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Cluster Head Selection using Honey Bee Optimization in Wireless Sensor Network

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Abstract: Wireless Sensor Network(WSN) are very popular as they are low cost solutions to many real-world challenges with limited computational power, battery life and memory resources. Past few years have witnessed increased in the potential use of wireless sensor network (WSN) such as military surveillance, tracking and monitoring, disaster management and combat field reconnaissance. Sensor nodes involved in these applications are remotely deployed in large numbers. These autonomous nodes are used to monitor an environment. Many issues in WSN are formulated as multidimensional optimization problem and solved through bio-inspired techniques. The main problem in WSN is the lifetime of network. To support scalability, nodes are often grouped in clusters having a leader, often referred as cluster head (CH). A CH is responsible for not only sending data to base station but also assist the general nodes to send sensed data to target nodes. The energy consumption of CH is greater than general nodes. Therefore CH selection will affect the lifetime of WSN. In this paper, an approach is introduced for the selection of cluster head by using swarm intelligence. This proposed approach is based on energy distributed clustering (EDC) algorithm. Honey bee optimization with some parameters are employed over EDC algorithm for effective cluster head selection. This approach helps in reducing the energy consumption. This proposed technique works in three stages: Cluster nodes sends data to CH, CH sends data directly to Leader and leader sends data to BS. Simulations results demonstrate that EDC-HBO algorithm improves the life time of network.

KEYWORDS: Wireless Sensor Network, Cluster Head, HBO, Energy Distributed Clustering, Fitness Value.

I. INTRODUCTION

WSN is a network with large collection of tiny self-aware, battery-operated, analyzable sensor devices. These sensor devices are capable of detecting environment conditions such as temperature and sound. WSN combines sensing, computation and communication in a single tiny device. These tiny devices provide ample number of remote sensing applications [1].

Due to distinguishable applications, implementations and efficient designs of WSNs [2] make it affective area of research. A sensor network consist of various tiny sensor nodes closely deployed inside the phenomenon. The position of sensor node need not to be pre-determined or engineered because of deployment in terrain or disaster relief areas.This proof that sensor network algorithm and protocols have self-organized capabilities [3].

WSN consist of sensor nodes and a sink and the group of these sensor nodes form a cluster. The main problem in WSN is to increase the network life and it can be achieved through max. data delivering with min energy consumption. This is named as data aggregation. The goal of data aggregation is to collect data from various nodes and pass the usable data to CH and then to BS. It is shown in fig. 1 below.

Sensed data is transmitted through sensor node to BS using aggregation algorithm like centralized approach and low energy adaptive clustering hierarchy (LEACH) through selected path. Path is selected by using 4 ways: By network structure, protocol operation, path establishment and communication initiator.

In each cluster a sensor node is elected named as CH [4]. The CH is responsible for transmitting sensed data in same cluster to sink. It reflect that CH have higher energy than cluster nodes. The selection of cluster head effect the lifetime of network. The power consumption between two nodes is based on transmission distance. As the distance increase more power will be consumed. Since the hierarchical architecture provides more flexibility to handle data routing problem, it is applied extensively to WSNs.

To preserve the energy consumption in WSN there are number of relevant energy saving techniques, which increase the network lifetime. In this paper, we are going increase the network lifetime by using Energy Distributed Clustering protocol with Honey Bee Optimization technique (EDC-HBO). With these algorithms we will select the high energy cluster head which will devote less energy while transmitting aggregated data to base station. Clustering is one of best method to increase the lifetime of network by consuming less energy. In this whole network is divided into group of clusters.

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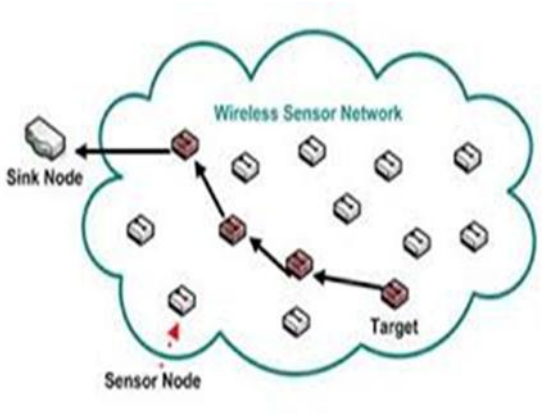

Fig. 1.Architecture of Wireless Sensor Network.

Some of the advantages of clustering are [5]:
Size of routing table stored at individual nodes is reduced. Battery life of individual sensor and whole network is extended. Data aggregation is performed by CH in its cluster which decreases the number of redundant packets. Scheduling the activities in CH can reduce energy rate.

Swarm Intelligence SI is a computational approach, [6] that depends on study of collective behavior of social insects in decentralized, self- organized systems. Ant Colony Optimization [7] and Bee Colony Optimization [8] are widely studied among the other Swarm Intelligence techniques utilized for networks. They have grabbed the attention of researchers because they are more reliable, scalable and robust than other conventional routing algorithms. Here we are using honey bee colony optimization. The remaining paper is distributed as follows: Section. 2 described related work, Section. 3 described background, Section. 4 discussed implementation and proposed algorithm and Section. 5 presented simulation and results and conclusions are given at the last.

II. RELATED WORK

To develop a low power wireless sensor application number of important issues are related , i.e., by using present energy in the most efficient way, without disturbing the performance. Batteries used by sensor nodes act as power source but with limited lifetime. So capability of energy management becomes very important in wireless sensor network design. The nodes of WSN have limited power constrain and WSN are placed in challenging conditions, a radio device i.e. transmitter, is employed for wireless communication for the transmission of data to sink node. The routing protocols in sensor networks could be classified into three categories:

- flat-based,
- hierarchical-based and
- location-based routing.

In Energy Balanced Clustering in Wireless Sensor Network [9], algorithms for energy balanced cluster formation, cluster head selection, intra cluster and inter cluster communication are proposed to prolong lifetime of wireless sensor network. The performance of energy balanced clustering algorithm is compared with LEACH and UCR protocol.

In Energy Adaptive Cluster-Head Selection [10], optimization of LEACH algorithm is proposed for random selection of cluster head. It guarantees that energy consumed over the whole network is balanced to prolong the network lifetime.

To suit the periodical data gathering applications An Energy Efficient Clustering Scheme [11] a novel scheme (EECS) for single-hop wireless sensor networks is proposed. In this paper an approach to elect cluster heads with more residual energy in an autonomous manner using local radio communication is used. By this good cluster head distribution and by balancing the load among the cluster heads using a novel distance-d method.

In Energy Efficient Hierarchical Clustering Algorithm [12] a randomized, distributed clustering algorithm is proposed. The algorithm generates hierarchy of cluster heads. It has been observed that by increasing the number of levels in the hierarchy energy is saved.

Load balanced clustering [13] algorithm has been proposed for load balancing among cluster heads. This algorithm helps to group together sensor nodes close to cluster head. Load balancing increases the sensor network stability and communication between different nodes in the sensor network is improved.

A novel cluster-based routing protocol [14] has been proposed to extending lifetime of cluster head. This paper discusses approach that allows sensors to vote for their neighbors to elect the cluster heads. It utilizes hybrid protocol that combines the cluster architecture with multi-hop routing for the reduction of the transmission energy.

Distributed energy-efficient clustering [15] approach uses residual energy for the selection of cluster head. Communication cost is minimized by joining cluster with sensor nodes. The approach exploits the availability of multiple transmission power levels at sensor nodes. In, A Routing Protocol [16] U-LEACH algorithm is proposed to address the problem in LEACH. Algorithm uses uniform distribution technique for selecting CHs and their corresponding clusters to prolong the lifetime of the network.
Energy efficient clustering scheme [17] selects cluster head with more residual energy in an autonomous manner through local radio communication for single-hop WSN. In this paper a novel distance-based method is discussed to balance the load among the cluster heads.

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An improved clustering algorithm is proposed which takes residual energy of node and location information into account. It uses the selection method of the threshold for selecting cluster head, and improves optimal cluster head selection strategy, i.e. normal nodes select the more prominent cluster head on the basis of cost function. If the number of cluster heads can be optimized, the energy consumption of the sensor nodes can be more evenly distributed in the WSNs. It can avoid extra energy consumption of single node to untimely death, which directly affects the network life cycle [18]. Honey Bee colony algorithms (HBOs) are speculative procedures for searching.

The routing protocols using swarm based optimization algorithms present an alternative way of efficient data collecting techniques on sensor network routings. The nodes having algorithms running on them is in simple form providing fast execution and little energy consumption. Ant colony optimization (ACO), modeling ants behavior of finding food sources [19], is a method for multi-path routing using a swarm based algorithm to maximize network life time in event based applications. However, this proposal is not suitable for monitoring applications which require periodic data transferring. Particle swarm optimization (PSO) which simulates the social behavior of a folk of birds flying to resources is used in LEACH based routing. In these studies, PSO algorithm is used to form clusters and to define cluster-heads in a WSN having the same conditions with simulated network and PSO algorithm produces promising results.

The network life-time could be increased by using other optimization techniques that are successfully applied on clustering. Artificial bee colony (ABC) algorithm a new swarm based optimization technique is applied on clustering of WSN used for monitoring purposes.

III. BACKGROUD

In this section we are going to discuss two steps

- Honey Bee Algorithm
- Network Environment.

A. Honey Bee Algorithm

Artificial Bee Colony (ABC) algorithm was proposed by Karaboga for optimizing numerical problems in [20]. The algorithm simulates the intelligent foraging behavior of honey bee swarms. It is a very simple, robust and population based stochastic optimization algorithm. In ABC algorithm, the colony of artificial bees contains three groups of bees: employed bees, onlookers and scouts. Onlooker bee waits on the dance area for making a decision to choose a food source and the bee going insearch of food source is named employed bee. The scout bee carries out random search for discovering new sources. The position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution, calculated by:

$$fit_i = \frac{1}{1+f_i} \quad (1)$$

Where f_i is the cost function of clustering problem and fit_i is fitness of solution in eq. (1).

Food source chosen by onlooker bee depend on the probability value associated with that food source p_i. It is calculated by:

$$p_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_n} \quad (2)$$

Where SN is the number of food sources equal to number of employed bees.

B. Network Environment

A sensor network can be considered as a directed graph G(V,E) where V is the set of sensor nodes and E is set of path connecting nodes in the network.

In this paper, the number of assumption is adopted which are given below:

- 100 sensor nodes are uniformly distributed within a monitoring area.
- Each node has its unique identification.
- All nodes and base station are stationary.
- All nodes are homogeneous and have the same capabilities.
- The sensor nodes energy is non-renewable.
- Each node have same initial energy.
- There is less mobility factor of nodes after being deployed.

IV. IMPLEMENTATION AND PROPOSED ALGORITHM

Using the concept of honey bee algorithm in WSN, each node calculate its best fitness value to elect as cluster head. In this section of paper, this basic idea of proposed algorithm is summarized. Initially, modified honey bee optimization is explained and then proposed EDC-HBO algorithm is described.

A. Modified Honey Bee Optimization

Generic HBO algorithm pseudo code is given below, based random initial positioning:

- Set swarm size S, dimensionality N, search space domain MI.
- Generate initial population X_i,i=1….SN
- Evaluate the population
- Set cycle to 1
- Repeat
- FOR each employed bee
- Produce new solution $v_i$by using eq:
  $v_i = x_{ij} + \theta_{ij}(x_{ij} - x_{kj})$
- Calculate the fitness
- Apply the greedy selection process
- FOR each onlooker bee

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- Choose a solution $x_i$depending on p_i
- Produce new solutionv_i
- Calculate the fitness
- Apply the greedy selection process
- If there is an abandoned solution then
- Replace it with new solution produced by scout using eq:
  $x_j^i = x_{min}^j + rand\ (0,1)(x_{max}^j - x_{min}^j)$
- Memorize the best solution achieved so far
- Cycle=cycle+1
- Until cycle=MCN

The fitness of cluster head selection is stated as fitness value which is in inverse proportion to amount of energy consumption for round. A certain transfer time is required for data package and then the energy consumption is calculated by multiplying transmitting power (P^s) and time(t).

$$E = \sum_{i=1}^{m} (P^s . t)$$

$$E \geq \alpha.(\sum_{i}^{m} d_i^2 + b^2).t$$

Where m is no. of nodes, i is node index,d_i is distance between ith node and cluster head, b is distance between cluster head and base station, a is energy costant and E is transfer energy of cluster.

B. *Description Of EDC-HBO*

Important factor behind the improved lifetime of wireless sensor network is its design. Proposed clustering algorithm is divided into three phase: initialization, set up phase and steady phase. These are explained below.

1) *Initialization Phase*

Sensor nodes are deployed over flat area with different energies randomly. Random deployment is achieved by choosing random locations in coordinate system.

2) *Setup Phase*

The setup phase consist of cluster formation. The flat area is divided into equal parts, nodes belong to same part form cluster. Cluster head having highest energy is nominated as leader cluster head its responsibility is to communicate with all sensor nodes within that cluster, gather the data and sends to base station.

3) *Steady Phase*

In this phase, once the leader among the cluster heads is identified, it takes the ownership of the communication. Sensor nodes communicate with the leader cluster head based on TDMA schedule and in turn it communicates with sink. After each round of communication based on the energy levels of cluster heads leadership is rotated. Rotation of the leadership allows balancing of the energy consumption among the cluster heads and prolongs life of cluster thereby sensor network.

C. *Algorithm*

- Form the cluster based on x, y location of grid.
- Select high energy node as a cluster head within in cluster as leader.
- Leader sends join request message to all sensor nodes within the given cluster.
- Leader CH is selected as highest energy node.
- Sensor node within the cluster communicate the sensed data to CH in allocated time using TDMA schedule.
- CH collect data from all nodes in its cluster.
- CH transmits data to sink node.

V. SIMULATION RESULTS

5.1 Simulation Environment

The proposed algorithm is simulated using MATLAB.

Table I

Parameter	Value
Network Coverage	200m*200m
BS location	100m, 220m
N	100
Initial Energy	1J
E_{elec}	50nJ/bit
E_{fs}	10pJ/bit/m^2
E_{amp}	0.0013Pj/bit/m^4
d_o	87m
E_{DA}	5nJ/bit
Data packet size	4096bits
Control packet size	200bits

5.2 Simulation Results

To prove the advantage of proposed algorithm, we have compared it with LEACH and UCR.

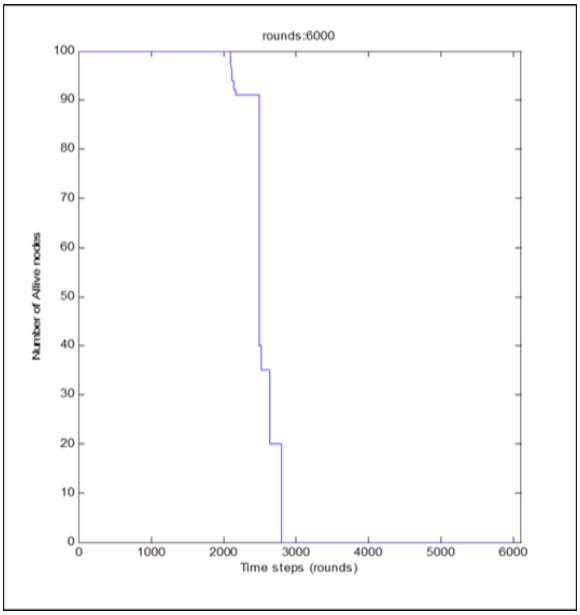

Fig 2. Graph between number of Alive nodes and number of rounds.

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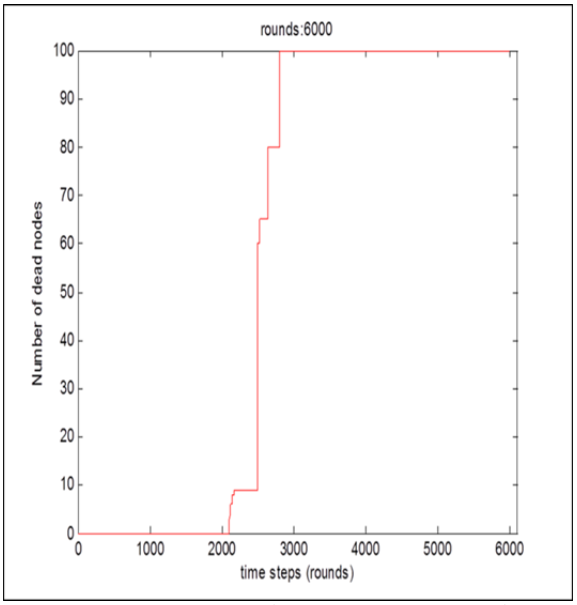

Fig 3. Graph between number of dead nodes and number of rounds.

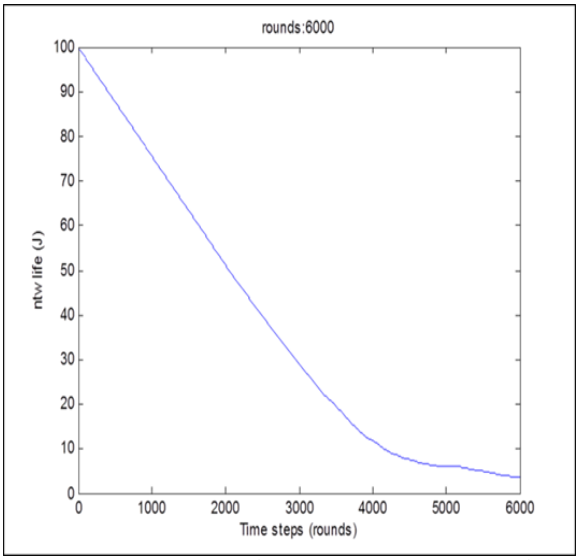

Fig 4. Graph between network lifetime (in joules) and number of rounds.

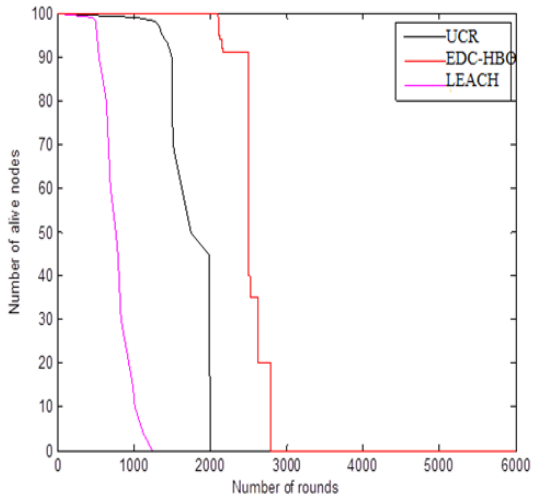

Fig 5. Graph showing the performance comparison between proposed and the existing UCMR and LEACH.

Fig 2. Shows that number of alive node start reducing in number after nearly 2000 number of rounds. This is much enhances as compared to previous existing UCR protocol which was covering 1200 rounds only. So there is much enhancement in network lifetime. Fig 3.Shows that first node dead start after 2000 rounds and it goes up higher and higher with increase in number of rounds. So, it clearly works on dead aspects of network in which existence of dead nodes is clearly shown w.r.t number of rounds. Fig 4. Shows the representation of lifetime with increased number of rounds, lifetime goes on decreasing as number of rounds enhances. Most of lifetime is being covered up to 3000 number of rounds. Fig 5.Shows the performance comparison between proposed and existing UCR and LEACH. As it can be clearly seen that number of alive nodes are 100 for all the three protocols, but these alive nodes get reduced in number after covering different number of rounds.

VI. CONCLUSION

On the basis of HBO algorithm, this paper proposes EDC-HBO a cluster head selection algorithm for effective cluster head selection. This algorithm considers the energy and distance factor as parameter to improve cluster head selection. The main goal of EDC-HBO is to enhance the network lifetime as well as to improve the power consumption of network. Simulation results show that EDC-HBO is more energy efficient than LEACH and UCR protocol. As the WSN has data redundancy, how to design and realize routing protocol with optimal data aggregation will be our future research work.

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