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Enhanced I-SEP Protocol Using Fitness Function For Cluster Head Selection

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Abstract: Sensor Networks build a self-organized network by utilizing a range of low-cost sensor nodes scattered across the region. These sensor nodes identify files and transmit the data to a base station, which consumes much power. Developing an energy-efficient wireless sensor network (WSN) routing protocol is a significant challenge. Clustering is a new strategy for improving a sensor network's energy efficiency. Two or three-node energy levels are frequently defined in heterogeneous protocols; however, there is now an extensive range of energy levels in heterogeneous WSNs. For many years, energy efficiency has been a highly demanding research topic for WSNs. It is impossible to change the sensor batteries for several sensor nodes installed in a hostile environment. The suggested protocol is a clustering algorithm that works on an improved mobile agent-based FFI-SEP (Fitness Function Improved-Stable Selection Protocol) protocol. The primary objective of this work is to create an energy-efficient Wireless Sensor Network protocol based on the Stable Election Protocol (SEP).

Keywords: Fitness Function, Cluster Head, Sensor Networks, Stable Election Protocol, Throughput, Energy Efficiency, Clustering, Stable Election Protocol.

I. INTRODUCTION

Wireless Sensor Networks [1] establish a self-organized network by deploying a range of low-cost sensor nodes around the region. These sensor nodes recognize files and deliver them to the base station, which consumes much energy. For many years, energy management and efficiency have been a popular and in-demand research topic for WSNs. Developing a low-energy WSN routing protocol is a significant challenge [15]. Clustering is a new strategy for improving a sensor network's energy efficiency [16]. Two or three-node energy levels are frequently defined in heterogeneous protocols. However, with heterogeneous WSNs, there is now a wide variety of energy levels. It is impossible to change the sensor batteries for a significant number of sensor nodes installed in a hostile environment.

Wireless sensor networks have been identified as essential facilitators from the inception of the Internet of Things (IoT) [2], [11] concept. The WSN is a robust and powerful distributed data gathering system, but concerns with dependability, autonomy, cost, and usability continue to limit its widespread adoption by application domain specialists. WSN is critical to the realization of the IoT goal. Commercial solutions can effectively solve vertical applications, but they can also result in technological locks that prevent horizontal composability and reuse.

The number of daily objects that are connected to the Internet is growing. The tendency with the new approach, where intelligent devices, persons, and systems are linked, will see a transition in understanding what it means to be "on the Internet" during the next several years. As a result, WSN technologies, which contain a collection of sensor nodes connected to the real world via wireless channels, are essential for IoT [12]. Despite this, new research that includes WSN applications is referred to as IoT without mentioning the most recent category criteria. All detectors in an IoT device immediately send data to the Internet [3]. Like a sensor could be utilized to measure the temperature of the water body. On the other hand, the WSN lacks a reliable Internet connection. Instead, a system or central node connects all of the sensors.

Sensors powered by more minor batteries power the wireless sensor networks [13] that serve as the backbone for IoT applications. So, increasing their lifetime to save the deployment cost is the first major issue in such networks. Academics widely employ the clustering technique to tackle this problem [14].

In the existing clustering approach, nodes with high energy are given more chances to become cluster heads because of the heterogeneous environment. However, while picking cluster head, this technique disregards the influence of the node's distance from BS (Base Station) and the member nodes. Furthermore, transferring data from CH (Cluster Head) to Base Station is not optimal since they only use single-hop communication, an energy-expensive procedure. So these two key points are figured out as drawbacks to the existing approach, which we intend to improve in the proposed protocol.

This article is organized as follows: Internet of Things and Wireless Sensor Networks are briefly discussed in Section I. Section II depicts a survey of the literature. Section III describes a proposed technique used in research. Section IV presents various parameters used in the investigation and computed results. The whole effort of this paper comes to a close in Section 5.

II. REVIEW OF LITERATURE

Ahmed et al. [4] introduce an energy-saving clustering approach and a hierarchical routing algorithm (EESRA). The application aims to maximize system lifespan irrespective of the network's expanding size. The approach computes a three-layer structure to reduce cluster head burden and randomly choose cluster heads. EESRA also uses multi-hop broadcasts for intra-cluster communications to produce a hybrid WSN Authentication method. In terms of system performance as network scale changes, the study compares EESRA to various WSN routing protocols. As per simulation results, EESRA outperforms benchmarked schemes in load balancing and power output on large size WSNs.

Ali et al. [5] To expand the life of WSN, researchers developed an energy-efficient clustering protocol. Proposed protocol decreases and balances nodal energy usage by enhancing clustering structure, with IEECP being particularly effective for long-lived channels. The recommended IEECP is broken down into three sections that must be performed correctly. For overlap balance groups, an ideal set of groups is first proposed. Balanced-static clusters are built using an improved fuzzy C-means method and a mechanism for reducing and stabilizing energy usage of nodes. Finally, CHs are chosen at appropriate positions by rotating cluster head functional among a large number of group members, utilizing the new cluster head selection-rotation method that integrates a back-off time method for cluster head selection with a rotational process for CH rotations. The IEECP surpasses current techniques, according to the data.

Trupti Mayee Behera et al. [6] by executing a threshold-based cluster head selecting for a heterogeneous environment; we may improve the stable election approach. The threshold guarantees that energy is distributed evenly throughout cluster head nodes and members. Sensor nodes are divided into three categories based on their initial energy production to distribute network load properly. According to the simulation outcomes, the suggested approach outperforms SEP (Stable election protocol) and DEEC (Distributed energy efficiency clustering) procedures by 300 percent in network lifetime and 56 percent in throughput.

Jinpa et al. [7] introduced the M-SEP (Modified Stable Election Protocols) protocol, an energy-efficient WSN that chooses its cluster leader independently based on its starting energy ratio. M-SEP protocol expands the stable area by using multilayer power transmission instead of SEP protocol, which works similarly except that SEP assumes the same energy for all types of transmission. This shows a better throughput than the SEP and Mod-leach protocols because to the longer network lifetime and expanded stable area.

Naeem et al. [8] DARE-SEP is a hybrid distance aware residual energy efficient stable election protocol that combines characteristics of the remaining energy efficient SEP with direct transfer and range based algorithm. The new scheme tries to give the best routing path from the sensor network to cluster head while considering topology changes. Multi hopping route is utilized among cluster heads and sink nodes to lower energy usage. In Heterogeneous WSN, data demonstrate a 10% increase in power efficiency compared to standard arrangements, extending the network's lifetime.

Singh and Malik [9] developed a three-level heterogeneous network for WSN applications with a single variable for increasing network longevity. Based on the input parameters value, it may describe 1, 2, or 3-level heterogeneity. The heterogeneous wireless model aids in the identification of cluster leaders and related cluster members by utilizing averaged election likelihood and a threshold function. Values of system longevity in SEP-3 and hetSEP-3 increase by 164.18 percent and 192.80 percent compared to previous SEP implementations, for a total increase of 100 percent in system energies.

III. METHODOLOGY AND PARAMETERS USED

The simulated results of the proposed methodology, and the technique used are discussed in this section. This work's simulation is done in MATLAB.

In the SEP routing protocol, new cluster heads are elected and new clusters are formed regularly for each cycle. As a result of the routing overhead, this leads to unnecessary energy consumption, which influences the production of IoT devices linked to the sensor network. The constraint mentioned above in SEP encourages researchers to explore as well as develop an efficient cluster head replacement strategy. A cluster head selected in the present round cannot engage in the cluster head election system in the subsequent round, as per standard SEP procedure. However, it is possible that cluster head does not use enough power in the first round and qualifies for the next round cluster head election process. It is also possible that, as a result of the subsequent selection process, a sensor with far less energy is classified as cluster head, resulting in the network's early death. Furthermore, every round involves the formation of a new cluster, which absorbs node power by sending messages such as ADV (advertisement) and ACK (acknowledgement) to cluster heads back and forth.

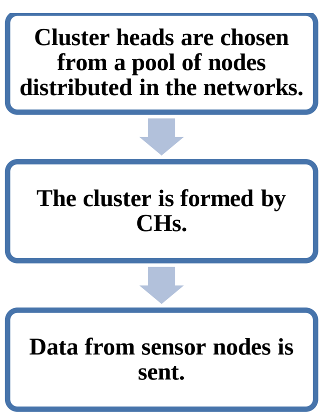

Figure 1: Flow of Work

In this work, the cluster head selection process is modified by adding fitness function value for each node as shown in Figure 1. The proposed protocol is FFI-SEP, i.e., fitness function based I-SEP. Here the fitness function is computed using cluster compactness and distance from the base station. The cluster compactness parameter considers the proximity of the cluster head and its members.

$$\text{Cluster compactness} = \frac{d_0}{\sum_{i=1}^{n}(D_s - D_i)/n}$$

Where

d_0 is the communication range of the node‘s’,

$D_s - D_i$= distance between node‘s’ and neighbor node ‘i’,

‘n’ is the number of neighbors

Now the fitness function of the node will be:

$$f = \text{Cluster compactness} + \frac{d_0}{D_{bs}}$$

This fitness function will be included while computing the probability of the node becoming Cluster Head.

After cluster formation, the next step is the data forwarding step. Instead of transmitting data directly to the base station, CH will use crow search optimization to select the best neighboring cluster head. The optimal neighbor chosen will act as a relay node to forward the data to the base station. Once the cluster heads have been selected, they will form a cluster with their neighboring nodes. This marks the end of one round. Now, at the beginning of the second round, the decision to retain the cluster head will be taken according to the threshold value given in the existing scheme.

The following parameters were examined and measured [6]:

i. No. of Alive Nodes

It is calculated for every round to determine the network's energy efficiency.

ii. No. of Dead Nodes

it is calculated for every cycle to determine the energy efficiency of a network.

iii. Throughput

The quantity of successful data transfer in the network is typically characterized as throughput. The following formula is used to determine throughput:

$$\text{Throughput} = \frac{\textbf{Totalno. ofpacketssuccessfullysent}}{\textbf{Totalno. ofpacketstransferred}}$$

iv. Average Residual Energy

Residual energy is the primary determinant of sensor network lifespan.

IV. RESULTS AND DISCUSSION

This chapter includes a tabular and graphical representation of the experimental analysis and a summary of the findings. 100 nodes were placed at random in a 100m*100m network space. The various existing and new results at different levels are shown below in a table.

The Base Station is deployed in the centre of a network. Because each node has a distinct energy level, this network is referred to as a heterogeneous network. The deployed random nodes are shown in Figure 2. In the diagram, blue nodes represent normal sensor nodes with low energy; green nodes represent nodes with intermediate energy, whereas pink nodes represent nodes with maximum energy.

Figure 3 depicts the number of living nodes for the new FFI-SEP protocol, consisting of 100 nodes with varying energy levels. In the existing I-SEP protocol, the node gets dead faster than the proposed FFI-SEP. It indicates that the suggested protocol is more stable than the present method. Figure 3 demonstrates that the new protocol surpasses the present in terms of stability duration, system life span, and messages sent to the Base Station; because the suggested protocol used less energy that why there were more living nodes in the network, indicating a longer network lifespan.

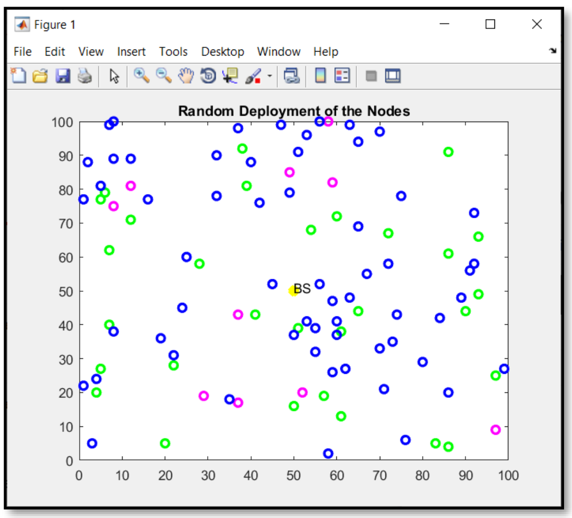

Figure 2: Random Deployment of Nodes

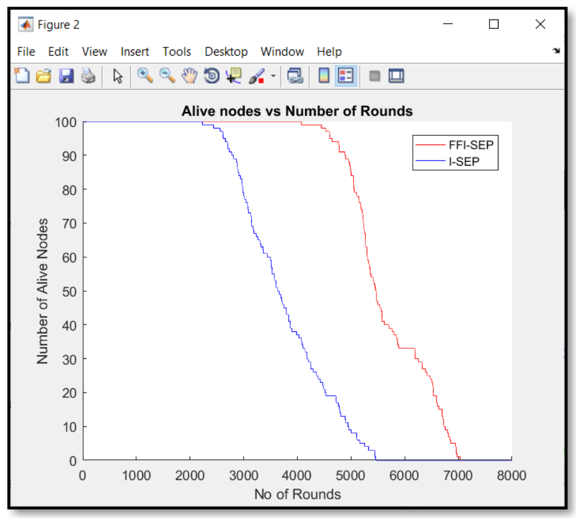

Figure 3: Alive Nodes w.r.t. Number of Rounds

Table 1: Number of alive nodes w.r.t. Number of rounds

Number of Rounds	Existing protocol (I-SEP) [6]	Proposed protocol(FFI-SEP)
1	100	100
500	100	100
1000	100	100
1500	100	100
2000	100	100

2500	98	100
3000	79	100
3500	59	100
4000	37	100
4500	21	98
5000	9	85
5500	0	46
6000	0	33
7000	0	1
8000	0	0

Table 2: Number of dead nodes w.r.t. Number of rounds

Number of Rounds	Existing Protocol (I-SEP)[6]	Proposed Protocol (FFI-SEP)
1	0	0
500	0	0
1000	0	0
1500	0	0
2000	0	0
2500	2	0
3000	21	0
3500	41	0
4000	63	0
4500	79	2
5000	91	15
5500	100	54
6000	100	67
7000	100	99
8000	100	100

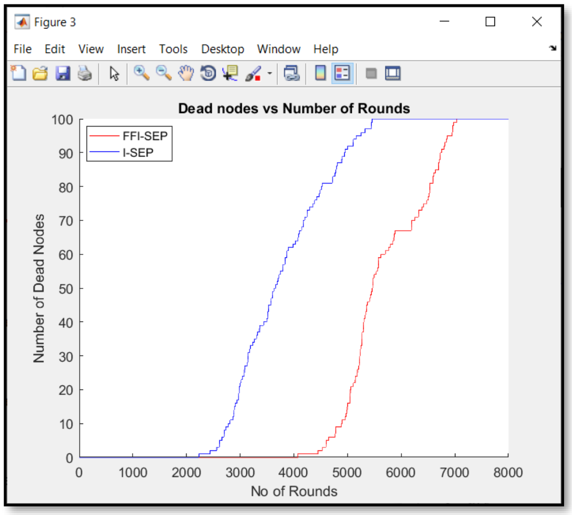

Figure 4: Dead Nodes w.r.t. Number of Rounds

Table 3: Average Residual energy w.r.t. Number of Rounds

Rounds	Existing Protocol (I-SEP)[6]	Proposed protocol (FFI-SEP)
1	62.48	62.49
500	54.58	57.39
1000	46.66	52.27
1500	38.68	47.15
2000	30.76	42.03
2500	22.83	36.90
3000	15.46	31.79
3500	9.90	26.68
4000	5.78	21.56
4500	2.87	16.46
5000	0.99	11.58
6000	0	4.55
7000	0	0.07
8000	0	0

Number of Rounds	Existing Protocol (I -SEP)[6]	Proposed Protocol (FFI-SEP)
1	100	100
500	50000	$50x10^3$
1000	$100x10^3$	$100x10^3$
1500	$150x10^3$	$150x10^3$
2000	$200x10^3$	$200x10^3$
2500	$249x10^3$	$250x10^3$
3000	$295x10^3$	$300x10^3$
3500	$328x10^3$	$350x10^3$
4000	$351x10^3$	$400x10^3$
4500	$366x10^3$	$449x10^3$
5000	$374x10^3$	$496x10^3$
5500	$376x10^3$	$529x10^3$
6000	$376x10^3$	$548x10^3$
7000	$376x10^3$	$563x10^3$
8000	$376x10^3$	$568x10^3$

Table 4: Throughput w.r.t. Number of rounds

Figure 5: Average Residual Energy w.r.t. Number of Rounds

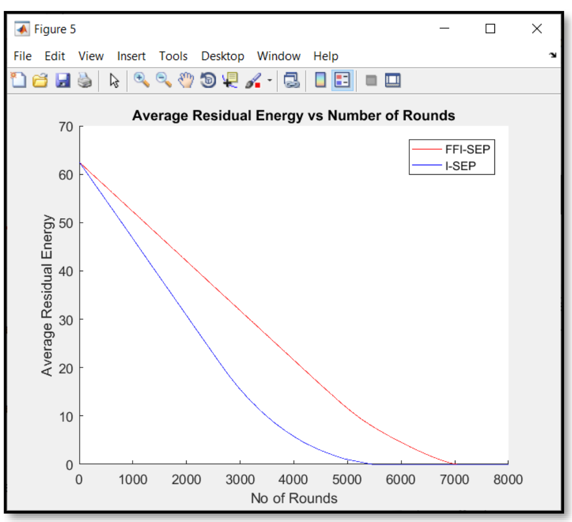

Figure 4 shows that the number of dead network nodes varies, it also indicates that the current FFI-SEP protocol has fewer dead nodes than the previous I-SEP protocol. Compared to the prior system, the number of dead nodes has decreased and the network lifespan has enhanced because cluster heads are selected randomly in the current procedure. The network's residual energy variation is depicted in Figure 5 for both proposed and existing protocols. At the outset, the network had about 60 Joules of energy. Figure 5 show that the existing algorithm has steeper declines in average residual energy than the proposed method with steeper dips indicating quicker energy depletion. It implies that the suggested FFI-SEP protocol will have a longer network lifespan.

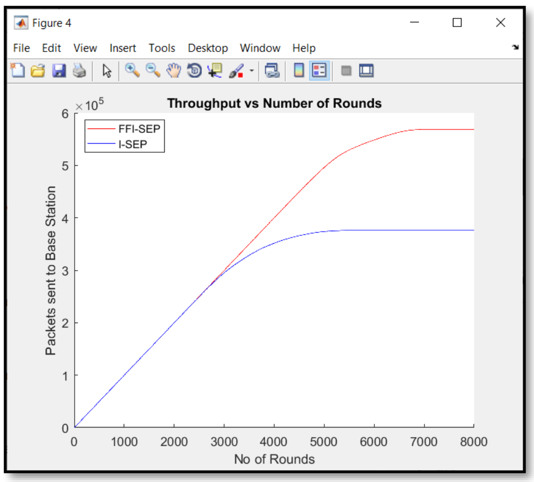

Figure 6: Throughput w.r.t. Number of Rounds

When an algorithm is more efficient, it performs better. Figure 6 indicates that the suggested FFI-SEP algorithm has a considerably greater throughput than the existing I-SEP protocol. The higher throughput is attributable to a decrease in the number of data transfers and secured cluster head replacement, which conserves power at a global scale with dual management for various transmission methods. Because the network lifespan of the FFI-SEP was longer, nodes sent more packets to the base station, resulting in higher network throughput.

V. CONCLUSION AND FUTURE SCOPE

The primary goal of this paper is to expand an energy-efficient wireless sensor network protocol based on the SEP (Stable Election protocol).The suggested approach is an improved FFI-SEP protocol which is a clustering algorithm. The study provides energy-efficient cluster head selection techniques based on the fitness function. The conclusions are derived by comparing network performance in terms of average residual energy, number of living nodes, number of dead nodes and network throughput. The results demonstrate that the FFI-SEP outperformed the previous method by lowering the rate of packet losses. Simulation results demonstrate that the new method outperformed the prior technique.

The current study focuses on developing energy-efficient methods for Wireless sensor networks. However, the development of more energy-efficient algorithms will lead to new wireless sensor network application areas.

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