A Review on Energy Efficient Techniques to Extend the Lifetime of Wireless Sensor Network

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Abstract.

Wireless sensor networks (WSNs) have gained in popularity over the years and also have a wide range of applications, such as healthcare, the ecosystem, and the army. Despite its impressive capabilities, the creation of WSN remains a difficult process due to its limited lifespan. This paper reviews the current Wireless systems, their applications and the challenges faced by these systems in real world. In addition to this, different phases of wireless communication and its impact on efficiency of various wireless networks is also analyzed. A literature survey is conducted in which various methods that have been proposed by different researchers over the years are discussed. The techniques used by these researchers in order to extend the lifetime of wireless network along with the outcomes achieved by them is also analyzed. In the end, an analytical study is conducted on the basis of routing-based energy efficient protocol and clustering and CH based protocols. After reviewing the different approaches, it is concluded that the selection of appropriate technique can vary from one application to another in order to extend the lifespan of wireless sensor network (WSN).

Keywords. Wireless sensor network, clustering protocol, Energy efficient, routing approach, LEACH, etc.

1. INTRODUCTION

Wireless sensor networks have been popularizing increasingly in recent years. A WSN is made up of many sensor nodes that can only interact with one another across a limited communication range [1]. The Wireless Sensor (WS) is a tiny sensor that performs critical operations such as transmission, sensing, and data processing. Sink nodes and sensor nodes (SNs) are two types of wireless sensor nodes depending on their operation. SNs sense the surroundings and may also send data to other SNs. The base station (BS) or sink node, gathers information from SNs and aggregates it. Memory, Micro-sensor, transceiver, battery, and microprocessor are the major components of a wireless sensor node [2]. ease of use, ability to survive harsh environmental conditions, scalability to large-scale deployment, heterogeneity of nodes, mobility of nodes, ability to cope with node failure, and energy harvesting are some of the primary properties of wireless sensor networks. The above characteristics ensure that WSN can be used in a variety of applications [3]. A WSN's primary application domains can be categorized as indicated in Fig.1.

Precision farming detects factors such as pressures and temperatures, as well as providing a precise atmosphere for agricultural purposes [4]. Environmental monitoring detects all climatic characteristics to avoid disasters such as forest fires, floods, and gas leaks [5]. Vehicle tracking aids in the prevention of traffic jams and the parking system, as well as the tracking of the vehicle's movement. Medical care monitoring aids in the real-time tracking of physiological signals and helps to avoid life-threatening risks [6]. Smart Buildings use less electricity and provide higher security. Security and Surveillance system assists in early enemy identification and vehicle detecting. Animal tracking system keeps track of the animals by optimizing rearing scenarios and managing the stress level of the animals by movement and vibration monitoring [7,8,9]. It is impossible to replace or even recharge the SN's battery in these systems. As data transmitted from SNs to BS is the main task in sensor networks, therefore clustering is the best option for extending their lifetime[10,11].

Clustering is a form of topology management approach that groups SNs to increase network performance by distributing energy and rotating duties between SNs to ensure equality [12,13]. The clustering implementation phases in all cluster-based methods: The steady-state phase (data transmission phase), set-up phase (cluster formation), and CH selection phase [14,15].

. Kavitha Kayiram et al. [16], the authors presented a unique data management method in this study that allows for (I) time and energy-efficient data aggregation, (ii) optimal storage space use, and (iii) energy-efficient sensing in a wireless sensor network. Collaborative sensing and Sleep-scheduling strategies were used in suggested data storage and sensing methods. Secondly, the authors used a Lookup approach to take advantage of the collaborative sensing that occurs as a result of the sleep-scheduling of SNs in wireless networks. The accuracy of the suggested approach has been proven by simulation findings. Asad Raza et al. [17], this paper covered all of the risks to encrypted transmission in a wireless network. The purpose of this study was to highlight the safety challenges surrounding broadcast authentication in sensor networks and to evaluate the suggested solutions in terms of several metrics. A. Aliti et al. [18], In this research, authors presented a security architecture for dealing with the most significant security challenges in wireless sensor networks. The concentration of the study was on an optimal CH selection mechanism that rotates the CH location between SNs with greater energy levels than others. According to simulation results, the updated version outperformed the low energy adaptive clustering hierarchy method by increasing performance by 60 percent, lifespan by 66 percent, and remaining energy by 64 percent. R. J. Bhuiyan, et al. [19], The authors presented a simple cluster head selection mechanism in this paper that saves significant energy for SNs while also extending the network's lifetime. The suggested methodology considered the one-hop neighbor data, the distance between Cluster heads and the BS, neighbor data, and the amount of residual energy. They compared the proposed technique to LEACH-C and ECHS in a simulation. They noticed significant improvements in energy usage in each round, Last Node Death (END), First Node Dai (1ND), and total packets sent to Base station as throughput. The fuzzy inference approach was used in this paper to identify the suitable cluster head. The residual energy of the SN, node degree, and distance to the Base station were fuzzy input variables, while 'size' and 'competition radius' are fuzzy output variables. A. Lipare et al. [20], The suggested method surpassed the EAUCF and LEACH algorithms in terms of network stability, active sensor nodes per round, and energy consumption.

Routing algorithms are essential in cloud computing for spending power efficiently and maintaining other service quality. Routing algorithms face a variety of architectural difficulties. To address these problems, several researchers have devised a variety of solutions, some of which are listed below:

Hao Li et al. [21], For the loss of LEACH-M packets, this study presented the Leach-MON cluster method focused on mobile sensor networks, that introduced the concept of on-demand routing to the mobile WSNs. The packet loss was relatively lower than LEACH-M when the performance and energy usage of the SNs were fully considered during simulation using the NS3 Network simulator. V. K. Kumar et al. [22], This article proposed a chain-based routing system for the PEGASIS "Power-Efficient Gathering in Sensor Information System". To increase efficiency, a new PEGASIS method was presented, which is more energy-efficient and offers a longer lifespan than the original PEGASIS method. X. Wang et al. [23], the paper considered the energy barriers of clustered sensor networks and suggested an enhanced routing algorithm for these sensor networks to obtain an optimal solution for energy usage in SNs, reducing the impacts of hot spots in some SNs close to the BS and preventing the hot head nodes from becoming overloaded for data communication. A Matlab simulation tool was used to evaluate the new technique. The simulation findings indicated that the revised routing algorithm was highly reliable than the traditional EEUC and LEACH protocols in reducing the overall energy usage of sensor networks with more balanced transmission loads and extending the systems' lifespan. D. Pal et al. [24], In this paper, a clustering strategy based on fuzzy logic was used to improve the network longevity and transmission efficiency of a WSN. The CH was selected using fuzzy logic. In the present architecture, the first node dead (FND) and the longevity of the network employing fuzzy logic were compared to four alternative approaches. In this study, FND and lifespan were determined to be superior, resulting in a more efficient strategy for Sensor networks. C. Xu et al. [25], The authors presented a unique energy-efficient region source routing strategy in this paper to optimize the lifespan of the sensor networks (referred to as ER- SR). V. K. Kumar et al. [26], The authors presented an HDPORP "Heterogeneous DSR PEGASIS Optimization Routing Protocol" in this work, which combines the best characteristics of both PEGASIS and DSR technologies. They utilized Dijkstra's method to discover the lowest route between each SN and the CH in the simulation, and then they utilized an energy list to update the network with high energy SNs and reject SNs with less energy. According to the simulation findings, the HDPORP method increased the lifespan of the Network by 10percent when compared to other methods.After reviewing the techniques proposed by various researchers in order to extend the lifespan of the wireless network, it is observed that most of the researchers worked mostly on two domains;

i.e. either on routing protocols or clustering and CH selection methods. In order to analyze, which technique is providing efficient results, an analytical study is conducted for the traditional models by analyzing their First node death (FND), half node death (HND) and last node death (LND) values. The performance of the traditional model is firstly analyzed for different LEACH variants in terms of their FND, HND and LND and is shown in figure 2. Figure 2 represents the Comparison graph of different traditional models which included LEACH-C, LEACH-MAC, ECHS, R.j Bhuiyan in [19] and D.pal in [24] in terms of FND, HND and LND. The x-axis represents the variants of LEACH protocols and the y-axis represents the total number of rounds

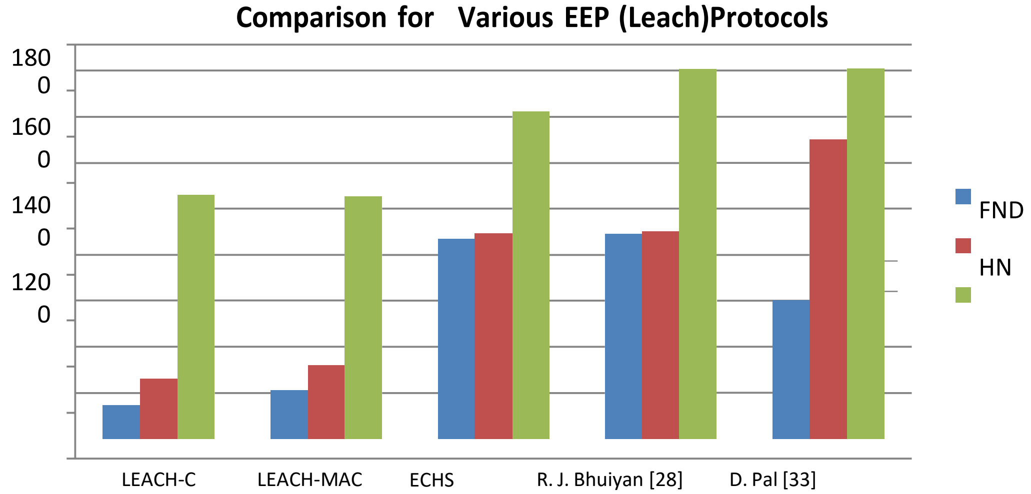

Fig 2. Comparison graph for different LEACH variants

The blue colored bar depicts the FND value whereas the maroon and green colored bars depict the HND and LND values respectively. From the graph, it is analyzed that the value of FND is good in R.J. Bhuiyan in [28] while as the HND and LND value are better in D.pal in [33]. The best results are given by the techniques used by D.pal in [33], followed by R.J. Bhuiyan in [28], then ECHS, LEACH-MAC and lastly LEACH-C.This proves that the technique used by D.pal in [33], are more efficient, long lasting and stable.The specific value of each protocol in terms of FND, HND and LND are given in table 1.

2. TABLE 1: PERFORMANCE COMPARISON OF ENERGY EFFICIENT PROTOCOLS (LEACH VARIANTS)

Factors	**LEACH-C**	**LEACH-MAC**	**ECHS**	**R. J. Bhuiyan [28]**	**D. Pal [33]**
FND	146	211	870	889	600
HND	261	320	892	900	1300
LND	1060	1054	1422	1607	1610

In addition to this, the efficiency of the routing-based protocols is also analyzed in which PEGASIS protocol is used as chain-based clustering protocol. The PEGASIS routing protocol works on the principle in which the node that is closer to the next neighbor node is selected as the CH node that transfers information from sensor node to the BS node. The performance of the different PEGASIS variants is analyzed in terms of FND, HND and LND and is shown in figure 3. Figure 3 represents the Comparison graph for different PEGASIS variants which include PEGASIS, PDCH, EPEGASIS and EE-PEGASIS in terms of their FND, HND and LND values. The x-axis represents the variants of PEGASIS protocols and the y-axis represents the total number of rounds. The blue colored bar depicts the FND value whereas the maroon and green colored bars depict the HND and LND values respectively. From the graph, it is analyzed that the value of FND, HND and LND are best in EE-PEGASIS. The best results are produced by EE-PEGASIS, followed by EPEGASIS and then PEGASIS and lastly PDCH. After analyzing the results, it is concluded that EE-PEGASIS is providing more efficient, long lasting and stable results.

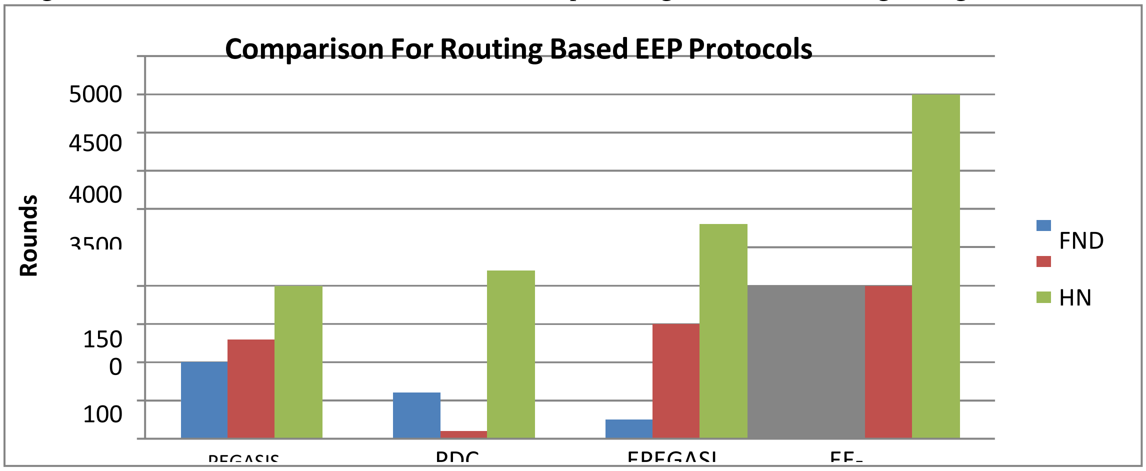

Fig 3. Comparison graph for different PEGASIS variants

3. Table 2: Performance comparison of Energy Efficient Protocols (PEGASIS Variants) [35]

The specific value of each protocol in terms of FND, HND and LND are given in table 2.

Factors	PEGASIS	PDCH	EPEGASIS	EE-PEGASIS
FND	1000	600	250	1450
HND	1300	100	1500	2000
LND	2000	2200	2800	4500

4. Conclusion

This paper reviewed various techniques that are used by various researchers in order to enhance the lifespan of wireless networks. From the literature survey, it is conducted that most of the experts focused on two domains; one is called as normal energy efficient protocols which are basically the different variants of LEACH protocol and second is based routing-based protocols which are variants of PEGASIS protocols. After analyzing the results, it is observed that the results produced by different techniques may vary from one application to another. Furthermore, it is also analyzed that, if the model is entirely focused on the routing-based protocols then PEGASIS variants provide a better option as they can extend the lifespan of network efficiently. However, if the model is not based on the routing mechanisms then LEACH variants can also provide good results. The main goal of reviewing different techniques is to look into the viability and use of high-level-based techniques to make WSN design easier and to extend its lifespan.

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