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Optimization of Energy Efficient Advance Leach Protocol

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Abstract: In WSNs, the only source to save life for the node is the battery consumption. During communication with other area nodes or sensing activities consumes a lot of power energy in processing the data and transmitting the collected/selected data to the sink. In wireless sensor networks, energy conservation is directly to the network lifetime and energy plays an important role in the cluster head selection. A new threshold has been formulated for cluster head selection, which is based on remaining energy of the sensor node and the distance from the base station. Proposed approach selects the cluster head nearer to base station having maximum remaining energy than any other sensor node in multi-hop communication. The multi hop approach minimizing the inter cluster communication without effecting the data reliability.
Keywords: Optimization, Energy Efficient, Advance Leach Protocol, WSN, Multi-hop Communication, Wireless Sensor Network

1.1 INTRODUCTION

1.1.1 Wireless Sensor Networks

Wireless Sensor Networks (WSNs) comprise of tiny, battery-operated sensor nodes (SNs) with limited process involvement, storage & radio abilities. WSNs may contains hundreds or thousands of multi-functional power SNs which works in harsh environments. They have the capability to sense and perform computations. SNs sense the data and transmit the reports belonging to the sensed data to sink node. The SN components includes: a Central Processing Unit (CPU), a sensor device unit, a power unit for energy, a communicating unit and an analog to digital (A to D) converter. The miniatured SNs embedded are micro-electro-mechanical systems (MEMS) which are actually accountable to make a calculable alteration in some physical situations linked with pressure & temperature. The SNs computes by sensing the physical data of the monitored part. The tiny SNs senses the analog signals and are then digitized by A to D converter and transmits to a controller for execution. The SNs of small size are low powered and are operated in high volumetric density. These SNs can be independent of an adaptive surrounding and its customary architecture utilizes costly macro-sensors to receive accurate information. For illustration, the gas & oil companies employed large number of sensors (geophone) linked by cables/wires to perform oil investigation. The SNs needs huge energy or power for their operation. One of the limitations is to encounter controlled operation in WSNs. Owing to the high utilization of WSNs, it also faces the problem of control energy restraints particularly in battery limitations. As the SNs are have lot of major issues in WSNs, the failure of one node due to energy can interrupt the complete working environment. In Inactive mode, the SNs are in a processing state in which energy consumption during receiving or transmitting of data takes place. In sleep mode, the SNs are shut down for saving an energy. Constraints related to power end by generating further computational and storage limitations which leads to architectural problems. Platform of WSNs should offer support for applications of specific protocols which minimize node's size, cost, and power consumption.

The steps given below assists in saving energy consumed by communication in WSNs:

- Modifying the transmission range within the SNs.
- To change the state (transmitting, receiving, idle or sleep) of SNs.
- Proper data collection schemes with utilization of appropriate routing algorithm.
- Circumventing the management of meaningless data.

In WSNs, the only way to save battery of SNs is to diminish the consumption of battery. As communication within SNs or sensing activities uses immense power during the data processing and transmission, the battery re-charging or saving becomes utmost important. In defence application and surveillance applications it is hard to alter the batteries that

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drains out [4]. Myriad of scientists are thus finding out energy-aware ways for WSNs to mitigate this limitation of energy efficiency.

Some soft and real-time support must be provided by the protocols designed in these areas in WSNs. The applications in these areas performs the task of data processing, sensing and transmitting the data. The base station (BS) or sink employs the data collected by all the detecting SNs to organize in proper way.

1.1.2 Wireless Sensor Networks VS Wireless AD-Hoc Network

Remote Sensor Systems have been considered as one of the foremost critical exceptionally later advances for the twenty - to begin with century. Empowered by later development innovations in microelectronic mechanical frameworks and remote communication innovations, tiny/small, cheap/low taken a toll, and savvy information sensors conveyed in a physical range arrange and organized through a remote joins and the based Web give uncommon openings for a assortment of people/civilian and discuss protection applications, for illustration, natural observing, resistance fight field observation, AI mechanical autonomy and mechanical handle control framework. A gigantic sum of analyst exercises have been carried out by, to clarify, to investigate and to fathom different arrange plan issues and application issues, and critical progresses have been made within the advancement arrange and arrangement of sensors in WSNs. Close to of this conventional remote communication systems, for case, neighbourhood cellular frameworks and portable ad hoc network (MANET), WSNs have a special characteristic, for case, denser organize level and number of information node sending, higher instability of information sensor nodes, and serious control vitality framework, computation, and tremendous capacity imperatives, which display many new level challenges within the advancement of arrange and application of WSNs.

1.1.3 Design Goals for WSN

The main section of network is the clustering protocols which are one of the routing protocols of WSNs. There are various factors that affect the working of routing protocols in WSNs, so, before moving further, the detailed study of about such factors are reviewed. The performance efficiency of WSNs depends upon the following factors:

a) Use of network power

Network energy is used by all the SNs deployed in the defined area that assists these nodes to perform functions like: sensing, data processing or formation of groups in a network. The network power use is defined as the total amount of energy used by the SN within that network.

b) Energy Awareness

For data sensing, its processing, storage and transmission, every node in a network area makes use of power. A SN in a network area must know the amount of energy that once utilized by SN in order to perform a new task. The type of functionality determines the amount of power energy that is distributed i.e it could vary from high to low or moderate.

c) Transmission Method

SNs that gathers the transmitted data and sends it to the BS by making use of multi-hop routing method or flat routing.

d) Easy Installation

SNs consists of thousands of SNs that may require the node to be deployed in the remote areas/fields. Hundreds to thousands of SNs can be easily thrown from a plane over a remote field where human reach is difficult. It permits us to gather information that otherwise would be impossible.

e) Synchronization

When SNs guarantee that receiver side could identify the data transmitted in an exact order like it was sent. This process is called synchronization i.e when the sending and receiving flow rate is almost similar between the two SNs in a network. The SNs in this case ought to have similar time notion that is sleep and wake up state.

f) System lifespan

The WSNs must operate for longer duration and the total lifetime of system in a network area must be computed by making use of parameters like: time for node to become dead. It can also be computed using parameters such as: time until the SN gives unacceptable results.

g) Processing time of node

The entire time taken by the SN in WSN for accomplishing all the functions initiating from its first activity of sensing to its processing or storage within the buffers is known as processing time of node.

h) Latency

Data packets from SNs are classically time-sensitive, therefore it is quite significant to take a data packet in an appropriate manner i.e no time delay should be there. Long latency because of processing or communication is undesirable.

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i) Quality

There are some quality parameters that must be matched with the data that has been sensed by the SNs in order to prove the accuracy. The various applications of WSNs have distinct Quality of Service (QoS) needs such as: loss of data packet and delay time. One of the examples of this is: fire monitoring in which timely delivery of service is important and it is very sensitive application. Therefore, QoS parameter is one of the imperative requirements of the designing of WSNs.

j) Latency

The time taken by the SN to sense the data is known as Latency. It totally relies upon the type of application being used. SNs gathers the data and subsequently process it and transmit the same to the BS. It is computed based on the activities and the time a SN takes to send the data packet in loaded environment or where there is a low traffic.

k) Channel Utilisation

SNs are quipped with limited bandwidth resources. Therefore, an efficiency must be considered while designing the communication protocols for WSNs and this can be possible if proper bandwidth is used with an objective of improving channel utilization.

l) Self Configurability

Mostly, the SNs are deployed without planning or engineering in WSNs. But it is mandatory to carefully plan the design and deployment positions for efficient results because once the deployment of SNs is done, it should be capable of organizing themselves without failure or must reconfigure itself if any topological changes occur.

m) Small Node Size

One of the main design aims of WSNs is to minimize the size of SN, so that large number of SNs could be deployed easily in a hostile environment. Minimizing the size of SN can considerably reduce its associated deployment cost as well as low battery consumption takes place.

n) Low Node Cost

SNs cost reduction is another chief concern of WSNs. As the SNs are placed in those regions where the environment is harsh, so the nodes deployed once cannot be reused. Thus, it is very important to minimize the cost of SN in order to reduce the cost of entire WSNs, so that large number of nodes can be deployed.

o) Fault Tolerance

Owing to the dangerous or rough environment, the SNs are sensitive to the failure and therefore it becomes important to deploy those SNs which are robust and less prone to failure. It becomes necessary to use SNs that have the abilities of self-improvement in terms of repair, recovering and testing.

p) Security

There are high chances of security breaches for the SNs that are deployed for military applications. Therefore, it is vital to introduce effective security features to prevent an unauthorized information leak. The implementation of high security mechanisms would upbring the security level and would make the network more secure and robust.

q) Scalability

In WSNs, scalability is an imperative factor as the it is not obligatory that the network is static. There might be several situations where the network is dynamic and it changes as per the requirements given by the user. Thus, it is necessary that the SNs must have scalable nature such that it can adjust to the changes or requirements in the network.

r) Low Power Consumptions

One of the vital aims of the WSNs is to design a network that consumes lesser power. Moreover, the SNs are battery operated and they require frequent change of their batteries which is actually very difficult task. Thus, reducing the amount of energy or charging SN from distant are the only two ways to extend the lifespan of WSNs.

r) Scalability

The large number of SNs are deployed in a network ranging from hundreds to thousands. Thus, a scalable design of network is mandatory to adjust the protocol in accordance with the varying network sizes.

s) Adaptability

It is very crucial for the SNs to adapt to the changing environments in a network, for example topological changes might disturb the network, therefore the SNs must be such that they can adapt to the changes. Thus, adaptive nature of SNs in terms of density and topological changes could improve the lifespan of WSNs

t) Reliability

There could be myriad of situations which could affect the reliability of WSNs such as: noise, error and delays. To overcome such issues, the protocols in WSNs must provide an error correction method to guarantee reliable data transmission service.

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2.1 Problem Formulation

WSNs area involve thousands to millions of sensor data nodes, with a restricted energy. As there are different clustering protocol in wireless sensor area networks used for cluster area head selection, some depends it upon the average energy of a node and some protocols depends upon probability basis. These protocols works either on homogeneous or heterogeneous networks, For Paper "Energy Efficient Data Communication Approach in WSN" In this paper the node Id is missing on the basis of location (have not consider) so, this portion of energy loss will be conserved (which will loss in framing the data packet into the payload and at the time of data aggregation).

This approach is failed when a malicious node is in the sensor network which continuously send the hello packet to the networks (flooding attack), because on the basis of Id we can detect the malicious node in a routing path. System Model is similar to W. B. Heinzelman, A. P. Chandrakasan, H. Balakrishnan, "An application specific protocol architecture for Wireless Microsensor Networks"

3.1 Objective

The following are the objectives of my work

1) To study the various energy efficient routing protocols in WSN.
2) To design the energy efficient clustering strategy for the deployment of sensor nodes.
3) To simulate the proposed approach and evaluate its performance and to compare the proposed technique with the conventional technique.

By doing these objectives it will improve the overall WSN life time and energy consumption with sensor node.

4.1 Proposed Algorithm

Below are some mandatory steps that could be followed in order to save energy in WSNs:

1) Scheduling the among the state of transmitting, receiving, idle and sleep.
2) Modifying the transmission range amid the SNs.
3) Making use of effective routing strategy with improved method of data collection.
4) In case of overhearing, the meaningless/unwanted data must be avoided.

Battery utilization in effective way is the only remedy to save SNs from dying in WSNs. When communication takes place within the SNs, ample of power is consumed in the phase of data processing and transmission or reception to the BS. However, it is quite challenging to replace the batteries of such sensing nodes which die off from extra power utilization. Saving the battery is thus very crucial part specially for critical applications which need immediate attention such as: defence, surveillance applications and many more. It is hard to substitute the batteries gets drained off and therefore various researchers are continuously working on to improve the power through energy-aware protocols in WSNs so as to outweigh the energy issues appropriately.

Some real-time supports are being provided in all the protocols designed for WSNs as there are certain applications in these areas where SNs sense, processed and transmit data to other SNs within a network. Therefore, quick and reliable reactions are indeed important in protocols which are said to provide real-time assistance in improving the network lifespan. A redundant and identical data must be sent to the BS. It should provide a redundant and duplicate data to the BS. The BS makes use of the data being collected by the SNs in a network. The transmission delay of analysed data to the BS from the SNs must be small to generate quick reply.

Working flow:

Deployment ➔ Sensing ➔ Network Setup ➔Root➔ Data Aggregate ➔ Cluster Head Selection ➔ Routing Path Selection ➔ Downlink ➔ Data Aggregation ➔Cluster Head Selection➔ Routing Path Selection ➔ Uplink then whole the process will repeat again and again until all the nodes are dead.

Energy Model

Based on LOS or Two ray propagation model.

$$E_{tx}(i,j) = \begin{cases} \left(\alpha_{tx} + \epsilon_{fs} D_{ij}^{2}\right) * \mathcal{L}, & D_{ij} < d_0 \\ \left(\alpha_{tx} + \epsilon_{mp} D_{ij}^{4}\right) * \mathcal{L}, & D_{ij} \geq d_0 \end{cases}$$

$$E_{rx} = \alpha_{rx} * \mathcal{L}$$

Deployment of Node

May be solid angle based (Proposed) for adaptive sensing

Random basis or

Grid Basis

Clustering Algorithm (proposed)

$T(i) = \rho(i) * T_{cH}$

Or

$T(i) = \frac{\sum_{i=1}^{N} m_i * r_i}{m_i}$

Or

Power radiated by B.S to the node (Antenna lobe beamforming)

Which is convenient?

Time complexity

May be TDMA scheduling

Or

New proposed

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Data Aggregation
Existing or proposed
Routing Protocol (Down-Link and Up-Link)
Existing or proposed
Or
TDMA || FDMA || CDMA || SDMA
Which balanced the energy?
Comparing results with the base paper or existing protocols.

5.1 Programming Environment

MATLAB will be utilized as test bed to execute the required objective proposed within the paper. MATLAB may be a high-level dialect and intuitively environment that empowers you to perform computationally seriously assignments which can be speedier than with programming dialects such as C++, C, and FORTRAN. MATLAB stands for "Lattice Research facility" and may be a most numerical computing environment and unused fourth-generation programming dialect. Typically created by The Math Works, it permits lattice controls, like plotting of charts, capacities and information, usage of strategy calculations, creation of modern client interfacing, and meddle with programs composed in other dialects, like C, C++, and FORTRAN.

In spite of the fact that the basically expecting of MATLAB is to computing numerical values, an discretionary tool compartment in MATLab employments the MuPAD typical motor, which permits get to to typical computing capabilities. Along this an extra bundle, like Simulink, includes graphical multi-domain recreation and other like Model-Based Plan for energetic and implanted frameworks. In 2004, Math Works claimed that MATLAB was being utilized by more than one million individuals over the world in industry and the scholastic areas. MATLAB clients come from different foundations of building, science and financial matters.

MATLAB is an ambitious program. It contains hundreds of commands to do mathematics. We can use it to graph functions, solve equations, perform statistical tests and do much more. It is a high level programming language that can communicate with its cousins e.g., FORTRAN and C. We can also produce sound and animate graphics. We can do simulations and modeling (especially if we have access to not just basic MATLAB, but also to its accessory SIMULINK). We can use MATLAB in conjunction with the word processing and desktop publishing features of Microsoft Word, to combine mathematical computations with text and graphics to produce a polished, integrated and interactive document. It is very easy to install this software on your computer. It can be installed by running the set up file.

5.2 Proposed work Implementation and Results

In this section the comparison of proposed technique with LEACH, and SEP is discussed. The comparison will show the improvement on network life time and throughput of network affected with the help of residual energy and compression.

The evaluation and the implementation is done in MATLAB. The simulation has been peformed in the network of 100 nodes and are placed randomly in the network. The nodes are in the diameter of field 400m x400m.

The different value of parameters used in the network is shown Table 5.1. the comparison of different metrics of the protocols are dead node evaluation, alive node evaluation, packets to CH, packets to BS and number of cluster heads.

Table 5.1 Value of Parameters used

Parameter	Values
Area (x, y)	400,400
Base station (x, y)	200,200 or mobile
Nodes (n)	100
Probability (p)	0.1
Initial Energy	0.5J
Transmitter energy	$50*10^{-9}$
Receiver energy	$50*10^{-9}$
Free space(amplifier)	$10*10^{-12}$
Multipath(amplifier)	$0.0013*10^{-12}$
Effective Data aggregation	$5*10^{-9}$
Maximum lifetime	2000

The network consists of 100 nodes and the deployment of the of nodes having cluster heads and normal nodes are shown in figure 5.1.

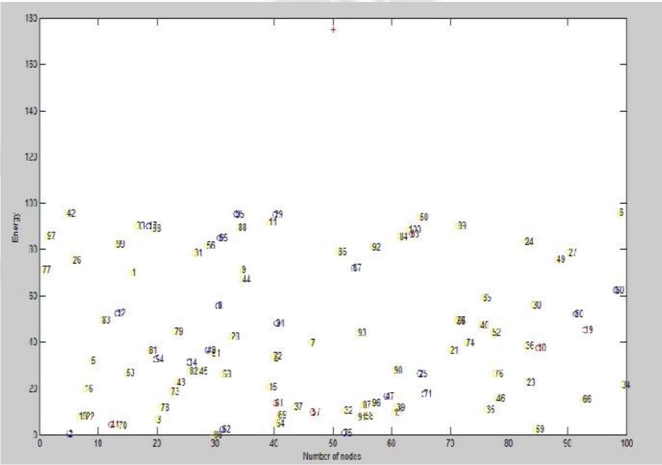

Figure 5.1 Deployment of sensor nodes

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Data sending from cluster heads to cluster heads are shown in figure 5.2 shown by links and data transmission from cluster head to neighbouring nodes are shown in figure 5.3.

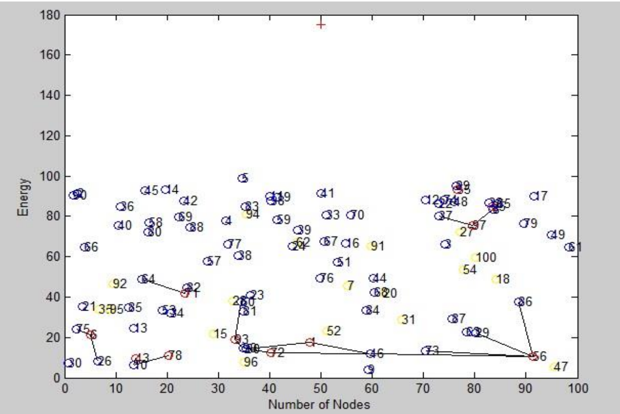

Figure 5.2 Data sending CH1 to CH2

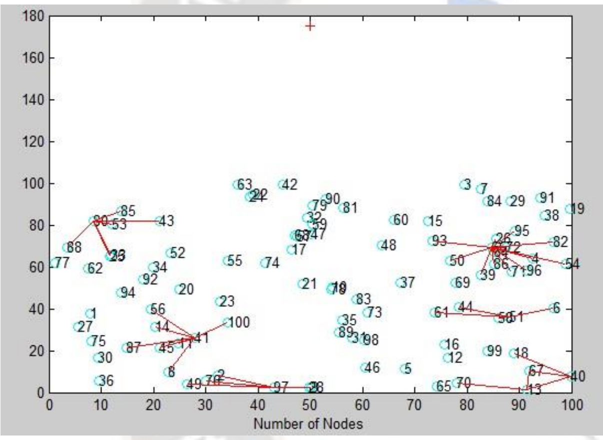

Figure 5.3 Data sending CH to neighbour nodes

The complete data sending from CH to nodes are shown in figure 5.4.

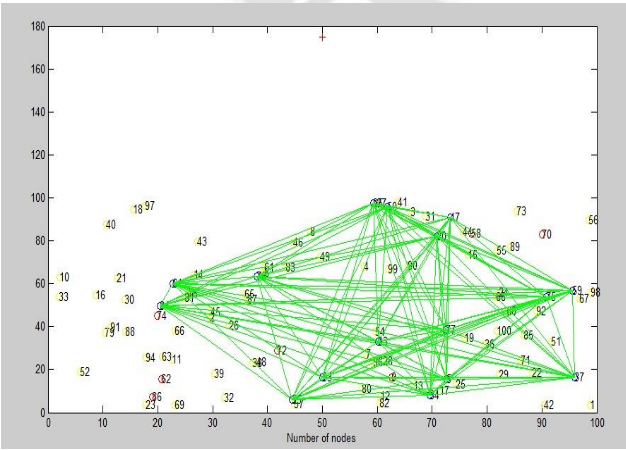

Figure 5.4 Data sending to CH

Data transmission from CH to base station is shown in figure 5.5 and figure 5.6.

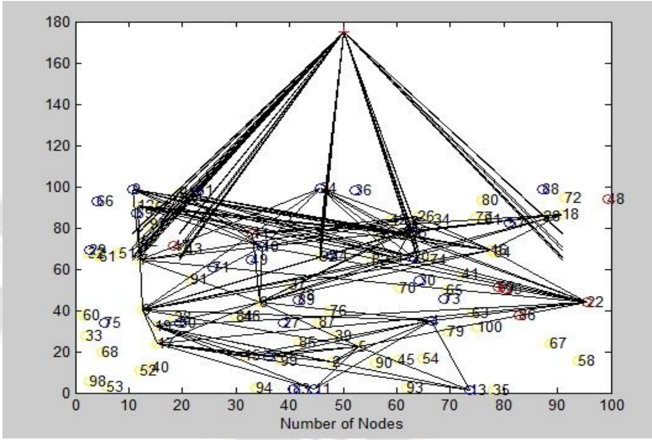

Figure 5.5 Data sending to BS

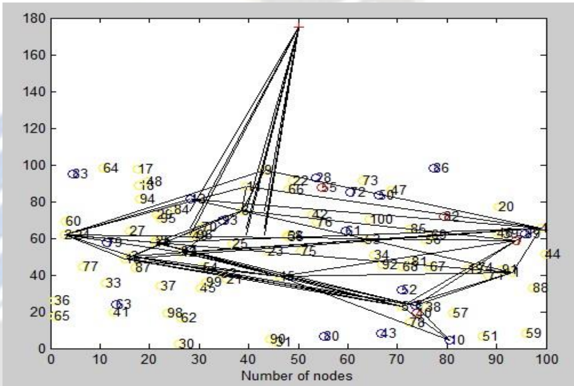

Figure 5.6 Data sending in rounds to BS

The stability period and network lifetime are used as key indicators to estimate performance of the proposed approach. The stability period shows that the time interval from the start of the operation to the first node dies. In 2000 rounds the stability of the network and set of alive nodes are shown in figure 5.7 and figure 5.8.

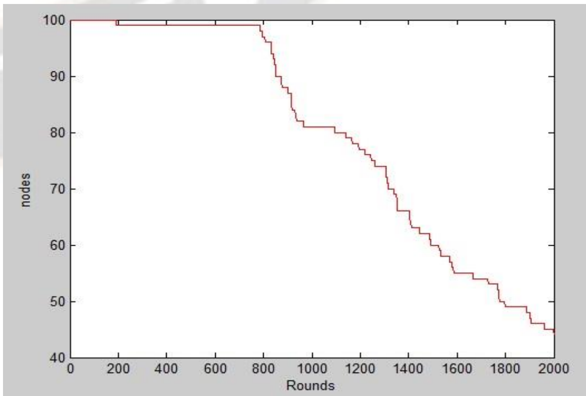

Figure 5.7 Stability of nodes

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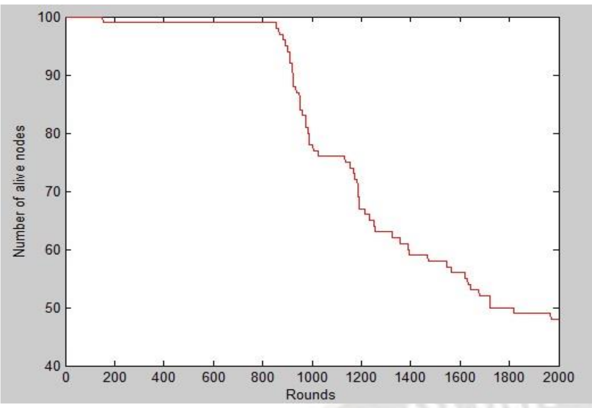

Figure 5.8 Alive nodes

The concept of multi-hop using on previous deployment technique show the improvement over the network life time and enhances the chance of efficiency of the network as shown in figure 5.9, figure 5.10, figure 5.11, figure 5.12, figure 5.13 and figure 5.14.

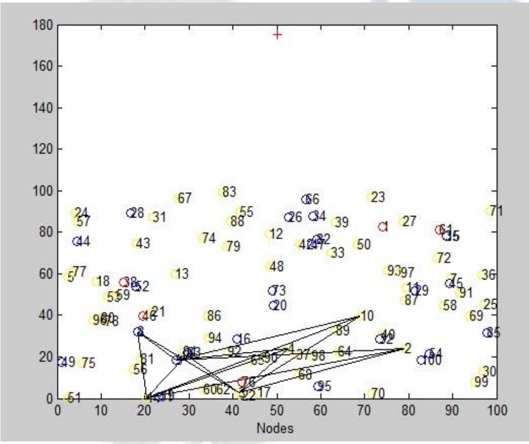

Figure 5.9 Multi hop level1

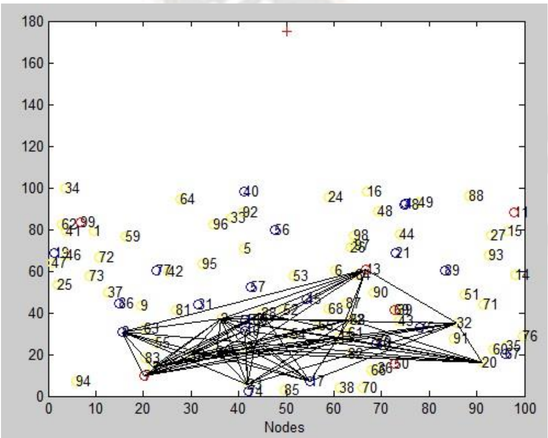

Figure 5.10 Multi hop level2

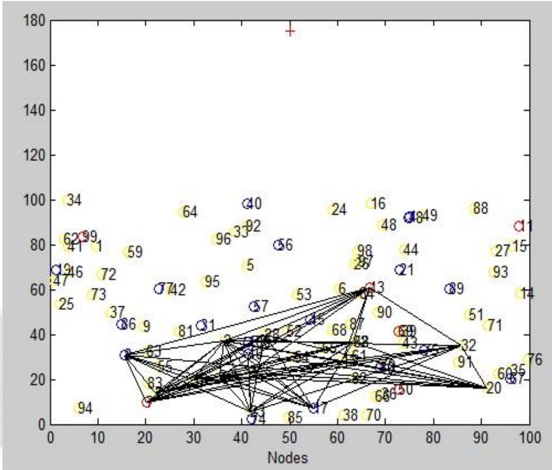

Figure 5.11 Multi hop level3

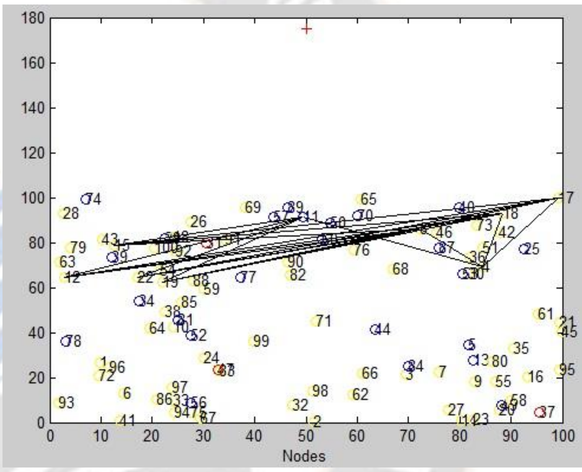

Figure 5.12 Multi hop level 4

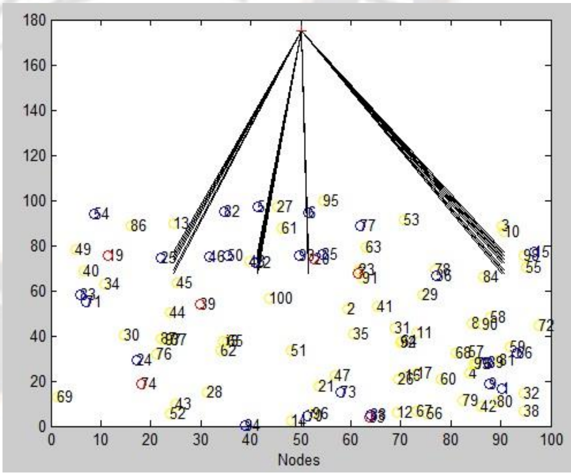

Figure 5.13 Multi hop level 5

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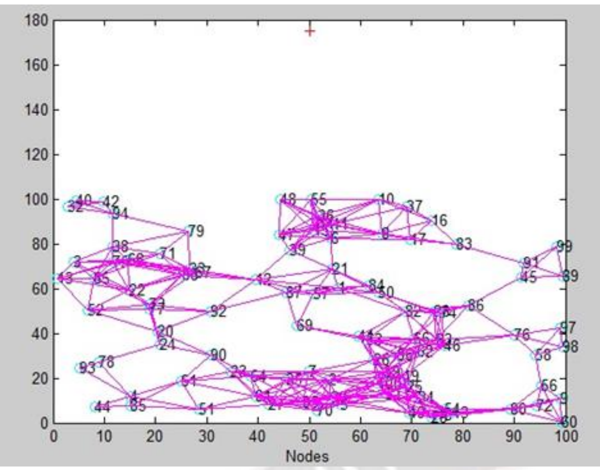

Figure 5.14 Multi hop deployment

Comparative Analysis of Node Energy Efficiency show the following result

Comparison(rounds)	Leach	Proposed Protocol
First Node Died	948	1383
Last node Died	2593	3412
Average Life of The node	2184	2732

6.1 Conclusion

In WSNs, the only source for saving life for the SNs is the optimum utilization of battery. During communication with SNs, sensing process use lot of battery power and therefore sends the gathered data to the BS. In wireless sensor networks energy conservation is directly related to the network lifetime and also energy play an important role in the cluster head selection. A new threshold has been formulated for cluster head selection which is based on the remaining energy of the sensor node and the distance from base station. Proposed approach selects cluster head nearer to base station having maximum remaining energy than any other sensor nodes in multi-hop communication. The multi-hop approach minimizing the inter cluster communication without effecting the data reliability. The main objective is to find ways to distribute the cluster head throughout the sensing field that will improve energy efficiency and help in reliable transmission of sensed data to the base station in wireless sensor networks.

6.2 Future Work

In future work the compression technique can be used to maximize the data transmission so that the maximum data can be transmitted through the sensor nodes in minimum energy.

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