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Research Article

A COMPREHENSIVE RESEARCH ON ICH-LEACH PROTOCOL AS AN ENERGY EFFICIENT ROUTING IN WSN

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ABSTRACT

Wireless Sensor Network (WSN) can be deployed in different applications like Medical analysis, Climate change observation, Military support applications, mechanical stress in bridges and building etc., more energy efficient WSN is required for seamless performance of such tasks. Here we'll discuss WSN, Routing Protocols and Routing models which would help us to understand the various methodologies available in WSN especially the Hierarchical Routing Protocols that are designed for energy efficient WSN. Also we will discuss about basic LEACH, various phases to implement basic LEACH, its drawbacks. Additionally, this paper will propose a new version of LEACH protocol named as ICH-LEACH with a change in implementation, which would show that its better than the basic LEACH or previously researched MODLEACH as the number of dead nodes will becomes less and the energy of each node participating in clustering increases significantly. The formula basically changes Cluster Head (CH) selection probability in Hierarchical Routing Protocols in the LEACH Protocol. Thus better than previously researched output. Later the formulae of basic and improved ICH-LEACH are compared and effectiveness is shown with the help of Result and conclusion.

INTRODUCTION

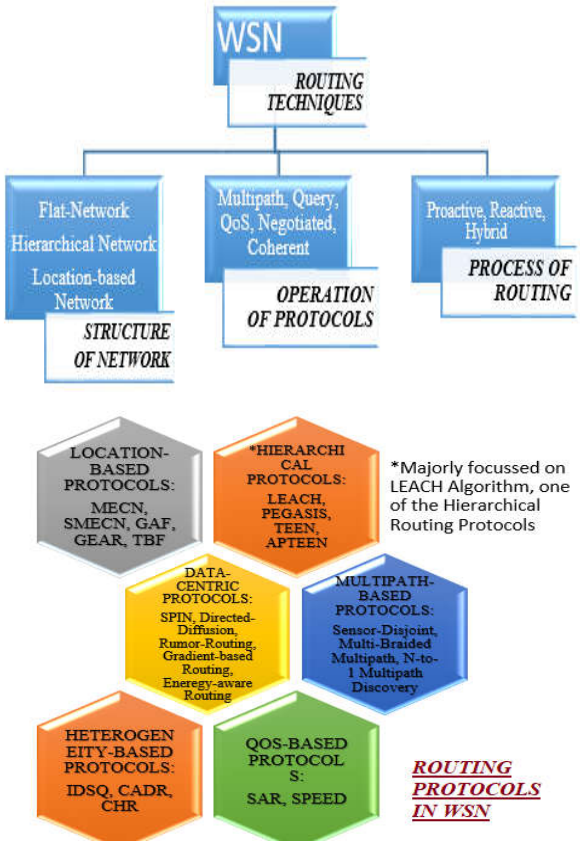
WSNs are generally known for economical and rapid deployment for applications that usually do not require much human supervision. The sensor nodes in WSNs are usually battery operated limited energy operated sensing devices. Therefore, efficiency of the energy is one of the most important considerations while modelling any protocols for routing in WSN as it decides the lifetime of any node. Practically, WSNs have been considered for applications that are suitable to work with constraints like limited power, short range communication and of course, economical along with an efficiency to provide reliable data transfer [1].

The concept of clustering helped to design several energy-efficient routing protocols using data aggregation technique which is used to combine source nodes' data into a meaningful information cluster [2].

Wireless Sensor Network (WSN)

Routing Protocols

The routing protocols are classified according to various routing techniques used in WSN. The routing techniques used in a WSN are classified according to network structures, protocols' operations and routing processes that decide the routing algorithms for routing protocols.



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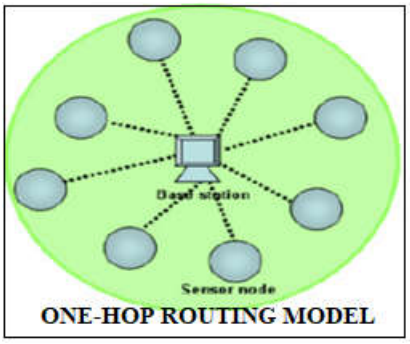
Routing Models

In WSN, a routing protocol generally coordinates activities of transmission of sensed data by the sensing nodes to the BS within. Thus, following three models have been categorized for the routing protocols in WSN:

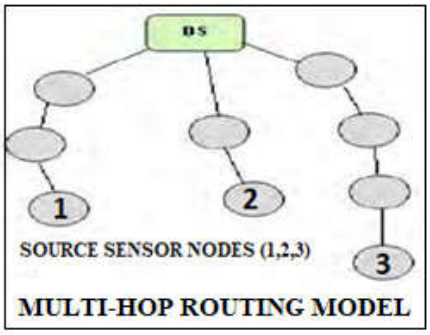
One-hop model

One-hop routing model is the best known model to represent a direct communication since, the information transmission only and only happens from all sensor nodes to BS within a network. However, due to restricted range of transmission of sensor nodes, the direct communication may not be sensible for routing in WSN, therefore, it's not preferable for practical purposes.



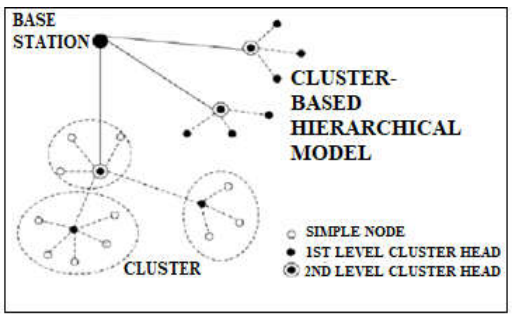
Multi-hop Model

In multi-hop routing model, a sensor node sends the data to one of its neighbouring nodes which is closer enough to the BS and after multiple hoping the data finally reaches to the BS from a particular source sensor.



Cluster-based hierarchical Model

Cluster-based hierarchical routing is modelled for energy efficiency purpose in which sensor nodes are packed into a cluster with a single assigned CH to transmit data towards BS, thus, it's practically, suitable for the hierarchical routings in WSN. In this model, a node could be a CH for one cluster and alsoa member for other(s) which is nearer to the BS.



ICH-LEACH is one of the energy efficient hierarchical routing protocols. So, it's important to know the basic structure and function of hierarchical protocols along with basic LEACH with which a comprehensive comparison based research on ICH-LEACH has been done.

Overview

A number of routing protocols have been introduced since thedevelopment of WSN including LEACH [3], TEEN, PEGASIS, SEP, DEEC [2] and so on.

Several research and implementation have been done towards the energy-efficient protocols for routing in WSN. LEACH is one of the well-known and popular energy-efficient hierarchical routing protocols that further amended into other protocols such as AS-LEACH [4], Enhanced LEACH [5], LEACH-CC [6], Ad-LEACH [7] and MODLEACH [8] and many others.

This paper comprehensively surveyed on one of the popular Hierarchical Network Routing Protocols of WSN so, it's contained with the information relevant to understand ICH-LEACH.

ICH-LEACH protocol has been taken as the reference and thus, paper research is focussed on its important parameter 'P' (Probability of select a CH) that been used in this protocol to further enhance the performance of the LEACH protocol. As the functionality of the protocol is to work on 'P' while the selection of the CH, hence the name is given as ICH-LEACH (Improved Cluster Head LEACH).

Problem Definition

Low Energy Adaptive Clustering Hierarchy (LEACH)

Heinzelman, et al. [3] Low Energy Adaptive Clustering Hierarchy (LEACH) is a cluster-based protocol. LEACH defined the two main functions of the cluster member nodes (non-CH) that are:

- The capability to sense the surrounding environment
- The role of transmitting the sensed datato a CH
- Whereas the basic functions of CH are:
- Data aggregationfrom the member nodes
- Transmission of the sensed data to the BS

This entire procedure rather reduces the amount of information that must be transmitted to the BS than draining out more energy of the CH ascompared to the member nodes. A few sensor nodes are randomly selected as CHs and to lessen the effect of intra/inter-cluster collisions, a TDMA/CDMA MAC (Time Division Multiple Access/Code Division Multiple Access Medium Access Control) is used by LEACH protocol. After a given span, a random role-rotation of member nodes and CH is done for uniform distribution of energy among the sensor nodes in WSN.

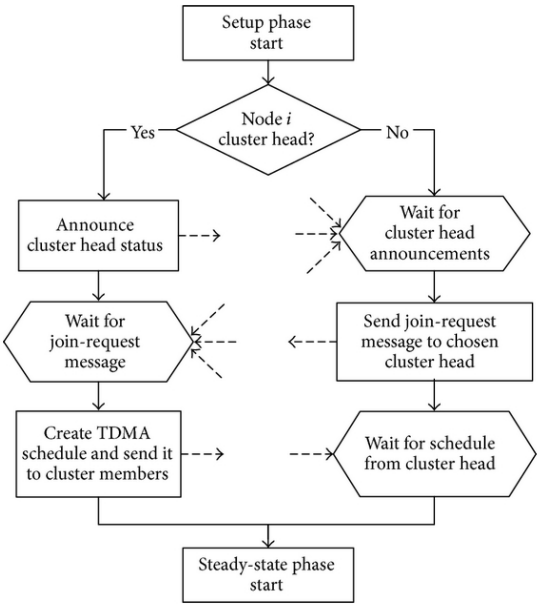
In LEACH, a parameter 'P' is formulated which shows the probability of selecting a CH among the cluster member nodes that is followed by several variants of LEACH that are designed to improve different characteristics and measurable factors of LEACH.

MODLEACH [8] is one of those protocols that introduced the parameters viz. soft threshold and hard threshold, along with the assignment of the fixed values to these respective

thresholds. It has the limitation that lacks of performance check without considering the following factors:

- The role of 'P'
- Network stability
- Data packets transmission to CH and BS and so on.

When a network ora power source fails, LEACH protocol comes into action as it's is an adaptive clustering self-organized protocol in which random cluster formation of sensor nodes and selection of CH by the cluster members (non-CH) starts. The CH functions to guide its respective cluster. Thus, LEACH protocol operation is categorized into two phases viz. Setup Phase and Steady-State Phase.



Stepwise operation followed in LEACH

Step1: During the setup phase, a predetermined fraction of nodes, P, elect themselves as CHs for which a sensor node randomly selects a number, R, ranges between 0 and 1.

Step2: For the current round, if R < T(n) then the sensor node becomes a CH, where, T(n) is the threshold value.

The equation that helps to determine T(n) includes:

- the desired percentage to become a CH,
- thecurrent round and
- the set of nodesthat have not been chosen as a CH in the last 1/P rounds i.e., G is the set of nodes that incorporates in the CH election

where,

$$T(n)Leach = \{\frac{P}{1 - P\left(Rmod\frac{1}{P}\right)} if n \in G$$

Step3: Advertisement message is broadcasted by each elected CH to the rest of the nodes within the network that for the current round they are the new CHs.

Step4: After receiving this advertisement, all the non-CH nodes depending on the signal strength of the advertisement, decide on the cluster to whichthey want to belong to.

Step5: The CHs are acknowledged by the non-CH about their membership in the respective cluster.

The non-CH member get added in the cluster only after receiving all the acknowledgement messages from them.

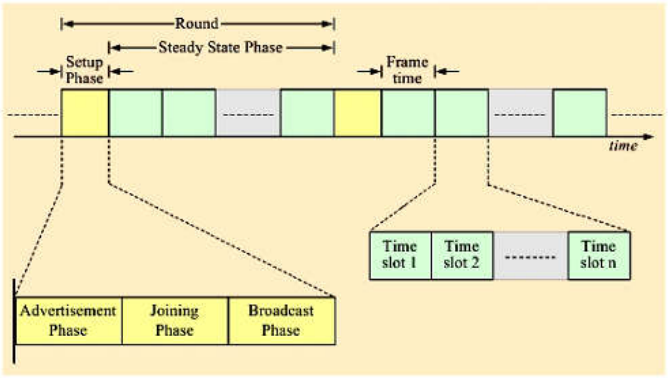
Step6: The CHforms a TDMA schedule as per the count of member nodes in its cluster.

Step7: A time slot is allocated to each of its non-CH node to know when it can send the data to their CHs. This TDMA schedule is broad casted to all the member nodes inthe cluster.

Step8: During the steady state phase, the non-CH nodes can start sensing and transmitting data to the CHs.

Step9: Before sending data to the BS, the CHs aggregate the received data.

Step10: After a certain time, which is determined a priori, the WSN returns to the Set-up Phase again and enters into another round of choosing the new CH. To reduce inter-cluster collision, each cluster communicates using different CDMA codes.



In this research, certain mathematical analysis has been done to check the Network lifetime using the parameter 'P' by selecting certain nominal values while considering the application domain of the WSN. Experiments were performed on MATLAB to observe the comparative accuracy of the mathematical analysis done as described in the sections below.

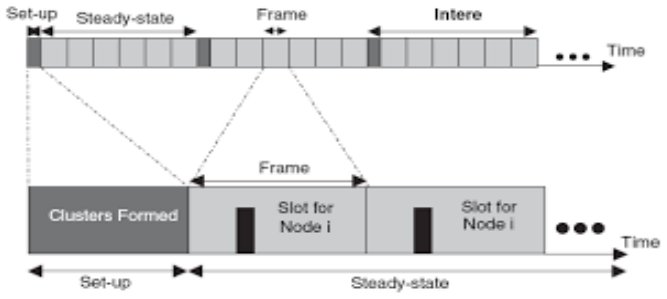
Proposed Work

To achieve this, we cut back range of full transmission by proposing that every cluster can transmit its information in its several cluster so all the cluster members can cipher the distinction between its own detected information and received information. After this we tend to use hierarchy technique, in which we tend to divide the cluster-heads into 3 levels. Firstly, we tend to realize the cluster-head nearest to the bottom station referred to as the primary level node. After that we discover subsequent 2 cluster-heads nearer to the bottom station referred to as the second level nodes. Now the farthest 2 cluster-heads transmit their information to the second level nodes that combination this information and then they transmit collective information to the level node. Finally, at this level cluster-head aggregates the whole data and transmits to the bottom station. Since energy consumption is less in computation as compared to transmission, proposed technique can save energy by reducing range of full transmission while not poignant the integrity of information assortment at base station. The various steps for the method are followed.

Step 1: In sq. field, deployment of all nodes.
Step 2: Outlining of Co-ordinates of BS for its location
Step 3: Outlining of Initial Energy of individual node.
Step 4: Computation of the Threshold Worth (say T).

Step 5: Assignment of random number between 0 and 1 to all node.
Step 6: Comparisonof each node's TWwith the Brink Value (BV).
Step 7: If a Node's worth<TW, declaration of that node as CH.
Step 8: Accounting of N where, 'N' is the number of CHs. If N < 5, then move to step 6 different wise move to next step.
Step 9: Computation of Nodes' distancesfrom their respective CHs.
Step 10: Declaration of Nodes as cluster members to their nearbyCHs.
Step 11: Any acknowledgement of information transfer from CHs to their respective cluster members only after cluster formation.
Step 12: Computation of the distinction between the own senseddata and received information by the cluster member.
Step 13: Transmission of distinct information by the cluster member nodes to all CHs. This shows a huge distinction between LEACH and projected technique as there's transmission of utterly detected information however during this solely difference information is being transmitted.
Step 14: Division of CHs into 3 levels. The first CH nearest to the bottom station is referred as initial level node. Then the next 2 CHs nearer to the bottom station would refer as second level node. Finally, the farthest CHs referred to as third level CHs.
Step15: The 3rd level CHs can transmit their information to the 2nd level CHs followed by received data aggregation.
Step 16: The 2nd level CHs will send the collective information to the initial level CHs, which again followed by received data aggregation
Step 17: The 1st level CHs can finally, transmit the collective data to the bottom station.
Step 18: A check for live nodes after the completion of first round.
Step19: If there is alive node, then it starts iteration from step4.
Step 20: Absence of alive node shows that lack of communication, generally, at the end of the network.

ICH-Leach Protocol



In LEACH protocol for a particular round, when T(n) is employed for the calculation of CH, there's a probability that each node find yourself mistreatment identical threshold i.e. every node is examination their haphazardly generated worth calculated for that spherical. However, in random selection of cluster heads, it is possible that elect cluster head energy is extremely owing to that the chosen cluster head dies quickly and there is rise within the energy consumption of the network. For increasing the lifetime of the network the residual energy of each node is enclosed for the choice of cluster head i.e. by making changes in the threshold equation. By including residual energy every node has totally different threshold as compared to random range. So nodes with higher energy has higher chances to get elect as cluster heads once its compared to nodes with less energy.

If, E_o=Initial Power of each node
And E_c = Current Energy
Then, Rem=E_c/E_o
Where,

$$T(n)new_{Leach1} = \{Rem * \frac{p}{1 - p\left(rmod\frac{1}{p}\right)} ifn \in G$$

From Equation (2), we get our network got struck after a few rounds of data transmission, but we still have available nodes with energy enough to transfer the information to sink. The reason behind this problem is threshold of cluster head selection is very less, because the residual energy of the available nodes is very less. To take care of this issue, we utilize W1 as the weight exponent to further adjust the threshold.

$$T(n)new_{Leach2} = \{ Rem * W1 * \frac{p}{1 - p\left(rmod\frac{1}{p}\right)} ifn \in G$$

W1 is the weight exponent of the network. Now, each and every node in the network has the distinctive residual energy. So the best threshold value can be accomplished by modifying W1. Both equation (2) and (3) represents nodes with more energy is selected as cluster head as compared to nodes with lower energy level.

Formula changes in cluster head of LEACH vs Proposed Approach (ICH-LEACH)

In LEACH, for Energy derivation the condition for Election of CH is represented by:

temp_rand <= (P/ (1-P*mod (r, round(1/P))))

Where,
P = Probability of nodes reaching to base station.
temp_rand = A temporary random variable as accumulator and nodeArch_node denotes node architecture of the cluster model

ICH-LEACH make use of residual energy and for Energy derivation the condition for Election of CH is represented by:

$$\text{temp\_rand} \leq (\text{p}/((1 - \text{p} * \text{mod}(\text{r}, \text{round}(1/\text{p}))))) * (\text{nodeArch.node(i).energy})$$

Or
nodeArch.node(i).G <= 0) && ...(temp_rand<=(p/(1-p*mod(r, round(1/p))))*(nodeArch.node(i).energy)) && ... (nodeArch.node(i).energy > 0)

Where,
nodeArch.node(i).G <= 0): shows that there is no pre-defined cluster head selected.

temp_rand<=(p/(1-p*mod(r, round(1/p))))*(nodeArch.node(i).energy)):shows the random temperory variable which has basic Leach formula for random selection of cluster head with residual energy of each node which gets added to the CHfor more energy.

(nodeArch.node(i).energy > 0): shows that the nodes participating in custer head selection should be greter than zero.

LEACH vs Proposed Approach (ICH-LEACH)

Security is one of the major limitations in LEACH represent though as an energy-efficient hierarchical routing protocols. The CHs are electoral willy-nilly each for each run of LEACH for every new routing a replacement cluster head is electoral willy-nilly reckoning on the receiving energy of the signal packet as a result although a 3rd party oppose node exhibits itself as node causation high energy packets, it can be chosen as cluster head and therefore confidential energy will suffer this third party head node and that we lose knowledge. The modified LEACH is planned to provide vast modification in security and increment in network life of WSN. In the proposed methodology the cluster heads of the cluster area unit chosen considering the energy remaining in every node, furthermore it includes the distance threshold i.e. position of each node are noted within the routing table as a result if a replacement oppose node tries to enter, it will not be amused as its position is new and not recorded in routing table. A Factor F is employed to seek out clusterhead a node has highest worth of F behaves as cluster head. The formulas used are shown below.

$$E_u = E_e - [2E_{tx} + [E_{gen} - d^{\delta}]]$$

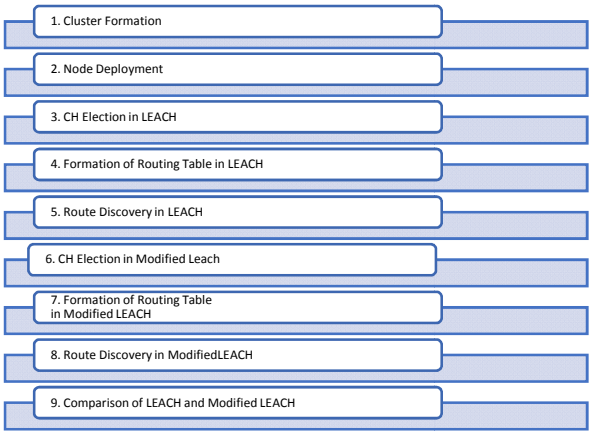
$$D = \sqrt{(x_2 - x_2)^2 + (y_2 - y_1)^2}$$

$$F = \frac{1}{D} + E_u$$

Where,

1. E_u =Updated Energy of each node after communication.
2. E_c = Current Energy of the node.
3. E_{tx} = Required Energy to transmit Control Packets.
4. E_{gen} = Required Energy required to generate Control Packets.
5. δ = Attenuation Factor with range $0.1<\delta<1$
6. D = Euclid's Distance formula for two locations of a node with co-ordinates (x_1, y_1) and (x_2, y_2).
7. F = A factor that includes distance and updated energy.

This kind of choosing cluster head is utilized in the proposed methodology and the execution of Modified LEACH is assessed toward the end both normal LEACH and modified LEACH are contrasted with deference with respect to few network parameters like detection time to detect adversary node and energy consumption. The execution flow of the proposed approach is shown in the below figure.



Observation and Analysis

The results obtained by simulating the protocol are discussed. All the test cases for normal LEACH and ICH-LEACH have been executed. MATLAB is the software used to simulate the project scenario.

Parameters	Values
Total dimension of Area	100m×100m
Number of clusters	4
Area of each node	25m ×25m
Total Number of Sensor Nodes	41 (incl.1 adversary node)
WSN Max. Energy	200mJ

CLUSTER	Node IDs
Cluster 1	1,2,3,4,5,6,7,8,9,10
Cluster2	11,12,13,14,15,16,17,18,19,20
Cluster 3	21,22,23,24,25,26,27,28,29,30+31(advisory node)
Cluster 4	32,33,34,35,36,37,38,39,40

Table 1 Simulation Parameters

CONCLUSIONS

A new framework for security is made during this project as security is major concern in WSN. From the approach and upon analyzing results it can be seen that the changed algorithmic rule for LEACH offers best performance. The performance of Normal LEACH and changed LEACH was compared in the terms of energy consumption, detection time and modified LEACH gave higher results as compared to these parameters, MATLAB was used to simulate the scenario. The advisory node was introduced in that ever cluster as per the need and also the reaction was studied for all the check cases. The proposed approach on LEACH with success detects the mortal node and avoids the investment of mortal node in the communication. As a result a major security threat is avoided, performance and network life time are increased.

Wireless Sensor Network (WSN) contains device nodes, which type a network by building connections wirelessly, to send detected information from supply to destination. Routing protocols are used from honest to goodness and littlest routes between a beginning node (source) and ending node (destination). Numerous WSN Applications use numerous hierarchic routing protocols.

Low energy adaptive grouping (LEACH) is the initial hierarchic routing protocols and it takes once the quality of forming cluster of nodes and type of cluster head arbitrarily among the nodes for bury cluster communication. This type of cluster head election ends up in attack by mortal node, hence a changed LEACH is assed utilizing distinctive performance measurements and modified LEACH was discovered to be very compelling in enhancing overall performance of WSN. MATLAB is made use of, to simulate the undertaking state of affairs.

Efficient bunch strategy is a very important downside during this field of WSN. Moreover, in human accessible or in-accessible area, where sensors are not place in brief time gap, people should use some energy economical bunch strategy and examined for higher result. Proposed theme is essentially a modification of associate existing theme, LEACH (Low-Energy Adaptive bunch hierarchy). Concept of temporary-cluster-head (TCH) is being transmitted from the EECPNL (Energy efficient bunch theme to prolong device network

lifetime) [14] to scale back the machine overhead of cluster head. Efficiency of the planned theme, is measured against LEACH [3] and EEPSC [4] via simulating a set of experiments in MATLAB 7.1 that validates the theme in order to realize higher network lifespan and an improved performance. As a future expansion of this work, this type of cluster head selecting strategy, I may use during a range of energy economical competition theme head selecting strategy. I may use during a range of energy economical competition theme with some numerous node distribution like passion distribution, Sparse distribution, Monty Carlo distribution etc. instead of random distribution so as to attenuate the energy dissipation thus increasing the lifespan of network.
By making the above changes we will get output twice better than the previous research. Below graph shows the same.

Figure below shows output as per the basic Leach showing 96% nodes get dead at around 1200 rounds.
Also Sum of energy is around 1J after 1200 rounds

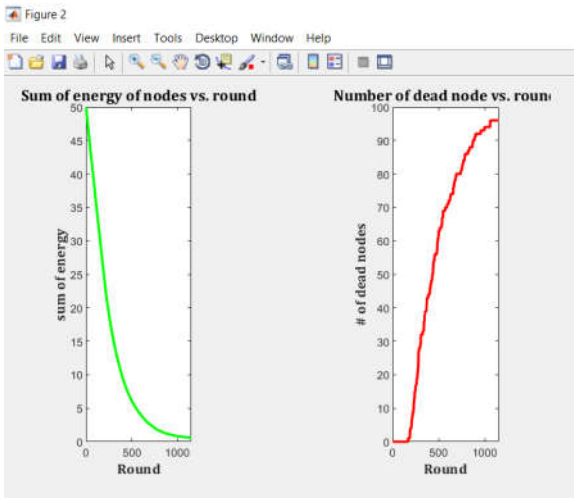


Fig 1 The simulation of the network lifetime showing number of node dies with number of rounds using basic Leach

Figure below shows output as per the basic Leach showing 24% nodes get dead at around 1200 rounds.

Also Sum of energy is around 5J after 1200 rounds.

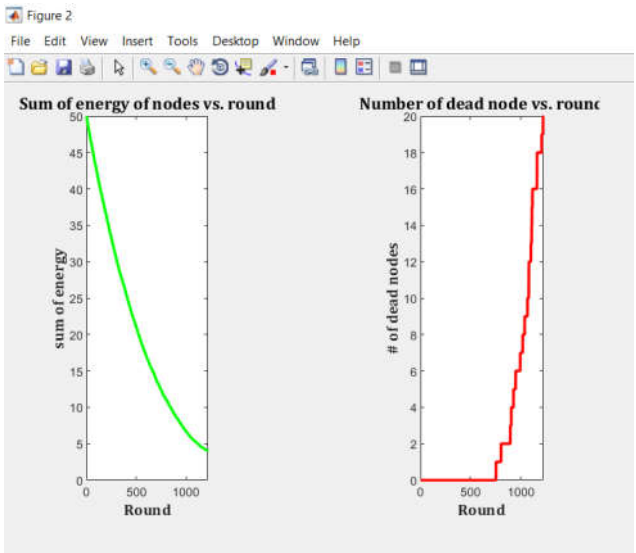


Fig 2 The simulation of the network lifetime showing number of node dies with number of rounds according to new improved Leach

Previous version of modLeach shows that 96 nodes (y=96) dies for 1200 rounds (x=1200) how ever in our modified iClusterHead Leach 20 nodes (y=20) dies for 1200 rounds (x=1200), which is a significant improvement over the previous version. Shown in red color.

Second observation is Sum of energy also gets improved as Previous version of modLeach shows that 1J (y=1) left after 1200 rounds (x=1200) how ever in our modified iClusterHead Leach 5J(y=5) left after 1200 rounds (x=1200), which is a significant improvement over the previous version.

As a scope of future work security features can be added in the Leach protocol and we can increase the number of nodes reaching to the base station by improving the algorithm. Also, we can increase the sum of energy by adding more energy parameters.

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