EECRPSID: ENERGY-EFFICIENT CLUSTER-BASED ROUTING PROTOCOL WITH A SECURE INTRUSION DETECTION FOR WSN-ASSISTED IOT

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ABSTRACT

A revolutionary idea that has gained significance in technology for Internet of Things (IoT) networks backed by WSNs is the " Energy-Efficient Cluster-Based Routing Protocol with a Secure Intrusion Detection" (EECRPSID). A WSN-powered IoT infrastructure's hardware foundation is hardware with autonomous sensing capabilities. The significant features of the proposed technology are intelligent environment sensing, independent data collection, and information transfer to connected devices. However, hardware flaws and issues with energy consumption may be to blame for device failures in WSN-assisted IoT networks. This can potentially obstruct the transfer of data. A reliable route significantly reduces data retransmissions, which reduces traffic and conserves energy. The sensor hardware is often widely dispersed by IoT networks that enable WSNs. Data duplication could occur if numerous sensor devices are used to monitor a location. Finding a solution to this issue by using clustering. Clustering lessens network traffic while retaining path dependability compared to the multipath technique. To relieve duplicate data in EECRPSID, we applied the clustering technique. The multipath strategy might make the provided protocol more dependable. Using the EECRPSID algorithm, will reduce the overall energy consumption, minimize the End-to-end delay to 0.14s, achieve a 99.8% Packet Delivery Ratio, and the network's lifespan will be increased. The NS2 simulator is used to run the whole set of simulations. The EECRPSID method has been implemented in NS2, and simulated results indicate that comparing the other three technologies improves the performance measures.

KEYWORDS

Cluster-based routing protocol, Low-power and Lossy Networks, Internet of Things (IoT), Position Information Response, Position Information Request packet, WSN, PDR, EECRPSID.

1. INTRODUCTION

The development of a static hub and “cluster-based routing strategy” (CRPSH) is necessary for an “Internet of Things” (IoT) network with low energy. As a result, to operate in locations with limited energy resources, WSN-assisted IoT networks need energy-efficient routing algorithms. However, hardware problems and excessive energy consumption may cause device failures in WSN-assisted IoT networks [1-2]. Data retransmissions are significantly decreased by a reliable channel, which can reduce traffic, increase output, and save energy. The primary sensor hardware is usually dispersed widely over IoT networks that enable WSNs. Duplicate data may occur if many sensor devices monitor the area. This issue can be fixed using the clustering approach. A cluster head (CH) receives data from all cluster members and sends it to the hub. While the clustering strategy reduces network traffic, the multipath system ensures dependable pathways [3].

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The two strategies aid in developing a hybrid plan that combines the benefits of the two methods. Devices in WSN-enabled IOT networks must connect to the IOT hub to convey data [4-5]. The battery life of smartphones is not keeping up with their quickly growing technological capabilities [6]. For IOT devices, low-power, non-rechargeable batteries are required. Replacing the batteries while the gadgets are in operation could be challenging. We also need sophisticated power-saving techniques to make this Internet of Things technology more adaptable. Because these IoT devices' memory and power resources are constrained, transmitting data to the IoT hub requires more power-efficient routing algorithms [7]. One of the IoT networks enabled by WSN is "Low-power and Lossy Networks" (LLN). Low-power and energy-consuming devices are connected using this connector. LLN devices can use both routers and data sources. One of LNNs' two primary drawbacks is the challenge of constructing reliable, low-power networks.

The RPL protocol (RFC 6550) standard was developed by the LLN working group of the "Internet Engineering Task Force" (IETF routing) with several improvements relating to various router metrics, targeting capabilities, and multicasting [13]. Wireless transmission is lossy because of the poor radio and constrained LNN size. As a result, internal routing is supported by the LLN routing protocol. WSN offers three cutting-edge routing methods for IoT networks: location-based, flat, and hierarchical. Using flat-type routing protocols, all sensor devices contribute equally to collecting and transmitting environmental data to the IoT hub [8]. Algorithms for location-based routing determine the distance between the devices based on the received signal strength. The utilization of this information enables efficient data transfer. Hierarchical routing protocols are the most widely used routing techniques for IoT networks supported by WSNs. They separate the entire network into various sections. Each division has numerous member nodes and a primary node [9].

Data from member nodes must be gathered and sent to the hub by the primary node [10]. One might be able to balance the load on your sensor devices by giving various tasks to various devices [11]. Reducing unnecessary data transport by hierarchical routing might significantly reduce energy consumption. It performs better than other routing strategies because of its improved energy efficiency [12]. The building quadtree structure in QDD is modest compared with other hierarchical techniques. The QDD has been unable to resolve the hotspot issue. For WSN-assisted IoT networks, the Centroid-Based Routing Protocol (CBRP) suggested an energy-efficient data routing protocol. It establishes the Candidate Cluster Head (CH) device, which ensures a consistent allocation of energy in the cluster. Cluster formation is delegated to the BS, which helps to reduce cluster formation overhead [13].

The data packets are sent using a threshold distance. Data loss happens when the distance exceeds the threshold. Based on the following discussion, the proposed technology is an energy-efficient cluster-based routing protocol (EECRP-SID) with a secure intrusion detection system introduced in HWSN. The contribution of this paper is defined as follows. The next sections lay out a comprehensive literature assessment and the proposed model. The simulation results and analyses compare the efficiency curve's output. A summary and recommendations for future study are provided at the end [14].

The remainder of the paper is structured as follows: In Section 2, we present a Literature review. Section 3 provides a brief Problem identification. Section 4 introduces the proposed model. Moving on to Section 5, we present the simulation results and discussion. Finally, in Section 6, we conclude the paper with a summary of our findings.

2. LITERATURE REVIEW

Sharma et. al.,[15] introduces the P-LUET algorithm, which aims to enhance the stable operating period of WSN-IoT through clustering and parameter considerations, addressing various network issues. Clustering is a widespread energy-efficient technique that primarily shortens distances in large-scale networks while also bringing down commuting packets over improved connectivity.

Bilal et., al. [16] The study evaluates the performance of the suggested hybrid clustering as well as routing algorithm for diverse wireless sensors using threshold-based data collection, with a focus on balance of load, end-to-end delay, network scaling, energy consumption, and all-around network stability. The paper also discusses the role of threshold values in affecting model performance. The authors want to gather the least amount of data from member nodes to improve performance and reliability in circumstances involving unexpected or rapid changes.

Karthick et., al. [17] introduces a mobility-aware routing protocol for MANET using a hybrid optimization algorithm to maximize QoS in data transmission and compares it with existing routing protocols in various performance metrics.

Rahman et., al. [18] presents a real-time lightweight dynamic clustering algorithm (LDCA) for IoT-connected wide-area WSNs, aiming to reduce energy requirements by optimizing cluster and hop numbers, validated through hardware-based evaluation.

Tunca et., al. [19] introduces Ring Routing as an energy-efficient mobile sink routing protocol to address uneven battery depletion near the sink in wireless sensor networks, aiming to minimize overhead while maintaining all advantages of mobile sinks, evaluated through simulations.

Zhu et., al, [20] introduces an clustering algorithm to balance energy consumption in wireless sensor networks, demonstrating its effectiveness in postponing node deaths compared to other clustering algorithms in small-scale WSNs with single-hop transmission. The proposed algorithm can postpone the first node death, half of node death, and the last node death on average for small-scale wireless sensor networks with single-hop transmission.

Morsi et., ai, [21] introduces an efficient and secure malicious node detection model based on a hybrid clustering network for Wireless Sensor Networks (WSNs) to address security issues, avoid specific attacks, and improve network lifetime and efficiency. The outcome measured in the study includes an increase in network lifetime, efficiency and security of the clustering network, performance metrics such as delay, packet delivery ratio, drop, and throughput, as well as a comparison of performance and security with other models.

Kalidoss et., al., [22] presents a type 2 fuzzy logic-based clustering scheme in a multi-hop wireless sensor network to enhance energy efficiency and network scalability, outperforming existing schemes in terms of network lifetime and other metrics. Clustering is one of the best approaches to enhance energy efficiency and network lifetime in wireless sensor networks.

Daniel et., al. [23] introduces the Energy Aware Cluster-based Multihop (EACM) Routing Protocol, which utilizes clustering and multihop communication, with both static and dynamic clustering methods. The protocol partitions the network into load-balanced clusters using a voting technique and shows improved performance compared to LEACH in terms of network lifetime and energy dissipation. Clustering combined with multihop communication is a promising solution to cope with the energy requirements of large-scale Wireless Sensor Networks.

Lenka et., al. [24] introduce the Cluster-Based Routing Protocol with Static Hub (CRPSH) for WSN-Assisted IoT Networks, aiming to reduce energy consumption, increase network lifetime, address duplicate data issues, ensure path reliability, and outperform existing protocols in terms of efficiency and reliability. The clustering technique reduces network traffic.

Sharif et., al. [25] presents the Robust Cluster-Based Routing Protocol (RCBRP) as a solution to enhance energy efficiency and network lifespan in IoT-enabled Wireless Sensor Networks (WSN) through clustering and optimized routing paths, validated through simulations.

The ring receives the “AN Position Information Request packet” from the source device. The “AN Position Information Response” (ANPIRES) packet is sent in response to requests from the ring devices and provides information on the location of the current AN. Data may be transferred to the AN when the source receives the response packet from the ring node. Several LEACH protocol variations enhance its performance [26].

According to Heinzelman et al. proposed LEACH-C [27], successive rounds use a fixed number of CHs, and CHs are assigned to clusters via a base station. During the LEACH-F setup phase, clusters only form once and last the whole network [28]. New IoT devices are not allowed to join the network in this arrangement. BS controls the web and uses single-hop communication to transmit data. The IoT hub is the root of a multi-hop LEACH in which an ideal multi-hop tree is built between all CHs. The network's communication is handled via this path. MS-LEACH, an alternative variant, transmits data using one- and multi-hop communication.

3. PROBLEM IDENTIFICATION

The identification of the problem is covered in several works of existing literature. In addition to offloading typical sensor devices, we have looked at the reliability of the current network and routing technologies. The EECRPSID approach is more reliable since it employs a multipath methodology. The CRPSH, PCMRP, and REDCL approach has been determined to be superior in power usage, network reliability, and packet delivery rate. Therefore, we assessed EECRPSID's performance in comparison to other models. Hubs have access to cutting-edge features, including clustering, route selection, and power management, thanks to EECRPSID.

4. PROPOSED MODEL

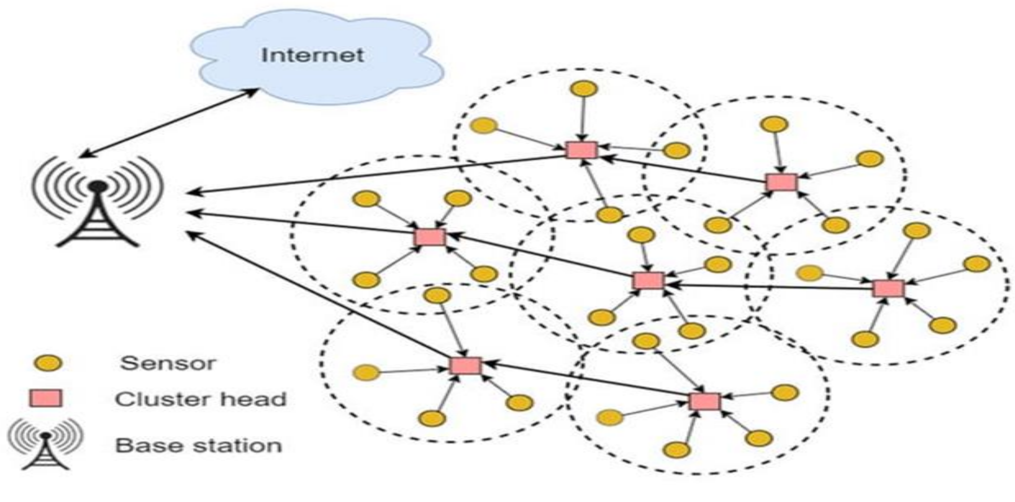

Figure 1. Cluster-based WSN structure

In WSNs, clustering effectively manages network problems related to service life and energy use. Clustering ensures energy conservation by adopting low-cost communication techniques when it divides the network into different groups of nodes, called clusters. Each cluster has a CH that oversees the activities of the other nodes in the cluster. The CHs can also reach the BS by creating a group and communicating with the BS in a multi-hop pattern. The CH first gathers the data collected by all the nodes before forwarding them to the BS. The schematic of a cluster-based WSN structure is shown in Figure 1.

1.1. Proposed EECRPSID System for Effective Data Transmission in WSN

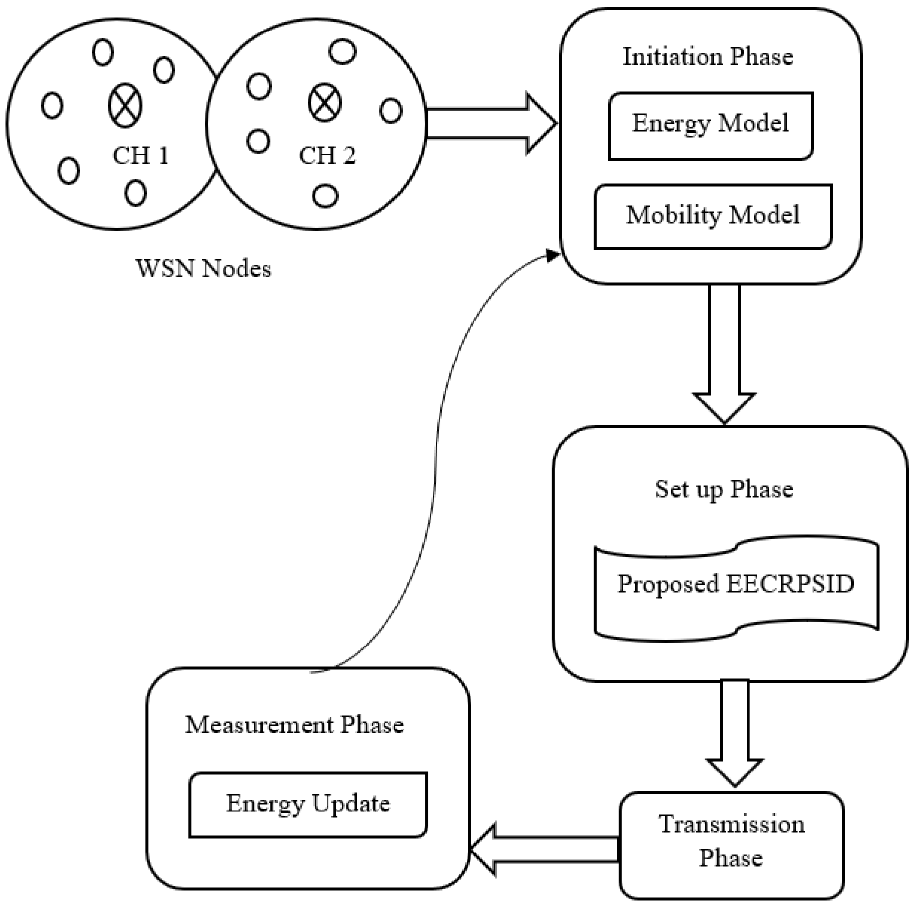

Figure 2. Proposed block diagram of Energy Efficient Cluster-Based Routing Protocol with a Secure Intrusion Detection (EECRPSID) for WSN-assisted IoT networks model.

4.1.1. Initialization Phase

This section illustrates the WSN system model [28,29], which contains both the energy model and the mobility model included in it. The very most significant challenge that the WSN must contend with is the insufficient amount of energy, which is depleted as the number of rounds increases. Based on the energy levels, the WSN has been partitioned into three sections to address this problem. The lowest zone, which is located closer to the base station, is home to regular nodes that have a lower energy level. The intermediate region, on the other hand, is home to super nodes that have a medium energy level. Finally, the final regions, which are located further away from the base-station, are home to advanced nodes, which have a high energy level. Therefore, it is the responsibility of these SNs to detect the information and then broadcast the information that they have felt to the BS. To lessen the amount of energy that is expended during transmission and receipt by the SN, the clustering method was developed. Clustering involves selecting the CH based on the energies that are still within the system. The CH is responsible for gathering the data from each of the SNs and then sending it to the BS. Let us consider a wireless sensor network (WSN) that consists of a total of g nodes, where S represents the number of typical nodes and T denotes the number of CHs. Let us also consider a base station (BS) that is involved in the process of selecting the most energy-efficient CH illustrated in figure 2.

4.1.2. Energy Model

In this subsection, the energy model [29] for WSN is broken down in greater detail. There are a great number of nodes with sensors that are powered by batteries that are contained within this WSN. As a result of the fact that every node requires a significant amount of energy to participate in data transmission, energy is a crucial component. As a result of the fact that the sensor nodes are powered by batteries, the nodes make use of the energy that is supplied by the power sources, which are kept fully charged during the opening phase. After that, gradual reductions in energy use occur while the data is being transmitted. Presented here is an illustration of the model of energy consumption. When it comes to this scenario, the transmitter is the one that is accountable for the production of electromagnetic waves to transmit data across an antenna.

Just like the transmitter, the receiver requires energy to power the radio equipment. In the event that the transmitter node sends a message consisting of M bits across a distance of h, the node will then release energy, which may be expressed as follows:

$$G_t(M,h) = \begin{cases} MG_e, + MH_a\ h^2 & h \le h_0 \\ MG_e, + MH_r\ h^4 & h > h_0 \end{cases} \tag{1}$$

where Gt (M, h) represents the energy of the transmitter, Ge represents the energy of the electronics, Message is denoted by M, distance is denoted by h, threshold distance is denoted by h0, amplifier energy in free space is denoted by Ha, and radio amplifier energy is denoted by Hr. The energy that is released into the environment is provided when the message is received by the receiver node.

$$\mathbf{G_r\ (M)=M\ G_e} \tag{2}$$

Gt (M) stands for the energy of the transmitter.

4.1.3 Mobility Model

The purpose of the mobility model is to provide an illustration of the movement of sensor nodes and to assess the change in the positions of the nodes based on speed, acceleration, and location at a certain point in time. To accomplish this, the mobility model is modified to ascertain the routing capability of the approach. Additionally, it is used to simulate the movement among the nodes.

Let's say that at the moment z=0, the nodes bf & bl are situated at the coordinates (u, v) & (u*, v*).

By using the formula, we can get the Euclidean distance among the nodes bf & bl at the moment z=0.

$$D(b_f, b_1, 0) = \sqrt{|u - u*|^2 + |v - v*|^2} \tag{3}$$

4.1.3. Set Up Phase

The ideal CHs are selected at this step using the D-FEED clustering algorithm as the basis for the decision. The D-FEED clustering technique is developed based on the EECRPSID model that has been presented recently. The D-FEED clustering method is described in the subsection, which contains a concise explanation of the algorithm.

4.1.4. D-FEED Algorithm for Cluster Head Selection:

The EECRPSID technique is proposed in this part as a means of facilitating effective communication among the SNs that are present in the WSN. This section provides an example of the dynamic energy-aware routing protocol in WiFi networks. The dynamic technique that has been developed is broken down into three steps, which are referred to as the setup stage, the gearbox stage, and the measurement stage. In this case, the networks are given beginning energy, and the mobility model is used to describe the mobility of the nodes in the network. The CHs are selected during the setup phase to transfer the data from the source node to the BS. This is accomplished by the implementation of a novel routing protocol known as D-FEED clustering, which is developed through the utilization of optimum threshold and CHs. Through the use of the FEED model, it is possible to achieve a longer network lifespan, faster throughput, and lower energy use. In this instance, the FEED model is optimized by making use of the EECRPSID method that was presented. The EECRPSID method that has been suggested is a hybrid optimization algorithm that has been recently developed. This algorithm will be achieved by incorporating CSO [30] into ROA [31]. Within this context, the threshold and CHs are selected based on the multi-objective characteristics, which include energy, network lifespan, throughput, packet delivery ratio, and latency. Following the selection of the most suitable CHs, the process of conveying information between CHs and BS is initiated [32]. Following the completion of the measurement phase, the nodes' remaining energies are updated to complete the processing of the measurement phase.

4.1.5. Transmission Phase

The communication of data from CH to BS is initiated after the appropriate CHs have been selected via the use of the suggested EECRPSID. To put it another way, the communication between a CH and a sink is facilitated by a handful of parameters that are modeled by the energy, threshold, and distance.

4.1.6. Measurement Phase

When the measurement phase is finally complete, the remaining energies present in the nodes are updated. After that, the operation is repeated until the data transfer to the CH is completed.

5. Simulation Results and Analysis

Analysing simulation results and implementing the revolutionary “cluster-based routing protocol with static hub (CRPSH)” for WSN-aided IOT networks. Expected energy use, typical end-to-end latency, and various simulated outcomes are stated. We discuss the outcomes that are listed below. The (EECRPSID) is the proposed method for achieving the target results. The parameters of the proposed technology are shown in Table 1.

Table 1. Simulation Parameters

Sl. No.	Parameter	Value
1	Network Size	100×100 m^2
2	Number of Sensor devices	100
3	Data packet Size	512 bytes
4	Control packet size	32 bytes
5	Initial Energy	1J
6	MAC Protocol	TMAC
7	Simulation Time	500sec

5.1. Average Energy Consumption

The simulated result of average energy consumption is shown in Figure 4. The graph shows how much energy is used over time. The proposed development of (EECRPSID) has achieved the target result. The proposed method (EECRPSID) has the best result compared with the other three protocol models. The energy consumption ranges are 0.25, 0.5, 0.75, and 1. 50, 100, 150, 200, 250, 300, 350, and 400 are the time ranges. The PCMRP values, representing average energy consumption, are 0.25, 0.3, 0.35, 0.4, 0.45, and 0.5.

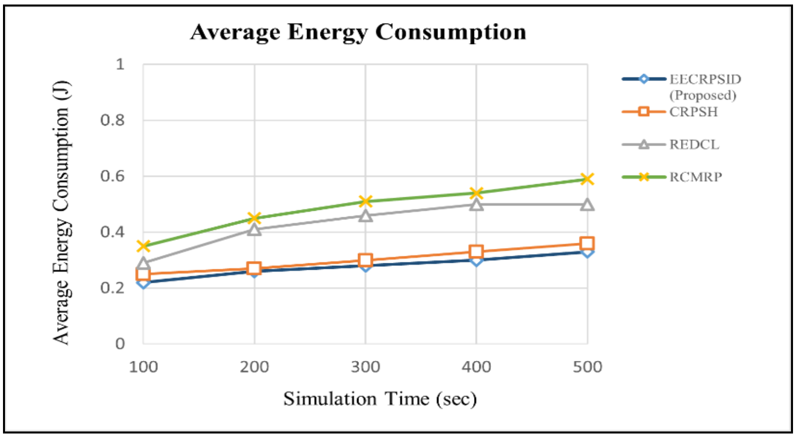

Figure 4. Simulated result of average energy consumption

Table 2. Average Energy Consumption

Simulation Time(sec)	EECRPSID (Proposed)	CRPSH	REDCL	RCMRP
100	0.22	0.25	0.29	0.35
200	0.26	0.27	0.41	0.45
300	0.28	0.3	0.46	0.51
400	0.3	0.33	0.5	0.54
500	0.33	0.36	0.5	0.59

These values rise over time. The values for the REDCL range from 0.25 to 0.5 for average energy consumption. The CRPSH ranges from 0.25 to 0.35 for average energy use. The average energy consumption increases with respect to time. The comparison of three different algorithms ranges is discussed in Table 2. The ranges of energy consumption expand throughout time. Utilizing energy affects the routing protocol's effectiveness. Network lifespan increases as network energy usage decreases. As a result, it alludes to the energy used by IoT devices for transmission, reception, sleep, and data processing. The network lifetime to delivered packet ratio is shown.

5.2. Average End-to-End delay:

Table 3. Average End-to-End Delay(Sec)

No. of Nodes	EECRPSID (Proposed)	CRPSH	REDCL	RCMRP
20	0.14	0.16	0.18	0.25
40	0.17	0.18	0.2	0.28
60	0.23	0.24	0.26	0.35
80	0.27	0.28	0.28	0.4
100	0.28	0.3	0.31	0.5

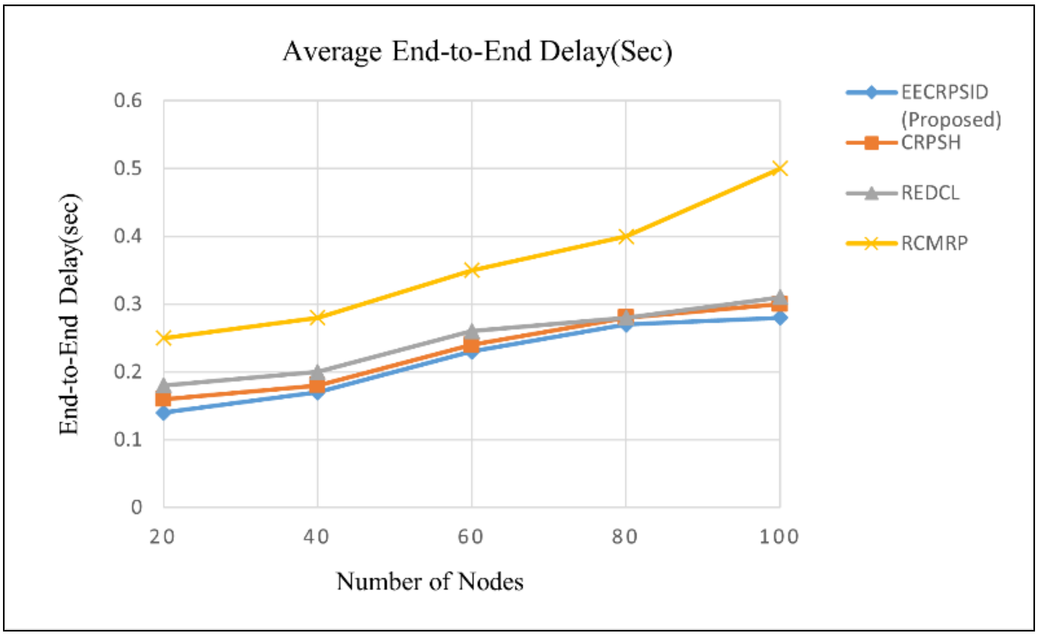

Figure 5. Simulated result of average End-to-End delay

Figure 5 illustrates a typical start-to-end delay. According to the graph, it may be stated that as the total number of devices rises, so does the typical end-to-end latency. The average end-to-end delay with respect to time is simulated, and the results are presented on a graph. The PCMRP average end-to-delay ranges from 0.3 to 0.5. The time ranges are 30, 40, 50, 60, 70, 80, 90, and 100. REDCL average end-to-delay ranges from 0.2 to 0.25. The CPRSH average end to delay ranges from 0.3 to 0.5. RCMRP outperforms the other two techniques when comparing the results shown in Table 3. RCMRP effectively generates results with high output values that are regarded favorably. A data packet's speed is determined by how long it takes to travel from its source to its sink. RCMRP requires all future cluster chiefs to postpone assuming leadership positions. When the source node changes, the protocol must construct a new multipath for each recent event's nodes. The total latency of the protocol, therefore, rises. In reaction to a single event, REDCL delivers data packets to the primary route. Before packets are transmitted to the hub, data must first be obtained, which delays packet delivery. CRPSH offers you several possibilities.

5.3. Packet Delivery Ratio

Table 4. Packet Delivery Ratio (%)

No. of Nodes	EECRPSID (Proposed)	CRPSH	REDCL	RCMRP
20	99.8	98.2	97.3	95
40	99	97.3	96.2	94
60	98.5	96.1	95	92
80	97	95.6	94	90
100	96	94.5	93.2	88

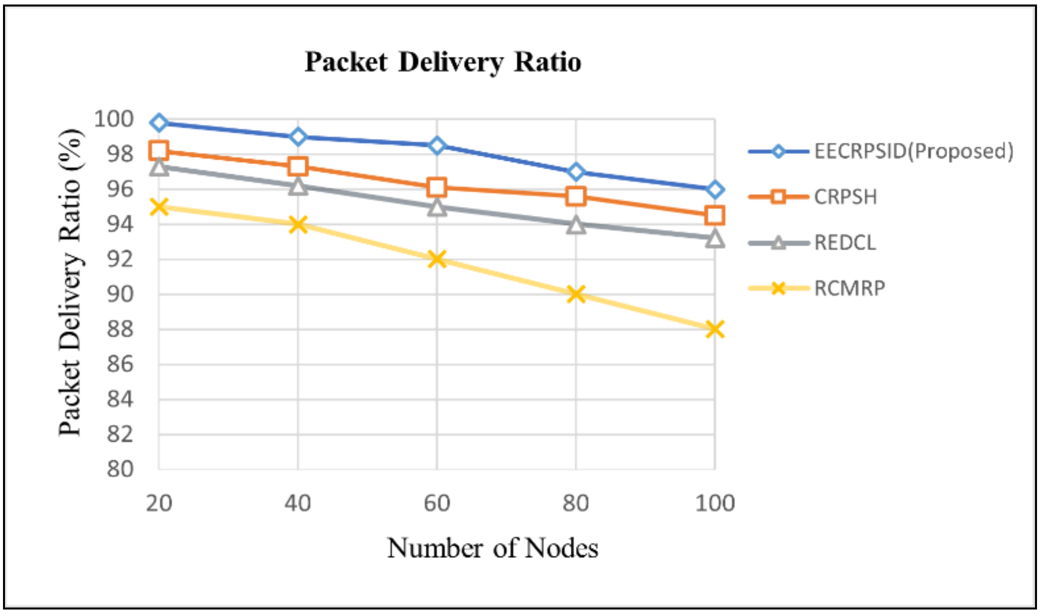

Figure 6. Simulated result of Packet Delivery Ratio

The packet delivery ratio is shown in Figure 6. The graph shows the connection between the quantity of devices and the packet delivery rate. The graph is plotted between simulated results of packet delivery ratio with respect to time. The range for the RCMRP packet delivery ratio is 95%. The ranges for REDCL packet delivery ratio are (80 to 90)%. The ranges for CPRSH average packet delivery ratio are 100%. Among the numerous results are (CRPSH), (REDCL), and (RCMRP) as shown in Table 4. The RCMRP increases dependability and, consequently, the delivery ratio by utilizing node-disjoint multipath routing. Data from many event monitoring device routes are combined into a single route using the REDCL technique. It performs better to the extent that bundle transport extent stands out from RCMRP. The middle point tracks the usual way while keeping an eye out for how much press each gadget has left (CRPSH). As soon as it is detected that the device's power is falling under the threshold, it immediately switches to another type of data transfer method. As a result, very little data is lost.

5.4. Network Lifetime

Table 5. Network Lifetime

Simulation Time(sec)	EECRPSID (Proposed)	CRPSH	REDCL	RCMRP
100	99	98	98	98
200	98	97	96	95
300	97	95	88	85
400	96	86	78	75
500	95	80	72	68

Figure. 7 depicts the network's lifespan waveform. A graph describes the simulation timings concerning the number of devices. The range for the EECRPSID number of devices is 95%. The ranges for RCMRP number of devices are 80 to 90%. The range for REDCL number of devices is 95%. The range for CPRSH's average number of devices is 100%. The three waveforms are as follows: Regarding network lifetime, the proposed method performs significantly better than REDCL and RCMRP. This is because control messages are used sparingly, and all sensor devices share the burden equally. The simulated result of the Network lifetime is 99% shown in Table 5.

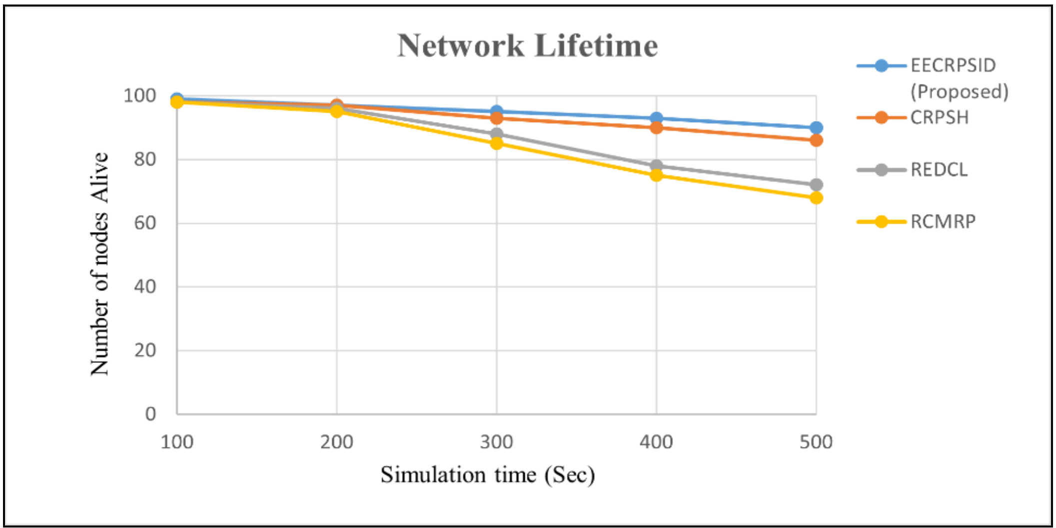

Figure 7. Simulated result of Network Lifetime

6. CONCLUSION

In this study, the EECRPSID for WSN-enabled Internet of Things networks is discussed. Because it is common practice to group sensor devices together in a network and generate duplicate data, a monitored zone may be covered by a significant number of sensor devices. This is because of the prevalent practice of positioning sensor devices to operate together.

EECRPSID not only enables hubs to access cutting-edge capabilities like as route selection, clustering, and power management, but it also allows conventional sensor devices to be offloaded. Currently available routing solutions have a significant issue with the reliability of the network. Because it makes use of a multipath technique, the EECRPSID approach is more trustworthy than other approaches. As a result, we evaluated the performance of EECRPSID in contrast to that of other models such as RCMRP and REDCL, and we found that it performed better in terms of power efficiency, network stability, and the speed at which it delivered packets.

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