An Energy Efficient Cluster Based Routing Protocol for WSN: I-LEACH protocol

Minor Project I

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Abstract:

The popularity of Wireless Sensor Networks have increased tremendously due to the vast potential of the sensor networks to connect the physical world with the virtual world. Since these devices rely on battery power and may be placed in hostile environments replacing them becomes a tedious task. Thus, improving the energy of these networks becomes important.

Wireless sensor network (WSN) is a network Consists of large number of low power sensor nodes. Leach is a less energy adaptive clustering hierarchy protocol. The main goal of cluster based sensor networks is to decrease system delay and reduce energy consumption. Leach is a cluster based protocol for micro sensor networks which achieves energy efficient, scalable routing and fair media access for sensor nodes. Many improvements are done in wireless sensor network. Security is very essential in wireless sensor network.

Further, we will modify one of the most prominent wireless sensor networks routing protocol LEACH as Improved LEACH (I-LEACH) by introducing efficient cluster head replacement scheme and dual transmitting power levels.

Keywords:

Wireless Sensor Network, Clustering, Energy efficiency, LEACH, I-LEACH, Network Lifetime

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ABBREVIATIONS:

Abbreviation	Description
ADV	Advertisement
BS	Base Station
CDMA	Code Division Multiple Access
CH	Cluster Head
C-Leach	Centralized Low-energy Adaptive Clustering Hierarchy
CM	Cluster Member
GPS	Global Positioning System
LEACH	Low-energy Adaptive Clustering Hierarchy
Leach-F	Fixed no. of clusters Low Energy Adaptive Clustering Hierarchy
Leach-S	Solar aware Low energy adaptive clustering hierarchy
MAC	Media Access Control
QoS	Quality of Service
REQ	Request
TDMA	Time Division Multiple Access

TTL	Time To Live
WSNs	WSNs Wireless Sensor Networks

I. Introduction:

WSN form a subset of Ad-hoc networks. WSN consists of specially distributed autonomous sensors to cooperatively monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion etc. LEACH protocol is the first protocol of hierarchical routing which proposed data fusion; it is of milestone significance in clustering routing pro- tocol. Routing strategies and security issues are great research challenge. Nowadays in WSN, numbers of routing protocols have been proposed for WSN but most well-known protocols are hierarchical protocols like LEACH. Hierarchical protocols are defined to reduce energy consumption by aggregating data and to reduce the transmissions to the base station.

1.1 Wireless sensor network

A Wireless Sensor Network or WSN is supposed to be made up of a large number of sensors and at least one base station. The sensors are autonomous small devices with several constraints like the battery power, computation capacity, communication range and memory. They also are supplied with transceivers to gather information from its environment and pass it on up to a certain base station, where the measured parameters can be stored and available for the end user. In most cases, the sensors forming these networks are deployed randomly and left unattended to and are expected to perform their mission properly and efficiently. As a result of this random deployment, the WSN has usually varying degrees of node density along its area. Both the probably difference of node density among some regions of the network and the energy constraint of the sensor nodes cause nodes slowly die making the network less dense. Also it is quite common to deploy WSNs in harsh environment, what makes many sensors inoperable or faulty. For that reason, these networks need to be fault-tolerant so that the need for maintenance is minimized. Typically, the network topology is continuously and dynamically changing, and it is actually not a desired solution to replenish it by infusing new sensors instead the depleted ones. A real and appropriate solution for this problem is to implement routing protocols that perform efficiently and utilizing the less amount of energy as possible for the communication among nodes.

The WSN consist of two main components:

1. Sensor Nodes, and
2. Base Station (Central Gateway).

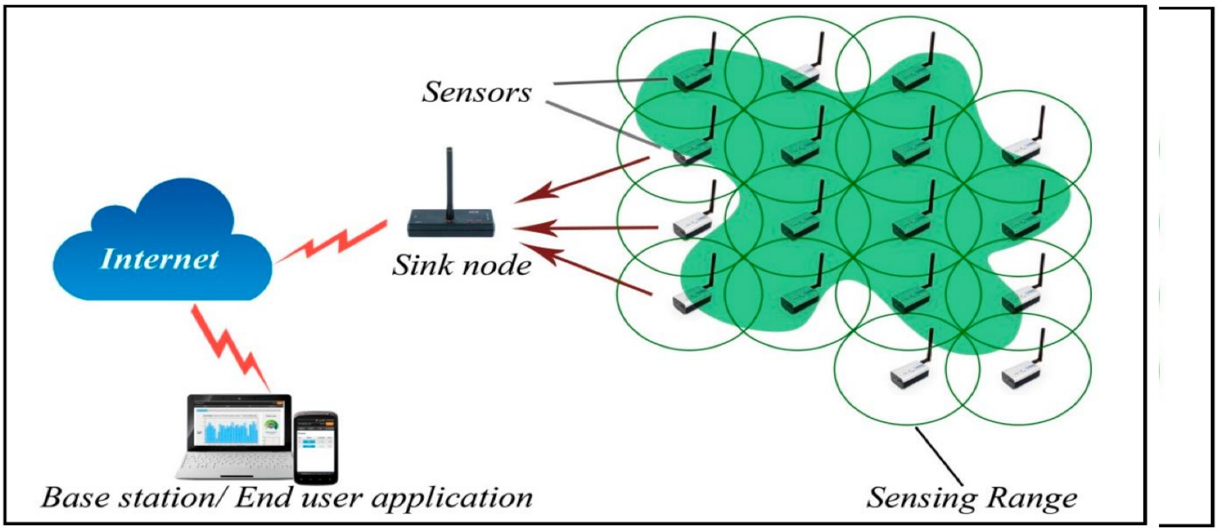


Figure 1.1: Wireless Sensor Network

1.1.1 Sensor nodes

Sensors nodes are typically built of few sensors and a mote unit. Sensor is a device which senses the information and pass it on to mote. Sensors are typically used to measure the changes in physical environmental parameters like temperature, pressure, humidity, sound, vibration and changes in the health parameter of person e.g. blood pressure and heartbeat. MEMS based sensor have found good use in sensor nodes. A mote consists of processor, memory, battery, A/D converter for connecting to a sensor and a radio transceiver for forming an ad hoc network. A mote and sensor together form a Sensor Node. A sensor network is a wireless ad-hoc network of sensor nodes. Each sensor node can support a multi-hop routing algorithm and function as forwarder for relaying data packets to a base station.

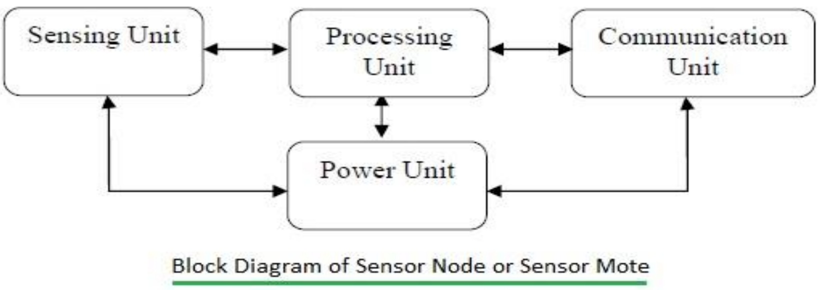


Figure 1.2: Block diagram of Sensor Node

1.1.2 Base Station

A base station links the sensor network to another network. It consists of a processor, radio board, antenna and USB interface board. It is preprogrammed with low-power mesh networking software for communication with wireless sensor nodes. Deployment of the base station in a wireless sensor network is very important as all the sensor nodes handover their data to the base station for processing and decision making. Energy conservation, coverage of sensor nodes and reliability issues are taken care of during deployment of base station in sensor network. Generally base stations are assumed static in nature but in some scenarios they are assumed to be mobile to collect the data from sensor nodes.

Figure 1.3: A Base Station Node

1.2 Energy-efficient Routing Algorithms:

Energy efficient routing algorithm can be categorized as follows: data centric routing algorithm, location based routing algorithm and hierarchical routing algorithm. Data centric routing algorithm uses Meta data to find the route from source to destination before any actual data transmission to eliminate redundant data transmission. Location based routing algorithm requires actual location information for every sensor node. Hierarchical routing algorithm divides the network into clusters. Cluster head (CH) is elected in each cluster. CH collects data from its members, aggregates the data and sends to sink. This approach is energy efficient but relatively complex than other approaches.

1.2.1 Data centric

Data centric protocols are query based and they depend on the naming of the desired data, thus it eliminates much redundant transmissions. The BS sends queries to a certain area for information and waits for reply from the nodes of that particular region. Since data is requested through queries, attribute based naming is required to specify the properties of the data. Depending on the query, sensors collect a particular data from the area of interest and this particular information is only required to transmit to the BS and thus reducing the number of transmissions. E.g. SPIN was the first data centric protocol.

1.2.2 Hierarchical

Hierarchical routing is used to perform energy efficient routing, i.e., higher energy nodes can be used to process and send the information; low energy nodes are used to perform the sensing in the area of interest. E.g. LEACH, TEEN, APTEEN.

1.2.3 Location Based

Location based routing protocols need some location information of the sensor nodes. Location information can be obtained from GPS (Global Positioning System) signals, received radio signal strength, etc. Using location information, an optimal path can be formed without using coding techniques. E.g. Geographic and Energy-Aware Routing (GEAR)

II. BACKGROUND STUDY:

LEACH PROTOCOL (Low Energy Adaptive Clustering Hierarchy)

LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or *cluster-head*. If the clusterheads were chosen a priori and fixed throughout the system lifetime, as in conventional clustering algorithms, it is easy to see that the unlucky sensors chosen to be cluster-heads would die quickly, ending the useful lifetime of all nodes belonging to those clusters. Thus LEACH includes randomized rotation of the high-energy cluster-head position such that it rotates among the various sensors in order to not drain the battery of a single sensor. In addition, LEACH performs local data fusion to "compress" the amount of data being sent from the clusters to the base station, further reducing energy dissipation and enhancing system lifetime.

Sensors elect themselves to be local cluster-heads at any given time with a certain probability. These clusterhead nodes broadcast their status to the other sensors in the network. Each sensor node determines to which cluster it wants to belong by choosing the cluster-head that requires the minimum communication energy. Once all the nodes are organized into clusters, each cluster-head creates a schedule for the nodes in its cluster. This allows the radio components of each non-cluster-head node to be turned off at all times except during its transmit time, thus minimizing the energy dissipated in the individual sensors. Once the cluster-head has all the data from the nodes in its cluster, the cluster-head node aggregates the data and then transmits the compressed data to the base station. Since the base station is far away in the scenario we are examining, this is a high energy transmission. However, since there are only a few cluster-heads, this only affects a small number of nodes.

1 A decentralized energy efficient hierarchical cluster-based routing algorithm for wireless sensor networks

Abstract

A new decentralized hierarchical cluster-based routing algorithm for WSNs is proposed. The most of energy consumption occurs due to transmission of messages, such as data and control packets. In our new approach clustering and multi hop routing algorithms are performing at the same stage to decrease control packets. According to non-uniform energy consumption among nodes, clusters are formed in such a way that cluster heads have the most competency in forwarding task of intra-cluster and inter-cluster transmission tree.

Introduction

Tiny-size battery-operated sensors which are capable of monitoring physical phenomena like temperature, humidity, vibrations, seismic events, and so on. Due to widespread use of WSNs and sensor's constraint issue, the necessity arises for new and energy efficient protocols around data aggregation subjective. Therefore, using energy-aware programs and algorithms is greatly significant. The key issue of our protocol scheme is that during construction of routing tree, CHs would be selected at the tree edges, based on effective local information. For CH decision-making procedure, we use multiple criteria, such as each node's residual energy and its distance to the base station along the created routing tree. Each node decides independently whether to become a CH. Usual nodes join to the appropriate CHs. Due to combination of routing and clustering essential scheme, the number of control packets would be reduced and consequently more power would be saved in each sensor node.

Cluster based routing protocol

This protocol contains a multi-criterion clustering algorithm and a cluster-based routing algorithm which are performed concurrently. In order to select CH nodes we utilize each node's local information such as residual energy, distance to the BS and proximity to its neighbors. Nodes residual energy factor is important due to balancing energy consumption among CHs. Finally, adjustment degree could help to adjust intra-cluster and inter-cluster energy consumption. CH would be selected in such a way that the constructed route to the BS becomes optimal.

In cluster-based routing algorithm our primary aim is to minimize message transmission cost by constructing a minimum spanning tree which covers the entire network. We assume BS place at the root and CHs at each edge. Cluster member nodes form the leaves of the constructed tree as well.

Simultaneously, with determining CH based on hybrid criterion, next hop CH through thepath to the BS is also characterized. With this method we optimize resource usage and delay the death of sensor nodes.

Conclusion

In this paper we proposed a decentralized energy efficient hierarchical cluster-based routing algorithm for wireless sensor networks. Our main objective is to reduce the energy consumption caused by extra control message transmissions. Therefore, concurrently with the CH selection a routing tree is constructed and BS is located at the root, a CH at each edge and cluster member nodes in leaves. The proposed protocol selects a next hop relay node with more residual energy, in a low-density area.

2. P-LEACH: Energy Efficient Routing Protocol for Wireless Sensor Networks

Introduction

The PEGASIS protocol, a chain of sensor nodes is formed and leader node is selected for each round randomly. Leader of a particular round collects the data, fuses the data, and sends the data to the base station. Although clustering overhead is avoided, PEGASIS still requires dynamic topology adjustment since a sensor node needs to know about the energy status of its neighbors in order to know where to route its data. Such topology adjustment can introduce significant overhead, especially for highly utilized networks. Hence, in this paper we propose the protocol P-LEACH, which overcome the shortcomings of LEACH and PEGASIS both. In P-LEACH, we use the cluster formation technique of LEACH in the chain based architecture of PEGASIS. As a result, the system will have higher lifetime, low energy consumption, and unlike PEGASIS, can also deal with a dynamic system.

Design and Functional components of P-LEACH

The cluster head set is responsible for data forwarding in LEACH, while in PEGASIS, hierarchical chain formation is implemented through an energy efficient algorithm for the same. We propose the new protocol P-LEACH that combines the chain formation technique within the clusters for data forwarding. All the nodes (N) send their location L(x,y) and energy (E) information to Base Station (BS) in step-1. BS receives location (L) and energy (E) from nodes N1, N2, N3, N4, N5, N6 and so on, of each cluster. For Cluster Head Selection in step2, BS selects a node Ni with the maximum
remaining energy as the Cluster Head CH for each Cluster. In Step 3, once the BS selects the Cluster Head, it informs every node in the network about the selection of the CH. Nodes send an acknowledgement message back to the BS informing the BS that it has successfully received the information.
In step 4, a CH with maximum energy and minimum distance from the base station is selected as the Leader, so as to contact the BS directly. Hence, the minimum path from source to destination is drawn. In step 5, the data is transferred through the path drawn. First, the data of each node is sent to the CH of the cluster. Now the CH gathers the data from all the nodes and forwards it to the next CH in the chain. In step 6, IF loop is implied if the energy of the cluster head goes below the expected energy level. If CH fails to maintain the same maximum energy, then the node with the second highest maximum energy is selected and declared as the CH as per step 2. This ensures successful working of the Cluster Head in the Cluster-Chain-based architecture of the P-LEACH routing protocol.

Conclusion

In this paper, we proposed the P-LEACH Routing Protocol for improving energy efficiency in wireless sensor networks. The performance of P-LEACH is compared with the LEACH and PEGASIS protocols. With simulation we observed that P-LEACH performs much better than LEACH, and PEGASIS in terms of network lifetime, number of dead nodes and energy consumption. MATLAB is used for evaluating the performance of the protocol. Based on the simulation results, we determined that P-LEACH performs better than LEACH and PEGAIS in terms of energy and lifetime of the network. The simulation results validate that our proposed approach could extend the network for WSNs applications.

3. Optimizing LEACH Algorithm with Mobile Sink and Rendezvous Nodes

Abstract

Wireless sensor networks are usually composed of large volumes of sensors. This method is more efficient than LEACH in terms of energy consumption, particularly in large regions. In WSN's sensors do not have rechargeable batteries, increasing their lifetime is important and various methods have been proposed to increase the lifetime of the sensor nodes in a network. Some researchers recommend a mobile sink (MS) as a way to reduce energy consumption and a rendezvous node (RN) to act as a store point for the MS. The present study proposes an algorithm that combines the use of the LEACH clustering algorithm, MS and rendezvous points (RP).

Introduction

Each sensor node has a disposable battery supply. This means that saving energy and minimizing computational complexity and storage space are very important. Placement of the sensor nodes are often random and without planning. In this situation, they must be selfconfigurable to adjust themselves so that they can communicate with the entire network. A sensor node consists of four basic components: a sensing unit, a processing unit, a communication unit and a power unit. The communication unit contains a short-range radio used to transmit and receive data over radio channels.

Related works

A wireless sensor network (WSN) typically contains a large number of sensor nodes and a sink or base station located in a sampling environment. Long distance transmission is not optimal in terms of energy consumption; thus, decreasing the distance can increase energy efficiency and prolong the network lifetime. A promised method is using a multi-hop scenario. In this method, each node routes its data through other nodes and those nodes send the data to the sink. It decreases the transmission distance and total energy consumption when other nodes act as routers.

A mobile sink (MS) is an alternate way to reduce energy consumption. The MS moves inside/around the environment to collect node data. Sink movement may be controlled or uncontrolled. In controlled methods, the MS trajectory is predefined; in uncontrolled MS, the sink moves randomly in a predetermined environment. Moving the sink close to normal nodes decreases the transmission distance.MS cannot be closed to collecting data from all nodes. Therefore, one idea has been developed, which is called Rendezvous Points (RPs). The RP is a point near the trajectory of a MS and a node (rendezvous node; RN) located nearby. This node transmits data to the MS as it passes nearby. The MS sends signals called beacons that notify the RNs of the MS arrival.

In the present study, the nodes form a cluster using an optimized LEACH algorithm and normal node (NN) data is transferred to the CH, which aggregates the data. If the CH has suitable distance from a MS, the CH will directly transmit the data to the MS. If the distance is greater than a predefined threshold value (do), the data will be transferred to the nearest living RN which will transfer it to a MS in a suitable time.

System model/routing protocol

The proposed algorithm was split into several rounds that are similar to LEACH. Each node generates data with the same rate and sends them once in each round. In the proposed algorithm, each round starts with a setup-phase and continues with a steady-state phase. The set-up phase consists of 3 stages. -Task Ordination -Cluster Selecting -Scheduling

The steady phase. After the CHs have been created and the schedule established, data transmission can start. Assume nodes have data in all rounds and that the rate of data generation is the same for all nodes. The data will transmit to a CH during each node's allocated time slot. To minimize energy consumption, each NN radio will be ON only during its transmission time slot; however, all CHs and RNs must keep their receivers ON during the DT stage. When all data has been collected, CH begins to aggregate the data received and transmit it to the MS or the nearest living RN.

Node Energy Awareness (NEA) and Self-Organization

During the cluster set-up phase, each node informs the amount of energy remaining to the MS through the CH or RN. In each round, the MS averages all energy values and broadcasts that average back to the nodes using a beacon. The nodes that receive the message compare their remaining energy with this averaged value. If their energy is greater than or equal to the averaged value, they will be tagged for CH selection. This procedure is self-organizing because the MS does not decide for the nodes; it only informs them of the average energy value of the network. Each node decides for itself whether or not to be a CH.

Conclusion

It was found that if the widths and lengths of a network are more than twice that of do (boundaries of far-field and near-field), the proposed algorithm performs better. First node death and the death of 25% of the nodes occur later; this improves as the size of the region increases.

4. A proposed energy efficient distance based cluster head (DBCH) Algorithm

Abstract

The main challenge of Wireless Sensor Networks is communication with low energy consumption. In order to overcome the problem of energy consumption, clustering algorithm LEACH (Low Energy Adaptive Clustering Hierarchy) was designed. In this paper, a new clustering algorithm proposed based on LEACH. This includes node energy, distance between node and base station, distance between cluster head and base station. Simulation result shows proposed algorithm is better than LEACH in order to balance node energy.

Keywords: Wireless Sensor Network; Node energy; distance between node and base station, distance between cluster head and base station; LEACH.

Introduction

A Wireless Sensor Networks (WSNs) consists of large number of sensor nodes, which are capable of detecting various event related to surrounding like speed, temperature, pressure, light etc. WSNs implemented in layers (application layer, network layer etc.). Numbers of protocol has been designed for wireless voice and data communication network such as TDMA (Time Division Multiple Access), CDMA (Code Division Multiple Access).LEACH is a hierarchal routing protocol that uses mechanism of cluster head rotation. LEACH algorithm is

used to increase the life time of sensor network but not ideal for sensor network. Thus an advance clustering algorithm is proposed on the basics of distance between cluster head and base station and node energy to improve LEACH algorithm.

Proposed DBCH algorithm

In the LEACH algorithm, the node elected as cluster heads are not an ideal choice for transmitting the data to base station. In order to solve this problem, new algorithm named Distance Based Cluster Head (DBCH) is proposed. According to this algorithm, cluster head is chosen based on distance of node and base station. The node which is nearer to the base station will be elected as cluster head. This improvement takes residual energy and distance into account, further it considers the distance from node to cluster head and base station and compares the distance from node cluster head and base station.

Conclusion

Clustering algorithm is an approach to enhance the network lifetime. Based on shortcomings of original LEACH, this paper proposed a modification to original LEACH algorithm using distance measure with the current node. It does so by introducing a new Threshold from node energy and distance factor of individual node. Simulation result shows that the new algorithm has better performance compared to original LEACH.

5 Energy Optimization of PR-LEACH Routing Scheme

Abstract

In this paper, we present presents an efficient cluster based routing protocol for IoT. The protocol aims at increasing lifetime and stability of networks. The paper introduces a new routing scheme Modified-Percentage LEACH Protocol based on existing protocol namely Percentage LEACH. Extra amount of energy wastage is alleviated by reducing communication between Cluster Heads (CHs) and sink. Thus, it increases the lifetime of sensor nodes in IoT communication networks. It is achieved by introducing threshold calculation on each CH, which is used as basic criteria for CH election and selection. The protocol also takes into account distance parameter of nodes from sink. This protocol helps plummeting energy wastage which results in more lifetime and high throughput.

Percentage leach protocol

PR-LEACH protocol is variation of LEACH protocol that limits number of CHs in network. It introduces threshold for selection of CHs. If a node value is greater than defined threshold it can become CH otherwise it cannot. The protocol operates in rounds such that each round has two steps.These steps akin to its coreLEACHprotocol. The steps are Set-up phase and Steady-state phase. First round of PR-LEACH protocol is similar to LEACH protocol because nodes deployed are similar in terms of energy. In second round, nodes energy changes because of their usage in communication. Nodes send their energies to CHs. CHs forward it to sink via other CHs as intercluster communication and intra-cluster communication. Both these communications are multi-hop in the said protocol. Sink receives energies from all CHs of network and calculate range from these energies. Sink broadcast this range to all CHs which forward it to their cluster members. Each member of cluster now uses this range to calculate threshold for itself. If energy of node is greater than calculated threshold the node is eligible for CH otherwise the node does not participate in election of CHs.

The threshold is calculated using the following formula:-

Threvalue _ min.energy(node) + (PR ∗ NER) (2)

where *PR* _Fractional value from 0 to 1, *NER* _Network energy range.

The protocol repeats this procedure in all rounds of network except first round. The results show extension in stability period of network and increase in number of alive nodes.

Conclusion

The proposed protocol has shown a significant improvement over its parent protocols. The major difference among our proposed protocol and its parent protocol is that our protocol transforms global threshold calculation mechanism to local threshold calculation. This extension improves the selected protocol and makes it more energy efficient. The modified protocol plays a significant role in IoT networks by reducing the amount of energy required for communication between the sensor nodes and outside world such as hubs connected to Cloud. The protocol considers nodes to be immovable in the network. The protocol takes into account only two main schemes of nodes deployment i.e. free space and multi-path schemes. In future we will work on improvement of clustering mechanism and different deployment strategies to make it more efficient.

III. DETAILED DESIGN

1. Improved-LEACH

1.1 Energy Dissipation Radio Model:

In this study, we used the energy model proposed by Mittal, *et al.* [11] in which the transmitter runs the radio electronics to amplify and transmit the signal by dissipating the energy. From the other side, the receiver dissipates energy for the purpose of reception. For relatively short distances a free-space model is used, while for long distances a multi-path fading model is used.

When a *K*-bit message is transmitted over distance *d*, the amount of energy consumed by the radio can be calculated using below equations, depending on the distance:

ETx (K, d) =K * Eelec + K * Efs * d^2; d<=d0;

ETx (K, d) =K * Eelec + K * Emp * d^4; d>d0;

The energy consumption to receive a *K*-bit message can be calculated as given below:

$$ERx\ (K, d) = K * Eelec$$

;

The value of d0 can be calculated as:

$$d0 = sqrt\ (Efs / Emp);$$

Where:

1. Eelec represents the dissipated energy per bit to run the receiver or Transmitter circuit.
2. Efs and Emp are amplification factors that depend on the transmitter Amplifier model used.
3. d represents the distance between sender and receiver.
4. ETx denotes the energy spent per bit during transmission.
5. ERx denotes the energy spent per bit during reception.
6. *K* is the number of message bits.

1.2 Proposed Improved LEACH

In this section, the enhanced algorithm named Improved LEACH (ILEACH) is presented, which was developed to achieve fair distribution of energy consumption in wireless sensor networks. Like traditional LEACH, the proposed algorithm has two phases of operation: the set-up phase and the steady state phase. In the set-up phase, cluster-head selection and cluster formation are done. Every node randomly generates a number between (0 and 1) and compares the generated number with the calculated threshold value. The nodes with a number larger than the threshold are chosen as cluster heads. Otherwise, a node will be made a cluster member. The energy dissipation radio model for wireless sensor networks shows that a node's residual energy and its distance to the base station is an important factor in the network's lifetime. In order to provide energy-efficient selection of cluster heads, we modified the way of threshold calculation by formulating a cost function. This cost function combines both the node's distance to the base station and its residual energy. In addition, the transmission model shows that when the node's distance to the base station increases, the power consumption increases as well. Therefore, we propose to express the node's residual energy and its distance to the base station in percentages to distinguish between nodes with high residual energy and a longer distance to the base station, and nodes with high residual energy and a shorter distance to the base station. In our experiment, we chose the X and Y values that gave the best network lifetime considering all probabilities:

1. X= Y means that residual energy and node distance to the base station have equal weight in cluster-head selection.
2. X larger than Y means that residual energy is the dominant factor in cluster-head selection.
3. X smaller than Y means that node distance to the base station is the dominant factor in cluster-head selection.

Since the base station in the scope of our research was located far from the deployment area, we found that when we set beta larger than alpha, the node distance to the base station was the dominant factor in cluster-head selection.

As a result, the selection of cluster heads improved after each consecutive round:

$$Cost = X * Energy + Y / Distance;$$

Where:

1. Cost is distance to the base station and residual energy cost for each node;
2. Energy is remaining energy;
3. Distance the node distance to the base station;
4. X and Y are percentages assigned to residual energy and node distance to the base station respectively. These percentages were measured during the simulation. We assigned more weight to the node distance to the base station because it has a greater impact on power consumption

Finally, the threshold value is calculated as given below:

$$Th(r) = p / (1 - p * mod(r, round(1/p)))) * cost;$$

Where:

Th(r) is the threshold value of the current round;

p is the percentage of nodes that will become cluster heads;

r is the round number.

After cluster-head selection has been done, the non-cluster head nodes join the cluster heads to form clusters. We modified the way of cluster formation so that the non-cluster head nodes will join the nearest cluster head closer to the base station than the other non-cluster head nodes as shown below:

$$CH \text{ to } BS < NCH \text{ to } BS$$

Where:

1. NCH to BS is the distance between a non-cluster head node and the base Station;

2. *CH to BS* is the distance between a cluster head and the base station

We can see that considering the distance between the nodes and the base station is very important because the data transmission consumes the largest part of the energy and the power consumption increases when the distance between the sender and the receiver is increased.

The second phase is the steady state phase, where the nodes sense the environment and send data to their cluster head, which in turn aggregates the data and sends them to the base station. All these operations are repeated each round.

2. PHASES

ILeach protocol consists of two phases:

1) Set-up phase

2) Steady phase

Operation of ileach protocol consists of several rounds with **two** phases in **each** round. iLeach protocol is a typically representation of hierarchical routing protocol. It is self-adaptive and self-organized . Leach protocol uses round as unit, each round is made up of cluster set-up stage and steady state storage for the purpose of reducing unnecessary energy costs. Phases of leach protocol are as follows:

2.1. Set-up phase

In the set-up phase, the main goal is to make cluster and select the cluster head for each of the cluster by choosing the sensor node with maximum energy. Set-up phase has three fundamental steps:

1. Cluster head advertisement
2. Cluster set up
3. Creation of transmission schedule

During the first step cluster head sends the advertisement packet to inform the cluster nodes that they have become a cluster head on the basis of the following formula:

$$T(n) = \begin{cases} p/(1-p*(r \bmod(1/p)))*\text{cost}\,, & \text{if } n \in G \\ 0\,, & \text{otherwise} \end{cases}$$

T(n) is the threshold, where **P** is the desired percentage of cluster heads which is a predefined value, r is the current round number and **G** is the set of nodes that have not been selected as the cluster heads in the last **1/p** rounds

Node becomes cluster head for the current round if the number is less than threshold T(n). Once node is elected as a cluster head then it cannot become cluster head again until all the nodes of the cluster have become cluster head once. This is useful for balancing the energy consumption.

In the **second step**, non-cluster head nodes receive the cluster head advertisement and then send join request to the clusterhead informing that they are members of the cluster under that cluster head. All non-cluster head nodes save a lot of energy by turning off their transmitter all the time and turn it on only when they have something to transmit to the cluster head.

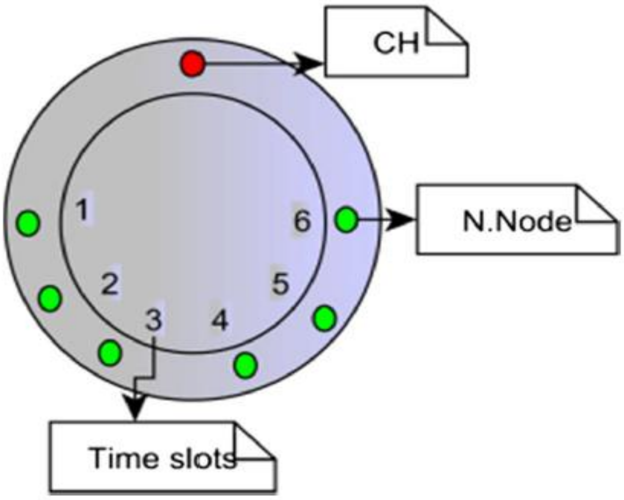
In **third step**, each of the chosen cluster head creates a transmission schedule for the member nodes of their cluster. TDMA schedule is created according to the number of nodes in the cluster. Each node then transmits its data in the allocated time schedule.

1.2. Steady phase

This phase describes intracluster communication among nodes and their CHs.The member sensors in each cluster can communicate only with the cluster head via a single hop trans-
mission.

CH defines time slots for each of its member and forwards it to the nodes. Nodes now use its specific time slot to transfer data to CH. This reduces chances of collision of data and its corruption.

The figure below shows the same -



Cluster head aggregates all the collected data and forwards data to the base station either directly or via theother cluster head along with the static route defined in the source code. After predefined time, the network again goes back to the set-up phase.

Where the nodes sense the environment and send data to their cluster head, which in turn aggregates the data and sends them to the base station . All these operations are repeated
each round.

3 ALGORITHM

The pseudocode of the proposed iLEACH (Low Energy Adaptive Clustering Hierarchy) algorithm is shown below:

E0 = initial node energy
Eelec represents the dissipated energy per bit to run the receiver or transmitter circuit.
ϵfs and ϵmp are amplification factors that depend on the transmitter amplifier model used.

BEGIN

1: Specify the initial probability (p), number of nodes (n), sensor (s);

2: set node Initial energy(s) E0, for s = 1,2, …, n;

3: specify Eelec, ϵfs, ϵmp

4: compute distance of each node from BS

1: for r = 1 to rmax

(I) SET-UP PHASE

2: **if** mod(r, round(1/p) = 0) then

3: reset all nodes to non-CH

4: **end if**;

5: **for s =** 1 to n

6: compute Th(s) = (p/ (1-p*mod(r, round (1/p))))*cost (t))

7: **if** (temp < Th(s)) & (E(s) > 0) **then**

8: CH{r} = TRUE; //node s be a candidate cluster head

9: **else**

10: CHs = false;

11: **end if**

12: **if** (CH{s} = TRUE) **then**

13: Broadcast an advertisement message;

14: Join cluster head that has (CH to the base station < (NCH to BS));

15: Cluster(c); //form a cluster c;

16: **end if**

17: **if** (E(s) <= 0) **then**

18: set s to dead

19: compute dead nodes

20: **end if**

16: **end**

Algorithm 1 Pseudocode of the proposed ILEACH algorithm

IV. SIMULATION AND GRAPHS:

Simulations are conducted using MATLAB 8.2.0.701 (R2013b) and to get precise plots , confidence interval is taken . Sensor nodes are deployed in random manner and made homogeneous and heterogeneous WSN using MATLAB. The wireless channel is used because the nodes deployed in the network are communicating wirelessly based on their distance, transmission range etc.

4.1 Network Scenario Assumptions and Parameters:

The simulation assumed that there are sensor nodes are randomly and densely scattered in a two-dimensional square field, and the sensor network has the following properties:

1. Sensor nodes are unaware about their locations, non-rechargeable i.e. energy constrained, and always have data to send.
2. There is only one sink in the field, which is deployed randomly.
3. node is considered to be dead when it is not capable of transmitting data to the sink
4. It is assumed that the probability of signal collision and interference in the wireless channel is ignorable and the radio transmitter, radio amplifier and data fusion unit are the main energy consumers of a sensor node.
5. The consumed energy in aggregating Lk bit signals into a single k bit signal.
6. Transmission power varies depending upon the distance between node and receiver.

parameter	values
Network Area(meter)	100x100
Number of Nodes	100
Location of Sink	50,175
Initial Energy	0.5 J
ETX	50nJ
ERX	50nJ
Emp	0.0013pJ/bit/m4
Efs	10pJ/bit/m2
Eda	5nJ/bit/signal
Number of Rounds	9000
Routing Protocol	LEACH

Table 4.1: Network Parameters

4.2 Experiment And Graphs

Firstly, Homogeneous WSN was created and simulations were obtained for ILeach Protocol. After considering the assumptions, the simulated environment execution consists nodes, 'o' represents the sink node in the simulated environment. Then to assess the performance of the protocol ls, a set of simulation runs were carried out

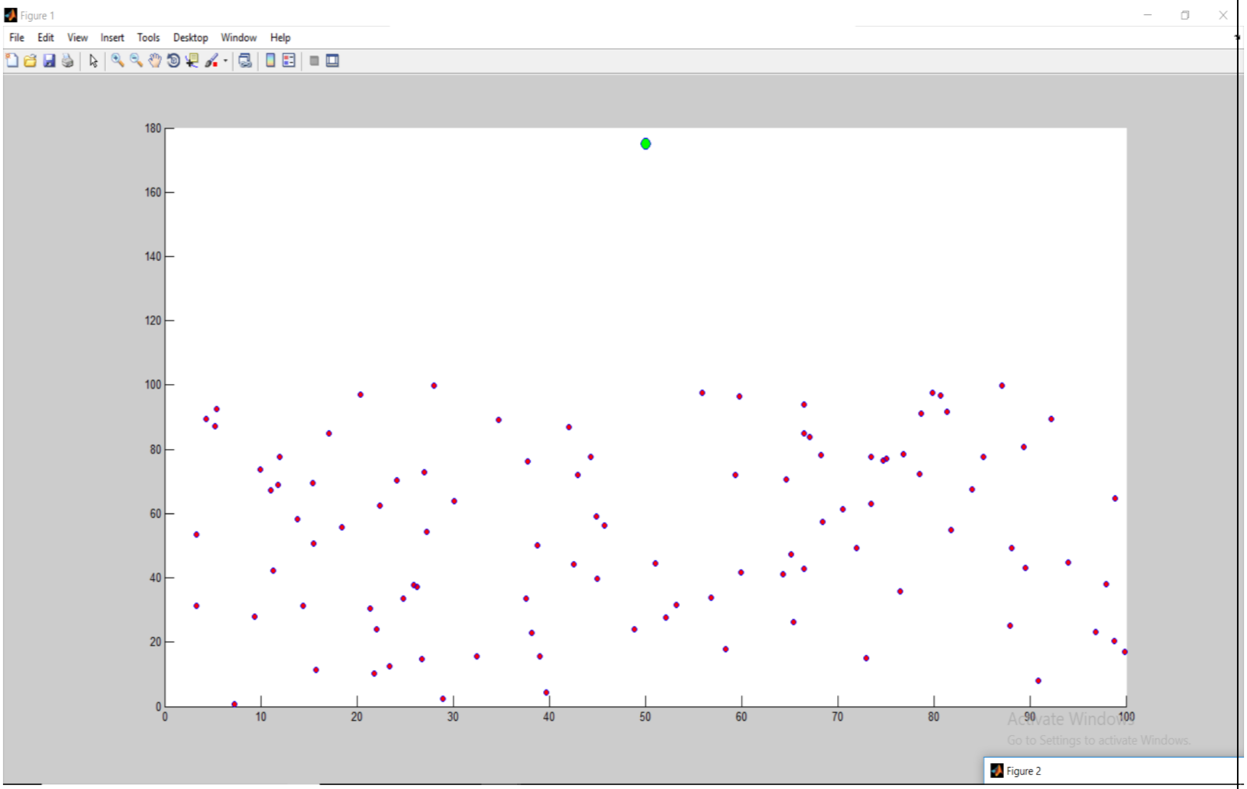


Figure 4.1: Homogeneous WSN

Simulation Results of iLEACH protocol:

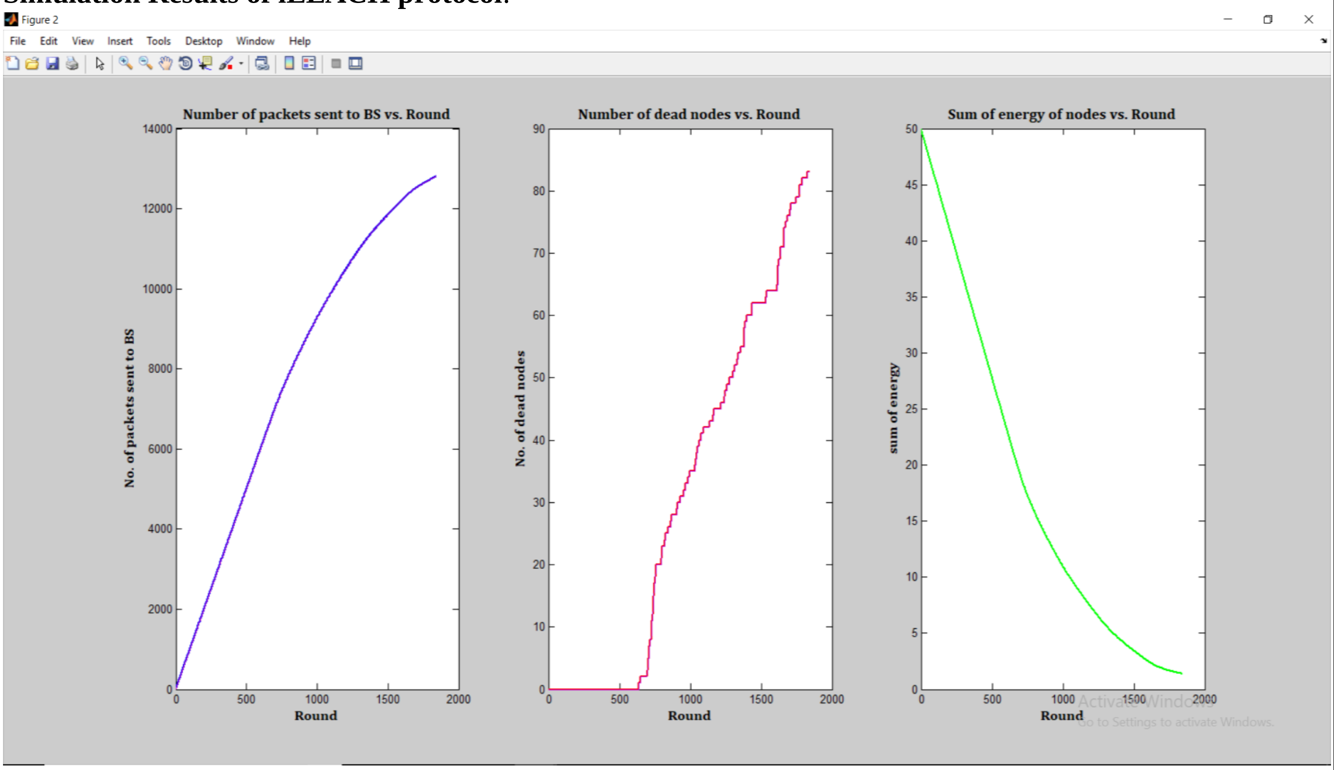


Figure 4.2:(a) Number of packet send to base station Vs round ,(b)Number of dead nodes Vs round,(c)sum of energy Vs round

Simulation results of LEACH protocol:

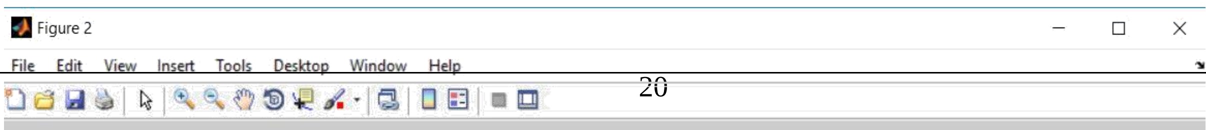


Figure 4.3:(a) Number of packet send to base station Vs round ,(b)Number of dead nodes Vs round,(c)sum of energy Vs round

4.2.1 Network Stability Period

The network stability period is defined as the time required for the first node to die. First dead node (FDN) denotes the number of the round in which the first sensor node dies. Our simulation results showed that the proposed protocol has higher stability compared to the LEACH protocol

4.2.1 Network Lifetime

The network lifetime is defined as the time interval from starting communication until the last dead node. Our simulation results showed that our protocol outperformed LEACH in terms of network lifetime

A comparison between our proposed protocol iLEACH and LEACH protocol in terms of network lifetime and stability period is presented below

Protocol	FDN	HDN	Dead nodes at 500 rounds	Dead nodes at 1000 rounds	Dead nodes at 1500 rounds	Percentage of Alive nodes after 1500 rounds
ILEACH	620 rounds	1200 rounds	0 nodes	35 nodes	62 nodes	38%
LEACH	180 rounds	500 rounds	50 nodes	82 nodes	93 nodes	7%

CONCLUSION:

Nowadays, wireless sensor network lifetime and stability are main research concerns because the sensor nodes depend on batteries as their energy source, which are difficult to change when deployed. In this study, the LEACH routing protocol was used, being a state of the art protocol, as the basis for the proposed protocol to extend sensor node lifetime by considering the nodes’ residual energy and their distance to the base station. The LEACH protocol considers only lifetime, ignoring the importance of the network stability period, which is an important factor for applications that require reliable feedback from the network. The proposed protocol (ILEACH) gives nodes that have more residual energy and are closer to the base station a higher chance to be selected as cluster head. Our simulation results showed that ILEACH is able to overcome the limitations of LEACH in terms of network stability period and network lifetime.

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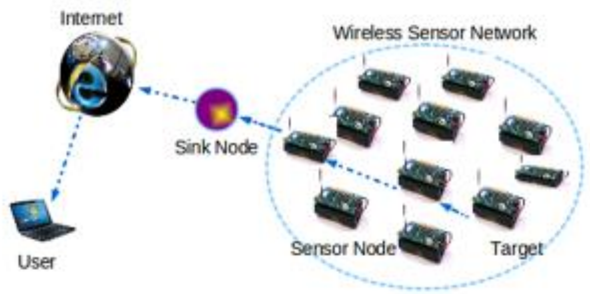
Energy efficient cluster based routing protocol for WSN:I-LEACH



Problem statement

The wireless sensor nodes are having limited amount of node energy. When the node senses the given area, it sends the data to head node. The head node collects data (performs aggregation) from node and sends it to the base station. This process utilizes large amount of energy. Thus, the question can be formulated as: How can we improve the lifetime and stability of network by reducing utilization of node energy in wireless sensor network using the proposed routing protocol?

Objective of the project:

To develop modified leach, our primary objectives of this project work are summarized as follows:

1. Develop a simulated environment of WSN having configurable parameters.

2. To study previous routing protocols and their features.

3. Investigation in Energy efficient routing algorithm with an application of optimizing WSN.

4. To create Improved Leach (I-LEACH) from Leach and proposed a further Stable Improved LEACH on MATLAB for optimizing its Various parameters.

5. To conduct a comparative performance evaluation for network lifetime, dead Nodes, alive Nodes, packets send to base station, packets send to cluster head and throughput .

Proposed work plan

1. Deploy WSN by initializing the parameters.

2. Selecting the cluster head in the sensor network in a optimized way.

3. Initializing the communication by sending the data packets in efficient manner.

4. Implementing ILEACH, a routing protocol used for finding optimal solution in WSN.

5. Proposing a further Improved Leach from existing P-leach and I-leach.

6. Evaluating the performance and observing the comparative analysis.

ILEACH (Improved Low-Energy Adaptive Clustering Hierarchy) protocol

1. Self-Organizing, adaptive clustering protocol.
2. Even distribution of energy load among the sensors.
3. *Dynamic* cluster formation.
4. Randomized rotation of cluster heads after each *round*.
5. *Cluster-heads* communicate data with the base station.
6. Application-specific data processing, such as data aggregation.

Phases

1) Set Up Phase:

Every node randomly generates a number between (0 and 1) and compares the generated number with the calculated threshold value. The nodes with a number larger than the threshold are chosen as cluster heads. Otherwise , a node will be made a cluster member. In order to provide energy-efficient selection of cluster heads , we modified the way of threshold calculation by formulating a cost function. This cost function combines both the node's distance to base station and its residual energy.

2) Steady Phase:

In this nodes sense the environment and send data to their cluster head, which in turn aggregates the data and sends them to the base station. All these operations are repeated each round.

Set Up Phase

Cost(n)=(x* Ei) +(y/di)

x and y are percentages assigned to residual energy and node distance to the base station respectively. These percentages were measured during the simulation. We assigned more weight to the node distance to the base station because it has a greater impact on power consumption.

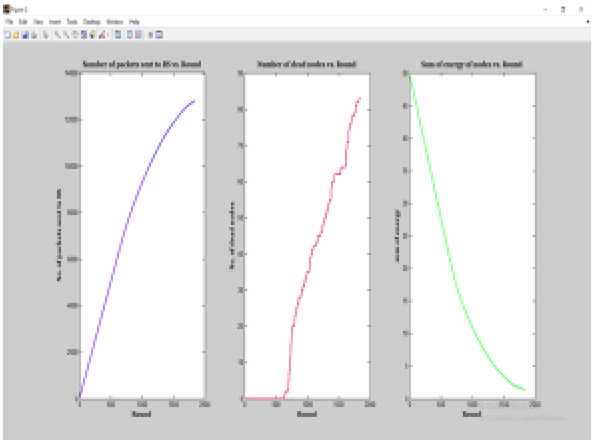
Finally, the threshold value is calculated as given below:

Th(r) =p/ (1-p*mod(r, round (1/p))))*cost(n);

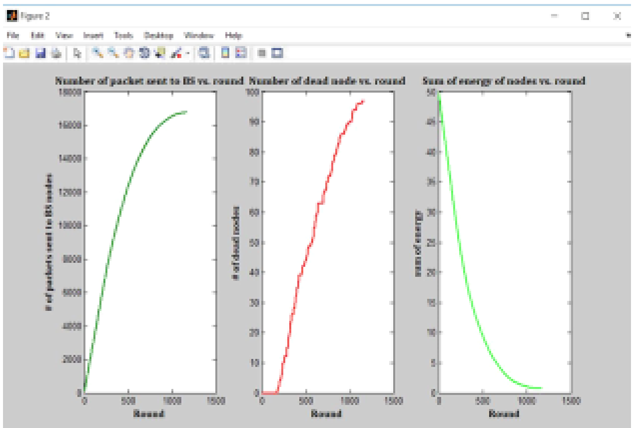
After cluster-head selection has been done, the non-cluster head nodes join the cluster heads to form clusters. We modified the way of cluster formation so that the non-cluster head nodes will join the nearest cluster head closer to the base station than the other non-cluster head nodes as shown below:

CH to BS < NCH to BS

Simulation results



I-LEACH



LEACH

CONCLUSION

Nowadays, wireless sensor network lifetime and stability are main research concerns because the sensor nodes depend on batteries as their energy source, which are difficult to change when deployed. In this study, the LEACH routing protocol was used, being a state of the art protocol, as the basis for the proposed protocol to extend sensor node lifetime by considering the nodes' residual energy and their distance to the base station. The LEACH protocol considers only lifetime, ignoring the importance of the network stability period, which is an important factor for applications that require reliable feedback from the network. The proposed protocol (ILEACH) gives nodes that have more residual energy and are closer to the base station a higher chance to be selected as cluster head. Our simulation results showed that ILEACH is able to overcome the limitations of LEACH in terms of network stability period and network lifetime.