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Optimal Cluster Head Election using Cuckoo Search Algorithm

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Abstract – **This paper is based on indoor wireless sensor networks, in conjunction with an appropriate management methodology that allows us to analyse and verify the behaviour of these wireless networks in an internal way. To make WSN energy efficient and to increase the lifetime of the network, this paper presents an energy-efficient clustering algorithm optimized by Cuckoo Search Algorithm (CSA). Performance of this approach is evaluated using certain evaluation parameters; Throughput and Network Lifetime.**

Keywords – **CSA, LEACH, WSN.**

I. Introduction

Wireless sensor network composed of numerous of sensor nodes which communicate with each other through wireless network [1]. Each sensor node is required to be capable of sensing, processing and communicating the processed data to the neighbouring nodes to form a network. The data packets travel through these sensors nodes from source node to destination node via several intermediate nodes [2]. The data packets can uses long as well as short route to reach to the destination node. The long route may results in network delay and can take larger time while simulating it. On the other hand short route results in better network performance by consuming lesser energy and lowest network delay. Finally, the routing targets are oriented by the application, therefore different routing protocols have been offered for easily accessibility of those applications [3].

Wireless sensor network also termed as distributed sensor nodes network in which each node are independent of each other and can perform transferring of data packets individually. A wireless sensor network is an accumulation of small randomly dispersed devices. Moreover in WSN, each node communicates with their neighbour node for transferring data from source node to sink node [4]. The size of sensor nodes may change from small grain size to large box according to the requirement of application. Networking topologies may also vary. In WSN assumption, a user may retrieve the information by sending query to the system and then getting the results accordingly [5].

One issue that has arisen around the world is that of energy efficiency, that is, it refers to the intelligent consumption of energy because most of the energy sources are finite, and what is sought is to have a consumption of energy responsible in the present so that future generations can continue to enjoy them. According to different studies carried out, a considerable increase in the demand for residential electricity is expected within the following decades, so that our traditional electricity networks will not be able to meet the requirements of the 21st century [6]. But there have been two major drawbacks for these energy management systems: the large number of residential homes without adequate automation systems that are efficient and the high cost of implementing them [7]. For this reason, for this type of energy management, changes will have to be made in terms of the way in which energy is supplied, and the form of the energy market [8], which requires different types of networks, such as they are wireless sensor networks, as well as different energy management systems within smart homes. This article focuses on the implementation of these energy management systems using wireless sensor networks, which by maximizing coverage as a basis will allow better and more extensive services to users. It should be noted that this corresponds to the issue of smart grids, which through the use of smart meters, sensors and different actuators will allow obtaining more detailed information on the consumption of each residential area, and even obtain individual consumption of each of the electrical and electronic devices within a specific dwelling, with which you can have a remote control of them [9]. We can also mention that wireless networks currently play a very important role in the improvement of technology and our quality of life,

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because they allow us to have a great freedom to communicate with the world at anytime and anywhere [10-12].

This paper proposes an investigational comparison among LEACH and cuckoo search algorithm based cluster head election approach for indoor wireless sensor networks, so as to find a method which increases the lifetime and reduces the energy consumption of the network.

II. Proposed Methodology

A. Method of Cluster Head Election

The threshold formula given by Qian Liao et al. [13] is:

$$T(n) = \frac{p}{1-p^*\left(r \bmod \frac{1}{p}\right)} * \frac{E_{cur}}{E_0} \quad (1)$$

Where, E_0 and E_{cur} represent initial energy and current energy of the node respectively. The improvement in proposed protocol takes place using the increment in probability of high energy nodes, by which the nodes turn into the cluster-head. Although, this process causes an issue. The threshold $T(n)$ turn out to be small if the residual energy becomes very low resulting a reduction in nodes of the network. It will results the early death of nodes and finally the network lifetime will be less. Also, the threshold formula in equation (1) does not contains any impact of the distance between base station and nodes for cluster-head election.

Then the improvement in threshold is given as:

$$T(n) = \begin{cases} f(E_{cur}) * \left[\dfrac{(1-\alpha)p}{1-p^*\left(r \bmod \frac{1}{p}\right)} + \alpha p^* h(D_{toBS})\right] & n \epsilon G \\ 0 & n \notin G \end{cases} \quad (2)$$

Where, $f(E_{cur})$ is the function related to the current residual energy of the node. It shows the impact of node energy on the election probability. It is given by:

$$f(E_{cur}) = \frac{E_{cur}}{E_{ave}} \quad (3)$$

E_{ave} is the average residual energy of entire nodes in the current round.

In generalized protocol, the optimal cluster-head are selected by normal nodes and the communication takes place between base station and nodes. While the proposed protocol calculates the distance between base station and normal node. If it is found to be minimum then there is no selection takes place for cluster head which causes a direction transmission of controlling packages to the base station and data transmission occurs.

B. Optimized Cluster Head Election using Cuckoo Search Algorithm

Let n_{alive} represents the number of alive nodes with residual energy greater then the threshold energy and p be the clusterhead election probability, then the optimum number of CH elected for a given round will be:

$$P_{opt} = n_{alive} * p \quad (4)$$

Here P_{opt} is optimized using Cuckoo Search Algorithm which is described as:

1) Cuckoo Search Algorithm

The implementation of the Levy flight in the Cuckoo Search approach is aimed to produce a novel resolution during the exploration process [14].

$$x_i^{t+1} = x_i^t + \alpha \oplus Levy(\lambda) \quad (5)$$

Where, $\alpha(\alpha > 0)$ is the jump size, x_i^{t+1} is the new solution and x_i^t is the current solution. This equation represents a random step called the Markov chain. This means that the next solution depends on the current solution and the probability of transition. $Levy(\lambda)$ follows a Levy distribution with infinite mean and infinite variance $(1 < \lambda \leq 3)$, Equation (6). This allows a part of the generation to move away from the current solution, preventing the algorithm from being trapped in the local minimums.

$$Levy(\lambda) \sim u = t^{-\lambda}, \quad (1 < \lambda \leq 3) \quad (6)$$

The cuckoo search technique works on the basis of the ideal rules, which are as follows [15]:

- Each egg of the cuckoo in a nest represents a solution.
- Each cuckoo lays a single egg at once, and choose to nest "randomly". Therefore, each single cuckoo algorithm holds the right to randomly produce only one new solution.
- The best nests of better quality eggs will lead us to the new generations. Here, we have implicitly introduced the notion of advancement or research around the best solutions.
- Some of the solutions have to be managed by the Levy flights around the best possible solutions of time. This accelerates the local search.
- The no. of cuckoo nests are limited, and the bird's egg is hence easily discovered by the host with a probability $p_\alpha \in [0,1]$. In this case, the host bird chooses to get rid of the

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egg, or abandon the nest and rebuild another nest somewhere. For simplification, the latter hypothesis will be approximated by the fraction p_α of n nids which are replaced by new ones (new random solutions).

- A significant proportion of the new solutions must be produced by remote-area hikes and the placements must be far away from the best existing solution, so there are no chances of system for being trapped in a local optimum.
- Each nest can contain several significant eggs a set of solutions.

III. Simulation Results

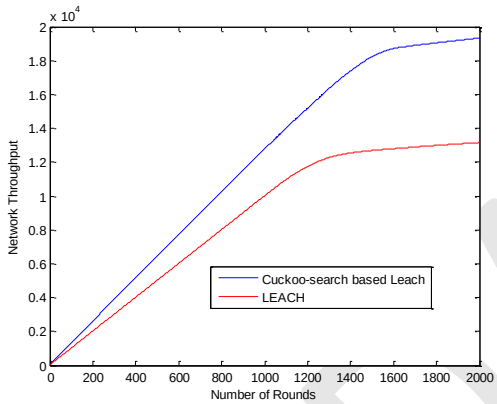

Figure 1: Network throughout comparison for proposed algorithm

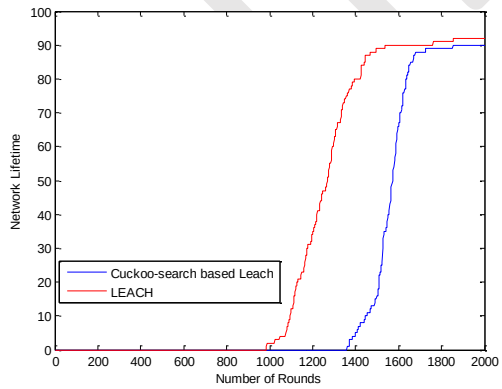

Figure 2: Network lifetime comparison for proposed algorithm

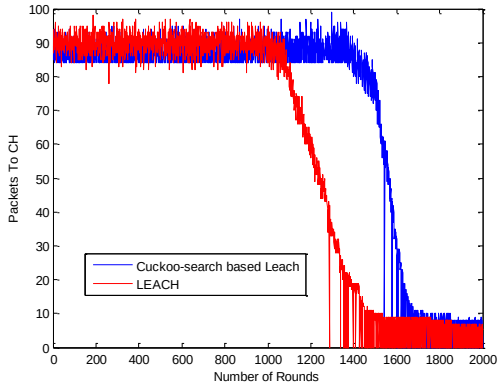

Figure 3: Comparison for number of packets transmitted with respect to rounds

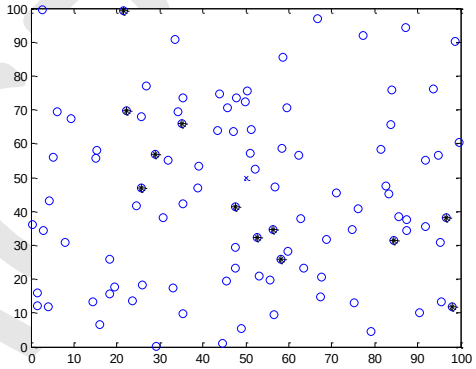

Figure 4: Sensor node deployment

IV. Conclusion

Cuckoo Search Algorithm has been a famous procedure used to take care of optimization issues in WSNs because of its straightforwardness, high calibre of result, quick joining and inconsequential computational complexity. In any case, iterative nature of Cuckoo Search Algorithm can deny its utilization for rapid ongoing applications, particularly if optimization needs to be done frequently. Cuckoo Search Algorithm obliges a lot of memory, which may limit its execution to asset rich base stations. Literature has inexhaustible fruitful WSN applications that endeavour preferences of Cuckoo Search Algorithm. We have examined LEACH and Cuckoo Search algorithm based cluster-head election for heterogeneous WSNs containing different level of heterogeneity. Simulations prove that Cuckoo Search algorithm based cluster-head election performs well in all scenarios. It has best performance in terms of Network Throughput and Lifetime. Since the routing methods in WSNs are application specific, there is always scope for improvements. Moreover, future work can be carried out to improve the

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throughput of this method using other optimization algorithms.

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