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A Modified LEACH Protocol for Network Lifetime Enhancement in Wireless Sensor Networks

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Abstract: Wireless sensor network consists of one or more base station and lots of sensor nodes. These sensor nodes are scattered in a specific area and these are battery operated. Since, the energy of battery is limited alternative to this problem is either to recharge the battery or to replace it with other one .In wireless sensor networks (WSNs), due to the limitation of nodes' energy, energy efficiency is an important factor should be considered when the protocols are designing. As a typical representative of hierarchical routing protocols, LEACH Protocol plays an important role. In this paper we proposed a modified LEACH which extends the LEACH clustering routing algorithm protocol in which cluster head chosen criteria is on the basis of minimum distance, maximum residual energy, minimum energy transmission. The result of simulations conducted indicates that the proposed clustering approach is more energy efficient and hence there is enhancement in the sensor network lifetime.

Keywords: LEACH Protocol; Energy consumption; Network lifetime.

INTRODUCTION

A Wireless Sensor Network consist of small devices, called sensor nodes that are equipped with sensors to monitor the physical and environmental conditions such as pressure, temperature, humidity, motion, speed etc. and to cooperatively pass their data through the network to the main location. Wireless Sensor Networks (WSNs) are networks of light-weight sensors that are battery powered majorly used for the monitoring purposes. The WSN is built from several hundreds to thousands number of nodes where each node is connected to one or several sensors. These small sensor nodes which consist of the sensing, processing and communicating unit leverage the idea of sensor networks based on collaborative effort of a large number of nodes.

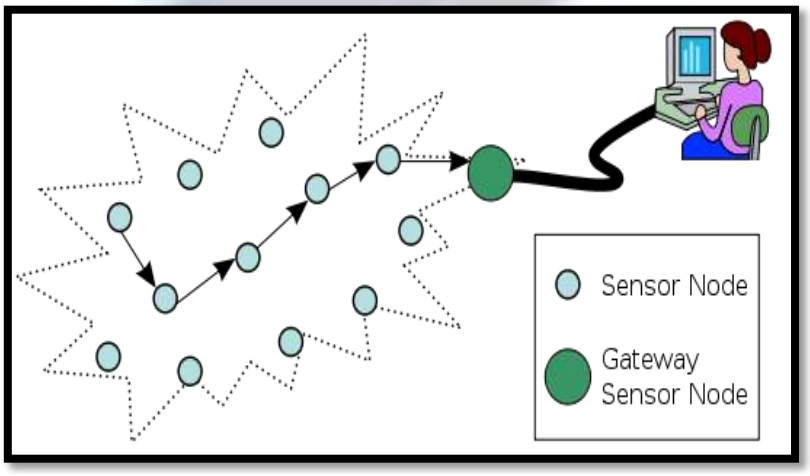


Figure 1: Typical Wireless Sensor Network Architecture

The size of the sensor node may vary from shoebox down to the size of a grain of dust. Initially the development of wireless sensor network was motivated by the military applications such as battlefield surveillance, but today's such networks are used in almost every field like health monitoring, industrial application, home automation etc. The sensor node has mainly several parts that are: a radio transceiver, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, which is usually a battery.

Network design objective

The main design objective considered in the design of wireless sensor network is following:

Small node size: The size of the node should be small, it will reduce the power consumption and cost of the node, and it is easy to deploy the small nodes.

High energy efficient: The sensor nodes are powered by battery and it is often very difficult or even impossible to charge or recharge their batteries, it is crucial to reduce the power consumption of sensor nodes so that the lifetime of the sensor nodes, as well as the whole network is prolonged.

Scalability: The number of sensor nodes in a network may vary from hundreds to thousands so network should be scalable to different sizes.

Channel utilization: The wireless sensor networks have limited bandwidth resources; communication protocols designed for sensor networks should efficiently make use of the bandwidth to improve channel utilization.

Fault tolerance: Due to the harsh environment deployment and because of unattended operations, the nodes should be fault tolerable.

Reliability: The network should be reliable, error control mechanism to ensure the reliability.

Leach Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first and most popular energy efficient protocol in wireless sensor network that was proposed for reducing the power consumption. The clustering task is rotated in the LEACH and cluster heads are selected randomly. It uses clusters to increase the life of the wireless sensor network. LEACH is based on aggregation technique that combines or aggregates the original data into a smaller size of data that carry only meaningful information to all individual sensors LEACH divides the wireless sensor network into several clusters.

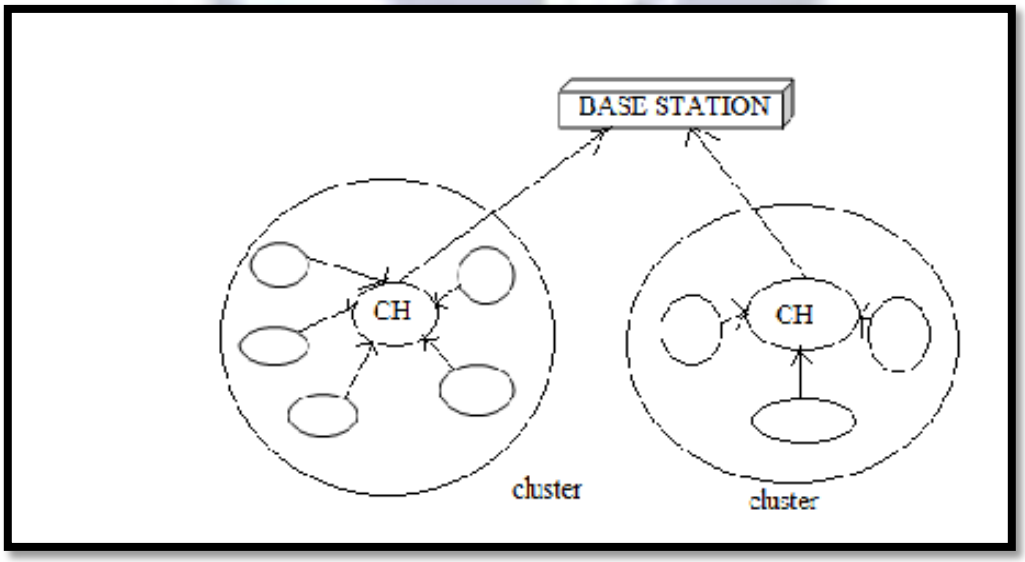


Figure 2: LEACH Protocol

Each cluster has a cluster head that aggregate the data from the cluster nodes and process the data and transmit it to the base station. LEACH uses a randomize rotation of high-energy CH position rather than selecting in static manner, to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor and die quickly as in direct communication, in which the node near to the base station depletes energy more quickly. The numbers of cluster heads and cluster members generated by LEACH are important parameters for achieving better performance.

LEACH Protocol Phases

This protocol is divided into rounds; each round consists of two phases:

Set-up Phase

(1) Advertisement Phase
(2) Cluster Set-up Phase

Each node decides independent of other nodes if it will become a CH or not. This decision takes into account when the node served as a CH for the last. In the following advertisement phase, the CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength In the next cluster setup phase, the member nodes inform the CH that they become a member to that cluster with "join packet" contains their IDs using CSMA. After the cluster-setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members. After that steady-state phase begins.

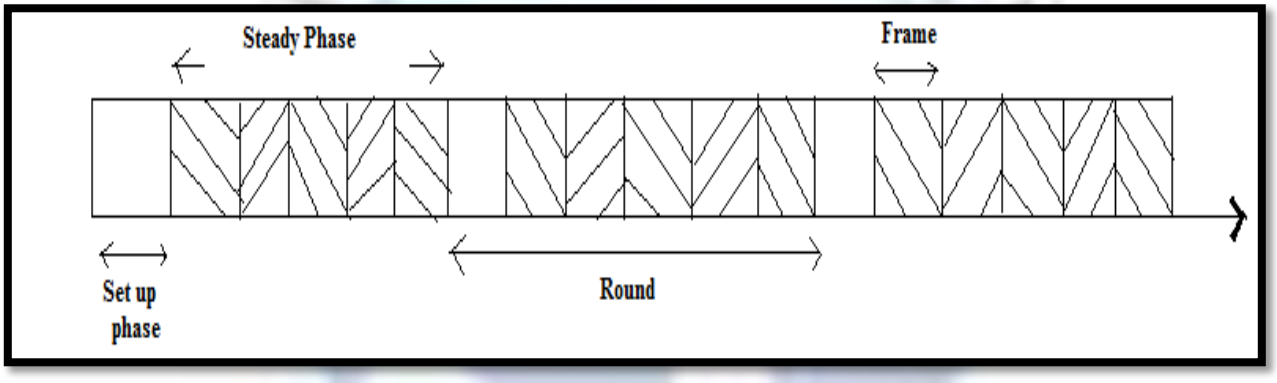


Figure 3: LEACH protocol phases

Steady Phase

(1) Schedule Creation
(2) Data Transmission

Data transmission begins; Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement). The radio of each non-CH node can be turned off until the nodes allocated TDMA slot, thus minimizing energy dissipation in these nodes. When the complete data has been received, the CH aggregates these data and sends it to the BS. LEACH is able to perform local aggregation of data in each cluster to reduce the amount of data that transmitted to the base station. Although LEACH protocol acts in a good manner, it suffers from many drawbacks such like:

- CH selection is randomly, that does not take into account energy consumption.
- It can't cover a large area.

Drawbacks of LEACH protocol:

(1) The main problem with LEACH protocol lies in the random selection of cluster heads. In LEACH there exists a probability that the cluster heads formed are unbalanced and may remain in one part of the network making some part of the network unreachable.

(2) Also, the protocol assumes a homogeneous network i.e., all nodes begin with the same amount of energy capacity in each election round, assuming that being a CH consumes approximately the same amount of energy for each node. The protocol should be extended to account for non-uniform energy nodes, i.e., use energy-based threshold.

Modified LEACH:

In this proposed work, there is modification in the LEACH, where the parameters considered to elect the cluster head are: minimum distance, maximum residual energy, minimum distance used to select the cluster head instead of probability as used in the LEACH, so that it can be used for the sensor nodes with different initial energy among the sensor nodes so that energy is optimally consumed for the cluster members to interact with Cluster Heads. The cluster head is rotated so that the en consumption can be distributed evenly and the lifetime of the wireless sensor network can be extended. Secondly it selects optimal path and adopts multi hop communication between cluster head and sink is presented here. Then, according to the selected best path, these cluster heads transmit data to the corresponding cluster head which is nearest to sink. Finally, this cluster head sends data to sink. Experimental results show that the life time of the network is extended as compared to other approaches like LEACH.

Algorithm for the modified LEACH:

The algorithm used for the modified LEACH is as follows:

1. Create the random sensor network first.
2. In the first round the cluster head selection procedure is same as in basic LEACH.

A sensor node chooses a random number, r between 0 and 1. If this random number is less than a threshold value, T(n), the node becomes a cluster head for the current round. This threshold value is calculated using :-

$$T(n) = \begin{cases} \frac{P}{1-P*(\frac{rmod1}{p})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

If n < T (n), then that node becomes a cluster-head.

3. Calculate the distance between the cluster head and the sensor node, which have the shortest distance that node join that cluster.
4. Now CH receives data from Non-CH nodes and aggregates them. And send to the BS. If the distance between the CH and the BS is more than here we used multi-hopping concept, acc to this if the distance between the CH and the BS is more than one CH send data to the other CH which is closer to the BS.
5. Now energy dissipated is calculated and subtracted from the remaining energy of every node and if some nodes are having energy less than minimum than those nodes are deleted from the network and the life time close .and we get the output. Hence this round will be completed. Otherwise, it repeated from the STEP 2 to STEP 5.except the cluster head selection criteria is different. It is on the basis of three factors i.e. Minimum distance, maximum residual energy, and minimum distance. Based on received signal strength, each non-cluster head node determine its cluster head, greater the signal strength means shorter the distance between them and if distance is small then for the transmission less energy is required
6.

Parameters used for the simulation:

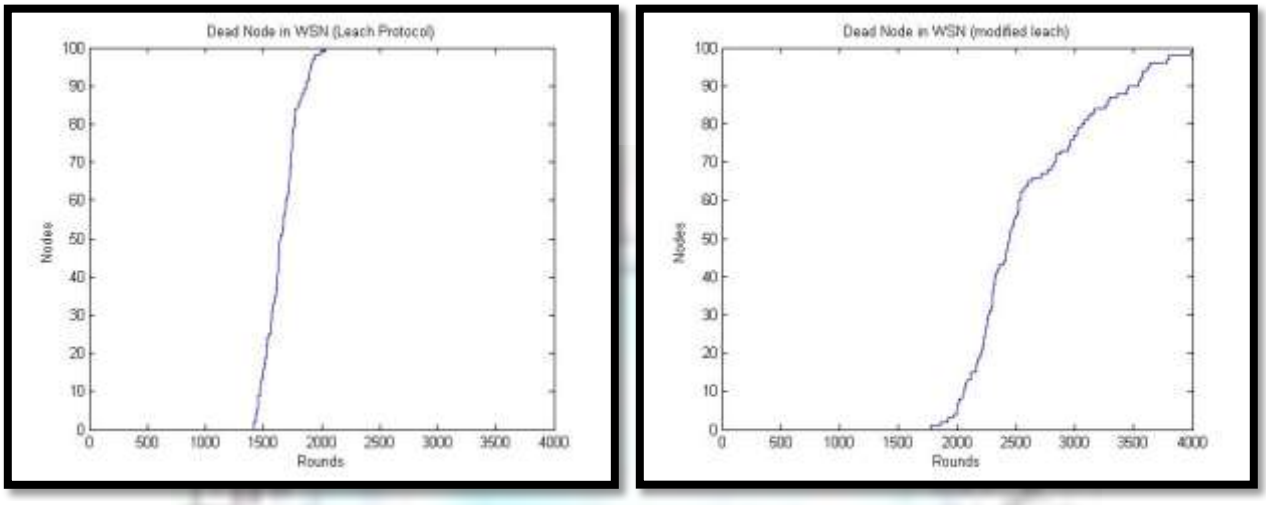
The parameters which are used for simulation for LEACH and Modified LEACH are following;

n=100	where n is the total no. of nodes
P=0.2	probability of a node to become cluster head
Eo=0.5	initial energy of the nodes
ETX=50*0.000000001	transmission energy
ERX=50*0.000000001	receiving energy
Efs=10*0.000000000001	forwarding energy
rmax=4000	maximum no. of rounds

We have take all these values for the simulations and find that there are less dead nodes and more alive nodes in proposed system. Also rate of packet transmission is enhanced and due to more alive nodes cluster formation process is ensue for a long time which tends o increase life time of wireless sensor network. Here figures are presented which shows the output of modified system, existing LEACH output is also considered for the purpose of comparison..

Results & Discussion

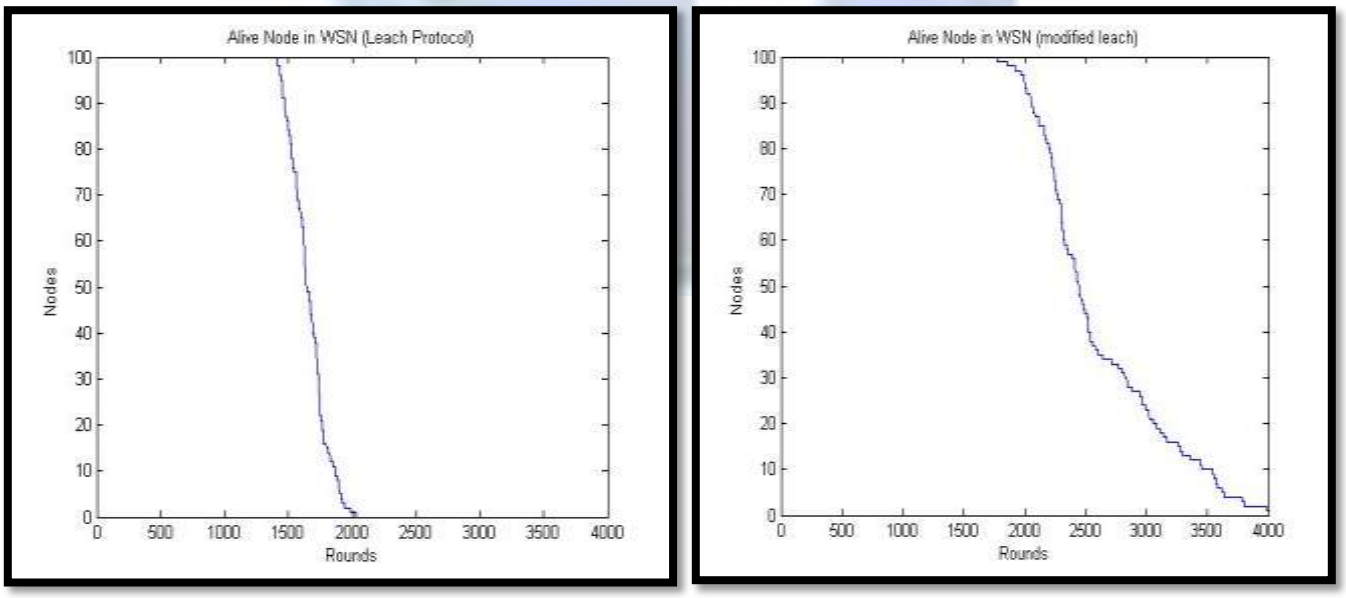
The below figures shows the simulation result of the LEACH protocol and the Modified LEACH, from which we will analyses the difference between the Modified LEACH over basic LEACH.



(a) (b)

Fig 4: Simulation result for (a) LEACH (b) Modified LEACH

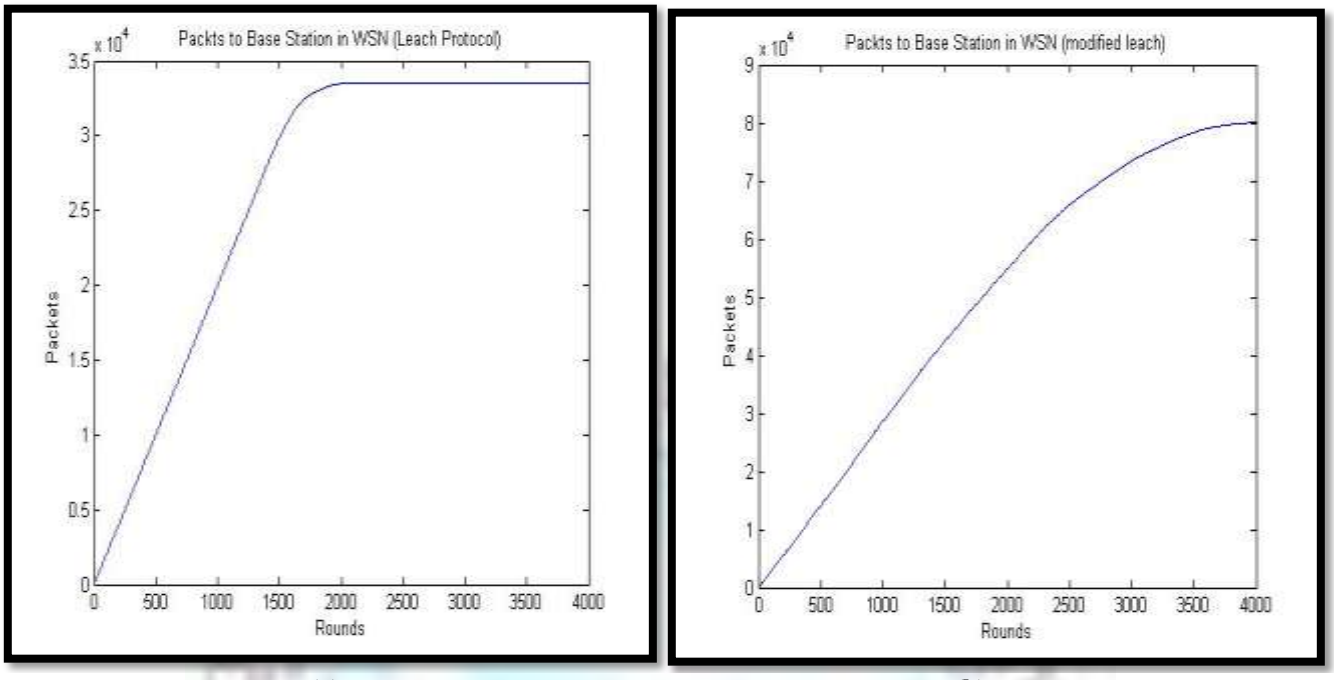
The above fig. 4 (a) & (b) that Modified LEACH is better than the LEACH as the first nodes die start at 1418 rounds in LEACH and in modified LEACH at 1778



(a) (b)

Fig 5: Simulation result for (a) LEACH (b) Modified LEACH

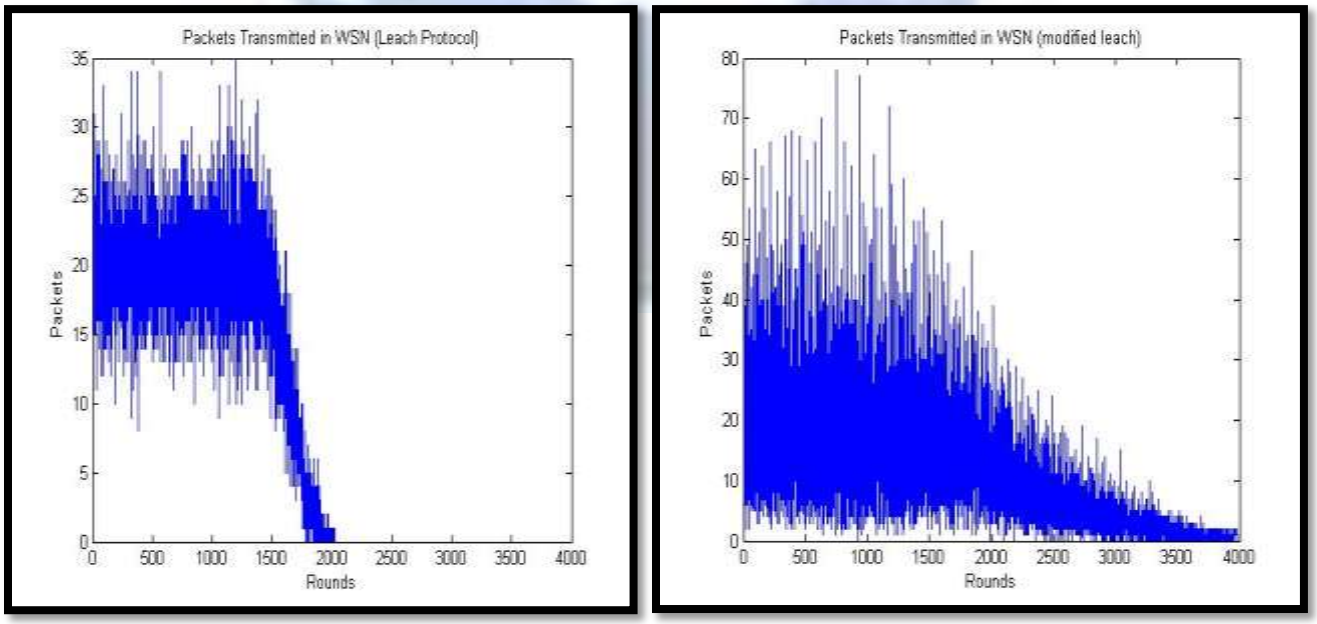
The fig 5 (a) & (b) shows that till round 1418 all nodes are alive in LEACH, whereas in modified LEACH all nodes are alive till 1778 rounds. And all dead at 2032 in LEACH whereas in modified all nodes not died until 4000 rounds.



(a) **(b)**

Fig 6: Simulation result for (a) LEACH (b) Modified LEACH

The fig 6 (a) & (b) shows that packet transmitted to base station in LEACH is132429, whereas in Modified LEACH it is 180850.



(a) **(b)**

Fig 7: Simulation result for (a) LEACH (b) Modified LEACH

As from fig 7 (a) & (b) shows that the network is connected till round 2032 in LEACH, whereas in Modified LEACH network is connected till 4000 rounds. So from the above analysis it is clear that the Modified LEACH performs better than the basic LEACH.

Analyzed Parameters	LEACH protocol (existing work)	Modified LEACH (proposed work)
First dead node	1418(rounds)	1778
All dead node	2032(rounds)	Live up to 4000
Packets transmitted to base station	33513(no. of packets)	80131
Connectivity of network	2032(rounds)	Till 4000 rounds

Conclusion

In this proposed work we have proposed a modified LEACH which extends the LEACH clustering routing algorithm protocol in which cluster head chosen criteria is on the basis of minimum distance, maximum residual energy, and minimum energy transmission. The result of simulations conducted indicates that the proposed clustering approach is more energy efficient and hence there is enhancement in the sensor network lifetime. In the existing system data transmission depends on current energy of nodes and distance between nodes whereas the modified-LEACH algorithm works on the additional parameter i.e. minimum distance, maximum residual energy of node and minimum energy transmission. From the simulations result we concluded that the death of first node and last node is comparatively later as compared to original LEACH, and also the packet transmitted to the base station is more as compared to original LEACH. Hence overall there is enhancement in network lifetime.

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