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# Performance Evaluation of PEGASIS and IEEPB Routing Protocols in Wireless Sensor Networks

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## ABSTRACT
Sensor webs consist of nodes and have limited battery power. Wireless Sensor Network is deployed to collect useful information from the field. Wireless Sensor Networks have characteristics like low cost, low energy consumption, distributed and self-organizing. WSN can be split into two groups that are hierarchical routing and flat routing. This paper focuses on efficient routing of energy. A detailed comparison with simulations on NS-2.35 of PEGASIS (Power Efficient Gathering In Sensor Information Systems) and IEEPB (Improved Energy Efficient (Power Efficient Gathering In Sensor Information Systems) and it has been deduced that IEEPB outperforms PEGASIS in terms of packet delivery ratio, energy efficiency, number of nodes active in every round and network lifetime.

## Keywords
Wireless Sensor Networks, PEGASIS, IEEPB, Packet Delivery Ratio, Energy efficiecncy.

## 1. INTRODUCTION
Wireless Sensor Networks reside of thousands of Sensor Nodes that encompasses of sensing, processing, transmission, mobilizer, position finding system and power units with some optional components. WSN faces a challenge in energy consumption. Because the sensor nodes in WSN are provided energy by compact batteries and the data transmission is frequent, the energy could be used up in a short time. Therefore, to design a kind of routing protocol that can reduce the energy consumption, and prolong the lifetime of WSN is necessary. Sensor networks have a wide variety of applications. A WSN is made up of nodes which are wireless sensor units. The key components of a node are: a micro-sensor to sense the desirable event; memory; microprocessor; battery; and a transceiver to communicate with the rest of the network. As the power supply, transmission bandwidth and processing capability are limited efficient routing becomes very important.

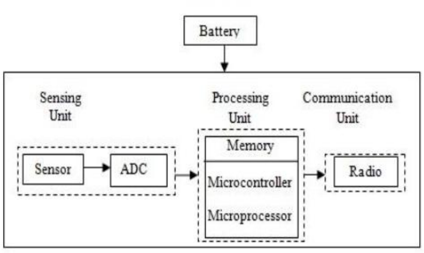


**Figure1: Sensor Node Structure [2]**

A typical sensor node includes four basic components: a sensing unit, a processing unit, a communication unit, and a power unit as in Figure 1. The sensor networks can be used in military environment, Home networks, nuclear and explosive material, Disaster management, Medical and health care, Industrial fields, Habitat monitoring, radiological. For example, in a disaster relief operation, sensor nodes are dropped from an aircraft over a wildfire, each node then measures temperature and an overall temperature map can be derived. [1]

### 1.1 Characteristics of WSNs
Unlike traditional wireless sensor networks like MANETs, WSN has unique characteristics as follows:

#### *1.1.1 Dynamic Network Topology*
Network topology changes frequently as nodes can be added or removed, node failure, energy depletion, or channel fading.

#### *1.1.2 Application Specific*
The design requirement of the network varies with required application.

#### *1.1.3 Energy constrained:*
Nodes are portable and are highly limited in energy, computation and storage capacities. This is the most important design consideration of WSN.

#### *1.1.4 Self-configurable:*
Nodes are randomly deployed without careful planning. Once deployed, nodes have to configure autonomously themselves into a communication network. [2]

## 2. DESCRIPTION OF PEGASIS AND IEEPB PROTOCOL

### 2.1 PEGASIS Protocol
The PEGASIS protocol forms a chain of the sensor nodes and the chain is formed using a greedy approach, starting from the node farthest to the sink node. The nearest node sends data to the neighboring node. This procedure continues until all the nodes are included in the chain.

We used random node network for our simulation. For a 50m x 50m plot, our BS is located at least 100m from the closest sensor node. Here before passing the information to the adjacent neighbor data aggregation takes place, this process can be classified in two steps:

i. Chain Construction
ii. Gathering Data

iii. *Chain* Construction

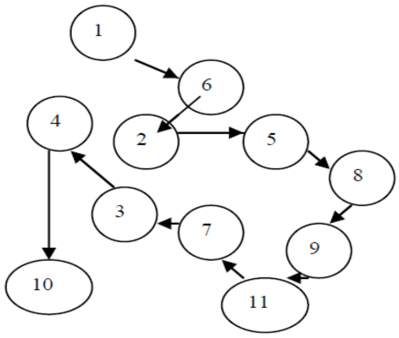


**Figure 2: Chain Construction using Greedy Algortihm**

For constructing the chain, we assume that all nodes have global knowledge of the network and employ the greedy algorithm. To construct the chain, we start with the furthest node in the base station. We begin with this node in order to make sure that nodes farther from the base station have close neighbour's, as in the greedy algorithm the neighbour distances will increase gradually since nodes already on the chain cannot be revisited. In Figure 2 chain is constructed between the nodes and finally node 10 is selected to pass the data to sink node. Figure 2 shows node1 connecting to node 6, node 6 connecting to node 2, and node 2 connecting to node 5, node 5 connecting to node 8, and node 8 connecting to node 9, node 9 connecting to node 11, and node 11 connecting to node 7, node 7 connecting to node 3, and node 3 connecting to node 4, node 4 connecting to node 10. When a node dies, the chain is reconstructed in the same manner to bypass the dead node.

i. Gathering Data

For gathering data in each round, each node recieves data from its one neighbour, fuses with its own data, and transmits to the other neighbour in the chain. A leader node is selected and this leader node is responsible for forwarding the aggregated data to the base station.

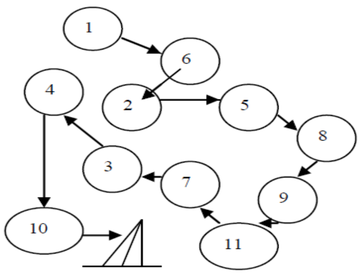


**Figure 3: Token passing approach**

PEGASIS performs data fusion at every node except the last node in the chain. In the above example, node 1 will pass its data to node 6. Node 6 fuses nodes 1's data with its own and then transmits to the leader. Finally node 10 transmits one message to base station. Thus, in PEGASIS each node will receive and transmit one packet in each round and the leader once in every 100 rounds.

In this model, a radio dissipates $E_{elec}$ = 50 nJ/bit to run the transmitter or receiver circuitry and $€_{amp}$ = 100 pJ/bit/m$^2$ for the transmitter amplifier. The radios have power control and can expend the minimum required energy to reach the intended recipients. The radios can be turned off to avoid receiving unintended transmissions. The equations used to calculate transmission costs and receiving costs for a *k*-bit message and a distance *d* are as follows:

**Transmitting:**

$$E_{Tx}(k, d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$

$$E_{Tx}(k, d) = E_{elec} * k + €_{amp} * k * d^2$$

**Receiving:**

$$E_{Rx}(k) = E_{Rx\text{-}elec}(k)$$

$$E_{Rx}(k) = E_{elec} * k$$

## 2.2 Improved Energy Efficient PEGASIS Based Protocol (IEEPB)

IEEPB is an improved chain based routing algorithm over PEGASIS. It contains 3 stages:

i. Chain construction phase
ii. Leader selection phase
iii. Data transmission phase

### i. Chain Construction Phase

a) Initializing the network parameters.

b) Determining the number of nodes, initial energy, base station location. Then chain construction starts.

c) BS broadcasts the whole network a hello message to obtain basic network information such as ID of nodes alive and distance from each node to BS.

d) Set the node which is farthest from BS as end node, it joins the chain first and is named as node 1.

e) Each node gets information of distance between itself and surrounding nodes which have not joined the chain, it finds the nearest node names it as *i* where i represent the *i*-th node that has joined.[3]

f) Node *i* finds the information between itself and *i*-1 nodes which are there in the chain, then it finds the nearest node *j* and connects with it to join the chain.

g) Repeat the same steps to connect node *i*+1, *i*+2….and continue this till all sensor nodes have joined the chain.

### ii. Leader Selection Phase

IEEPB chooses the leader by weighting method taking into consideration residual energy of nodes and the distance from node to base station. The steps are as follows:

a) Estimate distance between node and base station. It can be calculated as:

$$D_{bs} = D_{to(bs)}^4 / D_{avg}^4$$

Where $D_{avg}$ represents the average distance between sensor node and BS

b) Calculate energy portion $E_p$ as follows:

$$E_p = E_{init} / E_i$$

Where $E_i$ is the residual energy of node *i* for round *n*

Where $E_{init}$ is the initial energy of node *i*

c) Calculate weight of each node by using the formula:

$$W= w_1E_p+w_2D_{bs}$$

Where $w_1$ and $w_2$ are coefficients of weight factors such as

$$w_1 +w_2=1$$

d) Compare different weights of each node and the node with minimum weight are selected as the leader in this round.

**iii. Data Transmission Phase**

Once the chain formation phase and CH selection phase are accomplished, each node transmits its data to the adjacent node. The adjacent node then fuses its data with the data of previous node and sends it further. Once the data reaches CH, it sends data of all nodes to next CH. One round of communication terminates when BS receives all the data from last CH.

## 3. NETWORK PARAMETERS

| Parameters | PEGASIS Protocol | IEEPB Protocol |
|---|---|---|
| Sensor Field | 50m*50m | 50m*50m |
| Number Of Nodes | 100 | 100 |
| Initial Energy Of Nodes | 100J | 100J |
| Transmitting Energy | 0.1J | 0.1J |
| Receiving Energy | 0.01J | 0.01J |

**Table1: Parameters Used In Model**

## 4. SIMULATION RESULTS

To evaluate the performance of PEGASIS and IEEPB it has been simulated on Network Simulator 2.35. This simulation emphasizes on various performance parameters of IEEPB such as Packet Delivery Ratio, number of nodes active after every round, Energy Efficiency and Network Lifetime.

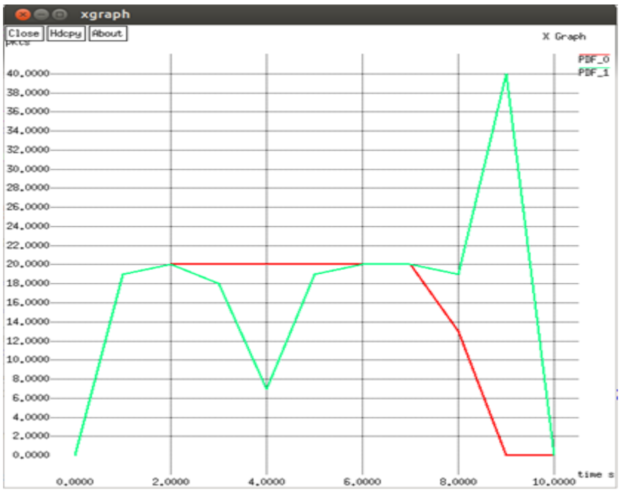


**Figure 4: Packet Delivery Ratio**

Figure 4 shows Packet Delivery Ratio of both protocols. It can be seen that IEEPB delivers more packets than PEGASIS protocol.

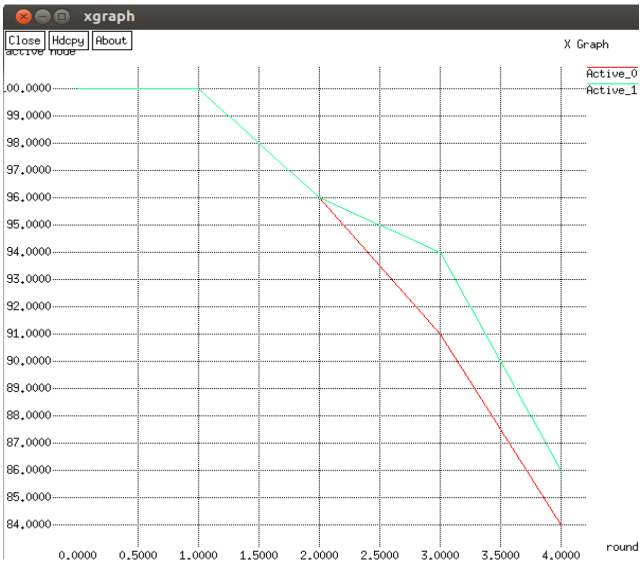


**Figure 5: Nodes Active After Every Round**

Figure 5 shows number of active nodes after every round in both protocols. It can be seen that number of nodes active are more in IEEPB than PEGASIS protocol.

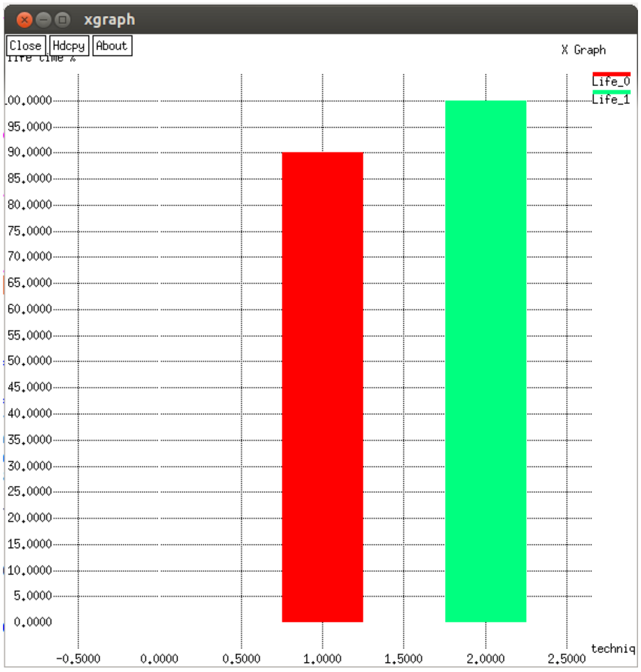


**Figure 6: Network Lifetime**

Figure 6 shows Network Lifetime of both protocols. It can be seen that IEEPB has longer Network Lifetime as compared to PEGASIS protocol.


**Figure 7: Energy Efficiency**

Figure 7 shows Energy Efficiency of both protocols. It can be seen that IEEPB is more energy efficient as compared to PEGASIS protocol.

## 5. CONCLUSION AND FUTURE WORK

In this paper IEEPB protocol has been explained in detail. Unlike PEGASIS, IEEPB builds chain by considering residual energy and distance between the nodes. IEEPB outperforms PEGASIS in terms of terms of packet delivery ratio, energy efficiency, number of nodes active after every round and network lifetime. In future, IEEPB protocol can be compared with other PEGASIS protocols and performance can be evaluated.

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