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# New Proposed Wireless Sensor Network Protocol for Internet of Things Applications

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**Abstract**: Modeling and constructing energy-efficient routing solutions to maximize the total network lifetime has become one of the most important techniques in wireless sensor networks (WSNs) due to the sensor nodes' limited hardware resources. In a distributed sensor network, cluster-based heterogeneous routing protocols, a common aspect of routing technology, have shown success in managing topology, energy consumption, data collection or fusion, reliability, or stability. This paper shows a new variation of Distributed Energy-Efficient Clustering (DEEC) protocol for WSNs, an energy-efficient three-level heterogeneous clustering method based on the DEEC protocol named Internet of Things DEEC (IoT-DEEC) protocol, is proposed. Unlike most other research, this considers the influence of the balanced thresholded sample in the energy consumption model. The current DEEC clustering protocol is enhanced by adding a threshold limit for cluster head selection and switching the power level across the nodes simultaneously. Our model is compared to Improved Distributed Energy Efficient Clustering (IDEEC) Protocol using MATLAB as a scenario based on quality metrics to measure network efficiencies such as the number of packets received by the base station (BS), overhead, packet delivery ratio, and throughput. After that, simulation results show that the suggested model is more efficient than the other protocol and substantially extends the sensor network lifetime.
**Keywords**: Cluster, Stability period, DEEC, IDEEC, IoT-DEEC.

## 1. Introduction

Wireless Sensor Networks (WSNs) include tiny sensor nodes with data sensing, processing, and wireless channel communication capabilities that can send data [1]. One of the primary issues in the WSN is the sensor nodes' restricted battery power. Routing protocols around the WSN's working areas are essential. In addition to extending the life of the sensor nodes, it is also important to distribute the available energy to the WSN in a uniform manner. The energy consumption of the power source is an essential aspect of WSNs due to the restricted power supply in the sensor nodes. When data is transferred to other nodes via sensor nodes, the most energy is utilized. A lot of studies have been performed as a result of all of these factors to develop routing algorithms to extend a sensor network lifetime [2].

### 1.1. Problem Definition

Sensor networks are based on the commonality of sensors to provide energy savings and scalability, which is known as aggregation, to extend the lifespan of sensor networks. In this way, nodes in the WSN collaborate by grouping together into clusters [3]. However, the benefits of distributing energy in a more balanced manner throughout the network have been highlighted in a few literature studies. Different cluster size structures should be adopted as a base due to the heterogeneous structure of the nodes in the network, whether the nodes are close to BS or not. Some research employed just homogeneous nodes, while others did not consider the issue of distributed energy. Our goal in this research is to look at all of these issues holistically, solve them, and make energy-efficient networks more qualified.

## 1.1. Related work

WSNs have been published in the literature. A routing technique for homogeneous WSNs with LEACH clustering adaption is provided in one paper [4], where sensor nodes are randomly chosen as Cluster Heads (CHs) and the system's energy load is shared with the WSN. [5] proposes a novel routing protocol for energy optimization based on LEACH. This approach is said to be more efficient than the LEACH algorithm since it selects cluster heads evenly. A modified LEACH developed from the LEACH algorithm is presented in the work [6,7] presents and compares a mobile sink enhanced energy efficient method with mod-LEACH and PEGASIS [8]. For single pass, heterogeneous WSNs, [9] proposes a novel energy efficient (EE) clustering-based technique. Simulations in MATLAB show that the mentioned method has a 1.62-1.89 times better stability than known protocols such as LEACH, DEEC, and SEP. The cluster's stability is reduced in [10] since the LEACH protocol on an irregular network reduces aggregate data efficiency. As a result, to improve the LEACH procedure and enhance cluster head stability, this paper [10] proposes a technique for choosing a cluster head. A LEACH version combining HEED and the LEACH protocol is presented for this purpose, and simulations show that this strategy is effective. Two energy-efficient route planning routing algorithms, Central Energy Efficiency Clustering (CEEC) with Two-Hop Heterogeneity awareness (THCEEC) and Advanced Equalization, are presented in [11] for three levels of heterogeneous WSNs (ACEEC). Comprehensive simulation results have shown that CEEC, ACEEC, and THCEEC central cluster deployments have enhanced reliability and energy efficiency, resulting in longer network lifetimes and effective data transmission than classic distributed routing protocols LEEC, SEP, ESEP, and DEEC. Furthermore, ACEEC performs CEEC and increases network stability time. The THCEEC conducts CEEC, ACEEC, and other existing road planning routing procedures, according to an analytical assessment. The paper [12] proposes a method for collecting data with a support vector in the WSN that is both efficient and effective. WSNs are used to evaluate the performance of clustering methods in [13]. Sensor node clustering is a useful strategy for achieving these goals. Other clustering models (LEACH, LEACH-C, and HEED) were assessed and compared using this method. Clustering approaches are evaluated after this based on a variety of parameters, including convergence speed, cluster stability, cluster overlap, location awareness, and node mobility support. Another research [14] examines several routing models for sensor networks and provides a survey with classifications based on model types. Data-centric, hierarchical, and location-based are the three basic types investigated. The goal of all routing strategies and algorithms is to improve output and extend the sensor network's useful life. Flood and direct diffusion, two routing techniques based on network speed and lifetime, were compared. Two topologies with identical source and target nodes were also used to simulate AODV (Ad Hoc on Demand Distance Vector). Random coverage and connection analyses in three-dimensional heterogeneous WSNs are presented in the work [15]. The SEP algorithm, in which each sensor node in a two-level heterogeneous sensor network independently classifies itself as a CH based on the initial energy relative to the other sensor nodes of the sensor network, according to the study [16]. The paper [17] proposes an approach called DEEC, in which the CH selection is based on the ratio of the node's remaining energy to the sensor network's average energy. The DDEEC technique is provided in research [18] based on the recalibration of the energy for CH. The public wireless network has optimized this protocol. In this sense, advanced nodes are more likely to be selected as CH in the first broadcast rounds. Furthermore, when energy is lowered, these sensor nodes will have the same CH selection probability as normal sensor nodes. The study [19] demonstrates EDEEC, a clustering method with a three-level heterogeneous structure that yields a high amount of energy level called super sensor nodes. A clustering strategy called EDDEEC was proposed in one research [20]. The probability of CH selection is determined by the residual energy quality of the sensor nodes in comparison to the WSN's average energy. According to one study, each node's chance of being selected as a CH is determined by its energy level and the quantity of depleted energy. Delay periods are shorter for nodes with more opportunities. CH is the node with the shortest time delay when compared to its neighbors. Following the formation of a cluster and the selection of a CH, all nodes in the cluster begin sending packets to the CH using energy-aware multi-hop routing. The packets are then sent to the BS using multi-hop routing [21]. The goal of paper [22] is to examine the performance of the artificial bee colony optimization algorithm (ABCO) in terms of the clustering approach used to increase network lifetime. In a certain interval, the node in a cluster with the highest energy is selected as CH, and the entire field is reclustered based on the selected CHs. An energy-efficient routing technique for wireless sensor networks is suggested in one study [23]. This technique comprises a data transmission routing algorithm, a CH selection mechanism, and a cluster construction scheme. The TDEEC approach was developed by Parul Saini and Ajay K Sharma [24], and it selects the CH from high-energy nodes to improve network energy efficiency and longevity. In 2017, Xie [25] introduced the Improved Distributed Energy Efficient Clustering algorithm (IDEEC) for WSNs. The multilevel energy model is taken into consideration by IDEEC, which simplifies the threshold, enhances the likelihood of cluster head selection, and optimizes the network's average energy.

### 1.3. Contributons and Motivation

i. The proposed methodology (IoT-DEEC) for distributed sensor networks is a DEEC-based, energy-efficient three-level heterogeneous clustering model called IoT-DEEC.

ii. An Improved DEEC (IDEEC) protocol-like network model is used in the suggested technique. However, the threshold energy level for the energy consumption model is different from other protocols.

iii. The threshold value was better set in this research, and CH selection was better because of our algorithm - which we explain in section 3. As a result, all heterogeneous nodes' energy has been used to the greatest extent feasible.

In this study, the suggested model was compared against IDEEC as a simulation using MATLAB software for network performance, network throughput, number of packets received by BS, number of packets received by CH, overhead, number of CHs, and packet delivery ratio. The parameters used to program the two techniques are all the same. The results indicate that the suggested model extends the lifetime of the network and outperforms the other two clustering methods in terms of packet delivery ratio, overhead, and throughput.

## 2. Energy Efficient Modelling

When creating energy-efficient WSN models, clustering is important. The following are the components of the clustering network structure: Sensor nodes are responsible for data detection, data memory management, data routing, and data processing. Clusters are the WSNs' collecting units. To implement energy-efficient WSNs, large sensor networks should be separated into clusters. Cluster heads (CHs) are the cluster's leaders. Data aggregation, communication organization inside the cluster, and communication with the base station (BS) are all operations that CHs carry out. The BS sensor node is the location where network data is gathered. The BS serves as a connection between the end user and the sensor network. A person who accesses the WSN and uses the data obtained in various applications is known as an end user [26]. Fig. 1 shows a clustering structure heterogeneous model in WSNs. DEEC, IDEEC, and the proposed model are explained in detail in this section. First, we describe a two-level heterogeneous model for the DEEC protocol, followed by a three-level heterogeneous network model for the IDEEC protocol, and finally the suggested algorithm's heterogeneous and energy consumption model.

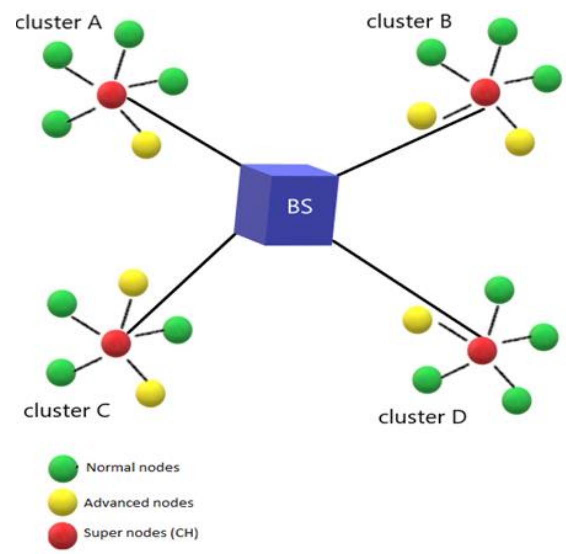


**Fig. 1**: A clustering heterogeneous WSN model.

## 2.1. DEEC Model

In terms of energy levels, hardware structure, and other special properties, heterogeneous WSNs are made up of two, three, or more types of sensor nodes [20]. The DEEC protocol is based on a two-level heterogeneous WSN, with normal and advanced battery levels assumed for sensor nodes [11]. DEEC, on the other hand, can take into account multilevel heterogeneity. The initial energy of a normal and advanced sensor node is represented by $E_0$ and $E_0 a$, respectively. $a$ indicates how many times energies advanced node has been relative to the normal node. The numbers of normal and advanced nodes in the network are $N_{nml}$ and $N_{advcd}$, respectively. So, the total numbers of nodes ($N$) in WSN are defined in

$$N = N_{nml} + N_{advcd} \quad (1)$$

The total first energy ($E_{nml}$) of the normal nodes in the WSN is given in

$$E_{nml} = N_{nml} E_0 \quad (2)$$

The total first energy of the advanced nodes in the WSN ($E_{advcd}$) is given in

$$E_{advcd} = N_{advcd} E_0 a \quad (3)$$

Thus, the total first energy of the two-level heterogeneous WSNs is calculated as given in

$$E_{\text{total}} = E_{nml} + E_{advcd} \quad (4)$$

Due to the different energy dissipation of the sensor nodes, a heterogeneous WSN becomes homogeneous after several rounds. Sensor nodes and other member nodes use less energy than CH. The energy level of all sensor nodes varies compared to each other after numerous rounds. As a result, a clustering network protocol that uses heterogeneity is more significant than a homogeneous network technique [20]. Models that require energy for a sensor node to perform certain operations such as sensing, processing, and wireless communication of collected data [27–29]. By calculating energy consumption, these models have become functional. When the CH selection is performed, the DEEC model contains the idea of the probabilities of the nodes based on the initial and residual energy, as well as the average energy of the network. For $r$. round, the network's average energy is provided as (5).

$$E_{\text{avg}} = \frac{1}{N} E_{\text{total}} \left(1 - \frac{r}{R}\right) \quad (5)$$

As seen in (5), $E_{avg}$ is found as $E_{\text{total}}$ is the total energy of the $N$ nodes and $r$. round in all rounds $R$ is defined as the number of rounds predicted according to the available energy and energy consumed at the current round is given by (6). $E_{\text{round}}$ refers to the energy consumed for each round.

$$R = \frac{E_{\text{total}}}{E_{\text{round}}} \quad (6)$$

At the beginning of each round, the decision as to whether the nodes are CH is decided by the threshold value or not. The threshold value is recommended as in (7). It is important to note that desired probability ($p_i$) is between 0 and 1, which is the fraction remaining in the inverse of the $p_i$ with r. That is why the mod is used. This residual is subtracted by 1 and $T(K_i)$ is calculated.

$$T(K_i) = \begin{cases} \frac{p_i}{1-p_i(\text{mod}(r,1/p_i))} & \text{if } S_i \in G \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

The selection for CH and G includes the appropriate set of nodes, and $p_i$ is the desired possibility for CH. $S_i$ is $i$. a node within the cluster. The possibilities for CH selection in the DEEC model are given in (8). $E_i(r)$ is the energy of the node. $p_{opt}$ is used constant probability for CH. In (8), because $E_{avg}$ is recalculated for each round, $E_{avg}$ is important to be here. If it is also assumed to be $E_i(r)p_{\text{opt}} = E_{\text{avg}}$, then the sum of all possible states of $p_i$ is 1.

$$p_i = \begin{cases} \frac{E_i(r)p_{opt}}{(1+a)E_{avg}} & \text{if normal node} \\ \frac{E_i(r)p_{opt}a}{(1+a)E_{avg}} & \text{if advanced node} \end{cases} \quad (8)$$

the probability of CH selection in a multilevel heterogeneous network model is as in

$$p_{\text{multi-level}} = \frac{p_{opt}N(1+a)}{(N+\sum_{i=1}^{N} a_i)} \quad (9)$$

$p_{opt}$ is constant and given value of this in Table 1. It only used $a$ coefficient as we show the multilevel heterogeneous network. When the $N$a is in the case of a denominator, $p_{\text{multi-level}}$ is found. In this case, the probability of $p_{\text{multi-level}}$ is in only one multiplication factor in $N$ nodes.

## 2.2. IDEEC

Improved Distributed Energy-Efficient Clustering Protocol (IDEEC) [25] is similar to DEEC; the only difference is the scaling factor which means the simplification of power $\in_{fs}$ is compact by factor 10. The scaling factor could be measured using the following equation:

$$\text{Scaling factor} = \left\{ \text{rand}() \times \frac{\text{Area of Network field}}{\text{area of the cluster} \times \text{no.of nodes in a cluster}} \right\} \quad (10)$$

And the possibility of the knob should develop the cluster head using the equation:

$$P_i = \frac{\text{The energy of the i th node}}{\sum_{i=1}^{n} \text{Total energy of all the nodes within a cluster}} \quad (11)$$

Threshold value will decide whether the particular knob will become the cluster head or not.

$$T(s_i) = \begin{cases} \frac{P_i}{1-P_i\left(r \bmod \frac{P_i}{\sum_{i=1}^{n} P_i}\right)} & \text{if } S_i \in G \\ 0 & \text{otherwise} \end{cases} \quad (12)$$

## 3. Proposed IoT-DEEC (Internet of Things DEEC) Model

As shown in the following algorithm, after deploying sensor nodes in the area of WSN, count alive and dead nodes, count packets sent to the base station, calculate the maximum distance between Base Station and Cluster Head, and check for sleep nodes. Our new proposed protocol is about using the Threshold Energy ( $E_{Th}$) - which we set its value from the beginning of the round - then we compare the energy of each node with this Threshold Energy ( $E_{Th}$); if the energy of the node is more than ( $E_{Th}$) then we select this node as a Cluster Head (CH), else, this node will be entered in sleep mode as a normal node and check if its energy had been finished or not to return it to the beginning of the cycle again.in the operation of cluster head selection, we broadcast CH attributes and check if this node is a CH then we give it more energy; otherwise, we reduce its energy. Then we check again for the selected CH energy if its energy becomes lower than ( $E_{Th}$), then we repeat the steps from the beginning of CH selection; if not it remains as a CH for the next round, wich means that we reduce the energy used in CH selection every round. Finally, if the lifetime ended then we end this algorithm; if not we continue repeating the last steps until all nodes die.

**Tabel 1**: Simultation parameters

| Symbol | Description | Value |
|---|---|---|
| ***Xm*** | distance at *X*-axis | 100 m |
| ***Ym*** | distance at *X*-axis | 100 m |
| - | base station node position | (50, 50) |
| ***N*** | total number of sensor nodes | 100 nodes |
| ***$P_{opt}$*** | Probability of CH | 0.1 |
| ***$E_t$*** | the total energy of the network | 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 |

## 4. Simulations Results

In this study, the simulation results of IDEEC and the proposed protocol for three levels of heterogeneous WSNs were analyzed using MATLAB programming (Table 2). While WSN was being constructed, 100 sensor nodes were randomly distributed in a 100m-by-100m area with a centrally positioned BS. It is assumed that all of the sensor nodes are in a fixed position. Live and dead nodes in the network, number of packets received by BS, throughput, overhead, number of packets sent to cluster head, count CH, and packet delivery ratio are the quality performance parameters used for model analysis. In terms of residual energy, throughput, network lifetime, and CH count, simulation results indicate that IoT-DEEC surpasses the IDEEC protocol. When the IDEEC protocol is adjusted to include a threshold power level for the CH replacement criterion, the number of CHs increases to 9639 for IoT-DEEC, compared to only 2923 for IDEEC, owing to the effective CH replacement approach shown in Fig. 2.

The number of data packets sent to BS in IDEEC is limited to $0.6 \times 10^5$, whereas in IoT-DEEC, the number rises to $5.28 \times 10^5$ as indicated in Fig. 3a which proves the efficiency of the proposed protocol. But in the number of data packets sent to CH, IDEEC protocol beats IoT-DEEC as you can see in Fig. 3b. The sensor node's energy reduces as the number of rounds increases until it eventually dies. The network lifetime is depicted in Figs. 4a and 4b by the number of alive and dead nodes, respectively. For IDEEC, the number of active nodes drops to zero after around 3995 rounds, however for IoT-DEEC, some nodes are still active beyond 10000 rounds. This results in a comprehensive scenario for maximizing network lifetime, which is owing to the assignment of different power levels for different forms of communication inside the network.

**Table 2:** Proposed protocol Algorithm.

| Algorithm: IoT-DEEC |
|---|
| Input: |
| Xm,Ym %diameters of sensor network |
| Eo %energy supplied to each node |
| rmax %number of rounds |
| $E_{Th}$ % Threshold energy. |
| Output: |
| Count Alive nodes during round |
| Count Dead nodes during round |
| Count the number of packets sent to Base Station (BS) |
| Extend the lifetime of sensors nodes and improve throughput |
| Step 1: start |
| Step 2: deploy sensors nodes into the WSN field |
| Step 3: loop for count dead and alive nodes |
| Step 4: Check for sleep nodes |
| Step 5: loop for count packets sent to Base Station (BS) |
| Step 6: Calculate the maximum distance node. |
| Step 7: Enter $E_{Th}$ " threshold energy ". |
| Step 8: compare each node with $E_{Th}$. |
| if S(i).E > $E_{Th}$ |
| Step 9: Select this node as a Cluster Head. |
| else |
| . Enter nodes in sleep mode |
| Step 10: if sleep > Sm (number of sleep nodes) |
| return to step 6 |
| Step 11: After the node has been selected as CH |
| then it takes a high-power level |
| else |
| It takes low power |
| Step 12: if node = CH |
| Do Cluster head broadcast attributes . |
| Step 13: if the energy of CH < $E_{Th}$ |
| Return to step 9 |
| else |
| previous CH and cluster |
| Step 14: if lifetime ended |
| then end |
| else |
| Return to step 8 |

The quantity of data packets transmitted to BS determines the efficiency of any routing protocol. The algorithm improves as the throughput increases. The throughput of IoT-DEEC is much higher than that of the IDEEC protocol, as seen in Fig. 5. Limiting the number of data transmissions, along with an effective CH replacement mechanism that conserves energy globally with multiple power levels for distinct modes of transmission, results in an increase in throughput by 700 % in our new proposed protocol (IoT-DEEC) than the old protocol (IDEEC). In Fig. 6, the proposed IoT-DEEC method performed better than IDEEC according to network overhead and was found to end after approximately more than 10000 rounds for IoT-DEEC, whereas it ends after only 4000 rounds for IDEEC. This is achievable because energy was saved in the needless cluster creation and CH selection processes, allowing the existing CH to continue as CH for the following cycle. In Fig. 7, we can see obviously that the proposed IoT-DEEC protocol is better than IDEEC in Packet Delivery Ratio, it performs better with more than 4536 packet delivery ratios. Whereas, IDEEC has less performance with 346 only.

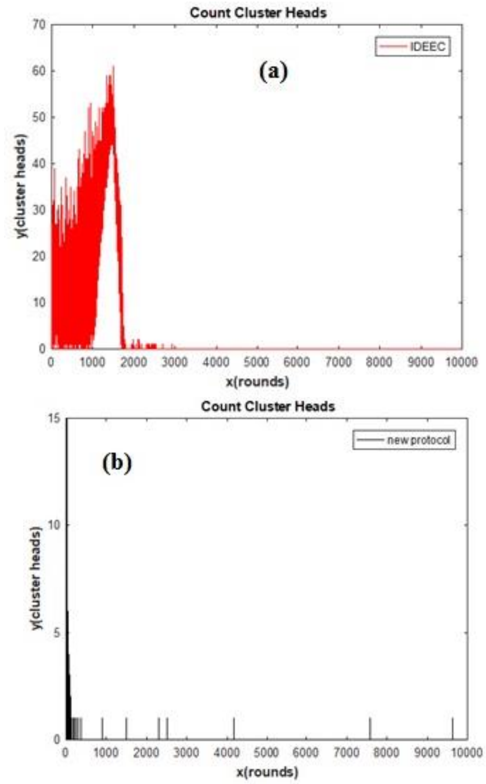


**Fig. 2:** Cluster count where (a) IDEEC, (b) IoT-DEEC.

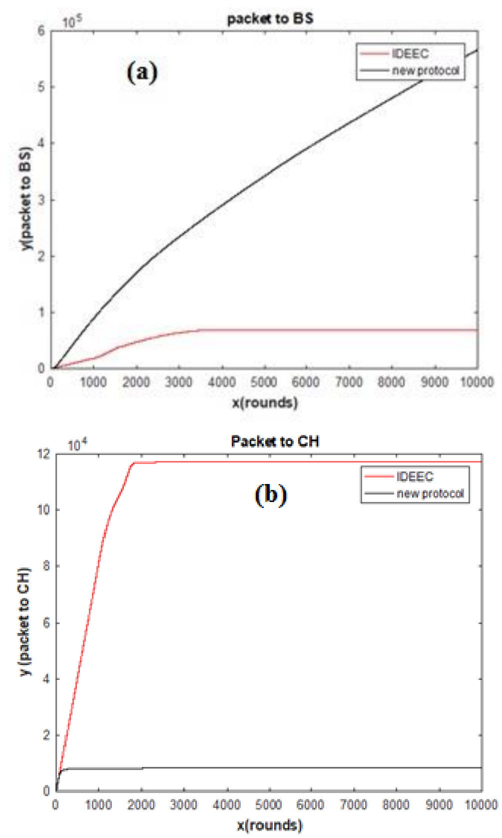


**Fig. 3:** Packets Communicated where (a) to BS, (b) to CH.

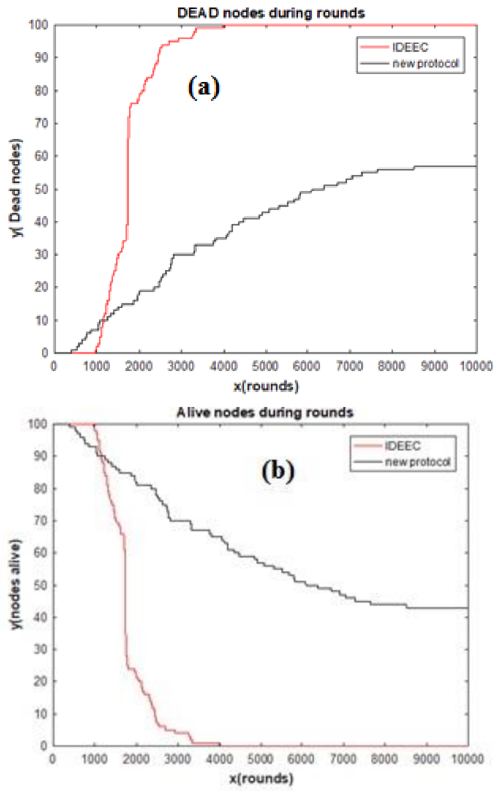


**Fig. 4:** Lifetime Metrics where (a) Dead nodes, (b) Alive nodes.

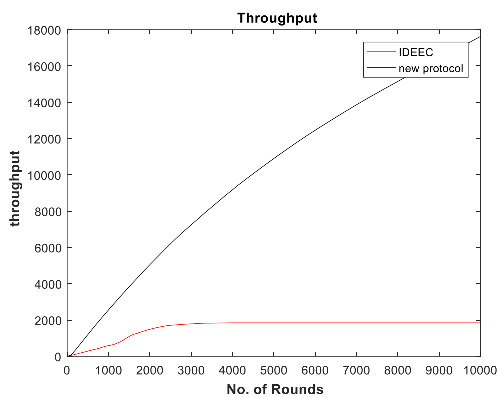


**Fig. 5:** depicts Throughput.

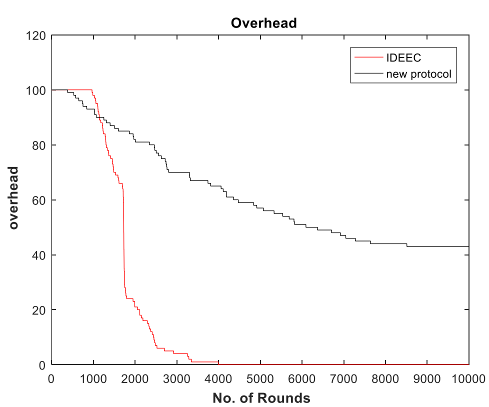


**Fig. 6:** shows the overhead.

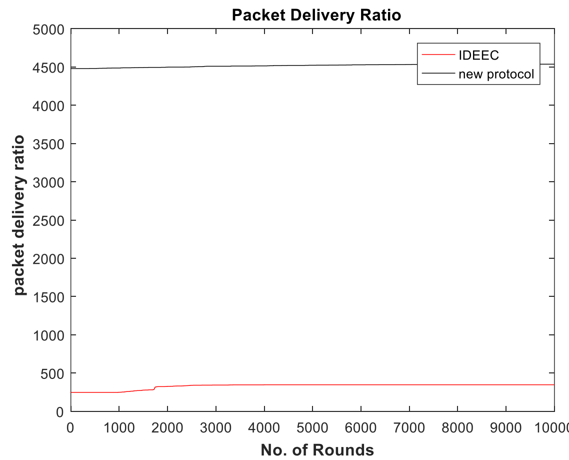


**Fig. 7:** depicts the packet delivery ratio.

## 5. Conclusion

This study presents an energy-efficient clustering heterogeneous protocol based on DEEC protocol variants in distributed WSNs. We analyzed the performances of the proposed protocol in comparison with IDEEC in terms of criteria, alive and dead nodes during the network life, throughput of the sensor network, number of packets received by BS & CH in the network, packet delivery ratio, and overhead of the algorithms in MATLAB simulation environment. The suggested approach (IoT-DEEC) outperforms the old IDEEC in terms of the parameters concerned, and it has been determined to be more efficient in terms of increasing the network's lifetime by reducing energy consumption in a distributed manner. In this way, we provide a new energy consumption CH selection approach for heterogeneous WSNs, and the suggested algorithm may serve as a model for future study.

## References

[1] S. Vancin, E. Erdem, Sadhana, 42, 6 (2017) 841–854.

[2] J. Burrell, T. Brooke, R. Beckwith, International Journal of Computer Applications (0975 – 8887), 97, **7** (2014) 9–16

[3] R. Kumar, R. Kaur, International Journal of Computer Applications 97, 7 (2014) 9–16.

[4] W.R. Heinzelman, A. Chandrakasan, H. Balakrishnan, in Proceedings of the 33rd Annual Hawaii International Conference on System Sciences (HICSS '00), 2, IEEE January (2000).

[5] T. Kang, J. Yun, H. Lee et al.., in Proceedings of the International Conference on Electronics, Hardware, Wireless and Optical Communications, Corfu Island, Greece (2007) 133–138.

[6] J. Singh, B.P. Singh, S. Shaw, in Proceedings of the 5th IEEE International Conference on Computer and Communication Technology, ICCCT (2014) 181 – 186.

[7] A. Kumar and V.F. Katiyar, International Journal of Computer Applications, 110, 5 (2015) 18 – 22.

[8] S. Lindsey, C.S. Raghavendra, in Proceedings of the IEEE Aerospace Conference, Big Sky, MT, USA 3 (2002) 1 – 6.

[9] N. AT, D. SM, Journal of Electrical & Electronic Systems, 4 (2015) 3.

[10] J.-Y. Lee, K.-D. Jung, and D. Lee, International Journal of Control and Automation, 8, **7** (2015) 385–394.

[11] M. Aslam, E.U. Munir, M.M. Rafique, X. Hu, Sustainable Computing, 12 (2016) 57 – 71.

[12] M. Mohammad, M. Noorian, in Proceedings of the The International Conference on Computing Technology and Information Management (ICCTIM), Society of Digital Information and Wireless Communication, 2014.

[13] S. Dhankhar, E.S. Singh, International Journal of Technical Research, 5, 1 (2016) 167 – 170.

[14] K.H. Krishna, Y.S. Babu, T. Kumar, Procedia Computer Science, 79 (2016). 817 – 826.

[15] H.P. Gupta, S.V. Rao, T. Venkatesh, Pervasive and Mobile Computing, 29 (2016) 38 – 56.

[16] G. Smaragdakis, I, Matta, A. Bestavros in Proceedings of the Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA), 97 (2004) 1 – 11.

[17] L. Qing, Q. Zhu, M., Wang, Computer Communications 29, 12 (2006) 2230 – 2237
.

[18] B. Elbhiri, S, Rachid, S., El Fkihi, D. Aboutajdine, D., in Proceedings of the 2010 5th International Symposium on I/V Communications and Mobile Networks, ISIVC, (2010) 1 – 4.

[19] P. Saini A.K. Sharma, in Proceedings of the 2010 1st International Conference on Parallel, Distributed and Grid Computing, PDGC (2010) 914 – 919.

[20] N. Javaid, T.N. Qureshi, A.H. Khan, A. Iqbal, E., Akhtar, M. Ishfaq, Procedia Computer Science, 19 (2013) 914 – 919.

[21] S.M. Bozorgi, A. Shokouhi Rostami, A.A. R. Hosseinabadi, V.E. Balas, Computers and Electrical Engineering, 64 (2017) 233 – 247.

[22] A. Gambhir, A. Payal, R, and Arya, Procedia Computer Science, 132 (2018) 83 – 188.

[23] M.K. Khan, M. Shiraz, K.Z. Ghafoor, S. Khan, A.S. Sadiq, G. Ahmed, Wireless Communications and Mobile Computing 2018 (2018).

[24] P. Saini, A.K. Sharma, International Journal of Computer Application, 6 (2010) 2.

[25] S. Alsafi, A.S. Talab, Int. J. Advanced Networking and Applications, 12, 3 (2020) 4596 – 4600.

[26] S. Vancin, E. Erdem, in Proceedings of the 2017 24th IEEE International Conference on Electronics, Circuits and Systems (ICECS) ( 2017) 247 – 251.

[27] F. Engmann, F.A. Katsriku, J. Abdulai, J., K.S. Adu-Manu, F.K. Banaseka, Wireless Communications and Mobile Computing (2018) 1 - 23.

[28] M. Nicolae, D., Popescu, R., Dobrescu, I. Costea, Control Engineering and Applied Informatics, 18, 2, (2016) 95 - 102.

[29] A.A. Babayo, M.H. Anisi, I. Ali, Renewable o Sustainable Energy Reviews, 76, (2017) 1176 - 1184.