

## Highly Energy Efficient and Scalable Distributed Clustering Procedure for Dense Wireless Sensor Networks

R.Satheesh Kumar<sup>1</sup>, N.Krishnaraj<sup>2</sup> and G.Keerthana<sup>3</sup>

<sup>1</sup>Associate Professor, Department of Computer Science and Engineering, Sahridaya College of Engineering and Technology, Kerala, India.

<sup>2</sup>Professor, Department of Computer Science and Engineering, SASI Institute of Technology and Engineering, Andhra Pradesh, India.

<sup>3</sup>Fulltime Research Scholar, Anna University Chennai, Tamilnadu, India.

Article Received: 15 August 2017

Article Accepted: 30 November 2017

Article Published: 30 December 2017

### ABSTRACT

Wireless sensor network (WSN) is a low-powered prestigious network fashioned by sensor nodes that treasures application in civilian, military, visual sense models and many others. Reduced energy utilization is an exigent task for these sensor networks. By the data aggregation procedure, needless communication between sensor nodes, cluster head and the base station is eluded. An evaluation of energy efficient optical low energy adaptive clustering hierarchy has been performed and the enactments have been compared with the prevailing low energy adaptive clustering hierarchy algorithm, between two detached wireless sensor network fields. The proposed clustering procedure has been primarily implemented to join two distinct wireless sensor fields. An optical fiber is used to join two reserved wireless sensor fields. This distributed clustering methodology chiefly targets in exploiting the parameters like network lifetime, throughput and energy efficiency of the whole wireless sensor system.

Keywords: Distributed clustering algorithm, energy efficiency, wireless sensor network, clustering, network lifetime.

### 1. INTRODUCTION

Wireless Sensor Networks (WSN) finds applicable in many real-world applications (figure 1) like military, target tracking, environmental monitoring and civilian applications. A WSN can be generally styled as a network of nodes that cooperatively sense and regulates the environment. The activity of sensing, processing and communication under restricted amount of energy projects a need to pattern distributed mechanisms for data processing, MAC and communication protocols. Generally, a wireless sensor node is powered by limited- powered battery. Much of the energy consumption takes place during wireless communications.

On the other hand, data processing in WSN requires consuming tasks to be accomplished to avoid unnecessary processing power. Energy efficiency can be accomplished at different levels starting from physical layer, MAC layer and routing protocols up to the application level. The concerning protocols in WSNs can be classed into three major categories: routing protocols, sleep/awake scheduling protocols and clustering protocols [1].

One prime method to attain energy efficiency is to efficiently group the sensor nodes into clusters. In order to trim down the data transmission time and energy consumption, the sensor nodes are clustered into a number of small groups called clusters. The grouping of sensor nodes is known as clustering. Each and every cluster has a leader which is branded as cluster-head (CH). A CH is also one of the sensor nodes which are basically affluent in resources. The CH is selected by the sensor nodes in the respective cluster.

The CH may also be pre-assigned by the user. The main advantages of clustering are that it transmits the aggregated data to the sink or base station (BS), provides scalability for large number of nodes and diminishes the energy consumption.



Figure 1: Application of WSN for environmental monitoring.

Clustering may be centralized or distributed, based on the planning of CH. In centralized clustering, the CH is fixed but in distributed clustering CH has no fixed architecture. Distributed clustering mechanism is used for some exclusive reasons like sensor nodes prone to failure, better collection of data and minimizing redundant information [2]. Hence these distributed clustering mechanisms have highly self-organizing capability. The rest of this paper has been prearranged as follows. The existing clustering methodologies have been discussed in section II. Section III gives the conceptual description and review of a well-distributed clustering algorithm, the optical low energy adaptive clustering hierarchy (O-LEACH). Simulation results have been briefed in section IV. Section V concludes the paper and gives few ideas for an improvement over the existing algorithm.

## 2. EXISTING CLUSTERING METHODOLOGIES

Massive research efforts have been taken to lessen the energy consumption and to prolong the lifetime of WSNs. The algorithms described here are utterly distributed and CH changes from node to node based on some criteria. They diverge in the methodology by which the CH is elected. Algorithm for Cluster Establishment (ACE) [3] is a highly uniform clustering, self-organizing, effectual coverage, lesser overlapping and emergent cluster forming algorithm for WSNs. This is scale-independent and converges in time proportional to the deployment density of the nodes regardless of the overall number of nodes in the network. ACE requires no understanding of geographic location and requires only petite amount of communication overhead [4-6].

In a distributed clustering algorithm, the nodes make autonomous decisions. In Hausdroff Clustering (HC), once cluster formations take place it remains unchanged throughout the network lifetime. Moreover, to evenly use the energy among all the nodes, CH is rotated among the cluster members. This algorithm expands the lifetime of each cluster in order to increase the life time of the wireless sensor system. CH selection is essentially based on residual energy of the sensor nodes. Clustering methods have reduced the running down of energy in WSNs. Ring-structured Energy-efficient Clustering Architecture (RECA) uses deterministic CH management pattern to evenly distribute the work load among the nodes within a cluster. Nodes within a cluster make local assessments on

the length of their duty cycle according to their remaining energies. RECA is effectual in managing energy in a wide range of networks settings.

Low Energy Adaptive Clustering Hierarchy (LEACH) is a clustering mechanism that distributes energy consumption all along its network; the network is broken down into clusters. The CHs which are purely distributed in manner and the randomly elected CHs, gathers the information from the nodes which are coming under its cluster. It forms clusters based on the received signal strength and uses the CH nodes as routers to the BS. LEACH also forms one-hop intra and inter cluster topology where each node can transmit directly to the CH and thereafter to the BS. Consequently, it is irrelevant to networks deployed in wider regions. In the case of Two-Level Low Energy Adaptive Clustering Hierarchy (TL-LEACH), the CH collects data from other cluster members as original LEACH, but rather than transferring data to the BS directly, it uses one of the CHs that lie between the CH and the BS as a relay station. The primary CH in each cluster communicates with the secondaries, and the secondaries communicate with the nodes in their sub-cluster. Data fusion is also tasked as in LEACH. The two-level structure of TL-LEACH reduces the number of nodes, which need to transmit data to the BS, effectively lowering the total energy usage.

CLUBS is an algorithm that forms clusters through local broadcast and converge in a time proportional to the local density of nodes. CLUBS can be implemented in asynchronous environment without losing efficiency and simplicity. Furthermore, CLUBS satisfies many constraints that are common in other distributed environment such as limited topology knowledge or access to global IDs. The major problem of CLUBS algorithm is the clusters having their CHs within 1-hop range of each other. If this is the case, both clusters will collapse and CH election process will restart. Multi-hop Overlapping Clustering Algorithm (MOCA) is a randomized, distributed multi-hop overlapping clustering algorithm for organizing the sensors into overlapping clusters. The aspiration of the clustering process is to ensure that each node is either a CH or within the cluster radius from at least one CH. The CH nomination probability is used to control the number of clusters in the network and the degree of overlap amid them.

In Threshold sensitive Energy Efficient Network (TEEN), at every cluster change time, in addition to the attributes, the CH broadcasts to its members. This scheme is eminently suited for time critical data sensing applications. A smaller value of the threshold gives a more accurate picture of the network, at the expense of improved energy consumption. Thus, the user can govern the trade-off between energy efficiency and accuracy. The decentralized technique, Fast Local Clustering Service (FLOC) is suitable for clustering large-scale wireless sensor networks. It is fast, scalable, produces non-overlapping and approximately equal-sized clusters. This algorithm achieves locality, in that each node is only affected by the nodes within two units. Distributed Weight-based Energy-efficient Hierarchical Clustering (DWEHC) is a well distributed clustering algorithm which spawns well balanced clusters. The high-ranking advantage of DWEHC is that, it shows a vast improvement in both intra-cluster energy consumption and inter-cluster energy consumption.

In O-LEACH algorithm, the infrastructure of a sensor network is composed of a distributed optical fiber sensor (DFS) link and two separated WSN fields. The two WSN fields are crowded with randomly deployed nodes and these nodes can or cannot communicate with each other depending on the required applications. Unlike simple WSNs, since the DFS provide data processing, at one end of the DFS link, the sink or the BS for all WSN nodes is located. The CH node compress data arriving from nodes that belong to the relevant cluster, and sends the fused data to the BS in order to further reduce the amount of information to be transmitted to the BS. After a given interval of time, to maximize the uniformity of energy consumption of the network, randomized rotation of the role of CH is conducted. Sensors elect themselves to be local CHs at any time with a certain probability. The O-LEACH algorithm is only a fairly incremental modification to the original LEACH algorithm. Though O-LEACH protocol is comparatively much more energy efficient, the focal drawback in this approach is the random selection of CHs. In the worst case, the CH nodes may not be evenly distributed among the nodes and it will have its effect on the data gathering. Hybrid Energy Efficient Distributed Clustering (HEED) is a distributed clustering algorithm which selects the CH based on both residual energy and communication cost. Principally HEED was proposed to avoid the random selection of CHs.

### **3. THE OPTICAL LEACH CLUSTERING METHODOLOGY**

In O-LEACH algorithm, the construction of the sensor network encompasses of a distributed fiber sensor link and two detached wireless sensor network fields. Figure 1, displays the disposition of sensor nodes in the two fields. The Distributed Fiber Sensor (DFS) link is positioned at the center of the sensor fields and can cover a certain area. The two WSN fields are occupied with randomly scattered nodes and these nodes can or cannot communicate with each other liable on the required applications. Since the DFS offer data processing, at one end of the DFS link, the base station for all the sensor nodes is situated.

Although the lifetime of the DFS may have to be deliberated as well, the lifetime of such a sensor network is largely determined by the WSN. It consequences that the clustering based algorithm still displays good energy efficiency in the sensor network, particularly when two WSNs are not accessible to each other. As the DFS shelter extended rectangular area, O-LEACH algorithm is used to examine the lifetime of the hybrid sensor network with rectangular topology by isolating and connecting a series of WSNs around the DFS.

The CH nodes aggregates the arriving data from the nodes that fit to the suitable cluster and propel the aggregated packet to the base station in order to furthermore trim down the amount of data that must be forwarded to the base station, thereby augmenting the system lifetime. Succeeding to a given interval of time, to adjust the uniformity of energy dissipation of the network, randomized rotation of the concern of cluster head is carried out. Sensors elect themselves to be local cluster heads at any precise time with a definite probability.

As the operation of the standard LEACH algorithm is separated into setup phase and steady phase, O-LEACH operation is likewise separated into two phases, and the steady phase is as same as LEACH.

During the setup phase, the selection of cluster head follows the analogous criteria as LEACH, but there are two major alterations between O-LEACH and LEACH: (i) Nodes in WSNs cannot be deployed in the DFS coverage area and (ii) The cluster head and the node must be within the same WSN field if two WSNs cannot communicate with each other.

For most applications, it is superior to assume that the two WSN fields are isolated due to the following reasons: (i) Lengthier data transfer distance over the DFS terrain ends with advanced energy consumption and (ii) Wireless communication over the DFS area is not even permitted for some applications.

Table 1: Simulation Parameter Setup

Parameter	Values
Topology	500x500 m <sup>2</sup>
Number of nodes	30
Data packet size	4000 bytes
Control packet size	550 bytes
Initial energy	1 Joule
Transmitter power	31.32 mW
Receiver power	35.28 mW
Ideal power	712 mW
Sleep power	144

#### 4. SIMULATION RESULTS

The O-LEACH algorithm has been simulated using the network simulator (NS-2). Table 1, displays the necessary simulation parameter setup. In O-LEACH, the base station is expected to be situated at the center of the left edge of the two wireless sensor fields. The network energy dissipation is absolutely a arithmetical behaviour due to the random distribution of WSN nodes. As the DFS is absolutely active, the lifetime of the DFS is not deliberated. Figure 2, demonstrates the network performance in terms of the percentage lifetime of O-LEACH and LEACH.

Initially in 100 rounds, the percentage lifetime is 90 for both the algorithms. In 500 rounds, the percentage lifetimes of O-LEACH and LEACH are 72 and 53 respectively. Similarly in 3000 rounds, the percentage lifetimes of O-LEACH and LEACH are 14 and 1 respectively.

The percentage lifetime is found to be linearly increased in O-LEACH, when compared to LEACH. This is because of the usage of DFS link for connecting the sensor fields, which greatly reduces the losses while routing the packets to the base station. It is to be noted that in most practical applications, the DFS coverage is very specific and cannot be freely varied. Sometimes, parallel DFS links may be deployed to cover more broad areas.

Table 2: Percentage lifetime for LEACH and O-LEACH

Number of Rounds		100	500	1000	1500	2000	2500	3000
% Lifetime	LEACH	90	53	40	20	4	2	1
	O-LEACH	90	72	62	43	24	20	14

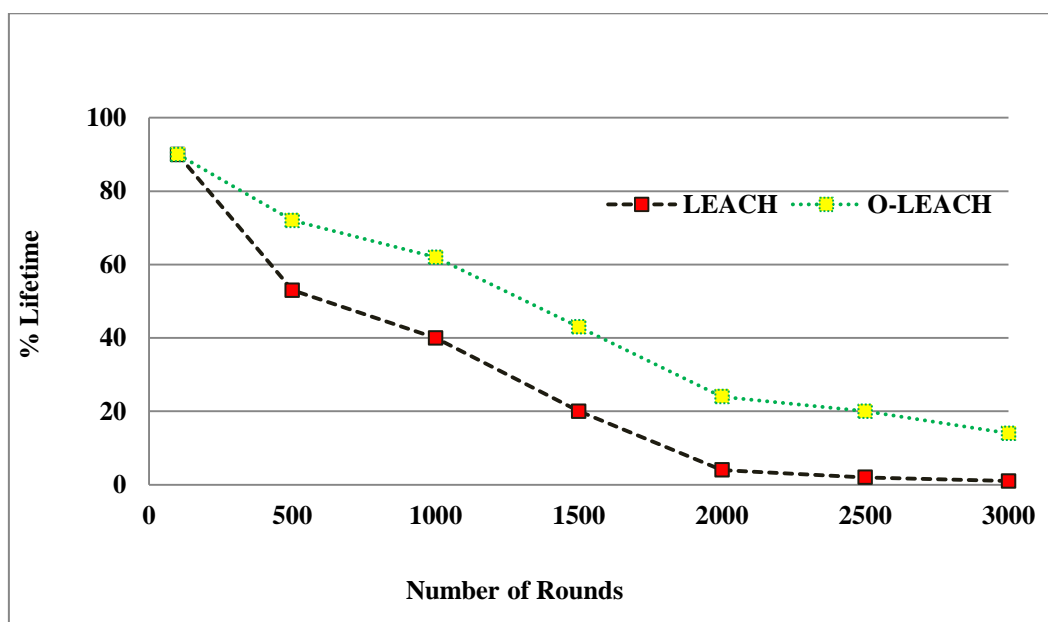


Figure 2: Percentage Lifetime versus Number of Rounds

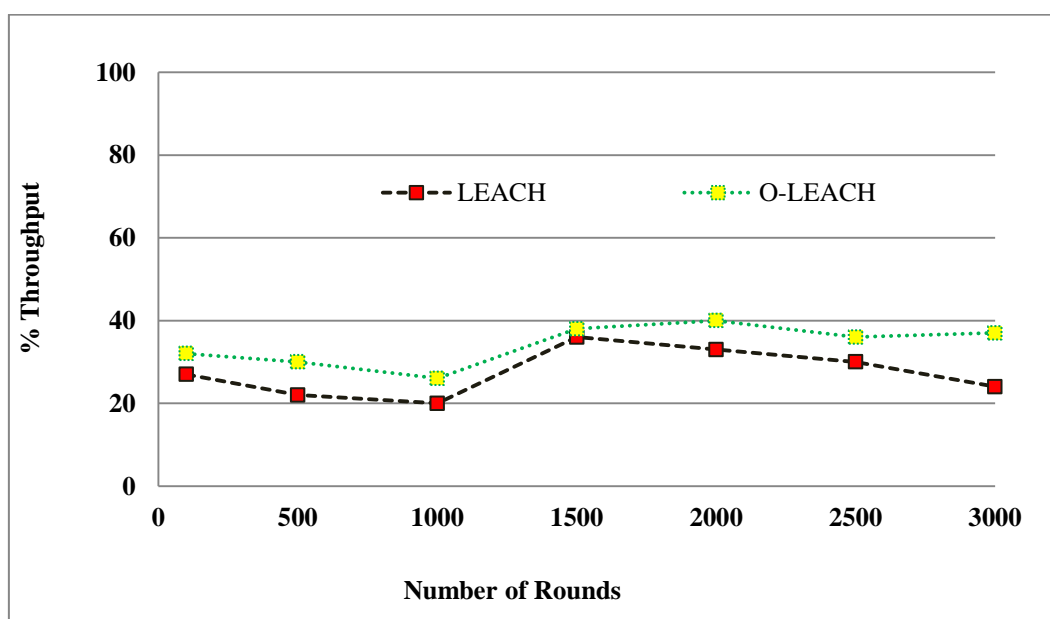


Figure 3: Throughput versus Number of Rounds (O-LEACH and LEACH)

Table 3: Percentage throughput for LEACH and O-LEACH

Number of Rounds		100	500	1000	1500	2000	2500	3000
% Throughput	LEACH	27	22	20	36	33	30	24
	O-LEACH	32	30	26	38	40	36	37

Figure 3, shows the performance evaluation of throughput and number of rounds for the two algorithms. Initially in 100 rounds, for O-LEACH and LEACH, the percentage of throughput is 32 and 27 respectively. Similarly in 3000 rounds, the throughput is 37 and 24 for O-LEACH and LEACH respectively. This slight increase in throughput in O-LEACH is mainly due the usage of DFS link for data packet transmission to the base station. Figure 4, shows the energy efficiency comparison of the two algorithms. After 100 rounds, the energy efficiency is found to be improved linearly in O-LEACH when compared to LEACH, for every successive rounds. This clearly indicates that, O-LEACH is efficient mainly when two wireless sensor networks have to be connected together.

Table 4: Energy Efficiency for LEACH and O-LEACH

Number of Rounds		100	500	1000	1500	2000	2500	3000
% Energy Efficiency	LEACH	42	45	43	46	38	27	20
	O-LEACH	40	35	30	17	12	8	5

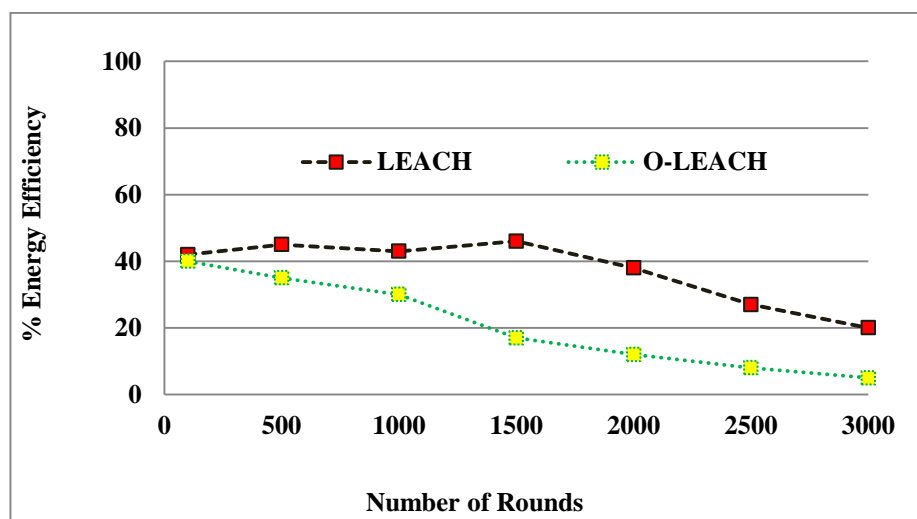


Figure 1: Energy efficiency versus Number of Rounds (O-LEACH and LEACH)



## 5. CONCLUSION

Generally, a wireless sensor node is powered by limited- powered battery. Much of the energy consumption takes place during wireless communications. On the other hand, data processing in WSN requires consuming tasks to be accomplished to avoid unnecessary processing power. Energy efficiency can be accomplished at different levels starting from physical layer, MAC layer and routing protocols up to the application level. Clustering is the most significant issue for networks where resources are restricted. Thus, it is required to make use of the available energy efficiently. There becomes a need in wireless sensor network to effectively group the sensor nodes in to clusters. In this paper, a review of O-LEACH algorithm has been carried out and the performance evaluation has been done against the existing LEACH algorithm, between two separate wireless sensor network fields. It could be clearly seen that the performance of O-LEACH is comparatively better, thereby O-LEACH is efficient mainly when two separate wireless sensor networks have to be connected together. The optical fiber links leads to various disadvantages like: i) Scattering losses, it is not applicable to use the DFS link for efficient long haul communications, ii) The changes in the light properties usually happen in the sensor, iii) Need for more expensive optical transmitters and receivers, iv) More difficult and expensive to employ splices and v) Difficult to carry electrical power to operate the terminal devices. These drawbacks could be overcome by changing the DFS link with an alternate medium for communication and effectively connecting two separate wireless sensor fields.

## REFERENCES

- [1] Akyildiz, I, Su, W, Sankarasubramaniam, Y & Cayirci, E 2002, 'A survey on sensor networks', IEEE Communications Magazine, vol. 40, no. 8, pp. 102-114.
- [2] Ali, M, Voigt, T & Uzmi, ZA 2006, 'Mobility management in sensor networks', Proceedings of the 2nd International Conference on Distributed Computing in Sensor Systems, pp. 131-140.
- [3] Baranidharan, B & Shanthi, B 2010, 'A survey on energy efficient protocols for wireless sensor networks', International Journal of Computer Applications, vol. 11, no. 10, pp. 0975-8887.
- [4] Guo, L, Xie, Y, Yang, C & Jing, Z 2010, 'Improvement on LEACH by combining adaptive cluster head election and two-hop transmission', Proceedings of the 9th International Conference on Machine Learning and Cybernetics, pp. 11-14.
- [5] Haitao, Z, Shiwei, Z & Wenshao, B 2014, 'A clustering routing protocol for energy balance of wireless sensor network based on simulated annealing and genetic algorithm', International Journal of Hybrid Information Technology, vol. 7, no. 2, pp. 71-82.



[6] Han, L 2010, 'LEACH-HPR: An energy efficient routing algorithm for heterogeneous WSN', Proceedings of the IEEE International Conference on Intelligent Computing and Intelligent Systems, pp. 507-511.

## AUTHOR BIOGRAPHIES



**Satheesh Kumar R** is an Associate Professor in Sahrdaya College of Engineering & Technology. He received his Master's degree in Information Technology and MBA degree in Information Systems. He also received his PhD degree in Information and Communication Engineering. His research areas are Cloud Computing, Natural Language Processing, Network Security, Data Mining, Web Mining, Text Mining and Opinion Mining. E-mail: satheeshpkd@gmail.com



**Krishnaraj N** is a Professor in SASI Institute of Technology and Engineering, Andhra Pradesh, India. He received his Master's degree in Software Engineering and. He also received his PhD degree in Computer Science and Engineering. His research areas are Image Processing, Network Security, Cloud Computing, Data Mining, Text Mining and Opinion Mining. E-mail: haikrishna84@gmail.com



**Keerthana G** is a Research Scholar in Anna University Chennai, Tamilnadu, India. She received her Bachelor's degree in Electronics and Communication Engineering and Master's degree in Applied Electronics. She is a Life Member in various Professional Bodies like IAENG, IRED, SDIWC. Her research interest includes image processing, mobile wireless ad hoc networks (MANETs), Data Mining, and Network Security. E-mail: gkeerthu21@gmail.com