INCREASING LIFETIME OF NODE IN WIRELESS SENSOR NETWORKS USING LOW ENERGY ADAPTIVE HIERARCHY CLUSTERING PROTOCOL

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ABSTRACT

Wireless Sensor Networks (WSN) are a collection of several low-power and low - cost network sensors whichareusedtosensetheenvironment,collectthedata,processthecollecteddata,andtransferthehandleddatatoabas estation(BS).Thistypeofnetworksuffersfromlimitedenergyandashortlifetimeinadditiontothenonuniformdistrib utionoftheclusterheads.Toovercomethis problem LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is used which ensures that the elected cluster heads will be uniformly distributed over the network whichresultsinthedecreaseofEnergy.Simulatedresultsshowsthattheenhancedmethodcandecreasetheconsumptio n of energy and prolong the life-cycle ofthe network.

Keywords: Energy, Cluster, LEACH, Cluster Head, Sink node

INTRODUCTION

In recent era, a variety of modern devices and equipment relies on the sensory data from the real world around it. These sensory data comes is provided by Wireless Sensor Networks(WSN). Which is the combination of Sensor Nodes(NS), wireless communication process, embedded system, and few other supporting technologies .WSN consists of several tiny sensor nodes which are usually spread over a fixed region in order to collect various types of environmental data send the information to the base station(BS) for processing and analysis. However, many requirements are needed in these networks, such as low latency in data transmission, long-lifetime system, and fast processing of data, detect events, and transfer data. Due to the limited non rechargeable power of the small batteries, In sensor nodes this type of network suffers from less energy and also short life time. Leads to great impact of communication on the consumption of the power energy of nodes reducing the node lifetime. Therefore, the efficient use of energy to face these challenges and to prolong the network life time is the most critical issue in WSNs. In WSNs' cluster based mode, the network area is separated into clusters by separation of data into groups that share the same object which is known as clustering. The importance to divide sensors into clusters is to decrease the consumption of energy and scalability to make the network lifetime longer, minimize the delay in message delivery. This clusters formed chooses Cluster Head(CH) in the network. Only CH is allowed to take the information exchanged by a sensor node. This data is then aggregated by cluster head and then transferred to Base Station(BS). This aggregation of data of the sensor nodes happens in the CH due to its important fusion role that decreases the data sent to the Base Station and so saves energy and bandwidth resources thus increases the lifetime of the network. Power consumption of a wireless network basically depends on the distance between source and destination, the multi hop connection will reduce the network power consumption comparatively to single hop connection. However, applying the multi hop routing technique will surely lead to weighty over head for other sensor nodes leads in decrease of node energy. Hence single-hop routing will be more effective if all the sensor nodes are very close to the sink node. The routing protocol is a procedure of choosing the right route for transferring data from source to destination The objective of routing protocols is to intensify the scalability of the network, strengthen transfer data, and energy efficiency. LEACH(Low Energy Adaptive Clustering Hierarchy is a hierarchical routing protocol used in wireless sensor networks to expand lifetime of the network LEACH is capable of adapting, self organizing, and clustering protocol. LEACH is based according to the features of sensors and base station. In the LEACH protocol, sensors arrange themselves in groups called as clusters, and a single sensor node in the group is chosen as head called as cluster head. Only the CH will gather the data from all nodes and cumulates them and send it to the base station. For the stabilization of cluster head in LEACH it established over the round concept and each round includes two phases:

1) setup phase2) steady phase

Setup Phase:

This stage is intended to select CH sand form clusters in the network. Every sensor node votes to turn into a leader (or CH) of its cluster for a particular round .For this each and every node chooses number is between 0 and 1. The sensor node becomes a CH in this round if this number is lower than the threshold function defined in Eq 1 T(n) Where n is a random number between 0 and 1. P is the cluster head probability r is the current number of rounds, S is the set of nodes that were not cluster heads in previous 1/P rounds T(n) depends upon desired rate of cluster heads of network. Each node who wants to be the cluster head select value, in the range of 0 and 1. If this arbitrary number is less than T(n), the node turns into the cluster head For that particular round. The nodes that are cluster heads in current round cannot be cluster head till end of next 1/P th round. Every node that has chosen as cluster head for the current round communicates and send advertisement message to the rest of the nodes declaring that they are CH and allows them to join the cluster. This phase is also called as cluster head advertisement phase. When the non cluster-head node receives this advertisement message then based on the strongest signal strength which needs minimum energy for data transmission with that cluster head , non-cluster-head nodes make decision to form cluster with that particular cluster head. These cluster heads generates time-slot for all nodes. Only in that time slot nodes can transmit data to cluster head. Schedule Creation is based on the total number of nodes present in network. TDMA (Time Division Multiple Access) determines when node transmits the data to cluster head. Election of cluster heads are depend on threshold value (Tn).The formula is as follows:

$$T(n)=\frac{P}{1-P(r*(mod(1/p)}\quad \forall n\in S$$

Steady Phase: In this phase, the sensor nodes i.e. the non-cluster head nodes begins sensinginformation and send it to their cluster head as per their TDMA. The cluster head gatherinformationfromeveryoneofthenodesincluster,aggregatesthisdataandsenditobasestationor sink.

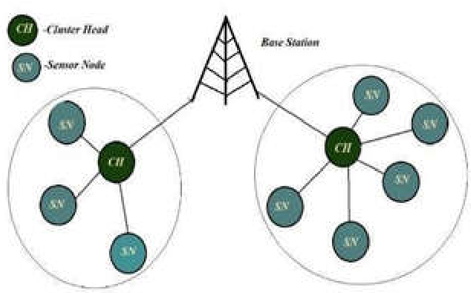

Figure1: Clustering

Figure 1 shows hierarchical clustering representation of nodes, in which all cluster heads communicate directly with base station. After completion of steady state, network goes in setup phase again.

RELATED WORK

[1] LEACH is a traditional energy-saving protocol that uses clustered routing to extend the life of the network and use less energy. Cluster Head selection, data transmission, and a combination of the two were the three approaches Daanoune and Ikram divided LEACH-based routing protocols into. They offered a comparative analysis of these clustered routing protocols based on variables including CH selection technique, communication method, scalability, energy efficiency, mobility, and node localisation. The LEACH variation protocol's advantages and disadvantages were also covered in the survey. The report concludes with suggestions for future WSN research, particularly in clustering-based routing protocols that provide advantages including data aggregation, load balancing, reduced energy usage, and scalability. Unfortunately, the original LEACH protocol has a number of short comings that reduce the network's lifetime, including problems with data transfer, CH selection, and energy efficiency. Several academics have proposed different routing protocols to enhance LEACH inorder to over come these issues. The survey covers 27 LEACH descendant routing protocols that have been proposed to address the problems with the original protocol in addition to discussing the advantages and disadvantages of the original LEACH strategy. Based on their CH selection processes and data transmission procedures, the discussed LEACH-based protocols were given a new taxonomy. This new taxonomy divided the protocols into three categories: (1) protocols that enhance LEACH by enhancing the CH selection phase; (2)protocols that increase LEACH by enhancing the data transmission techniques; and (3)protocols that evolve both CH selection and data communication techniques. To make this classification even clearer, each class was then broken down into sub categories like residual energy, energy efficiency, single-hop, multi-hop, etc. The described protocols were arranged according to criteria like how they affected the longevity and stability of the WSN. In this study, LEACH-based clustering methods totaling 27 were explored. Each described protocol's advantages and disadvantages were examined and contrasted with those of the original LEACH. The survey took into account a variety of parameters, including the clustering mechanism, self-organization, number of CHs, number of cluster nodes, energy efficiency, scalability, and communication strategy, among others, to evaluate and compare these LEACH descendent protocols. This survey’s main objective was to categorise the upgraded LEACH protocols, which would make it simpler for researchers to select effective protocols that met their requirements.

[2] Akash Chandanse's study emphasizes that energy efficiency is a primary concern in wireless sensor networks because batteries tend to die out quickly. Since data transmission consumes a significant amount of energy,it affects the network's life span. Routing protocols are necessary to reduce energy consumption, and various algorithms and techniques have been developed in recent years to address this issue in different layers such as the hardware layer, network layer, and application layer. One such protocol is the Low-Energy Adaptive Clustering Hierarchy(LEACH), which is a hierarchical-based routing protocol designed to be energy-efficient. The focus of this paper is on the implementation and analysis of the LEACH protocol.In MATLAB, simulation is used to research and analyse different metrics. A network of dispersed sensors or microsensors is known as a wireless sensor network (WSN). It has the capacity to detect environmental factors such as temperature, moisture, humidity, etc. Engineering, medicine, environmental monitoring, industrial automation, and military surveillance are just a few of the fields where WSN is used.
Three primary parts makeup a wireless sensor network: a sensing element(anode),a processing unit (a base station), and a power unit (Battery).In wireless sensor networks, data is sensed, processed, and transmitted to the base station during base station communications. The suggested network model in this research represents the LEACH algorithm' simplementation, together with clustering and routing. They have taken into account 100 nodes with equal beginning energy in the proposed simulation. The nodes are thought to being fixed. Because batteries have a finite lifespan, Chandanse and Akash evaluated the energy efficiency of wireless sensor networks because they realised that energy consumption isa significant problem. They suggested the Low Energy Adaptive Clustering Hierarchy(LEACH) protocol as away to make routing systems use less energy. The study concentrated on the use and evaluation of LEACH, taking into account

single-hop communication between sensing nodes and cluster heads as well as between cluster heads and the base station. They discovered using MATLAB that LEACH is more effective than conventional routing protocols with regard to lifetime, through put, and energy consumption. The vitality and effectiveness of WSN are enhanced by the uniform distribution of energy consumption among nodes, which is accomplished through the selection of cluster heads.

[3] The suggested technique attempt store solve this problem by choosing CHs while taking into account the remaining power of each network node. Inorder to prevent overloading some nodes and underutilizing others, the algorithm also balances the number of nodes in each cluster. In order to optimized at a transmission, the algorithm also finds abandoned nodes and transfers their Data to the sink via the CHs. The programme increases the effectiveness of the data transmission and decreases energy consumption by optimising the path taken by the CHs. According to the findings of the simulation, the suggested algorithm performs better than the original LEACH interms of energy usage and network lifetime. The improved protocol achieves more evenly distributed energy usage among the nodes, extending the life time of the network.The suggested method makes an effort to address this issue by selecting CHs while taking into account each network node's remaining power. The programme also balances the number of nodes in each cluster to avoid overloading some nodes and underutilizing others. The algorithm also locates abandoned nodes and sends their data to the sink via the CHs in order to optimise data transmission. By maximizing the path used by the CHs, the programme improves the efficiency of data transmission and reduces energy consumption. The results of the simulation show that the recommended algorithm out performs the original LEACH in terms of energy consumption and network lifetime. The enhanced protocol increases the nodes' lifetime by more equally distributing energy usage among them. This research suggests a new method for choosing CHs in the network based on the remaining energy of the sensor nodes and for creating clusters. With the help of this method, abandoned nodes that are unable to connect to any cluster can send data to the sink. In the paper, it is also discussed how to choose the best path to the BS by using a multi-hop strategy between CHs or, if the sink is the best option, a single-hop technique. Two phases are introduced by the proposed protocol: In order to save energy in the WSN, the initial phase concentrates on the CH selection and cluster creation. CHs are chosen depending on the remaining power of nodes, and clusters are formed using a specified number of nodes. By implementing the CH formation in each round, the proposed protocol presents a dynamic method for choosing a CH. Each sensor in the network chooses at random value between zero and one[0,1] during each round. The sensor node will be identified as a common node (CN) in that iteration if the value it selects exceeds the threshold function that has been predefined. The sensor node will be chosen as a CH for that round if the value is more than the threshold but less than or equal to it. With this dynamic method, energy consumption is allocated more evenly among the CHs and the CHs are chosen based on the network's current. In the suggested method, at hreshold function based on a node's remaining energy determines the likelihood that it will become a CH.

Tpr(s)=(PL/(1−PL∗(i%(1/PL))))∗Erem/Ei,s∈C 0otherwise

Here PL represents the CHs probability in the network, i is period number; C is a set of that have not become CH in the previously 1/PL iterations. Ei represents the beginning energy of nodes and Erem represents the remaining energy at the iteration.

[4] In his paper, Abu Salem focuses on avoiding the limitations of the LEACH protocol, a clustering routing technology. The primary goal is to reduce power usage in cluster head nodes as well as throughout network by selecting the cluster head with closest base station. This solution extends the network lifetime and uses less power. The study illustrates just how effective the LEACH protocol is at meeting these goals. The setup and stable stages of the suggested method's two stages are comparable to those of LEACH. The setup phase, where each regular nodes elects a random number between 0 and 1, is different.The node becomes a cluster head if the number is less than or equal to the threshold (T(n)),as determined by the equation shown below (CH). If not, the node continues to be an ordinary or common node(CN).

T(n)=(p/(1-p)[r*mod(1/p)]),nEG0otherwise

Where P is the desired percentage to be elected as a cluster head, r is current and G is a set of nodes that are

not been selected as a CH in the last1/P rounds.
Instead of choosing the cluster head that is closest to it, a node in this method chooses a cluster head based on the distance to the base 5 station. This is done to reduce the amount of energy used by cluster head nodes and the entire network, hence lengthening the lifespan of the network. The distance in this approach is alculated according to the equation given below: D(x,y)=squareroot[(x1-x2)^2+(y1-y2)^2]
In particular, it intends to reduce the distance to the base station and battery power consumption by examining the effect of suitable cluster head selection on power sensitivity. The study uses simulations to assess performance, and the findings show a reduction in power consumption and an expansion in network life time. Power usage continues to drop as the number of rounds rises. When it comes to power consumption reduction, the suggested technique performs better than LEACH. It is impossible to exaggerate the significance of lowering power consumption in wireless sensor networks (WSNs), as it is directly related to network lifetime. Further research on this subject might examine expanding the suggested approach to multi-hop routing.

[5] With regard to the Low Energy Adaptive Clustering Hierarchy (LEACH)protocol, Abidi developed a novel approach for choosing the Cluster Head (CH). Traditional LEACH selects the CH at random, however the proposed approach considered three crucial variables: the amount of energy left, the number of neighbours within the cluster range, and the distance between the node and CH. The threshold for CH selection was calculated using these variables. The suggested approach out performs the LEACH protocol interms of extending network life time and reducing Residual energy, according to simulation results. The primary drawback of the conventional LEACH technique is that CH is chosen at random for each sensor node. The CH selection threshold should be altered to increase the longevity and energy effectiveness of the network. Three important criteria must be taken into account in order to accomplish this: the distance between the node and the base station (BS), the remaining energy, and the quantity of nearby nodes within the cluster range. The overhead of data transmission can be decreased by taking into account the distance between the node and the BS. The selection of CHs can also be optimized by taking into account the node's remaining energy as well as the neighbours who are still alive in each round.As a result, high residual energy nodes with close proximity to the sink and many neighbours are chosen as CHs. By incorporating above criteria, we can use a cost function then the threshold can be written as follows:
T(n)=(p/(1-p)[r*mod(1/p)])*cost(n) , nEG0otherwise
The remaining nodes must choose the cluster to which they will belong in each round once the CHs have been chosen. The choice is made depending on the node's proximity to the CH; nodes select the closest CH and join its cluster. This strategy's main goals are to prolong the WSN's lifespan and lower energy consumption. The non-uniform distribution of CHs, however, is a key flaw in the LEACH procedure. In one area of the network, CHs may group together, causing energy loss. Inorder to maximize the life time of the WSN, this research's next work will therefore focus on ensuring the uniform distribution of CHs.

PROPOSED WORK

It is critical to address the LEACH protocol's primary flaw, the random selection of CH without taking any parameters into account. A new strategy that takes into account a threshold-based CH voting procedure is necessary to increase the network's longevity and energy efficiency. In order to do this, three crucial metrics must be taken into account: the separation between the node and the BS, the remaining energy, and the quantity of nearby nodes inside the cluster range. These metrics can be multiplied with a function P(i) to get the threshold. The CHs can be spread uniformly by taking into account the distance between the node and the BS, which can minimized at a transmission over head and lower energy consumption in the sensor nodes. The Setup Phase and the Steady Phase arethe two steps that make up the LEACH Protocol. Cluster Heads are chosen for each round of the Steady Phase using the Threshold functionT.(n).
The function P(i), which has parameters necessary for producing the desired results,is utilised to further optimise this procedure. This makes sure that candidates for CH positions are chosen based on

predetermined criteria rather than at random. The network can perform better in terms of energy efficiency and network longevity by including these capabilities. The function P(i) is given by the formula :

P(i)= Erem(i)/Einit + Nneign/Nalive + (DtoBS(i)- DtoBSmin)/(D to BSmax- D to BSmin)

Where Erem(i) is the remaining energy of node i, Einit is the initial energy, Nnb(i) is the number of neighbors of node i, Nalive is the number of alive nodes, D to BS(i) is the distance between the node i and the BS, DtoBSmin is the distance between the closest node to the BS and the BS and D to BS max is the maximum distance to the BS. Then the threshold can be written as follows: T(i) = P/(1–P)□(r*mod 1/P) □ P(i) if i □ G

0 otherwise

The procedure is then repeated once each CH has been chosen. Each CH transmits promotional messages to let the rest of the network know that it has been selected as a CH. Based on their proximity to the CH, the remaining nodes then choose the appropriate cluster for each round. Clusters are created when nodes decide to join the nearest CH and get linked to it. The non-CH nodes sense and gather data according to their TDMA schedule during the Steady Phase and transfer it to their respective CHs. The CHs then transfer the data they've collected from the cluster's nodes as a whole to the base station or sink. This process ensures that the network operates efficiently and that data is collected and transmitted to the base station in a timely and organized manner.

SIMULATION RESULTS AND ANALYSIS

The output of the suggested strategy was demonstrated using MATLAB simulations. For wireless sensor networks, there are numerous protocol options that can lengthen network lifetime. In the LEACH protocol, a node chooses a Cluster Head based on a threshold value that takes into account three factors: the distance between the node and the CH, the node's residual energy, and the quantity of neighbour nodes in the cluster range. The network can improve its performance in terms of energy efficiency and network lifetime by including these criteria into the CH election procedure. The proposed approach may be thoroughly examined through the use of MATLAB simulations, which can help with wireless sensor network optimization.

Parameters	**Values**
Simulation area	300mX 300m
Number Of Nodes	50
Number of rounds	500
Packet Size	512
Initial energy of node	0.5J
Probability to node to become a CH	0.1
Energy for transferring each bit (ETX)	50*0.000000001
Energy for receiving (ERX)	50*0.000000001
Electric field strength(EFS)	10e-12
Electromagnetic pulse (EMP)	0.0013e-12
Energy for data aggregation(EDA)	5*0.000000001

Table1: Specifications

The above table summarizes the parameters and the default values of LEACH protocol. To measure the performance of LEACH protocol, we took the following parameters inconsideration:

- Nodes
- Clustering
- CH's Count
- Packets to CH
- Packets to BS Per Round
- Live Nodes
- Dead Nodes
- Average Residual Energy
- Throughput

1) Nodes: Nodes are the physical network devices such as sensors which are used to send and receive information. Figure2 shows the distribution of nodes in a region

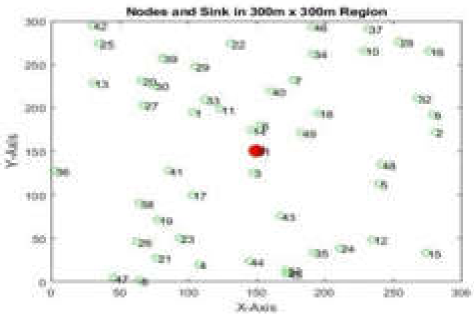

Figure2:Distribution of Nodes

2) Clustering : Clustering is the process of dividing the nodes into a group which has similar properties. A cluster consists of a Cluster Head which transmits the information to the Basestation.Figure3 shows the formation of clusters.

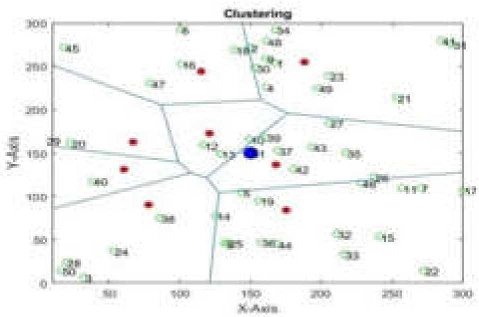

Figure3: Cluster Formation

3) Cluster Head's Count: In every round, the cluster formation and the number of CH's alsochange.Figure4 shows the count of CH' selected per round.

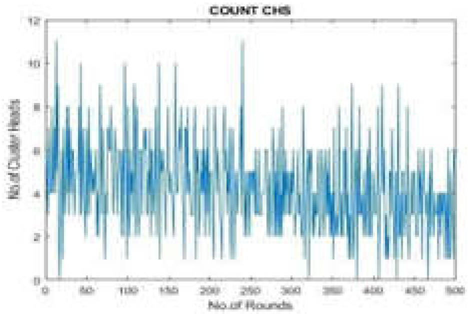

Figure4:CH'sCount

4) Packets to CH: The nodes in the cluster should send the information to their respective Cluster Head in the form of packets. Figure5 shows the number of packets sent to the CH.

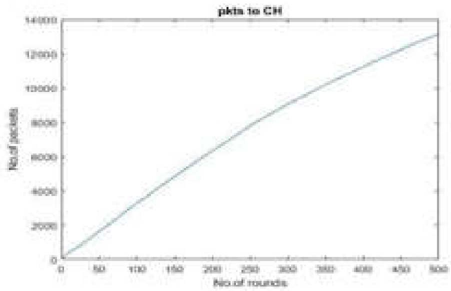

Figure5: PacketsTo CH

5) Packets to Base Station : The information collected by the Cluster Head from their members is sent to the base station in the form of packets. Figure 6 shows the number of packets sent to the Base Station.

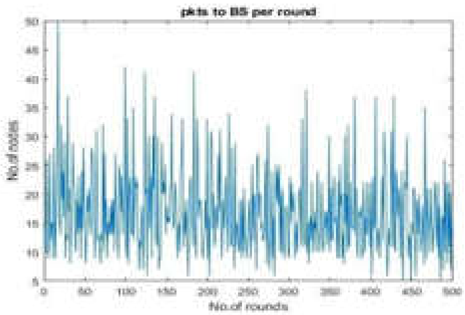

Figure6: PacketsTo BS

6) Live Nodes : These are the count of nodes that are alive after every round. Figure 7 shows the count of live nodes in every round.

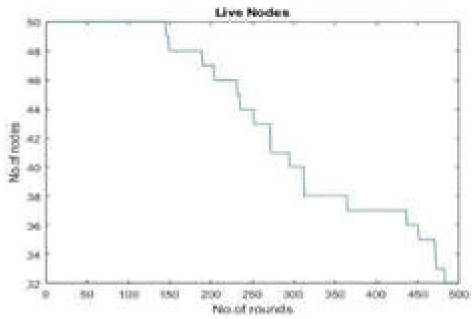

Figure7: Live Nodes

7) Dead Nodes: The nodes with residual energy zero are dead nodes. Figure8 represents the dead nodes in a network.

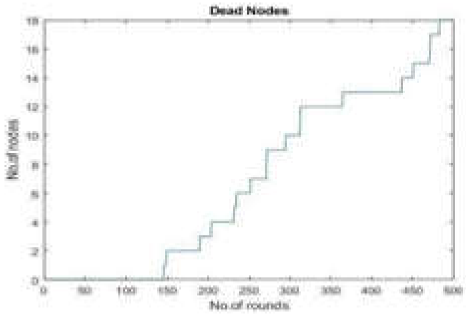

Fig8: Dead Nodes

8) Average Residual Energy

The performance of the above proposed method was shown below:

No.of Rounds	42	175	227	268	334	422	500
Average Residual Energy	23	16.5	14.2	12.5	10	7.5	5.6

Table2:Residual Energy

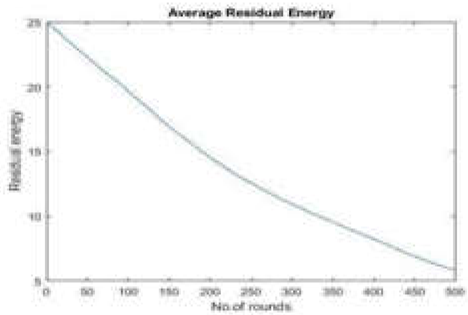

Figure9:Average Residual Energy

Figure 9 shows Average Residual Energy in the network. As the number of rounds increases the average residual energy decreases. From the above table, we can observe that at 500throundthe remaining energy is 5.6J.

9) Throughput : Throughput is maximum rate of successful message delivery at the base station. We measured throughput interms of data packets(bits).Figure10 shows throughput in network.After the simulation, we got throughput of2.15x10^4 bits(15pprox..) during the lifetime of network.

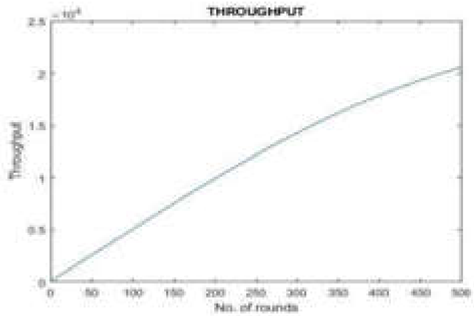

Fig10:Through put

CONCLUSION

This paper's primary goal is to solve the non-uniform distribution of Cluster Heads (CHs) in the LEACH protocol, with the ultimate objective of extending the network's lifespan and reducing energy usage. Three factors are included in the suggested technique to accomplish this: residual energy, the distance between the node and the Base Station (BS), and the quantity of nearby nodes in the cluster. The suggested technique seeks to generate a more uniform distribution of CHs while consuming less energy by adding these criteria into the CH selection process. A simulation- based performance analysis was carried out to assess the effectiveness of the suggested method by contrasting its performance with that of LEACH Protocol.

FUTURE WORK

Future research for this thesis will concentrate on minimising assaults in wireless sensor networks in order to address security problems. More investigation will be done to examine additional quality-of-service factors that may affect the network's overall effectiveness and performance. They may include elements like network coverage, the dependability of data delivery, and scalability. The suggested technique can be further enhanced to improve the overall performance and efficiency of wireless sensor networks by addressing other quality of service metrics and enhancing security.

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