An Approach to Improve the Energy Efficiency of LEACH Protocol using Genetic Algorithm

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Abstract

Wireless sensor network (WSN) plays significant role in wireless communications. The major constraint with WSN is limited battery power nodes. In this report, we propose a modification to a popular protocol for sensor networks called LEACH (Low Energy Adaptive Clustering Hierarchy). LEACH is known as one of the best hierarchical routing protocols concerning energy efficiency in the networks. In this work, we enhance the life span of the nodes in the LEACH protocol using Modified-LEACH. The results of Modified-LEACH are further improved using Genetic Algorithm, which is more effective in enhancing the network lifetime when compared to LEACH.

Keywords: WSN, LEACH, M-LEACH, GA, CH, BS

I. INTRODUCTION

The Wireless sensor networks have been utilized as a member of an extensive variety of both nonmilitary personnel and military applications and the sensor nodes constrained limit has postured numerous difficulties in the design issues. The assets, for example, communication, bandwidth and the energy are more limited than those in a conventional wireless sensor networks. This impediment requires any design protocols and network to use their sources accessible viably and effectively. In this report, we portray about the configuration of clustering protocol for Wireless sensor networks considering the energy utilization issues as the fundamental requirement. Different clustering strategies have been intended for wireless sensor networks previously. Although a hefty portion of these networks performed adequately in numerous techniques, there are still a few regions that are to be tended to in these methods.

Low Energy Adaptive Clustering Hierarchy (LEACH) proposed by Wendi B. Heinzelman, et al. is the primary progressive, self-arranging, versatile cluster based routing protocol for wireless sensor networks which parcels the nodes into clusters, in every cluster a dedicated node with additional benefits called Cluster Head (CH) is in charge of making and controlling a TDMA (Time division multiple access) schedule and sending amassed information from nodes to the Base Station (BS) where these information is required utilizing CDMA (Code Division Multiple Access). Remaining nodes are cluster individuals.

Clustering is an energy proficient protocol that has been executed in numerous correspondence protocols for wireless networks. In a clustering based protocol, nodes are being characterized into a few clusters. Every cluster is constituted by one cluster head and number of member nodes.

In this protocol, all the member nodes of the cluster send their information to their respective cluster head which then advances the aggregated information to the base station. The base station then communicates with outside world through Internet or satellite connections. The cluster head performs information handling, for example, information aggregation, before sending the prepared information. Clustering reuses transfer speed and in this manner expands the framework limit. It is watched that this protocol gives better execution and results as far as network stable area, alive nodes and the lifetime of the network in contrast with the current protocols.

This report likewise analyzes the elements and execution of LEACH, M-LEACH, and Genetic Algorithm based LEACH protocol. Finally, it can be finished up from the given review that GA-LEACH can be utilized for energy effective and delayed wireless sensor networks. Still it is expected to discover more effective, versatile and strong clustering plan.

II. LITERATURE REVIEW

In this report, we show a review of innovative routing methods in WSNs. The routing schemes are arranged in three classes in light of fundamental network form: flat, hierarchical, and location-based routing. Besides, these protocols can be classified into
multopath-based, query-based, negotiation-based, QoS-based, and coherent based depending with respect towards protocol operation. In flat networks, all nodules assume similar member, beguile various hierarchical protocols plan towards cluster nodules with the goal that cluster heads can aggregate and diminish information keeping in mind the end goal towards spare energy. Location based protocols employ locale data towards hand-off information towards coveted locales instead of the entire network. The last classification incorporates routing approaches in light of protocol operation, which shift as indicated by the methodology utilized as a member of the protocol. [1]

In this report, change towards a comprehended convention known as Low Energy Adaptive Clustering Hierarchy (LEACH) is proposed. Sensor systems are expected towards remotely screen nature. In this condition, data from every nodule should be sent towards a base station, much of the time arranged away from sensor system, where end-client can get towards data. Here, dedication is addressed by constructing a two-level chain of importance of significance towards comprehend a convention that extras better the vitality use. Our TL-LEACH uses unpredictable unrest of neighborhood cluster base stations.

Thusly, a two-level movement is manufactured wherever it is possible. This license towards better scatter the vitality burden amid the sensors in organizes individually when thickness of system is more. TL-LEACH utilizes constrained collocation towards engage adaptability, energy. [2]

This report presents another adjustment of LEACH convention called VLEACH which intends towards reduction vitality use inside the Wireless system. Each CH particularly talks with BS paying little mind towards the detachment amongst CH and BS. It will eat up package of its vitality if detachment is far. Besides, Multihop-LEACH convention picks perfect route between CH and BS via various CHs, utilize these CHs as an exchange station towards transpose details over through them. [3]

### III. PROPOSED SYSTEM

WSN is anecdotal to be comprised of an extensive number of sensors and no less than one base station. LEACH decreases explanation energy by as much as 8x related with direct transmission and least transmission-energy routing. The GA-based advancement practice is performed to build the outcomes originating from adjusted Leach protocol for different base station arrangements. Cluster head assortment is arbitrarily done, that consider the additional energy variable among advanced and normal nodes (α) of sensor node. It is a more drawn out permanency district for higher morals of additional energy. The networks a portion of the nodes changed over cluster heads amassed the information of their cluster supporters and transmit it to the BS. This is a wellspring of heterogeneity which may come about because of the opening setting or as the operation of the network develops. In this work, we propose an alter execution of LEACH protocol taking into account energy heterogeneity and hoist it through Genetic algorithm. At first the brazen energy is zero and persisting energy is the measure of starting energ.

In this Model, a heterogeneous-mindful protocol to draw out the time interim before the demise of the primary node (we allude to as stability period), which is critical for some applications where the input from the sensor network must be dependable. Our altered protocol enhances the steady area of the clustering progression process utilizing the trademark parameters of heterogeneity, to be specific the extra energy variable amongst advanced and normal nodes (α). Cluster head determination is haphazardly done, that consider the extra energy element amongst advanced and normal nodes (α) of sensor node.

This protocol effectively broadens the steady locale by monitoring heterogeneity through allocating probabilities of cluster head decision weighted by the relative introductory energy of nodes. This yields a more drawn out steadiness district for higher estimations of additional energy.

A Genetic algorithm (GA) is an effective hunt algorithm that impersonates the versatile advancement procedure of normal frameworks. We propose to apply a GA to the issue of discovering ideal number of CHs taking into account minimizing the correspondence utilization energy of all sensor nodes to proficiently boost the network lifetime and to enhance the stability period.

### A. Advantages

- It accomplishes better execution in this appreciation, looked at LEACH in both heterogeneous and homogenous situations.
- Clustering is a decent approach, which, if executed legitimately, can prompt energy productive networks administration in WSNs.
- LEACH yields broad steadiness area for higher estimations of additional energy got by even more capable nodes.
IV. METHODOLOGY

A. LEACH

LEACH is the primary network protocol that utilizes various hierarchical routing for wireless sensor networks to expand the life time of network. Every one of the nodes in a network sort out themselves into neighborhood clusters, with one node going about as the cluster head. All non-cluster head nodes transmit their information to the cluster head, while the cluster head node get information from all the cluster individuals, perform signal handling capacities on the information, and transmit information to the wireless base station. In this way, being a cluster head node is significantly more energy escalated than being a non-cluster head node. Therefore, when a cluster head node dies every one of the nodes that have a place with the cluster lose correspondence capacity. Since the cluster head node knows all the cluster individuals, it can make a TDMA plan that advises every node precisely when to transmit its information.

The operation of LEACH is separated into rounds. Each round starts with a set-up stage when the clusters are sorted out, trailed by a set-up stage where a few edges of information are exchanged from the nodes to the cluster head and onto the base station.

1) Set-up phase:

In LEACH, nodes take self-governing choices to frame clusters by utilizing a conveyed algorithm with no concentrated control. Here no long-remove correspondence with the base station is required and disseminated cluster development should be possible without knowing the definite area of any of the nodes in the network. Finally, the cluster head nodes ought to be spread all through the network, as this will minimize the separation the non-cluster head nodes need to send their information. A sensor node picks an arbitrary number, \( r \), somewhere around 0 and 1.

Give an edge a chance to esteem be \( T(n) : T(n) = \frac{p}{1-p} \times (r \mod p-1) \). In the event that this arbitrary number is not exactly a limit esteem, \( T(n) \), the node turns into a cluster head for the current round. The limit quality is ascertained in light of the above
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2) Steady-State phase:
The consistent state operation is broken into casings where nodes send their information to the cluster head at most once per design amid their assigned transmission space. The set-up stage does not ensure that nodes are uniformly circulated among the cluster head nodes. In this manner, the quantity of nodes per cluster is very variable in LEACH, and the measure of information every node can send to the cluster head differs relying upon the quantity of nodes in the cluster.

![Fig. 4.2: Phases of LEACH](Image)

### B. Modified LEACH (M-LEACH):

Heterogeneous networks are more productive than the homogeneous network in WSN. The quantity of individual nodes are assembled together or gathered in one spot known as clustering. The routing protocols are performed in clustered network. The clustering algorithms, for example, LEACH; PEGASIS and HEED expect the sensor networks are homogeneous which are ineffectively performed in heterogeneous environment. Modified LEACH algorithm is energy effective correspondence protocol for WSN.

The correspondence happens between all the cluster individuals and cluster heads. In addition, cluster makes a beeline for Base Station. MLEACH accomplishes energy proficiency and diminishes the network activity.

The first form of LEACH does not think about the heterogeneity of nodes as far as their underlying energy, and thus, the utilization of energy assets of the sensor network is not upgraded within the sight of such heterogeneity.

- This protocol enhances the steady locale of the clustering hierarchy of command procedure utilizing the trademark parameters of heterogeneity, in respective the extra energy variable amongst advanced and normal nodes ($\alpha$).
- Cluster head determination is arbitrarily done, that consider the extra energy element amongst cutting edge and ordinary nodes ($\alpha$) of sensor node.
- This protocol effectively expands the steady area by monitoring heterogeneity through doling out probabilities of cluster head weighted by the relative starting energy of nodes.
- This yields a more extended soundness locale for higher estimations of additional energy. Advanced nodes have $\alpha$ time more energy than a typical node.
- Hence energy of cutting edge node gets to be $= \text{initial Energy} \times (\alpha)$.
- Initially the disseminated energy is zero and lingering energy is the measure of beginning energy in a node.

Here, an Advanced will get to be Cluster Head, if a Temporary number appointed to it is less than the Probability Structure Below,

$$T(s_i) = p_i/1-p_i(r \mod(1/p_i)) \text{ if } s \in G$$

Here, $P_i$ is turned out from new expression for ideal probability $p(i)$

- After a advanced node gets to be cluster head, energy models are connected to ascertain the measure of energy spent by it on that specific round and finish the round of steady state stage.
- If a node won't have a advanced node and disposed of from the criteria above, than it goes to an arrangement of ordinary node, and take after the conduct of typical node and complete the round of consistent state stage.
- Each node is chosen cluster head once every $1/P$ rounds (race length).
- On normal, $n \times P$ nodes chose per round.

The execution is investigated by considering the time frame and it demonstrates that the quantity of alive nodes is less. Since the alive node is less, the energy utilization is additionally less and along these lines expanding the energy productivity of the network. The relative investigation is made between the current and the proposed technique. Simulation result demonstrates that the proposed strategy is more energy productive than the current LEACH protocol.

### C. Genetic Algorithm:

Genetic Algorithms are a cluster of computational models roused by advancement. These algorithms encode a potential answer for a respective issue on a basic chromosome-like information structure and apply recombination administrators to these structures as to safeguard basic data. Genetic algorithms are regularly seen as capacity streamlining agent, despite the fact that the scopes of issues to which Genetic algorithms have been connected are entirely expansive. An execution of Genetic algorithm starts with a population of chromosomes. One then assesses these structures and allotted concepive open doors in a manner that these chromosomes which speak to a superior answer for the objective issue are given more opportunities to recreate' than those
chromosomes which are poorer arrangements. The "decent" of an answer is commonly characterized concerning the present population.

Genetic algorithm created by Goldberg was propelled by Darwin's hypothesis of development, which expresses that the survival of a living being is influenced by principle "the most grounded species that survives". An answer created by Genetic algorithm is known as a chromosome, while aggregation of chromosome is alluded as a population. A chromosome is created from qualities and its worth can be either numerical, double, images or characters relying upon the issue need to be explained.

A Genetic Algorithm performs fitness tests on new structures to choose the best population. Fitness decides the nature of the person on the premise of the characterized criteria.

1) Population: A population comprises of a gathering of people called chromosomes that speak to a complete answer for a characterized issue. Every chromosome is a clustering of 0s or 1s. The underlying arrangement of the population is a haphazardly created set of people. Another population is created by two techniques: steady state GA and generational GA. The steady state GA replaces maybe a couple individuals from the population; while the generational GA replaces every one of them at every era of advancement.

2) Fitness: In nature, an individual's fitness is its capacity to go on its Genetic material. This capacity incorporates attributes that empower it to survive and assist replicate. In a GA, fitness is assessed by the capacity characterizing the issue. The destiny of an individual chromosome relies on upon the fitness esteem. The odds of survival are higher for better fitness values.

3) Selection: The selection procedure figures out which of the chromosomes from the present population will mate (crossover) to make new chromosomes. These new chromosomes join the current population. This consolidated population will be the premise for the following choice.

4) Crossover: Crossover is otherwise called recombination of segment materials because of mating. It is a reenactment of the sexual conceptive procedure which is in charge of the exchange of Genetic legacy. The result of crossover vigorously relies on upon the determination of chromosomes produced using the population. A case of single-point crossover is appeared in Figure 4.3.

<table>
<thead>
<tr>
<th>First</th>
<th>Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 S2 S3 S4 S5 S6 S7</td>
<td>S1 S2 S3 S4 S5 S6 S7</td>
</tr>
<tr>
<td></td>
<td>1 1 0 0 0 0 1 0 1 1</td>
</tr>
<tr>
<td>Parent</td>
<td>0 0 1 1 0 1 1 0 0 0</td>
</tr>
<tr>
<td>Offspring</td>
<td>0 0 1 1 0 1 1 0 1 1</td>
</tr>
</tbody>
</table>

Fig. 4.3: Single-point crossover

In Figure 4.3 the bit arrangements of first chromosome, beginning from the crossover point, are replicated to the second chromosome and the other way around. Crossover is done after the determination procedure and relies on upon the probability characterized for the crossover called crossover rate. The probability that the crossover will occur relies on upon the crossover rate. By and large the crossover rate is high, around 80 to 95 percent.

5) Mutation: As a consequence of crossover, the new era presented will just have the qualities of the guardians. This can in some cases lead to an issue where no new Genetic material is presented in the posterity. Mutation permits new Genetic examples to be presented in the new chromosomes. Mutation presents another clustering of qualities into a chromosome however there is no assurance that mutation will create alluring components in the new chromosome. Similarly as with crossover, the mutation rate is characterized to control how regularly transformation is connected Figure 4.2 demonstrates the impact of mutation on the two posterity made as an aftereffect of crossover. Amid mutation, the eighth piece of posterity 1 is mutation from 1 to 0; In any case, because of low probability of mutation, there is no mutation in posterity2.

<table>
<thead>
<tr>
<th>Original</th>
<th>Mutated</th>
</tr>
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<tbody>
<tr>
<td>S1 S2 S3 S4 S5 S6 S7 S8 S9 S10</td>
<td>S1 S2 S3 S4 S5 S6 S7 S8 S9 S10</td>
</tr>
<tr>
<td>1 1 0 0 0 0 1 0 0 0</td>
<td>0 0 1 1 0 1 1 0 1 1</td>
</tr>
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</table>

Fig. 4.4: Mutation

D. Fitness Parameters

The fitness of a chromosome speaks to its capabilities on the bases of energy utilization minimization and scope amplification. Some critical fitness parameters are depicted beneath:

1) Direct Distance to Base Station (DDBS):

add up to direct separation between the entire sensor nodes and the BS, indicated by \(d_i\), and is figured as beneath:

\[
DDBS = \sum_{i=1}^{m} d_i
\]

where "m" is the quantity of nodes. As can be seen from the above recipe, energy utilization sensibly relies on upon the quantity of nodes, such that it will be great for substantial WSN. Then again, DDBS will be satisfactory for littler networks with a couple firmly found nodes.
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Cluster based Distance (CD):
This parameter is the whole of the separations amongst CHs and BS, added to the entirety of the separations between related member nodes and their cluster heads.

\[ CD = \left( \sum_{i=1}^{n} \left( \sum_{j=1}^{m} d_{ij} \right) + Dis \right) \]

where "n" and "m" are the quantity of clusters and the comparing individuals, separately. "d_{ij}" is the separation between a node and its CH, and "Dis_n" is the separation between the CH and the BS. This arrangement is proper for networks with an extensive number of generally separated nodes.

Cluster-based Distance-Standard Deviation (CDSD):
Standard derivations measure the variety of cluster separations, instead of one normal cluster separation. CDSD is distinctive relying upon whether there is an arbitrary or deterministic situation of sensor nodes. On account of arbitrary arrangement, there will be clusters of various sizes such that a SD inside a predefined variety in the cluster separation is satisfactory. In the accompanying, \( \mu \) registers the normal of the cluster separations, which will be our standard SD recipe for figuring cluster separation variety.

\[ \mu = \frac{\sum_{i=1}^{n} d_{cc}}{n} \]

\[ SD = \sqrt{\sum_{i=1}^{n} (\mu - d_{cc})^2} \]

Transfer Energy (E):
This metric, E, shows the measure of devoured energy to exchange all the gathered information to the BS. Considering m-numerous related nodes in a cluster, E is processed as takes after:

\[ E = \sum_{i=1}^{n} \left( \sum_{j=1}^{m} e_{jm} + m \times Er + ei \right) \]

Where \( ejm \) is the energy important to transmit information from a node to the relating CH. Thusly, the primary term in the summation of "i" is the aggregate energy expended in exchanging the amassed information to CHs. The second term in the "i" summation demonstrates the energy required to get information from individuals, lastly ei speaks to the energy expected to transmit from the cluster head to the BS.

Number of Transmissions (T):
Generally, the BS decides number of transmissions for every observing period. This measure is processed by conditions and the energy level of the network; thus, a substantial T speaks to quite a while stage for which just a prevalent ideal answer for amplification and a second rate answer for minimization can be acknowledged. The execution of past GA-based arrangements decides the nature of the best arrangement or chromosome.

V. RESULTS AND ANALYSIS

Figure 5.1 shows the graph of number of alive nodes vs number of rounds. It is observed that GA LEACH has less number of alive nodes that lasts for longer duration than LEACH protocol.
Figure 5.2 shows the graph Energy level vs number of rounds. It is observed that GA LEACH consumes less energy and increases the energy efficiency of the network than LEACH protocol.

Figure 5.3 shows the graph number of dead nodes vs number of rounds. It is observed that GA LEACH has less number of alive nodes and more dead nodes. Dead nodes are discarded from the network thus increasing the lifetime of the network.

VI. CONCLUSION

In this proposed network, the steadiness time of network and network lifetime have been enhanced. Reenactment results demonstrate that there is huge mutation in every one of these parameters when contrasted and existing routing protocols LEACH, M-LEACH, and GA-LEACH. This calls for utilization of a suitable routing protocol to guarantee productive
information transmission through the network. In this work, an alter execution of LEACH protocol in view of energy heterogeneity has been proposed and upgrade it through Genetic Algorithm.

REFERENCES


