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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 12, Issue, 04, pp.11176-11181, April, 2020

DOI: https://doi.org/10.24941/ijcr.38545.04.2020

ISSN: 0975-833X

RESEARCH ARTICLE

ENERGY EFFICIENT ALGORITHM FOR WIRELESS SENSOR NETWORKS BASED ON CLUSTER HEAD SELECTION

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ARTICLE INFO

Article History:
Received 28th January, 2020
Received in revised form
05th February, 2020
Accepted 28th March, 2020
Published online 30th April, 2020

Key Words:
Pulmonary Function Tests, Spirometry, Swimming, Children.

ABSTRACT

This paper presents on key issue in WSN is to develop an energy-efficient clustering Protocol with lower energy consumption for transferring information from channel heads to BS (Base Station). A multi-level hierarchical structure performs in effectively route and collect data in WSN. Hierarchical clustering algorithms are having the increased network lifetime. The primary point in these algorithms is the cluster head selection using midpoint algorithm to improve initial centroid selection procedure. The proposed protocol works on selecting the best Cluster Head (CH) by considering some parameters such as residual energy, distance between cluster heads, nodes and base station to work on long lifetime of network. Overall simulation performance is compared with standard algorithms and achieved efficient energy consumption.

Citation: ***Dr. Arunkumar, J.R., Dr. SundarRajan M. and Dr. Anusuya, R..*** **2020.** "Energy Efficient Algorithm for Wireless Sensor Networks Based on Cluster Head Selection", *International Journal of Current Research*, 12, (4), 11176-11181.

INTRODUCTION

WIRELESS Sensor Network (WSN) (Lin-Feng *et al.*, 2014) is collected with hundreds of sensor nodes that communicate with low energy consuming routing protocols. The main issue in WSN is the energy to be utilized in efficient way in order to extend the lifetime in sensor networks. By considering the model of sensor nodes (Celebi, 2013; Park *et al.*, 2013) and their constraint lead to design energy efficient routing protocols. It should be low cost and low power sensors are able to communicate in a limited range and work together to form a sensor network for gathering data from a field. These sensors carry out data processing and communication within the nodes. It is enable to monitor and collect data in open medium and the data is transmitted to electronic signals. Those signals are carried out to the base station (BS). The energy consumption is the problem in energy efficient routing protocol. So should be simple and light weighted. According to the topology of network Wireless sensors networks routing protocols, LEACH (Low Energy Adaptive Clustering Hierarchy) (Chen, 2006) is the simplest hierarchical protocol carry out clustering approach with low energy consumption in a wireless sensor network. Clustering is the main factor in LEACH algorithm to reduce the overall network energy consumption, balance the energy consumption among the sensors and extend the lifetime of the network. To reduce the amount of information that must be transmitted to base station data fusion into routing protocol is followed. LEACH assumes each node in base station is transmitted directly with high power. LEACH K-MEANS chooses k nodes as K clusters with calculated nodes cost. Node having the smallest cost is selected as cluster head. This cycle stops after fixing K-cluster heads with random distribution. Following, channel heads gets overloaded and dies faster. The proposed Midpoint Leach K-means (MPLK-means) algorithm is to overcome the above issues through midpoint algorithm (Krishnasamy, 2014) by accomplishing the selection process with primary centroid and limited resource using k-means. It performs CH selection using residual parameter and provides equal amount of sensor nodes to each cluster. Through this CH gets balanced and gives better lifetime of nodes can be achieved. It reduces energy consumption of CHs for data communication. The threshold residual energy is defined to calculate the amount of energy required to receive, combine and transmit the average number of sensor nodes in the cluster. Energy consumption is reduced by keeping CHs and the BS closer for communication. If the distance between selected CH node and the BS is greater than some threshold distance, the CH will not communicate to the BS directly. In this case, multi-hop communication will occur via other CHs. As a result, it provides enhanced network lifetime in WSN.

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The main goal of this paper is to enhance a distributed clustering protocol in wireless sensor networks. There are four parameters considered as residual energy of node distance between node and base station and its neighboring nodes, along with selection of cluster heads. A combined function of parameters with different weights carried out in each node to receive a score. This is used to choose a Cluster heads CHP. The parameters are weighed based on their effects on energy-consumption decrement in different rounds of clustering. Aggarwal, N., *et al*. proposed the midpoint algorithm (Jenq-Shiou Leu, 2015) which has been used for initial CH selection assuming that the data points contain only positive values Ashish Upadhyay, et. al. (2006) introduced a hierarchical clustering algorithm for sensor networks, called Low-Energy Adaptive Clustering Hierarchy (LEACH) is a classical clustering routing in wireless sensor networks .However the cluster-head selection in LEACH protocol is lack of balancing the whole network energy consumption, with the result that low energy nodes run out of energy prematurely and decline the network life. This paper analyses the effectiveness of LEACH protocol in cluster-head selection, and proposes an improved energy balanced clustering algorithm. Prerna*et al*. (Periyasamy, 2016; Kuila, 2014) authors proposed Energy Efficient Clustering Algorithm (EEAC)for WSN.

This algorithm is based on static clustering concept and dynamic cluster heads selection technique, which divides the entire network area into a number of fixed regions. Cluster head (CH) is selected that it reduces Communicating distance between nodes, for this reason energy consumption reduces while transmitting the data from one node to another and increases network efficiency as energy consumed. The proposed (EECA) algorithm gives better result than the LEACH, LEACH-C and DR scheme with respect to throughput and stability. Jenq-ShiouLeu *et al*. (2014; Chamam, 2010) proposed Energy Efficient Clustering Scheme for Prolonging the Lifetime of Wireless Sensor Network with Isolated Nodes. A new regional energy aware clustering method using isolated nodes for WSNs, called Regional Energy Aware Clustering with Isolated Nodes (REAC-IN). In this algorithm cluster heads (CHs) are selected based on weight which is determined according to the residual energy of each sensor and the regional average energy of all sensors in each cluster and improves the cluster head selection process and solves the problem of node isolation, lifetime and stability of a network is more favorable. The rest of paper is structured as follows: Section II discusses about the issues in existing algorithms to be overcome. Section III Provides complete understanding of our proposed hierarchical clustering algorithm with the ability of cluster head Selection. Section IV provides the simulation set up and result analysis respectively. Section V gives concluding remarks.

Problem Statement: There is significant research effort for the development of energy efficient routing protocols in Wireless Sensor Networks. several factors that should be taken into account when designing energy efficient routing protocols for WSNs. Energy efficiency is the most important factor, as it directly affects the lifetime of the network.. Some of the existing approaches for clustering based on K-means algorithm are discussed as follows:

Leach K Means: In Low Energy Adaptive Clustering Hierarchy (LEACH) (Lin-Feng, 2014), a hierarchical protocol in which most nodes transmit to cluster heads. This section describes the original k-means clustering algorithm.

The given set of data with fixed knumber of values into disjoint clusters is designed. The algorithm processed with two separate sections the first stage is to define k centroids for each cluster. The second stage to the given data set is fixed with a point to the nearest centroid. Euclidean distance is generally considered to determine the distance between data points and the centroids. The first step is completed after all the points are included in clusters, and an early grouping is done and to the new centroids are calculated again, as the inclusion of new points may lead to a change in the cluster centroids. Once k new centroids are found, a loop is generated to create a new binding between the same data points and the nearest new centroid. As a result of this loop, the k centroids may change their position in a step by step manner with fixed centroids positions results in coverage demand. The k means algorithm is a popular method for automatically classifying vector-based data. In k-means algorithm (Kumar, 2014; Periyasamy, 2016), the initial centroids are randomly selected from input data set provides the algorithm with best outcome. From a given set of data set compute the k means algorithm by considering first 3 points as initial centroids. If suppose the last 3 points as the initial centroids is selected and third time selects any 3 arbitrary data points as initial centroids and finally compute the k-means algorithm. Each time the end clustering results will be different by analyzing which one is the most suitable result. This is the limitation which needs to be dealt with in order to make the k-means algorithm more efficient.

Proposed Clustering Algorithm: Inorder to produce the initial centroids (Park, 2013) efficient mid-point algorithm is proposed. The Midpoint Leach K-means (MPLK-means) algorithm gives a regular method to establish the initial centroids. It also produces good clusters using k-mean method, compared with random selection of initial centroids. In proposed algorithm, if the input data set contains the negative value attributes, then all the attributes are transformed to positive space by subtracting each data point attribute with the minimum attribute value in the data set. This transformation is required because in the algorithm the distance is calculated from origin to each data point. Then for different data points same Euclidean distance will be obtained to avoid incorrect selection of initial centroids. The next step is to calculate the distance of each point from the origin. After Then the original data points are sorted into k equal sets. The mid-point is calculated in all over the process. All the mid-points are taken as the initial centroids. The following section explains about the algorithm carried out in balanced cluster formation and the evaluation of clustering parameters in node.

Selection of Cluster Head: The midpoint algorithm (Heinzelman *et al*., 2002) which has been used for initial CH selection assuming that the data points contain only positive values. Here obtained from (1). Fig. 2 shows an example of a particular cluster of ten nodes where initial CHs have been selected through the midpoint algorithm. Here the centroid of desired number of clusters kept is cluster is a virtual node locating at the center position of the cluster. In this figure, initial CH is denoted by encircled sensor node. To maintain the connectivity of the network, residual energy of the CH is checked every round. If the energy of the CH is smaller than the threshold energy, the node having the next ID number is selected as a new CH as in (Kumar, 2014). The newly elected CH informs other nodes about the change of the CH. All other remaining node joins the nearest cluster channel head and the centroid of each cluster is calculated.

ID number is given to each node in which smaller number is given to nearest one. The selected cluster head is compared to residual energy is to be greater than threshold energy and node parameters as follows:

Calculation of Residual Energy Between Nodes: The CH node consumes more energy than its member nodes (8). They combine data together and send them to the BS. Therefore, the clustering process assigns CH nodes with the highest residual energy. So, score parameter (SP) is defined as a criterion for a node with higher residual energy to obtain more score than other nodes to be qualified as the cluster head. SP1 is defined as follows:

$$SP_1 = \frac{E_{current}}{E_{max}} \quad (1)$$

Where, Ecurrent denotes the volume of residual energy and Emax is the maximum volume of the energy of a node when it is fully charged. Since residual energy appears in the numerator, nodes with higher residual energy b\is selected as CH.

Distance Between Node And Bs: After the selection of CH it should carried out in collecting data from member nodes, deleting repeated data, conducting a limited processing operation on the data, and finally sending them to the BS (20). The CH selects its nearby node to the BS so the energy consumption will be lower. It results in increase of CH lifetime and the duration of the steady-state phase. In each round of clustering that allows to lower energy consumption for reselecting CHs. Thus, nodes that are closer to the BS more likely become a CH. SP2 is defined by below equation as a criterion for the closer node to BS, in order to obtain more score than other nodes as a prerequisite to become a cluster head.

$$SP_2 = 1 - \frac{d_{bs}}{d_{far}} \quad (2)$$

where, dbs the distance between each node and BS. The dimension of the network in this paper is 200 _ 200 and the location of BS is 100 _ 250. Therefore, distance of the farthest node to BS is 269.25 m.

The Distance Between Node and Its Neighboring Nodes: The direct relationship is carried out **between distance** and the energy consumed for transmitting data in which each member node sends the data nearby is sensed by its CH. SP3 is defined by Eq. (3) as a criterion for the node that is closer to its neighboring nodes to obtain more score than others as a pre-requisite to become qualifies as a cluster head.

$$sp_3 = 1 - \frac{\sum_{i=1}^{N} dis_i}{N\ X\ dis_{max}} \quad (3)$$

where, disi denotes the distance between the node and its i^{th} neighbor. dismax denotes the distance between the node and its remotest neighboring node and N is the number of neighboring nodes. Since the total distance is the numerator and N _ dismax is the denominator in Eq. (3), multiplied by a negative number, the smaller the total distance between a node and its neighbors is, the lower the SP3 is obtained

Number of Neighboring Nodes: The number and size of clusters should be balanced (7). It is must to set a threshold for the number of cluster members with number of neighbors nodes close to the threshold will have the higher chance to be selected as CH.SP4 is defined by Eq. (4).

$$SP_4 = 1 - \frac{(count_{nig} - threshold)^2}{threshold^2} \quad (4)$$

SP4 will be equal to 1 if the number of the node's neighbors counting is equal to the optimal number of neighbors threshold), and less than 1 if counting is either higher or lower than the threshold.The threshold is obtained as follows:

$$threshold = \frac{N_{total}}{K_{opt}} \quad (5)$$

where, countnig denotes the number of neighboring nodes of each node and threshold stands for the optimal number of neighbors for each node. The combination of SP1, SP2, SP3 and SP4, score function (SF) for CH selection is designedas per the midpoint algorithm sensor nodes are collected into nearest channel heads and the process is carried out by following condition

if (Residual energy of cluster head ≥ $E_{threshold)}$ and (SP_1) and (SP_2) and (SP_3) and (SP_4)
then

The node will remain as cluster head

Else

Check ID number of all sensor nodes in that cluster
The node I the next order of ID number is selected as a new CH. Then the newly elected channel heads inform other nodes about the change until the cluster heads are not changed any more. After then sensor nodes sends data packet to their channel heads and calculates the distance between elected CH by satisfying the following condition

if (d_{bs}<$d_{threshold}$)

then

Cluster head directly connected to the BS

Else

It selects the nearest neighbor cluster head whose $d_{bs}$is less than the$d_{threshold}$ to communicate to BS

In our approach, an estimation of threshold residual energy is given. Here the threshold energy is the amount of energy required to receive, aggregate and transmit the average number of sensor nodes in the cluster.Sensor nodes send data packet. From the proposed algorithm noticed if it is a higher energy level of the node indicates that it has a higher chance to become a CH.

SIMULATION RESULTS

Energy Model: Eelec is the power consumption of sending and receiving, determined by the circuit. If the transmission distance is less than threshold d0, the power amplifier Efs of free space model is adopted.

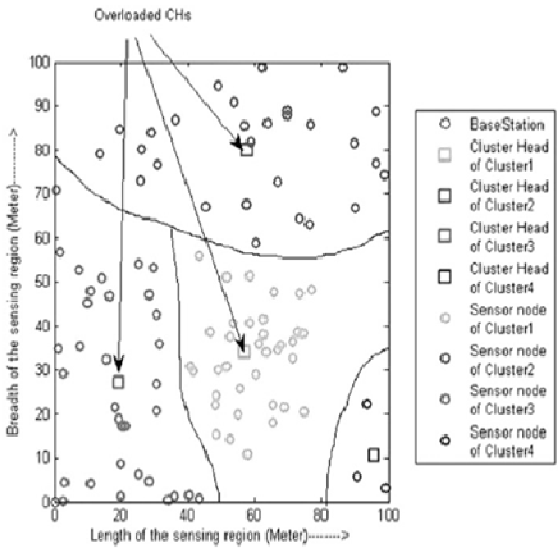

Fig.1. Unbalanced clustering

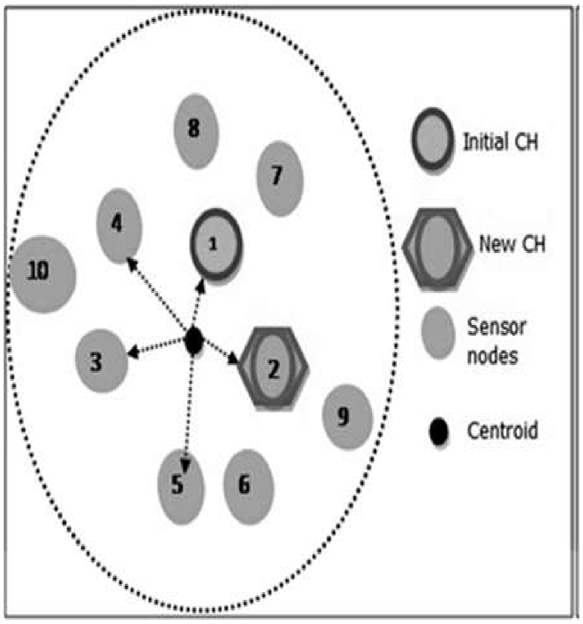

Fig. 2. Channel heads and centroids are selected using ID number

Table1. Parameters for clustering

Parameter	Value
Number of sensor nodes (N)	100
Network size	100x100 m^2
Base station	(0,0)
Number of clusters (K_{opt})	4,5
Initial energy of node	1J
Data packet	3200 bits
E_{elec}	50 nJ/bit
E ε_{amp}	0.0013 pJ/bit/m'
E ε_{fs}	10 pJ/bit/m^2
Energy for data aggregation (E_{DA})	5 nJ/bit/signal
d_{BS}	85_100 m
d_{CH}	d_{BS}/2
$d_{threshold}$	88 m

Conversely, when the transmission distance is equal or greater than the value, the power amplifier Ɛamp of multi path attenuation model is adopted.

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{amp}}} \quad (6)$$

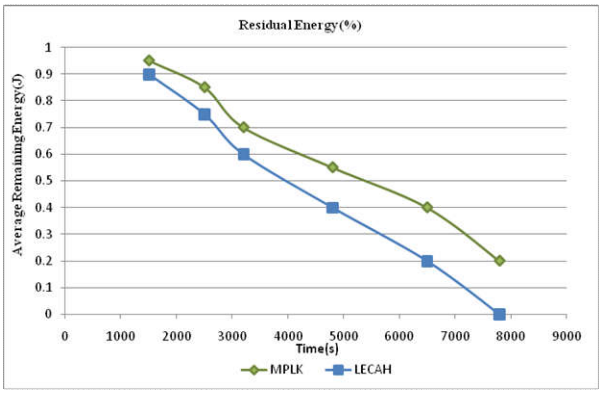

Fig. 3. Residual Energy Parameter in Reducing Energy Consumption

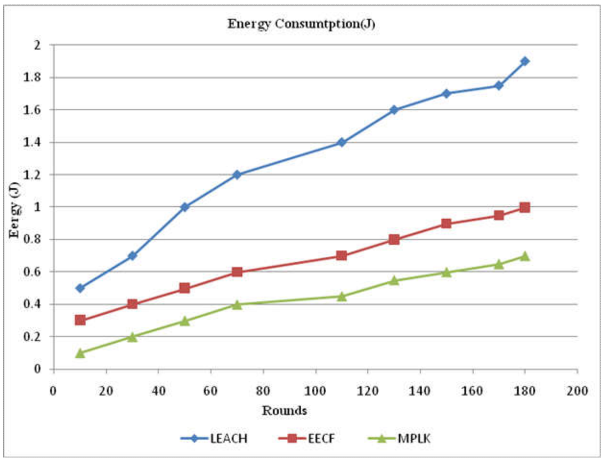

Fig. 4. Comparison of Energy Consumption by Nodes

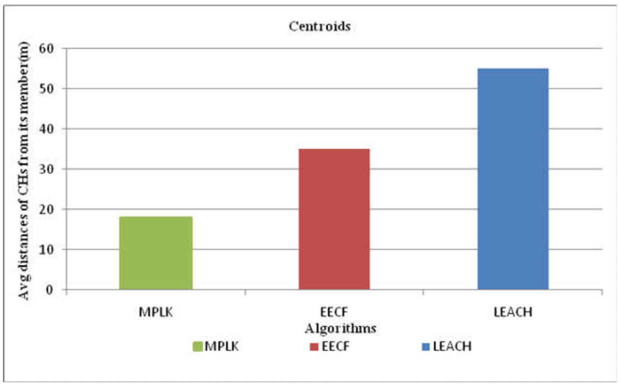

Fig. 5CH Centroid in Clusters

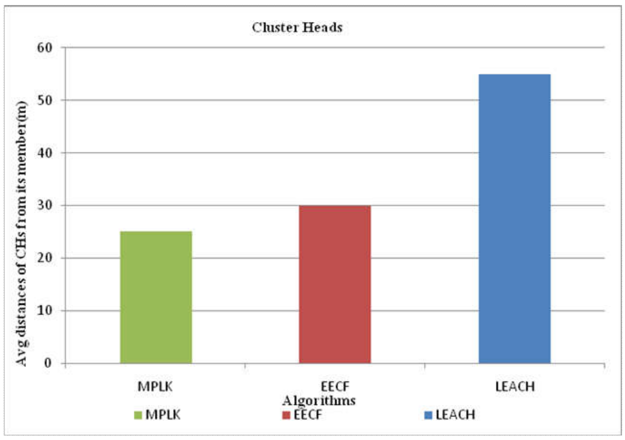

Fig. 6 Distribution of Channel Heads

Parameter Selection for Simulation: Following table presents the list of parameter required for the simulation. The proposed method is simulated using, MATLAB 7.7 and C language. Table 1 is summarized with Simulation parameters. As per given in base paper considering in d BS = 100, gets the number of desired CH = 4 having 100 sensor nodes in 100 × 100 m2 sensing region. As well as, our proposed approach has been compared with existing approaches (Chen, 2006; Barati *et al*., 2012; Jenq-Shiou Leu, 2015) with respect to different network parameters. By considering BS = 85, the number of desired CH = 5 having 100 sensor nodes in 100 × 100 m2 sensing region. It forms unbalanced cluster formation like 4-clustered network. Here amongst the seven observations, it is found that a particular cluster contains 33 nodes in cluster 4, which is much higher than the average number of sensor nodes (20) to be present in a cluster. At the same time for same observation 1, cluster 5 contains only 11 sensor nodes, which is much lower than the average number of sensor nodes. Using our proposed protocol, the seven observations a particular cluster contains maximum 24 nodes and minimum 16 nodes, which is much closer to the average number of nodes to be present (20) in a particular cluster is found. Therefore our proposed approach produces balanced cluster compared to existing methods. Simulations results are shown in Fig. 3 and 4.

Fig. 3 and 4 shows the energy consumption of the protocols in different rounds. It is clear from above graph that proposed protocol MPLK (Mid Point Leach K-means) outperforms LEACH (Low Energy Adaptive Clustering Hierarchy) and EECF (Energy Efficient Cluster Formation) in energy consumption and network lifetime. Fig. 5 and 6 shows the selected CHs of proposed protocol MPLK (Mid Point Leach K-means) are well distributed across the network due to cluster formation proposed protocol outperforms LEACH (Low Energy Adaptive Clustering Hierarchy) and EECF (Energy Efficient Cluster Formation). Including the parameters: (1) distance between node and BS and (2) distance between a node and its neighboring nodes in the CHs selection.The proper distribution of CHs across the network provides connected CHs for multi-hop communications.

Conclusion

In this paper, by considering the advantages and disadvantages of previous works, proposed a MPLK (Mid-Point Leach K-means) new Energy-Efficient Clustering algorithm for Wireless Sensor Networks. Evaluated the performance of proposed scheme and compared with standard protocols (Low Energy Adaptive Clustering Hierarchy) and EECF (Energy Efficient Cluster Formation) in different network scenarios, simulation result shows that the proposed scheme provides better results than the other protocols with respect to low energy consumption and increase in lifetime of nodes. It also provides to select cluster head from the selected cluster heads of cluster and try to consume more energy with less delay.

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