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Efficient Energy Optimization Routing for WSN Based on Even-Odd Scheduling

Muhammad Zafar Iqbal Khan*, Kamarularifin Abd Jalil and Mohd Faisal Ibrahim

Faculty of Computer & Mathematical Sciences, Universiti Teknologi Mara, 40450 UiTM, Shah Alam, Selangor, Malaysia

ABSTRACT

Several routing protocols are being developed and used to develop energy-efficient wireless sensor networks. The necessity of saving energy is the need for technology as well as the scarcity of conventional energy. The wireless sensor nodes are run on battery power with energy limitations; therefore, this study needs to develop wireless sensor networks that can be kept alive for a longer period. From a computer science point of view, a routing mechanism can help in the improvement of the network. This research aims to design and develop a routing protocol that utilizes less energy and keeps sensor networks alive for longer period while using limited energy. An efficient and intelligent even-odd scheduling-based routing protocol influenced by LEACH has been proposed to achieve this goal. During transmission, this protocol alternatively considers evenly or oddly indexed nodes. The concept in this approach is to keep the node into consideration when it is ready to send data and when it is in the queue. Any node that is not in the queue or does not have data will not consume any significant energy, and thus the whole network conserves energy after each transmission round.

Keywords: Energy-efficient routing, even-odd scheduling, LEACH, WSN

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E-mail addresses:
zafar.iqbal@nct.edu.om (Muhammad Zafar Iqbal Khan)
kamarul@tmsk.uitm.edu.my (Kamarularifin Abd Jalil)
faisal@tmsk.uitm.edu.my (Mohd Faisal Ibrahim)
* Corresponding author

INTRODUCTION

The new headways in wireless communications and gadgets have prompted the advancement of ease, low-power, multifunctional small smart sensors. These sensors ought to detect, measure information, and speak with one another through a wireless association. A wireless sensor network is a foundation containing

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several spatially disseminated independent wireless sensors nodes to screen a wonder in a predetermined climate and to helpfully advance their measures (gathered information) through the network to an ideal sink(s) Gupta et al. (2016).

Wireless Sensor Networks (WSNs) have drawn in a ton of consideration from the scholarly world and industry in recent years. Because of the qualities of adaptability, simplicity of sending, and self-association, an assortment of uses has been created dependent on the advances of WSN. In any case, restricted battery, huge crude information, and precarious wireless connections prompt a few challenges (like energy imperative, memory requirement, and network limit limitation), which limit the performance of wireless sensor networks. Discovering answers for the above imperatives have made roads for research. Information accumulation which is a path for saving energy and network limit has been now and again researched (Mahajan & Banga, 2015). By contemplating the connections of crude information, information collection diminishes the information parcels in the network, consequently saving correspondence costs and facilitating network congestion. In this assessment, an ideal thickness and distance-based versatile, low accumulation energy grouping WSN has been accounted for in Akila and Sheela (2017).

Typically, a WSN comprises hundreds or thousands of wireless sensor nodes and a sink node, where the sensor nodes own the capacity of detecting, preparing, imparting, and sending. As demonstrated in Figure 1, these sensor nodes sense the ecological elements (temperature, moistness, pressing factor, movement, and other actual factors), speak with one another, and send data. Like a base station, the sink node is sent to gather the data. The small, appropriated, and practical sensor nodes quicken the improvement of WSN. As demonstrated in Figure 2, there are assortments of utilizations profiting by WSNs, like structure checking, medical services, smart agribusiness, military reconnaissance, environment monitoring, and location issues.

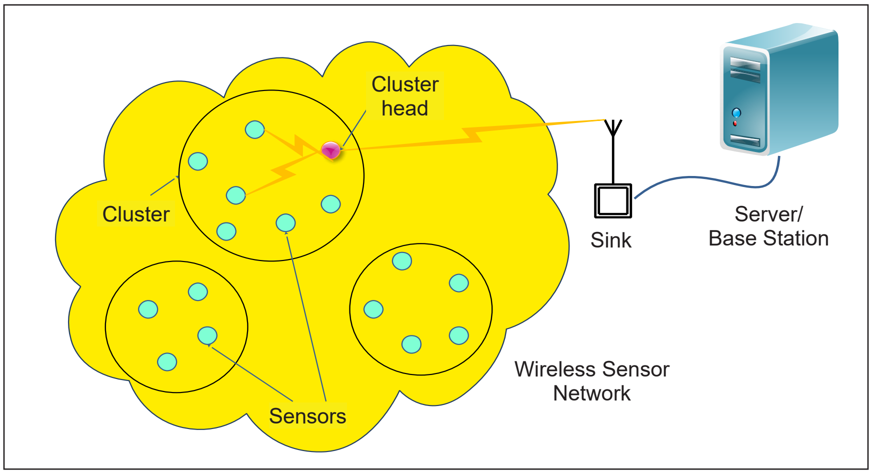

Figure 1. General architecture of WSN

However, due to the limited battery power of sensor nodes, the network lifetime and performance are restricted. Meanwhile, in several applications (e.g., temperature monitoring), sensor nodes are prone to transmit redundant or correlated information to the sink, which wastes the bandwidth, thereby wasting the network capacity and accelerating battery depletion.

Therefore, measures to save energy and network capacity are central challenges for researchers in this field of research. This study found that the major power drain occurs from wireless communication by investigating energy consumption in one sensor node. Thus, a reasonable solution is to reduce the communication activity to save energy. Data aggregation, which can reduce communication by reducing the number of data packets transmitted in the network, is considered a fundamental way to save energy in Yan and Wang (2017).

In Manzoor et al. (2019), the authors proposed an extended version of the Two-Level Hierarchy for Low Energy Adaptive Clustering Hierarchy (TL-LEACH) protocol, named Extended TL-LEACH (ETL-LEACH), to enhance the energy efficiency of the network in terms of communication overhead. Furthermore, an Energy-Aware Sink Mobility (EASM) algorithm is proposed for intelligent communication and increasing the sensor network lifetime in Kumar et al. (2019), considering the sink mobility in a routing protocol. In this study, the packets' drop and delay were not considered. Finally, in Kavya et al. (2020), the authors presented a cluster rotation scheme for multiple base stations to enhance the lifetime of the network by decreasing the communication overheads and minimizing the distance between the nodes Sengar et al. (2016).

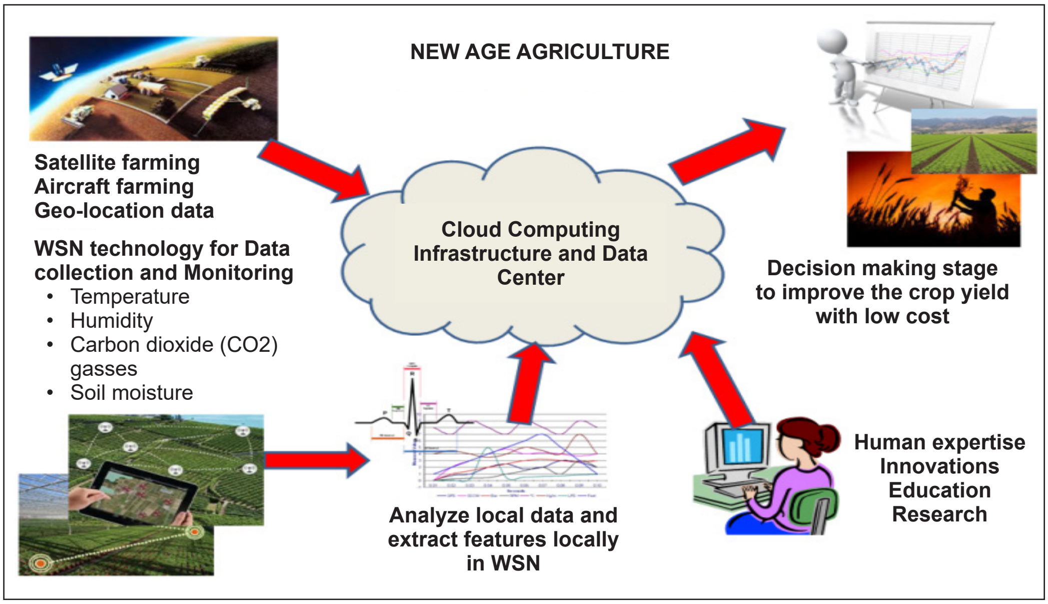

Figure 2. Various applications based on WSN in Yan and Wang (2017)

In this article, an energy-efficient routing protocol has been proposed that works on the principles of even-odd scheduling. The proposed protocol alternatively considers only those nodes in a queue and ready to transmit data. The rest of the nodes will remain in sleep to conserve their energy, and hence the whole network will conserve the energy after each round of transmission.

CLUSTERING

Clustering is the way toward gathering the information into classes or clusters so that objects inside a cluster have high comparability in contrast with each other however are extremely unlike items in different clusters (Pushpalatha & Nayak, 2015). Dissimilarities are evaluated dependent on the trait esteems depicting the articles. Regularly, distance measures are utilized in Cao and Zhang (2018). The field of clustering has gone through significant unrest throughout the most recent couple of years; it has been established in numerous regions, including information mining, measurements, science, and AI. Clustering is described by progress estimated and randomized in calculations, novel plans of the clustering issue, calculations for clustering enormously huge informational indexes, calculations for clustering information streams, and measurement decrease strategies in Akila and Sheela (2017).

The guideline routing protocol is cluster-based WSN. The critical thought of LEACH is that the clustering calculation proposes to decrease the energy utilization utilized by information sending from sensor nodes to the BS, and the network lifetime is partitioned into adjusts. Each round has two stages, the Setup stage or Cluster development and the Steady State Phase (information transmission), as shown in Figure 3. In the Setup Phase, the choice to be a cluster head is made locally at the node level. Then, every node n chooses an arbitrary number somewhere in the range of 0 and 1. If the irregular number is not exactly a limit T(n), the node chooses itself as a CH and reports itself as a CH. The node will be ordinary and hang tight for CH's ads in Basavaraj and Jaidhar (2017).

An ordinary node chooses one CH to join and sends a joining message. After accepting the joining message, the CH makes and broadcasts the transmission (TDMA) plan. The

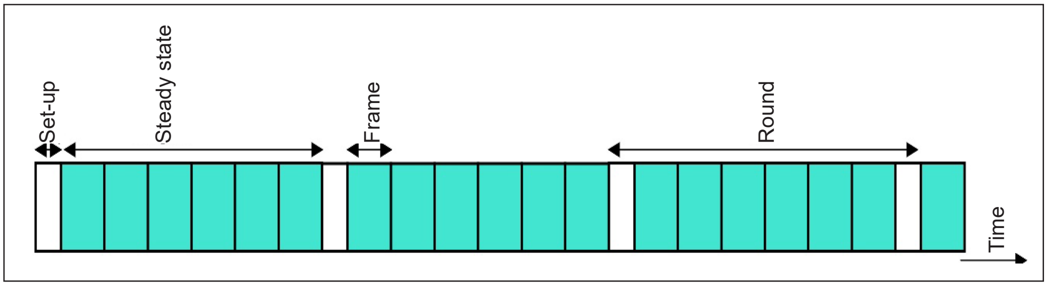

Figure 3. Activity timeline of LEACH. Adaptive clusters are shaped during the initialization stage and data transfers during the steady-state stage

TDMA plan contains a scheduled opening for every node to speak with the CH. At the point when a node gets the timetable, at that point, it can acquire a time allotment, and it goes rest trusting that its apportioned time will speak with its CH in Karmaker et al. (2016).

In the Steady State Phase, the information transmission stage is separated into a bunch of edges.

In each casing, a customary node sends its acquired information to the CH (as per its TDMA schedule opening) at that point, goes into the rest mode hanging tight for its time allotment in the following edge. The CH stays conscious of getting all individuals' information in the interim. Toward the finish of each edge, the CH totals the got information signals with information detected by itself and afterward advances the collected information sign to the BS. The interaction will be rehashed until the finish of the multitude of edges. Before the finish of the last edge, the cluster has finished a solitary round, and all nodes enter the arrangement stage to choose a new cluster head for the following round.

METHODOLOGY

In this research work, an optimal routing protocol is developed to build a reliable wireless sensor network. Such a networks system can be deployed to monitor the various parameters or factors like temperature, humidity, air pressure, soil moisture, motion, and other surveillance needs.

The proposed routing protocol has been intended to remember that the energy utilization ought to be minimized to keep the network active for long data transmission rounds. It was done with the help of optimization in the algorithmic part of sensor communication. The sensor communication with the base station is possible with the help of routing protocols, i.e., how data generated at the sensor is communicated to the base station (sink).

This study believes that while collecting sensitive information through a sensor network, it is most important to keep the network alive as long as the monitoring is going on. The biggest hurdle to keeping the node alive is battery-supplied power. Due to the limited source of energy, it is good to save energy so that sensors can send data for a longer period instead of every information trigger.

Implementation of the proposed routing algorithm has been done on MATLAB simulation software because it is high-performance numerical computation and visualization software. It provides an interactive environment with flexibility and reliability. It is easy to learn and use software that allows a user to develop functions. Moreover, this provides access to FORTRAN and C codes by means of external interfaces. Since this software serves the purpose of implementation and analysis quite effectively; therefore, in various research articles, for example, Cao and Zhang (2018), Chowdhury et al. (2018), and Shangyang et al. (2018), this software has been selected by the researchers to implement and judge the performance of their proposed protocols. Due to its efficient and easy-to-use modeling and analysis capabilities, this study has also selected this software to analyze the performance of the proposed protocol. In wireless sensor networks, a longer network lifetime and more network capacity are required in a variety of applications, such as long-term monitoring. Thus, the problems of energy and network capacity consumption are considered central to the sensor research model. The proposed algorithm scheduling of even sensors and odd sensors approach has been used. This algorithm is motivated by the very first kind of routing protocol, LEACH, which utilizes hierarchical clustering to minimize the energy consumed in various operations involved to complete the transmission of data to the sink (Base Station-BS).

Energy-consuming operations are performed at sensor node and cluster head level. These operations are as follows:

- *Energy consuming operations at Sensor Node*
- *Energy consuming operations at Cluster Head (CH)*

Above mentioned operations consider only those parts that are being improved by optimization in routing algorithms because several domains can improve the energy efficiency of sensor networks. However, this research covers those part that comes under the computer science domain.

Energy-Consuming Operations at Sensor Node

In every wireless network, wirelessly nodes operate, which means the circuit used for wireless signal transmission must be present. This study is aware that to generate wireless signals, consumed energy is higher than in the wired counterparts (Figure 4).

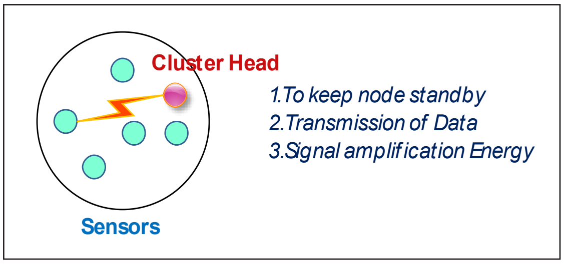

Figure 4. Energy consuming operations at Sensor Node

Energies involved to transmit data from sensor nodes to cluster head involve following during active network:

- To keep node standby
- To Transmit Data to Cluster Head
- Signal amplification energy

To Keep Node Standby. After deployment of a sensor in the surveillance field, mostly it is kept on standby mode so that their position or location can be curated properly as per the application. When the whole network is deployed, nodes will be activated with a command or manual activation. It could also be considered as energy consumption when no trigger is detected during the sensing period. This kind of operation takes a very low amount of energy so generally not considered in any routing protocol. Energy consumed with this operation is displayed in the algorithm with the notation E_{rx} - Energy of Reception. During simulation of routing value considered for this energy is 50×10^{-9} Joules.

To Transmit Data to Cluster Head. Sensor nodes are generally made to send information when a trigger is detected. This trigger and its tolerance can be set as per need so that only significant information can be detected. When significant change has been detected, the sensor sends data wirelessly to the cluster head, which requires energy to generate wireless (microwave/RF) signals to produce significant power so that it reaches the sink or base station.

Energy consumed with this operation is displayed in the algorithm with the notation E_{tx} - Energy of Transmission. During simulation of routing value considered for this energy is 50×10^{-9} Joules.

Signal Amplification Energy. Signal amplification energy is generally considered two types based on the distance between node and cluster head. First, if the distance is higher than the referenced distance (d_0) and the second is lower than the referenced distance (d_0).

The referenced distance (d_0) is a square root of the ratio of amplification energy for lower distance (E_{fs}) and amplification energy for higher distance (E_{mp}).

$$d_0 = \sqrt{\frac{E_{fs}}{E_{mp}}} \qquad [1]$$

The values of the above energies considered are $E_{fs} = 10 \times 10^{-12}$ Joules and $E_{mp} = 0.013 \times 10^{-12}$ Joules.

Energy-Consuming Operations at Cluster Head (CH)

When data is transferred from normal nodes to cluster head, some other kinds of energy need to be calculated for more precise energy consumption calculations at the cluster head (Figure 5).

For a cluster head node, three main operations need to be performed. One is data reception sent from normal node and second is collection or aggregation of data and third transmission of data to sink or base station (BS).

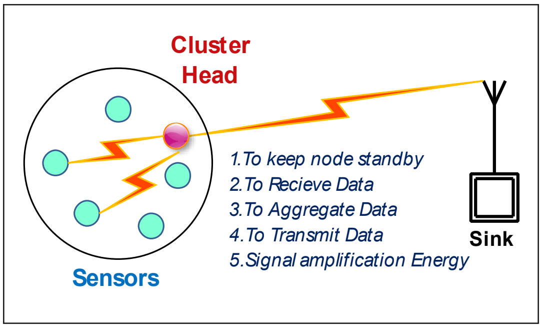

Figure 5. Energy consuming operations at Cluster Head

Energies involved to receive data from sensor nodes, aggregate data received from various normal nodes, and transmit data to base station involves following energies which will consume during active network:

- To keep node standby
- To Receive Data from Sensor Nodes
- To Aggregate Data Received from multiple sensor nodes
- To Transmit Data to Cluster Head
- Signal amplification energy

To Keep Node Standby. Like normal nodes, after deployment of the sensor in the surveillance field, it is mostly kept on standby mode so that during deployment, their position or location can be curated properly as per the application. When the whole network is deployed, cluster nodes will also be activated with a command or manual activation like normal nodes. It could also be considered energy consumption during the sensing period when no trigger is detected. Every cluster head is a normal sensor node until clustering takes place. After clustering, one of the normal nodes is selected as a cluster head for that transmission round.

To Receive Data from Sensor Nodes. Data or information transmitted from normal nodes is received at the cluster head because the cluster head (CH) is an aggregation point where all the data from the cluster is received and combined at the cluster head (B. Sun et al., 2016). Energy consumed with this operation is displayed in the algorithm with the notation E_{rx} - Energy of Transmission. During simulation of routing value considered for this energy is 50×10^{-9} Joules.

To Aggregate Data Received from Multiple Sensor Nodes. The aggregation function is the computation part of data aggregation, which is responsible for performing the collection of received data (X. Sun et al., 2016). After forming the cluster and cluster head, data sent from the normal sensor nodes is received and combined at the cluster head during data transmission in the network. Combining or aggregating data from multiple nodes also consumes some energy. Aggregation energy is displayed as E_{da}-energy of data aggregation, with a value 5×10^{-7}.

Transmit Data to Base Station (BS) or Sink. After collection or combining, all the received data from sensor nodes will be transmitted to a base station (BS). This operation consumes the same energy as a normal sensor node to transmit data. Energy consumed with this operation is displayed in the algorithm with the notation E_{tx} - Energy of Transmission. During simulation of routing value considered for this energy is 50×10^{-9} Joules.

Signal Amplification Energy. Signal amplification energy is generally considered two types based on the distance between node and cluster head. First, if the distance is higher than the referenced distance(d_0) and the second is lower than referenced distance(d_0). Refer to Equation 1 for the formula.

Following are the possible energy consumption parameters that consume battery power. The possible solution to reduce such consumption is to manage those during data routing.

The proposed model utilizes sensor node data transmission scheduling based on even and odds. After starting network data transmission, every node with data to send to the base station will wait for its turn. Every transmission round allows evenly indexed sensors to transmit data, and in the next round, oddly indexed sensors can send data to BS. It would go round and round and alternately send data to the base station.

The following mechanism keeps sensor nodes more on standby than transmitting on each trigger. As a result, in every transmission round significant amount of node energy is saved, and the life of the overall network increases. The small amount of energy saved per sensor node will collectively increase the lifespan of the network, which will help to monitor the network for a longer period.

The execution of the whole procedure is explained with the help of a flow chart and algorithmic steps. The whole algorithm is divided into three main modules:

- Network Initialization Module
- Cluster Head Election Module
- Sensor Node Module

Network Initialization Module. This module has a step-by-step procedure to set up and initialize a wireless sensor network. Which are as follows:

- *Declaration of network parameters*: All the parameters are defined: sensor network like network area, number of nodes, reference distance, aggregation energy, amplification energy, transmit and receive energy, initial energy, transmission rounds, packet length, and sink position.
- *Place sensor nodes on random locations*
- *Assign them initial energy*
- *Label all nodes as normal node 'N'*
- *Define all the flags and network log parameters*
- *Activate network and start transmission of data*

Cluster Head Election Module.

- *Scan and choose cluster head using energy and probability*
- *Set cycle information as per probability*
- *Define CH co-ordinates and label node as 'C'*

- *Calculate cluster distance and define index to it*
- *Calculate energy consumption at CH*
- *Update network log after all cluster creation*

Sensor Node Module.

- *Apply even-odd scheduling*
- *Scan and choose node having energy>0 and label 'N'*
- *Calculate distance from cluster head*
- *Calculate energy consumption at the sensor node*
- *Update Network logs*

Information accumulation lessens the repetitive or associated transmissions in a network, which straightforwardly limits the energy utilization for the entire network. Since the energy limit is a primary limitation for WSN, the plan of information total should put energy saving as the fundamental concern.

In the current work, a few accumulation plans depend on the crude information to amass sensor nodes to total data. Be that as it may, strange information frequently shows up in crude information. In this way, the information unsteadiness unquestionably impacts the presentation of such plans.

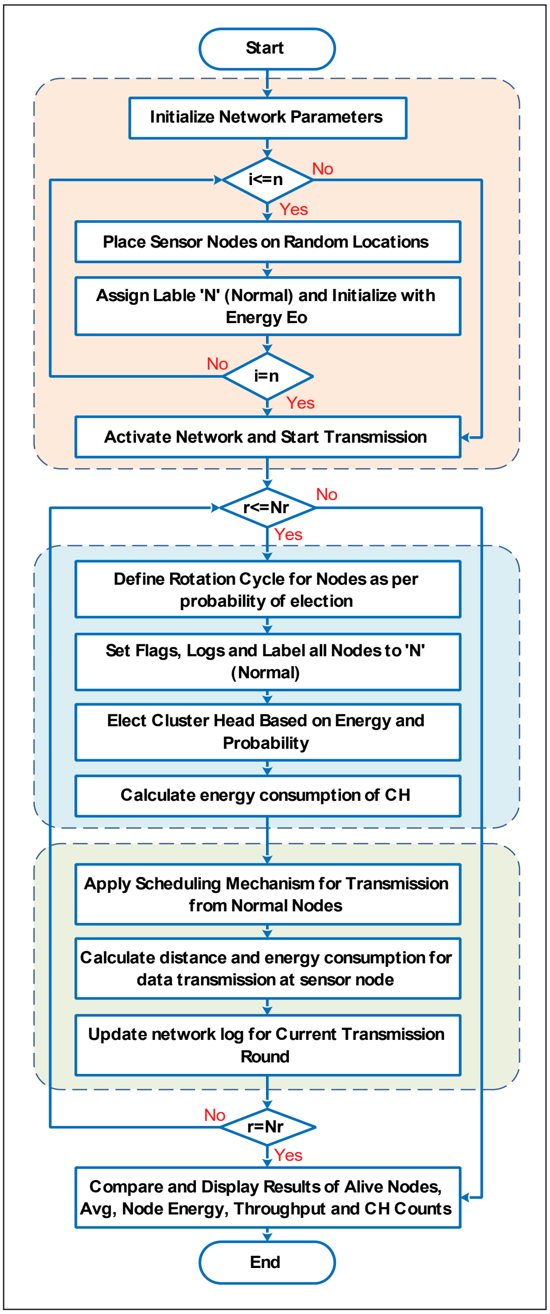

Figure 6. Flow of the even-odd scheduled LEACH routing protocol

The flow of executions to implement and execute the proposed algorithm is described in Figure 6. First, various simulation parameters are defined in MATLAB to execute the proposed algorithm. Second, create a network node at a random location with low inertial energy. Then, begin data transmission between nodes and cluster head and base station—update nodes statistics.

Use cluster head election module aggregation energy consumption during transmission and reception of cluster head—energy utilization at the node. Revise remained alive node after transmission and reception. Calculate residual energy and alive node. Compare and display residual energies and the number of alive nodes.

Table 1
EOS-LEACH routing simulation parameters

Parameters	Values
Area of Sensing Network	100m × 100m
Initial Energy of Nodes(E_0)	0.5J
Sending/Receiving Energy for 1 Bit (E_{tx}/ E_{rx})	5×10^{-8}J/bit
Transmit amplifier E_{fs} (if d to BS < do)	10pJ/bit.m^2
Transmit amplifier E_{mp} (if d to BS > do)	0.013pJ/bit.m^2
Energy consumption of data fusion or aggregation E_{da}	5×10^{-7}J/bit
Packet Length	1000bit
No. of Nodes	200

Table 1 shows the simulation parameters are considered to examine the performance of the proposed algorithm in MATLAB. The fundamental parameters listed in Table 1 are Area of Sensing Network, a number of nodes, reference distance, aggregation energy, amplification energy, transmit and receive energy, initial energy, transmission rounds, packet length, and sink position.

RESULTS AND DISCUSSION

For testing of the following wireless sensor model MATLAB based simulation has been carried out to examine the performance of the proposed algorithm and to verify the results of the proposed algorithm. Since sensor nodes are randomly deployed in the area, the network might have high density and low-density regions which means many nodes are deployed in some regions. In some areas, nodes are deployed further away from each other, so a clustering approach is adopted for such a network that cares about the density of every node to shape the clusters. In the proposed algorithm, an even-odd scheduling-based LEACH routing is used for wireless sensor networks, which significantly reduces the energy consumption of nodes.

To evaluate the effectiveness of the whole performance of the network, diverse simulation analysis has been done to demonstrate how the proposed methodology has better performance against the existing base algorithm. Subsequently, to gather nodes' data, the BS at that point elects a lot of eligible nodes to treat as cluster heads toward the current round. A node is qualified if its present residual energy is more noteworthy than the normal energy of every single live node. At the point when the eligible node-set is characterized, the BS plays out the clustering calculation to divide the network into the ideal number of clusters. The yield of this capacity is the arrangement of clusters with a cluster head for each cluster. After the network is clustered, the length of the current round is processed.

Since the performance of the LEACH protocol has already been analyzed in the literature and the proposed protocol is an extension to the LEACH protocol; therefore, it was required to judge the performance of the proposed protocol with the LEACH.

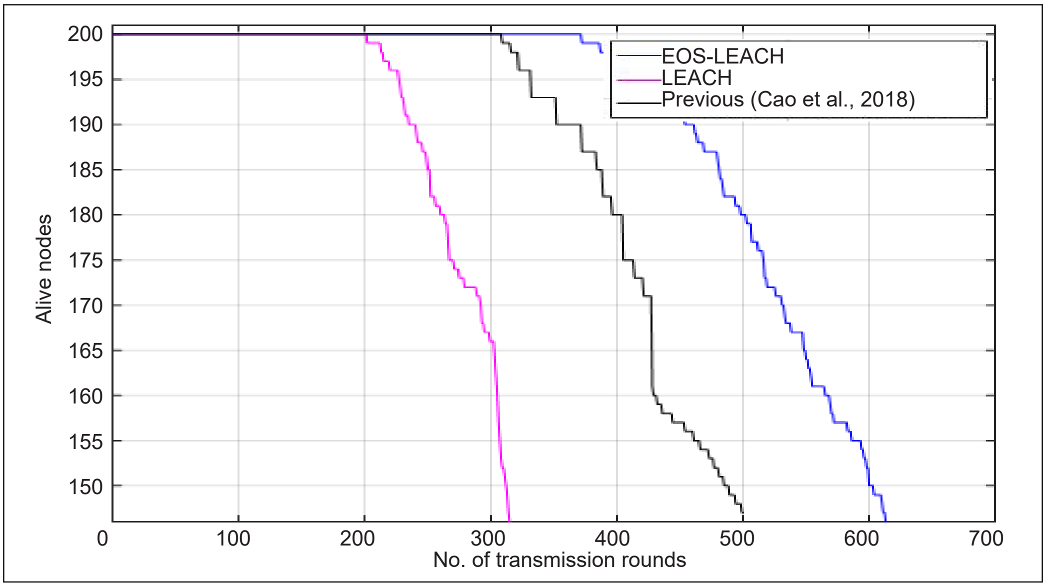

Figure 7. Number of alive nodes vs. transmission rounds

Table 2
Alive nodes comparison after different 100, 300, and 500 rounds (Figure 7)

Trans. Rounds	Previous (Cao and Zhang, 2018)	Standard LEACH Routing	Even Odd Scheduling (Proposed) Routing
100	200	200	200
300	200	156	200
500	146	25	176

A randomized selection method is used for each round to study the system performance for the aggregation; a random value has been chosen. Based on the parameters considered from Table 2, some simulation outcomes while executing the proposed algorithm are discussed in Figures 7 to 13.

Figure 7 shows the plot of a number of Alive nodes vs. transmission rounds for up to 700 transmission rounds, and Figure 8 shows the corresponding Average Node Energy for up to 700 rounds. Table 3 shows the average energy comparison after 100, 300, and 500 rounds.

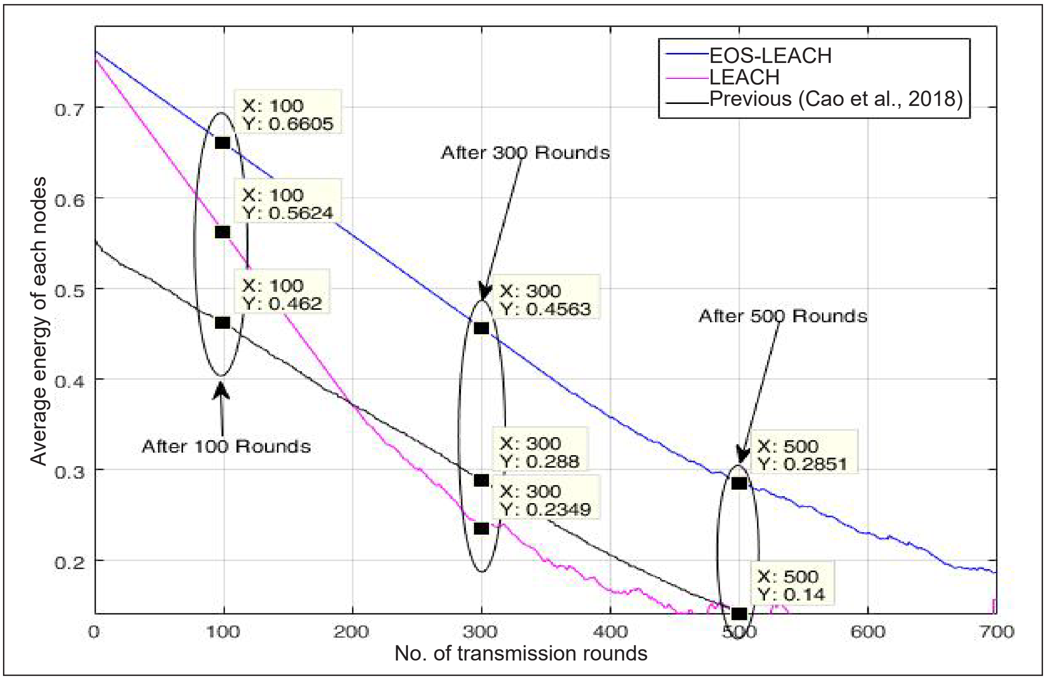

Figure 8. Residual energy vs. transmission rounds

Table 3
Average energy comparison after different 100, 300, and 500 rounds (Figure 8)

Trans. Rounds	Previous (Cao and Zhang, 2018)	Standard LEACH Routing	Even Odd Scheduling (Proposed) Routing
100	0.462	0.562	0.660
300	0.288	0.234	0.456
500	0.141	0.140	0.285

Figure 9 shows the throughput proposed algorithm for up to 700 rounds in packets sent to the base station. Figure 10 shows the cluster headcounts per transmission round for up to 700 rounds. Table 4 shows the Throughput comparison after 100, 300, and 500 rounds. Figure 10 shows the cluster headcounts per transmission round for up to 700 rounds.

Figure 11 shows how the sensor node is dead while the network is active; as one can see, the first node was dead after 323 transmission rounds for previous work and 43 rounds for LEACH and 366 rounds for EOS-LEACH. It clearly shows how efficient the algorithm is; it keeps the network activity with full strength up to 366 rounds.

Similarly, the 10^{th} node was dead after 390 transmission rounds for previous work and 252 rounds for LEACH, and 459 rounds for EOS-LEACH. Here is also a big difference of 69 rounds for nodes dead. When 146^{th} node dead, previous work has 500 rounds, LEACH has 314 rounds, and EOS-LEACH has 597 rounds. The round difference is 97, which is

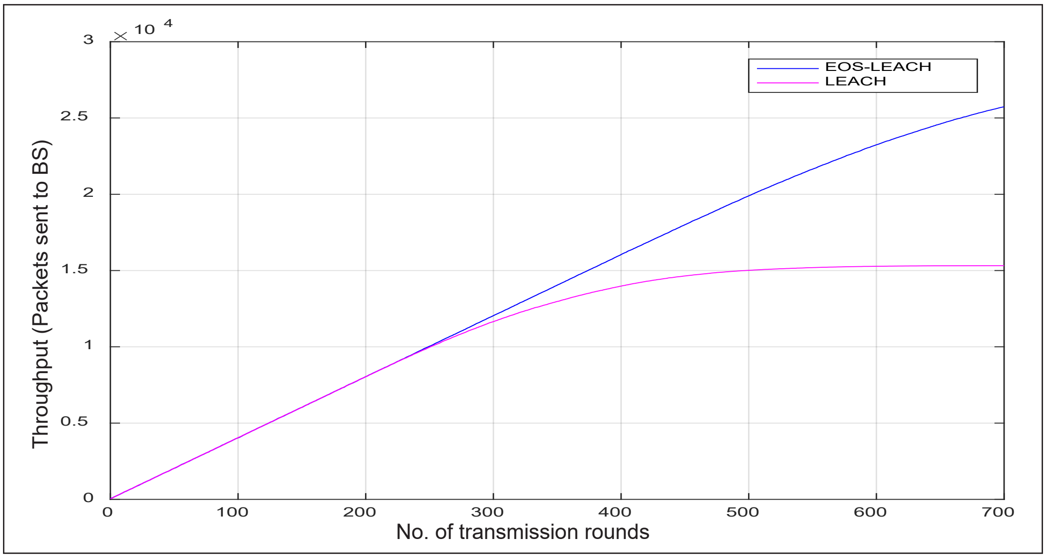

Figure 9. Throughput of the network

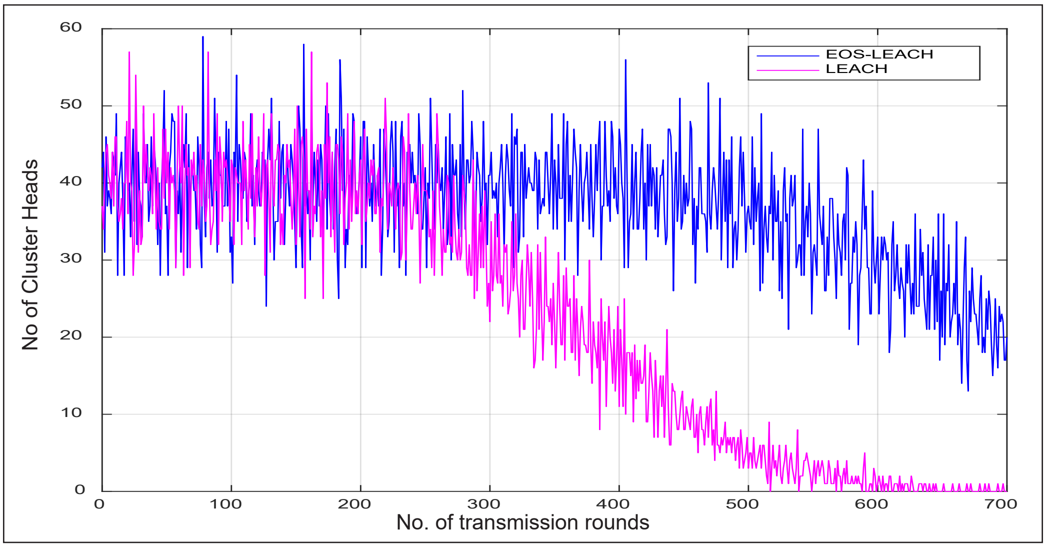

Figure 10. Cluster head counts vs. transmission rounds

Table 4
Throughput comparison after different 100, 300, and 500 rounds (Figure 9)

Trans. Rounds	Previous (Cao and Zhang, 2018)	Standard LEACH Routing	Even Odd Scheduling (Proposed) Routing
100	Not Available	0.403×10^4	0.403×10^4
300	Not Available	1.177×10^4	1.204×10^4
500	Not Available	1.542×10^4	1.984×10^4
700	Not Available	1.584×10^4	2.562×10^4

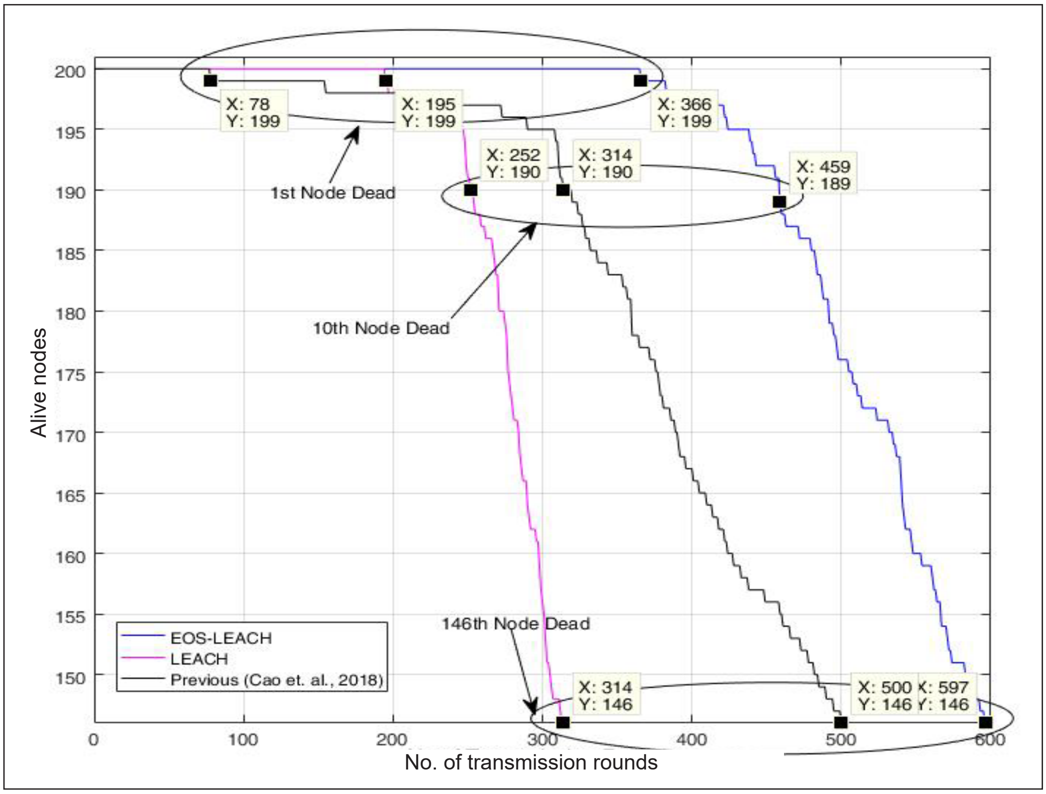

Figure 11. Details of first, tent hand 146th node dead

the positive sign of the proposed algorithm. Table 5 shows the Statistics of dead nodes on transmission rounds.

Figure 12 shows the remaining dead node statistics until the network is fully dead. Figure 12 shows statistics for LEACH and EOS-LEACH because statistics for previous work are not available. Here the proposed routing algorithm works till 1697 rounds which is a much longer network lifetime than various routing protocols. A comparison for network lifetime is shown in Table 6. Furthermore, since the proposed routing protocol works on the principles of even-odd scheduling and alternatively considers nodes in the queue and

Table 5
Statistics of dead nodes on transmission rounds (Figures 11 and 12)

Node Dead	Previous (Cao and Zhang, 2018)	Standard LEACH Routing	Even Odd Scheduling (Proposed) Routing
First	323	195	366
Tenth	390	252	459
50%	-	387	717
All	-	803	1697

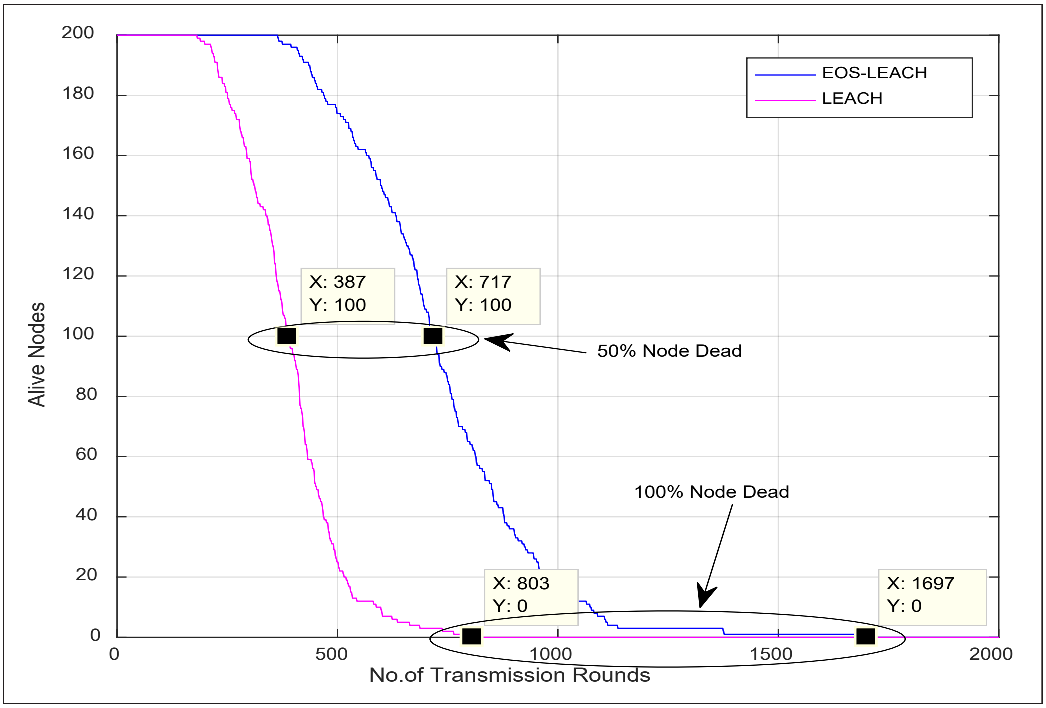

Figure 12. Statistics of dead nodes 50% and 100%

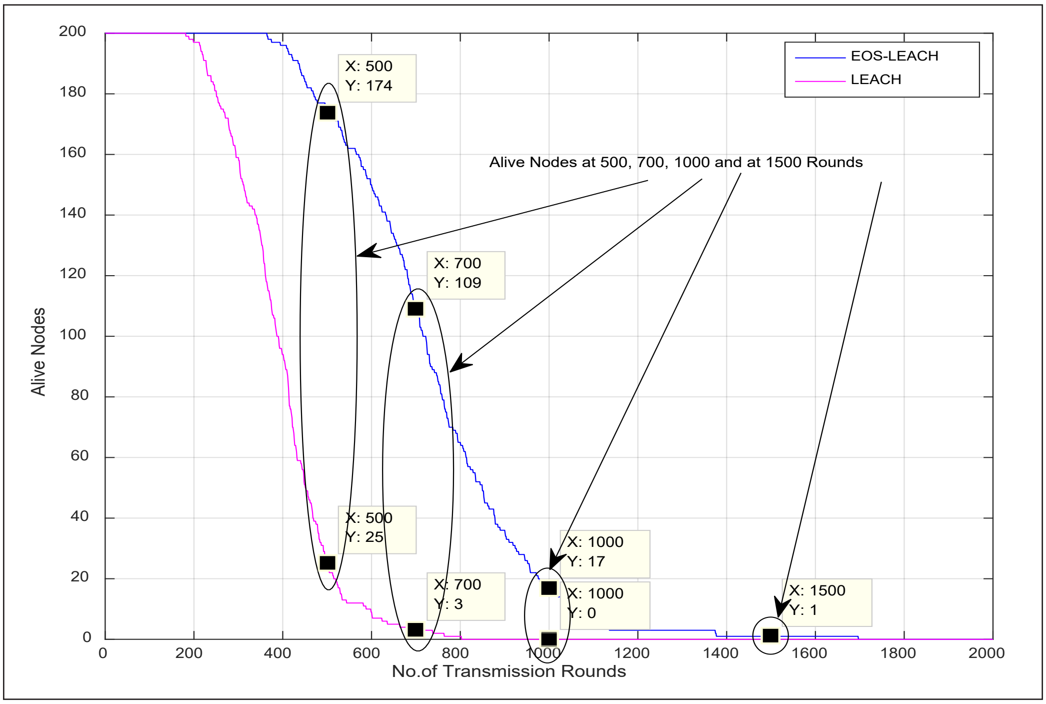

Figure 13. Statistics of alive nodes on different transmission rounds

Table 6
Alive nodes comparison up to 2000 rounds (Figures 7 and 8)

Trans. Rounds	Previous (Cao and Zhang, 2018)	Standard LEACH Routing	Even Odd Scheduling (Proposed) Routing
100	200	200	200
300	200	156	200
500	147	25	176
700	-	3	109
1000	-	0	17
1500	-	0	1

are ready to transmit data; therefore, the rest of the nodes remain in sleep and consume very less energy. Due to this reason, the nodes, which are not ready to transmit data, save energy and increase the lifetime of the whole network.

CONCLUSION AND FUTURE SCOPE

In this research, work an optimal, even odd scheduling algorithm-based routing protocol for WSN has been proposed. Out of every one of these models, clustering is most appropriate for WSN due to its highlights, for example, adaptability, robustness, versatility, and energy effectiveness. The main objective of this work is to design an effective energy organization scheme to attain the intended goals, lifetime permanence, and the preferred amount of data delivered. The performance of the proposed algorithm has been verified based on simulation in MATLAB. The results network lifetime is 1697 transmission rounds with the given parameters; these parameters are taken per previous work in Cao and Zhang (2018). Results contain the alive nodes vs. transmission rounds in reference to previous work in Cao and Zhang (2018) network start with dead node 323 rounds onwards where EOS-LEACH starts losing sensor nodes 366 onwards, which is 43 higher rounds than previous in Cao and Zhang (2018) work. Throughput also has the optimal value of 2.562 x 10^4 on 700 rounds. The average node energy for EOS-LEACH is higher than the previous work in Cao and Zhang (2018), i.e., 0.6605 against 0.462 respectively after 100 rounds, 0.4563 and 0.2349 after 300 rounds, 0.2851 and 0.140 after 500 rounds respectively.

The simulation and result analysis verify that this routing algorithm makes this work more appropriate has achieved its research objectives of a longer lifetime, average energy, and throughput. Even though the algorithm designed in this examination shows huge enhancements for energy conservation in WSN, it is accepted that there is still an opportunity to get better, and these feature future research opportunities. In the upcoming era, various scopes are there to work towards data fusion (data aggregation energy), probability of election and other energy-consuming parameters.

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REFERENCES

Akila, V., & Sheela, T., (2017). Preserving data and key privacy in data aggregation for wireless sensor networks. In *2017 2nd International Conference on Computing and Communications Technologies (ICCCT)* (pp. 282-287). IEEE Publishing. https://doi.org/10.1109/ICCCT2.2017.7972286

Basavaraj, G. N., & Jaidhar, C. D. (2017). H-LEACH protocol with modified cluster head selection for WSN. In *2017 International Conference on Smart Technologies for Smart Nation (SmartTechCon)* (pp. 30-33). IEEE Publishing. https://doi.org/10.1109/SmartTechCon.2017.8358338

Cao, Y., & Zhang, L. (2018). Energy optimization protocol of heterogeneous WSN based on node energy. In *2018 IEEE 3rd International Conference on Cloud Computing and Big Data Analysis (ICCCBDA)* (pp. 495-499). IEEE Publishing. https://doi.org/10.1109/ICCCBDA.2018.8386566

Cao, Y., & Zhang, L. (2018). Energy optimization protocol of heterogeneous WSN based on node energy. In *2018 IEEE 3rd International Conference on Cloud Computing and Big Data Analysis (ICCCBDA)* (pp. 495-499). IEEE Publishing. https://doi.org/10.1109/ICCCBDA.2018.8386566

Chowdhury, M. M. J., Sadi, S. H., & Sabuj, S. R. (2018). An analytical study of single and two-slope model in wireless sensor networks. In *2018 IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS)* (pp. 1-6). IEEE Publishing. https://doi.org/10.1109/ANTS.2018.8710109

Gupta, S. K., Kuila, P., & Jana, P. K. (2016). Energy efficient multipath routing for wireless sensor networks: A genetic algorithm approach. In *2016 International Conference on Advances in Computing, Communications and Informatics (ICACCI)* (pp. 1735-1740). IEEE Publishing. https://doi.org/10.1109/ICACCI.2016.7732298

Karmaker, A., Hasan, M. M., Moni, S. S., & Alam, M. S. (2016). An efficient cluster head selection strategy for provisioning fairness in wireless sensor networks. In *2016 IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE)* (pp. 217-220). IEEE Publishing. https://doi.org/10.1109/WIECON-ECE.2016.8009121

Kavya, B., Vani, V., & Roopa, H. (2020). Efficient cluster head rotation based on residual energy to extend network lifetime. In *2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA)* (pp. 774-777). IEEE Publishing. https://doi.org/10.1109/ICIRCA48905.2020.9182843

Kumar, H., Nagarjun, E., & Kumar, S. M. D. (2019). EASM: Energy-aware sink mobility algorithm to prolong network lifetime in WSN. In *2019 IEEE 16th India Council International Conference (INDICON)* (pp. 1-4). IEEE Publishing. https://doi.org/10.1109/INDICON47234.2019.9029040

Mahajan, S., & Banga, V. K. (2015). ICBEENISH: Inter cluster data aggregation balanced energy efficient network integrated super heterogeneous protocol for wireless sensor networks. In *2015 Twelfth International Conference on Wireless and Optical Communications Networks (WOCN)* (pp. 1-5). IEEE Publishing. https://doi.org/10.1109/WOCN.2015.8064507

Manzoor, K., Jokhio, S. H., Khanzada, T. J., & Jokhio, I. A. (2019). Enhanced TL-LEACH routing protocol for large-scale WSN applications. In *2019 Cybersecurity and Cyberforensics Conference (CCC)* (pp. 35-39). IEEE Publishing. https://doi.org/10.1109/CCC.2019.00-12

Pushpalatha, D. V., & Nayak, P. (2015). A clustering algorithm for WSN to optimize the network lifetime using type-2 fuzzy logic model. In *2015 3rd International Conference on Artificial Intelligence, Modelling and Simulation (AIMS)* (pp. 53-58). IEEE Publishing. https://doi.org/10.1109/AIMS.2015.19

Sengar, C. S., Venugopal, K. R., Iyengar, S. S., & Patnaik, L. M. (2016). RRDVCR: Real-time reliable data delivery based on virtual coordinating routing for Wireless Sensor Networks. In *2016 2nd IEEE International Conference on Computer and Communications (ICCC)* (pp. 2227-2234). IEEE Publishing. https://doi.org/10.1109/CompComm.2016.7925096

Shangyang, H., Jianjian, W., & Zexuan, S. (2018). An improved wireless sensor network for natural gas monitoring. In *2018 Chinese Automation Congress (CAC)* (pp. 2542-2547). IEEE Publishing. https://doi.org/10.1109/CAC.2018.8623622

Sun, B., Ma, C., Jin, X., & Ma, Z. (2016). Data aggregation scheme based on compressive sensing in wireless sensor network. In *2016 9th International Symposium on Computational Intelligence and Design (ISCID)* (pp. 453-456). IEEE Publishing. https://doi.org/10.1109/ISCID.2016.2112

Sun, X., Yu, J., & Song, T. (2016). Data aggregation scheduling in wireless sensor networks under SINR. In *2016 International Conference on Identification, Information and Knowledge in the Internet of Things (IIKI)* (pp. 202-207). IEEE Publishing. https://doi.org/10.1109/IIKI.2016.66

Yan, A., & Wang, B. (2017). An adaptive WSN clustering scheme based on neighborhood energy level. In *2017 IEEE 3rd Information Technology and Mechatronics Engineering Conference (ITOEC)* (pp. 1170-1173). IEEE Publishing. https://doi.org/10.1109/ITOEC.2017.8122540