Journal of Information & Optimization Sciences
ISSN 0252-2667 (Print), ISSN 2169-0103 (Online)
Vol. 44 (2023), No. 6, pp. 1203–1214
DOI : 10.47974/JIOS-1458

DC-LEACH: A unique cluster head selection algorithm with improved QoS in real time applications for WSN

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Abstract

The Wireless sensor network incorporates high density tiny sensor nodes. These sensor nodes are placed in the mission critical areas where human intervention becomes difficult. Sensor nodes run through the disadvantage of limited battery life because of which they die out in the network. There are several techniques to make these sensor nodes to stay for a longer period; Out of this clustering is widely used practice. The LEACH clustering technique is one of the simple protocols to study upon improvement of network lifetime. All nodes get a chance to become a cluster head which aggregates data within the cluster and sends data to the base station. This paper presents the selection of dual controller cluster heads. The selection is done on the basis of the first highest and the second highest energy node, these dual controllers are selected for transmission and reception which is based on residual energy in each round. The nodes are made alternatively on and off, so that the round time for selection increases. When both controller nodes have energy value less than threshold values the round occurs. The simulation result shows an increase in the time required for the last

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node to die. The proposed method extended the network lifespan and hence QoS using the unique dual controller approach. The prime criteria for improvement of network lifetime is achieved by this unique method which is a necessary component for real time applications due to the fact that deployed sensor nodes keep collecting the data and communicate it to the base station.

Subject Classification: *91A28.*

Keywords: *Wireless Networks, Clustering, LEACH, IOT, QoS.*

1. Introduction

The Wireless sensor networks have grown in popularity due to the interest of researchers because of the development in the field of embedded systems, real-time applications, automation, IOT applications, surveillance, fault detection and smart system development. These sensor networks comprise of thousands of sensor nodes which in turn have trans-receiver, battery, processor and memory. These self-governing devices work cooperatively to specially monitor the abandoned environment where the human intervention is hardly possible like mines, forest fire, landslides, search for life in collapsed buildings, environment monitoring, battlefields, leakage plant etc. Thus, the sensor nodes work together in a power efficient manner to collect and gather information of the target region. WSN sends information to the base station with the help of the sensor node and the base station process data and send to the end user there are many challenges faced by WSN in doing so, among them network life span is one of the most important parameter. The life span of the sensor node can be increased by managing the power of the tiny sensor nodes with limited energy and improving the computation capability of the nodes.

There are many techniques to deal with the power management of WSN; clustering technique is one of them. The cluster has controller nodes cluster head (CNCH) and member nodes in rotation (MN). The CNCH communicates with the Base server and with the MN of its own cluster and the aggregated data is from MN is communicated to BS. The transmission of data directly to the base station consumes energy of nodes more speedily than using a head node to send collected data to the base station. The selection of cluster head is done randomly [1-4]. LEACH protocol uses confined coordination between cluster formation and its operation. Each node within the network has the probability to become CNCH [5]. The election of the cluster head is one of the most important features of LEACH [1] as shown in Figure 1. There are numerous algorithms

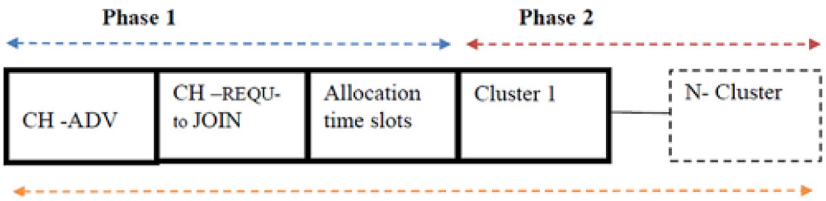

Figure 1

The time line for LEACH Protocol [1]

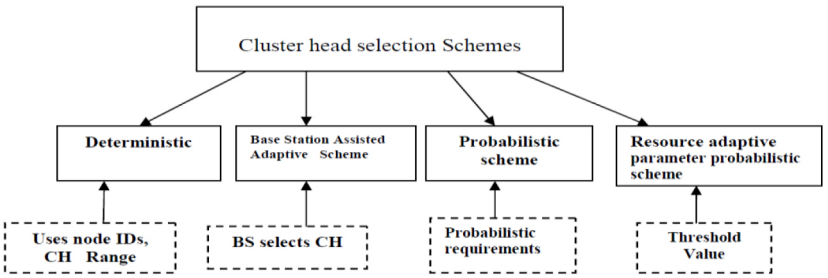

Figure 2

Cluster head selection methods

for improving lifespan based on cluster head selection. This paper takes a novel approach to cluster head selection, resulting in improvement in the network life as compared to LEACH [1]. Two cluster heads are picked based on energy, when CH dies, the next cluster head is chosen in this way, it takes more time for the last node to die. The time line for this approach is the same as LEACH [1]. The cluster head election can be done on the basis of parameters, and cluster allocation as shown in Figure 2 each using different methods of CNCH selection.

The remaining paper is divided into three more sections. Section 2 discusses related work of trust based WBSNs. Section 3 provide network model and some concept regarding time window. Moreover, it provides a trust assessment scheme for WBSNs. Section 4 discusses the results of the proposed approach. Finally, sections 5 provide a conclusion and future work.

2. Literature Review

LEACH [4] proposed an uncomplicated localized coordination mechanism and control during its two phases. The authors established the concept of cluster formation and cluster head selection at random. LEACH

is a clustering protocol that is self-organizing and adaptive [4]. Time synchronization is required with this algorithm. During each time interval, cluster heads are rotated at random, this is because it forms clusters dynamically to distribute energy. The network's lifetime is divided into separate time intervals in LEACH. As shown in Fig 1, each time interval is divides into subsections for cluster head advertisement to cluster head rotation in various. Authors in [2] describe the chain-based protocol, in this protocol each node communicates with only to the neighboring node and transmits to BS in turns, thus saving energy in comparison to LEACH. [3] Clustering considers distance and energy between sensor nodes and CH. [5] proposed a flexible method of cluster selection on the basis of position of the head node and the member nodes within the cluster. Network deployed with smaller number of sensor nodes can be analyzed for the performance parameters with statistical regression techniques [6]. [7] is the addition of clustering location-based LEACH, in this protocol four regions of clustering are employed. Authors in [8] explain the importance of residual energy consideration for IOT applications. Authors in [10] given the detailed survey for clustering techniques considering the challenges faced by 5G applications. Researchers in [11] Presents a technique that discuss the selection of CH on the basis of probability, position of nodes and radii of the region where nodes are deployed. Researchers proposed a new mathematical model in [12] for improving the parameters of LEACH by optimum percentage of cluster head. Sana Amjad.et.al. Proposed a new model of LEACH to overcome the workload of Cluster head and saving the network lifetime, Block-chain is applied for the nodes authentication [13].Researchers in [14] discussed the classification of various clustering and routing techniques in WSN. [15] Discuss small region arrangement of nodes. The MAC protocols reduce the consumption of energy by applying the duty cycle [16] researchers compared MAC protocols and their performance. The randomness present in the selection [17] of Cluster head in the clustering protocol was controlled and makes the cluster head stable. [18] Multiple weights LEACH proposed with initial set of the high- residual energy nodes thus, selecting the CH node. [19] Presented balancing of energy consumption among nodes using centralized energy and coverage aware scheme. [20] algorithm improves the election criteria of CH. The work in [21] used network application to improve the QoS using a LEACH-APP approach and QoS evaluated in terms of throughput and latency.[22] discuss about network improvement on the basis of redundant data. Two algorithms [23] applied for CH selection resulting in enhanced network parameters.

3. Dual controller Proposed Work

The key idea of clustering technique is to improve the network life span by selecting the algorithm which saves energy of sensor nodes, thereby increasing the span of the network. LEACH [1] and its variants [9-10] attain this aim by setting its parameters suitably. The DCS approach makes certain assumptions about the network configuration and sensor nodes, and we employ the base model in expressing of our mathematical and statistical model. The LEACH [1] protocol selects CH by comparing with the defined threshold as given by Eq.(1)

$$T(n) = p/1\text{-}[(r \bmod(1/p)] \; n \in G \tag{1}$$

Here, n is the total number of nodes, p is the probability and G is the nodes that have not been cluster head in the last round [1]. Nodes are deployed at random making them suitable for any target region. The transmission channel is symmetric. Therefore now two cluster heads are chosen in a cluster with the first highest energy E1 and the second highest energy E2. Heinzelman [1] first Order Radio model is taken as shown in Figure 3 for receiving and processing a message. For transmitting a k-bit length message if each bit consumes EelecJ of energy,[1] then the total amount of energy consumed given by Eq.(2).

$$E_{Elec}(k) = (E_{Elec} * k) \tag{2}$$

A message of k bit length is transmitted to a distance, 'dist' and the energy required is given as (εamp *k*dist γ) where εamp is the constant of radio transmission and γ is the path loss exponent. The complete model is as shown in Figure 4. The dual controller are selected on the basis of the energy for first highest and second highest energy in each round, the selection is done randomly in the first phase similar to LEACH protocol

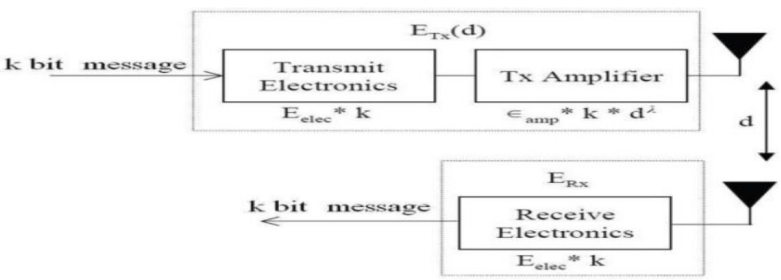

Figure 3

Heinzelman first-order radio model [1].

[1], the steady state phase remains the same Energy for Transmission is given by Eq.(3) with $\gamma = 2$ or 4 depending on the environment.

$$E_{TX}(k,dist) = (E_{Elec} * k) + (\varepsilon_{amp} * k * dist\ \gamma) \quad (3)$$

The Dual controller selection (DCS) selects two cluster heads in each round with the highest and second highest energy, and then compares them with the defined probability as in LEACH [1]. The Dual controller selection saves the network lifetime because it now works first with E1 energy according to the LEACH time line and then with E2 energy as shown in Figure 4 along with its algorithm steps. During the set up phase instead of one cluster head selection two controller cluster heads are selected on the random basis, CH1 and CH2 will participate in the aggregating the data from nearby node members within the cluster, initially CNCH will be selected on the basis of residual energy.

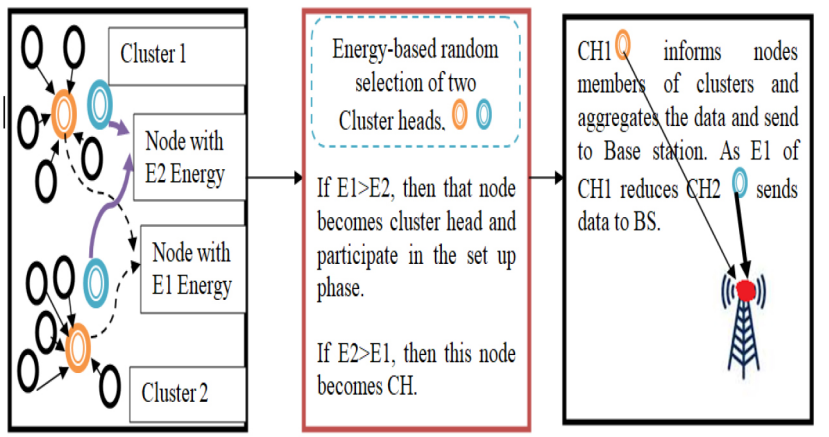

Figure 4

Dual Controller Approach model.

The Dual controller Selection (DCS) algorithm generates a fixed number of clusters, denoted by k during each round as given by Eq.(4). While comparing the energy of the node with the defined probability for the cluster selection, now two cluster heads called as controllers are selected according to the first highest and second highest energy level. Eq. (5) relates to non controller nodes and Eq. (6)-(7) denotes cluster formation. Table 1 gives parameters representation.

$$E\,[CNCH] = \Sigma_{i=1}^{N} P_i(t) * 1 = k \quad (4)$$

$$E_{N\text{-}Cluster}=E_{N\text{-}CH}+(N/k)*\left(E_{Non\text{-}Cluster\ head}\right) \quad (5)$$

$$k_{Optmi} = f(N_{ntm}, N, d_{BS}) \quad (6)$$

$$k_{Optmi} = \sqrt{N}\ /\sqrt{(2*pi)} * \sqrt{(N_{ntm}*E.freeSpace\ /\ N*E.multiPath)} *M\ /(d_{BS})^2 \quad (7)$$

For dual controllers formations first the field locations are set in X and Y coordinates then best possible election probability for CH is formulated as given by Eq.(8) the first and the second maximum energy nodes are selected and compared for CH election.

$$(MaxE_{CH1}, MaxE_{CH2}) <= \frac{p}{(1-p*\mathrm{mod}(r,\mathrm{round}(1/p)))} \quad (8)$$

Table 1

Symbol Representation for equations

Parameters used for Dual Controllers	Parameters
Network model	N_{ntm},
total deployed nodes	N
distance to the base station	d_{BS}
network area	M
amplification factors	E.free, E.multipath
Controller node cluster head	CNCH
Member nodes	MN
Nodes-(N)	100
X-Y specifications	x=0- 100, y=0-100
Initial node energy E_i (Joules)	0.50 J
CH probability (p)	0.10
Channel Bandwidth (BW)	1Mbp/s
small distance Amplifier energy	10-^3pJ/bit/m^2
Large distance Amplifier energy	$1.3*10\text{-}^3$ pJ/bit/m^4
E_{elec}	50.00nJ/bit
Data aggregation energy	5nJ/bit/signal
Starting status of nodes	100-alive
E_{CH1} (The First max controller), E_{CH2}-(The second Max controller)	Keeps changing randomly

First, CH1 collects data in the cluster; when its energy runs low, CH2 begins transmitting to BS as a result, the network lifespan has improved.

The controller selection approach (DCS) is statistically analyzed using a regression model and compared with the cluster formation, residual energy, the first node and the last node with the classical LEACH [1]. Eq. (9-10) gives the energy dissipation of controller node and member node respectively.

$$E_{DCH}=l*E_{elec}N/k_{optmi}+l*E_{DA}N/k_{optmi}+l*E.multipath*d^4 \quad (9)$$

$$E_{non\text{-}CH}=l*E_{elec}N/k_{optmi}+E.\ freespace*1/2\pi*M^2/k_{optmi} \quad (10)$$

4. Result and analysis

The two nodes with first maximum and second maximum energy as shown in Figure 5. Thus, Dual controller Selection Approach has increased the sensor network lifespan. As illustrated in Figure 6-7, the residual energy of the CH selected using the DCS approach takes longer to die out, extending the network life span. Compared to LEACH [1], it takes 5124 rounds for the last node to die. The energy of the nodes to be chosen as E_{CH1} and E_{CH2} in each round with respect to the first highest and second highest node energy within the cluster is shown in Figure 5.

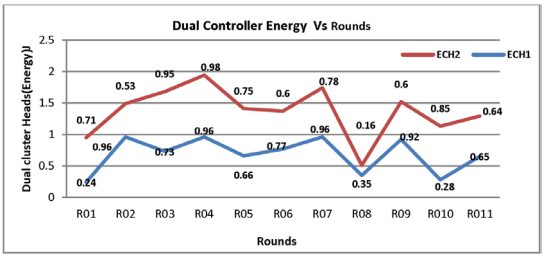

Figure 5

Residual Energy of CH1 and CH2.

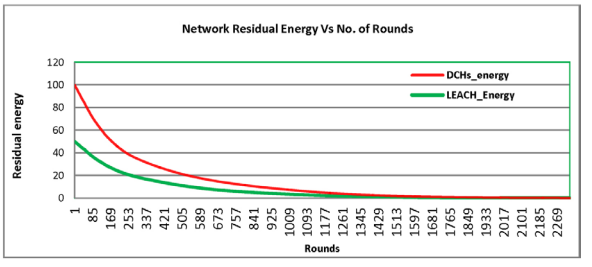

Figure 6

Residual Energy with each round

Results in Table 2 shows the same number of alive nodes before 240 rounds, but as the number of rounds increases the nodes for n_{leach} =0 and nodes for dual controller approach n_{DCH}=92. Thus, the Dual cluster head selection approach has increased the life span of WSN.

The Dual controller selection (DCS) regression analysis shown in Figure 8. In addition,an intercept value of 0.045 as given by Eq.(11) and R square values of 0.793.

$$y = 0.045x + 92.93 \tag{11}$$

Table 2

Alive Nodes with for DCHS and LEACH Protocol

Rounds	Alive Nodes for LEACH	Alive Nodes for DCHS
240	99	99
340	99	98
440	98	98
540	98	97
640	94	96
740	92	96
840	73	96
940	40	95
1040	1	94
1140	0	92

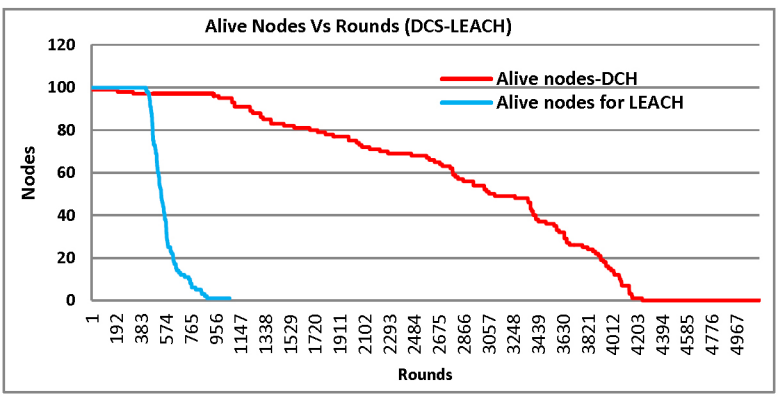

Figure 7

Alive nodes for LEACH and DCS

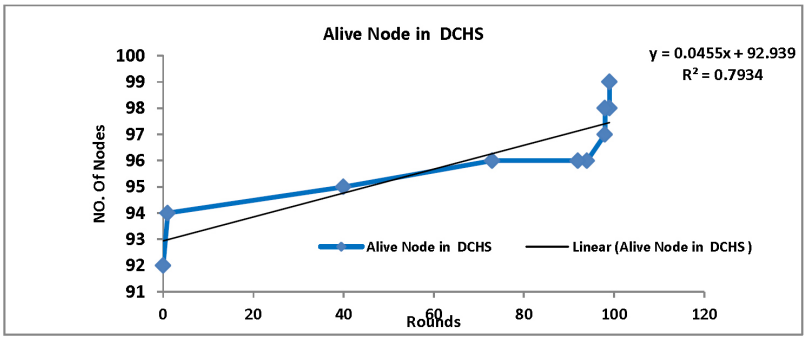

Figure 8

Statistical Analysis for Dual Contreoller

5. Conclusion and future work

This paper aims to maximize the network lifetime for the LEACH protocol by using the dual controller cluster head selection, allowing sensor nodes to remain alive for a long period of time. Thus, this approach can be applied for real time applications. The last node in the network dies at 5124 round resulting in more alive nodes as compared to the LEACH. The Dual controller selection approach addresses this issue and improves lifetime as evidenced by the results.

Conflicts of Interest

The authors declare that they have no competing interests.

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