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A Survey and Analysis of An Energy Optimized Routing Protocol based Data Communication Process Model for IOT Enabled WSN

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ABSTRACT

The Internet of Things network depends heavily on wireless sensor networks because they make it possible for dispersed sensor nodes to efficiently gather and transmit data to centralized processing units. Energy efficiency in WSNs is essential for ensuring a long network lifetime and dependable data transport in Internet of Things applications, where sensors are frequently placed in remote or unreachable locations. For IoT-enabled WSNs, this review article offers an extensive investigation of energy-optimized routing protocols. Their application in real-world circumstances, performance measures, and design principles are the main topics of the article. The review begins with a survey of conventional wireless sensor networks routing protocols and an evaluation of how well they balance end-to-end latency and energy usage. The paper then explores current developments in routing protocols for WSNs that are based on software-defined networking. It demonstrates how they could improve networks. to improve energy efficiency and network reliability by using dynamic resource allocation and centralized administration. In order to maximize energy consumption and prolong network lifetime in wireless sensor networks, the paper examines hybrid systems that include neural network architectures, metaheuristic algorithms, and reinforcement learning techniques. To meet the requirements of delay-sensitive Internet of Things applications, the assessment also addresses the difficulties with flexibility, mobility, and integration of clustered and routing systems. This study contributes significantly to our understanding of the state-of-the-art energy-optimized routing techniques for IoT-enabled WSNs by synthesizing the available literature and highlighting research needs. In order to fulfil the changing needs of Internet of Things applications across a range of sectors, the article proposes future research areas targeted at enhancing routing protocols and overcoming current obstacles.

Keywords: *Energy optimization, Wireless Sensor Networks, Internet of Things, Energy optimization, Routing protocols, Software-defined networking*

1. INTRODUCTION

The Internet of Things and wireless sensor networks have become a viable replacement for conventional data gathering methods (such as data loggers and sensing stations), allowing for more affordable implementations across a wider range of scientific and technical fields. Multi-hop WSN deployments have significant communication issues because to the resource constraints of WSN nodes, which are usually placed outside in harsh conditions. These constraints include memory, processing, bandwidth, and energy. While energy collecting techniques can sometimes help WSN nodes overcome their energy limitations, in many other scenarios WSN deployments must utilize batteries as their primary energy source [8]. WBAN and the Internet of Things have a shared future. Smart devices are increasingly using the Internet of Things as a common platform to transmit and receive smart data, making it one of the most promising and current study topics. The globe is embracing the deployment of 5G, and the next generation of wireless technology—the 6G protocol is rapidly approaching and will greatly improve IoT-based technologies. When more and more devices are connected to it, the Internet of Things keeps expanding. By 2023, there will be close to 100 billion smart IoT devices worldwide, according to general estimates.

The protocol, which is referred to as the collection of rules that transmit the data packet between source to destination, is used with a particular routing approach. Routing rules are already included in protocols. Wireless communications are designed with many layers in order to carry out protocols and transport data across them. Data transfer in mobile wireless communications is based on the transport layer, which initiates a specific protocol for the transfer of data. The transport layer protocol makes use of the congestion-management mechanism to verify optimal network resource allocation.WSN is a crucial piece of technology for the Web and the Internet of Things; the system as a whole relies on it. It uses tens of thousands or even millions of sensors to connect wirelessly, allowing for low-cost devices and the provision of services and goods that may change people's lives. With the advancement of sensor technology, small- to enormous scale appliances may now be equipped with intelligent wireless sensors that are affordable and compact in size, thanks to the Internet of ThingsWSN may be used in application, monitoring, Healthcare and so on.

Moreover, radio-frequency identification, wireless sensor networks, and smart gadgets may all anonymously communicate physical data. IoT-based sensors transmit the collected data to BS for further analysis and decision-making. However, because of their limited resources, particularly with regard to memory, battery life, and processor power, low-powered sensor nodes are more vulnerable to security risks [18]). A subset of WSNs are on-demand routing strategies in the same way as wireless ad hoc networks. The protocol for routing that has been used to construct the path connecting the nodes that are source and destination has to flood the sensor network's wireless connections using route requests packets to find a workable route. That's what the phrase "route discovery process" means. It takes a lot of cognitive power to send and receive the torrent of packets. Thus, the routing protocol used for WSNs has a greater influence on the application lifetime. Wireless sensor network (WSN) routing protocol uses similar shortest path criteria to choose the route through an initial node to a target node[25].

Important experimental examination of several WSN-based load and energy optimization strategies has been started, which offers fresh inspiration for further study. In this regard, the lifetime and connection availability of the whole network are guaranteed by the unique energy optimization rules set up for the WMAC and route functions at each node. The significance of energy-sensitive protocols for communication is given careful consideration for study[13].In order to efficiently capture the dynamic aspects of WSNs for their energy-efficient functioning, such as changes in node topology, restricted energy circumstances, event detection, and communication costs, a variety of machine learning approaches have been employed. Among these, issues involving a trade-off between long- and short-term rewards are best suited for reinforcement learning (RL). It offers a framework that enables a system to pick its actions wisely going forward by learning from its prior interactions with its surroundings. With the help of RL-based routing protocols, complicated network circumstances and quality of service needs may be accommodated by adaptively determining the best path.

2. LITERATURE REVIEW

In a WSN, the energy limitation issue has grown in significance due to the restricted battery capacity. One key component in lowering a WSN's energy use is routing. Because of this, a lot of routing techniques are designed to minimize a wireless sensor network's energy usage. Traditional networking and software-defined networking-based wireless sensor networks routing are the two main categories of energy-efficient WSN routing techniques. Several routing techniques have been proposed recently for WSN-assisted IoT networks [24].

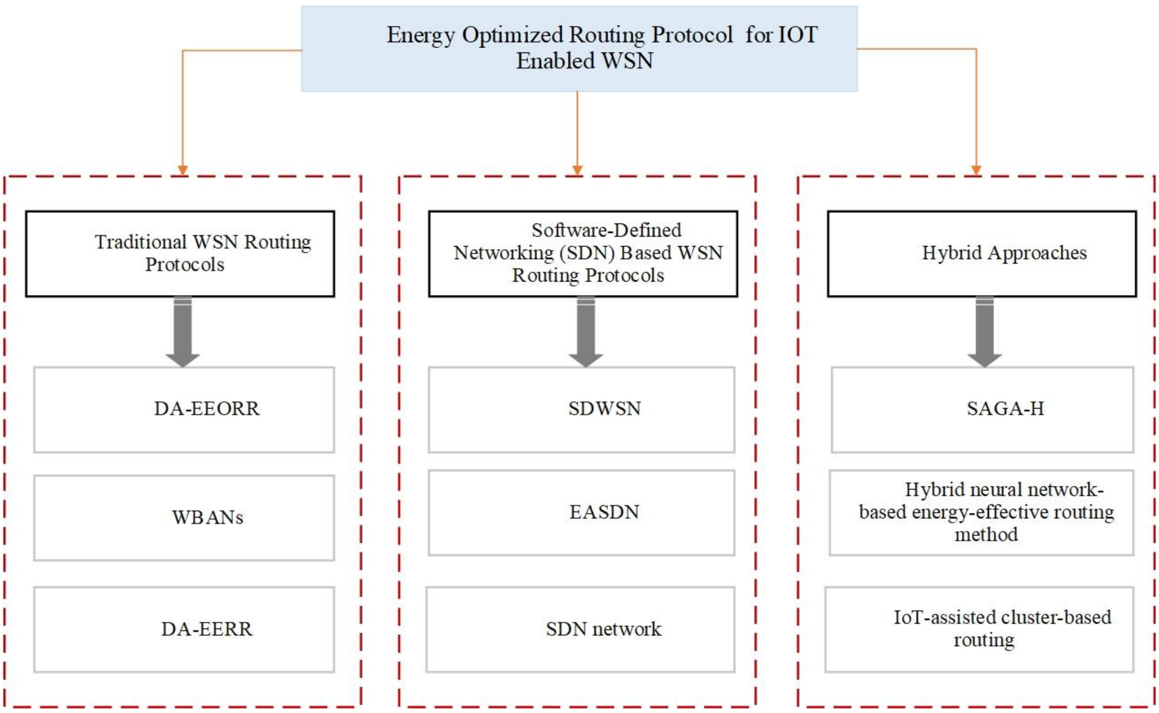

Figure 2.1: Different approaches of Routing Protocols for IOT enables WSN

The figure 2.1 illustrates "Energy Optimized Routing Protocol for IoT Enabled WSN" classifies routing protocols for Wireless sensor networks for energy optimization. Three primary categories are highlighted in the chart and are shown as red dashed boxes: There are three types of WSN routing protocols: hybrid approaches, SDN based protocols, and traditional protocols. Three particular protocols are emphasized in the Traditional WSN Routing Protocols category: DA-EORR, WBANs, and DA-EERR. These protocols most likely use standard techniques for routing and optimizing in wireless sensor networks. Three protocols are specified under the SDN Based wireless sensor networks Routing Protocols category: SDWSN, EASDN, and SDN networking. This shows that central supervision and administration of network facilities is achieved by these standards through the use of software-defined networking concepts. Protocols that include aspects of conventional WSN networking with SDN concepts or other optimization methods fall under the category of Hybrids Approaches. There are three procedures mentioned inthis category: IoT-assisted cluster-based routing, SAGA-H, and hybrid neural network-based energy-efficient routing technique. A organized overview of different protocols for routing for wireless sensor networks based on their power efficiency measures and underlying concepts is provided by the arrows linking the categories and protocols, which show how each method fits into the larger classification framework.

2.1Traditional WSN Routing Protocols

- ***Constrained routing methods, delay-aware and energy-effective opportunistic node selection***

In this section,exploring different types of new protocols suggested by (Anees et al. 2020). The authors argue that this approach is innovative and suited for a delay-sensitive setting. By identifying an ideal approach, the suggested model finds a favourable trade-off between average end-to-end latency and energy usage. To choose the subsequent hop, the model makes use of the idea of an exploitative connectivity random network. By taking into account many parameters including transmission frequency ranges, residual energy, connection quality, and more, OCRG is also utilized to determine the ideal path connectivity. To determine the closest next-hop node, the suggested model also made use of the idea of a confined research space. But the study's primary focusrather than on finding the best path inside a hierarchical network, focus is placed on route tracking and path rectification. As a result, the suggested work strikes a fantastic compromise. MANETs generate a large number of free-to-communicate nodes that move in different locations.

Multi-Point Relays are individual nodes in OLSR that are favoured for purchase above special edition nodes, which may be vulnerable to the use of MPR nodes for a energy guideline. Excessive competitive MPR nodes, however, benefit the resources by deleting many node packets rather than delivering them, which results in significant energy waste and undermines the effectiveness of several existing energy-efficient MPR choice attempts. An improved routing model that takes stability and energy efficiency into account established MANET for this service[11][3].Developed an approach stating that every Internet of Things device had a unique capacity to spare its information or data sensing and detection. It has the ability to receive data from other gadgets. The suggested algorithms is to combine the available data in order to enhance the effectiveness of energy consumption, IoT lifespan, traffic injection into the network, and traffic bottleneck following. An energy-efficient network was proposed in[2][22]. A few writers suggested using encrypted communication to transfer data, however this is more appropriate for social interactions than industrial procedures. Although [1] uses a QoS-based approach, smart grid applications necessitate some improvements since control packets and reliability are the primary concerns.The following is not possible without the aid of network (Khasawneh et al. 2018)slicing Systems for augmented reality[12] are also concentrating on the viewpoints of the industry. However, to address industrial restrictions, an integrated method is needed.

- ***In wireless body area networks, the most efficient route selection***

In the study, researcher proposed a routing mechanism for Wireless Networks. WBANs are made up of small wearable devices that collect data and communicate it around the human body. Among other uses, they are frequently employed in monitoring patients from afar and sports activity tracking. Effective and conservation of energy routing algorithms are necessary since WBANs have limited resources. The authors suggested ERRS, an energy-efficient and dependable routing strategy, to increase resource stability and dependability in WBANs. Adaptive stable clustering routing is used by ERRS to extend network life and lengthen stability periods. To do this, the suggested strategy rotates and chooses the forwarder node. In terms of performance and network stability, ERRS outperformed existing protocols by 26% throughout the simulation. Additionally, it showed an improvement in end-to-end latency. Although the paper offers a useful simulation-based approach for WBANs, scalabilityand mobility continue to be issues that must be resolved for practical implementation, as seen in the Table 2.1.1.

Table 2.1.1Review of Traditional WSN Routing Protocols

Method	Advantages	Disadvantages	Inference
DA-EEORR	Novel energy-effective and delay-aware opportunistic node design	Control packet overhead may limit applicability to large networks	Achieves balance between energy consumption and end-to-end delay

ERRS	Energy-efficient and reliable routing scheme	Challenges with scalability and mobility must be resolved for real-world implementation.	Improves reliability and resource stability in WBANs
DA-EERR	Considers heterogeneous nodes	Control packet overhead may limit applicability to large networks	Significantly improves data packet delivery in large and densely deployed networks

A different study provided a dependable and effective routing scheme for WBANs. The human body has eight sensor nodes positioned at various points to gather both routine and vital data. The computed cost function, which takes into account the network's residual energy and sink node, is used to determine which forwarder node is optimal. Numerous simulations were run in order to verify the reliability of the findings. E-HARP is the name of the routing strategy that was described in third research. A multi-attribute energy harvesting routing system called E-HARP chooses the best forwarder nodes tothe node that sinks. Sen ensed data is only sent by the scheme when required. Four primary factors are taken into consideration by the cost function when choosing a cluster head (CH): transmission power, residual power, overall energy use, and signal-to-noise ratio (SNR). By avoiding sending redundant that collects data to the CH, the approach lowers the energy usage of the network. To conserve network resources, information is also verified for duplicate before to transmission.

- ***Delay-aware energy-efficient reliable routing***

Extended network lifetimes and quick data transfers are necessary for unattended time-sensitive nodes, according to the authors of a research. They pointed out that the majority of routing strategies for these kinds of applications frequently overlook all relevant factors at once, including energy usage, packet loss, and network traffic. A homogenous sensor network is also a major difficulty since real-world deployments require handling diverse nodes. The authors suggested a unique method that takes into consideration diverse nodes and is dubbed (DA-EERR) to address these issues. To guarantee the prompt transmission of time-sensitive data, the suggested method establishes a limited search space. Then, inside the search, an algorithm chooses an energy-balanced, delay-aware path connecting the point of origin and the sinkin the search area to guarantee prompt communication. In large networks, the proposed method has improved data packet reception success at the sink. For large and densely distributed networks, the suggested routing strategy offers a considerable improvement over comparison methods. However, the suggested method will add a control packet burden for smaller and sparser networks, which can lead to the ring node terminating abruptly. As a result, the suggested technique can only be used in huge networks.

2.2Software-Defined Networking Based WSN Routing Protocols

- ***Improved SDWSN framework***

One important problem that might increase in WSN energy usage is the distribution of loads in WSN clustering. Solutions that take the clusters' hop distances into account have been put forth by some writers. A method for achieving this goal is the Energy-Delay Index for Trade-Off scheme, which chooses the CH to maximize both energy and delay. An further remedy is a framework intended to improve network resilience in an SDN-based network and is known as Improved SDWSN [15]. This framework contributes to the improvement of network resilience and the administration of WSNs in the context of the Industrial Internet of Things. It does not employ any power-aware methods to regulate the electrical power consumption of nodes, despite its promises to also solve node failure concerns associated with energy usage. They also presume that every node may be reached one hop for the controller. In a big network, it is not feasible for the controller to send straight to every node after creating the flow table. The SD-EAR energy-aware routing algorithm [9], which aims to lessen WSN network flooding and broadcasting issues, is an additional remedy.

- ***Software-defined network routing method with energy Algorithms***

Every sensor node in a network of wireless sensors has a unique communication range that it uses to target and periodically relay data. On the other hand, sensors in a traditional WSN regularly broadcast data and control messages, wasting energy. Software Defined wireless sensors networks, it is in charge of creating the topology and allocating resources, the controller gathers topology data from the network's foundation at the first stage of SDWSN. Due in large part to the controller's global perspective, SDWSN greatly reduces the power consumption of sensor nodes, hence facilitating user productivity and optimizing network resources, even with some reasonable expenses .

Table 2.2.1: Review of Software-Defined Networking and Hybrid approaches

Method	**Advantages**	**Disadvantages**	Inference
EDIT	Optimizes for both delay and energy consumption	Requires detailed network information for optimization	Achieves trade-off between energy consumption and delay in WSNs
SD-EAR	Reduces flooding and broadcasting issues	Impractical for large networks	Addresses flooding and broadcasting issues in WSNs
EASDN	Balances energy consumption of sensor nodes	Requires initial topology information for controller	Efficiently manages network resources to prolong network lifetime
SAGA-H	Hybrid routing method for improved energy efficiency	Requires simulation for performance comparison	Improves energy efficiency compared to contemporary methods
SFO-directed protocol	Utilizes Sailfish Optimizer for CH selection	Results need to be compared with existing techniques for validation	Enhances energy efficiency and reduces dead sensors in WSNs
Hybrid NN-based routing	Utilizes neural networks for optimal route determination	Complexity involved in clustering and routing process	Proposes a novel method for energy-efficient routing using neural networks
CBR-ICWSN	Black widow optimization for efficient CH selection	Requires further validation against existing methods for performance comparison	Efficiently selects CHs for information-centric WSNs
RCBRP	Recognizes minimal energy routing paths	Complexity in transmission and exploration methods	Enhances network lifespan by minimizing energy consumption in WSNs
Grey wolf optimization	Utilizes social behaviour of grey wolves for energy optimization	Depends on accurate parameter tuning for optimal performance	Improves energy efficiency in WSNs using metaheuristic approach

Reinforcement learning for LPWANs	Optimizes energy usage and data transmission in multi-hop routing	Complexity involved in Q-matrix updates and relay device selection	Improves energy efficiency and data transmission in LPWANs

To balance the sensor node's energy and extend network lifespan, this research provides an energy-aware software-defined architecture routing method. A different strategy for increasing energy efficiency in WSNs is a collected and Sailfish Optimizer-directed protocol. Fitness criteria that represent numerous objectives are used to choose the Cluster Head, which helps limit energy consumption and reduce the quantity of dead sensors. SFO the best path for information transmission to a sink node after CH selection. The discussed approach was examined, and the outcomes were contrasted with those of recent methods.

❖ ***Routing algorithm for SDN network***

A routing technique is presented for a software-driven network. The controller uses multihop communication to obtain node information as part of the algorithm. After that, the controller creates a flow table using the energy and hop count. Since distant nodes often perish soon and shorten the lifetime of the network, the hop count is employed to calculate their energy consumption. The authors compared the outcomes using Ad Hoc On-Demand Distance Vector and Optimized Link State Routing after simulating using OPNET. Additionally, the authors suggested two SDN-based techniques, greedy integrated global greedy, to maximize network-level energy utilization of chassis and line cards.

❖ ***Hybrid cluster-based routing using genetic algorithms and simulated annealing***

EH-WSNs are built on Wireless Sensor Networks, a variety of WSN routing algorithms may be employed as a foundation for the creation of EH-WSN routing protocols. For WSNs, a number of protocols for routing have been introduced. One such geographic-aware protocol for routing is the Greedy Peripheral Statelessness Route GPSR algorithm (Karp and Kung 2000). To transfer the packets avoiding the routing hole region—an area where greedy forwarding fails—thus guaranteeing reliable transmission.Another adaptive clustering topology approach for routing. It is divided into two stages. A probability function is used to randomly choose the head node of the cluster during the setup phase. Other nodes join the related cluster by the proximity concept. Another routing system that takes into account the energy limitation, network load balancing, and dynamical network topology is the Ant Colony Optimization combined with the Hop Count Minimization algorithm. It chooses the subsequent hop in accordance with the minimal hop algorithm and the ant colony algorithm.to the distance and remaining energy. With minimal energy usage and balanced consumption of energy on each node, this method can determine the best routing path [24]. MATLAB was used to simulate and illustrate the approach that was provided. The observed findings were compared with genetic algorithm-based technique in terms of packet transmission count between the source and sink, network longevity, and average residual energy.

❖ ***Hybrid neural network- Hybrid Approaches***

An approach of distributing energy in wireless sensor is recommended in [5], which involves utilizing a blend of neural networks.- Using a routing protocol (RP), the process determines the most efficient path to take. First, the sensors are grouped together using clustering method. Next, the system uses the bald eagle search approach to choose the cluster heads (CHs) from the grouped nodes. Later, the RP is chosen by looking at how far away each hop is and how much data needs to be moved, instead of going to each CH. At long last, a mixture of NN is proven to determine the most efficient route through the use of a team-based teaching algorithm. A novel method for transmitting data in wireless sensor networks, known as CBR-ICWSN, was presented in. The utilization of clusters is enhanced by the Internet of Things. The new technique utilizes a black widow optimization (BWO) to aid in the selection process of the most suitable set of CHs. Furthermore, the CBR-ICWSN approach involves the utilization of the OABC routing method to select optimal routes.

❖ ***Cluster-based routing with IoT support***

Problems with hot-spots are widespread in wireless sensor networks. This occurs when certain devices lose power and cause a disruption in the network. Researchers attempted to address this issue using various techniques. A study is being conducted on how groups organize themselves and select leaders through direct communication. The choice of CH is based on the amount of battery power remaining in the sensor node. Despite this, these guidelines do not consider real-world situations in networks utilizing multiple wireless connections, where all sensor nodes, including the primary one, have restricted data transmission distances. Furthermore, there is a focus on separate clustering and routing in numerous studies, resulting in unbalanced energy consumption and hot-spot challenges in WSNs. Energy issues often lead to the division of wireless sensor networks, creating hot-spots, a common problem in the field. In (Harmanpreet Singh and Singh 2019), the authors argue that routing and clustering should be approached as interconnected problems rather than separate ones. CH selection can be done in two ways: by looking at how much energy cluster members have left, or by rotating which cluster members get to be the leader. Nodes positioned at a distance from the BS often die out prematurely due to the choice of a CH located far away from the Base Station. The solution involves the use of the LEACH-XMP protocol, which utilizes clustering techniques to select the Cluster Heads. It considers factors such as the number of nodes, their distance from each other, and their remaining energy. The O-LEACH protocol was developed to address the issue of random selection of Cluster Heads by the LEACH protocol, which can result in some Cluster Members being disconnected without a connection. The protocol discussed in[23] proposes the idea of intermediary gateway nodes that transfer information to CHs and gather data from CMs. The selection of gateway nodes is solely based on arrival order, without considering their remaining battery capacity. O-LEACH surpasses LEACH with its reduced energy consumption and extended coverage. Finding information about orphan nodes is challenging, which poses a significant issue for researchers.

It is necessary for us to address the issues with slow data delivery and the additional effort required to manage it. Only a limited amount of research addresses the integration of clustering and routing in WSNs. In the case of the JCR protocol, a timer and routing method are used to design a network configuration for gathering data in a extensive WSN. The LEACH protocol uses a short direct path for communication between a Cluster Head and a sink node. This can use up a lot of power if they are far apart. In order to address this problem, the HEED protocol was developed. A distinctive way for clusters of sensors to reduce energy consumption in wireless networks. It illustrates how different levels of variation can extend the network's lifespan. This consists of paraphrasing at various levels, such as rephrasing it at a simpler, more complex, and multi-layered level. The leader node in HEED is determined by the energy level of each node, resulting in an optimization of the system's performance.The TEEN network has been introduced for applications that require speed. A hard threshold displays the value of the detected characteristic. Nevertheless, this technique has a drawback in that when there are no thresholds and nodes do not interact, the individual using[19] it does not get any data. It also has trouble with the intricacy of cluster formation at several levels. It is fully regulated by a set of controlling parameters. Based on the capabilities of the nodes and resources, many wireless sensors network clustering techniques have been divided into both homogeneous and heterogeneous networks. The difficulties associated with each protocol, such as cluster measure, inter-cluster interaction, CH count, clustering objects and overall complexity, were examined (Arjunan and Pothula 2019). Based on their goals and characteristics, unequal clustering strategies were examined, classified into preset, predictable, and stochastic approaches, and compared in terms of clustering/cluster qualities and the method of clustering. Based on their basic classification parameters and criteria, existing clustering approaches[16] were also examined and classified into four categories.

The two main categories of cluster-based routing algorithms were clustering-based characteristics and methodology-based parameters. Developing approaches to continuing learning through machines or intelligent computation were showcased, classified into five categories: reinforcement learning, artificial neural networks, fuzzy logic, swarm intelligence, and genetic algorithms, according to their diverse applications in computer intelligence. Based upon their scalability, data supply rate, and data aggregation, these applications of artificial intelligence were examined. It was observed that these techniques enhanced the network's capacity and service quality, and that the combination of both combinations reduced interference in the network. Two routing protocols, FLMPC-One and FLMPC-Two, suggesting in the study[2]. These protocols adhere to the advantageous features of the LMPC protocol and are depth-based. What separates FLMPC from LMPC mostly isthat FLMPC introduces cross nodes to solve the void hole regions issue and creates the binary tree from the node hosting the sensor rather than the source node. Retransmissions decreased as a result of the suggested techniques. However, there was a significant energy usage as a result of the binary tree creation and the utilization of 3-hop neighbours information. A methodology known as WDFAD-DBR was put out in a different study by Yu et al. to improve data transmission reliability by lowering the likelihood that data packets may enter void hole areas.

The RE-PBR protocol, a pressure-based routing method that is trustworthy and energy-efficient, was recommended by another research (Khasawneh et al. 2018). Link prominence, depth, and enduring energy limitations were taken into consideration while choosing the forwarder nodes that would go to the destination. This technique was able to achieve a balanced energy use because it could stop irreversible forwarder-selection of neighbours. An extra procedure called OR was proposed to avoid void hole locations. Unlike the current void node retrieval approach, this protocol uses a depth adjustment mechanism to vertically alter the node locations. All nodes keep an adjacency graph of their neighbours so that they may select potential forwarder nodes to send to the destination. With this protocol, the absence of nodes may be avoided. However, there is a significant compensation for energy utilization. A robust cluster-based routing technique was given byto find the least energy-consuming routing path, hence increasing network lifetime. The presented strategy consisted of the transmission and researched ow strategies. The paper then presented two methodologies: (i) a routing and energy-efficient bunch approach; and (ii) an energy consumption and range evaluation method. presented the study illustrated a variety of complexities and energy consumption in the clustering technique.

Various research has recommended different approaches to enhance the performance and durability of wireless sensor networks. According to a study a resilient cluster-based routing protocol was able to discover the most efficient path with the lowest energy usage. This technique involves two strategies: one assesses distance and energy consumption, while the other prioritizes route planning and energy conservation. It uses transmission and flow methods. Another research study introduced a new way to route data in CRSN by using clusters and focusing on stability.The research investigated the formation and utilization of energy by clusters of objects. Simultaneously, to decrease the energy consumption of wireless sensor networks in the agriculture sector. Multi-hop data direction techniques, or LPWANs,. This approach utilizes a form of learning that incentivizes positive conduct to address issues in complex data systems, including data stagnation, increased external interference, and inefficient use of internet resources. The updated technique regularly refreshes to capitalize on the growing reward for linking specific devices to the gateway. Additionally, a new way to send data is shown. It conserves energy and increases the speed of data transmission without consuming additional energy. A new tool has been created to promote the collaboration of device nodes and prevent sensor nodes from exhibiting selfish behavior in the future.The findings suggest that employing game theory can aid sensor networks in optimizing energy utilization and improving data delivery.This can lead to the network being more durable[25].

3. RESULT AND DISCUSSION

There are several research gaps in the literature on routing protocols for wireless sensor networks. One major gap is the lack of addressing the needs of realistic delay-sensitive applications, particularly in hierarchical networks. Although many proposed protocols aim to balance energy consumption and end-to-end delay, more research is needed to extend existing protocols to incorporate multiple sink nodes to better serve such applications. Secondly, scalability and mobility challenges continue to persist despite the effectiveness of some routing protocols demonstrated in simulation environments. Hence, further research is required to develop protocols that can efficiently handle large-scale networks and dynamic node movements while ensuring energy efficiency and reliability. Moreover, there is a gap in the development of energy-aware algorithms for software-defined networking (SDN)-based WSNs that can effectively control node energy consumption while maintaining network performance. Therefore, integrated approaches that simultaneously address clustering and routing are also needed to improve network performance and energy efficiency.

Efficient routing protocols are extremely important for optimizing energy usage and ensuring reliable communication in Wireless Sensor Networks that are enabled with the Internet of Things. In this review paper, we explore innovative strategies aimed at enhancing energy efficiency, scalability, and ensuring Quality of Service in large-scale, heterogeneous IoT environments. Our investigation includes exploring the integration of machine learning techniques, novel approaches to scalability challenges, and leveraging the concepts of network slicing.

- ✓ How canimprove the energy efficiency of routing protocols in IoT-enabled Wireless Sensor Networksthrough the integration of machine learning techniques?
- ✓ What new approaches could be developed to address the scalability challenges of energy-optimized routing protocols in large-scale IoT- WSN deployments?
- ✓ How can leverage the concept of network slicing to optimize energy consumption and ensure quality of service in heterogeneous IoT-enabled WSN environments?
- ✓ *How can improve the energy efficiency of routing protocols in IoT-enabled Wireless Sensor Networks through the integration of machine learning techniques?*

The integration of machine learning techniques into routing protocols is a transformative approach that can enhance energy efficiency in IoT-enabled Wireless Sensor Networks. By leveraging ML algorithms, routing protocols can analyze vast amounts of data collected from sensor nodes, including environmental conditions, traffic patterns, and energy levels, to make intelligent routing decisions tailored to the network's requirements. One of the primary advantages of integrating ML into routing protocols is its ability to facilitate data-driven routing decisions. ML algorithms can sift through historical data to discern intricate patterns and correlations between various network parameters and energy consumption trends. This analytical prowess empowers routing protocols to make informed decisions aimed at optimizing energy usage while adhering to the requisite Quality of Service (QoS) metrics demanded by diverse applications. Moreover, ML-driven routing protocols exhibit dynamic adaptation capabilities, enabling them to respond swiftly to changes in network conditions. Through techniques like reinforcement learning, these protocols can continuously learn from feedback loops, refining and optimizing routing paths in real-time. This adaptability ensures that routing strategies remain responsive to fluctuations in network dynamics, ultimately leading to more efficient energy utilization and prolonged network longevity. Additionally, ML algorithms can be deployed for predictive routing, where they forecast future network states and energy consumption patterns.

This foresight allows routing protocols to proactively adjust routing paths, pre-emptively mitigating potential energy inefficiencies and optimizing resource allocation to sustainnetwork performance over time. Furthermore, ML techniques facilitate load balancing among sensor nodes within the network. By optimizing the distribution of workload across nodes, ML-enabled routing protocols prevent energy depletion in specific regions, thereby promoting uniform energy utilization throughout the network. This load balancing mechanism not only enhances energy efficiency but also contributes to overall network resilience and stability. Additionally, ML algorithms can aid in the dynamic formation of clusters within the network. By grouping nodes with similar energy levels and communication patterns, ML-driven clustering algorithms enable efficient data aggregation and reduce redundant transmissions. This, in turn, translates to significant energy savings by minimizing unnecessary data traffic and transmission overhead. Overall, the integration of ML techniques into routing protocols represents a powerful paradigm shift towards more intelligent and energy-efficient operation of IoT-enabled

WSNs, offering substantial benefits in terms of sustainability, reliability, and performance optimization.

- ✓ *What new approaches could be developed to address the scalability challenges of energy-optimized routing protocols in large-scale IoT-enabled WSN deployments?*

Scalability is a major challenge in large-scale IoT-enabled WSN deployments. To ensure energy-optimized routing, novel approaches are needed. One such approach is hierarchical routing architecture. By segmenting the network into multiple hierarchical levels, such as clusters and super-clusters, hierarchical routing makes data aggregation more efficient and reduces the overhead associated with routing decisions. This hierarchical organization allows for the delegation of tasks and responsibilities, enabling streamlined communication and routing processes across various network tiers. Hierarchical structures promote scalability by providing a framework for managing and coordinating a growing number of sensor nodes while minimizing energy consumption and optimizing network performance. Another way to address scalability challenges is through distributed optimization algorithms. Unlike traditional centralized control mechanisms, distributed optimization algorithms distribute decision-making processes across the network.

They leverage local information and collaborative efforts among sensor nodes. By decentralizing control and computation, these algorithms reduce communication overhead and enhance scalability. They enable the network to scale gracefully with increasing node density. Distributed optimization fosters a self-organizing network architecture where nodes autonomously adjust their behaviours based on local observations and interactions. This leads to efficient and energy-optimized routing in large-scale deployments. Additionally, edge computing can help mitigate scalability challenges in IoT-enabled WSNs. By utilizing edge computing resources, processing and decision-making tasks can be offloaded from centralized controllers and distributed closer to the data source. This minimizes latency and communication overhead associated with transmitting data to a central processing unit. It enhances scalability by relieving the burden on centralized resources. Edge computing empowers sensor nodes to perform localized data processing and routing decisions. This leads to more efficient resource utilization and improved scalability, particularly in environments characterized by vast amounts of data and stringent latency requirements.

- ✓ *How can we leverage the concept of network slicing to optimize energy consumption and ensure quality of service in heterogeneous IoT-enabled WSN environments?*

In heterogeneous environments of Wireless Sensor Networksenabled by the Internet of Things, network slicing can be an effective strategy to optimize energy consumption while ensuring Quality of Service for diverse applications. One of the primary benefits of network slicing is resource isolation, wherein resources are segregated to avoid energy-intensive applications from impacting the performance of energy-constrained applications. By doing so, critical applications receive the necessary resources without being adversely affected by others, thereby optimizing energy usage across the network. Moreover, network slicing allows customized routing policies for each slice, further enhancing energy efficiency and QoS. By tailoring routing algorithms to the specific characteristics and requirements of each application, such as low-power routing for energy-constrained devices and robust routing for high-priority applications, network slicing optimizes energy consumption while meeting QoS demands.

Dynamic resource allocation capabilities inherent in network slicing enable the efficient utilization of resources based on real-time application demands. Resources such as bandwidth and processing power can be allocated dynamically to different slices, ensuring optimal energy consumption while maintaining QoS standards across heterogeneous IoT environments. Furthermore, the establishment of Service Level Agreements (SLAs) for each network slice ensures the fulfilment of QoS requirements while optimizing energy usage. SLAs define performance guarantees such as latency, throughput, and reliability for each slice, providing a framework for monitoring and enforcing QoS standards. By adhering to SLAs, network slicing enables efficient resource allocation and management, ensuring that energy is utilized judiciously to meet the diverse needs of IoT applications while maintaining satisfactory levels of performance.

Overall, the utilization of network slicing in heterogeneous IoT-enabled WSN environments holds immense potential for achieving energy optimization and QoS assurance, thereby enhancing the efficiency and reliability of IoT deployments.

4. CONCLUSION AND FUTURE ENHANCEMENT

The main objective of WSNs is to collect ambient data with minimum cost and transmit these data to the destination. Routing protocols must be utilized to forward the ambient data from the sensor nodes While they have certain scalability and mobility issues, conventional WSN routing protocols like DA-EEORR and optimal route selection in wireless body area networks demonstrate promising outcomes in balancing consumption of energy and end-to-end latency. However, there is still room for improvement when it comes to focusing on node energy consumption and scalability issues. Examples of software-defined network-based WSN routing protocols that could be used to enhance reliability of the network and energy efficiency include the Energy-aware software-defined routing network algorithm and the Improved SDWSN framework. The hybrid methods that combine metaheuristic algorithms, neural networks, and reinforcement learning show creative ways to maximize energy use and expand network lifetime in WSN. However, there is a clear research gap in effectively integrating clustering and routing strategies to address the needs of realistic delay-sensitive applications in hierarchical networks. More, scalability and mobility challenges remain unresolved despite the progress made in simulation environments. For future research, it is crucial to develop integrated approaches that simultaneously address clustering and routing to improve network performance and energy efficiency. Additionally, there is a need to develop energy-aware algorithms specifically tailored for SDN-based WSNs to control node energy consumption effectively while maintaining network performance. Moreover, further investigation into scalable and mobility-aware routing protocols is crucial for the deployment of WSNs in real-world scenarios. Additionally, exploring novel techniques such as reinforcement learning and metaheuristic algorithms for optimizing energy consumption and extending network lifetime could pave the way for more efficient and reliable WSNs in various application domains.

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