A Survey on Leach and its Enhanced Protocols in WSN

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ABSTRACT
Wireless Sensor Networks (WSN) are an promising and very appealing technology applied to different applications. They are formed by small, self organized devices that collaborate to form a large range of network with thousands of nodes covering a large area. Wide practice of wireless sensor network (WSN) is the reason of development of many routing protocols. Routing as one input technologies of wireless sensor network has currently become a hot research because the applications of WSN is everywhere, it is impossible that there is a routing protocol suitable for all applications. In WSN, due to limited power of sensor nodes, one of the key challenge is to achieve minimum energy consumption in order to maximize network lifetime. In this paper, the routing protocol of WSN are classified and described. This paper things to see a number of the drawbacks and issues in LEACH and further discussed to resolve all these problems by its enhanced protocols.

***Keywords*:** WSN, Hierarchical routing protocols, LEACH, Energy Efficiency.

1. INTRODUCTION

A wireless sensor network (WSN) consists of spatially spread self-governing sensors to examine physical or environmental conditions such as temperature, sound, pressure, etc and to cooperatively pass their data through the network to a main location. A wireless sensor network consists of a huge number of nodes widen over a particular area. A wireless sensor network (WSN) consists of thousands of low-power multi-functional sensor nodes, functioning in an unattended environment, and having sensing, computation and communication capabilities. Wireless Sensor Networks(WSN) are provoked by military applications such as battlefield examination .Today such networks are used in industrial and consumer applications such as industrial practice monitoring and control, machine health monitoring and so on. The WSN is built of "nodes"---from a small number to thousands, where every node is connected to one or several sensors. Its key components are:-sensor unit, an ADC, a CPU, a power unit. Sensor nodes are micro electro mechanical systems (MEMS) [1] that produces a experimental response to a change in a physical situation like temperature and pressure. Sensor nodes sense or determine physical data of the area to be monitored. The continual analog signal sensed by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing. Sensor nodes in WSN are of very small size, use particularly low energy and are operated in high volumetric densities. The density of the sensor nodes in the field may be as high as

20 nodes /m^3.As wireless sensor nodes are normally very small electronic devices; they can be set with a limited power source [2].

Since a sensor node has limited sensing and computation capacities, communication performance and power, a huge number of sensor devices are spread over an area of interest for collecting information (temperature, humidity, motion detection, *etc.*). These nodes can communicate with each other for sending or getting information either directly or through other intermediate nodes and therefore form a network, so each node in a sensor network acts as a router [3]inside the network. In direct communication routing protocols (single hop), each sensor node communicates straightforwardly with a control center called Base Station (BS) and sends gathered information. The base station is fixed and located far away from the sensors. Base station(s) can communicate with the end user either directly or through some existing wired network. In another approach (multi hop), data is routed via intermediate nodes to the base station and thus save sending node energy. A network with clustering is divided into several clusters. Within each cluster, one of the sensor nodes is chosen as a cluster head (CH) and with the remaining being cluster members (CM). All sensor nodes work considerately to serve the requests. Cluster head collects the data locally from the cluster members and transmits the aggregated data either directly or via multi-hop transmission to the sink. Since the cluster heads use more energy than the non-cluster heads so to distribute the workload of the cluster heads among the wireless sensor nodes their job is rotated among all nodes in order to equalize energy utilization [4]. The main problem in using these networks is limited battery life. This is due to fact that the size of a sensor node is anticipated to be small and this leads to constraints on size of its components i.e. battery size, processors, data storing memory, all are needed to be small. So a few optimization in these networks should focus on optimizing energy consumption. In WSN a lot of sensed data and routing information has to be sent so that the information can be utilized before any mash up occurs.E.g. industrial monitoring, machinery monitoring, etc. The energy power consumption is much high in data communication than internal processing. So energy preservation in WSN is needs to be addressed. Usually sensor nodes depend on a battery with limited lifetime, and their alternate is not possible due to physical constraints. Moreover the architecture and protocol of sensor networks must be able to balance up any amount of sensor nodes. Since the battery lifetime can be extended if we manage to reduce the amount of communication, caching only the useful data for each sensor either in its local store or in the neighborhood nodes can prolong the network lifetime[5],[6].

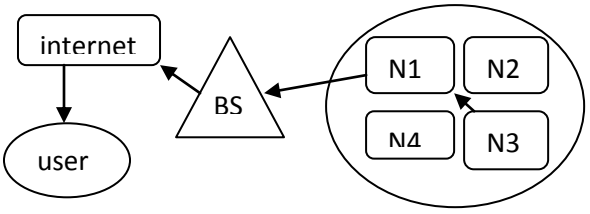

Figure1: Wireless sensor network

In this paper, we have presented the LEACH protocol including its advantages and disadvantages and then further eliminated all its drawbacks by introducing its enhanced protocols.

2. ROUTING PROTOCOL

A routing protocol[7] is a protocol that defines how routers (sensor nodes) communicate with each other, disseminating information that enables them to choose routes between any two nodes on the network, the selection of the route is done by routing algorithms.

3. CLASSIFICATION OF ROUTING PROTOCOLS

Hierarchical: The main intend of hierarchical routing is to efficiently retain the energy consumption, as higher energy nodes are used to process and send the information and low energy nodes are used to carry out the sensing[8]. Eg: LEACH, TEEN, APTEEN, PEGASIS.

Data centric: It is query based and thus eliminates the redundant transmission. Here, the BS sends queries to a certain region for information and waits for reply from the nodes of that particular region. SPIN[9] is the first data centric protocol, which consider data transmission between the nodes in order to eliminate redundant data and save energy. Eg: SPIN, DD.

***Location based*:** It is based on the location information of the sensor nodes in order to calculate the distance between two particular nodes so that energy consumption can be estimated. It performs well when the density of the network increases and is poor when the deployment is sparse.
Eg. GEAR,GAF.

4. ROUTING PROTOCOLS IN WSN

4.1 LEACH (Low Energy Adaptive Clustering Hierarchy):

It is the most popular hierarchical routing protocol for wireless sensor networks. LEACH is a cluster-based routing protocol where the network is divided into clusters and each cluster has a cluster head, which collects all the data from all the sensor nodes within its cluster and sends the data to the base station after data compression and aggregation process[10].LEACH protocol randomly changes the cluster head so that all the nodes can consume energy equally and also to extend the life time of the network to reduce the overall cost, the cluster head performs data aggregation and send the data to the base station. The decision of the cluster head is made by the nodes by choosing a random number between 0 and 1.The node becomes cluster head for the current round if the number is less than the threshold value T(n).

$$T(n)= \begin{cases} P/1-P(r.mod1/p) & \text{if } n\in G \\ 0 & \text{otherwise} \end{cases}$$

Where, *P* is the desired percentage of cluster heads (0.05), r is the current round number, G is the set of nodes that have not been cluster heads in the last 1/ *p* rounds. In LEACH the whole process is divided into two phases—set-up phase and steady state phase. In the set-up phase, clusters are created and a CH is selected for each cluster and in the steady-state phase, nodes sends their data to their cluster heads throughout their allocated time slot using TDMA. Then the cluster heads aggregates the data and send the compressed data to the BS[11].

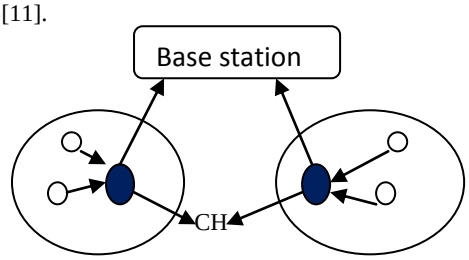

Figure 2: Clustering in LEACH protocol

4.2 ADVANTAGES OF LEACH

It confines most of the communication inside the clusters, and thus provides scalability in the network. The CHs aggregates the data composed by the nodes and this leads to a limit on the traffic generated in the network. Hence, a large-scale network without traffic overload could be deployed and improved energy efficiency compared to the flat-topology could be achieved.

1. Single-hop routing from node to cluster head, thus saving energy.
2. Distributiveness, where it distributes the role of CH to the other nodes.
3. It increases network lifetime in three ways. Firstly, distributing the task of CH (consumes more energy than normal nodes) to the other nodes. Secondly, aggregating the data by the CHs. Finally, TDMA, which assigned by the CH to its members, puts most of the sensor in sleep mode, especially in event-based applications. Hence, it is capable to increase the network lifetime and get a more than 7-fold reduction in energy dissipation compared to direct communication [12].
4. It does not require location information of the nodes to form the clusters. So, it is powerful and simple.
5. Finally, it is dynamic clustering and well-suited for applications where regular monitoring is required and data collection occurs periodically to a centralized location.

4.3 DISADVANTAGES OF LEACH

1. It significantly depend on cluster heads and face robustness issues such as failure of the cluster heads.
2. Additional overheads due to cluster head changes and calculations leading to energy inefficiency for dynamic clustering in large networks.
3. CHs directly communicate with sink—there is no inter cluster communication, and this needs high transmission power. Hence, it does not work well in large- scale networks that need single-hop communication with sink.
4. CHs are not uniformly distributed; CHs could be located at the edges of the cluster.
5. CH choice is random, which does not take into account energy consumption.
6. Leach is not applicable to networks that are deployed in large region as it uses single hop routing where each node can transmit directly to the cluster head and the sink.

5. ENHANCEMENT IN LEACH

5.1 Enhanced-leach (E-LEACH)

The E-LEACH adopts the similar round concept with the original LEACH. It overcomes the limitation of intercommunication of clusters and also solves the problem of energy consumption. In hierarchical routing protocols, the number of cluster-heads is a input factor that affects the performance of routing protocols. Since, the communication between cluster heads and the base station needs much more energy than common nodes, the extreme number of cluster-heads will increase the energy consumption and shorten the network lifetime. Therefore, it is required to select optimal cluster head number to make the energy consumption minimum. In the E-LEACH minimum spanning tree between cluster heads is used, to select the cluster head which has largest remaining energy as the root node [12].

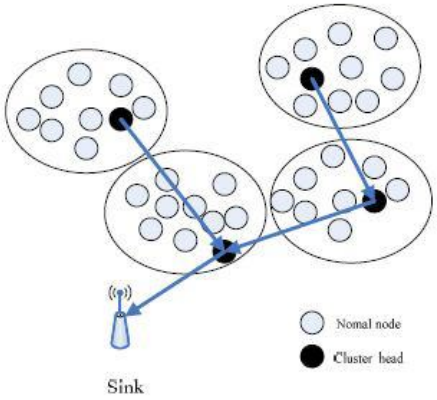

Figure.3: Architecture of E-LEACH

5.2 Two level leach (TL- LEACH)

In LEACH protocol, CHs may be situated far away from the BS, hence it uses a large amount of its energy for transmitting and by which it will die faster than other nodes. A latest edition of LEACH called Two-level Leach was proposed. It eliminates the limitation of non-uniformly distribution of CHs. In this protocol; CH collects data from other cluster members as original LEACH and relays the data to the base station through the CH that lies between the CH and the BS. [12].

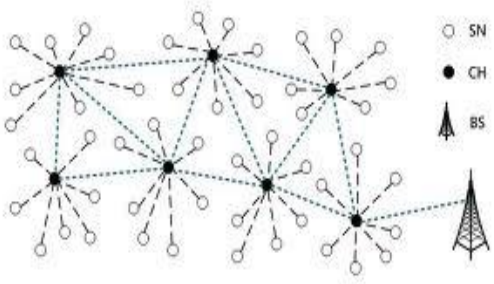

Figure 4: Architecture of TL-LEACH

5.3 Multi-hop leach (M-LEACH)

In LEACH protocol single hop communication is there between the CH and the BS. Energy consumption will be more if distance is extreme. This new M-LEACH protocol eliminates problem of single hop communication and introduces multi-hop communication in order to increase the energy efficiency. In this protocol, the CH sends the data to the Bs using the other CHs as relay stations.

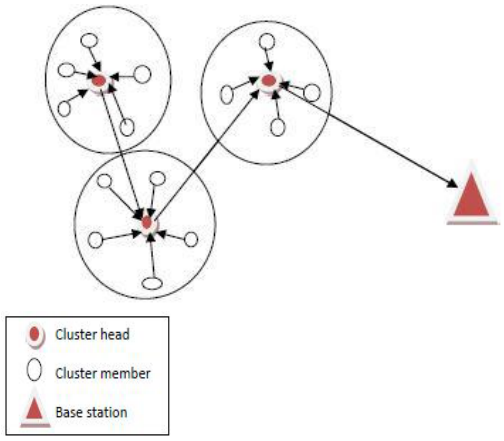

Figure 5: Architecture of M-LEACH

5.4 Leach – centralized (LEACH-C)

LEACH has no understanding about the number of CHs and their location. However, Centralized LEACH protocol suggest enhanced performance by distributing the cluster heads all through the network. During the set-up phase, every node sends to the sink its remaining energy and location. The sink then runs a centralized cluster formation algorithm to decide the clusters for that round. It has problems such as pre-selection cluster-head, equal opportunities for cluster-head selection mechanism, and the unbalancing energy loads. . However, since this protocol requires location information for all sensors in the network (normally provided by GPS), it is not robust [13].

5.5 Cell-LEACH

LEACH has the problem of redundant data to the BS. This cell-LEACH protocol eliminates the problem of redundancy. In this method the network is divided into sections called "cells". One sensor inside this cell will be selected as the head of the cell. Other seven cells nearby this cell will form a cluster and all these seven cells have their own cluster heads. cell head inside each cell will allocate the time limit to all the sensor nodes where each cell should transfer its data to its cell-head in its designated time. When transferring data, all the cell nodes remain off except the nodes which have the time slot. Then cell head will either delete redundant information or aggregate received information from different sources. After removing redundant information and aggregating data in cell-head, this information will be send to cluster-heads. All the functions that are done in cell-head will be performed in cluster-head as well. To select cell-head and cluster-head the same technique will be used. Primarily after the network arrangement, a cell-head within each cell and a cluster-head inside each cluster will be determined randomly, since all the sensors have the same energy. In next times, as an example, each old cell-head have to select a new cell-head dynamically and replace it [14].

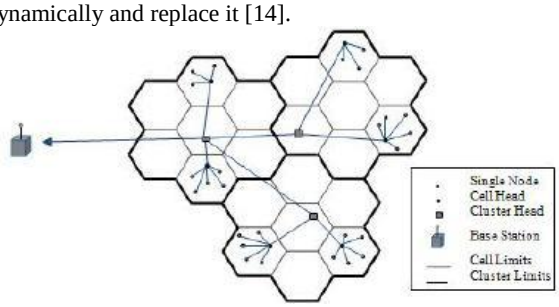

Figure 6: Architecture of LEACH-C

5.6 Vice-cluster head LEACH (V- LEACH)

In LEACH the CH dies when it doesnot have enough energy to transmit which is the key problem in LEACH.Therefore,V-LEACH was introduced to overcome this problem.In the V-LEACH protocol there are CHs that are responsible for sending data that is received from the cluster members to the BS and a vice-CH that will turn into a CH of the cluster in case of CH dies. When the CH die, the cluster will become ineffective because the data gathered by cluster nodes will never reach the base station. In our V-LEACH protocol, in addition of having a CH in the cluster, there is a vice-CH that takes the position of the CH when the CH dies because the reasons we described above. By doing this, cluster nodes data will always reach the BS; no need to elect a new CH each time the CH dies. This will expand the overall network life time [12].

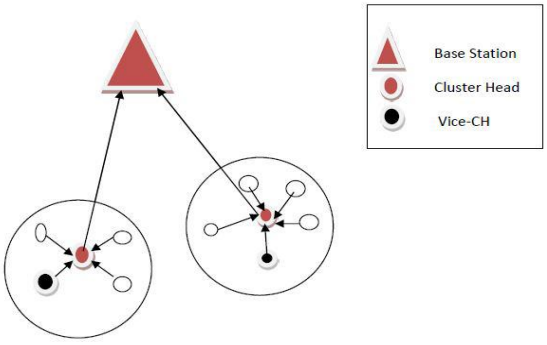

Figure 7: Architecture of V-LEACH

6. OTHER HIERARCHICAL PROTOCOLS

6.1 TEEN (Threshold sensitive Energy Efficient sensor Network)

TEEN[15] is a cluster based hierarchical routing protocol based on LEACH. In this protocol the nodes sense the area continuously, but the data is not transmitted continuously. The architecture of the network consist of nodes, first-level cluster heads and second-level cluster heads are created near to the BS. The nodes in the network sense the medium continuously and store the sensed value for transmission.

The nodes transmits the sensed data to the CH and BS if-

a. sensed value >hard threshold(HT)
b. sensed value~hard threshold>=soft threshold(ST)

In TEEN routing protocol, the CH sends two type of data to its neighbouring nodes---hard threshold and soft threshold. In hard threshold, the nodes transmit data if the sensed data is in its range, thereby reducing the number of transmissions and in soft threshold any small change in the sensed data is transmitted. This protocol is used for time-critical applications but has a limitation that it is not suited for applications where periodic reports are needed. and other limitations are-(a) a node has to wait for its time slot for data transmission and also the time slot may be wasted if the node has no data for transmission. (b) cluster heads always wait for data from the nodes by keeping its transmitter on. This will consume more energy and the cluster head will die early which will cause problem. Therefore it is efficient to use V-LEACH.

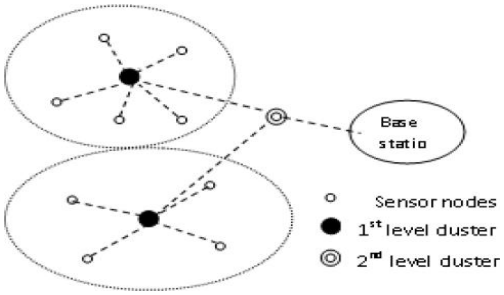

Figure 8: Architecture of TEEN protocol

6.2 PEGASIS (Power efficient Gathering Sensor Information System)

PEGASIS [16] is a chain-based power efficient hierarchical routing protocol based on LEACH. In this protocol all the nodes have information about all other nodes and each node has the capability to transmit data to the base station directly. It is an improved version of LEACH protocol, in spite of forming clusters as in LEACH it forms chains such that each node can transmit and receive from its neighbor and only one node is selected to transmit to the BS from the chain. In each round, each node receives data from one neighbor, fuses with its own data and transmit to the other neighbor and finally all the data is aggregated by the leader and is transmitted to the BS.

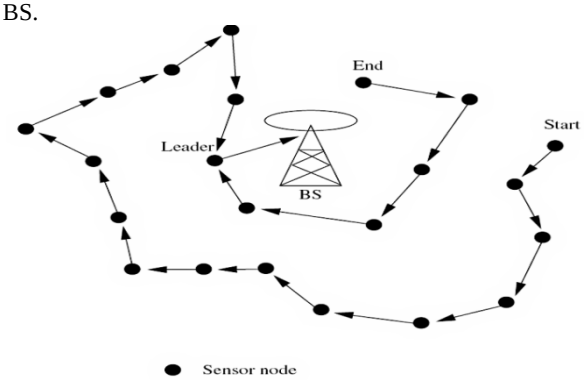

Figure:9 Chaining in PEGASIS

PEGASIS overcome LEACH by eliminating the overhead of forming dynamic clusters, minimizing the sum of distances that other nodes must transmit and limiting the number of transmissions. However its main limitation is that a single leader can become a bottleneck.

7. CONCLUSION

In this paper, a well-known protocol in wireless sensor networks called LEACH is described.

Earlier LEACH was the protocol which has number of limitations in terms of energy consumption, lifetime, non-uniform distribution, etc as compared to the other protocols in hierarchical routing i.e. TEEN, APTEEN, and PEGASIS. But, still all these other protocols have some limitations. Therefore it is not efficient to use any particular protocol for any application..

With the number of advantages of LEACH protocol it also comes with some disadvantages. To overcome those disadvantages and make LEACH more efficient many enhanced protocols of LEACH are introduced and some of them like E-LEACH, TL-LEACH, MULTI-HOP LEACH, LEACH-C, CELL-LEACH and VLEACH are described in this paper that how these protocol overcome the disadvantage

of the LEACH protocol to make it more efficient for the applications.

Finally, we have concluded that with some enhancement in LEACH, it is the low energy protocol introduced in WSN which save energy and increase lifetime of the sensor networks. But, there are some limitations in the enhanced centralized LEACH protocol.

This paper has covered performance of LEACH protocol only, we can also compare this protocol with other routing protocols that may or may not be hierarchical in nature.

8. REFERENCES

[1] Younis, M.; Youssef, M.; Arisha, K. Energy-aware routing in cluster-based sensor networks. In *Proceedings of the 10th IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS2002)*, Fort Worth, TX,USA, October 2002.

[2] S. Dai, X. Jing and L. Li, "Research and Analysis on Routing Protocols for Wireless Sensor Networks",*in Proc. of IEEE International Conference on Communications Circuits and Systems,* vol2,2012

[3] Shah, R.; Rabaey, J. Energy aware routing for low energy *ad hoc* sensor networks. In *Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC)*, Orlando, FL, USA, March 2002.

[4] Chi-Tsun Cheng, Chi K. Tse and Francis C. M. Lau "A Delay-Aware Data Collection Network Structure for Wireless Sensor Networks" 2011 IEEE

[5] Vivek Katiyar Narottam Chand Surender Soni "Improving Lifetime of Large-scale Wireless Sensor Networks through Heterogeneity" ICETECT 2011

[6] M. Bani Yassein, A. Al-zou'bi, Y. Khamayseh, W. Mardini "Improvement on LEACH Protocol of Wireless Sensor Network (VLEACH)" International Journal of Digital Content Technology and its Applications Volume 3, Number 2, June 2009

[7] Rodoplu, V.; Meng, T.H. Minimum energy mobile wireless networks. *IEEE J. Sel. Area Commun.* **1999**, *17*, 133344.

[8] P.Tyagi and S.Jain,"Comparative Study of Routing Protocols in WSN",International journal of advanced research in Computer Science and SoftwareEngineering,vol2 .issue 9,sep 2012

[9] Q. Jiang and D. Manivannan, "Routing Protocols for Sensor Networks," *in Proc. of IEEE Consumer Communications and Networking Conference (CCNC*), pp. 93-98, January, 2004.

[10] Shmsad Parvin and M.S.Rahim,"Routing protocols for WSN",International conference on Electronics,Computer And Communication(ICECC).2008

[11] Barati, H.; Movaghar, A.; Barati, A.; Azizi Mazresh, A. A review of coverage and routing for wireless sensor networks. *World Acad. Sci. Eng. Tech.* 2008, *37*, 296-302

[12] Jia Xu,Ning Jin, Xizhong Lou,Ting Peng,Qian Zhou,Yanmin Chen"Improvement of LEACH protocol for WSN" 2012 IEEE

[13] Jamal, N.; E. Kamal, A.-K.A. Routing techniques in wireless sensor networks: A survey. *IEEE Wirel. Commun.* **2004**, *11*, 6-28.

[14] Intanagonwiwat, C.; Govindan, R.; Estrin, D. Directed difusion: A scalable and robust communication paradigm for sensor networks. In *Proceedings of ACM MobiCom' 00*, Boston, MA, USA, 2000; pp. 56-67.

[15] Manjeswar, A.; Agrawal, D.P. TEEN: A protocol for enhanced efficiency in wireless sensor networks. In *Proceedings of 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing*, San Francisco, CA, USA, 2001; p. 189.

[16] Y. Yu, Estrin, D.; Govindan, R. *Geographical and Energy Aware Routing: A Recursive Data Dissemination Protocol for Wireless Sensor Networks*. UCLA Computer Science Department Technical Report, UCLA-CSD TR-01-0023. UCLA: Los Angeles, CA, USA, May 2001.

[17] Manjeswar, A.; Agrawal, D.P. APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks. In *Proceedings of 2nd International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing*, Fort Lauderdale, FL, USA, April 15–19, 2002; pp. 195-202.

[18] Barati, H.; Movaghar, A.; Barati, A.; Azizi Mazresh, A. A review of coverage and routing for wireless sensor networks. *World Acad. Sci. Eng. Tech.* 2008, *37*, 296-302

[19] Jiang, Q.F.; Manivannan, D. Routing protocols for sensor networks. In *Proceedings of Conference on Consumer Communications and Networking*, Las Vegas, NV, USA, January 5–8, 2004; pp. 93-98..