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Optimization Approach for LEACH Routing Protocol in WSN

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Abstract: *Wireless sensor network is built of several sensor nodes and a base station, where each sensor node connected to the base station. The main demanding task in this network is lifetime and energy consumption. . The cluster based routing protocols are most accepted to improve the network lifetime and to lessen the energy consumption of wireless sensor network. This paper presents the flower pollination optimization algorithm also called OLEACH-C to improve the performance of LEACH-C protocol. The FPO algorithm used for clustering in WSN. In FPO algorithm CH will be selected on the bases of remaining energy and distance of the node. If two nodes have the same residual energy then CH will be selected on the bases of distance. The node having minimum distance will be selected as a CH. The Simulations results show that the OLEACH-C protocol selects the best CHs that assurance a routing optimization with the minimum energy consumption and minimum communication links` cost between nodes within each cluster and other energy efficient communication protocols for WSN routing protocol improve the energy consumption and network lifetimes.*

Keywords: *Wireless Sensor Network, OLEACH-C, Efficient Energy, Network Lifetime, CH (cluster head).*

I. INTRODUCTION

WSN composed of a base station and several sensor nodes which have restricted memory, computational and communicational resource. Wireless sensor networks have huge potential for usage of sensor networks in different areas like military area, debacle management, sensing environment conditions such as temperature, humidity etc[1]. A power source is also required by a sensing node to perform the task. The power source used by sensor node is a battery with limited energy and also it is not possible to recharge or replace the battery because nodes may be deployed in unpractical environment and thus the sensor network must have enough lifetimes to fulfill the requirements of the application. The wireless sensor networks can be utilized in a various information, home, military and telecommunications applications [2].

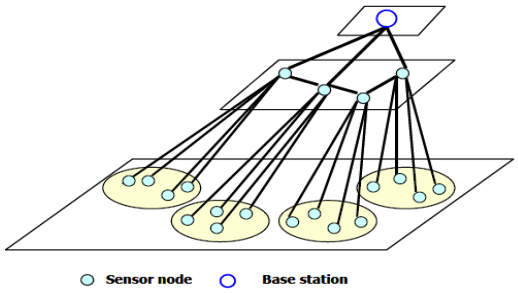

Figure 1: Hierarchical wireless sensor network [4]

Wireless Sensor Network (WSN) consists of number of sensor nodes. These sensor nodes are scattered in an environment called sensor field.
They also are used with transceivers to get the information from its environment and transfer that information to the base station, where the calculated parameters can be stored and obtainable for the end user [3]. The basic communication architecture for WSN is shown by Figure1

There are a number of protocols in wireless sensor network which are used to reduce the energy consumption and to increase the network lifetime. But

the hierarchical based Routing protocol is the best protocol and is the cluster based protocol [4]. The cluster based routing is a technique to reduce the energy consumption by using the data Aggregation algorithm. Data Aggregation is a process of combining and summarizing the data from sensor nodes in wireless sensor networks by using aggregation function such as MAX, MIN, AVG, COUNT, SUM as in [2] etc. on Aggregator nodes[5]. Data Aggregation is a process of eliminating redundant data from various sensor nodes [6]. In WSN nodes can't directly communicate to the base station. Nodes send the information to their CH, CH aggregate the information and then send this aggregated information to base station.

The primary hierarchical protocol is the Low Energy Adaptive Clustering Hierarchy (LEACH). The LEACH enhances the energy utilization because the transmission will only be completed by the cluster heads rather than the all the nodes [7].

LEACH PROTOCOL

LEACH (low energy adaptive clustering hierarchy) is a clustering protocol for wireless sensor network. In LEACH each node selects itself as a cluster head. The cluster head receive the data from other nodes then aggregate that data and send the data to base station. The LEACH algorithm works in rounds such that each round has two phases i.e. setup phase and a steady state phase [8].

In the setup phase [HYPERLINK \l "Rae13" 8], p% of n sensor nodes are randomly chosen a cluster heads (CHs) based on a threshold value. A sensor node chooses a random number, r, between 0 and 1. If the random number is less than threshold value, (T (n)), then, the node become a cluster head for the current round else node is a simple node. The threshold value calculated based on the equation [9] i.e. given below:

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(r \bmod \frac{1}{p}\right)}, & if\ n \in G \\ 0 & otherwise \end{cases}$$

Where p is the percentage of cluster heads (e.g. 0.05), r is the current round, and G is the group of nodes that have not been CHs in the last rounds. The node whose number is greater than the threshold value will be select as a cluster head and then send the message to the encircle sensor nodes. The sensor node that is selected to be CH is not selected in the next rounds until all other nodes in the network becomes cluster heads.

In the steady state phase, Each CH obtain information from all the nodes in the cluster based on Time Division Multiple Access (TDMA).CHs then aggregate the data and send to the base station. Figure.2 shows the LEACH protocol as given below.

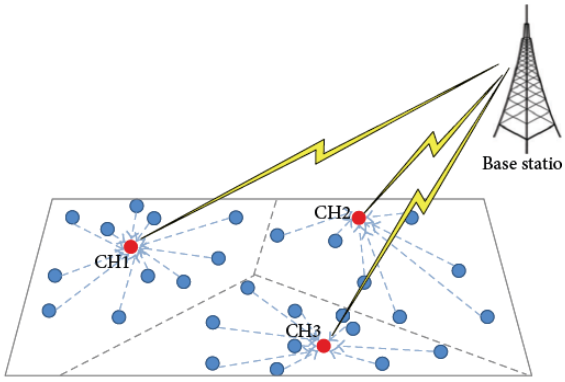

Figure 2: LEACH aggregation algorithms [9]

II. RELATED WORK

In clustered routing protocols whole network is separated
into several clusters. One node in each cluster acting the leading role known as cluster head (CH). Cluster head is only the node that can communicate to base station in clustering routing protocol. LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering –based protocol that utilizes randomized rotation of local cluster base stations to equally allocate the energy weight amongst the sensors in the network

2.1 LEACH

LEACH randomly selects only some sensor nodes as cluster heads (CHs) and rotates this task to equally assign the energy load among the sensor in the Network. LEACH protocol is able to enhance the network lifetime. But there are some issues about the LEACH protocol [10].

- LEACH is not suitable for large areas networks.
- Data is sending to the base station at every round so energy consumption is high.
- LEACH protocol cannot be useful for mobile nodes; breakdown of cluster-heads creates the many problems.

2.2 Multi-hop LEACH-C

An enhanced version of LEACH protocol called Multi-hop LEACH (LEACH-M) [HYPERLINK \l "Sal14" 11].In this protocol, the sensor nodes can communicate with in multi-hop fashion. In this It's not necessary that all the nodes send the data only to base station, node can send the data to its neighbor then neighbor sends the data to the base station [11]. However, this proposed protocol requires each sensor should be able to aggregate data, which increases the cost and overhead of sensor nodes.

2.3 LEACH-C

LEACH-Centralized (LEACH-C) is similar to LEACH protocol. In this LEACH performs a centralized algorithm. The base station gathers the location data of all the sensor nodes and then transmits its result of which node act as a cluster head [12]. The overall operation of LEACH-C is better than LEACH. But when the energy charge of communicating with the base station becomes higher than the energy cost for cluster formation, then, LEACH-C don't provides good performance. The base station may be placed far away from the network. in much WSN application.

2.4 LEACH-V

To reduce the energy consumption of the nodes, new version has been proposed i.e. LEACH-V [HYPERLINK \l "Nut13" 13]7]}. In this, CH (responsible only for sending data that is received from the cluster members to the BS), vice-CH is a node that will become a CH of the cluster when the CH dies, and the cluster nodes gather information from environment and send to the CH. There is no need to select a new CH every time the CH dies. This will expand the overall network lifetime [13].

2.5 EELEACH-C

To improve the energy consumption and to improve the network lifetime of the WSN, new version of LEACH-C has been projected. This presents the energy efficient LEACH-C protocol. In this, the base station runs a sorting algorithm and creates a list of nodes in sliding order based on their remaining energy. The node that has maximum left over energy will be overall performance of the protocol is good. But there are some disadvantages of the EELEACH-C protocol. Because if the two or more nodes having the same energy in the network then, cluster head will be selected on the bases of their id rather than distance [12].

So this technique will not be able to amplify the performance of existing LEACH protocol in a very significant manner. It consumes the more energy and superior cost. So in the proposed work our aim is to design a protocol over which the cluster head will be selected on the basis of optimization technique such as FPO (Flower pollination optimization), in this, CH will be selected as the cluster head will be selected on the bases of energy and distance. If the two nodes that can be selected as cluster head having same energy, then cluster head will be selected on the basis of distance rather than their ID. The node that has least distance from the base station will be selected as a CH. The proposed system model will be able to improve the performance of existing LEACH protocol to significant level in terms of energy efficiency, cost and network lifetime.

III. PROPOSED WORK

The proposed work is the improvement over the LEACH-C protocol by using the optimization technique i.e. flower pollination optimization (FPO). In this proposed work we are trying to increase the network lifetime and to diminish the energy consumption of the sensor nodes. Flower pollination optimization is a new population-based sharp optimization algorithm by simulating flower pollination behavior.FPO is used to solve the problems related to optimization and wireless sensor network. The main objective of the FPO is to reproduce the new generation of plants and survival of the fitness. The reproduction in plants happens by combination of the gametes. The pollen grains produced by male gametes and send to the female part is called stigma of the flower and reproduce the plant.

There are two types of pollination: first is biotic, in biotic pollination pollen is transfer to the stigma by insects and animals. Second is abiotic pollination, pollen is transfer by wind or diffusion in water. Pollination can be achieved by two types:

- Self pollination
- Cross pollination
- **Self pollination:** self pollination is a process in which pollen transfer from flower or flowers of the same plant. It occurs when a flower contains both the male and the female gametes. The self and abiotic pollination used for short distance and local pollination.
- **Cross pollination**: Cross Pollination occurs when pollen grains are moved to a flower from another plant. In cross pollination flowers are communicated to the flowers of another plant. Cross pollination and biotic pollination used for long distance. Biotic pollination and cross pollination used for global pollination.

The global and local pollination is controlled by the switch probability i.e. $p \in [0, 1]$.

In wireless sensor networks, the flower pollination optimization improves the network lifetime by associating the nodes of the cluster according to the distance to the proper cluster head. The main purpose to intra- cluster distance, the FPO algorithm divides the network into clusters and selects the cluster head based on energy as well as distance. It associate the cluster nodes to each cluster based on the intra cluster distance optimization function. It selects the best cluster head that gives the guarantees of least amount of cost between the communication of cluster head and cluster members and communication between base station and cluster head and nodes also guzzle less energy for transferring the data between the cluster and from cluster head to base station[18].

Pseudo code for selection of cluster head and cluster member nodes using proposed pollination based algorithm

Considering BS as the base station, A_E is the average energy of the network, CH is the cluster head, and CM is the cluster member, $dist_j$ and $dist_k$ are the distance of nodes from the base station. Considering E as the set of energy of all the nodes, N is the total number of nodes.

a) All the nodes send their location and present energy to BS.
b) BS marks only the higher energy nodes and calculates the A_E of the network

Cluster head Selection (A_E, CM, N, CH, E)

1. J ← 1
2. While J <= N
3. If (E_J >A_E) then
4. CH (j) = True
5. Else
6. CM (j) = True
7. End if
8. For(k = 1; k < N; k++)
9. If (E_j = E_k)
10. j++ then
11. Apply the FPO algorithm
12. If ($dist_j$ < $dist_k$) from BS, then
13. CH (j) = True
14. Else
15. CH (k) = True
16. End if
17. End if
18. End while

IV. SIMULATION RESULTS

To verify the performance of OLEACH-C, we create a Wireless sensor network. The matlab software MATLAB (Matrix laboratory) has been used to suggest the results. After creating nodes are deployed into the network. Numbers of nodes are fixed. There are 100 nodes in the network as shown in Figure. The nodes are moving to their respective places in the network. All the nodes considered here are identical in nature. Each function in the network consumes significant amount of energy of the nodes. This section presents the results obtained for the EELEACH-C protocol and the Proposed optimized LEACH-C (OLEACH-C) protocol as well as its comparison with other protocols like LEACH and LEACH-C. The figure.3 shows the wireless sensor network.

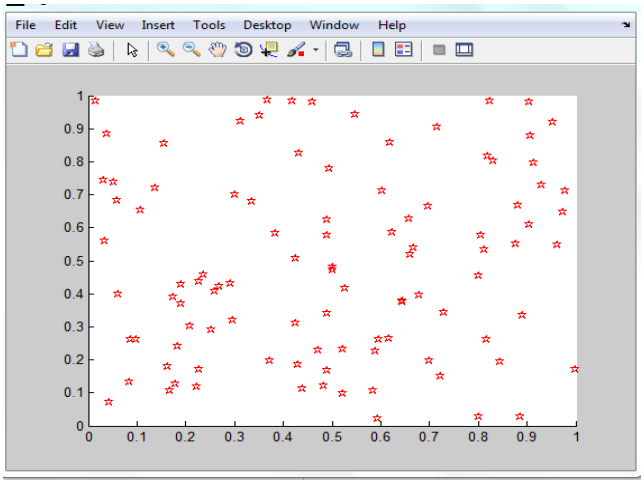

Figure 3: wireless sensor network

The figure.4 shows the comparison of proposed OLEACH-C with existing LEACH, LACH-C, and EELEACH-C protocols. The LEACH protocol loose their energy in cluster creation. Because clusters are created after every round so that it guzzle more energy.But in case of LEACH-C cluster formation is done by Base Station. But here the energy charge of communicating with the base station becomes higher than the energy cost for cluster formation. In case of EELEACH-C cluster formation is done in an energy efficient manner and in OLEACH-C cluster formation is done based on the energy and distance by using the optimization technique called flower pollination optimization(FPO) The node that has least distance from the base station will be select as a cluster head.So that number of nodes alive in case of OLEACH-C is greater than the LEACH, LEACH-C, EELEACH-C. The OLEACH-C protocol gives the performance around 3217 rounds. It give the better results than the existing protocols.

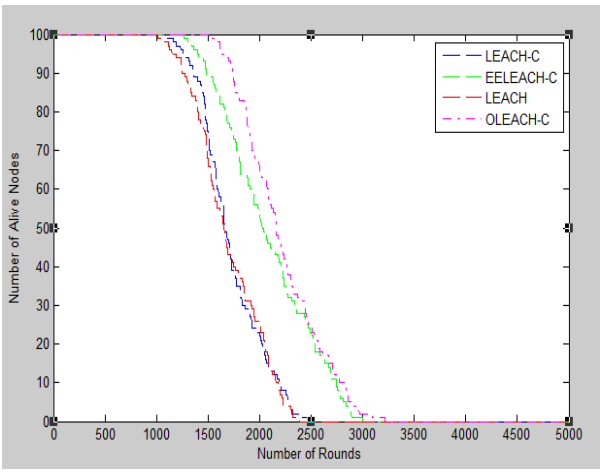

Figure 4: Alive nodes v/s rounds plot comparison of proposed OLEACH-C with other existing protocols

The figure.5 shows the comparison of dead nodes between the proposed optimized LEACH-C (OLEACH-

C) protocol and the existing protocols (LEACH, LEACH-C, and EELEACH-C). The OLEACH-C protocol gives the better results than the other protocols. In OLEACH-C, the first node is dies around 1553 rounds. The tenth node is dies around 1738 rounds and the last node is dies around the round number 3217.

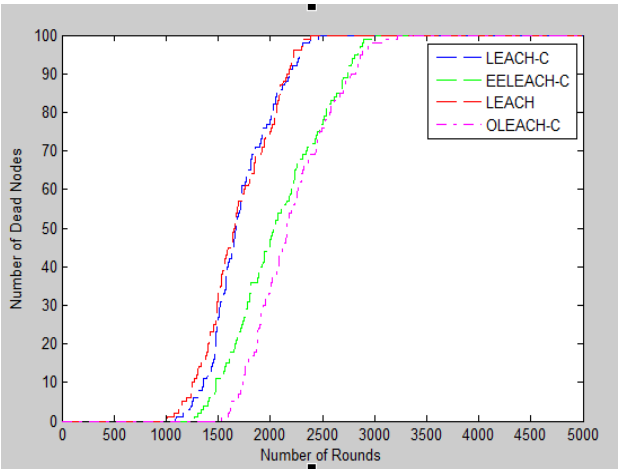

Figure 5: Dead nodes v/s rounds plot comparison of proposed OLEACH-C with other existing protocols

In the figure.6, the purposed optimized LEACH-C (OLEACH-C) protocol gives the better results than existing protocols (LEACH, LEACH-C, and EELEACH-C). In optimized LEACH-C (OLEACH-C) protocol, packets that are sending to base Station and packets sent to cluster head are more than the other protocols and it gets better the network lifetime and also diminishes the energy consumption.

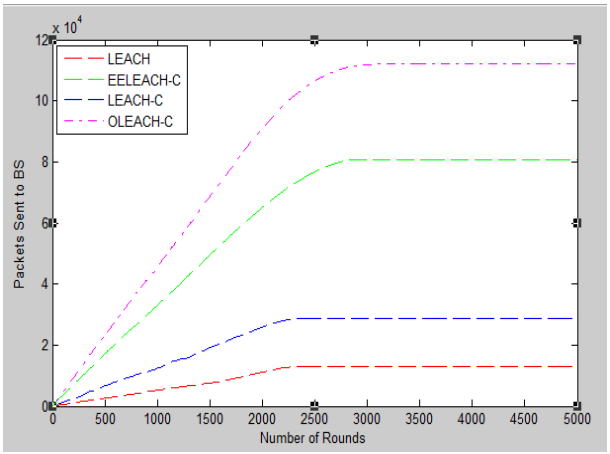

Figure 6: Packets to BS v/s rounds plot comparison of proposed OLEACH-C with other existing protocols

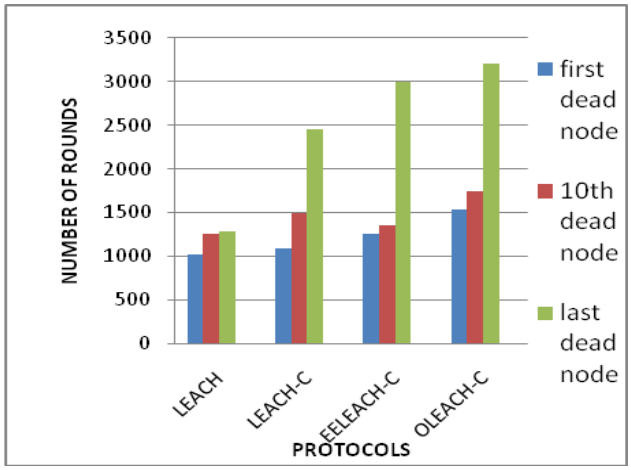

Figure 7: Network lifetime comparison of proposed OLEACH-C with other existing protocols

The figure.7 shows the comparison of lifetime of the network between the purposed optimized LEACH-C (OLEACH-C) protocol and the existing protocols (LEACH, LEACH-C, and EELEACH-C). From the figure, the proposed optimized LEACH-C protocol provides the more network lifetime than the other protocols.

CONCLUSIONS

Energy efficient cluster based routing protocol is used to improve the lifetime of the network. In this paper, The FPO algorithm is used for clustering in WSN. It is showing for homogenous wireless sensor environment. This protocol improves the wireless sensor network lifetime by selecting the cluster head based on their remaining energy as well as distance. And it associates the cluster nodes according to the distance to the proper cluster head. Therefore, OLEACH-C protocol selects the best CHs that guarantee a routing optimization with the minimum energy consumption and minimum communication links` cost between nodes within each cluster and other energy efficient communication protocols for WSN. The simulation is done by using MATLAB. The simulation results shows that proposed OLEACH-C protocol has better performance than the existing LEACH, LEACH-C and EELEACH-C protocols, because in optimized LEACH-C protocol, cluster head is selected based on the node's remaining energy and distance.

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