Journal of Theoretical and Applied Information Technology
31st May 2024. Vol.102. No. 10

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

DISTRIBUTED LEDGER TECHNOLOGY ON ENHANCED PEGASIS ALGORITHM FOR MOBILITY MANAGEMENT IN WSN

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ABSTRACT

Today, in order to monitor and observe many factors in any environment wireless sensor technology is being widely used. Sensor node is the major component of WSN which lacks in its limited energy resources and lifetime duration. The deployment of sensors takes place in a hostile environment that is typically unavailable for the replacement of worn-out batteries. As a result the sensors have to use their original energy to do those tasks. Due to this restriction, energy efficiency is a crucial WSN characteristic. To get over these constraints Distributed Ledger Technology (DLT) and Enhanced PEGASIS (Power-Efficient Gathering in Sensor Information Systems) Algorithm can be integrated to enhance mobility management in Wireless Sensor Networks (WSNs). DLT, commonly associated with block chain technology, offers a decentralized and immutable ledger for recording transactions across a network of nodes. While PEGASIS is an energy-efficient data gathering algorithm that organizes sensor nodes into a chain topology and employs a greedy algorithm to minimize energy consumption during data transmission. For enhancing mobility management, energy efficiency, security, and resilience in Wireless Sensor,an overall, integrating Distributed Ledger Technology with the Enhanced PEGASIS Algorithm was introduced. The results revealed that the network lifetime has improved using DLT-EPEGASIS when compared to the previous protocols like LEACH and PEGASIS

Keywords: *WSN, Energy Efficiency, EPEGASIS, LEACH*

1. INTRODUCTION

WSN is a network composed of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc., and to cooperatively pass their data through the network to a main location. Improving the lifetime of sensors in Wireless Sensor Networks (WSNs) is crucial for ensuring the longevity and effectiveness of these networks[1],[2]. Here are some strategies to enhance sensor lifetime. By implementing energy-efficient protocols at various layers of the network stack, including the physical, MAC, routing, and application layers. For instance, protocols like LEACH (Low Energy Adaptive Clustering Hierarchy) and DEC (Deterministic Energy efficient clustering protocol) are designed to minimize energy consumption.[3],[4]. Using data aggregation techniques to reduce the amount of data transmitted over the network. Aggregating data at intermediate nodes can help in reducing redundant transmissions and hence conserve energy[5][6]. Using localization techniques to accurately determine the positions of sensor nodes. Knowing the exact locations of nodes can help in designing more efficient routing protocols and minimizing energy consumption during data transmission. Pegasus refers to a routing protocol designed for Wireless Sensor Networks and Its primary aim is to enhance the network's energy efficiency and extend its lifespan while maintaining reliable data transmission[7][8][9]. In Pegasus, sensor nodes are organized into clusters, with each cluster having a cluster head responsible for managing intra-cluster communication and coordinating inter-cluster communication. Pegasus may introduce overhead due to the maintenance of the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

hierarchical structure and the communication overhead associated with cluster heads. Since each cluster has a single cluster head, the failure of a cluster head can disrupt communication within the cluster[10][11][12][13][14].To overcome EPEGASIS an enhanced version of the Pegasus routing protocol was introduced. EPEGASIS optimizes energy consumption by minimizing unnecessary communication and reducing the overhead associated with routing. It is designed such that to adapt changes in network topology and environmental conditions, making it suitable for dynamic WSN deployments. Enhanced PEGASIS algorithm for mobility management in WSNs may include Dynamic topology reconfiguration, Mobility prediction, Energy-aware routing, Fault tolerance In simple, when nodes move, the algorithm may reorganize the chain structure or establish new communication paths to maintain efficient data transmission. The algorithm may incorporate mobility prediction techniques to anticipate node movements and proactively optimize network topology before nodes actually change their positions. Enhanced PEGASIS takes into account the energy consumption of mobile nodes when selecting communication paths and organizing the network topology. It aims to minimize energy expenditure while ensuring timely and reliable data delivery. The algorithm may include mechanisms to handle node failures or disruptions caused by node mobility. It can dynamically reroute data paths and reconfigure the network to maintain connectivity and data transmission reliability. Enhanced PEGASIS may face challenges in maintaining network connectivity and data integrity in the presence of node failures or mobility-induced disruptions. Ensuring fault tolerance and resilience against unpredictable events is crucial for the robust operation of WSNs, especially in dynamic environments. To overcome Distributed Ledger Technology (DLT) is introduced along with EPEGASIS algorithm. DLT, commonly associated with block chain technology, offers a decentralized and immutable ledger for recording transactions across a network of nodes. It ensures transparency, security, and trust among participants without relying on a central authority. Each node in the network maintains a copy of the ledger, and consensus mechanisms ensure agreement on the state of the ledger. Integrating DLT with the Enhanced PEGASIS Algorithm in WSNs can offer several benefits like Security and Integrity, Decentralization, Trust and Accountability, Efficient Resource Management and Fault Tolerance and Resilience. The designed work clearly states the effectiveness of key performance metrics such as energy efficiency, packet delivery ratio, end-to-end delay, and network lifetime Overall, integrating Distributed Ledger Technology with the Enhanced PEGASIS Algorithm can enhance mobility management, energy efficiency, security, and resilience in Wireless Sensor Networks, making them more suitable for various applications, including environmental monitoring, industrial automation, and smart cities.

1.1 Methods and Materials

The primary procedures for using the intended model are

1.1.1 Network Design

Consider a 10000 square meters of communication area. In our scenario, 100 nodes are deployed. All these nodes are divided into 4 equal parts having 25 nodes in each part. Using uniform random distribution the nodes are partitioned randomly into areas with identical spacing. The mobility of sink is in such a way that it completes its trajectory in one round collecting the data from each cluster head. In each round the sink will stay for a specific period of time at each cluster while collecting the data from cluster head. We determine the energy used by sensors to transmit data using first order radio model

$$(k, d) = E_{tx} - \mathrm{E}(k) + E_{tx} - \mathrm{E}_{amp} (k, d) \quad (1)$$

$$E_{rx} (k) = E_{rx} - \mathrm{E}(k) \quad (2)$$

$$E_{DA} (k) = E_{DA} - \mathrm{E}_{elec} (k) \quad (3)$$

Where

E_{elec} : The energy that consumed by the radio to run the transmitter or receiver circuitry, (equal to50 nJ/bit).

E_{amp} : The required energy for transmitter amplifier, (equal to 100 $J/bit/m^2$)

K : Number of bits.

D : distance

E_{DA} : The energy that consumed by Transmitter circuitry to aggregate the data received by the child nodes, (equal to50 nJ/bit).

1.1.2 Working diagram of EPEGASIS

In EPEGASIS [15], [16] transmission and reception of data between cluster head and neighbors are done by capturing the communication range between one and another also it is purely performed on residual energy rather than initial energy.

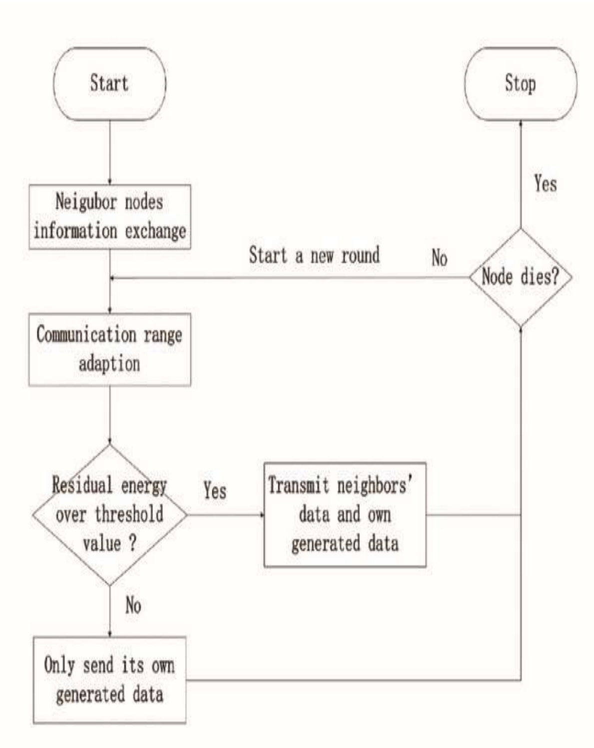

Figure 1: Flowchart For EPEGASIS

1.1.3 Algorithm for Distributed Ledger Technology:

We considered four chains in our proposed model. The chain formation is done in the following way:
Step 1: To obtain information about each node, sink delivers hello packets to each node.
Step 2: The sink calculates its distance from each and every node of the cluster to identify theextreme node.
.Step 3: The chain formation takes place initially from the extreme node x. x finds its nearest node y and connect withit.
Step 4: Similarly, every node finds its nearest neighbor by calculating its distance from the other nodes and forms achain..
Step 5: Each node x in the chain that receives the data from the node y, is a parent to node y while node y is a child ofnode x.
All four regions go through the same chain formation process, resulting the production of four chains.

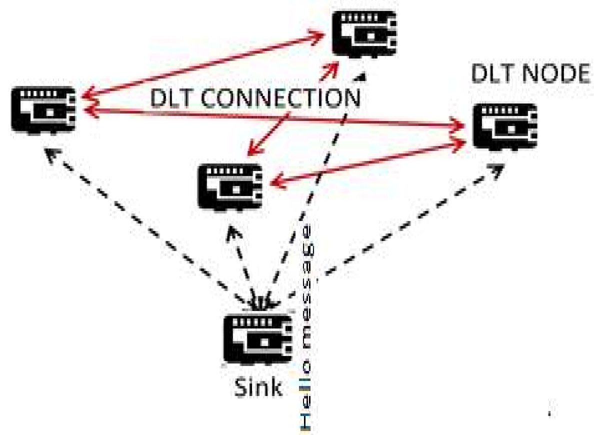

Figure 2 : Connection Utilization And Broadcasting Of Messages Between Sink And DLT Nodes.

1.1.4Selection of Leader Node

Leader node is elected based on the quantity 'R', which is the ratio of residual energy of the each node to its distance from the sink. The node whose 'R' value is maximum becomes the chain leader.

$$R_x = \frac{E_x}{D_x}$$

(4)

Where,
E_x : Residual Energy of Sensor node
D_x : Distance between Sensor node x and sink.

1.1.5 Mobility of Sink

We assume that the sink has infinite energy and its mobility is employed to enhancing network lifetime. Sink move in a trajectory path from one region to the region and it stays for a temporary period of time at each region until it collects the data from the leader node. The coordinates are chosen to collect the data from the leader node by sink.

2 EXPERIMENTAL METHODS

2.1Proposed Algorithm for Mobility of Sink:

Designing algorithms for the mobility of sinks in wireless sensor networks is crucial for efficient data gathering, energy management, and network lifetime extension. The main aim is to provide reliable data transmission between sink and chain leaders.
Sink mobility consists of three stages
Stage 1: The time taken by sink at a particular location where it collects the data is calculated first.
Stage 2: Based on time profiles, sink starts its

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journey by identifying locations, where it collects the data.

Stage 3: In this stage, sink calculates the time taken to collect data in complete one round.

The sink calculates the total time at all 4 locations in one round using following equation.

$$T_s = \sum_{i=1}^{4} T_I \qquad (5)$$

Ts: Total time taken in one round.

$$\sum_{i=1}^{4}(Ti) \qquad (6)$$

Subject to:

$$x_{ij} = \begin{cases} D & if\ i = j \\ 0 & otherwise \end{cases} \qquad (7)$$

Xij: No. of bits transmitted between chain leaders and sink at locations i & j, i=1, j=4.

D: Data transferred between leader nodes and the sink.

2.2 Transmission of Data

In EPEGASIS protocol all the cluster members need to transmit the data directly to cluster heads, therefore all the nodes in a cluster are formed as a chain. Leader node sends a token to the extreme node Leader node sends a token to the extreme node. Extreme node sends data to the next neighboring node after sending its data. The same process is continued, each node x passes token to the next neighboring node (x-1) after sending its data. In this way all nodes in the chain send their data to the leader node, sink moves to each chain and collects data from leader node[17],[18],[19],[20]. Since token passing mechanism is the basis for data transmission in DLT EPEGASIS, the process of token passing begins with the extreme nodes and moves towards the leader nodes of the chains. The TDMA mechanism is used for process of transmission of data, if any node 'x' is having more than one child. In DLT EPEGASIS the smaller chains primarily reduce the time in data delivery. The novel aspects of this proposed work mainly aimed at improving the efficiency and adaptability of sensor networks in dynamic environments.

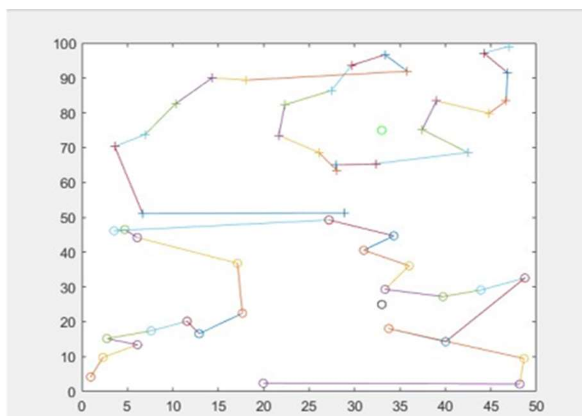
3. SIMULATION AND RESULT

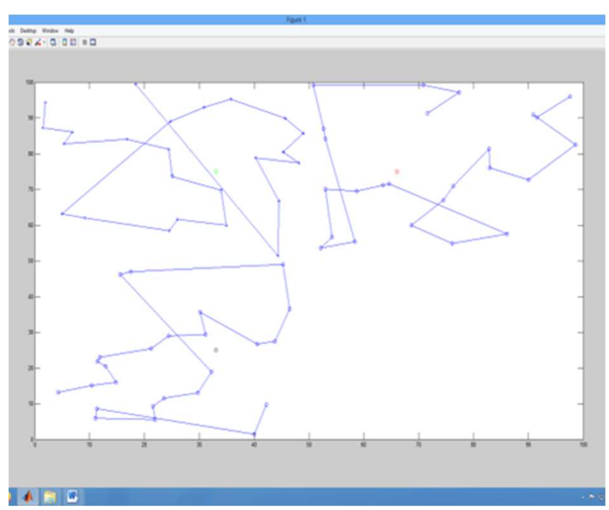
In this section, we use MATLAB to evaluate the performance of sink mobility in DLT EPEGASIS. For WSN, we consider an area of 100m×100m. In our suggested scenario, 100 nodes are then divided arbitrarily into four evenlyspaced sections, totaling 25, 25 in four parts. The idea of sink mobility is that the sink can move between the centersof areas that are evenly spaced apart and complete its course in a single round. For this, we perform simulation for 5000 rounds.

Table. 1: Fundamentals For Simulation

Fundamental	Value
Network radius®	300m
Number of nodes (N)	100
Packet length (l)	500 bits
Initial energy (E_0)	0.05J

The Fig.3 represents the chain formation and locations where sink collects the data from Leader node. All the nodes in the communication region formed as chains.





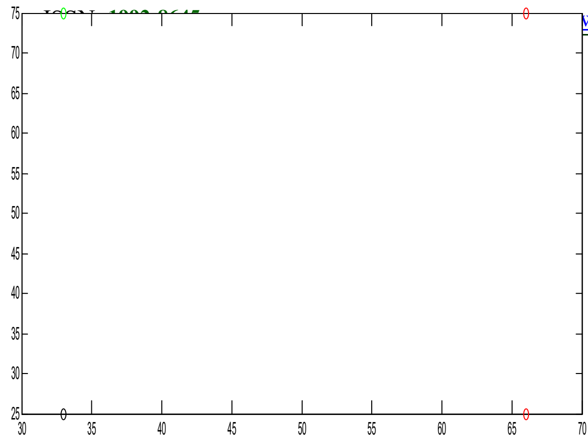


Figure 3: Simulation Results Of (A) Chains Formation And (B) Sink Halt Locations At Starting, Middle And (C) End Of Rounds

3.1 The Dead Nodes

When a node's energy level drops to zero, it is considered to be died. Fig.4 estimates and shows the total number of dead nodes for each data transmission cycle. According to our estimates, sink mobility with EPEGASIS with DLT significantly lengthens the duration of instability and improves coverage. The smaller chains also make it preferable for applications that are sensitive to delays.

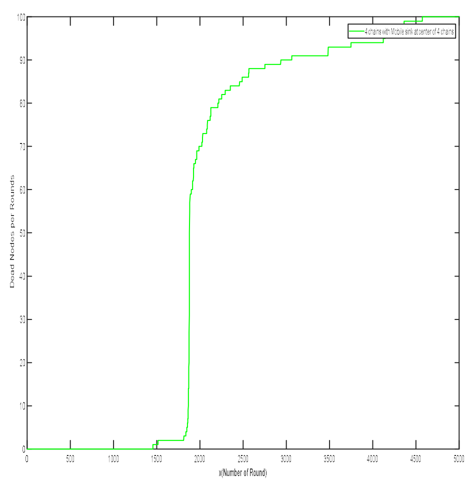


Figure 4: Count Of Nodes That Just Aren't Alive

After the first 25 nodes in each of the four regions die, the remaining nodes of the multi-chains have relatively short distances between them due to minor chains in the simulation process. Due to sink mobility, there is less delay in data delivery in the last 1000 rounds in leader and is smaller in sink. The nodes transmit more packets to BS since the proposed protocol's network lifespan is substantially longer than the previous one i.e., it has high throughput. A lot of vacant spaces are created during the last 1000 rounds of instability, which results in a network with a sparse structure. The BS receives more packets in our proposed scenario because, despite the big vacant spaces, our proposed approach provides superior coverage in the last 1000 rounds. The initial energy of all the nodes will be 0.5 joules in the process of simulation. The nodes are said to be "dead" if they run out of energy and can no longer send or receive data.

Table 2: Comparison Table Of LEACH, PEGASIS, MC-PEGASIS, And EPEGASIS With DLT In Terms Of Dead Nodes

No. of Rounds	*Dead Nodes*			
--	*LEACH*	*PEGASIS*	*MC-PEGASIS*	*EPEGASIS with DLT*
1500	*99*	*5*	*1*	*0*
2000	*100*	*31*	*20*	*10*
2500	*100*	*96*	*90*	*80*
3000	*100*	*100*	*98*	*90*
3500	*100*	*100*	*100*	*100*
4000	*100*	*100*	*100*	*100*

3.2 The Number of Alive Nodes

Fig.5 demonstrates that the network lifetime and stability period are considerably better and are around 4300 cycles. The chain leaders in this proposed protocol die more slowly as a result of sink mobility. The period of instability is the interval between the first and last living nodes in the network dying at the same instant. As a result of the efficient energy distribution in our proposed scenario, instability time is improved over that of earlier protocols.

The alteration of the chain in each round makes it feasible to use energy efficiently. The initial node in this protocol expires after approximately 1500 rounds. Additionally, the first 10 nodes lifetime is significantly increased compared to the previously discussed ways since less strain is placed on the chain leaders, which results in network-wide load balancing. Distances between connected nodes are shorter in the multi-chain idea than in the single chain, and as a result, less energy is used to transmit data. Therefore, network residual energy declines more gradually.

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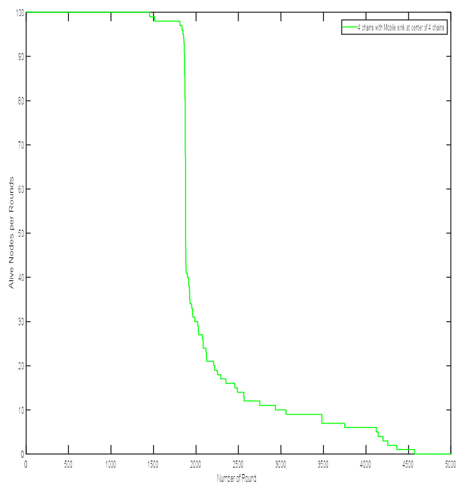

Figure 5: Network Lifetime

Table 3: Comparison Table Of Leach, Pegasis, Mc-Pegasis, And Epegasis With Dlt In Terms Of Alive Nodes

No. of Rounds	Alive Nodes			
--	LEACH	PEGASIS	MC-PEGASIS	EPEGASIS with DLT
1500	1	95	99	100
2000	0	69	80	90
2500	0	4	10	20
3000	0	0	2	10
3500	0	0	0	0
4000	0	0	0	0

More effective use of energy results in a 79% longer network lifetime in this protocol than in the earlier method. The network runs out of life with our suggested approach at 4300 rounds, making the instability time 86% longer than with other protocols. The long link (LL) issue is eliminated by the multi-head chain model by transferring data directly to the sink in the event of a distant parent node and it further reduces the time taken for data to reach the base station.

3.3The Residual Energy

The residual energy of this well-proven technology steadily depletes after 5000 cycles, confirming its dependability. As the energy of our established model gradually depletes, the network's lifespan is increased to additional rounds. The simulation results demonstrate that the residual energy of the network over rounds rapidly diminishes, and our suggested technique utilizes energy very well.

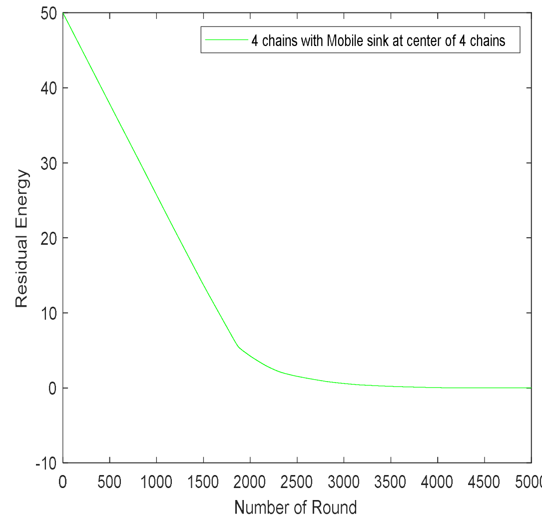

Figure 6: The Residual Energy

As the sink is mobile in this proposed work, there is less distance between the chain leaders and the sink, requiringless energy to transfer data.

Table 4: Comparison Table Of LEACH, PEGASIS, MC-PEGASIS, And EPEGASIS With DLT In Terms Of Residual Energy

No. of Rounds	Residual Energy			
--	LEACH	PEGASIS	MC-PEGASIS	EPEGASIS with DLT
1500	13	18	30	34
2000	2	9	21	27
2500	0	5	16	22
3000	0	1	3	11
3500	0	0	0	0
4000	0	0	0	0

3.4 The Normalized Average Energy

According to the simulation results, this suggested protocol uses 2% less energy on average for sensor nodes throughout the course of rounds than the previous approaches. The sparse nodes are closer to the base station because of the shorter distance between them, which results in significant energy savings.

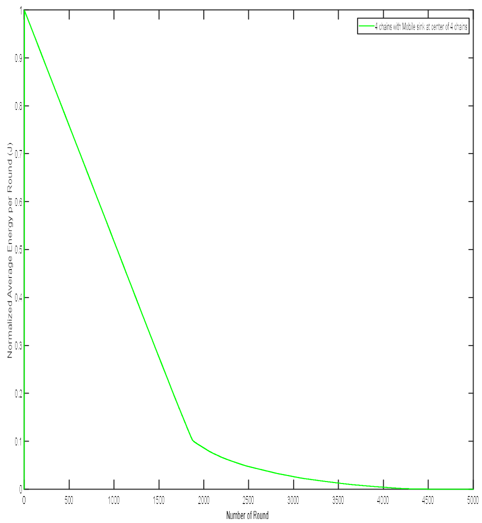

Figure 7: Normalized Average Energy

Table 5: Comparison table of LEACH, PEGASIS, MC-PEGASIS, and EPEGASIS with DLT in terms of Average Energy

No. of Rounds	Average Energy			
--	LEACH	PEGASIS	MC-PEGASIS	EPEGASIS with DLT
1500	0.13	0.18	0.3	0.34
2000	0.02	0.09	0.21	0.27
2500	0	0.05	0.16	0.22
3000	0	0.01	0.03	0.11
3500	0	0	0	0.06
4000	0	0	0	0.01

3.5 Comparison Results

The comparative outcomes of the developed technique are examined in this section. it is found that EPEGASIS with DLT is more efficient than remaining protocols.

Table 6: Total Energy for the network

No. of Rounds	Total Energy			
	LEACH	PEGASIS	MC-PEGASIS	EPEGASIS with DLT
1500	477	1193	1406	1478
2000	377	1007	1183	1203
2500	241	830	997	1005
3000	201	664	817	889

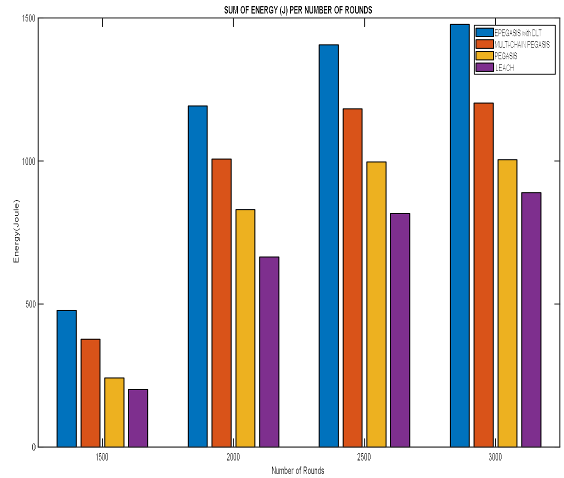

Figure 8: Comparison of Energy Consumption in LEACH, PEGASIS and EPEGASIS with DLT

4 CONCLUSIONS AND FRAMEWORK

In conclusion, the integration of Distributed Ledger Technology (DLT) with the Enhanced PEGASIS (Power-Efficient Gathering in Sensor Information Systems) algorithm presents a promising approach for mobility management in Wireless Sensor Networks (WSN). Through our research, we have demonstrated the potential of combining DLT's decentralized and tamper-resistant characteristics with the efficiency and adaptability of the Enhanced PEGASIS algorithm to address the challenges of mobility in WSNs. Our study has shown that leveraging DLT enhances the security, reliability, and integrity of data transmission and storage in WSNs. By employing a distributed ledger, we can maintain an immutable record of data transactions and network events, ensuring transparency and accountability across the network. Moreover, the decentralized nature of DLT mitigates the risk of single points of failure and malicious attacks, thereby enhancing the overall resilience of the WSN. Furthermore, integrating DLT with the Enhanced PEGASIS algorithm improves the efficiency of data aggregation and routing in dynamic WSN environments. By utilizing smart contracts and consensus mechanisms, we can automate and streamline the process of node selection, data aggregation, and task coordination, thereby optimizing resource utilization and prolonging network lifespan

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

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