Journal of Harbin Engineering University
ISSN: 1006-7043
Vol 44 No. 8
August 2023

A Review On Energy Efficient Routing For Internet Of Things In Wireless Sensor Network

Sulalah Qais Mirkar*
*Department of Information Technology, NMIMS, Mukesh Patel School of Technology Management and Engineering, Mumbai, India. Email: *sulalah.mirkar@gmail.com*

Dharmesh Ishwerlal Rathod
Department of Information Technology, NMIMS, Mukesh Patel School of Technology Management and Engineering, Mumbai, India. Email: *dirathod@gmail.com*

Abstract
In the present mechanical world, different actual items can be utilized to work with human undertakings. The Web of Things (IoT) is an innovative and prevalent arrangement that can associate the physical and computerized universes using heterogeneous organizations and correspondence advances. In an intelligent climate, the IoT connects with Remote Sensor Organizations, making it more financially practical and valuable to clients. In any case, it simultaneously carries new provoking issues to the organization. The possibility of the IoT is considered to comprise an enormous number of remote asset-compelled gadgets associated with the Web.

Moreover, numerous clever actual administrations given by IoT gadgets are carried out through remote sensor organizations. Subsequently, the combination of WSNs into the Web has advanced a necessity for start to finish nature of administration confirmation. Indeed, even in these dispersed organizations for IoT, the energy effectiveness of hubs is critical in calculating network execution. In this audit, we voyager the ongoing specialized obstructions and difficulties working on receptive directing in light of the energy-productive convention for IoT in WSN. It will likewise give an unmistakable perspective on the versatility and heartiness of the decrease concerning power utilization and expanded network life expectancy.

Keywords: IoT, Wireless Sensor network, Energy-efficient routing, Quality of service.

1. INTRODUCTION

The need for automation in various fields demands IoT devices to ease various human activities. As a result, the requirement for amenities and facilities will increase as the city and population growth. Therefore, the novel development in technical support is to overcome the ever-increasing demand for various services [1]. In such actions Internet of Things (IoT) is an upcoming and fast-growing technology that provides better solutions [2], [3], that can connect the physical and digital worlds using a mixed (wired and wireless) form of networks and communication medium.

The most proficient and flexible wireless sensor networks (WSN) provide a scalable communication environment for IoT devices, which makes them more viable for today's automation needs. The interaction of IoT and wireless sensors can construct a new design of WSN-IoT and IT-based networks systems [4]. In such current development of IoT, the World Economic Forum [5] also ensures the inclusion of digital future and digital economy for various social systems. It was expected by 2025 approximately more than 75 billion new IoT-connected devices will be integrated with various methods [6]. Even the economical growth of IoT by 2025 is accepted to be more than $11 trillion [5], so it is essential to develop novel Energy-Efficient Routing (EER) mechanisms to have cost-effective routing schemes.

IoT [7] is a heterogeneous network of communication devices that interchange information exclusive of individual intervention to present intelligent services to end clients. In recent years, the field of IoT has been extensively explored through considerable research and development of a smart metering solution, monitoring home appliances, weather monitoring, surveillance, traffic control, and various safety systems using IoT [8]. Even the usage of IoT is extended and integrated with RFID and mobile phone-based devices, which generally have constraints of low computation and energy for information gathering and lives to monitor the physical parameters. Such diversification of usage of IoT is building a huge level of interconnected networks for communication, and with time it might become more complex and extensive. An IoT-based system will provide users with greater agility and reduce network deployment costs while opening up new challenges for the network.

Device energy balancing is one of the key factors in the WSN-IoT system. An IoT system consists of a collection of sensor devices, whereas WSN routing schemes support discovering the most efficient and shortest path for communication. Multi-Hop WSN [9] uses sensor devices for routing and these devices have a low battery which is essential to maintain the network connectivity. As a result, many researchers are focusing on developing EER protocols that extend

the life of these networks. The routing schemes of WSN or MANET might not be used directly on the IoT due to the computation limit of sensor devices and devices density in the network. Therefore, an integrated solution is needed for the WSN-IoT network routing, which can efficiently use the remaining device power and extend the network's life.
There are several routing protocols are designed to provide efficient routing in WSN. According to their storage and route-finding process the routing protocols are categorized as Table-Driven, On-demand, and Hybrid. In Table-Driven schemes, information regarding the routes are broadcast in regular interval by all devices to acknowledge others which is term as proactive, OLSR [12] is a prominent protocol in proactive routing, whereas in On-demand routes, a build-up dynamically as per the source device demand for a routing term as reactive; AODV [10] and DSR [11] are prominent protocol in reactive routing, and in case of Hybrid routing it combines the feature of both reactive and proactive to deliver efficient routing, ZRP [13] is the prominent protocol in hybrid routing.

WSN devices function on limited storage, processing, and powered capacity. The deployments of these devices are normally in regions that are nearly impossible to reach for humans. So, it is challenging to replace the battery regularly. Like WSN, energy consumption in IoT devices is also a major drawback. The past studies [15] state that the inefficiency of energy IoT routing has a critical impact on IoT-based applications. So, it is highly challenging for the researchers to design EER suitable for all usage.

In the literature, many efforts are made to improve energy efficiency by different researchers. But still, the problem of designing EER persists and remains an open field of research in WSN-IoT. To improve the lifespan of the sensor device and network, the demand for EER is increasing. In the literature, most EERs are designed utilizing the feature of reactive protocols such AODV or DSR to improve the EER performance of IoT applications. The proactive routing scheme shows additional routing overhead in maintaining routing information, making it unfit for WSN-IoT routing.

Hence, it is significant to use reactive (on-demand) based EER protocol for WSN-IoT. It will provide scalability and robustness with the reduction in terms of power consumption and increase network lifespan. So, with motivation from the above discussion and limitation, this review article will aim to discuss the significance of EER protocol for WSN-IoT to optimize power consumption for the route establishment and communication among the sensor devices in the future works of IoT routing.

2. NEEDS OF ENERGY EFFICIENT ROUTING IN IoT

In the past few years, we have been facing a lot of geographic disasters and epidemics because of various impacts on the environment. This has led to many people being disconnected from the connected system. Due to the loss of infrastructure, it is difficult for the military and rescue teams to stabilize the situation in an unrelated environment. Installing a new system in such a situation is always difficult, slow, and costly. In such cases, IoT-based mobile devices are extremely helpful in building a special mobile network utilizing the WSN environment to quickly accomplish citizens who are in problem or need help. But, due to the power limitation of these types of equipment, this type of emergency communication system will cause uncertainty in the long-term constancy of the network.

It also encountered several technical barriers such as inadequate energy consumption, unreliable connections, and random changing network topologies. So, it is essential to maintain a stable and secure communication system along with low energy consumption usage. The past works on WSN performance over different emergencies make it effective usage for different situations. The freedom of dependency from infrastructure creates it helpful and adaptable to WSN communication. But, the scarcity of resources, especially in energy, leads to low stability and performance. So, energy management is essential to have a stable and longer life in WSN. It will ensure a longer life span of devices in the network and also ensures higher network stability, capacity, and productivity.

Designing EER techniques for WSN is the major issue of concern. It was observed that most of the energy is utilized in the process of route establishment and data transmission [17]. It indicates that the majority of wastage of energy is cause by improper routing design or overhead in the network due to unnecessary data transmission or exchange of information. Therefore, it will be practical to design and implement a system that aims to minimize the usage of energy and, in turn, enhance the life of devices that provide stability and the lifespan of the entire network. Hence, this review will mainly aim to assist in designing novel solutions for the following problems identified in the IoT communication as given below.

- The issue of energy loss and delays during the transmission of the route for IoT.
- Difficulty in planning route data for IoT networks to work efficiently in terms of energy conservation.
- It is a matter of making the right decision to select energy-efficient devices to reduce energy utilization by the IoT networks while sending information.

IoT applications are utilized in a diversity of environments and control multiple locations. However, there are many complex problems with using IoT. As presented in [25], the following are the pros and cons of IoT being identified.

Pros:

- *Information Gaining*: Intelligent sensor devices are linked for easy communication. They provide real-time, non-physical access to information from any location.
- *Transmission*: It enables speedy and proficient transmission between linked sensor devices.
- *Cost-Efficient*: As mentioned earlier, fast and proficient transmission among network sensor devices facilitates daily tasks while minimizing time and cost.
- *Automation*: This is the key advantage of IoT. Automated tasks prevent human error and in turn, enhancing service and quality.

Cons:

- *Security and Privacy*: It is considered a major issue of IoT data transmission. Because all the information is shared over the internet. The privacy and security of the data transmission might be compromised and intruded on by the intruders.
- *Complexity*: The IoT has a vast network that includes the different devices underneath. A hardware or software flaw can influence a complete system with disastrous outcomes. So this is the most difficult characteristic of the IoT.
- *Smaller Tasks*: The necessity for manpower has dropped dramatically by automating all tasks. The utilization of IoT devices is growing rapidly, and the influence of the "future IoT" is growing. The recruitment of skilled workers will be significantly reduced.
- *Technology Reliability*: There is no uncertainty that technology directs the lifestyle of people and makes considerable changes in the introduction of technology into our everyday activities. Thus, it imitates human reliance on equipment and its impact on required social interaction skills. Due to the low self-esteem and upbringing of patients suffering from depression, people enjoy virtual interactions more than real ones.

3. IMPORTANCE OF THE INTERNET OF THINGS

The development of automation, monitoring, and control systems using intelligent sensor devices make on the rise in IoT. The increasing popularity of smart sensors, such as smart buildings, smart meters, wearable devices, and many other systems, has enabled the scalability of IoT [18], [19].

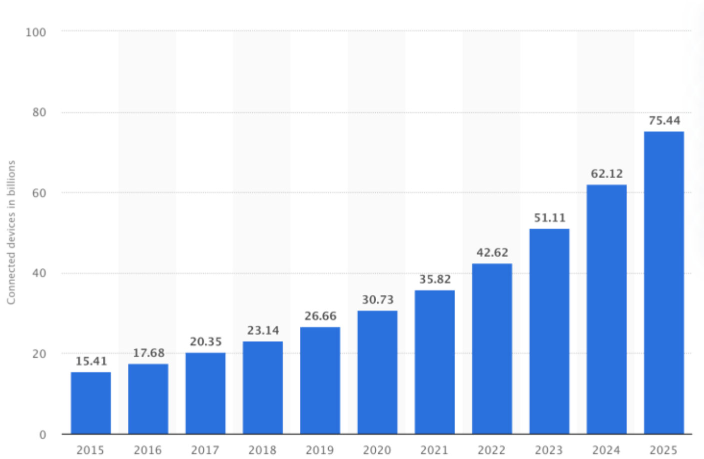

Fig. 1: An illustration of the growth of IoT devices [6].

As per the forecast illustrated in Fig.1, the number of active device connections in IoT will grow to more than 75 billion by 2025 in various domain systems [6].

According to this estimate, the complexity of IoT systems increases as the quantity of dynamic device connections increases, regardless of their complication. Each communication and ancillary service needs to be available when and where needed. So, it requires simplified IoT architecture to manage such complexity in communication. Fig.2 shows the context of IoT in terms of multiple scopes of usage in different domains. It conveys the functionality and interoperability of each other to accomplish a task or distribution of information using the IoT components and network in a different data form and operations [20].

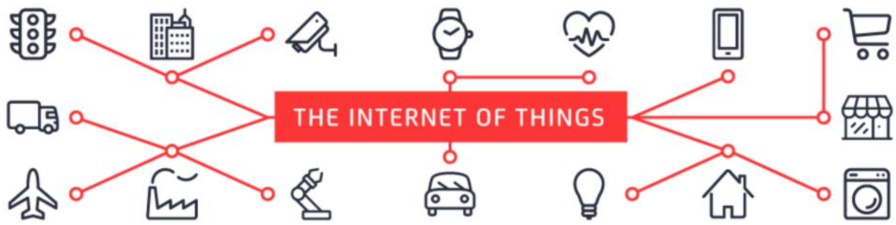

Fig. 2: Illustration of IoT scope of utilization [20].

Since each IoT structure is diverse from others, but the underlying and underlying data processing flow of IoT architecture is almost identical. Even though there is no generally accepted idea of IoT framework, as the researcher still needs different architectures.

A framework of IoT consists of intelligent devices, which are used to acquire the system information from edge devices via different routing gateways to their data centers [21]. A device or object here is an internet-connected object that can sense its environment with built-in sensors and actuators. It receives raw data using these built-in sensors and actuators on IoT by the input methods of the data acquisition systems. The obtained raw data are pre-processed to transform into digital form to utilize in further investigation. The advanced analytical functions remain in the third layer of the IoT framework in the form of edge devices. It performs different learning techniques to introduce the visualization information for analysis. Later, it is stored in a suitable cloud or local data storage for further usages.

IoT constructs a distributed architecture where most sensor devices are linked and activated to focus on the dedicated task. For example, a network of street lights are embedded with the sensors with a capability of image identification, fact augmented with the integration of the base location communication to support in managing different assets and service of the system. It opens the scope for different business entities but at the same time enhances the complexity of the function of IoT [22]. Even though IoT's operational overhead and communication complexity is increased with time, it is still a promising field in every sector.

To create a comprehensible image of the defined IoT, it is constructive to list the properties of the IoT. The properties of IoT presented in [23] are discussed below.

- *Interlinking of Things*: This is the most important property inherited from the name identity. It is a structure that handles the connection among "things". The term "things" means a physical entity or devices that are helpful to any consumer or application.
- *Linking of Things to the internet*: It is considered another important property of the IoT. In this case, all the entities are prearranged and connected to the internet. But, this connection is not true for the systems of intranet and extranet of thing.
- *Distinctively Recognizable Things*: To communicate among IoT devices, every device has to maintain a distinct recognition. It is mostly determined as the address of the things.
- *The facility of Sensing and Actuation*: IoT systems are designed with sensors and actuators to do a specific task. It provides additional intelligence to things to do their function smartly.
- *The facility of Interoperable Communication*: The IoT system utilizes a standard transmission scheme that permits the sensors or actuators to communicate with each other.
- *Self-configuration*: This is a significant property of IoT systems. The ability to discover neighbors and services, organize networks, and provide resources is subject to self-tuning. Because IoT devices such as sensors, actuators, and mobile phones are heterogeneous, network elements connected to the Internet must control themselves concerning software and hardware configurations and their use of their resources. Here, resource utilization points to the energy consumption, mode of communication, bandwidth utilized, obtaining to the medium, etc.
- *Programmability*: The entities of IoT are intelligent due to their programmable capacity. It can program a device of IoT to customize the user's needs. It can easily and quickly be the program to change the function without any physical modifications.

IoT will integrate many diverse devices and frameworks under one roof, and, as a result, a significant increase in the number of Internet connections approx. the 80 billion intelligent devices will create a major problem [24]. Each device and program will work with its processing schemes, architects, and data formats. This will indicate that communication between these entities might not be efficient, easy, and secure.

4. WIRELESS SENSOR NETWORK IN IoT

IoT's framework relies on several activation technologies over the WSN network. It can be integrated with learning and analysis with cloud and peer-to-peer systems [26]. WSN is the most significant functional network component in an IoT network. It consists of a sequence of sensor devices accountable for gathering basic information, executing calculations, and establishing connections among the devices [27]. These devices can be located over a big geographic region and are typically built up in a network, eventually, transfer huge amounts of data to a base station (BS) or gateway and typically sending several hops to access the BS. These networks are devices with limited battery usage and computation capability. It is therefore important to develop the most efficient path mechanism for transmitting data.

WSNs are independently built networks with no fixed topology. Each device in these networks acts as a router and a host simultaneously. All network devices are identical and can move freely or join the network at any time. Mobile devices with each other can communicate directly and transmit the necessary information. There is a wireless interface to communicate with other devices between network devices. Such networks are fully scattered and can function wherever exclusive of requiring specialized infrastructure to do communications. Fig. 3 shows an example of MANET interaction [28].

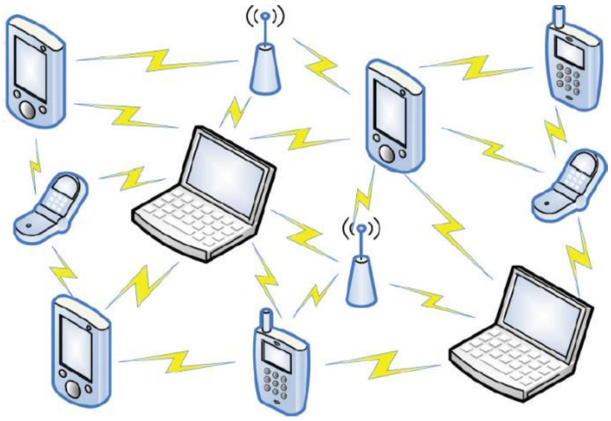

Fig. 3: Illustration of MANET

MANET has a wide range of operating procedures and at the same instance requiring a relatively composite configuration process in contrast to conventional sensor networks directly connected to the central manager. Mostly MANET provides a different kind of property [29] which is generally described as dynamic topology, distribution computation, multi-hop or source driven routing, self-organized and lightweight devices with sharing over a substantial communication medium. Generally, WSN or MANET routing schemes are classified into three different types based on their mechanism which we discuss below.

A. Topology-based Routing: There are three types of topology-based routing available in this scheme. (1) The routing mechanism based on table-driven is categorized as proactive routing, (2) the routing mechanism based on on-demand by sources is categorized as reactive routing, and (3) the routing mechanism based on both proactive and reactive are categorized as Hybrid routing.

B. Location-based Routing: Location-based routing uses the physical location of devices in every zone to make routing decisions. Location data can be used to determine the Global Positioning of a device. Location-Assisted Routing (LAR) is an example of location-based routing schemes.

C. Energy-Aware-based routing: The entire device in the network maintains multiple route information in the route data table of a wireless environment. It is possible to route a network that assesses the power level of the network devices to select the most convenient method. In such a situation, the routing table after the device energy level is maintained by transmitting hello messages between the devices to acquire their energy levels. The collection of entries in the device transmission table corresponds to the number of devices that can be accessed using the energy level. Therefore, the several entries in the routing table represent the availability of the total devices in the network [30].

WSN mobile devices run on battery power and routing protocol capabilities and must consist of a better rate of data forwarding while sustaining lower power utilization. The rate of complete throughput relies primarily on the interval of the device with the remaining ability of the device. To make the network more appropriate, the routing schemes have to attempt adeptly to prevent the premature shutdown of mobile devices and significantly extend the network's life.

5. SIGNIFICANCE OF EER IN WSN-IoT

The system of WSN-IoT networking depends on dynamic routing protocol and principles of WSN for gathering sensing data from things for processing. In general, establishing a network in these systems is very difficult regarding routing. It is also related to system mobility and the limited resources of the entire devices in the network. The WSN protocol is created with QoS in mind [31] and is aimed at the energy efficiency of routing system devices in WSN [32]. The internet connections to things have limited capabilities and different interactions in the WSN. Connectivity, access, and reliability of the WSN-IoT system should be ensured in an intelligent environment.

The purpose of the energy-saving and switching protocol is to decrease energy utilization in packet distribution among socket devices and target devices, prevent package transmission to low-power devices, improve flow details in the network, and prevent interference and interference. In sensory networks, the failure of a device does not lead to sensor loss and communication vulnerability, which is less noticeable, but dedicated networks focus on the loss of individual communication and connectivity with many large devices. The edge device in the communication network acts as a different state of forms during the communication according to their level of energy usage as given below.

- *Transmit:* Devices send frames with less transmit power.
- *Receive:* Devices receive frames that receive a lot of energy. This energy is applied even if the device ignores or incorrectly encodes the window because it is expected to increase the target device space.
- *Idle (hearing):* Even if the message is not transmitted over the communication medium, the device does not continue to operate or receive the transmitter.
- *Sleep:* As long as the radio is "off" and the device cannot detect a signal, it cannot connect. Power devices use much less power than others.

Majority of EER protocols of WSNs attempt to reduce power utilization by using energy-reducing routing metrics that are used to compute routing metrics instead of "least hops metric". These four possibilities for energy-saving devices are:

1. *Least Energy utilization per Packet*: The utilization of entire energy adds to the energy used in each hop to send the packet. The use of energy in the device benefits the gap between the neighbors, and it carries the device. It is therefore appealing to determine a direction that is not too wide between the devices and to take a shorter route so that there is not a lot of rotation in an attractive and low-energy direction.
2. *Maximize Network Connectivity*: The measure seeks to increase the balance at every device in the network. This assumption is important in a networked situation where network linking is guaranteed.
3. *Lowest inconsistency in Device Energy Levels*: This measurement recommends distributing the overload between each device so that the energy utilization for each device is constant. This difficulty is exacerbated when "rate" and "package data" change. The network can be guaranteed to work when each device has the same power phase. Having to disable the circle at the power level can jeopardize the connection between the entire network and cause the devices to disconnect.
4. *Reducing Maximum Device Cost*: This value reduces the "maximum value for devices" per packet outside several packet paths or after a certain point. So the knot is blocked for the way to collect the battery power. These measurements collect the connection from each device. When a knot is used several times for a path, it is not designed to save power.

Many researchers have generated news and new ideas in this area. It includes many suggestions on reactive, proactive, and hybrid approaches to energy efficiency. Since the power of special wireless networks comes first, much of today's work relies on the "energy saving path". Each protocol has different advantages and disadvantages. Depending on the network constraint which protocol should be used has to be decided. Many protocols have been introduced for effective energy orientation, and changes have been proposed for WSN usage.

6. MECHANISM OF EER FOR WSN AND IoT

A. Proactive EER

1) *Destination-sequenced distance vector (DSDV)*: DSDV [16] is the most prominent proactive protocol based on the "Billman Ford algorithm." It eliminates the limitation of looping and the "infinite count problem" in modern interval vector protocol that are not suitable for WSN. The destination vector routing protocols depend on the destination where each device maintains its routing table. The route table has available routing directions for the next device and the number of hops to the destination. Each time the position of a device changes, then its path also will update and also need to update other devices. To avoid the looping problem sequencing of route updates is maintained.

It maintains the easiness of the distance vector protocol and provides a loop-free routing that immediately responds to topological changes. This is because the route to the destination always exists in the routing table for each device. Therefore, there is no time needed to search for routing directions. However, broadcast updates can increase traffic between sites if the site is highly mobile. Therefore, this protocol is more convenient if the network capacity of the distributed network is low and the distribution information might be delayed.

2) *Optimized Link State Routing protocol (OLSR):* OLSR [12] provides two additional features for the standard Link State Routing (LSR) in the user network. Every device defines a group of neighboring devices term as a "Multipoint Repeater (MPR)." Additionally, when LSR data is exchanged, the device refers only to the association that the device defines as MPR, which defines some transmitting points. This greatly reduced the number of retransmissions. A device's MPR is essentially the smallest neighbor group that can reach all devices within the two hops in a particular device. The device changes with the device operation and is updated by intermittent HELLO communication periodically. The route from the source device to the target device is mainly via an MPR. The precise routes are shorter and loop-free, as in the conventional LSR algorithm, which defines a two-way connection for the routing schemes.

Table-1: Exploring Proactive Routing Protocols for the IoT Environment Supported by WSN

Ref.	Proposed protocol	Merits	Limitations	Performance Metrics	Energy Efficiency
[33]	QG-OLSR	• Transmission performance is increased • Reduced time delay and energy consumption	The network topology control cost is higher	• Rate of Packet delivery • Avg. end-to-end delay	High
[34]	LAMAR	• Improved Performance of the conventional LANMAR protocol	Low Scalability	• Jitter • Throughput • End-to-end delay. • Control Overhead • Power utilization during transmit, receive, and idle modes. • Number of control packets	High
[35]	DSDV	• Less Jitter Delay and performance improves with increasing transmission power	Less PDR	• Throughput • PDR • End-to-End delay • Jitter • Packet Loss	High
[36]	Re-clustering Scheme for DSDV	• Less energy consumption in the static and semi-dynamic category	High energy consumption in the dynamic category	• Rekeying Cost • Energy Consumption	High
[37]	TBRPF	• Efficient Minimum Broadcasting • The efficient Neighbour discovery protocol • Utilizes less than 85% of bandwidth	Propagation path loss	• Routing Control Traffic • Maintenance Overhead	Medium

B. Reactive EER

1) *Dynamic Source Routing protocol (DSR)*: DSR [11] is a source-based and on-demand loop-free routing protocol. The source device initiates this protocol on the requirement. It is primarily designed to take advantage of multi-hop wireless mobile devices. The DSR protocol doesn't require any standard system infrastructure or management, and it builds this network fully randomly and self-organized.

This protocol has two core functions. The first function is to find the route for routing, and the second is to maintain the route. Each device holds a cache to save recently identified routes. If a device wants to send a packet to the device, then the route cache is first checked. If any paths are available with source and destination path devices, then it is used to transfer data packets. If it's unavailable in the cache or discovered routes are expired, the source device distributes a route-finding request to all its neighbors to obtain a route to the target device. Once the source device is discovered, the route cache is updated and initiates the transmission process.

2) *Ad hoc On-Demand Distance Vector Protocol (AODV)*: AODV [10] is a form of vector routing

protocol based on DSDV and DSR. Its objective is to reduce the systematic broadcasting mechanism for route finding to a greater extent. Each device does not support routes to other devices in the network. On the contrary, it is only found when necessary and stored until it is needed. The main procedure utilized by AODV is to find a unique route to the destination and maintain it efficiently.

3) *Energy-Aware Algorithm for AODV*: The mechanism of the energy-optimized algorithm can be employed to present WSN route protocols such as AODV [38]. The value function is derived from information on large-scale energy loss and device battery power, and paths have been adjusted based on the routing channel and device functionality. A low battery warning mechanism is introduced to improve routing update behavior, particularly by preventing critical devices from being misused. Network bandwidth is not significantly affected, and it is a matter of the level of low battery warnings. The main power utilization is stabilized, and the inadequate battery sources are used resourcefully.

4) *Power-Aware AODV (PAAODV) Protocol*: PAAODV [39] is an extension of the AODV routing scheme that employs power supervising information during route finding. PAAODV consists of two methods: (i) multi-energy level path detection, and (ii) path energy administration.

In the search for a route, route request packets are used to find routes that save energy. On the other hand, route response packets are used to monitor the power transmitted on the way. When a route is found, several power levels are used. Initially, devices try to find a low-power route to their destination. If this fails, the power level is increased. This will continue until a successful path is found with two energy levels as minimum and maximum.

Table-2: Exploring Reactive Routing Protocols for the IoT Environment Supported by WSN.

Ref.	Proposed Protocol	Merits	Limitations	Performance Metrics	Energy Efficiency
[40]	AR-TORA	• Overall performance improvement in terms of PDR and an E-2-E delivery.	The flooding problem needs to be solved	• Avg. E-2-E delay • Topology Control overhead • PDR	Medium
[41]	IoT-AODV	• Reduction in Routing Traffic Load	Increased Routing Overhead	• Normalized Routing Load • Routing Overhead • PDR • Packet Loss Rate. • E-2-E Delay.	Low
[42]	LOADng	• Significant reduction in Route Overhead • Shortest Delay	Increased Route Discovery Delay	• Point-to-Point Traffic • Point to Multipoint traffic • Lossy network scenario	Medium
[43]	DP-AODV	• Improved Network Performance • Improved packet delivery and throughput • Minimized Interference	Increased Control Overhead	• Jitter • Control Overhead • PDR • E-2-E delay • Throughput	High
[44]	Associative Based Routing	• Maximizes Energy Efficiency	Increased power consumption due to periodic beaconing. Increased Signaling Traffic	• Control Overhead. • Data Throughput. • E-2-E Delay.	High

[45]	EECP	• Network Lifetime Improvement • Energy Saving	Less Robust due to network Coding	• Network Size • PDR • Avg. Energy usage	High
[46]	ODSR	• Improved throughput • Reduces the end-to-end delay of retransmission	More intermediate devices between source and destination.	• Throughput • E-2-E Delay • Routing and Controlling overhead	Medium
[47]	GA-BFO	• 18% improvement in control overhead	Needs route discovery optimization	• PDR • Control Overhead • Avg. E-2-E Delay.	High
[48]	AQ Routing	• Increase in Packet Delivery Ratio • Enhanced stability of links	Needs an energy-aware protocol to maximize the lifetime of the network.	• Mean Packet Loss Ratio • E-2-E Delay	Low

C. Hybrid Routing EER Protocol

1) *Zone Routing Protocol (ZRP)*: ZRP [13] is a hybrid protocol that uses proactive routing schemes around the range of devices and communication employing reactive schemes. Each device determines the area around it and the area radius to determine the number of hops around the zone. A source device will perform a fast-paced global search, requiring only a select group of devices in the network. The devices required are located in the zone and were put to a vote during the flooding of the entire network.

If the range of the region of the zone is cautiously selected, the devices can be located in numerous overlapping areas. Consequently, the path detection efficiency is reduced. In addition, the progress of devices and the range of a zone can quickly affect the operation of devices within the region's boundaries. The "Intra Zone Routing Protocol (IARP)" used within a part is not a specified routing scheme with constraints. Likewise, a region is a collection of reactive routing schemes to facilitate advanced finding and persistence using IARP local device information. Accordingly, it cannot classify ZRP simultaneously into a category and its kind as a structure for proactive and reactive routing schemes.

2) *Optimizing power-Aware Routing using ZRP in WSN*: This mechanism provides a different route with the optimized energy management method. A control structure for improving energy-based routing was developed with a power-aware routing optimization (PARO) method and ZRP [49] to efficiently manage power and communications. This routing procedure tries to decrease power consumption by transmitting a packet with better energy of the network to reduce the overhead on the devices with less lifespan.

Therefore, it is essential to study how to reduce the power consumption of sensor devices and extend the network's life. The network's lifetime is considered one of the most essential parameters in the evaluation of sensor devices. Still, there are various interpretations regarding network life in the literature. Typically, this is when the sensor assemblies will be completely functional. In other words, the life cycle of a network is the time it takes for the first device to go down [54]. A different description of network life is the time it takes for the earliest sensor device or cluster of sensor devices to complete the energy loss [61].

Devices can only fulfill their mission during their lifetime, so losing a device damages the network and loses some of its functionality. Therefore, the foremost purpose of the energy-efficient method is to extend the device's useful life and the network's helpful life. The literature describes different causes of energy loss and other solutions. These are described below.

Some studies have shown that communication devices are comparatively energy-intensive [50]. In WSNs, most energy processes transmits, or receives data to meet program necessities. Dropping data transfer will certainly preserve energy for these limited devices. As for communication, several studies have shown that it does not contribute to large amounts of energy consumption to the application, such as:

- **Collision:** Packet conflicts occur when a device receives more than one packet at a time. As a result, packets are dropped or sent back to the original host, and then those packets must be sent again, which increases packet latency and power consumption, which negatively affects the lifespan of the network [51].
- **Overhearing:** This is a significant energy loss, especially with a high load density of traffic. When a device transmits a packet, every device in its range of communication gets the packet, even if that device is not the intended target device [52]. If device D1 wants to transfer its data to device D2. However, most of the devices around it are in the radio range of device D1. Every one of these devices will get information from device D1. The device loses energy when receiving/sending data packets to other devices. Even device D1 will also receive information from the devices around it when transferring information.
- **Control packet overhead:** It is collectively due to lack of memory, delay in computation, lack of bandwidth, or other sources to perform a particular task. Thus, it is necessary to develop the minimum number of control packets to control the transmission.
- **Idle listening:** This occurs when the device has to remain open to get idle traffic for potential traffic, so many neighboring devices are often active. The reason for this is to listen to the broadcasts; it can use several methods of transporting neighboring discovery or device information to neighboring devices [53]. Of course, a device that has a shorter waiting time stores better energy than other devices.
- **Interference:** Any intersection with two or more devices in the communication range will create interference by local adjacent devices. The intervention increases with the number of neighboring devices. This will increase traffic congestion and communication problem, leads to re-transmission [54]. Therefore, mitigating interference from higher devices can decrease packet loss, thereby reducing the overall power utilization in the network.
- **Redundant Data:** Sensor devices are usually disassembled randomly, monitoring several areas of two or more sensors simultaneously. However, this type of separation increases the number of redundant data reports on the network. These results in energy consumption are due to collecting, computing, and transmitting repeating data by eliminating unnecessary device functions which can reduce energy consumption.
- **Length of Communication:** Communication length between devices is a significant part of energy efficiency. The communication between the device and the CH/BS can be a particular link or multiple links. Since the transmission power utilization is comparative to the square of the length [55], the energy needed for communication enhances quickly as the dimension of the network increases, which means that if the network scale is large then the power utilization for the transmission also will increase. Most of the literature demonstrates that communication with multi-hop is the optimum approach to decrease the communication length among the devices. The shorter communication length from the source device to the next hop device decreases device power utilization and extends the network's life.
- **Non-Clustering:** Direct transmission length from each source device to BS significantly reduces the lifetime of the WSN because of excess power consumption. As a result, hierarchical routing schemes are implemented, which designed systems based on sequences, clusters, and tree forms [56]. In sequential plans, devices are arranged in series, where a device is preferred as a CH device to broadcast data from every one device to the BS. When using clusters, the devices are separated into sub-clusters, and since each sub-cluster has several sensor devices linked to the CH device, their data can be sent to the BS. In tree-based clusters, every source data is transmitting from each sensor device to the CH device relies on the concept of multi-hops [77]. Aggregation is the best technique for sensor networks to reduce transmission costs and maximize network life.

Table-3: Exploring Hybrid Routing Protocols for an IoT Environment Supported by WSN

Ref.	Proposed protocol	Merits	Limitations	Performance Metrics	Energy Efficiency
[57]	EELB-ZRP	• Energy Efficient route selection • Less packet drop rate due to overload • Low delay rate • Reduction of the queue waiting time during congestion	The packet delivery ratio decreases when there is a rise in the number of devices	• E-2-E Delay. • Throughput • PDR • Energy utilization	High
[58]	ZRDM LFPM	• Improvement in Packet Delivery rate • Significant reduction in Routing overhead and Avg. E-2-E Delay.	Additional traffic created during the route discovery process	• Normalized Routing Overhead. • Avg. E-2-E Delay • PDR	Medium
[59]	PSO-ZRP	• Low control traffic overhead • High packet delivery ratio • Low E-2-E Delay.	Low convergence rate of PSO algorithm	• Avg. E-2-E Delay • Normalize routing overhead • Packet delivery ratio	Medium
[60]	MDE-ZRP	• Improves the network's lifetime • Minimizes overall routing overhead	Increased proactive routing overhead	• Routing overhead • Jitter • Energy utilization • PDR • Rate of Collision	High
[61]	CHER	• Overcomes problems such as • A large Number of Transmitters • Huge Network Size • Higher device mobility	Less PDR	• PDR • Normalized routing load	Low
[62]	ZHLSR	• Reduces Communication overhead	The energy-saving strategy is not implemented	• Communication overhead	Low
[63]	SL-ZRP	• Improved Response Time • Low network overhead	It is not scalable for a smaller number of regions	• PDR • Network overhead • Avg. E-2-E Delay.	Medium
[64]	AOLSR	• Improved network lifetime • Enhanced performance • Improved scalability and reliability		• Avg. E-2-E Delay • PDR • Avg. time in the first-in-first-out queue • Throughput	High

The paradigm of the IoT network is a relatively new approach that attracts researchers because of its susceptibility. For over a decade, the research society has been exploring developing EER that extends network life. Recent schemes that describe their methods and focus on concerns that direct to high energy utilization in devices by the various actions they achieve are presented [3].

Energy savings are believed to be a foremost occurrence and several strategies are used to advance network connectivity. Multi-hop IoT systems that receive a large quantity of data cause traffic congestion, and to overcome such conditions, device priority, and transmission speed ratios are considered as parameters.

Energy efficiency is an essential parameter in determining the survivability of a WSN-IoT network since every device operating on this network has a limited battery charge. Many such IoT-based schemes have been determined using standard routing schemes presented in the literature. A comparative study of EER schemes used in the WSN-IoT EER environment is shown in Table 4.

Table-4: Summary of EER Deployed in MANET-IoT Environment.

Ref.	Proposed Protocol	Aim	Energy Efficiency	Performance metrics used
[65]	EPA-AODV	Shortest Path Metrics	High	• Avg. Energy utilization • Percentage of Devices under energy loss • PDR • Throughput
[66]	ESSAR	Shortest Path Metrics	High	• Average Dissipated Energy • Residual Energy
[67]	DPLAM-DSR	Load Balancing	High	• Network lifespan • Avg. E-2-E delay.
[68]	Bandwidth Estimation Scheme	Load Balancing	High	• PDR • Throughput • Energy utilization • Avg. E-2-E delay • Normalized Routing overhead • Number of Dropped Packets
[69]	PCG	Transmission Power Control	High	• Transmission power • Energy consumption per device • Network delay
[70]	OPERA	Battery cost lifetime Aware Routing	High	• Energy utilization • Avg. E-2-E delay • PDR • Network lifespan • Packet Integrity rate • Detection efficiency
[71]	Triangular Technique	Battery cost lifetime Aware Routing	High	• Energy consumption
[72]	FEEC-IR	Cluster head selection	High	• Network lifespan • PDR • Throughput • Rate of Packet Loss • Energy utilization • Routing overhead • Jitter • Bit Error Rate • Buffer usage • Avg. E-2-E delay
[73]	IKTRP	To maintain the workflow and application	High	• Avg. E-2-E delay • Routing overhead • PDR

		scenarios of this protocol		
[74]	MFGSA	To identify the optimal cluster head	High	• Delay • Distance • Link Lifetime • Energy
[75]	EEOM	To create multiple routes based on the optimality factor	High	• PDR • Throughput • Energy utilization • Avg. E-2-E delay • Network lifespan

Sensor devices utilize energy when transmitting and receiving data packets in the IoT system [76]. Due to the inadequate network exposure of sensor devices in the IoT network, data packets are routed through consistent multi-hop connections. The routing procedure makes to choose a route to transmit data packets from a source device to a destination point, which works on a wireless communication principle. Therefore, the routing procedure is an essential function in efficiently transferring data packets from the source to its target location. The proficient utilization of sensor device energy through routing schemes extends the life of the IoT network [77]. This expresses the low energy utilization for IoT sensor devices.

Similarly, there are several journals and research articles on efficient power routing protocols in the IoT concept, as power is the driving source for IoT networks, and incompetent power expenditure at sensor devices reduces the reputation of IoT. Thus, EER has been thoroughly considered for developing novel EER to enhance the network's lifespan. A few of the considerations are presented below:

- *Reducing energy utilization over a route*: The main principle of this type of routing scheme is to locate a way to deliver data with the lowest possible cost between the transmitter and receiver devices. To this end, the necessary routing guidance has been drawn up based on the distance vector.
- *Reducing the routing overhead*: Necessary functions for the route are periodic check status of messages for route managing packets, topology survey packets, path request packets, and so on. But occasionally, if they are too many on the network, they become overhead for routing and need to be reduced.
- *Enhancing the network's lifetime*: The routing schemes stabilize the battery life of every device to enhance the life span of the network. For this purpose, they utilize several improved algorithms to provide the solution with assessment parameters, such as device location, the volume of traffic processed by explicit devices, and so on.

Thus, enhancing the effectiveness of sensor devices is essential to reduce device power utilization and increase network lifetime. The usage of IoT devices in several current systems demands further exploration of EER in IoT routing and remains a challenge for researchers.

7. FUTURE ASPECTS OF EER IN WSN-IoT

A literature review has demonstrated many opportunities to reduce power consumption and increase network life. It suggested various feasibilities and also exposed several restrictions. So, according to the conclusion of the literature study, we get an idea of the perspectives considered by the past researchers with the identified gaps in present proposals.

• ***Limitation in Managing Route Scheduling to Destination***: A literature review suggests that the energy consumed is due to the delivery of data from the transmitting device to the receiver. Depending on the multi-hop perception, the transmitted packets reach multiple machines and pass through additional hops to get their final receiver. Each device concerned in the communication practice has a diverse number of transmitters. However, more transmitting devices result in other power consumption. Thus, a new approach to routing in WSN-IoT to manage a shorter route with fewer forwarders can optimize power consumption.

• ***Limitation in Managing Energy Loss during Long Routing***: Even in the data acquisition area, sensor devices are based on other in-between devices to deliver their packets. A sensor device transmits data via particular or multi-hops devices to arrive at BSs via CH devices. The CH device may be overloaded because of the associated and linked devices. CHs will be more likely to retransmit some of these packets. Therefore, the data transmitted by the sensor devices should be prioritized by the CH devices, relies on the energy utilized by every package. Although the author knows No high-priority reports were found for packets traveling from the furthest distance to CHs. However, as far as literature is concerned, no data have been found which gives priority to boxes from remote areas to CHs. As these packets quickly deplete network resources and need additional connections and devices to reach their receiver, so WSN-IoT can be a solution to improve energy by reducing long distance routing.

• ***Limitation in Managing Overhearing during Routing***: In the past, research studies have focused on proposing solutions for routing in IoT using WSN principles. However, most of these proposals did not address replicating data eavesdropping during route establishment or remote monitoring of active devices. This is one of the main factors in energy loss that must be effectively managed to facilitate the reduction in energy utilization. Eavesdropping and interference of a device are usually higher if several neighboring devices bound it. Thus, a new mechanism for reducing the number of listening devices can reduce the number of retransmissions and provide energy efficiency.

8. CONCLUSION

Energy is undoubtedly one of the most essential components of IoT and wireless networks. The data-gathering area might need multiple sensor devices to read the data and pass it on to the final recipient. However, these architectures are inadequate due to the power limitation constraints and the battery's lifetime, a foremost limitation in IoT communication. This review article discusses the need and significance of EER in WSN-IoT. It also explores the different mechanisms of EER concerning WSN and IoT. This study will assist in designing EER to achieve efficient energy management and enhance the network life span over WSN-IoT in future works.

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