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# UNIFORM CLUSTERED ENERGY EFFICIENT PROTOCOL FOR WSN

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**ABSTRACT: Wireless sensor nodes are highly energy constrained devices .Energy is a most important in wireless sensor network to improve the lifetime of the senor, having so many methods in that clustering provides an effective method to extend the network life time. Some of the vital issues that need to be considered in wireless sensor network (WSN) based applications are improving the network lifetime without replacing the batteries of node and elimination of energy imbalanced hotspots in the network. Many protocols are proposed for energy efficient cluster based sensor network. In this paper, Energy efficient relay based protocol is proposed for wireless sensor network where cluster heads are evenly distributed. The proposed protocol is combined with the Multi Input Single Output (MISO) technique which is extended for dual hop wireless sensor network to improve the network life time. Further, the selection of relay nodes for cluster heads is designed to avoid unexpected partitioning. We also found the efficient relay positions for dual hop transmission. We compare the performance of this proposed protocol with the existing standard protocol Low Energy Adaptive Cluster Head (LEACH).**

**Key words:** BCDCP, MIMO, MQAM, MISO,LEACH, Cluster head, network life.

## I.INTRODUCTION

Recent advances in low-energy wireless communication embedded computing and electronics have enabled the development of the low-power wireless sensor network (WSN) technologies. A WSN consists of a large number of low-cost micro-sensors, which are randomly deployed and self-organized through wireless links. The primary function of a sensor network is to collect the physical data from the environment and propagate to sink node or base station (BS). Sensor nodes are capable of monitoring a wide variety of ambient conditions. They can also be deployed over a battle field for military surveillance as well as emergent environments for search and rescue.

However, wireless sensors are limited in their energy and hence the lifetime of wireless sensor networks is finite. Routing algorithms determine the efficiency of utilizing distributed energy resources and hence greatly affect the lifetime of wireless sensor networks.

In conventional data transmission technique for WSN such as direct transmission, to transmit sensed data each sensor node has to be directly communicate with sink node, depending on nodes location which drain the large amount of energy from the nodes. In such a scenario, nodes which are far away from sink node drains their energy resources much faster than nodes near to sink. In other traditional technique such as multi-hop transmission, the nodes closer to sink have to pay penalty on their energy resource by transmitting their data and routing other nodes data to sink node. To improve the network life time by effectively utilizing resources (Bandwidth, power) and data aggregation technique, cluster-based approach is suitable for WSNs. But whenever cluster head (CH) ran out from the network cluster members lose their communication paths with Base Station (BS).

In general, the data monitored by sensors need to be analyzed at the base station. Thus, we can take the advantage of BS to form good clusters in the network by adding the few information bits to payload. BCDCP uses the centralized control for entire cluster formation with proper separation between the CHS and data transmission technique is improved by providing multi hop communication between CHS. Cooperative MIMO technique has been seems to decrease the energy consumption in WSN over multipath fading channels For the same throughput requirements Multi Input Multi Output systems require less transmission energy than Single Input Single Output system and they compared MIMO transmission technique with cooperative MIMO transmission technique.

## II. SYSTEM ARCHITECTURE AND PROTOCOL DESIGN

Consider a two dimensional network area where large numbers of energy constrained sensor nodes are randomly deployed and self organized through wireless links. Similar to the conventional WSN architectures we assumed the sink node or BS is placed far away from all the sensor nodes. Additionally, following assumptions are made:

• Sensor nodes can estimate their positions with the help of few properly placed nodes which are embedded with the GPS devices
• All nodes are homogeneous in terms of computation, communication capabilities and power resources.
• Each sensor node has power control capabilities to vary their transmission power depending on distance to receiver

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• Further, we consider that all the sensor nodes are stationary for their entire lifetime and time synchronized with local BS (CH).

**Protocol design**

In this protocol, initially all sensor nodes communicate with BS through transmitting their ID, residual energy and position in the network. Based on received information BS selects the primary set of CH nodes using cluster head selection algorithm described later and broadcast the selected CHs' ID to all the nodes in network. The remaining operation of our protocol can be divided into two different phases. These are described in the following sections.

***1. Setup phase***

• Once any node finds its ID in the CHs list, it becomes a CH for the current round and broadcasts the advertise packet (PAC−ADV) using CSMA MAC protocol.

• All non-CH nodes receives the PAC−ADV from each CH node and decides to which cluster it belongs based on Received Signal Strength Indicator (RSSI). After selecting the suitable cluster, a node transmits joining request (PAC−JOIN) to chosen CH.

• After a predefined time, based on the received PAC−JOIN messages each CH node creates the TDMA schedule for its cluster members and broadcast the schedule along with specified spreading code which mitigates the intra cluster interference in network.

***2. Data Transmission Phase***

In this phase, data transmission in intra-cluster and CH to BS takes place using TDMA and CSMA MAC protocols, respectively. Each cluster member node transmits its monitored data to local base station (CH) during its allocated time slot. Once CH nodes receive the sensed data from their cluster members. Each CH node performs the data aggregation operation on the correlated data and transmits the compressed data to BS. Data aggregation is done with an assumption that all the deployed sensor nodes are in a limited area.

***3. Cluster Head Selection Algorithm***

Whenever cluster formation is required the current CH nodes collect their members' residual energy information and transmit to the BS. After receiving the information about network, BS finds the desired number of CHs using equation similar procedure.

$$K = \sqrt{\left(\frac{(n-dead)*E_{fs}*X_m*Y_m}{2*\pi*E_{mp}}\right)\left(\frac{1}{A\_d2bs}\right)} \rightarrow 1$$

Where $n - dead$ is the total number of nodes participating in the network, $X_m * Y_m$ is the network area, $E_{fs}, E_{mp}$ are the energy for free space, multipath respectively, A_d2bs is the minimum distance from network to the base station.

Once BS finds the desired number of CHs is required, it makes the set of nodes which consists their residual energy more than the average network energy to become as CH. Remaining selection procedure of the CH nodes from the set follows as like

1. From the set BS selects the two nodes as CHs, which are spatially separated with maximum distance?

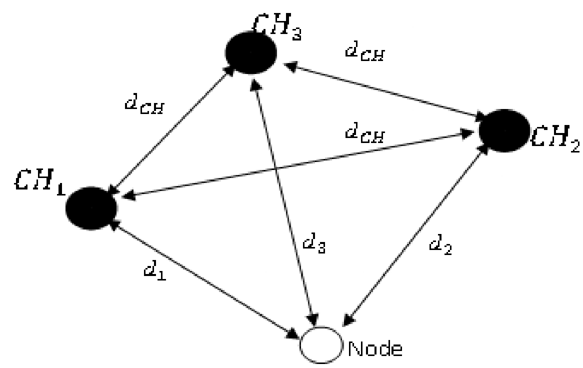


**Fig 1**: Cluster Head Node Distribution

2. Next cluster head is selected based on the weighted sum of distances from previously selected CH nodes, as shown in Fig.1 BS calculates the 'F' values to all competing nodes and chose the node as CH which has maximum F value.

$$F = \frac{W_1}{n} * \frac{(d_1+d_2+\cdots\ldots\ldots+d_n)}{\max(d_1+d_2+\cdots\ldots\ldots+d_n)} + \frac{W_2}{n} * \frac{(d_{CH1}+d_{CH2}+\cdots\ldots\ldots+d_{CHn})}{\text{mean}(d_{CH1}+d_{CH2}+\cdots\ldots\ldots+d_{CHn})} \rightarrow 2$$

Where W1, W2 are the weight parameters and these values are chosen such that CHs are separated with maximum distance.

3. BS repeats the step.2 until the desired number of CH nodes is selected and broadcast their IDs to network.

Compared to other protocols, we considered that the CH election phase is not taken place for every round. This is based on their present energy, previous round energy and network average energy. Even if any one of the CH does not have sufficient energy to serve next round it sends small packet which inform that cluster formation is required. Then all the CHs collect their member's energy information and transmit to the BS along with present round data.

## EVENLY DISTRIBUTED CLUSTER HEADS

Because of, random deployment of sensor network LEACH, LEACH-C and other protocols based on LEACH suffer from CH selection. That is, if CHs are distributed evenly in the network, it might not be selects the CHs based on their residual energy and vice-versa. This issue creates the unexpected partition or energy imbalanced hotspots in the network.

To overcome the above, in our protocol, we have chosen the CHs such that they are evenly distributed throughout the network and we have chosen relay nodes such that they balance the energy in the network. To achieve above goal we found optimum relay positions which balance the energy consumption in clusters which are near and far away from BS.

To balance the energy consumption throughout the network and to avoiding the hot-spots we designed a protocol where relay nodes are selected on the basis of the CH distance from the BS. If the CH is far away (distance greater than the minimum distance to the BS i.e., >=130) from the BS then two relay nodes are selected and for the CH's which are near to the BS only one relay node is selected. Based on the CH positions the relay nodes are selected and broadcasted their ID's along with CH ID's. The node which comes under CH ID acts as CH and the nodes which come under relay ID's acts as relay nodes.

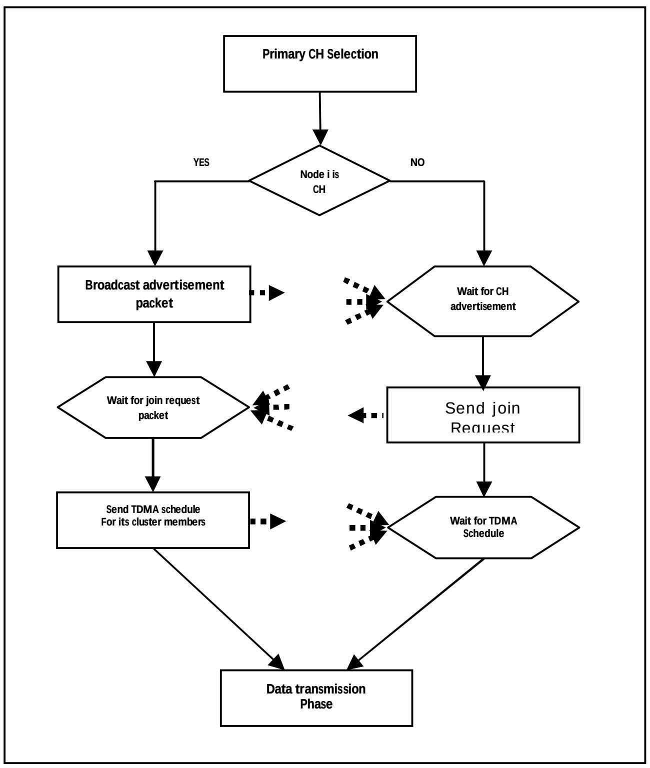


**Fig 2**: Flow chart for setup phase

## III. ENERGY CONSUMPTION

We considered an AWGN channel with squared power path loss for intra cluster communications. For the inter cluster communications, we assume the transmission from each cooperative node experiences frequency nonselective and slow Rayleigh fading channel. We use multi-rate quadrature amplitude modulation (MQAM) technique to improve the network energy efficiency.

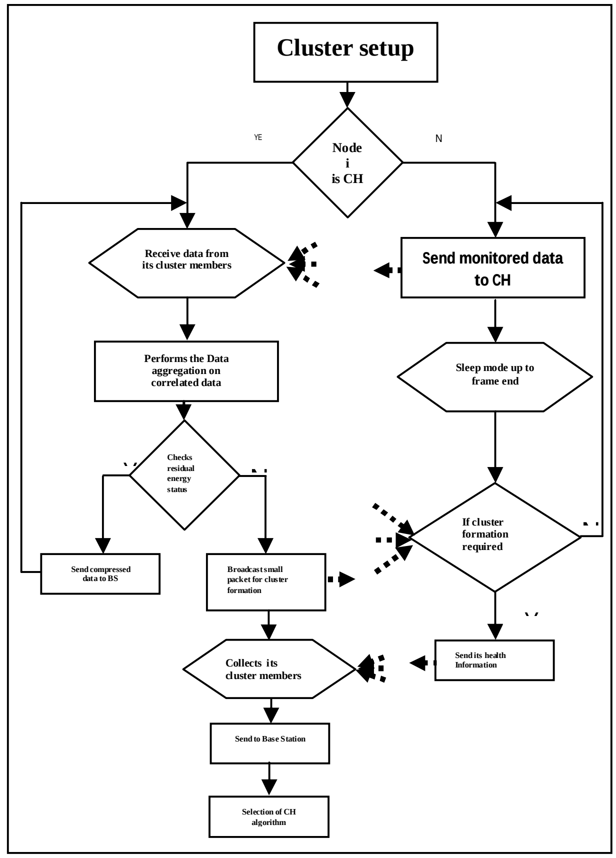


**Fig 3**: Flow chart for data transmission phase

Unlike in cellular mobile communications, in wireless sensor network the circuit energy consumption may not be negligible compared to actual transmission power. Thus, the total power consumed in a node for the transmission of single bit is given as

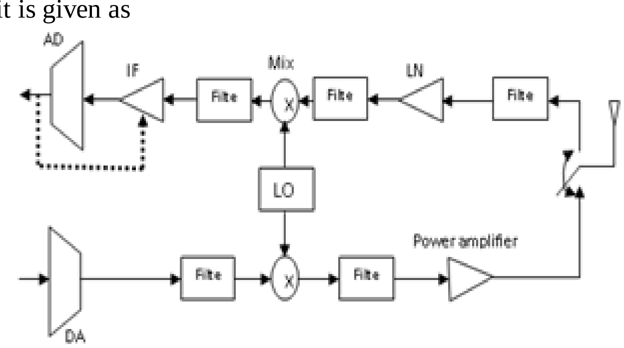


**Fig 4**: Transceiver of sensor radio

$$P_{bit} = \begin{cases} P_{tr} + P_{ct} + \propto P_{tr} & \text{Transmit Mode} \\ P_{cr} & \text{Receive Mode} \end{cases} \quad \rightarrow 3$$

Where Pct (or) Pcr is the power consumed in transceiver circuit blocks, Fig.4 shows the typical transceiver of sensor radio, Ptr is transmission signal power and it can be find out from link budget relation. Assuming a simplified path-loss model Ptr shown as

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$$P_{tr}(d) = \frac{(\widehat{E_b}\, R_b)*(4\pi*d_o)^2}{G_t*G_r*\lambda^2} * \left(\frac{d}{d_o}\right)^{\eta} * M_1 \qquad \rightarrow 4$$

$$P_{ct} = P_{DAC} + P_{Mix} + P_{Fil} + P_{syn} \qquad \rightarrow 3.5$$

$$P_{cr} = P_{LNA} + P_{Mix} + P_{IFA} + P_{Fil} + P_{syn} + P_{ADC} \qquad \rightarrow 6$$

$$E_{bit}(d) = \frac{P_{bit}(d)}{R_b} \qquad \rightarrow 7$$

where $\widehat{E_b}$ is the required energy per bit at the receiver to achieve the predefined bit error rate (BER), $R_b$ is bit rate, $M_1$ is the link margin to compensating the hardware process variation and additive background noise, $d$ is the distance between transmitter node and receiver node, η is the path loss coefficient for wireless channel and $d_o$ is a reference distance for the antenna far-field, $G_t$ and $G_r$ are transmitter gain and receiver gain, respectively, λ is the wave length of the signal and $E_{bit}(d)$ is the energy consumed for transmission of a single bit over a d distance. Further, energy analysis of a system is divided into two phases; these are intra cluster data transmission and CH to BS data transmission.

### *Intra Cluster Data Transmission*

In this section, Energy analysis is divided into CH node and cluster members, energy consumption for each cluster member transmission of monitored data to CH $E_{intra\_non\_CH}$, CH receiving and performing the data aggregation $E_{intra\_CH}$ is given as

$$E_{intra} = E_{intra\_CH} + E_{intra\_non\_CH} \qquad \rightarrow 8$$

$$E_{intra\_non\_CH} = L * E_{bit\_tr} \qquad \rightarrow 9$$

$$E_{intra\_CH} = nL(E_{dagg} + E_{bit\_tr}) \qquad \rightarrow 10$$

where $E_{intra}$ is total energy consumed in a cluster, n is the number of cluster members, L is the size of the packet(in bits) and $E_{dagg}$ is energy consumption for data aggregation.

### *Inter Cluster Data Transmission*

We consider a 2x1 MISO Almost scheme for long-haul transmission with MISO protocol and when $M_t = 1$, SISO system is special case of 2x1 MISO system. With MQAM modulation, the required $E_b$ at receiver for a given BER ($P_b$) is shown

$$\widehat{E_b} \le \frac{2}{3}\left(\frac{P_b}{4}\right)^{\frac{-1}{M_t}} \frac{2^b - 1}{b^{\frac{1}{M_t}+1}} * M_t N_0 N_f \qquad \rightarrow 11$$

$$M_t = \begin{cases} 1 & \text{SISO} \\ 2 & \text{MISO} \end{cases}$$

where $N_f$ is the receiver noise figure and $N_0$ is the thermal noise power spectral density(PSD).

## NETWORK WITH RELAY NODES

In this protocol, CHs which are far away from BS utilize the dual-hop transmission and CHs near to BS use the single-hop transmission, but in both case CHs utilize the MISO scheme by selecting the cooperative nodes either within the cluster or other cluster. Total energy consumed in CH node $E_{CH}$ and relay node ER is given as

$$E_{CH} = \beta(nL) * E_{bit\_tr}^{SISO}(d_{S2R}) \qquad \rightarrow 3.12$$

here β is percentage of data compressed from received correlated data and it is chosen between 0 to 1. $\beta(nL)$ is total compressed data available at the CH node.
Total energy consumed in this scheme is equal to

$$E_R = \beta(nL) * M_t * (E_{bit\_tr}^{MISO}(d_{S2D}) + E_{bit\_r}) \qquad \rightarrow 13$$

From eq. 14& 15 optimum and minimum relay positions are calculated as like:

$$\text{minimum}(d_{StoR}) = \min\{(E_{intra} + E_{CH}) + 2 * E_R\} \qquad \rightarrow 14$$

$$\text{opt}(d_{StoR}) = \min\{(E_{intra} + E_{CH}) - 2 * E_R\} \qquad \rightarrow 15$$

## IV. SIMULATIONS AND RESULTS

To evaluate the performance of proposed protocol, we have developed a simulation model of our proposed protocol in MATLAB with the random network generated over 100mx100m area. We randomly deployed N=100 sensor nodes in network area and each node contains the initial energy of 50 joules. In two dimensional networks, we placed BS at (50,175) and assumed BS powered by external source. The necessary communication parameters are listed in Table .1

By using the above parameters a network was generated with the relay nodes, cluster heads and sensing nodes. The generated network was shown below in Fig .5

**Table1**: communication parameters

| | | | |
|---|---|---|---|
| $X_m = 100$ | $f_c = 900MHz$ | $M_l = 40dB$ | $P_{IFA} = 3mW$ |
| $Y_m = 100$ | B=10kHz | α=0.45 | $P_{mix} = 30.3mW$ |
| N=100 | η=3.6 | b=2 | $P_{Filt} = 2.5mW$ |
| BS_x=50 | $G_tG_r = 0dBi$ | $P_b = 10^{-3}$ | $P_{Syn} = 50mW$ |
| BS_y=175 | $N_o = -174dBm/Hz$ | $P_{ADC} = 20mW$ | $P_{LNA} = 20mW$ |
| k=5 | $N_f = 10dB$ | $P_{DAC} = 20mW$ | Dead <= 0.5J |

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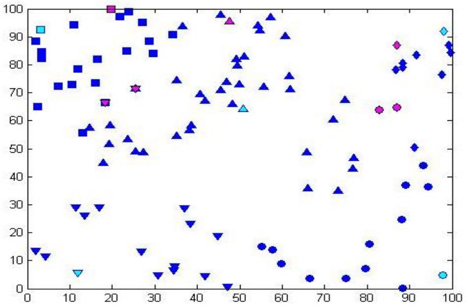

**Fig 5**: Node deployment

From the above figure it was observed that the cluster heads which are near to the base station are having only one relay node, where others are having two relay nodes for forming MISO.

Fig. 6, 7. Gives the cooperative relay position in network such that it balance the energy dissipation in cluster which are near and far from BS, minimize the total energy consumption in the network respectively. Certainly, optimum relay positions minimize the energy imbalanced hotspots in the network through approximately balancing the energy consumption.

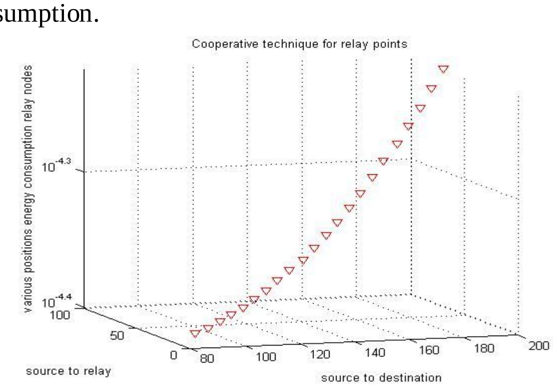


**Fig 6**: Energy consumption for various relay positions

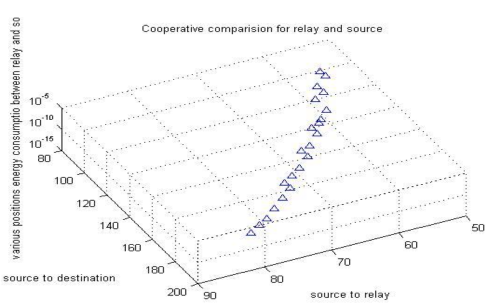


**Fig 7**: Optimum relay positions

The main difference between the standard LEACH and the designed relay LEACH is the node starts going inactive for LEACH from the bottom end and the network will be with hot spots. The proposed protocol uses the relay nodes and uniform clustering technique to overcome the above problems. These can be observed from the below figures.

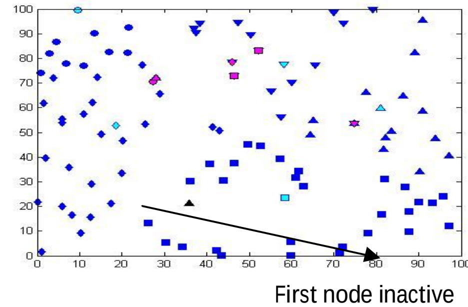


**Fig 8**: first node scenario from proposed protocol

From the below figures 9 .it can be observed that the proposed protocol overcomes the network hot spots.

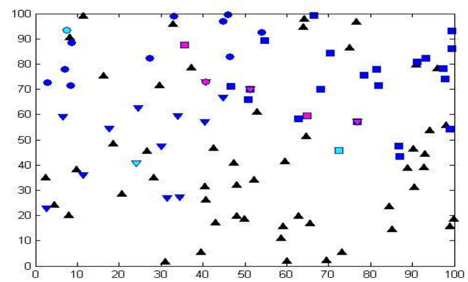

**Fig 9**: Half network died scenario from proposed protocol

If all the nodes gone inactive then the network will look like below in the figure 10

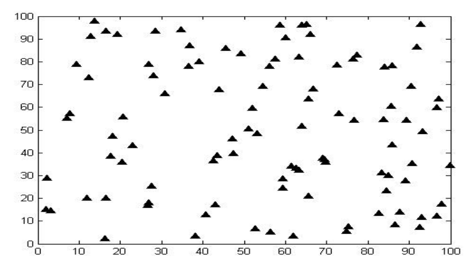

**Fig 10**: all nodes are inactive scenario

From the below Fig.11, it can be concluded that Relay LEACH with uniform clustering technique improves the network life time than LEACH protocol. Observations from slope of the curve after first node is dead shows that LEACH with Relay and uniform clustering technique utilizes the entire network energy without making any partitions in network.

From figure 11 it was observed that the node starts died in the standard LEACH at the round of 495, but by using our proposed protocol the node gets died at the round of 710. From this it was observed that it will be an efficient communication from the sensors to the base station.

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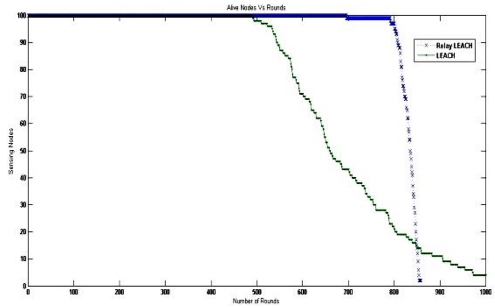


**Fig 11**: Alive nodes Vs No. of rounds

From the above Nodes Vs Rounds Graph it is also observed that the Proposed Protocols Lifetime is less than the LEACH but it shows that the data collection is throughout the network.

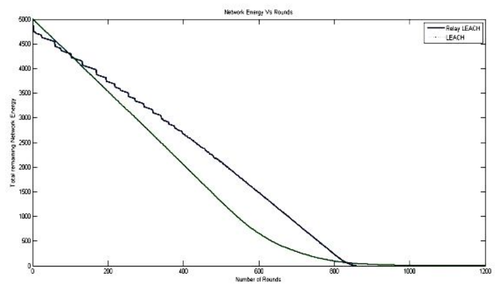


**Fig 12** : Avcarage Network Energyu Graph

From Fig 12, it shows that the total remaining Average Network Energy was also increased when compared with the standard LEACH protocol. We can observe from the below graph that at the setup phase the proposed protocol is taking more network energy than the standard LEACH. But after the setup phase the proposed protocol consumes less energy than the LEACH.

## V. CONCLUSION AND FUTURE WORK

Due to the wide variety applications of WSNs, sensor nodes are designed to be small in size and their operations rely on the batteries. In most of the applications it is impossible to replace or recharge the battery of a node from the network. However, in wireless medium, communication through weaker channels requires huge energy as compared to relatively stronger channels. Thus, it is very important to develop and design protocols that are energy efficient and effectively use the available bandwidth. So, with this regards several protocols such as LEACH, LEACH-C, MTE, HEED, EEUC, BCDCP and many others are developed. From the designed relay based LEACH protocol, it was proved that the proposed protocol is more efficient than the standard LEACH and also shown that the average network energy is also decreased using the uniform clustering technique. Thus taking these two advantages together can produce an efficient protocol for wireless sensor networks.

This proposed protocol uses the homogeneous nodes. To generalize it more this can be extended further for heterogeneous network. Here we used dual hop scheme in the data transmission phase, for the large area networks this can be extended to multi hop scheme with the proper selection of relay nodes.

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