IMPLEMENTATION OF SLEEPING MECHANISM CONCEPT USING LEACH PROTOCOL IN WIRELESS SENSOR NETWORKS

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Abstract - Wireless sensor networks are employed in several applications, including military, medical, environmental and household. In all these applications, the deployed sensor nodes contain limited energy resource and hence the lifetime of the wireless sensor network is the most restrictive factor to be considered. Communication protocols highly affect the performance of WSNs by an evenly distribution of energy load and decreasing their energy consumption and thereupon prolonging their lifetime. Thus designing energy efficient protocols is crucial for prolonging the lifetime of wireless sensor networks.
In this paper an energy efficient protocol called Low-Energy Adaptive Clustering Hierarchy-Centralized Sleeping Protocol (LEACH-CS) is proposed for routing in wireless sensor networks which employs a novel algorithm named Intelligent Sleeping Mechanism (ISM) to enhance network lifetime by performing an intelligent choice of functioning nodes depending on the data sensed at the time being. If the data received from certain clusters appears insignificant in a period of time, these clusters are set to sleeping mode till the next data round.

Keywords: WSN, Sleeping nodes, Lifetime.

I. INTRODUCTION

Wireless sensor networks are composed of small sensor nodes, computation, and wireless communication capabilities which form an ad hoc distributed sensing [1].WSN is widely used to collect accurate and reliable information in the distance and hazardous environments. WSNs can be used in Industrial Control, Military Affairs, Environmental Monitor, Traffic Management, National Defence, Smart Homes and Medical care [2-4]. In wireless Sensor Networks energy plays an important role because the nodes in the network are battery operated and usage of this Energy efficiently prolongs the lifetime of the network [3].Consequently, many protocols have been proposed in order to minimize the consumption of energy of these nodes. The sensor network is equipped in such a way that each sensor node consists of one or more sensors, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source which acts as a battery in most of the applications of Wireless sensor networks [4].As energy plays an important role in wireless sensor network, while developing a routing protocol preservation of the consumed energy of each node is also an important goal to be considered. To evaluate and improve routing protocols in wireless sensor networks a lot of research work has been done such as [5] and many routing protocols have been proposed in the literature such as LEACH [6-7]. Leach is the most popular energy efficient cluster based routing protocol which minimizes the energy consumption. In this paper we propose a protocol called LEACH-CS which is an improvement on the Leach-C Protocol that further enhance the lifetime of the network [8]. The architecture of the WSN is described in c, where the nodes in the sensor network are shown in a cloud. These sensor nodes transmit the data to the sink node or base station. Base station or sink node aggregates the data which from sensor nodes and transmit this aggregated data to the internet. Thus, the consumer receives data from sink node through internet.

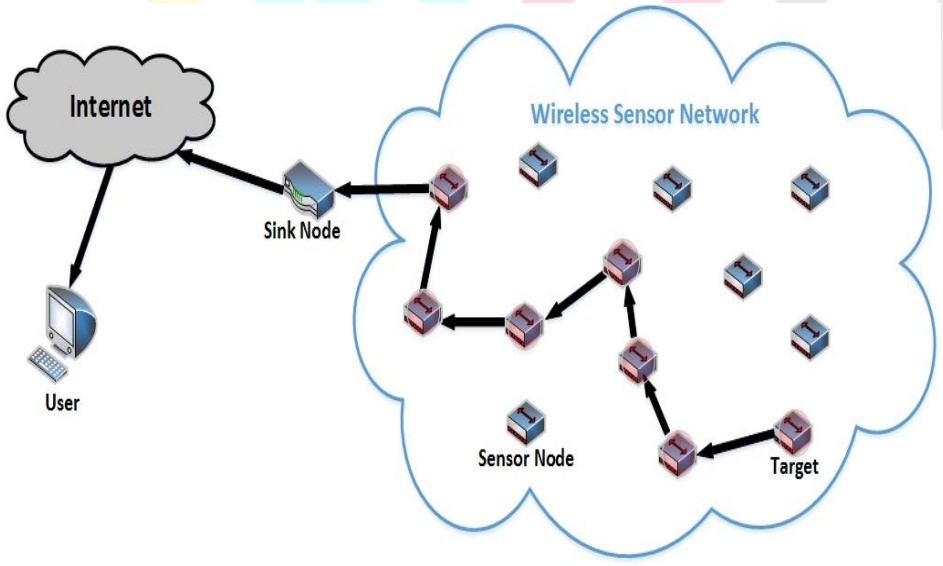

Figure 1:Architecture of Wireless Sensor Network

II. LITERATURE SURVEY

LEACH

Leach is called "Energy Efficient Adaptive Protocol for Clustered Wireless Sensor Networks". This protocol facilitates that the node with more residual energy have more chances to be elected as a Cluster head in a particular cluster. The energy load should be evenly distributed among all the cluster members of the particular cluster in order improve the life time of a wireless sensor network. By doing so the energy at a single node or a small set of nodes will not drained out soon [9]. LEACH is a first energy efficient routing protocol for hierarchical clustering. By implementing LEACH protocol on a sensor network we can make the network more energy efficient. LEACH protocol divides the nodes in a sensor network in the different clusters. Then one node from each cluster is elected as a cluster head (CH) and the other nodes in the clusters are known as cluster members (CM). Cluster member nodes sense the sensing field and get the data [10]. Then the sensed data is transmitted to the cluster heads by the cluster members. The cluster head receives the data and aggregate the data. Now this aggregated data is transmitted to the sink node by the cluster heads.

There are mainly two phases in LEACH protocol one is Setup phase and other is Steady-state phase. In the first phase that is setup phase nodes in a sensor field are divided into clusters and then the cluster head is elected from these nodes. In steady-state phase, the data is transmitted from cluster member nodes to the cluster head and then again data is transmitted from cluster head to sink node or base station. TDMA scheme that is time division multiple access is used for the efficient communication between the sensor nodes. A particular time slot is provided to the cluster members for transmission of data, in this time slot cluster members can transmit data to the cluster head. This scheme is used to avoid collision that occurs during data transmission. The selection of cluster head is takes place randomly after every round.

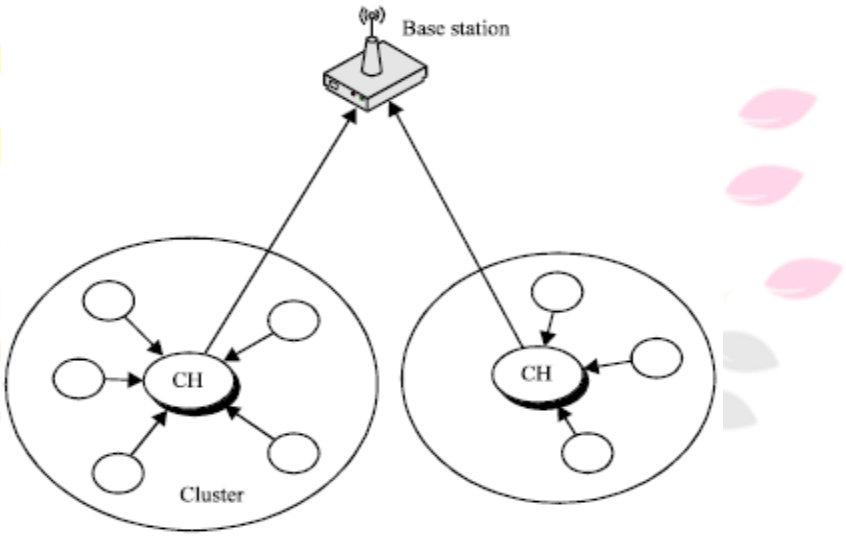

Figure 2: LEACH Protocol Architecture

LEACH-C

LEACH-C is a protocol that uses a centralized clustering Algorithm which forms better clusters by dispersing the cluster head nodes throughout the network and the same steady-state protocol as LEACH .During the set-up phase the BS receives the information about the energy level and current location of each node. The BS has to determine good clusters and it also needs to ensure that the energy load is evenly distributed among all the sensor nodes[7].The BS computes the average node energy to perform this and if the nodes having energy below this average those nodes are not considered as cluster heads for the current round. To solve the NP-hard problem of finding optimal clusters ,the BS finds clusters using the simulated annealing algorithm[11] and by using the remaining nodes as possible cluster heads. By minimizing the total sum of squared distances between all the non cluster heads and the closest cluster head, this algorithm attempts to minimize the amount of energy for the non cluster head nodes to transmit their data to the cluster head. If the cluster heads and clusters are found, the message that contains the cluster head ID is broadcasted by the BS to each node. If the nodes own ID and cluster head ID are matched ,that particular node is considered as a cluster head; otherwise the node goes to sleep until it is time to transmit data ,by determining its TDMA slot for data transmission.

Although these two protocols LEACH and LEACH-C provide energy saving significantly because of dense deployment in WSNs, the network is comprised of redundant nodes, which allows the on duty neighbors [12] to fully overlap with sensing ranges. By considering this issue, the main motivation of this research is to save the energy of the network by eliminating the insignificant data but not by eliminating the redundant data.

III. METHODOLOGY

LEACH-CS

Low Energy Adaptive Clustering Hierarchy-Centralized Sleeping (LEACH-CS) protocol is the modified version of Low Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C) protocol**.** This LEACH-CS protocol employs an intelligent scheme called Intelligent Sleeping Mechanism for nodes in the network to extend the lifetime of the overall network. This intelligent scheme(ISM),depending on the data sensed at the particular time slot performs an intelligent choice of functionality modes of nodes. Depending on this analysis the data clusters are either switched to sleeping mode or selected to complete data sending in a round. As the previous protocols[13],which adopt sleeping mode for nodes did not consider the quality of data sent because of the missing of data packets, this Intelligent Sleeping Mechanism analyzes the initial packet of all alive nodes in the network intelligently to expect whether the consequent packets in the round will be of Significance or not. The architecture of LEACH-CS protocol is shown in the following figure.

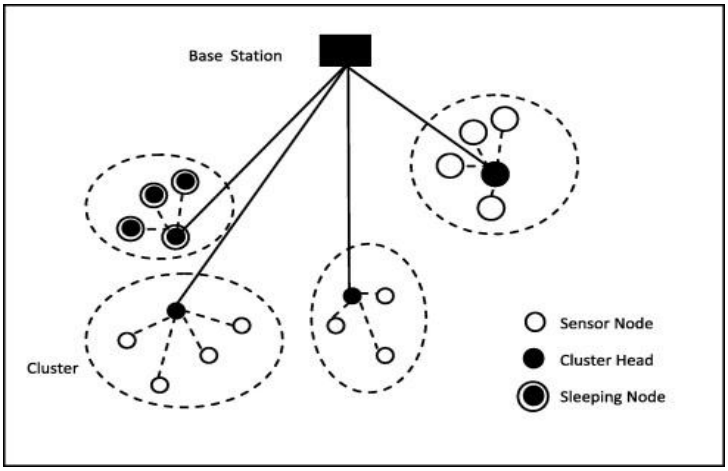

Figure 3: Architecture of LEACH-CS network

In the operation of LEACH-CS protocol, the current energy level of each node in the network is received by the base station in the form of packets. By considering this current energy level the base station sorts the nodes according to their energy levels in the descending order and chooses 5% of alive nodes to be cluster heads of the round ,which is concluded by authors of [14] as the optimal number of cluster heads for energy minimization. By choosing the minimum square distance between the node and the cluster heads the base station assigns the remaining nodes to their corresponding cluster heads. The nodes start sending their to their corresponding cluster head in sequential TDMA slots by assigning a time TDMA frame slot .The cluster head which receives the data from the cluster members aggregates it and sends it to the base station. Thus, to decide the sleeping and the awake clusters the base station employs the Intelligent Sleeping Mechanism on the first packet. The timeline of the LEACH-CS protocol is shown in below figure.

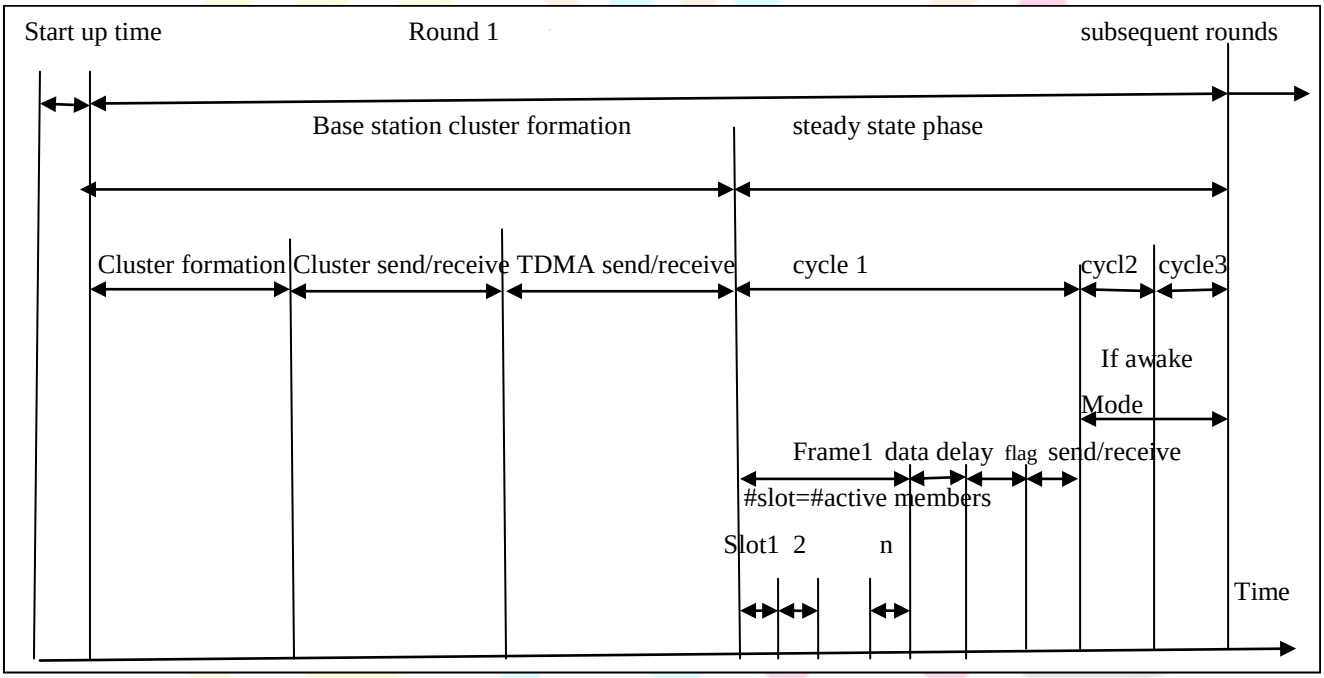

Figure 4: Timeline of LEACH-CS protocol

INTELLIGENT SLEEPING MECHANISM

The data packets received from cluster nodes by cluster heads aggregates the data packets to get an average of the data. The base station then receives and analyzes the data of the first frame and compares it with the defined threshold value which is defined by the user according to the sensed application. If the data received is below the defined threshold value ,it is to be insignificant in that particular round. Suppose if we consider the humidity in an agricultural field and if the humidity is under user defined threshold ,then it will reach a critical value in the data round and will remain stable for a while. Hence, according to this analysis the base station decides which clusters to be switched to sleeping mode in that particular round.

If the QoS flag set to 1 with the address of the cluster nodes it broadcasts the packets to be switched to sleeping mode set as 1 and the nodes with their address specified as destination receive the packet and stop sending the data during this round. Thus these nodes and their corresponding cluster heads send back their information of energy to the base station by ending their role in that round, whereas the remaining clusters continue their round by sending their data to base station in their fixed TDMA slots consequently. The functionality of the LEACH-CS protocol is described in the following pseudo code as follows.

S_{alive} : Set of alive nodes in the network

k : The number of cluster heads
N_{alive} : The number of alive nodes in the network
S_{CH} : The set of cluster heads
S_{NCH} : The set of non cluster head nodes
S_{NCH2} : The set of non cluster head nodes assigned to clusters.

1. For every node in S_{alive} do
   Send Energy _Level to Base_station
2. k = N_{alive} * 0.05
3. Sort (Energy_ Level (S_{alive})) desc_distance
4. Choose first k node in S_{alive}
5. Sort (S_{CH}) desc_energy
6. For every node in S_{NCH} do
   For every node in S_{CH} do
   If Distance (Node1, Node2) < Minimum_distance
   Minimum_distance = Distance (Node1, Node2)
   Cluster_head (Node1) =Node2
   End If
   End For
   End For
7. Cluster_head send TDMA slots to S_{NCH}
8. S_{NCH} send data to S_{CH}
9. S_{CH} aggregate data
10. S_{CH} send data to BS
    If Data (Cluster_Head) < threshold
    Send_Flag (Cluster_Head, Cluster_Nodes) =1
    Else
    Send_Flag (Cluster _Head, Cluster_Nodes) =0
    End If
11. S_{CH}, S_{NCH} recieve flag
    If Flag=1
    Sleep_Mode, End-Round,Send_Energy Level to Base_Station
    Else
    Resume_Round
    End If
12. S_{NCH} send data to S_{CH}
13. S_{CH} aggregate data
14. S_{CH} send data to BS

IV. RESULT

The simulation results are obtained by using MATLAB software. Fig.5 represents the cluster head selection using the proposed protocol called LEACH-CS protocol.

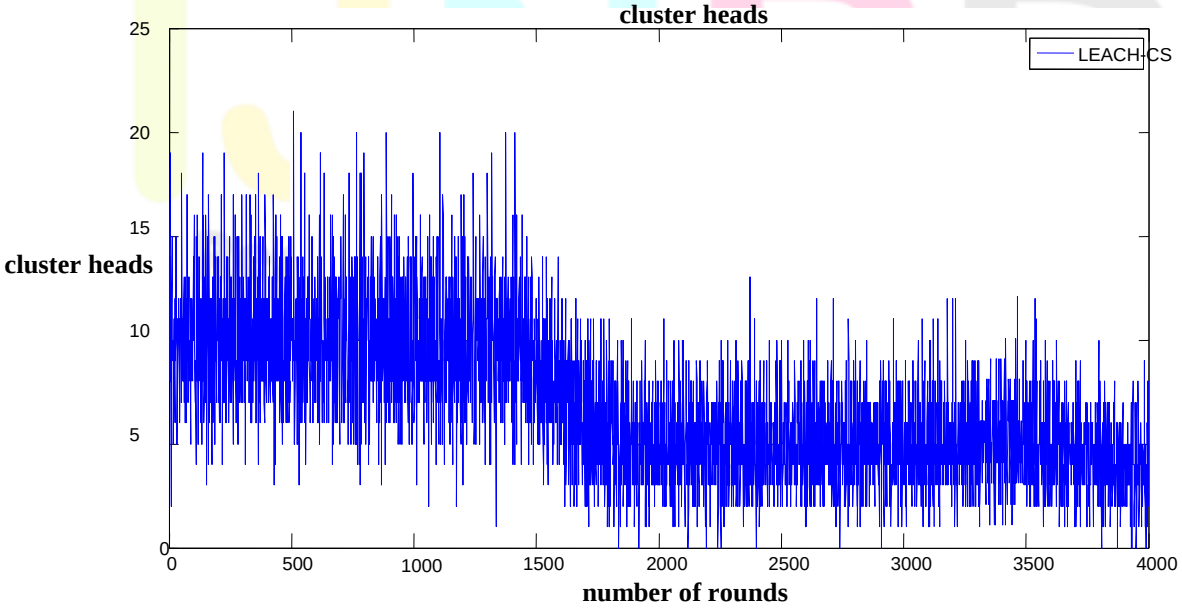

Figure 5: Cluster head selection using LEACH-CS Protocol.

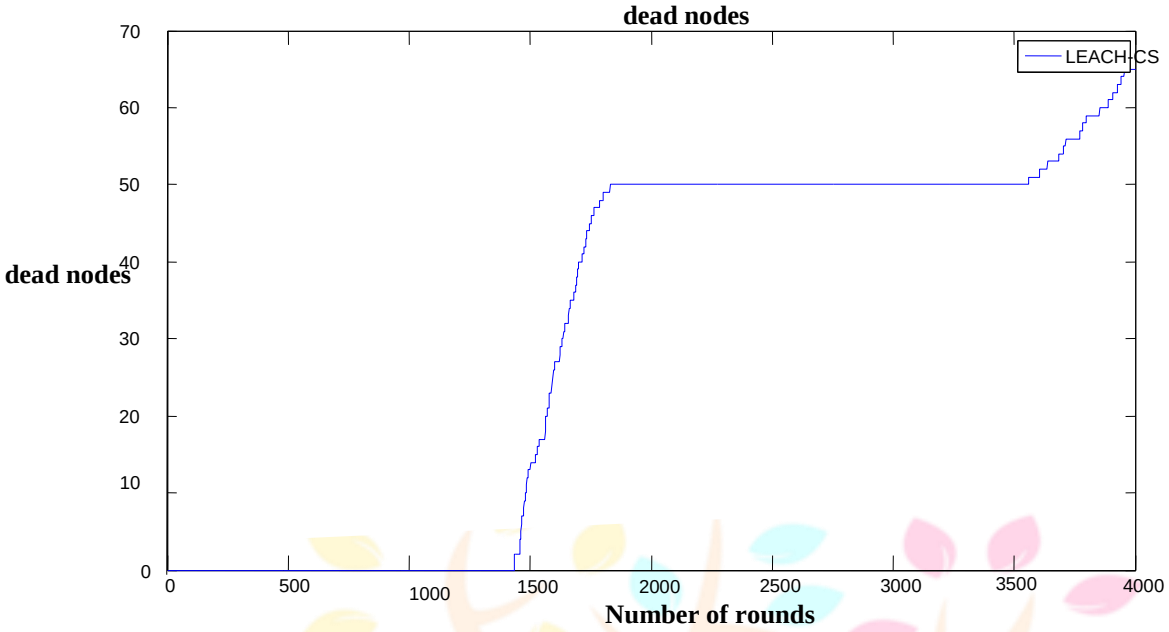

Figure 6: Dead Nodes count using LEACH-CS Protocol.

Figure 5 shows that as the number of rounds increases the cluster head selection decreases from 1500 round and remains same till the last round. Fig. 6 explains that the dead nodes count starts at approximately 1400 round and increases the count till the range of 50 and remains same up to 3500 round and then increases for further rounds.

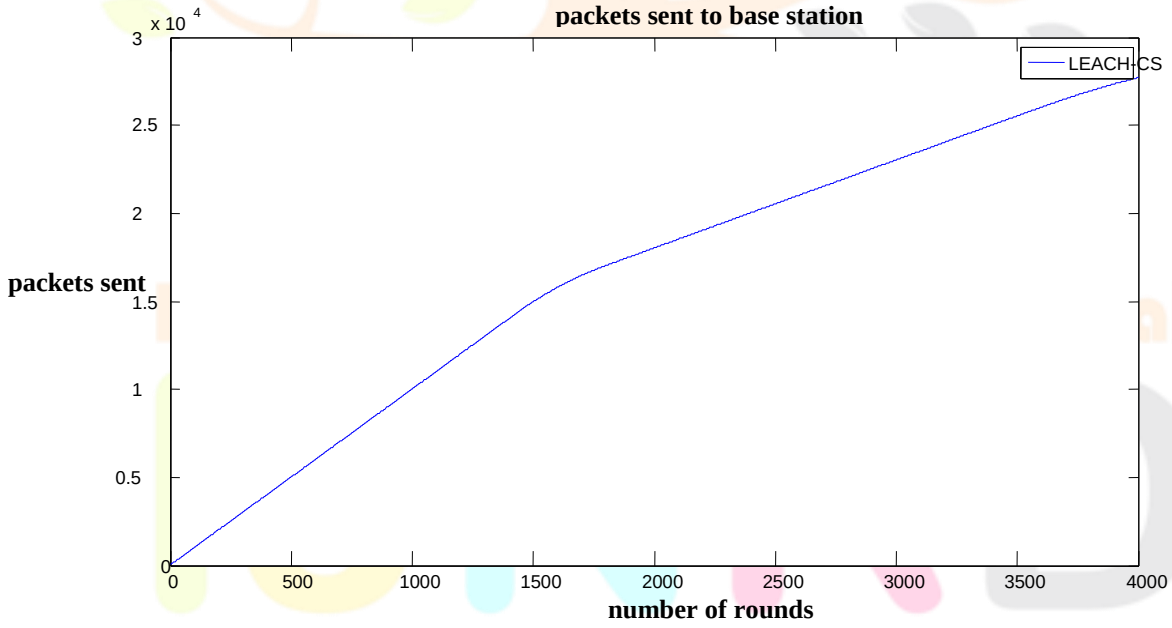

Figure 7: Packets sent to Base station using LEACH-CS Protocol.

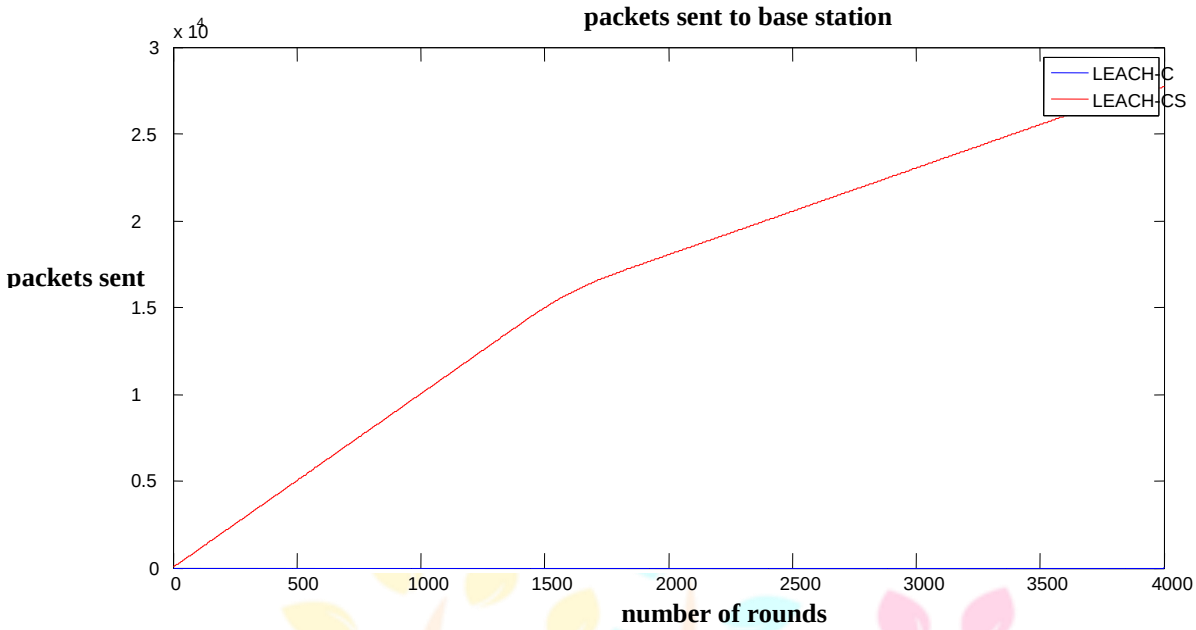

Figure 8: Comparison of Packets sent to Base station between LEACH-C and LEACH-CS Protocol

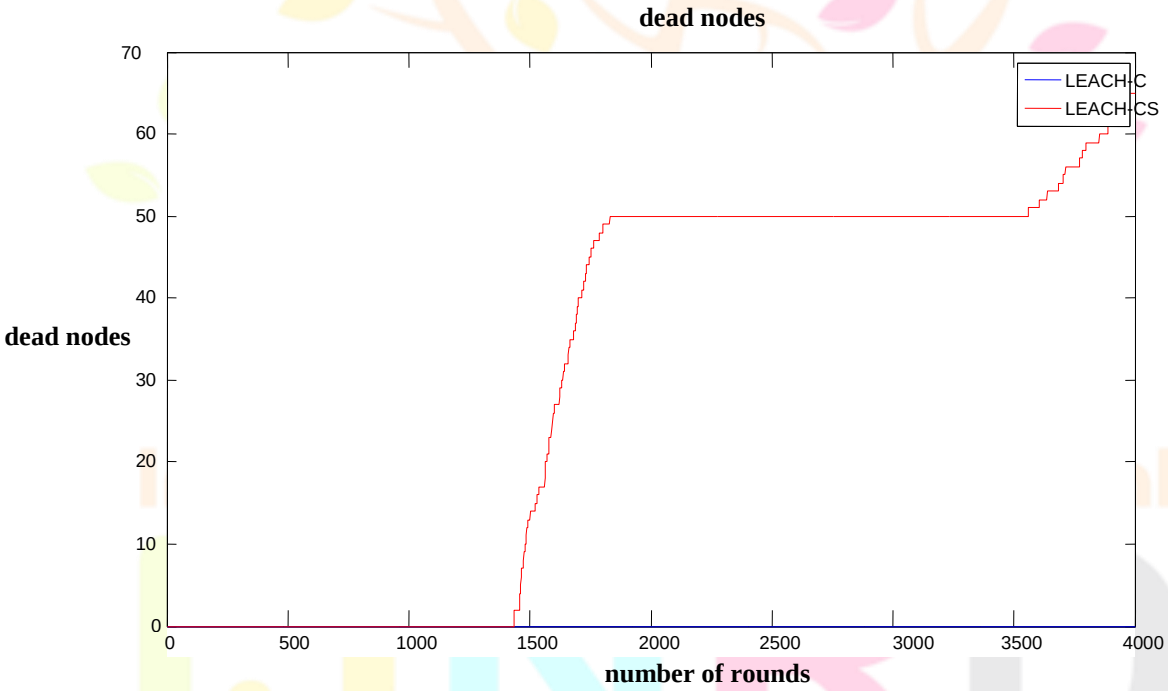

Fig 9: Comparison of dead nodes between LEACH-C and LEACH-CS Protocol.

Figure 7 shows that as the number of rounds increases the data packets sent to base station increases using LEACH-CS protocol. Fig.8 shows that the data packets sent to base station in LEACH-CS protocol increases than in LEACH-C protocol. Fig. 9 shows that as the number of rounds increases the dead nodes increases from 0-50 in LEACH-CS protocol whereas in LEACH-C protocol the dead nodes remains constant.

V. CONCLUSION

The simulation of LEACH-CS protocol is performed using MATLAB. Performance of LEACH-CS (Low Energy Adaptive Clustering Hierarchy-Centralized Sleeping) protocol is analyzed with the help of performance metrics such as lifetime, throughput and end-to-end delay. From the simulation results analysis of LEACH-CS protocol it is concluded that LEACH-CS performs better than other protocols in terms of lifetime, throughput and end-to-end delay. LEACH-CS offers an extended lifetime of network by using concept of Intelligent Sleeping Mechanism that adopts a sleeping mode for a percentage of nodes in the network depending on the effective in prolonging the network life time compared to LEACH based algorithms effective in prolonging the network life time compared to LEACH based algorithms .In the future work, it is intended to extend LEACH-CS protocol with more improvements in choice of the sleeping nodes, to increase the network lifetime. The proposed LEACH-CS protocol is not suitable for applications where data is crucial from one moment to another, so mobility of nodes is a big challenge in wireless sensor networks.

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