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MODIFIED LEACH ALGORITHM FOR ENERGY EFFICIENT CLUSTERING IN WIRELESS SENSOR NETWORKS

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Abstract

In wireless sensor networks, node clustering is an essential process that aims to balance load and enhance network longevity. An improved strategy, balanced cluster generation, provides the extra benefit of comparable clusters at the expense of clusters overlapping. But the most extensively used technique is the low-energy adaptive clustering hierarchy protocol.

In the following study, a node overhaul technique is proposed for energy efficiency and balancing of load while preserving uniform-size clusters with no overlap. The proposed technique builds clusters initially, then refurbishes them with a second-best option cluster head as necessary. When compared to previous simulated methodologies, the findings obtained thus far demonstrate a significant enhancement in node death rate and network longevity.

Keywords- *Energy efficiency, Sensor networks, uniform size clusters (USCs), Load balancing, Network lifetime.*

1. INTRODUCTION

Computing equipment have grown less expensive, more portable, and more widespread in daily life as laptops, mobile phones, smart electronics, PDAs, GPS devices and RFIDs, and have proliferated in the post-PC age. With commercial off-the-shelf (COTS) components, an embedded system that is the same size as a wallet and has the characteristics of a PC from the 1990s may now be developed. Various versions of the Linux or Windows operating systems can handle such embedded devices. According to this viewpoint, the rise of wireless sensor networks (WSNs) is simply a continuation of the Moore's Law trend of computer system downsizing and proliferation.

A sensor node, often termed as a wireless sensor node, is comprised of sensing, communication, actuation, computation, and power components. These components are packaged in a few cubic inches and incorporated on one or more boards. Due to networking technologies and low-energy circuit, a wireless sensor node charged by two AA batteries may run in the 1% low duty cycle mode for more than three years. A WSN is often composed of several of these nodes that interact, share information, and collaborate through wireless channels.

A sensor, such as a strain gauge or

thermocouple, analyses a physical quantity and converts it into a signal that an observer or instrument can comprehend. A network is commonly defined as any interconnected group or system. Wireless sensor networks (WSNs) are rapidly gaining appeal for both commercial as well as military applications.

An AWSN is an interconnected network comprised of small sensor nodes that exchange data. These nodes collect and communicate environmental information to a base station, such as temperature, humidity, pollution levels, and pressure. Depending on the volume and type of data being examined, the latter either transfers the data to a wired network infrastructure or activates an action or alarm. Tracking wildlife and human movement in forests and along borders, battle surveillance, weather and forest monitoring, and environmental elements such as pressure, temperature, vibration, and pollution are all common applications.

The suggested network layout aims to reduce delays in wireless sensor networks' data gathering procedures, extending the network's lifetime. Several routing protocols for WSN have been developed, however the hierarchical protocols which are most extensively used are PEGASIS and LEACH. Hierarchical protocols are used to aggregate data and minimize base station broadcasts i.e., transmissions. To save energy and convey data to the BS (base station), data is collected in hierarchical protocols. To reduce energy, LEACH, the most widely used routing protocol, employs cluster-based routing. This article first reviews the LEACH technique and then describes its steps.

2. LITERATURE SURVEY

The concept of sensor networks is presented in the paper [2], which has been facilitated by the confluence of microelectromechanical wireless communications technology, digital electronics, and systems technology. The initial stage is to investigate prospective sensor networks and sensing tasks, as well as a summary of variables impacting sensor network design is offered. The following stage is to sketch out the communication architecture for WSNs. Furthermore, algorithms and protocols created for each particular layer are investigated. According to the research [9], the majority of clustering algorithms are unable to accommodate mobile and heterogeneous network infrastructures. Given that a number of applications demand the support of such network properties, more emphasis must be put into addressing mobility and heterogeneity through clustering. The results also demonstrate that clustering techniques are capable of addressing a wider range of problems, despite their primary focus on lowering energy usage and improving load balancing. This will encourage scientists and researchers to use clustering to address additional networking problems.

LEACH also outperformed static clustering techniques by encouraging nodes to commit to cluster heads of high- energy and modifying relevant clusters based on which, at any moment in time, nodes opt to be cluster heads. It is also noted that each node is responsible for gathering data from the cluster's nodes at different times, integrating the data or information, and then communicating the aggregate signal to the BS (base station).

3. LEACH ROUTING PROTOCOL

The LEACH routing algorithm was developed by Heinzehnan et al. at MIT in the United States and is the first conventional hierarchical routing system.

The LEACH protocol is a clustering-based routing method designed for WSNs. LEACH is the first conventional hierarchical routing protocol and is specified as a WSN routing approach. It employs a distributed CH (Cluster Head) election process wherein specific network nodes are arbitrarily selected as CHs while others become MN's (member nodes) of the cluster.

The CH transmits the message indicating that it has become a CH, followed by the remainder of the nodes choosing the CH with the strongest received signal to combine to form a cluster. Data is collected by the cluster members and relayed to the CH, who gets it and relays it to the sink or BS (Base station) via a technique known as single-hop communication. The CH takes on the difficult jobs and issues. This comprises managing cluster member nodes, acquiring data sent by member nodes, inter-fusion of data and cluster forwarding. As a result, CHs rotate, and the cluster topology is changed on a regular basis to regulate node energy usage. LEACH is a self-adaptive cluster creation mechanism. The LEACH protocol's core idea or strategy is to split the network into clusters of uniform-size.

A "round" is referred to as one cycle of CH's periodic rotation. Every round is divided into two stages: the stable transmission stage of the cluster and the establishment stage. Each node produces a number between 0 and 1 at random. Equation (1) is used to calculate threshold T(n). This T(n) is then compared to the number generated arbitrarily for each node. If the calculated threshold T(n) is greater than this number, the node is chosen as the CH.:

$$T(n) = \begin{cases} \frac{p}{1 - p * (r \bmod ((1/p)))}, & n \in G, \\ 0, & n \notin G, \end{cases}$$

Where, p = Cluster Head percentage in all nodes,

r = number of active or current election rounds,

The number of sensor nodes chosen in this round is (r mod (1/p)), and G is the collection of nodes chosen in this round excluding CHs. Upon the conclusion of each CH selection round, each qualified CH broadcasts its message regarding becoming a CH to all other nodes. When the broadcast message is received, subsequent nodes determine whether to become a MN of the cluster based on the strength of the received signal and transmit their message to the chosen CH. After joining its member nodes, each CH establishes and allocates a TDMA schedule amongst each member node. The cluster establishment step will then be completed, and then the data transmission stage will begin.

If the T(n) value exceeds the number, the node becomes the CH for the current round If a node has previously functioned as the cluster head, it cannot be selected again unless and until all the nodes in the cluster have previously served as CH.

3.1 LEACH PROTOCOL OPERATION

principles to reduce data transmission between the BS and nodes. As a result, this protocol not only reduces loss of energy but also increases network longevity. Furthermore, the CH employs a data aggregation strategy that can decrease corelated or associated data locally.

The LEACH procedure is executed in discrete rounds that are classified into two sections: The setup phase and then the steady phase.

The major goal of the setup phase is to construct clustersand to pick the right cluster head by selecting the sensornode which has the highest energy levels. The LEACHprotocol is a popular example of a hierarchical routingmechanism. Rounds are used as units in the Leachprotocol, with each round containing storage for the clusterset-up phase and steady-state, both of which areresponsible for reducing redundant energy expenditures. The setup phase has three steps:

1. Advertisement of cluster head (CH)
2. Setup of the cluster
3. Transmission schedule creation

In the initial step, the cluster head delivers the advertisement packet to alert the cluster nodes that they have took over as cluster heads for the current round. The steady phase lasts for a longer period of time than the set- up phase and is largely concerned with data accumulation at cluster heads and transfer of this information to the sink (BS). During this phase, the cluster head gets information from the cluster nodes with which it is associated.

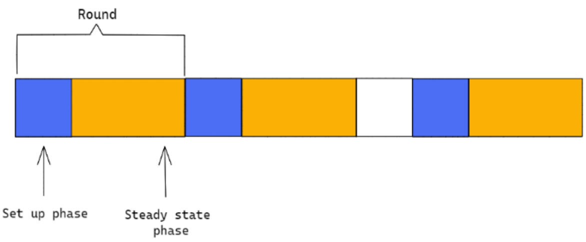


Figure 1: Stages of Leach

Each cluster's member sensors can only communicate with the cluster head in one direction, i.e. via single hop communication. The CH (cluster head) combines all acquired information and relays it to the sink/BS (Base Station) either via another CH using the static route provided in the source code or directly.

The network eventually returns to the setup phase after a predefined length of time. The LEACH protocol makes use of periodic data collection and clustering

This technology can help optimise network data volume and minimise consumption of energy. Additionally, LEACH's time division multiple access (TDMA) scheduling enables the member nodes to enter sleep mode, preventing collisions among clusters and extending sensor battery life.

3.2 NETWORK MODEL FOR LEACH

The following describes the network model used to create the clustering and routing algorithm:

1) There are 50 identically energy initialised nodes in our model. The transmit power can be changed within a range and the base station, which is manned, has unlimited power.

2) The nodes are thought to be immobile, and either GPS or node self-localization techniques have been used to determine where they are.

3) There is a single mobile sink node available. Information exchange allows for the determination of the separation between network nodes and the sink node. The sink node can be shifted to determine the ideal location. Communication with low energy will occur over the shortest feasible distance.

4) Because they are closer to the CHs, the CHs may take a single hop to the sink node, consuming more power in the course of sending data to the sink/base station. The MNs of the cluster employ single-hop communication with CHs.

5) Sensors constantly monitor their surroundings and transmit collected data to the sink/BS (Base Station).

4. PROPOSED METHOD

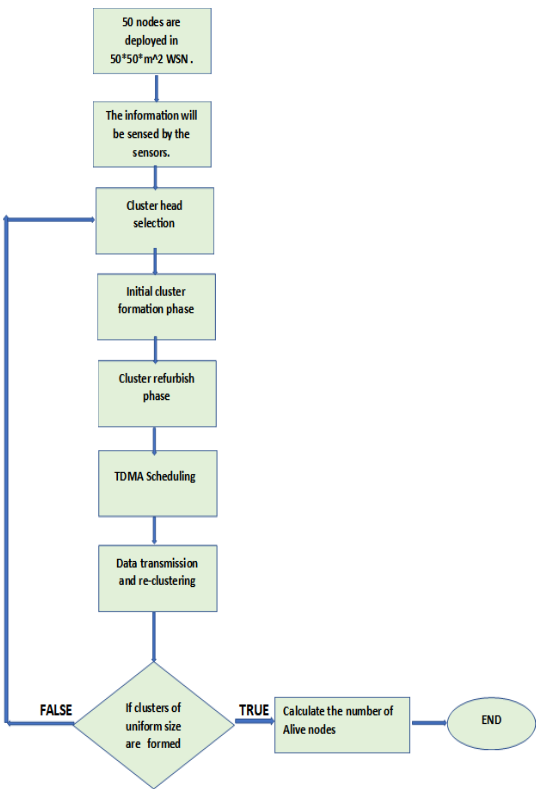
The three goals of the suggested LEACH-USC techniqueare as follows:

- Produce clusters of homogenous distribution (as in[7]);
- Produce clusters with distinct limits ; and
- Increase the network’s lifetime (as in [7]).

Similar to the LEACH protocol, a cluster head is assigned to each and every node in the proposed solution; however, because of the Thcluster threshold, a few nodes will stay un-clustered. In our proposed approach, the goal of the cluster refurbishment phase is to permit more

member nodes (MNs—Thcluster) from different clusters to enter other clusters in accordance with the cluster leaders' second-best pick. Because the proposed method incorporates clusters of uniform or equal size, the approach is referred to as LEACH-USC and has less intra-cluster communication (USCs).

5. FLOWCHART FOR SIMULATION



6. ALGORITHM

The proposed strategy's functioning also employs a probabilistic strategy for cluster head selection. All nodes join the closest cluster head during the first cluster-building procedure.

After the initial cluster creation or formation operation, clusters of various sizes exist as a result of the allocation of nodes to the closest cluster head and probabilistic cluster head selection as in the LEACH methodology, but unlike the BCF method, every node will be assigned to a specific cluster head. Nodes from large clusters will be moved to other clusters throughout the cluster refurbishing process of the suggested approach depending on the second best choice of CH.

Pseudo Code for Refurbish Phase of the Clusters Input: Total Number of cluster heads (N), Number of nodes in each cluster (CLUSTER[]), Thcluster **Important Parameters**: k, MN (Member Nodes), Biggest, SecondBestCH[]

Result: Clusters of Uniform or Equal size

i. CLUSTER[] is sorted in Decreasing order

ii. **for** j=1; j<=N; j++ **do**

iii. Biggest = j

iv. MN =CLUSTER[Biggest]

v. **for** c = 1; c <= MN; c++ **do**

vi. SecondBestCH[j] = Distance between the current MN and the Cluster Head which is its second-best choice

vii. **end**

viii. SecondBestCH[ ] is sorted in Increasing Order

ix. Thcluster = sum(CLUSTER[])/N

x. k = (MN - Thcluster)

xi. **If** k > 0 **then**

xii. The cluster head which is the second-best choice is assigned from the sorted SecondBestCH[] to first k nodes.

xiii. CLUSTER[ ] is updated

xiv. **end**

xv. Cluster Head is removed from the list to avoid any further processing

xvi. CLUSTER[ ] is sorted in Decreasing order

xvii. **end**

After determining the biggest cluster among all clusters, the distance between its member nodes and the remainder of the CHs is determined. This is carried out to identify the CH which is the second-best alternative. These second-best clusters of the CHs will receive the k number of nodes (MN—Thcluster) with the shortest communication distance to the remaining cluster heads. As a result, different cluster heads are allocated to the nodes nearest to the cluster boundary. Also, Algorithm 1 is utilized in the Cluster refurbishment phase.

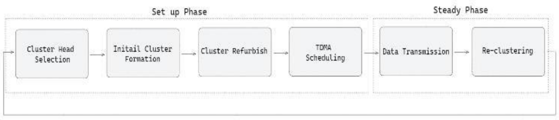
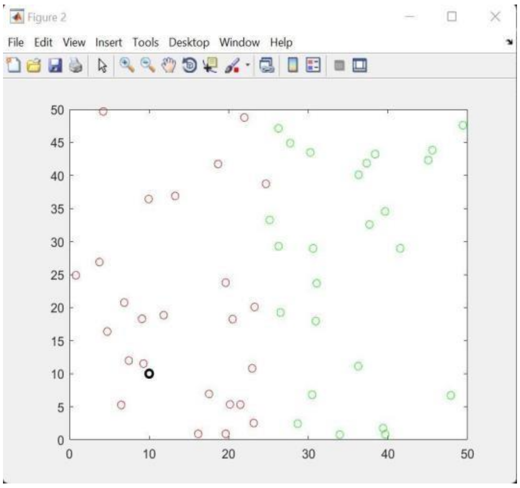


Figure. 2. Procedure involved in the



presented LEACH-USC.

In accordance to the second-best distance, the final step comprises shifting the first k nodes (k = CLUSTER[Biggest] - Thcluster) from the second biggest cluster to corresponding newer clusters. Every cluster head in the network sets a TDMA schedule based on the entire population of nodes in each cluster following the cluster refurbishment operation. During the data transmission process, information is gathered by the CHs from the associated nodes, aggregated, and then transferred to the sink/base station. The CHs are eventually rotated for the subsequent cycle during re- clustering.

Parameter	Value
Number of Nodes	50
Size of the Field	50m x 50m
Initial Energy	2J
Maximum Frame Length	N
Optimal Cluster Head	5%

Table 1: Parameters of Network.

RESULTS AND ANALYSIS

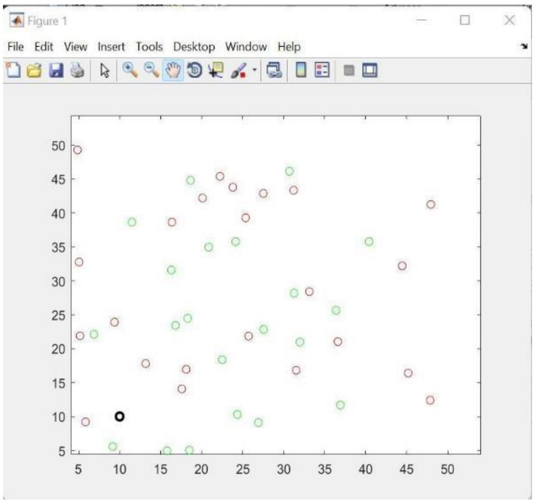


Figure 3: Formation of Clusters in LEACH

Figure 4: Formation of Clusters in LEACH-USC

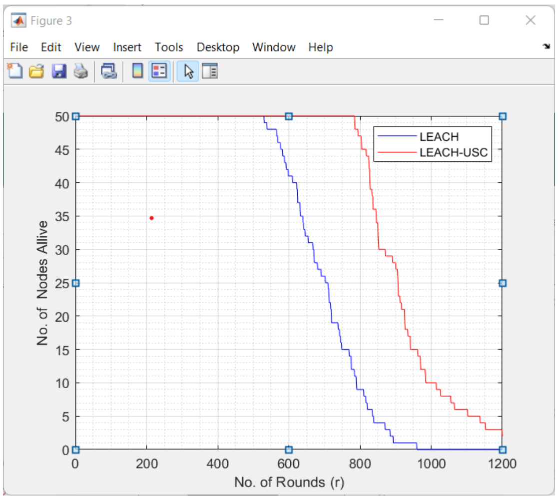


Figure 5: Comparison of the node death ratesbetween LEACH and LEACH-USC.

We compared the clusters produced by a round of LEACH with the LEACH-USC. In Figures 3 and 4, a sensor node is represented by a hollow circle, a cluster head is represented by a red star inside the circle, and a base station is represented by a red cross. In this case, the network may display two clusters: Cluster 1 in red and Cluster 2 in green.

As seen in Fig. 3, Cluster 1 in the case of LEACH has 23 nodes, while Cluster 2 has 21. However, as depicted in the Figure. 4, both the clusters have 25 nodes in LEACH-USC. From this observation, we realize that the Leach- USC clustering technique facilitates the formation of clusters of uniform size and prevents the overlapping of these clusters by setting distinct boundaries. Thus, the total intra-cluster communication distance is reduced, which ultimately reduces energy consumption. This enhances the cluster as well as the overall network quality.

Table 2 : Network Lifetime

PROTOCOLS	FND	HND	LND
LEACH	552	693	904
LEACH-USC	769	911	1141

Figure 5 represents how many nodes are stillfunctional throughout the network's existence. The graph

shows that the death rate of the nodes is consistently lower in LEACH-USC than that of LEACH across the network. This is due to the fact that LEACH-USC clusters have more equally distributed sizes than LEACH clusters, extending the network's total life.

Table 2 presents the network lifetime comparison, FND (First Node Death), HND (Hundredth Node Death) and LND (Last Node Death), for LEACH and LEACH-USC. The percentage of enhancement in LEACH-USC compared to LEACH is 26.2%, 31.4% and 39.35% for last node death, half node death and first node death respectively. These results clearly indicate that LEACH- USC improves network longevity over current LEACH.

7. CONCLUSION

Wireless sensor networks are extensively used in various applications. The LEACH protocol is widely applied approached in WSN. In this paper, we have compared Leach and Leach USC clustering techniques and we have observed that the nodes are split into clusters of uniform size with distinct boundaries without any overlapping in the case of Leach USC, while the same is not the case for Leach. Another comparison made is on network lifetime, and from the observations, it is concluded that node lifetime is significantly higher in the case of Leach USC compared to the traditional Leach technique. By forming clusters of identical size, the LEACH-USC clustering technique, which is mostly observed in this study, balances the network's load. High-quality clusters with uniform size and total intra-cluster communication distance have been constructed using the suggested model, LEACH-USC.

8. REFERENCES

[1] F. Karray, M. W. Jmal, A. Garcia-Ortiz, M. Abid, and A. M. Obeid, "A comprehensive survey on wireless sensor node hardware platforms," Comput. Netw., vol. 144, pp. 89–110, 2018.

[2] A. Shahraki, A. Taherkordi, Ø. Haugen, and F. Eliassen, "Clustering objectives in wireless sensor networks: A survey and research direction analysis," Comput. Netw., vol. 180, 2020, Art. no. 107376.

[3] M. Hanif and M. S. Islam, "Life Time Enhancement of Wireless Sensor Network by Modified Threshold of LEACH Protocol," 2022 International Conference on Advancement in Electrical and Electronic Engineering (ICAEEE),pp.1-6, July 2022,

[4] S.Bhowmik; Amartya Sen; Sanghita Bhattacharjee, "Balanced neighborhood aware clustering technique in Wireless Sensor Networks" IEEE 2nd International Conference on Power, Control and Embedded Systems, 2012.

[5] H. Shin, S. Moh, I. Chung, and M. Kang, "Equal-size clustering for irregularly deployed wireless sensor networks", Wireless Pers. Commun., vol. 82, no. 2, pp. 995–1012, May 2014.

[6] C. Bejaoui, A. Guitton, and A. Kachouri, "Equal size clusters to reduce congestion in wireless multimedia sensor networks", Wireless Pers. Commun., vol. 97, pp. 3465–3482, 2015.

[7] V. Pal, G. Singh, and R. P. Yadav, "Balanced cluster size solution to extend lifetime of wireless sensor networks", IEEE Internet Things J., vol. 2, no. 5,pp. 399–401, Oct. 2015.

[8] N. Qubbaj, A. A. Taleb and W. Salameh, "Review on LEACH Protocol", 2020 11th International Conference on Information and Communication Systems (ICICS), pp. 414-419, 2020.

[9] I. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: A survey", Comput. Netw., vol. 38, no. 4, pp. 393–422, 2002.

[10] P. Yuvaraj and K. V. L. Narayan, "Energy Efficient Structured Clustering Algorithm for Wireless Sensor Networks" International Conference on Computing Analytics and Security Trends pp. 523-527, 2016.

[11] N. Kumar, J. R. Desai and D. Annapurna, "ACHs- LEACH: Efficient and Enhanced LEACH protocol for Wireless Sensor Networks," 2020 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT), pp. 1-6, 2020.

[12] T. Dey and Mst. J. Ferdous J. Ferdous, "Central Base-Station Controlled Density Aware Clustering Protocol for Wireless Sensor Networks"; International Conference on Computer and Information Technology pp. 37-43, 2009.

[13] A. Karmaker M. Mahedee Hasan M. Showkat Moni and M Shah Alam, "An efficient cluster head selection strategy for provisioning fairness in wireless sensor networks", IEEE International WIE Conference on Electrical and Computer Engineering

(WIECON-ECE) pp. 217-220 December 2016.

[14] H. K. Sivaraman and R. L, "Minimizing the Energy Consumption and Enhancing the Network Lifetime in WSN using Advanced LEACH Protocol," 2022 Fourth International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT, pp. 1-6), March 2022.

[15] A. More and V. Raisinghani "A survey on energy efficient coverage protocol in wireless sensor networks" Journal of King Saud University-Computer and Information Science vol. 29 pp. 428-448 ,Oct. 2017.