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Extending The Lifetime of The Wireless Sensor Network with The Help of Low Energy Adaptive Clustering Hierarchy

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ABSTRACT

A WSN is comprised of at least one sink hub and topographically scattered sensors (likewise called base stations). Sensors produce tangible information and consistently screen actual variables including temperature, vibration, and movement. A sensor hub might go about as an information switch and information originator at the same time. Then again, a sink accumulates data from sensors. The advancement of the remote sensor organization, which was first upheld by military applications like battle and reconnaissance, brought about this arising area of innovation. A remote sensor network is responsible for a social occasion, handling, and communicating remote information to the assigned data set storage spaces. Throughout the course of recent many years, applications for remote sensor networks have extended rapidly in different enterprises, including agribusiness, the military, home computerization, and medical services. Little sensors that can detect, investigate, and convey information have been planned because of the issue getting consideration and the related innovation's quick progression. At remote destinations, sensor networks are as often as possible introduced. The external climate, directing, information conglomeration, keeping up with the nature of administration (QoS), and security are extra WSN challenges. For a few sorts of utilization situations, arrangements have been made, albeit many issues are yet unsettled research challenges. Clustering, which includes gathering sensor hubs into groups and picking group pioneers for each bunch, basically expands the organization's life expectancy. The challenges experienced in the remote sensor network establishment of grouping and filter executions have additionally been canvassed in this review.

Keywords: *Climate, Clustering, QoS, Sensors, WSN*

1. INTRODUCTION

1.1 Understanding about Wireless Sensor Network

Three unique terms consolidate to create the expression "wireless sensor network". The first is term is "wireless", where nothing should be wired to work; all that will be done remotely or wireless. The sensor, which is the subsequent part, is used to measure the condition of the general climate or surrounding environment actions or conditions. The last network comprises of just single hubs, and how they are associated can change contingent upon what they are utilized for.

1.2 Wireless Sensor Network- Architectures

The fundamental engineering of the WSN is displayed in the above representation, which consolidates the entryway — a base station and sensor hubs — as well as the application hubs. Inside a similar cluster, there is correspondence between the sensor hubs and application hubs. In this plan, sensor hubs accumulate ecological information, and application hubs communicate that information to cluster nodes. To pass the accumulated information on to the entryway or base station, the cluster head will speak with the other cluster heads. Information may not be procured from the cluster head because of the transmitter issue. A correspondence connect is in this manner fundamental to recover the information from the other cluster head.

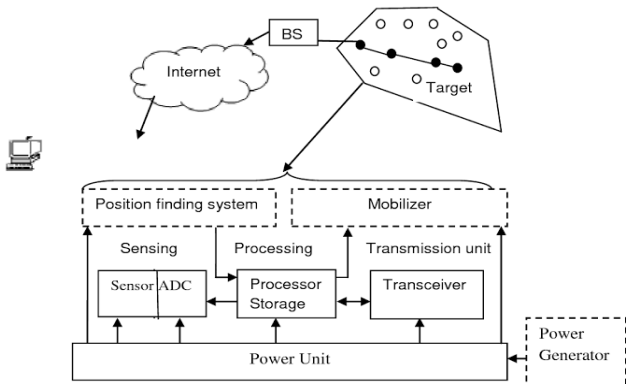

Fig.1. Sensor Node [1]

The wireless sensor network incorporates sensor innovation, correspondence innovation, implanted registering innovation, appropriated data handling innovation, and so forth. It can cooperatively and progressively screen, sense, and accumulate information on different observing articles in the network dissemination region [2].

Information driven structures, various leveled designs, and area-based models, portability-based structures, QoS-based structures, network stream structures, and heterogeneity-based structures are a portion of the classifications wherein the current WSN structures can be put.

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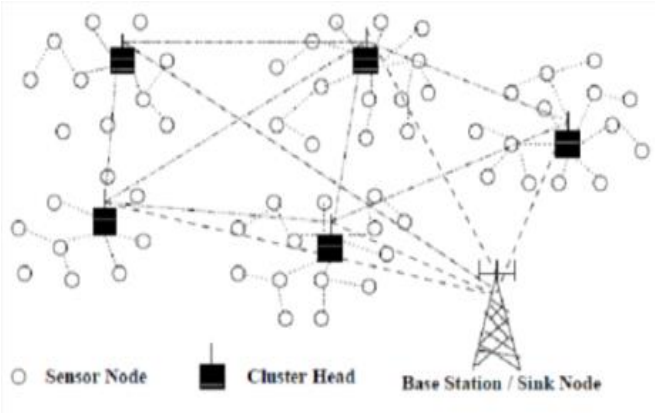

Fig.2. Hierarchical wireless sensor network (HWSN) [3]

1.3 Components of the Wireless Sensor Network

Sensor Nodes: The expression "sensors" can be utilized to allude to any instrument that actions an outside ecological condition, like humidity, temperature, development, or light.

The size of a solitary sensor hub can go from hubs the size of a shoe box down to particles of residue. As indicated by the size of the sensor node and the degree of intricacy expected of the singular sensor hubs, the expense of a sensor hub can fluctuate similarly, from many dollars to a couple of pennies [4]. Different types of sensors: Sensors for temperature, light, stickiness, sound, and commotion, sensors for water level, sensors for presence and closeness, radio recurrence, ultrasonic, and radar.

How about we rapidly turn out every single sensor?

1. **Photodiode sensors or phototransistors** are utilized in lightning sensors, considering the observing and the executives of lightning levels.
2. **Temperature sensors:** These sensors' essential capability is to measure the temperature of the prompt climate. They are for the most part utilized in assembling processes, family applications, horticulture, and medical services. It very well may be utilized in horticulture to decide the best ecological circumstances for crop development and to carry out agribusiness in an IoT vehicle.
3. **Pressure Sensors:** Used on the Internet of Things (IoT) network, pressure sensors basically measure the framework or gadget's tension. The gadget will advise the client when the level has been arrived at about any issues that should be addressed.
4. **Humidity sensors:** These sensors screen the moistness in the prompt environmental factors and change that estimation into electric driving forces. Different humidity sensors exist as indicated by their size and helpfulness. This sort of sensor is utilized in both the assembling and clinical areas.
5. **Commotion sensors:** These gadgets are as often as possible used to quantify the clamor delivered by hardware, vehicles, electrical apparatuses, and so forth. It might likewise be utilized to measure the encompassing external commotion levels.
6. **Radar sensors:** These are the sensors that are utilized to distinguish, track, and recognize various types of things at significant distances.
7. **An ultrasonic sensor** is a piece of innovation that utilizes ultrasonic sound waves to distinguish an objective item's distance and afterward transforms the sound that is reflected once more into an electrical sign.
8. **Regulator:** A regulator that can run any code and interaction every single fundamental datum. The critical part of a remote sensor hub is the regulator. It accumulates sensor information, processes it, picks when and where to convey it, gets sensor information from other sensor hubs, and picks actuator activity.
9. **Gadget** Called a Transceiver because it has both a transmitter and a beneficiary, it falls under this classification. Handsets' principal capabilities are to send and get information.
10. **Microchips** make up the handling unit, which is responsible for overseeing correspondence conventions and controlling the sensors.
11. **Memory:** Random Access Memory is expected in WSN stockpiling units to store middle of the road sensor readings, clusters from different hubs, and different information.
12. **ADC:** A persistent simple sign from the sensor's result is changed over into a computerized signal by means of a simple to computerized converter (ADC).
13. Ordinarily, a battery was required for the power supply for the network all in all to work. The sensor hubs are controlled by batteries.
14. **Base Station:** An exceptional class of hubs with critical computational power and handling power.

2. WIRELESS SENSOR NETWORK TOPOLOGIES

In the single hop worldview, each sensor hub sends information straightforwardly to the sink hub. Enormous size districts make these frameworks unreasonable because to high energy costs related with transmission and, in the direst outcome imaginable, possibly difficult to reach sink hubs [5].

We might consider both the flat model and the cluster model in the multi-hop models. Because of the requirement for all hubs in the multi hop model level model to have similar information, for example, the directing table, above and energy utilization might increment [5].

Since explicit cluster heads accumulate information and move it to the sink hub, sensor hubs can hold negligible above and energy utilization in the multi-hop clustering worldview [5].

To develop a workable WSN application. The following characteristics a WSN sensor should have been [6] Minuscule size: For enormous scope, down to earth network, a WSN sensor ought to be convenient. For example, a few little sensors might be dropped from a plane to perform ecological reconnaissance in a major city. The size of the sensors might make deployment troublesome.

- **Minimal expense:** Even on the off chance that there are numerous sensors in the networks; a WSN ought to have

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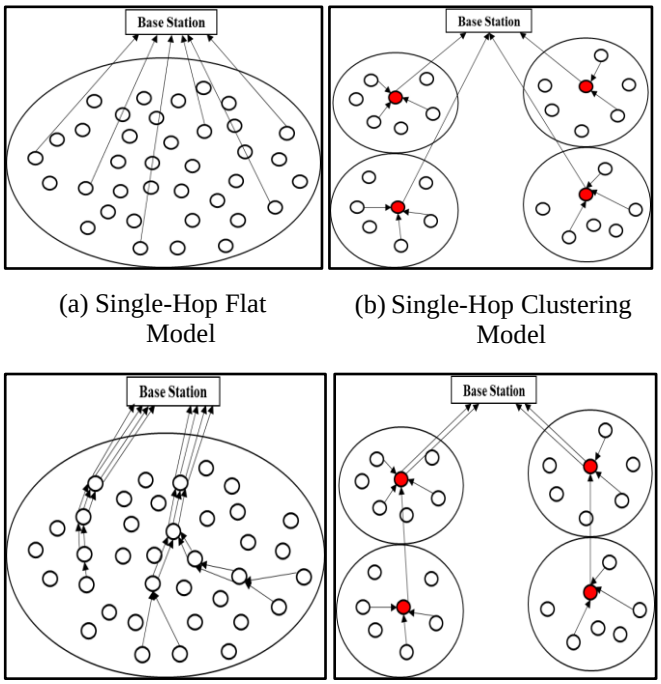
the option to work well. Subsequently, every sensor ought to be reasonable for normal applications.

- Low energy utilization: In an enormous scope network, we don't be guaranteed to have to supplant each sensor since they are completely intended to be dispensable. A WSN ought to have insignificant power utilization on the off chance that we believe it should run for a significant stretch.

It is classified into the four categories. Single hop model and multi hop model.



(a) Single-Hop Flat Model (b) Single-Hop Clustering Model

(d) Multi-Hop Flat Model (e) Multi-Hop Clustering Model

Fig.3. WSN Topologies

3. CLUSTERING IN WIRELESS SENSOR NETWORK

Clustering is a type of geography the executive's methodology that cluster hubs to increment network effectiveness by overseeing assets and pivoting undertakings across hubs to guarantee reasonableness [7, 24]. Different hubs are classified as cluster individuals in the wake of being coordinated into many clusters considering a few common qualities. The "cluster head" hubs, which address each, are explicitly made hubs that accumulate and deal with the information from each cluster part. Intra-cluster traffic portrays the data moving between the cluster nodes. Furthermore, the base station gets information from the cluster either straightforwardly or through a multi-hop process. Inter-cluster traffic portrays the data moving ever changing between the different clusters. The battery of the cluster head might run out more rapidly since the hub completes the significantly more energy-escalated tasks of social event and amassing the information got from its individuals and moving such handled information to the base station. In this manner, the cluster heads are pivoted to guarantee load adjusting across the network's hubs [8].

Since sensor hubs could move about, the arrangement of the Cluster head can likewise fluctuate frequently, in this manner diminishing the quantity of Cluster heads becomes significant. A gathering of hubs that are situated inside the transmission scope of the cluster head are supposed to be its area or neighborhood. Clustering can offer an energy-productive arrangement as a couple of hubs is expected to carry out the essential roles in the sensor network, like network, directing, information conglomeration, and so forth. This improves the lifetime of the remote sensor network, which is a significant need. To make a wireless sensor network that is energy productive, clustering can be a tremendous help.

4. SELECTION OF THE CLUSTER HEAD

There are three significant philosophies for the determination of the cluster heads-preset choice, irregular determination, and ascribed determination. Preset determination alludes to the cluster heads that are deterministically introduced for this specific explanation, while the entryway hubs are put to simply serve the capability of the cluster heads [8].

Arbitrary determination alludes to how the heads for the different clusters are picked. Rather than picking aimlessly, the ascribed determination of cluster heads thinks about the condition of the hubs with regards to their area, remaining energy, and closeness, and so on to pick a suitable cluster head for a cluster [8].

5. MOBILITY OF THE CLUSTER HEAD

Contingent upon the application, cluster heads might be either fixed or versatile. Be that as it may, geography the executives are somewhat more testing when the cluster heads are versatile rather than fixed hubs [8].

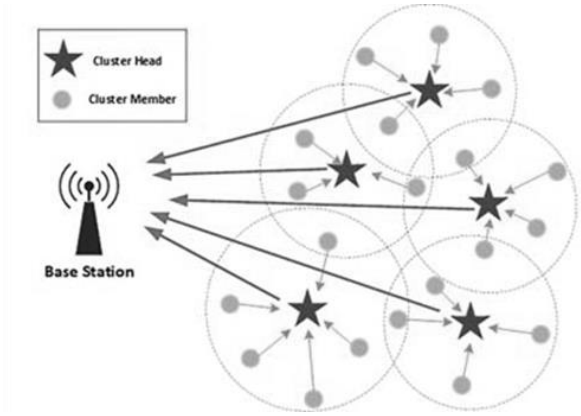


Fig.4. Clustering in WSN [9]

The adaptability of execution across the developing sensor networks is the clustering's fundamental advantage. The clustering methodology likewise offers many different advantages. Because of its restricted arrangements, it ensures trustworthiness and forestalls weak links. To effectively diminish power utilization, a clustering arrangement could

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suggest a rest/wake plan for a WSN. There is no prerequisite for all sensor hubs to be conscious and involving energy in numerous sensor applications. A sensor hub can enter a without energy rest state considering the transient and topographical conditions. As a result of its semi-disseminated character, clustering guarantees the versatility of the presentation of the program [10].

6. CLUSTERING ALGORITHMS

There are a lot of clustering frameworks in the writing, and they have been gathered in different ways relying upon different standards as observes.

• **Disseminated versus centralized plans:** Given the tremendous number of hubs in a WSN, circulated plans are the regular decision, rather than centralized plans, which have various disadvantages, including a weak link that could make the network bomb sooner. Furthermore, disseminated approaches are versatile, which fulfills one of the key WSN needs.

• **Deterministic versus irregular plans:** This characterization depends on how the network chooses the cluster heads. The plans wherein the cluster heads are picked indiscriminately are known as irregular plans. Conversely, cluster heads are acquired graphically in deterministic strategies, which may likewise be partitioned into weight-based, fluffy based, heuristics-based, and compound methodologies.

• **Equivalent versus inconsistent clustering plans:** This division alludes to the techniques used to orchestrate hubs into clusters in a network. Clustering methodologies produce clusters that are similar size or various sizes relying upon the heap appropriation and distance from the base station.

• **Dynamic clustering strategies:** After each cycle, clusters are occasionally delivered in powerful clustering procedures. For this classification, various clustering calculations have recently been introduced, some of which are given underneath with regards to homogeneous and heterogeneous information, individually.

7. SCHEDULED BASED PROTOCOL-LEACH

LEACH Means Low Energy Adaptive Clustering Hierarchy Technique. The LEACH convention stretches the network's life expectancy, similar as different conventions. This is the LEACH convention's fundamental objective or goal. Pivoting the clusters heads broadens the existence of the remote sensor network. Since every hub in the remote sensor network has similar usefulness and capacity, we can expect that they are homogeneous with regards to work and ability. These cluster head positions will be disseminated among the comparing part hubs considering the lingering energy present in that specific hub.

In the Leach convention, the network is partitioned into clusters, with a cluster head supervising each cluster. This cluster head accumulates data from part hubs or cluster hubs, and afterward moves that data — either in its individual or total structure — to the sink hub or base station. The cluster head is in this manner responsible for keeping the Time Division Multiplexing Access plan state-of-the-art.

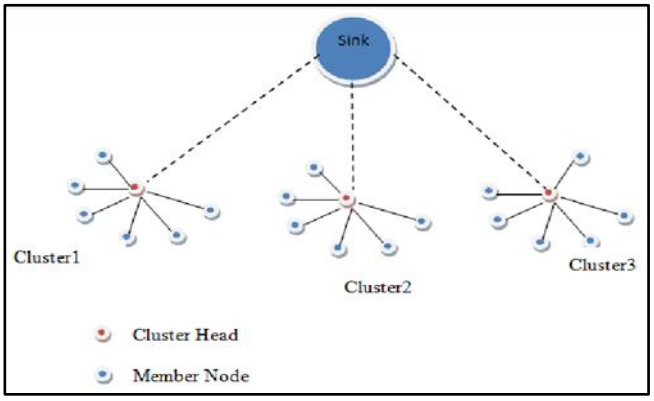

Fig.5. LEACH [13]

In the LEACH convention we are using the TDMA with the goal that it is called as a planned based convention. As a result of the TDMA, the quantities of the hubs are accessible in this specific cluster each hub having its own schedule opening to communicate their own data to the cluster head. The any remaining hubs of the part or cluster hub the schedule openings are appointed which can be utilized to trade the information between the cluster hub and the cluster head.

In the LEACH planned based convention one hub won't impart to other hub straight by the part hub needs to convey the information just to the cluster head. the cluster will convey data to the sink hub or the base station.

The main pressing concern is that in light of the fact that the sink hub or base station is far away from the cluster head, it should exhaust a lot of energy to send the stack of info that has been collected to the base station.

The TDMA convention is utilized for correspondence inside the cluster, while the CDMA convention is utilized for correspondence between clusters. This In request to forestall obstruction in remote sensor networks, TDMA and CDMA are both utilized. In contrast with direct routing and negligible energy transmission routing, the LEACH convention diminishes correspondence energy more fundamentally [11].

The WSNs are partitioned into a few clusters by LEACH. Each cluster has a cluster head, what isolates and investigations the information from the cluster hubs prior to communicating it to the base station. LEACH utilizes a randomized revolution of the great energy cluster head position as opposed to a static determination to allow every sensor an opportunity to work as the cluster head and keeps the singular sensors' batteries from running out too quickly. To further develop speed, it's significant to consider the cluster head and part counts delivered by LEACH [14].

7.1 Cluster Head Selection Algorithm in LEACH Protocol

LEACH picks a couple of sensor hubs at irregular to act as cluster heads and pivots this capability to adjust the energy load across the network's sensors similarly. While utilizing LEACH, the cluster heads hubs pack the information that roll in from the

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hubs in their singular clusters. A CH then, at that point, communicates a collected cluster to the base station to eliminate how much information that must be communicated [14,23].

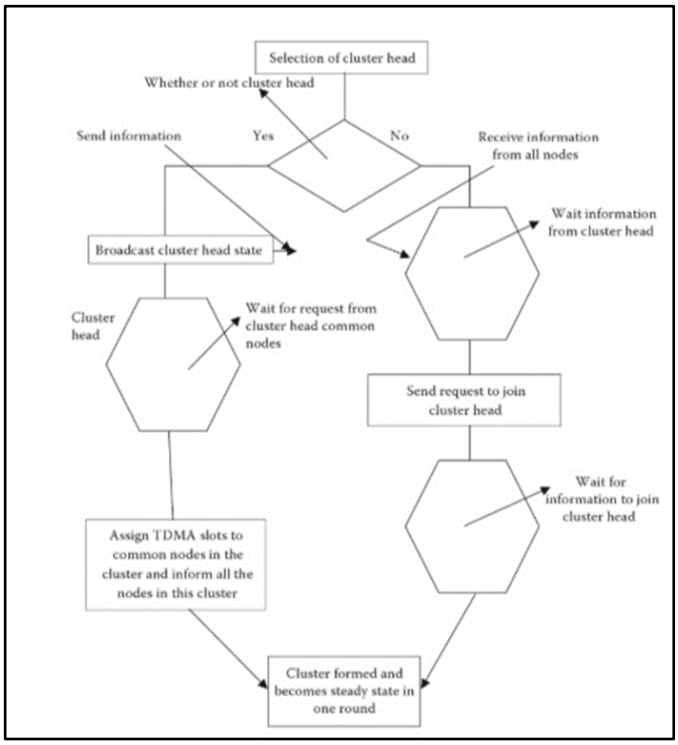

Fig.6. Selection of Cluster Head [14]

7.2 Operations it has two phases

1. **Setup phase:** In light of the energy present in every individual hub, we are building a cluster and choosing a cluster head during this arrangement stage. The few activities that are associated with arrangement include:
   - Cluster head advertisement.
   - Cluster Setup.
   - Creation of Transmission Schedule.

2. **Steady Phase:** Data is sent by non-cluster heads to the cluster heads, which then, at that point, total it and convey it to the sink hub. [15] Data transmission in light of the TDMA plan happens during the Steady State stage and the cluster heads total information through neighborhood registering, involving energy simultaneously. Another arrangement stage will start when a particular measure of time has elapsed. LEACH use TDMA/CDMA to decrease crashes inside and across clusters [16, 17].

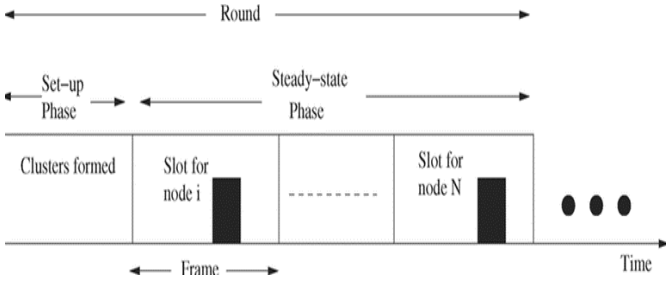

Fig.7. Operational phases of the LEACH [18]

7.3 Cluster formation in LEACH

The appropriated calculation is utilized in the LEACH to produce the clusters. This procedure permits sensor hubs to settle on their own choices when control is missing. Every sensor hub I decides to be the cluster chief toward the beginning of round r+1, which starts at time t with likelihood Pi(t). The Pi(t) is picked such that outcomes in a normal number of clusters sets out toward this round of k. The above condition might be utilized to work out every hub's probability of turning into a cluster chief at the determination of round r if there are N sensors hubs in the network [14,15,19].

$$P_i(t) = \begin{cases} \dfrac{k}{N - k * (r \bmod N/k)} & c_i(t) = 1 \\ 0 & c_i(t) = 0 \end{cases}$$

When Ci(t)=0, hub I is thought to be the cluster chief. These cutoff points who can be chosen as cluster pioneer in the resulting round, or r+1, to hubs that haven't proactively stood firm on the foothold as of late. On the off chance that p has a likelihood part; the limit esteem is gotten by subbing k/N in equa1 for p. Furthermore, this might be applied as a limit worth to pick a hub as the cluster head. An irregular whole number somewhere in the range of 0 and 1 is chosen by every sensor hub. The hub is picked as the cluster head for the ongoing round on the off chance that this number is under a limit esteem T(n). The accompanying condition might be utilized to ascertain the limit esteem:

$$T(n) = \frac{p}{i - p\left[r \bmod \left(\frac{1}{p}\right)\right]}, \text{if } n \in G$$

Where G is the assortment of sensor hubs that took part in the last 1/p rounds of the cluster head political decision [14,15,19,20].

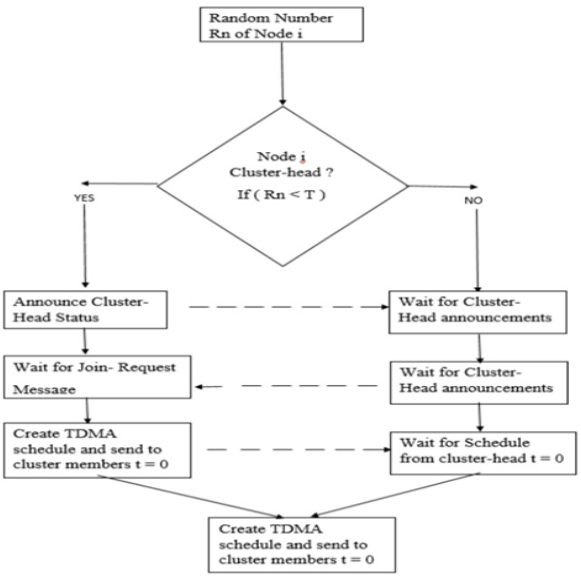

Fig.8. Cluster formation of LEACH Protocol [20]

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The cluster development's movement is found in the going with figure. Considering the consequences of contrasting a worth of likelihood p(u) and limit, sensor hubs apply a calculation to decide if they ought to be cluster pioneer or part hubs at irregular. LEACH will consistently pivot the cluster head hubs with the end goal that every hub in the network is distributed the job of cluster head. This will keep any hubs from emptying out [20].

Cluster head declared that it would be the cluster head for the ongoing round through a transmission message. Non-cluster heads hear the publicizing message from different cluster heads, and in light of the power of the radio transmission they get, they pick which cluster to join. When the cluster head has gotten all messages from the hubs, the cluster is made. Considering the quantity of hubs, the cluster then, at that point, makes a TDMA plan for every part hub and doles out a schedule opening to every part hub, which educates a hub when to communicate the sent information [20].

7.4 LEACH Schedule-based Protocol: Pros and Cons

Plan based conventions LEACH that utilization TDMA strategies to address the aversion of inactive listening explicitly. Transmission timetables might be determined to such an extent that collector crashes are stayed away from.

The timetable of a hub might require a lot of memory, which is a scant asset in numerous sensor hub plans.

On the off chance that a TDMA variation is utilized, time is partitioned into equivalently little openings, and both transmitter and beneficiary need to consent to space limits to really meet one another and to try not to cover with different openings, which would cause crashes.

7.5 Performance of the LEACH Protocol: Estimation

We considered the accompanying three variables to measure how well the LEACH procedure performed:

- **Throughout:** The most extreme pace of effectively conveyed messages at the base station is known as throughput. Utilizing the information parcels, we measure throughput (bits) [12].
- **The network's life expectancy:** The number of sensor hubs are alive and the number of are dead is demonstrated by the lifetime of the hubs. The quantity of hubs that are dynamic at a given time period is reflected by the network's lifetime. Over the long haul, the network's life expectancy progressively abbreviates [12].
- **Energy was lost**: Absolute energy lost in the network over the long haul at customary stretches. In the Leach convention, network reproduction is gone on until the sensors' all's absolute energy has been utilized [12].

8. CHALLENGES IN WSN CLUSTERING

Clustering is a technique that has guaranteed for bringing down energy utilization while upgrading the versatility and life span of WSNs in a cluster-based engineering. The extra exertion for information getting conglomeration and between cluster correspondences falls on the cluster head. In this manner, picking the cluster head from the standard sensor hub is an exceptionally significant undertaking.

- **Adjusting the heap:** The heap on various hubs ought to be pretty much as equitably disseminated as attainable to work with cluster correspondence and broaden network life [21, 22]. Some cluster heads might be overburdened with an enormous number of sensor hubs on the off chance that the sensor hubs given to them for cluster development are not working accurately. Such over-burdens could increment correspondence inactivity and mischief the WSN's general presentation. In this manner, the most significant issue for clustering sensor hubs is load adjusting of the cluster areas.
- **Inability to Correct:** A WSN hub may as often as possible should be conveyed under unforgiving circumstances. Hubs are defenseless against actual mischief and breaking down under these conditions. In numerous applications, shortcoming lenient activity within the sight of disappointments is attractive. The cluster heads must essentially work shortcoming leniently.
- **Least potential clusters:** Ordinarily, the hubs with the possibility to act as a cluster head cost more. In this manner, it makes legitimate to utilize less sensor heads in the network.
- **Most noteworthy conceivable network life span:** A critical issue is the conveyed WSN's life expectancy. Along these lines, it means quite a bit to use as little energy as feasible for intra-cluster correspondence. The cluster head ought to in a perfect world just requires one bounce to be reached.

9. CONCLUSION

The motivation behind this study is to make sense of the hypothetical underpinnings, activity, and certain execution related issues of the remote sensor organization. The significant perspectives and characteristics of clustering in remote sensor organizations, as well as its many aspects with respect to its targets, prerequisite, and applications, were endeavored to be introduced in this examination. This paper's key disclosure depends on the LEACH technique's execution, how we pick the clusters, and how the groups are made utilizing comparing flowcharts. Additionally, the LEACH convention's activities and stages.

REFERENCES

[1] Jain SA, Maineka S, Nimgade P. Application of IoT-WSN in home automation system: a literature survey. Multidiscip J Res Eng Technol. 2017; 3(1): 916-22
[2] Xue Q, Che W, Ren L, Dong L. The world of 5G. World Scientific.
[3] Das AK. A key establishment scheme for mobile wireless sensor networks using post-deployment knowledge. arXiv preprint arVix: 1108.1302. 2011 Aug 5.
[4] Macii E. Modeling Simulation and Runtime Management. InDesign, Automation, and Test in Europe 2008 (pp.187-193). Springer, Dordrecht.

©2012-24 International Journal of Information Technology and Electrical Engineering

[5] Ramesh K, Somasundaram DK. A Comparative Study of Cluster Head Selection algorithms in wireless sensor networks. arXiv preprint arXiv: 1205.1673. 2012 May 8.

[6] Hu F, Cao X. Wireless sensor networks: principles and practice. Auerbach Publications; 2010 May 6.

[7] Shahraki A, Taherkodi A, Haugen O, Eliassen F. Clustering Objectives in wireless sensor networks: A survey and research direction Analysis. Computer Networks. 2020 Oct 24; 180: 107376.

[8] Dumka A, Chaurasiya SK, Biswas A, Mandoria HL. A Complete Guide to Wireless Sensor Networks: From Inception to Current Trends. CRC Press; 2019 May 31.

[9] Han Y, Li G, Xu R, Su J, Li J, Wen G. Clustering the wireless sensor network: a meta-heuristic approach. IEEE Access. 2020 Nov 27; 8 : 214551-64.

[10] Akila Is, Manishekaran SV, Venkatesan R. Modern Clustering Techniques in wireless sensor networks. Wireless Sensor networks. Wireless Sensor networks-Insights and Innovations; Sallis, PJ; Ed.; InTech Open: London, UK. 2017 Oct 4: 141-56.

[11] Sujatha Priyadarshini A, Arvind C. Security- Based LEACH Protocol for Wireless Sensor network. InInternational Conference on Innovative Computing and Communications 2021 (pp. 855-863). Springer, Singapore.

[12] Chandanse A, Bharane P, Anchan S, PAtil H. Performance Analysis of leach protocol in wireless sensor network. In 2nd International Conference on Advances in Science and Technology (ICAST) 2019 Apr 8.

[13] Usman MJ, Xing Z, Chiroma H, Gital AY, Abubakar AI, Usman AM, Herwan T. Modified low energy and adaptive clustering hierarchy protocol for efficient energy consumption in wireless sensor network. International Review on Computers and Softwares. 2014 Nov; 9(11): 1904-15

[14] Marriwala N. Routing Protocols. Wireless Sensor networks: from theory to applications. 2013 Aug 28; 11(6): 6-28.

[15] Shivakumar P, Radhika M. Performance analysis of leach-ga over leach and leach in wsn. Procedia Computer Science. 2018 Jan 1; 125: 248-56.

[16] Ali Norouzil, Abdul HalimZaim. An integrative Comparison of Energy Efficient Routing Protocols in Wireless Sensor network. Wireless Sensor Network, 2012, 4, 65-75.

[17] Mohapatra H, Shivkumar SA, Muzumdar AA. A Survey on Leach in WSN

[18] Kodali RK, Aravapalli NK. Multi-Level LEACH protocol model using NS-3. In 2014 IEEE International Advance Computing Conference (IACC) 2014 Feb 21 (pp. 375-380). IEEE.

[19] Mishra Ak, Kumar R, Kumar V, Singh J. A grid-based approach to prolong lifetime of WSNs using fuzzy logic. InAdvances in computational intelligence 2017 (pp. 11-22). Springer, singapore.

[20] Birajdar DM, Solapur SS. LEACH: An energy efficient routing protocol using Omnet++ for wireless sensor networks. In2017 International Conference on Inventive Communication and Computational Technologies (ICICCT) 2017 Mar 10 (pp. 465-470). IEEE.

[21] Kuila P, Jana PK. Clustering, and routing algorithms for wireless sensor networks: energy efficient approaches. chapman and Hall/CRC; 2017 Sep 22.

[22] Pattnaik PK, Mall R. Fundamental of Mobile Computing. PHI Learning Pvt Ltd.; 2015 Nov 30.

[23] Ritika, Farooqui, N.A., Tyagi, A. (2020). Data Mining and Fusion Techniques for Wireless Intelligent Sensor Networks. In: Singh, P., Bhargava, B., Paprzycki, M., Kaushal, N., Hong, WC. (eds) Handbook of Wireless Sensor Networks: Issues and Challenges in Current Scenario's. Advances in Intelligent Systems and Computing, vol 1132. Springer, Cham. https://doi.org/10.1007/978-3-030-40305-8_28 .

[24] N. A. Farooqui, A. K. Mishra, and R. Mehra, "IOT based automated greenhouse using machine learning approach", Int. J. Intell. Syst. Appl. Eng., vol. 10, no. 2, pp. 226-231, 2022.

AUTHOR'S PROFILES

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