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Energy Efficient Clustering Algorithm in Wireless Sensor Networks using Genetic Algorithm

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Abstract – **Sensor nodes in a heterogeneous Wireless Sensor Network (WSN) have different capabilities, such as computational power and sensing range. When compared to homogeneous WSN, heterogeneous WSN layout and topology control are more confusing. Distinctive energy-efficient clustering methods for wireless sensor networks systems are considered, with clustering method, location awareness, heterogeneity level, and clustering features all being considered. However, each protocol is incompatible with heterogeneous WSNs. In this research, we put the Low-Energy Adaptive Clustering Hierarchy (LEACH) and the Genetic Algorithm (GA) optimized-LEACH to the test in a few different scenarios where high level heterogeneity is held to a minimum. To bring the conduct of these disparate protocols to a stop.**

Keywords– **Genetic Algorithm, Low-Energy Adaptive Clustering Hierarchy, Wireless Sensor Network.**

I. Introduction

The main challenge in the setup and proper functioning of a WSN is to extend the system's lifetime by reducing energy usage. Since the previous few years, a slew of advancements have been produced to point of confinement the energy requirement in WSN, owing to the fact that energy dispersal is more important for wireless transmission and reception [1]. Until far, the main techniques have been centred on bringing out enhancements at the MAC layer and network layer to reduce energy dissipation. The manner in which the cluster heads are placed over the network, as well as the quantity of clusters that would be present in a framework, are two more serious challenges. If the cluster heads are precisely placed across the network and there are enough clusters,are exhibited, it will aid in reducing energy dispersal and extending the system's lifetime to deal with all of the aforementioned challenges. Clustering has been identified as a successful approach [2] [3]. Clustering has consistently been mentioned as a viable strategy for extending the life of WSNs.applications of WSN. WSNs are extremely valuable in a variety of essential applications, including military surveillance, environmental, traffic, temperature, pressure, vibration monitoring, and disaster relief. WSNs are made up of hundreds or even thousands of sensors that are randomly placed inside the area of interest to ensure fault tolerance [4].

All nodes must send their data to BS, also known as the sink, on a regular basis. Because of the limited battery capacity of WSN nodes, it is also impractical to energise or replace the battery of successfully delivered nodes, and nodes may be placed in inaccessible locations. Because nodes may be located far from the BS, control correspondence is not possible due to battery limitations, as direct connection necessitates a large amount of energy. Clustering is the most important system for reducing battery usage.. . In this regard, a number of clustering conventions are described [5, 6]. All nodes that have a cluster give their information to CH, which totals it and delivers the data to BS [7-9]. Fewer messages are delivered to BS with aggregation, and just a few nodes must broadcast over long distances, saving energy and extending the network's overall lifetime. When compared to data transmission, energy usage for data aggregation is substantially lower. Clustering is possible in two sorts of networks: homogeneous and heterogeneous. Homogeneous systems have nodes with the same energy level, while heterogeneous systems have nodes with different energy levels.

In this paper, we compare and contrast a number of different things. LEACH and GA optimised LEACH in order to create a method that might achieve the following objectives:

- Reduce the network's energy consumption.
- Extend the network's life span.
- Clusters must be more evenly distributed.
- The network's cluster heads are distributed more evenly.

II. Proposed Methodology

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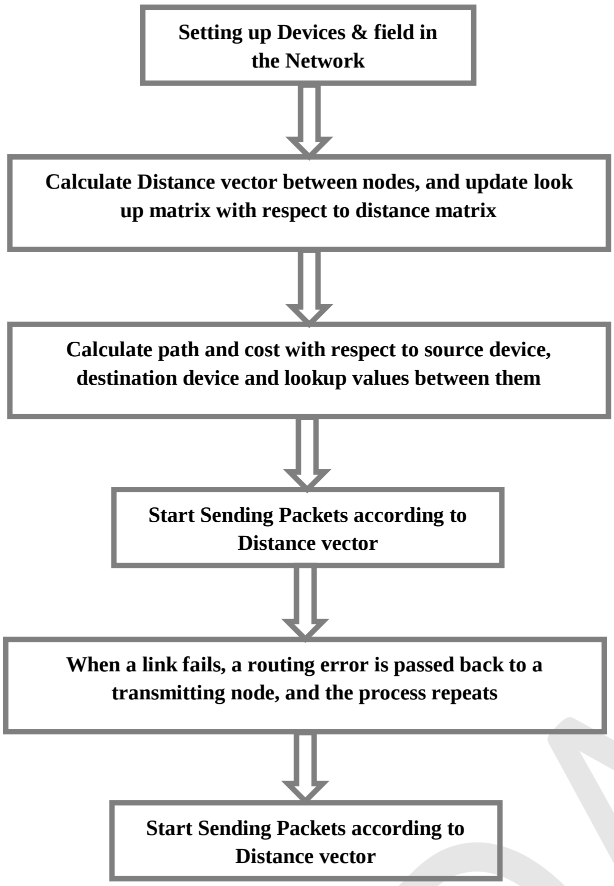

Figure 1: Flow diagram of proposed work

Cluster Head Selection Methodology

Let pi = 1/ni, which can also be thought of as the average likelihood of being a cluster head over ni rounds. When nodes have the same amount of energy at each epoch, choosing the average probability pi to be popt guarantees that there are popt N cluster heads each round and that all nodes pass in the meantime, give or take. If the nodes have different amounts of energy, the pi of the nodes with more energy should be greater than popt. Let (E)(r) denote the average energy of the system at round r, which can be obtained by:

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r) \qquad (1)$$

The probability of the nodes of nodes will be given by:

$$\sum_{i=1}^{N} P_i = \sum_{i=1}^{N} P_{opt}\frac{E_i(r)}{\bar{E}(r)} = \sum_{i=1}^{N}\frac{E_i(r)}{\bar{E}(r)} = Np_{opt} \qquad (2)$$

It's the ideal number of cluster heads. The probability threshold that each node si uses to determine if it will become a cluster head in each cycle, as follows:

$$T(S_i) = \begin{cases} \frac{p_i}{1-p_i\left(r mod \frac{1}{p_i}\right)} & if\ s \in G \\ 0 & otherwise \end{cases} \qquad (3)$$

Where G is the set of nodes sat around r that are qualified to be cluster heads. We have si G if node si has not been a cluster head throughout the most recent ni cycles. When node si realises it is qualified to be a cluster leader in each round r, it will choose an arbitrary integer between 0 and 1. If the number is less than T(si), the node si becomes the cluster head for the current round.

Heterogeneous Nodes

When networks are heterogeneous, each node's reference value should differ depending on the initial energy. We substitute the reference value popt in two-level heterogeneous networks with the weighted probabilities given in the equations below for normal and advanced nodes [10].

$$p_{adv} = \frac{p_{opt}}{1+am}, P_{nrm} = \frac{p_{opt}(1+a)}{1+am} \qquad (4)$$

Therefore p_i changes to

$$(P_i) = \begin{cases} \frac{p_{opt}E_i(r)}{(1+am)\bar{E}(r)} & if\ s_i\ is\ the\ normal\ node \\ \frac{p_{opt}(1+a)E_i(r)}{(1+am)\bar{E}(r)} & if\ s_i\ is\ the\ advanced\ node \end{cases} \qquad (5)$$

Thus the threshold is correlated with the initial energy and residual energy of each node directly.

Average Energy Estimation of Network

In an ideal situation, the energy of the network and nodes are uniformly distributed, and all the nodes die at the same time. Thus estimated average energy $\bar{E}(r)$ of r^{th} round is as follow:

$$\bar{E}(r) = \frac{1}{N}E_{Total}\left(1-\frac{r}{R}\right) \qquad (6)$$

Where, R signifies the aggregate rounds of the network lifetime. It implies that each node expends the same measure of energy in each one round, which is additionally the focus on that energy-efficient algorithms ought to attempt to attain [11].

Genetic Algorithm

Genetic algorithms (GA) were first introduced by John Holland in the 1970s (Holland 1975) as a result of research on the likelihood of computer programmes progressing in a Darwinian sense.

GAs are a subset of the evolutionary calculation model, which is a more comprehensive delicate registering ideal model. They are attempting to achieve optimal outcomes using a process known as living advancement. This is after the survival of the fittest criteria have been met, and crossbreeding and from a pool of existing outcomes, transformation is used to get better results.

Genetic algorithms have been discovered to be capable of finding solutions to a wide range of problems for which no acceptable algorithmic solutions exist. The GA concept is particularly well adapted to optimization, a

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problem-solving method in which one or more excellent results are sought in a solution space that contains innumerable possibilities. GA reduces the inquiry space by continuously evaluating the current era of hopeful outcomes, discarding those deemed terrible, and delivering new era through hybrid and altering those deemed fantastic. The placement of applicant results is determined by some predetermined criterion of kindness or wellness.

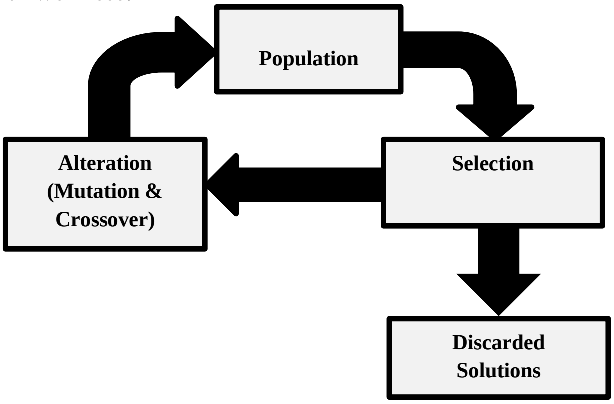

Figure 2: Genetic algorithm evolutionary cycle [12]

A genetic algorithm is a probabilistic investigation technique that computationally models biological advancement methodology. It mimics natural evolution by repeatedly altering a population of applicant results until an optimal result is obtained.
The GA advancement cycle begins with a population that has been self-selected. The populace evolves as a result of techniques of determination centred on wellbeing, as well as change utilising hybrid and metamorphosis. The provision of determination and change leads to a population that produces better results to a greater extent. The evolutionary cycle continues until a suitable result is achieved in the current population generation, or a control parameter, such as the number of generations, is exceeded.
A gene is the most basic unit of a genetic algorithm. , which refers to a metric in the issue space. A chromosome is a collection of genes that represents one possible solution to the problem. Every chromosomal gene corresponds to a certain component of the solution pattern.

Genetically Optimized Cluster-Head Selection

, Various routing techniques have been developed for wireless networks with overlap and non-overlap communication, where communication nodes play a significant role in an energy efficient routing scenario. With clustering-based routing protocols, this study presents an efficient node selection strategy. Some cluster-heads reduce node overheads, and cluster-heads are in charge of node selection and intercommunication with other nodes. In addition, genetically improved cluster-heads selection for End-to-End communication in routing protocol is proposed in this study. The sink and source communicate with one another and keep the routing going with enough leftover energy that the clustered structure can claim the longest lifetime in a given routing protocol.

- The study suggests a network scenario in which network nodes are initially unresponsive until and until they are triggered..
- The number of nodes in a network must be specified.
- A mobility assessment is required.
- Where source and sink are defined, nodes are chosen at random.
- Each node starts with the same energy value (i.e. 1 Joule), however the energy level of nodes might change over time depending on communication.
- To choose a source, calculate the shortest distance from the sink.
- Create cluster-heads to provide the best possible selection of communication-related devices in the cluster.
- Use the fitness function of a Genetic algorithm to optimise cluster-head selection for maximum network life-cycle.

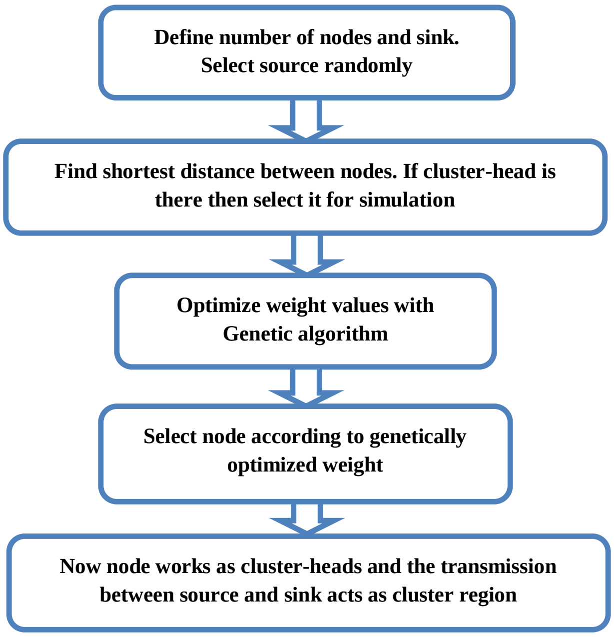

Figure 4: Flow diagram of genetically optimized cluster-heads

III. Simulation and Results

Simulation is carried out using MATLAB 2010a:

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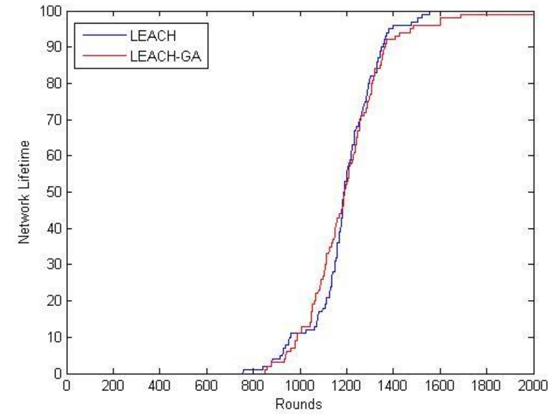

Figure 5: Network Lifetime comparison for LEACH and GA optimized LEACH

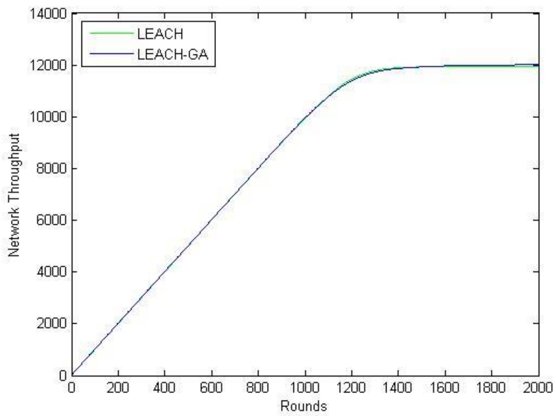

Figure 6: Network Throughput comparison for LEACH and GA optimized LEACH

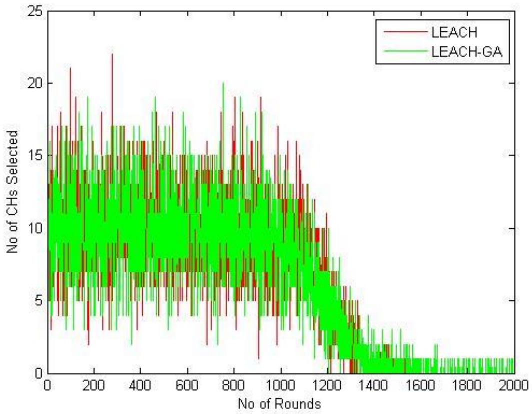

Figure 7: Cluster Head selection for LEACH and GA optimized LEACH

IV. Conclusion

n this research, we examined the current state of the suggested clustering algorithm, focusing on the power and reliability quality requirements. The energy limits of nodes play a critical role in the planning of any protocol for execution in wireless sensor networks.

Because of its simplicity, good quality of results, speedy joining, and low computational difficulty, Genetic Algorithms (GA) has been a popular approach for dealing with optimization challenges in WSNs. In any event, the iterative nature of GA makes it unsuitable for long-term applications, especially if optimization is required regularly. GA necessitates a lot of memory, which may limit its application to base stations with a lot of assets. We looked at LEACH and GA-LEACH for heterogeneous WSNs with varying degrees of heterogeneity. Simulations show that GA-LEACH is effective.

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