FUZZY LOGIC BASED IMPROVED STABLE ELECTION PROTOCOL TO INCREASE LIFETIME OF WSN ASSISTED IOT NETWORK

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Abstract: Due to their amazing capabilities and expanding array of applications, wireless sensor networks have attracted a lot of interest from general public and scientific groups. A specialised transducer that is part of WSN brings sensing capabilities to IoT. Low battery and resource capacity of this equipment poses numerous difficulties for both academia and business. Many current WSN routing protocols have been improved to solve certain LEACH protocol problems. The goal of suggested approach is to prolong network longevity while maintaining good scalability because LEACH's performance rapidly degrades with growing networks. The fuzzy logic-based Stable Election Protocol (FI-SEP) is described in this work. suggested approach aims to increase network longevity in spite of network size growth. In this study, the network performance of the FI-SEP and I-SEP routing protocols are compared. According to simulation results, FI-SEP performs better in terms of energy efficiency on large-scale WSNs than the benchmarked protocol.

Keywords: *WSNs, Clustering, IoT, Routing, I-SEP, Energy efficiency, Fuzzy logic*

I. INTRODUCTION

IoT research is presently considered to be an emerging field in science and technology. Because of their affordability, interoperability, and ease of deployment, IoT devices are perfect for a variety of smart apps. An internet-connected network of intelligent devices, or IoT, must be addressable and able to respond to commands [1]. The IoT is currently viewed as a merger of heterogeneous networks that presents security challenges resembling those of a WSN. Similar principles govern how cellular systems work. A WSN typically has millions of nodes. Communication between sensory nodes can be facilitated via radio waves. Nodes for wireless sensors contain power sources, computing elements, radio transceivers, and detectors. SN in WSN is naturally resource constrained due to limited computing power, storage capacity, and communication bandwidth. After installation, SNs are capable of independently constructing a suitable network infrastructure and often interacting with it over a number of hops. The ability of a system to organizing and enabling itself to join with more nodes fast and automatically. These systems are made up of one or more base stations called sinks and several small, low-cost gadgets called nodes. These nodes send data to the BS. Users, a sensor network, sensor nodes, and the Internet make up a basic WSN topology. Examples of WSN constants are network bandwidth, computing speed, and storage capacity [2]. When source nodes transfer data to base stations, they expend a lot of energy. As a result, they need intermediate nodes to function. Scientists have used WSNs to detect minute soil changes that could trigger major earthquakes and to predict the initiation of forest fires by altering temperature. WSNs help farmers in many different ways, such as waste reduction, irrigation mechanisation that promotes more efficient water usage, and wiring repairs in difficult areas. Current WSN difficulties can be grouped in five different categories. These guidelines must be closely followed by researchers. Although some studies have already addressed topics such production costs, security, and energy efficiency, there is still a need to go into greater detail about them [3]. One of the most popular strategies for extending network longevity is clustering, as demonstrated in the figure below.

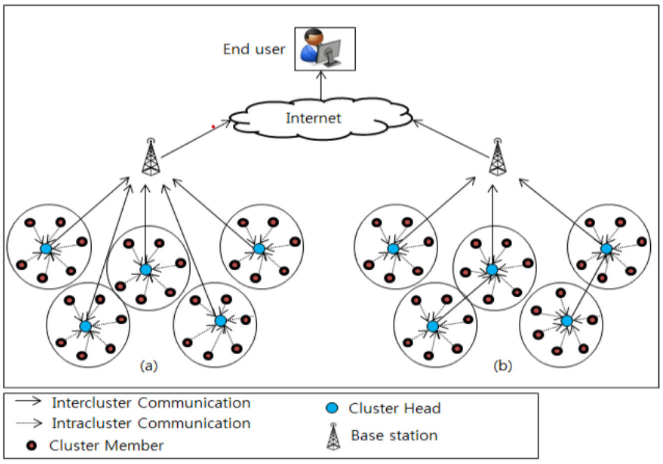

Fig 1: Clustering in WSN [4]

In essence, clustering algorithms serve as a form of energy-efficient communication protocol that groups sensors together. Sensor's nodes are separated into clusters. Every cluster consists of a CH and a few node members. The heads of each cluster receive sensed information from member nodes. This information is collected, compiled, and sent to BS by CH. Each CH uses up energy at a higher pace than typical sensor nodes. Clustering, where node transmits data to either CH or relay node rather than transmitting it straight to BS, aids in energy conservation when distance between node and BS is greater. By managing congestion, preventing long-distance communication, and enabling load balancing amongst available paths towards relevant destinations, the data aggregation at CH before transferring it to BS helps in decreasing redundant data and enhances network lifespan [5]. LEACH, DEEC, SEP, K-Means, and Fuzzy C-Means are a few of clustering methods. Clustering might help make a system more scalable. Data collection procedure is improved and life time is extended as a result of employment of cluster heads. However, each CH must perform additional jobs, which causes their own energy to run out more quickly than energy of nearby sensors. When a CH's batteries die, a substitute CH must be chosen among cluster's other sensors to carry on head's operations. It's possible that cluster heads will be selected at random or in accordance with specified criteria like residual energy, node distance, signal intensity or connectivity [6].

This paper is divided into six pieces. Section II discusses fuzzy logic control, while Section III discusses literature reviews. Methodology for conducting research is in Section IV. Section V gives details of simulation results. Total effort of the research is concluded in Section VI.

II. FUZZY LOGIC CONTROL

CH selection issue is expressed as a broad case of a multi-objective optimisation issue, including the problem of resource allocation with input information, required outputs, objective function optimisation, and constraint fulfilment. However, it is an NP-hard challenge to optimise CH selection to accomplish QoS-based energy efficiency [7]. The authors suggest bio-inspired approaches like ACO, PSO and fuzzy logic to name a few, to enhance energy efficiency and life cycle of WSN with more research on WSN. A method for adding human-like thoughts into a control system is fuzzy control. Although it is not meant to be accurate, it is meant to be justifiable logic. . It can simulate human deductive reasoning, which is how individuals draw conclusions from information they have. Fuzzy logic can be used to conveniently handle any uncertainty. FL control systems assess analogue input data in terms of logical variables with continuous values between 0 and 1, as opposed to classical or digital logic, which operates on discrete numbers of 0 or 1 (true or false). Three phases make up a general FL system: input, processing, and outcome [8]. A schematic depiction of a general FL control system and its full operation is shown in figure 2 below.

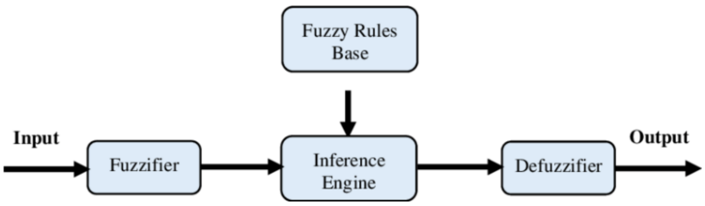

Figure 2: Fuzzy logic control system [9]

III. LITERATURE SURVEY

This section will go through earlier research on EESRA routing protocol and LEACH clustering protocol. Through LEACH protocol and its modifications, researchers have made significant progress towards improving energy efficiency of WSNs.

M.Liu et al. [10] demonstrated the significance of cluster formation The energy-efficient Cluster formation algorithm based on GA-optimized Fuzzy Logic, which contributes significantly to a revolutionary cluster formation technique for WSNs. During the CGAFL cluster generation step, FIS is utilised. As parameters, FIS considers CH's residual energy, distance among CH & BS, and the range among CH & node. Each non-CH looks at each CH's FIS and selects the CH with highest potential value to develop cluster. In contrast to several other fuzzy logic techniques, creators of FIS employ GA to maximise fuzzy inference rule. CGAFL finds best fuzzy logics and extend life of WSNs when contrasted to LEACH, CFFL, and FLCFP.

Verma et al [11] employed multi-input multi-output clustering technique to more effectively utilise node energy and lengthen lifespan of network. FIS regulations set stage for better network performance. Multiple rounds of simulations are performed to implement regulations. Three input and three output variables are required to adequately explain clustering. Researchers impose restriction on every cluster size in order to effectively load balance entire system. Capacity of SN to quickly carry load requirements as energy is depleted. CH nomination improves performance of new plan to limit cluster expansion. And contrast LEACH and DUCF, two clustering techniques with OCSSP. Numerous studies demonstrate that OCSSP produces superior results.

Witkowski et al [12] Using NS2, LEACH, LEACH-FL, K Means-LEACH, and FL-EE/D energy efficient clustering algorithms were compared to fuzzy logic-network coding-efficient routing methodology. These clustering protocols were successfully handled by the FL Based Energy Efficient Routing Protocol with Network Programming, based on the results. According to simulation studies, PPEECS extends network lifespan, particularly FND by 28%, HND by 45%, and 10PND by 50%, when contrasted to LEACH. Whenever it comes to network lifespan and energy efficiency in a range of scenarios with varied numbers of sensor networks, FL-EE-NC models perform better than other methods.

Ibrahim et al. [13] proposed WSN that is based on ACO and K-means clustering. It allows extremely safe transfer from energy-saving perspective, as well as being dependable for a specified period of time, in Sensor networks of any scale regardless of facilities or special nodes, thereby allowing WSN execution and broadening the spectrum of potential application domains. Suggested model outperforms Fuzzy-leach and other clustering methods as well as Leach in terms of routing and energy usage.

Jayakrishna et al. [14] a hybrid WSN technique has been developed that is more efficient than LEACH protocol and less energy-intensive than consensus mechanism. Authors compared energy consumption of Leach with hybrid protocol to show effectiveness of suggested protocol. Suggested hybrid procedure utilizes less electricity than consensus technique. Hybrid approaches promise improved dependability because CH participates in a decentralized consensus process, even though they consume a little bit more energy than Leach algorithms.

Basavaraju et al [15] For applications like HWSNs, an energy-efficient cluster-based routing protocol with noticeably superior cluster formation technique is presented. To begin with, writers use PSO to achieve effective clustering for assembling nodes based on geo-location characteristics. As a result of PSO, all nodes will group together without any residual nodes, and CH and super CH will primarily concentrate on trusted integration of every node's unique Differential Evolution based Trust Inference layout. GSA employs inter-cluster routing. Suggested EERRCUF protocol was found to be effective in terms of QoE constraints like PSNR, SSIM, and Video Quality Measurement, as well as QoS limitations like throughput, latency and energy usage.

IV. PROPOSED METHODOLOGY

Most crucial component of a sensor network is energy conservation. Every protocol should be designed to conserve nodes' energy. One such technique is current I-SEP, which clusters nodes and chooses CH based on nodes' remaining energy. Since network under consideration is heterogeneous, it is a good idea to give higher energy nodes more priority. However, in addition to nodes' remaining energy, there are other factors that might be taken into account while choosing CH. Additionally, radio energy model is one used in sensor networks, where relationship between energy use and communication distance between two nodes is direct. The direct communication between CH and BS in I-SEP consumes energy. In I-SEP, CH and BS interact to one another directly, which uses more energy in the radio energy model because of the greater distance involved. To minimize network's energy usage, this must be optimised.

- I-SEP selects CH depending on node type, giving higher energy nodes a higher priority. Other node variables that might be taken into account while selecting CHs are ignored.
- A single hop contact between CH and BS is used to convey data. Longer distances between CH and BS are used in this method, increasing energy consumption.

To address the aforementioned research gaps, we establish the following objectives:

- To study various past research papers related to achieving energy efficiency in clustered WSN.
- To optimize cluster head selection using Fuzzy logics and data transmission process using ACO routing.
- To implement the proposed protocol in MATLAB.
- To compare the performance of suggested and existing protocol based on no. of alive nodes, dead nodes, residual energy and packets sent to base station.

To fulfil objectives, the following research methodology is proposed:

Step 1: As opposed to other research that merely selected CHs based on nodes' remaining energy, this study will focus on making best choice of CHs. Other factors, such as node's distance from BS or cluster's size, etc., have not been taken into account. As a result, fuzzy logics would be used to select CHs in recommended technique. Following variables are fed into fuzzy box:

i. Remaining energy of node
ii. Distance from BS
iii. Density of neighborhood

Step 2: Best node for fuzzy output will have maximum remaining energy value, be closest to BS, and not be too large.

Step 3: Clusters of CHs form in following stage. During this stage, head nodes transmit advertisement datagram to neighbor nodes. Node with shortest distance joins CH after receiving packet. Phase of data gathering and data transmission starts after clusters have been formed. Cluster member nodes send their data to appropriate CHs during this phase. Data must be sent from each CH to BS utilizing multi-hop communication. Multiple roads will be constructed from CH to BS to accomplish this. Pheromone value, which is calculated using ACO technique, will be used to calculate each route's optimality. Route with highest pheromone value will be chosen for data transfer.

Figure 3.1 represents step wise workflow of proposed methodology.

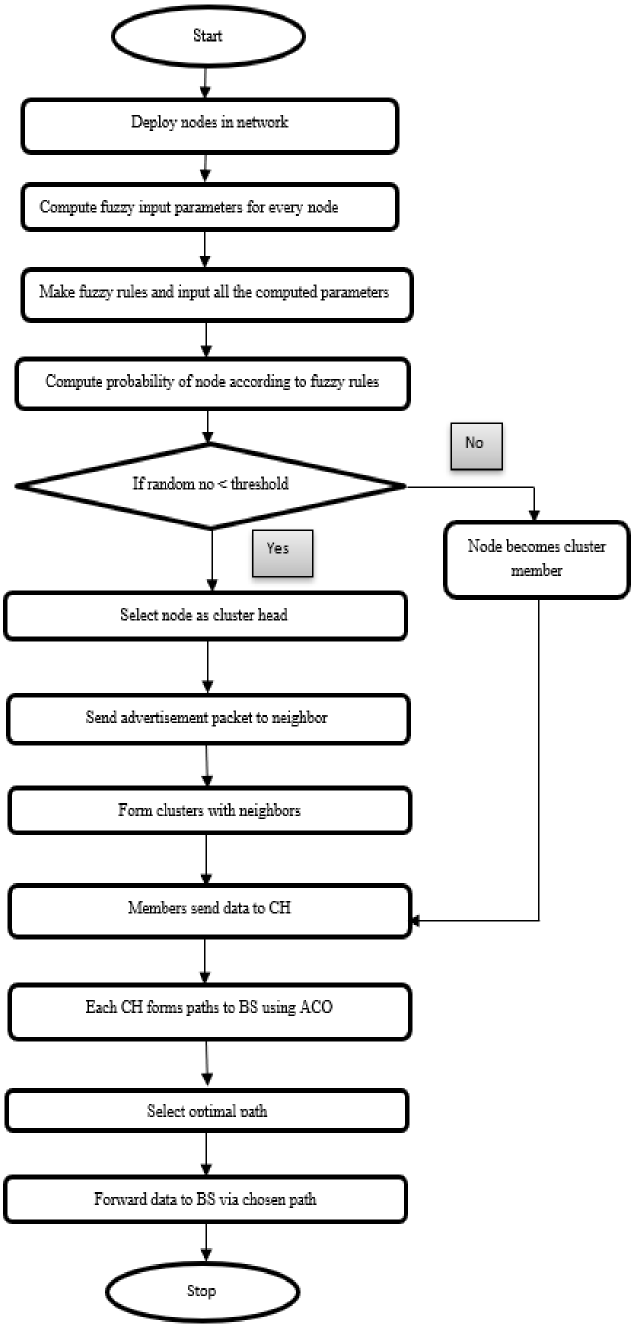

Figure 3: Flowchart of proposed work

V. RESULTS

MATLAB was used for modelling both planned and actual work. A 100 square metre network with 100 random located nodes was used for simulation. Residual Energy consumption, no. of alive and dead nodes, throughput are used to evaluate effectiveness of a network. Results of planned FI-SEP and existing I-SEP are shown in this section.

a) No. of Alive Nodes: This metric helps to calculate how much energy device used throughout each round.

Figure 4 shows that first node for current work died immediately on 5100th round, but first node for planned work died on 5500th round. Therefore, it is evident that proposed work has greater network stability.

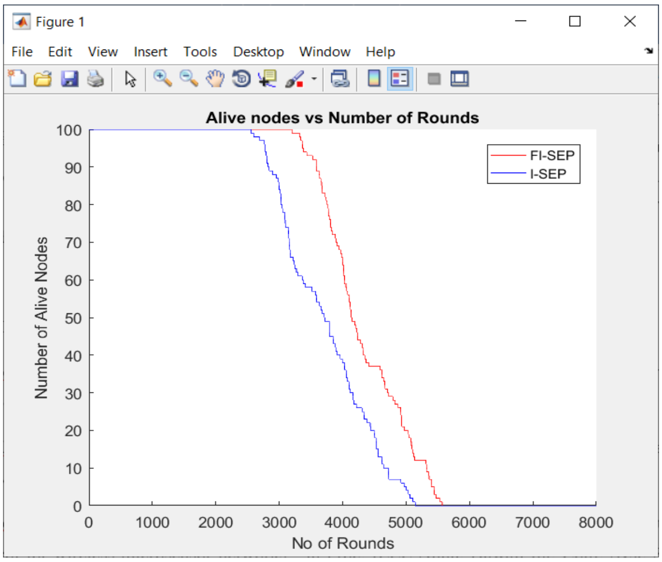

Figure 4: Alive Nodes

Table 1: Alive Nodes Comparison

Approach	No. of Rounds
I-SEP	5100
FI-SEP	5500

b) No. of Dead Nodes: This was used to determine how much energy the device utilised throughout each cycle [16].

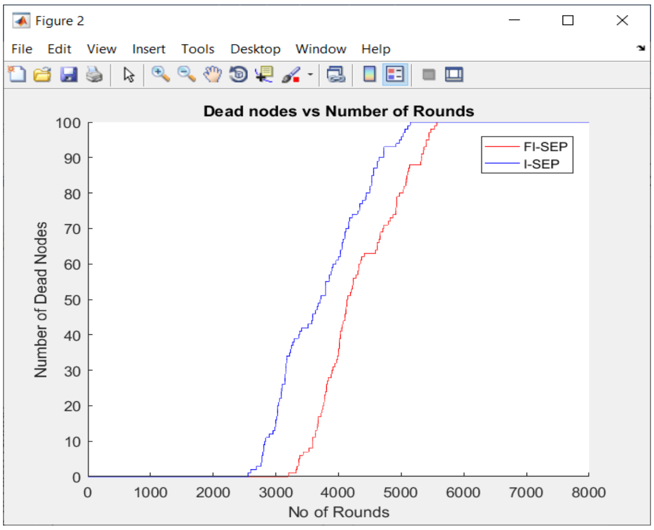

Fig 5: Dead Nodes

According to Fig 5, no. of dead rounds for suggested methodology is [1000, 2000, 3000, 4000, 5000, 6000,

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7000, 8000] . Table 2 shows that intended work network died on 3100th cycle while actual work network died on 2500th round.

Table 2: Dead Nodes Comparison

Approach	No. of Rounds
ISEP	2500
FI-SEP	3100

c) Throughput: Throughput is the volume of data transferred successfully via a network [17].

$$\text{Throughput} = \frac{\text{Total No.of packets successfully transferred}}{\text{Total Number of packets transferred}}$$

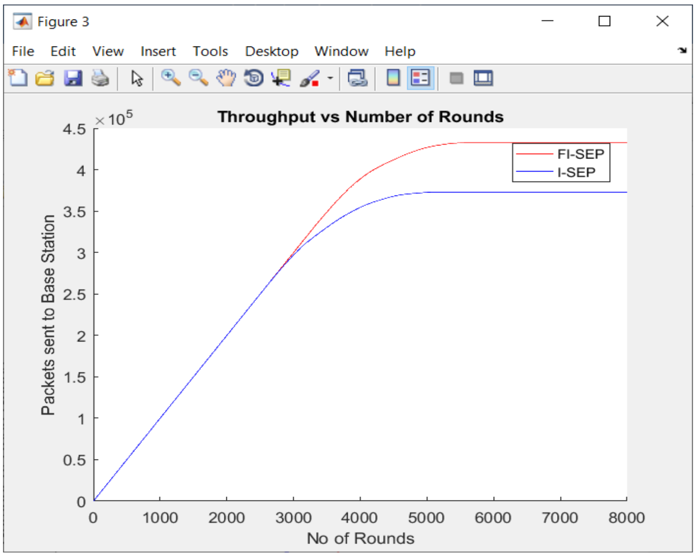

Figure 6: Throughput

From Fig 6, it is clear that throughput for suggested FI-SEP algorithm is increased with 4.4×10^5 no. of packets transmitted. It's greater than existing I-SEP where no. of packets transferred is 3.6×10^5

d) Average Residual Energy: Main resource that WSN nodes require is energy, which also influences how long network can -last. Figure 7 demonstrates that RE for existing I-SEP methodology is steeper than for suggested method, showing that steeper declines imply an increased rate of energy consumption.

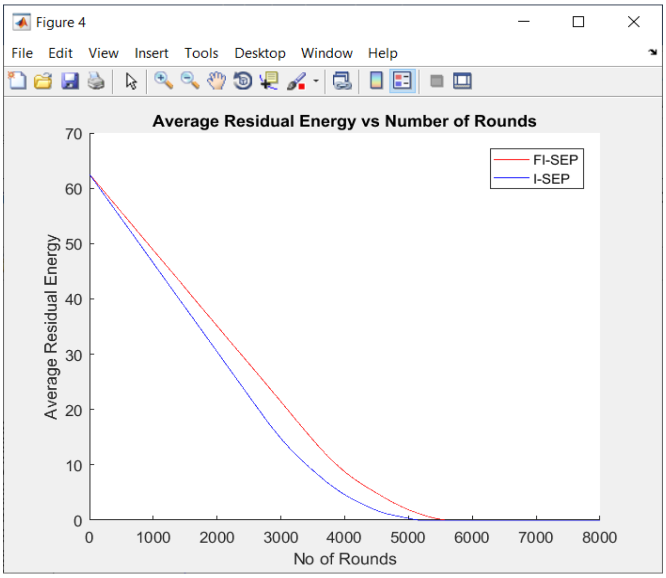

Figure 7: Average Residual Energy

The four metrics, Residual Energy, throughput, and no. of active nodes, are all improved by the suggested method.

VI. CONCLUSION

Creating a WSN protocol that is energy-efficient is really challenging. A special technique for enhancing performance of a sensor network that helps with CH selection and data transfer is cluster-based routing protocol. The clustering protocol must be created to minimise power consumption while ensuring that packets are transported to their intended locations. I-SEP is changed in proposed work to improve network performance. This study suggests choosing Cluster Heads based on fuzzy logics and properly transmitting data utilising ACO routing. The study examines best CH selection-prioritizing routing algorithms like I-SEP and FI-SEP. Alive nodes, throughput and remaining energy are considered while comparing performance of two approaches. The suggested FI-SEP has higher throughput figures and more energy reserves. We can draw the conclusion that suggested strategy is preferable to current one. A variety of actual WSN-based IoT situations can be used to evaluate proposed technique. Suggested method was evaluated in this study for a maximum of 100 nodes, but more investigation might be done to determine how it performs in a larger system.

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