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# Enhanced LEACH Multipath Based Energy Efficient Routing for Wireless Sensor Network

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**Abstract**: Wireless sensor networks are widely used in many applications now days. WSN's equipped with large number of wireless sensors programmed to sense physical parameters and transmit to remote location. Sensors composed of battery having limited power constraint. This lead many routing protocols designed for WSN to use energy efficiently. One of the most popularly used energy efficient clustering protocol is LEACH. In this work we propose multipath LEACH protocol based on LEACH. The main intention of this protocol is to offer energy efficient and robust communication. This is achieved by traffic multiplexing over multiple paths and introducing alternation of the cluster-heads for every given interval of time.

**Keywords:** Wireless sensor network, LEACH, energy efficient, Multipath.

## I. INTRODUCTION

Wireless sensor network concept exists since from 1990's. Wireless sensor network consists of lots of sensor nodes with one or more base station [9]. The sensors are independent tiny devices consists of battery power, computation capacity, communication range, memory with transceivers to transmit and receive communication data among sensors and base station. The sensors nodes are randomly deployed in networks and works unattended mode. All sensors are equipped with battery which has limited power source. Therefore it is essential requirement that the resources in the network should be get properly utilized.

## II. WIRELESS SENSOR NODES

In recent we have made rapid research in the field of mobile computing. The developments in the Micro-Electro Mechanical Systems (MEMS) have made low-cost and low-power WSN [2]. Therefore sensor nodes are inexpensive and smaller in size. Due to widely availability of wireless sensors, WSNs are widely used in many applications nowadays. These tiny nodes collaborate with each other via RF communication in ISM (Industrial, Scientific and Medical) band to form Wireless Sensor Network. Based on application specific wide range of sensors are available following figure for one of the sensor.

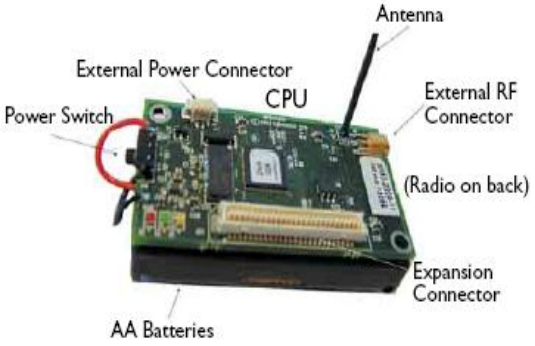


Fig. 1 Sensor Node

Each sensor node in the network consists of three subsystems:

*The sensor subsystem:* used to sense the environmental parameters such as temperature, humidity, pressure, etc.

*The processing subsystem:* It has microcontroller which performs the local computations on the sensed data and controlling actions and have internal memory to store processed data.

*The communication subsystem*: This is responsible for transportation of sensed data. The internal structure of sensor node is as shown in figure

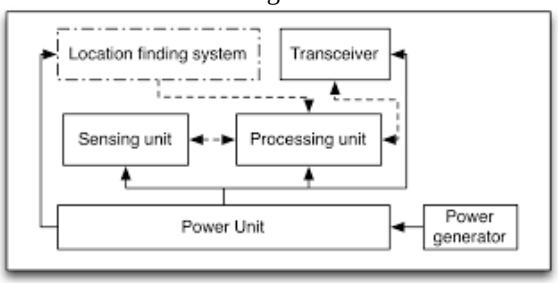


Fig. 2 Structure of Sensor node

## III. VARIOUS ISSUES IN WIRELESS SENSOR NETWORK

The major issues that affect the design and performance of a wireless sensor network are as follows [3] [4]. Hardware and Operating System for WSN, Wireless Radio Communication Characteristics, Medium Access Schemes, Deployment, Localization, Synchronization, Network Layer, Transport Layer, Architecture, Security, Fault tolerance and adaptability, Power consumption. Due to node failure rate topology of the sensor network changes continuously.

## IV. ROUTING PROTOCOLS IN WSN

Power consumption is one of challenging research issue. Energy or power consumed by the sensor nodes should get minimized resulting sensor nodes should get more energy efficient. To conserve power the node should shut off the radio power supply automatically when they

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are not in use. Another innovative technique is developed to use efficiently limited energy and maximize the lifetime of the network is to implementing routing protocols such that they perform efficiently and utilize the less amount of energy as possible for the communication among nodes within the network and along with between the networks [5] [6].

In general, depending on the network structure routing protocols can be classified as *protocol operation based*: negotiation based, multi path based, query based, QoS based, coherent based, hybrid. In addition to the above, *routing algorithm based protocols* can be classified into three subcategories namely, proactive, reactive, and hybrid

## V. RELEATED WORK

### 1. Architecture of LEACH protocol

Author [1] introduced the first and most popularly used energy-efficient hierarchical clustering algorithm for wireless sensor networks to reduce power consumption and known as Low-Energy Adaptive Clustering Hierarchy (LEACH). LEACH protocol is based following assumptions that all nodes can transmit with sufficient power to reach the base station, the nodes can use power control to vary the transmit power quantity, and every node has the computational power to support different MAC protocols and execute signal processing functions [7].

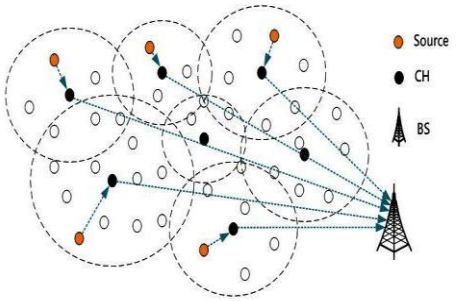


Fig. 3 Architecture of LEACH

Main art of LEACH protocol have algorithms for distributing cluster forming, adaptive cluster forming and cluster head position changing. Distributing cluster forming method ensures self-organization of most target nodes. The adaptive cluster forming and cluster header position changing algorithms ensure to share the energy dissipation fairly among all nodes and extend the life of the whole system at the end.

In LEACH, Cluster-heads are randomly selected by using a distributed algorithm [7] from deployed sensor nodes. It is a cluster based protocol adapting the stochastic model for randomized rotation of Cluster-heads for energy load balancing among sensor nodes in the network. It is based upon rounds in which sensor nodes transmit data to Cluster-head in their assigned time slot. Cluster-heads send aggregated data to Base Station by single hop transmission.

### 2. LEACH Operation

The LEACH protocol operation is divided into multiple rounds. Each round starts by a set-up phase and after clusters is prepared the steady-state phase start. Then data will be transferred from the nodes to the base station through cluster head.


Fig. 4 Operation Time of LEACH

#### i. Set-up Phase

During the setup phase, the CHs are selected based on an elective percentage of deployed nodes also by considering a factor that so far how many times an individual node performed the role of cluster-head. The selection depends on decision made by the node by choosing a random number between 0 - 1. If selected number is less than a set threshold value $\boldsymbol{T(n)}$ the sensor node becomes a cluster-head for the existing round. Where $\boldsymbol{T(n)}$ is calculated as

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(rmod\left(\frac{1}{p}\right)\right)} & n \in G \\ 0 & others \end{cases}$$

Where p - probability of the node being selected as a cluster-head node, r - Number of rounds passed, G - Set of nodes which have not been cluster heads in the previous 1/p rounds, mod - modulo operator.

Once the cluster-head is selected remaining all nodes joins the resultant cluster head as per the broadcast signal strength of the cluster head node. After this cluster set-up phase get finishes for this particular round. When the cluster head allots time slots for members using TDMA technique, the network starts the steady phase.

#### ii. Steady State Phase

Steady Sate operation is broken into frames, in which nodes send their information to the cluster head at most once per frame in their due time. Cluster head sends the aggregated data to Base-Station (BS) in one hop manner. LEACH is based on rounds and system repeats the clustering and transmission for each round. LEACH outperforms earlier existing protocols e.g. direct communication protocol, minimum-transmission-energy protocol and static clustering protocol in Wireless Sensor Network. Due to various redundant nodes, which observe similar events much more redundant information is available in wireless sensor network which is subsequently cancelled during aggregation process performed by Cluster heads. Our aim in the proposed idea is to utilize the redundant deployed nodes and take them as an advantage for prolonging network life time.

### 3. Drawbacks of LEACH

It significantly relies on cluster heads rather than cluster members of the cluster for communicating to the base station. Due to this it gains strength issues like failure of the cluster heads. It incurs additional overheads due to the process of cluster head changes in every cycle of the communication. It also incurs overhead due to calculations which leads to the energy incompetence for dynamic clustering in large scale networks. There is no inter-cluster contact in the network because CHs directly communicate with sink. This process requires high range of transmission power in the network. For this only, LEACH is not best

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suited for large- scale networks that interns require single hop communication with sink. In LEACH CHs are not uniformly distributed within the cluster that means CHs can be located at the boundaries of the cluster. In LEACH, CH selection is random process, which does not take energy consumption of the different nodes within the cluster along with CH into account and this leads to reselecting of CH as the sane node in many simultaneous iteration of data processing in the network [10, 11].

## VI. PROPOSED WORK

The anticipated algorithm is base on the concept of Multipath routing [8] in wireless sensor network. The multipath technique overcomes the problems raised in single path or multi hop routing algorithm. As we have seen that in sensor network in between sensor node and base station multiple number of paths are available. In below we discuss the principal and operation proposed algorithm.

As that of LEACH the proposed protocol also works in rounds and gets divided into setup phase followed by steady state phase [1]. In the setup phase the cluster heads are selected. Between of 0 and 1 a random number is elected by the sensor node. If chosen value is less than threshold value *T(i)* then node will elected as cluster head otherwise work as normal node the. In order to increase the energy efficiency the threshold function is modified as follows:

$$T(n) = \left( \frac{p}{1 - p * mod\left(t, round\left(\frac{1}{p}\right)\right)} - p * k \right)$$

Where the p is the probability and k is number of normal sensor nodes for that round.

Once the cluster heads are formed remaining member node join to the nearer cluster head. In steady state phase is the sensor nodes sends aggregated data to the base station if they are closer else information passed to the nearest cluster head and he will forward this information to the base station using shortest multipath to achieve higher lifespan. In this algorithm we have assumed that the sensor nodes know their location using GPS.

In this work we propose a routing protocol called multipath LEACH based on LEACH protocol to balance the energy consumption of sensor nodes in order to solve the overload energy consumption problem. In hierarchical routing protocols, the number of cluster heads plays important role and affects the performance of routing protocols. If the cluster heads are less in number each cluster head needs to cover larger distance, this will lead the problem that some cluster-members get far from their cluster heads and consume much more energy. As the communication between cluster heads and sink node consumes more energy than common nodes, the excessive number of cluster-heads will increase the energy consumption of the whole network and shorten the network lifetime. Therefore, it is necessary to select optimal cluster head number to make the energy consumption minimum.

In LEACH, some of the nodes have to select as a cluster heads that, those are far away from base station. These nodes data has to go through a long distance to reach the BS. Such transmissions waste the network's energy and are called extra transmissions. In order to solve the extra transmission problem, we made a change in the set-up phase of the LEACH algorithm. In this phase, once the cluster heads are selected, the other sensor nodes do not necessarily select the closest node. Among the cluster heads that, in comparison to them, have a shorter distance to the BS, these nodes select the closest cluster head and inform it that it will become a member of the cluster. If such a cluster head does not exist, it will not be the member of any clusters and will send its data directly to the BS.

In multipath LEACH protocol, the numbers of paths are introduced. This gives information about how long the cluster head from the sensing node. This knowledge is helpful for selecting the nearest cluster-head node. Duo to this energy gets saved and decreases messaging needed to communicate between cluster head and sensor node. Aim of this protocol is to provide considerably energy-efficient and robust communication. This can be achieved doing load balancing at *Network level* which involve traffic multiplexing over multiple paths and second at c*luster level* by introducing rotation of the cluster heads each interval of time. This avoids energy decay resulting from using continuously the same path for communication for a long period. The multi path technique can also be used when path failure occurs; an alternative path used without tampering quality of service.

## VII. RADIO ENERGY DISSIPATION MODEL

Wireless communication is the main part of energy dissipation in WSN. The same energy dissipation model as in [1] is used here. To achieve an acceptable signal-to-noise ratio (SNR) in transmitting k bit message over a distance d, the energy cost of transmission (ETx) and reception (ERx) are given by:

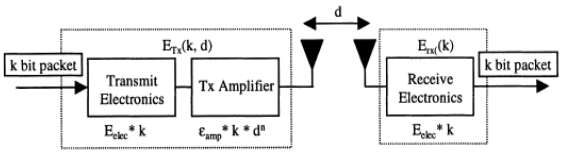


Fig. 5 Radio Energy Dissipation Model

$$E_{Tx}(k,d) = \begin{cases} k \times E(elec) + (k \times E_{fs} \times d^2) & d < d_0 \\ k \times E(elec) + (k \times E_{mp} \times d^4) & d > d_0 \end{cases}$$

Where,

***k*** is the number of bits transmitted

***d*** is the distance between transmitter and receiver

$\boldsymbol{d_o}$ is the constant referred as crossover distance.

$$d_0 = \sqrt{\frac{E_{fs}}{E_{mp}}}$$

Depending on the transmission distance both the free space $\boldsymbol{E_{fs}}$ and the multi-path fading $\boldsymbol{E_{mp}}$ channel models are used.

The energy consumption of receiving k-bit data is

$$E_{Rx}(k) = k \times E(elec)$$


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As communication cost is considered to be much larger than computational cost, so the contribution of computations to the energy consumption is considered to be negligible in this analysis. The assumed energy required for running the transmitter and *receiver electronic circuitry E(elec)* is 50nJ/bit and for acceptable SNR required energy for transmitter amplifier for free space propagation $\mathbf{E_{fs}}$ is 100pJ/bit/m2 and for two ray ground $\mathbf{E_{mp}}$ is 0.0013pJ/bit/m4. The energy for data aggregation is set as $\mathbf{E_{DA}}$ =5 nJ/bit/ signal. The crossover distance $\mathbf{d_o}$ is assumed to be 87m.

### 1. System assumptions

Following assumptions are made for proposed algorithm:

1. The Network is homogeneous that all nodes have equal initial energy at the time of deployment.
2. The Network is static and nodes are distributed randomly.
3. There exists only one base station, which is placed in the middle (50, 50).
4. The Energy of sensor nodes cannot be recharged after deployment of network.
5. Sensor nodes are equipped with GPS so aware about their location.
6. No power and computational constraints in Base-Station (BS).
7. Deployed Nodes can use power control to vary the amount of transmission power, which depends on the distance to the receiver.

### 2. Simulation Parameters

The simulation of LEACH, multigroup - LEACH and multipath-LEACH has 100 sensor nodes are randomly distributed in an area of 100 m x 100 m. BS is put at the location with x = 50, y = 50. The bandwidth of data channel is set to 1 Mbps, the length of data messages is 4000 bytes and packet header for each type of packet was 25 bytes. The number round is set to 10000s. When a node uses energy down to its energy threshold, it can no longer send data and is considered as a dead node.

Table 1. Simulation Parameters

| Sr. no. | Simulation parameters | Values used |
|---|---|---|
| 1. | Number of sensor nodes (N) | 100 |
| 2. | Network area (MxM) | 100x100 |
| 3. | Location of base station (x,y) | 50,50 |
| 4. | $E_{elec}$ (transmission & reception energy per bit) | 50 nJ |
| 5. | $E_{fs}$ (Transmit amplifier energy dissipation of free space model) | 10 pJ/bit/m2 |
| 6. | $E_{mp}$ (Transmit amplifier energy dissipation of two model) | 0.0013 pJ/bit/m4 |
| 7. | $E_0$ (Initial energy of deployed node) | 0.5J, 2J |
| 8. | $E_{da}$ (data aggregation energy per bit) | 5 nJ |
| 9. | K (number of bits in a packet) | 1000 bits |
| 10. | $d_0$ (Cross over distance) | 87 m |
| 11. | $E_{TX} = E_{RX}$ | 5 µJ |

## VIII. ALGORITHM OF MULTIPATH LEACH

Making assumptions, all nodes are unmovable with same initial energy.

Stage i In this stage the sensor nodes are deployed randomly

Stage ii Divide the sensor nodes in smaller parts depending on their location

Stage iii Start the round; Find the energy level of each node.

Stage iv Form cluster head for each partition from above information

Stage v Find the shortest path between sensor node and base station

Stage vi Start the communication from sensor node to selected cluster head,

Stage vii selected cluster head to nearest cluster head and at end to base station

Stage viii Calculate residual energy

Stage ix Repeat rounds until all node dies

## IX. SIMULATION RESULTS AND DISCUSSION

### 1. Simultion of Multipath LEACH Enahanced

The figure shows the simulation of multipath LEACH. In simulation of multipath LEACH the area is divided into small cells (groups) and each area is having a cluster head, so the nodes of that area will communicate with that cluster head only. The cluster head which is closer to base station get directly communicated with base station. Those cluster heads far away from the base station, they sends their information to base station through their cluster heads which are located to closer.

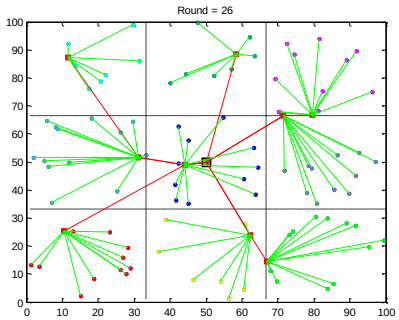


Fig. 6 Simultion of Multipath LEACH

### 2. Simulation comparison

We compare multipath - LEACH with LEACH and multigroup -LEACH based on two performance metrics: total energy consumption and lifetime. Multipath - LEACH protocol has more residual energy than LEACH and multigroup - LEACH. Following table shows the list of figures for node died in respect to round.

Table 2. Evaluation of Network Life Time of LEACH, Multigroup LEACH and Multipath – LEACH

| Initial Energy | Protocol | No. of Rounds | | |
|---|---|---|---|---|
| | | FND | HND | LND |
| 0.5 J | Leach | 28 | 69 | 73 |
| | Multigroup - Leach | 371 | 635 | 848 |
| | Multipath-Leach | 1108 | 1774 | 2798 |

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| | | | | |
|---|---|---|---|---|
| 2 J | Leach | 111 | 181 | 239 |
| | Multigroup-Leach | 810 | 2590 | 3890 |
| | Multipath – Leach | 5246 | 6850 | 11063 |

**FND:** First node dies; **HND:** Half node dies; **LND:** Last node dies

## 3. Discussion

The simulation result demonstrates the relative behaviour of LEACH, multigroup LEACH and multipath - LEACH discussed. Algorithms with parameters values total number of sensor nodes N = 100, probability p = 0.1, with initial energy $E_o$ = 0.5 J. Graphs are plotted with parameters dead nodes, alive nodes and residual energy are taken at y-axis and different time steps (Rounds) were taken on x-axis.

The following figures indicates round Vs dead nodes, round Vs alive nodes and round vs. residual energy shows the network life time of LEACH, multigroup LECAH and multipath LEACH. In round Vs dead nodes the network life time of multipath LEACH is more as compared to LEACH and multigroup LEACH. When the initial energy is $E_o$ = 2J, the network life time of multipath LEACH is 2798 rounds approximately.

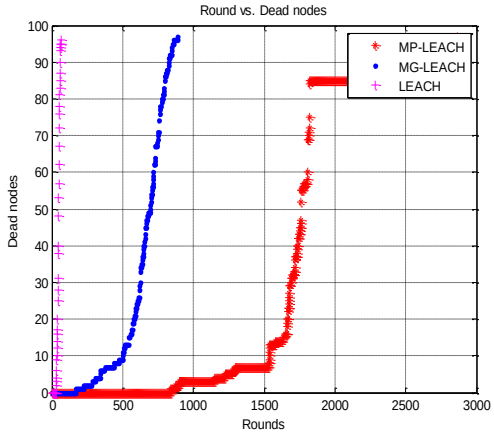


Fig. 7 Round vs Dead Nodes

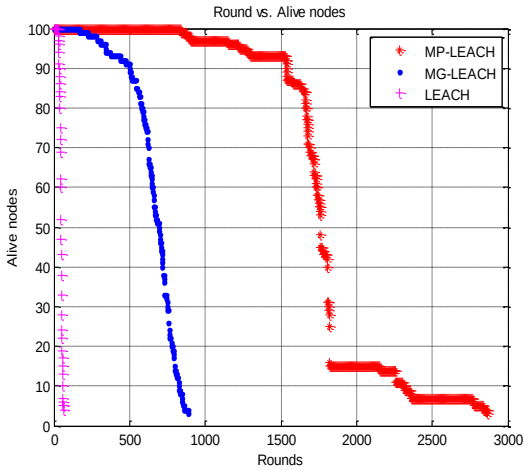


Fig. 8 Round vs Alive Nodes

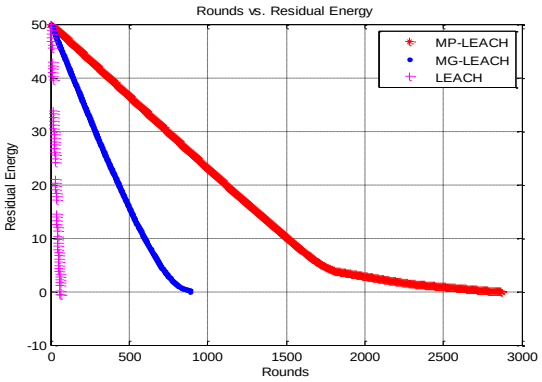


Fig. 9 Round vs Residual Energy

The simulation result showing relative behaviour of above discussed algorithms with parameters values n =100, **p** = 0.1, **Eo** = 2 J. The below figures round Vs dead nodes, round Vs alive nodes and round Vs residual energy shows the network life time of LEACH, multigroup LECAH and multipath LEACH.

In round vs. dead nodes, the network life time of multipath LEACH is more as compared to LEACH and multigroup LEACH. When the initial energy is Eo = 2 J, the network life time of multipath LEACH is 11076 rounds approximately.

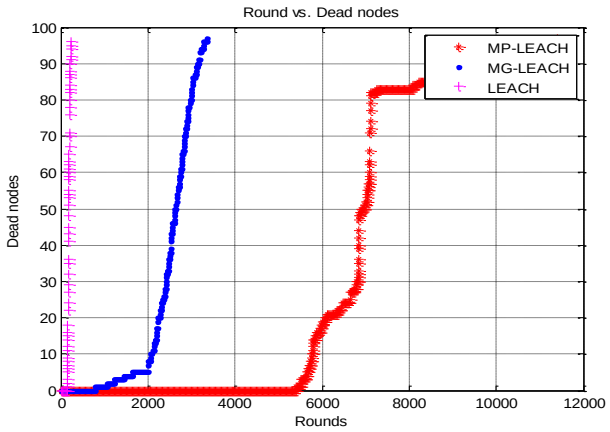


Fig. 10 Round vs Dead Nodes

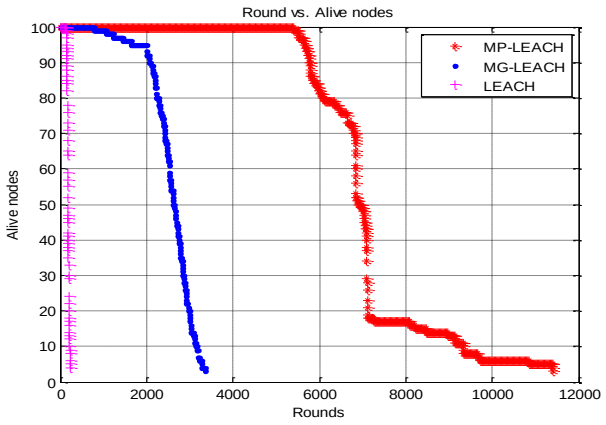


Fig. 11 Round vs Alive Nodes


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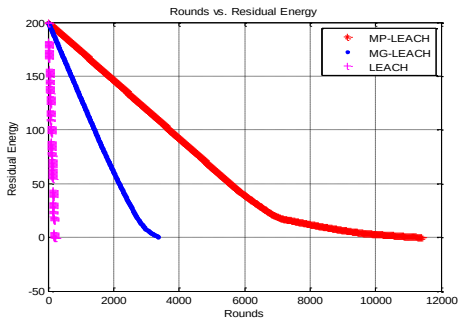


Fig. 12 Round vs Residual Energy

## X. Conclusion And Future Work

### Conclusion

The LEACH is one of the most popular algorithms used in WSN for routing the packets in the network. The proposed algorithm is capable of searching multiple paths Here, LEACH and its advance multigroup LEACH protocol compared with multipath LEACH. The simulation results shows energy consumption of both are maximum as compared with multipath LEACH. Hence multipath LEACH is most efficient among these and best suited.

### Future Work

The future work will be focusing, still there is a need to decrease the energy utilization of the nodes while transmitting and receiving making advanced in multipath routing. So it will increase the life time of the network. Further work to improve the algorithm support for node mobility.

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## BIOGRAPHIES

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