ISSN:0975-9646
Umapathi G R et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 13 (1) , 2022, 33-38

Ileach- an integrated leach routing protocol to elongating the network lifetime in WSN for Cyber Physical System

Umapathi G. R[1], Dr. Ramesh Babu H S[2]
[1]*Department of Information Science and Engineering, Acharya Institute of Technology, Bangalore, India*
[2] *Sai Vidya Institute of Technology, Bangalore, India*

Abstract: **The Wireless Sensor Network (WSN) is composed of a collection of sensor nodes, which are small and energy constrained device. The efficient use of energy source in a sensor node is most desirable criteria for prolong the life time of wireless sensor network. So designing efficient routing for reducing energy consumption is the important factor. In this paper, we propose an effective version of LEACH routing protocol, ILEACH which will extend the performance of the system by extending the network lifetime by modifying the threshold equation for selecting the cluster head (CH) for every round of clustering. We experimentally showed that our proposed mechanism give better network performance in terms of lifetime and less amount of power consumption in the network. We also showed a situation of critical packet delivery and able to get less delay for critical packet delivery to the base station (BS) directly with a differential routing approach. We stated our future work forextending our research work.**

Keywords: **Wireless Sensor Network, LEACH, ILEACH, energy efficiency, network delay**

I. INTRODUCTION

In the advancement of Micro-Electro-Mechanical System (MEMS) has highly influenced the development of miniaturized sensor nodes [12]. These tiny nodes collaborate with each other via RF communication in ISM (Industrial, Scientific and Medical) band to form Wireless Sensor Network (WSN) [12].WSN consist of tiny sensor nodes, these sensor nodes are consist of sensors, microprocessor, memory, transceiver, and power supply [7]. These smart sensor nodes are deployed in a physical area and networked through internet and wireless links, which provide unprecedented opportunities for a variety of civilian and military applications, for example, environmental monitoring, battle field surveillance, and industry process control [2]. Multi-hopping in the WSNs can cause a sensor node to communicate with a node which is far away from it. This allows the sensor nodes in the network to expand the monitored area and hence proves its scalability and flexibility property [8].

In this paper, the rest of the sections are organized in the following way. In section 2, we described about energy model for LEACH protocol. In section 3, we described about existing LEACH protocol with some advantages and disadvantages. In section 4, we proposed our own mechanism for increasing the performance of the network along with a mechanism for dealing with emergency packets. In section 5, we showed our simulation result and in section 6 we concluded our paper with our probable future enhancement.

II. ENERGY RADIO CHANNEL DISSIPATION MODEL FOR LEACH

In LEACH radio hardware energy dissipation model transmitter evanesce energy for the process of running the radio electronics and the power amplifier, and the receiver evanesce energy for the process running the radio electronics. We used both the free space and the multipath fading channel models based on the distance between the transmitter and receiver. We will calculatethreshold value and based on this value only the two models has been choose. If the distance is less than the threshold then we use free space model or else the multipath model has been used [13].

For the experiment that is been described in this paper, we have been assumed a simple radio hardware energy dissipation model where transmitter evanesce energy for the process of running the radio electronics and the power amplifier, and the receiver evanesce energy for the process running the radio electronics and this is been showed in the Figure 1. The radio channel model that has been used here is modeled by free space model (d2 power loss) and the multi path fading model (d4 power loss) based on the distance between the transreceiver. If the distance between the transceivers is less than a previously defined threshold than free space model is used or else the multipath model is been used [13].

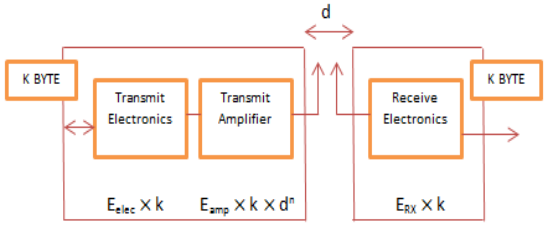

Fig. 1 A Simple Radio Channel Dispersion Model

In our simulation work it is been assumed that all nodes have enough power to reach the BS if it is required. This algorithm also assumes that node would send data periodic manner. In the simulation process, in each election round of CH all the nodes have the same amount of energy capacity which is based on the assumption of the algorithm and CH is been choose efficiently.

III. LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY PROTOCOL

Low-Energy Adaptive Clustering Hierarchy (LEACH) is a clustering based protocol that uses a randomized

rotation of local cluster BS [8]. LEACH is one of the most popular distributed cluster-based routing protocols in WSNs [11]. LEACH is the first and most popular energy efficient hierarchical clustering protocol for WSNs that was proposed for reducing power consumption and also to increase the lifetime of the network [2, 7].

In order to extend the lifetime of the whole sensor network, energy load must be evenly distributed among all sensor nodes, so that energy at a single sensor node or a small set of sensor nodes will not be drained out very soon [11]. In every cluster one of the sensor node acts as CH and remaining sensor nodes as member nodes of that cluster. Only CH can directly communicate to sink and member nodes use CH as intermediate router in case of communication to sink [10]. CH collects the data from all the nodes, aggregate the data and route compressed information to sink. Because of these additional responsibilities CH dissipates more energy and if it remains CH permanently it will die quickly as happened in case of static clustering. LEACH tackles this problem by randomized rotation of CH to save the battery of individual node. In this way LEACH maximizes life time of network and also reduces the energy dissipation by compressing the data before transmitting to CH [7]. Leach is completely distributed which requires the global knowledge about the network.

The Leach operation is classified into different rounds and each of these rounds having mainly two phases and these are called [2, 7, 9],

a) Setup phase

- For the process of organizing the whole network into different clusters
- Advertisements of the CHs to its different individual cluster members
- Transmission of the schedule that has been created during the setup phase

b) Steady state phase

- The process of data aggregation within the different clusters of the network
- Compression of the sensed information that is being sensed by the sensor node into its different CH within the cluster only
- Transmission of the compressed data to the sink via different CHs

During the process of setup, each sensor node would choose a constant number between 0 and 1. After this, a threshold value for each node is been calculated with the help of equation (5). After this, a comparison is been carried out between threshold and the constant and if the constant is less than the threshold T (n), the sensor node is a CH. T (n) is been calculated as follows,

$$T(n) = \frac{P}{1 - P \times \left(r \bmod \frac{1}{p}\right)} if\ n \in G \qquad (5)$$

$$T(n) = 0 \qquad otherwise$$

Where, P is the aspired percentage to become a CH, r is the current round, and G is the set of nodes that have not being preferred as a CH in the last 1/P rounds.

IV. PROPOSED IMPROVEMENT OF LEACH

In this section we discussed about the changes we had done to our proposed work so that we able to getbetter performance results compared to existing system. We added some extra features in the LEACH routing protocol for comparing our proposed model with the existing model in an efficient way. We have considered an added factor called delay in propagating information in the network for the emergency packets. In LEACH routing protocol due to aggregation process, packet which has to transmit to the BS immediately after the sensing process has to wait until the fusion process completed and due to this fusion process in CH, a serious damage in the network may happen which have been deployed for very sensitive work like battle-field and patient monitoring area. In ILEACH we have added delay aware routing scenario for propagating emergency information directly to the BS without aggregation process in the CH. We differentiated normal packet with emergency packets as PRIORITIZED and NON PRIORITIZED packets. We have made the routing scenario i.e. from sensor nodes to their respective CHs as per TDMA mechanism that has been used within the clustersfor sending information from sensor nodes to CHs in both LEACH and ILEACH. We have added a radio model in both LEACH and ILEACH for calculating and updating with the energy dissipationvalue for the nodes in the network with respect to sending and receiving of information by the nodes.

The changes done in LEACH routing protocol for making compatible with ILEACH are as follows,

a. ***PRIORITY ALGORITHMS*:**Additional algorithm for sending PRIORITIZED packet (emergency packets) form sensor nodes to the BS through CH without aggregation process.
   - For this we have made a packet PRIORITIZED by the process of choosing a packet with a value which should return ZERO (0) when a MOD operation is done on the value of the packet by 10.
   - After this packet is being sent to the BS without aggregation.
   - For aggregation process in LEACH we made a condition that two normal packet (NON-PRIORITIZED) packet should be received in the CH, if not wait for receiving other packet in the CH.

b. ***TDMA ALGORITHM*:**Additional algorithm for making the routing within the clusters, based on TDMA slots allocated by the CHs.

c. ***RANDOM FUNCTION*:**For calculating the energy dissipation of normal sensor nodes and CH nodes for transmission and reception of sensed information, we have used a random function. For normal sensor nodes we have found a random number between 1 and 3 and this is been deducted from the energy of the node it having before sending the sensed information to its destination. The same have been applied for CH nodes also but random number has been choose between 3 and 6.

d. ***ENERGY MODEL:*** We have added a radio energy model for the Tx (transmitter) and Rx (receiver) of

the sensor nodes for calculating the energy dissipation for the node while sending of information to other nodes and receiving information from the other nodes, it will be helpful for calculating the remaining energy of the node and also calculating the remaining energy of the network after the simulation process got over. This energy model has been described in above section very clearly. It is been added in ILEACH also for better performance. The equation used for energy model for both Tx and Rx are as follows,

$$E_{tx}(\mathrm{k}, \mathrm{d}) = \begin{cases} E_{elc} \times \mathrm{k} + E_f \times \mathrm{k} \times d^4 \text{if d} \geq d_0 \\ E_{elc} \times \mathrm{k} + E_f \times \mathrm{k} \times d^2 \text{if d} < d_0 \end{cases} \quad (2)$$

$$d_0 = \sqrt{\frac{E_f}{E_m}} \quad (3)$$

Where, E_{elc} is the energy dissipates in transmitting and receiving data for a sensor nodes and E_f and Em are the energy dissipates in amplifying process. E_f for free space radio model and E_m is multipath fading model. These are chosen based on the distance between nodes, d is the distance factor and d_0 is the threshold value calculated by the node based on equation 3. E_{rx} is calculated by the following equation,

$$E_{rx}(\mathrm{k}) = E_{elc} \times \mathrm{k} \quad (4)$$

We have added RANDOM FUNCTION and ENERGY MODEL algorithms alternatively and check the results of using both in an alternative manner. The results of this have been shown in further section.

4.1 Integrated Low Energy Adaptive Clustering Hierarchy protocol (ILEACH)

From previous study that had been done on LEACH protocol we are able to conclude that, it rotatesCH in each round in a random fashion based on a threshold value and by doing this it would able to improve the performance of the network and hence life time of the network get increased and also able to save the energy of the sensor nodes which had been deployed in the network, but we also got to know that in LEACH, a problem occurs when we unable to select a CH due to low energy of the sensor nodes. This is because of randomized selection of CHs without taking the account of energy value of the choose CH nodes. This situation may lead to effect the sensor network scenario, because sensor network having a major concern about energy efficiency of the network.

In the proposed ILEACH protocol, the sensor nodes would organize themselves into different clusters and each cluster would have a local BS which would work as a CH in the cluster and which would be only responsible for the routing of aggregated information to the BS or any other nodes in the network. The proposed mechanism uses same processes to choose cluster members and data transmission as the conventional LEACH protocol in the wireless sensor network environment.

We have calculated a new Threshold Equation [T(n)v] for each node so that the problem occurs in LEACH routing can be minimized in a better way. This can be done in the following way,

$$T_{(n)v=} \frac{P_v}{1 - P_v \times mod(r \; mod \; \frac{1}{P_v})} \quad (5)$$

The value of Pv can be calculated in the following way,

$$P_v = \frac{P_c \times n \times (i_{node} \times E_n)}{E_i \times E_v} \quad (6)$$

Where, P_c is the initial chosen probability, n representsto the no of nodes, i represents to the individual node, $E_n$is the energy of the network, E_i is the initial energy of the node and E_v is the new calculated initial energy level of every node for each round which has been calculated with the help of initial energy level of the nodes instead of using remaining energy level of the nodes as an energy level ofnodes for each round. This can be calculated as follows,

$$E_v = E_i \times \left(\frac{1 - \frac{tt_{round}}{R_m}}{n} \right) \quad (7)$$

Where, E_i is the initial energy of the node, tt_{round} is current combination of setup phase and steady state phase, R_m is the maximum no of round comprised of data sensing and transmission to the sink node.

After all these calculation for finding the new threshold equation $[T(n)_v]$ for each node for finding the CHs for each round of setup and steady phase, the rest of the procedure i.e. sending of information from the sensor nodes to their respective CHs at their allocated TDMA slots, aggregation process at the CHs and sending of aggregated information to the BS with the help of CSMA algorithm for avoiding collision in the network are same as the LEACH routing protocol.

The changes done in ILEACH routing protocol along with above alternation in the threshold equation for better CH choosing in the clustering process for making compatible with LEACH are as follows,

a. *PRIORITY ALGORITHM* is same as described before in LEACH modification.
b. *TDMA ALGORITHM* is same as described before in LEACH modification.

We have added the random algorithm (RANDOM FUNCTION)for calculating energy dissipation of normal sensor nodes and CH nodes that had been described before in this section. We have also added a radio energy model (ENERGY MODEL) for the Tx (transmitter) and Rx (receiver) of the sensor nodes for calculating the energy dissipation of the node while sending of information to other nodes and receiving information from the other nodes so that it will be helpful for calculate the remaining energy of the node and also calculate the remaining energy of the network when the simulation process ends. The equations been used for this is been explained before in this section. We are also checking the result if we add these two methods for calculating the dissipated energy of

the nodes in an alternative way. The result has been shown in further section.

V. Simulation Results

In this section, we want to present how our new protocol performance goes increased compared to conventional LEACH routing protocol under some system simulation parameters and how we are able to get higher life time compared to the original LEACH protocol. We did our simulation in NS2 simulation tool for showing our simulation result.

We have created a homogeneous wireless sensor network scenario and we randomly deployed 80 sensor nodes in the simulation area. We have took the dimension of the topology area is 900 X 900 m^2. We have set range for every node is to 40 m. we have set max_queue for every node to 40. We did our simulation for 100 mSec. We have set initial energy for every node to 20 KJ. The BS position is also set to random i.e. we did not set any fixed dimension to the BS. The BS color is set to black. In every round the colors for every cluster would get change, for this we had defined 7 colors. The system parameters we have used in our simulation are summarized in Table 1 and the simulation results are shown in the Figure 2, Figure 3,

PARAMETERS	NOTATION	VALUE
No of Nodes	N	80
Network Size	x * y m^2	900 * 900
BS Location	(x, y) m	Random
No of rounds	Rm	15
Cluster Head Probability	P_c	0.2
Initial Energy	E_i	20 KJ
Simulation Time	Tsim	40 Sec
Maximum Queue Length for Nodes	Qlen	40
Communication range for Sensor Nodes	Crnag	40 m
Energy of Electronics	E_{elc}	0.3 J
Energy of Free Space and Multi-path Fading	E_m	0.4 J
Data Packet Size	K	500 bits

Table1. System parameters used in simulation experiment

In this section, we also evaluate the performance the proposed routing protocol with the conventional LEACH routing protocol. We are evaluating the lifetime of the network by considering two terms that are FND (first node die) and HND (half of nodes die). We have successfully implemented our proposed protocol and it is showing better performance compared to conventional LEACH protocol in terms of better lifetime of the network. The result of this simulation is shown in the Figure 2 and Figure 3 by plotting no of round values (no of rounds) in Y-axis and in the Y-axis we have shown LEACH and ILEACH as bar graph. We got these two graphs by applying RANDOM FUNCTION algorithm as an energy dissipation process for the sensor nodes and CH nodes in the network.

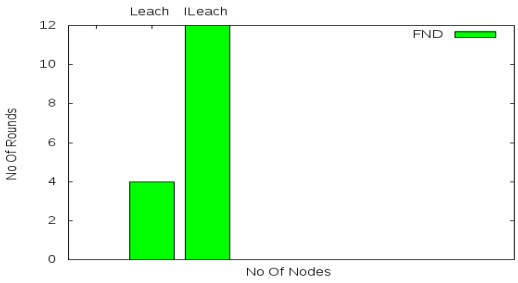

Fig. 2 Lifetime Comparison in terms of FND

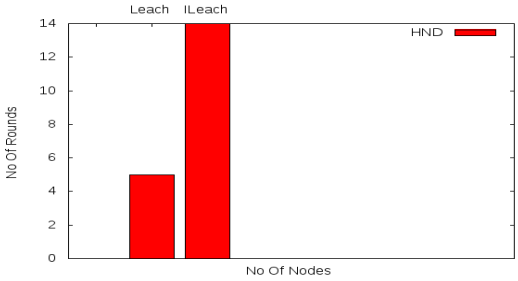

Fig. 3 Lifetime Comparison in terms of HND

In this section, we have also evaluate the performance the proposed routing protocol with the conventional LEACH routing protocol by taking ENERGY MODEL into the account for calculating the energy dissipation of the sensor nodes and CH nodes. We have also considered FND and HND for this evaluation. We have successfully got our expected results in this evaluation i.e. better performance in ILEACH protocol compared to conventional LEACH protocol in terms of better lifetime of the network. The result of this simulation is shown in the Figure 4 and Figure 5 by plotting no of round values (no of rounds) in Y-axis and in the Y-axis we have shown LEACH and ILEACH as bar graph.

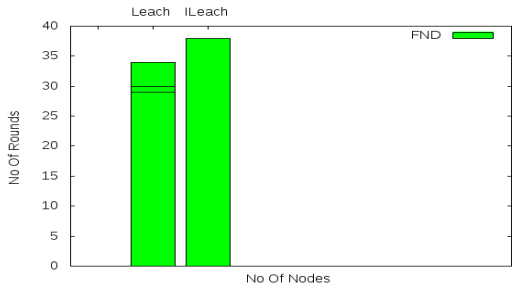

Fig. 4 Lifetime Comparison in terms of FND

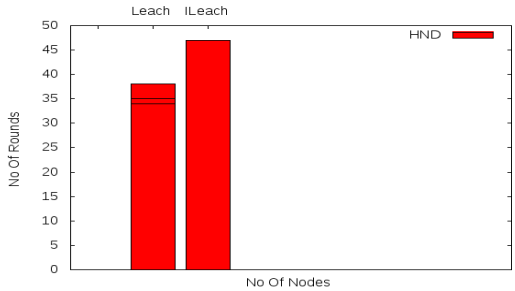

Fig. 5 Lifetime Comparison in terms of HND

From the above figures 2,3 and figures 4,5 we have successfully shown that we got our better performance evaluation in ILAECH protocol in compared to conventional routing protocol. We have also seen that if we go for ENERGY MODEL, we able to get more no of rounds in LEACH and ILEACH routing protocol as compared to if we go for RANDOM FUNCTION. It is clearly shown that if we go for ENERGY MODEL we able to get rounds in the range of 30 to 50 but, if we go for RANDOM FUNCTION we able get rounds in the range of4 to 12.

In this section we have also evaluated the propagation delay i.e. receiving of emergency (PROITARIZED) packets to the BS with respect to normal (NON PROITARIZED) packets, so that we can say that with this additional feature in the algorithm we can able to get less propagation delay in sending emergency packets. We have added these additional features in both LEACH routing protocol and ILEACH routing protocol and therefore we are showing delay graph for both LEACH and ILEACH routing protocol with respect to NON PRIORITIZED packets and PROITARIZED packets in the Figure 6 and Figure 7.. We have calculated the delay in mSec (Millisecond). We have plotted two graphs for showing this result and for this we have taken delay values (delay) into Y-axis and no of rounds values in X-axis.

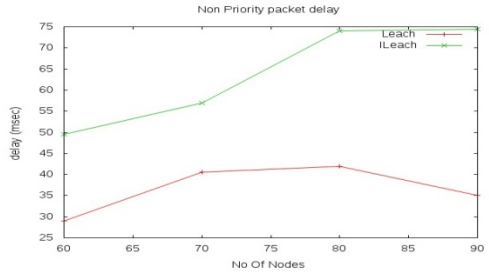

Fig. 6 NON PRIORITIZED Packet Delay in LEACH and ILEACH routing protocol

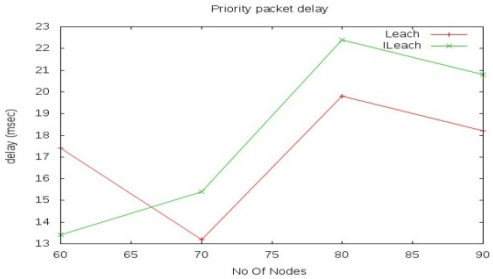

Fig. 7 PRIORITIZED Packet Delay in LEACH and ILEACH routing protocol

In this section, we also have evaluated total remaining energy of the network for both LEACH and ILEACH routing protocol. We are getting greater remaining energy in ILEACHin compared to LEACH routing protocol. We expressed the total remaining of the network in Joules (J). We have plotted a graph for showing this result in the Figure 8.

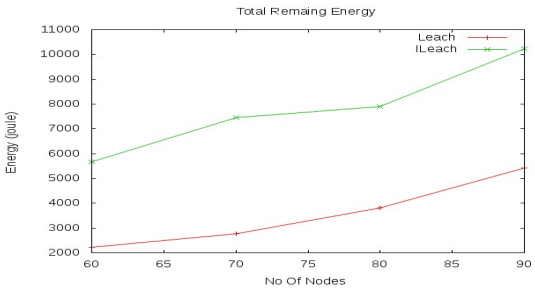

Fig. 8 Total Remaining Energy of network for LEACH and ILEACH routing protocol

VI. Conclusion And Future Enhancement

In Wireless Sensor Network the purpose of developing energy efficient routing protocol is for only getting the highest performance from the network. Among many of the energy efficient routing protocols clustered routing is one of the best suited for this type of network for prolonging life time of the network. As though LEACH routing protocol is one of the best routing protocol in this clustering section, but in this protocol the problem would arise when the battery power of the CH goes very low as it could not able to send information to the BS. In this paper, we proposed a new version of LEACH routing protocol called ILEACH and we compared this with the conventional LEACH. By doing this comparison we found ILEACH having greater performance (network lifetime) with respect to two factorsFND and HND respectively. We also showed a comparison between two models that are ENERGY MODEL and RANDOM FUNCTION and we got a greater performance if we add ENERGY MODEL as an energy dissipation model. We also showed that we able to get maximum number of remaining energy of the network at the end of simulation process in ILEACH compared to LEACH

We also work on network delay factor i.e. on delivery of message to BS as quickly as possible. We are specifying this work for time critical packet of information. We showed that as compared to NON PRIORITIZED packets we got less delay in case of PRIORITIZED packetcompared to NON PRIORITIZED packet. As a future enhancement we would like to change the CH selection function so that we able to get much better performance in the battery life time of the sensor nodes. We also would like to work on better routing of emergency packets in case of critical situation of the sensor network which is been deployed for most of the critical scenario.

References

[1] QiaoXuegong and Chenyan “A Control Algorithm Based on Double CH for Heterogeneous Wireless Sensor Network” in 2nd International Conference on Industrial and Information Systems, Vol.1, 2010, pp. 541-544.

[2] Shio Kumar Singh, M P singh D K singh , “A Survey of Energy-Efficient Hierarchical Cluster-Based Routing in Wireless Sensor Networks” in Int. J. of Advanced Networking and Applications, Vol. 02, Issue 02, 2010, pp. 570-580.

[3] Naveen Kumar, JasbirKaur, “Improved LEACH Protocol for Wireless Sensor Networks.” in Proceedings of 7th International Conference on Wireless Communications Networking and Mobile Computing, Wuhan, China, 2011.

[4] Rupesh Mehta, AbhishekPandey, Pratik Kapadia, "Reforming Clusters Using C-LEACH in Wireless Sensor Networks", in International Conference on Computer Communication and Informatics, 2012.
[5] JiaXu,Ning Jin, XizhongLou,TingPeng,QianZhou,Yanmin Chen "Improvement of LEACH protocol for WSN" 2012 IEEE.
[6] Parminder Kaur1, Mrs. MamtaKatiyar, "The Energy-Efficient Hierarchical Routing Protocols for WSN: A Review" in International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 2, Issue 11, November 2012, pp. 194-199.
[7] RENGUGADEVI G & SUMITHRA M.G, "HIERARCHICAL ROUTING PROTOCOLS FOR WIRELESS SENSOR NETWORK–A SURVEY" in International Journal of Smart Sensors and Ad Hoc Networks (IJSSAN), Vol. 2, Issue 1, 2012, pp. 71-75.
[8] Ali Norouzi1, Abdul HalimZaim, "An Integrative Comparison of Energy Efficient Routing Protocols in Wireless Sensor Network", in Scientific Research of Wireless Sensor Network, Vol. 4, 2012, pp. 65-67.
[9] J.Gnanambigai, Dr.N.Rengarajan, K.Anbukkarasi, "Leach and Its Descendant Protocols: A Survey", in International Journal of Communication and Computer Technologies, Vol. 01, No.3, Issue 02, September 2012, pp. 15-21.
[10] M. Aslam, N. Javaid, A. Rahim, U. Nazir, A. Bibi, Z. A. Khan, "Survey of Extended LEACH-Based Clustering Routing Protocols for Wireless Sensor Networks" in 11 july, 2011, arXiv:1207.2609v1 [cs.NI].
[11] RavneetKaur, Deepika Sharma and NavdeepKaur, "Comparative Analysis Of Leach And Its Descendant Protocols In Wireless Sensor Network" in International Journal of P2P Network Trends and Technology, Vol. 3, Issue 1, 2013, pp. 51-55.
[12] Mian Ahmad Jan, Muhammad Khan, "A Survey of Cluster-based Hierarchical Routing Protocols" in IRACST – International Journal of Computer Networks and Wireless Communications (IJCNWC), Vol.3, April 2013, pp. 138-143.
[13] Nitin Mittal, Davinder Pal Singh, AmanjeetPanghal, R.S. Chauhan, "IMPROVED LEACH COMMUNICATION PROTOCOL FOR WSN", in National Conference on Computational Instrumentation CSIO, Chandigarh, India, 19-20 March, 2010, pp. 153-156.
[14] Ashish Christian, Dr.HimanshuSoni, "Lifetime prolonging in LEACH Protocol for Wireless Sensor Networks", in IEEE TRANSACTIONS ON MOBILE COMPUTING, Vol. 1, Jan 2013, pp. 350-355.