Maximizing the Lifetime of Multi-chain PEGASIS using Sink Mobility

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Introduction

- In WSNs, the wireless routing protocols strives to ensure efficient energy consumption.
- Chain-based routing protocols diminishes energy consumption by utilizing the role of chain leaders.
- There is a need to utilize sink mobility in WSN to augment network lifetime.
- A sink can save the energy of sensor nodes by collecting data at their place.
- Heavy load on chain leaders causes quick collapse of network in terms of stability period and lifespan.
- Therefore, we require sink mobility and multi chain concept to ensure proficient data aggregation.

Related Work

- Previous literature set some specific trajectories for the movement of sink.
- Fixed path mobility constrain the sink in bounded region to decrease electricity or petrol utilization by sink.
- In set packing technique, the sink calculates trajectory among the cluster heads using traveling salesman algorithm.
- DAMLR employs Linear programming and Lagrangian method to design maximum lifetime algorithm.
- To determine the sink sojourn times and routing flow vector for each sink location, distributed algorithm is designed on the basis of sub-gradient method.

Related Work

- PEGASIS is based on the chain formation among sensors and then transmitting the data to the sink.
- EEPB removes the long link (LL) problem using threshold computations in chain formation.
- IEEPB modifies the process of chain formation and leader selection in EEPB.
- DCS suggest a new algorithm for in-network compression, based on distributed source coding (DSC) and compressive sampling (CS) aiming at longer network lifetime.

Motivation

- There is a major load on the single chain leader due to larger distance between chain leader and the sink.
- In instability period, the sparse nodes are badly affected because of long mutual distances.
- Minimization of data delivery delay is also an important acquirement to improve network performance.

Network Operations of the Proposed MIEEPB

- Based on the above analysis, this paper presents mobile sink improved energy-efficient PEGASIS-based routing protocol (MIEEPB).

The main steps in operations of MIEEPB are following

- Physical division of network using uniform random distribution
- Multi-Chain construction
- Chain Leaders selection

The two main subsections further describing sink mobility are

- Sink Mobility
- Proposed Algorithm for Sink Mobility

Network Operations of the Proposed MIEEPB

- Data Transmission
- Data Aggregation using DCS

Uniform random distribution

- 25, 25 nodes are deployed in the equally spaced 4 regions of WSN.
- MIEEPB employs First order radio model to calculate energy consumption of sensor nodes.

$$E_{tx}(k,d) = E_{tx} - elec(k) + E_{tx} - amp(k,d) \tag{1}$$

$$E_{rx}(k) = E_{rx} - elec(k) \tag{2}$$

$$E_{DA}(k) = E_{DA} - elec(k) \tag{3}$$

E_{elec} = 50 nJ/bit, E_{amp} = 100 pJ/bit/m2, E_{DA} = 50 nJ/bit

Multi-Chain Construction

- Sink sends hello packet to all the nodes.
- Sink finds the farthest node from itself in first region.
- The chain formation starts from the farthest node.
- Each node finds the the nearest node, not connected in chain and connects with it.
- In the chain, each node i receiving data from the node j, acts as a parent to node j, whereas node j acts as a child to node i.
- As the sink moves, same process of chain formation repeats in all 4 regions and thus, 4 chains are created.

Multi-Chain Construction

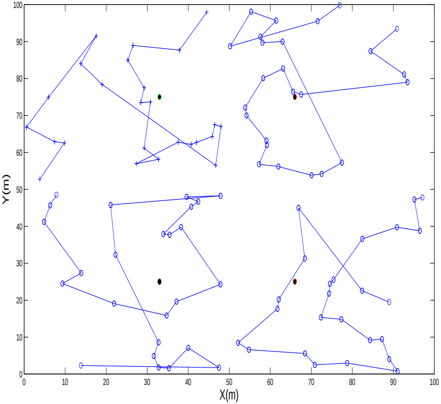

Figure 1: Nodes distribution and chains formation

Chain Leaders Selection

- Chain chooses the primary chain leader on the basis of weight Q assigned to each node.

  $$Q_i = E_i / D_i \tag{4}$$

  where E_i is the residual energy of node i while D_i is the distance between node i and BS
- The node with the highest weight is selected as a primary chain leader.
- The secondary chain leaders are selected on the basis of the distances between the child nodes and the parent nodes.

Sink Mobility

- Sink moves in a fixed trajectory, traverses from one region to the other and waits for a sojourn time at sojourn location.
- Sojourn time is the time interval for which sink stays at specific position and collects data from the chain leaders.
- Sojourn location is the location where the sink temporarily stays for data collection.
- In our proposed scheme, the sojourn locations are (33m,25m), (33m,75m), (66m,25m) and (66m,75m).

Proposed Algorithm for Sink Mobility

We suggest a scalable algorithm for the distance constrained mobile sink. It consists of following three stages

- The sojourn time profile at each sojourn location is calculated.
- Based on the sojourn time profiles, it then starts sojourn tour for the mobile sink by identifying the sojourn locations of (33m,25m), (33m,75m), (66m,25m) and (66m,75m).
- It calculates the total sojourn time in 1 round.

$$T_s = \sum_{i=1}^{4} \tau_i \tag{5}$$

where Ts is the total sojourn time of 1 course.

Proposed Algorithm for Sink Mobility

The objective (1) is to maximize the network lifetime by enhancing the total sojourn time.

$$Maximize \sum_{i=1}^{4} \tau_i \tag{6}$$

subject to:

$$x_{ij} = \begin{cases} D & \text{if } i = j \\ 0 & otherwise \end{cases} \tag{7}$$

where x_{ij} is the number of bits transmitted between chain leaders and the sink having potential locations i and j, $1 \leq i, j \geq 4$. D is the total data transferred between chain leaders and the sink in sojourn time.

Data Transmission

- Data transmission in MIEEPB is based on the token passing approach.
- Token passing starts from the end nodes towards leader nodes of the chains.

Data Aggregation using DCS

- Each node i receives the data of its child node and compresses it using DCT as proposed in DCS.
- It combines its data with the received one using compressive sampling.

Simulation parameters

Rounds	5000
Network size	100m x 100m
Node number	100
BS sojourn locations	(33m,25m),(33m,75m)
	(66m,25m),(66m,75m)
Initial energy of normal nodes	0.5J
Data aggregation factor	0.6
Packet size	2000 bits
BS location in IEEPB	(0m,0m)

Comparison of Network Lifetime

- Let suppose we have 100 nodes in 100*100 m^2 square region, in which 25, 25 nodes are further divided arbitrarily in equally spaced 4 regions.
- Sink mobility is proposed as the sink moves about the centers of equally spaced regions and complete its course in 1 round.
- Figure2 represents the number of alive nodes during the network lifetime.

Network Lifetime Graph

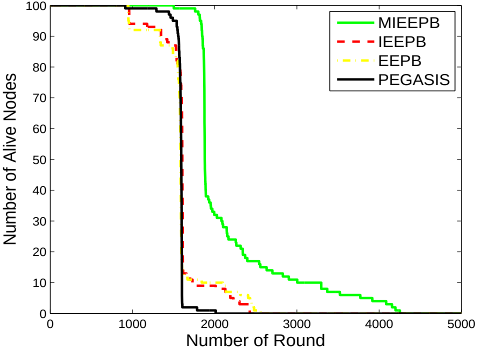

Figure 2: Network Lifetime Graph

Comparison of Dead nodes in MIEEPB, IEEPB, EEPB and PEGASIS

- Figure3 shows the assessment of MIEEPB and IEEPB in terms of dead nodes.
- The multi-head chain model removes the long link (LL) problem by sending data directly to the sink in case of remote parent node.
- It further diminishes the delay in data delivery to the base station.
- In spite of large empty spaces, our proposed technique provides better coverage in last 1000 rounds than of IEEPB.

Comparison of Dead nodes in MIEEPB, IEEPB, EEPB and PEGASIS

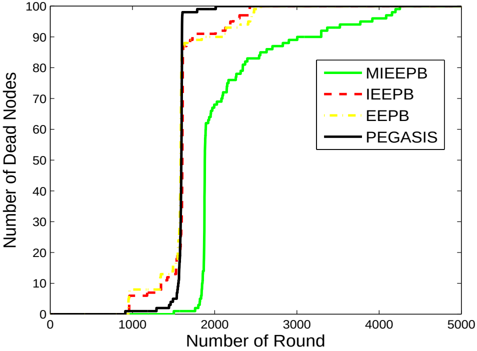

Figure 3: Comparison of Dead nodes in MIEEPB, IEEPB, EEPB and PEGASIS

Comparison of Energy Consumption in MIEEPB, IEEPB, EEPB and PEGASIS

- Figure4 presents the comparison of energy consumption in MIEEPB with other protocols.
- In MIEEPB, chain leaders consume less energy due to sink mobility and less distance between chain leaders and the sink.

Comparison of Energy Consumption in MIEEPB, IEEPB, EEPB and PEGASIS

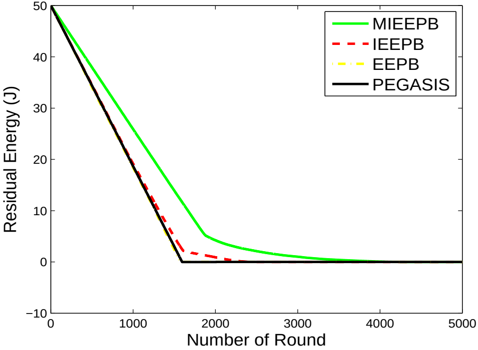

Figure 4: Comparison of Energy Consumption in MIEEPB, IEEPB, EEPB and PEGASIS

Comparison of Normalized Average Energy Consumption in MIEEPB, IEEPB, EEPB and PEGASIS

- Figure5 presents the comparison of normalized average energy consumption in MIEEPB with other protocols.
- The distance between sparse nodes themselves and the base station is fewer than in IEEPB; this practice saves plenty of energy.

Comparison of Normalized Average Energy Consumption in MIEEPB, IEEPB, EEPB and PEGASIS

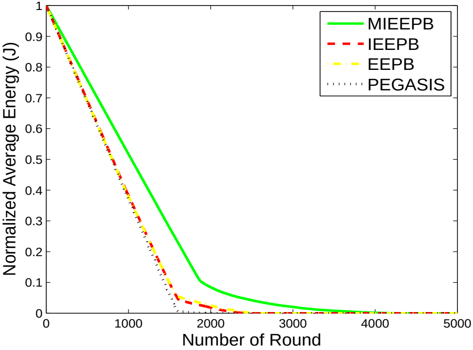

Figure 5: Comparison of Normalized Average Energy Consumption in MIEEPB, IEEPB, EEPB and PEGASIS

Conclusion

- In this paper, we recommend a multi-head chain model of PEGASIS along with induction of sink mobility to maximize the network lifetime.
- Our considerations are supportive in diminishing the delay in data delivery and distances between the connected nodes through smaller chains.
- Sink mobility not only lessens the load on chain leaders in starting rounds, but also reduces the stress on sparse nodes at the end of network termination.
- As for future directions, we are striving to get much better sink mobility specifically toward chain leaders in WSN.

Questions

Thank you!