ROUTING PROTOCOL FOR WSN: LEACH AND ITS VARIANTS

Abstract

A wireless sensor network (WSN) is made up of a number of distributed, self-directing, tiny nodes known as sensors that are able to interact with the base station and one another. These nodes are not suitable for very large networks due to their low memory, battery life, and computational capacity. In wireless sensor networks (WSNs), energy consumption and balancing are critical processes that call for an effective strategy. For wireless sensor nodes, the researchers have developed a number of proposed routing protocols that depend on clustering techniques. From a general perspective, a lot of the suggested methods mostly rely on the clustering hierarchy protocol's low energy demand. In order to produce more energy-efficient protocols, these protocols essentially aim to address the shortcomings of the leach protocol. Several well-known clustering-based routing methods for energy-efficient wireless sensor nodes are included in our investigation.

Keywords: WSN, Clustering techniques, energy-efficient.

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A number of routing protocols based on clustering techniques have been developed by the researchers for wireless sensor nodes. The Low Energy Adaptive Clustering Hierarchy (LEACH) protocol serves as the foundation for a variety of methods. In order to make the LEACH protocol more energy-efficient, these routing methods tried to address its drawbacks.

I. LITERATURE SURVEY RELATED TO LEACH PROTOCOL AND ITS EXTENSIONS

LEACH is proposed by Heinzelman et al. [1] for WSN. LEACH is a technique with a hierarchical structure. LEACH is divided into two stages. Cluster Heads (CHs) are chosen from cluster formation during the setup phase. In steady state phase, the data is detected and transferred to the Base Station (BS) through CHs. For WSNs, it is well-known energy-efficient hierarchical clustering approach. The CHs are in charge of data transmission from nodes to the base station. In comparison to typical nodes, all nodes must pay greater attention to the CHs. The information is gathered, consolidated, and sent to the BS through CHs. CHs consume more energy than normal nodes because more processing resulting in higher energy consumption [2]. As a result, the CHs life span is lower than other nodes, and it will die as soon as the energy supply is depleted. After each round, CH must be distributed to each node. The LEACH protocol proposes a dynamic CH selection method where a node chooses a CH with a certain frequency. Every other node in the whole network is informed of the newly chosen CH's status.

Yousaf et al. [2] compared the performance of LEACH, LEACH-C, MH-LEACH, TL-LEACH, E-LEACH, TB-LEACH, W-LEACH, and LEACH-VH in terms of energy efficiency. The major focus is on the several cluster-head selection mechanisms and their effects on energy usage. The MATLAB-based simulation scenarios are provided, which cover source and sink node placement techniques as well as various energy level situations.

Cao et al. [3] focused at single-hop communication in WSN using LEACH. For the investigation of sensor node lifetime and resilience in the worst environment, LEACH is compared to single hop communication techniques. With a high number of sensor nodes, LEACH operates better, but its maximum lifespan expectancy is lower than single hop communication. The performance comparison is being done for the purposes of estimating reliability and lifespan expectancy in relation to the density of wireless sensor nodes.

LEACH and its descendent protocols have been studied by Maurya et al. [4]. LEACH is a foundation for a variety of protocols that minimizes energy usage and extend network lifetime. Based on node mobility, node location through GPS devices, and data transmission mode between CH and BS, the various LEACH-based protocols may be grouped into different protocols types. The characteristics of mobility add to the difficulty of effectively monitoring a network. The movement management models are required to keep track of node mobility patterns. The use of GPS makes it easier to monitor movement and manage mobile networks.

Khediri and Peng et al. [5, 6] proposed the LEACH-Centralized (LEACH-C). LEACH-C selects CHs in the setup phase using a centralized clustering technique. All WSN nodes broadcast their information to the BS, including their current locations and energy levels, as opposed to selecting CHs at random. The BS then determines the average energy

level across all nodes. The cluster head might be any node with greater energy than the estimated average. The BS selects which nodes will be CHs and transmits this information to the whole WSN after collecting data from the nodes and calculating the average energy.

The LEACH-B technique proposed by Tong et al. [7]. In each round of the LEACH-B protocol, a certain number of nodes are chosen as CHs. In this approach, CH selection is done in two phases. In the first stage, CHs are selected according to the LEACH procedure results an unknown number of CHs, and then a second selection made to keep the number of CHs constant.

The second selection procedure takes into account the node's residual energy. Some of the lower energy CH are converted into normal nodes if the number of nodes elected as CH exceeds the constant number, while some of the higher energy normal nodes are converted into CH if the number of nodes elected as CH is less than the constant number.

The E-LEACH technique was suggested by Xu et al. [8]. The initial and residual energy of the sensor nodes are taken into account to improve the CH selection criterion. The round time is computed at the start of each round. CHs construct a spanning tree among them, and use this tree to convey data to the base station.

LEACH-VH, a novel cluster-based routing protocol, was introduced by Mehmood et al. [9]. Along with CH, a new node type called Vice CH (VCH) is incorporated in this protocol. The CH is the node in a cluster with the most residual energy, while the VH, which serves as the CH's backup node, is the node with the second highest residual energy. The chosen VH enters sleep mode, and when the CH's energy drops to a specific point, let's say 10%, it wakes up to become the CH and choose its VH. The longevity of a WSN has increased by up to 47% as compared to the LEACH routing protocol.

The LEACH-R technique was proposed by Kamath et al. [10]. The residual energy of the nodes is taken into account while choosing CHs in this protocol. The sensor nodes having more residual energy to take on the role of CH improves as a result of this change. Out of the selected CHs, one relay node is picked in each round. The remaining energy of CHs and their distances from the base station are used to choose relay node. CHs transfer data to the relay node after gathering information from local clusters. This data is delivered to the base station via the relay node.

Braman et al. [11] conducted a poll on the LEACH procedure. The benefits and drawbacks of different variants have been identified. Many enhancements to the LEACH procedure have been proposed. The key areas for the development are cluster formation, and data transmission methods. Energy usage and its drawbacks also draw greater attention to the inquiry. In comparison to previous LEACH dissidents, the Distributed Low Energy Adaptive Clustering protocol is more efficient.

Birajdar et al. [12] studied WSN in terms of physical situation and monitoring environments. A number of potential solutions for location and hierarchical based routing are being discussed. LEACH simulated with the OMNET++ in this study, and findings were explained in depth. LEACH outperforms sensor protocol, threshold sensitive energy efficient sensor network protocol, and Geographic Adaptive Fidelity in simulations.

Dhawan et al. [13] concentrated on energy efficiency assessments in WSN. Effective energy management is the key factor in extending the life of a network. The LEACH technique and its disadvantages were explored. The disadvantages of the LEACH technique have been solved by its successors. A brief examination of several variations of the LEACH protocol was conducted, as well as a comparison analysis.

Jaradat et al. [14] looked into the noisy WSN environment and proposed a model for the LEACH protocol. For the noise level model, the likelihood of reception is taken into account. When there is less noise, the number of packets received is the maximum and this number decreases as the noise level increases. The noise levels were randomly generated using a uniform random number generator. The implementation has been done with the Python tool to see how different noise levels affected the performance of the homogeneous LEACH algorithm.

Single-hop communication, a version of LEACH for WSN, was proposed by Mahmood et al. [15]. This method was compared against three other routing protocols including LEACH. A cost-effective CH replacement as well as a dual transmitting power level technique used. A CH is replaced in this manner if its energy falls below a specified threshold. At the start of each round, remaining CH energy is used in CH replacement operation. The simulation results reveal that its network longevity, throughput, and CH creation have all improved.

Joshi et al. [16] proposed a wireless sensor network design for smart monitoring of the system. A mechanism for detecting anomalous transmission and attacks during data transmission from one sensor node to another is included in the design. It aims to improve the energy efficiency of the wireless sensor network. The primary notion behind suggested method it for detecting network intrusion assaults. It largely enhances the system's resistance to an infiltration sink attack. A framework for analyzing acquired sensed data has also been built. The framework supports network traffic monitoring, filtering, and prediction. The results of the simulated environment reveal that the selected technique has defeated the sink entire infiltration impact. The suggested work hasn't been tested for different types of intrusion threats. It may be checked for various incursions in the future in order to enhance it.

Table 1: Summary of the Research Paper related to LEACH Protocol and Its Extensions

Year of Publication	Method	Findings	Energy Efficiency	Data Communication pattern	Limitation
2000	LEACH	LEACH is a hierarchical structuring technique in which CHs are chosen from cluster formation during the setup phase randomly. In steady state phase, selected CH collects data from the cluster members and transferred to the Base Station.	Low	Single-hop	Only designed for a small network, because the CH selection process is repeated again and again, more energy is consumed.
2017	Single- Hop and LEACH	For the purpose of evaluating the longevity and robustness of sensor nodes, LEACH is contrasted with single hop communication methods. LEACH functions better with more sensor nodes present, although it has a shorter maximum lifespan than single hop communication.	Poor	Single-hop	Only compare with single-hop protocol. Suitable for Small size of network only
2014, 2015	LEACH-C	LEACH-Centralized selects CHs in the setup phase using a centralized clustering technique. Rather than picking CHs at random, all WSN nodes broadcast their information to the BS. The BS calculates the average energy level of all nodes and determines which node become a cluster head.	Good	Single-hop	Not suitable for large network. CH re-selection process will consumed more energy.

2015	LEACH-VH	In the new cluster-based routing protocol LEACH-VH, Vice Cluster Head (VCH), a new node is introduced in addition to CH. The node in a cluster that has the highest residual energy is designated as the CH, and the node that has the second-highest residual energy is designated as the VH, which serves as the CH's backup node. The LEACH routing protocol was replaced and the longevity of a WSN increased by up to 47%.	High	Single-hop	When compared to multi-hop, the single hop approach consumes more energy. Multi-Hop should apply in future.
2013	LEACH-R	In LEACH-R, the residual energy of the nodes is taken into account while choosing cluster heads. Cluster heads transfer data to a relay node after gathering information from local clusters. This data is delivered to the base station via the relay node.	High	Two-level	If the rely node is unavailable for some reason, the data will be lost.
2017	Energy Efficient LEACH	Analyzed WSN with respect to physical situation and monitoring environment. Various solution is being discussed related to location and hierarchal based routing. According to simulation studies, LEACH performs better than sensor protocols for information via negotiation, threshold-sensitive energy-efficient sensor network protocols, and Geographic Adaptive Fidelity.	Good	Single-hop	In LEACH selection of CH is a random process. Non-cluster nodes join the cluster according to the signal strength. Therefore some non-cluster head nodes may become orphan nodes. To solve this problem need some improvement in existing LEACH.

II. LITERATURE SURVEY RELATED TO ENERGY EFFICIENCY BY USING MULTI-HOPING AND MULTI-LEVELING

Ansari et al. [17] suggested an enhanced version of the LEACH algorithm that used load balancing to save energy. This method has advantage of multi-hop routing. To minimize data collision and retransmission, CSMA/CA and TDMA have been implemented. The best path was chosen by locating node with the largest residual energy as compared to the other nodes. After discovering that an event started, the sensor node detected the data. The gathered and aggregated data collected and these data pooled and sent to a base station for processing. A more complex cluster selection methodology might be added to improve the suggested method.

Based on the LEACH routing method, Yarde et al. [18] offers the Multi-Hop Cluster LEACH (MC- LEACH) algorithm. MATLAB have been used to simulate and analyses the MC LEACH Protocol. Output of this protocol reveals that changing the number of hops to the sink instead of employing a single hop has a good impact on energy usage. By determining the optimum path between the source CH and destination, the advent of multi-hops communication significantly enhanced the LEACH. In terms of dead nodes, residual energy, and delay, the simulation results are consistent with the predictions. Throughput an analysis can also be performed on the proposed work. As a result, the decrease in number of packets drop can also be detected.

Neto et al. [19] develops MH-LEACH, an energy-saving strategy for establishing multi-hop communication between sensor nodes. A sensor that uses MH-LEACH is capable of transmitting data to neighboring nodes, while still sending the collected data to the base station. The LEACH approach incorporated this concept. When compared to the initial version of LEACH, it was discovered that the new method outperformed the LEACH technique. The power usage and network lifetime were both increased as a result of the improvements.

Improved Multi-Hop LEACH (IMHT-LEACH) was suggested by Alnawafa et.al. [20], which is an upgrade over multi-hop LEACH protocol. CHs are chosen from two or more levels using IMHT-LEACH. CH collects data from wireless sensor nodes using level techniques. Data is sent from CHs to base stations at many levels. By calculating the desirable energy for data transmission, IMHT-LEACH decreases the energy consumption of wireless sensor nodes for a very broad region of WSN. When compared to the LEACH protocol, the suggested technique enhances the life time and data transmission speed.

Several energy-efficient procedures have been developed including the LEACH technique. Kodali et al. [21] proposed a higher level model. The Multi-Hop as well as inverted tree has been introduced in 1L-LEACH and 2L-LEACH in the study. Cluster heads are elected at multiple hierarchical levels in the multi-level LEACH protocol. The CHs which are far away cannot reach the base station directly if the deployment area is big. In such instances, an energy-efficient routing strategy for communication among CHs and data forwarding to the base station is required. CHs are chosen at the first level in the same way as LEACH, and then at level-2 the structures are created. Among the level-1 CHs, the level-2 CHs are chosen depending on the current energy in the nodes. Level-1 CHs transmits data to level-2 CHs, while level-2 CHs transmits data directly to the BS. In an inverted tree, routing

begins with the creation of a tree containing all nodes, with root node being the one closest to the BS. For data communication, the inverted tree employs three-way handshaking. If one path fails, the nodes switch to another for data transmission. It is found and stated that hierarchical LEACH outperforms simple LEACH.

FAF-EBRM is an energy-balanced routing algorithm suggested by Zhang et al. [22]. By comparing link weight and energy density, the data forwarding node is chosen. The FAF-EBRM protocol is compared to the LEACH protocol. When transporting data from CH to the BS, the single hop protocol uses a lot of energy, but multi-hop uses less energy for the same data. For an applications requirement the WSN of fixed nodes is irrelevant. FAF-EBRM compared to LEACH and EEUC through experiments, and demonstrated that FAF-EBRM outperforms LEACH and EEUC in terms of balancing energy consumption, extending lifespan function, and ensuring excellent WSN QoS.

Many authors have proposed the low-energy multi-hop routing strategy for wireless sensor networks. Cengiz et al. [23] discussed how the Energy Aware Multi-Hop Routing (EAMR) standard succeeded in reducing unnecessary overhead. The main objective is to create a green routing system to be used in a wireless sensor network. The most significant contribution of our proposed protocol is lowering of unnecessary overhead present in most routing protocols using fixed clustering and reducing the frequency of CH changes. According to the results analysis, reducing overhead improves the lifespan significantly, because the energy consumption in sensor nodes may be reduced through the use of an energy-efficient protocol. Furthermore, the relay nodes' implementation enables the transfer of collected cluster data via inter-cluster communications. As an outcome, a wireless sensor network's scalability can be improved. The use of relay nodes has a great impact on the network's energy dissipation.

Fai et al. [24] studied a variety of WSNs ranging in different size from small to large. Their findings demonstrate that small-scale networks require the use of efficient transmission mechanisms. In small scale networks, each node must communicate directly to the BS through a single hop. Multiple hop solutions are essential in large-scale networks. Through cluster creation, it splits long-distance communication into short-distance communication. This transmission division spreads energy uses over all nodes resulting in reduction in total energy consumption. The shortest distance strategy does not necessarily outperform the long-distance. Because energy is so important in sensor networks, and path is chosen based on the energy requirements of the nodes along the way. The author presented an energy-efficient transmission method that allows the CH to determine energy-efficient next hop nearest to BS's within its transmission range. The suggested technique and simulation result reduces energy consumption, number of transmissions, and improving the performance of the proposed routing algorithm in a large sensor network.

Sharma et al. [25] presented a sophisticated single hop and multi-hop routing system to lengthen the life of sensors. The nodes are divided into two energy categories: low energy nodes are known as standard nodes, and high energy nodes. There were more high energy nodes than there were standard nodes beginning off in energy. The comparison between the recommended technique and the LEACH methodology shows that the node life has increased. Only a few clusters span the whole network, and cluster overlapping is minimized. Future improvements to the suggested approach's latency and power are possible.

Depedri and Kaur et al. [26, 27] proposed TL-LEACH (A Two-Levels Hierarchy for Low-Energy Adaptive Clustering Hierarchy). TL-LEACH functions opposite LEACH, which sends data to the base station in a single hop. Instead of transmitting data directly to the base station, a CH collects aggregated data from each CH. As this protocol is an improved the LEACH, therefore the data transmission energy reduced. CH nodes expire sooner than other nodes because they are located far from the BS, and TL-LEACH boosts efficiency of energy by employing a CH node as a relay node in between CH nodes.

Manzoor et al. [28] presents an extension to TL-LEACH protocol ETL-LEACH and focuses on two significant flaws in the TL-LEACH approach. TL-LEACH is an enhanced version of the current LEACH protocol that operates on two layers of the LEACH structure. The study aims to improve the Two-Level Hierarchy for Low Energy Adaptive Clustering Hierarchy (TL-LEACH) protocol in terms of energy efficiency, communication overhead, and ensuring the most reliable communication between end-nodes, cluster-heads, and base stations. This study concentrated on two significant limitations of the TL-LEACH protocol, which are mostly connected to deploying the protocol for large-scale WSN and making robust communication between nodes. To increase the TL-energy LEACH's efficiency, a new cluster-head selection process was added, and new version was dubbed Extended TL-LEACH i.e. ETL-LEACH. The simulation findings suggest that the ETL-LEACH is more energy efficient, a longer node lifespan, and a considerable reduction in communication delay.

Santha, et al. [29] concentrated on clustering dimensions in a WSN; the superior clustering dimensions technique reduces node energy usage. CH broadcasts a message to all nodes. CH is chosen by each node based on the time it takes to receive data. CHs get a request to join from nodes. Each slot has a TDMA slot for data transfer. They examine LEACH and the hierarchical LEACH has been carried out by assessing network throughput and life-time. The TL LEACH methodology beats both LEACH and LEACH-B.

The problem of employing many RPs to enhance the lifespan of WSN has been discussed by Li et al. [30]. Employing numerous sets of RPs for the average energy usage of the RPs extends the lifetime of WSN. The issue is deciding which of the numerous sets of RPs utilize and for how long. To solve this problem, an optimum algorithm and a heuristic method presented. The best method seems to be quite complicated, and it's only appropriate for small-scale WSNs. Simulations used to evaluate the performance of the proposed algorithms and the results demonstrates that the heuristic technique works well with multiple RP sets, implying that network lifespan may be extended.

Mehto et al. [31] discusses a rendezvous-based direction-finding strategy, which involves creating a rendezvous zone in the system's center and growing a tree within it. There are two transmission modes to choose from. To begin, the tree reflects the BS's direction, and the basis node communicates with the BS through it. The BS communicates location to the tree in the second way, and the foundation node retrieves the BS's position from the tree and immediately transmits information to the BS.

Sharma et al. [32] suggested a Rendezvous routing protocol. The rendezvous reign is established in the network's core, establishing a tree within the reign, according to this technique. There are two approaches: Because the first mode concentrates on the path to the sink, the source node transmits its information to the sink through this tree. The sink shares

its location with the tree in the second technique, and the source node receives the sink's position through the tree and provides data directly to the sink. In terms of latency, delivery ratio, and energy usage, this approach exceeds previous protocols.

Gowri et al. [33] discuss the issues of energy consumption in WSN were explored as well as numerous ways of optimal energy utilization for data distribution between cluster nodes. WSN is utilized to broadcast data in the network due to expanded tools of the wireless network and as a result of the data transfer betrays difficulty, other complications developed. Therefore as a result of the battery issue, several issues emerged throughout the data transfer procedure. Several processes have been proposed to address this problem. One of these is the mobile sink protocol and additional methods for transferring data using mobile sink approach has been developed. These technologies are effective in solving the data transmission problem, but they fall short of achieving energy-efficient node utilization. The notion of MME (Multiple Mobile Sink Element) has been introduced here. Using rendezvous points (RP), the MME transmit data between nodes in a cluster. The RP enables for low-energy data transport without the risk of data loss.

Anagha et al. [34] proposes a technique for cluster created rendezvous organization. This approach is used to find the finest RPs. A weight is assigned to each sensor node depending on its hop distance from the sink and the number of nodes in its immediate neighborhood. The highest weighted node is picked for RPs and data from sensor nodes will be delivered to CHs then pass it to the RPs in the area.

Jadoon et al. [35] evaluated zone-based routing to hierarchical routing and discovered that zone-based routing is more energy efficient than hierarchical routing. Over the lifetime of the network, zone-based routing promises to have reduced control and high latency. In this work, zone-based routing and static clustering hierarchical routing are compared. The simulation results showed that zone-based routing outperforms hierarchical routing with static clustering in terms of energy efficiency, network lifetime, and throughput.

For several zonal routing techniques, Mahboub et al. [36] suggested a clustering strategy. The bulk of WSN routing approaches have prioritized energy conservation. LEACH has been proposed as the basic protocol for the multiple zones (MZ-LEACH). Multiple partition triangular zones have been created within the WSN. The CH repartition strategy between CH and BS increased the communication efficiency. The result reveals that the network's lifespan has increased while its energy usage has decreased. The MZ-LEACH's efficacy in a smaller WSN network is to be investigated in order to improve it further.

Table 2: Summary of Research Paper related to Energy Efficiency by using Multi-hoping and Multi-leveling

Year of Publication	Method	Findings	Energy Efficiency	Data Communication pattern	Limitation
2019	Multi-Hop Cluster LEACH (MC-LEACH)	By identifying the most efficient route from the source CH to the destination, multi-hop communication dramatically enhanced LEACH. Dead nodes, lingering energy, and latency are all consistent with the simulation results. Consequently, by evaluating the data, a decrease in the amount of packet drops may also be found.	High	Multi-hop	CH must be distributed evenly. Design for small network.
2017	Improved MHT-LEACH	Improved multi hop LEACH (IMHT-LEACH) is proposed as improvement over multi hop LEACH protocol. IMHT-LEACH selects cluster heads from two or more level. Cluster heads uses level approaches to collect data from wireless sensor nodes. Data are transmitted from more than one level from cluster heads to base station. IMHT-LEACH reduces the energy consumption of wireless sensor nodes for a very large area of WSN by calculating the energy required for data transmission	Very High	Multi-level	Lifetime of the network increases by reducing the packets transfer between CHs.
2015	Multi-level LEACH	Multilevel LEACH is implemented by using 1L-LEACH, 2L-LEACH and Inverted tree. In 1L-LEACH first level CHs selected in level-1 same as LEACH. Now level-2	High	Two Level	Proposed approach should be enhanced to improve the performance for other topologies and

		structures are formed. Among the level-1 CHs, based on the energy present in the nodes, certain level-1 CHs are chosen as level 2 CHS. Level-1 CHs send data to level-2 CHs and level-2 CHs send data to the BS directly. Routing is initiated in inverted tree by a tree formation. Inverted tree uses three way handshaking for data communication. Tree is formed for multi-hop data transfer. If one path failed node select another path for sending data.			latency. If the nodes are mobile, the performance will be poor.
2014	FAF-EBRM (energy-balanced routing method based on forward-aware factor)	The forwarding node is chosen by comparing link weight and forward energy density. It is multi-hop protocols that use less energy to transmit data from CH to BS. FAF-EBRM is contrasted with LEACH and EEUC. In terms of balancing energy usage, increasing function lifespan, and assuring outstanding WSN QoS, the results show that FAF-EBRM beats LEACH and EEUC.	Very High	Multi-hop	A consistent distribution of CH is required.
2018	Energy Aware Multi-Hop Routing (EAMR)	The most significant achievement of our suggested protocol is the reduction of needless overhead in most routing protocols by adopting fixed clustering and minimizing the frequency of cluster head changes. A wireless sensor network's scalability can be improved by using relay nodes. Relay nodes' implementation enables the transfer of collected cluster data via inter-cluster communication.	Very High	Multi-hop	Not suitable for large network.

		The use of relay nodes has a great impact on the network's energy dissipation. It improves lifespan because energy consumption in the sensors reduces.			
2019	ETL-LEACH	The ETL-LEACH protocol is an extension to the current TL-LEACH protocol. It aims to improve energy efficiency, overhead and ensure reliable communication between end-nodes, cluster-heads, and base stations. The simulation findings suggested that the new version is more energy efficient and has a longer lifespan.	High	Two Level	The algorithm should ensure that all nodes join the cluster.
2015	Maximizing Lifetime of Wireless Sensor Networks Using Multiple Sets of Rendezvous	The problem of employing many RPs is to enhance the lifespan of WSN. Employing numerous sets of RPs can average the energy usage. An optimum algorithm and heuristic method are presented. Simulations result shows that the heuristic technique works well with multiple RP sets.	High	Multi-hop	it's only appropriate for small-scale WSNs.
2020	Rendezvous-based direction-finding technique	Describes a rendezvous-based direction-finding technique. Rendezvous region is created by growing a tree in the system's center. The basis node transmits information to the BS via this tree, which initially reflects the BS's direction. However, in the second technique, the foundation node receives the BS's position from the tree and sends the data straight to the BS after receiving the BS's location from the tree.	Very High	Multi-hop	Simulation cost is high.

2017	Protocol based on Rendezvous routing	This method creates a tree inside the rendezvous reign, which is created in the centre of the network. In terms of latency, delivery ratio, and energy usage, this method performs better than earlier methods.	High	Multi-hop	Appropriate for a small network.
2016	MZ-LEACH	suggested a clustering strategy for several zonal routing techniques. LEACH is the underlying protocol used by MZ-LEACH. Triangle zones with numerous partitions have been created within the WSN. The location of the base station, the distance d0, and the area dimension of the deployed network serve as the foundation for zone generation. The position of certain cluster heads should be as near to the base station as possible thanks to multiple partitioning. Using a cluster head repartitioned technique between CH and BS has increased communication efficiency. The outcome demonstrates an improvement in network lifespan and a decrease in energy usage.	Very High	Single-hop	MZ LEACH is effectiveness for smaller WSN network need to be tested for further enhancement. Multi-Hop communication should be included in future development.

III. LITERATURE SURVEY RELATED TO ENERGY EFFICIENCY THROUGH CH SELECTION AND CLUSTERING TECHNIQUE

Tan et al. [37] presents an enhanced LEACH-M protocol used in three-dimensional dynamic sensor network. This protocol addresses an issue of mobile nodes patrolling and then departing outside the cluster's communication range resulting in communication failure. The procedure has been improved based on the existing LEACH-M and MCR standards. An efficient solution is described to ensure that outlier nodes can operate. The simulation study findings show that the LEACH-M approach has been updated and now successfully extends the network's life and improves data transfer efficiency. The result analysis shows that the modified LEACH-M protocol extends network lifetime, improves information transmission efficiency, and optimizes network performance as comparison to old LEACH-M and MCR protocols.

Elsmany et al. [38] presented an Energy Efficient Scalable Routing Method (EESRA), and unique three-layer WSN routing algorithm based on the LEACH protocol. EESRA designed with the goal of increasing network's lifespan as it grows in size. Each cycle uses a hybrid MAC protocol with data detection, sleeping, conflict avoidance, and TDMA slots for data forwarding. Congregations (CGs) have also been used to gather sensed data from CMs in order to better balance load. In terms of network performance, EESRA is compared to other WSN routing methods as network size fluctuates. According to the findings of the simulation, EESRA performs task scheduling and energy efficiency better than other protocols on large-scale WSNs.

Solanki et al. [39] outlined the development of the direction finding technique, together with its crucial characteristics for the arrangement of distant sensors. The four basic concepts are the Network Structural Scheme, Transmission Model Scheme, Topology Based Scheme, and Efficient Routing Scheme.

The routing protocol for the WSN has been studied by Parihar et al [40] and suggested quadrant-based routing protocol. It brands advantage of the spanning tree idea. The fundamental goal of the suggested method is to extend the network's lifetime. The GPS system is included inside the sensors and the sensor transmits their location to the BS. Four zones have been created in the sensor region and each node connected to its parents. The remaining energy and distance from the other nodes are used to choose the parental nodes.

The TB-LEACH (Time-based LEACH) technique was proposed by Jet al. [41] which is an enhancement to the LEACH methodology. For better cluster partitioning, TB-LEACH protocol has updated the LEACH protocol's CHs selection process. In this protocol, a random timer is used to choose a fixed number of CHs for each round. The election of a fixed number of CHs is done with the help of a counter. Each node produces a random timer and backs off it to the beginning of each round. When a node's timer expires, it checks the number of CH messages received; if it's less than four, then it announces itself a CH, and the remaining procedure is the same as the LEACH protocol.

Weighted Low Energy Adaptive Hierarchy (W-LEACH) is an aggregation technique for WSN data streams is presented by Abdulsalam et al. [42]. This technique is an improved version of LEACH. W-LEACH adds sensor weights on which CHs selection perform. Sensor

density (the number of sensors around them) and residual energy are used to calculate sensor weights. In addition, W-LEACH does not mandate that all sensors submit data to their CHs. Instead, just x percent of sensors in each cluster are selected to submit data recordings at some round t. High-weight sensors are intended to be CHs, whereas low-weight sensors are intended to provide data to their CHs. W-LEACH surpasses LEACH in terms of first node dies, final node dies, average sensor lifespan, network residual energy, and number of nodes living in the network.

Shi et al [43] investigated data fusion in a clustering routing protocol technique in a WSN. By introducing data fusion technique, the LEACH enhancement has been proposed. The PSO algorithm and a neural network model have used in the data fusion algorithm. In WSN, a hybrid of two methods implemented. The parameters of the suggested technique optimized using the optimum neural network algorithm. Each particle is a set of network parameters, which are processed to determine the best values. The suggested method can be enhanced even further by including a genetic model into the data consumption algorithm.

Ahmed et al. [44] have addressed a modern way of LEACH protocol optimization. The most commonly used protocol is LEACH, which may be paired with the Particle Swarm Optimization (PSO) method to increase the performance. Many simulations are run to compare LEACH alone versus LEACH in combination with PSO. The PSO optimization approach can improve LEACH further. PSO uses a CH, determined by the algorithm to reduce the distance between nodes in a cluster, resulting in LEACH and PSO tuned systems which have superior residual energy than typical LEACH and PSO tuned systems. When the simulations finished, the number of dead nodes is counted in order to see how efficient they are in conserving energy. Experimental study shows that LEACH plus PSO performed better than LEACH alone. This provides a viable way for reducing dead nodes, enhancing energy utilization, and extending life of the networks.

For heterogeneous sensor networks, Zhao et al. [45] presented an enhancement in clustering methodology using data transmission status. The information intensity at the CHs is determined based on threshold for transmission of perceived information to the sink. If threshold level is not exceeded, the CH records the received data and continues receiving data from subsequent cluster-node. This sort of method extends the network's lifespan.

Li et al. [46] proposed a novel Energy harvesting wireless sensor networks (EH-WSNs) method, which incorporates node current residual energy and harvested energy in a short-term prediction horizon into distributed clustering routing CHs election process. A neural network-based solar energy forecast is used to make the routing protocol energy-aware in order to optimize the utilization of captured energy. CHs are more likely to be nodes with higher residual energy and better energy gathering capabilities. According to simulation findings, the suggested clustered routing has a higher capacity to balance energy consumption across sensor nodes and enhances network performance approximately 30% over LEACH.

I-LEACH proposed by Beiranvand et al. [47], which is divided into three stages. Various attributes of sensor nodes, including current energy level, number of neighbor nodes, and distances to base station have been taken into account during the CH selection phase to modify the threshold value. It also takes into account the network's average energy, average number of neighbor nodes, average distances between nodes and the base station. The

distances between CHs and the base station are taken into account by nodes during the cluster creation phase. After gathering data from their local cluster members, the CHs transfer data to the base station during data transmission phase. Nodes that are close to the base station can send data directly to the base station, reducing the number of transfers. The average amount of energy utilized is lowered, and also extended the WSN lifespan.

Alami et al. [48] suggested a novel fuzzy logic-based routing system that focuses on selection of CHs based on the residual energy. After the detected data is communicated, the energy used of CH node and normal node is determined in order to calculate the predicted clusters energy. The expected efficiency of each node is computed using fuzzy based parameter analysis after each round. The node having a higher efficiency than the preset criterion is chosen as CH. The suggested method aimed to extend the network life by lowering the average energy consumption of nodes.

Nayak et al. [49] predicted that LEACH appears to be a promising technique for future development. They concentrated on one aspect of the procedure that might be improved to make it more effective and acceptable. A clustering-based energy-efficient procedure has been suggested by combining the fuzzy logic notion. The CHs choose their super CH based on fuzzy parameters. The data must be sent to the base station via Super CH. The application of fuzzy logic extends the network's life. The fuzzy based clustering strategy is more advantageous in a variety of disciplines from health care to agriculture. The results of the simulation reveal that the suggested works outperform the LEACH procedure. It splits CH to BS communication into two parts: CH to super CH and super CH to BS. This technique saves a lot of energy though reducing BS communication cost. This method also improves network longevity and stability.

Kashyapet et al. [50] proposed a load balancing method that uses an energy-efficient hybrid neural fuzzy. By integrating residual energy, node distance from the base station, and node density, the Adaptive Neuro Fuzzy Clustering Algorithm (ANFCA) selects CHs. It does this by utilizing an adaptive neural network and a fuzzy logic inference engine. According to the findings, the recommended ANFCA generates clusters with uniform distribution and reduces energy dissipation in the network, increasing network longevity. This is due to the fact that ANFCA combined the characteristics of a fuzzy logic learning technique with an artificial neural network approach (ANFIS). The approach outperformed LEACH, the fuzzy-logic-based CHEF and LEACH-ERE in terms of cluster formation, energy dissipation, and network lifetime.

Sambo et al. [51] have addressed several load balancing techniques for big WSNs. In order to create hierarchical WSN, the discussion emphasizes the value of fuzzy logic and optimization techniques during clustering.

Gupta et al. [52] suggested an energy-efficient wireless sensor protocol based on the LEACH protocol to enable effective topology management. In the selection of CHs, the proposed protocol uses the remaining energy of each node. It employs a modified hierarchical method. The simulation result reveals that the WSN's life duration extended. This technique has been tried in both a simulation and a real-time setting in order to enhance it in the near future.

Sheta et al. [53] examines the WSN's limited resources and discovers that energy is the primary restriction that affects the performance. The influence of random number on network performance has been studied for 1000 rounds using various random number generators 25 times. The result reveals that the system's performance is off by 4.2 %. The LEACH protocol solely considers operation of nodes as a source of energy consumption. There are a number of different elements that contribute to energy depletion. Existing techniques overlooked these aspects. The suggested study eliminates the drawbacks of the LEACH procedure. This model put through its paces in a simulated environment to see what an improvement need can be made. Author investigated the numerous formulae and aspects that contribute to the development of a more feasible energy model for WSN. The formulae are dependent on how much energy, the nodes have used lately. The suggested formulae have an increase in network performance in terms of life time and residual energy. The adjusting energy consumption of nodes results in higher residual energy and network longevity. The suggested methodology increased the system's lifespan by 13.67 % and reduced residual energy by 94 %. A new energy model has been proposed and a compression between proposed and LEACH protocols carried out and find that that the proposed technique improves system performance.

GSTEB (General Self-Organized Tree-Based Energy-Balance) protocol for WSN is introduced by Han et al [54]. The approach of data fusion used and this assumption utilized since it is required. The sensor location is described into a square field using the system model. There is a BS in every field and each node has its own set of pore control options. To better communicate with distribute capabilities; the power level can be modified. The GPS mechanism determines the location of nodes. The outcome demonstrates that the information gathered is correlated. In comparison to LEACH and other versions, GSTEB performs better. It is self-contained and requires only a modest amount of energy every round.

Chaitra et al. [55] describes modern energy-efficient computational strategies for better CH selection. The algorithm's complexity and network connectivity concerns are not taken into account. The Multi-objective imperialist competitive algorithm (MOICA) is a unique multi-objective method for optimizing CH selection proposed in this paper. The goal of this study was to examine MOICA's performance in terms of routing and CH selection optimization. In comparison to the basic LEACH technique, the results showed that it can boost lifetime performance by over 56.32 %.

Sampling-Based Spider Monkey Optimization for Energy-Efficient Cluster Head Selection (SSMOECHS) was suggested by Lee et al. [56] for WSNs. In order to account the actual node location, SSMOECHS employs a CH selection process. The most energy-efficient CHs are found by sampling and then enhanced using a modified sample-based Spider Monkey Optimization (SMO) strategy that reduces the divergence between the ideal and actual CH node placements. The outcomes are evaluated in comparison to protocols such as Low-Energy Adaptive Clustering Hierarchy Centralized (LEACH-C), Particle Swarm Optimization Clustering protocol (PSO-C), and threshold-sensitive energy-efficient delay-aware routing protocol based on SMO in both homogeneous and heterogeneous configurations (SMOTECP). According to the study, the SSMOECHS aids WSNs in surviving longer and maintaining stability.

The efficiency of a novel energy-saving method is compared to the LEACH and Hybrid Energy-Efficient Distributed clustering (HEED) algorithms by Zahedi et al. [57]. Weighting coefficients are employed in this study to provide a new clustering method and choosing CHs, based on each node's energy efficiency and residual energy. The recommended strategy focuses on each node's residual energy and the chance of becoming CH improved the overall network's performance. The amount of energy saved and the durability of the network have greatly benefited from this endeavor.

A new clustering technique for wireless sensor networks was created by Pal et al. [58] and is known as the energy-efficient weighted clustering (EEWC) approach. Utilizing a newly created weighted fitness function, the proposed method takes into account clustering quality traits as compactness, separation, and CH counts. The suggested fitness function is used in the evolutionary process to choose the best group of CHs during the steady-state phase of the LEACH approach. Other clustering methodologies including the Stable Election Protocol (SEP), intelligent hierarchical clustering and routing protocol (IHCR), and evolutionary routing protocol are outperformed by the EEWC methodology in terms of stability period, network lifespan, and total residual energy (ERP).

Due to the energy limitations of sensor nodes, WSN network longevity is a significant issue. When enormous quantities of energy are used on sizable data sets and packet transfers in large-scale sensor networks, the problem is exacerbated. The Distributed Entropy Energy-Efficient Clustering Algorithm (DEEEC) is a clustering method that is energy-efficient for Heterogeneous Wireless Sensor Networks (HWSNs) is proposed by Ranganathan et al. [59]. There are two sections to the DEEEC Algorithm. In the first stage, the temporary CHs are determined; if any cluster member has a larger residual energy, the temporary CHs are changed. High energy nodes have a possibility to become CHs thanks to the aforementioned two processes, which are targeted toward CH selection. When compared to existing conventional clustering algorithms used in heterogeneous WSNs, the proposed DEEEC Algorithm's simulated result indicates an improvement in energy efficiency and lifespan.

The number of dead nodes, density inside the sensors zone radius, location, and velocity of the mobile sink are all factors that might affect the energy balance of WSNs. A brand-new cluster-based energy optimization method that takes into account is called Cluster-Based Energy Optimization with Mobile Sink (CEOMS). Wei et al. [60] reports the influence of the aforementioned parameters on the energy balance of WSNs. By initially building the energy density function by determining the residual energy rate and density within the radius of nearby nodes, the recommended method reduced the unpredictability of CH selection. Energy density function, motion performance function, and adaptive adjustment function all worked together to improve CH self-adaptability, balance network load, decrease data latency, and extend network life. Furthermore, when the monitoring region is large, the proposed approach only employs a mobile sink, resulting in fractional data loss and delay.

Kumar et al. [61] presented the DE-LEACH (Distance and Energy Aware LEACH) on hop protocol for WSN communication. To reduce energy usage, it makes use of the residual energy balance and the distance between nodes. The node scheduling naps and wakes has been adjusted, resulting in a significant reduction of energy path gaps. The process of lowering energy requirements leads to network stability. In comparison to other nodes identified as CHs, it selects the node having shortest distance from the BS and more energy-balance. In terms of network life, it outperforms LEACH.

The primary CH connects all other nodes in a wireless sensor network. Because of its nature of gathering data from all other nodes, the selection of the CH is the primary issue with a high energy. Maddali et al. [62] introduced a novel technique, Dynamic Energy Efficient Distance Aware (DEEDA), an Energy Efficient Cluster selection processes in Wireless Sensor Networks. When compared it to current methods, the DEEDA Algorithm outperforms in terms of CH Energy Savings and Power Consumption. The proposed approach can be used to extend the node's lifespan.

Richa et al. [63] presented an M-IWOCA (Modified - Invasive Weed Optimization Clustering Algorithm) technique that is energy-efficient. In this, an improved genetic algorithm (GA) is employed to choose CH. The fuzzy modeling component of GA is used when the node with the highest residual energy is chosen as the CH. Using a k-means clustering technique, the network is initially partitioned into clusters during the startup phase. After each round, the GA selects a new CH by considering remaining energy of the node. If the residual energy of the present CH is above the projected threshold, the CH is not modified. The distance from the cluster's center point and the position of the nodes participating in the selection process are used to determine the best CH. The simulation results demonstrate that M-IWOCA performs better.

In order to compare the energy consumption of CH and non-CH nodes, the distance between sensor nodes and BS is taken into account using the distance-based CH selection algorithm LEACH-DT which is proposed by Kang et al. [64]. The recommended strategy outperforms the current approaches in terms of node longevity and the amount of time until the first node dies. Reproductions show that the network lifetime of the LEACH-DT protocol is 10% longer than that of the standard LEACH protocol.

LEACH, SEP, and NHSEP (New Hierarchical Stable Election Protocol) protocols are all simulated by Pothalaiah et al. [65]. Ns2 simulator used to carry out the simulation. Each node's distance is recorded. The distance between two points is zero and CHs are chosen from nodes having the shortest distance. The results of the simulation reveal that the NHSEP protocol outperforms the other two protocols. Energy Remaining, Packet Delivery Fraction, Energy Consumed, End to End Delay, and Dead Nodes are the metrics of comparison. Both SEP and NHSEP created a non-uniform cluster region.

For WSN, Prerna et al. [66] suggested a new routing method. This method employs static clustering for cluster creation and CHs selected dynamically. The static clustering method assigned defined sections to the whole network. The leftover energy, surrounding nodes, and distance are all factors in the selection process. The network is divided into different areas. The separation was computed based on node communication ranges, and the outcome reveals that cluster formation improves with time.

K-LEACH proposed by Bakaraniya et al. [67] to extend the lifetime of a network. For uniform cluster generation, it employs the K-medoids method. It does not use LEACH protocol's random selection technique. Sensor node deployment can range from organized to random, depending on the requirements. Finding the best route from a remote site to the servers puts more load on the sensor node and uses more energy. It ensures that the CHs are properly positioned and that the nodes are clustered uniformly. The LEACH protocol uses a completely random selection of CHs, resulting in very poor CH selection and, as a result,

highly inefficient network lifetime and energy retention. It uses a combination of clustering, maximum residual energy criterion and a random selection of CHs only after nearly half of the network's operations are complete. The simulation findings show that the recommended technique may maintain a balanced distribution of energy consumption across sensor networks, hence extending the network's lifespan. In comparison to the LEACH, this process makes the network more energy effective.

Rodríguez et al. [68] proposed a novel energy-efficient routing system for WSNs. The purpose of this project is to provide an energy-efficient routing protocol for WSNs. The ideal CHs for each BS and sensor node are determined using the Yellow Goatfish algorithm. Through experiments it is suggested that this strategy, when compared to the Distributed Energy Efficient Clustering Algorithm (DEEC), LEACH, and Stable Election Protocol (SEP), reduces energy usage and increase network stability.

The work a LEACH-based multi-energy threshold-based routing protocol suggested by Mansura et al. [69], is a dubbed multi-energy threshold LEACH that provides varied energy thresholds for battery energy levels (MET-LEACH). For CH selection in the network, it takes into account several energy thresholds. The MET-LEACH selects the CHs based on the remaining battery energy. The performance parameters used to test the proposed MET-LEACH protocol are the FND, HND, and LND, PRR, and request level delay. The MET-LEACH working strategy indicates an increase in its performance as compared to existing.

The power consumption of the network's sensors is a topic that many academics are concentrating on at the moment because it is a hot topic. Ennaciri et al. [70] proposes the Energy Efficient Sleep Awake Aware (EESAA) technique to enhance clustering selection strategy to increase service quality and make the network more efficient. The approach used is the sleep and awakened mechanism, which helps nodes conserve energy. Nodes go into sleep mode when there is nothing to say; when they get a signal, they awaken and start talking. The author of this article highlights load balancing protocols including LEACH, EESAA, and Stable Election Protocol (SEP), which help control efficiency and energy consumption while extending the life of the network. Simulation results show that the EESAA operates better than the standard protocols in terms of network longevity and CH selection.

Harnn et al. [71], authors have proposed and analyze the performance of LEACH-GA (LEACH- Genetic Algorithm) protocol. The LEACH procedure is optimized via a genetic algorithm. In terms of extended network life, more vitality competence, and more data received by the BS, the simulation results of LEACH-GA outperform the LEACH. With the same number of nodes, a larger region is considered for the testing, and LEACH-GA performance is better than LEACH.

To reduce power consumption in a wireless sensor network, Amsalu et al. [72] created the GAICH (Genetic Algorithm Inspired Clustering Hierarchy). The CH is chosen using a genetic algorithm-inspired clustering hierarchy using the least amount of energy consumed. In CH selection process, the optimal energy consumption nodes are given priority. The number of effective CHs is chosen using a Genetic Algorithm (GA). It generates the most clusters in the shortest amount of time. In terms of average energy usage and total packets transferred, simulation data demonstrates that the evolutionary algorithm inspired

clustering hierarchy beats the LEACH protocol. The genetic algorithm-inspired clustering hierarchy may be improved even further by accounting for the time it takes for nodes to reach CH and the time it takes to run the algorithm. No conventional simulator has been used to evaluate the genetic algorithm-inspired clustering hierarchy. Its performance must be evaluated through the internet or in a real-time setting.

A new method called LEACH Mobile Sink RN (LMRNACH) with an updated CH Selection procedure and other adjustments to the CH Selection procedure was published by Pushkarna et al. [73]. Increasing the Network's lifespan was the aim of this study. The four parameters of node distance from the sink, node distance from other CH, energy remaining, and the amount of times a node becomes CH were changed to obtain LMRNACH. In simulations, the suggested approach performed better than the traditional LEACH mobile sink and RN node, common in high network configurations.

An EE-LEACH (Energy Efficient-LEACH) solution for improving CH selection strategy has been proposed by Mao et al. [74]. To offer optimum communication settings, the suggested method evaluates the energy and location parameters for each sensor node. Based on their residual energy and closeness to certain other sensors in the WSN as determined by a threshold, sensor nodes are categorized as CH. As a result, the suggested technique offers greater throughput, network lifespan, and energy utilization.

Kole et al. [75] suggested a change in LEACH procedure. The goal of this method was to extend the life of the networks. This work aims to reduce the energy consumption of wireless sensor networks by incorporating an innovative and adaptive approach into the wireless sensor network's standard clustering protocol. The Distance based LEACH method is presented to increase network performance by enhancing the cluster creation approach using the distance parameter. The distance between sensor nodes and CHs, as well as the distance between CHs and base stations are taken into account during the cluster formation phase in the procedure. The simulated study shows that the suggested technique beats LEACH in terms of network lifetime.

Vandana et al. [76] introduced the Multi-level Heterogeneous Energy Efficient Hybrid Clustering Protocol (MHEEHCP), which employed both static and dynamic clustering techniques. The hybrid approach helps networks last longer. Combining static and dynamic clustering extends the network's lifespan and stability. MATLAB has been used to construct the simulation environment. In comparison to LEACH, the simulated technique increases network lifespan and stability by 31.83% and 19.71% respectively. The suggested work needed to be improved by merging it with other LEACH variants and comparing its efficiency to that of other protocols.

A novel Hybrid Clustering Routing Protocol (HCP) was provided by Masoud et al. [77]. In this study, the two phase functioning mechanism has been applied. Based on a threshold value, the cluster formation process in the first phase and the packet transmission procedure in the second phase are utilized to determine whether to send data straight to the sink node or to the CH. Additionally, if there are fewer nodes overall in the network, lowering node density, or if nodes are dispersed, clustering is avoided. The authors' simulation of HCP and comparison of its functionality with LEACH and LEACH-T demonstrates a 30% improvement in network lifespan.

Gwavava et al. [78] studied the LEACH protocol and its amendment versions. They suggested YA-LEACH (Yet Another LEACH) protocol by including advantages of previous LEACH protocol amendments. It uses centralized cluster creation to reduce the amount of energy required for data transmission. By decreasing cluster formation, the centralized cluster formation strategy saves more energy. Before CH exhausts all of its energy, the vice CH shoulders responsibility of cluster failure. The suggested approach's demonstrates that the network performance improves and network life time rises as well. In the future, the data negotiation approach can be used to improve the steady phase of the planned task.

In WSN, Pandya et al. [79] shared their thoughts on clustering techniques and stated that in clustered setting, the WSN performs better. LEACH is one of the earliest clustering-based WSN applications. The proposed methodology is intended for both proactive and reactive situations. The protocol employs a variety of CH selection techniques and algorithms to extend network lifetime while lowering power consumption using various power settings. The authors distinguish between two types of thresholds: soft and hard thresholds. Threshold applications decrease the amount of data sent between nodes. Clustering performs better than the LEACH algorithm, according to simulation results. For further enhancement, the methodology must be evaluated in a variety of simulated environments.

Moghadam et al. [80] used firefly algorithm to find a way for improving ANFIS. The approach exhibits processing increase in terms of accuracy and neuron optimization, as well as a reduction in complexity.

Table 3: Summary of the Research Paper related to Energy Efficiency by using CH Selection and Clustering Technique

Year of Publication	Method	Findings	Energy Efficiency	Data Communication pattern	Limitation
2016	EEFL-CH	A novel fuzzy logic-based routing method is proposed. Residual energy, predicted efficiency, and proximity to the base station are the hazy parameters. The selection of CH depending on the remaining residual energy is the key topic. In terms of energy use and network lifespan, EEFL-CH is more productive than LEACH protocol.	Very High	Multi-hop	There are too many factors that can impact the network life of the WSN. EEFL-CH can be further modified with enhancement in fuzzy logic.
2019	Energy Efficient Scalable Routing Method (EESRA)	EESRA is a unique three-layer WSN routing procedure based on the LEACH protocol. Hybrid MAC protocol is used in each cycle, with data sensing, sleep, and collision avoidance mechanisms. EESRA is designed with the goal of increasing network's lifespan as its size increases. The EESRA has superior load balancing and is more energy efficient, according to simulation studies.	Very High	Multi-hop	Suitable for fixed nodes. Should be implemented in a very large network and then evaluated.
2019	LEACH-PSO	The most commonly used protocol is LEACH, which can be paired with the Particle Swarm Optimization (PSO) to increase the performance. PSO uses a CH determined by an algorithm that reduces the distance between nodes in a cluster. This provides a viable way for reducing dead nodes and enhancing energy utilization.	High	Single-hop	Multi-Hop communication should be a focus in the future. Suitable for small size of network only.

2015	Fuzzy Logic based clustering	With the use of fuzzy logic, a clustering-based energy-efficient strategy has been presented. Cluster heads selects their super cluster head based on calculation of fuzzy parameters. Super cluster head is responsible for communicating the data to the base station. According to the suggested method, CH to BS communication is split into CH to super CH and super CH to BS transmission. By breaking down extensive communication into brief communication, this method conserves a lot of energy. The reproduction output shows that the proposed method outperforms LEACH protocol. This approach provides better network stability and lifetime.	Very High	Two Level	The proposed approach need to be tested in different environment for further improvement.
2019	adaptive neuro fuzzy clustering algorithm (ANFCA)	By integrating remaining energy, node distance from the BS, and node density, a fuzzy logic reasoning method is employed to select a CH. In terms of clustering, energy dissipation, and network durability, the Adaptive Neuro Fuzzy Clustering Algorithm (ANFCA) outperformed LEACH and the fuzzy-logic-based CHEF and LEACH-ERE.	Very High	Single-hop	This is a centralized algorithm. This work can be extended for distributed system suitable for a scalable, fault-tolerant, cluster-based network in future.
2016	Modified LEACH-DT	LEACH-DT and its hierarchical extension are performed. The LEACH -DT Hierarchical Extension is developed for large area networks with two levels of CH. The first is CH; while the second is super CH. LEACH-DT is used to select Super CH. Nodes	High	Two Level	A consistent distribution of CH is required. It can be tested in real time environment for more improvement in near future.

		send data to CH, who then sends it to SCH, who then sends it to BS.			
2020	Energy-Efficient Weighted Clustering method (EEWC)	The suggested technique makes use of a newly developed weighted fitness function that considers clustering quality characteristics such as compactness, separation, and CH count. The EEWC algorithm outperforms conventional clustering schemes in terms of stabilization period, network longevity, and total remaining energy.	High	Single-hop	Multi-Hop communication must be a focused in the future. The protocol need to be tested in different simulated environment. Suitable for small size network.
2021	Cluster-Based Energy Optimization with Mobile Sink (CEOMS)	The amount of energy and density that is still present inside the sensor nodes' zone diameter, the amount of dead nodes, and the location and speed of the mobile sink can all have a significant impact on energy balance of WSNs. A unique cluster-based energy optimization method called CEOMS is used to choose CHs while analyzing the impact of the key parameters on the energy balance of WSNs. The recommended method first constructed the power density function by evaluating the remaining energy rate and density inside the neighborhood radius of nodes, which reduced the uncertainty of CH selection.	High	Single-hop	The advised method only employs a mobile sink when the monitoring region is sizable, which causes minute delays and data loss.
2014	DE-LEACH	It is a single hop communication protocol. The nodes' sleep and awoke schedule is optimized to provide suitable improvement in reducing the energy path holes. It calculates the node having the minimize distance from BS and having more energy-balance as compared	High	Single-hop	DE-LEACH work on only single hop. Need to be implementing and check on multi-hop.

		to other nodes selected as CH. Its performance is better than LEACH for network life.			
2017	Dynamic Energy Efficient Distance Aware (DEEDA)	The primary CH connects all other nodes in a wireless sensor network. Because of its nature, the selection of the CH is the primary issue with a high energy need. A Dynamic Energy Efficient Distance Aware (DEEDA) which is a novel technique has been introduced to solve this problem.	High	Single-hop	CH selection method may consume more energy. Suitable for small size network only.
2019	MIWOCA	An improved genetic algorithm (GA) is employed to choose CH. Using a k-means clustering technique. The network is initially partitioned into clusters during the startup phase. After each rounds, the GA selects a new CH by considering remaining energy of the node.	Very High	Single-hop	Multi-Hop communication could be a focus in the future. Suitable for medium size network.
2013	K-LEACH	The uniform cluster generation is accomplished using the K-medoids technique. While the LEACH protocol uses a completely random selection of CHs, this results in very poor CH selection and, as a result, highly inefficient network lifetime and energy retention. It combines the best of clustering, the maximum remaining energy criterion, and a random choice of CHs, only when nearly half of the network's processes are completed. The outcomes of the simulation show that the recommended strategy improves the network's energy efficiency when compared to LEACH.	High	Single-hop	Implemented on small network. Need to run on large network and then see the performance of the protocol.

2019	Energy Efficient Sleep Awake Aware (EESAA)	Energy Efficient Sleep Awake Aware (EESAA) is a method presented by the author to improve service quality. Nodes in this strategy employed the sleep and awoke mechanism. When nodes have nothing to communicate, they fall into sleep mode; when they get a signal, they awoke.	High	Single-hop	Only 100 nodes were used to test the system. It should be implemented on a larger number of nodes for the analysis.
2017	EE-LEACH	Proposed an energy efficient EE-LEACH approach to improve CH selection strategy. Sensor nodes are selected as CH on the basis of their remaining energy and location to other sensor nodes into WSN. The proposed energy efficient EE-LEACH is compared to LEACH and LEACH-C. Result shows that the proposed approach is better in respect to energy consumption, network life time and throughput.	High	Single-hop	CH need to be distributed uniformly Other parameters may also be considered for better analysis.
2014	Distance Based Cluster Formation Technique for LEACH	The Distance based LEACH method is proposed to increase network performance by enhancing the cluster creation approach using the distance parameter. The distance between sensor nodes and CHs, as well as the distance between CHs and base stations, are taken into account during the cluster formation phase of modified LEACH. The simulated analysis proves that proposed approach outperforms LEACH in respect to life-time of networks.	Very High	Single-hop	Multi-Hop communication can be included in future development. If the nodes are mobile, the performance will be poor.

2015	MHEEHCP	A Multi-level Heterogeneous Energy Efficient Hybrid Clustering Protocol has been proposed (MHEEHCP). It employs both dynamic and static clustering. The hybrid strategy extends the life of networks. The outcome demonstrates that the suggested method works better than LEACH. When compared to LEACH, the modeled environment increases the networks' longevity and durability by 31.83 percent and 19.71 percent, respectively.	High	Multi-leveling	The proposed work required further improvement by combining it with other LEACH variant to test its efficiency in comparison to the other protocol.
2016	YA-LEACH	YA-LEACH protocol proposed to minimize the energy requirements for data transmission by using centralized cluster formation. The centralized cluster formation approach makes increase the energy saving by reducing the number of cluster formation. The vice CH takes responsibility of CH to safeguards failure of clusters before CH exhausts all energy. The proposed approach improves the communication throughput. The analysis shows that the network life time increases.	High	Single-hop	For the best outcomes, the optimal number of clusters must be chosen. The data negotiation incorporated for enhancing the steady phase of proposed work. Multi-Hop communication can be included in future development.
2015	Advance MODLEACH	The proposed protocol is designed for proactive and reactive environment. The protocol uses various CH selection methods and algorithms. It increases the lifetime of networks and reducing the power requirement at different levels. As per simulation result, the proposed approach performance is better than the LEACH protocol	Very High	Single-hop	The protocol need to be tested for the different simulated environment.

| 2019 | LEACH-DA | Described a Dijkstra's Algorithm-which is an enhanced version of LEACH protocol (LEACH-DA). To reduce energy usage it adopted a shortest path selection technique. Fog computing has been used to extend the network lifespan of LEACH networks. Fog computing acts as a bridge between sensor nodes and base stations. Researchers have proposed the fog nodes with the functionality comparable to base stations, or fog nodes that operate as sub-base stations. | Very High | Multi-hop | Data will be lost if the chosen route fails for whatever reason. |

Rafi et al. [81] described a Dijkstra's Algorithm which is an enhanced version of LEACH protocol (LEACH-DA). To reduce energy usage, they adopted a shortest path technique. When choosing a node as CH, the traffic level analysis is taken into account. In comparison to the original protocol, fog computing approaches are used to extend the network lifespan. The fog computing act as bridge between the sensor nodes and the base stations. In this work, author proposed fog nodes with functionality comparable to base stations, or fog nodes that operate as sub-base stations. Fog nodes work as local data processing centers and act as bridge points to cover all of the targeted areas. Some test scenarios have been shown, and it has been concluded that changes in classic LEACH protocol increase network efficiency and network longevity.

An ideal path selection method for increasing the network's lifespan was provided by Baby et al. [82]. Weighted Rendezvous Planning is a method of planning rendezvous that assigns a weight to each sensor node based on the distance between each hop. A group of RPs is selected so that the communication consumes the least amount of energy possible. All sensor nodes send data to the designated RP; if a particular sensor node does not have a designated RP, the data is transferred through multi hopping to the closest RP. The findings showed that the suggested strategy reduced the energy consumption and extended the network lifetime.

IV. LIMITATIONS

The following are the research gap identified based on literature review

1. Wireless sensor networks (WSNs) are powered by auxiliary power. Because of long range of wireless transmission, the sensor nodes delivering data directly to the BS require a significant amount of energy in LEACH. Therefore there was a need to designing a protocol to reduce energy consumption of sensor nodes.
2. CHs are chosen at random in the LEACH protocol, and the residual energy used as a selection criterion for CHs. The other factors such as distance to the BS, distance to nearby nodes, and data communication cost have been considered.
3. The LEACH protocol is used to manage centralized and distributed sensor communication. It is not appropriate for use in a wireless wide area network. The Sensor nodes in large WSNs are distributed across large geographic areas. The nodes communication minimized by utilizing hierarchical system operation.
4. Existing LEACH techniques have an issue such as CH failure and extra overheads when CHs are re-selected. In large size networks, it was ineffective for dynamic clustering.
5. CH selection is a random procedure that ignores energy usage and distance from the sink. There is no consideration for the CH selection attempts, which might cause network nodes to become overloaded in CH selection tasks.
6. The existing protocols suggest that for choosing a CH, the residual energy and distance taken into account. The transfer of CH charge to other nodes considered on a regular basis to make the network more energy efficient.
7. The distance between selected CH and BS, as well as the distance between one CH from another CH considered while selecting a CH. When this process taken into account properly leads to a reduction in network energy usage and increase network longevity. The connection between the CH and BS includes additional nodes along the path, which results in needless
8. Usage of energy and a shortening of overall lifespan.

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