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

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Received 12 March 2022; Revised 2 May 2022; Accepted 14 May 2022; Published 28 June 2022

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
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 usage 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:

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

where \((x, y)\) represents each SN’s original location points. The standard deviations for the \(x\) and \(y\) dimensions are \(\sigma_x\) and \(\sigma_y\), respectively. Each node has its own unique ID with a specific position. \(x_0\) and \(y_0\) 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 \(\ell_{mp} \times d^4\) power utilization and the free space channel with \(\ell_{fs} \times d^2\) 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 \(d\):

\[ P = \frac{k \times \ell_{mp} \times d^4}{2} + \frac{k \times \ell_{fs} \times d^2}{2} . \]
\[ \begin{align*} \text{ETX}(k, d) & = k \cdot E_{\text{elec}} + k \cdot \varepsilon_{fs} \cdot d^2, d \leq d_0 \\ & = k \cdot E_{\text{elec}} + k \cdot \varepsilon_{mp} \cdot d^4, d > d_0, \end{align*} \] (2)

where \( d_0 \) can be calculated by \( \sqrt[4]{\varepsilon_{fs}/\varepsilon_{mp}} \). The electronic energy \( E_{\text{elec}} \) 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 \( \varepsilon_{fs} \) and \( \varepsilon_{mp} \) 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:

\[ E_{RX}(m, d) = k \cdot E_{\text{elec}} \] (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 \([SN.x_d, SN.y_d]\)

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 \(M \times M m^2\) area.

Generate the position value of sensor nodes \([SN.Pos_x, SN.Pos_y]\)

for \((i = 1: 1: N)\) // It runs for all the sensor nodes

\(SN(i).d = i;\) // Each node have their ID.

\(SN(i).x_d = SN.Pos_x(i)\)

\(SN(i).y_d = SN.Pos_y(i)\)

\(BS = BS.x, BS.y\)

\(DSNtoBS (SN_i, BS) = \sqrt{(SN(i).x_d - BS.x)^2 + (SN(i).y_d - BS.y)^2}\)

end

end

\(D_{SN_{to BS}} = \text{Average}(DSN_{to BS});\)

\(D_{max} = \text{max}(DSN_{to BS});\)

for \((r = 1: 1: \text{Simulation time})\) // Simulation time in seconds

for \((i = 1: 1: N)\) // It runs for all the SNs

if \((E_{initial}(i) \leq 0)\) // 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 runs for all SNs

\(\text{temp_rand} = \text{rand}();\) // Calculate random function \((\text{rand}([0, 1]))\) between \([0, 1]\)

Calculate Threshold \(T(S_i)\) for normal, advanced, super, and ultrasuper SNs by equation (4)

if \((\text{temp_rand} \leq T(S_i))\) // 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.

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 \((DS_{N\rightarrow BS})\), \(E_{initial}\) is the initial sensor 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:

$$T(S_i) = \begin{cases} 
\frac{P_i}{1 - P_i \cdot (r \cdot \text{mod}(1/P_i))}, & \text{if } S_i \in [S, S', S', S''], \\
0, & \text{else.}
\end{cases}$$

(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 m × 100 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 (Nalive): 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 (Ndead): 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:

$$\text{Total Packet Received} = \sum_{i=1}^{N} Pkt_{i,recv_{CH}} + \sum_{i=1}^{N} Pkt_{i,recv_{BS}}.$$  

(6)

(7) Average throughput (ThrAvg): the average throughput ThrAvg, shows total data delivery at the BS. The throughput ThrAvg is calculated by the received packets (N_Pktrecv) multiplied by the packet size Packet_size per time (t) as per equation (7). Its measure in terms of the Kilobytes/second :

$$\text{ThrAvg} = \frac{N_{Pkt_{recv}} \times \text{Packet_size}}{t}.$$  

(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:

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

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

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 | $\epsilon_s$ | 10 pj/bit/m² |
| Electronic energy           | $E_{elec}$ | 5 nj/bit/message |
| Multipath amplifier factor  | $\epsilon_m$ | 0.0013 pj/bit/4 |
| Sensor node                 | $N$     | 200     |
| Data packet size            | $P_{acket}$ | 4000 bits |
| Advanced SNs (35%)          | $m_a$   | 0.35    |
| Super SNs (12%)             | $m_s$   | 0.12    |
| Ultrasuper SNs (3%)         | $m_u$   | 0.03    |
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.

Acknowledgments

The research was supported by Key Scientific Research Projects of Henan Province (No.19A413012), the National Natural Science Foundation of China (No. U1904167).

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