Comparative Analysis of Leach And Its Descendant Protocols In Wireless Sensor Network

Ravneet Kaur[1], Deepika Sharma[2] and Navdeep Kaur[3]

[1]*Department of Electronics and Communication, Lovely Professional University Phagwara, Punjab, India*

[2] *Assistant Professor, Department of Electronics and Communication, Lovely Professional University Phagwara , Punjab, India*

[3]*Department of Electronics and Communication, Lovely Professional University Phagwara, Punjab, India*

Abstract:
Wireless sensor networks are composed of low cost and extremely power constrained sensor nodes. In many applications of wireless sensor networks, a sensor node senses the environment to get data and delivers them to the sink via a single hop or multi-hop path. In wireless sensor networks, due to limited battery power of sensor nodes, one of the key challenge is to achieve minimum energy consumption in order to maximize network lifetime. Low Energy Adaptive Clustering Hierarchy (LEACH) is a well known routing protocol in WSN. It is a Clustering based protocol which helps in improving the lifetime of wireless sensor network This paper describes the comparative analysis of LEACH protocol with its various descendant protocols.

Keywords: *WSN, LEACH, Energy Efficiency*

I. INTRODUCTION

The recent developments in making energy efficient Wireless Sensor Network is giving a new direction to deploy WSN in applications like surveillance, industrial monitoring, traffic monitoring, habitat monitoring , cropping monitoring, crowd counting etc . The growing use of these networks is making engineers to evolve innovative and efficient ideas in this field.

A lot of research in data routing, data compression and in-network aggregation has been proposed in recent years [1]. A wireless sensor network consists of a large number of nodes spread over a specific area where we want to look after at the changes going on there. A sensor node generally consists of sensors, actuators, memory, a processor and they do have communication ability. Wireless sensor nodes, which are compact, light-weighted, and battery-powered devices that can be used virtually in any environment. Because of these special characteristics, sensor nodes are usually deployed near the targets of interest in order to do close-range sensing. All the sensor nodes are allowed to communicate through a wireless medium. The wireless medium may either of radio frequencies, infrared or any other medium, of course having no wired connection. These nodes are deployed in a random fashion and they can communicate among themselves to make an ad-hoc network. Basically nodes are driven by batteries and in many applications it is not easy to replace the batteries or sometimes not even recharge the batteries so each node has a limited energy supply [2] [3].

If the node is not able to communicate with other through direct link, i.e. they are out of coverage area of each other. The data can be sent to the other node by using the nodes in between them. This property is referred as multi-hoping. A network with clustering is divided into several clusters. Within each cluster, one of the sensor nodes is elected as a cluster head (CH) and with the rest being cluster members (CM). All sensor nodes work cooperatively 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 spend more energy than the non-cluster heads so to distribute the workload of the cluster heads among the wireless sensor nodes their role is rotated among all nodes in order to equalize energy consumption [3].

Generally WSNs are not centralized one as there is peer-to-peer communication between the nodes. So there is no requirement of prior established infrastructure to deploy the network. WSN gives flexibility of adding nodes and removing the nodes as required. But this gives rise to many drastic changes to deal with in the network topology such as updating the path, or the network tree, etc. In a WSN the node that gathers the data information refers to sink. The sink may be connected to the outside world through internet where the information can be utilized within time constraints. The main problem in using these networks is limited battery life. This is due to fact that the size of a sensor node is expected 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 any optimization in these

networks should focus on optimizing energy consumption. In WSN a lot of sensed data and routing information has to be sent which often 3 have some time constraints so that the information can be utilized before any mishap occurs, e.g. industrial monitoring, machinery monitoring, etc. The energy power consumption is much higher in data communication than internal processing. So energy conservation in WSN is needs to be addressed. Usually sensor nodes rely on a battery with limited lifetime, and their replacement is not possible due to physical constraints. Moreover the architecture and protocol of sensor networks must be able to scale up any number 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[1], [4], [5].

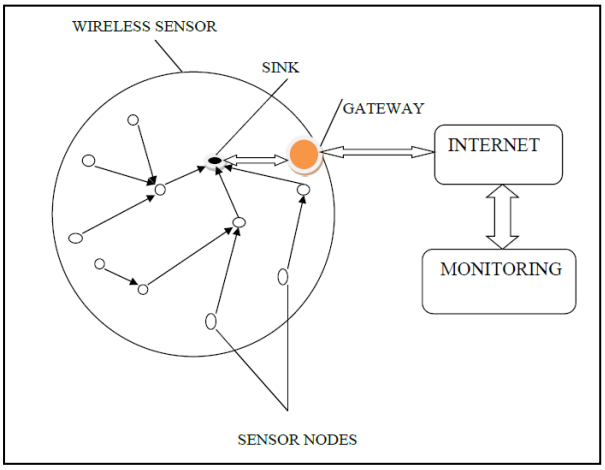

Fig.1 Wireless sensor network

II. LEACH PROTOCOL

Leach is called "Energy efficient Adaptive protocol for clustered Wireless sensor networks". This protocol facilitates the nodes with more residual energy have more chances to be selected as cluster head. In order to extend the lifetime of the whole sensor network, energy load must be evenly distributed among all sensor nodes so that the energy at a single sensor node or a small set of sensor nodes will not be drained out very soon.

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first energy efficient routing protocol for hierarchical clustering. It reduces the energy significantly. The LEACH protocol forms clusters in the sensor networks and randomly selects the Cluster-heads for each cluster. Non cluster-head nodes sense the data and transmit to the cluster-heads. The cluster-heads aggregate the received data and then forward the data to the sink.

The basic principle is that it assigns overall energy consumption of the network uniformly to each sensor node through periodically selecting different nodes as cluster-head. This makes the survival time of nodes close to the lifetime of network. Thus, the energy consumption can be reduced and the lifetime of the entire network can be prolonged. There are two phases in LEACH protocol: i) Setup phase ii) steady-state phase. In the setup phase the clusters are formed and the cluster-heads are selected. In the steady-state phase, the data from non-cluster heads are transmitted to the sink. The sensor nodes communicate to the cluster-heads using TDMA schedule. The nodes communicate to the cluster-head only in their allotted slots. It avoids collision. The cluster-heads are selected randomly for every round [4], [8], [9].

The operation of LEACH is divided into several rounds. Each round begins with a set-up phase when the clusters are organized, followed by a steady–state phase. In the set-up state when the clusters are organized, the LEACH sets a threshold value $T(n)$ first, and then sensor node i generates a random number between 0 and 1 automatically by distributed computing. If the random number $< T(n)$, the node will become the cluster-head of the current round r, and common nodes join in the nearest cluster. After a period of data transmission, the network starts cluster reconstruction of the new round. And the circular processes like that. The threshold value [6] is:

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

Where p is the probability of the nodded being selected as a cluster-head node; r is the number of rounds passed, and G is the collection of ordinary nodes; mod denotes modulo operator. The value of p is the expected number of cluster-head nodes. In the LEACH algorithm, all nodes in the cluster take it turns to act as the head node, to achieve the purpose of balancing node energy consumption. Therefore, only the nodes that have not already been cluster-heads recently and have more energy available may become cluster-heads at round r +1.

Once the cluster-head is selected, all nodes join the corresponding cluster according to the broadcast signal intensity of the cluster-head node. Then, the cluster set-up phase of this round is completed. When the cluster-head assigns time slots for its members using TDMA mode, the network will enter the steady-state. In this phase, after all member nodes sent monitoring data information, the head node will process data fusion, and then send data information to the base station. After this round, it turns to the next round, and starts cluster reconstruction of the new round [6].

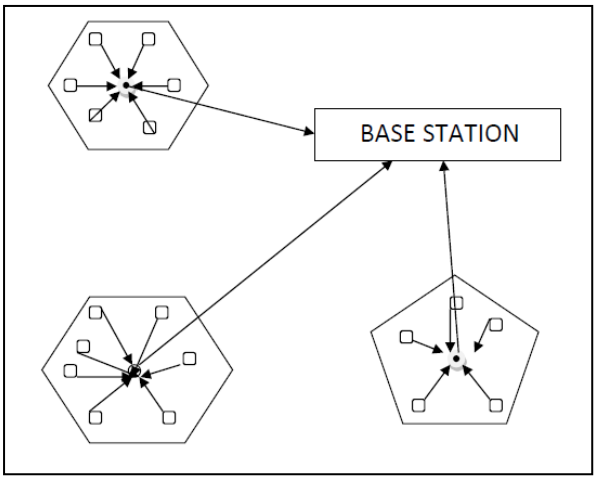

Fig.2 Leach protocol architecture.

III. DISADVANTAGES OF THE LEACH PROTOCOL

Although LEACH protocol prolongs the network lifetime in contrast to plane multi-hop routing and static routing, it still has problems. The cluster heads are elected randomly, so the optimal number and distribution of cluster heads cannot be ensured. The nodes with low remnant energy have the same priority to be a cluster head as the node with high remnant energy. Therefore, those nodes with less remaining energy may be chosen as the cluster heads which will result that these nodes may die first. The cluster heads communicate with the base station in single-hop mode which makes LEACH cannot be used in large-scale wireless sensor networks for the limit effective communication range of the sensor nodes [8].

IV. LEACH PROTOCOL'S DESCENDANTS

A. Enhanced-leach (E-LEACH)

E-LEACH IS based on LEACH protocol to balance the energy consumption of sensor nodes in order to solve the overload energy consumption problem. The E-LEACH adopts the same round concept with the original LEACH. In hierarchical routing protocols, the number of cluster-heads is a key factor that affects the performance of routing protocols. If the number of cluster-heads is less, each cluster-head needs to cover larger region, this will lead the problem that some cluster-members get far from their cluster-heads and consume much more energy. As the communication between cluster heads and the base station needs much more energy than common nodes, the excessive number of cluster-heads will increase the energy consumption of the whole network and shorten the network lifetime. Therefore, it is necessary to select optimal cluster head number to make the energy consumption minimum. In the E-LEACH minimum spanning

tree between cluster heads is used, choose the cluster head which has largest residual energy as the root node [8].

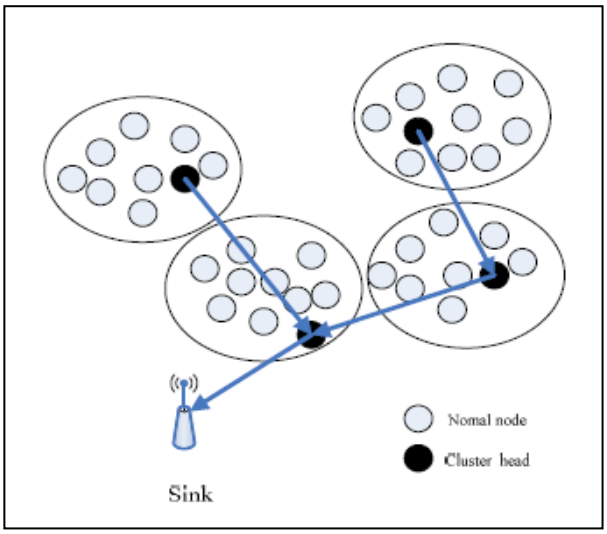

Fig.3 Architecture of E-LEACH

B. Two level leach (TL- LEACH)

In LEACH protocol, the CH collects and aggregates data from sensors in its own cluster and passes the information to the BS directly. CH might be located far away from the BS, so it uses most of its energy for transmitting and because it is always on it will die faster than other nodes. A new version of LEACH called Two-level Leach was proposed. In this protocol; CH collects data from other cluster members as original LEACH, but rather than transfer data to the BS directly, it uses one of the CHs that lies between the CH and the BS as a relay station [4].

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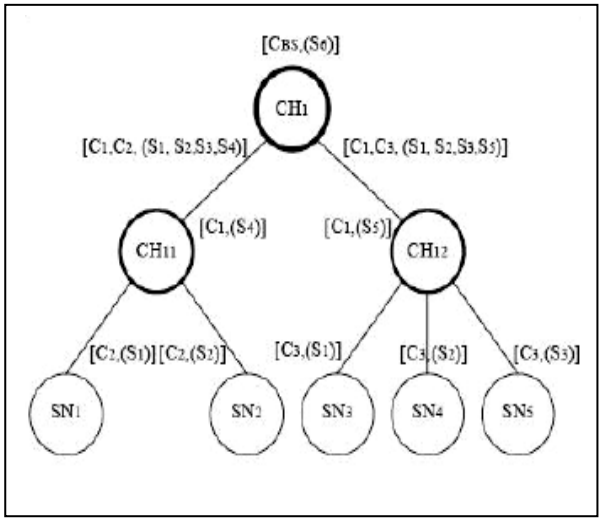

Fig.4 TL-LEACH

C. Multi-hop leach (M-LEACH)

In LEACH protocol the information is transmitted from cluster head (CH) to base station (BS) node through single hop communication no matter the distance between BS and CH. Energy consumption will be more if distance is far. This M-LEACH protocol modifies LEACH allowing sensor nodes to use multi-hop communication within the cluster in order to increase the energy efficiency of the protocol. This work extends the existing solutions by allowing multi-hop inter-cluster communication in WSNs in which the direct communication between CHs or the sink is not possible due to the distance between them. Thus, the main innovation of the solution proposed here is that the multi-hop approach is followed inside the cluster and outside the cluster. CHs can also perform data fusion to the data receive, allowing a reduction in the total transmitted and forwarded data in the network [7].

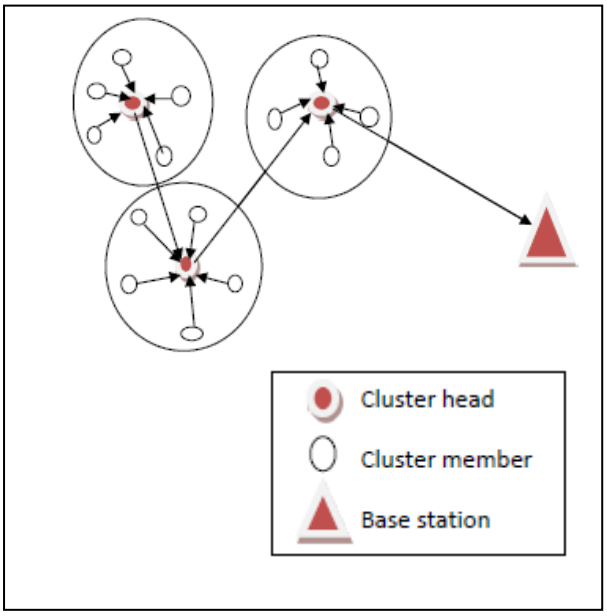

Fig.5 Multi-hop transmission (M-LEACH)

D. Leach – centralized (LEACH-C)

The disadvantage to LEACH is that the number of cluster head nodes is little ambiguous to count. LEACH-C. has been proposed to clarify this problem. LEACH-C provides an efficient clustering configuration algorithm, in which an optimum cluster head is selected with minimization of data transmission energy between a cluster head and other nodes in a cluster. In LEACH-C, the base station receives information about residual node energy and node positions at the set up phase of each round. The received data can compute an average residual energy for all nodes. The nodes with less than average energy are excluded in selection of cluster heads. Among the nodes that have more than average energy, cluster heads are selected with use of the simulated annealing algorithm. The base station sends all nodes a message of the optimum cluster head IDs (Identifiers). The node, the ID of which is the same as the optimum cluster head ID, is nominated as a cluster head and prepares a TDMA schedule for data transfer. Other nodes wait for the TDMA schedule from their cluster heads [9]. Although LEACH-C solves the problem of uncertainty on the number of cluster-head at each round in LEACH, it still has problems such as pre-selection cluster-head, equal opportunities for cluster-head selection mechanism, and the unbalancing energy loads. This phenomenon means that nodes with less energy remaining may be also become cluster-heads. However, once these nodes become cluster-head, their energy will soon exhaust. In the later periods of the network, even the phenomenon of the cluster-head is dead where it have not energy to forward the information may occurred. Therefore, the selection mechanism of cluster-head affects the performance and lifetime of the entire network. Besides, through the analysis of the node residual energy distribution, the network lifetime has direct relation to whether the energy utilization is balanced [9].

E. Cell-leach

In this proposed method, sensor network once will be divided in sections which are called cell. Each cell includes several sensors. One sensor which is inside the cell is selected as head of the cell. Each seven near cells will form a cluster, each provided with a sensor which is known as cluster-head, as shown in figure1. Clustering and celling will remain the same as long as network is working, just cell-heads and cluster-heads change dynamically. Cell-head inside each cell allocates a limit of time on the basis of TDM (Time Division Multiplexing) to sensor nodes. Each cell should transfer its data to the cell-head in designated time. This method is also used for transferring data from cell-head to cluster-head. When transferring data, all the cell nodes remain off (except the node that is already in charge of slicing time). 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.

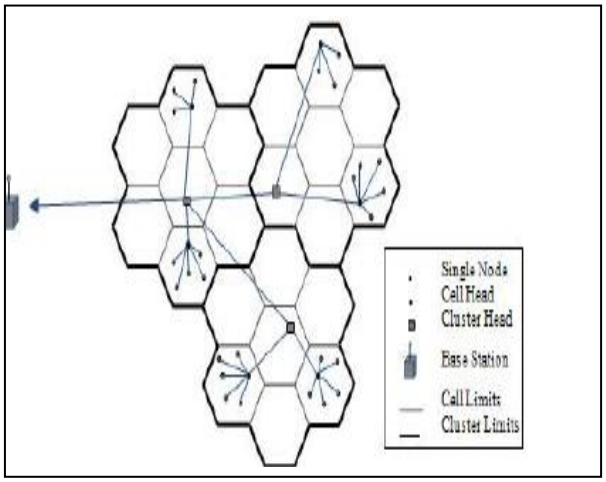

Fig.6 Cell-leach

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. The first time after the network setup, a cell-head inside 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 [9].

F. Vice-cluster head leach (V- LEACH)

In LEACH protocol, the cluster contains; Cluster Head (CH). But when the cluster head does not have sufficient energy to transmit the received data (from cluster members) to the base station (BS) and cluster head dies, in this case the data of the particular cluster will not reach to BS. To overcome this problem V-LEACH is introduced.

It includes CH (responsible only for sending data that is received from the cluster members to the BS), a vice-CH (the node that will become a CH of the cluster in case of CH dies), cluster nodes (gathering data from environment and send it to the CH). In the original leach, the CH is always on receiving data from cluster members, aggregate these data and then send it to the BS that might be located far away from it. The CH will die earlier than the other nodes in the cluster because of its operation of receiving, sending and overhearing. When the CH die, the cluster will become useless because the data gathered by cluster nodes will never reach the base station.

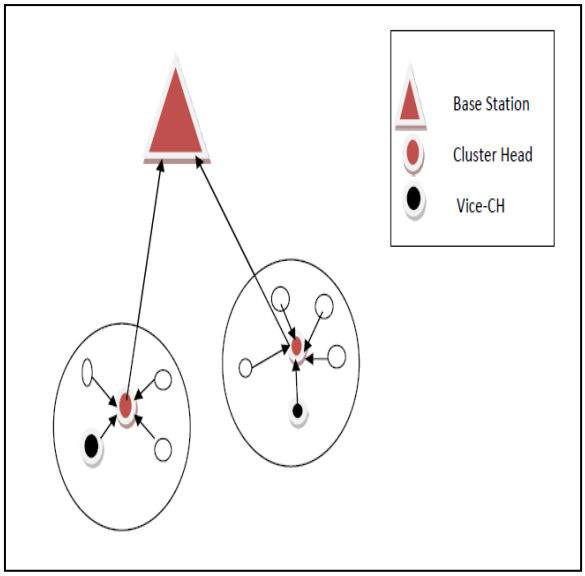

Fig.7 Vice-Cluster Head LEACH (V-LEACH)

In our V-LEACH protocol, besides having a CH in the cluster, there is a vice-CH that takes the role of the CH when the CH dies because the reasons we mentioned 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 extend the overall network life time [4].

V. CONCLUSION

In this paper, a well-known protocol in wireless sensor networks called LEACH is described. LEACH is first low energy protocol introduced in WSN which save energy and increase lifetime of the sensor networks. With the number of advantages of LEACH protocol it also comes with some disadvantages. To overcome those disadvantages and make LEACH more efficient many descendants of LEACH protocol are introduced and some of them like E-LEACH, TL-LEACH, MULTI-HOP LEACH, LEACH-C, CELL-LEACH and V-LEACH are described in this paper that how these protocol overcome the disadvantage of the LEACH protocol and make the sensor networks more efficient.

REFERENCES

1. Vivek Katiyar Narottam Chand Surender Soni ”Improving Lifetime of Large-scale Wireless Sensor Networks through Heterogeneity” ICETECT 2011
2. Chi-Tsun Cheng, Chi K. Tse, C. M. Lau “ A Clustering Algorithm for Wireless Sensor Networks Based on Social Insect Colonies” 2010 IEEE
3. Chi-Tsun Cheng, Chi K. Tse and Francis C. M. Lau “A Delay-Aware Data Collection Network Structure for Wireless Sensor Networks” 2011 IEEE
4. 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
5. Aruna Pathak, Zaheeruddin, D.K. Lobiyal, Manoj Kr. Tiwari “Improvement of Lifetime of Wireless sensor network by jointly effort of Exponential node distribution and mixed routing” 2012 International Conference on Communication Systems and Network Technologies

6. Chenmin Li , Guoping Tan , Jingyu Wu , Zhen Zhang , Lizhong Xu "Analyzing Cluster-head Selection Mechanisms and Improving the LEACH " 2011 IEEE
7. Hwa Young Lim, Sung Soo Kim, Hyun Jun Yeo, Seung Woon Kim, and Kwang Seon Ahn " Maximum Energy Routing Protocol based on Strong Head in Wireless Sensor Networks " 2007 IEEE
8. Jia Xu,Ning Jin, Xizhong Lou,Ting Peng,Qian Zhou,Yanmin Chen "Improvement of LEACH protocol for WSN" 2012 IEEE
9. Arezoo Yektaparast, Fatemeh-Hoda Nabavi, Adel Sarmast " An Improvement on LEACH Protocol
(Cell-LEACH) "