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An energy aware and secure Fuzzy logic based Clustering Algorithm for WSN'S

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Abstract - Concerns about preserving battery life and ensuring data integrity are two of the biggest in wireless sensor networks (WSNs). In addition, the sensor nodes that make up a WSN are themselves limited in terms of their available energy, therefore it's important that the network as a whole preserve as much of its energy as possible. When it comes to the issue of power consumption in WSN, the clustering mechanism is one of the most important solutions. The current clustering algorithms' biggest flaw is that they falsely assume that every node can be trusted equally. In spite of the fact that security is a major concern when planning a WSN's architecture, it is often not until clustering that this element of safety is given any attention at all. The use of a trust-based mechanism is an interesting strategy for achieving safe data transfer. As a result, it's important to have a single algorithm that combines trust awareness with energy efficiency, i.e. For efficient selection of dependable and energy-efficient node as Cluster Leader, a Fuzzy Logic-based Energy Aware Secure Clustering Algorithm is presented.

Keywords - WSN, Clustering, Fuzzy Logic Based Energy, Trust Management.

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1. INTRODUCTION

In recent years, there has been a parabolic development in the utilisation of wireless networks in comparison to wired networks across the board in terms of the most significant application areas. This shift in preference may be noticed across the board. This is due to the fact that users of wired networks need connections in order to connect their devices to other networks and the Internet. However, this is not necessary for a wireless network. When it comes to the internet, a lot of distinct smaller networks are joined to one another to construct a much greater network. These relationships are formed by the use of hyperlinks. It is tough and time demanding to unite all of the network nodes by employing cables, routers, and other forms of networking equipment in a world where more and more persons are using the internet. There's a lot of hard physical work involved, that's why. People in this age greatly benefited from wireless networks since they allowed them to communicate despite natural barriers like rivers and mountains. [1]

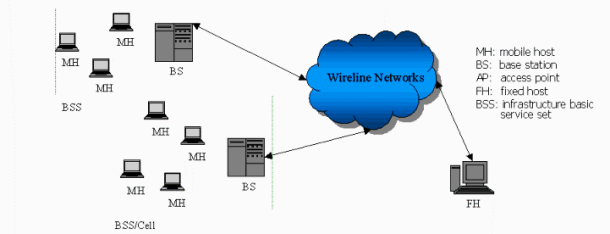

Figure 1: Wireless Network Structure

When talking about computer networks, the term "wireless" refers to the fact that the individual nodes don't need to physically be connected by wires in order to share information and function together. It is also a significant development since it allows companies to save time and money on the labor-intensive process of installing cables across their facilities and at the locations of their various pieces of equipment. This has the dual effect of cutting costs and reducing workload. Wireless networking makes use of technology based on radio waves and spectrum, which functions on a level consistent with the real world. In order to establish a network connection, electronic gadgets like notebooks, desktop computers, and mobile phones use radio waves. This link is becoming a need for the smooth functioning of business applications. Because they link mobile devices to one another and to other Wi-Fi-enabled devices, wireless networks provide users with the freedom to access the internet from virtually anywhere within range of the network. Laptops and desktop personal computers are two examples of portable electronics. Wireless networks' primary advantages lie in their portability, productivity, simplicity of installation and maintenance, scalability, safety, and low operational costs. In addition to a plethora of other advantages, wireless

networks also boost efficiency, mobility, and comfort. [2-5]

1.1 Wireless Sensor Network

Wireless sensor networks, or WSNs, are "an essential and complex subject of study" due to its wide range of potential applications and uses in a variety of industries. WSNs are composed of a large number of very small devices, all of which are collectively referred to as sensor nodes. These sensor nodes can keep tabs on their surrounding area, take readings, and log data from a wide range of sources. WSN has various potential applications in many fields, including as the healthcare industry, farming, the military, and even spying. A sensor node has a single microprocessor along with a number of other parts. Included in these parts are a central processing unit (CPU), a battery, and a miniscule transceiver. [6]

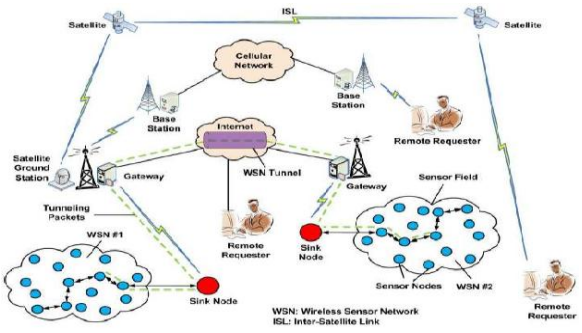

Figure 2: WSN Deployment model

Typically, the costs of physically putting sensor nodes are higher than the expenses of deploying a network of sensors. The obtained data from the sensor nodes can be sent either directly to the sink node or indirectly via other sensor nodes. No matter what happens, the information will get where it needs to go. Due to the large coverage area of each sensor network, data transmission from the sensor node to the sink node requires a significant number of hops in communication. When a sensor node transfers data to a sink node from a source node that is geographically far away, it might deplete some of its available energy. Since the sensor nodes' lifespan is directly proportional to the amount of energy they consume, finding ways to reduce this consumption during the design process is a challenging but essential goal. [7]

Since there is a limited amount of energy available at each node in a WSN, it can be costly to replace the nodes or the batteries that keep them running. Because of this, optimising the use of available power is crucial; this may be done by developing more efficient algorithms for network routing and improving data gathering techniques. In addition, strategic placement methods must be employed while setting up the sensor nodes. There is the option of grouping the nodes into clusters to facilitate better communication. In this setup, only the cluster leaders participate in the routing process. [8]

Additionally, it is essential that the sensor nodes cooperate well for a successful performance. For a successful presentation, this is a must. It is important to consider both the energy economy of the algorithm and the security issues inside the network when developing a routing algorithm for the transfer of data between sensor networks. Building a sensor network with improved Qi's metrics including packet delivery rate, latency, and power consumption is at the heart of this effort. It is with this goal in mind that we set out to work. [9]

1.2 Routing Techniques and Challenges

Modern technological developments have allowed businesses to mass-produce assemblages of sensor nodes at more affordable rates. An individual of this level of skill may now complete the task without issue. These nodes are available at a reasonable price, take up very little space, and run on only two AA batteries. Each sensor node includes the hardware to collect data, process that data, and then send it to a stationary or mobile processing centre, called a "sink," depending on the circumstances. The term "sink" is used interchangeably for both of these various types of sinks. Because of their uses, the sensor nodes were placed in a spot where they wouldn't be disturbed by people. In the sensing field, after an ad hoc network has been established, the sensor nodes will begin to collect data about their immediate surroundings. During the time when the new network is being built, this technique will be put into effect. [10]

A component of the system stores the digital signals acquired from the sensors before passing them on to the processing unit for analysis. A part of the system is the central processing unit. That is the main job of the CPU. The data, having been processed by the processor, are subsequently transmitted to the sink by means of a transceiver, a device capable of both sending and receiving data. The process begins after the data have been sent to the sink. Data can be sent and received simultaneously by a transceiver. It also includes a mobilizer unit that may be used to relocate the sensor node to a new place. This component is built in and available to all users without further cost. For this added convenience, we will not incur any further fees. It is necessary to employ a position finding method when pinpointing the precise location of a wireless sensor node inside the confines of a sensing field. It's always the case anytime there's a pressing requirement to do so. Each wireless sensor node is equipped with a global positioning system (GPS) since manual identification would be too expensive. We may also employ a variety of different well-specified localization methods to pinpoint the position of the wireless sensor node. Each sensor node incorporates a global positioning system (GPS) to help in the precise placement of mobile sensor nodes. [11]

1.3 Cluster Based Routing Techniques

Clustering not only facilitates communication between a set number of nodes and the sink node, but it also helps to arrange the sensor nodes in a way that makes them more accessible to end users. The improved accessibility that comes with clustering is another another benefit. This result occurs because a certain number of nodes can be used to establish a connection to the sink node, a feature made possible by clustering. Cluster-based routing begins with the creation of clusters, continues with the designation of cluster leaders, and concludes with the delivery of data via the selected cluster managers. The primary advantage of using cluster-based routing in WSN is a large reduction in the total number of nodes required to complete the routing operation. In turn, this will boost the potential for energy conservation. This is because a lesser number of nodes need to be connected before the routing process is judged successful.[12]

In order to begin implementing cluster-based routing, the first step is to construct the clusters that will be used. This is the first step that must be taken. Furthermore, the clustering procedure enhances the network's scalability by dividing the network into multiple logical groups based on a set of specified criteria. Be on the lookout for any patterns that emerge throughout the clustering process, as they may hold the key to deciphering the laws in question. As part of the cluster infrastructure, the sensor nodes are responsible for a wide range of tasks. The roles of cluster leader, gateway, and members are to be taken on in the order given. The cluster's next leader will be determined through a selection procedure of some description. Someone with these qualifications will be chosen to fill this role. This individual is in charge of acting as the local coordinator and is tasked with reaching out to the other cluster members first. [13-14]

2. METHODOLOGY

The planned study's overarching goal is to "improve secure communications, increase energy efficiency, and, consequently, expand the lifespan of network nodes." Because of this, a fuzzy inference system has been added into this study to oversee the development of both energy-efficient systems and secure clusterings. This was done to meet the needs of the job at hand. An inference system that relies on fuzzy rules can have its inputs and outputs mapped to one another with the help of fuzzy set theory.

There are two separate stages of the job that are meant to be finished: the "setup" stage and the "steady state" stage. The research that has been provided also takes into account other features of the cluster formation process, such as cluster density and residual energy. The recommended work will be carried out in stages, quite similar to the conventional leach method. The first step of the FBEASC's operation comprises the development of the cluster via the use of fuzzy logic, and the second stage involves the selection of a leader who is both safe and efficient via the use of energy. For a comprehensive breakdown of these steps, read the parts that follow, which are organised as follows.

2.1 The Method for Choosing the Heads of the Clusters That Are Efficient in Energy Use and Protective of the Environment

In accordance with the idea, the position of Cluster Leader will be awarded to the "node in the network that is both the most energy efficient and dependable" (CL). Therefore, the process of picking the leader of the cluster is a continuous operation; it is based on the computed trust score in addition to a review of the candidates' previous deeds. Please refer to the section that follows for more information on how we arrived at the trustworthiness scores that we utilised in this study.

- Statistical Method for Evaluating Credibility.
- Network-based Malicious-Node Detection

2.2 The approach to cluster formation that makes use of fuzzy logic

This article's focus is on the "fuzzy cluster generation process," which is dissected and investigated here. Because the FIS is used to decide the member choice of each CL, the other nodes in the network are able to find the appropriate CL and establish connections with it. Thus, the network is allowed to operate normally. In this investigation, the cluster leader's energy level and cluster density will be the primary factors in determining which CL the member nodes will employ. Figure 3 displays the workflow system architecture for the requested task.

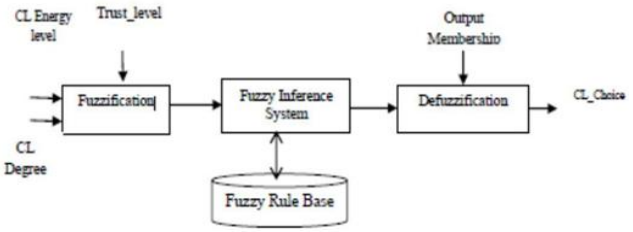

Figure 3: System architecture

- Cluster Leader Degree
- Design for Energy
- Fuzzy Membership Functions

2.3 Fuzzy Rules

The author's name, Mamdani, is also the name of the writer of this piece. The system employs an inference method called fuzzy logic to arrive at its findings. There are three possible values for each of the two input variables. For our perusal, Table1 is provided below, which summarises the fuzzy input variables.

Table 1: Fuzzy Variables

PARAMETERS	LEVELS
CL energy level	low, medium and high
CL degree	low, medium and high
Trust_level	low, medium and high

Choice measures of "32 = nine likely members" are derived from this using the if-then principles of fuzzy logic. The value of CL Choice, an output variable, can be one of nine possible values. These values can be as high as very high or as low as very weak, with very weak and high medium also being conceivable. Functions in the shape of triangles and trapezoids stand in for CL Choicelevels. Our system makes use of a number of fuzzy if-then rules, a subset of which are listed in Table2. the second table of the fuzzy rule

Table 2: Fuzzy rule

Set of Fuzzy Rules
Case 1: If (CL Energy Level is low) and (CL Degree is High) and (Trust_level is low) then (CL_Choice is weak)
Case 2: If (CL Energy Level is high) and (CL Degree is low) and (Trust_level is high) then (CL_Choice is strong).
Case 3: If (CL Energy Level is High) and (CL Degree is medium) and (Trust_level is high) then (CL_Choice is medium).

To answer this question, we employ the Mamdani inference system, the apex of which is the defuzzification process. In Afghanistan, investigators are trying to figure out what happened. In addition, an idea called the Center of Area (COA) was examined; this was expressed in the form of an equation.

$$COA = \frac{\int \mu_A(x)|x dx}{\int \mu_A(x) dx}$$

3. RESULTS

In this study, we use the MATLAB Fuzzy Logic Toolbox to probe the efficacy of fuzzy-based, energy-conscious, secure clustering (FBEASC). In order to gauge FBEASC's overall performance in the competition, LEACH and STRM were used to evaluate it. To conduct the experiment, anywhere from fifty to two hundred and fifty sensors are placed across a grid measuring 500 metres by 500 metres. "In the beginning of the process, the installation of each node takes a combined total of 2 joules of energy. After a rest period of twenty seconds, we are allowed to play another round. The simulation parameters that were used in the production of the FBEASC are shown in Table 3.

Table 3: Simulation Parameters

Parameters	Value
Area	500m x 500m
No of Sensor nodes	50-250
Basic routing protocol	LEACH
Initial energy	2 J
Eelec	50 nJ/bit
Packet Size	1024 bits
Mobility model	Random way mobility
Mobility Speed	10 m/s to 40 m/s

The visual representation of the packet delivery rate analysis may be found in Figure4. It has been demonstrated that the suggested work has a greater data chunk distribution rate when compared to the works LEACH and STRM that are available to the general public. This is demonstrated by the fact that it is currently available for purchase in the market. This is because the FBEASC uses an innovative trust mechanism, which helps to limit the amount of packet loss that may be attributed to hostile nodes. The rationale for this is as follows: Because of this, the pace has picked up thanks to the fact that packets are being delivered via the FBEASC.

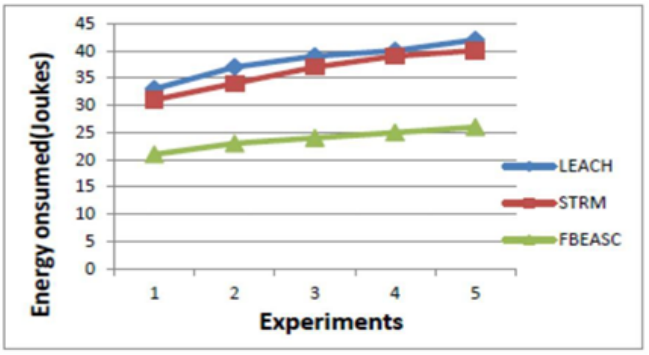

Figure 4: An examination of the delivery of packets

The HEED, FBEASC, and LEACH activities are now in the planning stages. Figure 5 represents the total quantity of energy that would be needed by these operations if they are fully implemented. According to the findings of the research that was discussed, one of the most important things to think about when selecting people to serve as Cluster Leaders is the entire amount of energy that a person possesses. The results of utilising the recommended method result in the detection and removal of a bigger number of potentially dangerous nodes found inside the network as compared to the findings of a prior research study. As a direct result of this, the amount of energy that is consumed by malevolent nodes has decreased, which has led to a reduction in the

amount of energy that is spent by projected nodes on "jobs FBEASC."

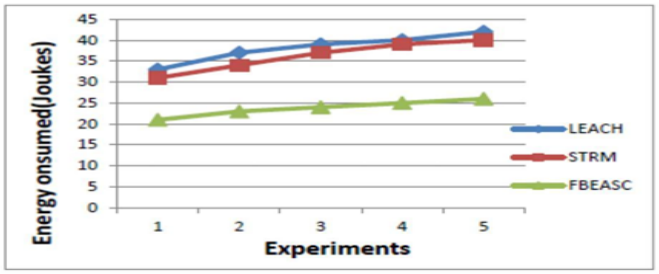

Figure 5: A breakdown of the energy that was consumed

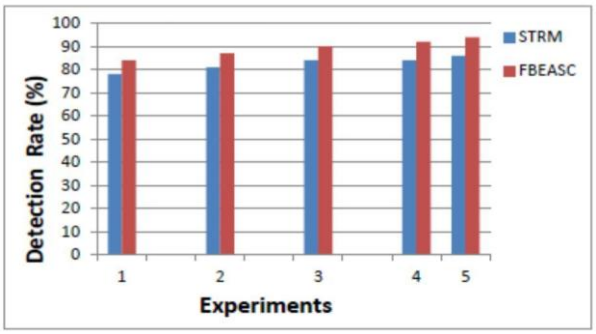

Figure 6: The rate at which malicious nodes are detected in the network.

Figure 6 compares the detection rate of STRM to that of the planned study to see which method is more effective. The proposed solution computes trust ratings for nodes by taking into account their energy levels and doing research on the patterns of behaviour they show when interacting with other nodes. As a result, the FBEASC has seen an increase in the number of nodes that are acting in an inappropriate way.

In the table further down on this page, you can see how the LEACH delay test and the indicated having STRM test turned out. From this, it's clear that the delays caused by STRM and LEACH are much bigger than those caused by FBEASC. The proposed solution, unlike LEACH and STRM, greatly reduces the transmission latency caused by malicious nodes because of a phenomenon. When we look at the three ways, we see that this is true. It happened because of the recommended strategy, which allowed a single node that was reliable and good at using energy to be the leader of the cluster while a chosen CL sent data. This made it possible for a single node to be the leader of the cluster while a chosen CL sent data. As a direct result of this, the FBEASC is less affected by the increased latency that rogue nodes cause.

Table 4: A Study of the Amount of Time Spent Waiting

Methods	Number of Packets Sent			
	4000	5000	6000	7000
Delay in LEACH(ms)	0.75	1.94	2.8	3.2
Delay in STRM(ms)	0.71	1.85	2.5	2.7
Delay in FBEASC(ms)	0.65	1.2	1.68	1.8

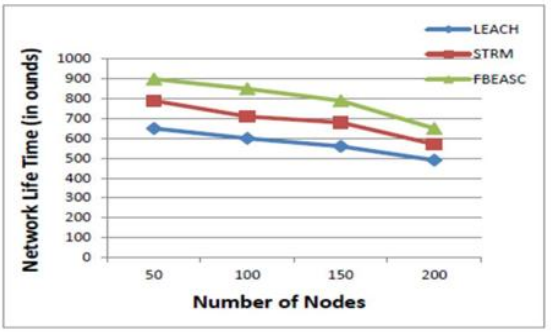

Figure 7: The Existence of the Network's Lifespan

As a suggestion for the network life cycle research process, work has to be done using LEACH and STRM. Figure 7 reveals that in comparison to LEACH and STRM, the FBEASC is capable of reaching greater levels of performance achievement. This is because the task that was expected to be completed throughout the whole process of creating the cluster has already been completed, which explains why this is the case. The degree of the CL as well as its energy are both included in the list of parameters. In addition to this, the degree that the cluster leader currently has will determine whether or not the new member node will join the CL. A more widespread network is going to be a component of the proposed endeavour "longer lifetime when compared with LEACH and STRM, respectively.

4. CONCLUSION

This study recommends a clustering approach and a tree-based routing algorithm to increase the reliability and lifetime of wireless sensor networks. With this approach, "the cluster is built utilising a single hop technique, where dead nodes generate energy hole issues, network partitioning, lower wireless sensor network lifetime, route break, and delayed packet delivery." However, by forming clusters, the number of backup paths and backup sensor nodes that may function as a cluster head is increased, which in turn increases the lifetime of wireless sensor networks and the packet delivery ratio. The proposed method makes use of two-hop clustering, tree routing, and two mobile sinks to achieve the greatest possible energy savings. This improves the efficiency of wireless sensor networks by decreasing their power consumption, averting route breakdowns, and accelerating packet delivery.

The simulation results demonstrate that the suggested strategy outperforms the alternatives.

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