Network Optimization for PEGASIS using PBO in WSN

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Abstract: ***Wireless sensor networks (WSN) are mainly known for their energy consuming sensor nodes. So, there is a need to formulate the energy efficiency of the nodes in order to enhance the network lifetime. Power efficient gathering in sensor information systems (PEGASIS) is a hierarchical based routing protocol which is used for their high energy and good expandability. In PEGASIS high energy nodes are randomly selected for processing and sending data and low energy nodes are used for sensing and sending information to chain heads. Pollination Based Optimization (PBO) is a metaheuristic approach used for the optimization of the routing networks.***

Keywords: Power-Efficient Gathering in Sensor Information System (PEGASIS), QoS, Wireless Sensor Network (WSN), Energy Efficiency, Pollination Based Optimization (PBO)

1. Introduction

Wireless Sensor networks are one of major wide spread networks because of the involvement of the network in terms of electronics, communication and information technology in the single network that are effective in recent years. A sensor network is composed of vast number of tiny sensor nodes. Specific parameters are defined for each sensor node in terms of energy. Some energy is consumed with each communication over the network. The type of energy in the network can be of different types such as solar, electronic energy etc. In terms of energy, the effectiveness of each kind of operation is required by the network. Lesser the network life will be, More the energy will be wasted. A network is the network of connected sensors defined in terms of radio frequency, range specification etc. Each device available these days have some sensors included in it such as laptops, mobiles etc. Because of this it is the challenging advance area that requires feasibility in terms of memory, power consumption, memory management, security etc. The economic and the technological factors are also required to be analyzed [1].

Sensing + CPU + Radio = Thousands of potential applications.

2. Components of Sensor Network

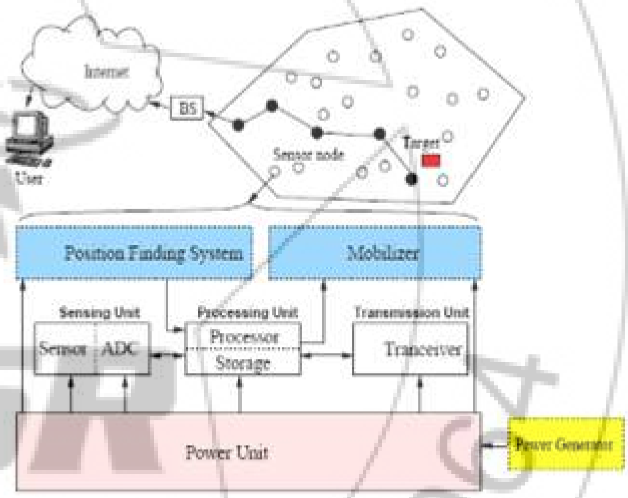

Figure 1: Components of Sensor Network [2].

2.1 Sensing Unit

Sensing Unit consists of Sensor nodes and ADC. Sensor nodes perform multiple functions in a network like sensing data, storage of data and processing in some networks. Sensor is a hardware device used to measure the change in physical condition of an area of interest and produce response to that change [3].

2.2 Memory Unit

This unit of sensor node is used to store both the data and program code. In order to store data packets from neighboring (other) nodes Read Only Memory (ROM) is normally used. To store the program code, flash memory or Electrically Erasable Programmable Read Only Memory (EEPRM) is used [3].

2.3 Power Unit

For computation and data transmission, the corresponding units in sensor node need power (energy). A power unit of a node is responsible to deliver power to all its units. Computation and Transmission are responsible for power consumption at the node. In terms of power consumption, transmission is the most expensive activity at sensor node [3].

2.4 Processing Unit

Sensor node has a microcontroller which consist a processing unit, memory, converters (analogue to digital, ATD) timer and Universal Asynchronous Receive and Transmit (UART) interfaces to do the processing tasks. This unit is responsible for data acquisition, processing incoming and outgoing information, implementing and adjusting routing information considering the performance conditions of the transmission [3].

2.5 Communication Unit

Senor Nodes use radio frequencies or optical communication in order to achieve networking. This task is managed by radio units in sensor nodes that use electromagnetic spectrum to convey the information to their destinations. Each sensor node transfers the data to other node or sinks directly or via multi hop routing [3].

3. Classification of WSNs

WSNs can be divided in two classes:

3.1 Structured

In a structured WSN, all or some of the sensor nodes are deployed in a pre-planned manner at fixed locations. The advantage of a structured WSN is that fewer devices can be deployed with lower network maintenance and management costs [4].

3.2 Unstructured

An unstructured WSN contains a dense collection of sensor nodes, which are randomly placed into the field (i.e., deployed in an ad-hoc manner). An ad-hoc deployment is preferred over a pre-planned deployment when the network is composed of hundreds to thousands of nodes in order to cover a larger area or when the environment is not directly accessible by humans attempting to construct WSN, e.g. polar regions, deep sea, or disaster areas such as a nuclear accident area or a war zone. WSNs has important applications such as remote environmental monitoring and target tracking. This has been made possible due to the availability of sensors that are smaller, cheaper and intelligent. These sensors are equipped with wireless interfaces with which they can communicate with one another to form a network. A sensor network is composed of a large number of nodes which are deployed densely in close proximity to the phenomenon to be monitored. The purpose of each of the nodes is to route this information back to a sink and collect data. Since the positions of individual nodes are not predetermined so the network must possess self-organizing capabilities. Groups of nodes cooperate to disseminate the information gathered in their vicinity to the user as the network must possess self-organizing capabilities [5].

4. PEGASIS

A PEGASIS being chain based hierarchical protocol transmits the data by selecting leader nodes. The leaders communicate with the Base Station. This approach is not only energy efficient but also distributes energy load evenly. The leader node keeps on rotating randomly as the data transmission rounds, the rounds namely chain formation, leader selection and data transmission, continue. Starting from a random node, the nodes will be organized to form a chain, which can be accomplished by the sensor nodes themselves using a greedy algorithm. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes [6].

5. Pollination Based Optimization (PBO)

Optimization is a natural process embedded in the living beings. The process of transfer of pollen from male parts of flower to the female part called Pollination. The male part of the plants is called Anther and female part is called Stigma. Stigma is a sticky part of a female flower due to which pollen stick with to it. Self-pollination and Cross-pollination are mainly two types of pollination in flowers. The scenario when pollen and pistil are from the same plant, often from the same flower is known as self pollination, some flowers build up their seeds with self pollination while Other plants require cross-pollination. In cross pollination pollen and pistil must be from different plants. Plants benefit from pollinators (for example water, air, nectar, bee etc.) because the movement of pollen allows them to reproduce by setting seeds. However, pollinators are not aware of or care that the plant benefits. They pollinate to meet their energy requirements, to get nectar and/or pollen from flowers and to produce offspring. Both the plants and the pollinators are dependent on each other, where the plants depend on pollinators for flowering, the pollinators need plants for food and their offspring. Few factors like floral display, fragrance and nectar lure pollinators leads to pollination. Some species of plants optimize their nectar and display producing resources. The expenditure on the resources is proportional to the level of pollination. Average resources will be spent by the plants if the pollination proceeds smoothly. The plants reduce expenditure on resources for producing nectar, floral display and fragrance in the flowers, if pollination process is above normal. Plants increase the resource expenditure such that more floral display, fragrance and nectar to attract pollinator, if pollination process is above normal. As more pollinators and their number of visits increase the pollination success rate increases [7].

6. Problem Statement

Energy efficiency is the most required quality in a sensor network where each node consumes some energy with each transmission over the network. Energy efficiency is one of the key factors to improve the network life. A sensor network is one of the busiest network on which large amount of different kind of data is communicated over the network. The aim of this work is to reduce the energy consumption by controlling the routing with the adjustment of the power with neighbouring nodes. In this work, opportunistic routing approach is defined to perform the energy effective route selection over the network. PEGASIS is combined with PBO for improving energy efficiency and optimizing the network to fulfill desired objectives.

7. Algorithm

Step1: Generate WSN Scenario.
Step 2: Initiate WSN parameters.
Step 3: Apply Chaining Algorithm based on PBO routing
Step 4: Optimize routing according:

- Plants = number of nodes.
- Weeks = number of iterations.
- Seasons = number of iterations to find the chain heads.
- Select neighbour node according to R(Reproductive Factor) [8].

$$R = \frac{(A \times D)}{(\alpha + A \times D)} + \frac{\left(\frac{a}{\alpha + A \times D}\right) \times N^P}{A^P + N^P} - C(N + D)$$

- Define Assumpted values.

a=1.2, A=0.9, D=1.2, N=41.9, P=2 [8].

Step 5: According to R factor define route.
Step 6: To define Chain head, we always check energy and distance

- Find parameters.
- Compare them.

8. Simulation and Performance Evaluation

8.1 Performance Metrics

(a) Packet Sent:
It is the number of packets sent by the application layer of source nodes.

(b)**Packet received:**
It is the number of packets received by the application layer of destination nodes.

(c) Throughput:
It is the average at which data packet is delivered successfully from one node to another over a communication network. It is usually measured in bits per second.

Throughput = (no of delivered packets * packet size) / total duration of simulation.

(d) Routing Overhead:
This is the total number of routing control packets generated by all nodes to the total data packets during the simulation time.

8.2 Simulation Parameters

We have simulated it in NS2. The simulation parameters are listed in the table below.

Table 1: Simulation Parameters

Parameter Name	*VALUE*
Topology	WIRELESS
Number Of Nodes	50
Mobility Model	RANDOM-MOTION
Channel Capacity	2
Mac Version	802.11
Pause Time	0S
Simulation Time	300SEC
Traffic Type	CBR
Traffic Rate	10 PACKET/SEC
Packet Size	512
Agent	UDP
Initial Energy	1J
Transmission Power	0.00005J
Receiving Power	0.000003J

(a) Result For Packet Delivery Ratio

Packet delivery ratio is the number of packet delivered in particular time. The graph below represents the packet delivery ratio for PBO and PEGASIS. Here red arc is for the PBO and green arc is for the PEGASIS. This graph shows that the packet delivery ratio of PBO is better than the PEGASIS.

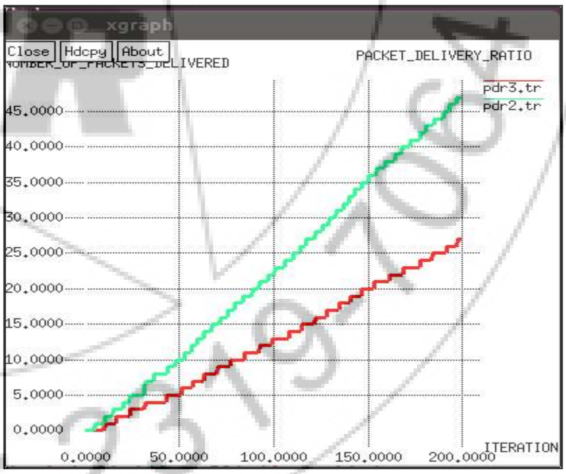

Figure 2: Packet Delivery Ratio for PBO and PEGASIS

(b) Result Showing Improved Throughput

The graph below represents the throughput for the PBO and PEGASIS. Throughput gives the efficiency of the system. The red line in this graph is for the PEGASIS and green line is for the PBO. Green arc shows that the throughput of the PBO is better than the PEGASIS.

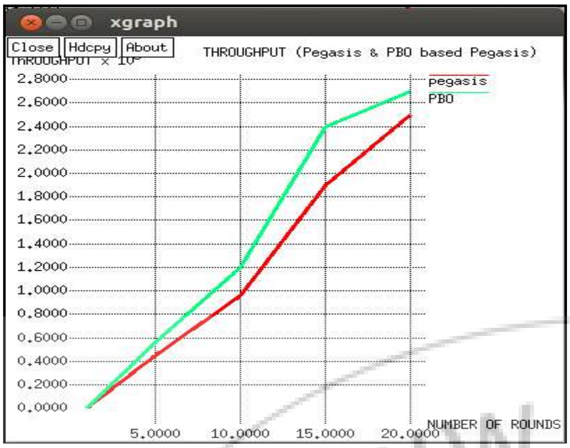

Figure 3: Throughput for the PBO and PEGASIS

(c)Results Showing Jitter

Jitter is the packet transmission delay caused due to queuing and serialization of packets. The result clearly shows that the jitter ratio for PBO is very less as compared to that of PEGASIS without PBO. Thus the graph shows a clear improvement in the jitter ratio for PEGASIS with PBO. Green arc gives the jitter ratio for PBO and red arc gives the jitter ratio for the PEGASIS.

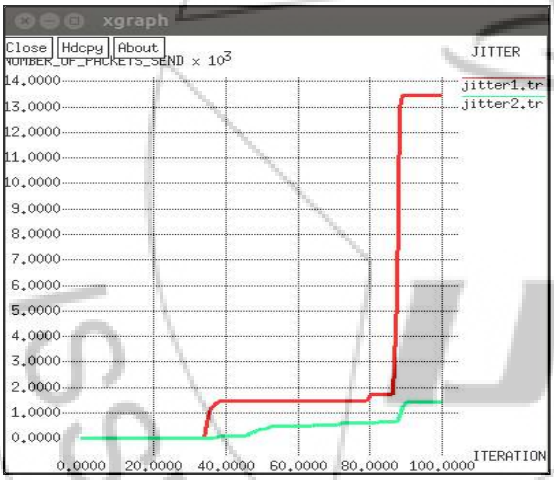

Figure 4: Jitter Ratio for the PBO and PEGASIS.

The table below shows the comparison of the percentage of the dead nodes with the number of rounds both in PEGASIS and after implementing PBO on PEGASIS.

Table 2: Comparison of Results

No of Dead Nodes (Percentage)	*PEGASIS (No of Iterations)*	*PPEGASIS(PBO with PEGASIS) (No of Iterations)*
1%	993	1323
50%	1981	2578
100%	2104	2900

The values of the table show that, 1% of the nodes went dead after 993 iterations in PEGASIS while the number of rounds increased to 1323 in case of PEGASIS with PBO. This shows that the energy efficiency of nodes in the hybrid protocol have increased from the PEGASIS and after calculations it is calculated that it has been improved by 22.74%.

9. Conclusion and Future Work

Wireless sensor network is collaboration of sensor nodes that have communicating and processing capabilities. These nodes have self organising capabilities. The basic task of sensor networks is to sense the events, collect data and send it to their requested destination. In this paper, we have improved the efficiency of WSN based, hierarchal routing protocol, PEGASIS by implementing an optimization technique, PBO, which uses artificial intelligence. A set of parameters have been improved using PBO and higher network lifetime have been achieved than with PEGASIS only. For future scope, more than one optimization techniques can be implemented to further improve the protocol. More number of parameters can be focussed than used in this paper. Future researches can even opt for more refined artificial intelligence approaches for network optimization.

References

[1] Celalettin Karakus, Ali CaferGurbuz, and Bulent Tavli, "Analysis of Energy Efficiency of Compressive Sensing in Wireless Sensor Networks" IEEE Sensors Journal, Vol. 13, no. 5, May 2013.

[2] Zulfiqar Ali , Waseem Shahzad, "Analysis of Routing Protocols in AD HOC and Sensor Wireless Networks Based on Swarm Intelligence", International Journal of Networks and Communication, 2013.

[3] Muhammad Ullah, Waqar Ahmad, "Evaluation of Routing Protocols in Wireless Sensor Networks", Master Thesis Computer Science, Thesis No: MCS-2009-14, May 2009.

[4] Anjali, Savita, Gurpal Singh, "Comparing Ant Colony Optimization & Genetic Algorithm for Solving Energy Efficient Coverage in WSNs", International Journal for Advance Research in Engineering and Technology, Vol. 1, Issue II, Mar. 2013, ISSN 2320-6802.

[5] Jennifer Yick, Biswanath Mukherjee, Dipak Ghosal, "Wireless sensor network survey", Department of Computer Science, University of California, Davis, CA 95616, United States, 2008.

[6] Feng Sen, Qi Bing, Tang Liangrui, "An Improved Energy-Efficient PEGASIS-Based Protocol in Wireless Sensor Networks", 2011 Eighth International Conference On Fuzzy Systems And Knowledge Discovery (FSKD), Volume: 4, PP. 2230 – 2233, 26-28 July 2011.

[7] S. Kumar & Singh Ajay, " Pollination based optimization", 6th International Multi Conference on Intelligent Systems, Sustainable, New and Renewable Energy Technology and Nanotechnology (IISN2012), March 16-18,2012,pp. 269-273.

[8] Vikas Gupta, Dhanvir Kaur, SimratPal Kaur, "Image Compression Using PBO", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 4, April 2014.

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