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J Wireless Com Network (2023) 2023:56
https://doi.org/10.1186/s13638-023-02265-0

EURASIP Journal on Wireless Communications and Networking

RESEARCH **Open Access**

Comparison of the new version of DEEC protocol to extend WSN lifetime

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Abstract

Wireless sensor networks (WSNs) are used in many different fields. One of the most recent and rapidly expanding applications is the Internet of Things (IoT), which enables the connectivity of numerous objects or devices over the Internet. However, WSNs have a bigger concern about battery power than mobile ad hoc networks, which shortens the network's lifetime. As a result, extensive research has been done on lowering WSNs' energy usage. Designing a hierarchical clustering algorithm is one of many methods for lowering the energy consumption of WSNs. Given the restricted hardware capabilities of the sensor nodes, modeling and building energy-efficient routing solutions to enhance the overall network lifetime has emerged as one of the most crucial approaches in wireless sensor networks. Cluster-based heterogeneous routing protocols, a typical feature of routing technology, have demonstrated efficacy in managing topology, energy consumption, data collection or fusion, dependability, or stability in distributed sensor networks. The existing Distributed Energy-Efficient Clustering (DEEC) clustering protocol is changed in this study by switching the power level between the nodes and adding a threshold limit for cluster head selection. The number of packets sent to a base station increases by 843% when comparing the proposed improved DEEC protocol to the existing DEEC protocol, increasing the number of living nodes to more than 10,000 rounds, or over 30,000 rounds, which can be used to extend the WSN lifetime. The suggested algorithm outperforms alternative energy-efficient protocols in terms of stability period and network lifetime under various scenarios of area, energy, and node density.

Keywords: Distributed energy-efficient clustering (DEEC) protocol, Internet of things, Wireless sensor networks, Lifetime, Dead nodes, Packet to BS

1 Introduction

Everything that can be tracked or managed online is connected via a concept called the Internet of Things (IoT). The best way for achieving this wide communication range is wireless. To sense and collect data from the environment and systems for a variety of applications, such as weather monitoring, animal tracking, disaster management, biomedical applications, and IoT, wireless sensor networks (WSNs) are a collection of enormous sensor nodes dispersed over a large area [1, 2]. In some situations when humans are unable to access it, wireless sensors can be helpful in IoT applications for receiving and processing data, extracting relevant information, and communicating it to the end-user. WSN may therefore be viewed as one of the crucial elements of IoT applications [3]. The development of smart sensors for Internet of Things (IoT) applications that need compact smart sensor nodes with constrained power and computing resources has shown to be highly beneficial [4]. WSN functions as a virtual layer and has developed into a safe IoT component. However, it has several challenges, including safety concerns, integration problems, energy efficiency, network longevity, and others. The sensor nodes, which are battery-powered and have a limited amount of power, must perform heavy processing and computing to extract important information from a massive volume of data.

As a result, some power and computation limitations for WSNs need to be taken into consideration [5]. The Internet of Things (IoT), on the other hand, connects a lot of different devices to gather metadata for processing. This will waste power that is already available and shorten the life of the network. The data packet routing pathways must be selected in a way that minimizes the total energy used on the path to maximizing the network lifetime in a WSN.

The remainder of this paper is as follows. Section 2 reviews the related work on Distributed Energy-Efficient Clustering (DEEC) and other successors of the DEEC protocol. Section 3 presents a methodology and proposed scheme in detail. Section 4 represents the simulation results and discussion and finally, the conclusion is presented in Sect. 5. The detailed abbreviations and definitions used in the paper are listed in Table 1.

2 Related work

A Wireless Sensor Network (WSN) is an arrangement of numerous sensor nodes that is intended to communicate wirelessly with one another. Together, these nodes may keep an eye on any potentially hazardous environment, gather measurement data, and communicate the findings to the base station, another resourced node. This kind of network does not need any established infrastructure and works well in many different industries, such as home intelligence, health monitoring, and many others [6]. However, because these sensor nodes are battery-powered, the network's lifespan depends on how quickly the batteries are depleted of their energy. One of the main energy-draining mechanisms in this network was found to be radio transmission [7]. This is one of the main justifications for why any routing system needs to be energy efficient. Based on how energy is distributed among nodes, wireless sensor networks

Table 1 List of abbreviations

WSNs	Wireless sensor networks
IoT	Internet of things
SEP	Stable election protocol
CH	Cluster head
BS	Base station
DEEC	Distributed energy efficient clustering protocol
DDEEC	Developed distributed energy efficient clustering protocol
TDEEC	Threshold distributed energy efficient clustering protocol
EDEEC	Enhanced distributed energy efficient clustering protocol
IDEEC	Improving distributed energy efficient clustering protocol
IoT-DEEC	Internet of things distributed energy efficient clustering protocol

(WSNs) are categorized into heterogeneous and homogeneous networks [8]. Heterogeneous networks are made up of sensor nodes with various abilities. They have a bigger memory space and more advanced processing capabilities than homogenous network nodes, which enables them to run complex algorithms more effectively. As a result, the network's throughput and battery life are improved by the addition of heterogeneous sensor nodes [9]. Here are a few examples of the various heterogeneous and homogeneous routing protocols that have been developed in the literature.

The results of the Stable Election Protocol were discussed by Amaragdakis et al. [10]. (SEP). The methodology relied on the energy-based weighted election probabilities for cluster head selection for each node. There are two types of nodes used in the method: normal and advanced, with advanced nodes having more residual energy and a higher likelihood of becoming cluster chiefs. Simulations show that SEP has increased network longevity.

Qing et al. [11] have introduced DEEC, another heterogeneous routing algorithm that chooses cluster leaders by dividing the residual energy of each sensor node by the network's average energy. In terms of the node type, the two-level nodes of DEEC are comparable to those of SEP. The main problem with this technique is that advanced nodes frequently suffer consequences when their energy levels drop to those of a typical node. Therefore, this study's objective is to enhance this strategy.

For heterogeneous networks, Elbhiri et al. [12] created an energy-efficient technique based on the DEEC protocol. The underlying flaw in DEEC's approach that penalizes advanced nodes has been fixed by the protocol DDEEC. The algorithm did not, however, take into account the distance between each node and the base station when choosing the cluster heads.

Saini et al. [13] suggested EDEEC, a new variation of DEEC, for heterogeneous networks. The approach evaluated the nodes at three levels according to their remaining energy. The residual energy of supernodes is highest, that of advanced nodes is middle, and that of standard nodes is lowest. When compared to the DEEC protocol, the system, according to the tests, was able to increase the network's lifespan.

The TDEEC algorithm, an enhanced variant of the DEEC protocol, was also discussed by the authors of [14]. The protocol modified the probability function significantly and used three different types of nodes, each with a different residual energy. Experimental findings showed that the strategy significantly extended the network's lifetime.

The authors of [15] also introduced the IDEEC algorithm, an improved variant of the DEEC protocol. The only distinction between DEEC and the Improved Distributed Energy-Efficient Clustering Protocol (IDEEC) is the scaling factor, which results in a factor tenfold reduction in the power of simplification.

The authors of [16] offer an improved LEACH variant for homogeneous networks they name MODLEACH. In this system, two crucial strategies have been provided. Several different amplification energies and the effective cluster head replacement concept are among them. The use of various amplification energy levels in data transmission between clusters, intra-cluster communications, and cluster head-to-sink communications, as well as the proposed procedures to ensure that if a cluster head's residual energy is not used, it may be used in the subsequent cycle.

No previous study that the author is aware of has described a special CH replacement technique with ideal power level switching. In this paper, we add threshold approaches to the fundamental DEEC algorithm to enable effective CH selection. In addition, we change the procedure so that a high-power amplification level is given to the CH node when it is selected.

It receives a low energy level if it rejoins as a member node in the following round. This again helps to keep the energy level constant throughout the network.

3 Methodology

In this section, we explained both the existing protocol and the proposed protocol.

3.1 The existing DEEC protocol

The DEEC is designed to manage the nodes of diverse WSNs. DEEC chooses the CH based on the nodes' initial and residual energy levels. Let's specify that the ideal number of nodes for our network to have throughout each round is the number of rounds. The energy levels of the nodes serve as the basis for the DEEC selection criteria. When nodes have the same amount of energy throughout each cycle, as in a homogeneous network, selecting ensures that CHs happen throughout each round. In WSNs, nodes with higher energy levels have a higher likelihood of becoming than nodes with lower energy levels, but the net value of CHs throughout each round is equal to the probability that each node will become. It follows that a node with high energy has a bigger value than the network's average energy for the round, which is denoted by [11].

$$\overline{E}(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r) \tag{1}$$

The probability for CH selection in DEEC is given as in [11]:

$$p_i = p_{\text{opt}}\left[1 - \frac{\overline{E}(r) - E_i(r)}{\overline{E}(r)}\right] = p_{\text{opt}}\frac{E_i(r)}{\overline{E}(r)} \tag{2}$$

In DEEC the average total number of CH during each round is given as in [11]:

$$\sum_{i=1}^{N} p_i = \sum_{i=1}^{N} p_{\text{opt}}\frac{E_i(r)}{\overline{E}(r)} = p_{\text{opt}}\sum_{i=1}^{N}\frac{E_i(r)}{\overline{E}(r)} = Np_{\text{opt}} \tag{3}$$

The value p represents each node's likelihood of becoming the round's CH *(i)*. G is the group of nodes that can transform into CH at round r. If a node recently changed from CH to G, it belongs to G. During each round, each node chooses a random value between 0 and 1. The number may become a *CH* if it is less than the limit stated in Eq. 4 as in [11], else it may not.

$$T(s_i) = \begin{cases} \frac{p_i}{1-p_i\left(r mod \frac{1}{P_i}\right)} & \text{if } s_i \varepsilon G \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

Since p opt serves as the reference value for the average probability, p *(i),* In homogeneous networks, p_{opti} is utilized as the reference energy because each node has the same initial energy at the beginning of the network. However, in heterogeneous networks, the value of p_{opt} fluctuates according to the node's initial energy. As shown in [11], the value of p_{opt} in a two-level heterogeneous network is given by:

$$p_{\text{adv}} = \frac{p_{\text{opt}}}{1 + am}, p_{nrm} = \frac{p_{\text{opt}}(1 + a)}{(1 + am)} \tag{5}$$

Then use the above p_{adv} and p_{nrm} instead of p_{opt} in Eq. 2 for a two-level heterogeneous network as mentioned in [11] :

$$p_i = \begin{cases} \frac{p_{\text{opt}} E_i(r)}{(1+am)E(r)} & \text{if } s_i \text{ is the normal node} \\ \frac{p_{\text{opt}}(1+a)E_i(r)}{(1+am)E(r)} & \text{if } s_i \text{ is the advanced node} \end{cases} \tag{6}$$

The above model can also be extended to a multi-level heterogeneous network given below as in [11]:

$$p_{\text{multi}} = \frac{p_{\text{opt}} N(1 + a_i)}{\left(N + \sum_{i=1}^{N} a_i\right)} \tag{7}$$

Above p_{multi} in Eq. 2 instead of p_{opt} to get p_i for heterogeneous nodes.p_i for the multi-level heterogeneous network is given as in [11]:

$$p_i = \frac{p_{\text{opt}} N(1 + a)E_i(r)}{\left(N + \sum_{i=1}^{N} a_i\right)\overline{E}(r)} \tag{8}$$

In DEEC for any round r, we estimate the average energy $E(r)$ of the network as in [11] :

$$\overline{E}(r) = \frac{1}{N} E_{\text{total}} \left(1 - \frac{r}{R}\right) \tag{9}$$

R represents the total number of network lifetime rounds and is calculated as follows:

$$R = \frac{E_{\text{total}}}{E_{\text{round}}} \tag{10}$$

E_{total} is the total energy of the network whereas E_{round} the energy used for each round.

3.2 Proposed new protocol (IOT-DEEC)

The DEEC protocol chooses CH at random for each round. For each round, the clusters are created based on the advertising message that the CH has transmitted. As an illustration, we configured 100 nodes in a 100 m × 100 m area. In the following round, the CHS shifted and new clusters emerged. The DEEC algorithm states that once a CH is selected, it cannot be changed for subsequent rounds if it has not used up all of its energy during its term. However, if a CH has not used up much of its energy throughout its term, it may still stay CH for the following round depending on residual energy. Setting a threshold value in the current DEEC protocol now known as New protocol (New protocol (IoT-DEEC)) will get around this restriction. The CH will remain like such for the following cycle if its energy level exceeds the threshold value. With this approach, less energy is spent when passing information to the subsequent CH during each round. It is also possible to control the additional energy needed for the growth of a new cluster brought on by fresh CH.

The nodes are randomly posted in the network. If the distance between N and CH (cluster heads) is $< d_0$ then the energy exhaustion for data transmission from N to the CH.

$$E_{\mathrm{N}}^{\mathrm{CH}} = D_{\mathrm{N}}^{\mathrm{CH}}(E_{\mathrm{ele}}) + D_{\mathrm{N}}^{\mathrm{CH}}\left(E_{fs}\right)\left(d^2\right) \tag{11}$$

where $d_0 = \frac{4\prod h_{tr} h_{rc}}{\lambda}$ h_{tr} and h_{rc} are the height of the antenna transmitting and receiving where the distance between N to CH is d > d0.

$$E_{\mathrm{N}}^{\mathrm{CH}} = D_{\mathrm{N}}^{\mathrm{CH}}(E_{\mathrm{ele}}) + D_{\mathrm{N}}^{\mathrm{CH}}\left(E_{\mathrm{amp}}\right)\left(d^4\right) \tag{12}$$

when the distance between S and CH is d < d0. The energy considered by CH to transmit data to S

$$E_{\mathrm{CH}}^{S} = D_{\mathrm{CH}}^{S}(E_{\mathrm{ele}}) + E_{\mathrm{DA}} + D_{\mathrm{N}}^{S}\left(E_{fs}\right)\left(d^2\right) \tag{13}$$

Also when the distance between CH and S is d > d0.

$$E_{\mathrm{CH}}^{S} = D_{\mathrm{CH}}^{S}(E_{ele}) + E_{\mathrm{DA}} D_C H^S\left(E_{\mathrm{amp}}\right)\left(d^4\right) \tag{14}$$

The total energy consumed by CH is

$$E_{\mathrm{T\_CH}} = E_{\mathrm{CH}} + E_{\mathrm{N}} \tag{15}$$

The average energy consumed by CH is

$$E_{\mathrm{av\_CH}} = \frac{E_{\mathrm{T\_CH}}}{N} \tag{16}$$

So saving energy for normal nodes in each round is:

$$E_{\mathrm{S\_N}} = E_{\mathrm{ele}} + E_{TX} + E_{\mathrm{amp}} \tag{17}$$

Saving energy for CH is

$$E_{\mathrm{S\_CH}} = E_{\mathrm{ele}} + E_{\mathrm{DA}} + E_{TX} + E_{RX} + E_{\mathrm{amp}} \tag{18}$$

Saving energy for all sleeping node is

$$E_{\mathrm{ST}} = \sum_{i=0}^{n} E_i \tag{19}$$

Average energy saving for n sleeping node is

$$E_{\mathrm{S\_AV}} = \frac{E_{ST}}{n} \tag{20}$$

ALGORITHM: IoT-DEEC

Input:

Xm, Ym

Eo

rmax

E_{Th}

Output:

Count Alive nodes during round

Count Dead nodes during round

Count the number of packets sent to Base Station (BS)

Improve throughput and extend the life of sensor

nodes

Step 1: start

Step 2: in the WSN field, deploy sensor nodes

Step 3: loop for counting dead and alive nodes

Step 4: Check for sleep nodes

Step 5: loop for count packets sent to Base Station (BS)

Step 6: maximum distance node calculated.

Step 7: put threshold energy "E_{Th} ".

Step 8: compare each node's energy with E_{Th}.

if S(i).E > E_{Th}

Step 9: Select this node as a Cluster Head.

else

Set the nodes to sleep, and then a high power level is required.

else

put it in low power

Step 10: if sleep > input the number of sleep mode node

return to step 6

Step 11: Once the node has been chosen as the CH

Step 12: if node = CH

Cluster head attributes broadcast

Step 13: if the energy of CH < E_{Th}

Return to step 9

else

previous CH and cluster

Step 14: if the end of lifetime

then end

else

Return to step 8

A cluster-based network [17] also supports intra-cluster, inter-cluster, and long-haul communication as its three data transmission modalities. Intra-cluster transmission occurs when members of a cluster send data to their respective CHs on a TDMA schedule. While long-haul transmission involves the CHs sending their fused data to the BS, inter-cluster transmission focuses on data exchange between CHs. Different quantities of energy are required for each of the three transmission modes. Intra-cluster transmission needs a lower power level than long-haul transmission to save a lot of energy and lower the packet loss ratio. In the suggested system, the algorithm instructs a node to use a high energy amplification level when it is elected as CH. The method switches it to a low-power mode when it joins the cluster in the ensuing rounds. The algorithm that we previously disclosed in a study [18] illustrates the suggested DEEC modification method.

Let A, B, C, D, E, and F be the CHs of five distinct clusters in a network with the initial energy E "Init," as in paper [19], as an example. Following the initial round, all nodes waste energy depending on several variables, including the distance, signal strength, and data packet size. Let E and F represent two CHs who still have some energy left over and can be chosen as CHs in the subsequent round. According to the conventional DEEC algorithm, none of the CHs A, B, C, D, E, and F are eligible for selection as a CH in the ensuing round. The suggested approach, however, includes a threshold limit of P This set, and any node (such as E and F here) can stay CH for the following round with the same cluster if the energy level is over. As a result, there is a considerable reduction in the energy required for CH and cluster formation.

4 Simulation results and discussion

A sensor network is built with 100 nodes randomly placed in a field with the dimensions 100 m by 100 m, as shown in Fig. 1. An energy sink with boundless energy is located in the center. It is believed that every sensor node is fixed in place. Normal sensor nodes are energy constrained. The suggested scheme is put into practice to produce simulation results by accounting for the variables listed in Table 2. In MATLAB, a simulation is run 10,000 times to generate several graphs. In this study, we simulate DEEC, DDEEC, EDEEC, TDEEC, and IDEEC, and suggested New protocol (New protocol (IoT-DEEC)) for multi-level heterogeneous WSNs. The simulation contrasts different existing energy-efficient protocols by ignoring the energy associated with the overheads for each packet with the proposed New protocol (New protocol (IoT-DEEC))protocol. The energy model utilized in the paper [19] has been applied to our work as well.

We use the radio parameters mentioned in Table 2 to estimate the performance for three-level heterogeneous WSNs when deploying multiple protocols. In simulations for a number of factors, including as network lifetime, packet to BS, packet delivery ratio, and CH count, New protocol (New protocol (IoT-DEEC))outperforms the DEEC protocol and its variations (Tables 3, 4, and 5).

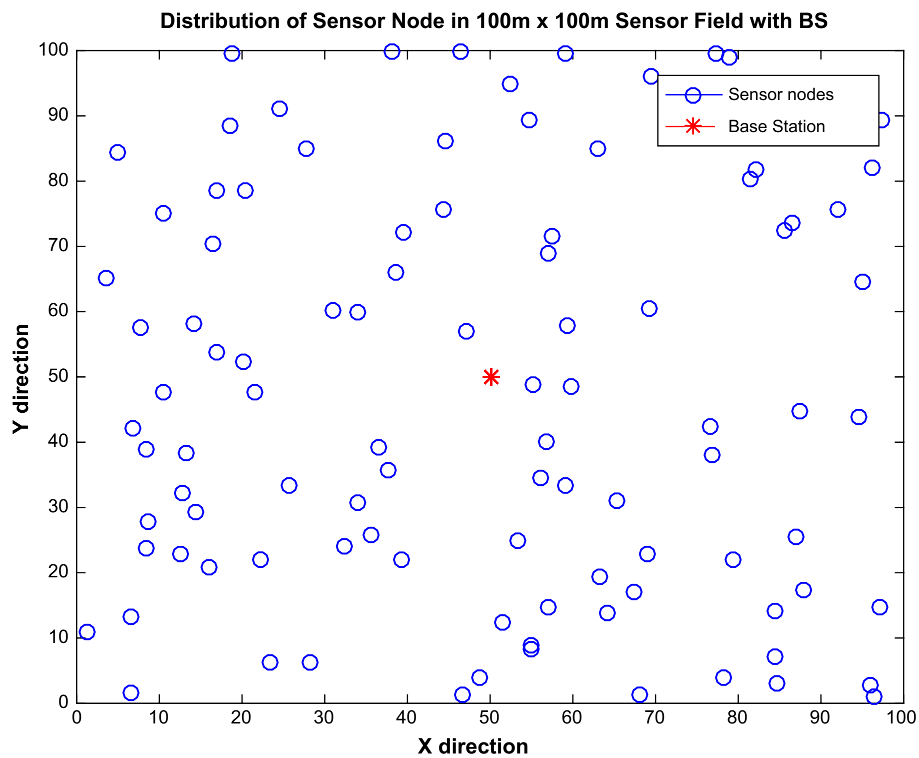


Fig. 1 Depicts node deployment

Table 2 Simulation parameters

Symbol	Description	Value
Xm	Distance at *X*-axis	100 m
Ym	Distance at *Y*-axis	100 m
–	Base station node position	(50,50)
N	Total number of sensor nodes	100 nodes
P_{opt}	Probability of CH	0.1
E_o	Initial energy supplied to each node	0.5 J
E_{mp}	Energy dissipation: Receiving (multipath loss)	0.0013/pJ/bit/m^4
E_{fs}	Energy dissipation: free space model loss	10/pJ/bit/m^2
E_{DA}	Energy dissipation: data aggregation energy	5/nJ/bit
L	Message size	4000 bits
R	Number of rounds	10,000
_	Network deployment	Randomly
E_{th}	Threshold Energy	$0.00000000001 = 1 \times 10^{-11}$

Table 3 Simulation results for protocols' lifetime, packets sent to BS and Packet delivery ratio

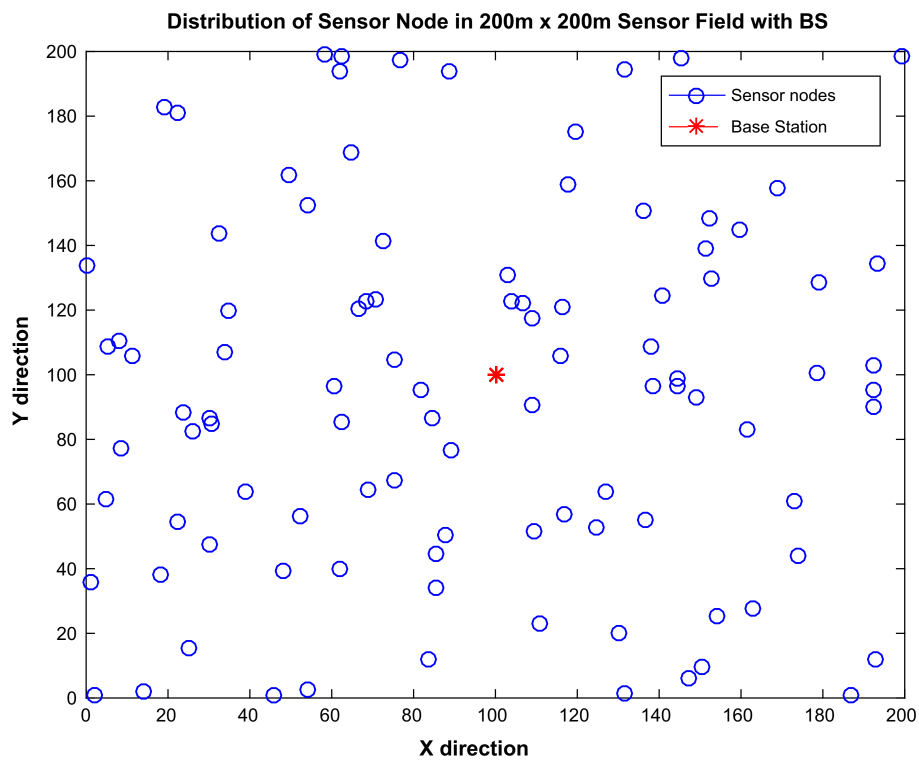
Protocols compared	First node dead	Tenth node dead	All node dead	Packets sent to BS	Packet delivery ratio
DEEC	1133	1233	2737	6.07×10^4	402
DDEEC	1167	1473	2966	8.5×10^4	514
EDEEC	1199	1380	9477	3.3×10^5	2555
TDEEC	1324	1590	9775	4.6×10^5	3665
IDEEC	870	1080	3773	6.8×10^4	382
Proposed (IoT-DEEC)	463	1384	30,000	5.7×10^5	4520

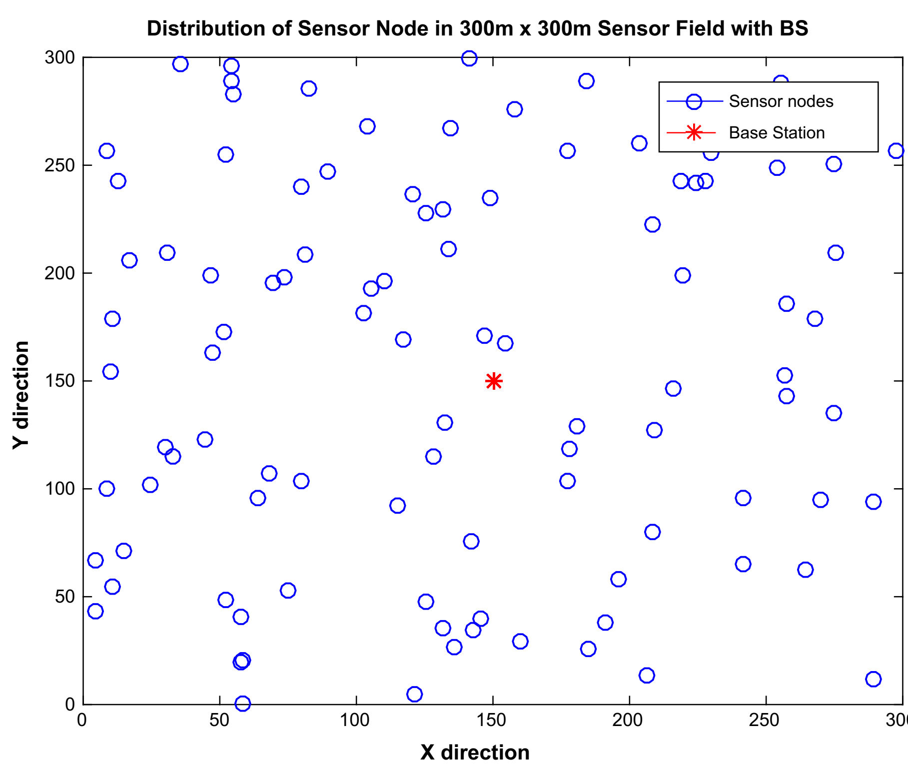
Table 4 Simulation results for protocols' lifetime, Packets sent to BS and Packet delivery ratio for 200 m × 200 m

Protocols compared	First node dead	Tenth node dead	All node dead	Packets sent to BS	Packet delivery ratio
DEEC	742	961	2841	5.1×10^4	357
DDEEC	1213	1481	3087	9.3×10^4	572
EDEEC	1339	1420	9899	3.4×10^5	2626
TDEEC	1375	1537	9537	4.5×10^5	3570
IDEEC	885	1170	3795	6.2×10^4	352
Proposed (IoT-DEEC)	316	928	42,000	5.8×10^5	4541

Table 5 Simulation results for protocols' lifetime, Packets sent to BS and Packet delivery ratio for 300 m × 300 m

Protocols compared	First node dead	Tenth node dead	All node dead	Packets sent to BS	Packet delivery ratio
DEEC	229	430	2422	3.4×10^4	289
DDEEC	1363	1538	3063	9.1×10^4	549
EDEEC	1300	1434	9867	3.3×10^5	2564
TDEEC	1402	1473	9795	4.4×10^5	3507
IDEEC	964	1176	3739	6.1×10^4	343
Proposed (IoT-DEEC)	518	825	> 50,000	5.4×10^5	4411


Distribution of Sensor Node in 200m x 200m Sensor Field with BS
Sensor nodes
Base Station
Y direction
X direction
0
20
40
60
80
100
120
140
160
180
200


Distribution of Sensor Node in 300m x 300m Sensor Field with BS
Sensor nodes
Base Station
Y direction
X direction
0
50
100
150
200
250
300

The initial node for DEEC, DDEEC, EDEEC, TDEEC, IDEEC, and the proposed New protocol (IoT-DEEC)dies at 1133, 1167, 1199, 1324, 870, and 463 rounds, respectively, according to Figs. 2 and 3. At rounds 1233, 1473, 1380, 1590, 1080, and 1384, the eleventh node passes away (Figs. 4, 5, 6, and 7). According to Fig. 8, all nodes are dead at rounds 2737, 2966, 9447, 9775, 3773, and more than 10,000, or almost 30,000 rounds. The results in Table 2 make it clear that our suggested New protocol (IoT-DEEC)protocol performs best of all in terms of stability period, whereas EDEEC performs better than DEEC, DDEEC, and IDEEC but less well than TDEEC and the proposed New protocol (IoT-DEEC)protocol. Only when compared against DEEC does DDEEC perform well, while DEEC performs the least well of all the protocols.

Because the probabilities in TDEEC, EDEEC, and the proposed New protocol (IoT-DEEC)protocol are defined separately for normal, advanced, and supernodes, whereas DEEC and DDEEC do not use different probabilities for normal, advanced, and supernodes, their performance is inferior to that of EDEEC, TDEEC, and the proposed New protocol (IoT-DEEC)protocol. As a result, the stability period of DEEC, DDEEC, and IDEEC is shorter than that of EDE However, compared to DEEC, DDEEC, and IDEEC, the instability period of EDEEC, TDEEC, and the proposed New protocol (IoT-DEEC) protocol is significantly longer. The proposed New protocol (IoT-DEEC)protocol has significantly more active nodes than TDEEC because it modifies the threshold calculation used by nodes for the CH election to take into account residual and average energy from that round. So, nodes having high energy will become CHs and get more energy, while nodes that aren't CHs lose energy.

As a result, nodes with high energy will become CHs and gain energy, whereas nodes without CH status will experience energy loss.

Figure 4 demonstrates that the proposed New protocol (IoT-DEEC)protocol, TDEEC, and EDEEC protocols perform better than DEEC, DDEEC, and IDEEC protocols in delivering packages to base stations, although the proposed New protocol (IoT-DEEC) protocol performance is very well other than protocols with 5.7 105 and the package arrives with excellent performance protocol and reaches the maximum with an increased number of rounds with 843% more packets sent to a base station than DEEC protocol, which only sends 6.07×10^4.

Figure 5 shows that the number of cluster heads decreases as the number of rounds rises for all protocols. Other than protocols, the New protocol (IoT-DEEC)protocol, TDEEC, and EDEEC are still used for extended rounds. DDEEC and IDEEC have a lot of cluster heads at the start of rounds, but they fade quickly. New protocol (IoT-DEEC) performs better than other protocols because it uses less energy during the CHs election process each round, which is preferable for protocols with low CH counts.

Figure 6 makes it clear which protocols, TDEEC and EDEEC, perform best in terms of packet delivery ratio. However, the proposed New protocol (IoT-DEEC)works better with a packet delivery ratio of over 4520. With only 382, IDEEC has the worst performance.

Network throughput in Fig. 7 shows that the new New protocol (IoT-DEEC)protocol is more effective than the current DEEC protocol after 3000 rounds and until 10,000 rounds, as well as more effective than other modification methods.

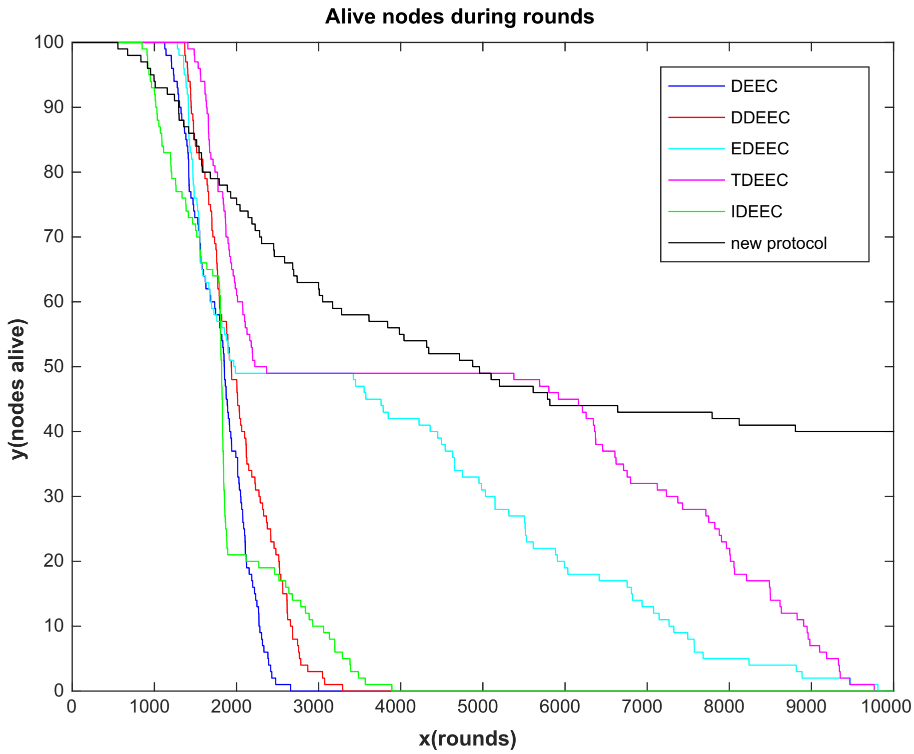


Fig. 2 Shows alive nodes during rounds

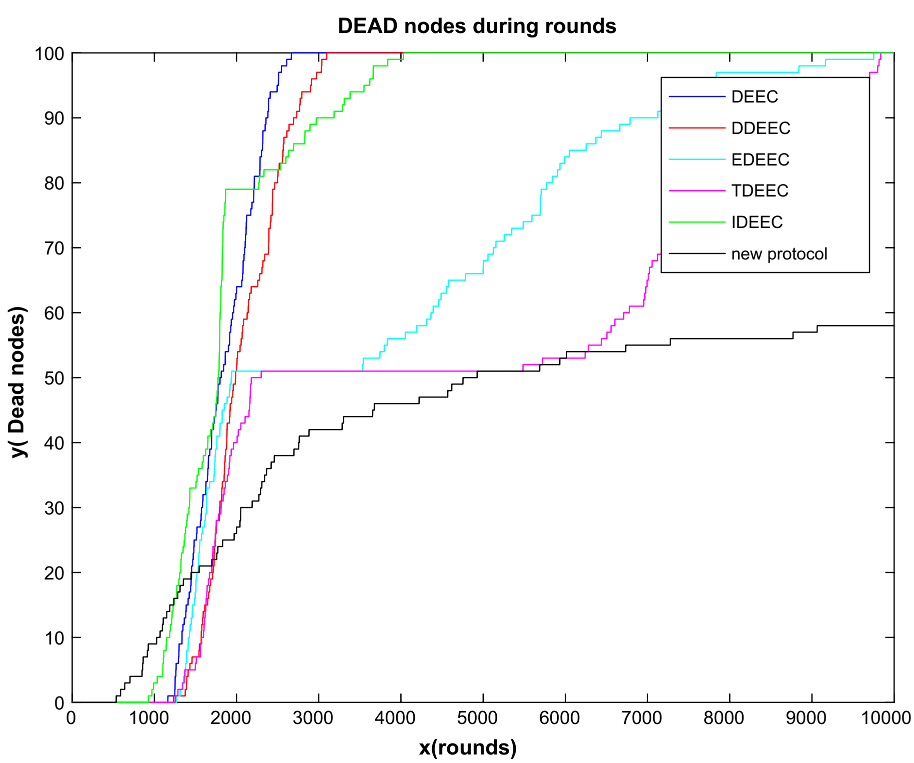


Fig. 3 Shows dead nodes during rounds

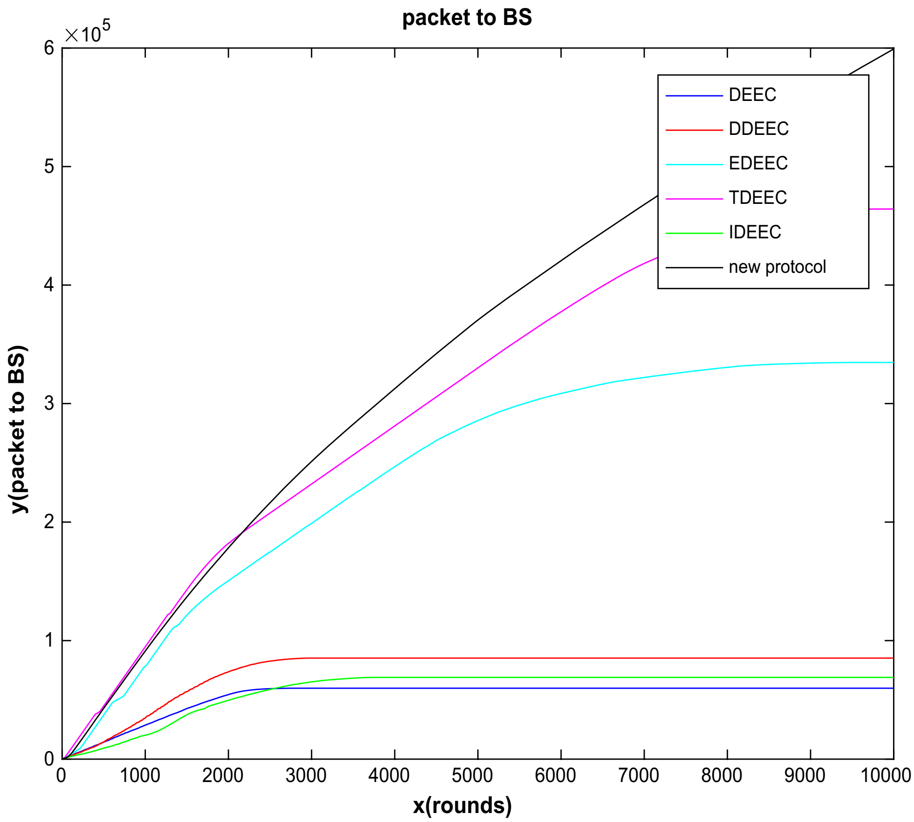


Fig. 4 Depicts packets sent to the BS

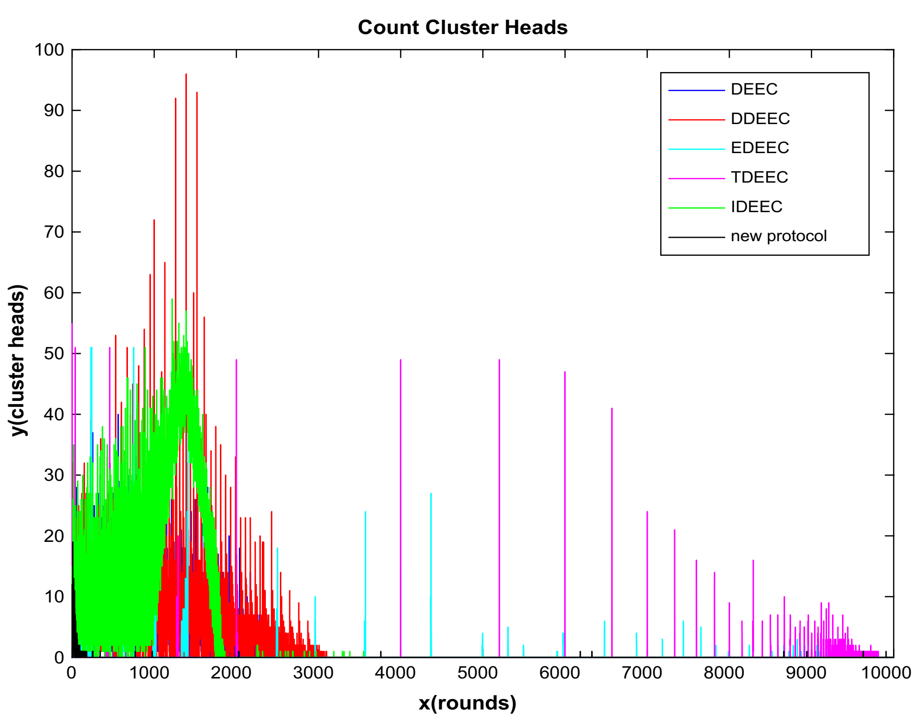


Fig. 5 Shows count cluster heads

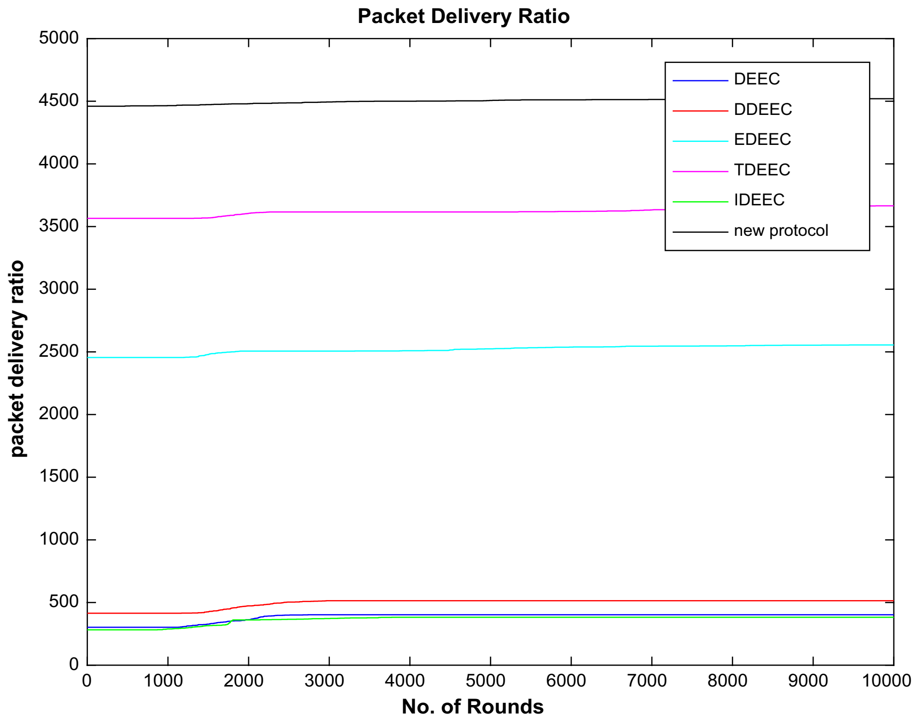


Fig. 6 Depicts the packet delivery ratio

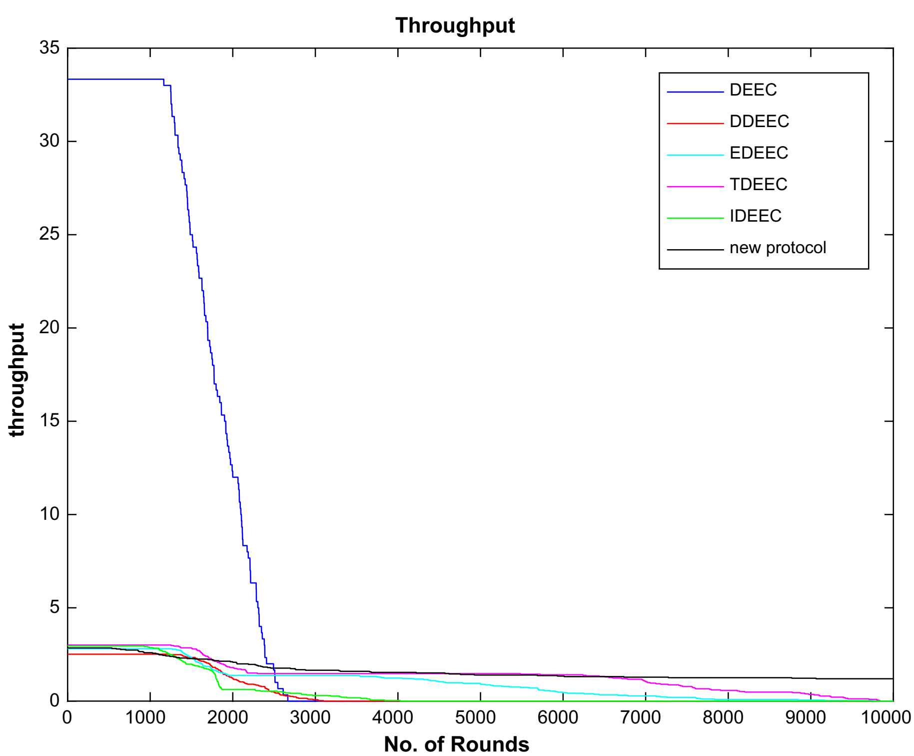


Fig. 7 Shows the throughput

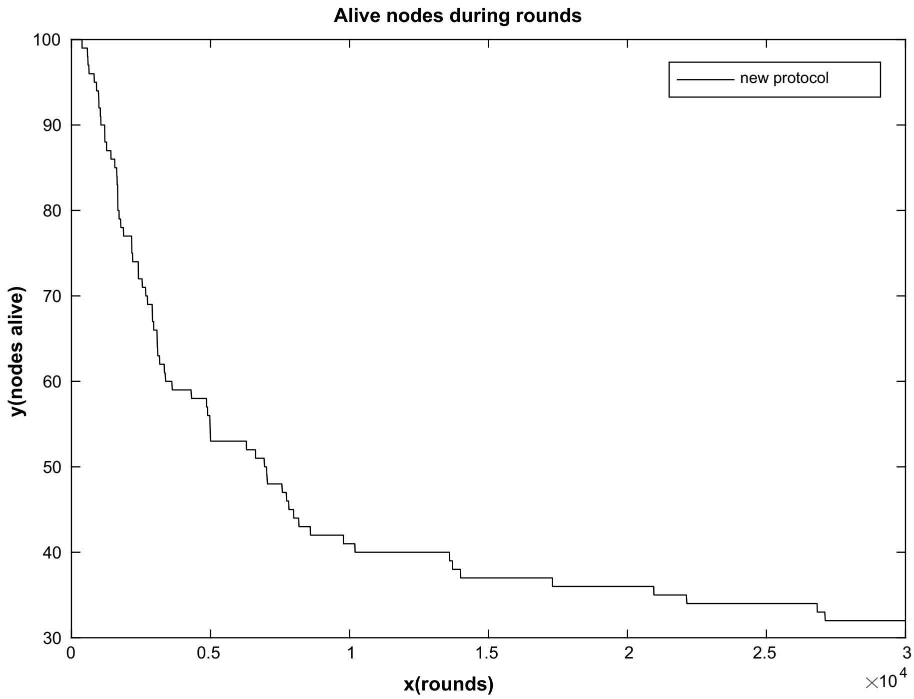


Fig.8 Shows alive nodes for proposed new protocol (IoT-DEEC)protocol in 30,000 round

All simulations, which were conducted in a 200×200 m area, demonstrated that the proposed protocol outperformed alternative options in terms of results value and protocol behavior, such as packets to the base station and lifetime. When the region is expanded to 300×300 m, however, the number of data packets transmitted to BS declines [20–22]. This is because fewer nodes remain alive and transfer sensory data to BS across the whole WSN after an early death of a node.

5 Conclusion and contribution

The DEEC protocol has drawn a lot of interest from researchers since its inception in the WSN sector, demonstrating its significance. Other DEEC offspring have also been sought for numerous uses. In this study, we altered the approach to accommodate both efficient CH selection and concomitant switching of various power levels. We discovered that the New protocol (IoT-DEEC)modified protocol performs better in simulations than the DEEC technique and can be applied to sensor networks for Internet of Things applications that need more processing capacity to analyze enormous amounts of data. The protocol also extends the lifespan of networks by dispersing energy usage decreases. Comparing the suggested protocol to other energy-efficient protocols, it was discovered to be the most suitable for a variety of applications. In future of design and process of the classification of these protocol must take in consideration these modifications because these protocols will be efficient for applications that are time critical by IoT. This is certainly a contribution to the scientific community. Another good topic is considering combine WSN with edge computing, some tasks can be executed on edge servers [23,24].

Author contributions
ZMH wrote the main manuscript text under the supervision of Prof. Dr. HHE. Preparing the simulation results and figures is joint work between the authors. All authors reviewed the manuscript.

Funding
Open access funding provided by The Science, Technology & Innovation Funding Authority (STDF) in cooperation with The Egyptian Knowledge Bank (EKB). The authors received no specific funding for this study.

Availability of data and materials
The materials, "figures and tables," used to support this study are included within the article.

Declarations

Ethical approval
This research does not use animals or humans to make research on them. It is just a computer simulation program.

Competing interests
The authors declare that they have no conflict of interest to report regarding the present study.

Received: 26 January 2023 Accepted: 20 June 2023
Published online: 01 July 2023

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