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Mobile Sink-Based Multi-Chain Pegasis Protocol for Improving the Lifetime of WSNs

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Abstract: This paper presents the improved multi-chain PEGASIS (Power-efficient gathering in Sensor Information Systems) with sink mobility to extend the wireless sensor network's (WSN's) lifespan. In proposed algorithm, whole network space has been divided into four smaller sub-regions and further greedy formula has been severally imposed in each sub-region to form a chain. The idea of the intelligent sink has been additionally used as the intelligent sink moves on its trajectory and stays for needed time at a prefixed location in all regions to assemble information from nodes. In this work, the mobility of sink has been enhanced in terms to boost the lifespan of the network by selecting superior sojourn locations. As by investigation, it is concluded that the additional scope of improvement has been acquired in MIEEPB (Mobile based improved energy efficient Pegasis-based protocol) by using compressive sampling. Simulation results show that the proposed protocol attain better results than the MIEEPB protocol in terms of normalized average energy and instability period.

Index Terms: MIEEPB, Sojourn location, WSN (wireless sensor network), Mobile sink, 2D-DCT.

I. INTRODUCTION

The development in wireless communication has evoked lots of attention in wireless sensor networks (WSNs). Owing to this growing attention, the nodes having small size, low cost and with less power consumption are developed. Wireless communication is the transfer of data over an expanse without employing electrical wires and conductors. It permits long-range communication that is unfeasible or impractical to be implemented by means of wired network only [1]. Many routing power management, and data dissemination protocols have been exclusively planned for wireless sensor networks where energy efficiency is a necessary design concern. To enhance energy potency, several researchers have advised numerous routing algorithms [3, 5]. The foremost objective of the design of numerous protocols is the energy proficient characteristics that are enhanced from time to time by researchers. Routing is a method of shaping a pathway between source and destination upon request of data transmission. Many energy-aware routing protocols have been proposed earlier by researchers such as LEACH (low energy adaptive clustering hierarchy), PEGASIS (Power-efficient gathering in Sensor Information Systems), and IEEPB (improved energy efficient PEGASIS-based protocol) etc [1, 3, 5].

Therefore based on the existing routing PEGASIS protocol, a modified protocol has been proposed and presented with the aim to lessen the energy expenditure of WSN. Pegasis is the well-known chain-based routing technique for data assembly. The sink is located far from sensor nodes. All sensor nodes are using global positioning system (GPS) to know their own location and that of their neighbor nodes [4].

In Pegasis, all sensor nodes in the network are randomly deployed as shown in Fig. 1. The sensor nodes are restricted with the same initial energy. These sensor nodes can manage their power and can communicate with the neighbor nodes or the sink directly. The sensor nodes deployed in the areas persistently gather data from that area and forward it to BS (Base Station) [1].

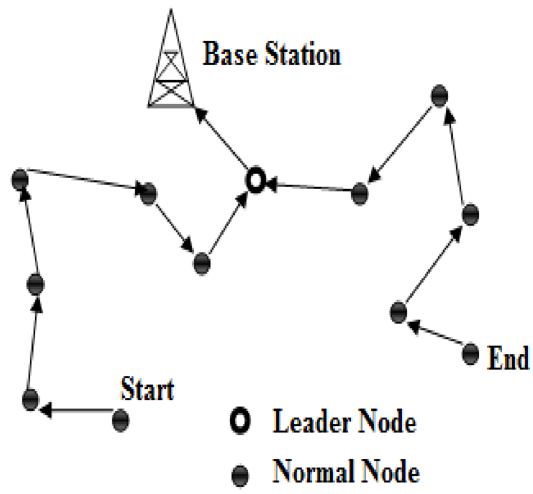

Fig.1. Formation of chain using nodes in Pegasis

In recent years, researchers have proposed numerous improved chain based protocols such as IEEPB (Improved Energy-Efficient Pegasis-Based protocol), MIEEPB etc [5, 8]. Improved Energy-Efficient Pegasis-Based protocol (IEEPB) is an improved technique of Pegasis. As Pegasis construct the chain using the greedy algorithm, it can cause extended remoteness between two nodes. Therefore, extra energy gets consumed in transmitting the data and the nodes die early. So, the efforts have been intended at establishing a new efficient information gathering method for mobile sinks as compared to the usual schemes. In this paper, a novel mobility technique has been proposed to guarantee information gathering from all nodes fairly in order to manage all the nodes of the network.

II. PREVIOUS WORK

The need of preserve energy to enlarge the network lifespan is the most critical issue in the design of WSNs. In wireless sensor network, routing is an important and vital aspect. The focus of this section is to present a brief description and review of various routing protocols deployed to improve the network lifespan. S. Lindsey et.al [4] exploited PEGASIS that is a chain based routing protocol and this protocol is an improved form of LEACH. In this technique, all nodes communicate with only close neighbor. Feng Sen et.al [5] introduced improved EEPB (Energy-Efficient PEGASIS-Based protocol) is a chain-based protocol which has few limitations. This technique adopts a much sensible method to form the chain in the network. This simplifies the formation of chain and avoids the construction of LL (Long Link). M. R. Jafri et.al [8] introduced the sink mobility in IEEPB (improved energy efficient PEGASIS-based protocol) to enhance the Wireless Sensor Networks (WSNs) lifespan.

The multi-head chain, sink mobility and multi-chain concept have great influence in enhancing the network lifetime of wireless sensors. From the survey carried out, it's gathered that energy consumption is one in all the primary hard factors for deploying wireless sensor networks. There is need to saving energy of nodes by proficient utilization of energy. For this motive, a range of techniques and algorithms are proposed by numerous researchers [7].

III. NETWORK MODEL

In this section, an improved technique has been proposed based on existing routing technique MIEEPB. During setup division, preliminary procedures to data communication like network space partitioning, multi-chain formation, determination of sojourn locations, data transmission and compression have been carried out.

A. Network Model

In the network model, a 100m *100m network space is considered in which 100 nodes have been randomly deployed. The network space has been partitioned into four equivalent regions. Further, these 100 nodes have been equally divided into all four regions. Now, the greedy algorithm has been severally enforced in all four regions for making chain. For additional enhancement in energy efficiency, mobile BS has been used instead of the fixed BS [8]. Here the first order radio model has been employed to analyze energy utilization in data communication by sensor nodes. The first order radio model has been shown in Fig. 2.

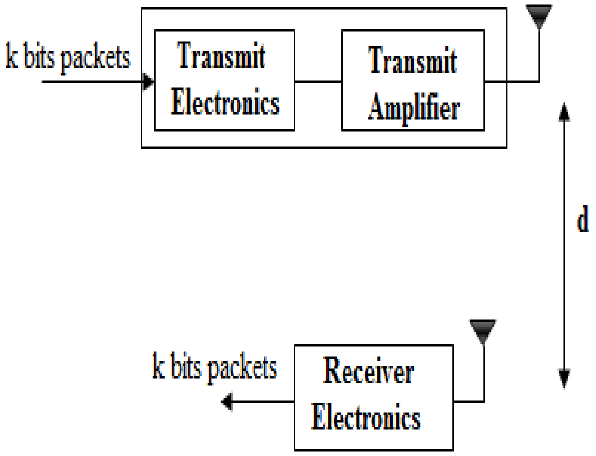

Fig.2. First order radio energy dissipation model

$$E_{Tx}(k,d) = \mathrm{E_{elec}} * \mathrm{k} + \mathrm{E_{amp}} * \mathrm{k} * \mathrm{d} \quad (1)$$

$$E_{Rx}(k) = E_{elec} * k \quad (2)$$

where, E_{Tx} and E_{Rx} are the total energy dissipated per bit at transmitter and receiver respectively.

E_{amp} = transmitter amplifier energy.

k = number of bits in the packet received by receiver electronics by following distance d.

E_{elec} = 50Nj/bit, is the energy dissipation requires running the transmitter or receiver circuitry of the radio energy dissipation model.

B. Multi-Chain construction and Sink mobility

In this section, the whole network space has been partitioned into four equivalent regions and additionally greedy formula has been individually imposed on the nodes in all four regions of the network for making chain. In the proposed technique, chain formation in all four logical regions is same as that of MIEEPB [8]. As the primary sink has send hello packet to all nodes of the network to collect data from all nodes. Now sink takes measures of all nodes so that BS can select node at the farthest distance from BS in the current region as an initial node. From the initial node, the chain formation would start. Then further initial node will find its neighbor node to form chain in the network. The formation of the chain in all four logical regions would be done by following the same approach. Chain leader of the chain has been elected on the basis of weight Q that is allotted to every node of the system. The weight Q of the node has been determined by dividing residual energy of node with the distance of the node from the sink as given in Eqn. 3. The node with highest value of weight 'Q' will be selected as the leader node.

$$Q_i = E_i / D_i \quad (3)$$

Where, E_i = residual energy of node, D_i =distance of i node from sink.

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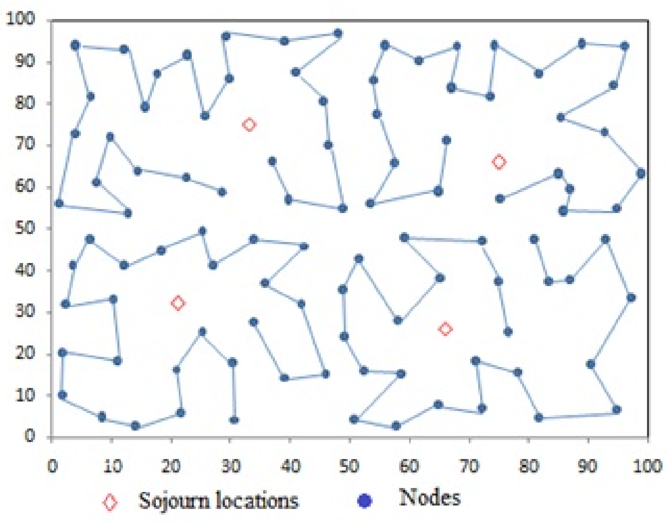
Now, the mobile sink moves on its prefixed trajectory and stays at sojourn locations to collect information from the leader node of all regions. The locations at which sink stays for a short time for collecting information from chain leader is known as sojourn location [10] The Fig. 3 shows the multi-chain formation and sink sojourn location of the proposed method. The sink initiates its sojourn tour by defining its sojourn locations to collect information from chain leaders of the network. The sink moves on its trajectory and stops at sojourn location for required time to collect data. The time for which sink stays at sojourn location is not fix [10]. This time varies according to data to be received from chain leader.



C. Data transmission and aggregation

Proposed multi-chain Pegasis uses the same method for data communication as used in MIEEPB. For data transmission, the chain leaders of the chain send the token to the initial nodes. The initial node sends data along with token to the neighbor node. Now each i node, after transmitting its own data, passes token to the next 'i-1' node by following the same approach in the chain. Finally, a chain leader of that chain receives all the data from all the nodes and then it transmits all the data to the sink. As the sink moves to the sojourn location of first chain region, it collects data from the chain leader of the first region. By repeating the same approach, sink collects the data from all four regions. Further compressive sampling is employed in the proposed technique for more enhancements in results. In compressive sampling, the node merges its own data with received data and compresses it with 2-D DCT (2-dimensional discrete cosine transforms). 2-D Discrete Cosine Transform is one-dimensional DCT which is applied twice on the data, once in the x-direction and then in the y-direction [9]. Using 2-D DCT data compression extends the lifetime of nodes and reduces the risk of data congestion. The received data is compressed by applying 2-D DCT as each parent node receives data from its child node, and then it is combined and compressed by using 2-D DCT. Hence, by applying 2-D DCT the complete data is compressed to enhance the lifetime of sensors.

IV. SIMULATION AND RESULTS

This section presents simulation-based experiments and results obtained through MATLAB. The performance of proposed technique is evaluated by comparing multi-chain Pegasis with MIEEPB. The simulation results show that the proposed technique reveals superior performances as compared to MIEEPB. The area is assumed as 100*100 sq. m. for wireless sensor network. The parameters and their values employed in the simulation have been listed in Table 1.

Table 1: Simulation Parameters

Sr. No.	PARAMETER	VALUE
1	Network size	100*100 sq. m.
2	Number of nodes	100
3	Number of rounds, r	5000
4	Initial energy of nodes	0.5J
5	Packet size	2000

In proposed multi-chain Pegasis, the first node dies at about 2100 round where in MIEEPB first node dies at 1500 round which shows the higher stability period of proposed technique. Stability period is the time duration of network function till first node die. Fig. 4 shows the graph of dead nodes versus number of rounds of proposed multi-chain Pegasis. If the node losses all of its energy, then it is termed as dead node.

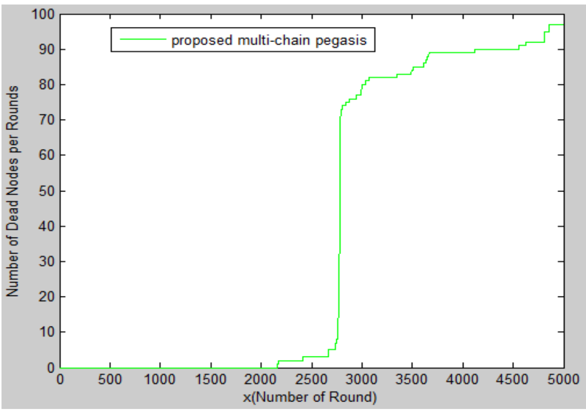


Fig.4. Dead nodes versus no. of rounds

The Proposed multi-chain Pegasis has higher instability period due to the better sink mobility and provides superior coverage as compared to MIEEPB.

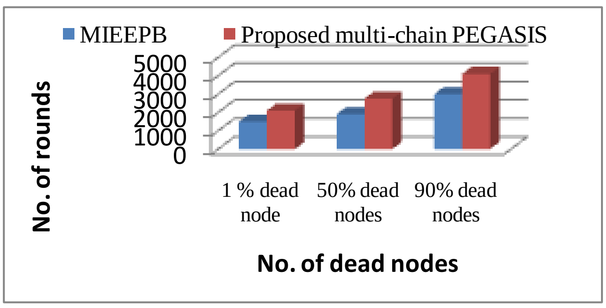


Fig.5. Dead nodes comparisons of MIEEPB and Proposed multi-chain Pegasis

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Fig. 5 shows the comparisons of dead nodes in MIEEPB and proposed multi-chain Pegasis. Dead nodes drop their transmitting or receiving capabilities. The instability period is the time duration between the first dead node to last alive node in the network.

Table 2: Dead nodes comparison

Dead Node %age	No. of Rounds	
	MIEEPB	Proposed multi-chain Pegasis
1%	1500	2100
50%	1900	2750
90%	3000	4100

Table 2 lists the operation rounds of the MIEEPB and multi-chain Pegasis when the dead nodes in the network are 1%, 50%, and 90%, respectively. This table shows that the proposed technique has more number of communication rounds and sensor node die more slowly as compared to MIEEPB.

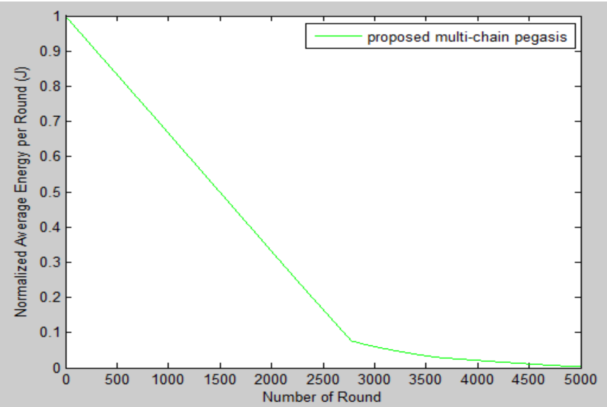

Fig. 6: Normalized average energy versus no. of rounds

The proposed technique efficiently increases the network lifespan as compared to the MIEEPB. Fig. 6 shows that the normalized average energy of all nodes is better in multi-chain Pegasis.

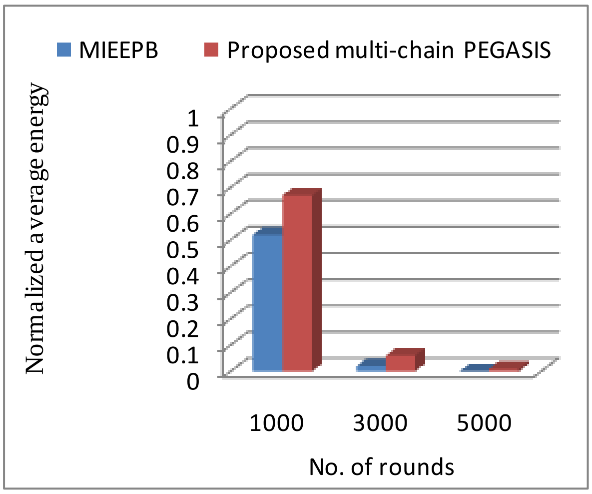

Fig.7. Normalized average energy comparisons of MIEEPB and Proposed multi-chain Pegasis

Fig. 7 shows the comparison of the normalized average energy of proposed technique and MIEEBP, which clearly shows that the lifespan of the network is improved by using proposed technique. This means that the energy efficiency of proposed multi-chain Pegasis is better than MIEEPB.

V. CONCLUSION

This paper proposes an improved energy-efficient multi-chain Pegasis based protocol to improve the limitations of MIEEPB. The idea of the intelligent sink with improved sink mobility has additionally used to enhance the network lifetime. In data transmission stage, proposed technique employs a 2-D DCT compressing technique that keeps energy utilization more sensible. The 2-D DCT is applied twice on the data in both directions. The simulation result shows that the proposed multi-chain Pegasis performs better than MIEEPB in term of normalized average energy and instability period. Simulation results also show that the proposed technique is more energy efficient and reliable as compared to MIEEPB. The stability period of proposed technique is 12% better as compared to MIEEPB. In MIEEPB, normalized average energy becomes 0 after 4200 rounds whereas in proposed algorithm normalized average energy becomes 0 after 4800 rounds. In future, one can employ other topologies instead of random deployment of nodes to enhance the performance of network.

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