Cuckoo based Energy Effective Routing in Wireless Sensor Network

Gurpreet Kaur Bhatti[1], Jatinder Pal Singh Raina[2]
[1, 2] Department of Electronics and Communication Engineering, BBSBEC, Fatehgarh Sahib, Punjab, India
[1]er.gurpreet@live.com, [2]rkpuneet@gmail.com

Abstract — 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 required to improve the network life. In this work we will move in the direction to improve the network life. The presented work is about to perform the energy effective routing so that the network life and network throughput will be improved. In this work the opportunistic routing will be defined to optimize the networks on the basis of Cuckoo Search. Also, modification is made in the PEGASIS(Power Efficient Gathering in Sensor Information System) protocol using fuzzy system. This work is done to improve the network throughput as well as the network lifetime. The presented work is about to define an energy effective routing over the sensor network so that effective communication will be performed without increasing the congestion over the network. We have defined opportunistic routing to identify the effective path based on the energy analysis, load analysis and the delay analysis.

Keywords— WSN; Energy Effective Routing; Routing Optimization; Cuckoo Based Optimization; Fuzzy; PEGASIS

I. INTRODUCTION

An emerging field of wireless sensor networks that merges sensing, computation, and communication to a single tiny device. It is the power of wireless sensor networks that lies in the ability to deploy the large numbers of tiny nodes that assemble and configure themselves [6]. The scenarios for these devices range from real world tracking, to detecting the environmental situations, to the ubiquitous computing environments, to in situ monitoring of the health of structures or other equipment.

The wireless sensor network is a wireless network that consists of spatially distributed autonomous devices by using sensors to monitor physical or environmental problems like temperature, sound, pressure, etc. and to cooperatively pass their data through the network to the intended location. A wireless sensor networks system includes a gateway which provides wireless connectivity back to the wired world and the distributed nodes. Wireless protocol that you select depends on your application requirements [2]. Some of the available standards are 2.4 GHz radios which is based on either IEEE 802.15.4 or IEEE 802.11 standards or proprietary radios.

Some more modern networks are bi-directional, that enabling control of sensor activity. The introduction of wireless sensor networks was motivated by the military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, like industrial process monitoring and control, machine health monitoring. Area monitoring is very important application of WSNs which includes the WSN that is deployed over a region where some phenomenon is to be found [2]. It is also applicable in health care examining and Air pollution detection.

II. ENERGY EFFICIENCY IN WSN

A sensor network consists of a large number of small low-cost devices with sensing and transmitting capabilities. The main goal of the operation is to observe a region and gather and relay information to set of sink nodes called Base Station (BS). Forwarding the data to the BS is possible in two ways: using direct or multihop communication. In the first case every sensor transmits its data directly to the sink; in the second case, the sensors are communicating with the neighbors that forward the information in the direction of the sink [3].

The sensor networks can be also categorized by the periodicity of data transmissions. In a time-driven network every node sends messages periodically but in an event-driven a node sends message only when sensing a phenomenon. The third category is the query-driven approach where the sensors send data only after receiving a query from the BS.

The sensors are usually deployed densely and often on-the-fly. They operate untethered and unattended, are limited in power, computational capacities and memory. Because of these constraints the sensor network must have efficient self-organizing capabilities, while optimizing energy consumption. A primary design issue in sensor networks is energy efficiency. The sensors are small-sized and usually deployed in inaccessible regions; therefore they are supplied only by a small battery which is impossible (or very costly) to recharge. The main goal is to prolong the lifetime of the network which can be defined in several ways [4]:

- The time when any node depletes its battery,
- The time to which a given percentage of the sensors has enough energy to operate,
- The time upto which a given percentage of the region is covered by alive sensors.

III. Chain Based & Clustering Based Protocols

Low Energy Adaptive Clustering Hierarchy (LEACH) is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor networks (WSNs). The goal of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the life time of a wireless sensor network.

LEACH:

LEACH is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station (sink node). Each node uses a stochastic algorithm at each round to determine whether it will become a cluster head in this round [4]. LEACH assumes that each node has a radio transmitter powerful enough to directly reach the base station or the nearest cluster head, but that using this radio transmitter at full power all the time would waste energy.

Nodes that have been cluster heads cannot become cluster heads again for P rounds, where P is the desired percentage of cluster heads [10]. Thereafter, each node has a 1/P probability of becoming a cluster head in each round. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data.

All nodes that are not cluster heads only communicate with the cluster head in a TDMA fashion, according to the schedule created by the cluster head. They do so using the minimum energy needed to reach the cluster head, and only need to keep their radios on during their time slot. LEACH also uses CDMA so that each cluster uses a different set of CDMA codes, to minimize interference between clusters.

PEGASIS:

Power Efficient Gathering in Sensor Information System (PEGASIS) is a typical hierarchical-based routing protocol. As an enhancement algorithm of LEACH, PEGASIS is a classical chain-based routing protocol. It saves significant energy compared with the LEACH protocol by improving the cluster configuration and the delivery method of sensing data. However, the PEGASIS protocol also has many problems requiring solutions [Lindsey and Raghavendra [2002]].

In recent years, researchers have proposed many improved algorithms based on PEGASIS such as PEG-Ant, PDCH and EEPB [17]. Among them, EEPB adopts threshold when constructing chain to decrease the formation of long link(LL), selects the leader by considering both the residual energy of nodes and the distance between node and BS, and adjusts the reselection frequency of leader according to remaining nodes in the network. EEPB overcomes several problems over PEGASIS but still has deficiencies as follows:

a) When EEPB builds a chain, the threshold adopted is uncertain and complex to determine, which causes the inevitability of LL if valued inappropriately.
b) When EEPB selects the leader, it ignores the suitable proportion of nodes energy and distance between node and BS which optimizes the leader selection according to various application environments [17].

PEGASIS is entirely based upon chain-based routing technique, on which the third objective is based.

IV. Cuckoo Based Routing Optimization

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 required to improve the network life. We will move in the direction to improve the network lifetime. The presented work is about to perform the energy effective routing so that the network life and network throughput will be improved. We will perform opportunistic routing where network optimization is done on the basis of Cuckoo Search. This routing optimization will result into the generation of better routes in the network [5]. This new routing will perform better than the previous routing scheme. After this, the PEGASIS protocol will be modified on the basis of fuzzy system.
The PEGASIS is an already existing protocol of WSN. In our work we will make few modifications to the existing protocol using fuzzy system then, this protocol will be implemented in the network .By doing this we will get new results. We will compare it with the previous ones and get a significant difference. This difference would be the basis of our research work. The objectives of our work are given below:

- The main objective of the work is to define an energy effective routing over the network so that the network life will be improved.
- To define opportunistic routing where network optimization is on the basis of Cuckoo Search.
- To make the modification in the PEGASIS on the basis of fuzzy system.
- The work is about to improve the network throughput as well as the network life.

4.1 Basic Design of work

Initializing the WSN parameters such as number of nodes, routing protocols, area size, base station, energy transmitted/received, amp energy and data packets. Then the deployment of nodes is done. The whole scenario of WSN is established. The protocol of WSN named PEGASIS is modified by using fuzzy system then it is

implemented in the scenario created by us. The cuckoo search technique will be used for optimization purpose. The overall performance will be analyzed.

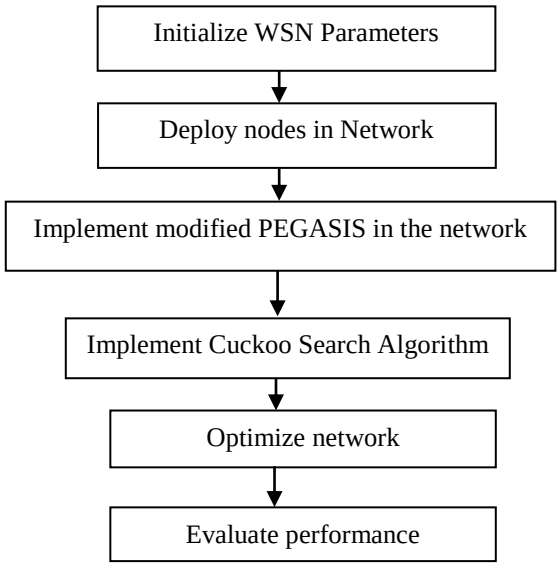

Fig 1: Basic Design

4.2 Source of Data

To define the sensor network we have to collect the information about different scenarios of sensor network. These parameters include:

1. Number of nodes and its placement topology
2. Energy parameters for the sensor nodes
3. Coverage area and architecture
4. Analytical parameters
5. Simulation time, response time etc.

This all information can be collected from the work done by earlier researchers [9]. We can collect this information from the study of earlier published paper.

4.3 Simulation Setup

A 100 node field is used and generated by randomly placing the nodes in a 100 m x 100 m square area. We assume that the area contains homogeneous sensor nodes with a communication range of 45m. The simulation focuses on number of sensor nodes alive, Average Energy of network and cost slot per iterations which are important indicators to measure performance of different algorithms. The simulation parameters used are shown below:

Table 1: Simulation Parameters

Parameter	Value
Number of Nodes	100
Area Size	$100\times100m^2$
Base Station	(50, 300)
Energy Transmitted	50nj/bit
Energy Received	$100pj/bit/m^2$
Amp Energy	$0.0013pj/bit/m^4$
Data Packets	3000 bits

V. RESULTS & DISCUSSION

A proposed chain based approach which is based on enhanced PEGASIS using cuckoo search approach is used to implement the desired solution for energy efficiency & to improve network lifetime. The simulation area is considered as 100 × 100 $meters^2$ with 100 sensor nodes has been considered. The enhanced chaining based on Fuzzy based PEGASIS and Cuckoo Search is as shown in fig 2.

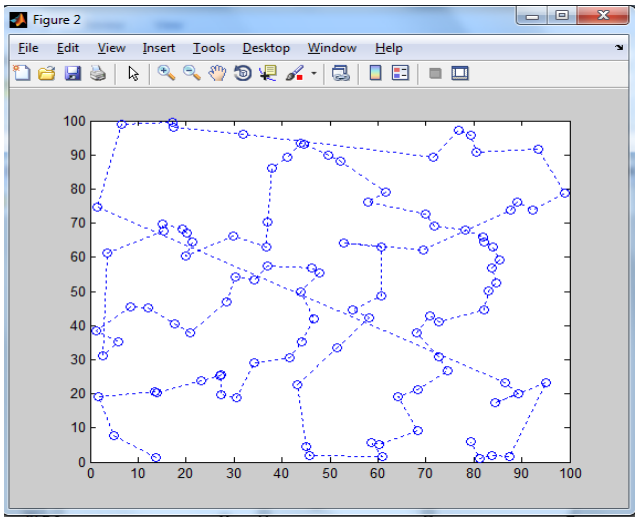

Fig 2: New chain formed in enhanced PEGASIS

The various performance parameters have been discussed below:

5.1 Number of Alive Nodes

In case of Fuzzy based PEGASIS, the numbers of alive nodes are more as compare to the previous work because in our work, an efficient routing optimization technique is used in an energy saving manner. We have saved a lot of resources by using innovative chain based approach. Fig 3 is showing the number of alive nodes with time.

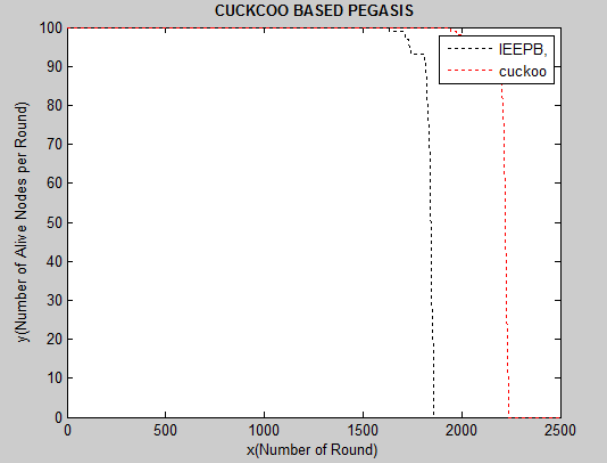

Fig 3: Number of alive nodes with accordance to number of rounds

5.2 Energy Consumption

Fig 4 explains that the energy consumption is less in case of proposed work using Fuzzy based PEGASIS protocol because in opportunistic routing the routes are smaller than previous routes, that is why the energy consumption is less. The average energy of all nodes per round in Fuzzy based PEGASIS & Cuckoo Search is higher than IEEPB. This proves that the energy efficiency of Fuzzy based PEGASIS & Cuckoo is better than IEEPB.

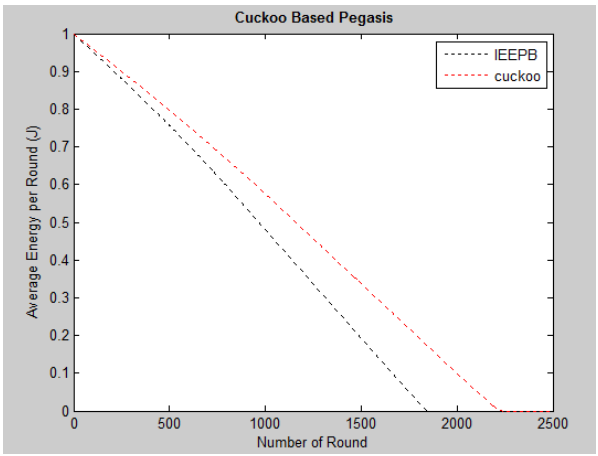

Fig 4: Average energy per round

VI. CONCLUSION

This paper proposes Fuzzy based PEGASIS & Cuckoo Search based energy-efficient routing in order to improve network lifetime by increasing the number of alive nodes and average energy per round. In presented work the energy effective routing is performed so that the network life and network throughput will be improved. In this work the PEGASIS protocol is modified using fuzzy system (Fuzzy based PEGASIS) and then cuckoo search algorithm is used for optimization. The simulation results show that this enhanced protocol save more energy and improve the network lifetime. Earlier the system's lifetime was 76 percent, after improving the PEGASIS protocol using fuzzy system we are getting more number of alive nodes and less energy is being consumed. Now the system performance is 92 percent, we are getting a significant difference of 16 percent.

REFERENCES

[1] Adrian Perrig," SPINS: Security Protocols for Sensor Networks", Mobile Computing and Networking 2001 Rome, Italy.

[2] FengyuanRen," EBRP: Energy-Balanced Routing Protocol for Data Gathering in Wireless Sensor Networks", IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS, VOL. 22, NO. 12, DECEMBER 2011 1045-9219/11@ 2011 IEEE.

[3] Hamid RafieiKarkvandi," Effective Lifetime-Aware Routing in Wireless Sensor Networks", IEEE SENSORS JOURNAL, VOL. 11, NO. 12, DECEMBER 2011 1530-437X © 2011 IEEE.

[4] Che-Jung Hsu," Economy: A Duplicate Free Opportunistic Routing", Mobility 2009, Sep 2-4, Nice, France ACM 978-1-60558-536-9/00/0009.

[5] Xufei Mao," Energy-Efficient Opportunistic Routing in Wireless Sensor Networks", IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS, VOL. 22, NO. 11, NOVEMBER 2011 1045-9219/11@ 2011 IEEE.

[6] Shiva Murthy G," Digital Signature-Based Secure Node Disjoint Multipath Routing Protocol for Wireless Sensor Networks", IEEE SENSORS JOURNAL, VOL. 12, NO. 10, OCTOBER 2012 1530–437X© 2012 IEEE.

[7] LlorençCerdà-Alabern," On the Performance Modeling of Opportunistic Routing", MobiOpp '10, February 22-23, 2010, Pisa, Italy.ACM 978-1-60558-925-1/10/02.

[8] AmrAljarhi," Rethinking Opportunistic Routing Using Space Syntax", CHANTS'11, September 23, 2011, Las Vegas, Nevada, USA. ACM 978-1-4503-0870-0/11/09.

[9] Zhongliang Zhao," Performance Evaluation of Opportunistic Routing Protocols: A Framework-based Approach using OMNeT++", LANC'12, October 4-5, 2012, Medellín, Colombia ACM 978-1-4503-1750-4/12/10.

[10] Libo Song," Evaluating Opportunistic Routing Protocols with Large Realistic Contact Traces", CHANTS'07, September 14, 2007, Montréal, Québec, Canada. ACM 978-1-59593-737-7/07/0009.

[11] Amir Darehshoorzadeh," Candidate Selection Algorithms in Opportunistic Routing", PM^{2}HW^{2}N'10, October 20–21, 2010, Bodrum, Turkey.ACM 978-1-4503-0278-4/10/10.

[12] Olaf Landsiedel," Low Power, Low Delay:Opportunistic Routing meets Duty Cycling", IPSN'12, April 16–20, 2012, Beijing, China. ACM 978-1-4503-1227-1/12/04.

[13] Eric Rozner," Model-driven Optimization of Opportunistic Routing", SIGMETRICS'11, June 7–11, 2011, San Jose, California, USA. ACM 978-1-4503-0262-3/11/06.

[14] Fan Wu,"Incentive-Compatible Opportunistic Routing for Wireless Networks", MobiCom'08, September 14–19, 2008, San Francisco, California, USA. ACM 978-1-60558-096-8/08/09.

[15] Junwhan Kim," Opportunistic RealTimeRouting in MultiHop Wireless Sensor Networks", SAC'09 March 812, 2009, Honolulu, Hawaii, U.S.A. ACM 9781605581668/09/03.

[16] Wenliang Du," An Efficient Scheme for Authenticating Public Keys in Sensor Networks", MobiHoc'05, May 25–27, 2005, UrbanaChampaign, Illinois, USA. ACM 1595930043/05/0005.

[17] FengSen, Qi Bing and Tang Liangrui, "An Improved Energy-Efficient PEGASIS Based Protocol in Wireless Sensor Networks" 2011 Eighth International Conference on Fuzzy Systems and Knowledge Discovery (FSKD), 978-1-61284-181-6/11/$26.00 ©2011 IEEE.

[18] Joon-Woo Lee and Ju-Jang Lee, "Ant-Colony-Based Scheduling Algorithm for Energy-Efficient Coverage of WSN" IEEE SENSORS JOURNAL, VOL. 12, NO. 10, OCTOBER 2012.