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Survey broach for clustering in wireless sensors protocols and types

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Abstract

Sensor network applications have become part of everyday life applications. Creating such networks needs to meet its own constraints, such as: the energy consumption, scalability, fault tolerance, estimated cost, and the possibility of changing the network topography and the environment. In this work, a survey on hierarchical routing protocols in Wireless Sensor Networks (WSN) was performed. WSNs hold tiny nodes with ability of sensing, communications, and computation. Due to the power limitation of the sensor unit, several hierarchical routing protocols have been proposed for minimizing power exhaustion. Much research labor has been implemented to overcome weakness and to upgrade the performance of hierarchical routing protocols. So, a universal review is needed which can review latest technologies, construe functional and performance sides, and focus on issues and challenges of hierarchical routing protocol in WSNs. lastly, the paper focus on issues and challenges in current routing protocols of WSNs, which can aide in outlook research for election of appropriate research field and supply guidance in selection of energy awareness techniques in the design of improving energy of routing protocols for WSNs.

Keywords: WSN; Cluster Head (CH); LEACH; TEEN; APTEEN; BCDC

1. Introduction

The modern technological revolution in the science of sensor networks has opened wide scientific doors in the agricultural, industrial, medical, environmental and military fields. A sensor network consists of a large group of sensor nodes that collect data and coordinate data transmission to other nodes in the network. The way the network is distributed is governed by a set of standards, where each group of sensor nodes has a cluster head (CH). Sensor nodes are characterized by their low power and simple architecture as the network efficiency depends on the efficiency of their operational lifetime while providing the power supply. Each sensor node has sensors, transceivers, has wireless microprocessors [1], and communicates with each other via multiple communication channels and different frequencies to send, receive, and process data and choose paths to the right destination [2], which makes it consume more energy. Other single channel sensors. This type of network faces difficulty in the network management process because the effort will fall on the central node [3]. Therefore, sensor nodes were distributed over a wide geographical area according to specific algorithms to facilitate the process of collecting and analyzing data and retransmitting the data according to specific paths using artificial intelligence methods [4, 5]. Reducing power and reducing transmission time are two vital issues to improve the operating efficiency of the system. Therefore, the method of distributing these nodes and choosing a head for each group, which is called the cluster head (CH). Each cluster head, in turn, sends data to the main station head according to distribution and collection protocols, while recycling the cluster head, which makes the system balanced to conserve energy and not consume it [6]. Researchers and developers have distributed these nodes and elected central nodes called the base node (BN), which act as central nodes that control the operations of the rest of the geographically dispersed nodes to reduce the load on the remote node, reduce energy consumption, and improve network operation. There are several types of distribution methods, such as based on cluster formation, the dynamic

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clustering method, the hierarchical clustering method, the probabilistic and non-probabilistic clustering method, and other methods, and each method has its good and bad advantages in dealing with members of the group of nodes and sending data to the BN or what is known as the node Pelvic [7]. Figure 1 Below is an illustration of the network components and their branches.

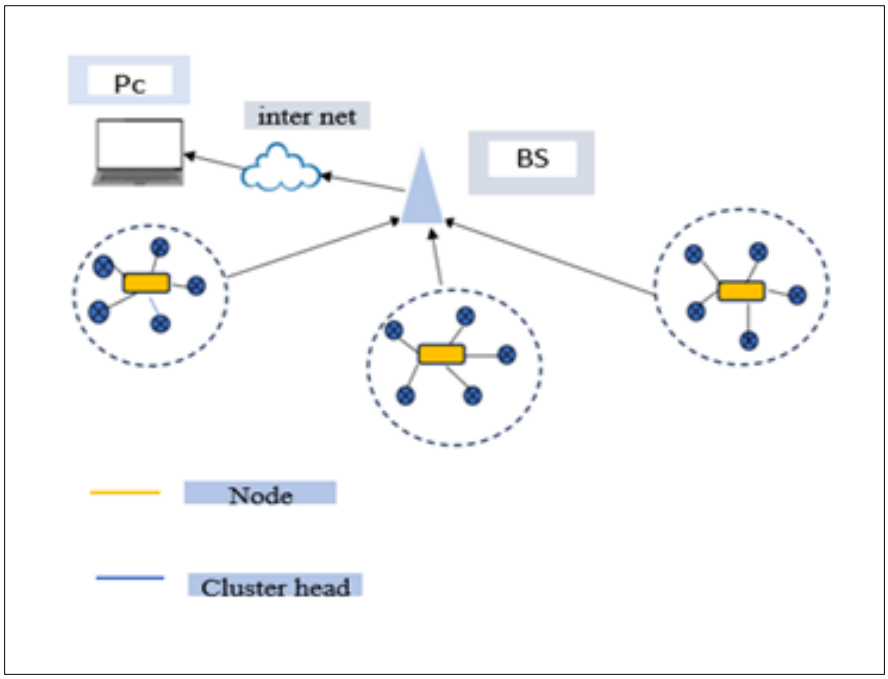

Figure 1 Network components and their branches

The distribution of these nodes and the election of their president depend on a set of classifications as shown in Table 1 below.

Table 1 Types of clustering in WSNs and general characteristics

Types of Clustering in WSNs	**General characteristics**
Flat	Each node communicates directly with the MBS
Hierarchical	Nodes are gathered in groups and each node is connected to the BS
Centralized	Each MBS is trained to take responsibility for selecting the group heads
Distributed	Nodes are trained to organize into groups without any control process
Grid-based	Each geographical area is divided into groups of networks with a fixed network
Dynamic	Depending on the energy levels and contact conditions, the heads of the aggregates are changed dynamically
Probabilistic	Nodes are more likely to be the head of a group given the available energy
Fuzzy Logic-based	In light of the available energy, the type of devices, and the distance between the nodes, the head of the group is chosen, and all that is said about it is a fuzzy distribution
Evolutionary Algorithms-based	Adopting advanced algorithms to improve the group formation process
Energy-efficient	The selection of conveyor heads is based on their reduction in energy consumption
QoS-aware	It depends on the quality and efficiency of the service and reliability of choosing the group heads from the nodes, in addition to other factors such as the packet bandwidth.

2. Related Works

The researchers (Faisal AlZyoud, at. el.) in 2024 focused on one type, which is (LEACH), as it is one of the types of Hierarchical Clustering because it is low in energy and facilitates the data transfer process between nodes and the BS. They developed an algorithm that outperforms the previous traditional methods and built a way to assign a head to the group of nodes in a way that ensures that there is no rapid energy consumption and speed in data delivery. In this, The proposed approach has reduced the delay rate to 10% [8].

K. Navaz et. al., in 2024, the searchers submit a study a new strategy based on a set of variables (energy, distance, degree, movement, time) called ED2MT, to choose the CH. The second stage is the byte compression process, and the final stage is choosing a method to route data packets and determining the shortest path with multiple goals. Based on these variables, the network's operation was evaluated. In light of this study, the percentage of remaining energy was 20.55% [9].

The researchers Arif Ullah at.,el. in 2024, they proposed an algorithm based on a Markov scheme to assign CH, which is an improved clustering algorithm based on the reduced energy factors of the network head, its location and density, and connecting the group heads to the network station through fixed-time transmission periods in order to improve the performance of WSN sensor networks. The results of the simulation improvement process showed 1.2% [10].

K. A. Sharada et al., al., In 2024, they presented an algorithm called Adaptive Ant Colony Intelligent Clustering (AACDIC) that outperforms multi-user cluster communication algorithms if experiments show a 9.646% energy reduction, as well as a percent energy reduction. From secondary nodes of users by 24.23%, as well as a decrease in noise ratio by 2 dB, which gave the ability to expand and improve network performance [11].

Sagun Subedi and Sang Il Lee, in 2024, they were developed a new algorithm, LEACH, that relies on energy reduction compared to the advanced ALEACH algorithm, by building a group of energy-sensitive nodes and assigning CH. It showed excellent outcomes results for building a network with reduced battery power. This network is also characterized by the speed of sending data to the base station, and the energy-saving ratio was -2.4346 when using 100 nodes [12].

Xiao Wang et., al., in 2024 they were proposed a new algorithm called KEGT, which emphasizes reducing and balancing energy loads, monitoring and adjusting node distribution areas using K-means, and using cluster balancing to achieve gains in energy reduction and network lifetime. This algorithm and the results obtained are: better than both (LEACH and PEGASIS), game theory, and assembly theory, and the percentage of results achieved was 21.2%, 11.1%, 6.7%, and 2.5%, respectively [13].

3. Components of A wireless Sensor

Most sensor nodes receive, process, and retransmit data to other nodes or the base station. These nodes are small devices consisting of the following parts: sensing unit, transceiver unit, processing and memory unit, and finally energy unit. Figure (2) below show the main parts of sensor node [14].

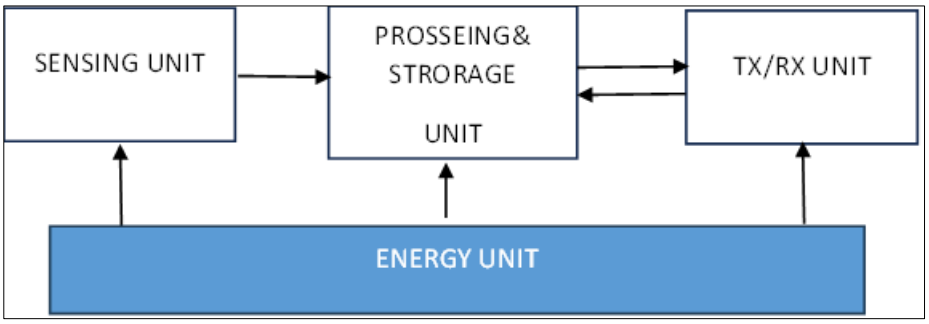

Figure 2 Main parts of sensor node

4. Benefits of Clustering

In this section, we will present, through the table below, the general characteristics of the benefits related to clustering, most of which are related to energy and the adaptive method of clustering of nodes.

Table 2 The benefits of the cluster

The benefit	Discerptions
Clustering	Organizing remote sensing nodes aims to improve data management and integration, reduce energy, and thus extend the life of sensors in the network
Energy Efficiency	Grouping nodes according to specific algorithms aims to distribute energy efficiently and thus prolong the life of the network, as well as rotating the group heads to redistribute and reduce energy [15, 16].
Data Aggregation	Ensuring the process of data aggregation and purification of duplicate data in the nodes before sending it to the BS leads to reducing the amount of non-redundant sequential aggregate data and preserving the energy used as well as the speed of response between the nodes [17].
Improve network longevity	Aggregation of dynamic sensor nodes in multiple levels based on the nodes' energy contributes to extending the life of the network, achieving continuity, and improvement of consumption energy through better algorithms [18].
Enhanced fault tolerance	Durability or tolerance is one of the distinguishing features of good sensor network nodes, as the failure of one of the nodes to transmit data for any reason, such as an electrical power outage, sabotage by a hacker, or the huge amount of data collected in the node, does not mean the failure of the network, as the rest of the nodes can exclude that node and perform the operation as an alternative about her [19].
Effective communication	Due to the divisions of the hierarchical network nodes and their organization of communication with nearby nodes, this will lead to saving transmission power from consumption, not running out of batteries, and working for a longer time, as the inter-level distance will be adopted at the level of nodes in the network and at the inter-level of networks, all the way to the BS, through the selection of aggregation and routing algorithms [20].

5. Classify the Cluster of Wireless Sensors with the Protocols

All sensor networks are a group of sensors that communicate with each other via CH to receive and send data such as temperatures, gases, movement monitoring, sound, etc. These sensors are geographically distributed within a spatially defined range, and these groups are arranged according to specific algorithms and protocols to forward the data to the BS. The goal here is to prolong the life of the network and preserve electrical energy from being lost. In this section, we will discuss these many types of clusters.

5.1. Hierarchical Cluster

The process of routing nodes takes place at two levels, the first is called the physical sensing layer, and the second is called the hierarchical routing layer. These two layers are called hierarchical classification, and several levels can be formed in the network. The benefit of this type of distribution is to reduce energy consumption in the network, and one of the tasks of the group head in the nodes is to process and disseminate data. Hierarchical clustering has several protocols, such as low energy adaptive clustering hierarchy protocol (LEACH), threshold sensitive energy efficient sensor network protocol (TEEN), a hybrid protocol (APTEEN), balanced cluster distributed clustering (BCDC), two-tier data dissemination approach (TTDD), and probabilistic agent negotiation for efficient long-lifetime sensing (PANEL). All low-power nodes in the groups sense and send data [21, 22].

5.2. Grid-Based Clustering

In this type of network division, the network environment is divided into levels of fixed size, and each level consists of equal-sized, rectangular areas called clustering. Each node sends its data to the CH and depends on the energy and the middle distance with the middle point. This method of division depends on the protocol power-efficient gathering in sensor information systems using genetic algorithms (PEGASUS) [23].

5.3. Weight-Based Clustering

In this method, nodes are clustered and the CH is proposed in light of several criteria, such as the effectiveness of that node through its weights based on its performance of its function, as well as the criterion for calculating the remaining energy and the criterion for the distance of the CH relative to the BS. The data load ratio criterion can be added to the data collection ratio. Examples of protocols for this method include energy efficient distributed clustering (EEDC) and weighted clustering algorithm (WCA) [24].

5.4. Density-Based Clustering

This method shows the process of distributing nodes on the basis of their cluster density criterion to choose the head of the cluster group, as well as calculating the noise ratio of the data to find the cluster head. Whenever this ratio increases, the cluster of nodes is also high to determine the cluster head. Examples of these protocols for this method are clustering based on density and clustering based on Noise basis [25].

5.5. Fuzzy Logic-Based Clustering

This algorithm is known as the fuzzy logic algorithm and relies on fuzzy logic in choosing the CH with uncertainty in selecting the CH. This algorithm outperforms previous clustering algorithms, especially when there is a large density of nodes in the clustering area and no boundaries between clusters. The goal of this algorithm is to prolong and improve the life of the network while preserving the remaining energy. The protocols adopted in this algorithm are fuzzy logic set head selection mechanism and fuzzy logic assembly [26].

5.6. Machine Learning-Based Clustering

To prolong the life of the network and preserve energy consumption, machine learning mechanisms were adopted due to the difficulty of automatic control without human action, as this assembly process requires a reprogramming process by learning from previous experiences and transforming it from a centralized system to a decentralized system in response to the time of collecting and communicating data and extending battery power. RL-and Deep Q Network based protocols [27].

6. Conclusion

Wireless sensor networks suffer from several limitations, and the most important of these limitations is the power source, because the life of the network depends on the life of the sensor unit, and the survival of the sensor unit depends on the basis of energy. It has been observed from previous studies that most of the energy consumed by the sensor unit is during the communication process. Routing protocols are considered one of the most important optimal solutions to improve the energy consumed during communication.

In this survey, well-known hierarchical routing protocols have been described along its extended versions as well. Improving hierarchical routing protocols leads to improve the network life time of WSNs. LEACH protocol is the popular hierarchical routing algorithm in terms of energy efficient. Therefore, many researchers focused on improving this protocol with the aim of optimally using the sensor unit's energy and maximizing the lifespan of the overall network.

It was noted from the above that most hierarchical network routing protocols work to significantly improve energy efficiency and thus network lifespan, but there is wide space to improve the routing protocol in terms of energy efficiency and performance. In this paper, we focused on reviewing the most important hierarchical routing protocols and their improvements that help in providing a good, energy-efficient hierarchical routing protocol.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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