An Energy Optimization in Wireless Sensor Networks using Clustering and PSO Algorithms

Madhuri M Barhate, Prof. SupriyaMadane
Department of Computer Engineering
TCOER Pune, India
E-mail: madhuri.talele3@gmail.com,
supriyamadane.tcoer@kjei.edu.in

Abstract: In Wireless Sensor Networks thousands of nodes are deployed in environment where there is no access to replace batteries. So, designing an energy efficient routing algorithm is a major challenge. Numbers of clustering algorithms such as LEACH, GSA, FCM, and DRINA have been developed to improve the energy balance of the WSN's as energy is the main aspect of WSN's during data transmission. Heuristic algorithms can find best solution in less time. These algorithms are used with mathematical and AI problems to find optimal solution. In this paper combination of fuzzy clustering and PSO algorithm is used to create clusters and find optimal route. Then, the proposed method is implemented in net beans. The proposed method is compare with two tire distributed fuzzy logic based protocol TTDFP which is investigated by energy consumption, packet delivery ratio, events monitored by sink, and event loss ratio.

Key words:—WSNs, Data Routing, Routing Protocol, ,Fuzzy Clustering, PSO.

I. INTRODUCTION

Wireless sensor networks are becoming more popular as cost of sensor gets cheaper [1]. A wireless sensor network is a deployment of numbers of small, less expensive, battery powered devices that can sense, compute, and communicate with other devices for the purpose of collecting local information to make worldwide decisions about a physical environment. Sensor nodes work with some limited resources like battery power, memory and bandwidth etc. The Sensor nodes sense the changes in external environment and send the data to other nodes in the network called sink node or Base Station (BS) located inside or outside the network via single hop or multi-hop. The performance of the wireless sensor networks gets affected by the limited battery lifetime of the sensor nodes [5]. The wireless sensor networks are used in many applications such as military applications, health monitoring, volcano monitoring, machine health monitoring and many more. Sensors handle sensitive and critical data in many applications and need accurate information. Large WSNs are created to cover large geographical area , as the number of nodes increases, the number of messages also increased, causing increase in communication cost and energy consumption, due to redundant data collected by sensor nodes[1]. The main problem in WSNs is that sensor is battery oriented device and need some energy for sensing, computing and transmission of message. Changing, charging or replacing battery is impossible or not easy in some application such as volcano monitoring, forest fire detection, natural disaster alert system, air pollution monitoring, landslide detection, Water quality monitoring etc. So saving energy utilization by sensors and networks during functionality is the only solution. To reduce large raw data transmission data aggregation is used. Clustering is most common method for data aggregation[6]. In WSNs cluster consist of one or more member sensor node and single cluster head. Cluster head gather data from member node and transfer it to main location (BS). The cluster head is selected by considering residual energy of a node[4]. The node having higher energy is selected as a cluster head in many algorithms. There are many algorithms for fuzzy clustering. In [4] the concept of GSA (Gravitational Search Algorithm) is used to find next hop using parameters such as particle position, velocity, and distance between cluster head to select next hop .The GSA have high computational complexity. In [1] TTDFP algorithm is divided in two phases a clustering phase and routing phase. In clustering phase TTDFP use three fuzzy parameters, connectivity of nodes, distance to base station and remaining node energy. In routing phase two fuzzy parameters are considered average link residual energy and relative distance for path establishment. But computational complexity is high also due to multi hop topology energy hole problem may arise. In this proposed work fuzzy clustering method is used with PSO. In this first sensors are divided into clusters for transmission of data from sensor to BS then PSO is used for cluster head selection and finding route. In section II, related works and researches are reviewed. Then in III section proposed mechanism is mentioned. In IV section proposed algorithm is evaluated. Then section V is for the conclusion.

II. RELATED WORK

In WSN, various clustering and routing techniques are used to improve the performance and prolong lifetime of the network. This mechanism is based on energy optimization during the routing processes. In this section, a brief overview of existing energy efficient Multi-hop routing protocol for Wireless Sensor Networks with energy harvesting and optimization tools is given. We present the review of related work based on both heuristic and nature inspired approaches.

A large number of clustering algorithms based on heuristic methods have been developed for WSNs. Among these LEACH [8] is a well known distributed clustering algorithm in which the sensor nodes elect themselves as a CH with some probability. LEACH provides more energy saving and prolongs the lifetime of the network compared to static clustering and minimum transmission energy (MTE) protocol. However, the main disadvantage of this algorithm is that there is a possibility to select a CH with very low energy, which may die quickly and thus degrades the performance of the network. so , number of algorithms have been developed to improve LEACH protocol, PEGASIS [9] and HEED [10] are popular among them. PEGASIS organizes the nodes into the chain so that each node transmits and receives the data only from its neighbour nodes. In each round, CHs are selected from the chain of nodes. PEGASIS is more energy efficient over LEACH but it is unstable for large size networks. Also the delay is significantly high.

In [4] The Data Routing In-Network Aggregation (DRINA) algorithm is proposed. The DRINA algorithm is a cluster-based approach. Aim of this algorithm is to build a routing tree that connects all source nodes to the sink while maximizing data aggregation by using the shortest paths. For every new event occurs in the network, a cluster is formed of the nodes that detected the same event as well as cluster head is elected among the nodes. After that, routes are created by selecting nodes in the shortest path. DRINA uses fewer control packets to build the routing tree also it does not flood a message to the whole network whenever a new event occurs. In this algorithm the number of overlapping paths are more, it increases the aggregation rate. It decreases the communication cost and energy consumption. This algorithm follows the static shortest path route that leads earlier network partition and also it requires efficient cluster head mechanism for cluster head selection for each cluster. In[7], author proposed EBDRA algorithm to overcome problems in DRINA like inefficient cluster head selection technique , it is unable to mange cluster head failures and the energy drain in sensor nodes in the common static path and create network partition. To overcome these problems author proposed new algorithm EBDRA (Energy Efficient Routing using Dynamic Cluster approach), which provide efficient cluster head selection technique and dynamic route selection for the reliable data transmission. In this approach the cluster head selection technique involves an efficient method of cluster head selection. This algorithm reduces the communication overhead, energy consumption and increases the network lifetime when compare to earlier state of art works.

In [12] a two-tier structure is made and is used for cluster head selection and the router problem. It is a two-step process. The first one helps in selecting the Cluster Heads (CH) and the second one helps in the formation of the routing tree that helps the nodes in a cluster to communicate with the Base Station (BS). In [13] Distance-Energy Cluster Structure Algorithm (DESCA) is proposed which is based on the famous clustering algorithm LEACH. It considers distance and residual energy of the nodes. It also improves the Cluster Head (CH) selection as well as the data transmission over the network

III. PROPOSEDSYSTEM.

Network Model: The sensor nodes are placed in 100 × 100 m area in grid format. All the placed nodes will perform both transmission and gathering of data (messages) . Every sensor node will send the information to CH or a cluster member and further, CHs process the information and send the processed information to the base station (BS). The base station decides the CH for every round based on the clustering algorithm. The CH is responsible for data aggregation and communication.

*Energy Model:*In WSNs, the CHs selection depends on the fitness function. In this work, a new fitness function is designed for CHs selection. This function comprises the two-important aspect of WSNs i.e. the energy consumption between CH and sensor nodes and the amount of energy consumption for aggregating the data at CHs level plus transmitting the information to BS.

Whenever a node sends or receives sensed information it has to spend some energy called free space (D2 power loss) for the purpose of one-hop ordirect transmission and the multipath fading channel (D4 powerloss) for packet transmission via multihop. Therefore, energy consumptionmodel can be mathematically defined as follows:

$$E_n T_{rx}(L, D) = \begin{cases} LE_{n(elect)} + L\varepsilon_{fresh} D^2, & D < D_0, \\ E_{n(elect)} + L\varepsilon_{mpx} D^4, & D \geq D_0 \end{cases} \text{----(1)}$$

Here, L is the size of data packet. ε_{fresh} represents free space energyloss. ε_{mpx} is multipath energy loss. D_0 is a threshold distance whichcontrols states whether to use ε_{fresh} or εmpat. $D_0$is computed asfollows:

$$D_0 = \sqrt{\frac{\varepsilon_{fresh}}{\varepsilon_{mpx}}} - - - -(2)$$

The estimation of fitness value will be done using fitness functionwhich is minimum path distance. The distance betweentwo nodes will be calculated using Euclidian distance as:

$$D = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \text{-------(3)}$$

Each particle's position is evaluated using a fitness function.Fitness value of each particle is calculated as,

$$fitness = \alpha 1.x1 + \alpha 2.x2 + \alpha 3.x3 - - - -(4)$$

Where $\alpha 1$, $\alpha 2$, be any constant 0 and 1 and $\alpha 3 = 1 - \alpha 1 - \alpha 2$.

$$x1 = \frac{\sum(d_N - d_p)}{C_n} \text{------(5)}$$

Where $d_N - d_p$distance between Nth node and particle p,

Cn is number of cluster node reachable from particle p.

$$x_2 = \frac{E_{avg}(C_n)}{E_{(p)}} \text{----(6)}$$

$$x_3 = \frac{1}{(C_n)} - - - (7)$$

Where, n no of particle reachable to particular particle.

New velocity is calculated as follows:

$V_{update} = \omega . V_{t-1} + \omega 1(P_{t-1} - P_t) + \omega 2 P_{t-1} * P_t$---(8)

Where, ω is weight of node velocity, $\omega 1$ and $\omega 2$ is weights of node location, V_{t-1} is previous velocity of node P_{t-1} is previous position of node, Pt is current position of a node.

The inertia weight can be defined using equation,

$$W = W_{initial} - \frac{maximum\ iteration - current\ iteration}{Total\ Number\ of\ Iterations}$$

$$X_{newj} = X_{oldi} + V_{newj} \text{---------(9)}$$

IV. PROPOSED ALGORITHM

Steps of the proposed PSO Algorithm

1. Set w, ω, C_1, C_2 and C_3parameters
2. Initialize particles

$P_{i,}\ i, j, 1 \le i \le NP, 1 \le j \le D = m$, Number of CHs.

3. Compute the fitness (Pi) of each particle using equation 6 and find the personal best position of particle and set it to $Pbest_i$.
4. Compute the global best position of particle using the following equation,

$$Gbest = \{Pbest_k | Fitness(Pbest_k = \min(Fitness(Pbest_i|), i, 1 \le i \le NP)\}$$

5. Update velocity and position of (Pi) using equations (8) and (10) and CalculateFitness (Pi).
6. If

$$Fitness(P_i) < Fitness(Pbest_i) < Fitness(Pbest_i) then\ Pbest = P_i$$

7. If

$$Fitness(P_i) < Fitness(Pbest_i) < Fitness(Gbest_i) then\ Gbest = P_i$$

8. Repeat the steps 3-7 until the stopping criteria are not met.

IV EXPERIMENTAL RESULTS

This section demonstrates experimental results of the proposed protocol. The proposed protocol is implemented in Net-Beans IDE 8.0.1 environment using window 7 based PC with 2.93 GHz, Intel Core i7 processor and 4 GB RAM. To validate the proposed algorithm, network life time and packets sent to BS are chosen as performance parameters. The result of the proposed algorithm is compared with TTDFP algorithm. Figure 1.Shows the comparison of TTDFP and Proposed Algorithm in terms of energy depletion.

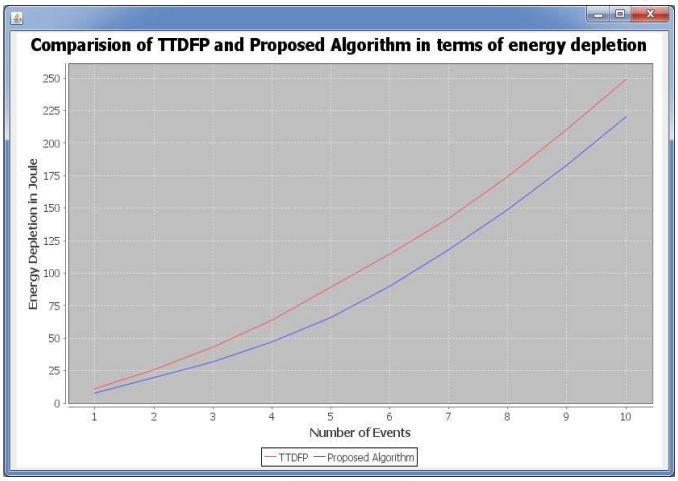

Figure.1comparison of TTDFP and proposed algorithm in terms of energy depletion.

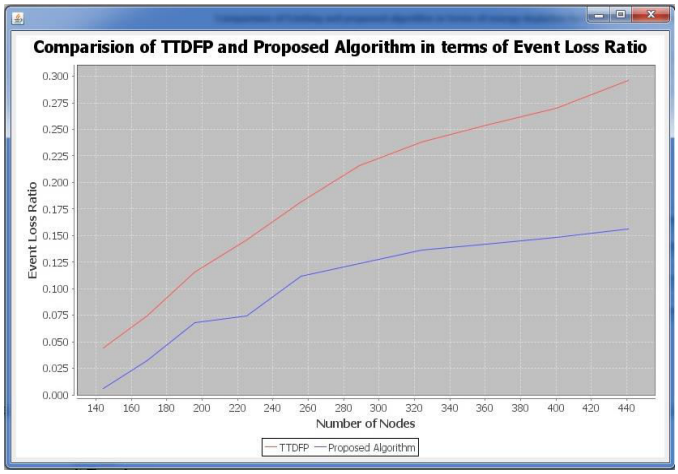

Figure 2 shows the comparison of TTDFP and proposed algorithm in terms of events loss ratio.

Hence, it is observed that combination of the PSO algorithm with fuzzy clustering increases the life time of the network and reduced the power consumption of nodes.

TABLE1*shows the parameter settings of the wireless sensor network are as described.*

Parameter	Value	Parameter	Value
Network field	100m x 100m	EDA	5 nJ/ bit/ Message
Number of nodes	100	Emp	0.00013pJ/bit
Initail energy of Nodes (E0)	0.5J	Message Size	4000 bits
ETX	50 nJ/ bit	Po	0.1
ERX	50 nJ/ bit	Efs	10pJ/bit
c1	2	c2	2

CONCLUSION

Today, Wireless Sensor Networks (WSN's) are used at various places such as forest fire detecting system, natural disaster alert system, area monitoring, and health care system. Numbers of clustering algorithms have been developed to improve the energy balance of the WSN's because energy is the main aspect of WSN's during data transmission. These algorithms are mainly used for increasing the lifetime of these sensor networks. One such algorithm is TTDFP. This paper suggests an algorithm based on fuzzy clustering and Particle Swarm Optimization (PSO) technique for improving network life time. It helps in forming the clusters as well as the Cluster Head (CH) selection. The proposed algorithm is extensively experimented and then the results of this algorithm are compared with the previous algorithm such as TTDFP. It is concluded that the PSO based clustering algorithm gives better results.

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Author's Biographies

Madhuri M Barhateis a pursung M E in computer Engineering form TCOER Pune.

Prof. SupriyaMadaneis Assistant Professor in TCOER Pune, having 12 years teaching experience. Her work is in wireless Sensor Network. .