

Wireless Sensor Networks and Its Clustering Algorithm

Akant Kumar Raghuwanshi^{1*}, Ajay Barapatre², Balajee Sharma³

Abstract

Distributed sensor nodes that gather and send data wirelessly make up Wireless Sensor Networks (WSNs), which are crucial for several applications, including industrial automation, smart cities, healthcare, and environmental monitoring. However, effective data transfer and network management are crucial issues because of their constrained battery life and processing power. By grouping sensor nodes, lowering energy usage, and extending network lifespan, clustering algorithms are essential for improving network efficiency. To reduce redundant transmissions, these algorithms designate cluster heads who oversee data aggregation and base station communication. To maximize energy efficiency, scalability, and reliability, a variety of clustering algorithms have been developed, such as LEACH, HEED, and fuzzy logic-based systems. This study examines the basic ideas of WSNs, talks about important clustering algorithms, and outlines the benefits and drawbacks of each, offering insights into practical uses and potential future research areas. Given sensor nodes' short battery life, one of the most challenging tasks in heterogeneous WSNs (wireless sensor networks) is creating an energy-efficient routing protocol that can boost the network's lifespan. This paper thoroughly evaluates the various routing protocols that many researchers have used to reduce node energy consumption and boost network life. It also gives an overview of different networks.

Keywords: WSN, heterogeneous wireless sensor networks, clustering algorithm

INTRODUCTION

WSNs (Wireless sensor networks) have grown popular due to the relatively inexpensive solutions they provide for a wide range of applications [1]. National security, surveillance, the military, healthcare, environmental monitoring, and many other fields are included in the vast application space of WSNs. WSNs can be classified as either heterogeneous or homogeneous, depending on whether some of their nodes are powered by more energy than the others or all their nodes are powered by the same amount of energy.

Many low-cost nodes are used for sensing in heterogeneous WSNs (HWSNs), while only a few relatively high-energy nodes are used for data filtering, transport, and fusion. Thus, heterogeneity in WSNs can improve the network's dependability and longevity. Wireless sensor networks (WSNs) are

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wireless networks that automatically configure themselves to monitor physical or environmental parameters, such as temperature, pressure, motion, sound, vibration, and pollutants. The networks then provide their information or data to a sink into commonly referred to as the primary location, where it is regularly monitored and analyzed. The base station, also called a sink, serves as the network's main user interface. Asking questions and receiving answers from the sink can aid in the recovery of some network data. A wireless sensor network typically includes thousands of sensor nodes. These networks are referred to as static

WSNs as each sensor node in different applications can remain stationary as shown in Figure 1. Mobile sensor nodes and networks have biological applications.

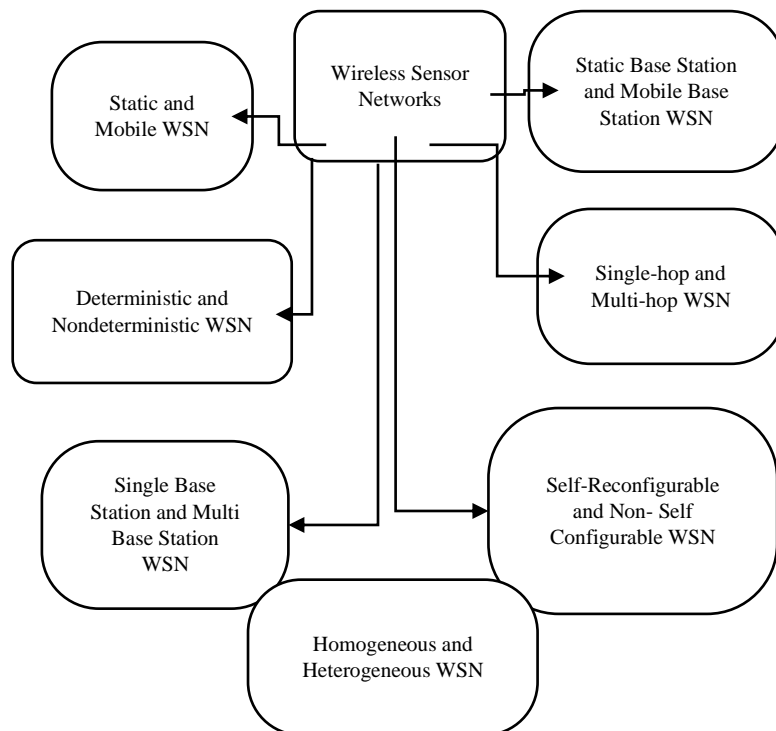


Figure 1. Classification of wireless sensor networks.

Animal tracking systems are probably the most visible application of a mobile network. In a deterministic network, the structure of sensor nodes can be estimated or predetermined. This sensor node's ability to operate on a fixed schedule can be limited to specific applications. As a result, these networks are classified as non-deterministic, necessitating the use of a sophisticated system of controls. In most applications, sensor node locations cannot be determined for a variety of reasons, including harsh and hostile working environments. In a network with a single base station, a sensor node can be close to the station. The base station allows sensor nodes to communicate with each other. In a network with multiple base stations, a sensor node sends data to the base station closest to it. Base stations, like nodes that collect data, can be mobile or stationary. To the distribution of load of the nodes that sense, the base station that is mobile rotates within the sensor, whereas the static based station continues to be stationary and is usually located near the sensing area. A single-hop network's sensor nodes can be set up to point directly at a base station, whereas a multi-hop network transmits data via both cluster leaders and peer nodes to save energy. In a non-customizable network, an information gathering control determines where sensor networks should be placed. Sensor nodes in wireless networks of sensors collaborate on completing tasks and maintain and organize the network. In a heterogeneous wireless sensor network, every sensor node has comparable processing and storage capacity, as well as approximately the same amount of energy consumption. Different nodes that collect data in a network that is diverse require varying levels of energy for processing power. As a result, communication and processing are distinct processes.

WSN design has become more challenging due to the routing problem. To improve WSN routing and reduce node energy consumption, several studies suggest routing strategies. Clustering is an important technique for extending the useful life of a system of sensors while consuming less energy. Clustering can help with a sensor network scale more effectively. The term "cluster head" (CH) refers to the cluster's leader. The network designer can pre-assign a CH or the sensors in a cluster can choose one. In traditional WSN clustering protocols, the energy supply of each node is assumed to be equal.

Clustering algorithms are classified according to two fundamental criteria: stability and energy efficiency. When deciding on CH, energy-efficient processes usually consider the initial energy, residual energy, network average energy, power consumption rate, or a combination of these. In clustered HWSNs, stable election techniques increase the stability period, or the time until the first node fails.

LITERATURE SURVEY

N. Dina Viet and N. D. Tan [1], to equalize the number of nodes, recommended sector chain based clustering (SCBC) routing protocol as it divides each network region into sectors. SCBC constructs chains for the cluster head (also known as CH) or secondary cluster head (SCH) that have the highest residual energy and the shortest distance between applicants' nodes and the network's base station (BS). This further reduces energy loss during network communication. The simulation results show that when compared with the power-efficient gathering in sensor information system (PEGASIS) and an enhanced energy-efficient PEGASIS-based (IEEPB) protocols, our proposed protocol can increase network lifetime by approximately 70% and 20%, respectively.

For wireless sensor networks, a novel multi-level heterogeneous routing protocol called LE-MHR is recommended by V. Sharma and D. S. Saini [2]. The horizontal energy heterogeneity of the LE-MHR consists of several levels. The number of advanced nodes in a network is unrelated to the level of a hierarchy, and LE-MHR guarantees that the network field's initial energy improves as the level of hierarchy rises. When the initial energy consumption and energy heterogeneity variables were changed, the network lifetimes of LE-MHR increased by 53.7%, 46.9%, and 44.1%, respectively, when compared to the SEP, MCR, and EEMHR protocols.

According to S. Tyagi, et al. [3], a hybrid approach combining the K-means and genetic algorithms is used to create energy-effective clustering rules for non-homogeneous sensor networks that are wireless. This hybrid approach is known as KGA. The optimum challenge is to determine the number of clusters in an extensive search space that maximizes WSN metrics.

S. Bhushan [4] used the method that seeks to simplify the challenge of wireless sensor networks. An energy-efficient procedure known as EDAL is utilized to increase energy efficiency. It is reconstructed from the NP-hard OVR system that is currently in use.

The proposed methodology in Y. Yao et al. [5] inherits from LEACH and uses distributed energy-efficient clustering (DEEC) as a cluster head selection criterion. As a result, Ad-LEACH can handle the diverse characteristics of nodes. Small static clusters reduce the strength of each node's broadcast message because of their restricted coverage. We evaluated Ad-LEACH's effectiveness using MATLAB simulations. Simulated results show that Ad-LEACH outperforms LEACH and DEEC in terms of productivity and energy efficiency.

To identify network anomalies quickly and accurately, the suggested approach uses an associative classifier. The main security concern with cloud computing is identifying and stopping malicious activity at the virtual network level, including distributed attacks. A security solution is proposed in A. Iqbal et al. [6] to address this issue.

This article provides a thorough examination of relevant communications. A novel method for clustering based on this topology is also proposed, as is an event-based cluster head rotation mechanism. V. Shetty NR et al. [7] supplied the information, and the original RPL message structure and RFC were used to create the acknowledgment message for clustering Energy-Efficient Heterogeneous Ring Clustering (E2HRC) is the proposed wireless sensor network routing protocol. The necessary maintenance protocols and algorithms for routing have also been established.

The authors of W. Zhang et al. [8] attempted to create a secure multicast routing system called Crypto-IoT that takes the limitations of both the WSN and IoT into consideration. They tested the

protocol's effectiveness utilizing Telos sensors in a real-world setting, and they compared its effectiveness to that of KDSR and LEAP. W. Jerbi et al. [9] ensured secure data transmission by introducing the NSRP (novel secure multipath routing protocol) for military heterogeneous wireless sensor networks (MHTWSN). In MHTWSN, NSRP uses elliptic curve cryptography (ECC) to identify trusted neighbor nodes and secure multiple pathways for dependable data transmission. In heterogeneous WSNs, K. A. Kumar et al. [10] analyzed cluster communication energy consumption and a wide range of energy consumption stages. In this paper, an improved balanced energy-effective network-integrated super-heterogeneous (E-BEENISH) routing protocol is proposed. To achieve optimal CH selection, Y. Zhang et al. [11] defined the genetic algorithm-based optimized clustering (GAOC) protocol, which incorporates node density, residual energy, and a distance to the sink into its fitness function.

A good protocol for routing is essential for energy efficiency, cluster stability, along with node reliability. S. Verma et al. [12] proposed the improved threshold-sensitive stable election protocol (ETSSEP) for heterogeneous wireless sensor networks. It is based on the cluster head's voting probability, which changes dynamically. In each round, the cluster is selected based on the minimum number of clusters and the nodes' remaining energy levels.

A vast array of sensors with diverse functions has been made possible by recent advances in multimedia technology. Most current sensor network wireless routing approaches suppose homogeneous nodes, which at first indicates each sensor node has the same communication, computation, and sensing abilities. However, the development of multimedia sensors has resulted in new challenges, such as the need for high bandwidth, low latency, and application-specific QoS. For heterogeneous wireless sensor networks, EAQHSeN presents an improved ant-based QoS-aware routing technique [13–20]. A. K. Jain and A. S. Toor [21] developed a service-based QoS routing protocol for wireless sensor networks with heterogeneous media and scalar nodes. The protocol created by the authors uses bio-inspired routing heuristics. It stands out for its ability to meet a wide range of QoS requirements imposed by the various traffic flowing through the nodes.

S. K. Malik et al. [22] developed the enhance threshold sensitive stable election protocol (DETSSEP) using the remaining energy of each node, the network average energy, and the distance between the nodes and the base station to calculate CH. Dual hop communication is used between distant CHs and BS to ensure constant energy consumption across the network. Simulation studies revealed that DETSSEP outperforms enhance threshold sensitive stable election protocol (ETSSEP) in a variety of performance matrices, such as stability period, throughput, longevity, and remaining network energy.

The longevity of the network is dependent on the sensing node's ability to manage energy resources efficiently. As a result, consumption of energy is an important aspect of design for WSNs. The most widely used energy-saving hierarchical routing protocols. By using a clustering technique, hierarchical methods of routing significantly reduce the amount of energy required for data collection and distribution. F. Farouk et al. [23] proposed the hierarchical adaptive balanced energy efficient routing protocol (HABRP) to increase the lifetime of heterogeneous WSNs, decrease the likelihood of failure nodes in a and extend the stability period. Each of these factors are important for a wide range of applications.

R. Rani et al. [24] proposed a novel routing method hierarchical clustering, for heterogeneous sensor networks that are wireless. The suggested protocol, (U-LEACH) universal-low energy adaptive cluster hierarchy, has a significant impact on sensor node energy consumption due to its efficiency. U-LEACH, unlike LEACH, selects a cluster-head based on the initial and residual energy of the nodes.

Homogeneous WSNs, where each sensor node has similar energy resources, processing power, and wireless communication capabilities, are the subject of most applications and research. However, with the many-to-one communication pattern, homogeneous WSN is typically inefficient in terms of energy

and lacks excellent support for network expansion and data aggregation. Heterogeneous WSNs address these problems by combining two or more types of sensor nodes with different energy levels, sensing radii, and communication ranges. To balance cost and performance for WSN, these sensor nodes can be installed in several ways. Numerous large-scale WSN applications benefit from heterogeneous sensor nodes.

The protocol that uses the least amount of energy to cluster sensor nodes is clustering algorithms. The cluster head (CH) of each cluster gathers information from sensing nodes. The CH merges the data to remove redundant information before sending it to the BS or sink node. To maintain adequate network balance for energy management, CH election should be carefully considered. It is possible that large-scale environments combining WSN and IoT will not be suitable for current routing techniques that select CHs optimally. Either a homogenous or heterogeneous ad hoc system may exist. Advanced nodes are a set of nodes that are more energetic than typical nodes. Homogenous network is shown in Figure 2 [25].

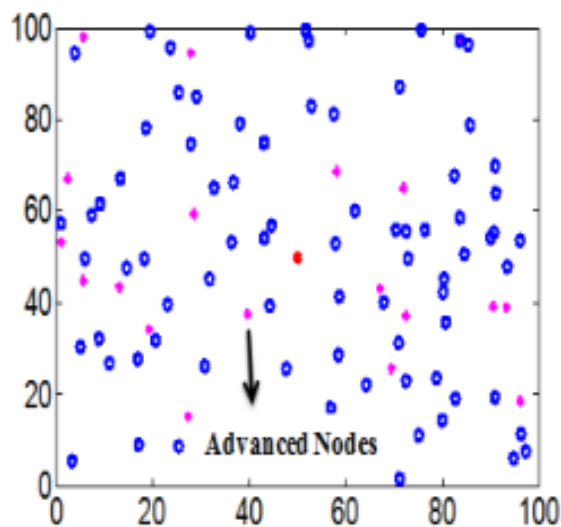


Figure 2. Homogeneous networks.

Several strategies have been put forth to increase the network's longevity. WSN energy consumption can be effectively managed through clustering, and network lifetime and stability problems can be dependably resolved with hierarchical architecture. Numerous layers make up a hierarchical network, and nodes carry out a range of tasks. Clustering is an approach for dividing a sensing area into various clusters, each featuring its own cluster head. In accordance with N. Kumar et al. [26], the BS must communicate with cluster members (CM), collect and aggregate data, and then send it to the BS via a hierarchical routing protocol. The LEACH algorithm (low energy adaptive clustering hierarchy), PEGASIS as, IEEPB, and other cluster-based routing protocols have gained popularity for their energy effectiveness and ability to adapt to both homogeneous and heterogeneous network layouts [27–30].

CONCLUSIONS

The algorithms for clustering are the most energy-efficient protocols that are for grouping nodes of sensors. Each cluster head (CH) is in charge of gathering data collected by sensing nodes. Before sending the data to the BS or sink node, the CH fuses it together to remove any redundant information. As a result, choosing a CH must be carefully considered in order to achieve an appropriate network of balanced things for conservation of energy purposes. Although the current routing techniques are the best options, they may not be appropriate for large-scale settings in which WSN and the Internet of Things are combined. Ad hoc systems can be either heterogeneous or homogeneous. Advanced nodes are nodes that have more energy than ordinary nodes.

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