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Enhancement of the Lifetime of a Wireless Sensor Network using Sink Mobility

Shailly Thakur[1], Balraj Singh[2]

M.Tech Research Scholar, Giani Zail Singh Punjab Technical University Campus, Bathinda[1]

Professor, Department of ECE, Giani Zail Singh Punjab Technical University Campus Bathinda[2]

Abstract: This paper presents the improved sink mobility of MIEEPB (Mobile sink Improved Energy-Efficient Pegasis-Based protocol) to prolong the network lifespan of wireless sensor networks (WSNs). In this work, the sink mobility improves to enhance the lifetime of the network by selecting better sojourn locations and using the idea of an intelligent sink. To achieve proficient energy consumption of WSNs, a multi-chain Pegasis has been proposed with enhanced mobile sink. As by investigating the further scope of improvement acquired in MIEEPB for selecting better sojourn locations to find desirable trajectory for the mobile sink. The wide ranges of experiments have been carried out to measure the proposed technique performance. The simulation study of work has been done using MATLAB-2013. The simulation study shows that the results of proposed work are better than MIEEPB in terms of network lifetime.

Keywords: Sojourn location, WSNs (Wireless Sensor Networks), Mobile sink, 2-D DCT, Intelligent sink.

I. INTRODUCTION

Wireless sensor network is the set of sensor nodes that can communicate wirelessly. The sensors are employed in the critical region of various applications like surveillance, ice mass monitoring, environmental sensing and so on. These days, wireless sensor network has been employed nearly in each field in our daily life. In a wireless sensor network, the energy of nodes is too restricted. As the sensor nodes have been deployed in harsh and complex environments. So, it is not possible to replace them once their energy gets drained out. Energy conservation is the essential concern in the design of any WSN system. For this, several algorithms have been developed. Moreover, the authors are focusing on further enhancements. The routing techniques like LEACH, PEGASIS, DEEC and MIEEPB do not present their impression to be satisfactory to beat the sensors energy dissipation efficiently.

Thus, the need for the improved mobile sink in WSN requires enhancing the network lifespan. PEGASIS is a classical hierarchical-based routing protocol [1]. Many PEGASIS based algorithms like PEG-Ant, and EEPB, IEEPB et al. has been proposed in recent years. Among them, EEPB [2] overcome many issues over PEGASIS to decrease long link formation, however it still have some limitations. IEEPB [3] presented improve EEPB (energy-efficient PEGASIS based protocol) chain-building technique that efficiently avoids the LL (long link) formation between neighbouring nodes. But, still it has some imperfections like less compatibility for delay-sensitive applications in WSN. MIEEPB presented improved multi chain PEGASIS model along with sink mobility to enhance the network lifespan. MIEEPB technique has been developed to prevail over the remoteness between nodes and delay in data delivery through smaller multi-chains. The mobility of sink is defined in a dynamic manner by many researchers. In MIEEPB, the trajectory on which the sink moves will be static, and for a fixed time sink stops at sojourn location to assemble data from leader nodes.

Several authors have proposed to improve techniques of PEGASIS protocol like no chain, single chain, multi-chain, and sink mobility algorithms. As per the literature review, the latest possibility of improvement of PEGASIS is often made by defining its better trajectory.

II. PREVIOUS WORK

In this section, the associated protocols in WSN will be discussed. Several routing protocols for typical WSNs, which are composed of static sensor nodes and a static sink, have appeared in the literature.WSN with mobile sink has attracted a lot of attention recently. The researcher has designed an IAR (Intelligent Agent-based Routing) protocol to reduce signal overhead by efficient data delivery to sink.

The concept of IAR is selecting some sensors as agents. If the agent is within the range of moving sink then the sink assembles data from that agent and if not, then it selects a device as a short-term relay node that collects data from agent and forwards it to moving sink [5]. Mobile Sink based Routing Protocol (MSRP) has been proposed for prolonging the network lifetime in clustered WSN. In MSRP, the sink has higher energy moves to CHs within the clustered network to assemble sensed information from them [6]. In MIEEPB, network area has been divided into four sub-regions. Then, the greedy formula has been implemented individually in each sub-region to achieve smaller chains. Due to this, the load on the leader node has also decreased. The sink moves on its static trajectory, and for a fixed time it sojourn location in every region to ensure information gathering from leader nodes. Within the existing routing protocols, the mobile sink has to follow a particular trajectory and stops at sojourn locations. This makes the sensors close to the sojourn location, dissipate their energy quicker than other nodes [4]. From the survey carried out, it has been gathered that energy consumption is one of the foremost tough factors for wireless device networks.

III. MOTIVATION

In WSN, many authors have been recommending a range of chain based routing techniques such as PEGASIS, EEPB, IEEPB and MIEEPB, etc. Out of these, MIEEPB has made a greater impact by introducing the concept of sink mobility and multi-chain formations which lead to lessening the extreme load on the single chain leaders. Sink mobility has fascinated a lot of research value in recent years because of its growing potential in WSN applications and its ability to enhance the network performance such as better energy efficiency and higher throughput. Many approaches based on exploiting sink mobility have been developed in recent years. A sink represents an important module of a WSN as it acts like a gateway which connects the sensor nodes with the end-user. For security-concerned applications, the mobile sink has many advantages. The mobile sink defines as the sink moves in the sensor field region and stops at a certain location to collect the data from the sensor nodes. To improve the network lifespan, DCS has introduced a new technique for in-network data compression based on CS (Compressive Sampling) and DSC (Distributed Source Coding). MIEEPB removes many problems in IEEPB, though it still has few limitations.

IV. NETWORK OPERATION OF PROPOSED PROTOCOL

In this section, based on existing routing protocol (MIEEPB), a modified protocol has been presented with the motive to improve the network lifespan by reducing the energy utilization of WSN. During setup section, preliminary activities to data communication, like region formation, chain formation, and determination of sojourn locations & intelligent sink have been carried out.

A. Network model

The network area comprising of 100 nodes in area of 100*100 meter sq. has been assumed. These 100 nodes have been divided equally into four regions of 25 nodes each and have been deployed randomly in each region of the network space. Now, when the sink moves on its prefixed trajectory to assemble information from head node, it is described as the sink mobility. To analyse the energy exploitation in data communication by sensors, the same radio energy dissipation model as described in previous work [4] has been used in this paper. Fig. 1 shows the radio energy dissipation model.

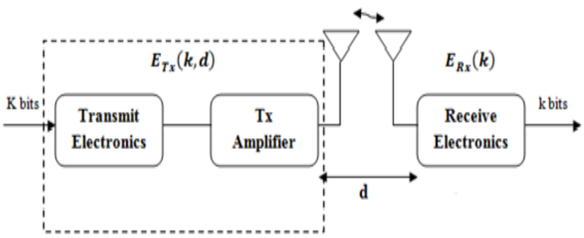

Fig. 1 Radio Energy Dissipation model

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

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

Where, E_{amp} = transmitter amplifier energy, k = number of bits, d = distance, E_{elec} = energy dissipation, and E_{Tx} & E_{Rx} are transmitter and receiver electronics, respectively. In this model, $\mathrm{E_{amp}}$ = 100 pJ/bit/m^2 for the transmitter amplifier and E_{elec} = 50 nJ/bit is required to run the transmitter and receiver circuitry.

The sink moves in all four regions one by one along its prefixed trajectory to complete its course in an exceedingly round.

B. Multi-chain construction

In this section, the proposed technique has divided the entire network region into four smaller sub-regions. Now the greedy formula is severally implemented in each sub-region as shown in Fig. 2.

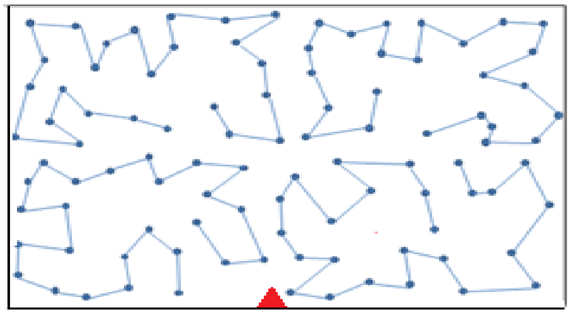

Fig. 2 Multi-chain algorithm

The digital communication from source to destination is done through shorter similar routes, which is the benefit of this system. In every region, one chain will be formed in a present round that builds data transmission pathway. So there are four chains formed in proposed work same as of MIEEPB [4]. The procedure of chain formation will happen in the following approach as first initial sink sends hello packet to all nodes in the network. Then the sink collects the data of all nodes and takes measures for the institution of temporary chains in all sub-regions. Now, BS selects the node farthest from itself in that region as the initial node and it then calculates the distances of all different nodes from itself. The chain formation starts from the initial node which then finds the nearest node from itself. By following the same approach, formation of the chain completes. In the chain, chain leader is elected on the basis of weight Q that has been allotted to all sensor nodes of the network. The enumeration of weight Q is done by dividing the residual energy of a node with its distance from the sink. The node with highest weight Q is selected as the chain leader of that chain [4].

$$\mathrm{Q_i} = E_i / D_i \qquad (3)$$

Where, E_i = sensor node residual energy, D_i = distance between node *i* and sink.

C. Sink Mobility

In the mobile sink, the sink will travel on a prefixed trajectory of the sensor field and stop at sojourn locations to gather the data from the sensor nodes. Assuming that the sink has unlimited energy and applying the conception of sink mobility enhances the lifespan of the network. For sink mobility, first the sojourn locations are defined. The

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locations at which the sink visits momentarily for collecting information from chain leader are called as sojourn locations [5]. The sink starts its sojourn tour by characteristic the sojourn locations to gather information from chain leader. The sink used in the network will be the I (intelligent) sink, whose speed varies as per data requirement and location. The intelligent sink moves on its prefixed trajectory and stops at sojourn location to gather data. But the time for which sink stays at sojourn location is not fixed. The time varies with the amount of data received from chain head. For data transmission, the token passing approach has been used. In this approach, chain leader will pass token to the end node. The end node first transmits its own data and transfers the token to the neighbouring node of the chain. Each node first transfers its own data and then passes the token to next node by following the same procedure in the chain. Now, chain leader will collect all data from the nodes and then transmit it to the sink. The multi-chain scheme is also valuable to lessen delay in data delivery. For better result, compressive sampling is also employed where the node combines its own data with the collected data and compresses it with 2-D DCT (discrete cosine transforms) [7]. Data compression has many advantages like enlarging the lifetime of nodes, reduced risk in congestion, and tolerance to losses. The data aggregation factor of compressed received data is better as compared to previous work in 2 D DCT, because it applies to the data twice in both directions; once in *x*-direction and other in *y*-direction. Each parent node receives data from its child node then combines the data and compresses it with 2-D DCT compressive sampling. Hence, by using data aggregation factor, the absolute data compresses.

V. SIMULATIONS AND RESULTS

In this section, the performance of proposed work has been evaluated by carrying out simulations. Now to prove the effectiveness of the proposed approach, its performance has been compared with existing MIEEPB. The area of the network is 100*100 meter sq. consisting of 100 sensor nodes, in which (25, 25) nodes are randomly distributed in four regions. The parameters have to be employed in the simulation listed in Table 1.

Table 1 Simulation Parameters

PARAMETERS	VALUES
Network size	100m*100m
Node number	100
No. of rounds, r	5000
Initial energy of nodes	0.5J
Packet size	2000 bits

A number of definitions of network lifetime are found in the literature. In this work, the network lifetime will be defined as when the sink is no longer capable of accepting information from the sensor's nodes, it is said to be detached from the nodes termed as lifeless network. Fig. 3 shows the variation of alive nodes with the number of rounds. The simulations results carry up to 5000 rounds. In fig. 4 comparisons clearly show that network lifespan of proposed multi-chain PEGASIS is better than that of MIEEPB. In the proposed algorithm, the chain leaders died more slowly than in MIEEPB as a result of better sink mobility.

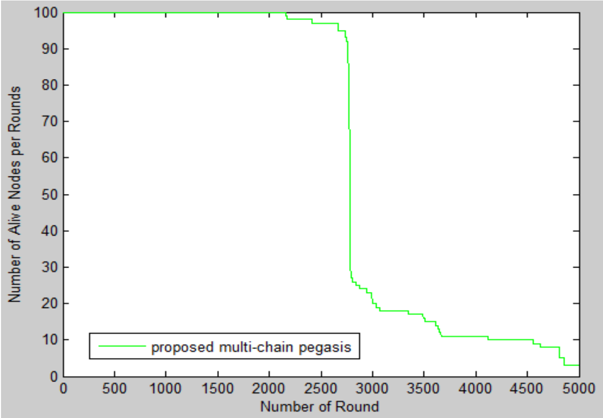

Fig. 3 Alive nodes versus no. of rounds

Unlike MIEEPB, proposed protocol has longer instability period. Instability period is defined as the time duration between the death instants of the first alive sensor node to the last alive sensor node in the network. In proposed algorithm, the first node dies at about 2100 round wherever in MIEEPB first node dies at 1500 round which shows the higher network lifetime of proposed algorithm. In MIEEPB, all nodes die after 4300 rounds whereas in proposed algorithm few nodes are still alive after 5000 rounds.

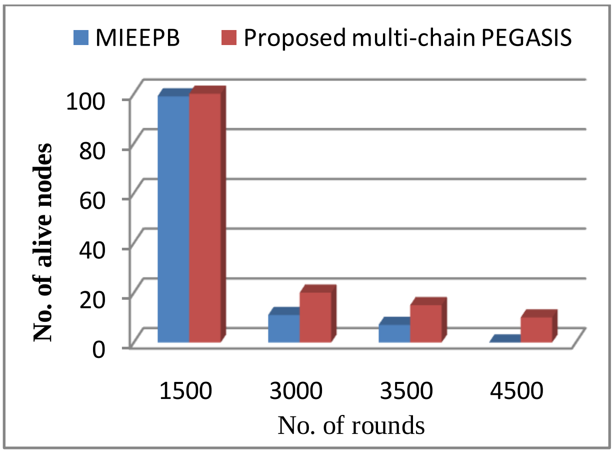

Fig. 4 Network lifetime comparisons of MIEEPB and Proposed multi-chain Pegasis

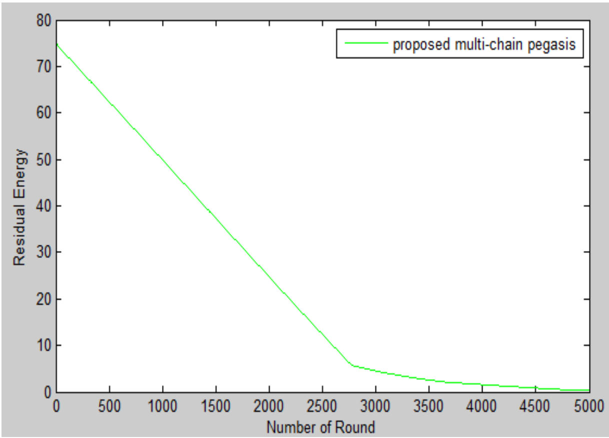

Fig. 5 Residual energy versus no. of rounds

The network lifespan is better than previous techniques due to proficient energy consumption shown in Fig. 5.Residual energy will ensure the polished degradation of network lifetime. The residual battery energy of network has been calculated by observing the nodes energy expenditure in each round.

The residual energy of network will decrease over rounds in an ideal way for the proposed routing technique which clearly shows that the residual energy of the sensor nodes, when utilized in a better way, results in energy conservation and enhanced network lifespan. The Fig. 6 shows the comparison of the residual energy of the proposed technique with the MIEEPB.

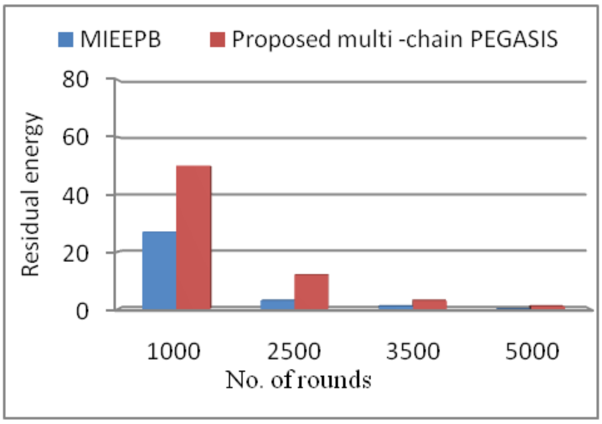

Fig. 6 Residual energy comparisons of MIEEPB and Proposed multi-chain Pegasis

From simulation results, it shows clearly larger instability period of proposed technique as a result of better sink mobility. The energy consumption is much efficient in proposed technique as compared to the MIEEPB.

VI. CONCLUSION

In this paper, a new framework has been presented to improve sink mobility in a wireless sensor network (W SN). The proposed technique adopts a more logical approach to applying intelligent sink with improved sink mobility. In data transmission phase, the 2-D DCT compressing method is used that keeps energy utilization reasonable. The simulation result shows that the proposed algorithm performs better than MIEEPB by achieving higher energy-efficiency and reliability. This technique extends the lifespan of the sensor network in terms of network lifetime and residual energy. The network lifespan is better than previous techniques due to proficient energy consumption. For future work, one can employ a different propagation model instead of first order radio model; different topologies can also be employed instead of random deployment of sensors.

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