Analysis and Improvement of Pegasis using Sink Mobility

Shifali Goyal
Dept. of Electronics and Communication Engineering
Giani Zail Singh PTU Campus
Bathinda, India
e-mail: goyal2shifali@gmail.com

Balraj Singh Sidhu
Dept. of Electronics and Communication Engineering
Giani Zail Singh PTU Campus
Bathinda, India
e-mail: erbalrajsidhu@rediffmail.com

Abstract**—** WSN is a distributed network to sense diverse physical conditions of the environment using sensors. Sensor nodes could be static or moving. Wireless routing protocols try to ensure efficient transmission of data in WSN. Many routing protocols have been proposed such as LEACH (low energy adaptive clustering hierarchy), PEGASIS (power efficient gathering in sensor information system), TEEN (threshold sensitive energy efficient sensor network protocol). The new algorithm is proposed on the basis of mobility of sink. Using multi-chain, multi-head and sink mobility algorithm, the network can achieve better lifetime. The PEGASIS protocol presented here is a chain-based routing protocol where sensor uses greedy algorithm to form a chain data. In the proposed technique, mobile sink moves along its path and stays at a sojourn location for a sojourn time and guarantees complete collection of data. In this proposed algorithm a path has been developed of mobile sink and then wide range of experiments have been performed to access the performance of the proposed model.

Keywords- *Wireless Sensor Network; Pegasis; Mobile Sink; protocol; sojourn time; sojourn location*

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I. INTRODUCTION

Wireless sensor network is a highly distributed network of specialized transducers called nodes which have communication infrastructure and they are intended to monitor and record conditions at diverse locations. Parameters that are generally monitored are temperature, humidity, pressure, wind direction, speed, light intensity and so on. Since any kind of physical parameters can be sensed and communicated by them, wireless sensor network have wide range of applications. Wireless sensor network falls under the range of wireless personal area network (W-PAN). As in W-PAN, data rate is very low and range is quite small. So technology employed here is low power, low data rate technology. Sensor nodes have capacity of sensing. It first senses the data and processes that data. After processing, it routes that data to base station through a communication medium.

Network lifetime is intended to reflect the time span from the network's initial deployment to the first loss of coverage. Network lifetime can alternatively be defined as the 'time until the first node dies'. The indicator for this metric is the maximum per-node load, where a node's load equals to the number of packets sent from or routed through the given node.

A. Routing protocols

Routing algorithm defines the route through which packet travels to reach the destination. Based on network structure routing protocols are divided into Flat, Hierarchical and Location based protocols. In Flat routing protocol, all sensor nodes have similar functionality in data collecting, transmitting and power consumption. In hierarchical routing protocol, nodes are divided into clusters and node with higher energy is selected as the cluster head. In Location based routing protocol, geographical information is used by the sensors to send data to specified regions.

1) Hierarchical routing protocol

The main aim of hierarchical routing protocol is to efficiently maintain the energy consumption of sensor nodes. Data aggregation and fusion is performed in order to decrease the number of transmitted messages to the sink. Routing protocols are distributed into LEACH and PEGASIS.

a) Leach: In this protocol, sensor nodes organize themselves into set of clusters. Each cluster has a cluster head or a local base station. In Leach protocol, the energy load gets distributed randomly among the various sensors in the network.

b) Pegasis: This protocol is an improvement over LEACH protocol. As in Leach, the periodic cluster head selection consumes an amount of energy and some resources. So PEGASIS, a chain based protocol was proposed for energy conservation and is near optimal protocol. The basic idea in PEGASIS is to form a chain among the sensor nodes. The nodes organize themselves to form a chain using greedy algorithm. Each node receives from and transmits to its close neighbor. Whenever a node dies the chain bypasses the dead node and reconstructs itself. Only one node has direct connection to the sink. Every node sends the data to its neighboring node, then it aggregates this information with its own data, extract a packet and then sends it to the nearest node on the chain. Compression of data takes place due to its aggregation and it reduces the load from node to node. PEGASIS saves considerable amount of energy as compared to LEACH by the improved cluster formation and delivery of sensed data. In PEGASIS, a chain is formed using greedy algorithm, and then a leader is selected randomly for the formed chain and then data transmission takes place.

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II. RELATED WORK

This section briefly states the previous work on the analysis of PEGASIS protocol.

Feng Sen et. Al. (2011), [1] proposed Energy-Efficient PEGASIS-Based protocol (IEEPB), a chain-based protocol which has certain deficiencies including the uncertainty of threshold adapted while building a chain, the unavoidable formation of long link (LL) when valuing threshold inappropriately and the non-optimal election of leader node. Focusing at these problems, an improved energy-efficient PEGASIS-based protocol (IEEPB) is proposed in this paper. IEEPB uses new method to create a chain, and uses weighting method while selecting the leader node, that is providing each node a weight so as to represent its appropriate level of being a leader which considers residual energy of nodes and distance between a node and base station (BS) as key parameters.

Yong chang Yu et. Al. (2010), [2] proposed EECB (Energy-Efficient Chain-Based routing protocol) that is an improvement over PEGASIS. EECB uses distances between sensor nodes and the Base Station and remaining energy levels of nodes to decide which node will be the leader that takes charge of the transmission of data to the BS. Also, EECB uses distance threshold to avoid formation of LL (Long Link) on the chain.

Stephanie Lindsey et. al. (2001), [3] proposed PEGASIS (Power-Efficient Gathering in Sensor Information Systems) Protocol which is a near optimal chain-based protocol that is an improvement over LEACH. In PEGASIS, each node interacts only with a close neighbour and takes turns transmitting to the BS, thus reducing the amount of energy spent per round.

Samia A.Ali et. al. (2011), [4] proposed Chain-Chain based routing protocol (CCBRP). The CCBRP mainly divides a WSN into a number of chains and runs in two phases. In first phase, sensor nodes in each chain transmit data to their chain leader nodes in parallel. In second phase, all chain leader nodes form a chain (using Greedy algorithm) and randomly choose a new leader then all leader nodes send their data to the new chosen leader. The new chosen leader fuses all the data and forwards it to the Base Station. The proposed CCBRP achieves both minimum energy consumption and minimum experienced delay.

III. PROBLEM STATEMENT

Wireless Sensor Networks gather and process the packets from its sensor nodes and pass it to the base station (BS). So the main requirement is to improve the lifetime of the sensors so as to increase the network efficiency. The key idea in PEGASIS is to form a chain among the sensor nodes so that each node will receive from and transmit to a close neighbor. Gathered data moves from one neighboring node to another, gets fused, and eventually the end node transmits it to the BS. Nodes take turn to transmit the data to the BS so that the average energy spent by each node per round is reduced. Although PEGASIS has better performance, it also has few shortcomings: using greedy algorithm will result in long link between pair of sensor nodes during the chain construction. In this situation, the sensors will consume more energy than other sensors in transmitting data phase. Thus, the sensors may die early. To get rid of this problem of long links and lower network lifetime, this paper proposes Pegasis using Sink Mobility. It is advantageous as it saves energy of chain leaders of the multi-head chain. Mobile sink is specially intended for the delay-tolerant applications. Due to small chains, consisting of fewer numbers of sensors tolerable delay in data delivery is caused. The multi-chain concept not only, decreases the network overhead due to fewer numbers of nodes in chains, but also shrinks the distance between the connected nodes due to their uniform random distribution. Sink mobility decreases the load on the nodes of chain closer to sink by using the idea of secondary chain heads. The conception of multi-head in the chains diminishes the delay in data delivery and the load on the single chain leader as was the case in Pegasis.

IV. NETWORK MODEL

In the proposed work an area of 100m x 100m for WSN has been considered. 100 nodes have been deployed randomly in equally spaced area using uniform random distribution, forming 4 equal groups of 25 nodes each. It has been assumed that as the sink moves through the centre of equally spaced regions and completes its full trajectory in one entire round. This is known as **Sink Mobility**. Sink stays at sojourn location for specific time duration known as sojourn time.

A . Network Construction

1) Following are the key points in building of the system model:

- In a bi-dimentional square grid composed of same-size cells, sensor nodes remain stationary.
- The sink can move freely on the grid from one node to another. During its sojourn time at a node, sensors can communicate with the sink. For analytical simplicity, the travelling time of the sink between two nodes is considered negligible.
- Data transmission and data reception are the major energy consuming activities.
- Wireless networks are bi-directional, symmetric and error-free and sensor nodes are homogeneous.
- Each node has unlimited buffer size and limited initial energy.
- Sensor nodes communicate with the sink by sending data via multiple hops along the shortest path; a hop is of one cell side length, i.e., the distance between two adjacent nodes in the grid equals the nodes' transmission range.

V. RESULTS

This paper uses MATLAB as simulator to improve the performance of Pegasis. The simulation focuses on number of sensor nodes alive, lifetime of network and energy efficiency which are important indicators to measure the performance. Under this section the comparison of the performance of

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existing Pegasis and mobile sink Pegasis has been done. In this 100m x 100m area has been considered which has been further divided into equally spaced 4 regions. The sink moves about the centers of equally spaced regions and completes its course.

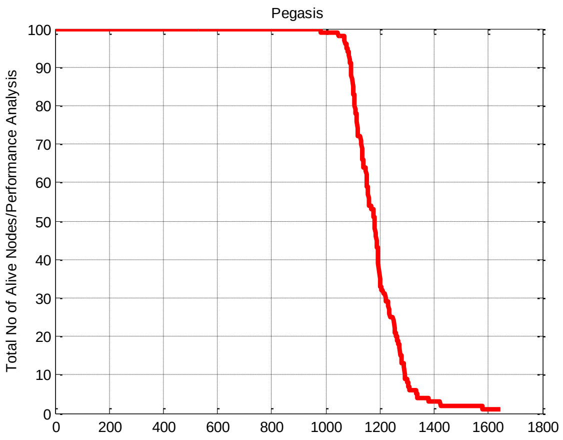

Figure 1. Applying Pegasis on 100 nodes

Fig. 1 shows the graph between the total number of alive nodes and the total number of rounds implemented using original Pegasis. It can be seen here that 100 nodes are alive till 900 rounds. Then the alive nodes decreases rapidly as the number of rounds increases. On reaching 1300th round, number of alive nodes are almost 20 and they reduce to 0 at 1650th round.

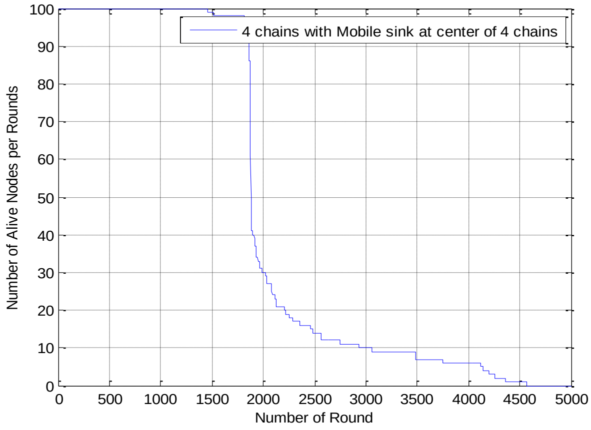

Figure 2. Modified Pegasis using Mobile Sink

Fig. 2 is the implementation of the modified Pegasis using Mobile Sink. The graph shows the comparison of number of alive nodes to the number of rounds. Initially the number of alive nodes are 100 till 1700 rounds. After this round, the number of alive nodes starts decreasing linearly. On reaching 2200th round we are left with 20 alive nodes. At the end all the alive nodes are dead by 4700th round.

TABLE I. COMPARISON OF PEGASIS AND MODIFIED PEGASIS

Number of Alive Nodes	***Number of rounds***	
	Original Pegasis	***Mobile Sink Pegasis***
100	1000	1450
90	1075	1850
80	1100	1860
70	1120	1870
60	1140	1880
50	1190	1900
40	1200	1920
30	1220	2000
20	1300	2200
10	1350	2950
0	1650	4550

Table I: shows the tabular representation of the alive node s and the number of rounds in the original Pegasis and in the Mobile Sink Pegasis (MS Pegasis). All the 100 nodes are alive for 1000 rounds in original Pegasis whereas lifetime of all the 100 nodes increases till 1450 rounds in MS Pegasis. With increase in number of rounds the alive nodes die out gradually. Covering 1650 rounds, all the nodes die out in original Pegasis whereas it goes to 4550 rounds in MS Pegasis.

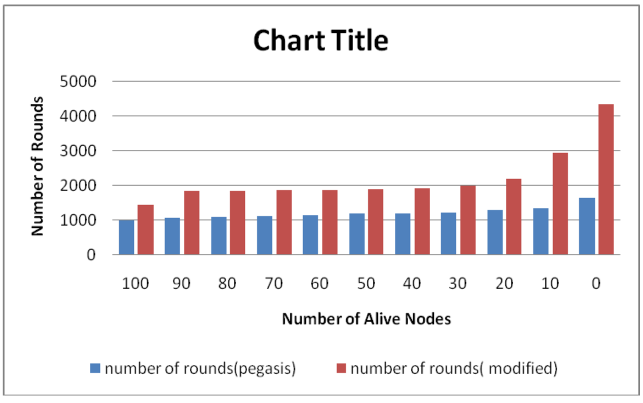

Figure 3. Graphical Comparison of Pegasis and MS Pegasis

Fig. 3 depicts the comparison between the original Pegasis and the MS Pegasis. It is authenticated that the MS Pegasis has better lifetime than the original one. This shows that the MS Pegasis is more efficient than the original Pegasis.

TABLE II. COMPARISON OF ROUNDS WITH DIFFERENT NUMBER OF NODES

Energy= 0.5							
Number of Nodes=50		Number of Nodes=75		Number of Nodes= 100		Number of Nodes=125	
Nodes	Rounds	Nodes	Rounds	Nodes	Rounds	Nodes	Rounds
50	1450	75	1450	100	1450	125	1450
30	1870	50	1830	75	1875	100	1820
15	2000	30	1900	50	1900	50	4500
0	3100	0	3450	0	4350	0	< 5000

Table II: shows the observations made using different number of nodes. Considering a total of 50 nodes initially, increasing them by 25 nodes repeatedly till the total number of nodes are 125, shows that with the increase in number of nodes the number of rounds increases which results in enhancement of the network lifetime.

TABLE III. COMPARISON OF PERCENTAGE INCREASE OF ROUNDS WITH DIFFERENT NUMBER OF NODES

Number of Nodes	Percentage increase in number of nodes(in %)	Minimum number of Rounds	Maximum number of Rounds	Percentage Increase in number of Rounds (in %)
50	-	1450	3100	117
75	50	1450	3450	137
100	33	1450	4350	200
125	25	1450	5000	244

In Table III: lists the variation of number of rounds with change in nodes. Following observations have been made:

- When the total number of nodes have been considered as 50, the alive nodes starting from 1450 rounds sustain up to 3100 rounds, giving efficiency of approximately 117%.
- When the total number of nodes have been considered as 75, the alive nodes starting from 1450 rounds sustain up to 3450 rounds, giving efficiency of approximately 137%.
- When the total number of nodes have been considered as 100, the alive nodes starting from 1450 rounds sustain up to 4350 rounds, giving efficiency of approximately 200%.
- When total number of nodes have been considered as 125, the alive nodes starting from 1450 rounds sustain up to rounds greater than 5000, giving efficiency of approximately 244%.

The increase in total number of nodes from 50 to 125 in steps of 25 does not show a specific trend in increase of number of total rounds for predicting the total number of alive nodes. However there is substantial increase in number of rounds with increase in total number of nodes.

VI. CONCLUSION

This paper proposes an improved Pegasis using Sink Mobility (MS Pegasis). In this proposed algorithm the longer chains have been replaced with the smaller multi chains which reduce the load on the chain leader and lessen the delay in the data delivery. Thus the network lifetime gets increased along with its efficiency.

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