Kufa Journal of Engineering
Vol. 17, No. 1, January 2026, P.P. 531-543
Article history: Received 18 October 2024, last revised 28 March 2025, accepted 28 May 2025

DATA FORWARDING ENHANCEMENT STRATEGY IN SENSOR NETWORKS

Ruslan Saad Abdulrahman[1] and Atheel Nowfal Alkhayyat[2]

[1] Department of Computer Engineering, College of Engineering, AL-Nahrain University, Jadriyah, Baghdad, 10001, Iraq,
Email: ruslan.s.al-nuaimi@nahrainuniv.edu.iq.

[2] Department of Computer Engineering, College of Engineering, AL-Nahrain University, Jadriyah, Baghdad, 10001, Iraq.

https://doi.org/10.30572/2018/KJE/170130

ABSTRACT

Nowadays, Internet of Things (IoT) and Sensor Networks (SNs) consider the transformative technologies that enable ubiquitous connectivity and data collection in various fields. In distributed sensor networks, the nodes are responsible on environments monitoring for sensing and collecting various conditions. The forwarding process for these data gains a significant attention in the researches because it considers the first step for the operation of any algorithm or techniques in routing process in any type of wireless networks. In general, during any routing process, the node with data needs to select its next hop efficiently and thus will affect the optimum route from source to destination. The most common techniques that utilized in this step are the flooding and gossiping. These two techniques suffer from different problems such as implosion, overlaps and blindness of any resources. Therefore, this paper proposed an efficient technique for best next hop selection by taking in consideration the main resources that effect the sensor's power level and thus will reduce the power consumption and then will improve network lifetime. In the proposed technique, the node that has maximum power level, nearest to the current node and it does not receive or send the required packet will be selected as the next hop node. These assumptions help mitigate flooding and gossiping issues. The proposed technique has been implemented using MATLAB simulator. The results show that the proposed system has reduce the node's power exhausting in single cycle and thus has improve network's performance.

KEYWORDS

IoT, Forwarding techniques, Wireless Sensor Networks (WSN).

1. INTRODUCTION

Recently, the concept of using Internet of Thing (IoT) has gain a significant attention in the field of utilization of the smart systems and devices. In IoT, the nodes itself dealing with the information and forwarding it to the other nodes within network for delivering it to the final destination. Because of Wireless Sensor Network (WSN) is the main part of the IoT network, managing and controlling the usage of the components of this network consider an important issue need to be managed. Furthermore, the main components of IoT is the sensors which have limited power and resources. In addition, these nodes may deployed in different environments and it may be difficult for the manager to charge or replace it battery when it drain. (Ahmed et al., 2012; Gulati et al., 2022)

The sensors exhausted their power in different places such as communication (transmission and receiving) , sensing , idle and sleeping. The most important section is how to forward the resulted packets to the best next hop for efficient route and thus will forward it to the final node which is the Base station (BS) (Obidike, Nwabueze and Onwuzuruike, 2018). There are different Packets forwarding techniques had been used such as flooding and gossiping (Mehbodniya et al., 2022).

The concept of flooding is the nodes forward the received message to all other nodes in the network. There are many problems deal with this approach such as Implosion, Overlap and Resource blindness. (Mehbodniya et al., 2022)

Furthermore, in gossiping, which considered as an improvement of flooding, the node s forwards the message to a random node within in range, this reduces the problem of overheads but increase other problems such as packet loss and Resource blindness.(Gulati et al., 2022)

In this paper, a new packet forwarding technique has been proposed in order to reduce the problems in flooding and gossiping and enhance the nodes' power conception and thus will improve network life span.

Additionally, the proprieties of the node are two main types, homogenous or heterogenous. The main different between them is whether the nodes are (homogeneous) that had the same characteristics and functions or (heterogenous) which had different characteristics and functions. The optimum selection of these type is depending on the specific design requirements and plays a significant role in network design and operations.

The proposed technique is based on the optimization process in the selection of the next hop for data forwarding in heterogenous sensor network. The selection of the next hop will be based on various parameters that consider are the distance among nodes, the resident energy and whether the node was selected before for forwarding or not within the same round. The above assumption of the proposed design will enhance and solve the main problems that occurs in flooding and gossiping

The remaining of this paper has contained the next sections: section two will include the concept of IoT, sensor networks as well as the flooding and gossiping. The proposed techniques and it mathematical formulas will be discuses in section three. For the implementation and results, section four will include the main points for the validation and evaluation. the conclusion will be introduced in section five.

2. INTERNET OF THINGS (IOT) AND SENSOR NETWORKS (SNS)

It has been observed recently that IoT-based wireless technologies have advanced quickly across a number of industries (Alaa, Hussein and Al-Libawy, 2024). The Internet of Things, or IoT, is a network that enables autonomous communication between physical objects, machinery, sensors, and other things (Zuhair Ghazi Zahid et al., 2025). A key element of the Internet of Things (IoT), which has quickly expanded into a variety of real-time applications, which is the WSN (Wireless Sensor Network). Almost every aspect of our daily lives is now impacted by the numerous essential and non-critical applications of the Internet of Things and WSNs. WSN nodes are typically tiny, battery-operated devices. Therefore, the data collection or delivery efficiently from the source to destination consider a significant issue should be studied Use the "Insert Citation" button to add citations to this document (Gulati et al., 2022). (Mia et al., 2025)

Various techniques had been used for data forwarding but most of these algorithms are not consider energy efficient and need to be improved. The improving will affect the energy consumptions for the node and thus will enhance the network lifespan (Gulati et al., 2021)

WSN consist of hundred or thousand modes known as sensor nodes cooperate together in order to monitor and manage the environment. The main function of these nodes are to sense and forward the sensed data to the required destination called based station. These nodes have limited resources. Therefore, in order to organize the power exhausting of this network it will be done by mange how these nodes consume their energy (Ahmed et al., 2012; Obidike, Nwabueze and Onwuzuruike, 2018)

In term of energy usage, these nodes consume their power in various domains such as in transmissions, receiving, sensing and even when they are idle case, however, the most consume field is the transmissions and receiving. Use the "Insert Citation" button to add citations to this document. (Gulati et al., 2022; Mehbodniya et al., 2022). Furthermore, the operation of this network had many steps depend on the application that used for, but the common stage is the operation of information transmission and receiving, there are various techniques for data separation such as flooding and gossiping. Each of these techniques has advantages and disadvantages. As well described in the next section. Finally, both IoT and Sensor networks had a crucial role in enabling the proliferation of smart systems and applications in today's interconnected world. For general vision, Fig. 1 represents the general ideas of how IoT and Sensor Networks link together.

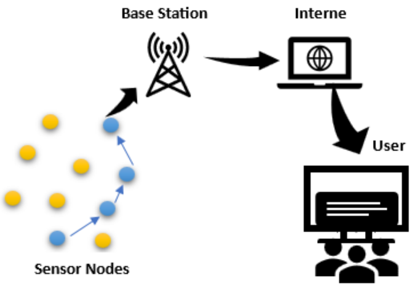


Fig.1 IoT and Wireless Network.

3. FORWARDING TECHNIQUES

As mentioned previously, Flooding and gossiping are two common communication approaches used in various types of wireless networks such as Sensor Networks (SNs) to forward the sensing information among sensor nodes util it reaches to the final destination (Begum and Nandury, 2023).

In flooding, a node broadcasts data to all its neighboring without any prior knowledge of the network topology. This ensures that the message reaches every node in the network, but it can lead to redundant transmissions and high-power consumption due to multiple nodes forwarding the same message. While in Gossiping consider best than flooding where nodes randomly select a neighbor to exchange information with. This method helps in reducing redundant transmissions and promoting energy efficiency in the network. Both approaches have their own advantages and limitations. Flooding is simple and guarantees message delivery, but it can be inefficient in terms of energy consumption. While Gossiping is more energy-efficient than flooding but it based on random selection and may not guarantee message delivery to all nodes in the network. Both techniques considered resources blindness which mean they don't take into account the node proprieties (Dutta and Paul, no date; Saha et al., 2022). The main operations of the flooding and gossiping are illustrated in Fig. (2 a and b) respectively.

a- Flooding **b- Gossiping**

Fig.2 Data Forwarding Techniques

4. METHODOLOGY: PROPOSED FORWARDING TECHNIQUE

In order to optimize the next hop selection and improve overall network performance, a new technique had been proposed in this paper. The new approach had aimed to improve the next hop selection with efficient method by taking into consideration various node's resources in heterogenous networks. As mentioned previously, in the other available forwarding techniques, the next hop selection was based on either send it to all nodes within network (as in flooding) or based on random selection (as in gossiping). For both above approaches, there are no consideration for node characteristics and resources.

In the proposed method, the data will be forwarded to the node with specific proprieties that had the significant effect on network lifetime and they are highest power level, nearest node with the current node and it didn't receive or send the required data as well as the node that has nearest neighbor within the destination. This will prevent the node from receiving or forwarded the same data that may be unneeded. Fig.3 and Fig.4 illustrates the overall view and the main flowchart of the proposed network.

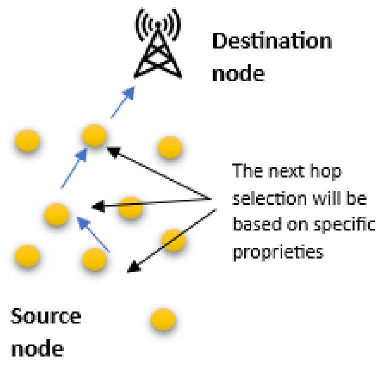


Fig.3 proposed network

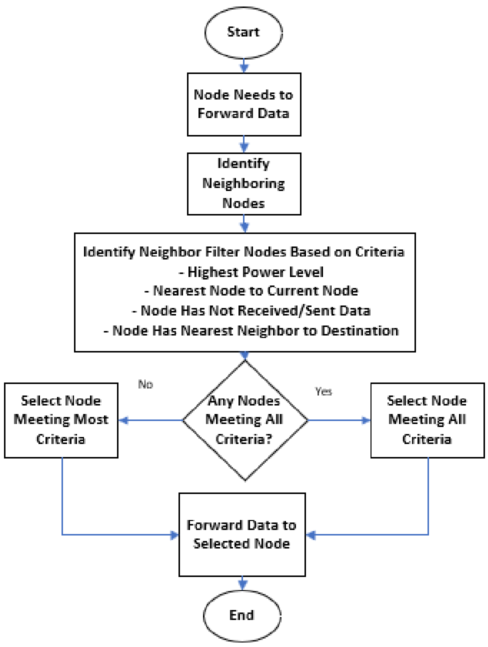


Fig.4 proposed network flowchart

Finally, Table 1 summaries the main different among the proposed method and the available forwarding methods.

Table 1. – The different among the proposed method and the available forwarding methods

Forwarding Technique	Node's current energy	Homogenous/ Heterogenous	Space between current node and the selected node	Received/ sent the data	Main proprieties
Flooding	No	Homogenous	No	No	Random transmission to all nodes
Gossiping	No	Homogenous	No	No	Random selection for forwarding node
LEACH	Yes	Homogenous	No	Yes	Random selection for forwarding node
Proposed Technique	Yes	Heterogenous	Yes	Yes	Select the required node that meet the required conditions

Furthermore, in terms of power consumption measurements, the general energy consumption model that proposed in (Heinzelman, Chandrakasan and Balakrishnan, 2000) had been adapted as seen in equations below. Eq.1 is used for calculation the power consumption in transmission process while Eq.2 represent the calculations in receiving process.

$$\mathbf{E_{TX}}(\boldsymbol{k},\boldsymbol{d}) = \mathbf{kE_{elec}} + \mathbf{k\epsilon_{fs}}\boldsymbol{d^2} \quad (1)$$

$$\mathbf{E_{RX}}(\boldsymbol{k}) = \mathbf{kE_{elec}} \quad (2)$$

Where ε_{fs} =power exhausting in power amplifier in free space mode =10 pJ/bit/m2 , E_{elec} is constant =50 nJ/bit (Heinzelman, Chandrakasan and Balakrishnan, 2000), k is the forwarding packet size =4000 bit, d is the distance between the nodes that calculated used Euclidian formula as shown in Eq.3.

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

In order to understand the different between the proposed design and available techniques in terms of communication styles, the following questions summarized the overall behavior of each used system in this paper.

For flooding and gossiping, the network power will be consumed based on the Eq.4 and 5 respectively.

$$\mathbf{E_{sn_{total-flood}}} = \sum_1^n \mathbf{E_{tr}} + \sum_1^{n-1} \mathbf{E_{re}} \quad (4)$$

Where (E_{tr}) represents the transmission energy for all nodes (n) within network and E_{re} represents the received energy from all nodes within network (except the current node)

$$\mathbf{E_{sn_{total-gossip}}} = \mathbf{E_{tr}} + \sum_1^m \mathbf{E_{re}} \quad (5)$$

Where (E_{tr}) represents the transmission energy for any node that selected randomly within network and (E_{re}) represents the received energy from group of nodes (m) within the current node range.

Additionally, the main different between LEACH and gossiping is that the first one is depend of grouping approach which mean that the random selection for next hop will be among a certain group (will arrange randomly) within the network, while in gossiping the selection is randomly from and nodes within network. Therefore, the mathematical model for LEACH will as shown in Eq.6 .

$$\mathbf{E}_{\mathbf{sn}_{\mathbf{total-leach}}} = \sum_1^g \mathbf{E}_{\mathbf{tr-group}} + \sum_1^g \mathbf{E}_{\mathbf{re-group}} \quad (5)$$

Where ($E_{tr\text{-}group}$) represents the transmission energy for any node that selected randomly from the selected group within network and ($E_{re\text{-}group}$) represents the received energy from any node that selected randomly from the selected group within network

Finally, for the proposed design, the node will transmits and receive the data from a certain hop with required criteria (not Received/Sent Data before, highest Power Level, nearest node to Current Node as well as node has nearest neighbor to destination) as shown in Eq.6.

$$\mathbf{E}_{\mathbf{sn}_{\mathbf{total-design}}} = \mathbf{E}_{\mathbf{tr-select}} + \mathbf{E}_{\mathbf{ra-select}} + \quad (6)$$

Where Etr-select and Era-select represent the transmission and received energy exchasted for the selected node.

5. SIMULATION AND RESULTS

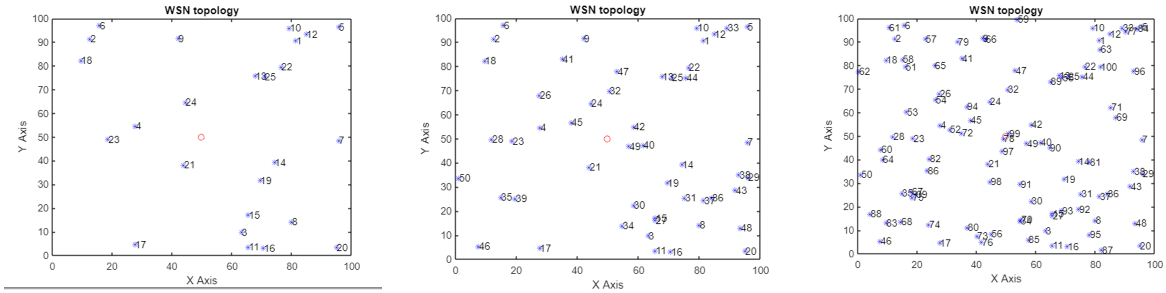
The first step is based to deploy various number of nodes with the network randomly in sensing area of 100*100 for different topologies (different positions for the nodes with each scenario). The platform that used in MATLAB. The maim parameters that were used are illustrated in Table 2.

Table. Simulation Parameters

Parameters	Valus
Simulation Area	100*100
Number of Nodes	25 , 50 and 100
Number of rounds	5000
Node Placement	Random
ε_{fs},	10 pJ/bit/m2
E_{elec}	50 nJ/bit
packet size	4000 bit
Initial Energy level	2 J

The deployed node is shown in Fig. 4-a,4-b and 4-c for number of nodes 25,50 and 100 respectively with initial power level equal to 2 J.

After the previous steps (nodes deployment) , the operation of the networks had been simulated for number of cycle and based on different scenarios for evaluation and validation processes as will described in the following sections.



a-Number of nodes=25 **b- Number of nodes=50** **c- Number of nodes=100**

Fig. 4. Network Topology

5.1. Simulation scenarios:

I- scenarios I: Node's energy consumptions/cycle

In this scenario, the proposed technique had been tested based on different number of nodes and topologies in order to measure the amount of node's energy that exhausted. The same simulation environment had been used to implement other data forwarding approaches (flooding and gossiping). The results are shown in Fig 5, Fig 6 and Fig 7 for various number of nodes (25 , 50 and 100) respectively.

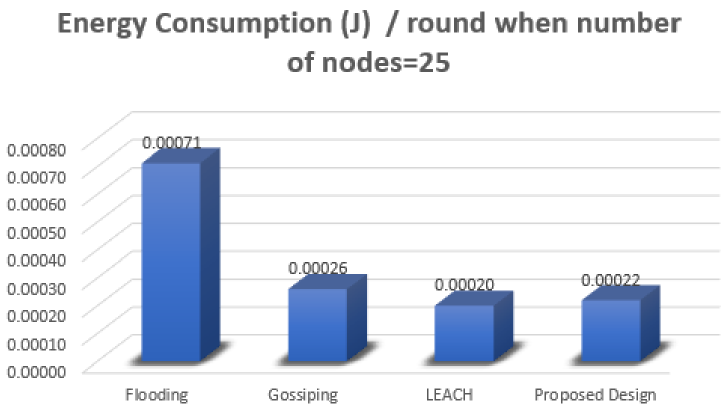


Fig.5 Node's energy consumptions/cycle (number of nodes=25)

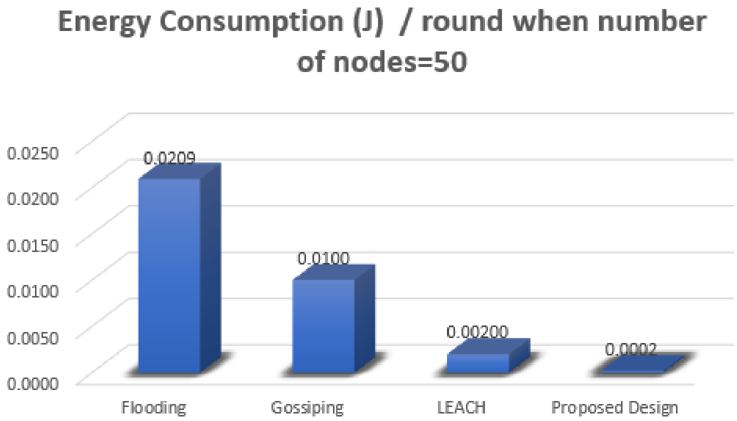


Fig.6 Node's energy consumptions/cycle (number of nodes=50)

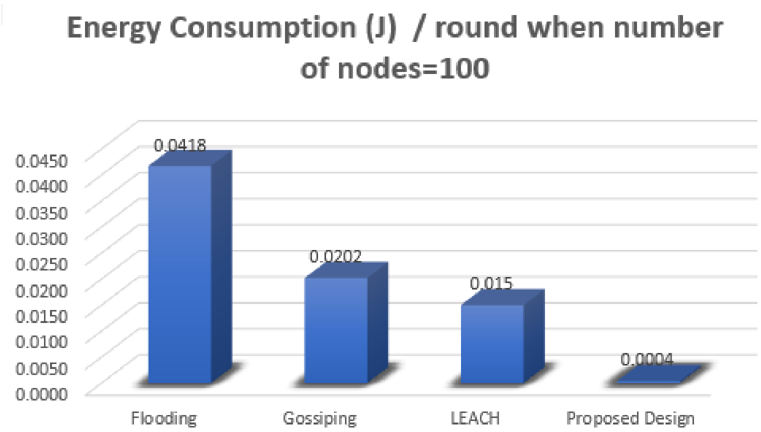


Fig.7 Node's energy consumptions/cycle (number of nodes=100)

According to the results in the above figures, it seems that the node in flooding tends to exhaust more power due to frequent communication process and redundant transmissions. This can lead to quicker battery drain and reduced network lifetime.

On other hand, Gossiping, with its random selective transmission approach, it helps in conserving energy more than the flooding by targeting specific nodes for message dissemination. However, for both techniques, there is resource blindness problem and overlap which mean the node may received the same data again.

For proposed system, by taking into account the nodes resources and the optimum number of hops to the destination, the network performance had been enhanced by reduce number of transmission and receiving and thus will minimize the power consumption of the nodes per cycle for different number of nodes and topologies.

II. scenario II: First Node Dead (FND)

In sensor network, in order to measure the overall network lifetime improvement, various parameters can be adapted such as First Node Dead (FND), Half of Node Dead (HND) and All Node Dead (AND).

In this paper, the First Node Dead (FND) had been tested for various number of nodes and different nodes' position within the network. The simulation results of this scenario are introduced in Fig 8.

Based on the above results, by minimize the power consumption for the node, the network lifetime can be improved by increase the time that need for the first node to be dead (loss it all power) under different number of nodes. This is because by changing number of nodes in the network, the distance among nodes will be reduced and thus will minimize their power consumption and enhance network lifetime

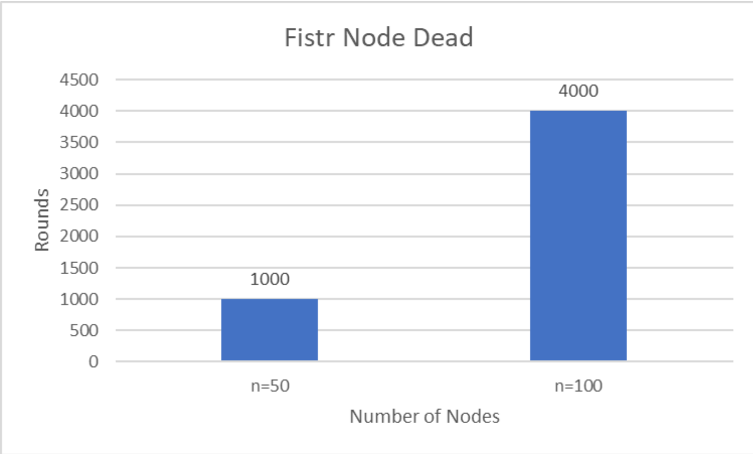


Fig.8 Fiest Node Dead (FND) in various scenarios

III. scenario III: System Evaluation

In this scenario, in order to obtain how the proposed approach has improved the network performance, the network had been simulated based the forwarding approaches that mentioned previously in this paper. The evolution had been done by comparing the performance of the three techniques (proposed design, flooding and gossiping) under same simulation parameters (number of node set to be 50 and 100 , the destination location outside the sensing area and all nodes are different characteristics). The result of this scenario is shown in Fig. 9.

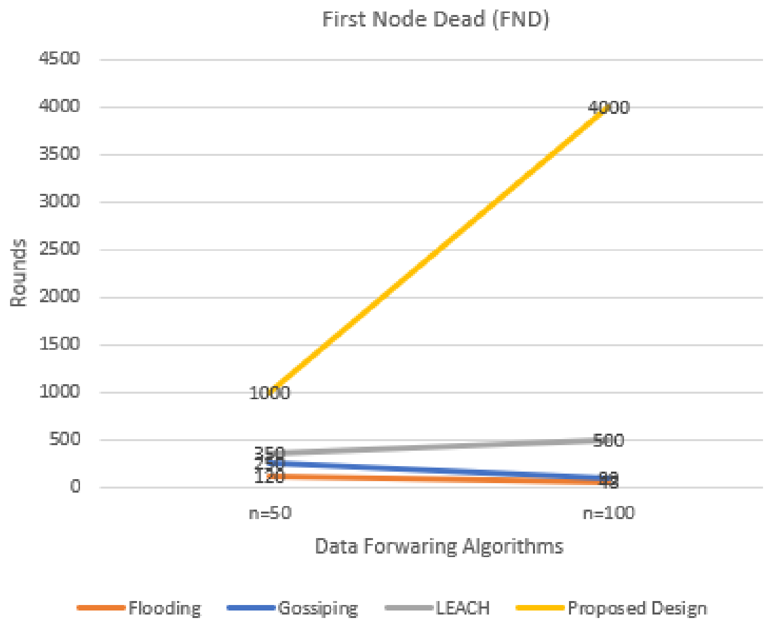


Fig.9 System Evaluation

From the results, the network lifetime had been enhanced by prolong the round time for the network.

As shown in the figure, for number of nodes that deployed in the sensing area set to 50, the round number when the first nod loss it all power in flooding was 120, in gossiping was 250 , in LEACH was 350 while it became 1000 in the proposed technique.

Furthermore, when number of nodes had been increased, which mean the distance among the nodes had been change, the first node was dead in rounds 48 for flooding, 99 for gossiping. this reduction because the number of neighbors' node had increase and thus will affect the nodes power level. However, by applying the best criteria in grouping the nodes and control the data transmission this will enhance the nodes level exhausting as shown in LEACH first node dead was at round 500. Finally by applying more criteria in next hoe selection, it will improve the network life time as illustrated in the proposed design where the first node dead was at round 4000.

According to these finding, the proposed system has achieved it aim and enhance the network lifetime

6. CONCLUSIONS

In conclusion, forwarding techniques play a crucial role in the efficient and effective operation of Sensor Networks (SNs). By understanding the significance of forwarding techniques in this type of wireless networks and their impact on routing efficiency and energy conservation, researchers can make informed decisions to optimize data forwarding processes and enhance the overall performance.

The choice of a specific and optimum forwarding process is depends on different factors like network topology, energy constraints, and sesnign application requirement and data importance. All these will affect the network performance and lifetime that can be managed by reducing the amount of the energy that drain during data transmission in the forwarding technique.

Furthermore, by taking into account the different characteristics and the resources of the nodes, it will enhance the next hop selection and thus will prevent the node form drain it power in useful transmissions or receiving process and thus will improve the network lifespan. All the mentioned above was adapted in the proposed design and the results showed how the energy consumption of the node had been reduced during the round and how the network lifetime had been prolonged.

Finally, as overall conclusion, the proposed method achieved high performance in terms of power consumption and system performance.

7. REFERENCES

Ahmed, M.R. et al. (2012) 'Wireless Sensor Network: Characteeristics and Architectures', 6(12), pp. 1398–1401.

Alaa, R., Hussein, E.A. and Al-Libawy, H. (2024) 'Object Detection Algorithms Implementation on Embedded Devices: Challenges and Suggested Solutions', Kufa Journal of Engineering, 15(3), pp. 148–169. Available at: https://doi.org/10.30572/2018/KJE/150309.

Begum, B.A. and Nandury, S. V. (2023) 'Data aggregation protocols for WSN and IoT applications – A comprehensive survey', Journal of King Saud University - Computer and Information Sciences, 35(2), pp. 651–681. Available at: https://doi.org/10.1016/j.jksuci.2023.01.008.

Dutta, R. and Paul, D. (no date) 'Comparison of Flooding and Gossiping Routing Protocols Using TOSSIM in Wireless Sensor Networks'.

Gulati, K. et al. (2021) 'A review paper on wireless sensor network techniques in Internet of Things (IoT)', Materials Today: Proceedings, 51, pp. 161–165. Available at: https://doi.org/10.1016/j.matpr.2021.05.067.

Gulati, K. et al. (2022) 'A review paper on wireless sensor network techniques in Internet of Things (IoT)', Materials Today: Proceedings, 51, pp. 161–165. Available at: https://doi.org/10.1016/J.MATPR.2021.05.067.

Heinzelman, W.R., Chandrakasan, A. and Balakrishnan, H. (2000) 'Energy-efficient communication protocol for wireless microsensor networks', in Proceedings of the Hawaii International Conference on System Sciences. IEEE Comput. Soc, p. 223. Available at: https://doi.org/10.1109/hicss.2000.926982.

Heinzelman, W.R., Chandrakasan, A. and Balakrishnan, H. (no date) 'Energy-efficient communication protocol for wireless microsensor networks', in Proceedings of the 33rd Annual Hawaii International Conference on System Sciences. IEEE Comput. Soc, p. 10. Available at: https://doi.org/10.1109/HICSS.2000.926982.

Mehbodniya, A. et al. (2022) 'Proportional fairness based energy efficient routing in wireless sensor network', Computer Systems Science and Engineering, 41(3), pp. 1071–1082. Available at: https://doi.org/10.32604/csse.2022.021529.

Mia, S. et al. (2025) 'Integrating Renewable Energy with Internet of Things (IoT): Pathways to a Smart Green Planet', Kufa Journal of Engineering, 16(1), pp. 361–404. Available at: https://doi.org/10.30572/2018/KJE/160121.

Obidike, I., Nwabueze, C. and Onwuzuruike, K. (2018) 'Wireless Sensor Network: Characteristics and Architecture', IJCAT-International Journal of Computing and Technology, 5(8). Available at: www.IJCAT.org.

Saha, S. et al. (2022) 'SIG: A Gossip Based Energy Efficient Routing Protocol For WSN', International Journal of Advanced Networking and Applications, 13(05), pp. 5108–5112. Available at: https://doi.org/10.35444/ijana.2022.13503.

Zuhair Ghazi Zahid, A. et al. (2025) 'a New Intelligent Driver Vigilance System Design Using Tilt Sensors', Kufa Journal of Engineering, 16(1), pp. 26–42. Available at: https://doi.org/10.30572/2018/KJE/160103.