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# ENHANCED CLUSTERING METHODOLOGY FOR LIFETIME MAXIMIZATION IN DENSE WSN FIELDS

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***ABSTRACT: Enhanced network lifetime is animportant 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 employsthree novel techniques:zone based transmission power (ZBTP), routing by means ofdistributed relay nodes (DRNs) and rapid cluster formation (RCF). The clustering process is effectively controlled, thereby the number of cluster heads selection and the number of packets delivered to the base station is also found to be effective.***
***KEYWORDS: Wireless sensor network, distributed clustering, distributed relay node, zone based transmission power, rapid cluster formation, energy efficiency, routing efficiency, clustering efficiency, network lifetime.***

## I. INTRODUCTION

A WSN is a network of wireless sensor nodes that cooperatively sense and regulates the environment [1]. The action of sensing, processing and communication under restricted amount of energy necessitates developing distributed mechanisms for data processing, MAC and data communication. In general, a wireless sensor node is powered by a limited-powered battery. Much of the energy consumption takes place during wireless communication. On the other hand, data processing in WSN requireschallengingtasks to be accomplished to avoid unnecessary processing power. Energy efficiency can beaccomplished at differentlevels starting from the physical layer, MAC layer and routing protocols up to the application level.The concerning protocols in WSNs can be classified into three major categories: routingprotocols, sleep/awake scheduling protocols andclusteringprotocols. One primary method to attain energy efficiency and improving network lifetime, is to efficiently groupthe sensor nodes into clusters (figure 1) [2-8]. In order to reduce the data transmission time and energy consumption, the sensor nodesare grouped into small clusters. This mechanism of grouping of sensor nodes into small-sized clusters is known as clustering. 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].

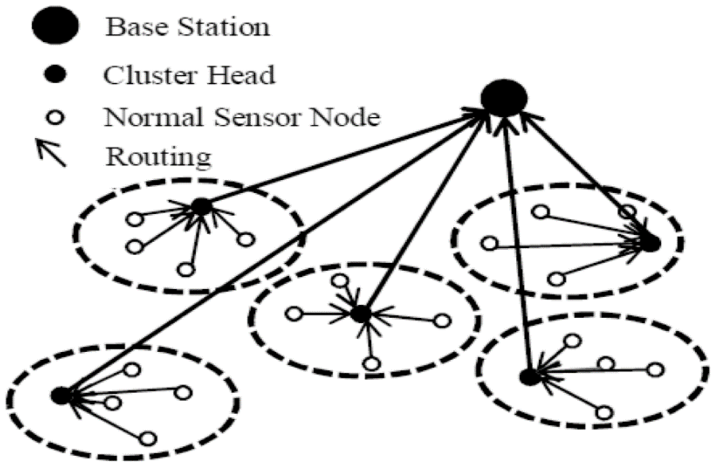


Figure 1: Clustering Process

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 clusteringthe 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 methodologyhas 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. The primary objective of the proposed algorithm is to achieve energy efficiency and extended network lifetime, when two far-away located WSN fields are to be effectively connectedtogether for cooperative communication.

## II. LITERATURE REVIEW

In a distributed clustering algorithm, the nodes make autonomous decisions. In Hausdroff Clustering (HC),once cluster formation takes place it remains unchanged throughout the network lifetime [16]. This algorithm extends the lifetime of each cluster in order to increase the life time of the whole wireless sensor system. The CH selection is particularly based on residual energy of the sensor nodes.Algorithm for Cluster Establishment (ACE)is a highly uniform clustering, lesser overlapping, efficient coverage and self-organizingcluster forming algorithm for WSNs. This is scale-independent and converges in time proportional to the local deployment density of the sensor nodes [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 gatherthe 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 aggregationis also carried out as in LEACH.The two-level structure of TL-LEACH reduces thenumber of nodes which need to transmit data to the BSeffectively,reducing the total energy usage.CLUBSis 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 probabilityis 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 balancethe trade-off between energy efficiency and accuracy.Distributed Weight-based Energy-efficient Hierarchical Clustering (DWEHC) is a well distributed clusteringalgorithm, 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.

## III. THE PROPOSED 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 (figure 2). The two separate WSN fields are connectedtogether with the help of distributed relay nodes (DRNs).

  

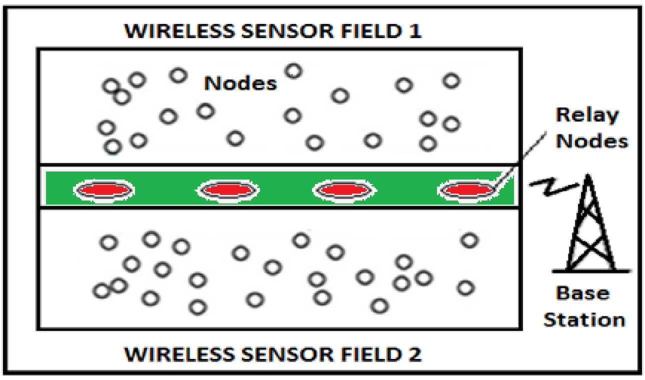


Figure 2: An articulation of the proposed algorithm

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) (figure 3). 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.

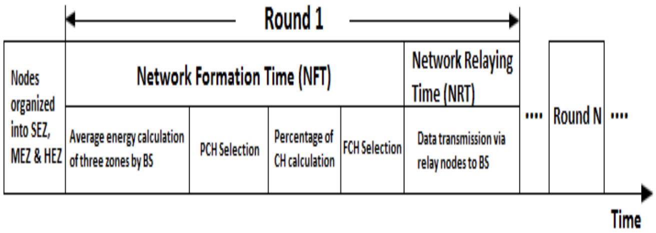


Figure 3: Time line depicting the clustering procedures of the proposed algorithm

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 (ZBTP)

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 P1 for communication, the nodes and CHs in MEZ use transmission power P2 for communication, and the nodes and CHs in HEZ use transmission power P3 for communication. Considering, N1 to be the nodes in SEZ region and thus the total transmission power in SEZ is expressed as

$$P_S = N_1 \times P_1 \quad (1)$$

Where, P1 is the transmission power assigned to the nodes in SEZ. The total transmission power in MEZ is given by

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 minimizes 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 processingcapability. 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 distantWSN 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 whencompared to the optical fiber, as the coverage of each and every DRNishigher.

3.3 Rapid Clustering Formation (RCF)

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 in to 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 regions and locationof 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 (NFT)

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. Average energy of all the SEZ nodes, which spreads closest to the BS is

$$E_S(r) = \frac{1}{N_1}\sum_{i=1}^{N_1} E_{(Si)}(r) \tag{2}$$

Where, ES(r) is average energy of the SEZ field, N1 is the total number of nodes in SEZ and r is the current round of operation. Similarly, the average energy of all the MEZ nodes, which gets spread next to SEZ from the BS is expressed as

$$E_M(r) = \frac{1}{N_2}\sum_{i=1}^{N_2} E_{(\mathrm{M}i)}(r) \tag{3}$$

Where, EM(r) is average energy of the MEZ field, N2 is the total number of nodes in MEZ and r is the current round of operation. Similarly, the average energy of all the HEZ nodes, which gets spread next to MEZ from the BS is given by

$$E_H(r) = \frac{1}{N_3}\sum_{i=1}^{N_3} E_{(\mathrm{H}i)}(r) \tag{4}$$

Where, EH(r) is average energy of the HEZ field, N3 is the total number of nodes in HEZ and r is the current round of operation.After calculation of average energies of each region, BS compares the energy of each node to theircorresponding average energy of the regions. The sensor nodes with higher or energy equal to the average energies (Ei≥ Average Energy) are selected by the BS as Possible Cluster Heads (PCHs). Again the BS selects desired percentage (P) of cluster heads in every round, for nodes in all the three regions. If the number of PCHs is greater than the required CHs, BS will select Alive Nodes × 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 computationaloverhead of non-CH nodes, BS multicasts the selection of FCHs. FCHs receive the final decision of selection from the BS and advertises their status updates to all other nodes lying in their communication range.

3.5 Network Relaying Time (NRT)

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.

## IV. CONCLUSION

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 (ZBTP), routing using distributed relay nodes (DRNs) and rapid cluster formation (RCF). The distributed relay nodes used effectively connects two separate wireless sensor network fields, with reduced packet loss than with an optical fiber link.

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