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Energy Efficient Evolutionary SEP Clustering Protocol for Wireless Sensor Network

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Abstract: **Wireless Sensors Networks (WSN) have become vital in many areas and critical applications. Some applications require a reliable network and less maintenance, especially the power consumption. The standard helps the overall network to reduce worries about the sensors power dissipation. Therefore, the longevity of the network is the main concern of the WSN. In this paper an evolutionary SEP protocol is designed and implemented in order to reduce energy consumption of the cluster based sensor network. For this cluster head election process is performed using genetic algorithm. Analysis and simulation results indicate that the Evolutionary SEP protocol can reduce energy consumption between sensor nodes and increase network performance during data transmission. In this experiment, the MATLAB simulator is used here to evaluate the performance of the proposed Evolutionary SEP algorithm and its comparative analysis of simulation results using an existing cluster protocol named LEACH protocol.**

Keywords –Wireless Sensor Network, Cluster-based, Secure Routing Protocol, Energy Efficiency

1. INTRODUCTION

Wireless sensor network systems accommodates an oversized range of low-power sensor nodes and conjointly resource-limited devices [1]. These sensor nodes communicate wirelessly primarily via radio. The number of sensor nodes used to study a development may be within the hundreds or thousands, depending on the application. Therefore, a WSN are often both high and high density [2]. Wireless sensor networks are typically employed in massive geographical regions to gather information on environmental device nodes of interest and to produce information to users situated far from the geographical area [3].

It is a form of gathering of knowledge from sensor nodes and their wireless connections from remote areas or generally even hostile environments, depending on how the WSN is employed. The info collected by the sensor nodes may be environmental parameters like temperature, pressure, humidity, etc. o could also be an even image or video depending on the kind of application and also the type of sensory device put in within the nodes [4]. Environmental observation, smart home applications, health applications, wildlife observation, fireplace detection and signal systems, etc. [5].

Each node of a network encompasses a sensor material called sensors, a transceiver, a memory, a microcontroller, and a power supply. The energy needed to work a sensor node is extremely restricted owing to the utilization of batteries as an energy supply. After all, the battery runs out and therefore the node dies, which may result in a network failure. Therefore, energy is extremely necessary for the utilization of a sensor network. To attain the required results of the network, it's important to balance the energy consumption of the sensor nodes [6]. A technique to do this can be to search out a way to reliably route data packets from the nodes to the base. To this end, various sensor network routing protocols are projected and discovered, capable of conserving the energy consumed by the nodes and improving system performance [7].

2. RELATED WORK

Divya Acharya et al. [1] analyzed the effect of the selected attack is that some data packets can be deleted. The Adaptive Low Energy Cluster Hierarchy

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(LEACHES) applies cluster rotation randomly to the distribution of energy between all sensor nodes. In this white paper, the creation, detection and removal of selective transfer attacks are performed on LEACH routing in wireless sensor networks. It analyzes how the performance of networks with selected transfer attacks and the performance of detection and suppression algorithms are analyzed. In addition, LEACH's performance in terms of package delivery ratio was assessed against the number of attack nodes in selected relay attacks. The proposed analysis is simulated with the NS2 Network Simulator. Preventive Technique Manages the attack successfully, while restoring network performance and reducing the impact of an attack on the network.

Fares Mezrag et al. [2] proposes a new secure protocol based on the well-known LEACH routing protocol called Hybrid Cryptography Based Scheme for the secure communication of data in the WSN cluster (HCBS). As an approach with several limited criteria, HCBS relies on a combination of elliptical cryptographic curve techniques for the exchange of keys that use symmetric keys for data encryption and MAC operations. After a series of tests on the TOSSIM simulator, the results showed that our proposal achieved good performance in terms of energy consumption, loss rate and end-to-end delay. Furthermore, HCBS guarantees a high level of security.

Kaur and Kaur [3] developed a paper for an analyzation and implementation of cluster based routing protocol in MANET networks. MANET is a self-supporting adhoc networks with cellular nodes that can be migrate and connection between each node. Clustering structured methods are used to improve performance. The main purpose of cluster is to boost the routing protocols in the network and the clustering-based routing protocol is developed.

H. V. Chaitra, et al. [4] discussed improving the life of the network to a certain extent. The routing of data in the sensor nodes plays a fundamental role in the transmission of data to the base station (BS). Different types of routing algorithms have been used as grid-based, multi-hop, hierarchical and Leach-based classification, HEED, etc. The existing LEACH protocol is designed in such a way that safety is not considered a problem. In this context, we focused on the integration of classification techniques based on a hierarchical technique, namely the optimization of the CEES ECC cluster to ensure safety and improve the life of sensor nodes.

Gambhir and Fatima [5] provided a version of the LEACH protocol called Optimized LEACH (OP-LEACH) to reduce energy intake in the WSN. Both the current LEACH and the LEACH operational project were evaluated using simulations using the OMNeT ++ simulator, which demonstrated that Op-Leach worked better on the LEACH protocol.

Ankit Thakkar [6] presented the Advanced LEACH protocol on distance and energy called DEAL. DEAL considers the energy and the suppression of a node during the electoral process of the parent company. The results of the simulation show that DEAL extends the stability period and reduces the period of instability compared to the ALEACH protocol.

Sharma and Sharma [7] proposed a modified LEACH protocol called the LEACH EEE protocol. The new version of the LEACH protocol recognizes a multilevel clustering approach to minimize the communication distance between the nodes and the CHMs proposed with CH. The simulations were performed in MATLAB and the results showed that EEE LEACH was more energy efficient than the LEACH protocol.

3. PROPOSED METHODOLOGY CLUSTER FORMATION

The distance function is used in proposed algorithm is the Euclidean distance. Suppose there are two nodes A and B in the network that the coordinates of point A is (x0, y0) and point B is (x1, y1) so the Euclidean distance is calculated as:

$$d = \sqrt{(x_0 - x_1)^2 + (y_0 - y_1)^2} \quad \text{(i)}$$

Some functions are performed in cluster formation which are discussed below:

- Selecting a random point to start a clustering.
- Other nodes join the cluster according to equation (i).
- When a node adds to the cluster, calculating the radius of the cluster according to the equation (ii).

$$Cluster\ radius = \frac{d}{Number\ of\ nodes} \quad \text{(ii)}$$

- Compare the value with cluster radius threshold d, if the value is greater than the threshold don't perform insertion and see the node as a new cluster.

Cluster Head Selection

In Evolutionary SEP algorithm genetic algorithm is used to associate cluster head which is shown in figure 4.

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The cluster heads are selected according to the genetic algorithm (GA) as a dynamic method for finding optimal states. A genetic algorithm is classified as a global heuristic search algorithm in which an optimal solution is estimated by generating different individuals. This algorithm includes procedures such as fitness function. At this point, sensor nodes are organized from a genetic algorithm to a new cluster which is illustrated in figure 2.

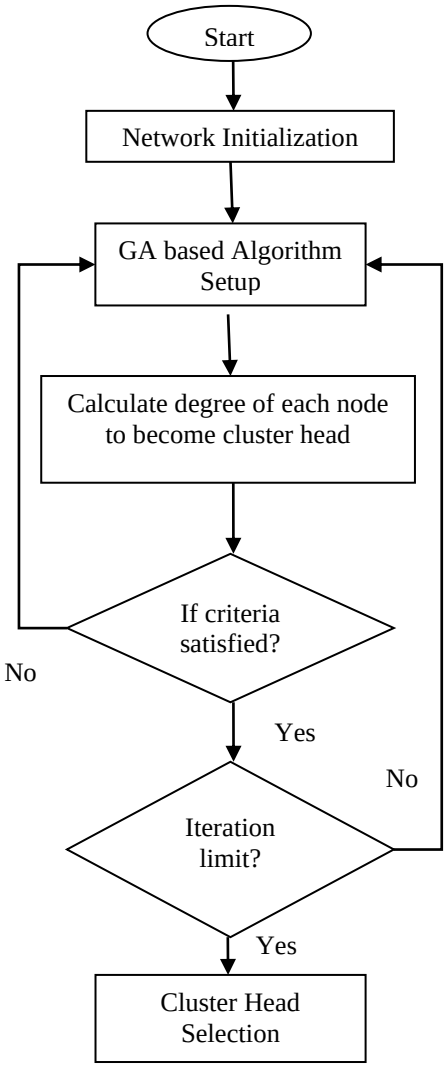

Figure 1: Evolutionary SEP based Cluster Head Selection

Algorithm for genetic algorithm based clustering

Initialization: Initial population can be generated through the source Nodes.

Calculate Fitness Function: The fitness function can be calculated as:

$$Fitness\ Function = D_c + E_c \quad \text{(i)}$$

Where D_c is the cost of distance and E_c is the cost of energy.

$$D_c = \frac{d_{sc}}{d_{sc} + d_{cb}} \quad \text{(ii)}$$

d_{sc} = distance between sensor and cluster head node

d_{cb} = distance between cluster head node and base station node.

$$E_c = \frac{E_s}{E_{Ts}} \quad \text{(iii)}$$

E_s = Each sensor node's energy

E_{TS} = Total residual energy of nodes residing in a cluster.

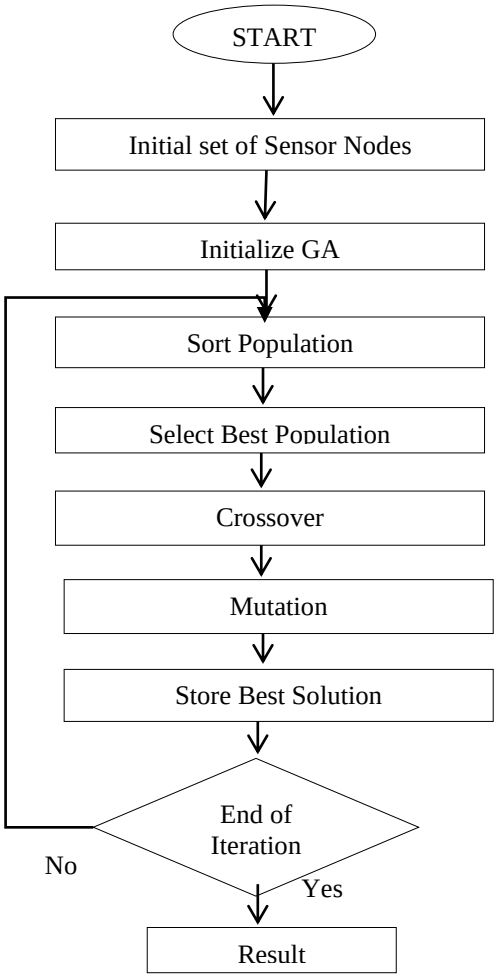

Figure 2: Genetic Algorithm Flow Chart

Initially, each node is assigned a weight corresponding to the optimal probability P_{opt}. The weight is equal to E_c of each node divided by the initial energy of the common node. It also defines the P_{nrm} probability of the weighted vote for the common nodes, the P_{adv} probability of the weighted vote for the extended nodes.

$$P_{nrm} = \frac{P_{opt}}{1 + am} \quad \text{(iv)}$$

$$P_{adv} = \frac{P_{opt}}{1 - am}(1 + a) \quad \text{(v)}$$

Where a= Initial energy of the advanced node and a multiple of the initial energy of the ordinary node.

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M = The proportion of the advanced node in the total number of nodes. Common nodes and advanced nodes become clusters head and T threshold respectively.

$$T = \frac{P_{nrm}}{1 - P_{nrm}[rmod\left(\frac{1}{P_{nrm}}\right)]} \quad \text{(vi)}$$

$$T = \frac{P_{adv}}{1 - P_{adv}[rmod\left(\frac{1}{P_{adv}}\right)]} \quad \text{(vii)}$$

Where r = The current number of rounds consequently, the nodes with high residual energy can turn out to be the nodes with lower residual energy.

Selection: In each successive generation, a new population is created by selecting the members of the current generation based on their relevance.

Crossover: To generate a new generation, the crossover process selects some people as parents from the collection selected by the selection process

4 SIMULATION AND RESULT ANALYSIS

The protocols was analyzed by using the radio model which is illustrated in figure 3.

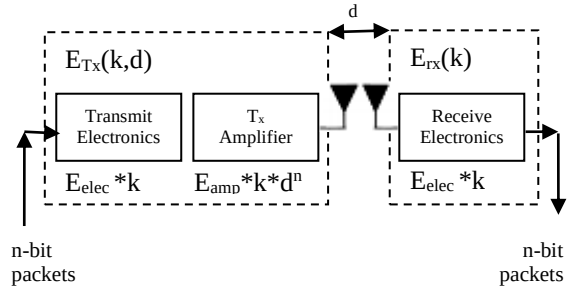

Figure 3: Radio Model

In WSN, the radio energy dissipation model is a simple model of wireless energy consumption. The transmitter circuit dissipates the energy needed to operate the transmission electronics and power amplifiers. The receiver circuit dissipates energy to operate only the electronics of the receiver.

Depending on the distance between transmitter and receiver, multiple fade and free space channel patterns are used. The free space model (loss of power d^2) is mainly used for communication in a cluster or when the threshold distance is less than d_0, while the power loss model d^4 is used for communication between clusters. The threshold distance is greater than or equal to d_0. The radio energy consumed by the transmitter to transmit a 1bit message at a distance d is:

$$\begin{aligned} E_{Tx}(I,d) &= E_{Tx-elec}(I) + E_{TX-amp}(I,d) \\ &= IE_{elec} + IE_{fs}d^2, d < d_o \\ &= IE_{elec} + IE_{amp}d^4, d \geq d_o \end{aligned} \quad \text{(viii)}$$

And energy consumed by the receiver is:

$$E_{Rx}(I) = E_{Rx-elec}(I) = IE_{elec} \quad \text{(ix)}$$

where E_{elec} = Per bit energy consumed to execute transmitter and receiver

E_{fs} = amplifier energies for free space

E_{amp} = amplifier energies for multipath models

The threshold transmission distance may be chosen as follows:

$$d_o = \frac{E_{fs}}{E_{amp}} \quad \text{(x)}$$

According to proposed algorithm different stages results are analyzed as following:

Table I: Simulation Parameters

Parameter Name	Values
Network Area	100*100
Number of nodes	100
Packet Size	4000 bits
Initial Energy, E_O	.5J
Transmitter Energy, ETX	50nJ/bit
Receiver Energy, ERX	50nJ/bit
Amplification Energy for short distance, Efs	10pJ/bit/m^2
Amplification Energy for long distance, Emp	0.0013pJ/bit/m^2
Number of Rounds	25

In this research work the MATLAB tool is used to simulate and verify the validity of Evolutionary SEP protocol. For simulation environment we have assumed WSN consisted of 100 sensor nodes and nodes are randomly distributed in the 100*100m area as well as base station is located at the coordinates (50,50). The simulation parameters are given below in table I.

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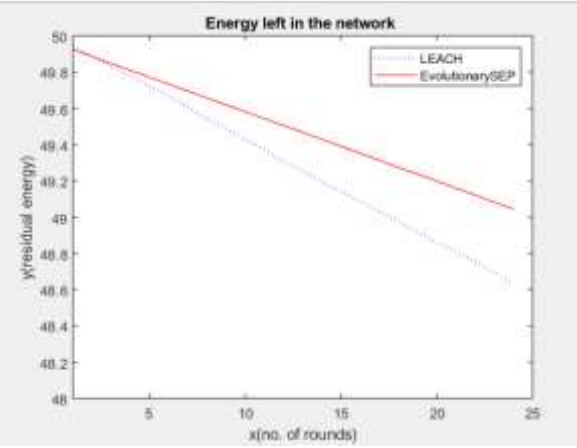

Figure 4: Comparative Graph of Evolutionary SEP and LEACH with respect to Residual Energy

Figure 4 represents the comparative graph of Leach protocol and evolutionary SEP algorithm. The graph illustrates that evolutionary SEP algorithm have higher residual energy with respect to LEACH protocol. Similarly, figure 5 represents that more packets are delivered in Evolutionary SEP as compared to LEACH protocol.

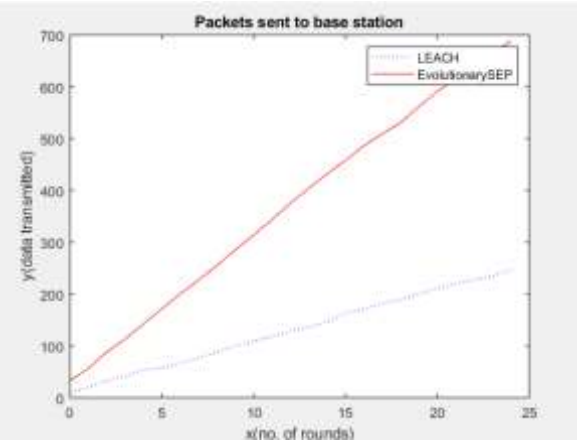

Figure 5: Comparative Graph of Evolutionary SEP and LEACH with respect to Data Transmitted

5 CONCLUSION

In this paper, a novel Evolutionary SEP algorithm is proposed for wireless sensor network. Following analysis are performed in this paper:

i. Cluster based wireless sensor network increases the energy efficiency of the entire sensor network.

ii. Genetic algorithm based SEP increases the performance of the network with respect to energy efficiency as compared to some existing clustering algorithms such as LEACH.

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