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EPEGASIS PROTOCOL: ENERGY-EFFICIENT AND RELIABLE DATA GATHERING IN SENSOR INFORMATION SYSTEMS

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ABSTRACT

Wireless Sensor Networks (WSNs) have grown in importance in the modern era due to advancements in communication and wireless sensor technology. Wireless sensor networks (WSNs) use gateway routers to transmit data collected from tiny sensor nodes to a large base station (BS) that focuses on environmental, biological, and physical factors. Access this info whenever and anywhere you choose. When sensor nodes have insufficient power, it might shorten the lifespan of a WSN. When it comes to communicating with sensor nodes, more than one routing method is at your disposal. Data transmission uses more electricity. That is why minimizing power consumption in WSNs is crucial. Researchers are continually looking for better data transmission methods to extend the lifespan of WSNs. In this study, we present the E-PEGASIS protocol, which is an extension of the PEGASIS protocol that allows for more efficient data transport in sensor information systems. The suggested method considers the average distance between sensor nodes when establishing chaining and communicating the radio range value of the furthest node to the base station. The next step is for it to configure radio links between nearby nodes. Before continuing to chain with the next node, each sensor node measures its distance to the other end of the connection to make sure data is transferred more effectively. Results from simulations show that the proposed network is more resilient than the LEACH and PEGASIS security protocols.

Keywords: Wireless Sensor Networks (WSNs); LEACH and PEGASIS

1.INTRODUCTION

To save power while transmitting data from sensors to base stations, the Low-energy Adaptive Clustering Hierarchy (LEACH) protocol creates small clusters. In a cluster, each node will collect data from its local area, add it up, and then transmit it to the main station. Compared to methods based on direct communication, the LEACH protocol's randomization made it a better choice for rotating the cluster head. It is among the most advanced choices for WSN data transport. The PEGASIS protocol was developed by **Kumar and Khunteta (2018) and Wang et al. (2018),** who both built upon earlier protocols and made improvements to them. Its foundation is the concept of near-optimal chaining, and it outperforms the LEACH protocol.

According to **Mahakud et al. (202116),** the PEGASIS protocol states that nodes should only communicate with their nearby neighbors before transmitting data to the base station (BS). It reduces the energy usage for one round as a result. One of the main ideas behind PEGASIS's architecture is to arrange sensor nodes in a chain such that they may all receive data and send

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it on to their neighbors. After information has been sent from one node to another, it will be fused. Finally, the designated node must send data back to the control center. **Gherbi et al. (2017)** compared constructing chaining to solving the intractable travelling salesman issue in terms of reducing data transmission length.

2. Literature review and research gap

Recent studies have extended the classic PEGASIS protocol to further augment energy efficiency in WSNs. For instance, **Adedokun, & Dahunsi, (2021),** introduces optimized chain formation and efficient leader selection to prolong network lifetime under real-world constraints Additionally, **Hassan Oudani, & Elmaimoun, (2018),** improves network longevity by over 10 % through multi-hop enhancements and refined cluster-head choices. While these advancements contribute meaningful performance gains, they largely rely on static criteria for chain construction and leader assignment, which may become suboptimal as node residual energy or topology dynamics change.

There remains a need for protocols that incorporate dynamic leader selection based on both residual energy and proximity to the sink, along with adaptive chain reconstruction to mitigate the impact of node failures. Addressing these aspects could significantly improve load balancing, extend network lifetime, and maintain data reliability in evolving network scenarios.

3.METHODOLOGY

E-PEGASIS is a protocol for an improved chain-based network. Identical to the PEGASIS model in its construction, the E-PEGASIS protocol is now under consideration (Lindsey, & Raghavendra, 2002). However, the suggested model was updated to include a few changes to the leader selection process. The following are the three main components of the proposed algorithm:

- **Construction of Chain Phase**

In the E-PEGASIS algorithm, the chain construction phase is the initial step. At the outset, the nodes in the network are dispersed across the field. After that, apply the greedy method to set up the chain in the network and make sure there's enough energy in the field. You can see a typical chain network in figure 1.1. In figure 1.2, the steps for building the network chain is shown in great detail.

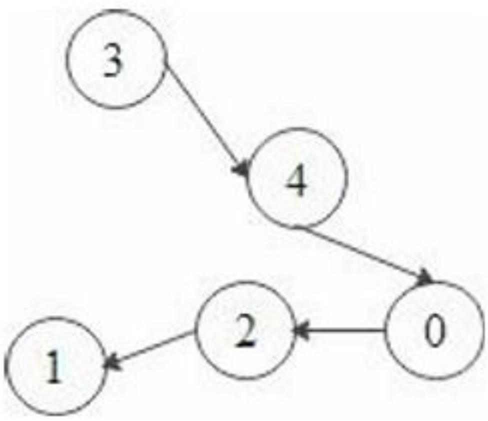

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Fig. 1.1. Sequence formation using a greedy approach

- **Improved Leader Determination Step**

The second step of the E-PEGASIS algorithm is to enhance the leader selection phase. A leader node, node *i,* chosen at random in the chain, is responsible for transmitting data to the base station (BS) in the PEGASIS protocol. To choose a random node for the next data transmission cycle to BS, apply the formula i mod x, where x is the number of nodes. We need to randomly select a new leader for every communication cycle if we don't want nodes to die of power outage. But in our proposed E-PEGASIS protocol, the weight W provided to each node determines who will be the first chain leader. The weight, W, of each node is determined by averaging the remaining energy with distance from the base station. It compares the weights of each node in the network. The network's computations will place the node with the greatest weight at the beginning of the chain. For every node *j* in a network chain, the distance to the parent node (d_p) is measured and compared to the distance to the sink node (d_s). After (d_p) is equal to or greater than (d_s) node *j* will be named the secondary chain leader. The data is sent to the sink node instead of the parent node. We can write

$$W_j = \frac{RE_j}{d_j} \dots \dots (1.1)$$

The symbol RE_j represents the residual energy of sensor node *j*, whereas the symbol d_j represents the distance between the sink and sensor node *j*.

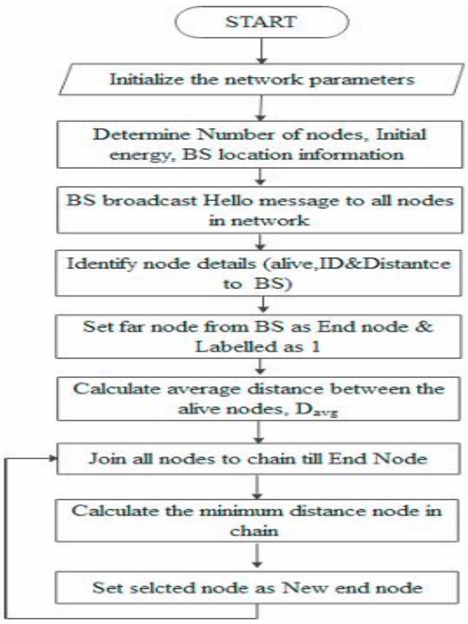

Fig. 1.2 Workflow of Chain Building

- **Data Transmission**

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Phase Once chain creation and leader selection are finished successfully, data transmission can commence. Using a token passing mechanism, the leader node initiates data transmission from several nodes with a single link. As the time slots are assigned in a chain using TDMA, every node transmits data that it has detected to its neighboring node. The nodes in close proximity will combine their own data with that which they receive and send to the master node. The round will be closed and the chain will be rebuilt for future transmission after BS receives the data from the leader. When simulating an experiment, it is useful in cases where the chain node dies.

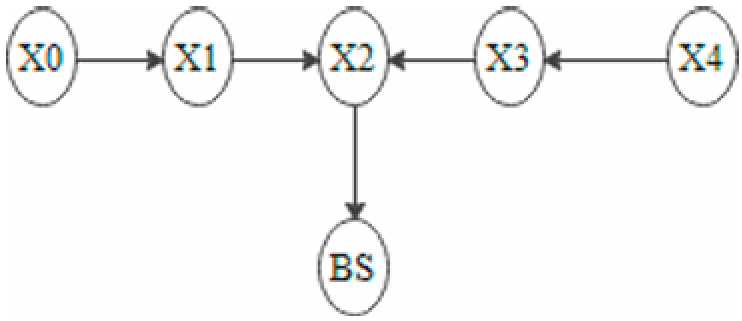

Fig. 1.3Token Passing Approach

The leader of the chain is the X2 node in Figure 1.3. The token was sent by the X2 node to the X0 node along with the chain. After then, data will be sent by the X0 node to the X2 leader node. X2 will transmit the token to the X4 node after receiving data from the X1 node. Afterwards, node X4 promptly transmits its data to X2. At last, X2 transmits the combined data to the BS, the base station.

4.PERFORMANCE EVALUATION

To evaluate the efficacy of the proposed regimen, the following criteria are considered: Data packets received by the base station, nodes actively transmitting data, remaining energy, and total energy used.

a. Energy consumed: An overall measure of the network's energy consumption. Energy available at start and finish points are different.

b. The quantity of energy that is left in the network, also known as residual energy.

c. Data packet count at BS: The sum of all data packets received by the base station or the quantity of information sent from the sensors to the base station.

d. Nodes still alive: The total number of nodes that did not drain their power supply before transmission ended.

e. Count of dead nodes: How many nodes in the network have stopped sending and receiving data due to power outages..

- **Results**

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Throughout the lifecycle of a network, from startup to shutdown, the aforementioned metrics are employed to ascertain the network's stability. The duration of data transmission from the network to the base station is called its lifetime.

By contrasting E-PEGASIS with both the PEGASIS and LEACH protocols, the performance of the proposed work is assessed **(Nehra, & Sharma, 2013).** As can be seen in Table 1.1, the software takes into account all of the simulation settings when it runs. We had anticipated that a 100 x 100 m area would be sufficient for the Wireless Sensor Network. In this hypothetical network topology, there are 100 nodes. At startup, the LEACH, PEGASIS, and E-PEGASIS algorithms all use the same amount of energy for each node in the network. If a node dies during the simulation, it will be classified as dead due to energy limits.

Table 1.1 Simulation Parameters

Parameters	Value
Size of Network	100×100 m
Number of nodes	100
Size of the data packet	2000 bits
Initial energy to nodes	0.5 J
E_{elect}	$60\ nJ/bit/m^2$
Efs_{fs}	$15pJ/bit/m^4$
Effusion	6 nJ/bit/ message

According to the results of the simulations, E-PEGASIS was able to accomplish:

1.The number of rounds completed is almost double compared to the LEACH and PEGASIS protocols.

2. Reducing energy consumption evenly across sensor nodes to maximize sensor network utilization.

3. Improved the network's lifetime by maximizing the amount of packets received at the base station while reducing energy usage.

4. When compared to current PEGASIS and LEACH based systems, the amount of live and dead nodes in the network is greater in the proposed E-PEGASIS. Figure 1 shows that E-PEGASIS outperforms LEACH and PEGASIS by 20% in terms of the number of packets received at the base station.

5. Our proposed method makes the sensor fields cut-off once a dead node is detected in the chain by identifying patterns in the network. This, in turn, makes sensor data available to the network for a longer duration..

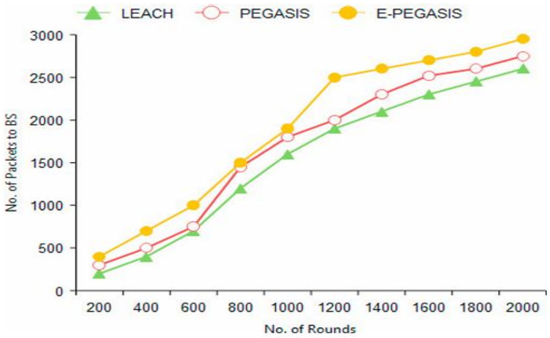

Fig. 1.4 Number of Packets Delivered to BS

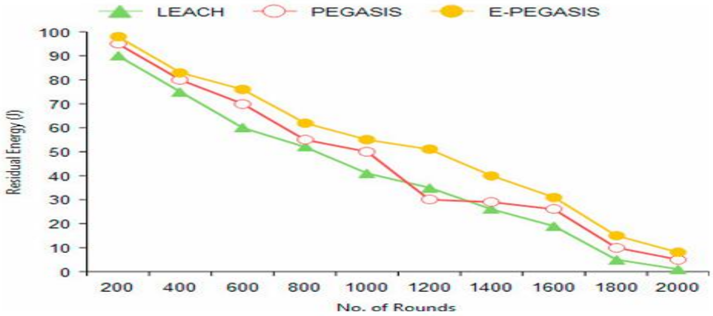

Fig. 1.5 Total Residual Energy

Figure 1.5 shows that E-PEGASIS has a longer network lifetime due to decreased energy loss during data transmission. Detailed comparison of network live nodes is shown in figure 1.6. The proposed network has a longer lifespan since the first node lives long and provides sensor data for a long time. Existing approaches like PEGASIS and LEACH have approximately identical energy dissipation at all network nodes, however E-PEGASIS has varying levels, with the end node having the highest. All of these factors made network lifetime more stable.

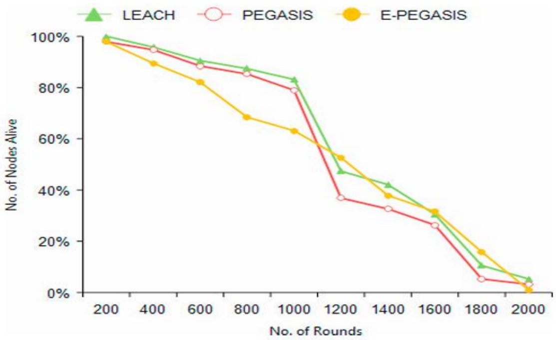

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Fig. 1.6 Number of live nodes

Energy consumption method E-PEGASIS is shown in Figure 1.7. Figure shows that the suggested method uses less energy than PEGASIS and LEACH due to network node coverage during simulation. In the suggested strategy, dead nodes are quickly identified and removed from network activity. Reduce the number of nodes covered to save energy by eliminating dead nodes during simulation.

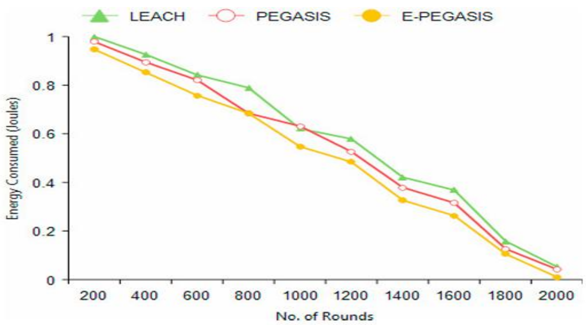

Fig. 1.7 Energy Consumption

5.CONCLUSION

Several issues arise for protocols constructed with PEGASIS due to data transfer delays. In this study, we propose a technique for more efficient energy gathering in sensor information systems; we call it E-PEGASIS. In addition to providing a threshold value for the network chain, the proposed method enhances the leader node selection process and simplifies network construction. The proposed strategy for chaining construction speed is much faster than LEAHC and PEGASIS. Overall, the simulation results demonstrate that E-PEGASIS outperforms PEGASIS, LEACH, and the other methods by attaining maximum energy efficiency and extending the lifetime of the network.

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