Volume 3, Issue 7, July 2013 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

# Network Lifetime Enhancement Using Genetic Algorithm

**Gurbhej Singh***
*Department of CSE*
*Sri Guru Granth Sahib World University*
*Fatehgarh Sahib, Punjab, India*

**Rajneet Kaur**
*Assistant Professor Department of CSE*
*Sri Guru Granth Sahib World University*
*Fatehgarh sahib, Punjab, India*

***Abstract- Major applications of Wireless sensor networks (WSNs) are monitoring and tracking. The large numbers of sensors are deployed in remote and inaccessible places therefore deployment and maintenance should be easy and scalable. Sensors have limited battery backup as they are small in size. The energy is a critical factor in order to extend the lifetime of the network as nodes once deployed cannot be recharged as deployed in dangerous areas. Clustering or chain based techniques are generally used in WSNs inorder to reduce energy consumption of sensor nodes. In this paper we discussed clustering based and chain based routing protocols for WSNs. In cluster-based routing special nodes called cluster heads form a wireless backbone to the sink or Base Station. Each cluster heads collects data from the sensors belonging to its cluster and forwards it to the sink. In chain-based routing protocols chain is formed a node called leader node forwards the data to the Base Station. We propose and simulated a protocol in which chain formation is done by using genetic algorithm and then leader is elected which forwards data packet to BS. Simulation results shows that the proposed protocol significantly increase the total lifetime of the wireless sensor networks and has less average round time as compared to the LEACH, PEGASIS and CHIRON protocols.***

***Keywords- WSNs, LEACH, PEGASIS, CHIRON, GA-CHIRON, Network Lifetime, Energy Efficiency, Average Round Time***

## I. INTRODUCTION

With the help of recent researches in micro-electro-mechanical technology, wireless communication and digital electronics low cost, low power multipurpose sensors nodes of small size have been developed. Wireless sensor node's major steps in their work are sensing, processing of data, and communicating with other nodes[5]. Wireless sensor network consists of electronics devices which form the network in which information sensed or gathered is transmitted to the sink node or Base Station (BS) from where the end-user can access the data. Each device in the sensors network is capable of sensing, processing and transmitting of the sensed data. Each device has battery power which is used during sensing, processing and sending of data. There are numerous areas of applications of WSNs e.g. environment and agriculture monitoring, industrial control and monitoring, home automation, Security monitoring and defense also [6][10].WSNs are used to collect information of hazardous areas such as battle fields, monitoring and tracking of animals in forest etc in which battery cannot be replaced easily so the power must be consumed efficiently to remain in working condition for long time. Lifetime of network is determined from energy consumption by sensor nodes .So, In order to enhance lifetime network energy must be consumed efficiently by using efficient protocols. Many routing protocols have been proposed for WSN. Based on the network topology, they can be classified as plane protocols and hierarchical protocols[7]. The hierarchical protocol aims at clustering sensor nodes so that cluster heads can do some aggregation and reduction of data in order to save energy. LEACH[1] is the hierarchical protocol in which all nodes are divided into clusters .Nodes from each clusters are selected as cluster head which collects the data from the cluster then perform data aggregation and then forward data to BS. PEGASIS[3] is Power-Efficient Gathering in Sensor Information Systems. PEGASIS form open chain staring from node which is farthest from Base Station .PEGASIS assume that global information is available. This algorithm uses greedy algorithm for chain construction. Before first round of communication chain formation is done [4].During formation of chain care must be taken so that nodes already in chain should not revisited . When a node die then chain is reconstructed by bypassing that node. In data gathering cycle each node forms a data packet of its own in network. For each data gathering cycle leader is elected among all nodes in network. Each node in network receives a data packet and fuses it with its own data and forwards it to other neighboring node. PEGASIS uses a simple token passing approach which is initiated by leader to start data transmission from ends of chain. CHIRON [11] is chain based hierarchical routing protocol which use the technique of BeamStar to divide the sensing area into several fan-shaped groups. The sensor nodes within each group are then self organized into a chain for data dissemination. Unlike traditional approaches, instead of taking turns, we consider the node with a maximum residual energy as chain leader candidate. In addition, for avoiding a longer transmission would be incurred among chain leaders, the nearest downstream chain leader will be elected for relaying the aggregated sensing information. Here we propose a protocol based on the enhancement of the CHIRON protocol. In CHIRON in fan shaped groups greedy algorithm is used but we will use genetic approach for construction of chain. The remainder of the paper is organized as follows: Section II presents network model, notations and assumptions used in our simulations. Section III describes phases of our proposed scheme. Section IV manifests our simulation environments, parameters, results and comparative study. Section V will conclude the simulation.

## II. NETWORK MODEL, NOTATIONS AND ASSUMPTIONS

### *A. Network Model*

For the sake of uniformity proposed GA-CHIRON we uses the same radio model as used in LEACH and PEGASIS [2]. In our work, we assume a simple model where the radio dissipates $E_{elec}$ = 50 nJ/bit to run the transmitter or receiver circuitry and $E_{amp}$ = 100 pJ/bit/m$^2$ for the transmit amplifier .We also assume an $r^2$ energy loss due to channel transmission. Thus, to transmit a k-bit message a distance d using our radio model, the radio expends:

$$E_{Tx}(k, d) = k*E_{elec} + k*E_{fs}*d^2 \quad d < d_o \ldots\ldots(1)$$

$$E_{Tx}(k, d) = k*E_{elec} + k*E_{mp}*d^4 \quad d \geq d_o \ldots\ldots(2)$$

To receive this message, the radio expends:

$$E_{Rx}(d) = k*E_{elec} \ldots\ldots(3)$$

Where do is= $(E_{fs}/E_{mp})^{1/2}$, $E_{fs}$= 10pJ/bit/m$^2$, $E_{mp}$= 0.00013 pJ/bit/m$^2$, $E_{DA}$= 5 nJ/bit/signal.

The medium assumed to be symmetric such that the energy required for transmitting a message from node A to B and from node B to A are same. Receiving is also a high cost operation, therefore, the number of receives and transmissions should be minimal.

### *B. Notations*

we define some notations as follows:

$R$: the transmission range of the BS. For simplicity, we use distinct integers (1 … $n$) to represent various ranges.

$\theta$: the beam width (covering angle) of the directional antenna. Also, similar to the definition of $R$, different integers (1 … $n$) are used to indicate distinct angles.

$n_i$: the node $i$; the node set $N=\{n1, n2, n3, \ldots, n_i\}$, where $1 \leqq i \leqq |N|$.

$C_{x,y}$: the id of a chain which was formed in group $Gx,y$. the chain set $C=\{c_{1,1}, c_{1,2}, \ldots\}$.

$l_{x,y}$: the leader node id of chain $cx,y$. The leader set $L=\{l_{1,1}, l_{1,2}, \ldots\}$.

### *C. Network Assumptions*

Here are some assumptions for our experiment setups are:

1. All sensors are within the wireless communication range when they communicate with each other or with the BS.
2. All sensors have homogeneous sensing, computing and communication capabilities.
3. All sensors are randomly deployed in WSN.
4. BS is located in the corner of the sensor networks and BS has infinity energy resource.
5. All sensors in the network have the same initial energy resource and dissipate their energy resource at the same rate. All the sensors would exhaust their energy resource at the same time.
6. Network lifetime is defined as the time span from the deployment to the instant when the entire sensors die.
7. Both the energy dissipation of sensing data and the energy dissipation for clustering are neglected. Compared with the power consumption of CPU and Radio, the power consumption of sensor part is so small that can be neglected. Also, we suppose that all the clustering algorithms are run on the BS and no energy dissipation of clustering on sensor nodes.
8. The time span that BS collects the information from all the sensors once is defined as a round. In a round, each sensor has only one sensed data with the same packet size.
9. The sensors that receive the data combine one or more packets to produce a same-size resultant packet, and by this way, the number of data that need to send by radio is reduced. This is reasonable, because it is generally used to the scenario that there is much correlation among the data sensed by the different sensors.

## III. PROPOSED PROTOCOL

The proposed protocol use genetic approach for construction of chain. First of all beamstar[8] algorithm is used to divide the whole area into fan-shaped area then genetic approach is applied to each group for construction of chain. The operation of proposed protocol consists of four phases

Phase: 1 Group Construction

Phase: 2 Chain Formation

Phase: 3 Leader Node Election

Phase: 4 Data Collection and Transmission Phase

1. **Group Construction Phase***:* In order to create multiple shorter chains the given area is divided. The given area is divided by using BeamStar technique. Nodes can easily determine in which group they are respectively belonging to after receiving such control packets. A grouping example with $R$=1..3 and $\theta$=1..2 is shown in figure 1

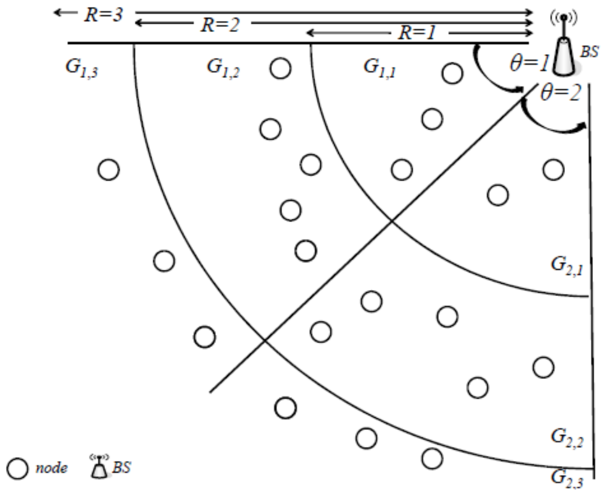


Figure 1 Grouping example with *R*=1..3 and *θ*=1..2[11]

2. **Chain Formation Phase:** The nodes within each group $G_{x,y}$ will be linked together to form a chain $c_{x,y}$ respectively in this phase . The chain formation process is different from the CHIRON. In this chain formation in each group is done by using Genetic Algorithm The process is repeated until all nodes are put together and thus finally a group chain is formed. Genetic algorithm is used for construction of chain for each group. Genetic algorithm is based on the concept of natural selection and evolution. Each individual is a coded form of a possible solution of the problem at hand and is called a chromosome. At each generation it maintains a population of individuals. A function called as fitness function is used to evaluate each chromosome .This is also called as cost function or the objective function of the corresponding optimization problem. Selection, crossover, repair and mutation operations are used for new population from the existing. Selecting more fit individual for crossover and mutation is major purpose of selection mechanism. Exchange of genetic material between parents to form offspring is caused by crossover. Incorporation of new genetic materials in the offspring is caused by mutation. The components of this scheme are as:

**A. Genes and Chromosome**

Routing chain is represented in terms of a chromosome which contains genetic information for the Genetic Algorithm. A chromosome is a collection of genes and each chromosome represents a particular arrangement of the nodes in the routing chain for a given network. The *gene index* represents the position of the node in the chain and *gene value* provides the node's identification number (ID). A chromosome is represented by an integer string of size N where each integer is unique and lies between 1 and N. These integers are the individual gene values that make up the chromosome. The example of six node's gene index and gene value is given as:

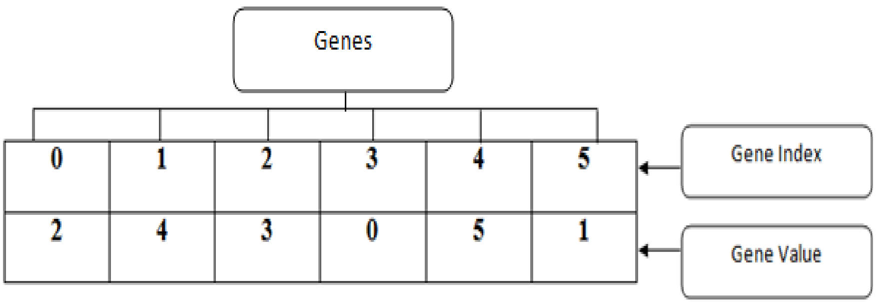


Figure 2 Gene index and gene value of 6 nodes

In this representation each chromosome encodes an ordered sequence of nodes. Also note that for a chromosome containing N genes there are N! different gene arrangements possible.

**B. Population**

A population is a collection of chromosomes where a family of *r* chromosomes is represented as P = ($C_1$, $C_2$ ……$C_r$ ) . The population has to be pre-generated to initiate the algorithm at first generation. In this scheme we have generated the initial population a sample random generation algorithm. No efforts have been made to construct initial population in some specific way. An initial population for our scheme is created with randomly chosen permutation of the integer string {1, 2… N}. It consists of *r* chromosomes. Greater the value of *r*, greater is the probability of reaching a better solution. While the chromosomes are generated it is ensured that the distances between any two consecutive nodes or gene values do not exceed the threshold distance for communication.

**C. Parent Selection**

It is the process of determining in order to create an offspring which two parents out of the total population of *r* chromosomes will take part in mating Two chromosomes are chosen randomly for mating as we use tournament selection.

 

**D. Generation**

Crossover and mutation operations are used for creation of new generation. A single point crossover is performed between two parent chromosomes to produce an offspring. The population size remains same for all the generations. We also keep a track of the historically obtained best or fittest chromosome $C_{best}$.

***Crossover***- Crossover indicates the combination of the two parent chromosomes to produce an offspring. The crossing method is used in this scheme. For e.g., Say, $C_1$ = {3,1,2,4,6,5} and $C_2$ = {5,2,1,4,3,6} are the two parent chromosomes selected for crossover. The slot {2,1,4} is randomly chosen from $C_2$ and inserted in the same position in $C_1$. Thus the offspring produced is O = {3,2,1,4,6,5}. The historically obtained best chromosome is also updated if applicable.

***Evaluation and Fitness***- The objective of the optimization problem and the cost function is designed in order to determine the fitness of candidate.

***Fitness function***- Fitness is the major component of a Genetic Algorithm. The Energy Function for our scheme is:

$$f(C) = \sum_{i=1}^{N} d_i^2 \quad \text{……………………………………………………………(4)}$$

The above equation is derived from first order radio order model. We have considered the terms in the chain related to distance only which is responsible for energy consumption. Equation (4) calculates the *energy* of a chromosome C containing *N* genes and $d_i$ denotes the distance between the $(i+1)^{th}$ node (or, gene) and the $i^{th}$ node in the data gathering chain. It should be noted that a greater value of the chromosome energy indicates a longer chain and corresponds to an inferior solution. When $C_{parent1}$ and $C_{parent2}$ produces a new offspring $C_{offspring}$

$$\Delta E = [\ f(C_{offspring}) - \{f(C_{parent1}) + f(C_{parent2})\} * 0.5\ ] \quad \text{……………………………………………(5)}$$

Equation (5) represents the energy difference between the two generations. Clearly, a negative ΔE indicates a superior offspring.

***Repair and Mutation***

***Repair***-If a produced offspring violates the constraints imposed in the optimization problem like distance threshold the solution is rejected and the crossover operation is performed again. This phenomenon is called the repair.

***Mutation*** adds variation in the next generation. In mutation a node is randomly picked slot from the historically obtained best chromosome is picked and inserted into the offspring. Similar to crossover mutation operation may produce an invalid chromosome which is also fixed by the repair function. The mutation operation can help the optimization problem to jump out of the local optimization by sharing the global information about the population.

3. **Leader Node Election Phase:** A leader node in each group chain must be selected for collecting and forwarding the aggregated data to the BS. In GA-CHIRON the election of chain leader is based on the maximum residual energy. The node with the maximum residual energy will be elected for each data transmission round.
4. **Data Collection and Transmission Phase:** The data collection and transmission phase begins after completed the previous three phases. The procedure of data transmission in proposed scheme (GA-CHIRON) is similar to that in CHIRON scheme. Firstly, the normal nodes in each group transmit their collected data along by passing through their nearest nodes, to the chain leader. And then, starting from the farthest groups, the chain leaders collaboratively relay their aggregated sensing information to the BS, in a multi-hop, leader-by-leader transmission manner.

## IV. SIMULATION RESULTS

For evaluating the performance of proposed protocol we use MATLAB [9] for simulation. We simulated proposed protocol, CHIRON, LEACH and PEGASIS using several random 100-nodes for 100m x100m and 200 x 200m area. BS is located at (100,100) for small area and (200,200) for large area. We ran the simulations to determine the number of rounds of communication when 1%, 50% and 100% of the nodes die using LEACH, PEGASIS, CHIRON and GA-CHIRON with each node having the same initial energy level. Table values are based on average of 10 runs of simulation. Once a node dies it is considered dead for the rest of the simulation. Our simulations show that proposed GA-CHIRON gives better performance.

Figure 3 shows the number of rounds until nodes die for a 100m x 100m network and Figure 4 shows same parameters i.e. initial energy of 0.5 J but for a 200m x 200m network. Proposed scheme has 3.2X , 1.7X , 1.2X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively for 100m X 100m area. For 200m X 200m with 0.5 J of initial energy the proposed scheme has 6X , 1.3X , 1.2X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively.

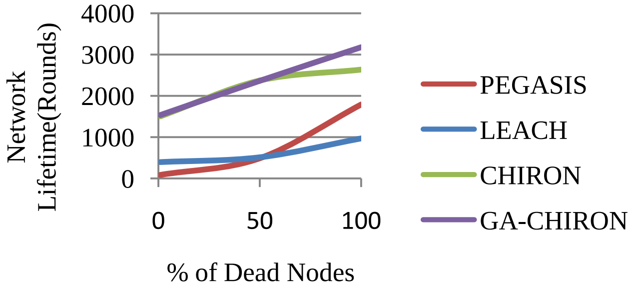


Figure 3 Performance results for a 100m x 100m network with initial energy 0.5J/node

 

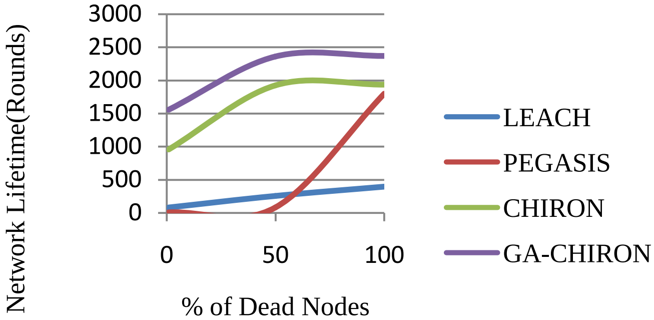


Figure 4 Performance results for a 200m x 200m network with initial energy 0.5J/node

Table 1 summarizes the results with initial energy per node of 0.25J, .5J, and 1.0J for the 100m x 100m and 200m x 200m networks. The shaded portion is for the 200m x 200m network.

| Energy J/Node | Protocol | Round when First node dies | Round when half node dies | Round when last node dies |
|---|---|---|---|---|
| 0.25 J | LEACH | 201 | 256 | 519 |
| | PEGASIS | 49 | 225 | 990 |
| | CHIRON | 836 | 1185 | 1316 |
| | GA-CHIRON | 771 | 1183 | 1608 |
| 0.50 J | LEACH | 399 | 514 | 971 |
| | PEGASIS | 90 | 489 | 1790 |
| | CHIRON | 1508 | 2369 | 2637 |
| | GA-CHIRON | 1534 | 2364 | 3175 |
| 1 J | LEACH | 875 | 1047 | 1815 |
| | PEGASIS | 211 | 960 | 3882 |
| | CHIRON | 2897 | 4738 | 4987 |
| | GA-CHIRON | 3082 | 4732 | 6000 |
| 0.25 J | LEACH | 35 | 130 | 198 |
| | PEGASIS | 4 | 52 | 977 |
| | CHIRON | 831 | 977 | 987 |
| | GA-CHIRON | 774 | 1181 | 1273 |
| 0.5 J | LEACH | 80 | 257 | 395 |
| | PEGASIS | 7 | 80 | 1796 |
| | CHIRON | 955 | 1923 | 1934 |
| | GA-CHIRON | 1556 | 2360 | 2369 |
| 1 J | LEACH | 228 | 512 | 709 |
| | PEGASIS | 11 | 15 | 3350 |
| | CHIRON | 3188 | 3885 | 3896 |
| | GA-CHIRON | 3101 | 4709 | 4728 |

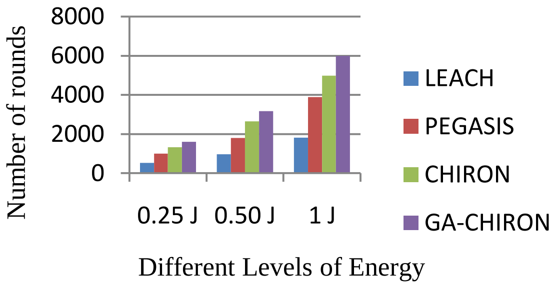


Figure 5. Performance results for power consumption Vs Number of rounds for 100m X 100m area

 

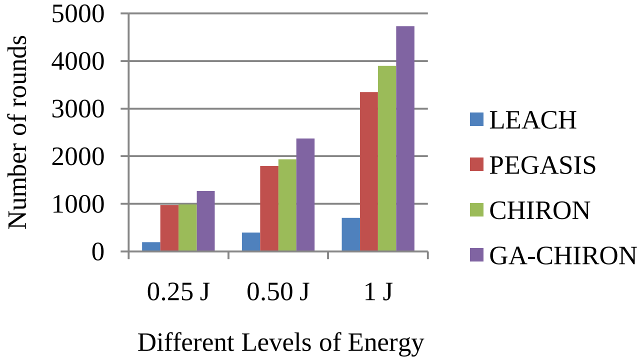


Figure 6. Performance results for power consumption Vs Number of rounds for 200m X 200m area

From figure 5 and figure 6 it is clear that GA-CHIRON is efficient as compared to LEACH, PEGASIS and CHIRON. Average round time is the average amount of time taken to complete one round. Average round time of different protocols is shown in figure 5 and figure 6. For real time application or critical applications round time should be less.

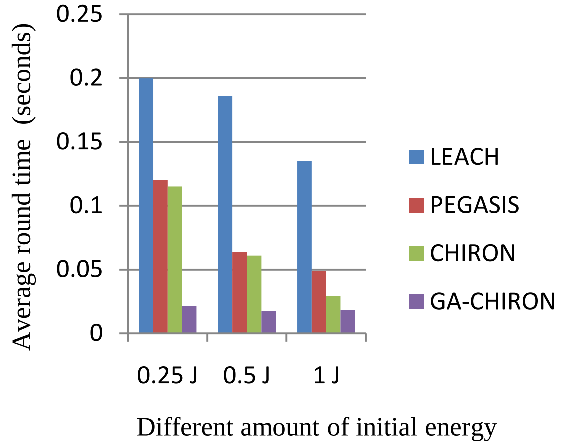


Figure 7 Average round time Vs Different amount of energy for 100m X 100m

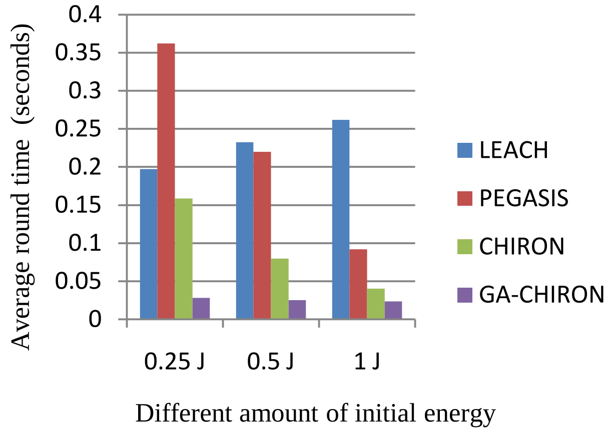


Figure 8 Average round time Vs Different amount of energy for 200m X 200m

Figure 7 and figure 8 show average round time of different protocols with different amount of initial energy. Based on simulation GA-CHIRON has less average round time as compared to LEACH, PEGASIS and CHIRON.

## V. Conclusions and Future work

In this paper inorder to maximize network lifetime an efficient routing scheme for wireless sensor networks has been proposed and simulated. The network lifetime and average round time are examined and compared with existing schemes. A comparison study is being performed with energy 0.25 J, 0.5 J ,1.0 J for 100m X 100m and 200m X 200m areas. For 0.25 J of initial energy the proposed scheme (GA-CHIRON) has 3X , 1.6X , 1.22X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively for 100m X 100m area For 0.5 J of initial energy the proposed scheme has 3.2X , 1.7X , 1.2X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively for 100m X 100m area . For 1 J of initial energy the proposed scheme has 3.3X, 1.5X, 1.2X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively for 100m X 100m area. For large area of 200m X 200m and with 0.25 J of initial energy the proposed scheme has 6.4X, 1.3X , 1.2X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively. For 0.5 J of initial energy the proposed scheme has 6X , 1.3X , 1.2X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively for 200m X 200m area . For 1 J of initial energy the proposed scheme has 6.6X, 1.3X, 1.21X maximum lifetime as compared to LEACH, PEGASIS and CHIRON respectively for 200m X 200m area. Average round time is less as compared to other protocols and different energy levels for both small and large areas. In this study we use genetic algorithm in order to form chain in the CHIRON .Other techniques such as swarm intelligence can be used. The methods of swarm intelligence like ant colony optimization (ACO), particle swarm optimization (PSO) can be used in existing work. In this study we have assumed the location of BS is fixed, future work can be done with mobile BS.

## ACKNOWLEDGMENT

The authors wish to thank Amandeep Kaur Virk, Assistant Professor (Computer Science and Engineering) for her support in research.

## REFERENCES

[1] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy Efficient Communication Protocol for Wireless Microsensor Networks,” Proceedings of the 33rd Hawaii International Conference on System Sciences, 2000.

[2] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “An Application-Specific Protocol Architecture for Wireless Microsensor Networks,” IEEE Transaction on Wireless Commun., Vol. 1, Issue 4, pp. 660-670, 2002.

[3] S. Lindsey, C. S.Raghavendra, and K. M. Sivalingam, “Data Gathering Algorithms in Sensor Networks Using Energy Metrics,” IEEE Transactions on Parallel Distributed System, Vol. 13, Issue. 9, pp. 924-935, 2002.

[4] A. Seetharam, A. Acharya , A. Bhattacharyya , M. K. Naskar , An Energy Efficient Data Gathering Protocol for Wireless Sensor Networks ,Journal of Applied Computer Science, no.1 (2) /2008,Suceava

[5] Gurbhej Singh,Harneet Arora, “Design and Architectural Issues in Wireless Sensor Networks”,International Journal of Advanced Research in Computer Science and Software Engineering (1), January - 2013, pp. 28-32

[6] I.F. Akyildiz, W. Su, Y. Sankarasubranmaniam, and Erdal Cayirci, “A Survey on Sensor Networks”, IEEE Communications Magazine, November 7, 2002, pp. 102-114, vol. 40(8).

[7] J. N. Al-Karaki and A. E. Kamal, “Routing Techniques inWireless Sensor Networks: A Survey,” Proceedings of the IEEE Wireless Communications, Vol. 11, pp. 6-28, 2004.

[8] S. Mao, and Y. T. Hou, “BeamStar: An Edge-Based Approach to Routing in Wireless Sensor Networks,” IEEE Transactions on Mobile Computing, Vol. 6, Issue 11, pp. 1284-1296, 2007.

[9] The MatWorks – MATLAB and Simulink for Technical Computer: http://www.mathworks.com/

[10] Xiangqian Chen Kia Makki, Kang Yen, and Niki Pissinou, “Sensor Network Security: A Survey”, Communication Survey & Tutorial, IEEE, second quarter 2009, pp.52-73, Vol. 11 (2).

[11] K.H. Chen, J.-M. Huang, and C.-C. Hsiao, "CHIRON: An Energy-Efficient Chain Based Hierarchical Routing Protocol in Wireless Sensor Networks", Wireless Telecommunications Symposium, pp. 1-5, 2009.

## AUTHOR’S PROFILE

**Gurbhej Singh** is currently pursuing Master of Technology Degree in Computer Science and Engineering from Sri Guru Granth Sahib World University, Fatehgarh Sahib. He has received his B.Tech degree from Punjab Technical University, Jalandhar, India. His interests include Computer Networks and Digital Image Processing.

**Rajneet Kaur** received her M.E Degree UIET, Panjab University Chandigarh. Presently she is working as an Assistant Professor at Sri Guru Granth Sahib World University, Fatehgarh Sahib. Her field of specialization includes Digital Image processing, Networks and Data Mining.

 