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Retraction

Retracted: EMEECP-IOT: Enhanced Multitier Energy-Efficient Clustering Protocol Integrated with Internet of Things-Based Secure Heterogeneous Wireless Sensor Network (HWSN)

Security and Communication Networks

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Y. Wang and G. Zhang, "EMEECP-IOT: Enhanced Multitier Energy-Efficient Clustering Protocol Integrated with Internet of Things-Based Secure Heterogeneous Wireless Sensor Network (HWSN)," *Security and Communication Networks*, vol. 2022, Article ID 1667988, 11 pages, 2022.

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Research Article

EMEECP-IOT: Enhanced Multitier Energy-Efficient Clustering Protocol Integrated with Internet of Things-Based Secure Heterogeneous Wireless Sensor Network (HWSN)

Yongcheng Wang and Guohui Zhang

School of Management Engineering, Zhengzhou University of Aeronautics, Zhengzhou, China

Correspondence should be addressed to Yongcheng Wang; wyc@zua.edu.cn

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In recent years, Internet of Things (IoT)-based constrained wireless sensor networks (WSN) have been observed with radical developments. The aligned phenomenon such as maximizing resource utilization and the delivery of efficient services is the need of the hour to suffice for the purpose of seamless connectivity. Typically, IoT devices have limited battery life and are deployed in remote areas. As a result, limited battery life limits the use of networks in some situations. To develop energy-efficient techniques for the IoT requires innovative ideas where the current techniques of using WSNs cannot directly apply to the IoT due to protocol issues, SLAs (service level agreements), scalability issues, and complexity levels. To overcome these issues, this article proposes an Enhanced Multitier Energy-Efficient Clustering Protocol integrated with the Internet of Things (EMEECP-IOT) based on the heterogeneous wireless sensor networks (HWSN) technique. The proposed approach has been compared with the current and standard protocols with respect to the parameters such as network stability, packets received, average throughput, standard deviation (SD), and residual energy. The simulation results show significantly better performance of the proposed EMEECP-IoT-based HWSN technique than the existing technique. Extensive performance factors show that the proposed EMEECP-IOT extends the network lifetime by 35% and decreases the network's energy consumption by 21%. This proposed approach can be applied to save energy and enhance network lifetime for WSN and IoT-oriented applications.

1. Introduction

In the Internet of Things-based heterogeneous wireless sensor networks (IoT-based HWSNs), many small smart devices (SDS) are located in challenging environments such as the deep sea, arctic regions, and hazardous battle zones for performing various tasks such as military operations, environmental observation, surveillance, household applications, and animal tracking. In addition to smart cities and intelligent water facilities and farming, IoT-based WSNs have been proposed for efficient farming and smart agriculture [1–3].

In the IoT, ubiquitous connectivity is the essential objective [4]. Various devices are included, such as smartphones and sensor node (SN) devices in an IoT environment as well as their energy consumption, cost, and Internet accessibility, IoT devices are heterogeneous in their nature. Different sensor nodes (SNs) with diverse networking knowledge capabilities are interconnected to provide the users with information and different high-quality services efficiently and at any time and place [5]. The WSN is different from the VANET [6–8] network due to its mobility [9].

In a world of IoT devices, self-configuring capabilities enable a large number of devices to provide certain functionality (such as weather monitoring). These devices can configure themselves (in conjunction with IoT infrastructure), set up the networking, and fetch the latest software upgrades with minimal manual or user intervention. IoT devices generate data in some form or another, which when processed by data analytics systems can provide useful information in order to guide further directions locally or

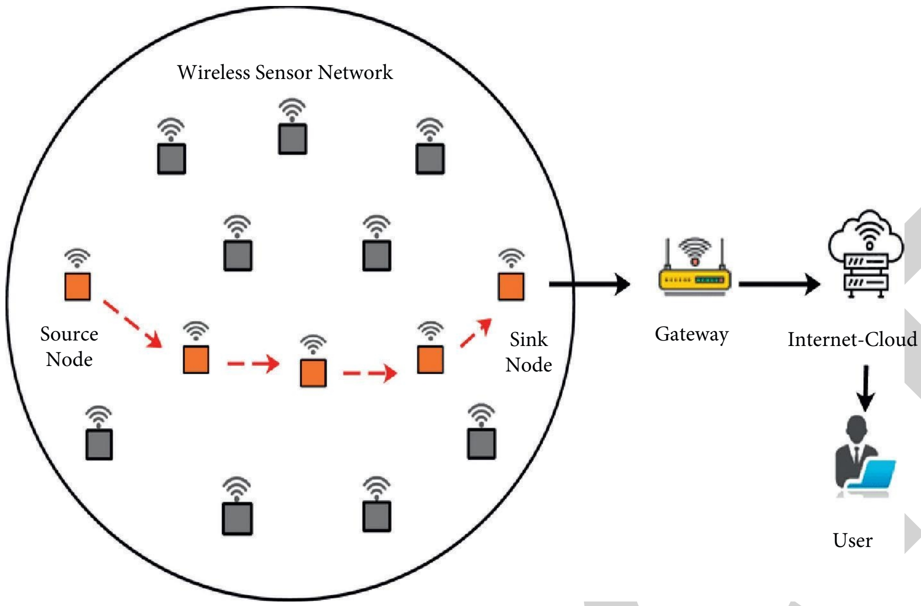

Figure 1: Clustering topology based on IOT and WSNs.

remotely; for instance, a soil moisture monitoring device in a garden can generate sensor data that when processed can help in determining the optimum watering schedule.

In a WSN, the primary task is to collect data from many sensors distributed across a target area randomly or uniformly. Therefore, IoT realization is dependent heavily on the standardization of the operations that ensure reliability, effectiveness, interoperability, and compatibility across the globe and the storage of large amounts of data over the cloud [3]. Figure 1 depicts the layout of the WSN for IoT applications. Figure 1 depicts the architecture of a WSN for IoT applications. The figure illustrates how the sensed data are transmitted from a sender to a receiver by using multiple hops and a gateway. It facilitates easy access to information anywhere at any time [10].

Energy-efficient routing is a fundamental principle to consider when designing wireless sensor networks (WSNs) for IoT applications. An energy-efficient routing protocol exploits the needs of the application in order to conserve precious energy and extend the lifetime of the network. In order to reduce energy consumption, routing protocols for delay-sensitive applications tend to reduce the number of transmissions. By optimizing network lifetime and minimizing energy consumption, designing novel protocols also improves network stability in the IoT-based HWSN.

1.1. Research Contributions. The objectives of this study can be summarized as follows:

(i) An optimization problem is considered for the proposed network structure in terms of load balance and energy consumption to implement an efficient IoT-based heterogeneous wireless sensor network (IoT-HWSN)

(ii) In this paper, we consider an optimization problem in terms of energy consumption and load balance to develop an IoT-HWSN

(iii) We have proposed the EMEECP-IoT clustering technique to resolve the energy consumption problem

(iv) The position of the sensor nodes (SNs) is restricted and deployed using 2D Elliptical Gaussian Distribution to achieve the balance energy consumption and improve the network lifetime of IOT-HWSN

(v) Internet of Things (IoT)-based HWSN performance depends on the SNs that are deployed

(vi) The energy-efficient proposed EMEECP-IoT technique enhanced the network lifetime, maintained the network stability, and minimized energy consumption in IoT-HWSN

1.2. Paper Organization. The paper is organized as follows. Section 2 explains the existing clustering techniques. Section 3 discusses the system model, sensor nodes deployed, and energy model. Additionally, the EMEECP-IOT technique is discussed in Section 4. Simulation results and analysis are discussed in Section 5. Finally, the conclusion and future work are discussed in Section 6.

2. Literature Review

In addition to launching an IoT and WSN integration structure, some industries are now conducting integrated projects using the combined infrastructure. As the networking industries profit immensely from an integrated environment, the demand for this environment increases rapidly [11]. John et al. [12] propose a dynamic CH selection method (DCHSM) for extending the network lifetime of IoT systems. The large-scale monitoring area is divided into small clusters using Voronoi diagrams to provide maximum coverage. After that, CH is selected in two phases. In the first stage of CH selection, the perceived probability is considered, while the second stage takes into account the survival time estimates. In [13], the authors propose an IoT-enabled WSN clustering routing protocol. The cluster-based routing protocol reduces the amount of data transmission to the gateway node by aggregating and reducing the number of data transfers within the CH. It results in lower energy consumption.

The integration of WSN and IoT has raised several open issues; thus, this work prioritized those performance measures. Additionally, new examination strategies have been developed, which should contribute significantly to enhancing communication networks in the future [14]. Smart SNs, which have power-constrained sensing devices, make up a WSN. The fact that SNs are energy-constrained devices distinguishes WSN from the other networks. Various clustering techniques have been presented to utilize the energy consumption of the WSN efficiently. The LEACH protocol is popular for microsensor network applications [15]. LEACH combines the principles of an energy-efficient clustering approach and media access into a single system. The goal of LEACH is to protect the energy for SNs to extend the network's lifetime. After deploying all SNs, the nodes that represent the CHs are selected randomly during the setup phase. The Cluster Heads selection procedure starts at the beginning.

Proposed algorithms [16–19] are used to achieve energy efficiency. The algorithms are run on MATLAB, and the results are analyzed for several performance characteristics such as stability, instability, network lifetime, throughput, and dependability. Some smart SNs in heterogeneous WSNs become CHs, aggregating data from their cluster SNs and sending it to the BS. The enhanced SEP approach is used for CHs election in a hierarchically clustered HWSN to remodel the network system effectively [20]. TSEP is a reactive protocol that is used for three tiers of HWSN, according to [21]. In contrast to proactive HWSNs, reactive HWSNs react rapidly to changes in significant constraints of interest. TSEP protocol results are compared with other protocols: LEACH [22], DEEC [23], SEP [24], ESEP [25, 26], and TEEN [27]. It is detected that the protocol outperforms the lifetime of the sensing nodes used.

In [28], the authors design a modified approach known as modified-LEACH. Its design is for lower energy usage and improved network lifetime. It improves the energy balancing in every cluster among SNs to decrease energy consumption throughout the data transmission. Implementation and analysis of cooperative communication have been performed [29]. Simulation outcomes show that total energy used by the WSN is significantly less when there is support than when there is none. The WSN is, therefore, more energy-efficient when there is cooperation. Wireless transmission is a well-known energy-intensive operation. LEACH is the most widely used routing protocol because of its superior performance in reducing energy consumption.

Behera et al. [30] enhance the SEP, which performs a threshold-based CH election for an HWSN. The threshold ensures that energy is distributed uniformly among cluster members and CH. The SNs are divided into normal SNs, intermediate SNs, and advanced SNs, based on the starting energy sources to spread the network load uniformly. According to the simulation results, the enhanced SEP beats the SEP and DEEC protocols by 300 percent of the network lifetime and 56 percent of the average throughput. A comparative analysis of the HWSN methods is mentioned in Table 1.

3. System Model

In this section, we discuss the four-tier IoT-based HWSN system model. Our basic assumptions for the network are mentioned below:

(i) All SNs and BS are stationary after deployment. Every SN has a unique ID.
(ii) While all SNs have the same capabilities, they differ in terms of energy consumption in the case of heterogeneity.
(iii) As a result, the batteries are not recharged after the deployment of SNs.
(iv) There is only one BS at the center of the network that is always highly powered, so there are no energy, memory, or computation constraints.
(v) The radio link is symmetric such that the energy consumption of data transmission from SN A to CH A is always the same as SN B to CH B.

3.1. Deployment of Sensor Node. Heterogeneous SNs are positioned using the 2D Elliptical Gaussian distribution approach. Since the standard deviation (SD) factor has a moderate effect on both the parameters, such as energy and network lifetime, this technique balances the energy and extends the network lifetime [28, 32–34]. The network's Gaussian distribution [28] is given in the following equation:

$$f(x, y) = \frac{1}{2\pi\sigma_x\sigma_y} \exp - \left(\frac{(x - x_0)^2}{2\sigma_x^2} - \frac{(y - y_0)^2}{2\sigma_y^2} \right), \qquad (1)$$

where (x, y) represents each SN's original location points. The standard deviations for the x and y dimensions are σ_x and σ_y, respectively. Each node has its own unique ID with a specific position. xo and yo have the origin value zero. Because SN batteries are not rechargeable, SNs get converted into dead SNs when their energy is zero.

3.2. Energy Model. Figure 2 depicts the radio hardware energy system. The transmitter is in charge of radio-integrated circuit technology and power amplification, while the receiver is in charge of radio electronics. Power is required for operations as well. The available multipath channel with $\varepsilon_{mp} * d^4$ power utilization and the free space channel with $\varepsilon_{fs} * d^2$ power utilization is implemented in energy consumption based on the distance between the source and destination [22, 32, 34, 35]. As a result, equation (2) provides the power consumption for transmission of the data packet of k bits over a distance of d:

Table 1: Comparative study of HWSN methods.

Authors and Year	Techniques	Advantage	Disadvantages
[15]	LEACH combines the principles of an energy-efficient clustering approach and media access into a single system	The goal of LEACH is to protect the energy for SNs to extend the network's lifetime	Higher energy consumption and sensor nodes were dead earlier
[16, 17]	SEP is a two-level protocol, introducing normal and advanced nodes; advanced nodes possess more energy; in SEL, both types of nodes (normal and advanced) have a weighted probability of becoming the cluster head	SEP increased the network lifetime and stability as compared to LEACH	Normal nodes died very fast at the start of the network
[18, 19]	DEC extends the lifetime of a WSN by using the residual or local energy (RE) of every node in the network	DEC routing that are used to achieve energy efficiency and the results are analyzed for several performance characteristics such as stability, instability, network lifetime, and throughput	A major drawback of DEC is that it does not guarantee that the cluster heads (CH) will be selected to be leaders with sufficient energy
[20]	TSEP is a reactive protocol that is used for three-tier of HWSN	TSEP has enhanced stability period than all other protocols	Decrease in throughput due to threshold sensitivity
[31]	Routing protocols, clustering algorithms, data communication, wireless sensor networks, stability criteria, routing protocols, telecommunication power management, and wireless sensor networks	The data transfer is working without any interruptions	Battery life is minimum
[30]	Threshold ensures that energy is distributed uniformly among cluster members and CH; the SNs are divided into normal SNs, intermediate SNs, and advanced SNs, based on the starting energy sources to spread the network load uniformly	According to the simulation results, the enhanced SEP beats SEP and DEEC protocols by 300 percent of network lifetime and 56 percent of average throughput	Energy is considered as prime factor and distance is not included for threshold value calculation
[32]	In this paper, design a novel approach for prolonging the network lifetime and reduction in the energy being consumed within the wireless sensor network (WSN)	The mathematical analysis and simulations using MATLAB 2015b show a fall of 35% in the total energy being consumed, while the longevity of the network has been enhanced by 80% over existing routing protocols	Work for two tier-heterogenous WSN

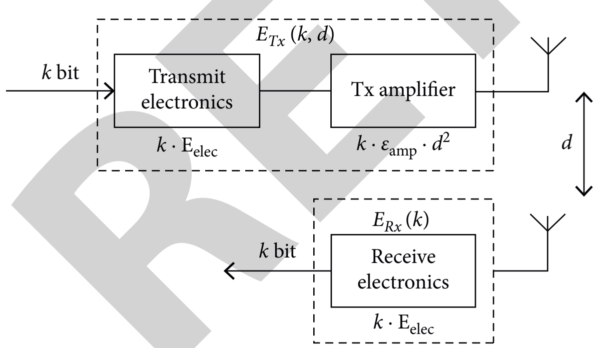

Figure 2: Radio energy model.

$$E_{TX}(k, d) = \begin{cases} k * E_{elec} + k * \varepsilon_{fs} * d^2, d \leq d_0 \\ k * E_{elec} + k * \varepsilon_{mp} * d^4, d > d_0 \end{cases}, \quad (2)$$

where d_0 can be calculated by $\sqrt{\varepsilon_{fs}/\varepsilon_{mp}}$. The electronic energy E_{elec} is employed based on the modulation, filtering, digital coding, and spreading of the signal.

As seen in Figure 2, the receiver's specific energy procedure is the inverse of the transmitters. The variables ε_{fs} and ε_{mp} are the amplification factors of the communicating data when $d \leq d_0$ and $d > d_0$. $d_{0,}$ is the threshold distance. To receive k bits message, the receiver spends energy as mentioned in the following equation:

$$E_{RX}(m, d) = k * E_{elec}. \quad (3)$$

4. Proposed EMEECP-IoT Protocol

The EMEECP-IoT protocol is designed for the IoT-based four-tier heterogeneous wireless sensor network (HWSN) with four different energy levels. The CH is selected based on the initial energy, residual energy, distance from the SNs to BS, and maximum distance from the SNs to BS. The proposed EMEECP-IOT technique has a higher number of energy levels and higher energy, which increases the network performance for the random selection of channels in HWSNs if energy levels are quantified and probabilities are defined for each energy level.

In this study, the proposed EMEECP-IOT technique with a four-tier IoT-based HWSN concept is presented. The EMEECP-IOT technique has four SNs: normal, advanced,

Input: Simulation time, No. of Nodes (N), Initial Energy (in), position $\lceil SN.x_d, SN.y_d \rceil$
Output: Performance Metric:-Alive/Dead SNs, Residual Energy, Network Stability, Average Throughput, Standard Deviation, Last SNs expiry, etc.
Assumption: Initial All SN is alive and has enough transmission energy.
Four-tier IoT based HWSN SNs deployed by the 2D Elliptical Gaussian distribution approach over $M \times M\,\text{m}^2$ area.
Generate the position value of sensor nodes $\lceil SN\_Pos_x, SN\_Pos_y \rceil$
for (i = 1: 1: N) // It runs for all the sensor nodes
  $SN(i).d = i$; // Each node have their ID.
  $SN(i).x_d = SN\_Pos_x(i)$
  $SN(i).y_d = SN\_Pos_y(i)$
  $BS = BS.x, BS.y$
  $D_{SNtoBS}(SN_i, BS) = \sqrt{(SN(i).x_d - BS.x)^2 + (SN(i).y_d - BS.y)^2}$
End
$D_{SNtoBS\,av} = Average(D_{SNtoBS})$;
$D_{\max} = \max(D_{SNtoBS})$;
for (r = 1: 1: Simulation time) // Simulation time in seconds
  for (i = 1: 1: N) // It run for all the SNs
    if ($E_{initial}$(i) ≤ 0) // Check Energy level for all SNs
    SN_dead = SN_dead + 1; // As SNs energy less than zero or equal to zero, it is a dead node and increases the dead counter by 1
  End
End
for (i = 1: 1: N) // It run for all SNs
  temp_rand = rand // Calculate random function (rand (n)) between [0, 1]
  Calculate Threshold $T(S_i)$ for normal, advanced, super, and ultrasuper SNs by equation (4)
  if (temp_rand ≤ T (S_i)) // for all normal, advanced, super, and ultrasuper SNs
    As per the condition that SNs become CH
  End
  Start the Cluster formulation procedure:-CH broadcasts the information by CSMA/CA to the nearest SN to join the cluster
  Data communication starts by energy model from a cluster member to CH and CH to BS.
  End
end

ALGORITHM 1: Proposed EMEECP-IoT technique.

super, and ultrasuper SNs. The probabilities for each of these levels are driven as follows:

$$P_i = \begin{cases} \dfrac{P_{opt} * \left(u\left(E_{roun\,d}/E_{initial}\right) + V\left(D_{SNtoBS}/D_{\max}\right) + \left(1/D_{SNtoBS}\right)\right)}{\left(1 + m\left(a + m_0\left(-a + b + m_1\left(\left(-b + c\right)\right)\right)\right)\right)} s_i \text{ is normal SN}, \\[2ex] \dfrac{P_{opt} * (1 + a) * \left(u\left(E_{roun\,d}/E_{initial}\right) + V\left(D_{SNtoBS}/D_{\max}\right) + \left(1/D_{SNtoBS}\right)\right)}{\left(1 + m\left(\alpha + m_0\left(-a + b + m_1\left(\left(-b + c\right)\right)\right)\right)\right)} S_i \text{ is advanced SN}, \\[2ex] \dfrac{P_{opt} * (1 + b) * \left(u\left(E_{roun\,d}/E_{initial}\right) + V\left(D_{SNtoBS}/D_{\max}\right) + \left(1/D_{SNtoBS}\right)\right)}{\left(1 + m\left(a + m_0\left(-a + b + m_1\left(\left(-b + c\right)\right)\right)\right)\right)} S_i \text{ is super SN}, \\[2ex] \dfrac{P_{opt} * (1 + c) * \left(u\left(E_{roun\,d}/E_{initial}\right) + V\left(D_{SNtoBS}/D_{\max}\right) + \left(1/D_{SNtoBS}\right)\right)}{\left(1 + m\left(a + m_0\left(-a + b + m_1\left(\left(-b + c\right)\right)\right)\right)\right)} s_i \text{ is ultra} - \text{super SN}. \end{cases} \quad (4)$$

The distance between the SNs and the BS should be reduced for the CH node to consume less energy. The modified design formula for clustering includes the addition of the distance from SNs to BS (D_{SNtoBS}), $E_{initial}$ is the initial senor node's energy, E_{round} is the residual energy per round, $D_{\max}$ is the maximum distance from SNs to BS, and U and V are the weight parameter and value between 0&1, whereas $u + v = 0$. The SN's distance is lesser from BS, which means less energy consumption in the IoT-HWSN.

Each SN must inform the CH that it has joined a cluster after determining its cluster membership. Each SN uses the CSMA (MAC) protocol to transmit this information to the CH. At this point, each CH node must keep its receivers operating. Once a cluster has been created and TDMA (Time Division Multiple Access) scheduling has been implemented, the data can be transmitted. The proposed technique workflow is mentioned in Algorithm 1.

When the cluster is established during the setup phase, the CH node operates its receiver to receive all data from the cluster nodes. The CH node transmits data to the BS during the steady-state phase. As a result, we can express the threshold of a four-tier HWSN as the following equation:

$$T\left(S_i\right) = \begin{cases} \dfrac{P_i}{1 - P_i\left(r.\mathrm{mod}\left(1/P_i\right)\right)}, & \text{if } S_i \in \left[S, S', S', S'^{'}\right], \\ 0, & \text{else.} \end{cases} \tag{5}$$

5. Result Simulation and Analysis

We estimate the performance of the EMEECP-IoT technique with its implementation and designing having been done on the Network Simulator (NS2) and MATLAB R2017b. All the assumptions and initial parameters are mentioned in Table 2. We calculate the performance parameter values based on the simulation time and the number of sensor nodes.

We have compared our proposed EMEECP-IOT technique to the most popular and recently used strategies, such as LEACH, Modified-LEACH, SEP, and ADV-LEACH1 [32, 35]. In this research, we have fixed the simulation area at $100\,\mathrm{m} \times 100\,\mathrm{m}$, the number of SNs (N) is 200, and the position coordinates of SNs are deployed by the 2D Gaussian distribution technique. The following charts and graphs show the comparison of the proposed EMEECP-IOT technique with LEACH [22], Modified-LEACH [36, 37], SEP [24, 30], and ADV-LEACH1 [35] techniques.

The proposed model's performance will be calculated in terms of network factors, such as throughput, the number of alive or dead SNs, stability, remaining energy, energy imbalance factor (EIF), and number of CHs. We have used the various network performance factors listed below to evaluate the proposed approach performance.

(1) Number of alive SNs (N_{alive}): when the SNs have more than zero energy, then SNs are counted as alive SNs. The total number of alive SNs is counted as alive after finishing the simulation time [38].

(2) Number of dead SNs (N_{dead}): when the SNs have less than zero energy, then SNs are counted as dead SNs. After finishing the simulation time, the total number of dead SNs is counted as dead.

(3) Network lifetime: it is calculated in terms of simulation time until the last SN expiry of the IoT-HWSN. The network's lifetime is measured based on three metrics, the first node's expiry and the last node's expiry [39]. The FND also indicates network stability.

(4) Residual energy (Joules): the network's remaining energy is measured after every round. That energy is used as initial energy for the next simulation time of packet transmission.

(5) The number of cluster heads (CHs): As the number of CHs increases, the energy consumption intensifies due to the extensive aggregation processes that these SNs perform in the CHs [40]. As a result, cluster heads are a significant energy drain on WSNs. In addition, as the number of CH nodes is minimized, the energy consumption is increased due to the large amounts of data aggregated by every CH and the longer period it takes for each CH to submit the bulk aggregated data to the BS. As a result, these CHs will die sooner.

(6) Number of packets received: the total number of packets received is calculated by the sum of the packets received at BS and CHs per round as mentioned in the following equation:

$$\text{Total Packet Received} = \sum_{i=1}^{r} Pkt\_recv_{CH} + \sum_{i=1}^{r} Pkt\_recv_{BS}. \tag{6}$$

(7) Average throughput (Thr_{Avg}): the average throughput $Thr_{Avg,}$ shows total data delivery at the BS. The throughput Thr_{Avg} is calculated by the received packets (N_Pkt_{recv}) multiplied by the packet size $Packet_{size}$ per time (t) as per equation (7). Its measure in terms of the Kilobytes/second :

$$Thr_{Avg} = \frac{N\_Pkt_{recv} \times Packet_{size}}{t}. \tag{7}$$

(8) The standard deviation of cluster size: to calculate the SN distribution between clusters, the standard deviation (SD) of cluster size (σ_{SD}) is used. This standard deviation (SD) is defined by equation (8), where m indicates the number of optimal clusters, M_i indicates the number of optimal cluster i members, and $\overline{M}$ indicates the average number of optimal cluster i members:

$$\sigma_{SD} = \sqrt{\frac{\sum_{i=1}^{m}\left(M_i - \overline{M}\right)^2}{m}}. \tag{8}$$

5.1. Number of Alive and Dead Nodes. Figure 3 illustrates the number of dead and alive SNs versus simulation time (minutes). In carrying out various network operations, the energy inside the network becomes exhausted as each communication consumes one unit of energy. As several communications occur, the SN energy decreases. A network using the proposed EMEECP-IoT technique can sustain higher rounds in the clustering processes because of SN's energy levels and CH's likelihoods. It is possible to evaluate

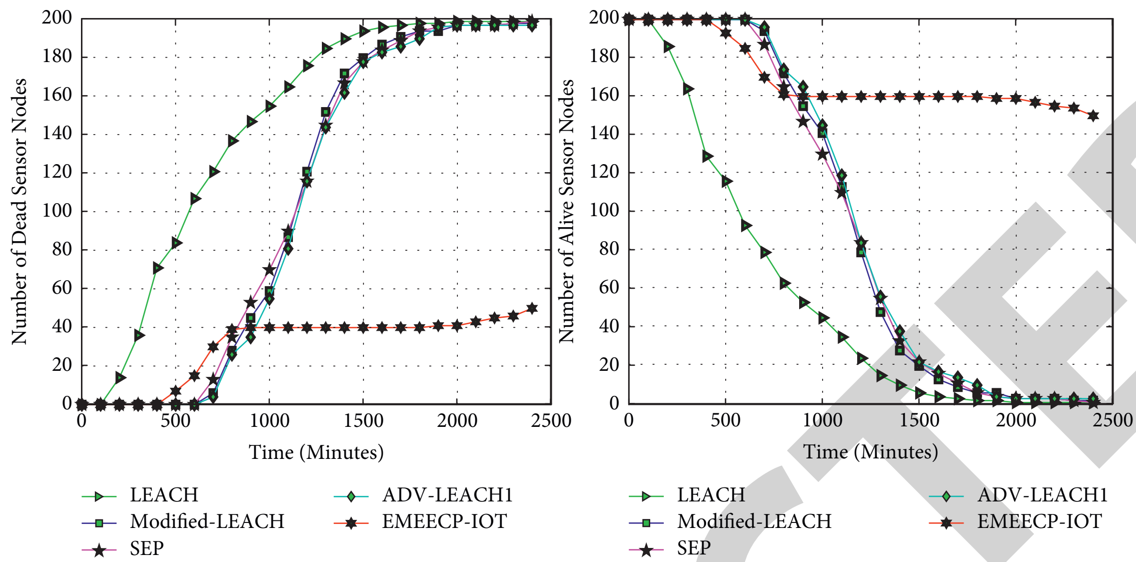

Figure 3: Comparative analysis of the number of dead and alive sensor nodes versus simulation time.

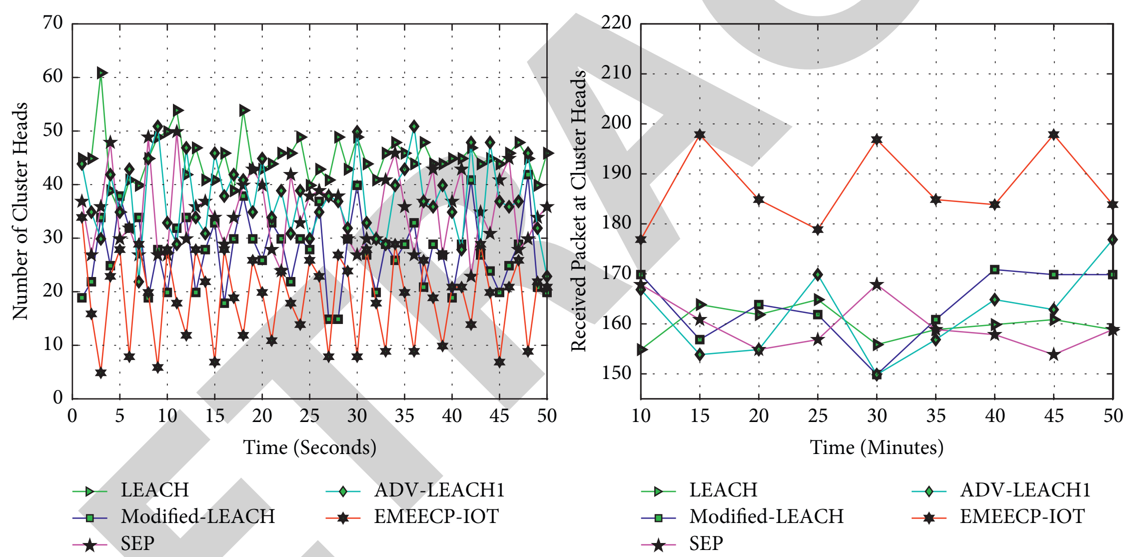

Figure 4: Comparative analysis of the number of cluster heads (CH) and received packets at CHs versus simulation time.

the graph to indicate the proposed protocol's effectiveness in enhancing network life.

As shown in Figure 3, the benchmark performance of EMEECP-IoT is compared to that of other existing approaches that create dead SNs per round. A total of 200 SNs have been considered for simulation. The dead SN rate for EMEECP-IoT is significantly lower than that for LEACH, SEP, Modified-LEACH, and ADV-LEACH1. In contrast to existing energy-efficient algorithms, the proposed EMEECP-IOT approach has a 35% reduction in node death ratio compared to the LEACH, SEP, Modified-LEACH, and ADV-LEACH1.

5.2. Number of Cluster Head and Received Packet on Cluster Head. The investigation of the CH formed every minute is shown in Figure 4. The number of CHs generated in the proposed EMEECP-IoT technique is stable and balanced compared to the existing clustering techniques. CH is selected using energy factors, which produce a uniform CH count for the network. Every SN has the same chance of winning CH, and they will utilize their energy and probability values.

Figure 4 illustrates the total number of packets received at the cluster head (CH) versus simulation time (minutes). The packets received are increased at the cluster head per simulation time. The proposed EMEECP-IoT collects more packets than LEACH, SEP, Modified-LEACH, and ADV-LEACH1.

5.3. Total Packets Received at Base Station and Average Throughput (kBps). Figure 5 illustrates the total received packets at the base station (BS) versus simulation time

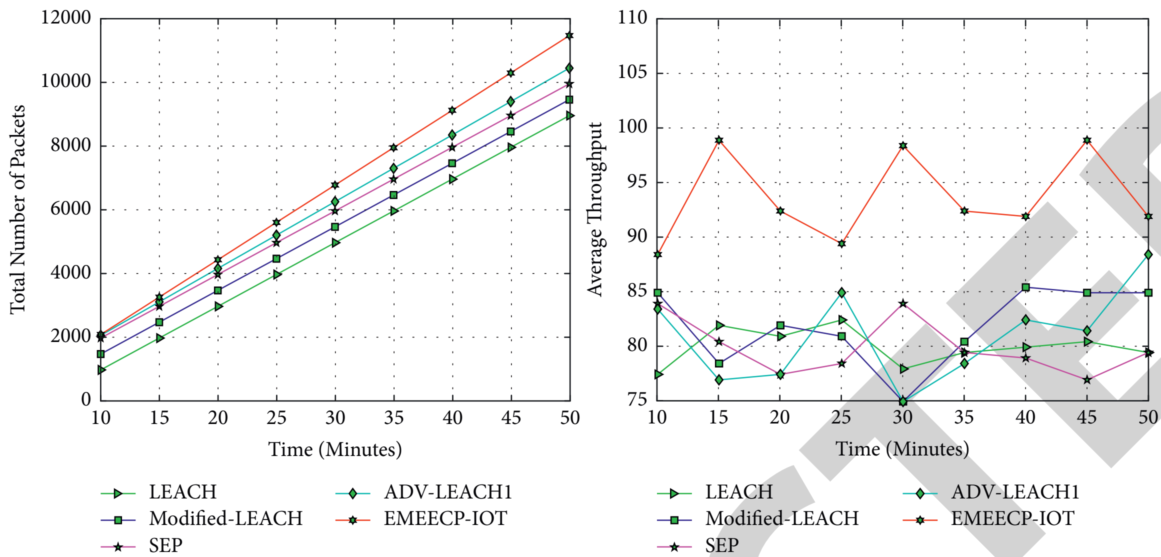

Figure 5: Comparative analysis of the total number of packets at BS and average throughput versus simulation time.

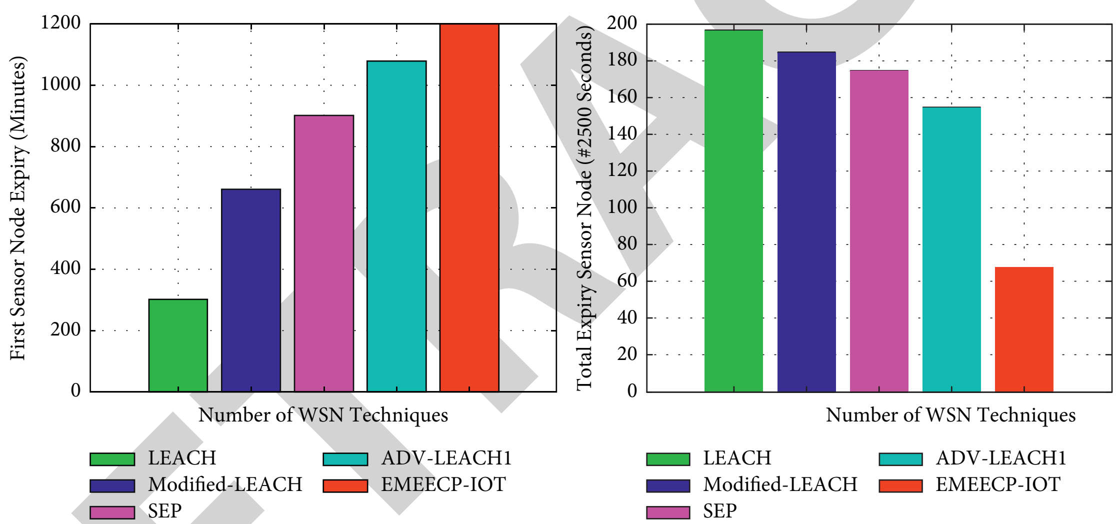

Figure 6: Comparative analysis of the first and total sensor node during 2500 seconds of simulation.

(minutes). The packets received are increased because of the data transmission in every simulation time. The proposed EMEECP-IOT collects significantly more packets than LEACH, SEP, Modified-LEACH, and ADV-LEACH1.

Figure 5 illustrates the average throughput (KBps) versus simulation time. The *Y*-axis shows the average throughput value measured for LEACH, SEP, Modified-LEACH, ADV-LEACH1, and the proposed algorithm EMEECP-IoT. Five different colors indicate the performance of all five techniques. The EMEECP-IoT performs better than an existing algorithm such as LEACH, SEP, Modified-LEACH, and ADV-LEACH1.

5.4. Network Stability and Lifetime. Figure 6 shows the evaluation of the LEACH, SEP, Modified-LEACH, and proposed EMEECP-IOT techniques regarding the first SN

Table 2: Initial parameters.

	Parameters	Value
Simulation time	r	2500
Probability	P_{opt}	0.2
Advanced SN's energy	a	2.0 J
Super SN's energy	b	2.5 J
Ultrasuper SN's energy	c	3.0 J
Normal SN's energy	E_{in}	0.5 J
Transmit and receive energy	E_{TX} or E_{RX}	50 nj/bit
Free space amplifier factor	ϵ_f	10 pj/bit/m^2
Electronic energy	E_{elec}	5 nj/bit/message
Multipath amplifier factor	ϵ_m	0.0013 pj/bit/4
Sensor node	N	200
Data packet size	$Packet_{size}$	4000 bits
Advanced SNs (35%)	m	0.35
Super SNs (12%)	m_0	0.12
Ultrasuper SNs (3%)	m_1	0.03

Table 3: Comparative analysis.

Algorithms	Total expiry SNs (#2500 second)	Network stability	Residual energy (Joules)
LEACH	197	300	3.12
Modified-LEACH	185	660	15.5
SEP	175	900	25.10
ADV-LEACH1	155	1080	45.05
EMEECP-IOT	68	1200	132.42

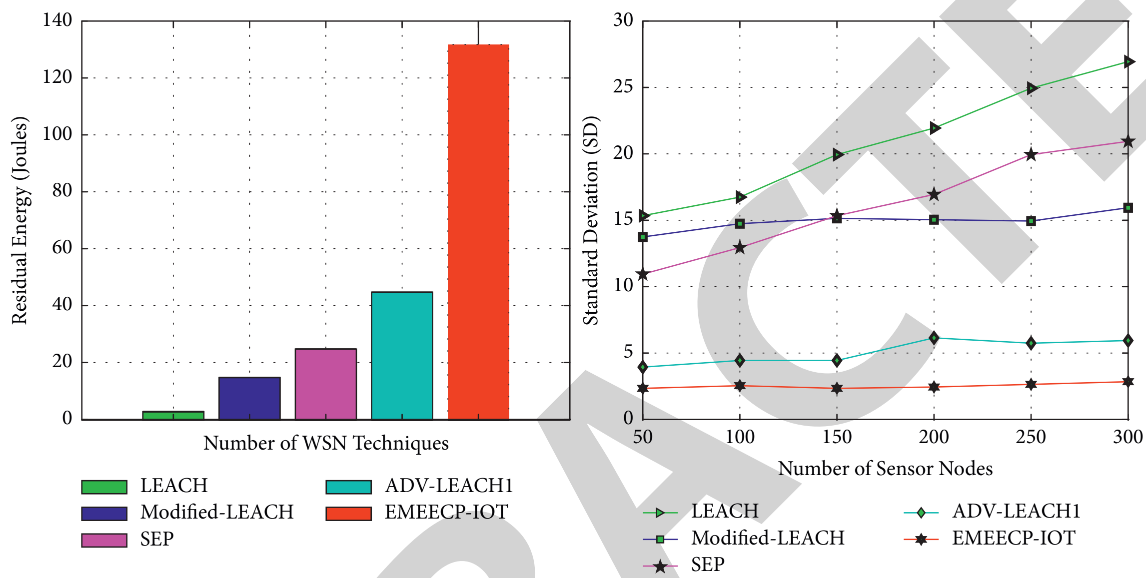

Figure 7: Comparative analysis of residual energy after 2500 seconds of simulation time and standard deviation (SD) versus simulation time.

expiry and total SN expiry in 50 minutes, respectively. The proposed EMEECP-IOT technique has a more significant network lifetime than all existing clustering-based techniques for IoT-based HWSN. EMEECP-IOT assigns fewer SNs to each CH for the network to proceed with less energy. This eliminates the initial death of the CHs and extends the network's lifetime, while other clustering approaches do not compact with the CHs' remaining energy. The proposed EMEECP-IOT technique has outlined better results in each round, demonstrating productivity by enhancing network capacity, as mentioned in Table 3.

Figure 6 illustrates the total expiry SN in 2500 seconds. The death rate of proposed EMEECP-IoT techniques is very low compared to the existing clustering LEACH, Modified-LEACH, SEP, and ADV-LEACH1 techniques. Our four-tier clustering function is used in the current EMEECP-IOT technique. The higher energy SNs are also superior. EMEECP-IOT is better performing than the existing clustering technique because it considers the distance between SNs to SNs and CHs to SNs. However, in EMEECP-IOT, while the SNs consume less energy, the CH nodes do not die faster since the remaining energy of the advanced SNs is considered higher.

5.5. Residual Energy and Standard Deviation. Figure 7 illustrates the average residual energy (Joules) for LEACH, SEP, Modified-LEACH, ADV-LEACH1, and EMEECP-IOT in the network with the 200 SNs. It can be seen from the chart that the obtained values for the EMEECP-IOT are considerably better than the existing LEACH, SEP, Modified-LEACH, and ADV-LEACH1.

Figure 7 illustrates the standard deviation (SD) versus the number of SNs. The standard deviation value depends on the number of network cluster sizes. The proposed EMEECP-IOT technique has the smallest SD cluster than LEACH, SEP, Modified-LEACH, and ADV-LEACH1. The established clusters have a balanced distribution of the proposed EMEECP-IOT method. The slightest standard deviation in EMEECP-IOT suggests that the cluster members of all clusters are almost equal and that there is no overloaded cluster with prominent members.

6. Conclusion

To develop energy-efficient schemes for the IoT, current techniques of using wireless sensor networks cannot directly apply to the IoT due to its large scale and complication. To overcome these issues, we designed and developed an Enhanced Multitier Energy-Efficient Clustering Protocol integrated with the Internet of Things (EMEECP-IOT)-based Heterogeneous Wireless Sensor Network (HWSN) technique. The proposed energy-efficient EMEECP-IOT technique enhances the CH selection and SN distribution. In a four-tier IOT-based HWSN system, the first stage determines the best CH for every cluster based on the simulation time. The 2D Gaussian distribution is used to deploy the SN around and close to the BS and CHs. For this purpose, we have implemented the proposed EMEECP-IOT technique on a network simulator (NS2) and MATLAB R2017b. In the simulation, the EMEECP-IOT technique performance is better than LEACH, SEP, Modified-LEACH, and ADV-LEACH1 in the IOT-HWSN system in terms of network stability, the number of alive and dead SNs, residual energy, approach throughput, and standard deviation on cluster size. The Extended Clustering Hierarchy (EMEECP-IOT-HWSN) for heterogeneous WSNs has been used to decrease the energy consumption of the entire HWSN. Extensive performance factors show that the proposed EMEECP-IOT extends the network lifetime by 35% and decreases the network's energy consumption. We will continue to develop this work in the future by considering security and privacy concepts. An attempt will be made to apply this paradigm to a real-world network.

Data Availability

The data used to support the findings of the study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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References

[1] L. Atzori, A. Iera, and G. Morabito, "The internet of things: a survey," *Computer Networks*, vol. 54, no. 15, pp. 2787–2805, Oct, 2010.

[2] Z. Muhammad, N. Saxena, I. M. Qureshi, and C. W. Ahn, "Hybrid artificial bee colony algorithm for an energy efficient internet of things based on wireless sensor network," *IETE Technical Review*, vol. 34pp. 39–51, sup1, 2017.

[3] H. Yetgin, K. T. K. Cheung, M. El-Hajjar, and L. H. Hanzo, "A survey of network lifetime maximization techniques in wireless sensor networks," *IEEE Communications Surveys & Tutorials*, vol. 19, no. 2, pp. 828–854, 2017.

[4] B. Dezfouli, I. Amirtharaj, and C.-C. C. Li, "EMPIOT: an energy measurement platform for wireless IoT devices," *Journal of Network and Computer Applications*, vol. 121, pp. 135–148, 2018.

[5] F. Jamil and F. Z. Khan, "Multi-criteria-Based mobile hotspot selection in IoT-based highly dense network," *Wireless Personal Communications*, vol. 112, no. 3, pp. 1689–1704, 2020.

[6] N. Hussain, P. Rani, H. Chouhan, and U. S. Gaur, *Cyber security and privacy of connected and automated vehicles (CAVs)-Based federated learning: challenges, opportunities, and open issues,Federated Learning for IoT Applications*, pp. 169–183, Springer International Publishing, New York City, 2022.

[7] N. Hussain and P. Rani, "Comparative studied based on attack resilient and efficient protocol with intrusion detection system based on deep neural network for vehicular system security," *Distributed Artificial Intelligence*, pp. 217–236, CRC Press, Boca Raton, FL, USA, 2020.

[8] P. Rani, N. Hussain, R. A. H. Khan, Y. Sharma, and P. K. Shukla, *Vehicular intelligence system: time-based vehicle next location prediction in software-defined internet of vehicles (SDN-IOV) for the smart cities Intelligence of Things: AI-IoT Based Critical-Applications and Innovations*, Springer International Publishing, New York City, pp. 35–54, 2021.

[9] V. Devarapalli, R. Wakikawa, A. Petrescu, and P. Thubert, "Network Mobility (NEMO) Basic Support Protocol," 2005.

[10] K. Jaiswal and V. Anand, "EOMR: an energy-efficient optimal multi-path routing protocol to improve QoS in wireless sensor network for IoT applications," *Wireless Personal Communications*, vol. 111, no. 4, pp. 2493–2515, 2020.

[11] V. Reddy and G. P, "Integration of internet of things with wireless sensor network," *International Journal of Electrical and Computer Engineering*, vol. 9, no. 1, p. 439, 2019.

[12] A. John, A. Rajput, and K. V. Babu, "Dynamic cluster head selection in wireless sensor network for Internet of Things applications," in *Proceedings of the 2017 International Conference on Innovations in Electrical, Electronics, Instrumentation and Media Technology (ICEEIMT)*, pp. 45–48, Coimbatore, India, February 2017.

[13] J. Mishra, J. Bagga, S. Choubey, A. Choubey, and K. Gupta, "Performance evaluation of cluster-based routing protocol used in wireless internet-of-things sensor networks," in *Proceedings of the 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT)*, pp. 1–10, Bhilai, India, Feburary 2021.

[14] S. Sharma and V. K. Verma, "An integrated exploration on internet of things and wireless sensor networks," *Wireless Personal Communications*, vol. 124, no. 3, pp. 2735–2770, 2022.

[15] W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," *IEEE Transactions on Wireless Communications*, vol. 1, no. 4, pp. 660–670, 2002.

[16] F. A. Aderohunmu and J. D. Deng, "An Enhanced Stable Election Protocol (Sep) for Clustered Heterogeneous Wsn," *Dep. Inf. Sci. Univ. Otago N. Z.*, 2009.

[17] A. Femi and D. D. Jeremiah, ""An Enhanced Stable Election Protocol (SEP) for Clustered Heterogeneous WSN," *ISDCA*, 2006.

[18] H. Koyuncu, G. S. Tomar, and D. Sharma, "A new energy efficient multitier deterministic energy-efficient clustering routing protocol for wireless sensor networks," *Symmetry*, vol. 12, no. 5, p. 837, 2020.

[19] D. Sharma and G. S. Tomar, "Energy efficient multitier random DEC routing protocols for WSN: in agricultural," *Wireless Personal Communications*, vol. 120, no. 1, pp. 727–747, 2021.

[20] M. M. Islam, M. A. Matin, and T. K. Mondol, "Extended Stable Election Protocol (SEP) for Three-Level Hierarchical Clustered Heterogeneous WSN," in *Proceedings of the IET Conference on Wireless Sensor Systems (WSS 2012)*, London, June2012.

[21] M. Kaur, S. Kadam, and N. Hannoon, "Multi-level parallel scheduling of dependent-tasks using graph-partitioning and hybrid approaches over edge-cloud," *Soft Computing*, vol. 26, no. 11, pp. 5347–5362, 2022.

[22] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," *Proceedings of the 33rd annual Hawaii international conference on system sciences*, vol. 2, p. 10, 2000.
[23] S. Singh, A. Malik, and R. Kumar, "Energy efficient heterogeneous DEEC protocol for enhancing lifetime in WSNs," *Engineering Science and Technology, an International Journal*, vol. 20, no. 1, pp. 345–353, 2017.
[24] G. Smaragdakis, I. Matta, and A. Bestavros, "SEP: a stable election protocol for clustered heterogeneous wireless sensor networks," *Second international workshop on sensor and actor network protocols and applications*, vol. 3, 2004.
[25] Y. Mishra, A. Singhadia, and R. Pandey, "Energy level based stable election protocol in wireless sensor network," *International Journal of Engineering Trends and Technology*, vol. 17, no. 1, pp. 32–38, 2014.
[26] O. Rehman, N. Javaid, B. Manzoor, A. Hafeez, A. Iqbal, and M. Ishfaq, "Energy consumption rate based stable election protocol (ECRSEP) for WSNs," *Procedia Computer Science*, vol. 19, pp. 932–937, 2013.
[27] A. Manjeshwar and D. P. Agrawal, "TEEN: ARouting protocol for enhanced efficiency in wireless sensor networks," *Ipdps*, vol. 1, p. 189, 2001.
[28] M. Elshrkawey, S. M. Elsherif, and M. Elsayed Wahed, "An enhancement approach for reducing the energy consumption in wireless sensor networks," *Journal of King Saud University - Computer and Information Sciences*, vol. 30, no. 2, pp. 259–267, 2018.
[29] V. Murali and S. H. Gupta, "Analysis of energy efficient, LEACH-based cooperative wireless sensor network," in *Proceedings of the Second International Conference on Computer and Communication Technologies*, pp. 353–363, 2016.
[30] T. M. Behera, S. K. Mohapatra, U. C. Samal, M. S. Khan, M. Daneshmand, and A. H. Gandomi, "I.-Sep An improved routing protocol for heterogeneous WSN for IoT-based environmental monitoring," *IEEE Internet of Things Journal*, vol. 7, no. 1, 2019.
[31] V. Singh, V. M. Thakkar, and V. Goswami, "SEESH: sleep-awake energy efficient super heterogeneous routing protocol for Wireless Sensor Networks," in *Proceedings of the 2017 3rd International Conference on Advances in Computing,Communication & Automation*, pp. 1–6, Dehradun India, Sep. 2017.
[32] N. Kumar, V. Kumar, T. Ali, and M. Ayaz, "Prolong network lifetime in the wireless sensor networks: an improved approach," *Arabian Journal for Science and Engineering*, vol. 46, no. 4, pp. 3631–3651, 2021.
[33] H. Li, V. Pandit, and D. P Agrawal, "Deployment optimization strategy for a two-tier wireless visual sensor network," *Wireless Sensor Network*, vol. 04, no. 04, pp. 91–106, 2012.
[34] N. Kumar, V. Kumar, and P. K. Verma, "An energy-efficient wireless sensor networks approach based on ADV-LEACH2 clustering protocols for heterogeneous and homogeneous," in *Proceedings of the in 2021 5th International Conference on Information Systems and Computer Networks*, pp. 1–6, Mathura, India, Oct. 2021.
[35] N. Kumar, V. Kumar, and P. K. Verma, "A comparative study of the energy-efficient advanced LEACH (ADV-LEACH1) clustering protocols in heterogeneous and homogeneous wireless sensor networks," in *Cyber Security and Digital Forensics*, pp. 433–444, Springer, 2022.
[36] Y. Zhang, S. M. Ehrlich, C. Zhu, and X. Du, *Platelets*, pp. 1–10, 2022.
[37] M. Kaur and S. Kadam, "Bio-inspired workflow scheduling on HPC platforms," *Tehnički Glasnik*, vol. 15, no. 1, pp. 60–68, 2021.
[38] A. Kashaf, N. Javaid, Z. A. Khan, and I. A. Khan, "TSEP: Threshold-Sensitive Stable Election Protocol for WSNs," in *Proceedings of the 2012 10th International Conference on Frontiers of Information Technology*, pp. 164–168, Islamabad, Pakistan, Dec2012.
[39] M. Kaur, S. R. Sakhare, K. Wanjale, and F. Akter, "Early stroke prediction methods for prevention of strokes," *Behavioural Neurology*, vol. 2022, pp. 1–9, 2022.
[40] A. Shokrollahi and B. Mazloom-Nezhad Maybodi, "An energy-efficient clustering algorithm using fuzzy C-means and genetic fuzzy system for wireless sensor network," *Journal of Circuits, Systems, and Computers*, vol. 26, pp. 1750004–01, 2017.