ENHANCING THE NETWORK LIFETIME OF WIRELESS SENSOR NETWORK USING LEACH PROTOCOLAND GENETIC ALGORITHM

Divya Parmar[1], Dhiraj Patel[2]

[1]*M.E. Students, Department Of EC, S. N. Patel Institute of Technology & RC, Umrakh, Gujarat, India*
[2]*Assistant Professor, Department of EC, S. N. Patel Institute of Technology & RC, Umrakh, Gujarat*

ABSTRACT

Wireless Sensor Networks (WSNs) are Group of small Sensor Nodes that are stand to sensing, Processing and transmitting data related to some occurrence in the network area. The major source of sensor network failure is battery exhaustion and replacing this energy source in the field is usually not practical. Therefore, the use of energy efficient infrastructure, such as repositioning the Base Station (BS) in clustered WSN is able to prolong the lifetime of the network and improve the overall network data. In this paper, different energy efficient routing techniques are discussed. an energy efficient Protocol for the repositioning of mobile base station using Genetic Algorithm (GA) in Wireless Sensor Networks can improve the network lifetime, data delivery and energy consumption compared to existing energy-efficient protocols developed for this network.

Keywords: *Wireless Sensor Networks, base station LEACH protocol, Genetic Algorithm*

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1. INTRODUCTION

Wireless Sensor Networks are family of networks in Wireless Communication System. . It is energy constrain network. Sensor network is composed of a large number of low cost and low power sensor nodes that can be spread on a densely populated area and a special node or machine known as base station in order to monitor and control various physical parameters [1] . These sensors are equipped with a less amount of computing and communication potential and can be deployed in situation that wired sensor systems couldn't be deployed Random deployment of sensor nodes in inaccessible terrain such as environment monitoring, military application and even health monitoring can be set up. In environment monitoring for instance, wireless sensor network can be used to monitor the environment such as chemical Pollutants or detecting early warning of disaster incident such as wildfires and earthquakes. WSN can also be used to monitor animals and plants in a wildlife habitat. Another type of application is the health monitoring where sensor nodes can be directly attached to intensive care patients and doctors can closely monitor their health progress.WSN must be operated with minimum possible energy to increase the lifetime of sensor node and hence the lifetime of whole network .protocols and algorithms in sensor network must possess self- organizing capabilities in order to achieve this target. The challenges in the designing and managing of sensor network rely on combination of the constraint in energy supply and bandwidth, and deployment of large number of sensor nodes [2].

The fundamental challenges in designing of WSN is to extend the network lifetime, hence all the network layers should be carefully designed in order to minimize the energy consumption in each sensor node. The objective is to implement Genetic Algorithm as optimization algorithm. To define a new fittest function to optimize the moving path of mobile base station and to investigate network lifetime and energy efficiency.

2. HARDWARE ARCHITECTURE OF SENSOR NODE

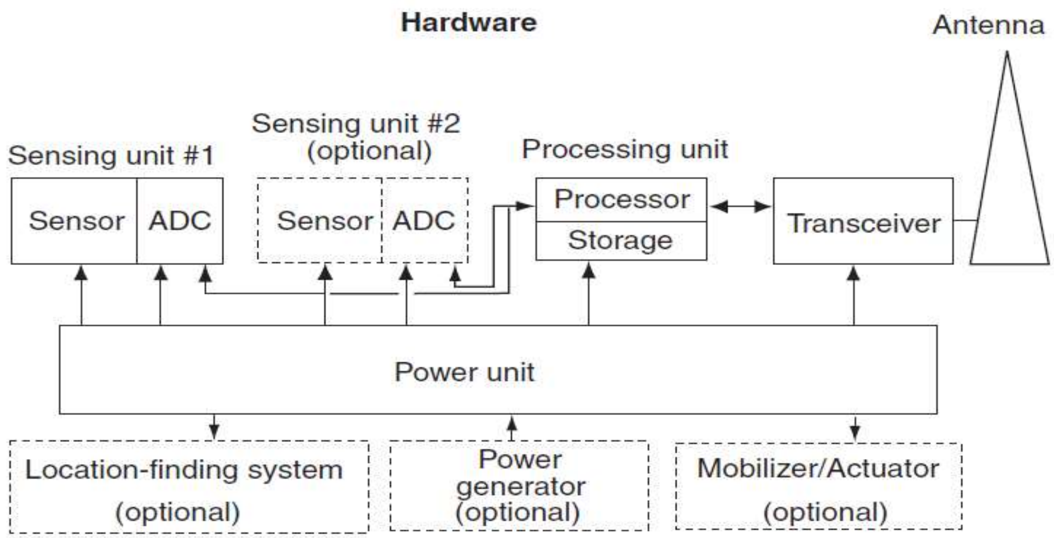


Figure 1 Hardware Architecture of Sensor Node [1]

The end device in WSNs, the sensor node, is composed of four basic units [1]

(1)Sensing Unit

It consists of an array of sensors that can measure the physical characteristics of its environment, like temperature, light, vibration, and others. Each sensor has the ability to sense environmental characteristics via the sensing unit and then use the Analog to Digital Converter (ADC) to convert the sensed analog data into digital.

(2)Processing Unit

It is, in most cases, composed of an internal memory to store data and application programs, and a microcontroller to process the data. The microcontroller can be considered as a highly constrained computer that contains the memory and interfaces required to create simple applications. This unit should be able to work with a limited resource of energy and process efficiently the digital data delivered by the sensing unit.

(3)Power Unit

A wireless sensor node is a popular solution when it is difficult or impossible to run a mains supply to the sensor node. However, since the wireless sensor node is often placed in a hard-to-reach location, changing the battery regularly can be costly and inconvenient. An important aspect in the development of a wireless sensor node is ensuring that there is always adequate energy available to power the system. The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process.

(4)Transceiver Unit

It is able to send and receive messages through a wireless channel. In other words, it gives the sensor the ability to talk to other sensor nodes and form an Ad Hoc Network.

2.1. LEACH-Energy Efficient Protocol [11]

Low Energy Adaptive Clustering Hierarchy (LEACH) is an adaptive clustering routing protocol proposed by Wendi B. Heinzelman, et al. LEACH arranges the nodes in the network into small clusters and chooses one of them as the cluster-head. Node first senses the environment and then sends the relevant information to its cluster-head. Then the cluster head aggregates and compresses the information received from all the nodes and sends it to the base station. The nodes chosen as the cluster head drain out more energy as compared to the other nodes as it is required to send

Data to the base station which may be far located. Hence LEACH uses random rotation of the nodes required to be the cluster-heads to evenly distribute energy consumption in the network. TDMA/CDMA MAC is used to reduce inter-cluster and intra-cluster collisions. This protocol is used were a constant monitoring by the sensor nodes are required as data collection is centralized (at the base station) and is performed periodically [11].

LEACH operation is divided into many rounds. Each round includes two phases:

1) Setup phase in which clusters head are selected and clusters are created

2) Steady data phase in which data communication take place.

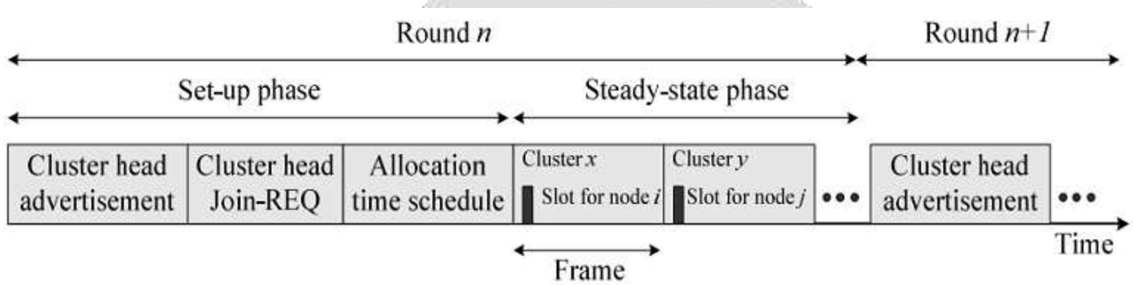


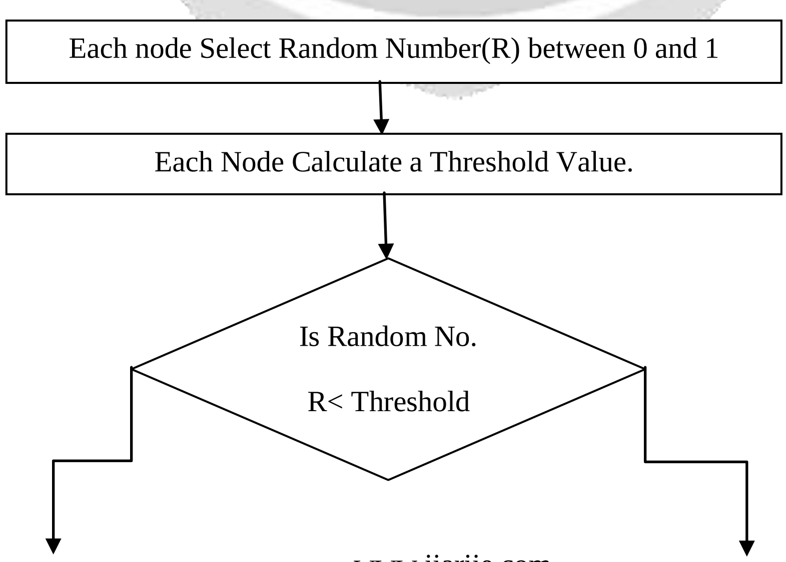
Figure 2 Time line of LEACH protocol [11]

(1)Setup phase

During the setup phase, when clusters are being created, each node decides whether or not to become a cluster head for the current round. This decision is based on a predetermined fraction of nodes and the threshold $T(n)$. The threshold is given by where p is the predetermined percentage of cluster heads (e.g., p = 0.05), r is the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds.

$$T(n) = \frac{p}{1 - p \times r \times mod\left(\frac{1}{p}\right)} \quad where \forall n \in G$$

$$= 0 \; else \qquad (2.1)$$



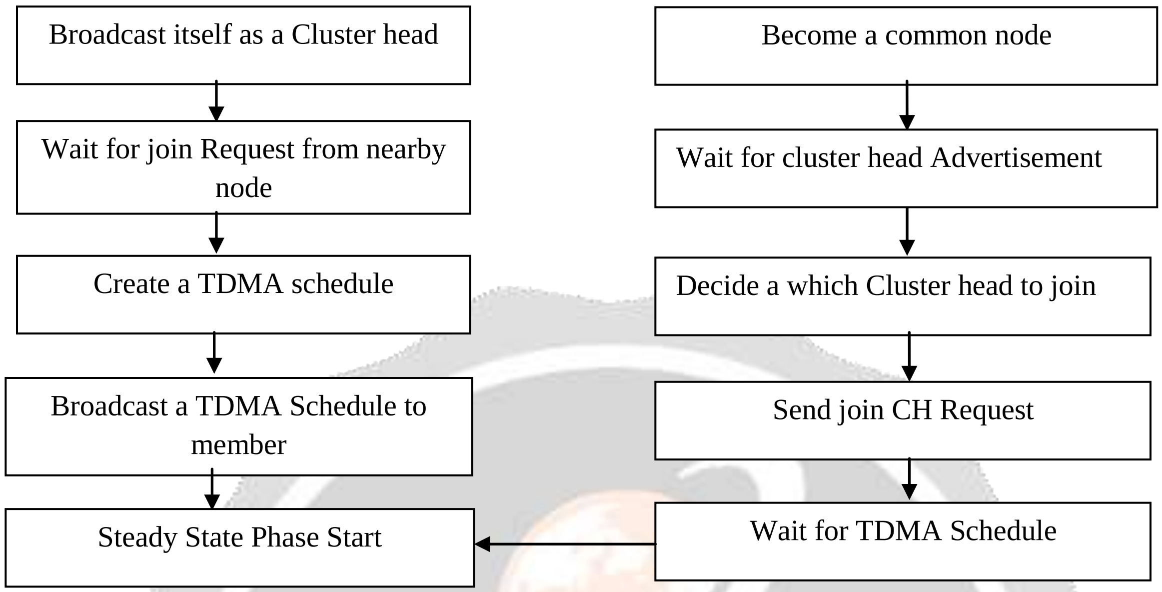


Figure 3 Steady state phase of LEACH protocol.

Every node wanting to be the cluster-head chooses a value, between 0 and 1. If this random number is less than the threshold value, T (n), then the node becomes the cluster-head for the current round.

After 1/p rounds, all nodes are once again eligible to become cluster heads. Each node that has elected itself a cluster head for the current round broadcasts an advertisement message to the rest of the nodes in the network. All the non-cluster head nodes, after receiving this advertisement message, decide on the cluster to which they will belong for this round. This decision is based on the received signal strength of the advertisement messages. After cluster head receives all the messages from the nodes that would like to be included in the cluster and based on the number of nodes in the cluster, the cluster head creates a TDMA schedule and assigns each node a time slot when it can transmit.

(2) Steady State Phase

During the steady-state phase, the sensor nodes can begin sensing and transmitting data to cluster heads. The radio of each non cluster head node can be turned off until the node's allocated transmission time. The cluster heads, after receiving all the data, aggregate it before sending it to the sink. Each cluster head communicates using different CDMA codes in order to reduce interference from nodes belonging to other clusters. After the steady-state phase, the next round begins.

2.3 Base Station Repositioning using Genetic Algorithm [6]

In Dynamic base station repositioning using genetic algorithm, the primal population consists of n chromosomes which show the position of BS. Each chromosome includes two parts; *X* (length of network environment) & *Y* (width of network environment). They have encoded by binary encoding scheme. Each chromosome is evaluated by fitness function. They have applied modified 2-point crossover and random point flip for mutation operation. In additional, for new population replacement, the selected population is replaced with next population. The condition of genetic algorithm expiry is based on the number of generations they have supposed.

(1)Population

They have applied binary encoding in the proposed algorithm that is each chromosome is related to BS position. The length and width are supposed for the environment which sensors are distributed. It has supposed that all of the sensors are placed in a point with a specific Width and length. Chromosomes are consisted of two parts: First binary part is related to X(length of sensor point) and the second binary part is related to Y(width of sensor point). The number of X& Y bits depends on the length and the width of network environment.

(2)Fitness

Fitness function is calculated based on distance and residual energy parameters in sensors. Each chromosome which enjoys random X & Y that it shows the position of BS. Summation of distance between this random point and all of the sensors is achieved by multiply ratio for each sensor (this ratio introduces inverse of residual energy in sensor) that shown in equation .Residual energy is supposed as a number between 1 and 10.

$$abf = \sum_{i=1}^{n} \frac{1}{W_i} \sqrt{(X - x_i)^2 - (Y - y_i)^2} \qquad (2.3.1)$$

Where n = number of sensor nodes.

The fitness function is given as follows:

$$Fitness = m - abf \qquad (2.3.2)$$

Table 1 Parameters used in a fitness function

Parameter	**Description**
I	Index of nodes
x_i	position length of node of i
y_i	position width of node of i
W_i	Residual energy node of i
M	A very large number

(3)Selection

The selection process selects chromosomes from the mating pool according to the survival of the fittest concept of natural genetic system. In each successive generation, a proportion of the existing population is selected to breed a new generation. This approach uses 80% as crossover probability, which means that 80% of the population will take part in crossover. The probabilities for each chromosome are calculated according to their fitness values, and selection is in proportion to these probabilities here the chromosome with lower probability has more chance of being selected. The proportions are calculated as given below.

$$prob(ch_i) = \frac{fitness\,(ch_i)}{\sum_{i=1}^{n} fitness\,(ch_i)} \qquad (2.3.3)$$

Once the probabilities are calculated, Roulette Wheel selection is used to select parents for crossover may be viewed as a roulette wheel where each member of the population is represented by a slice that is directly proportional to the member's fitness. A selection step is then a spin of the wheel, which in the long run tends to eliminate the least fit population members.

3. ASSUMPTIONS AND IMPLEMENTATION

3.1 Network Model Assumption

The sensor network model that is used in this project is following assumption.

All sensor nodes are stationary.

All sensor nodes are aware of their location information

BS is able to move in entire network.

The residual energy of sensors can be calculated.

For simplicity, the time taken for base station movement is negligible.

3.2 Implementation and Results

For basic understanding of functioning of genetic algorithm, simple single point of cross-over and mutation are implemented. Where we apply coordinates of single sink position and operate for cross over between both parents and mutation of a single

WSN network and Leach Protocol

STEPS:

1. Start
2. Define parameters: Node position, BS position, Energy
3. Create sensor network environment
4. Implementing Leach protocol
5. Measure residual energy of all nodes at the end of each specific round

Parameters:

Table 2 Network parameters

Description	Value
Network Area	100m*100m
Number of nodes and Round	100 and 500
BS Position	(50m,50m)
Initial energy	1 J
Data packet size	200 bytes
Electronics energy	50 nJ/bit
Free space energy	10 pJ/bit/m
Multipath co-efficient	0.0013 pJ/bit/m

Output:

Simulation is done in MATLAB as shown in fig, and network is simulated for 500 rounds. At the end of simulation residual energy is calculated which is shown in table. Later this energy will be compared by residual energy calculated incorporating Genetic Algorithm in WSN. Here, both X and Y axes are in meters

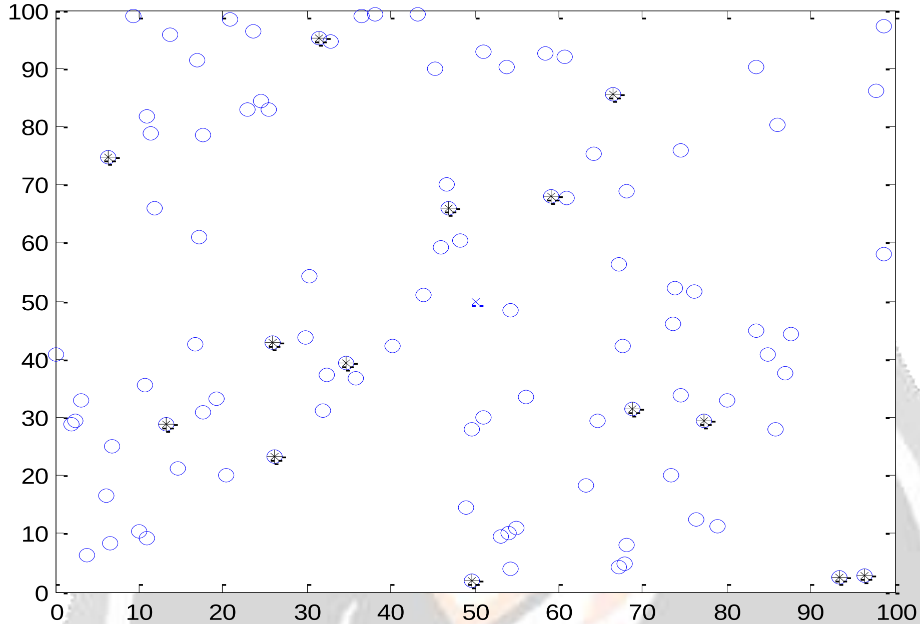


Figure 4 LEACH implementation in wireless sensor network

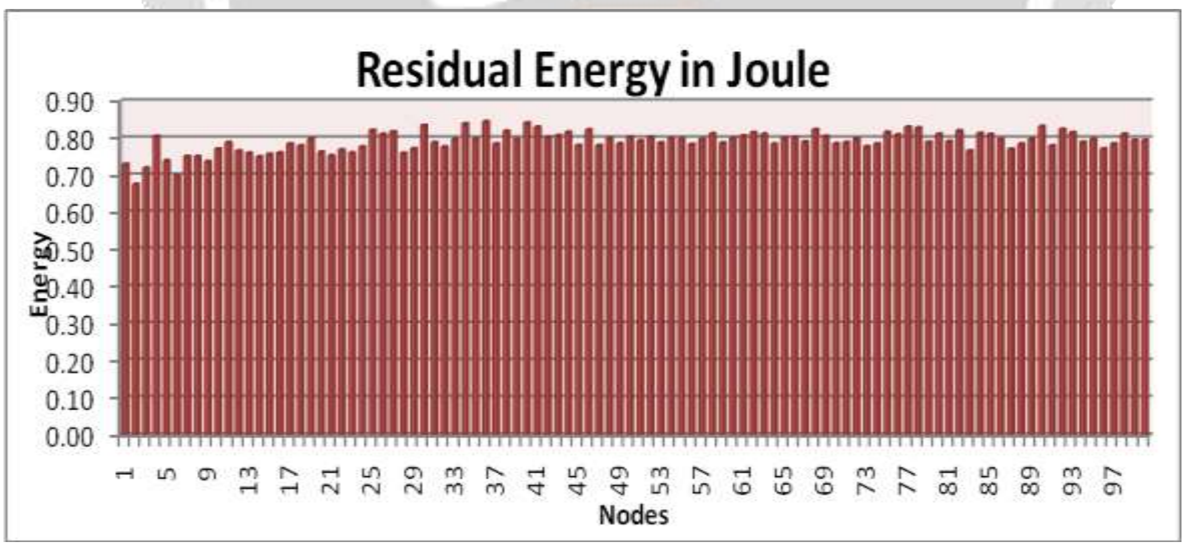


Figure 5 Residual energy measurements WSN with LEACH implementation

WSN network and Leach Protocol with Genetic Algorithm

STEPS:

1. Start
2. Define parameters: Node position, BS position, Energy
3. Create sensor network environment
4. Implementing Leach protocol
5. Apply Genetic Algorithm for the movement of base station
6. Measure residual energy of all nodes at the end of each specific round

Genetic Algorithm:

1. Start
2. Define Cost function, variable and Select GA parameter
3. Generate initial population
4. Decode chromosome
5. Find cost for each chromosome
6. Select mates
7. Mating
8. Mutation
9. Convergence check
10. Go to step no

Parameters:

Table 3 Network parameters

Description	Value
Network Area	100m*100m
Number of nodes and Round	100 and 500
BS Position	(50m,50m)
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Data packet size	200 bytes
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Free space energy	10 pJ/bit/m
Multipath so-efficient	0.0013 pJ/bit/m

Output:

Simulation is done in MATLAB as shown in fig, and network is simulated for 500 rounds.
At the end of simulation residual energy is calculated which is shown in table. This residual energy is compared with the residual energy of each respective node measured during simulation incorporating only LEACH in WSN. Here, both X and Y axes are in meters.

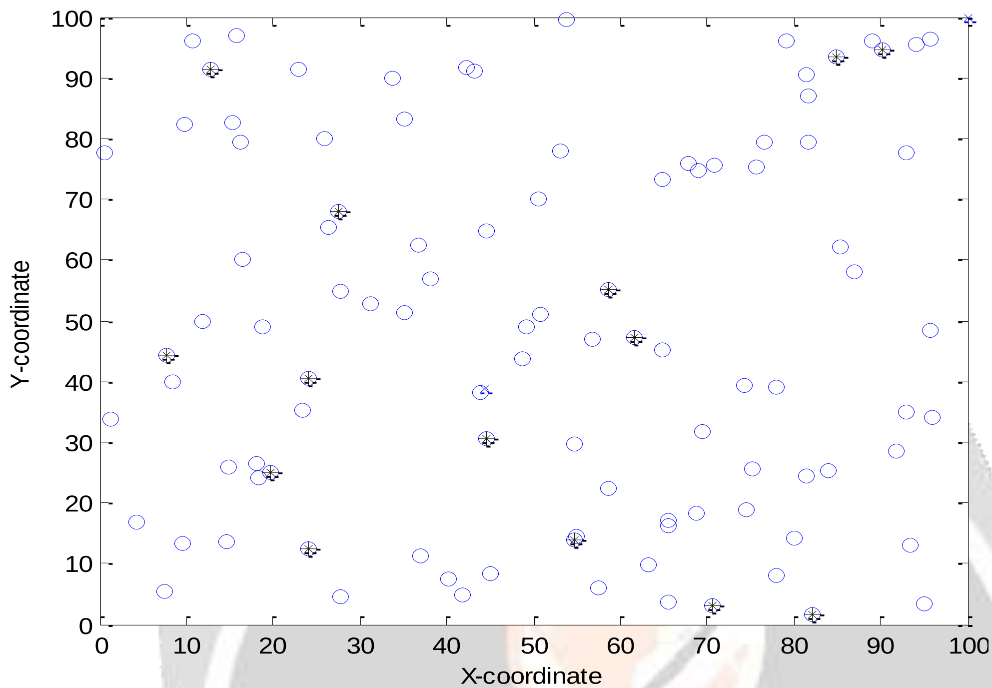

Figure 6 GENETIC and LEACH implementation in wireless sensor network

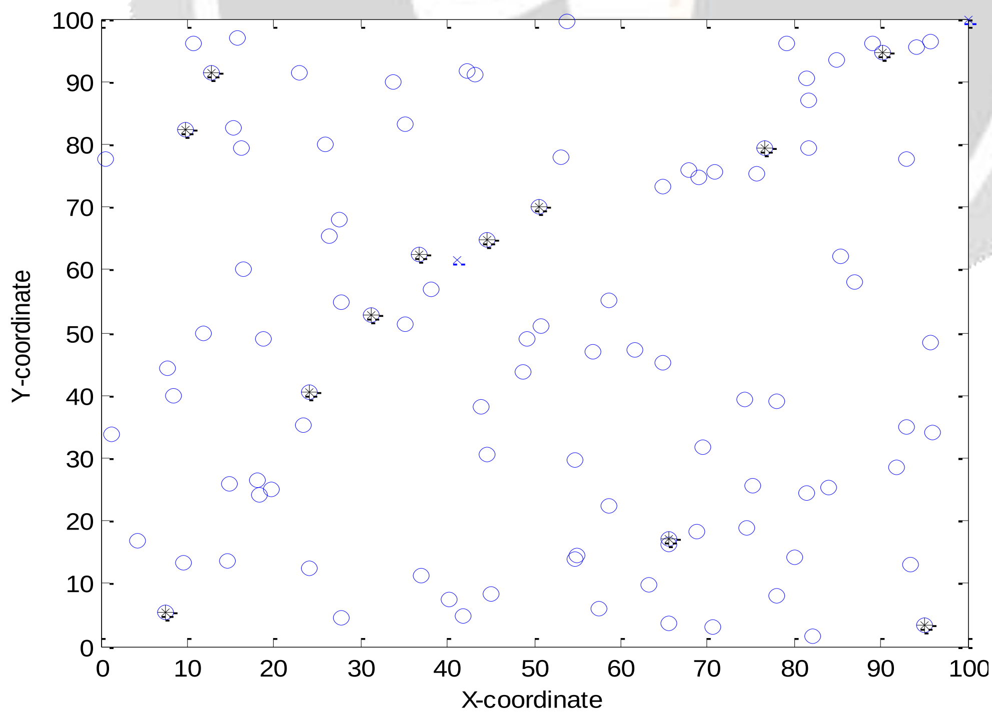

Figure 7 GENETIC and LEACH implementation in wireless sensor network

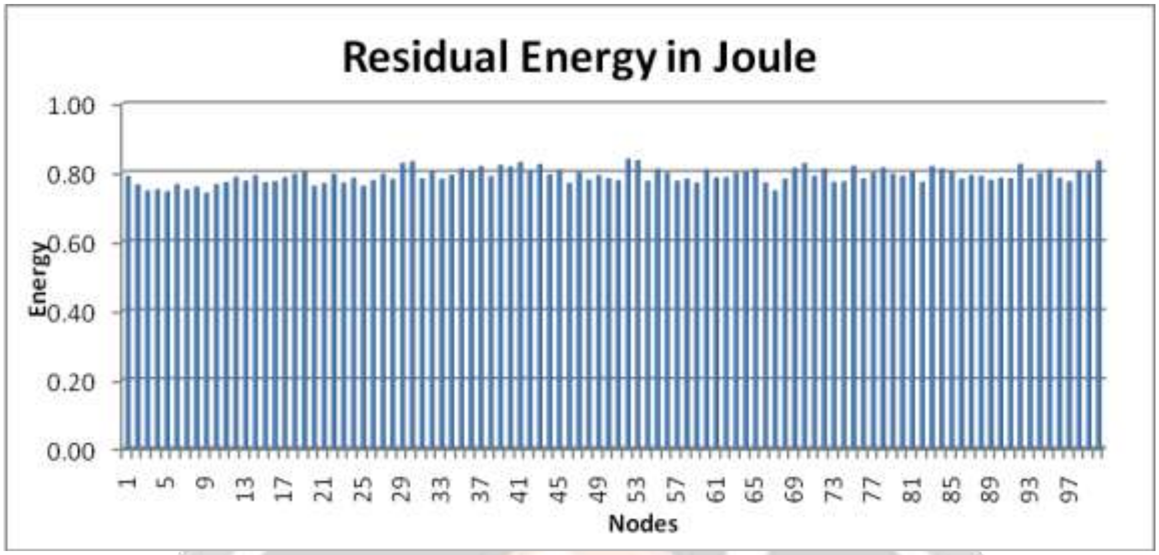

Figure 8 GENETIC and LEACH implementation in wireless sensor network

Residual energy comparison chart for WSN with LEACH and WSN with GENETIC and LEACH

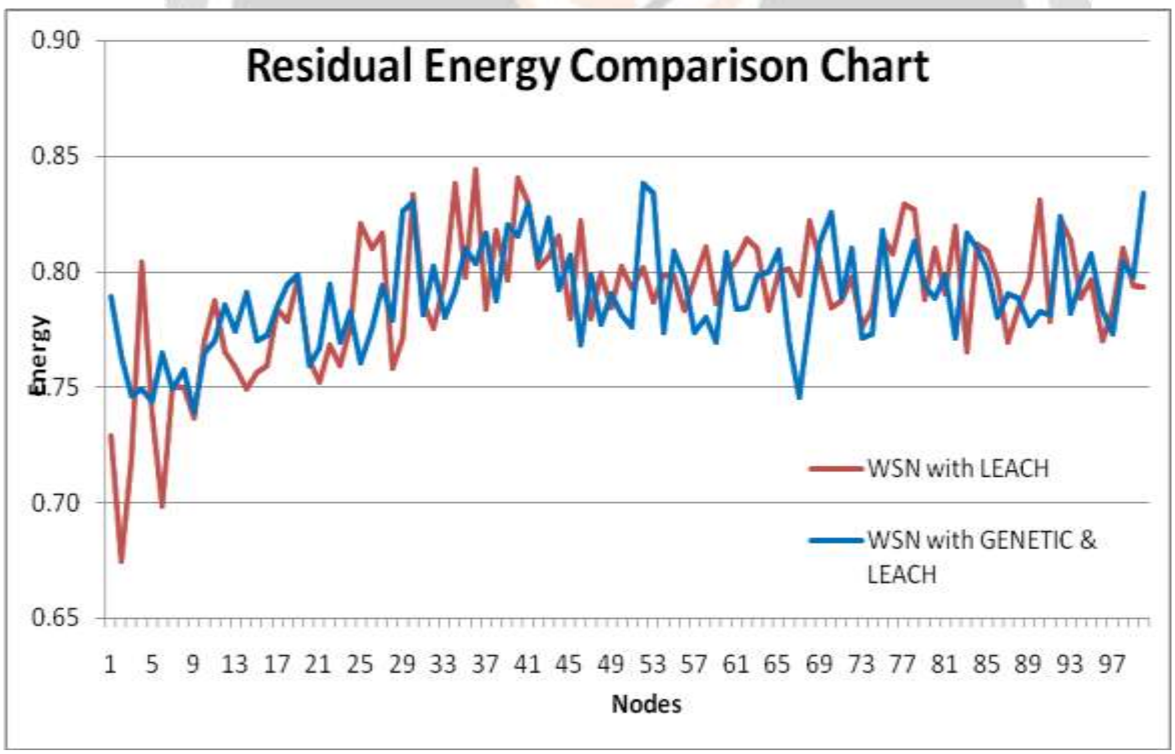

Figure 9 GENETIC and LEACH implementation in wireless sensor network

4. CONCLUSION

Simulation is carried out in MATLAB for two different analyses. First, sensor network is simulated with LEACH protocol incorporated for 500 rounds. Second, sensor network is simulated with Genetic and LEACH protocol incorporated for 500 rounds. As an end results in case of both type of simulations, residual energy of each node is calculated which interprets that, in communicating data packets to base station some of the energy is being consumed and left energy is measured as a residual energy. It can be infer from the results obtained and by having comparison of residual energy of both the cases, WSN with LEACH and incorporating Genetic Algorithm, which helps base station to move in WSN proves to be a competitive in terms of saving node energy as less energy will be used by nodes to sent data packets to Base Station when BSs is nearer to nodes transmitting data.

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