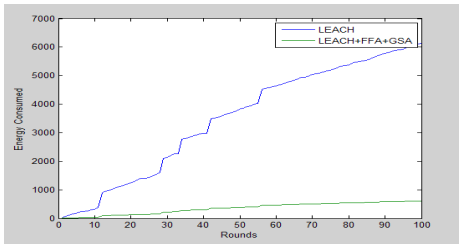

Figure 6. Comparison of energy consumption.

4.2.2 Network Lifetime

The network life time graph shows that the detail of rate of nodes getting dead during the simulation of the network. It shows the in the LEACH + FFA+GSA network performs better because the network energy efficient. Efficient network lifetime shown in Figure 7.

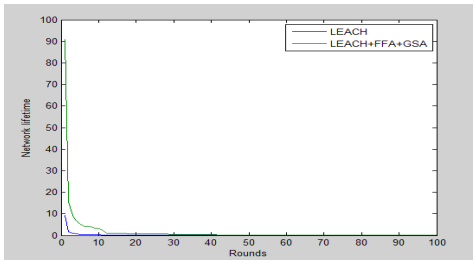

Figure 7. Comparison of network lifetimes.

4.2.3 Number of Dead Nodes

The number nodes graph shows that the detail of nodes dead during the simulation of the network. It shows the in the LEACH+FFA+GSA network performs better because the network energy efficient as shown in Figure 8.

4.2.4 Throughput

The ratio of total data received by a receiver from a sender for a time the last packet received by receiver measures in bit/sec and byte/sec.

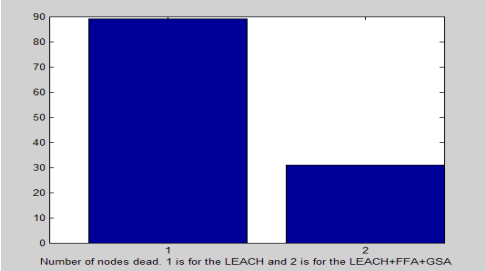

Figure 8. Comparison on basis of dead nodes.

The throughput since the energy consumption is small the transmissions are more effective so the network does not go under any congestion and the network also has very high packet transfer rate. So the throughput is very high in case of LEACH + FFA+GSA as in Figure 9.

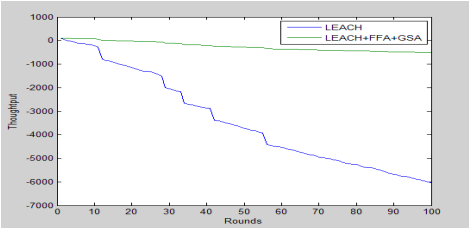

Figure 9. Throughput.

4.2.5 End to End Delay

It is the average delay between the sending of the data packet by the source and its receipt at the corresponding receiver including the delays due to route acquisition, buffering and processing at intermediate nodes, and retransmission delays at the MAC layer, etc. if the value of End-to-end delay is high then it means the protocol performance is not good due to the network congestion.

In delay because the throughput is high in the case of LEACH+FFA+GSA the delay between the packets is very less the and hence the end to end delay is very less as in Figure 10.

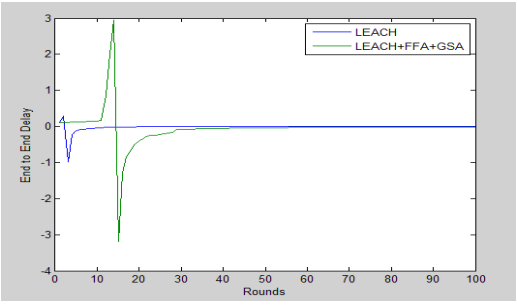

Figure 10. Comparison of end to end delay.

5. Conclusion and Future Scope

This paper describes Hybrid approach with LEACH, FFO and GSA algorithm. In the existing LEACH, the individual node formation takes place during cluster formation. These residual nodes send data directly to base station and consume large amount of memory. These nodes also die due to large energy consumption. The need of energy consumption reduction is huge. In this paper firefly algorithm used for prevention of residual nodes during clustering. GSA algorithm used to find best route information for less energy consumption. In this simulated the approach with parameter like energy consumption, Network lifetime, Number of nodes dead, Throughput and End to End delay. Results show that LEACH+FFA+GSA algorithm performs better than LEACH protocol and also prevents residual nodes formation during clustering. Future work can be done on multiple mobile base stations. Multiple mobile base stations also improve energy utilization, network lifetime and reduce number of dead nodes, it basically proceeds from future of tracking and observing in MWSNs.

6. References

1. Tolba FD, Ajib W, Obaid A. Distributed clustering algorithm for mobile wireless sensors networks. IEEE; 2013.
2. Varma GNSA, Reddy GAK, Theja YR, Kumar TA. Cluster Based multipath Dynamic Routing (CBDR) protocol for wireless sensor networks. Indian Journal of Science and Technology. 2015 Jan; 8(S2). DOI: 10.17485/ijst/2015/v8iS2/57793.
3. Abad MFK, Jamali MJA. Modify LEACH algorithm for wireless sensor network. International Journal of Computer Science. 2011 Sep; 8(5), No 1:219–24.
4. Revathi AR, Santhi B. Efficient clustering for wireless sensor networks using evolutionary computing. Indian Journal of Science and Technology. 2015 Jul; 8(14).
5. Chandl KK, Bharati PV, Ramanjaneyulu BS. Optimized energy efficient routing protocol for life-time improvement in wireless sensor networks. International Conference on Advances in Engineering, Science and Management (ICAESM -2012); 2012 Mar 30–31.
6. Aliouat Z, Aliouat M. Efficient management of energy budget for PEGASIS routing protocol. 6th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT); 2012.
7. Anitha RU, Kamalakkannan P. Enhanced cluster based routing protocol for mobile nodes in wireless sensor net-

work. International Conference on Pattern Recognition, Informatics and Mobile Engineering (PRIME); 2013.
8. El Khediri S, Nasri N, Wei A, Kachouri A. A new approach for clustering in wireless sensors networks based on LEACH. International Workshop on Wireless Networks and Energy Saving Techniques (WNTEST); 2014.
9. Kumar R, Kumar D. Hybrid swarm intelligence energy efficient clustered routing algorithm for wireless sensor networks. Hindawi Publishing Corporation, Journal of Sensors; 2016.
10. Elhabyan RS. PSO-HC: Particle Swarm Optimization Protocol for Hierarchical Clustering in wireless sensor networks. International Conference on Computing: Networking; 2014.
11. Latiff NMA, Tsimenidis CC, Sharif BS. Performance comparison of optimization algorithms for clustering in wireless sensor networks. IEEE; 2007.
12. Bains V, Sharma K. Ant colony based routing in wireless sensor networks. International Journal of Electronics and Computer Science Engineering. 2012; 1(4):2516–54
13. Parvin R. Particle swarm optimization based clustering by preventing residual nodes in wireless sensor networks. Sensors Journal; 2015.
14. Apostolopoulos T, Vlachos A. Application of the Firefly algorithm for solving the economic emissions load dispatch problem. International Journal of Combinatorics. 2011.
15. Arora S, Singh S. The Firefly Optimization algorithm: Convergence analysis and parameter selection. International Journal of Computer Applications. 2013 May; 69(3).
16. Manshahia MS. A Firefly based energy efficient routing in wireless sensor networks. African Journal of Computing & ICT; 2015.
17. Bansal JC, Deep K. Optimization of directional overcurrent relay times by particle swarm optimization. Swarm Intelligence Symposium (SIS 2008); 2008. p. 1–7.
18. Rafsanjani MK, Dowlatshahi MB. Using gravitational search algorithm for finding near-optimal base station location in two-tiered WSNs. International Journal of Machine Learning and Computing. 2012 Aug; 2(4).
19. Rashedi E, Nezambadi-pour H, Saryadzi S. GSA: A Gravitational Search Algorithm. Information Science; 2009.
20. Parvin JR, Vasanthanayaki C. Gravitational search algorithm based mobile aggregator sink nodes for energy efficient wireless sensor networks. International Conference on Circuits, Power and Computing Technologies; 2013.
21. Krishnaprabha R, Gopakumar A. Performance of gravitational search algorithm in wireless sensor network localization. 2014 National Conference on Communication, Signal Processing and Networking (NCCSN); 2014.