EFFECTIVE ROUTING PROTOCOL WITH OPTIMAL POSITIONING (ER-POP): AN ADAPTABLE APPROACH TO MINIMIZE ENERGY UTILIZATION IN WSN

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ABSTRACT

Due to the restricted battery capacity of sensor nodes, energy consumption is a significant concern in Wireless Sensor Networks (WSN). Increasing network longevity and guaranteeing dependable data transfer require optimizing energy use. Routing is a key factor in influencing the network's longevity and energy efficiency in Wireless Sensor Networks (WSNs). Monitoring energy consumption during routing guarantees optimal resource usage, extended network lifetime, and dependable data transfer because sensor nodes are usually battery-powered. Network partitioning will result from certain nodes using up their batteries more quickly if energy is not managed. By keeping an eye on energy levels, nodes' loads can be balanced, extending the network's lifespan. In Wireless Sensor Networks (WSNs), routing methods are essential for reliable data transfer, energy conservation, and network scalability. Since WSNs frequently function in resource-constrained settings, effective routing methods need to maximize bandwidth, energy consumption, and communication overhead. This paper focuses on suggesting a routing protocol that concentrates on minimizing energy consumption thereby prolonging the lifetime of the network. This paper proposes a new routing protocol Effective Routing Protocol with Optimal Positioning (ER-POP) that shows significant improvement in network lifetime, coverage and packet delivery.

Keywords: WSN, Energy, Routing, Protocol

I. INTRODUCTION

Networks of spatially dispersed autonomous sensors known as wireless sensor networks (WSNs) track and gather information on physical or environmental parameters like motion, pressure, temperature, humidity, and sound. Through wireless communication, these sensors provide data to a central point for analysis and processing. Sensor nodes often run on batteries, which can be challenging to replace or recharge, particularly in isolated or dangerous areas. To extend network lifetime, energy-efficient data processing, communication, and routing methods are needed. WSNs frequently have hundreds or thousands of nodes, which makes scalability, maintenance, and network deployment difficult. Managing connectivity, addressing, and data transfer is more difficult as the number of nodes rises. WSNs are susceptible to a number of security risks, including node capture, denial-of-service (DoS) attacks, and eavesdropping. Implementing robust authentication and encryption methods is challenging when computing power is limited. One of the main concerns is maintaining secure communication and safeguarding data integrity in hostile circumstances. The processing power, memory, and storage capacity of sensor nodes are limited. It is frequently impossible to run sophisticated algorithms for encryption and data processing. Data loss or inaccuracy may result from interference, node failures, or environmental factors. To increase data reliability, error correction methods and redundant data transmission are required. Nodes may relocate, malfunction, or become blocked in the dynamic contexts in which WSNs operate. It is difficult to maintain self-organizing network architectures and reliable communication channels. Real-time data transmission is necessary for certain applications, like industrial automation and healthcare monitoring. Performance may be impacted by delays brought on by processing time, congestion, or energy-saving techniques. Radio waves, Bluetooth, Wi-Fi, and other networks can interfere with wireless communication. Communication range can be shortened and messages weakened by environmental barriers like buildings and terrain. Robust and durable designs are necessary for large-scale WSNs deployed in difficult or distant areas (such as undersea, deserts, or battlefields). Self-healing methods are necessary because it is frequently impractical to replace or repair malfunctioning nodes.

The process of identifying effective routes for data transmission between sensor nodes and the base station (sink) is known as routing in Wireless Sensor Networks (WSNs). WSN routing protocols need to be scalable, dependable, and energy-efficient due to resource limitations such as limited computing power, bandwidth, and battery life. Most sensor nodes run on batteries, and changing the batteries is frequently not feasible. By minimizing pointless transmissions, efficient routing lowers energy usage and increases the network's lifespan. Multipath routing and cluster-based routing (like LEACH) aid in energy balance. Thousands of sensor nodes dispersed over wide regions can be found in WSNs. Even in big or dense networks, data flows smoothly thanks to proper routing. By lowering congestion, hierarchical routing methods aid in the management of big networks. Routing makes ensuring that, in spite of obstructions, interference, or node failures, data packets arrive at the base station accurately. The way data packets move from sensor nodes to the base station (sink) in Wireless Sensor Networks (WSNs) is determined by routing protocols. These protocols are made to maximize energy efficiency, provide dependable data transfer, and adjust to the changing needs of the network. WSNs function in unpredictably changing environments where nodes may malfunction as a result of physical damage or battery drain. Routing protocols divert data over alternate routes when they detect faults. The size of the network, energy limitations, and application needs all influence the protocol selection. This paper proposes a new methodology **EFFECTIVE ROUTING PROTOCOL WITH OPTIMAL POSITIONING (ER-POP)** which focuses on minimizing energy utilization during data transmission. The methodology works on four phases namely selection of gateways, tree construction, scheduling of nodes and data transmission.

II. LITERATURE REVIEW

[1] This study argues that optimum routing in sensor networks is not feasible. The authors suggest a practical guideline for uniform resource consumption, illustrated via an energy histogram. They understand that this is merely a starting step in addressing this complex issue. The DCE combining strategy cuts energy, while our spreading approaches distribute traffic more evenly. Although we started with GBR, our concepts and methodologies can be applied to improve other routing protocols. [2] This paper provides an up-to-date and analytical assessment of similar techniques. The traditional and modern protocols provided are classified based on i) network structure, ii) data interchange, iii) the usage of location information, and iv) the support for Quality of Service (QoS) or multiple pathways. Protocols are categorized and contrasted based on performance indicators, with discussion of pros and downsides. Finally, the study findings are examined, conclusions are taken, and open research questions are identified. [3] They suggest a method that uses the enhanced genetic algorithm to determine the smallest number of sensor nodes necessary to guarantee DPOI coverage. They suggest a novel adaptive clustering routing method that optimizes energy consumption based on the optimal node set. This method chooses the cluster head based on the sensor node's residual energy and distance from the base station, and it establishes the intra-cluster communication mode by taking the node space angle into account. It combines single-hop and multi-hop to determine the inter-cluster communication mechanism. We create a node wake-up scheme to activate the sleep node in order to replace the sensor nodes that run out of energy in order to properly utilize the network's energy. Their suggested technique may also be appropriate for the rechargeable WSN due to this regulation. Furthermore, they take into account the extra energy consumed for retransmission as a result of the unstable wireless channel. According to simulation results, their suggested approach clearly outperforms other current strategies in

terms of extending the lifetime of WSNs. [5] This paper uses the Particle Swarm Optimization (PSO) method to form the cluster and proposes a Fuzzy based Energy Efficient Routing Protocol (E-FEERP) that uses node density, energy, communication quality, and the average distance of SN from BS to optimally transmit data from the cluster head to the BS. In order to rapidly converge to the optimal solution with fewer iterations, the suggested methodology employed parallel fitness function computing. The protocol recognized the behavior of birds in a flock using a clustering technique based on PSO. It is an optimization technique that rapidly and efficiently reaches an optimal solution through the use of parallel fitness function computing. PSO and fuzzy are coupled to improve coverage while lowering computational overhead.

[5] This research proposes a hybrid sink-originating and dynamic clustering technique with routing. The suggested routing method helps identify the forwarder node and selects the CH based on each sensor node's node handling capacity. Additionally, when choosing a forwarder, the processing load of a sensor node is taken into account. Data from the clusters is gathered using both location and temporal correlation, and it is then combined to offer effective communication. Aggregation ratio, routing overhead, packet delivery percentage, throughput, packet latency, and energy consumption are the simulation parameters taken into account when evaluating the performance of the suggested algorithm. The introduced algorithm's experimental analysis produces the best possible aggregation quality results with a variety of crucial attributes and conditions as needed. [6] In order to reduce node energy consumption and facilitate fast data transmission, this study suggests a Meta-heuristic Optimized Cluster head selection-based Routing method for WSNs (MOCRAW). With the aid of the Dragonfly Algorithm (DA), MOCRAW eliminates isolated nodes or hot-spot issues and offers loop-free routing; the choice is based on Local Search Optimization (LSO) and Global Search Optimization (GSO). The Route Search Algorithm (RSA) and the optimum Cluster Head Selection Algorithm (CHSA) are the two subprocesses that this protocol takes advantage of. The Energy Level Matrix (ELM) is used by CHSA. Node density, residual energy, the separation between the Cluster Head (CH) and Base Station (BS), and inter-cluster formation are the foundations of ELM. Through levy distribution, the inter-cluster determines the best route between the source and the destination in RSA. [7] The BM-BWO with fuzzy logic based HEED protocol (BMBWFL-HEED) was proposed in this research. To choose the greater residual energy, BMBWFL-HEED combines the boosted mutation based black widow optimization (BM-BWO) algorithm with the HEED procedure. In particular, the direction average technique (BM-BWO) helps to improve the Black Widow Optimization (BWO)

algorithm's mutation phase. The most pertinent and optimal cluster heads are chosen by the fuzzy logic system. There are differences in energy consumption and the number of cluster heads that emerge in both homogeneous and heterogeneous environments when it comes to leftover energy. Out of all the options, the suggested BMBWFL-HEED method produces the best performance results. [8] This study suggests CBR-ICWSN, an Internet of Things (IoT) enabled cluster based routing (CBR) protocol for information centric wireless sensor networks (ICWSN). To efficiently choose the ideal set of cluster heads (CHs), the suggested model is subjected to a clustering technique based on black widow optimization (BWO). Additionally, the CBR-ICWSN technique uses a routing process based on oppositional artificial bee colonies (OABCs) to pick paths as efficiently as possible. To confirm the effectiveness of the CBR-ICWSN technique, a number of simulations are run, and the outcomes are analyzed from a number of angles. In terms of network longevity and energy efficiency, the CBR-ICWSN methodology has demonstrated superior performance in experiments compared to the other methods.

[9] They proposed a multipath routing technique for homogeneous WSNs in this paper. The firefly technique is used in the first phase to cluster wireless sensor networks. Routing between CHs is carried out using fuzzy logic in the second step. Two paths are created as a result of routing between CHs: the primary path and the backup path. CHs use primary paths to send data packets to the base station, but they also use backup paths in case the primary paths fail. The third phase involves maintaining the paths so that route finding must be restarted in the event of a path break. The simulation's findings show that the suggested multipath routing works better than alternative routing techniques in terms of network lifetime, packet loss rate, energy consumption, and end-to-end latency. [10] To improve performance, a distributed and scalable scheduling access strategy and QOS routing system are presented. These schemes can accommodate some mobility and reduce excessive data loss in data-intensive sensor networks. The algorithm uses the diversity of data traffic while taking into account latency, reliability, residual energy in sensor nodes, and transmission power between nodes to cast QoS metrics as a multi-objective problem. It also generates conflict-free time slot allocation schedules without requiring global overhead in scheduling. [11] In this research, they offer a fault-tolerant routing mechanism called the Grid Topological Routing Scheme, which provides an efficient route in the event of a faulty path. The simulation outperforms both the Routing Protocol for Low-Power and Lossy Networks and the Ad-Hoc On-Demand Vector algorithm in terms of power usage and packet delivery ratio. This type is specifically built for the smart grid in India. [12] The article introduced an Industrial IoT Fuzzy Logic Energy-Aware Routing Protocol (FLEA-

RPL) that reduces network traffic while also increasing network life. Because the load routing measure is considered when constructing the route, data traffic is distributed across the network. This extends the network's lifetime while maintaining a high packet delivery ratio. The suggested study presents a Multilayer Energy-Aware Aware RPL (MCEA-RPL) cluster for the Internet of Things, which reduces network data traffic while enhancing network lifetime. It is divided into three phases, each of which involves the formation of network rings, intra-ring divisions, and inter-cluster routing. Blockchain technology can extend a network's lifetime by minimizing the amount of identical data package transfers. This article discusses Enhanced Mobility Support RPL (EM-RPL) in Industrial IoT, which improves mobility support using blockchain and spreads system generation.

[13] This study proposes a new trust-based secure intelligent opportunistic routing protocol (TBSIOP). The proposed approach computes a node's likelihood of being malicious (Pm) using three distinct WSN properties. These traits are sincerity in forwarding data packets (Fs), sincerity in acknowledgment (ACKs), and energy depletion (Ed), which are used to compute trust. Based on the calculated trust factor, the proposed protocol's relay selection mechanism prohibits malicious nodes from being selected as relay nodes. The proposed TBSIOP outperforms the existing protocols in terms of Average Risk Level, Packet Delivery Ratio, End-to-End Delay, Energy Consumption, and Network Lifetime. [14] The proposed Energy Efficient Multilevel Region Based (EEMRB) protocol accomplishes this objective by dividing the entire network area into numerous levels and sub-levels. The sub-levels are partitioned into clusters that communicate with the sensor via CH (s) via single/multi-hop communication to the BS. Using the given protocol data set, a Multivariate Polynomial Regression (MPR) Model is proposed to forecast network longevity. The model's network design parameters include packet size and node density. According to the simulation results, network lifetime is heavily influenced by packet and network area size. This model can predict the lifetime of any network area. [15] This work introduces EECRAIFA, a revolutionary cluster-based routing mechanism. To select the optimal cluster heads, a Self-Organizing Map neural network is used to perform preliminary clustering on the network nodes, and then the relative reasonable level of the cluster, cluster head energy, average distance within the cluster, and other factors are introduced into the firefly algorithm (FA) to optimize network clustering. In addition, the concept of decision domain is included into the FA to help disperse cluster heads and build appropriate clusters. An improved ant colony optimization (ACO) is used to develop inter-cluster routing during this step. To increase network throughput, a polling control method based on busy/idle nodes is developed during the intra-cluster communication phase.

The simulation experiment findings demonstrate that, under various application circumstances, EECRAIFA can successfully balance network energy usage, extend network lifetime, and improve network throughput. [16] This study presents an energy-aware cluster-based multi-hop routing method in which clusters are re-formed if necessary during the routing phase. Furthermore, like other multi-hop routing algorithms, it ensures energy efficiency by balancing energy across the network. In this paper, we introduce a cluster-based multi-hop routing algorithm. In our suggested solution, we use a mix of two algorithms for clustering, K-means and Open Source Development Model Algorithm (ODMA), and the Genetic Algorithm for multi-hop routing. The simulation results show that our proposed method outperforms the MH-FCM, EEWC, and GAFOR algorithms on numerous parameters, including average residual energy, residual energy variance, number of packets received, number of dead nodes, and network lifetime.

[17] This paper proposed a technique for finding MNs in WSN that takes into account all of the SN properties. During the Malicious Nodes Detection (MND) phase, the Improved Deep Convolutional Neural Network (IDCNN) recognizes the MN and places them in the malicious list box. During the energy-efficient DT phase, the Extended K-Means (EKM) method clusters the Trusted Nodes (TN), and the t-Distribution based Satin Bowerbird Optimization (t-DSBO) algorithm chooses an individual CH for each cluster depending on the residual energy of those nodes. The data from that cluster is relayed to the Base Station (BS) via the CH. When the current CH loses energy, the t-DSBO selects an alternate CH. The suggested approaches effectively detect the MN and render energy-efficient DT, as demonstrated empirically by comparing it with current techniques. [18] In this paper, we present a particle swarm optimization-based energy efficient clustering protocol (PSO-EEC) to improve network lifetime and performance. The suggested protocol selects the network's cluster head and relay nodes via particle swarm optimization. The cluster head is chosen using a particle swarm optimization-based fitness function that takes into account the energy ratio (initial and residual energy) of nodes, the distance between nodes and the cluster head, and the node degree to select the most optimal node for the job. The proposed approach nominates relay nodes for multi-hop data transfer to the base station using a fitness value based on the residual energy of the cluster head and the distance to the base station . To evaluate its effectiveness, the suggested protocol's performance is compared to that of several existing techniques in terms of numerous performance factors such as energy expenditure, network lifetime and throughput. [19] To address the challenges and limitations of existing routing systems, this paper proposes two new heuristics algorithms, a gravitational approach-based

clustering method and a clustered gravitational routing algorithm, to provide an optimal solution for efficient clustering and effective routing. Furthermore, a fuzzy logic-based deductive inference system was devised and implemented in this work to select the most appropriate nodes as cluster head nodes from among the nodes in each cluster. The simulation results from this work show that using these proposed techniques improves clustering accuracy and network longevity while decreasing energy consumption and latency.

[20] In this paper, researchers present an energy-aware routing algorithm and a control overhead reduction technique for increasing the network lifetime of software-defined multihop wireless sensor networks (SDWSNs). This is an attempt to optimise the energy usage of WSNs that deliver services to the Industrial Internet of Things (IIoT). A centralized controller provides a global perspective of the sensor network by injecting more control overhead into the network, however this results in increased energy expenditures. However, the new algorithm takes use of this global perspective and balances network energy by selecting the way with the highest residual energy level from among alternative paths for each sensor node. They also identify important functions that drain energy from the SDWSN and reduce their impact by developing a data packet aggregation mechanism, as well as reducing control overhead by employing a simple checksum function to track the routing tables of the sensor nodes. They demonstrate that the suggested approach increases the network lifetime of the WSN by 6.5% on average when compared to the usual shortest-path algorithm, and that control overhead is reduced by around 12% while retaining a very high packet delivery ratio. [21] In this paper, we propose a deep reinforcement learning (DRL)-based intelligent routing method for IoT-enabled WSNs that dramatically reduces delay and increases network lifetime. The suggested technique separates the entire network into different unequal clusters based on the current data load present in the sensor node, effectively preventing the network from dying prematurely. The proposed technique is extensively tested using ns3. The experimental findings are compared to state-of-the-art algorithms to show that the suggested scheme is efficient in terms of the number of active nodes, packet delivery, energy efficiency, and communication delay in the network. [22] Due to the high energy requirements of radio transmission, power optimization and efficiency must be studied. As a result, energy conservation is a primary priority in wireless sensor networks. Recent research has focused on developing routing algorithms that utilize less energy during communication, therefore extending the network's life. Wireless sensor networks with energy recovery nodes employ nodes that can extract energy from their surroundings. This research study proposes and

analyzes the fuzzy-GWO method and the energy-saving routing algorithm. According to simulation results, the suggested F-GWO method outperforms in terms of network lifetime, packet delivery ratio, throughput, bit error rate (BER), buffer occupancy, time analysis, and end-to-end delay.

[23] This paper presents an energy-saving clustering technique called energy-saving clustering by Voronoi adaptive dividing (ESCVAD). The adaptive clustering method based on Voronoi dividing and the cluster head election optimization algorithm based on distance and energy comprehensive weighting are the ESCVAD protocol's novel features. The suggested methods successfully balance the energy consumption of cluster head nodes and cluster member nodes. The proposed ESCVAD protocol can effectively minimize clustering frequency and cluster head electing frequency, hence reducing signaling interaction frequency, resulting in lower energy consumption and increased network lifetime. Among the six protocols under consideration, ESCVAD has the highest network lifetime and energy efficiency. [24] The suggested IMD-EACBR model aims to maximize energy efficiency and network longevity. To do this, the IMD-EACBR model first develops an improved Archimedes optimization algorithm-based clustering (IAOAC) method for cluster head (CH) election and cluster structuring. In addition, the IAOAC algorithm generates a suitable purpose that connects several buildings based on energy efficiency, detachment, node degree, and inter-cluster distance. Furthermore, the teaching-learning-based optimization (TLBO) algorithm-based multi-hop routing (TLBO-MHR) technique is used for the optimal selection of routes to destinations. Furthermore, the TLBO-MHR technique derives a suitable purpose from energy and distance measures. The IMD-EACBR model's performance was evaluated in a variety of ways. Simulation results revealed that the IMD-EACBR model outperformed current state-of-the-art techniques. IMD-EACBR is a proposed model for emergency data transmission, while the TLBO-MHR technique is based on hop count and distance constraints. Finally, the proposed network is thoroughly tested utilizing NS-3.26's complete simulation capabilities. The simulation findings show improved performance in terms of the proportion of dead nodes, network lifetime, energy consumption, packet delivery ratio (PDR), and latency. [25] This work aims to identify the best cluster head for an energy-efficient routing algorithm in WSN. As the major contribution focuses on Cluster Head Selection (CHS), this work proposes a new hybrid algorithm, Ant Colony Optimization (ACO) integrated Glowworm Swarm Optimization (GSO) approach (ACI-GSO), which is a hybrid of (GSO) and (ACO) techniques. The goal of the CHS is to reduce the distance between the selected CH nodes. It makes the fitness function

work with several objectives such as distance, delay, and energy. Finally, the proposed work's performance is analyzed, and its efficiency is demonstrated relative to other traditional works.

III. PROPOSED WORK

The sensors are deployed randomly in a 2D region and their positions are fixed throughout their lifespan. The energy level for all the sensors is same initially. Each sensor is associated with a GPS device and the energy consumption for GPS is ignored. The coordinates of the sensors are transmitted to the mobile sink. The deployment area is divided into sections of 50m^2 intervals and clusters are formed in each section using interpolation. Assign each node to the nearest CH and the distance between the nodes and CH is calculated. Energy threshold is fixed for the CHs and once the energy is depleted below the threshold the node next CH is selected based on the residual energy and interpolation density. Data aggregation is performed at the cluster heads and the aggregated data is encrypted to maintain privacy and security. The goal of this research is to create an energy-efficient routing protocol, **Effective Routing Protocol with Optimal Positioning (ER-POP)**, to address energy difficulties in wireless sensor networks and improve their efficiency. This research assumes nodes in WSNs are aware of their geographical location by GPS. Sensor nodes are equipped with multichannel transceivers, allowing them to send and receive at several frequencies. The assumption is that each node can communicate data to the sink across extended distances. At the first stage, all nodes have the same energy level. The sink is placed in the centre of sensor network.

[26] The sensor nodes in the network are grouped into clusters on either side of the sink. Typically, tiers are established in radii around the sink, ranging from D_0 to D_1, and so on, depending on the network size. Initially, a signal with energy level E_0 is transferred from the sink to the network. The signal with energy E_0 will only be received by nodes near the sink. After listening to the signal, these nodes will respond to the sink and register as tier D_0 nodes. The sink will advertise the signal with a transmission energy of E_1, where E_1 is greater than E_0. Tier D_1 nodes are formed when nodes other than D_0 respond to this signal. The process will be repeated until the present number of tiers are formed. The power control model employed in this study assumes that energy consumption is proportional to transmission distance. Equation (1) calculates node energy usage for sending m bits of data across a distance of d meters. The energy utilised for receiving m bits is given in Equation (2).

$$E_T = mE_{elec} + mE_{amp}d^2 \tag{1}$$

$$E_R = mE_{elec} \tag{2}$$

Where E_{elec} is the electronics energy for receiving and E_{amp} is the amplifier energy.

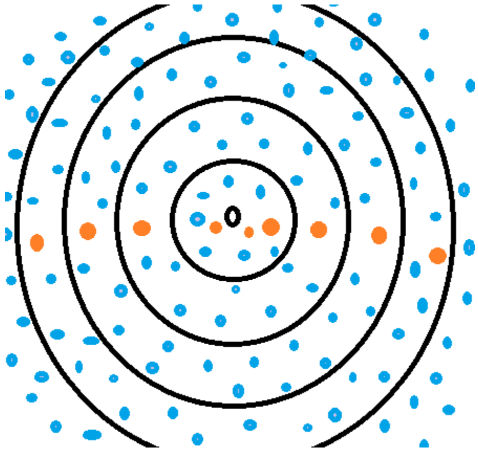

Figure 3.1. Distribution of nodes in the network area

Equation (3) specifies the minimal energy required for a node to participate in the next round of routing.

$$E_{min\ (thres)} = mE_{elec} + mE_{amp}d^2 + 8mE_{elec} \quad (3)$$

CH operates in three modes during its lifetime: receiving member node data samples, sending its own data (and/or member nodes' data), and sleeping. Let E_i, E_{thrs}, E_R, and E_T denote the beginning, threshold, reception, and transmission energy of a single data sample, respectively. We assume a fixed size for each data sample, resulting in the identical transmission and receiving times (T_s). During each sampling interval, a CH with x member nodes spends T_t time for transmission, xT_t time for receiving samples, and the remaining $T_s-(x+1)T_t$ in sleep mode. The CH is deemed to have died when its residual energy drops below the threshold (E_{thrs}) required for a node to function. The number of sampling intervals necessary to determine the life of CH is given in Equation (4)

$$N_s = \frac{E_i - E_{thrs}}{E_T + xE_R + (T_s - (x+1)T_t)P_s} \quad (4)$$

Suitable gateways are found from each cluster, as all nodes are aware of their location and distance from the sink and neighbouring nodes. The gateway is chosen depending on node distance, number of nearby nodes, and energy threshold. The energy threshold level is more significant compared to others. The suggested routing methodology is divided into four stages: data transmission (TD), schedule building (SB), tree building (TB), and gateway selection (GS). Processing cycles will go on until the gateway's energy level falls below the threshold, breaking the routing tree. Based on its position, residual energy level, and the number of nearby nodes, the GS process is finished in the first phase. This gateway will be in charge of sending the collected and aggregated data from the nearby nodes to the sink. This stage begins when the sink sends a message with an energy threshold level of E_0.A routing tree with its roots at the sink is constructed during the second phase (TB). Two different kinds of sensor nodes, such as non-leaf and leaf nodes, will serve as the foundation for the newly created tree. The leaf node sends its parent the sensed data from the monitored area. In order to transfer data from the lower to the upper levels of the tree, the non-leaf nodes serve as the intermediary nodes. A distributed Time Division Multiple Access (TDMA) schedule is then constructed in phase-3 (SB) based on this tree. Data is sent from nodes to the sink in the final phase (TD) according to the distributed TDMA scheduling schedule created in phase 3.

Initially, only a few nodes will be chosen as gateways to reduce energy usage in the WSN. The network is divided into grid cells, which are further divided into tiers, denoted as n on both sides of the sink. Initially, nodes in tier D_0 will be assessed as prospective gateway candidates based on their energy level e, distance from sink d, and number of neighbours n. Some nodes can advertise themselves as gateways. Priority will be determined by the amount of residual energy in each node. A potential gateway will function until its residual energy falls below a threshold value E_{thrs}. New gateways will be selected from nodes in tier D_1. Newly selected nodes will serve as gateways until their remaining energy falls below E_{thrs}, and so forth. Once all tiers are considered and no more nodes can be selected as gateways based on the current E_{thrs}, a new round will begin with a lower E_{thrs}. Up until the last tier (D_n), the mechanism will continue, and the same procedure will be followed with the second cycle. But at this period, E_{thrs} by the sink will be somewhat decreased by factor (e).Until the end, the same process will be used for every tier and every cycle. The CSMA technique will be used for message exchange between the sink and sensor nodes. The node will turn on until it receives the ADV message from the sink, then sends the JOIN message. After sending the JOIN message, the node will go to sleep without waiting for confirmation from the sink. The gateway selection is based on three parameters: energy level, number of surrounding nodes, and distance from the sink. After picking gateways, the tree-building process begins. The gateway nodes will start the tree-building process. As the root node, the sink will broadcast a Hello message to every node in the network. At first, H_i will have a value of 0. Every node monitors the hop counts of the nodes that are closest to it. If the node is only one hop away from the sink, the hop count is set to one. Equation (5) is used by the remaining nodes to determine their hop count.

$$Hop\ Count = HC_r + 1 \quad (5)$$

Where HC_r is the received hop count. Nodes update their newly received hop count if it is smaller than their current hop count. Each node selects a parent node from its neighbours based on the minimum hop count and residual energy. As the nodes spread, they create parent-child relationships, resulting in a tree structure rooted at the sink. Nodes share hop count information on a regular basis when the topology changes or nodes fail. If a parent node is relocated or loses energy, the tree is rebuilt. If the current parent node fails, each node searches for an alternative parent based on the residual energy. The schedule creation phase is crucial for creating a successful distributed scheduling strategy that utilizes TDMA data transport. The schedule assumes that all nodes linked with the same gateway will transfer data at the same frequency. This assumes that nodes connecting to different gateways use different frequencies for data transmission. Time Ready to Transmit (T_{RT}) and Time Ready to Receive (T_{RR}) are the two-time constants that we have determined. $T_{RT(n)}$ and $T_{RR(n)}$ indicate two distinct time slots: $T_{RR(n)}$ signals a node's readiness to receive from its offspring, whereas $T_{RT(n)}$ indicates a node's ability to transmit to its parent towards the sink. $T_{RR(n)}$ and $T_{RT(n)}$ data can be used to calculate a node's wakeup time, which determines how long its transceiver stays ON. For the leaf node, transmission time ($T_{RT(n)}$) equals the width of one time slot (t_0), while reception time ($T_{RR(n)}$) is zero since it doesn't have any children. For non-leaf node n

$$T_{RR(n)} = \left(T_{RT_i}\right) \ \ where\ i = 1,2,3 \dots \dots . N_n^c \quad (6)$$

$$T_{RT(n)} = T_{RR(n)} + N_n^c T_t \quad (7)$$

In the equation above, i indicates an index for the children of n node, whereas N_n^c represents the count of n's children, which equals one data packet transmission time. By using the max function, the parent node will only turn on when all of its offspring are ready to broadcast. This is preferable to switching from OFF to ON frequently. Once the data from children is aggregated, the parent can pass it to the next node. Initially, each leaf node will send its $T_{RT(n)}$value to the parent. After getting $T_{RT(n)}$ readings from all children, the parent will compute $T_{RT(n)}$ and $T_{RR(n)}$ using the equation above and create a timetable for them. Data transmission can be repeated multiple times for the same schedule, but each node requires energy to function. Non-leaf nodes will collect data from their kid and pass it to their parent, but leaf nodes will only be active for one slot to transfer data to their parent. Each node has a time slot labelled T_t for data transmission and T_r for data reception.

IV. PERFORMANCE EVALUATION

Parameter	Value
Network area	100 m x 100 m
Number of sensors	100
Deployment	Random
Location of the sink	Centre of network area
Radio propagation	50 m
Electronics energy (E_{elec})	50 nJ/bit
Amplifier energy (E_{amp})	100 pJ/bit/m^2
Initial energy of each node	2 J
Control packet size	48 bytes
Data packet size	100 bytes
Energy threshold (E_{thrs})	4 x 10^{-4}J
Energy threshold initial ($E_{thrs(i)}$)	1 J
e	0.5
Maximum communication distance	$\sqrt{2}$ x 5m

Table 4.1. Simulation parameters

The proposed methodology Effective Routing Protocol with Optimal Positioning (ER-POP) is simulated to identify its performance in terms of packet loss, energy consumption, network lifetime and coverage. The results are compared with three existing methodologies namely [5] Fuzzy based Energy Efficient Routing Protocol (E-FEERP), [13] Trust-Based Secure Intelligent Opportunistic Routing Protocol (TBSIOP) and [14] Energy Efficient Multilevel Region Based (EEMRB) protocol. The simulation parameters are stated in Table 4.1.

Energy consumption in WSNs is an important factor that directly affects the system's lifetime and performance. WSNs can manage their limited power resources effectively by employing energy-efficient protocols, power-saving approaches, and new energy harvesting systems. A crucial component of many systems is energy usage during data transmission, particularly in networks, data centers, and wireless communication where devices handle massive volumes of data or send data over great distances. Figure 4.1 illustrates the energy consumed during routing among the existing and proposed methodologies depicting that the proposed method consumes less energy than the other ones. Each node is given initial energy of 2J and when 100 nodes are deployed the energy of the sensor network is 200 J and based on data transmission ER-POP consumes 96.79% of energy during routing whereas E-FEERP consumes 100% , TBSIOP consumes 100% and EEMRB consumes of 99.88% energy after 500 rounds of data transmission.

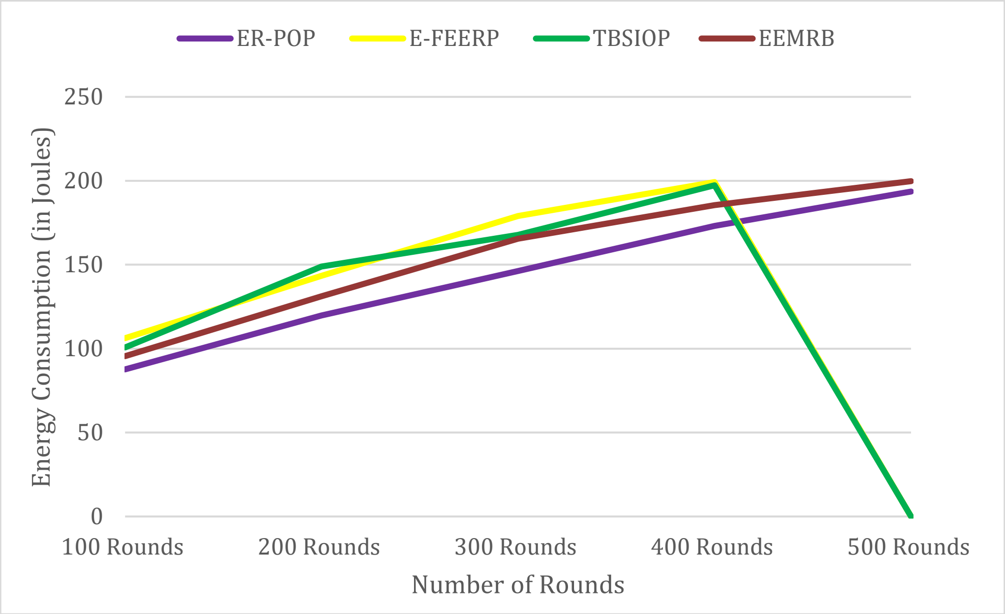

Figure 4.1. Comparison on Energy Consumption

A network's lifetime is the period of time during which it continues to function successfully, providing essential services (such as data transmission, sensing, or monitoring), before becoming non-operational or unusable due to energy depletion, hardware failure, or other causes. Nodes are frequently powered by batteries, and their lifespan is directly proportional to the amount of energy stored in their batteries. Once these batteries are depleted, the nodes become inactive, resulting in network failure. If a large number of the network's nodes fail (for example, due to battery exhaustion or hardware failure), the entire network may stop to function properly. Figure 4.2 displays the comparison on the network lifetime among the existing and proposed approaches. The results show that the proposed approach shows significant improvement in network lifetime.

Data packet loss is a major issue in Wireless Sensor Networks (WSNs), affecting network performance and dependability. This can happen for a variety of reasons, including ambient conditions, network congestion, device problems, and security risks. Sensor nodes can fail owing to battery depletion, hardware fault, or extreme weather conditions. Inefficient routing methods may cause excessive retransmissions and delays, resulting in dropped packets. Figure 4.3 shows the packet loss ratio among the different approaches and depicts that minimum packet loss is seen in the proposed methodology compared to the other methods.

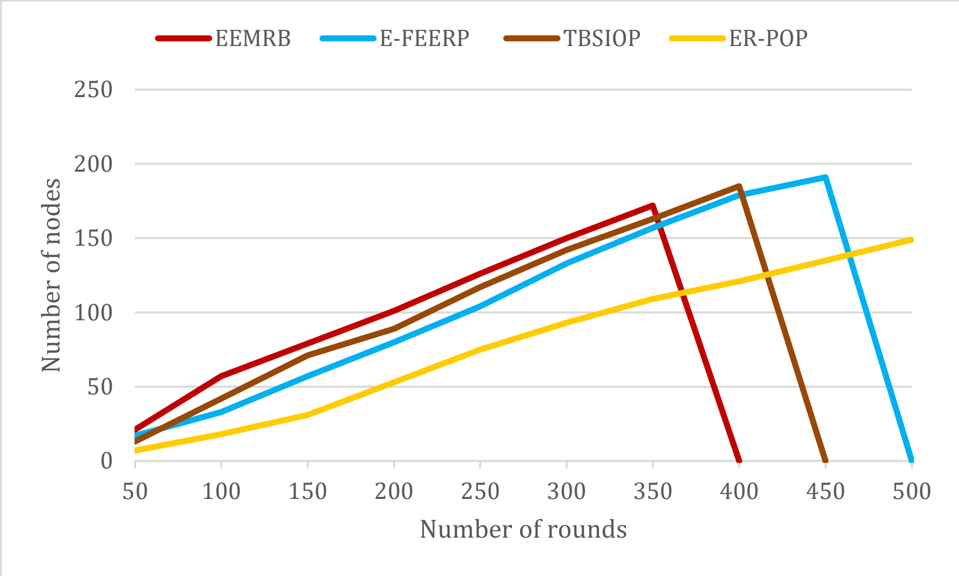

Figure 4.2. Comparison on Network Lifetime

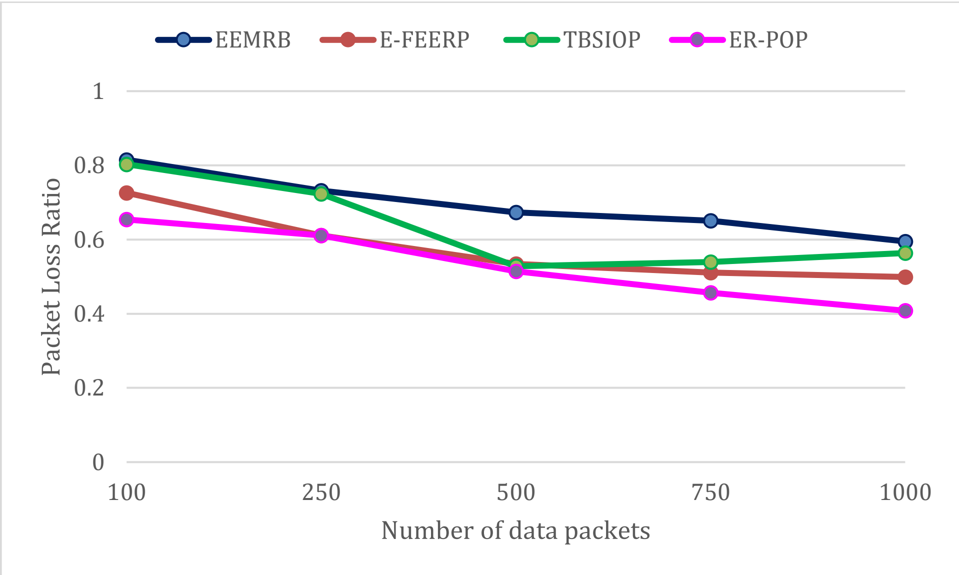

Figure 4.3. Comparison on Packet loss among different methods

Network coverage in Wireless Sensor Networks (WSNs) refers to the ability of deployed sensor nodes to monitor a specific area and transmit data effectively. It is a vital aspect in determining a wireless sensor network's efficiency, dependability, and longevity. Figure 4.4 illustrates network coverage of the proposed work with the existing ones and it is noticed that the network coverage of the proposed method is commendable when compared to the existing methods.

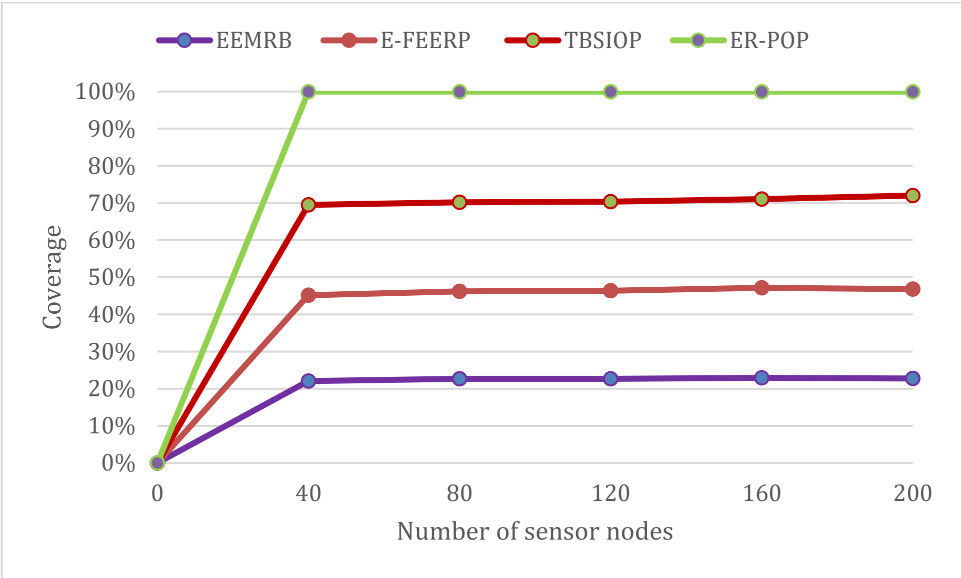

Figure 4.4. Comparison on Network coverage among different methods

From the results above it is seen that the proposed method Effective Routing Protocol with Optimal Positioning (ER-POP)outperforms the other methods proving that it is consistent and efficient in routing data packets to the destination.

5. CONCLUSION

This paper focused on the routing technique in wireless sensor networks, with the goal of reducing energy consumption and increasing network lifetime. The results reveal that the proposed strategy is efficient in terms of lowering energy consumption during data transfer. Security can be added in the future to increase the quality and dependability of transmission. Additional research can be conducted to incorporate security features and execute the technique for large-scale networks.

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