ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

ADVANCEMENT IN LEACH PROTOCOL: A REVIEW

Ankur Singh Bist*, Mohd. Mursleen
* KIET Ghaziabad
COT Pantnagar

ABSTRACT

WSN is a set of connected tiny devices (sensor nodes) with limited energy resource. WSNs have ability to extract the information from the harsh and hostile environment without human interaction. Once, WSN is deployed, it is impossible to recharge or replace the energy resource due to inaccessibility of nodes. So, network lifetime and fault tolerance are critical parameters. It's become very important to handle energy resource carefully as it plays vital role in prolonging the network lifetime. In this paper WSN ADVANCEMENT IN LEACH PROTOCOL Routing Protocols are discussed to enhance the deep understanding of underlying issues in this domain.

KEYWORDS: Leach Protocol

INTRODUCTION

CURRENT RESEARCH SCENARIO

Manjeshwar and Agrawal(2001)have proposed another hierarchical routing protocol TEEN (Threshold sensitive Energy Efficient sensor Network protocol)for reactive networks that responds immediately to changes in the relevant parameters of interest. During the whole lifetime of the reactive network each sensor nodes (SNs) continually sense the environment and are not supposed to go in sleep mode. In this protocol a clusters head (CH) broadcasts a hard threshold value and a soft one to its members. Hard threshold is an absolute threshold value for the sensed attributes. Soft threshold is a small change in the value of the sensed attribute. The nodes sense their environment continuously. The first time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends its sensed data. The nodes will then transmits data in the current cluster period if the following conditions are true: the current value of the sensed attribute is greater than the hard threshold, and the current value of the sensed attribute differs from sensed value by an amount equal to or greater than the soft threshold. Proposed protocol performs better in terms of energy spend in transmitting messages to the CH.

Heinzelman*et al.* (2002) proposed LEACH-C, which uses centralized clustering mechanism to form the clusters. Since LEACH selects the cluster head randomly, two or more CHs may be placed very close to one another that cause member nodes to bridge long distance to transmit the data. It results in draining the battery power. Also clustering is adaptive, it may obtain a poor clustering. LEACH-C proposes to overcome such clustering issues by dispersing cluster head nodes throughout the network. This is because the BS has global knowledge of the location and energy of all the nodes in the network, so it can produce better clusters that require less energy for data transmission. Each node is considered to have enough energy to reach the base stationand GPS system to locate the nodes. LEACH-C also has two phases as LEACH but it differs in setup phase. BS ensures evenly distribution of energy among the nodes. Every node sends the energy level and current location (determined by GPS) to base station. For effective clustering, BS calculates the average node energy in the network, nodes that have energy below average node energy cannot be cluster heads for the current round. Remaining nodes have the possibility to become a cluster head. BS uses simulated annealing algorithm to solve the NP-hard problem of finding optimal number of clusters. This algorithm attempts to minimize the amount of energy for the non-cluster head nodes to transmit their data to the cluster head, by minimizing the total sum of squared distances between all the non-cluster head nodes and the closest cluster head. Once the cluster heads and associated

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

clusters are established, BS broadcasts the clusters head IDs. If a node's ID matches with the cluster head ID, it becomes a cluster head, otherwise wait for its TDMA slot to transmit the data to CH and goes to sleep until its time to transmit data. The steady-state phase of LEACH-C is identical to that of LEACH.

Handy *et al.* (2002) propose LEACH with deterministic cluster head selection. This work proposes a modification of LEACH's stochastic cluster head selection algorithm by deterministic cluster head selection component. The stochastic cluster-head selection does not lead to minimum energy consumption during data transmission within a cluster. Cluster heads can be located near the edges of the network or adjacent nodes can become cluster heads. In these cases some nodes have to bridge long distances to reach a cluster-head. Authors compare the LEACH with the proposed method by introducing three new matrices, first-node-dies (FND), half of the nodes alive (HNA) and last node dies (LND). To replace the stochastic selection method by a deterministic element, authors modify the threshold equation to select the CHs.

$$T(n)_{new} = \frac{P}{1 - P\left(r \bmod \frac{1}{P}\right)}\left[\frac{E_{n\_current}}{E_{n\_max}} + \left(r_s div\ \frac{1}{P}\right)\left(1 - \frac{E_{n\_current}}{E_{n\_max}}\right)\right]$$

Where r_s is the number of consecutive rounds in which a node has not been cluster-head, $E_{n\_current}$ is the residual energy of n^{th} node and E_{n_max} is the initial energy of nodes. When r_s reaches the value 1/P, the threshold $T(n)_{new}$ is reset to the value it had before the inclusion of the remaining energy into the threshold-equation. Thus, the chance of a node *n* to become cluster head increases because of a higher threshold. Simulations show that such a modification of the cluster-head threshold can increase the lifetime of a LEACH micro sensor network by 30 % for FND and more than 20 % for HNA.

Lindsey and Raghavendra (2002) proposed an enhancement over the LEACH protocol known as Power-Efficient Gathering in Sensor Information Systems (PEGASIS). The main idea of PEGASIS protocol is for each node to receive from and transmit to closest neighbors and take turns in communicating with the BS in order to extend network lifetime. It is a near optimal chain-based protocol. When all nodes complete the round of communication with the BS, a new round starts, and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes. Hence, PEGASIS has two main objectives. First, increase the lifetime of each node by using collaborative techniques. Second, allow only local coordination between nodes that are close together so that the bandwidth consumed in communication is reduced. Unlike LEACH, PEGASIS does not organize the network into clusters rather build up neighbor nodes in a chain and let one of them to transmit the data to the BS. To find the closest neighbor node in PEGASIS, signal strength is used to measure the distance to all neighboring nodes and then adjusts the signal strength so that only one neighbor node can be heard. The chain in PEGASIS will consist of those nodes that are closest to each other and form a path to the BS. Each node fuses its data with the received message from the neighbor node and transmits to the next neighbor in the chain. Any node in the chain will be sent aggregated data to the BS and the nodes in the chain will take turns sending to the BS. The chain is formed by using the greedy algorithm. Simulation results showed that PEGASIS is able to increase the lifetime of the network twice that under the LEACH protocol. Although the clustering overhead is removed, PEGASIS still requires dynamic topology adjustment since a sensor node needs to know about the energy status of its neighbors in order to know where to route its data. Such topology adjustment can introduce significant overhead, especially for highly utilized networks. Moreover, PEGASIS assumes that each sensor node is able to communicate with the BS directly. In practical cases, sensor nodes use multi hop communication to reach the BS. Also, PEGASIS assumes that all nodes have knowledge of the network and all have the same level of energy and are likely to die at the same time. PEGASIS introduces excessive delay for distant nodes on the chain. In addition, the single leader can become a bottleneck.

Cui (2007)has proposed an enhancement in LEACH's cluster head selection algorithm by considering the network load balance, multihop, residual energy of nodes and other relative parameters. LEACH elects the CHs depending on the number of rounds from which a node is not selected as a CH. A node cannot be selected for CH until 1/p rounds from the current round, where p is the percentage of cluster heads. It may cause some nodes with small amount of energy die quickly. To prevent from such an unstable situation, author proposed a timer approach for CH selection. In set up phase each node produce a timer which is inversely proportional to the remaining energy. Each node generates a random number between 0 and 1 when timer value is reached. The generated number is compared with threshold as in LEACH, if it qualifies the CHs criteria than it broadcast the message to be a CH. If other nodes receive the cluster information before the timer reaches, it canceled the timer and join one of the appropriate cluster. Results showed that proposed method obtain longer live time and fair CH selection.

Xiangning and Song (2007) have proposed two modified protocols of LEACH as Energy-LEACH and Multihop-LEACH. Energy-LEACH protocol improves the way of selection of CH by considering the residual energy of nodes as the main matrix. Upon this residual energy matrix, proposed method decides whether a node is CH to next round or not. The nodes with higher residual energy have more chance for selection of CH in the very next round and prevent the whole network to die too early. Multihop-LEACH protocol improves the communication among the CH and sink. Some of the CHs are far away from the BS. They have to bridge long distance to reach the BS. Proposed method finds the optimal multihop path and allows sending the information to the BS. The results obtained by adopting these two approaches show considerable improvements in the proposed scheme compared to the earlier schemes of its category.

Junping*et al.* (2008) has presented a Time-based Cluster-Head Selection Algorithm for LEACH (TB-LEACH). Two major modifications have done to achieve the goal. First, each node will not choose a random number for cluster head competition instead will choose random time interval. Nodes which have the shortest time interval wins the competition and become cluster heads. Second, TB-LEACH makes constant the number of CHs. In order to achieve the constant number of CHs, a counter is set. When the number of CHs in a particular round reached the specified counter value, nodes no longer continue competition for CHs. Simulation results showed that TB-LEACH outperforms LEACH by 20% to 30% in terms of network lifetime.

Hou*et al.* (2009) has proposed Energy and Distance LEACH (EDL) by taking residual energy and distance of SNs as the key parameters. The proposed scheme performs CHs distribution in actual limited regions more uniformly and thus avoiding unnecessary energy loss which is due to the short distance between CHs. In data transmission stage, single hop communication mode is used among either SNs nodes or CH and sink node. The proposed protocol is suitable for both homogeneous and heterogeneous networks.

Liu *et al.*(2009)proposed a new clustering mechanism based on LEACH protocol (M-LEACH). Authors proposed two improvements on LEACH protocol. First, an improved approach is presented for adjusting the node threshold by multiplying the energy ratio factor to the classical LEACH threshold. Second, each node has to join the optimal cluster which is given by the following equation

$$F = w1 * \frac{E_{n\_residual} - E_{n\_initial}}{E_{n\_initial}} + w2 * \frac{d_{to\_ch}}{MAX_{\_d\_to\_ch}} + w3 * \frac{d_{to\_bs} - MIN_{\_d\_to\_bs}}{MAX_{\_d\_to\_bs} - MIN_{\_d\_to\_bs}}$$

Where, w1, w2 and w3 are the weights whose sum is equal to 1,$E_{n_residual}$is the current residual energy ofcandidate CH nodes,$E_{n\_initial}$ is the initial energy of candidate CH nodes, $d_{to_ch}$is the distance to between node and CH, $MAX_{\_d\_to\_ch}$ is the farthest range from cluster head nodes, $MAX_{\_d\_to\_bs}$ is the farthest distance from all the cluster head to BS while $MIN_{\_d\_to\_bs}$ is shortest.M-LEACH extends system lifetime 10% in terms of FND, 7% in terms of HNA.

Farooq*et al.* (2010) has proposed Multi-hop Routing with Low Energy Adaptive Clustering Hierarchical (MR-LEACH) protocol. It partitions the network into different layers of clusters. MR- LEACH introduced the concept of equal clustering, i.e., any node in the given cluster layer will reach the BS in equal number of hops. Major contributions of MR-LEACH were to reduce the average distance of each CH from its upper level CH so that in reaching the BS, the energy consumption is distributed among different CHs which results in longer network lifetime. Selection of CHs at second and other subsequent levels is made by the BS so that the computational cost at SNs level can be reduced. It works in the following three phases: cluster formation at the lowest level, cluster discovery at different levels by BSand scheduling. In the cluster formation at the lowest level, each node broadcast the HELLO message to its neighboring nodes within the transmission range. Each node maintains the table about the node ID, residual energy and current status. If a particular node has highest residual energy than all its neighboring nodes then it will elect itself as CH. In the second phase, BS locates the CH using the broadcast message. BS broadcasts its id to all the CHs which are one hop away from it and in reply the CHs also send their id and layer on which they are operating. After CH formation, a TDMA schedule is

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

performed for sending the data to CH to BS. The performance of the proposed MR-LEACH was found better than LEACH in terms of energy consumption and network lifetime.

Xu*et al.* (2010) has proposed Improved LEACH Cluster Head Multi-hops Algorithm in Wireless Sensor Networks (LEACH-R). Authors analyzed the LEACH protocol and put forward the improvement on LEACH by considering the CH multihop, node energy, optimal number of cluster head, CHs selection and limiting the number of nodes within a cluster parameters to balance energy depletion of each node. LEACH-R puts the restriction on the size of a cluster by defining the upper and lower limit on the number of nodes within the cluster. Clusters which are near the BS have smaller number of nodes making cluster heads consume less energy. In data transmission, the main idea is to find the cluster head which has shortest distance from the BS to all the cluster heads and finding the shortest distance between this cluster and another cluster head. Based on this, it established reverse shortest path. After establishing the path, CHs transmit data to the BS. The experiments showed that proposed methodology effectively balanced the node energy and extend the network lifetime.

Tong and Tang (2010) have proposed Balanced LEACH (LEACH-B) protocol that overcomes from the problems of fluctuation of the number of CHs.For the CH selection, it considered the residual energy of SNs as the parameter. Moreover, it has been found that the proposed protocol gives theconstant number of CHs and is near optimal per round. In the inception round, this scheme select the CH based upon the LEACH protocol and in the second round node residual energy parameter is considered for CH selection.

Xunbo*et al.* (2010) has proposed An Improved LEACH (LEACH_Sin) For Clustering Protocols in WSNs that solve the problem of the asymmetrical distribution of the CHs in LEACH. To select the CHs in a round, LEACH_Sin modifies the threshold equation in **(Heinzelman*et al.*, 2000)** by multiplying it with the proposed adjustment function which considers distance between nodes & the BS and round number. A node may be a CH depending on the threshold value.All the SNs in the network have equal chances to become the CH that balance the energy consumption. This new adjustment function provides symmetrical distribution of CHs in network. Simulation results show that the parameter FND has the improvement of 14%, in other words, the lifetime of the network is prolonged.

Based on the above problems, authors have designed ER-LEACH protocol that enhances the lifetime of WSNs through load balancing using following steps:

I. By enhancing the selection of the CH during setup phase.
II. By using an alternative CH to take the role of the CH in case that the underlying CH dies.
III. By using zone routing protocol for load balancing of WSNs.
IV. By performing well especially when the mobility is very high.

Bakr andLilien(2011)proposed LEACH-SM protocol by enhancing it with an efficient management of spares. In LEACH-SM, authors added a new phase called spare selection phase to LEACH. LEACH-SM reduces the energy-consumption inefficiencies of LEACH by identification of spares alone that increases the overall WSN lifetime. Spare phase follows the setup phase, and is followed by the regular operation of the WSN. Spare selection is done by running the Decentralized Energy efficient Spare Selection Technique (DESST). Each node in all clusters runs DESST in parallel to decide whether it should become a spare or not. It is done in such a way that the above-threshold target coverage is maintained by the WSN. All spares go asleep in terms to conserve energy and awakened when the probability that any primary node exhausted its energy reaches a predefined value. As the result, WSN's lifetime is extended.

Liu *et al.* (2011) has proposed Genetic Algorithm-Based Energy-Efficient Adaptive Clustering (LEACH-GA) Protocol for Wireless Sensor Networks with an optimal probability prediction to achieve long lifetime of the network. Before the first round, an additional preparation phase is added followed by the setup and steady state phases. In preparation phase, each node perform CHs selection procedure and then send messages with their status of being a CH or not, IDs and current positions to the BS. After receiving the messages from all nodes, BS searches for an optimal probability of nodes being CHs using genetic algorithm by minimizing the total energy consumption required for completing the round. Simulation results show that proposed protocol outperforms minimum transmission energy (MTE), direct transmission (DT) and LEACH protocols in terms of network lifetime.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

Padmanabhan and Kamalakkannan (2012)have proposed another energy efficient hierarchical routing protocol for WSNs. Authors proposed a modified energy efficient base station controlled dynamic clustering protocol (EBCDCP) in which CHs are selected on the bases of residual energy by the BS. BS uses iterative cluster splitting algorithm to find the number of clusters and CHs. A balanced clustering technique is used to make all the clusters equal in size. Minimum spanning tree algorithm is used to connect the CHs. All the member nodes send their sensed data to the associated CHs. CHs selects one of them as a leader dynamically and all other CHs have to send their data to the selected leader in term to transmit to the BS. The simulation results show that EBCDCP improves network lifetime by utilizing high energy BS and CH-to-CH routing scheme to transfer fused data to the BS.

Zhao *et al.* (2012) has improved LEACH routing communication protocol for WSNs. In this work, authors introduced the idea of vice CH. The classical hierarchical protocols such as LEACH and LEACH-C waste certain amount of energy in reclustering after every steady state phase. Proposed scheme introduces the concept of vice CH (VCH). During data transmission, each CH learns about the status of their member nodes. Based on the residual energy, CH appoints a member node as a CH for next round. Proposed scheme modifies the traditional equation for selecting the CHs by taking dynamic change of nodes' energy into consideration as follows.

$$T(n) = \begin{cases} \dfrac{p}{1 - p * (r \bmod \frac{1}{p})} \times \left[\dfrac{E_{n\_current}}{E_{n\_init}} + \left(1 - \dfrac{E_{n\_current}}{E_{n\_init}}\right) \times \dfrac{p}{CH_{\_times} + VCH_{\_times} + 1}\right] & if\ n \in G \\ 0 & Otherwise \end{cases}$$

Where E_{n_init},$E_{n\_current}$ are the initial and current energy of nodes respectively and $CH_{\_times}(VCH_{\_times})$ is the time of being selected for CH (VCH). In this work, authors used the member nodes' information dynamically achieved by CHs in the steady phase to choose the vice cluster heads (VCHs) which take over the role of cluster heads in the later period of steady phase. Comparing with the traditional LEACH and LEACH-C, the VCHs proposed will diminish the frequency of reclustering in the same interval and prolong the time of being in steady-state phase, which will prolong the lifetime of the whole network.

CONCLUSION

This paper gives a brief overview about ADVANCEMENT IN LEACH PROTOCOL. Lots of advancements are going on in this specific domain. Continuous evolution in this area has added various dimensions in base atoms of concerned area. This study will be helpful for those working in the area ADVANCEMENT IN LEACH PROTOCOL.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the many people who have assisted me during this. Special thanks must go to my guide Prof. Balaji Nelge for their continued support, guidance and friendship. Also I would like to give special thanks to my co-guide Prof. Ketan Dhumal.

REFERENCES

[1] Acs, G. and Buttyan, L. 2007. A taxonomy of routing protocols for wireless sensor networks, Budapest University of Technology and Economics, Hungary. Available: www.hiradastechnika.hu/data/upload/file/2007/2007 1a/HT 0701a-7.pdf
[2] Agre, J. And Clare, L. 2000. An Integrated Architecture for Cooperative Sensing Networks. IEEE Computer Magazine. 33(5):106–108.
[3] Akyildiz, I., Su, W., Sankarasubramaniam, Y and Cayirci E. 2002. A Survey on Sensor Network, IEEE Communication Magazine, 40(8), 102-114.
[4] Al-Karaki, J. N. and Kamal, A.E. 2004. Routing Techniques in Wireless Sensor Networks: A Survey, IEEE Wireless Communications,11:6–28.
[5] Al-Refai H., Al-Awneh A., Khaldoun, B., Amer, A. A. and Rahman, Y. M. 2011. Efficient routing LEACH (ER-LEACH) enhanced on LEACH protocol in wireless sensor networks. Part I. International Journal of Academic Research. 3(3):42–48.
[6] Bakr, B. A., and Lilien, L. 2011. Extending Wireless Sensor Network Lifetime in the LEACH-SM Protocol by Spare Selection. IEEE. 277 – 282.
[7] Bonnet, P., Gehrke, J. and Seshadri, P. 2000. Querying the Physical World. IEEE Personal

Communications. 7(5):10–15, doi: 10.1109/98.878531

[8] Cordeiro, C. and Agrawal, D. P. 2006. Ad hoc & Sensor Networks, Theory and Applications. World Scientific Publishing. 256-682.

[9] Cui, X. 2007. Research and Improvement of LEACH Protocol in Wireless Sensor Networks. International Symposium on Microwave, Antenna, Propagation, and EMC Technologies For Wireless Communications. IEEE 251-254.

[10] Dai, S., Jing, X. and Li, L. 2005. Research and analysis on routing protocols for wireless sensor networks. Communications, Circuits and Systems Proceedings, International Conference on IEEE.1:407–411.

[11] Deng, J., Han, R. and Mishra, S. 2003. A Performance Evaluation of Intrusion-Tolerant Routing in Wireless Sensor Networks. IEEE Workshop on Information Processing in Sensor Networks, (IPSN).

[12] Duan, S. and Yuan, X. 2006. "Exploring hierarchy architecture for wireless sensor networks management," IFIP International Conference on Wireless and Optical Communications Networks 6, 11-13.

[13] Farooq M. O., Dogar A. B. and Shah G. A. 2010. MR-LEACH: multi-hop routing with low energy adaptive clustering hierarchy. In: Fourth international conference on sensor technologies and applications. IEEE. 262–268.

[14] Feng, J., Koushanfar, F. and Potkonjak, M. 2005. Sensor Network Architecture. Chapter 12, Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems, CRC press (Edited By Mohammad Ilyas abnd Imad Mahgoub). ISBN 0-8493-1968-4. doi: 10.1201/9780203489635.sec3

[15] Handy, M.J., Haase, M. and Timmermann D. 2002. Low energy adaptive clustering hierarchy with deterministic cluster-head selection. IEEE.4(2):6–9.

[16] Hassanein, H. and Luo, J. 2006. Reliable energy aware routing in wireless sensor networks.

[17] Second IEEE Workshop on Dependability and Security in Sensor Networks and Systems 4, 54–64.

[18] Heinzelman, W., Chandrakasan, A. and Balakrishnan, H. 2000. Energy-Efficient Communication Protocol for Wireless Microsensor Networks, Proc. 33rd Hawaii Int'l. Conf.Sys. Sci.

[19] Heinzelman, W., Chandrakasan, A. and Balakrishnan, H. 2002. An application-specific protocol architecture for wireless microsensor networks. IEEE Transactions on Wireless Communications 1, 660–670.

[20] Hill, J. L. 2003. System architecture for wireless sensor networks. University of California, Berkeley, Ph.D. dissertation.

[21] Hoblos, G., Staroswiecki, M. and Aitouche, A. 2000. "Optimal Design of Fault Tolerant Sensor Networks," IEEE Int'l. Conf. Cont. Apps., Anchorage, AK, Sept. 2000, pp. 467–72.

[22] Hou R., Weizheng, R. and Zhang Y. 2009. A wireless sensor network clustering algorithm based on energy and distance. In: Second international workshop on computer science and engineering, (WCSE) IEEE. 439–42.

[23] Jiang, Q. and Manivannan, D. 2004. Routing protocols for sensor networks. IEEE Consumer Communications and Networking Conference. 93–98.

[24] Jolly, V. and latifi, S. 2006. Comprehensive study of routing management in wireless sensor. Available: www.larces.uece.br/ celestino/RSSF%20II

[25] Jone, C., Chen, J., Sivalingam, K., and Agrawal, P. 2001. A Survey of Energy Efficient Network Protocols for Wireless networks. Journal of Wireless Networks. 7(4): 343-358.

[26] Junping, H., Yuhui, J. and Liang, D. 2008. A Time-based Cluster-Head Selection Algorithm for LEACH (TB-LEACH). IEEE. 1172-1176.

[27] Kahn, J. M., Katz, R. H. and Pister, K. S. J. 1999. "Next Century Challenges: Mobile Networking for Smart Dust," Proc. ACM MobiCom '99, Washington, DC, 1999, pp. 271–78.

[28] Krishnamachari, B., Estrin, D. and Wicker, S. 2002. The Impact of Data Aggregation in Wireless Sensor Networks. International Workshop on Distributed Event-Based Systems, (DEBS '02), Vienna, Austria.

[29] Karl, H. and Willig, A. 2005. PROTOCOLS AND ARCHITECTURES FOR WIRELESS SENSOR NETWORKS. England, John Wiley & Sons Ltd. P.54

[30] Kumar, N. and Tyagi, S. 2012. A systematic review on clustering and routing techniques based upon LEACH protocol for wireless sensor networks. Journal of Network and

Computer Applications Elsevier Ltd. 36:623-645.
[31] Li, L., Dai, S. and Jing, X. 2005. Research and analysis on routing protocols for wireless sensor networks. Communications, Circuits and Systems Proceedings, International Conference on IEEE. 1:407–411.
[32] Lindsey, S. and Raghavendra, C. S. 2002. PEGASIS: Power-Efficient Gathering in Sensor Information Systems, IEEE Aerospace Conf. Proc. 3:1125–30.
[33] Lindsey, S., Raghavendra, C. S. and Sivalingam, K. 2002(b). Data Gathering in Sensor Networks using the Energy*Delay Metric. Proc. of the IPDPS Workshop on Issues in Wireless Networks and Mobile Computing, San Francisco, CA.
[34] Liu, J. L. and Ravishankar, C. V. 2011. LEACH-GA: Genetic Algorithm-Based Energy Efficient Adaptive Clustering Protocol for Wireless Sensor Networks. International Journal of Machine Learning and Computing. 1(1): 79-85.
[35] Liu, Y., Zhao, Y. and Gao, J. 2009. A New Clustering Mechanism Based On LEACH Protocol. International Joint Conference on Artificial Intelligence, IEEE.
[36] Loscri, V., Morabito G. and Marano, S. 2005. Two-Levels Hierarchy for low-energy adaptive clustering hierarchy(TL-LEACH). IEEE: 1809–1813.
[37] Manjeshwar, E. and Agrawal, D.P. 2001. TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks. In Proceedings of the 15th International Parallel and Distributed Processing Symposium (IPDPS), San Francisco, CA, USA.
[38] Megerian, S. and Potkonjak, M. 2003. Wireless Sensor Networks, Wiley Encyclopedia of Telecommunications. Wiley-Interscience, New York.
[39] MICAZ Mote: http://www.xbow.com.
[40] Mirembe, D. 2007. "A Model for Security Management in Ambulatory Wireless Sensor Networks (AWSN), Phd. dissertation, Makerere university, Kampala,Uganda, 2007.
[41] Padmanabhan, K. and Kamalakkannan, P. 2012. Energy Efficient Base Station Controlled Dynamic Clustering Protocol in Wireless S ensor Networks (EBCDCP). IEEE.
[42] Peng Z. and LI, X. 2010. The Improvement and Simulation of LEACH Protocol for WSNs. IEEE.
[43] Pottie, G. and Kaiser, W. 2000. Wireless integrated network sensors. Communication of the ACM. 43:51–58.
[44] Rabaey, J. M. 2000. PicoRadio Supports Ad Hoc Ultra-Low Power Wireless Networking, IEEE Comp. Mag., pp. 42–48.
[45] Shih, E., Cho, S. H., Ickes, N., Min, R., Sinha, A., Wang, A., & Chandrakasan, A. 2001. Physical layer driven protocol and algorithm design for energy-efficient wireless sensor networks. In: Proceedings of the 7th annual international conference on Mobile computing and networking, ACM, pp. 272-287.
[46] Srivastava, M., Muntz, R. and Potkonjak, M. 2001. Smart Kindergarten: Sensor-Based Wireless Networks For Smart Developmental Problem-Solving Environments. In: ACM Mobicom, Rome, Italy. pp. 132–138.
[47] Tiago, C., Jorge, M. and Fernando, W. 2006. Assessing the use of ad-hoc routing protocols in Mobile Wireless Sensor Networks. Proc. of Conference on Mobile and ubiquitous Systems, Braga. CMUS2006, 785–787.
[48] Tong, M. and Tang, M. September 2010. LEACH-B: an improved leach protocol for wireless sensor network. WiCom 23–25, p. 1–4.
[49] Xu L. L. and Jian-jun Z. 2010. Improved LEACH Cluster Head Multi-hops Algorithm in Wireless Sensor Networks (LEACH-R). Ninth International Symposium on Distributed Computing and Applications to Business, Engineering and Science, IEEE. 263-267.
[50] Xunbo L., Na L., Liang C., Yan S., Zhenlin W. and Zhibin Z. 2010. An improved LEACH for clustering protocols in wireless sensor networks. In: International conference on measuring technology and mechatronics automation. IEEE. 496–499.
[51] Ye, F., Luo, H., Cheng, J., Lu, S. and Zhang, L. 2002. A Two-Tier Data Dissemination Model For Large-Scale Wireless Sensor Networks, In Mobicom, Atlanta, USA. 148–159. doi: http://doi.acm.org/10.1145/570645.570664.
[52] Ye, W., Heidemann, J. and Estrin. D. 2004. Medium Access Control with Coordinated, Adaptive Sleeping for Wireless Sensor Networks. IEEE/ACM Transactions on Networking.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

[53] Yick, J. Mukherjee, B. Ghosal, D. 2008. Wireless sensor network survey, Computer Networks,Elsevier, vol. 52, pp. 2292-2330.
[54] Zhao, F., Xu, Y. and and Li, R. 2012. Improved LEACH Routing Communication Protocol for a Wireless Sensor Network. International Journal of Distributed Sensor Networks.