

## Enhanced Zone-Based Clustering Method for Energy Efficient Wireless Sensor Network

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**Abstract:** *Wireless sensor network contains a number of tiny sensors to get data from the surface where it deployed. Clustering is done to increase energy of the node to some certain period. Enhanced network lifetime is an important task to be achieved by these sensor networks. In this paper, a procedure for evaluation of clustering efficiency, routing efficiency, energy efficiency and lifetime of two impenetrable wireless sensor network fields, using a distributed clustering approach, the hybrid energy efficient clustering algorithm has been proposed, which targets mainly on effectively prolonging the lifetime of wireless sensor networks. It is a well-distributed and energy-efficient clustering algorithm which employs three novel techniques: zone based transmission power, routing by means of distributed relay nodes and rapid cluster formation. The clustering process is effectively controlled, thus the number of cluster heads selection and the number of packets delivered to the base station is also found to be effective.*

**Keywords:** *Distributed relay node, rapid cluster formation, energy efficiency, routing efficiency, clustering efficiency and network lifetime.*

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### 1. INTRODUCTION

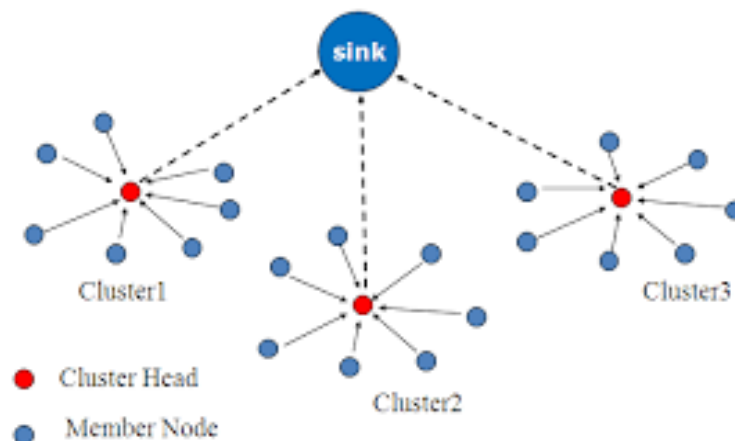
The concerning protocols in WSNs can be classified into three major categories: routing protocols sleep/awake scheduling protocols and clustering protocols [1]. One primary method to attain energy efficiency and improving network life time, is to efficiently group the sensor nodes into clusters [2-8]. In order to reduce the data transmission time and energy consumption, the sensor nodes are grouped into small clusters. This mechanism of grouping of sensor nodes into small-sized clusters is known as clustering (Figure 1). Each and every cluster has a leader which is termed as cluster head (CH). A CH may also be one of the sensor nodes which are basically rich in resources. The CH is selected by the sensor nodes in their respective clusters. 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 reduces the energy consumption [9-12]. Clustering may be centralized or distributed, based on the manner by which the CH gets selected. In centralized clustering, the CH is fixed but in distributed clustering the CH has no fixed architecture. The CH gets changed for every round based on some parameters like residual energy, number of neighbors, etc. Distributed clustering mechanism is used for some reasons like sensor nodes prone to failure, improved collection of data and lessening redundant information [13-15]. Hence, these distributed clustering mechanisms have high self-organizing capability. In this paper, a zone-based distributed clustering methodology has been proposed, employing three novel methodologies: zone based transmission power (ZBTP), routing using distributed relay nodes (DRNs) and rapid cluster formation (RCF), for effectively connecting two separate wireless sensor network fields.

### 2. LITERATURE SURVEY

Algorithm for Cluster Establishment (ACE) is a highly uniform clustering, lesser overlapping, efficient coverage and self-organizing cluster forming algorithm for WSNs. This is scale-independent and converges in time proportional to the local deployment density of the sensor nodes [16, 17]. ACE requires no understanding of geographic location and requires little amount of communication overhead. Clustering methods have reduced the energy utilization in WSNs. Ring-structured Energy-

efficient Clustering Architecture (RECA) uses deterministic CH management methodology to evenly allocate the work load amongst the nodes within a cluster. RECA is highly efficient in managing energy in a wide range of networks settings. 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.

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 [18]. The CHs which are purely distributed in nature and the randomly selected CHs gather the information from the nodes which are coming under its cluster. In case of Two-Level Low Energy Adaptive Clustering Hierarchy (TL-LEACH), the data collection by CH is done as the original LEACH, but 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 [19-21]. Data aggregation is also carried out as in LEACH. The two-level structure of TL-LEACH reduces the number of nodes which need to transmit data to the BS effectively, reducing the total energy usage.



**Figure1.** Clustering in Wireless Sensor Network

CLUBS is an algorithm that forms clusters through local broadcast and converges in time proportional to the local density of the nodes. CLUBS can be implemented in asynchronous environment without any loss in efficiency. The clusters having their CHs within one-hop range of each other, is the main problem in this methodology, if this is the case, both the clusters will collapse and CH election process will restart. Multi-hop Overlapping Clustering Algorithm (MOCA) is a randomized and distributed clustering mechanism for grouping the nodes into overlapping clusters. The main aim 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 between them. In Threshold sensitive Energy Efficient Network (TEEN), at every cluster change time, in addition to the attributes, the CH broadcasts to its cluster members [22-24]. This methodology is mainly suitable 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 balance the trade-off between energy efficiency and accuracy.

Distributed Weight-based Energy-efficient Hierarchical Clustering (DWEHC) is a well distributed clustering algorithm, for organizing the sensor nodes into well-balanced clusters. 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 have large number of randomly deployed sensor 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 compress the data arriving from nodes that belong to the relevant cluster and sends the aggregated 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 carried out. Nodes elect themselves to be local CHs at any time with a certain probability [25].

Though O-LEACH protocol is comparatively much more energy efficient, the main drawback of this approach is the random selection of CHs. Also, distributed optical fiber sensor (DFS) link is used to connect two separate wireless sensor fields. The aggregated data is forwarded from CH to the BS through this DFS link. The installation cost of this DFS link is costly and keeps on increasing with increase in communication distance. For transmitting the data over this DFS link, the data have to be converted into light. As the data has minimum energy level, the losses associated with the fiber are higher. It becomes necessary for replacing the optical fiber with some wireless medium, for connecting two wireless sensor fields.

Hybrid Energy Efficient Distributed Clustering (HEED) is a distributed clustering procedure which selects the CH based on both residual energy and communication cost. HEED was proposed to avoid the random selection of CHs when compared to O-LEACH algorithm. This algorithm gets executed in three subsequent phases: the initialization phase, the repetition phase and the finalization phase. During the initialization phase, the percentage of CH nodes is given to the sensor nodes initially, where each sensor nodes compute its probability to become a CH. In repetition phase, a CH with least transmission cost will be sorted out and in finalization phase, the CH selection will be properly finalized. The main disadvantage of HEED is that, the phases (especially repetition phase) consume much energy, as it takes large time duration to finalize a node with minimum cost. Also, all the nodes in the network use same amount of communication energy. Therefore, a method to reduce communication energy and selecting a CH in very short duration has to be developed.

### 3. THE PROPOSED CLUSTERING ALGORITHM

The proposed algorithm, hybrid energy efficient clustering algorithm is a well distributed clustering algorithm, where the sensor nodes are deployed randomly to sense the target environment, in two separate WSN fields, each fields being separated by some distance. The two separate WSN fields are connected together with the help of distributed relay nodes (DRNs). The sensor network is partitioned into clusters with each cluster having an individual CH. The nodes send the information during their TDMA time-slot to their respective CH which aggregates the data to avoid redundant information by the process of data aggregation. The aggregated data is then forwarded to the distributed relay nodes which in turn routes the data to BS by forwarding through other distributed relay nodes. Every single round in the clustering mechanism in the proposed algorithm is partitioned in to two time slots (duration): Network Formation Time (NFT) and Network Relaying Time (NRT).

Once for all, initially, the whole WSN fields automatically get organized into three different energy zones: small energy zone (SEZ), medium energy zone (MEZ) and highest energy zone (HEZ). During NFT, the finalized cluster heads get selected for the current round. During NRT, data transmission from cluster heads to the base station occurs via the distributed relay nodes. NFT and NRT get repeated for every successive round. The in-depth operations of NFT and NRT have been clearly discussed in the succeeding sections. The proposed algorithm has three main peculiar features. First, the proposed algorithm employs zone based transmission power (ZBTP). The entire sensor field gets divided in to three energy zones: SEZ, MEZ and HEZ. The nodes in SEZ use less power for communication and the nodes in HEZ use maximum power for communication. In the existing algorithms, every sensor nodes use same power, the power usage similar to HEZ nodes in the proposed algorithm. Second, CHs does not forward data directly to the BS, instead the cluster head forwards data packets to the DRNs, and these dedicated distributed relay nodes routes data to the BS, thereby considerable energy utilization can be reduced. Third, the rapid cluster formation (RCF) technique selects CH in just three stages, but the existing mechanisms use several stages to select a CH. the proposed algorithm use distributed relay nodes to connect two sensor fields, but in the existing O-LEACH algorithm, optical fiber is used, which encounters higher cost and greater losses during communication.

#### 3.1. Zone Based Transmission Power

In the proposed algorithm, the deployed sensor nodes get automatically organized in to three different energy zones: Small Energy Zone (SEZ), Moderate Energy Zone (MEZ) and Highest Energy Zone (HEZ) based on their distances from the BS. In the proposed algorithm, the base station is assumed to be located at the central position of the two WSN fields. Since the regular sensor nodes or CHs in the

three zones communicate with the base station using different power levels on the basis of zone, the technique is commonly referred as Zone Based Transmission Power (ZBTP). Here, the nodes and CHs in SEZ use transmission power  $P_1$  for communication, the nodes and CHs in MEZ use transmission power  $P_2$  for communication, and the nodes and CHs in HEZ use transmission power  $P_3$  for communication.

### 3.2. Routing using Distributed Relay Nodes

A distributed relay node (DRN) is a node which is comparatively rich in resources like battery, storage, etc. In general, similar to the normal wireless sensor nodes, DRNs are also battery operated devices employed mainly for wireless communication. The DRNs also minimize the transmission distance between a pair of distantly located nodes by acting as a hop between them. The DRNs have better capabilities than the regular sensor nodes in terms of initial energy provisioning, transmission range and data processing capability. The main benefits of using DRNs: extends the lifetime of sensor networks, energy-efficient and balanced data gathering, providing fault tolerance in sensor networks and providing wireless connectivity between two distant WSN fields. In the proposed algorithm, the DRNs perform only one function, routing the aggregated data from CH to the BS by forwarding through other DRNs, thereby providing wireless connectivity between two distant WSN fields. In the proposed algorithm, the DRNs are distributed evenly within the coverage range of the two WSN fields, but in the existing O-LEACH algorithm optical fiber is used for connectivity. If optical fiber is used for connecting two WSN fields, the fiber losses are more thereby leading to lower throughput which could be clearly seen from the simulation results. But DRNs provide effective data delivery to the base station with less loss. The deployment cost of DRNs is also less when compared to the optical fiber, as the coverage of each and every DRN is higher.

### 3.3. Rapid Clustering Formation

When compared to other distributed clustering mechanisms, the clustering happens in few stages, reducing the clustering time, thereby mentioned as Rapid Cluster Formation (RCF). The deployed sensor nodes get automatically organized into three energy zones: SEZ, MEZ and HEZ. The proposed algorithm considers four factors for selection of cluster-heads: the initial energy of nodes, the remaining energy of nodes, the average energy of every region and location of the sensor nodes. The operation of the proposed algorithm happens on the basis of rounds, with adjustable time duration. Each round is divided into Network Formation Time (NFT) and Network Relaying Time (NRT). During NFT, the cluster heads are selected and multiple clusters are formed in very short duration of time. During NRT, the sensed information (data) from all nodes is transmitted to the base station with help of distributed relay nodes.

### 3.4. Network Formation Time

Efficient cluster formation is a key methodology to prolong the network lifetime. During NFT, appropriate cluster heads are selected by the BS initially. The BS then calculates three different average energies for the nodes in SEZ, MEZ and HEZ, and thereby forms separate cluster heads for all three regions. The BS knows the initial energies of all the nodes for the first round and it can simply calculate the average energies for the first round. After first round, the nodes provide their residual energy information to the base station. Another significance of the proposed algorithm is, the sensor nodes provide their residual energy information along with the data packets transmission, thereby reducing extra transmissions. If the number of PCHs is greater than the required CHs, BS will select  $\text{Alive Nodes} \times P$  cluster heads with maximum residual energy and minimum distance to the base station. These finally elected cluster heads will be grouped as Finalized Cluster Heads (FCHs). Further, to minimize the computational overhead of non-CH nodes, BS multicasts the selection of FCHs. FCHs receive the final decision of selection from the BS and advertise their status updates to all other nodes lying in their communication range.

### 3.5. Network Relaying Time

In NRT, all the sensor nodes send their data to their corresponding CHs during their assigned time-slots. Cluster heads receive the data from its cluster members, and aggregate them. Data aggregation is a key technique to avoid unnecessary transmissions. The concept of threshold is applied in the proposed algorithm, which is highly significant in a variety of WSN applications such as fire alert, environmental monitoring, etc. The nodes send sensor values only when they fall above the hard threshold and change by given amount (soft threshold). The concept of soft threshold will further

reduce the number of transmissions, if there is little or no change in the value of the sensed attribute. It is possible to set both hard threshold and soft threshold values in order to control the number of packet transmissions. Cluster heads only send necessary data to the distributed relay nodes. These DRNs perform short-timed and effective delivery of the information to the base station, thus effectively prolonging the network lifetime.

#### 4. CONCLUSION

In today's scenario wireless networks equipped with sensors have gained a substantial attention and envisioned as a very propitious and benefit technology in vast amount of practical applications, that ranging from health and environment monitoring to industrial aspects, hence can be viewed as versatile technology. In this paper, a methodology for evaluation of clustering efficiency, routing efficiency, energy efficiency and lifetime of two dense wireless sensor network fields, using a distributed clustering approach, hybrid energy efficient clustering algorithm has been proposed, in which the optical fiber link in the existing method is replaced by distributed relay nodes for connecting two separate WSN fields. Based on three novel techniques: zone based transmission power, routing using distributed relay nodes and rapid cluster formation, the algorithm has been formulated for dense wireless sensor networks.

#### REFERENCES

- [1] Lianshan Yan., Wei Pan., Bin Luo., Xiaoyin Li. and Jiangtao Liu., "Modified Energy-Efficient Protocol for Wireless Sensor Networks in the Presence of Distributed Optical Fiber Sensor Link," IEEE Sensors Journal, Vol. 11, 2011, pp. 1815-1819.
- [2] Hamid Ali Abed Al-Asadi, "Temperature dependence of the lasing characteristics of vertical cavity surface emitting lasers," Engineering Journal of Technology University, Vol. 145, 1994.
- [3] Boselin Prabhu S.R. and Sophia S., "Environmental monitoring and greenhouse control by distributed sensor Network", International Journal of Advanced Networking and Applications, 5(5), 2014.
- [4] Boselin Prabhu S.R. and Sophia S., "Greenhouse control using wireless sensor network", Scholars Journal of Engineering and Technology, 2(4), 2014.
- [5] Hamid Ali Abed Al-Asadi, "Temperature dependence of the noise characteristics of Multiisecton semiconductor lasers," Science Journal, vol. 7, No. 3, 2001.
- [6] Hamid Ali Abed Al-Asadi, "Line width characteristics of vertical cavity surface emitting lasers due to external optical feedback," Science Journal, vol. 8, 2001.
- [7] Boselin Prabhu S.R. and Sophia S., 'Modern cluster integration of advanced weapon system and wireless sensor based combat system', Scholars Journal of Engineering and Technology, 2(6A), 2014.
- [8] Boselin Prabhu S.R. and Sophia S., 'A review of efficient information delivery and clustering for drip irrigation management using WSN', International Journal of Computer Science and Business Informatics, 14(3), 2014.
- [9] Hamid Ali Abed Al-Asadi, "Line width characteristics of vertical cavity surface emitting lasers due to external optical feedback," Science Journal, vol. 8, 2002.
- [10] Hamid Ali Abed Al-Asadi, "Theoretical investigation of spectral line width properties of double fused 1.3 um MQW-VCA in reflection and transition modes," Tikrit Journal for Pure Science, vol. 8, No. 2, 2002.
- [11] Boselin Prabhu S.R. and Sophia S., 'Mobility assisted dynamic routing for mobile wireless sensor networks', International Journal of Advanced Information Technology, 3(3), 2013.
- [12] Boselin Prabhu S.R. and Sophia S., 'A review of energy efficient clustering algorithm for connecting wireless sensor network fields', International Journal of Engineering Research and Technology, 2(4), 2013.
- [13] Hamid Ali Abed Al-Asadi, "Vertical cavity amplifiers and its cavity length dependence the saturation power and quantum efficiency," Tikrit Journal of Pure Science, vol. 9, No. 2, 2003.
- [14] Hamid Ali Abed Al-Asadi, "Effects of pump recycling technique on stimulated Brillouin scattering threshold: A theoretical model," Optics. Express, Vol. 18, No. 21, pp. 22339-22347 Impact factor: 3.88, 2010.

- [15] Boselin Prabhu S.R. and Sophia S., 'Variable power energy efficient clustering for wireless sensor networks', Australian Journal of Basic and Applied Sciences, 7(7), 2013.
- [16] Boselin Prabhu S.R. and Sophia S., 'Capacity based clustering model for dense wireless sensor networks', International Journal of Computer Science and Business Informatics, 5(1), 2013.
- [17] Hamid Ali Abed Al-Asadi, "Brillouin Linewidth Characterization in Single Mode Large Effective Area Fiber through the Co-Pumped Technique," International Journal of Electronics, Computer and Communications Technologies (IJECCT), Vol. 1(1), pp. 16-20, 2010.
- [18] Boselin Prabhu S.R. and Sophia S., 'An integrated distributed clustering algorithm for dense WSNs', International Journal of Computer Science and Business Informatics, 8(1), 2013.
- [19] Boselin Prabhu S.R. and Sophia S., 'A research on decentralized clustering algorithms for dense wireless sensor networks', International Journal of Computer Applications, 57(20), 2012.
- [20] Hamid Ali Abed Al-Asadi, "Analytical study of nonlinear phase shift through stimulated Brillouin scattering in single mode fibre with pump power recycling technique," Volume 13 Number 10, Journal of Optics. Impact factor: 1.99, 2011.
- [21] Hamid Ali Abed Al-Asadi, "Architectural Analysis of Multi-Agents Educational Model in Web-Learning Environments," Journal of Emerging Trends in Computing and Information Sciences, Vol. 3, No. 6, June 2012.
- [22] Boselin Prabhu S.R. and Sophia S., 'Hierarchical distributed clustering algorithm for energy efficient wireless sensor networks', International Journal of Research in Information Technology, 1(12), 2013.
- [23] Boselin Prabhu S.R. and Sophia S., 'Real-world applications of distributed clustering mechanism in dense wireless sensor networks', International Journal of Computing Communications and Networking, 2(4), 2013.
- [24] Younis, O. and Fahmy, S., "HEED: A Hybrid Energy-Efficient Distributed Clustering Approach for Ad Hoc Sensor Networks," IEEE Transactions on Mobile Computing, 2004.
- [25] Chan, H. and Perrig, A., "ACE: An Emergent Algorithm for Highly Uniform Cluster Formation," First European Workshop on Sensor Networks (EWSN), 2004, Germany.

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