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Survey on WSN Network Lifetime Through Leach Clustering Schemes

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Abstract: ***Sensor nodes deployed in wireless sensor networks (WSN) are resource constrained, battery operated and have a restricted energy resource. The significant number of wireless sensor network applications aim to extend the longevity of the network by using various strategies. Clustering algorithms were proven to be among the best efficient ways for increasing wireless sensor network reliability. In a wireless sensor network, clustering-based solutions control the network operations to manage the restricted energy in the optimal effective way to extend the network lifetime. Reviews in related subject could assist in gathering thorough and timely information about wireless sensor networks lifetime study through different clustering protocols. This research review study paper presents an extensive study of existing low energy adaptive clustering hierarchy (LEACH) homogeneous clustering procedures and analysis.***

Keywords: Clustering, Energy Efficient, Homogeneous, Network Lifetime and WSN

I. INTRODUCTION

The advances of the wireless sensor network (WSN) could presently be found in major fields [1]. It serves a variety of applications, including the military, healthcare, industry, and the environmental monitoring, agriculture, and IoT (Internet of Things). The sensor consists of processing unit, battery, memory, and radio unit shown in the Figure1.

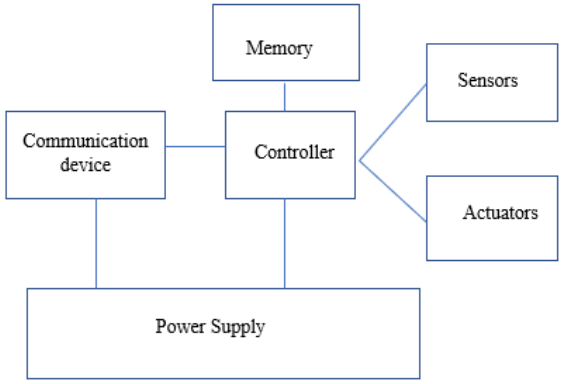

Fig. 1: Sensor Hardware

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Wireless links interconnects the massive number of tiny sensors that comprise a WSN. WSN sensors can detect events in the sensing field and process information, compute, analyse and communicate with other sensors [2-5]. Sensor distribution in a sensing area of WSN can be done either manually or at random. The sensors may be installed and functioned in areas where humans are restricted. In such instances, the sensors monitor the sensing area and transmit the observed information to the base station (BS) without the need for human participation [6]. Besides from its many advantages, the WSN has several drawbacks, like the limited battery power of its sensors [7].

The researchers are emphasizing on developing algorithms and designs to optimize the restricted battery power in order to alleviate the battery concerns. However, there is 20% battery power is wasted most of the time due battery issues, sometimes sensor nodes are not deployed properly. Many other factors, such as deployment method, sensor density, bandwidth, and security have an impact on WSN performance. Despite of adopting the linear transmitting method, the routing can conserve energy by giving alternative channels to the BS. Many studies have benefited from the development of cluster-based routing in dealing with the WSN's energy problems. The clustering algorithms are able to balance nodes energy consumption of the sensors and regulate the workload on the network to extend lifetime. The kind of sensor used and number of sensors in the network present can be varied depending on the specific applications. Aggregating multiple streams of data into single packet, clustering methods can avoid data redundancy in the network and thus conserve network energy [8-11].

II. MOTIVATION

A cluster-based routing protocol has benefited the numerous areas of WSN applications in efficiently utilizing the sensor's limited power to extend the network lifetime. To operate clustering tasks efficiently, the WSN suggested clustering algorithms using various approaches and optimization techniques. Wireless Sensor Networks are very much useful to capture the data with the help of cutting-edge new technologies which includes health, industrial and military applications.

There is often a necessity for a survey that can offer a clearer understanding of the various clustering methodologies in order to assist the researcher in getting the necessary expertise in such domain in order to undertake on a new research path in the area of cluster-based networks.

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With this in view, the purpose of this survey is to provide an overview of the numerous clustering protocols which have been utilized to increase network performance through the implementation of diverse approaches and architectural features.

III. MAIN CONTRIBUTIONS

The fundamental objective of this review is to present a comprehensive overview of the LEACH clustering algorithms by exploring the key characteristics of the many existing methods.

- It analyses the objective, significant aspects, advantages, and disadvantages of the various protocols, which can assist researchers in setting the framework for new research methodologies.
- It offers a unique insight on the existing LEACH clustering protocols classification and their performance.

IV. EXISTING LEACH PROTOCOLS

An energy efficient algorithm known as low energy adaptive clustering hierarchy (LEACH) [12] which considers hierarchical and adaptive clustering method to provide energy savings for WSN. In LEACH, CH (cluster head) is chosen at random to sustain the network's energy consumption in balance. It is still adopted as a foundation for numerous clustering approaches in WSN. It can be viewed as a statistical, random, stochastic, and hierarchal clustering protocol. The data is transferred to the BS by the CH using the single-hop communication mode. In this protocol, cluster formation and CH selection are done without the use of a centralized control system. This feature provides to more reliable and adaptable routing, which reduces data transmission to the sink. LEACH is executed in phases, such as setup and steady phases being the most important. To begin the cluster formation, the CH transmits the advertisement message. By responding to the CH message, the nodes decide to join the cluster within its transmission range. During formation of clusters nodes respond to the CH with the strongest signal.

After the nodes have been determined to be members of their respective clusters, the next phase begins. The CH collects, aggregates, and forwards aggregated data to base station. The duplication of data is eliminated by using data aggregation methods which reduce energy waste. Time Division Multiple Access (TDMA) slots are used to schedule sensor transmission. The slot time is fixed for sensors to schedule data, and the overall time is determined by the number of nodes. After a few rounds, the protocol's drawbacks may be observed when CH's random selection mechanism will choose low-energy nodes to become CH, thus reducing network stability and leading CH's early death. In [13] author proposed multi-level route aware clustering algorithm (MLRC). The BS initiates the cluster head (CH) identification process through sending broadcasting message to nodes in the network this scheme. Nodes having high residual energy compared to pre-defined threshold value can participate in the cluster head election process and, if they qualify, can transform their classification to CH.

A message comprising energy details and the proximity to BS will be sent to the nodes in cluster head transmission range. Node will determine its role (member or CH) after obtaining the CH message. The message that the BS transmits to the nodes assists in the selection of the first layer CH. The decision process of CH starts with random value selection (between 0 and 1), which is then matched to a preset threshold considering energy and distance parameter for selecting reliable cluster head. CH's geographic coordinates are sent to the nodes within its transmission range. The relay node (gateway node) for transferring data is chosen by the nodes. This procedure is performed until each CH has its own gateway node to transmit data to the BS. Tree based routing is employed to send data to BS which reduces the cost of transmission caused by the longer distance across the relay nodes. The nodes connect the CH for cluster formation by taking into account the CH's signal strength. To alleviate the load on CHs, the CHs closer to BS are assigned with fewer members. In [14] author proposed energy efficient scheme integration dijkstra and vector quantization to enhance network efficiency, a clustering method focusing on the vector quantization algorithm was presented. The conventional LEACH protocol was incorporated with dijkstra and vector quantization methods.

The vector quantization technique is employed in this protocol to discover low-energy paths for cluster communication, minimizing network energy consumption. The intra-cluster communication within cooperative network is performed by this algorithm through vector quantization. It also uses the Dijkstra function to discover the shortest cost route in regards of energy across the CHs for interconnecting together.

This protocol outperforms the conventional LEACH in terms of network lifetime and energy consumption due to low transmission routes predicated on vector quantization and the use of the Dijkstra algorithm to discover the best path among the CHs. In [15] author proposed Energy-aware and layering-based clustering and routing protocol (EA-CRP), in this scheme a multilevel structure is used to minimize the network's energy consumption. The sensing area is divided into layers that descend towards the BS and comprises an array of clusters. The protocol decreases the time it needs to set up a cluster and the amount of time it requires for nodes to communicate with one another.

In each layer, the BS notifies all nodes regarding their neighbours. Each node maintains the neighbour information in a table and broadcasts their ID and energy values to all of their neighbours. Employing threshold energy, the algorithm determines the leading master head and CH to different sub layers. Nodes with an energy value over the threshold could participate for the role of CH or master head. The nodes which are participating can operate as provisional head calculating and comparing their functional values with those of other nodes in order to choose the CH or master head. The provisional nodes estimate the mean energy and distance from the BS of all nodes. The provisional nodes generate the weight function of being the CH and master nodes through calculating average distance and energy.

The provisional heads transmit message that includes the provisional head's ID, as well as the energy and weight of sub-layer nodes. When the provisional heads obtain the neighbour weights, they correlate them to their own weight.

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In [16] author proposed balanced power aware clustering and routing protocol (BPA-CRP) clustering in this protocol is accomplished by dividing the complete network into groups of clusters and layers. This enables clusters to operate for numerous rounds, with the exclusion of the setup stage. It employs sender node to collect data from multiple layers for forwarding it to BS. The CH and sender nodes can run indefinitely for numerous rounds unless the energy level of the CH or forwarder exceeds a specified threshold. Each layer's CH takes sensor data and aggregates it before sending it to the closest forwarder. Information is forwarded from one sender node to the next till it reaches the BS.

BS then determines the appropriate forwarders to send the data for the initial round of communication. Forwarder responsibilities are given to the nodes having greater energy levels in the subsequent batch. This approach's cluster can run for numerous rounds (batch). Each node transmits its information to all cluster members (energy, CID (cluster-id) and ID). CH responsibilities are rotated across all cluster members nodes in round-robin fashion. In [17] author proposed improved energy efficient cluster head selection scheme, the current study solves the issue of CHs being selected at random, resulting in energy dissipation across sensor nodes. The initial aspect of this research is to improve LEACH by changing setup phase, and choose cluster head following these parameters: communication cost to BS, residual energy, distance, and network size. The availability of residual energy to meet the required communication cost in every round is used to identify cluster heads in this investigation.

As a result, we can successfully minimize the elected CHs' energy while maintaining the system 's effectiveness. The power which consumption retains in conveying duplicate information to BS by numerous CHs is additional cause of WSN energy dissipation. Due to overlapping CH in the same sensing area, where the distance between any two or more CH may overlaps, duplicate information is provided. The second aspect of this work is to improve LEACH by detecting one or more vices for every CH in order to prevent transmitting repetitive information.

The objective is to find a group of headers which can compete with each other (cover the same monitoring area). The existence of the cluster header's defined vices (candidate headers) motivates this job for third contribution as scheduling mechanism which arranges the specified CH in correct order with its vices. This research aims to reduce the energy consumption of WSNs by adopting active-sleep scheduling method to determine which head must wake up to execute all operations related to aggregating, receiving and data delivering to BS. The advantages and disadvantages of surveyed LEACH scheme is shown in Table-I:

Table I-Advantages and Disadvantages of Surveyed LEACH scheme

Protocol	Advantages	Disadvantages
LEACH	Every node has an equal opportunity of being the CH, dividing the workload among all nodes.	CH selection is done randomly without considering nodes energy and also there is a possibility of selecting nodes with lower energy as CH which leads to death of node
MLRC	The same approach is employed for data forwarding and CH redistributions. Issue of hotspot is solved by dispersing nodes surrounding the CH closer to the BS.	No uniform CH distribution Causes more delay
VLEACH-VD	The shortest path is determined by Dijkstra and vector quantization for reduced energy path while cooperative forwarding	Does not consider energy parameters and has non-uniform CH selection
EA-CRP	Reduces overhead by dividing into layers and sub-layers and minimizes communication cost	The application part is not included and increase in delay
BPA-CRP	The network can run for a number of rounds until the forwarder energy reaches a certain level.	Geographical location of each node is aware, therefore increases the cost and energy requirements.
Improved-LEACH	Efficient CH selection by considering four parameters and minimizes energy consumption	Throughput is lower, which is lesser around 20% as compared to other protocols.

V. CONCLUSION

The effectiveness, methodology, and aspects of cluster-based LEACH protocols are reviewed in this survey to offer a greater understanding of the clustering principle of various clustering strategies. The papers related to LEACH clustering protocols are studied and analyzed. Operational capabilities, network topology, and techniques are all taken into account while classifying existing clustering approaches. With the goal of providing researchers with a broader and better vision of the cluster-based routing approaches, this survey provides a summary of various clustering algorithm and its clustering methods, functionality and characteristics. The characteristics and feature assessment of clustering protocols compares the methods on different significant ideas and optimizing energy, using parameters such as key characteristics, goals, benefits, and drawbacks.

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