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"A TRUST-BASED PEGASIS ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORK WITH ANN"

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Abstract:
This paper presents Trust-Based PEGASIS (TB-PEGASIS), a novel routing protocol for Wireless Sensor Networks (WSNs) that integrates Artificial Neural Network (ANN) and trust-based mechanisms. By utilizing PEGASIS' energy efficiency and combining trust values for node selection, TB-PEGASIS seeks to improve the performance and security of WSNs. Based on elements including behaviour, performance, and interactions, sensor nodes are given trust values by an ANN model. The protocol performs better than conventional protocols in terms of network longevity, energy efficiency, and data transmission dependability. It also effectively reduces the effects of compromised nodes and detects and isolates misbehaving nodes. TB-PEGASIS advances trustworthy data transmission in WSNs and shows promise for further study in this area.

Keywords: Wireless Sensor Networks, Trust-Based PEGASIS, Artificial Neural Network, Packet Drop Ratio, Cluster Head, Data Aggregation.

1. Introduction

A wireless sensor network is made up of nodes that each have a certain energy level [1],[2]. Nodes or sensors are arranged in a network-like structure. The source sends packets in the direction of the destination. As more and more packets are sent via the network, energy is drained [2],[3]. As soon as a sensor's energy is totally used up, it can no longer retain any more packets. As a result, packets intended for that node are discarded. The packet drop ratio rises as more and more packets are dropped.

$$\textbf{Packet}_{\textbf{Dropratio}} = \frac{PacketsDropped}{TotalPacket} \qquad (1.1)$$

where, equation-1.1: Indicating packet drop ratio.

The packet drop ratio is derived by dividing the number of dropped packets by the total number of packets sent [4]. The primary reason for packet loss is energy dissipation. Equation 2 depicts the energy dissipation while packets are transmitted.

$$\mathbf{E(k,d) = E(k) + E_{rs}(k,d)} \qquad (1.2)$$

where, equation-1.2: Dissipation of energy during packet transport K is the packet size, and d is the separation between the transmitter and the receiver. The protocols were developed to address the problems of energy loss and congestion. The details of the current methods utilized to attain optimality are described in the next section.

LEACH and PEGASIS are two of the protocols used to reduce packet loss and increase energy efficiency.

LEACH:

The LEACH protocol employs a cluster with a CH to broadcast packets that it receives from cluster members toward the base station [5]. If the CH's energy runs out, the subsequent sub-CH will take over as the cluster head [6], [7]. Normally, LEACH data is gathered at CH and transmitted all at once. All the aggregate packets are lost if CH fails. This causes a network's lifespan to shorten and the packet loss ratio to rise. Leach Architecture is depicted as under:

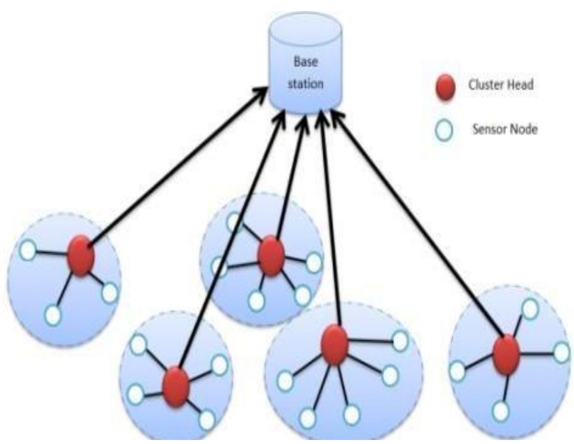

Figure. 1: Architecture of LEACH

The LEACH protocol is associated with the following parameters:

Table 1: Parameters considered in LEACH

Parameter	Value (Approx.)
Number of Nodes	100
Base station position	50*50
Propagation delay	3 us
Processing Speed	5 m/s
Data Size	100
Time	900 sec

There are several phases associated with LEACH [8], [9]. These steps consist of the following:

- **Setup phase:** Each node creates a random value between 0 and 1 during the setup phase. The node becomes the cluster head if the values generated for that node are fewer than the threshold value.

- **Steady phase:** Time division multiplexing is used by nodes to relay data to the cluster head during the steady phase. Each node is given a slot during which they can send data in the direction of the destination.

At the cluster, data is compiled before being sent to the base station [10],[11]. The position of data aggregation at the cluster head is shown below.

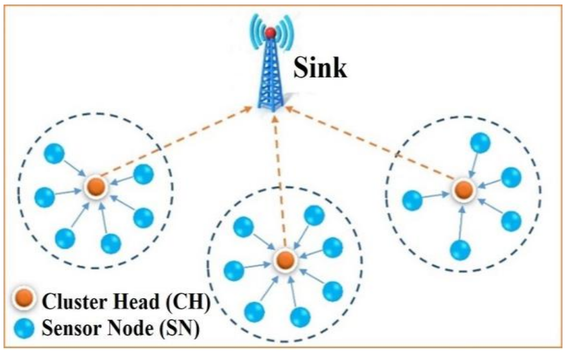

Figure.2: Data Aggregation at Cluster head location

Through the LEACH algorithm, power consumption and energy efficiency are achieved. The LEACH algorithm uses a probabilistic methodology. PEGASIS was developed to further minimize energy use.

Since this method is less probabilistic in nature, less energy and power are used during data transmission.

The comparison is given as a tabular structure that lists the parameters related to each approach.

2. Literature Review

In the year 2015, the authors of this work presented LEACH, PEGASIS, and TEEN, three wireless sensor network protocols, were compared in this article by . This research compares three "Wireless Sensor Networks" protocols depending on how they function. "Threshold Sensitive Energy Efficient Sensor Network," "Power-Efficient Gathering in Sensor Information System," and "Low Energy Adaptive Clustering Hierarchy" are a few of the WSN protocols (LEACH). Given that they organise themselves hierarchically in order to get things done and save energy, these network protocols are intriguing to research. In order to compare these three protocols, this research uses the four performance variables "Hop count," "Expected Transmission Count," "Expected Transmission Time," and "Energy Consumption." In relation to the performance measures, the author develops a broad view of the protocols [1].

In the year 2015, the authors of this work presented the hierarchical routing protocol PEGASIS and a comparison of several PEGASIS protocol versions as described in this work. In WSN, efficient routing is carried out through hierarchical routing. The author primarily focused on hierarchical routing methods, their many subtypes, as well as PEGASIS-based routing protocols such as the PDCH (PEGASIS with Double Cluster Head) protocol, which distributes workload fairly among all nodes and increases the longevity of a network. When picking the leader, the chain-based protocol EEPB (Energy-Efficient PEGASIS Based protocol) uses a threshold to avoid creating a long link [2].

In the year 2016 the authors of this paper focused on a few key protocols built on the PEGASIS architecture: To name a few, we have PEGASIS, EEPB, IEEPB, PDCH, PEG-Ant, PEGASIS-PBCA, PEGASIS-IBCA, MH-PEGASIS, Multi-chain PEGASIS, as well as Modified-PEGASIS. It compares and contrasts these procedures based on criteria that are crucial to think about while deciding on a method for a certain W. The author discussed comparison studies, which evaluate various methods according to predetermined performance indicators. It aids researchers in gaining an understanding of several factors relevant to procedures, paving the path for future development in the discipline. Wireless sensor networks are becoming more advanced on a daily basis. PEGASIS is a WSN routing protocol that is hierarchically chain-oriented [3].

In the year 2018 the authors of this work presented to address issues with energy usage, the author for Energy-Efficient Data Acquisition from Sensor Information Systems (PEGASIS) to the field of ecological monitoring equipment. The next stage is to contrast PEGASIS and Low-Energy Adaptive Clustering Hierarchy (LEACH). The number of active nodes, the number of inactive nodes, and the amount of available energy are the primary emphasis of this study. The results show that in real-world scenarios, the PEGASIS protocol is superior to the LEACH implementation. In LEACH, there are around 600 total die nodes, but in PEGASIS, there are about 1000 [4].

In the year 2017, the authors of this work presented have examined both of the current methods analytically. All of the routing protocols that have been put forward so far are intended to use less energy and prolong the lifespan of the network. Two examples of such routing methods are Low Energy Adaptive Cluster Hierarchical Routing (LEACH) as well as Power Efficient Gathering in Sensor Information Systems (PEGASIS). Combining sensor nodes into unique clusters is the goal of LEACH, a cluster-based routing strategy. Each cluster has a central node called the "cluster head" (CH). However, the PEGASIS protocol relies on a chaining notion in which sensor nodes create a logical chain and each node in the chain relays the information it has seen to the node in the chain after it, and so on. Information gathered by the sensors is transmitted from node to node to a central base station [5].

In the year 2019, the authors of this work presented the main area of interest in this research was hierarchical (cluster-based) routing systems. Additionally, the author thoroughly covered the origins and advancements of the PEGASIS protocol, a thorough explanation of each stage of advancement, and models. Finally, the author provided a comprehensive overview of these protocols by comparing them and determining their favourable and unfavourable effects on WSN. Collecting as much data as possible about its surrounding environment is a WSN's primary goal as transmitting it to its base station, depending on the kind of application for which it is installed. The environment might be a physical system, an information technology framework, or a biological system (BS). Due to the strict energy budget that sensor nodes must adhere to, the energy resource is of the utmost significance in wireless sensor networks (WSNs). Various Routing Protocols, which may be divided into different categories in WSNs, are used by Sensor Nodes to interact with one another [6].

In the year 2021, the authors of this work introduced a novel method for improving the energy efficiency of WSNs utilizing the PEGASIS (Power Efficient Gathering in Sensor Information Systems) routing protocol. This strategy tries to reduce sensor energy consumption as well as maximize the lifetime performance of a network. The findings of the simulation have shown that the suggested protocol performs very well in regard to the amount of energy that it consumes in wireless sensor networks, which ultimately leads to an extension of the network's lifespan. Using the MATLAB environment, the author carried out simulations that compared the suggested method to the conventional LEACH (Low-Energy Adaptive Clustering Hierarchy) methodology [7].

In the year 2021, the authors of this work compared wireless sensor network (WSN) routing methods based on network longevity. The Low Energy Adaptive Clustering Hierarchy (LEACH), Power-Efficient Gathering in Sensor Information Systems (PEGASIS), as well as Threshold Sensitive Energy Efficient Sensor Network Protocol, were selected as the hierarchical routing protocols to compare in this research (TEEN). These network protocols are intriguing to study because they employ hierarchical architectures to conserve energy. Living nodes, average energy wasted, functioning nodes per round, and network lifetime were the four performance parameters that were examined in this research. The researcher analyzed the procedures' performance indicators. PEGASIS has a longer network lifespan and lowers power usage than LEACH, according to the research. TEEN's power usage and network lifespan are both medium. LEACH is appropriate for small networks and during crucial situations. PEGASIS is appropriate for big networks because its low power consumption extends network life [8].

In the year 2018, the authors of this work presented Improved Power-Efficient Gathering in Sensor Information System (PEGASIS) now has a chain-based routing protocol available. However, there are issues when there is a great distance here between nodes or devices, since the protocol selects the leader node to connect with the cell tower as well as connects the sensor nodes to the subsequent nearby nodes. This issue results in significant transmission delays, leader selection, scalability, and uneven energy usage. Performance is increased by introducing an improved PEGASIS protocol that, in comparison to the old PEGASIS protocol, delivers superior energy economy and good longevity sensor networks [9].

In the year 2020, the authors of this work presented. The initial goal of this paper is to examine the LEACH and PEGASIS protocols. Finally, to provide the findings of the comparison research of the LEACH and PEGASIS protocols' energy usage in WSN. Typically, sensors near to the cluster head and their energy reserves are used to construct clusters. LEACH is one of the first approaches to routing for sensor networks (Low Energy Adaptive Clustering Hierarchy). To speed up data transmission, LEACH's central concept is to divide the network into several

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dispersed clusters all at once. A new protocol called PEGASIS (Power-Efficient Gathering in Sensor Information Systems), which has been proposed in place of the LEACH protocol, has been revised. Instead of clusters, Using a chaining structure, PEGASIS ensures that only adjacent sensor nodes may transmit and receive data from one another [10].

3. METHODOLOGY

This study is conducted by simulation of a network of 10 nodes 1 Base Station, the attack detection is carried out by using ANN with trust values of each node.

The Pegasus protocol does the rooting while taking into account the nodes' distance from the base station and their node's remaining energy for leader selection.

The performance is analyzed by running the model several times in order to determine the performance metrics.

4. RESULTS

- **Simulation set up:**

The simulation is done using MATLAB 2021A, the simulated network contains 10 nodes and 1 Base Station as shown in the figure.

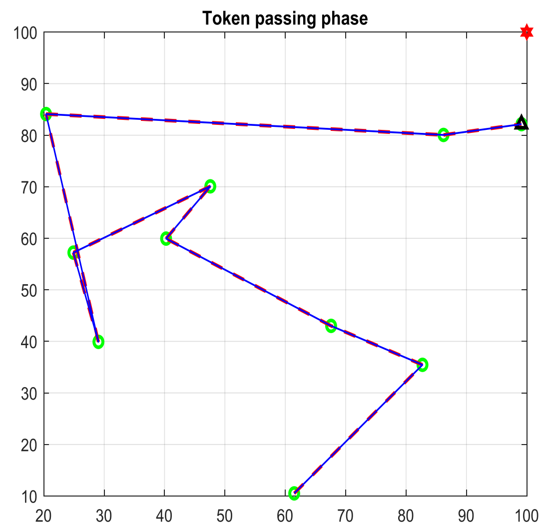

Figure.3: Token Passing Phase

Initially, the simulated network run for N number of times without ANN in order to acquire trust data later on this trust data is used to predict normal and abnormal behaviour of the nodes. The trust data generated from the simulation is used to train the ANN.

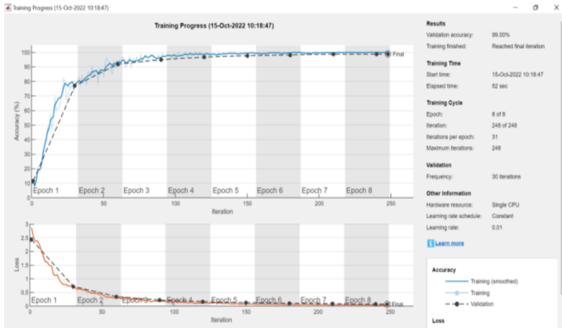

Figure.4: Training Progress

The above figure shows the training accuracy and validation loss of the ANN, and it is absorbable that the accuracy of the model increases epoch by epoch whereas loss value is decreasing epoch by epoch.

The obtained validation confusion matrix is given below

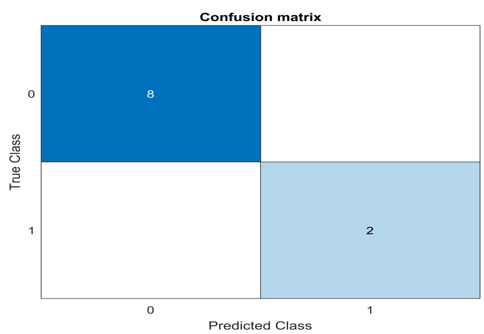

Figure.5 Confusion Matrix

From the above figure it is observable that out of 10 samples ANN can able to predict 8 normal and 2 abnormal nodes correctly.

After training the ANN, it is used to modify the path by ignoring the attack nodes, the performance of the proposed strategy is identifying by running the model for number of dead nodes, throughput, BitError rate, and jitter may all be calculated by running the test a large number of times.

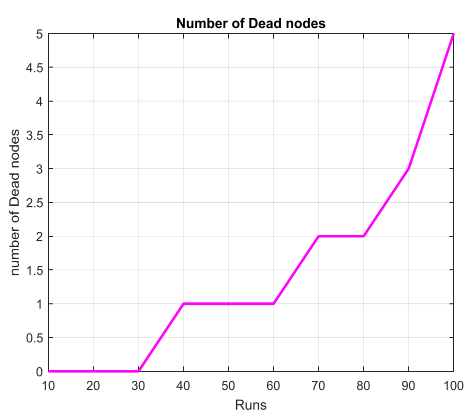

Figure.6: Number of Dead Nodes

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From the above graph, it is apparent that the ratio of dead nodes to runs is growing.

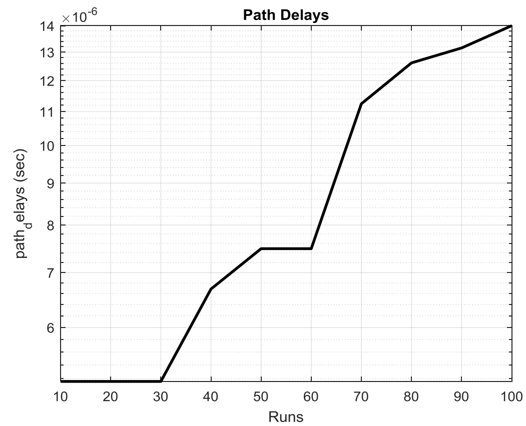

Figure.7: Path Delays vs Runs

From the above figure it is observable that the Path Delays increasing proportionally with respect to the number of runs.

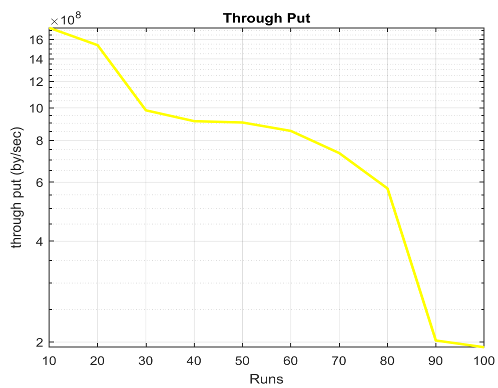

Figure.8 Through Put vs Runs

From the above figure it is observable that the Through Put inversely proportional with respect to the number of runs.

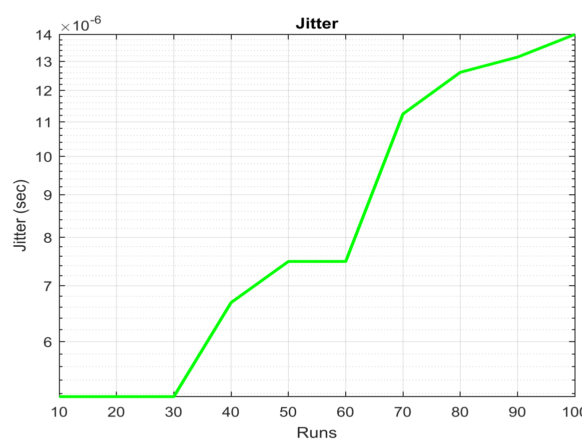

Figure.9: Jitter vs Runs

From the above figure it is observable that the Jitter increasing proportionally with respect to the number of runs.

5. Findings, Conclusion and Suggestions

In this study the simulation is done using MATLAB 2021A, the simulated network contains 10 nodes and 1 Base station, the suggested method's effectiveness is evaluated using the number of dead nodes, through put, bit error rate and Jitter and the trained ANN performance is evaluated with the obtained confusion metrics.

All the obtained performance metrics ensures that our proposed scheme is able to generate a path of lesser distance, energy
efficient and secured.

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