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Enlightening Network Lifetime based on Dynamic Time Orient Energy Optimization in Wireless Sensor Network

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Abstract— Mobile Ad-hoc Networks (MANET) are a set of Large-scale infrastructure and mobile device networks that build themselves without centralized control to provide various services through mobile. However, the quality of service of MANET is highly dependent on multiple parameters. Many routing schemes in literature use hop count, mobility speed, direction, etc. Similarly, the flow-based approach chooses long routes, which increases latency and reduces throughput efficiency. However, not all methods work well with all Quality of Service (QoS) parameters. To introduce a Dynamic Time Orient Energy Optimization (DTOEO) algorithm to construct the energy-based tree formation to achieve the minimum energy consumption network. Energy-based Dynamic Tree Routing to provide higher energy node and shortest route estimation that help to better transmission quality. In this proposed DTOEO method, perform three stages, there are i). Source node discovery process, ii). Time-orient density estimation, and iii). Energy-based Dynamic Tree Routing. In this stage, orient density estimation evaluates the data transmission size for each window period. To assess the consuming energy in the overall network. The proposed method of performance evaluation using various QoS matrices and its comparison to the existing process provides better performance.

Keywords- MANET; Energy optimization; DTOEO; Dynamic tree routing; Time orient routing; QoS; Lifetime improvement.

I. INTRODUCTION

MANET nodes are prone to random movement due to frequent changes in network topology. Each node acts as a router when it sends traffic to specific other nodes in the network. MANETs can operate independently or as part of the wider Internet. They use one or more different transceivers between their nodes to form highly dynamic autonomous topologies. MANET's primary challenge is to provide each device with the information it needs to be consistent and route traffic appropriately. MANET consists of peer-to-peer, self-generating, and self-healing networks

In most cases, these gadgets can detect wonders that are not physical, process (preliminary) coarse data, provide data, and prepare by hubs adjacent to them. Inspection centers can form MANETs either by special appointments or, for example, group-related designs. Routing protocols specify how routers communicate with each other to distribute information for routing among nodes on a network. Routers perform traffic control functions over the Internet. Data packets travel across the Internet between routers until they reach their destination at the computer. The routing algorithm determines the specific routing. The sink hub can question some of the behavior of the data & detector hub's time command. The data is often a unidirectional overflow from the detector hub drop. Similar areas allow wireless sensor networks to monitor air pollution deployed in some cities to monitor dangerous gas citizens' concentration. When the fire is started, the MANET can be used for control for forest fire detection.

Time-oriented parameter estimation techniques for rapid data collection with energy-efficient routing and time-based wireless sensor network energy management. It uses a large part of the data communication network and the total power coefficient between the sensor nodes. An effective data collection technique in this field can significantly help us reduce energy consumption. The issue of energy maximization in wireless sensor networks (MANETs) has been well studied. The researchers describe many methods to solve this problem but need help to achieve higher

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performance. To increase the life of a wireless sensor network, we need an energy-efficient routing solution. Saving clustering and maximizing the network life cycle is the biggest challenge for wireless sensor networks.

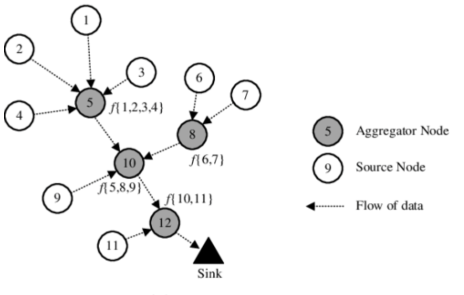

Figure 1. MANET data flow and path routing

Fig. 1 depicts the MANET data flow and path routing. Optimized Link State Routing (OLSR) is an IP routing protocol developed for MANET and other wireless ad-hoc networks. OLSR is an active link-state routing protocol that uses Hello and Topology Control (TC) messages to discover and disseminate link-state information in a MANET. A node uses this topology information to calculate the next-hop destinations of all the nodes in the network and uses the shortest hop forwarding path. As a proactive protocol, routes to all destinations on the web are known and maintained before being used. Depending on your computer or network usage, the available routes in the standard routing table may be helpful. This is because there is no path discovery delay associated with discovering new paths. While generally more critical than reactive protocols, the routing overhead remains the same with the number of routes created.

Wireless Sensor Networks (WSN) are a significant challenge with limited computing, energy, and memory resources to achieve efficient routing. Clustering technology plays a vital role in WSNs, enabling energy-efficient routing schemes to increase networks' life cycles. Since then, much of the work at MANET has been related to energy efficiency for various applications and systems. Simultaneously, different energy-saving routing protocols are designed to improve wireless sensor networks' energy efficiency. Therefore, each energy-saving routing protocol can have characteristics that depend on a particular application and network architecture.

WSNs include many autonomous sensor nodes used in various physical and environmental conditions to sense the limited battery and computing power. In the last few days, wireless sensor networks have had effective mechanisms for improving networks' energy efficiency needed for complete data transmission. Wireless sensor networks are a vital challenge for real-time applications that optimize energy consumption. Dynamic anonymous nodes modify the network topology of the wireless sensor network. Routing protocols play a crucial role in WSN, maintaining routes and ensuring reliable communication. The solution suggests that collecting information needs to discover the finest path to minimize the cost of exchanging information nearby. It offers a better energy consumption solution and latency and is improved for the amount of forwarding hop packets on the sink node. These sensor nodes are used as autonomous devices and can be deployed in different environments. The sender node sends the observation data to the sink node from the sudden changes in the field and the observation data. Observational environmental conditions depend on a continuous method in which the observed data have a specific correlation.

II. RELATED WORK

Consider configuring a TDMA-based radio energy harvesting sensor network (WEHSN) [1] with two-time slots. The first is to use, and the second is to transmit data from the sensors and absorb energy. The study describes an efficient, power-aware multipath routing protocol for MANETs. The suggested EPAM-AODV method utilizes received power, transmission distance, and the number of hops when request packets are received during path discovery.

The on-time EH sensor will transmit its data parameters and transmissions if the amount of energy it collects exceeds the energy consumption allocated for adequate resources. A Wireless Powered Sensor Network (WPSN) obtains power from a Hybrid Access Point (H-AP). Then it sends data to the H-AP via a sensor with no orthogonal multiple access (NOMA) methods [2]. The Wireless Portable Charger (WPCD) is an immortal node of all these questions about MANET drift and pricing. This article [3] uses optimized multipurpose functions to charge WPCD traces, and self-learning algorithms are used for general data routing. The objective function we have developed can optimize fair energy consumption and maximize WPCD routing efficiency. A data gathering plan based on autoencoder [4] denoising was introduced to resolve the overhead challenges. In the data training phase, a DAE is trained to calculate the data rebuild matrix using the data measurement matrix and historical sensitivity data.

Simultaneous radio information and power transmission (SWIPT) Using the same radio frequency signal, [5] transmit information and power radio node. The energy perceives information in the route search process in the Petal Spider-Ant Routing (PSAR) distribution process and links the energy in the distributed algorithm. Large-scale zero-energy connected analysis model cluster WPSN [6] provides two typical transmission schemes under unicast and

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broadcast. The resource allocation (ResAll) algorithm is designed to consider the different power allocation capabilities of the relay via [7] in two cases: In the first case, the repeater's power is divided into successive power groups and flows with a random power division ratio. Solve the Energy Efficiency (EE) optimization problem to maximize WBAN with the proposed [8] and a sensor node (SNS) with energy harvesting capabilities to communicate with the aggregator. The proposed energy-efficient routing mechanism [9] is EE-integrated routing for heterogeneous wireless sensor networks.

This paper [10] considers a cluster-based MANET where random differences are realistic in random early energy and data generation rate. The sensor node model is suitable for multi-sensor applications. The character put the scheme's energy model and presented a Transport and Energy-Aware Routing (TEAR) system to increase the solidity period. This paper [11] Key issues in the framework of essential optical noise sources and range estimation cause Seawater channel damage. Optical radio sensor networks receive signal strength (RSS) converted to underwater energy harvest. If they are elected to the cluster head, the remaining non-elected nodes [12] will retain some of the collected energy used by them. As a result, cluster head nodes can no longer survive with the energy collected by the preparation—route data from the cluster head node to the receiver via the shortest available route. The network node-level collaboration has been proposed based on a multi-sensing strategy [13] to improve energy efficiency. Spatial proximity for the former application Nodes with active sensors (obtained from MS) to reduce further functional sensor sleeves, the latter using inter-correlation between parameters observed at each node.

Mean Squared Error (MSE) [14] is used for channel-based opportunity transmission schemes, namely, two essential classifications of censorship and order transmission to present the lower bound. For the latter, we propose that the emergence of EH sensor node battery energy depends on whether the two new variants are pre-ordered. An experimental test has identified the main components [15], and two methods have been proposed. The first proposed method is for a more efficient calculation of the energy consumed by nodes in various broadcast states. To improve lifespan and provide energy-saving MANET, a new technique called PSAR is used in the WSN transmission model [16] to propose a method. The state of one node is changed during the dynamic PSAR data set, and each node adapts to the new state based on the content of the detected data packet. The mixture's nature derives primarily from a continuous physical process, the node battery charge/discharge combination. Still, the discrete portion is associated with changes in operating mode and the node's inaccessibility [17]. The study presented using E-BEENISH [18] analyzes the Energy Consumption (EC) of a wide range of energy levels in cluster communications and heterogeneous wireless sensor networks.

All the above-discussed approaches have the problem of energy depletion and latency, which has to be reduced to maximize the sensor nodes' lifetime and energy.

III. IMPLEMENTATION OF PROPOSED DYNAMIC TIME ORIENT ENERGY OPTIMIZATION (DTOEO)

The DTOEO algorithm estimates node density and energy estimation in this proposed method. The strategy selects a list of nodes with the correct information and essential data for each time window. The technique determines a small arrangement of sensor nodes when looking at individual nodes.

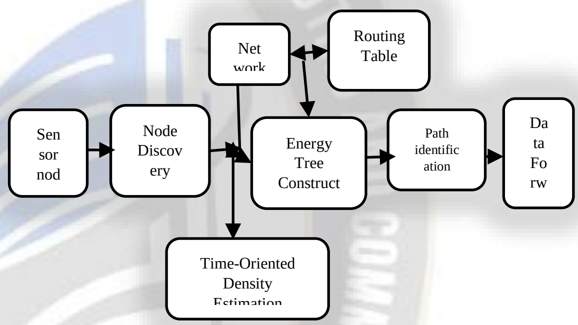

Figure 2. Proposed method block diagram

Fig. 2 represents the proposed method function block diagram. The first stage is constructing the topology network and discovering the node location. To find each node data transmission time window and energy usage with time-oriented density estimation. The node values are traced, and the details of each piece of information are stored in the network trace file. After that, to identify the path and energy-based routing to forward the data.

A. Source Node Discovery

Node startup and data obtained from various sensors assume that any network source detection information is practical. The wireless sensor terminals have limited power, and the computer receives information as soon as the terminals are fitted using the information output message request. The sink gets the message to start with the hub and finds solutions from each structure's node. Eliminates the contraction of the hub nodes from the appropriate response. Information notification enhances the message about the subject matter or neighbors by receiving the request message. Algorithm steps:

Input: PacketP_i, Neighbor TableN_{table}, Route Table R_{table}
Output: Source node discover
Start function
Initialize the node list as nlst and construct the node
Read incoming packetP_i.
Create Ndr Message.
PLRR = {Source, Destination, PID}
Transmission of PLRR message in the network.
While (i<=n) // i denotes iteration and n number of nodes in the network
The intermediary node obtains packet PLRR.
If $\int_{i=1}^{size(NT)} NT(i) == NDrDestination$ Then
Generate Ndr. Message.
PLRREP = { $\sum^{(Routes \in PNdr)} \cup \{Location, Energy, Speed, Direction, NN, Traffic, Flow\}$
Forward the P_i to the source
Else
Forward Ndr to its neighbors
End
If P.Type==Ndr then
Extract routes and statistics from the reply and update the routing table.
$R_{table} = \int_{i=1}^{size(PLRREP)} \sum(Routes \in R_{table}) \cup \sum Nodes(R\{Location, Energy, Speed, Direction, NN, Traffic, Flow\})$
End
End
Stop function

When all the appropriate responses are obtained, the method removes the summary of nodes, and the sink assembles the course information from the appropriate response being got.

B. Time orient density estimation

The sink center point performs the density estimation at each time interval. A density estimation technique is the number of small parts into parts, and each area must be surveyed to achieve the run geographic domain. The method of separating the courses' strategy is used to aggregate the data from the structure made in the last data collection. This method calculates the average hop number and the average delay in collecting data using the data density score.

Algorithm steps:
Input: node list nlst, Network Trace file ntr, geographic information Gi
Output: node density and energy estimation.
Start
To find the node geographic location details, Gi(n)
Gi(n) =$\sum_{x=1}^{n} get(lan * lat(n_x))$
For node list nlst, each Gi(n)
Estimate the sensor data s_d
$s_d = \sum nlst(i) * Gi(n) \in da$
To estimate the trace file each time window (T) // ti = time
Trace bandwidth = $\sum_{i=1}^{ti} \sum trace(ti) \in ntr$
For each time window ti from trace T
Compute the density (ds) and energy (En)
ds = $\sum_{j=1}^{T} \sum \frac{payload(T \in ti(j))}{number\ of\ trace\ at\ T(j)} X\ total\ sensor\ node$
En = $\sum_{k=1}^{p} \frac{transmit\ p(k) * En(p)}{total\ En}$ // p= packet
End
End

Both steps are calculated to be carried out at the chamber's node at the final stage of the data collection process.

C. Hop intensive probabilistic Link stability rate

The Probabilistic Link Availability (PLA) metric is used for routing in MANET. When doing routing information, they are identified by their approximate network topology, and their status is monitored. Any method can be as subjective as a link failure, which causes the movement of the intermediate node to another location at any time. Such link failures introduce route discovery and increase frequencies. It can be used as a backup route for continuous data transmission and does not significantly degrade performance. Therefore, it is necessary to consider the availability of links on any route in the event of a link failure. It is measured according to public hops present on any route. First, this method calculates the identification routes and their respective lists, and the method calculates the hop similarity measured based on the similarity of the routes to their intermediate nodes. According to this, this method calculates the PLA value for routes that are different from the table.

Input: Route TableR_{table}, Probabilistic Route Table PRT
Output: PLA
Start
ReadR_{table}, PRT
For each route R from R_{table}
For each other route PRT
Compute the number of hops of R and PR.
NhR = $\int \sum Hops \in R$
NhPR = $\int \sum Hops \in PR$

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Estimate common hops NCh = $\int \sum Hops(R) \in PR$

Estimate Hop-based route similarity HORS.

HORS = $\frac{NCH}{NhPR} \times \mu$ // μ=0.8 if NCH>3/4 of hop count of R else μ=0.6 if NCH>2/3 //of hop count of R else μ=0.2

End

Estimate Probabilistic Link Availability PLA.

PLA = $\frac{\sum_{i=1}^{Size(R_{table})} HORS}{size(R_{table})}$

End

Stop

The probabilistic link availability estimation algorithm provides random link availability measurements. This method estimates the PLA value for different route selections.

D. Energy-based Dynamic Tree Routing

The energy depletion-based Dynamic Tree framework enrollment considers the data usage for each that is apparent at the initial stage. The node technique selects the bio utility handle using the time it takes to organize the density estimate and defer the time formula rating components when sending data. The proposed technique designs the pocket and energy consumption scale to access each data, which informs the sensor centers at the focal point. At this point, from the source node taken at the last energy and density, the demand is exchanged to each neighbor node. The sensible sensors send the request to complete the data sensor. The data sensor responds with the latest data accessible towards the sink.

Algorithm steps

Input: density score, energy value, node list.

For each node list from Route Rn

Identify the node location with the help of node discovery

Identify the node density score of each node Density = data (bandwidth rate)

To evaluate the delay estimation, each neighbor node from the routing table list

Delay = $\sum_{n=1}^{rreq} node\ (i)[rreq] \rightarrow node\ (i+1) * t$

To estimate the number of hubs

$NH_n = \sum hops \in rreq(node(i))$

To estimate the transmitted energy

$E_n = \frac{Delay(i)}{NH_n} X \frac{Density\ (i)}{NH_n} X\mu$ //μ = threshold energy value each transmission

End

The technique finds accessible transmit nodes per the structure's topographical status. The framework utilizes a comprehended AODV protocol revelation strategy to the open transmission port. The system makes disclosure ask for by sending the packet to ask for assign is performed on request. Additionally, the sink requests an answer, and when a suitable reaction is being gotten from the neighbor focus, the sink deals with the node as the hop number appears.

VI. RESULT AND DISCUSSION

The proposed Dynamic Time Orient Energy Optimization (DTOEO) algorithm has been effected using an NS version 2 tool. The speed of the mobile nodes is taken as 5 m/s, 10 m/s, and 20 m/s. The mobility model for the nodes in the network follows the random waypoint model. The Constant Bit Rate (CBR) sessions for each topology are considered 20, and the data rates are regarded as 0.5 p/sec, 1 p/sec, and 2 p/sec. This research has been evaluated for its performance in various parameters. The results produced by the proposed DTOEO technique compared with other methods like Content-based Adaptive and Dynamic Scheduling (PSAR) and Spanning Hyper-graph Tree (SHT) methods.

TABLE. 1. SIMULATION PARAMETERS

Parameters	Values
Simulation area	1200X1200m
Number of nodes	80
Traffic	Constant Bit Rate
Simulation time	8minutes
Deployment	Randomly
Communication	wireless

The multi-parameter performance of the proposed method was evaluated under different simulation conditions. Thus, simulation results are presented below.

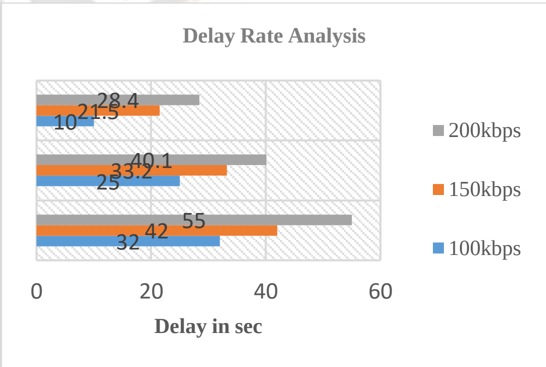

Figure 3. Delay analysis of the proposed method

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Fig. 3 describes the analysis of the delay comparison proposed and the existing method. The existing SHT has a 55sec for 200kbps size of the packet, PSAR has a 40.1sec higher delay, and the proposed DTOEO has a 28.4sec for 200kbps less delay.

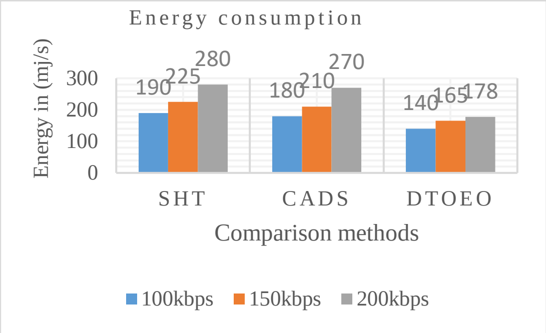

Figure 4. Energy consumption rate analysis

The current SHT is 280mj/s seconds per 200 kbps packet, the PSAR has a maximum energy of 270mj/s, and the proposed DTOEO has 178mj/s minimum energy consumption. Figure 4 above describes the proposed DTOEO and existing PSAR and SHT methods of energy consumption comparison.

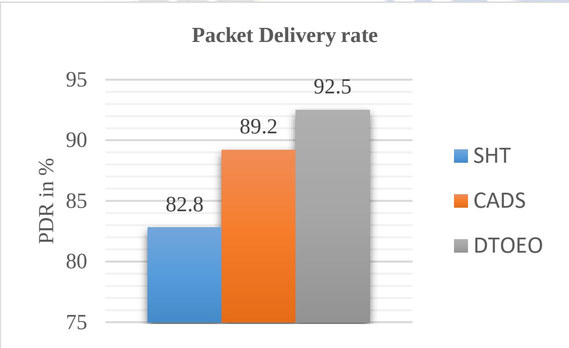

Figure 5. Packet Delivery rate analysis

This proposed method of packet delivery ratio in the proposed comparison graph is presented in Fig. 5. In this analysis, the packet delivery rate of the proposed method DTOEO has been 92.5% or better result compared to existing methods SHT and PSAR. Similarly, the existing techniques have 89.2% and 82.8% of the lower packet delivery rate.

TABLE 2. ROUTING PERFORMANCE ANALYSIS

Routing In %			
Time in sec	**SHT**	**PSAR**	**DTOEO**
120	12	16	18
140	18	20	25
160	30	33	47
180	64	70	79
200	71	80	92

Table 2 and Fig. 6 compare routing performance in the proposed DEOT existing method SHT, PSAR.

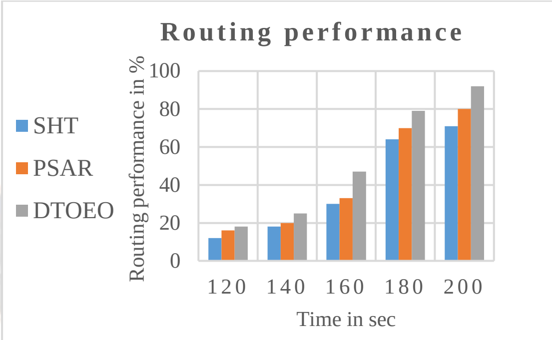

Figure 6. Analysis of routing performance

This analysis result proposed that DTOEO provides a 92% higher routing than the existing method. The result analysis takes different time sequences 120, 140, 160, 180 seconds, 18%, 25%, 47%, and 79% routing ratio. In this existing method, PSAR provides 80% of the routing packet and 71% of delivering an SHT method.

V. CONCLUSION

The method proposed here, the sensor nodes' to increase energy efficiency, reduce computational complexity, and select the best way to increase the life cycle of network routing, provides useful. This proposed Dynamic Time Orient Energy Optimization (DTOEO) method to achieve a better energy management network than the existing process. In Time orient density estimation to evaluate each node's transmission data bandwidth and energy. The Energy-based Dynamic Tree Routing to find the higher energy route when the energy reduces on a path dynamically forwards another possible route to achieve low data delay over the network. In this method, the overall performance analysis of the proposed DTOEO is 92% routing performance with 28.4m/j of energy consumption compared to the existing method.

REFERENCES

[1]. H. Azarhava, and J. Musevi Niya, "Energy Efficient Resource Allocation in Wireless Energy Harvesting Sensor Networks," in IEEE Wireless Communications Letters, vol. 9, no. 7, July 2020, pp. 1000-1003, doi: 10.1109/LWC.2020.2978049.

[2]. M. Song, and M. Zheng, "Energy Efficiency Optimization For Wireless Powered Sensor Networks With Nonorthogonal Multiple Access," in IEEE Sensors Letters, vol. 2, no. 1, March 2018, pp. 1-4, Art no. 7500304, doi: 10.1109/LSENS.2018.2792454.

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[3]. N. Aslam, K. Xia, and M. Hadi, "Optimal Wireless Charging Inclusive of Intellectual Routing Based on SARSA Learning in Renewable Wireless Sensor Networks," in IEEE Sensors Journal, vol. 19, no. 18, Sept.15, 2019 pp. 8340-8351, 15 doi: 10.1109/JSEN.2019.2918865.

[4]. G. Li, S. Peng, C. Wang, J. Niu, and Y. Yuan, "An energy-efficient data collection scheme using denoising autoencoder in wireless sensor networks," in Tsinghua Science and Technology, vol. 24, no. 1, Feb. 2019, pp. 86-96, DOI: 10.26599/TST.2018.9010002.

[5]. S. He, K. Xie, W. Chen, D. Zhang, and J. Wen, "Energy-Aware Routing for SWIPT in Multi-Hop Energy-Constrained Wireless Network," in IEEE Access, vol. 6, 2018, pp. 17996-18008, doi: 10.1109/ACCESS.2018.2820093.

[6]. P. Mekikis, E. Kartsakli, A. Antonopoulos, L. Alonso, and C. Verikoukis, "Connectivity Analysis in Clustered Wireless Sensor Networks Powered by Solar Energy," in IEEE Transactions on Wireless Communications, vol. 17, no. 4, April 2018, pp. 2389-2401, doi: 10.1109/TWC.2018.2794963.

[7]. S. Guo, Y. Shi, Y. Yang, and B. Xiao, "Energy Efficiency Maximization in Mobile Wireless Energy Harvesting Sensor Networks," in IEEE Transactions on Mobile Computing, vol. 17, no. 7, 1 July 2018, pp. 1524-1537, doi: 10.1109/TMC.2017.2773067.

[8]. O. Amjad, E. Bedeer, and S. Ikki, "Energy-Efficiency Maximization of Self-Sustained Wireless Body Area Sensor Networks," in IEEE Sensors Letters, vol. 3, no. 12, Dec. 2019, pp. 1-4, Art no. 7501204, doi: 10.1109/LSENS.2019.2946851.

[9]. L. Hung, F. Leu, K. Tsai, and C. Ko, "Energy-Efficient Cooperative Routing Scheme for Heterogeneous Wireless Sensor Networks," in IEEE Access, vol. 8, 2020, pp. 56321-56332, doi: 10.1109/ACCESS.2020.2980877.

[10]. D. Sharma, and A. Bhondekar, "Traffic and Energy Aware Routing for Heterogeneous Wireless Sensor Networks," in IEEE Communications Letters, vol. 22, no. 8, Aug. 2018, pp. 1608-1611, doi: 10.1109/LCOMM.2018.2841911.

[11]. N. Saeed, A. Celik, T. Al-Naffouri and M. Alouini, "Localization of Energy Harvesting Empowered Underwater Optical Wireless Sensor Networks," in IEEE Transactions on Wireless Communications, vol. 18, no. 5, May 2019, pp. 2652-2663, doi: 10.1109/TWC.2019.2906309.

[12]. J. Geoffrine, and V. Geetha, "Energy Optimization With Higher Information Quality for SHM Application in Wireless Sensor Networks," in IEEE Sensors Journal, vol. 19, no. 9, 1 May 1, 2019, pp. 3513-3520, doi: 10.1109/JSEN.2019.2892870.

[13]. V. Gupta, and S. De, "Collaborative Multi-Sensing in Energy Harvesting Wireless Sensor Networks," in IEEE Transactions on Signal and Information Processing over Networks, vol. 6, 2020, pp. 426-441, doi: 10.1109/TSIPN.2020.2995502.

[14]. S. Gupta and N. Mehta, "Revisiting Effectiveness of Energy Conserving Opportunistic Transmission Schemes in Energy Harvesting Wireless Sensor Networks," in IEEE Transactions on Communications, vol. 67, no. 4, April 2019, pp. 2968-2980,doi: 10.1109/TCOMM.2018.2889331.

[15]. H. Ayadi, A. Zouinkhi, T. Val, A. van den Bossche and M. Abdelkrim, "Network Lifetime Management in Wireless Sensor Networks," in IEEE Sensors Journal, vol. 18, no. 15, Aug.1, 2018, pp. 6438-6445, doi: 10.1109/JSEN.2018.2840830.

[16]. M. Khan et al., "Improving Energy Efficiency With Content-Based Adaptive and Dynamic Scheduling in Wireless Sensor Networks," in IEEE Access, vol. 8, 2020, pp. 176495-176520, doi: 10.1109/ACCESS.2020.3026939.

[17]. C. Albea Sanchez, O. Mokrenko, L. Zaccarian and S. Lesecq, "A Hybrid Control Law for Energy-Oriented Tasks Scheduling in Wireless Sensor Networks," in IEEE Transactions on Control Systems Technology, vol. 26, no. 6, Nov. 2018, pp. 1995-2007, doi: 10.1109/TCST.2017.2750999.

[18]. Y. Zhang, X. Zhang, S. Ning, J. Gao and Y. Liu, "Energy-Efficient Multilevel Heterogeneous Routing Protocol for Wireless Sensor Networks," in IEEE Access, vol. 7, 2019, pp. 55873-55884, doi: 10.1109/ACCESS.2019.2900742.