# Energy Efficiency Protocol for Wireless Sensor Network: Survey

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*Abstract*— Due to the resource limitations in wireless sensor networks such as low network bandwidth, short range of wireless communication, limited storage capacity and power supply, prolonging the network lifetime have received fabulous attention in recent years. One of the most challenging issues is related with the energy consumption during sensing and data transmission, since, sensor nodes are limited power. And it is also impractical to maintain the network lifetime by changing the battery frequently because in many environments it is either very difficult or not possible at all, to recharge sensor. Many routing protocol have been proposed for energy efficiency of both homogeneous and heterogeneous environment. An efficient routing technique is known as hierarchical routing based on clustering that enhances the network lifetime. This paper presents an overview of areas in WSN which can give rise to energy efficiency of node and how researcher have worked to prolonging the network lifetime. Also, this paper presents the comparison of the performance of different cluster-based routing protocols on the basis of different parameters.

***Key words:*** Wireless Sensor Network, Lifetime of Sensor, Clustered Protocol, Energy Efficiency

## I. INTRODUCTION

Due to technological advancement, WSN is considered as one of the most important technologies for the twenty - first century [1]. WSNs exhibits unique features for example, denser node deployment, higher unreliability of sensor nodes, and a lot of energy, computation, and storage constraints [1],[9] ,which presents a lot of new challenges in the development and various application of WSNs.

### *A. Network Architecture:*

A sensor network typically consists of large number of sensor nodes densely deployed in an area of interest, and one or more data sinks or base stations that are located close to or inside the sensing region. The sensor nodes are battery operated. They sense the data and transmit requested data to the base station.

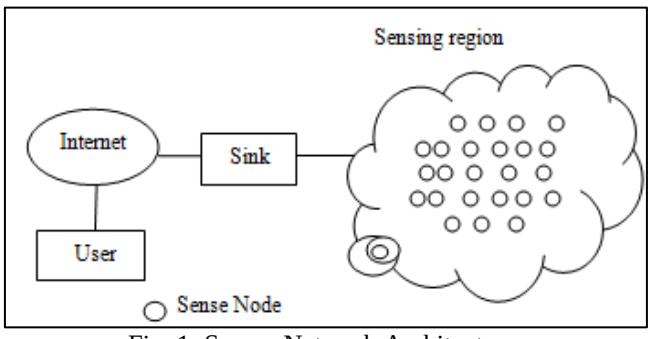



Fig. 1: Sensor Network Architecture.

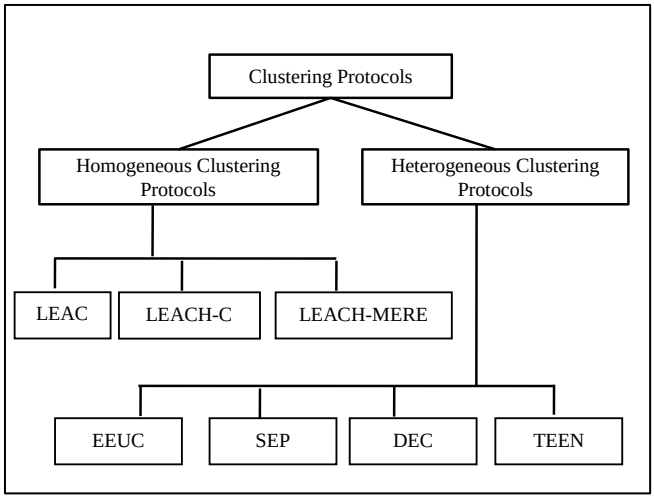
### *B. Major Challenges:*

1) Limited Energy Capacity: Sensor nodes are battery operated and thus have very limited energy capacity. To prolong the operational lifetime of a sensor network, energy efficiency needs be considered.
2) Limited Hardware Resources : Sensor nodes have limited processing and storage capabilities, and thus can only perform limited computational operations
3) Random and Massive Deployment: Most sensor networks consist of a large number of sensor nodes, from hundreds to thousands or even more. Sensor node deployment is usually application dependent, which can be either manual or random
4) Diverse Applications: Sensor networks have a wide range of diverse application and. the requirements for different applications may vary.
5) Unreliable and Dynamic Environment: A sensor network usually operates in a dynamic and unreliable environment. Due to node failures, damage or energy depletion, the topology of a sensor network may change frequently. The sensor nodes are linked by a wireless medium, which is noisy, error prone.

The rest of the paper is organized as follows: Section II, represents various classification of clustering protocol. Section III describes comparison of protocol based on network creation attribute for WSN. Section IV describes the comparison of clustering protocol based on the baise of network creation parameter and performance evaluation parameter. and Section V presents the conclusion.

## II. CLASSIFICATION OF CLUSTERING PROTOCOL

Energy efficiency routing is the most highlighted research issue in WSNs. The clustering routing protocol are proven to perform better than the flat protocol.[1] Clustering can be done in two types of networks, homogenous and heterogeneous network on the basis of energy.. ). This paper discusses about energy efficient clustering algorithms for homogenous and heterogeneous WSNs describing their merits and demerits. This fig. shows the homogenous and heterogeneous protocols that are discussed in this paper as follows:



## III. LEACH

Low Energy Adaptive Clustering Hierarchy (LEACH), 2000 considered to be a dynamic clustering strategy. LEACH[3] ensures that every node will become a cluster head exactly once in each round .LEACH is based on the fusion strategy. It includes two phases, 1.Setup phase and 2. Steady phase.

Clusters formation is done in the first set-up phase while data are transmitted to the BS in the second phase i.e. steady-phase. At the beginning of each round, all nodes generate a random number and compares it with a threshold $T(n)$, give in (1). These nodes become CHs if their numbers are less than $T(n)$.The algorithm is designed in such a manner that each node become cluster head atleast once. Then each cluster head broadcast an advertisement message (ADV)let all the other node that they have chosen this role for the current round. Non cluster head transmits a join request message back to select cluster head. The cluster head node setup a TDMAs schedule and transmit this schedule to the nodes belongs to cluster. The value of threshold is calculated using the following formula:

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

Setup Phase

Where n is the number between 0 and 1

P is the cluster head probability and g is the set of the nodes that were not elected cluster head by previous round. In steady phase, the cluster head forwards the data to the base station. The cluster head is maintained after the data is transmitted between the nodes.

Merits:

1) It avoids the interference among the nodes using TDMA schedule.
2) It provides equal chance for each node to become a cluster head.
3) LEACH is completely distributed and did not require the global knowledge about the network

Demerits:

1) Unequal cluster size.
2) Cluster head selection is not reasonable.
3) Cluster members are unaware about the lifetime of CH and deplete their energy when the cluster head is dead.

## IV. LEACH-C

LEACH-Centralized (LEACH-C),2004 [12] has been stated that a wireless sensor network contains a large no. of sensor nodes enables the monitoring a large variety of environments for various applications that includes home security aspects, biological detection etc. This protocol is improvement of LEACH. It is low energy consumption chain based routing protocol .This protocol is characterized by each node will send information about the current energy level and location to the base station. Then the BS runs the simulated annealing algorithm to determine the cluster for that round. Then a chain routing between clusters is established to minimize the amount of nodes which communicate with the BS. Its not just enhanced the lifetime of the network, but also improves the energy efficiency.

Merits:

1) Optimum cluster head election.

It provides proper balanced clustering.

Demerits:

1) Wastage of energy for the collection of global information.
2) Lack of robustness.
3) High overhead.

## V. LEACH MERE

To overcome the problems of LEACH protocol LEACH-MERE, 2013 is proposed. [6]. No doubt, cluster head selection helps to prolong the network lifetime. But cluster head election in each round can severely decreases the overall lifetime of the network. Thus new protocol is designed using fuzzy logic name as LEACH-MERE by considering 4 descriptors – Energy, Concentration, Speed of mobile nodes, Centrality. The concentration means the no. of nodes present in the vicinity, centrality is basically specify that classifies the node on the basis of how central the node is to the cluster. This protocol selects the CHs by considering expected residual energy of the sensor nodes and also take into account the hot-spot problem in cluster structure. In this approach all the nodes are mobile .So the speed of the node is also used as fuzzy descriptor. The objective behind this is not only to enhance the network lifetime but also evenly distribute the workload.

Merits:

1) It is used to address the Hot Spot problem.
2) Higher throughput.

Demerits:

1) Unbalanced cluster formation.
2) High overhead.
3) Requires a universal knowledge at each cluster head selection.

## VI. TEEN

Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN), 2001 [2] a clustering wireless sensor network protocol that targets a reactive network and enable cluster heads to restrict that when the sensor should report their sensed data to cluster head, Each cluster head inform its cluster member 2 types of values i.e , called hard Threshold (HT) and Soft Threshold(ST). when the value is bigger than the HT, the sensed attribute, beyond which a sensor should turn on its transmitter and report its sensed data to its cluster head. In addition, a cluster head also inform another value to cluster member, called Soft Threshold (ST), which indicates a minor change in the value of sensed attribute, which fire a sensor to turn on its transmitter and send its sensed data to the cluster head. The cluster member in a cluster can be scheduled using either TDMA or CDMA in order to avoid collisions in a cluster. However, defining threshold may introduce some delay when reporting time – critical data to the sink. At the beginning of a network operation, a sensor transmits its sensed data to cluster head when its value is larger than the hard threshold specified by its cluster head and additionally a sensor save the current value SV of the sensed attribute. Based on the value of the hard and soft threshold, a sensor

transmits its sensed data only if its value is bigger than HT and the difference between this current value and the previous stored value SV is greater than ST. When a sensor succeeded by sending its sensed data, it update SV with the current value of its sensed data. Hence it is clear that, the hard threshold helps the sensors to transmit only when significant information sensed, while the soft threshold further decreases the number of transmissions for sensed data. Thus, the sensors will send only sensed data that are of concerned to the user based on the hard threshold value and the change with respect to the previously reported data, thus yielding more energy efficiency.

Merits:

1) Reduces the energy transmission consumption, only the sensitive data that is often demand are transmitted.
2) Good for time critical applications.
3) Data transmission is controlled in efficient manner using two type threshold values.

Demerits:

1) TEEN does not suits for the applications that require periodic reports.
2) There is a chances of data to be lost if CHs don't within the communication range.

## VII. SEP

Stable Election Protocol[4] for Clustered Heterogeneous Wireless Sensor Network (SEP), 2004 .SEP is heterogeneous protocol consists two types of nodes, advanced nodes and normal nodes. The election probabilities to elect CH are weighted according to initial energy of a node relative to that of other nodes in network. This enhanced the stability period that is very crucial for many applications where feedback from the sensor Network must be timely and reliable. SEP elects cluster heads in a distributed manner in two-level hierarchical wireless sensor networks. In analysis of SEP nodes are uniformly distributed over the sensor field and sink has large the amount energy which is rechargeable position of sink is well known. SEP is more energy efficient and lifelong than LEACH in consuming the extra energy of advanced nodes. SEP yields longer stability region for higher value of extra energy. In order to enhance the energy efficiency, SEP maintains the well uniform and stable energy consumption intuitively; advanced nodes have to become cluster heads more often and repeated in a give epoch than the other normal nodes, which is equivalent to a fairness constraint on energy consumption. In SEP (Stable Election Protocol), the cluster head formation threshold based on the initial energy of the nodes. SEP is to assign a weight to the optimal probability Popt. This weight must be equal to the initial energy of each node divided by the initial energy of the normal node.

Merits:

1) SEP does not require the universal knowledge of energy at each round.
2) It works well with both small and large networks .i.e scalable.
3) SEP yields longer stability period.
4) Due to expended stability region the throughput is also higher.

Demerits:

1) It does not use the residual energy of higher level nodes in efficient manner.
2) It does not guarantee the efficient nodes deployment.
3) Not applicable for multi-level networks.

## VIII. EEUC

An Energy-Efficient Unequal Clustering [5] EEUC, 2005 considered when the network is partitioned into clusters, data transmission classified into two stages: Intra-Cluster communication as well as Inter-cluster communication. First of all non-cluster-head nodes send their data to the respective cluster head, and then cluster heads send the data to the base station. The many-to-one traffic pattern results in the hot spot problem when the multi-hop forwarding mode is a adopted in inter-cluster communication. Because the cluster-heads closer to the base station are highly burdened with heavier relay traffic, the area near the base station causes a hot spot problem. Because nodes in the hot spot drain their energy and die at much faster rate than other nodes in the network, reducing sensing coverage and causing network partitions. To address the hot spot problem, author proposed a clustering mechanism to balance the energy consumption among cluster heads. Cluster closer to the base station have smaller sizes than those father away from the base station, thus they must be consume lower energy during the intra-cluster data processing and can preserve some energy for the purpose of intra-cluster communication in EEUC mechanism.

Merits:

1) Reducing the cluster size.'
2) Cluster head is elected in simple way by local interaction.

Demerits:

1) Not a practical approach for real environment.

## IX. DEC

Deterministic Energy Efficient Clustering Protocol [8] i.e DEC, 2011 stated that previously the cluster-head's rotation is carried out in a randomized manner and the cluster head election is not guaranteed to be optimal. In DEC better and optimal election of cluster-heads is proposed. This proposed protocol uses the sensor node's residual energy solely as the election criterion. Simulation results show that the proposed model is able to manage energy consumption better and achieves the desired result for wireless sensor network. In DEC, at round 1, the BS elects N (No. of cluster-heads that requires) cluster head for the network. The elected CHs advertise their role using CSMA MAC just as in LEACH. The join-request massage will be send by cluster member to their cluster head which contain CM-ID, CHID, CM-RE (cluster member-residual energy) and the header that indicates it as a request. In this way the information of CM's RE come to know by their respective CH's and it can be utilized for CH rotation in the next rounds. After the setup phase ends, the steady phase begins, but before the end of this phase, the current CHs checks the piggy-backed CM-RE's information received to decide whether they will remain as CHs or give up their roles by choosing any highest RE node in their clusters as the new CHs. After this decision is made for the new CHs and all the data from the

current round is communicated to the BS, the round ends. The next round begins; but since the new CHs are already chosen in the previous round, they broadcast their role in the new round; CMs join their cluster as already explained above. The steady phase begins again. This process continues in each round until the last node dies. With this method, the battery life of WSNs is significantly optimized.

Merits:

1) EC does not requires a universal knowledge at each election round.
2) DEC performs efficiently in multi level heterogeneous WSN.

Demerits:

1) Advanced nodes are die rapidly than other because advanced nodes are always punished. At a certain time their residual energy becomes equal to the normal nodes.

## X. COMPARISON OF CLUSTERING PROTOCOL

### *A. Based on Network Creation Attributes*

| PARAMETERS | LEACH (2000) | TEEN (2001) | EEUC (2003) | LEACH-C (2004) | SEP (2004) | DEC (2011) | LEACH - MERE (2013) |
|---|---|---|---|---|---|---|---|
| Network Types | Homogeneous | Heterogeneous | Heterogeneous | Homogeneous | Heterogeneous | Heterogeneous | Homogeneous |
| Heterogeneity level | Not Present | Two Level | Multi-hop | Not present | Two | Multi level | Not present |
| Mobility | Stationary | Stationary | Stationary | Stationary | Stationary | Mobile | Mobile |
| Location Awareness | No | No | No | Yes | No | No | No |
| Cluster-Head Election | Random | Random | Based on energy | CH Selection done by basis of energy. | Based on initial and residual energy | Based on initial, residual and Average energy | Select CH considering actual and expected residual energy. |

### *B. Based on Performance Evaluation Parameter*

| PARAMETER | LEACH (2000) | TEEN (2001) | EEUC (2003) | LEACH-C (2004) | SEP (2004) | DEC (2011) | LEACH-MERE (2013) |
|---|---|---|---|---|---|---|---|
| Stability Period | Low | Large | Medium | Moderate | Moderate | High | Better than LEACH &LEACH-C |
| Cluster Stability | Very less | Good | Low because cluster are Unbalanced. | Better than LEACH. | Moderate | Highest | Good |
| Throughput | Low | Moderate | Moderate | Larger than LEACH. | Highest | Average | Average |
| Network Lifetime | Low | Better | Moderate | Average | Moderate | High | Better |
| Energy Efficiency | Low | High | High | Medium | Medium | High | Medium |
| Scalability | Limited | Limited | Medium | Limited | High | High | Low scalability due to extra overhead. |

## XI. CONCLUSION

As we know that, WSN takes a lot of attention today and energy saving is most challenging issue in designing the wireless sensor network. This paper surveyed and summarized resent research work which mainly focused on energy-efficient hierarchal clustered routing protocol for WSN. The ultimate objective behind these protocol designs is to increasing the network lifespan and energy efficiency of sensor nodes as long as possible. Significant research is done in this area to prolong the overall lifetime of network. As LEACH uses the probability model to distribute the energy consumption of CHs, so energy efficiency is not maximized. In case of homogenous protocol LEACH-C performs well, selecting optimum cluster head. But LEACH –C require universal knowledge of the network. This survey conclude that the LEACH-MERE perform well. But it is possible to enhance energy efficiency more than all homogenous protocol by using optimal fuzzy set. In case of heterogeneous clustering protocol, SEP performs well due to higher stability period and throughput, But DEC performs better as compare to other heterogeneous discussed earlier in this paper. The result of DEC protocol is close to ideal solution. Certain further energy improvement is possible in future work by using optimal fuzzy set, because the factors effecting the cluster formation and CHs communication are one of the challenging and open issue for future research.

REFERENCE

[1] Zheng J. and Jamalipour, A., "Wireless Sensor Network, A Networking Perspective", Edited By A John Wiley & Sons, Inc, Publication, 2009
[2] Manjeswar, A. and Aggarawal, D.P.," TEEN: A protocol for enhanced energy efficiency in wireless sensor netwok," In Proceeding of 1st International Workshop on Parallel and Distributed Computng Tssues in Wireless Network and Mobile Computing, San Francisco, CA, USA, 2001.
[3] Heinzelman, W.R,; Chandrakasan, A.; Balakrishna, H., "Energy-Efficient communication protocol for wireless sensor network," System Sciences, 2000. Proceeding of the 33rd Annual Hawaii International Conf. on, pp.10, vol.2, Jan, 2000
[4] Smaragdakis, G., Matta, I., and Bestavros, A., Stable Election Protocol for clustered heterogeneous wireless sensor network," In Proceeding of the International Workshop on SANPA, 2004
[5] Li, C.F.; Ye, M.; Chen, G.H., " An energy-efficient unequal clustering mechanism for wireless sensor network ," In Proceeding of the 2nd IEEE International Conference on Mobile Adhoc and Sensor Systems ( MASS 2005), Washington, DC , pp. 597-604,2005
[6] T. Preethiya and G. Santhi, "Enhancement of lifetime using fuzzy based clustering approach", International Conference on Computer Communication and Informatics,2014
[7] Baiping Li, Xiaoqin Zhang," Improvement of LEACH protocol in WSN",2012
[8] Aderohunmu, F.A, Deng J.D, Purvis, M.K,"A deterministic Energy-efficient clustering protocol for wireless sensor networks," in the Proceeding of seventh IEEE International Conference on Intelligent Sensor,Sensor Networks and Information Processing. P341 -346, 2011
[9] International Journal of Computer Science Issues (IJCSI), Volume 2, Number 3, 2009, pp 54-59.
[10] A. A. Abbasi and M. Younis" A survey on cluster in algorithms for wireless sensor network Compute Communications,vol.nos.1415,Oct.2007pp.2826– 2841.
[11] J.N. Al-Karaki and I.T. Al-Malkawi, "On energy efficient routing for wireless sensor networks", Innovations in Information Technology, 2008,
[12] A. Rahmanian, H. Omranpour, M. Akbari, K. Raahemifar "A Novel Genetic Algorithm in Leach-C Routing Protocol for Sensor Networks,(2004)