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Improving TEEN Protocol for Wireless Sensor Networks

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---**ABSTRACT**---

The Wireless Sensor Network (WSN) has a wide range of many areas of applications. One of the most modern and popular is the Internet of Things (IoT). The nodes are randomly deployed in WSN; nodes close to the sink have more energy than the nodes away from the sink this dying node quickly creates an energy hole problem around the sink nodes. From this, we can say that the data that is well transferred to the sink will be lost exactly which also leads to the end of the network life. In this paper, we improve the strength of enhancing the network lifetime problem by mixing some methods and using a new method (sleep awake mechanism to remove the energy hole and choose the cluster head by switching the power level between nodes) these methods extend the lifetime of the network. The IoT-TEEN protocol expands the number of surviving nodes to 3,500 rounds that can be used to improve WSN age also increasing the package rate to a base station of more than 2500. The network's life span has been extended more than in previous studies. IoT-TEEN can remove the energy hole from the diffuse network and save more energy than LEACH, iLEACH, and TEEN. The proposed algorithm performs better in terms of the stability period and the network lifetime other than the LEACH, iLEACH, and TEEN (Threshold sensitive Energy Efficient sensor Network) protocol. The result will be useful in the WSN design process for IoT applications.

Keywords: WSN, TEEN protocol, lifetime, dead nodes, throughput, overhead, end-to-end delay.

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1-Introduction

Normally WSN information rates on the air vary from twenty kbps to one Mbps. Consequently, they'll work in lower power consumption that successively leaves battery-powered nodes well and physically small. WSN is self-organizing and self-healing. Self-organizing networks leave the nodes mechanically to be a part of the network while not need for manual involvement. Self-healing networks license nodes to reorganize their link groups and sense many ways around failing or break-down power nodes. however, these might be performed particularly to the network management protocol and therefore the constellation, and ultimately can confirm the network's flexibility, measurability, price, and performance [1]. each sensor node contains a sensor, processing, transmission, packing, position-finding system, and power units (such as mobile communications). These nodes or devices are usually distributed in a very device field. Format the device contract among themselves to provide high-quality data regarding physical surroundings [2].

Each device node rules its selections on its operation, presently data, and information on its sensing, computing, resources, and communication. every of those sparse sensor nodes has the efficiency to mobilize and route information to different sensors or back these for into or out base station. Because of the data communication environment in IoT, the main design standards are needed for WSN that they are trying to extend network life. Employing efficient power techniques must be preventing any connection degradation and must design procedures for that. Security in IoT is needed. WSN plays the role of security as a virtual layer and part of IoT.

The IoT [3] is the brain that could store the real data of the world and also is used to monitor the real parameters of the world and based on sensor data make a decision. So that the IoT is responsible for decisions and data processing. WSN [4] is the bridge that connects the real world to the digital world. It's the control of the Internet of Things. It is also responsible for the real-world values of the Internet. In this work, we have been trying to present and remove the energy hole problem. Also, we used the sleep and awake technique to improve WSN's lifetime by using these protocols. sleep and awake are used to reduce the energy hole problem. Our results show that the network lifetime increased and the network more stable.

The rest of the sections in this paper will be as follow: in section 2 we have presented related work, in section 3 the system model is presented, in section 4 proposed system is presented, in section 5 simulation results and discussion

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are shown, in section 6 we present the conclusion. section 7 presents the references.

2-Related Works

The Energy Hole Problem (EHP) is defined as nodes near the sink having a greater amount of data and therefore a lot of energy is lost. Thus, the nodes near the sink gained more energy and die quickly, this is called EHP around the sink. In this case, no data back could be going to the sink. Thus, the lifetime network will end well due to further energy depletion near the sink. The sensor contract may overlap further due to the heavy propagation in any area and the increased cost of the devices. However, the dense propagation is another reason for creating a problem of holes in WSNs [5,6]. In the case of CH did not use its energy during the terminology CH can remain based on the next round of remaining energy but according to TEEN once you choose CH cannot become CH for the next rounds. Paper [6] Solve this problem with a new modification called the IoT-LEACH protocol. This limitation can be overcome by the LEACH threshold value.

2.1-Problem formation

The sleep control mechanism is to avoid the active position of the node for a long time because it consumes a lot of energy. The second method of transmission creates more delay for a long period of sleep. TEEN is a homogenous protocol. All nodes have the same probability of becoming the head of the block. The mass head consumes more energy during transport because the data is loaded into the member nodes. Contract their data to the cluster headers according to the TDMA [6]. All nodes are in sleep mode and their transmission is turned on while data is transferred to save energy. The IoT-TEEN nodes that have a power level below the threshold are in sleep mode to save energy. In this way, we provide energy to prolong network life and stability period. To design a sensor network for the IoT application there is a need to perform different processes, such as data collection, sensing, and data transfer. All this needs to be done with limited power.

This is becoming one of the main challenges in the design process. Therefore, network life needs to maximize energy by maintaining energy during the transmission phase. This could be possible if only a small percentage of the nodes were allowed to transfer data to the base station and the rest of the nodes becomes inactive and sleeps [7,8].

3-System Model

The model has used sleep and wakes to schedule two situations [6].

First state: $E_r > E_{th}$ when E_r is greater than E_{th} the node is ready for communication it is active.

Second state: : $E_r < E_{th}$ when E_r is less than E_{th} the nods become in sleep mode.

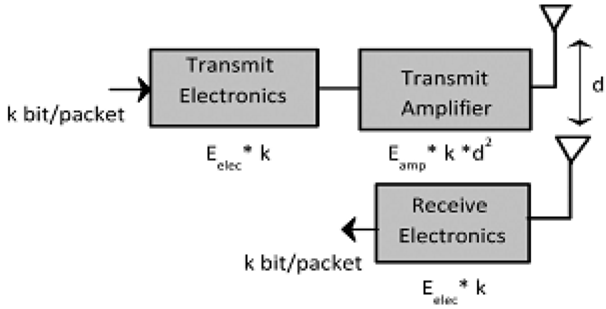

Figure 1: First-order radio model for TEEN protocol

For each node set to sleep according to E_{th} which calculated from

$$E_{th} = \left(\left(E_{Tx} + E_{pA}\right) * D\right) + \left(E_{amp} * D * d^4\right) \quad .(1)$$

Where D is the length of the data pack and d is the distance between the maximum distance node and the sink. The energy consumed by the sensor node in sending K bit/pack to a node that the distance d meter between can be written [9].

$$E_{Tx}(k,d) = E_{Tx_{elec}}(k) + E_{Tx_{amp}}(k,d) \ldots \quad ....(2)$$

$$E_{Tx}(k,d) = \begin{cases} E_{elec} * k + E_{fs} * k * d^2, & d \le d_0 \\ E_{elec} * k + E_{amp} * k * d^4, & d > d_0 \end{cases} \ldots\ldots\ldots \quad .(3)$$

Where E_{elec} is the energy considered for a bit by the receiver and E_{amp} and E_{fs} are amplifier parameters of transmission and free-space model.

If N_d is the number of data bits in a packet and

N_{ov} is the number of overhead bits with E_d and E_{ov} are the energy for each data bit and overhead respectively. Then the total energy E_P of the packets could be calculated from

$$E_P = N_d \times E_d + N_{ov} \times E_{ov} \ldots\ldots\ldots\ldots \quad \ldots ...(4)$$

The network efficiency could be given by the following equation.

$$NF = \frac{N_d \times E_d}{E_P} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots \quad ....(5)$$

The efficiency will be almost 100% for large N_d. In our proposed work the threshold value of energy has been estimated to conserve energy and increase network lifetime.

The nodes are randomly posted in the network in the form used in [6]. If the distance between N and CH (cluster heads) is < d_0 then the energy exhaustion for data transmission from N to the CH.

$$E_N^{CH} = D_N^{CH}(E_{ele}) + D_N^{CH}(E_{fs})(d^2) \ldots\ldots \quad \ldots\ldots.(6)$$

Where $d_0 = \frac{4\prod h_{tr} h_{rc}}{\lambda}$ h_{tr} and h_{rc} are the height of antenna transmitting and receiving.

where distance between N to CH is d > d_0.

$$E_N^{CH} = D_N^{CH}(E_{ele}) + D_N^{CH}(E_{amp})(d^4) \ldots\ldots \quad \ldots.(7)$$

when the distance between S and CH is d < d_0. The energy considered by CH to transmit data to S

$E_{CH}^S = D_{CH}^S(E_{ele}) + E_{DA} + D_N^S(E_{fs})(d^2)$….Also when the distance between CH and S is d > d_0.

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$E_{CH}^{S} = D_{CH}^{S}(E_{ele}) + E_{DA}D_{C}H^{S}(E_{amp})(d^{4})$… ….(9)

The total energy consumed by CH is

$E_{T\_CH} = E_{CH} + E_{N}$……………………….. …(10)

The average energy consumed by CH is

$E_{av\_CH} = \frac{E_{T\_CH}}{N}$…………………………… ...(11)

So saving energy for normal nodes in each round is:

$E_{S\_N} = E_{ele} + E_{TX} + E_{amp}$……….……...…………………..… …..(12)

Saving energy for CH is

$E_{S\_CH} = E_{ele} + E_{DA} + E_{TX} + E_{RX} + E_{amp}$……(13)

Saving energy for all sleeping nodes is

$E_{ST} = \sum_{i=0}^{n} E_{i}$………………………… .…….(14)

The average energy saving for n sleeping node is

$E_{S\_AV} = \frac{E_{ST}}{n}$ ……………………………………(15)

4-Proposed Scheme

TEEN is improved by LEACH, a reactive aggregation protocol. CH the mass head for each block collects data from block members. It processes data and sends data to BS or a higher CH. CHs need to collect data because some nodes need to transfer data to their CH, a feature of the group's routing protocols. It's energy-efficient. CH nodes become to distribute energy consumption evenly. Once groups are formed, charters allocate a period for cluster members where block members can send their data. [10] For each round, groups are formed according to the ad message sent through CH.

We have deployed the 100 nodes in the network area of 400x400m. it has been clear that the IoT-TEEN protocol remains the CH for the next round if it has more energy than the threshold value. Also, it could be removing energy holes from the deployed network and saving energy more than TEEN. The sm parameter of our flowchart algorithm refers to the number of nodes in sleep modes.

Table1: simulation parameters value

Symbol	**Parameters**	**Values**
X_m, y_m	Network Area	400*400
N	Number of Nodes	100
P	Cluster head probability	0.05
E_0	Energy for each node	0.5 j
E_{TX}	transmitter energy	50*0.000000001
E_{RX}	receiver energy	50*0.000000001
E_{DA}	Aggregation Energy	5*0.000000001
E_{amp}	amplification energy	0.0013*0.000000000001
	Number of Rounds	3500
sm	Number of sleep nodes	10
d_0	distance	87 meter
E_r	Remaining energy	

The scenario that was used is randomly deployed in a particular network area. Some nodes are selected to be in active mode and others reset in sleep mode to make the sensor, connect and cover the area. The position of the sink node in the network center that has been deployed. All the node energy is the same while the thought energy is unlimited. For our work based on the remaining energy and the distance between the sink and the data nodes are sent to the sink.

We consider the scenario where the nodes are randomly deployed in a particular area. Some nodes are chosen to be active and rest in sleep mode to keep the sensor, coverage, and connectivity. Position in the center of the work network. The strength of all nodes is equal while they think energy is unlimited. In our model, the nodes transfer the data to the sink based on the remaining energy and the distance between the sink nodes.

The IoT-TEEN protocol begins with the initialization phase and calculates the threshold phase and cluster formation until ending working and computing results. The sink firstly checks the maximum distance node in the field for every round. After that compute the required energy to transmit data to the sink.

5- Simulation

The network is included 100 nodes that are randomly deployed in the 400 × 400 area. These parameters have been included in Table 1. Simulations are produced using Matlab for 3500 repetition rounds.

At the center of the field, the basin is located. The sensor contract was not moved after deployment. Power to unlimited sink node.

Holding the sensor and transfer ranges hold the adjustable sensor according to the distance of the tub. The contract cycle time required is used to send data packets to the sink.

The sensor nodes that are selected in each round are set to work and the rest of the nodes are set to sleep mode to save energy. This mechanism is called sleep and waking [5].

Proposed protocol Algorithm.

Algorithm: IoT-TEEN

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 number of packets sent to Base Station (BS)
Extend lifetime of sensors nodes and improve throughput

Step 1: start
Step 2: deploy sensors nodes into wsn field

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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 between Base Station and Cluster Head.
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 > S
return to step 6
Step 11: after the node has been selected as CH
Do cluster head broadcast.
Step 12: if node = CH
then it takes high power level
else
It takes low power
Step 13: if energy of CH < E_{Th}
previous CH and cluster
else
Return to step 9
Step 14: if life time ended
then end
else
Return to step 8

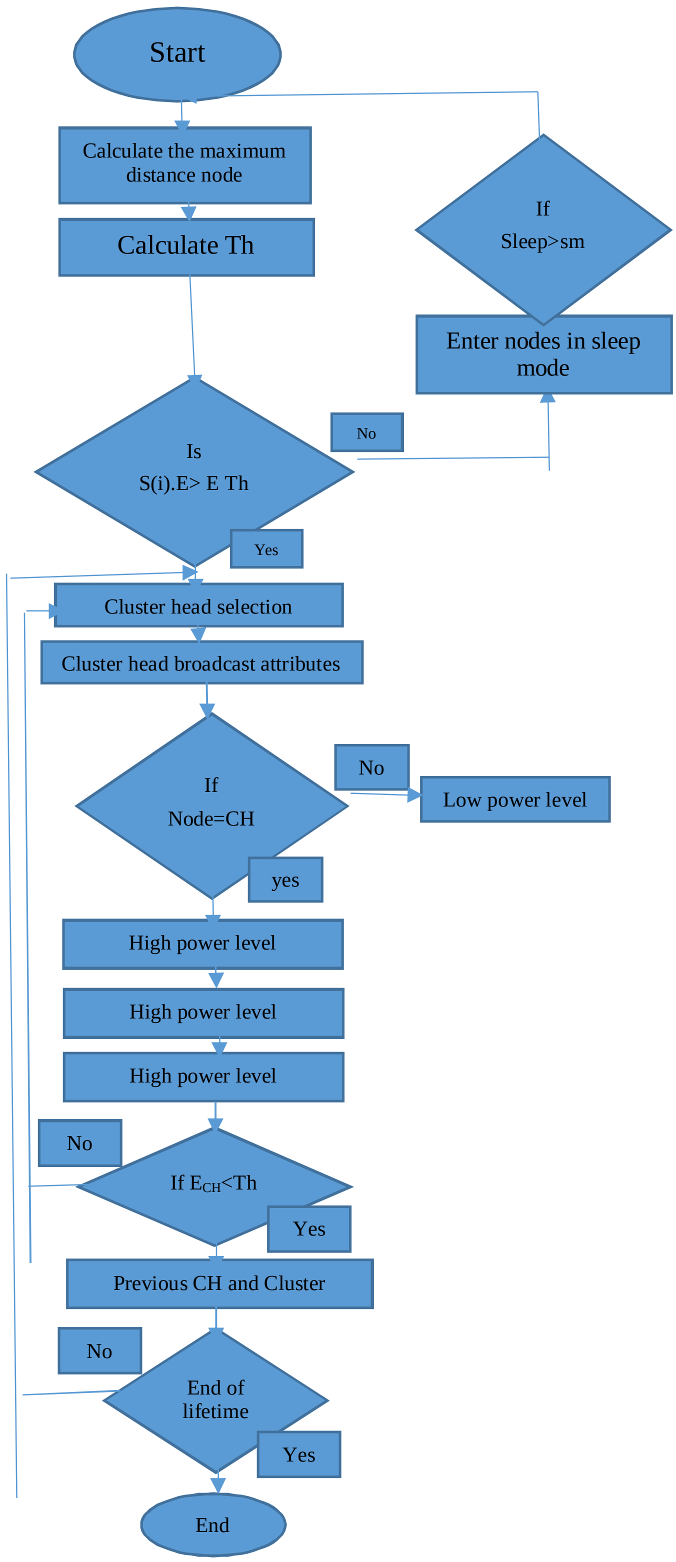

Figure 2: IoT-TEEN algorithm

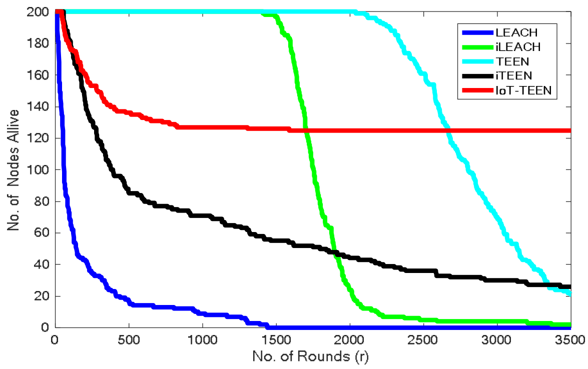

Figure 3: Comparison of the alive node between LEACH, iLEACH, TEEN, and IoT-TEEN protocols.

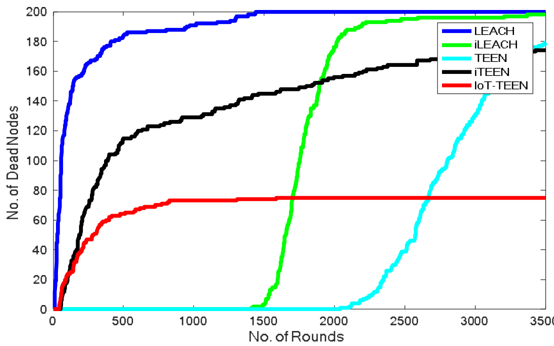

Figure 4: Dead nodes comparison between LEACH, iLEACH, TEEN, and IoT-TEEN protocols.

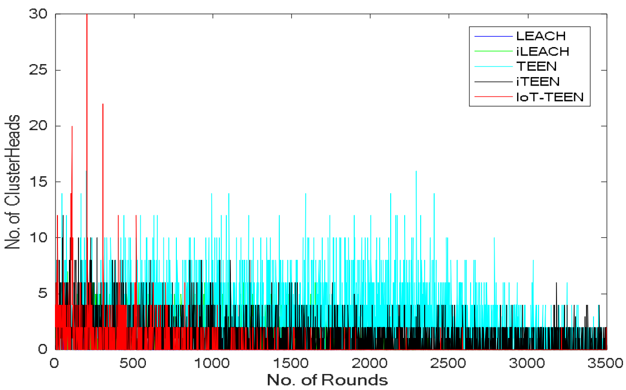

Figure 5: Comparison between LEACH, iLEACH, TEEN, and IoT-TEEN protocols for the Number of CH.

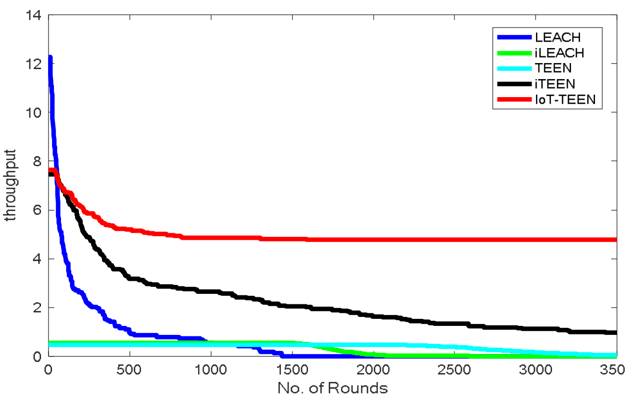

Figure 6: The throughput comparison between LEACH, iLEACH, TEEN and IoT-TEEN protocols.

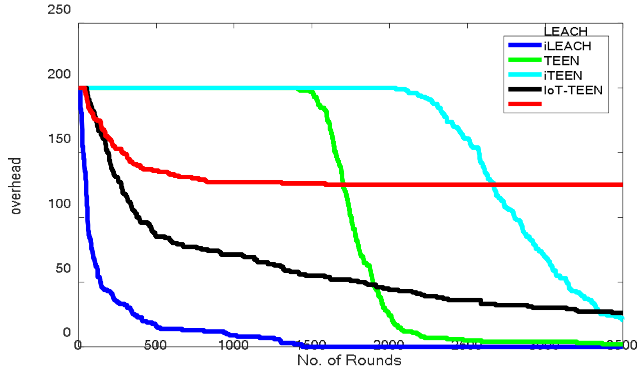

Figure 7: The overhead comparison between LEACH, iLEACH, TEEN, and IoT-TEEN protocols.

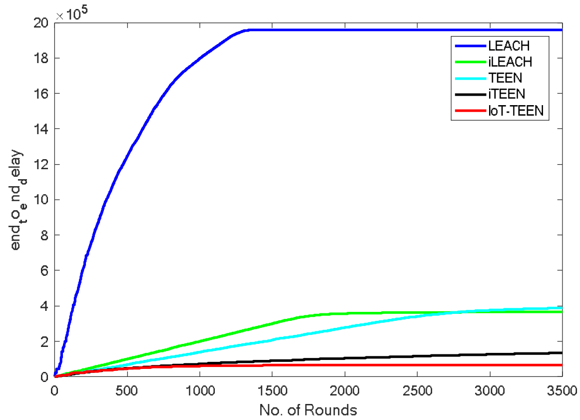

Figure 8: The end-to-end delay comparison between LEACH, iLEACH, TEEN, and IoT-TEEN protocols.

5.1- Results and Discussion

The alive node exceeds in IoT-TEEN in 3500 rounds and will extend if we exceed the rounds other than LEACH, improved LEACH (iLEACH), TEEN and iTEEN protocols will be less as in figure 3. Figure 4 shows the dead node number which our algorithm is less than other protocols. When reaching 3500 rounds it is stable and in the same manner. We are expected the dead node of our proposed algorithm could be decreased with more rounds. We found that the number of CHs has been less in the LEACH, iLEACH, TEEN, and iTEEN protocols which decreased as seen in Figure 5. The protocol has provided the formation of an unnecessary cluster and the cluster head selection process where energy remains in exiting CH to continue as CH for the next round. The packets that are sent to the base station are an important parameter to measure the efficiency so in figure 5 we see that in the IoT-TEEN protocol, the throughput exceeds the TEEN, iTEEN, LEACH, and iLEACH protocols. Also, the number of packets sent to CH which also a good parameter for the protocol efficiency. It exceeds and continues to 3500 iterations so the lifetime of the network is good. The overhead and throughput of the IoT-TEEN protocol is exceeding other LEACH, iLEACH, and TEEN protocols until 2400 but in 3500 be the same and IoT-TEEN overhead is less when exceeds so the proposed algorithm is better than others protocols as the definition of the overhead in [11,12,13,14]. Also, the delay of the

IoT-TEEN protocol is less than LEACH, iLEACH, and TEEN, iTEEN protocols.

From the above analysis of the performance of our protocol, we could conclude that the IoT-TEEN protocol shows better performance for small and large network areas. Also, we could increase more attributes of WSN lifetime so the protocol is suitable for IoT connection devices and networks.

6-Conclusion and Contribution

The sleep and wake-up mechanism is used to remove power holes in WSN networks. We investigated it after our proposed plan, by merging some methods and using a new method (sleep-awake) mechanism to remove the energy hole and cluster head selection by switching power level between nodes) these methods extended the network lifetime and better energy consumption is achieved. This work results in terms of network age and stability period. The holding sensor consumes balance energy. In this paper, we modify the TEEN algorithm, which can be adopted in WSN and used in IoT applications that require an additional process. The proposed protocol is suitable for changing the region and different scientists. Simulation results show that our chart results perform better than previous charts in terms of network lifetime, stability, package period to BS, and end-to-end delays. It can also improve results by different criteria.

Also, it is could improve results with different parameters. Again this work could be applied to other routing protocols (homogenous or heterogeneous). It could be obtaining different results and efficient work.

Abbreviations

WSN	Wireless Sensor Network
IoT	Internet of Things
TEEN	threshold-sensitive energy efficient sensor network
LEACH	Low Energy Adaptive Clustering Hierarchy protocol
iLEACH	Improve -Low Energy Adaptive Clustering Hierarchy protocol
IoT-TEEN	Internet of Things threshold-sensitive energy efficient sensor network protocol
EHP	Energy Hole Problem
CH	Cluster Heads
BS	Base Station
TDMA	Time-division multiple access

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Author contributions

all authors helped revising the algorithm and designing the experiment. All authors read and approved the final manuscript.

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Declarations

Ethics approval and consent to participate: Not applicable.

Competing interests: The authors declare that they have no competing interests

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