Balanced-DESA for Cluster Formation to Prolong Lifetime of Wireless Sensor Network

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***Abstract*- The energy consumption in wireless sensor network is main concern because the power sources are non-rechargeable just like batteries. Better utilization of contained energy is important because network need the energy for continuous communication. One of traditional approach to do this is clustering. Here we present optimization techniques which are useful in selection of optimal cluster head. As the selection of improper cluster head cause earlier death of nodes because the nodes communication depends on cluster head. Here we going to propose a CH election technique to prolong the lifetime of wireless sensor network.**

***Index Terms*- Wireless Sensor Network, Clustering, Leach Protocol**

I. INTRODUCTION

Recent expansion in sensor technology enable us in the development of low cost and low power wireless micro-sensors [1].WSN consists of a large number of tiny sensor nodes which are distributed over a large application area with one or more powerful sinks or base stations (BSs) collecting information from these sensor nodes. All sensor node have some limited resources like battery life, bandwidth and have the capabilities of information sensing, data processing and wireless communication. Sensor nodes work together to perform the task in time and provides information accurately.

Sensor nodes sense the external environment or application area and send the data to base station located inside or outside the network via single hop or multi-hop. User access the collected data through some remote access. Sensor nodes work with some limited resources like battery power, bandwidth, and memory etc. Wireless sensor network lifetime depends upon limited energy of nodes as every node operation consumed energy. These nodes cannot be replaceable and rechargeable so efficient energy consumption by the nodes is the main design issue in Wireless sensor network (WSN) from the circuitry of sensor nodes to application level to network protocols [2].

Clustering protocols [3] aim to achieve energy efficiency. The whole network is divided into clusters where each cluster have one cluster head. All nodes in the cluster collected the sensed data and send to the base station or sink node. This eliminates a lot the redundancy in packet forwarding. (LEACH) Low Energy .Adaptive Clustering Hierarchy is considered to be the best protocol which used Clustering technique to save wsn lifetime. Multihop-LEACH, LEACH-MF, MR-LEACH or M-LEACH are examples of few Clustering Protocols which are the improvements of LEACH. “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”. [4].The optimization technique are useful in selecting the optimal cluster head and preventing the earlier death of nodes [5].optimization technique is divided in two types. First is heuristics which work on one problem at a time and greedy in nature give local minimum and fail in finding global minimum. Second is meta heuristics which work on set of problem at a time and depend on problem find the global minimum.

II. RELATED WORK:

In recent years, many researchers develop new routing protocol for wireless sensor network. (LEACH) Low energy adaptation clustering hierarchy [6] is one of the main distributed cluster based routing algorithm used to increase the lifetime of WSN.

In this algorithm cluster head is selected randomly. It work in two phase set up phase and steady state phase. In set up phase each node in the cluster choose a random number between range [0, 1], then this value of node compare with the threshold value T, if the value is lesser then the node is chosen as cluster head.

$$T(n) = \begin{cases} \frac{p}{(1-p*[rmod(\frac{1}{p})])} & if\ n \in G \\ 0 & if\ n \notin G \end{cases} \quad (1)$$

Where, r represent the round, p is the probability that each of the node will become cluster head. G is set of all nodes that are eligible to become a cluster head.

Mu Tong et al. [7] Based on the analysis on the defect in LEACH including the fluctuation of the number of cluster heads and the ignorance of the node's residual energy, presented a novel protocol called LEACH-B (LEACH-Balanced). At each round, after first selection of cluster head according to LEACH protocol, a second selection was introduced to modify the number of cluster head in consideration of node's residual energy. As a result the number of cluster head was constant and near optimal per round. The enhanced algorithm has overcome the shortcoming of the original protocol by taking the node's residual energy into consideration and keeping the constant and near optimal number of cluster heads at each round.

Vipin pal and et. al. [8] GA is an optimization technique for selection of optimal cluster head. In GA cluster head is elected according to their residual energy and take care of distance of cluster head to node, cluster head to base station and vice-versa.

Storn rainer and et. al. [9] DE is evolutionary algorithm which is aim at global optimization. DE is similar to genetic algorithm in many sense only difference is that in GA the crossover is done first after that mutation is done. In GA mutation is applied after crossover but in DE for every round the mutation is done to produce the better fitness children.

Das S koner and et. al.[10] simulated annealing is a meta- heuristic technique for global optimization . SA represent the probability of accepting worse solution and provide best solutions. Worse solution is a fundamental property as it allow most of extensive search for optimal solution. The rejection probability is given as follows:

$$p=\exp\left(\frac{\Delta E}{k_b T}\right) \quad (2)$$

$$\Delta E = \gamma \Delta f \quad (3)$$

Where Δf change in fitness function and γ is inverse Boltzmann's constant. ΔE Change in energy, k_b is Boltzmann's constant and T is the temperature for controlling the annealing process.

III. SYSTEM MODEL

The radio energy model is free space model. K-bit data is transmitted from transmitter section to receiver section which are separated by distance d. The transmitter section consist of transmit electronic and amplifiers in which energy is dissipated. On the other hand the receiver section have receiver electronics that also dissipate energy. The transmit energy (E_{Tx}) and receive energy (E_{Rx}) is require for communication is given as follow:

$$E_{Tx} = \begin{Bmatrix} k\ E_{elec} + k \in_{fs} d^2, & d \le d_0 \\ kE_{elect} + k \in_{mp} d^4, & d > d_0 \end{Bmatrix} \quad (4)$$

$$E_{Rx} = kE_{elec} \quad (5)$$

Where E_{elec} is energy required for transmit one bit of data. $\in_{fs}$ is amplification coefficient of amplifier in free space and $\in_{mp}$ is amplification coefficient in multipath. There are several assumption that are consider in our purposed technique:

- The nodes are deployed randomly.
- Every node have their fixed energy.
- The energy consumed by node in communication depend on the distance from BS or CH.
- All nodes are homogenous and stationary.

IV. PURPOSED ALGORITHM

The lifetime improvement is main issue in WSN so here we do this improvement by forming cluster using hybrid approach gives a cluster which is an optimal solution of this problem. Here we are using a hybridization of Differential evolution with simulated annealing with a global property as in Leach.

The global property have the extra benefit that a node become cluster head for one round is not selected as CH for certain round define by user.B-DESA is consist of following stps:

1. The set of nodes denoted as n=100 . from these set of nodes 0.10% is taken as cluster head.

2. Cluster is form by using DESA algorithms follows:

The algorithm is divided in four phases initialization, mutation, crossover then by using concept of stimulated annealing the selection of the new generation is done. The each step is discuss in detail as follow:

a. Initialization

The population vector$X_{i,gen}$ initialized randomly. Where i = 1,2,3….n. Gen represent the one generation. There is one population for every generation. This vector representation is part of clustering algorithm as maximum size of vector is equal to sensor node in network..

b. Control Parameter

In this purposed algorithm new version of DE is used with self- adaptation parameter [11]. The amplification factor (F) and crossover rate (CR) are control parameters which are adjusted for better result in terms of offspring. These control parameter is adjusted as given follow:

$$F_{i,Gen+1} = \begin{Bmatrix} F_l + rand_1 * F_u & if rand_2 < \tau_1 \\ F_{i,Gen} & otherwise \end{Bmatrix} \quad (6)$$

$$CR_{i,Gen+1} = \begin{Bmatrix} rand_3 & if rand_2 < \tau_2 \\ F_{i,Gen} & otherwise \end{Bmatrix} \quad (7)$$

Where the $rand_j$, j=1, 2, 3 ,4 are uniform random value in range [0,1] . $\tau_1 = \tau_2 = 0.1$ is probability to adjust F and CR. $F_l = 0.1$ is lower bound and $F_u = 0.9$ is upper bound. All these parameter effects mutation, crossover and selection.

c. Mutation

A random number in range [0, 1] is distributed all population and compared with a threshold value taken 0.5 here in this paper. If the number is less than threshold value DE/rand/1 is chosen else DE/best/1 variation I used for mutation.

$$v_{i,Gen+1} \begin{Bmatrix} x_{r1,Gen} + F_{i,Gen+1}(x_{r2,Gen} - x_{r3,Gen}) & rand \le 0.5 \\ x_{i,Gen} + F_{i,Gen+1}(x_{best,Gen} - x_{i,Gen}) + & \\ F_{i,Gen+1}(x_{best,Gen} - x_{i,Gen}) & otherwise \end{Bmatrix}$$

From mutation the new vector generated is called donor vector

d. Crossover

New child vector or trail vector is obtained by crossover operation of donor vector and the target vector as given follows:

$$u_{j,i,G} = \begin{Bmatrix} v_{j,i,G} & if\ (rand[0,1] \le CR \\ x_{j,i,G} & otherwise \end{Bmatrix} \quad (8)$$

e. Selection

In selection we take the decision which vector trail vector or target vector will survive in new generation depending upon the fitness function.

$$X_{i,Gen+1} = \begin{Bmatrix} u_{i,Gen,} & f(u_{i,Gen}) \ge f(X_{i,Gen}) \\ x_{i,G} & otherwise \end{Bmatrix} \quad (9)$$

The selection is done here by using SA algorithm which reject the worse solution in each round. The probability is exponential of difference fitness function and average fitness function in each round give as follows:

$$\text{Probability= Exp}\left(-\frac{fitness_{u_{t+1}} - fitness_{x_t}}{average(fitness)}\right) \quad (10)$$

This is the final step and we get new vector whose member are chosen as cluster head for that round. For every round this process is repeated to get optimal CH.

f. Fitness Function

The main objective of this paper is prolong the lifetime of WSN. Here we make balance in residual energy of nodes. The node with lower residual energy should consume low energy as compared to higher residual energy. The distance and energy taken in consideration in fitness function [12, 13].

$$\text{Fitness=} \in * f_1 + (1-\in) * f_2 \quad (11)$$

$$f_1 = \frac{E(i)}{\sum_{k=1,k\neq 1}^{m} E(k)}$$

$$f_2 = \frac{(m-1)}{\sum_{k=1,k\neq 1}^{m} d(i,k)}$$

Where m is number of cluster heads. f_1 is ratio of energy of present node to nodes in cluster. And f_2 is distance of clusters node to node i and node k. $\in$ is user define constant.

Cluster Distribution

1. The set of cluster head comCH is obtained which are within 20 m from sensor node.

2. The index number is comCH consider.

3. From the update population random number is generated in range [0,1]

4. The ceil of (comCH*$x_{i,G}$) is computed.

5. The cluster is Assign using the obtained number.

V. SIMULATION RESULT

The simulation is carried out in Matlab 2010a simulator. The comparison of DESA with purposed algorithm is done. The network parameter taken for the comparison is shown in table 1.

TABLE:1 Simulation Parameters

Parameter	**Value**
Area	100*100
No. of nodes	100
Initial energy of nodes	0.5J
k, packet size	4000
E_{elect}	70Nj
E_{da}	5nJ
E_{fs}	10pJ
E_{mp}	0.0013pJ
E_{amp}	120nJ

The wireless sensor network shown in fig.1 which show random deployment of nodes. The Area is taken100*100. There is one base station in network shown by red colour (×) and nodes shown by blue colour (.).

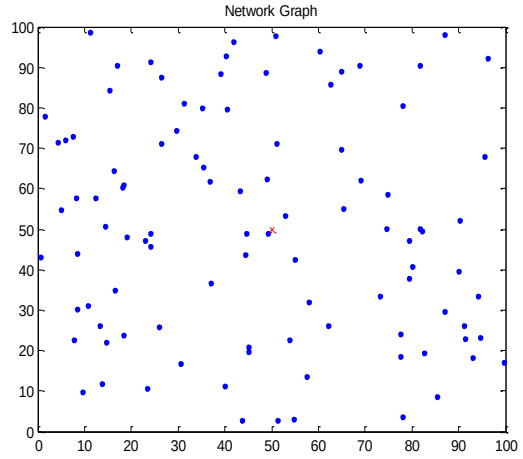

Figure: 1 Random deployment of nodes in WSN

The figure 2 shows the FND performance comparison of DESA with balanced DESA. Here we can see the purposed perform better than DESA written base in figure (2).

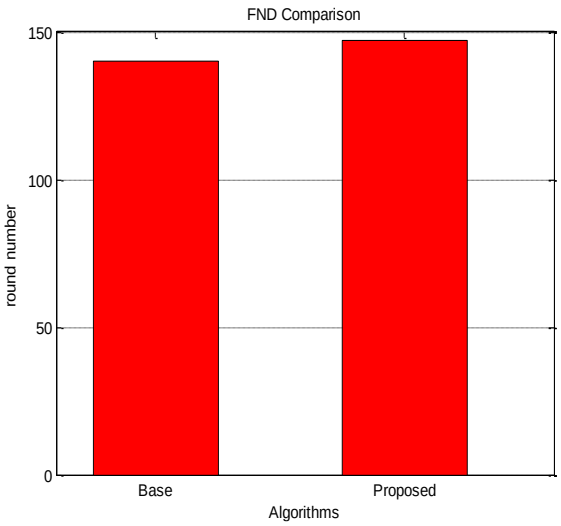

Figure 2: First node dead comparison

Next figure (3) show the comparison of half node dead that is 50% of the total nodes of the network i.e 100 here. Purposed will gives the better result in this case also.

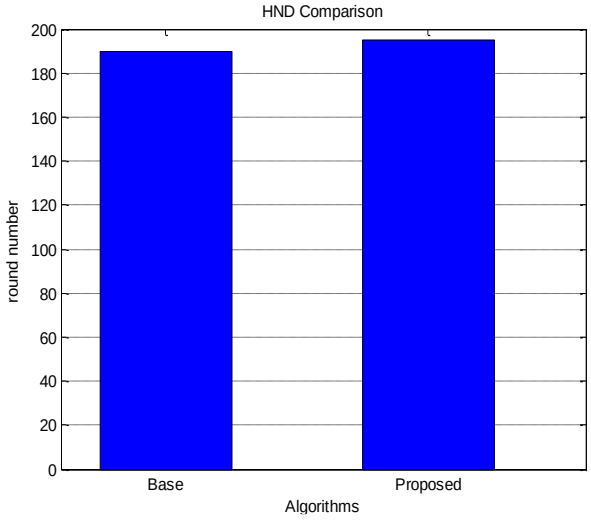

Figure 3: Half node dead comparison

Figure (4,5) show the network energy comparison of balanced DASA and DESA. From this figure the difference between energy is not clearly seen so the bar chart is also shown for make the comparison

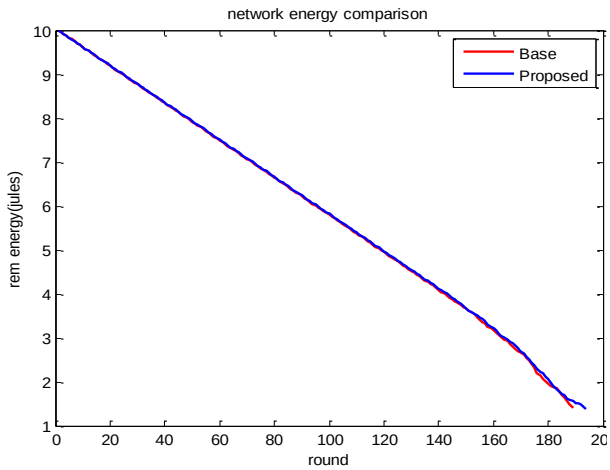

Figure 4: network energy comparison

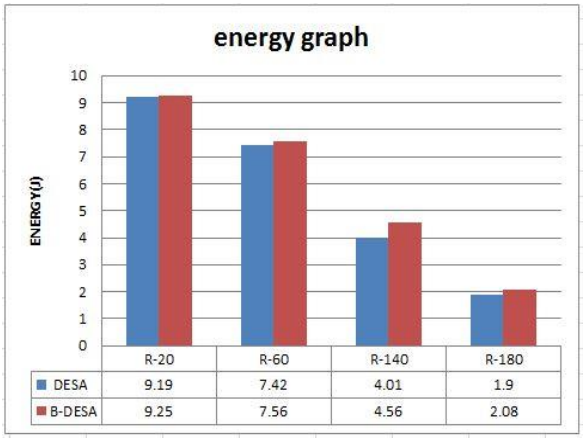

Figure 5: Energy Grap dead node comparison shown in figure (6) that is better in case of purposed shown by blue colour. The DESA is shown by red colour.

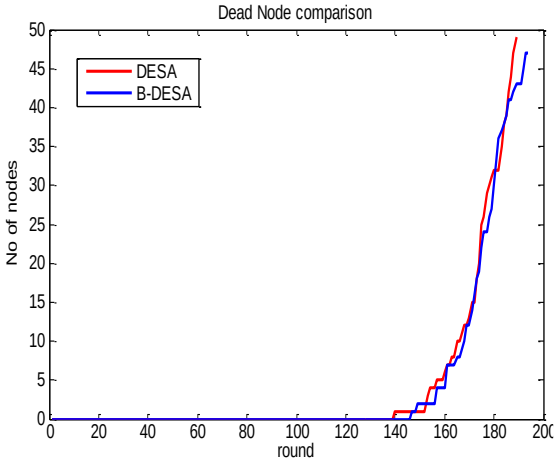

Figure6: Dead node comparison

The alive node comparison is shown in figure (7) shows better result in balanced DESA than DESA.

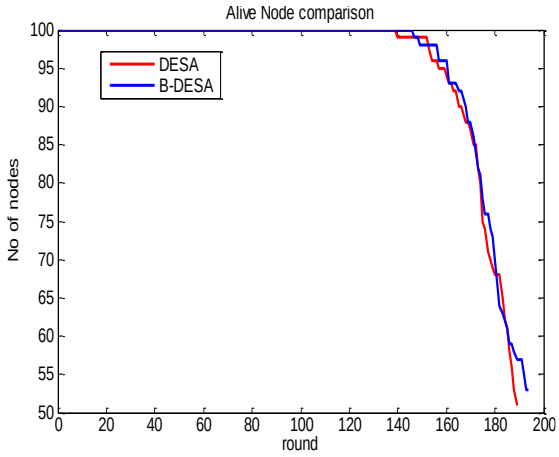

Figure7: alive node comparison

VI. CONCLUSION

In this paper, a balanced cluster head is elected with using a hybrid algorithm differential evolution stimulated annealing and it is seen that it improves the lifetime of wireless sensor network. The fitness function takes distance and energy of cluster head and nodes into consideration.

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