A Novel Minimized Energy Routing Technique for IoT Assisted WSN

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Abstract

The problem of routing in WSN (Wireless Sensor Network) is to minimize the energy consumption during data transmission, the IoT (Internet of Things) monitoring system use the horizontal clustering of WSN to achieve this goal. The goal of this work is to create multi clusters with multi cluster head to communicate with sink node, the sink node directly connects to IoT server. A set of clusters has been created by dividing the WSN area in to 5 clusters horizontally, in each cluster the CH (Cluster Head) collects the data from all sensor nodes and communicate with sink node. The energy consumption is calculated based on wireless radio model and proposed clustering algorithm. The total energy consumption, normalized average energy and residual energy of proposed protocol is better than the two existing protocols that compared, the two protocols are PEGASIS (Power-Efficient Gathering in Sensor) and IEEPB (Improved Energy- Efficient PEGASIS- Based protocol). The results show that the H-IEEPB (Horizontal Improved Energy- Efficient PEGASIS- Based protocol) has an improvement in energy consumption and minimize it more than 10% and 25% compared with PEGASIS and IEEPB respectively, the residual energy and the normalized average energy also get good results compared with the others.

Keywords

WSN, IoT, IEEPB, PEGASIS, Clustering, H-IEEPB

1. Introduction

Routing protocols in wireless sensor network represent the backbone of any reliable communication in sensor network. Therefore, the goal is how can enhance and improve the behavior of wireless sensor network by improving the routing protocols to overcome any deficiencies or constraints exist in this type of network. There are many techniques and many algorithms proposed by different authors to improve many kinds of routing protocols. In this paper, we are focusing on the chain routing protocols. chain based routing protocols which is already one of the hierarchal routing protocols types [1] to ensure energy efficiency broadcasting [2]. Thus, based on chain based routing protocols an improvement is achieved on IEEPB protocol by create multi chain and sink node.

The object of this study is proposing a new routing technique and divide the network area in to deferent clusters, these clusters has unequal number of nodes, all nodes in each cluster collect its data and forwarding it's to CH. All Cluster Heads communicate with the unlimited power node called sink node.

The subject of this study is the routing method that increase the transmission time as well as reduce the energy consumption in all network devices. Section 3 represent the system model briefly.

The purpose of the work is to design a new topology of sensor network with IoT monitoring system based on horizontal clusters of chain routing protocol, the WSN area has been divided in to 5 regions and the proposed protocol is H-IEEPB.

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2. Problem Statement

Clustering in WSNs is an excellent way to reduce the energy consumption of the sensor nodes, as it depends on the batteries on its work, so a mechanism must be suggested to reduce its energy consumption. In fact, the clustering technique leads to Collect and combine data to reduce the number of messages sent and reduce the transmission.

3. Review of the Literature

In [3] the author presents a survey on different hierarchical routing protocols and showing the taxonomy criteria of hierarchical-based routing protocols in wireless sensor networks. The most information that is related to the types of routing protocols based on the network architecture, clustering attributes, protocol operation, path establishment, and others. The author focus on the chain based routing protocol with the importance of choosing the right cluster properties and sensor capabilities with taking more than one protocol as an example by giving a quick review for each protocol.

In [4] the author suggests a protocol that offering a chain into the clustering concept. This suggestion generates a new chain based routing protocol PEGASIS. PEGASIS protocol is chain based routing protocol that constructs chains between the neighboring nodes to collect the data and send it to the next node in an accumulative way to aggregate the data in a cluster head or can be called leader node and forward it to sink node.

The authors in [5-9] propose an improved protocol over PEGASIS protocol to Multi-Chain PEGASIS protocol by using the concepts of relative distance and this led to allows sink node to generate the location information table and construct the multi-chain topology without the need for GPS.

Multipath routing for the directional diffusion routing protocol from the source to the destination node with a certain probability of selecting one path among all possible paths was proposed in [10-14].

Authors in [15-16] advocated load balancing energy schemes for wireless sensor networks and energy harvesting for the overall network. They utilized Ant Colony Optimization for multiple path finding and claimed satisfying results. The study used an electromagnetic antenna-based approach for energy harvesting to gain high performance of IoT and WSNs. Numerous studies have been carried out on minimum energy consumption.

4. System Model

The proposed system in this paper is built in the wireless radio model and clustering algorithm was proposed.

For WSN connected to IoT system the energy consumption in transmission side and receiving side can be calculated as in (1) and (2) based on Figure 1.

$$E_{TX} = \begin{cases} \kappa(e_{elec.} + e_{amp.} * d^2), & d < d_0 \\ \kappa(e_{elec.} + e_{amp.} * d^4), & d \geq d_0 \end{cases} \quad (1)$$

Where E_{TX} is the energy consumption in transmission side, κ is the data size that can be send through wireless channel, d_0 is the threshold distance, d is the distance between two sensor nodes , $e_{amp.}$ and $e_{elec.}$is he required energy for transmitter amplifier in free space, (equal to 100 pJ/bit/m^2) and the energy consumed by the radio to run the transmitter or receiver circuitry, (equal to 50nJ/bit) respectively.

$$E_{RX} = \kappa * e_{elec.} \quad (2)$$

E_{RX} is the energy consumption in transmission side.

The distance between two nodes showing in (3)

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (3)$$

Where x_2 is the x dimension of node no.2, x_1 is the x dimension of node no.1, y_2 is the y dimension of node no.2 and y_1 is the y dimension of node no.1.

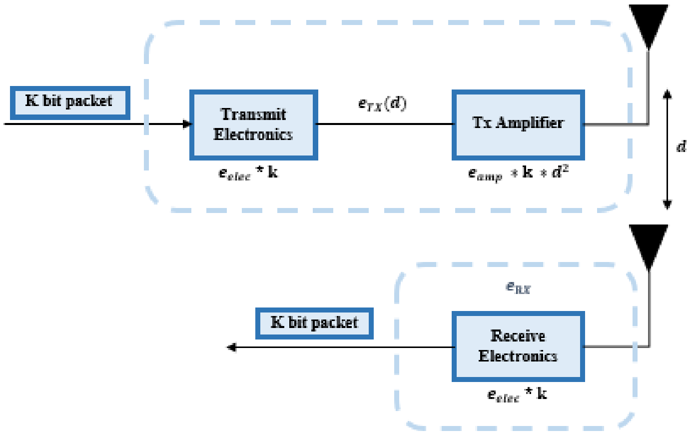

Figure 1: First-order radio model

To calculate the energy consumption in any node, the system selects the mode and compute it based on (1) and (2), the consumption mode presented in (4) and (5):

$$E_{Consumption} = \begin{cases} E_{TX}, & Transmission\ mode \\ E_{RX}, & Receiving\ mode \end{cases} \tag{4}$$

$$E_{\ Total/consumption} = \sum_{i=1}^{n} E_{Consumption}\,(i) \tag{5}$$

The residual energy E_i can be calculated as in (6) and (7) for total residual energy:

$$E_i = \begin{cases} E_0 - E_{Consumption}\,(1) \ , & i = 1\ (First\ Round) \\ E_{(i-1)} - E_{Consumption}\,(i)\ , & Other\ Rounds \end{cases} \tag{6}$$

Where $E_{(i-1)}$ is the residual energy for the previous sensor node, $E_{Consumption}$ (i) is the energy consumption of sensor node and $E_{Consumption}$ (1) is the energy consumption of the sensor node in first round

$$E_{Total} = \sum_{i=1}^{n} E_i \tag{7}$$

Normalized average energy NE can be calculated as in (8):

$$NE = \frac{E_{Total}}{n * E_0} \tag{8}$$

Where E_0 is the initial energy

WSN area in this system is 200*200 so the clustering algorithm divide this area horizontally for 5 clusters. The cluster size is 200*40 and the propose algorithm as shown:

- Clustering Algorithm

M1, M2, M3, M4, M5 =0 // No. of nodes in each cluster
Load nodes locations // node.x & node.y

```
for i=1to n
    if node(i).y <= 40
         M1=M1+1;
         node(M1).x=node(i).x;
         node(M1).y=node(i).y;
    end if
    if node(i).y > 40 && node(i).y <=80
        M2=M2+1;
        node(M2).x=node(i).x;
        node(M2).y=node(i).y;
    end if
        if node(i).y > 80 && node(i).y <=120
        M3=M3+1;
        node(M3).x=node(i).x;
        node(M3).y=node(i).y;
    end if
        if node(i).y > 120 && node(i).y <=160
        M4=M4+1;
        node(M4).x=node(i).x;
        node(M4).y=node(i).y;
    end if
       if node(i).y > 160 && node(i).y <=200
        M5=M5+1;
        node(M5).x=node(i).x;
        node(M5).y=node(i).y;
    end if
end for
end
```

5. Experiments

The proposed work has been simulated using Matlab simulator to examine and investigate enhanced IEEPB using proposed algorithm and the simulation parameters as shown in Table 1

Table 1
Simulation parameters

Parameters	Values
E0	0.5 J
No. of nodes	100
No. of rounds	4000
Protocols	PEGASIS, IEEPB, H-IEEPB
WSN area	200 m * 200m

The network topology of proposed work as shown in Figure 2.

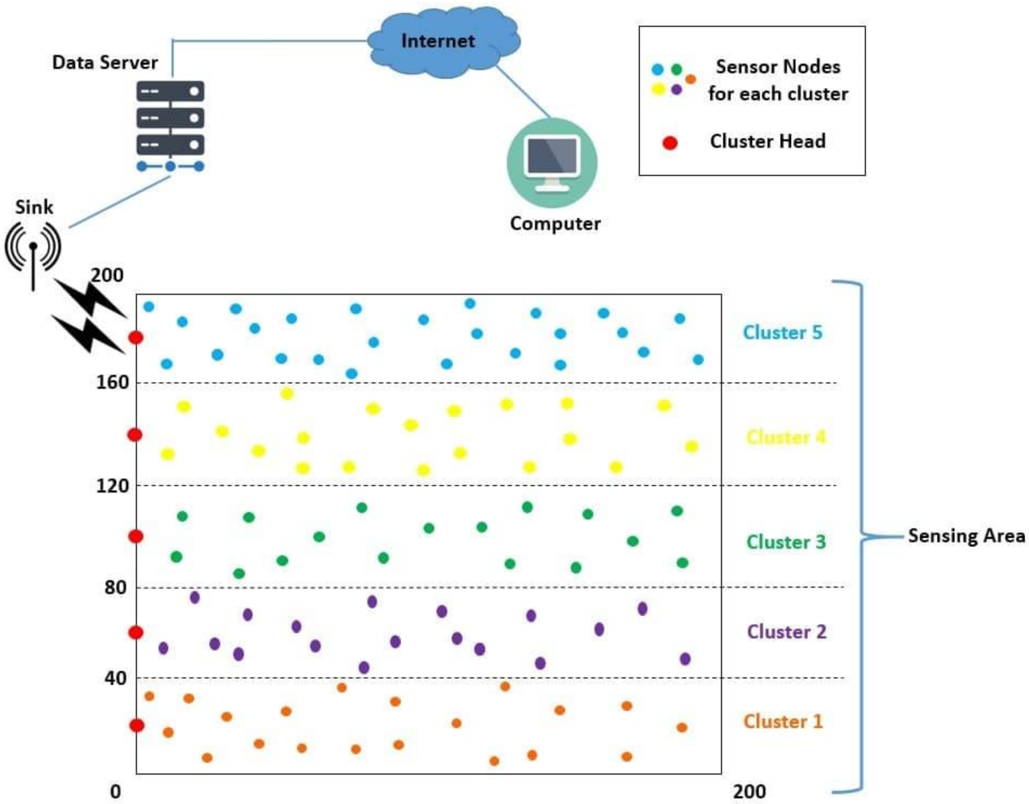

Figure 2: Proposed Clustering WSN

As in Figure 2 each cluster communicates with its CH, sink node connect with all cluster heads. Clustering algorithm classify the sensor nodes in to 5 clusters and select the CH locations. Table 2 and Table 3 are showing the number of nodes in each cluster and the cluster heads locations respectively:

Table 2
Number of Nodes / Cluster

Cluster No.	No. of Nodes
1	25
2	20
3	17
4	18
5	20

Table 3
Cluster Heads Locations

Cluster No.	Location
1	(0,20)
2	(0,60)
3	(0,100)
4	(0,140)
5	(0,180)

6. Results

The simulation time of this experiment is 100 ms, as shown in Figure 2 the network area has been divided in to 5 regions, the shortest path to connect all nodes was created.

- Alive Nodes comparison

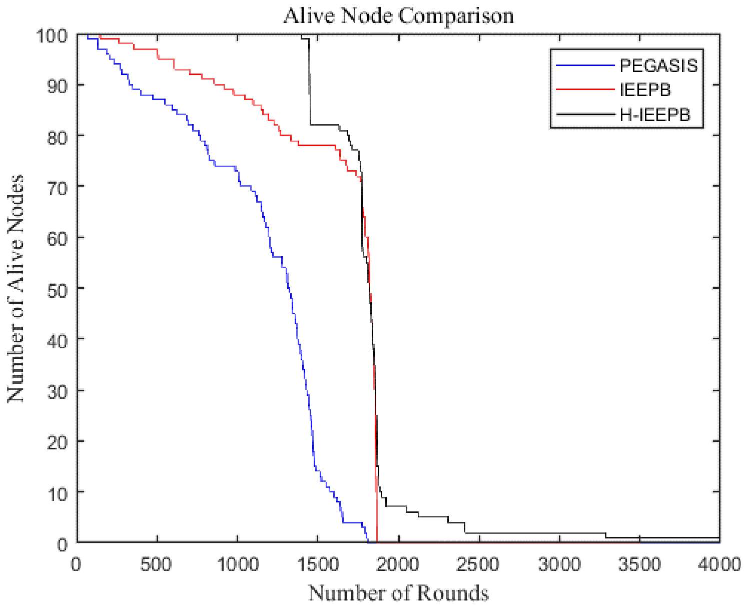

Figure 3: Alive Nodes comparison

As shown the proposed protocol in this work H-IEEPB has batter result in Alive nodes, so in Figure 3 the proposed protocol nodes still working till round No.3999 and the first node die at round No.1395 compared with others is very good to get more time for network to work in full nodes, as shown in Figure 4 and the network lifetime percentages in Table 4 respectively.

- Network lifetime for all protocols

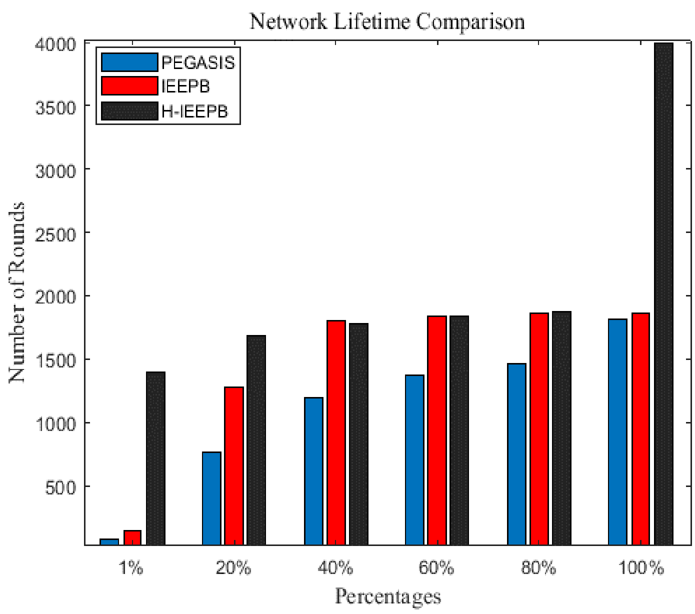

Figure 4: Network Lifetime

Table 4
Network Lifetime Percentage

Percentage	PEGASIS	IEEPB	H-IEEPB
1%	78	151	1395
20%	762	1275	1684
40%	1198	1805	1777
60%	1373	1840	1841
80%	1467	1858	1867
100%	1808	1865	3999

- Residual Energy comparison

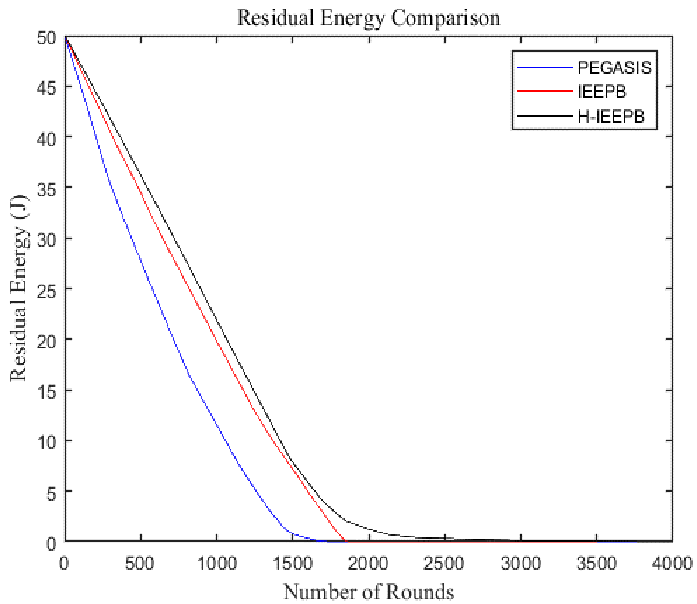

Figure 5: Residual Energy comparison

The residual energy comparison in Figure 5 explained that the residual energy of H-IEEPB is more than 10% energy saving compared with IEEPB protocol and more than 25% saving energy compared with PEGASIS protocol, for 0.5 J initial energy and 100 nodes distribution the total energy is 50 J and for example the total energy of H-IEEPB after 1000 round is 21.8927 J, while the total energy of IEEPB and PEGASIS are 19.8664 J and 11.5491 J respectively.

- Normalized Average Energy comparison

The normalized average energy starting from 1 to 0, the proposed protocol success and save more energy than others as shown in Figure 6.

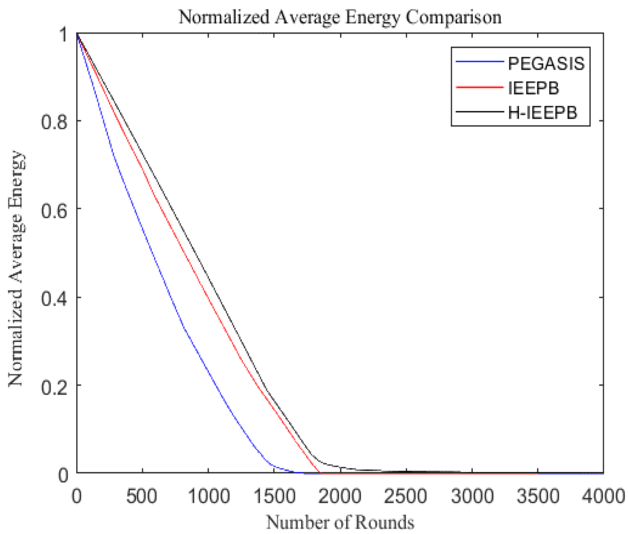

Figure 6: Normalized Average Energy comparison

- Energy Consumption comparison

The stability of energy consumption per node during the simulation rounds is shown in Figure 7, our protocol has an average consumption 0.24 $*10^{-3}$ J for all nodes till round no. 1867, at this round the network lost 80% of its nodes as mentioned in network lifetime table. When the network work in the last 20% the average energy consumption is increased for 200 rounds extra then decreased till end of the simulation but the other protocols operations are stopped in rounds 1808 and 1865 for PEGASIS and IEEPB respectively.

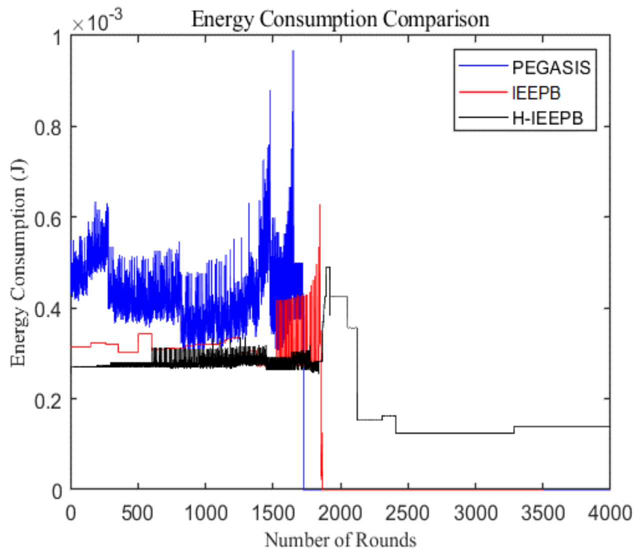

Figure 7: Energy Consumption comparison

7. Conclusions

In WSN routing protocols, the energy saving and reducing the energy consumption of nodes is a main goal. IoT monitoring system in different applications need to work with WSN together. In this paper the proposed routing protocol success in saving energy compared with others. The scientific novelty is by dividing the area in to multi slides as a clusters, and select multi cluster heads to communicate with sink node and IoT server. The practical significance is to make a flexibility in distribute sensor nodes and create multi path at the same time so we can save energy and time also.

Prospects for further research are to increase the number of clusters according to the area size and can use different intelligent systems to improve this work.

8. References

[1] A. A. Hussein and R. A. Khalid, “An IMPROVED ENERGY EFFICIENT CHAIN-BASED ROUTING PROTOCOL USING ACO”, *Iraqi Journal of ICT*, vol. 2, no. 3, pp. 11-29, 2019

[2] Qasim, N. H. Shevchenko, Yu. P., V. V. ,2019, Begell House, ANALYSIS OF METHODS TO IMPROVE ENERGY EFFICIENCY OF DIGITAL BROADCASTING, 1457-1469,2019. DOI:10.1615/TelecomRadEng.v78.i16.40

[3] A. A. Hussein and R. A. Khalid, “Improvements of PEGASIS routing protocol in WSN”, International advance journal of engineering research, vol. 2, no. 11, pp. 1-14, 2019.

[4] S. Lindsey and C. S. Raghavendra, "PEGASIS: Power-efficient gathering in sensor information systems," *Proceedings, IEEE Aerospace Conference*,2002, doi: 10.1109/AERO.2002.1035242.

[5] B. Gi Min and J. Park,” Improvement of Multi-Chain PEGASIS Using Relative Distance”, *Advanced Multimedia and Ubiquitous Engineering, Lecture Notes in Electrical Engineering*, Springer, vol. 518, 2019

[6] Z. Wang, H. Ding, B. Li, L. Bao and Z. Yang, "An Energy Efficient Routing Protocol Based on Improved Artificial Bee Colony Algorithm for Wireless Sensor Networks," in *IEEE Access*, vol. 8, pp. 133577-133596, 2020, doi: 10.1109/ACCESS.2020.3010313.

[7] Xingxing Xiao and Haining Huang, "A Clustering Routing Algorithm Based on Improved Ant Colony Optimization Algorithms for Underwater Wireless Sensor Networks", *Algorithms*, vol. 13, no. 10, pp. 250, 2020

[8] A. A. Hussein and R. A. Khalid, "Performance Analysis of Chain-Cluster based Routing Protocols in WSN." *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)* ,vol 15, no.1, pp 01-12, 2020

[9] Bok Gi Min, Jim Park, Hyoung Geun Kim and Jin Gon Shon, "Improvement of Multi -Chain PEGASIS Using Relative Distance" *in Advanced Multimedia and Ubiquitous Engineering Lecture Notes in Electrical Engineering*, Springer, vol. 518, 2019.

[10] M. Zhou, Y. Wang, Y. Liu and Z. Tian, "An Information-Theoretic View of WLAN Localization Error Bound in GPS-Denied Environment," *in IEEE Transactions on Vehicular Technology*, vol. 68, no. 4, pp. 4089-4093, April 2019, doi: 10.1109/TVT.2019.2896482.

[11] W. Ma, F. Yan, X. Zuo, L. Ren, W. Xia and L. Shen, "Coverage hole detection algorithm without location information in wireless sensor networks," *2017 3rd IEEE International Conference on Computer and Communications (ICCC)*, 2017, pp. 357-361, doi: 10.1109/CompComm.2017.8322571

[12] M. Zhou, Y. Wang, Z. Tian, Y. Lian, Y. Wang and B. Wang, "Calibrated Data Simplification for Energy-Efficient Location Sensing in Internet of Things," in *IEEE Internet of Things Journal*, vol. 6, no. 4, pp. 6125-6133, Aug. 2019, doi: 10.1109/JIOT.2018.2869671.

[13] M. Zhou, X. Li, Y. Wang, S. Li, Y. Ding and W. Nie, "6G Multisource-Information-Fusion-Based Indoor Positioning via Gaussian Kernel Density Estimation," *in IEEE Internet of Things Journal*, vol. 8, no. 20, pp. 15117-15125, 15 Oct.15, 2021, doi: 10.1109/JIOT.2020.3031639.

[14] 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*, 2000, pp. 10 pp. vol.2-, doi: 10.1109/HICSS.2000.926982.

[15] A. Nayyar and R. Singh, "IEEMARP—A novel energy efficient multipath routing protocol based on ant Colony optimization (ACO) for dynamic sensor networks", Multimedia Tools Appl., May 2019.

[16] Gharghan, S.K.; Mohammed, S.L.; Al-Naji, A.; Abu-AlShaeer, M.J.; Jawad, H.M.; Jawad, A.M.; Chahl, J. Accurate Fall Detection and Localization for Elderly People Based on Neural Network and Energy-Efficient Wireless Sensor Network. Energies 2018, 11, 2866. https://doi.org/10.3390/en11112866