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REVIEW ARTICLE

Taxonomy of Various Routing Protocols of IoT-Based on Wireless Sensor Networks for Healthcare: Review

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Abstract – In recent decades, the world's largest sector has undergone enormous transformations with the emergence of a new platform, denoted as 'healthcare' and based on the IoT (Internet of Things). Numerous hospital administrators are increasing their investment in converting existing activities to maximize the benefits of IoT, creating the foundation for the wireless healthcare system through a vast network of sensing devices and equipment. The wireless sensor system comprises minimal sensor equipment with limited processing capacity. IoT-based WSN systems are beneficial for smart healthcare. Healthcare has become one of the WSN (wireless sensor network)-based IoT application fields that have attracted much more attention from corporate, government sources, etc in the past few years. In the medical industry, the growth of IoT enhances patient safety, employee engagement, and productivity improvement for the overall system. Healthcare-based IoT wireless sensor systems for patients have several benefits: tracking and alerting, patient information management, remotely assisting the healthcare system, etc. In the context of wireless sensor healthcare systems utilizing Internet of Things (IoT) technology, the infrastructure encompasses a range of essential elements. These include sensing devices responsible for data collection, communication protocols facilitating data transmission, data storage devices for retaining collected information, and subscribers who access and utilize the acquired data. The IoT framework in healthcare systems comprises three fundamental components: the publisher, broker, and subscriber. The publisher is known for sensors and wearable devices. Brokers process the sensing data and then make it available to subscribers. The three components are connected via a wireless connection like Bluetooth, Wi-Fi, etc. The routing protocols are used for wireless connections in healthcare based on IoT systems. There are various categories of routing protocols used in the wireless healthcare network. This paper discusses various routing protocols with types, and comparison tables of routing protocols are depicted. A comprehensive review of healthcare-based IoT applications and an advanced medical care system benefits doctors and patients. The experts monitor ECG (electrocardiography), blood pressure, temperature, etc. The comparison of several methods based on throughput, E2D (end-to-end) delay, consumption, and data packet delay ratio (PDR) is depicted in this paper for a better understanding of the existing systems.

Index Terms – Wireless Sensor Network (WSN), Internet of Things (IoT), Healthcare Systems, Medical Systems, Routing Protocols, Healthcare.

1. INTRODUCTION

A significant challenge faced by humanity is the pursuit of prosperity. The World Health Organization's constitution emphasizes the importance of achieving the highest possible level of well-being for individuals as a key objective. Empowered individuals play a crucial role in promoting sustainable financial security throughout their lives, increasing overall productivity and disposable income within a country. Additionally, individuals with empowerment contribute to alleviating the strain on healthcare facilities, institutions, and professionals, as well as the broader socio-economic structures, organizations, and regulated associations. Therefore, a strong and easily accessible modern social safety net is critical for people's health [1] . Digitized social safety systems must provide superior rehabilitative administrative enterprises to individuals at any time and place in a cost-effective and patient-friendly manner. Figure 1 represents the healthcare-based IoT structure that can be implemented in healthcare colleges or medical departments. When patients live in hospitals, they wear clothes that have "body sensors" fixed to the part of the clothing and gather their physiological metrics like BP (blood pressure), HB (heartbeat), BP (body pulse), and BT (body temperature). The healthcare system can distantly inquire about and monitor physiological patient data with the help of a TA (trust

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authority). Before considering the system, customers must register with the TA in person. After the effective registration, the TA problems use an SC (smart card) on the customer's smart mobile phone, laptop, etc., to log into the MC (medical care) system.

The architecture of personnel administration is enduring a sociological transition from a conventional to a modernizing physician approach. Professionals in the field of medicinal administration are expected to perform notable duties in accordance with the conventional approach. Physicians must visit patients in order to conduct a survey and provide a referral. There are numerous significant issues with this strategy. Therefore, the pharmaceutical company's physician must always be in close proximity to the patients. The individual must be admitted to a doctor's office for a predetermined period while connected to bedside medical and biological devices. The planned and conducted technique of the patient has also been devised to address some of these two goals. This concept provides participants with information and communication technology to play a more active role in disease prevention and deterrence. A robust and quickly accessible healthcare monitoring process is a crucial component of such a second alternative [2]. The structure of the medical healthcare system is presented in Figure 1. The advancement of technology in recent years has enabled the diagnosis of a wide range of diseases using small devices, such as wearable devices.

Furthermore, the paradigm has shifted from being hospital-centred to patient-centred. Numerous research findings, for instance, may also be done at home even without the help of a medical expert, e.g., monitoring hypertension, blood sugar levels, etc. Medical information can also be transmitted to medical services in distant communities using sophisticated telecommunication systems. Developing these communication systems with rapidly evolving technologies like computer vision, advanced algorithms, healthcare based on IoTs, remote detection, personal devices, and cloud-based services significantly increased healthcare organizations' usability. The IoT has tremendous individuality while enhancing the ability to engage with the outside environment. With the assistance of advanced technologies and standards, healthcare based on the IoT has become a major contribution to the broadcast of information. It connects many pieces to the Internet, including remote monitoring, home appliances, and electronic components. Farming, transportation, residential, and medical care are all examples of IoT [3].

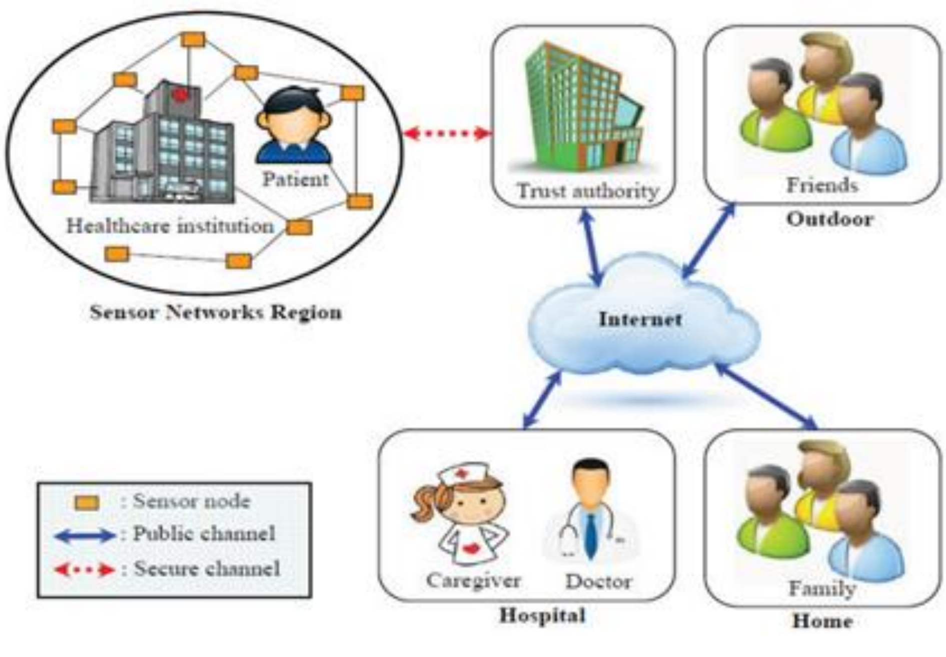

Figure 1 Structure of the Medical Healthcare System [3]. Remote Monitoring, Household Appliances, and Electrical Components are Just some of the Many Things that May be Connected to the Internet Using the Architecture

IoT is increasing in popularity with its high efficiency, greater precision, reduced expense, and ability to estimate events in the future accurately. Furthermore, the advanced transformation of the IoT has been facilitated by improved information on mobile applications, the development of computer and mobile technology, the widespread availability of wireless connectivity, and the rise of digitalization. Detectors, controllers, and other Internet of Things objects have been combined with specific other hardware objects in order to observe and transfer information via communication channels, such as Wi-Fi, Bluetooth, and IEEE 802.11 (enabled devices). Detectors, which are generally integrated or primarily accessible on the body, are frequently used in smart healthcare to detach sensor characteristics from the patient's body, such as temperature, respiration level, heartbeat, EEG (Electroencephalography), ECG, etc. Environmental information, such as temperature, precipitation, time, and duration, can also be captured. This information facilitates the development of accurate and appropriate conclusions regarding the health complications of an individual. In the Internet of Things (software, sensors, e-mail, mobile devices, and applications), availability is particularly important due to the large amount of information obtained from these storage capacities. Specialists, caretakers, and other designated individuals have access to the data collected by the pertinent sensing applications [4]. Sharing information with healthcare professionals via the Internet expedites patient diagnosis and any necessary healthcare action. Clients, recipients, and transmitters must collaborate for effective and dependable communication. Most IoT applications include an interface that serves as a showcase for medical staff, enabling them to control, monitor, and analyse data. Regarding medical monitoring, control, confidentiality, and security, the literature review revealed crucial information regarding developing IoT systems. These accomplishments establish the value and potential of IoT in the medical domain. Moreover, preserving the dimensions of service superiority, such as the secrecy of data exchange, privacy, dependability, and accessibility, is the top priority when developing an IoT system. Figure 2 illustrates the fundamental presentation of IoT-based advanced healthcare systems.

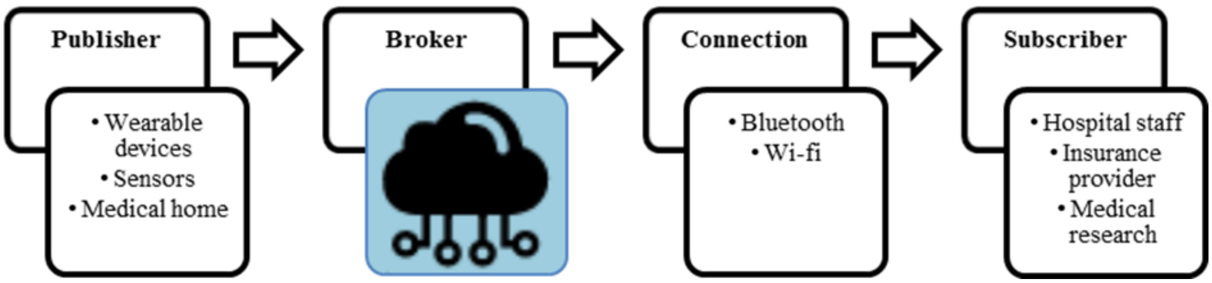

Figure 2 Healthcare Based on IoT System [5]

In IoT-based healthcare systems, publishers collect and publish data, brokers manage data flow, connections establish communication links, and subscribers receive and utilize the data for monitoring and analysis, enabling improved patient care and remote monitoring. This architecture facilitates seamless connectivity and real-time data exchange for advanced healthcare applications.

Advanced healthcare enterprises based on IoT systems consist primarily of three components. The publisher is the first component, the broker is the second, and the subscriber is the third. Included in the publisher component are the sensors and medical devices. The sensors store patient data and transmit it to the broker for further processing. The subscriber then retrieves the information through various smart devices.

IoT-architecture-based healthcare relies heavily on wireless sensor networks. WSNs consist of minimal sensing devices with limited processing capacity and resources. The device primary function is to receive and transmit data to the outside world via gateways. WSN systems are crucial components of IoT-based healthcare systems. WSN enhances healthcare and medical systems by providing real-time patient monitoring, drug administration, analytical assistance, patient tracking within medical institutions, etc. If a patient cannot come to the clinic, remote monitoring of the patient's condition can be advantageous for medical professionals. When focusing on a particular wireless sensor network area, energy consumption and life extension for rechargeable batteries and sensor devices have long been researched topics, with MAC (Medium Access Control) layer protocols focusing on controlling the sensor device's duty cycle and forwarding layer protocols essential for data transmission from many to one and data aggregation. Moreover, because sensor nodes and IoT devices of the IoT network architecture are battery-powered, energy consumption is considered when deploying IoT-based healthcare [6].

This literature review focuses on wireless sensor networking components for increasing IoT efficiency. This paper summarizes intelligent healthcare systems based on IoT and WSN systems. The fundamental IoT-based healthcare mechanisms consist of a publisher (wearable device), connection (Bluetooth), and subscriber (hospital personnel). The WSN system utilizes wireless sensors to transmit data from one node to another. The challenges IoT poses in healthcare, such as generating voluminous amounts of data, adoption, authorization, security, confidentiality, integrity, and authentication, are discussed. Cloudlet processing, data collection, and analytics (prediction) are the three fundamental steps of a WSN-based IoT healthcare system. In addition, the fundamental components and healthcare functions of IoT-based systems are discussed. The taxonomy of various routing protocols used in IoT-based advanced

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healthcare is illustrated. The applications of IoT wireless sensor networks in healthcare are discussed, including blood pressure surveillance systems, body temperature measuring systems, ECG surveillance systems, glucose level monitoring, mood prediction, asthma monitoring, etc. The advantages of IoT-based healthcare systems include end-to-end connectivity, monitoring, simultaneous reporting, affordability, data collection, analysis, tracking, remote medical assistance, etc. Existing healthcare system methods are compared to end-to-end delay (E2D), packet delivery ratio (PDR), energy consumption, and network throughput. This paper provides a comprehensive overview of wireless sensor-based IoT healthcare systems. Also described are the primary challenges in WSN-based healthcare IoT systems, such as security, confidentiality, adoption, etc. This work provides an IoT System Framework-based evaluation of healthcare. The framework consists of several steps: cloudlet processing, prediction, and analytics. Existing methods of IoT-based healthcare WSN systems are analyzed by reviewing existing methods. Routing protocols play an important role in wireless networks. This work also includes classifying and comparing healthcare protocols based on IoT systems. In addition, the various applications and benefits of IoT-based healthcare systems are discussed. Finally, various evaluation parameters are compared to the existing techniques.

Section 2 describes the healthcare challenges associated with an IoT wireless sensor network and the healthcare system. Section 3 presents the main framework for IoT healthcare systems in WSN. Comparative review of the existing methods of advanced healthcare delivery through wireless IoT-based systems. Section 4 also depicts the weaknesses and strengths of existing healthcare systems. Section 5 presents the taxonomy of various protocols for comparison and analysis of healthcare based on IoT systems in WSN. In Section 6, various IoT WSN-based healthcare applications are discussed. Sections 6 and 7 emphasize the applications and advantages of advanced WSN healthcare based on IOT. In Section 8, performance analyses of existing methods are provided. Finally, section 9 concludes the present study and provides scope for future work.

2. MAIN CHALLENGES OF HEALTHCARE-BASED IOT SYSTEMS IN WSN

According to the explosive growth of IoTs, healthcare based on IoT systems will embrace IoT using IoT programs and applications. Such services and devices may handle users' private medical data. Through the deployment of online sources, services can be accessible everywhere. For example, privacy and security concerns must have been addressed. This can include things like safety needs, types of threats, and flaws, among other things. The followings are some obstacles and challenges that must be overcome within healthcare based on IoT services [7]:

Adoption: The conventional wireless sensor networks used primarily for monitoring and diagnosis must have been modified to reconfigure the sensory components based on angular displacement between detectors and the medical Centre and to obtain additional physiological data by eliminating redundant activities. We should establish emergency response thresholds when concerned with minimizing energy consumption. Additional detectors can be turned off for the first time to conserve battery life.

Authorization: It ensures that only authorized individuals have access to the Internet of Things' medical information. Authorization is a technique for determining customer permissions and access to resources such as documents, applications, software programmers, statistics, and software requirements. The procedure for approving or denying access to system assets based on the decision of the system administrator permits users to connect various options.

Security: IoT-based healthcare offers enormous benefits to the medical industry but introduces numerous security flaws. Intruders could compromise interconnected medical devices and steal or alter data. Using well-known ransomware malware, hackers can also compromise the healthcare system by targeting connected technologies. Attackers will hold individuals and accompanying heart monitors, electrocardiograms, and central nervous system scan for ransom [7].

Authentication: It contributes to the confidentiality of information by allowing only authorized users to access data. Verification is the process of validating the consumer's uniqueness. This connects a set of distinct characteristics, such as user requests. Before allowing other functionality, the verification system executes at the start of the service, just before authorization and throttle inspection [8].

Fault tolerance: Methods must be devised to determine if the system continues to function in the event of failure. The sensing devices and transmission components that transport data to the processing layer or cloud affect the accuracy of Internet of Things-based medical systems. Therefore, its operation is essential for emergency medical care's professional and trustworthy operation. The only realistic alternative to fault tolerance presented in the current research is an IoT design that uses recovery units for miscommunication [3]. The solution's entry point executes the sensing evaluation by monitoring statistics regularly and taking appropriate action.

Robustness denotes that the system will continue to operate unless there is a connection failure or if the peripherals lose power. Certain technologies are required for the connection's security to be maintained.

Scalability and data overload: Medical equipment and web-connected detectors are used to collect massive quantities of information with tremendous results. On the one hand, clinicians can better understand patients' data, remotely monitor their health, provide online consultations, and improve patient assessment and treatment. On the other hand, the Internet of Things may complicate the determination and preservation of its validity. Moreover, as IoT-based healthcare expands, the need for additional storage will increase [9, 10].

3. MAIN FRAMEWORK OF HEALTHCARE BASED ON IOT SYSTEM IN WSN

The Internet of Things (IoT) is a swiftly advancing technology that combines legitimately linked objects with the Internet. As a result of the general convergence from such a specific form to such a new device, it is indeed appealing to various industries. This will have a lasting impact on the patient's health, surveillance, medication, and diagnostic capabilities related to physiological data. Individuals are affixed to sensing devices, and the information is integrated into CSs before being transmitted to the HMS [11]. Frequently, statistics are stored in the cloud, facilitating the management of immense quantities of data while safeguarding privacy [12]. Security is an essential aspect of the IoT. Transferring data from the sensing element to the cloud service may compromise authenticity and privacy, and decrypting received data with low-resource tools is challenging. Because the internet is a decentralized platform, it is also the best option for storing more diverse health information, allowing professionals to obtain remote patient management or vice versa.

3.1. Steps of Healthcare-Based IoT System

The communication system in a healthcare-based IoT System comprises four levels: network, application, middleware, and physical layers. The physical layer consists of devices equipped with transmitters and sensors. The network layer facilitates the transfer of sensory data to cloud data centers. The middleware layer aggregates the data stored in the cloud, making it accessible to relevant individuals. Finally, data analysis and treatment take place at the application layer.

Data Collection and Transmission: Figure 3 depicts the data collection and transmission process. Individuals are equipped with sensors capable of measuring various physiological parameters such as ECG, temperature, EMG, muscle activity, oxygen consumption, perspiration, and sugar levels. These devices can aid in diagnosing conditions related to heart rate, temperature, neurological abnormalities, hypertension, overweight, and diabetes. Sensors should be non-intrusive, small, affordable, and not restrict the participant's movement. Additionally, they should be powered by compact, energy-efficient batteries that allow continuous operation without frequent replacement or charging.

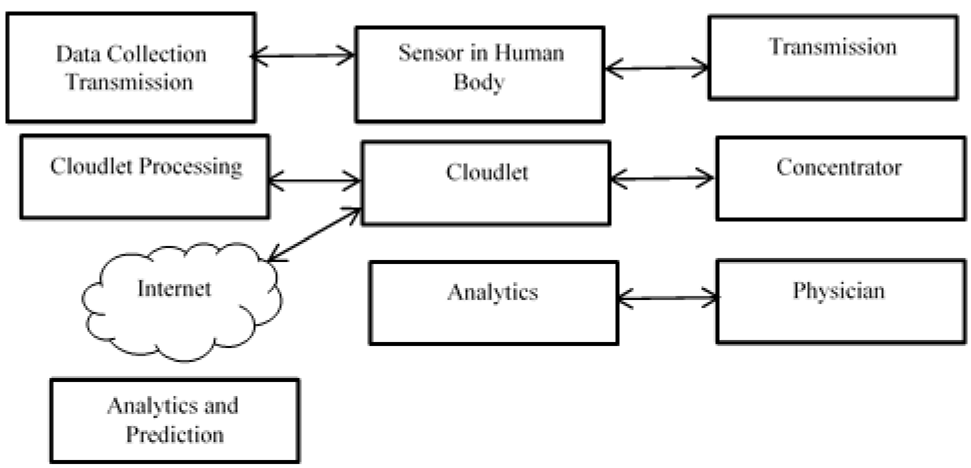

Figure 3 The Architecture of Healthcare-Based IoT [12]

The data transmission components of the system should ensure accurate and reliable transfer of information from any location to the medical center. Short-range data transmission devices like Zigbee and Bluetooth can be used for this [13]. Collected data can be transmitted to a medical center over the Internet for storage and analysis. The sensors within the Internet of Things (IoT) system can be remotely accessed through the World Wide Web using a concentrator, which could be a mobile phone. Efficient management of wireless sensor networks in the monitoring and diagnosis process involves adapting the sensory components based on angular displacement between sensing devices and the medical center. This ensures obtaining more accurate and diverse sensory data over time, avoiding redundant activities. Energy optimization strategies should be employed to define threshold values for handling critical scenarios. For example, some sensor nodes can be selectively turned off in disaster scenarios to conserve battery performance [14].

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Healthcare-based IoT has numerous levels and components. These layers allow smooth IoT integration into healthcare systems. 1. Sensing Layer: Sensors and wearable devices acquire physiological data. These sensors detect ECG, temperature, EMG, muscular activity, oxygen consumption, sweat, and sugar levels. Small, inexpensive, and unobtrusive sensors are ideal. They run continuously on small, energy-saving batteries. 2. Network Layer: The network layer sends sensor data to cloud data centres. Zigbee and Bluetooth can transport data efficiently. These technologies reliably transfer data from everywhere to the medical centre. 3. Middleware Layer: It aggregates and manages cloud data. It makes gathered data available to appropriate parties. This layer stores, retrieves, and processes data for healthcare analysis and decision-making. 4. Application Layer: The application layer processes and analyses sensor data for healthcare. This layer uses sophisticated analytics and prediction models to get useful insights from data. The application layer supports diagnosis, treatment, and prevention. Based on these keywords, the architecture of Healthcare-Based IoT involves a series of interconnected components and processes, as shown in figure 3. Sensors embedded in the human body are used to collect various physiological data, such as heart rate, temperature, and other vital signs. Transmission: The collected data is transmitted wirelessly from the sensors to external devices or systems for further processing and analysis. Cloudlet refers to a localized cloud infrastructure closer to the data source. In Healthcare-Based IoT, cloudlet processing involves the analysis and processing of collected data in the vicinity of the data source, reducing latency and enabling real-time insights. A concentrator gathers and aggregates data from multiple sources, such as sensors or devices, before transmitting it to the cloud or other systems for further processing. The Internet serves as the connectivity medium, enabling data transfer between various components and systems involved in Healthcare-Based IoT. The collected data is subjected to analytics techniques and algorithms to extract meaningful insights, identify patterns, and predict healthcare conditions or trends. Healthcare professionals, such as physicians, utilize the analytics results to make informed decisions, diagnose patients, and develop treatment plans. After undergoing analytics and prediction processes, the collected data can provide valuable information for proactive healthcare management, early disease detection, and personalized treatment strategies. Furthermore, in the case of detectors, they must be tiny, inexpensive, and not obstruct the participant's movement or activities. Compact, energy-saving batteries must power these detectors. The devices are required to work continuously without requiring additional charging. The components of the system in charge of transferring data should be able to more precisely and strongly transmit specific information from every place to the medical centre. Zigbee and Bluetooth are short-range data transmission devices. These components are defined as;

- Cloudlet Processing: Mobile memory is filled with useful applications that enable Volte and Wi-Fi connectivity. Smartphones and devices can function as extractors or concentrators using this method. The data from the concentrator will be moved to the cloud database. If this information is recorded, it will be invaluable to clinicians for saving requests and analyses. When native properties become available to meet expectations, limited computational units known as "cloudlets" are utilised for remote computing and data storage.

- Additionally, it facilitates the execution of time-sensitive tasks based solely on healthcare patient data. Information stored in a cloudlet is completely accessible, allowing data analysis to produce more precise clinical data. Cloudlet Computation has been made available in PAN (Personal Area Network) as a superior option for applications and services that frequently manage fundamental data and information. A wireless connection enables the cloud and concentrated resources to interact, thereby reducing data latency for activities that rely heavily on information garnered from the cloud. Ultimately, the cloud environment's data will be transferred to a data centre, facilitating data storage and decentralized accessibility [15, 16].

- Prediction and Analytics: Due to the expansion of medical database size, predictive analytics is an immense undertaking. The process of correlating sensing characteristics and medical data is managed using machine learning techniques. The overall efficacy of medical diagnosis can be improved by extending the duration of this analysis. Classification methods and artificial intelligence techniques will collect and analyse information through sensor devices. Machine learning must be improved to cope with ubiquitous sensors that are increasingly diverse and dynamic [17, 18]. In addition, due to the frequent evolution of sensor designs, such methods must be prepared with incomplete numerical values, streaming data, and data with shifting dimensions and interpretation [19, 20]. Figure 4 depicts the fundamental elements and their functions, including topology, structure, and platform.

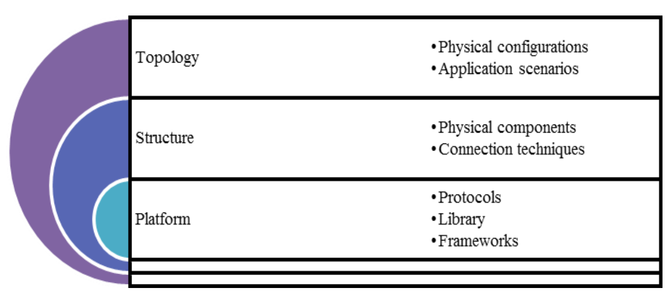

Figure 4 Advanced Wireless Healthcare Based on IoT Basic Components and their Functions [21]

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4. LITERATURE REVIEW

In the medical sector, IoT has developed into a sophisticated application framework. It is used to acquire and analyze the physiological data of a patient. To effectively evaluate sensing nodes embedded within medical implants within patients' bodies. Medical data security and confidentiality are becoming challenging for the Internet of Things. In [21[22], the author analyzed privacy protection concerns in the Internet of Things medical field; consequently, an anonymity-based user authorization framework was favored. The authors also discussed how an adversary could not assume the identity of an unauthorized user to acquire illicit access to or delete the health smartcard. A safe and anonymous biometric-based user verification system, abbreviated SABUAS, was devised for a wireless sensor system to ensure secure communication in the healthcare system. A systematic, random-oracle-based method and device management were presented to demonstrate protection and data efficiency improvements in health systems and applications. To surmount all obstacles, the author of [23] devised a cluster-based, emission-free system for patient tracing, termed "green communication" The proposed procedure divides the monitoring instruments into comparable-sized groups. Each cluster is designated a Cluster Head (CH) to collect data from its adjacent sensing devices and relay it to the central base station (BS). The technique measures the energy consumption of each device in various states, such as dormant, rest, unconscious, and alert, as well as the transitions between states. The authors employed an analytical strategy. The authors were able to validate the objective method through computational experiments by comparing it to existing methods. The preliminary results of the proposed method indicated that it enhanced network lifetime while utilising minimal energy in various phases. According to Alzub et al. [24], cybercriminals frequently misuse sensitive patient information. Motivated and guided by these considerations, the authors introduced a block chain technology-based secure data framework for biomedical sensor networks employing Lamport-Merkle digital signatures. Initially, the LMDSG system authenticated smart electronic products by establishing leaves within the tree-based structure to represent the hash algorithm of vital patient medical data. In addition, a central healthcare controller employs Lamport-Merkle digital signature verification to ascertain the LMDSG's origin. The proposed LMDS was evaluated based on CT (Computational Time), authentication precision, and CO (Computational Overhead). The framework provides advanced security and safer CT and CO in biomedical Internet of Things networks than other extant methods, as determined by evolutionary estimation. Sen et al. [25] designed an IoT-based surveillance system for coronavirus pandemics and implemented a regional routing algorithm for inter-WBAN (Wireless body area networks). The proposed system could monitor coronavirus symptoms, including oxygen consumption, temperature, heart rate, respiratory rate, and pulse rate. Using healthcare-based IoT software, the social distance between individuals could be represented. Comparing the regional routing algorithm to AODV (Ad hoc distance vector routing) in terms of delivery rate, priority, node latency, and error rate in public areas. The results demonstrated that the spatial routing algorithm effectively serviced the intended architecture. The findings indicate that it was possible to incorporate WBAN technology, an authentication protocol, and smart cities to produce an effective and pertinent control measure with enhanced data. According to Lometey et al. [23] the inability to ascertain who accurately relates to whom in real-time posed a problem for physicians. This issue arises as a result of the fact that healthcare providers have numerous consumers with diverse devices, resulting in high source variability and distribution method inconsistencies.

To address the challenges of identifying and correlating system data to users, the authors proposed an enhanced Petri Net service model to assist with explicit information, pathway trace, orientation monitoring, and potential identification of biomedical information compromises. Elappila et al. [26] presented a survivable route protocol, a congested and intervention-tolerant WSN for energy-efficient routing methods. The proposed protocol was intended to operate in high-traffic networks where multiple sources simultaneously attempted to transmit files to the same destination, such as IoT devices reporting healthcare data. The algorithm employs a criterion based on three factors: the waveform and distortion ratio relative to the durability factor of the route towards neighboring member nodes at the final receiving point and the net final transmitting point at the interference level. The proposed technique performs better regarding point latency, PDR (packet delivery ratio), network throughput, and node energy level, as determined by simulation results. In densely populated topologies, the packet loss rate was also lower. Smart Cattle Surveillance utilizing IoT sensors necessitates accurately anticipating and responding in advance to cattle illness. Additionally, communications must be error-free, secure, and energy-efficient. Therefore, the authors in [27] proposed a health surveillance system based on intelligent cattle with reliable transmission utilizing IoT sensing devices. A fuzzy-based healthcare prediction platform has been proposed to accurately forecast cattle disease in advance. A diverse antenna framework and SIIGRP, also known as Secure Inter and Intra Gateway Routing Protocol, were utilized to ensure the integrity of data transmission between the cattle collar and the gateway. The system framework was implemented using NS2 and then applied to an Arduino sensing framework. The proposed device obtained a 4% higher packet transmission ratio, a 14% lower latency, and a 12% higher power consumption than the existing model, as determined by an analysis of the results. Ellaji et al. [28]

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determined that numerous smart peripheral IoT devices could improve quality. The primary purpose of these intelligent devices was to make medical care more convenient for patients. There were no contact guidelines for all intelligent and clever medical devices. Therefore, a disjointed architecture is required to connect multiple household devices. Consequently, the implemented system was a revolutionary Narrow Band - Internet of Things (NB-IoT) system inspired by the architecture of Narrow Band IoT. The NBIoT was used to connect multiple smart sensors within sophisticated healthcare organizations. In the proposed Narrow Band IoT, edge computing was used to model latency requirements in biomedical transformation. Onasanya et al. [29] focused on economic data analysis, computation, and medical treatment facilities of healthcare systems. The healthcare facilities are equipped with an Internet of Things deployment that facilitates access to and analysis of medical health records collected via the Internet of Things and various wireless communications. The other connected devices were utilized to optimize clinical practice and aid in creating medical health care statements for more efficient cancer treatment. The framework also considered business intelligence and cloud platforms to assure the availability of patient data streams via implementable medical concepts and recommendations based on scientific evidence. Due to the system design and the preservation of patient records, organizational and cybersecurity concerns with implementing IoT-based healthcare systems were also examined. In [29], the authors focused on accepting and implementing unified communications technology to supplement existing alternative treatments or provide quality healthcare, the Internet of Things, wireless communications for cancer treatment, and value-based organization solutions.

Web-based data analysis management platforms facilitate actionable insights, problem-solving, wireless communication, and reporting to enhance cancer therapy. E-health was identified as one of the most effective health system innovations by Sarwesh et al. [27]. Throughout e-health implementations, autonomous systems and reduced connections power rechargeable battery sensor networks, indicating the channel's energy-constrained and unstable existence. Thus, in a network configuration constrained by battery power consumption, the top priority was the delivery of effective healthcare services with regular monitoring and tracking of patients' medical data. The proposed model utilized a dependable cross-layer architecture to extend the life of connected devices and ensure dependable communication in IoT-based healthcare settings. The NL (network layer) and MAC layer were combined in the designed architecture. The route discovery method incorporates consistency parameters, and the MAC-based power control method later used network traffic to determine the suitable available bandwidth. The results indicated that the proposed cross-layer model was more appropriate for IoT-based smart e-health implementations because it was more stable and energy efficient. Prasad et al. [30] designed a routing mechanism that relies on hybrid energy-distributed wireless sensor area networks. The authors examined a hybrid transmission strategy and a contemporary synchronization algorithm. By eliminating packet collisions, the synchronization scheme consumes little energy, which increases the network's lifespan. The efficiency of the designed protocol was evaluated and compared to three baseline routing protocols using two ultra-low power transmitters in the 2.4 GHz ISM band. Onasanya et al. [31] utilized the recently established Saskatchewan Health Authority, comprising various healthcare regions. In turn, the authors suggested the Saskatchewan Healthcare System. This smart system focuses on an Internet of Technology-based framework in four areas: enterprise service providers, such as automation and computing, medical treatment, rescue services, and administrative service providers.

The methodology also elaborated the framework and execution of Saskatchewan's enhanced electronic health records program, augmenting and supporting the existing healthcare delivery plans to ensure patients' life quality by incorporating IoT smart systems and other applicable innovations under the programs' devices. These services have been incorporated to expedite and improve the delivery of care. The avalanche of patient medical data provided by IoT-enabled smart devices would improve decision-making and expertise. The organizational and security problems of the IoT platform-based healthcare architecture were addressed. Based on IoT and healthcare, an energy-efficient web service was proposed [28]. The proposed network architecture described how two distinct approaches were combined beneficially: routing and node positioning. Using routing techniques, the energy levels of the nodes were monitored to ensure the most energy-efficient data transfer. Using the node positioning technique, data traffic was balanced by adjusting the intensity of the nodes. The main determinants of power consumption and strategies for increasing the efficacy of an Internet of Things system were discussed by Nidhya et al. [32]. The patient's privacy and environmental and operational hazards are jeopardized by the emergent technological development in healthcare systems that disregards energy conservation. Existing IoT-based healthcare technologies do not guarantee node-to-node security and routing based on energy-awareness protocols. The authors proposed a new stable for Internet of things health coverage and peripheral emission connectivity design systems and described how healthcare systems could be improved. The proposed system has superior latency, recipient, interactional overhead, and user interface compared to the current system. Binu et al. [33] presented a smart proxy that protects the entire device with an updated host uniqueness protocol, diet exchange key algorithm (HIP-

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DEX), and an enhanced symmetric encryption method based on the LEACH protocol. The framework relied on a dependable and efficient Internet of Things-based medical care method. Due to advances in healthcare enabled by IoT technology, it was possible to implement this device. The system comprised an advanced gateway that administers the framework from beginning to end, which was accessed via an AB known as an Arduino board that implemented a rule adaptive engine to collect and analyze sensing prior to data transmission. An IoT-based smart healthcare system was designed to address node-to-node security and privacy concerns. Muhammed et al. [37 [34] proposed the UberHealth model, a pervasive medical care system incorporating a Smart grid, expert systems, predictive analytics, IoT, and advanced computation. The platform's three phases and four layers allowed the service's network superiority to advance. Supervised learning and HPC (high-performance computation) were implemented to forecast network traffic. The network layers and phase transitions were subsequently implemented to optimize the high data rate, memory caching, and routing decisions. The application parameters of traffic movements were categorized, allowing the NL (network layer) to better the requirements of respondents and identify intruders and anomalous data. Clustering is classifying multiple data types from the same application protocol. Utilizing the architecture, a proof-of-concept UberHealth method has been developed. Detailing the algorithmic integration of the three elements and four levels. Ahad et al. The proposed system outperforms the LEACH protocol regarding energy consumption and network lifetime. MATLAB (Matrix laboratory) was used to develop the proposed system. Using a clustering technique based on game theory with time division, multiple access enhanced the network's lifecycle, data packet transmission and reduced power consumption, according to the obtained results. Abou-Nassar et al. [35]designed a BDIT, also known as a "blockchain decentralized interoperable trust platform," for the Internet of Things domain, wherein smart contracts ensure expenditure validation and the indirect trust inference system eliminates logical holes and improves reliable factor approximation via device nodes and edges. The introduced DIT IoHT (Internet of Healthcare Things) uses a private blockchain cascade layer to create reliable interaction by validating nodes based on their interoperable layout, enabling supervised communication to resolve collaboration and distribution issues across various IoHT architecture zones. In addition, C#-deployed frameworks for associating and aggregating requests across trustworthy zones, as well as Ethereum and cascading blockchains, were incorporated into the system. Haghi et al. [36] developed a flexible IoT gateway and an innovative wrist-worn application for environmental monitoring. The model accumulates environmental data to determine the most crucial parameters. Using an Internet of Things gateway as an intermediary between fitness monitors and the Internet of Things database, the proposed network enables real-time, bidirectional transmissions between a specific patient and physician. In addition, as an authorized observer of the participants, the physician could use the IoT gateway to configure the necessary parameters for the calculation and activate/deactivate the detectors with the wearable technology. Consequently, medical professionals could select the estimation configuration based on the investigation's objective, the patient's condition, specifications, and requirements. Consequently, the platform could be utilized in various contexts, including daily life and medical research. Users were not restricted to selecting a single product; multiple options were available. Li et al. [37] implemented SDN-based edge computing standards in an IoT-enabled health service. Using an adaptable cryptographic method, the proposed system encrypts sensor nodes at the network's periphery.

Following encryption, the plans were used to transmit patient data to peripheral servers for processing, recovery, and examination. The server edges were connected to an SDN (Software-defined networking) architecture, which implements load balancing, network administration, and dependable resource utilization for the health service. Models of machines were used to evaluate the proposed structure. The findings demonstrated that the proposed architecture provides more effective IoT-based healthcare options. Mezghani et al. [38] proposed a set of involuntary muscle intellectual architectures centered on mental abilities and the peripheral nerves of organisms that reduce the implementation of smart Internet of Things-based system applications, taking control of large datasets and compatibility into consideration. The primary objective of such ideas was to provide simple, re-usable methods for developing sophisticated healthcare systems based on IoT systems that could adapt to shifting conditions. The purpose of these patterns was to provide standard and scalable methods for constructing modular, intelligent Internet of Things-based methods for data interpretation and decision-making. Using the proposed methodology, the authors integrated and implemented a group of instances designed for a scalable authentication framework to control patients' health utilizing interdependently connected systems. The system could integrate and process large-scale, heterogeneous data sources to enhance adaptability. There are numerous categories of research on IoT-based intelligent healthcare systems. Zawar Shah et al. [39] described less expensive fixed devices' energy consumption efficiency and connectivity. Therefore, the RPs (Routing protocols) provide an important paradigm for achieving these objectives. Internet communities approved lossy networks and the earlier homogeneous IPv6 (Internet protocol) routing protocols developed by the IETF (Internet-Engineering Task Force). However, RPL (Routing protocol for low-power and lossy networks) was considered for fixed IoT devices but had

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problems with portable IoT devices. The authors proposed a survey and proposed solutions for RPL-related issues. This proposed survey divided alternative solutions such as tracker-timer-based solutions, ETX-based (Expected transmission count), RSSI-based (Received Signal Strength Indicator), position-based, and other solutions into five categories.

We comprehensively evaluated their strengths and weaknesses for each category of these proposed solutions, working methods, and newly discovered and developed problems. In addition, the outcome analysis contains numerous defects, such as node flexibility, time intervals, etc. This survey also proposes future research to enhance performance estimates of these resolutions in real-world infrastructure. In addition, the authors outlined future directions for RPL, which include support for multiple time-based applications, mobility finding, and energy- and security-aware routing. Bangotra et al. [40] proposed an opportunistic RP with an ML (Machine Learning) technique to select a relay node from the group of likely transmitter nodes to achieve EE and network dependability. The authors intended to develop a method with multiple applications, such as intelligent healthcare facilities. The planned ORP (opportunistic routing protocol) method attained dependability in the WSN due to connectivity with healthcare network components, efficient methods, and the delivery of improved services. In addition, the proposed method resulted in energy savings, which aided the remote patient's connection with healthcare services in reducing delay time by incorporating IoT services. Haque et al. [41] characterized a structural health monitoring [42] (SHM) model as a method for detecting harm caused by various types of models with multiple functions. They provided the necessary response regarding the development conditions.

Civil structures were regarded as a community pillar, so determining routine-based operations posed a significant challenge. The performance of these models was manually approximated while a computerized system detected and classified the damage models and their actual position. Previously, the WSN devoted much attention to remote identification applications due to their adaptability in calculating various large-scale network actions. Due to technological advancement, the total system's implementation costs have decreased. Using large-scale provision, it intended to resolve the power consumption issue via a hybrid strategy. The IoT-built maintenance approach improved the network's longevity more effectively. Thus, the primary objective of this proposed endeavor was to develop a model for monitoring topology in real-time. This was responsible for maintaining the network environment and collecting node data in order to frequently change its state when the extant work was not effectively extended. Dogra et al. [43] characterized WSN as the common model that paved the way for the emergence of IoT. Still, the coupling of IoT and WSNs presents a challenge due to the nodes' excessive power consumption and the network's longevity. As a final product, power limitations in sensor nodes, the sharing of sensor data, and RPs were characterized as fundamental WSN concepts. The authors proposed an enhanced clever EERP (Energy efficient routing protocol) method that extended the network's life and enhanced the connection to the previously mentioned. The selection of CH is based on a superior optimization strategy arising from distinct goals. The reduction of slumber nodes and power savings supported this. SFO (Sailfish optimization) is required to find an appropriate path to the sink node. Comparing GA (Genetic algorithm), ALO (Antlion optimization algorithm), PSO (Particle Swarm Optimization), etc., with the implemented method, which includes parameters such as energy consumption, PDR, bandwidth, network life, etc., the implemented method attained superior performance. For their networks, the simulated results of the proposed method were implemented, including energy consumption of 0.5 J, network bandwidth that transmitted packets at a slower rate of 0.52 MBPS, and packet delivery ratio (96%) for 500 nodes. Omer et al. [44]described the energy-efficient collection of data-related issues using a mobile sink and a UAV (Unmanned aerial vehicle) with a limited battery life in a remote network subdivided into several robot clusters. In these robot clusters, the CH robot allocated duties and collected data from the remaining robots.

The primary objective of this proposal is to reduce the fixed total power consumption of the UAV to reduce the cost of data acquisition over CH robots while preserving the optimal segment of the CH robot. The UAV determined which subset of CH robots to visit based on their locations and remaining battery power. The UAV did not visit all CH robots, and data transmission was straightforward. The selection of transmission paths for communicating machines has been motivated by minimizing costs. Therefore, the optimal solution proposed to resolve the issue of network life is related. The table below details the existing simulation methodologies and instruments. William Alberto Cruz-Castaneda et al.[45] outlined significant health concerns associated with chronic noncommunicable diseases (NCDs). From a financial standpoint, these maladies imposed a significant burden on communities. The mortality ratio of these diseases, including cancer, respiration, infections, diabetes, and cardiovascular disease, was anticipated to increase in Brazil until 2030. A distinguishing characteristic of these non-communicable diseases is their protracted duration, which requires care supervision. The authors proposed an AI-based chronic disease management platform to disseminate digital health facilities universally. The envisioned platform was protected and built using healthcare 4.0 tools, including wearable policies, IoMT, and AI cloud-based resolution. This made it possible to implement an intelligent healthcare model. Additionally, the authors

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presented the platform's viability at a diabetes forecast learning event. To compare analytical outcomes based on capillary blood glucose concentrations, ten regression prototypes were used to evaluate the MSE, RMSE, and r-squared scores' forecast performance. The proposed model performed more effectively than existing methodologies. Koduru Hajarathaiah et al. [46] described the expansion of healthcare, specifically IoT components, which has opened up enormous opportunities for automated healthcare supervision systems. Integrating the health treatment system via IoT networks is essential for time-sensitive, mission-critical applications. Advanced IoT devices communicate the data application with non-deterministic preeminent strength traffic flows; however, the data accessed by multiple nodes must be scheduled on a separate shared channel. This data type was transmitted to healthcare models with predetermined per movement deterministic movement flows to guarantee the QoS concerning communication latency and packet loss. Therefore, the authors proposed that E-services in healthcare utilizing IoT networks incorporate protocol features such as scheduling and RPs to affirm predetermined transportation flows with expected total delays. The comparative analysis with existing methods and problem definition is outlined in Table 1. Various parameters such as PDR, node-to-node latency, network throughput, etc., are used to measure advanced healthcare based on IoT systems. Table 1 lists the proposed algorithm with various performance metrics.

Table 1 Comparison Analysis of Existing Healthcare Based on IoT Systems in WSN

Author Name	Year	Proposed algorithms	Comparison Algorithms	Problems	Performance Metrics	Simulation Tools
Sarwesh et al. [22]	2017	Efficient energy protocol	Multiple rounds based comparison	Security issues	Node-to-node delay, PDR, routing overhead network throughput rate	NS3
Lomotey et al. [23]	2017	IoT Data Stream Traceability system	Wearable fitness tracker	High cost	Energy consumption, Data aggregation, Data Quality	-
Mezghani et al. [38]	2017	CDP (cognitive design patterns) based system	-	-	CO, CT	-
Binu et al. [33]	2017	HIP-DEX key exchange protocol and LEACH	Comparison based on different datasets	Hard data mining	throughput, delay, energy consumption	Riverbed Modeler
Elappila et al. [26]	2018	Survivable Path Routing	CDTMRLB, Directed Diffusion Routing Protocol , SGEAR (Sub-Game Energy Aware Routing) Protocol 310	Easily accessible to an unauthorized user	Throughput, sensitivity, specificity, precision, recall, F1-score Accuracy	-

Onasanya et al. [47]	2018	Cloud Services based wireless system	-	More energy consumption	Node-to-node delay, throughput, PDR, and energy level of nodes	NS2
Sarwesh et al. [27]	2018	Integrated layer model	-	Need to work on the packet delay process	Residual energy, PDR, and delay	NS2
Muhammed et al. [34]	2018	Healthcare systems based on edge enable network	Wide-18	Hard to implement	-	-
Deepak et al. [48]	2019	SABUAS	DES, SHA 1	Authentication errors	Power Consumption	-
Onasanya et al. [29]	2019	healthcare based on IoT	-	Large volume data hard to handle	-	-
Onasanya et al. [31]	2019	healthcare based on IoT Saskatchewan system	RFID WBAN	More time is taken for the transmission of data packets	Energy efficiency, Throughput, and Reliability	-
Nidhya et al. [32]	2019	IoT-based medical care system	Hummen model	The high temperature of the sensor's nodes	Residual energy, Number of dead nodes	-
Yang et al. [49]	2020	cluster-based hierarchical approach	DEEC and LEACH	Security and Operational Challenges	Reliability	Smart devices connection
Ellaji et al. [28]	2020	WSN system	-	Data re-transmission issues	Throughput, Network Lifetime	AODV
Prasad et al. [30]	2020	Hybrid protocol with ultralow power transceivers	Three baseline protocols	End-to-end node delay in data transmission	Execution time, Data latency	-
Ahad et al. [50]	2020	Blockchain Decentralised Interoperable Trust system	LEACH	Difficult to achieve hard threshold	Processing Time	IBM Bluemix
Abou-Nassar et al. [35]	2020	Game Theory Based Clustering Scheme (GCS)	-	Delay in ECG signals transmission	MAE, RMSE, Accuracy	ICANCloud
Haghi et al. [36]	2020	healthcare based on IoT	Monitoring activity protocols	Limited lifetime of sensor nodes	PDR, Residual Energy	MATLAB
Li et al. [37]	2020	SDN-Based Edge Computing	-	Authentication issues	-	-

Bangotra et al. [40]	2020	Naïve Bayes Intelligent Opportunistic Protocol	EEOR MDOR	Breakage in end-to-end communication	Node transmission	-
Gul et al. [51]	2020	Cluster head Robot allocation	Optimal UAV-Oriented	Edge computing is time-consuming	PDR, Delay, Throughput	-
Haque et al. [41]	2020	Integrated topology maintenance and construction methods	CDS-Rule-K EECDS Methods	Performance degradation due to a variety of data	Response Time	Cloud server
Alzubi et al. [24]	2021	LMDS	-	Problems faced by RPL when IoT equipment is non-stationary	Delivery Energy consumption	Contiki - 207
Şen et al. [25]	2021	IoT and an inter-WBAN geographic routing algorithm	AODV	High energy consumption	Energy Latency Throughput Lifetime	TOSSIM
Shah et al. [39]	2021	RPL	Multi-fuzzy model, ETX, and RSSI-based solutions	Travelling salesman problem	Energy Consumption	-
Suseendran et al. [43]	2021	Antenna diversity scheme and (RIIGRP)	-	High installation cost	Active Nodes	Atarraya s/w
Dogra et al. [44]	2022	ESEERP method	GA PSO ALO	Energy hole problem	Energy Bandwidth Packet delivery	MATLAB
Tallat et al. [52]	2022	Cryptographic algorithm	-	Security Issues	Total Cost Computation	MATLAB
William Alberto Cruz-Castaneda et al. [45]	2023	AI-based platform	DT RF AdaBoost SVR	The large amount of health data hard to handle	MSE RMSE r-squared score	Healthcare 4.0 Tools
Koduru Hajarath aiah et al. [46]	2023	RREP	Scheduling and RPs	Traffic flow Issues	Transmission delay Packet Loss	-

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Table 2 Weakness and Strengths of Existing Techniques of Smart Healthcare Based on IoT Systems in WSN

References	Weakness	Strengths
[22]	Break down to handle excess traffic on the network	Protect sensitive information
[23]	Data aggregation	Less Energy Consumption
[38]	High computational time	Provided better results with statistical data
[33]	Less bandwidth data transmission	Monitor the health conditions
[26]	Divergent transaction	Reliable
[47]	In some cases, packets disconnection results in more delay in communication.	It improves the channel's durability and preserves continuity by selecting more stable routes as navigation options.
[27]	Packet transmission from one node to another anode is low in some cases	High packet delivery
[34]	Deployment of the system is challenging	Mesh topology provided the best results
[48]	Security challenges	Helpful in improving quality of life
[29]	Critical to handle huge data amount	Allows more geographically separate decentralized devices to be connected to the specific program using metropolitan connectivity from transmitter to receiver, making transmitting data and sharing easier.
[31]	Slow transmission of data packets	Highly secure
[32]	The temperature of the sensor node rapidly increases, which is harmful to the sensitive organs of the patients.	A lifetime of the network is very long.
[49]	Hard to resolve operational issues	Reliable
[28]	Breakage in packet flow generated retransmission of packets	A lifetime of the network is elevated
[30]	End-to-end node delay in data transmission	Highly secured platform with end-to-end encryption provided
[50]	Difficult to achieve hard threshold	Provide security and data breaches protection
[35]	Delay in the transmission of ECG signals	Highly efficient
[36]	Shortage lifetime of sensor nodes	Easy to implement
[37]	Implementation is challenging	Smoothly resolve the issues of authentication

[40]	Due to breakage in transmission, delays in packets occur	Real-time bidirectional communication is possible
[51]	Time-consuming process	Very Light weighted framework for authentication
[41]	Performance degradation due to a variety of data	More flexible and provided efficient results with heterogeneous sensors devices
[45]	Economically Burdon on the public to access smart services	Provide smart services for diabetes patients.
[46]	More transmission delay and packet drops.	It integrates E-services, healthcare and IoT tools for end-to-end delivery.

5. TAXONOMY OF DIFFERENT PROTOCOLS HEALTHCARE BASED ON IOT SYSTEM IN WSN

The routing protocol is a set of procedures to identify and manage network connections. This facilitates the transfer of information between nodes. Consequently, the RP (routing protocol) is essential in WSNs for guaranteeing secure transmission between sensor devices [53]. Figure 5 illustrates the dissimilar categories of RPs.

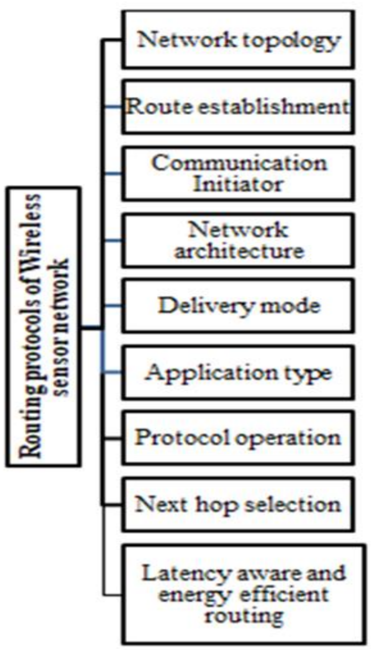

Figure 5 Routing Protocols of Wireless Sensor Network [53]

5.1. Network Topology [2]

Network topology [2] is an alternative method for categorizing routing algorithms based on their communication network. The methods in this category are subdivided based on their characteristics into five main subgroups: hierarchical, flat, heterogeneity-based, geo-routing, and mobility protocols. Figure 6 shows the network topology-based routing protocols.

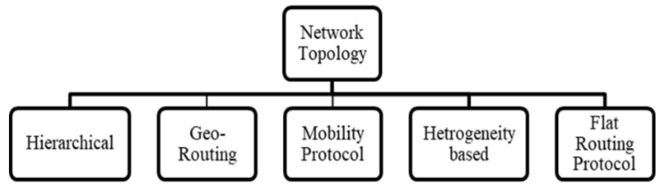

Figure 6 Network Topology-Based Routing Protocols in WSN [54]

5.1.1. Hierarchical-Based RP (Routing Protocol)

A cluster-dependent protocol is an algorithm for wireless routing. The protocol distributes the terminals of the network into interconnected or isolated groups. Every group has a root node responsible for maintaining membership records [54].

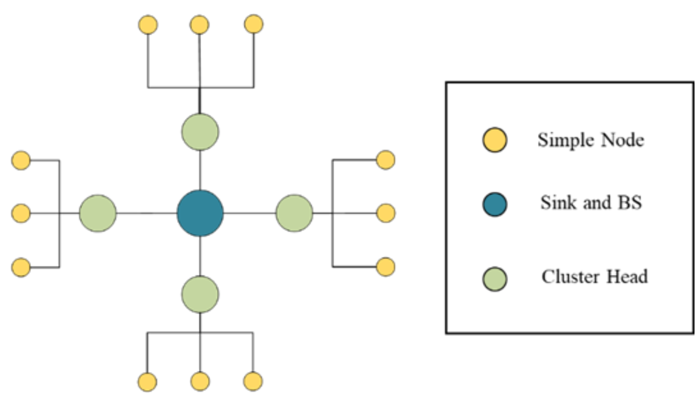

Figure 7 Hierarchical-Based Routing Protocols in WSN [54]

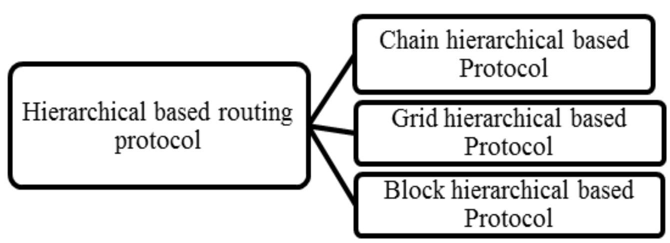

Figure 8 Types of Hierarchical-Based Routing Protocols in WSN [55]

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Figure 7 depicts the generic representation of hierarchical-based RPs, while Figure 8 explains several cluster-based RPs.

5.1.1.1 Chain Hierarchical Based Protocol

Such protocols create component chains with excellent communication across sensor devices. Therefore, the hierarchical chain protocol is further subdivided into different parts.

PEGASIS is a “protocol for efficient sensor information gathering based on power”. Therefore, each sensor node in PEGASIS primarily requires providing information to its neighbor closest to the end nodes [56].

CCS: The acronym CCS stands for "concentric clustering scheme." Messages are sent in two stages: cluster and chain routing [57] due to the sensor's horizontally clustered and vertically connected network. The CCS divides the detecting region into a series of concentric circuits, each with its phases, before constructing chains within each track. CCS is the next evolutionary stage for PEGASIS.

5.1.1.2 Grid Hierarchical-Based Protocol

These protocols partition the connection into panels and place units in the appropriate locations. Moreover, to control data transmission, individuals create their connectivity architecture.

- HGMR: The acronym HGMR stands for "hierarchical geographical routing protocol." This protocol is a geolocation-dependent broadcast method. It employs a geographical multiplayer route to transmit data across the broadcast network in a particular type, an iteration and a hierarchy rendezvous point multichannel to divide the mesh network into subsets, thereby effectively resolving the scalability issues of networking [58].

5.1.1.3 Block Hierarchical-Based Protocol

The connection is divided into blocks using block hierarchical RPs. The arrangement of the block hierarchy-based protocol is given below:

- LEACH: LEACH is a "low-energy adaptive clustering hierarchy protocol" LEACH is a group method that provides randomised cluster head rotations that evenly distribute power consumption across all devices in a channel. In the LEACH algorithm, the cluster leaders coalesce to form smaller groupings, one of which functions as the base station [59].
- TTDD is a hierarchical grid-based "two-tier data dissemination" (RP) protocol. Every base station develops an interactive grid-based system model in advance, while the current information is becoming a grid origination point [60]. Table 3 provides a comparison of network topology-based hierarchical protocols for WSNs.

Table 3 Comparison of Network Topology-Based Hierarchical Protocols of WSN

Protocols	Block hierarchical based Protocol	Grid Hierarchical-based Protocol	Chain Hierarchical based Protocol	Cluster Scalability	Scalability	Delivery	Efficiency of energy
LEACH [60]	Yes	No	No	Medium	Very low	Very small	Very low
TTDD [61]	Yes	No	No	High	Very low	Small	Very low
HGMR [58]	No	Yes	No	High	Very high	Very small	Medium
CCS [57]	No	No	Yes	Low	Low	Large	Low
PEGASIS [56]	No	No	Yes	Low	Very low	Very large	Low

5.2. Application Type

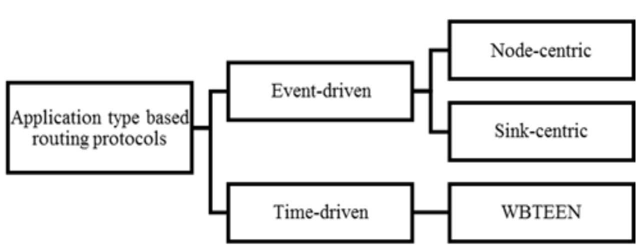

Figure 9 Classification of Application Type-Based Routing Protocols in WSN

In the application type of the routing protocol, data is sent in either a time-driven or event-driven way. The application type is subdivided into two types of protocols: event-driven and time-driven routing protocols. Figure 9 depicts the organisation of application-type-based RPs.

5.2.1 Event-Driven Routing Protocol

As shown in Figure 5.6, a sensor node in an event-driven model cannot transmit data until it has detected a particular event in its detecting zone. Due to their numerous benefits, these methods are utilized in numerous industries. They permit the instantaneous recognition of a variety of active events. In addition, they permit a reduction in transmission

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and the elimination of wasteful node energy consumption and computing assets. Further classifications of the event-driven routing protocol include node-centric and data-centric routing protocols [60]. The protocol for event-driven routing is depicted in Figure 10.

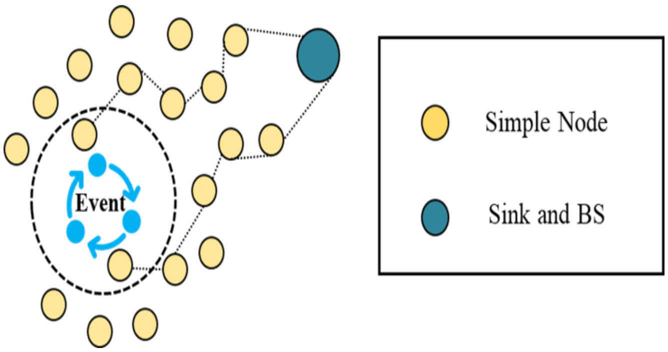

Figure 10 Event-Driven Routing Protocol [62]

5.2.1.1 Node-Centric Routing Protocol

These protocols specify detection capabilities for the detectors; as a result, terminals make decisions inside the building following an occurrence when outlets receive the received information. Several types of protocols are used in node-centric mode. Some of them are mentioned below:

EEDP Protocol: EEDP is an "efficient event detection protocol" EEDP is a data transmission mechanism developed by component manufacturers who require rapid data identification and communication [63]. It allows stations to make accurate decisions in SDR and CDR. SDR is a straightforward decision rule, whereas CDR is a composite decision rule. According to specialists, the EEDP offers a precise prediction method but is less reliable.

ERP Protocol: ERP stands for "event reliability protocol" ERP is a protocol for transmitting dependable and real-time events. It employs a location-targeted multipathing strategy to reduce identical redundant information to reduce collisions. As a result, it provides dependable event distribution and prevents collisions, but it consumes a great deal of power [64].

IQAR Protocol: IQAR (Information quality aware routing) employs IQ restrictions to determine the configuration structure with the smallest energy footprint. It reaches the point where it can determine whether or not to verify and record an event. According to the research, this method enhances service quality and saves time and effort within the connection; however, it has a high burden [65].

EELLER Protocol [66]: EELLER is the "Energy Efficient Low Latency Express Routing Protocol" Using a clustering technique, the EELLER protocol eliminates, duplicates, and improves data paths to convey data through the terminal to outlets. EELLER creates highways that do not rely on a connection component to transmit sensory data but rather distribute acquired data across pre-established groups.

CollECT Protocol: CollECT is a "collaborative event tracking and detection system". By employing three primary methods, this technique facilitates rapid and effective condition monitoring in various sensor-based wireless systems. One of the advantages of this protocol is that it employs a highly decentralized network approach, which results in rapid spectrum sensing [67].

5.2.1.2 Sink-Centric Routing Protocol

Such protocols handle detecting degrees as well as routing decisions based on the data gathered and supplied by the sensor network throughout the communication range.

- CODAR: The congestion and delay-aware routing protocol (CODAR) [68] is called CODAR. CODAR employs various mitigating, collision avoidance, and end-to-end (E2E) delivery information management strategies to reduce processing time and ensure the accurate transport of vital data. In addition, it distinguishes between edge nodes (those closest to the event) and normal nodes [69].
- SMESRT: Simultaneous Multiple Event-to-Sink Reliable Transport Protocol is the abbreviation for SMESRT. In wireless sensor networks, the combined carrier controller typically aligns simultaneous spectrum sensing while reducing energy costs. This method combines all payloads at a designated CH (cluster head) and sends a single message to the source, thereby reducing congestion [70].
- RRRTP: The acronym RRRTP stands for Reliable Robust Real-Time Protocol. The RTRT protocol utilizes the congestion control process to increase efficiency and conserve energy [71].
- LTRES [69 [72]: LTRES calculates the ESFL (Event-Sensing Fidelity Level), except that the edge nodes modify the respective sourcing levels, and was developed primarily for variable spectrum sensing within WSNs. It manages network activity via a distributed source process that creates and enables knowledge to enable accurate spectrum sensing; however, the system-built approach makes it extremely resource-intensive.
- (RT) 2: (RT) 2 is an abbreviation for "real-time and reliable transport." (RT) 2 is a precise and targeted time transit system that employs collaborative content-based event transmission. It differentiates sensor nodes from actor nodes. Sensitive data is transmitted via available routes to the ground station (BS) whenever cluster leaders identify a trigger event [73].

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5.2.2 Time-Driven Routing Protocol

Numerous wireless sensor network applications rely on time detection, particularly those with a material component. In time-driven procedures, sensitive data is occasionally provided, and the required quantity can be predefined or modified during execution, depending primarily on the application's requirements. The comparison of various application-type RPs is presented in Table 4.

Table 4 Comparison of Different Application Category-Based Protocols in WSN

Protocols	Time driven Routing protocol	Event-driven Routing protocol	Type of modes	Reliability	Congestion control	Efficiency of energy
EEDP [57]	NO	Yes	Node centric	Yes	Yes	No
ERP [58]	NO	Yes	Node centric	Yes	No	No
IQAR [59]	NO	Yes	Node centric	No	No	Yes
EELLER [60]	NO	Yes	Node centric	No	No	Yes
Collect	NO	Yes	Node centric	Yes	No	No
WB-TEEN [74]	Yes	No	-	Yes	No	No
SMESRT [64]	NO	Yes	Sink centric	Yes	No	No
RRRT [66]	NO	Yes	Sink centric	Yes	No	No
LTRES [67]	NO	Yes	Sink centric	No	Yes	No
(RT) [68]	NO	Yes	Sink centric	No	No	Yes

5.3. Delivery Mode

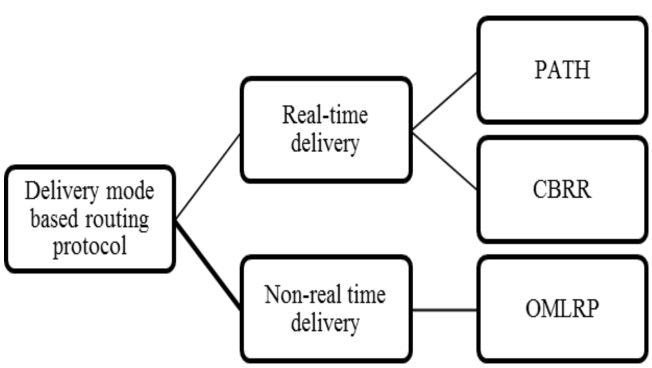

Figure 11 Delivery Mode-Based Routing Protocols

In certain instances, sensor data can be transmitted well beyond the time constraints, and the information will always be valuable; however, additional precision and real-time broadcasting are required in several other application areas. In addition, data transmission between two devices can be concurrent or non-concurrent. Different concurrent and non-concurrent time delivery transit protocols are explained in the delivery mode type of protocol. Figure 11 depicts several categories of delivery mode-based routing protocols.

5.3.1 Real-Time Delivery Routing Protocol

The vast majority of application domains, such as radiation tracking, fire monitoring, and healthcare monitoring, require real-time and a high degree of time-based precision; otherwise, the collected data becomes ineffective or loses value after the time-bound period. These systems are known

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as "real-time solutions" [69]. The real-time delivery routing protocol is subcategorized as follows:

- PATH (Power-Aware Two-Hop) Routing Protocol [75].
- CBRR (Contention-based Beaconless Real-time Routing) Protocol [76].

5.3.2 Non-real-Time Delivery Routing Protocol

Several sensor applications, including certain environmental surveillance systems, such as soil and water monitoring and ecosystem surveillance, differ from real-time applications in that they do not require the ability to schedule data transmission and are therefore classified as non-application areas [77]. Non-real-time delivery RP is OMLRP (On-Demand Multi-Hop Look-Ahead Real-Time Routing Protocol) [78]. Table 5 provides a comparison of numerous delivery mode-based RPs.

Table 5 Comparison Analysis of Various Delivery Mode Dependent Routing Protocols (RPs) in WSN

Protocols	Type of delivery mode	Type of real-time type protocol (Hard/ Soft)	Energy efficiency	Reliability
PATH [70]	Real-time delivery	Soft type	High	Medium
OMLRP [72]	Both	Soft type	Low	High
CBRR [71]	Real-time delivery	Soft type	Medium	High

5.4. Network Architecture

The routing protocols of wireless sensor-dependent systems are divided into two modes, depending on the network's architecture: geo-centric mode and data-centric mode. Figure 12 depicts a further classification of data and geo-centric routing protocols.

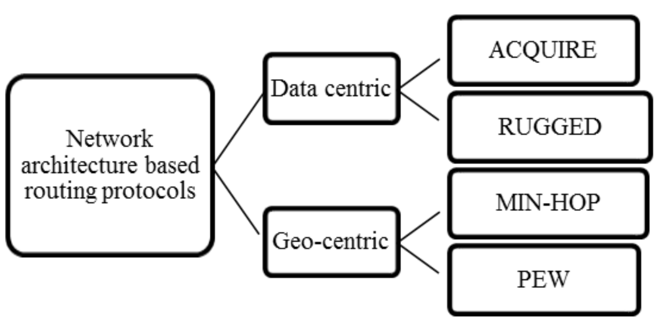

Figure 12 Network Architecture-Based Routing Protocols in WSN [79]

5.4.1 Data-Centric Routing Protocol

The data-centric configuration is a query-based method that can respond to this data-centric scenario due to its nomenclature system foundation and data appraisal throughout the responses. Multiple varieties of data-centric routing protocols (RPs) exist, including ACQUIRE [80] and RoFGSN [81].

5.4.2 Geo-Centric Routing Protocol

The term for geocentric is location-centric RP. Location-aware queries use location data derived from global positioning system (GPS) data or wirelessly transmitted signals as forwarding parameters when dispatching requests to a specific region and relaying information to the receiver, thereby minimizing transfers. MIN-HOP [82] [83] and PWE (path energy weight) [84] are examples of Geo-Centric Protocols. Table 6 depicts a comparison of network architecture-dependent routing protocols (RPs).

Table 6 Comparison of Network Architecture-based RPs [39]

Protocols	Type of network architecture	Data aggregation	Scalability	Usage of power
ACQUIRE [74]	Data-centric based	Yes	Low	Low
RIGGED [75]	Data-centric based	No	Low	No
MIN-HOP [78]	Position-centric based	No	Medium	No
PEW [79]	Position-centric based	No	Medium	No

5.5. Communication Initiator

When a network endpoint, either a detecting station or a source, requires a connection to another terminal, the routing paths are initiated [80]. This form of communication begins with the communication initiator RPs. There are two types of communication initiator-based RPs: source-based and destination-type initiators.

5.6. Route Establishment

The route establishment protocol is used to identify the packet's possible transmission routes. The route establishment routing protocol is classified into reactive, proactive, and hybrid.

- Pro-active: The protocol is known as a table-driven protocol. Because redirecting and advertisement tables are maintained throughout the storage of each sensor network, the path is known prior to the demand for proactive protocols. SinkTrail is a proactive RP type. It determines distances based on logical dimensions and selects the optimal path for performance monitoring pathways. As a result, it saves energy and facilitates mobility across communication organizations [85].
- The protocol is known as a table-driven protocol. Because redirecting and advertisement tables are maintained throughout the storage of each sensor network, the path is known prior to the demand for proactive protocols. SinkTrail is a proactive RP type. It determines distances based on logical dimensions and selects the optimal path for performance monitoring pathways. As a result, it saves energy and facilitates mobility across communication organizations [85].
- Hybrid Routing Protocol: The primary objective of hybrid methods is to integrate assertiveness and reactivity by combining proactive and reactive tactics and utilizing their respective advantages. Hybrid protocols determine a significantly more reliable transmission method during packet forwarding in order to accelerate performance and reduce the specified burden.

5.7. Protocol Operation

The protocol operations are used to divide the WSN into different types. For example, the routing protocols based on operations are classified into five types: multipath, quality of service, query, coherent, and negotiation. In Figure 13, operation-dependent protocols are shown.

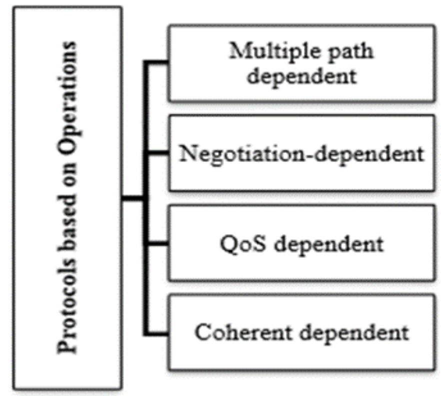

Figure 13 Protocols Dependent on Operations

5.8. Next-Hop Selection Routing Protocol

Like all routing protocols, every sensor chooses the hops to the final destination based on a collection of data. Location-based, opportunistic-based [86], hierarchical-based, content-based, broadcast, and probabilistic routing protocols can all be used to determine the next hop.

5.9. Energy-Efficient (EE) and Latency-Aware (EELA) Routing Protocol

Despite the limited processing and storage capacities of terminals, these protocols extend the life of the network. The five primary classifications and protocols these protocols fall under are multi-path, cluster, swarm-based, location-based, and heuristic-based [87]. Table 7 compares EE and latency-aware (EELA) routing protocols. Table 8 contrasts numerous classifications of routing protocols.

Table 7 Comparison of EE and Latency Aware (EELA) Routing Protocols in WSN

Type of protocols	Energy efficiency	Aggregation of data	Selection of route
Swarm-based data-centric	Strong	Yes	Reactive
Swarm-based location-centric	Strong	No	Hybrid
Swarm-based hierarchical routing protocol	Strong	Yes	Proactive
QoS aware and Network flow routing protocol	Strong	No	Proactive

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Table 8 Comparison of Various Routing Protocols of Different Classes

Protocols	QoS	Fault tolerance	Lifetime of network	Delay in delivery	Scalability	Energy efficiency	Congestion control	Reliability
EEDP [57]	No	No	No	Moderate	No	Low	Yes	Low
EAQR	No	No	Medium	No	Medium	No	No	
PEW [78]	No	No	No	No	Low	High	No	Medium
SPIN	No	No	No	No	Low	High	No	Low
HGMR	Yes	No	High	Moderate	High	Medium	No	Low
EQSR	Yes	Yes	No	Moderate	Low	Medium	No	Medium
BEENISH	No	No	High	Moderate	No	High	No	No
FTCP-MWSN	No	Yes	No	No	Medium	Medium	No	No

6. APPLICATIONS OF HEALTHCARE BASED ON IOT AND WSN

The Internet of Things has enabled medical devices to perform real-time analyses that professionals could not perform just a few decades ago. It has enabled healthcare systems to simultaneously communicate with more individuals and provide affordable, high-quality care. The considerable impact of IoT over the past few decades has facilitated the development of healthcare IoT solutions, such as disease diagnostics, home healthcare for pediatric and adult patients, fitness and health monitoring, and monitoring of chronic conditions [86]. Various healthcare-based IoT solutions have been developed utilizing IoT applications and principles. Experts in these fields have proposed numerous solutions for the betterment of humanity. In other words, concepts are more developer-centric, whereas implementations are more user-centric. Significant advancements in IoT have made sensors that enable users to create things, such as medical apparatus, more affordable and accessible to consumers [87]. Automated devices are utilized to collect patient records, corroborate a diagnosis, monitor individuals' conditions, and send emergency alerts. Figure 14 depicts one of the most prevalent commercial applications.

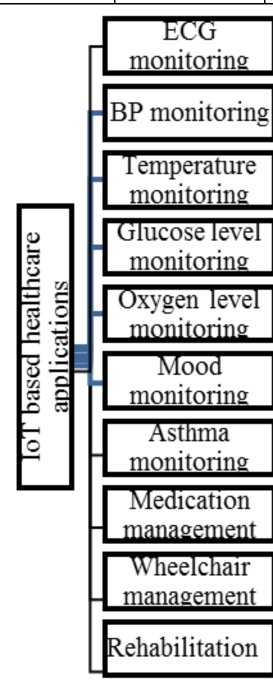

Figure 14 Healthcare Based on IoT Applications [88]

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- ECG monitoring: The heart's electrical impulses are represented by an electrocardiogram, which shows the polarization and ventricular depolarization of the ventricles and atria. An ECG is a category of an electrocardiogram that demonstrates the fundamental beats of the cardiovascular system and can be used to sense different cardiac issues. Irregular heartbeats, long QT duration, myocardial infarction (MI), and other anomalies are among them. IoT and WSN have played significant roles in the application of ECG monitoring for early diagnosis of cardiac problems. Here are more details on how these technologies have been utilized:

1. Wireless Sensor Network (WSN): WSN permits the attachment of wireless ECG sensors to the patient's thorax. These sensors detect the heart's electrical impulses and convert them into ECG signals [89]. Multiple sensor modules that communicate wirelessly with each other to form a network constitute the WSN infrastructure. The sensor nodes transmit the collected ECG data to a central centre or gateway as the communication interface between the WSN and IoT platforms.

2. Internet of Things (IoT): The IoT aspect of ECG monitoring involves integrating WSNs with cloud-based platforms or healthcare information systems. The wireless sensors transmit the ECG data to an IoT gateway that is connected to the internet. The data is then transmitted to cloud servers or healthcare databases for storage, analysis, and display [89]. This allows medical professionals to access ECG data and remotely conduct real-time surveillance and diagnosis.

3. Data Transmission and Analysis: The ECG signals collected by the wireless sensors are transmitted to the IoT gateway in real-time via the WSN. The gateway then transmits the data to a cloud platform for storage and processing. Advanced algorithms and analytics can be applied to ECG data to detect cardiac abnormalities such as irregular heartbeats, extended QT duration, and myocardial infarction [89]. Developing predictive models for early diagnosis and intervention using machine learning techniques is possible.

4. Remote Monitoring and Diagnosis: The integration of IoT and WSN enables remote surveillance of ECG signals, enabling healthcare professionals to evaluate a patient's cardiac health remotely. Physicians or cardiologists can access and examine the ECG data via mobile interfaces or web applications. This remote access enables healthcare providers to make informed judgements regarding treatment plans and interventions [89].

5. Cost-Effective Sensor Technology: The ECG electrodes on the patient's thorax are connected to cost-effective sensors, such as the AD8232 heart rate monitor, in IoT-based ECG monitoring systems. The AD8232 functions as an operational amplifier (OP-AMP) and aids in removing noise from the received ECG signal [88. These sensors are inexpensive, user-friendly, and provide dependable signals in terms of the PR (P wave to R wave interval) and QT (ventricular depolarization and repolarization) intervals, enabling healthcare professionals to evaluate the various cardiac parameters.

- BPM (blood pressure monitoring): It has become one of the mandatory operations in every clinical examination. IoT and WSN have been instrumental in transforming how blood pressure (BP) is monitored and recorded. Here are more details on how these technologies have been utilized in BP monitoring:

1. Wireless Sensor Network (WSN): WSN enables the deployment of wireless blood pressure measuring sensors. Typically, these sensors are attached to the patient via a collar or other wearable device. The sensors obtain blood pressure readings and wirelessly transmit the information to a central node or gateway [88]. Multiple sensor modules within the WSN infrastructure communicate with one another and relay data to the IoT platform.

2. Internet of Things (IoT): The IoT component of BP monitoring entails integrating WSNs with cloud-based platforms or healthcare systems. The wireless sensors transmit collected data to an IoT gateway that is connected to the internet. The data is then stored and analysed to cloud servers or healthcare databases [88]. This enables healthcare professionals to remotely access BP data and monitor the blood pressure trends of patients over time.

3. Remote Monitoring and Analysis: The integration of IoT and WSN enables remote blood pressure monitoring. Through web-based applications or mobile interfaces, healthcare providers have real-time access to their patient's blood pressure readings. This remote monitoring capability allows healthcare professionals to make informed judgements regarding medication adjustments or lifestyle recommendations [89 [88].

4. Automated Analysis and Alerts: Blood pressure monitoring systems based on the Internet of Things frequently employ automated analysis algorithms to interpret data and detect abnormal blood pressure readings. These algorithms can identify episodes of hypertension or hypotension and send alerts to healthcare providers or patients. This automated analysis aids in the early detection of blood pressure abnormalities and enables preventative measures [88].

5. User-Friendly Applications: IoT-based blood pressure monitoring systems provide intuitive applications that enable individuals to visualise their BP analysis. These applications allow users to observe their blood pressure readings, monitor trends, and gain insight into their cardiovascular health. Some

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systems offer additional features like email notifications or medication adherence reminders [88].

6. Smart Sensors and Raspberry Pi: The Internet of Things and intelligent sensors have revolutionised BP monitoring. Smart sensors can provide accurate and dependable blood pressure measurements, ensuring the integrity of the data collected. Additionally, USB TTL serial cable-connected Raspberry Pi devices enable seamless integration and data processing [88].

- Temperature monitoring: A person's body condition, such as the temperature aspect of several diagnostic procedures, is a sign of homeostasis. For many disorders, monitoring such temperature changes during the patient's schedule permits clinicians to form assumptions about the patient's health conditions. Here are more details on how these technologies have been utilized for temperature monitoring:

1. Wireless Sensor Network (WSN): WSN enables the deployment of temperature sensors that wirelessly detect and transmit temperature measurements. These sensors may be incorporated into wearable devices, patches, and other sensor nodes. The sensor nodes comprise a wireless network that transmits temperature data to a central base or gateway [90 [90]. The WSN infrastructure enables remote and continuous temperature monitoring.

2. Internet of Things (IoT): The Internet of Things (IoT) component of temperature monitoring requires the incorporation of WSNs with internet connectivity and cloud-based platforms. The wireless sensors transmit the temperature data to an IoT gateway that is connected to the internet. The information is then transmitted to cloud servers or healthcare databases for storage, analysis, and additional processing [90]. This allows medical professionals to access and monitor temperature data remotely.

3. Real-time Monitoring and Alerts: IoT-based temperature monitoring systems monitor a person's body temperature in real-time. Continuous data collection enables clinicians to monitor and identify anomalous temperature fluctuations over time. In addition, automated alerts can be generated when temperature readings exceed predefined thresholds, indicating potential health risks. These alerts can be sent directly to healthcare providers or patients, allowing for opportune interventions [90 [90].

4. Data Analysis and Insights: Platforms for the Internet of Things facilitate the analysis of temperature data gathered from multiple individuals. Using advanced analytics algorithms, temperature measurements can be analysed for patterns, trends, and anomalies. This analysis allows for the early detection of fever, infections, and other temperature-related abnormalities, allowing clinicians to make informed decisions about their patients' health. In addition, aggregated and anonymized data can be utilised for research and population-level insights [90].

5. Remote Access and Communication: IoT-based temperature monitoring systems provide healthcare professionals with remote access to temperature data. Through web-based interfaces or mobile applications, clinicians can access and examine the temperature readings of their patients securely from anywhere. This remote access facilitates efficient monitoring, particularly in situations where patients are located remotely or in settings of home healthcare. Additionally, communication channels can be established to facilitate direct communication between patients and healthcare providers, enabling virtual consultations or advice based on temperature data [90].

6. LM-35 Temperature Sensor: The LM-35 temperature sensor is widely used in IoT-based healthcare applications for temperature monitoring. It provides precise temperature measurements that are accurate and dependable. The sensor generates an electrical output proportional to Celsius centigrade, making it compatible with Internet of Things systems that digitally process temperature data. The inherent precision and stability of the LM-35 sensor contribute to the dependability of temperature monitoring in healthcare contexts [90].

- GLM (glucose level monitoring) [91]: Diabetes is a prevalent metabolic disorder characterized by prolonged elevation of blood sugar levels. The advancements in IoT technology have facilitated the development of transparent, suitable, and effective tools for managing diabetes. These IoT-based solutions have the potential to improve the management and monitoring of diabetes significantly. Here are some key applications of IoT in diabetes management:

1. Continuous Glucose Monitoring (CGM): IoT technology has facilitated the development of continuous glucose monitoring (CGM) systems. CGM devices utilise subcutaneously inserted sensors to measure glucose levels in interstitial fluid. The collected data is wirelessly transmitted to a receiver or mobile device, enabling individuals to monitor their glucose levels in real time. This continuous monitoring enables individuals with diabetes to make informed decisions regarding insulin dosages, dietary choices, and physical activity in order to maintain optimal glucose control.

2. Insulin Delivery Systems: Insulin delivery systems based on the Internet of Things automate insulin administration based on real-time glucose monitoring. Integrating CGM data with insulin devices, these systems enable personalised insulin administration. The IoT platform calculates and adjusts insulin dosages based on an individual's glucose levels, insulin sensitivity, and carbohydrate intake. This

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closed-loop system, also known as an artificial pancreas, delivers insulin precisely, lowering the risk of hypoglycemia and hyperglycemia.

3. Mobile Applications and Data Analysis: The Internet of Things enables the integration of diabetes management devices and mobile applications. These applications enable users to record their dietary intake, physical activity, medication adherence, and other pertinent information. The IoT platform analyses this data to reveal trends, patterns, and correlations between lifestyle factors and glucose regulation. Individuals can receive individualized feedback and recommendations, empowering them to make informed decisions regarding their diabetes management.

4. Remote Monitoring and Telemedicine: Diabetes patients can be remotely monitored by IoT devices, allowing healthcare personnel to assess their condition without frequent in-person visits. Healthcare providers can receive glucose readings, medication adherence data, and other vital information from remote monitoring systems. This remote connectivity improves communication between individuals and healthcare teams, allowing for more timely interventions and modifications to the diabetes management plan.

5. Predictive Analytics and Early Detection: In conjunction with machine learning and predictive analytics, Internet of Things technology can identify patterns and predict future glucose fluctuations. IoT systems can provide early warnings of imminent hypoglycemic or hyperglycemic events by analysing historical data and incorporating factors such as dietary intake, physical activity, and sleep patterns. This allows individuals to take preventative measures and avoid complications resulting from uncontrolled glucose levels.

- Oxygen level monitoring: IoT technology has revolutionized oxygen level monitoring by incorporating pulse oximetry, a non-invasive method for measuring oxygen saturation in the blood. Pulse oximeters equipped with IoT capabilities enable continuous monitoring of oxygen levels in real-time, providing valuable information for medical research and patient care. IoT-enabled pulse oximeters typically consist of a sensor device that is placed on a patient's fingertip, earlobe, or other suitable body parts. The sensor emits light wavelengths that can penetrate the skin and measures the amount of oxygenated and deoxygenated haemoglobin in the blood. The collected data is then transmitted wirelessly to a connected IoT platform or healthcare provider's system. The IoT platform analyzes oxygen saturation data, tracks trends, and alerts healthcare professionals to any significant changes or abnormalities. This allows for timely interventions in cases where oxygen levels drop below a certain threshold, indicating potential respiratory distress or hypoxemia. In addition, remote monitoring capabilities provided by IoT technology enable healthcare providers to monitor patients' oxygen levels from a distance, enabling proactive care and early intervention [92].

IoT technology has also found applications in mood monitoring, which can be valuable in assessing and managing psychological conditions such as anxiety, tension, and chronic depression. IoT-based mood monitoring systems utilize various sensors and devices to capture and analyze individual psychological state data. For example, wearable devices equipped with sensors can track physiological indicators such as heart rate variability, skin conductance, and sleep patterns, which are correlated with mood and emotional well-being. These devices continuously collect data and transmit it to an IoT platform or mobile application. The IoT platform utilizes machine learning algorithms to analyze the collected data and generate insights about the individual's mood patterns. The system can provide personalized feedback and recommendations to the user and their healthcare provider by detecting patterns and correlations between physiological indicators and mood states. Mood monitoring through IoT technology empowers individuals to understand their psychological well-being better and provides healthcare practitioners with objective data to support diagnosis and treatment decisions. It enables early detection of mood fluctuations, facilitates timely interventions, and promotes proactive mental health management.

- AMS (Asthma Monitoring System): Asthma is a dreadful complaint that affects the lungs and can cause airway inflammation. An IoT asthma monitoring model containing a heart pulse sensor was familiarized. In asthma monitoring, IoT and wireless sensor network (WSN) technologies have been utilized to develop asthma management systems that provide real-time monitoring and remote access to patient data. Here is a more detailed explanation of how IoT and WSN are used in asthma monitoring:

1. IoT Asthma Monitoring Model: The IoT asthma monitoring model includes a cardiac pulse sensor for capturing the patient's vital signs and asthma-related data. Sensor-based data, such as heart rate and respiratory parameters, are gathered and wirelessly transmitted to a microcontroller in real-time [93].

2. Data Transmission and Remote Server: Using technologies such as Bluetooth or Wi-Fi, the sensor data is wirelessly transmitted to a microcontroller or gateway device. Using Internet connectivity, the microcontroller then transfers the data to a remote server. This facilitates the transmission of a patient's health information to a central location.

3. Data Storage and Analysis: The transmitted data is securely stored in a database on the remote server, where authorised healthcare professionals can access it. A hospital or cloud-based infrastructure may host the server. The preserved data

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may include vital signs, respiratory parameters, and other pertinent patient condition information

4. Web-Based Monitoring: The hospital personnel or healthcare providers can monitor patients' condition and access their data via a web interface. A dedicated website or application enables authorised personnel to view real-time information regarding the asthmatic patient's vital signs, symptoms, and medication usage.

5. Alerting and Intervention: The Internet of Things asthma monitoring system can be configured to generate alerts and notifications based on predefined thresholds or patterns identified in the patient's data. For instance, if the system detects a sudden decrease in peak expiratory flow rate or deterioration of symptoms, it can send an alert to healthcare providers, allowing them to intervene quickly and administer the appropriate treatment.

6. Patient Empowerment: Asthma monitoring systems enabled by the Internet of Things can also empower patients by granting them access to their own data. Using mobile applications or web portals, patients can monitor their symptoms, medication usage, and lung function trends over time. This aspect of self-monitoring promotes patient engagement and enables individuals to take an active role in asthma management.

By utilizing IoT and WSN technologies in asthma monitoring, healthcare providers can gain real-time insights into a patient's condition, enabling timely interventions and personalized care. In addition, these systems help in the early detection of asthma exacerbations, improve treatment outcomes, and provide patients with a sense of security and support in managing their condition.

- Medication management: Within the health sector, medication adherence seems to be a widespread issue. Individuals' terrible health problems may be exacerbated if they do not take their medications regularly. In addressing the issue of medication adherence, IoT and wireless sensor network (WSN) technologies have been employed to develop innovative solutions. Here are more details on how IoT and WSN have been utilized for medication adherence monitoring:

1. Wireless Medication Box: A wireless medication box is used as a smart medication storage device. The box is equipped with compartments or slots for different medications, and each compartment has an LED indicator on top to display the correct box to be opened.

2. Wireless Connectivity: The medication box is wirelessly connected to the hospital management system or a central monitoring platform. This connectivity is typically established using technologies like Wi-Fi or Bluetooth.

3. Monitoring and Data Collection: The hospital management system monitors the data from the wireless medication box through an on-site portal. The system collects information about medication consumption patterns, such as when a compartment is opened and if the correct medication is taken [94].

4. Mobile Application for Patients: Patients utilize a smartphone application, typically available for Android devices, to interact with the medication adherence system. The application provides a user-friendly interface for patients to view their medication schedules, receive reminders for medication intake, and track their adherence progress.

5. Adherence Warnings and Alerts: The smartphone application sends notifications and warnings to patients regarding medication consumption. These alerts can be in the form of push notifications, SMS messages, or audible reminders. For example, if a patient forgets to take a medication or opens the wrong compartment, the application can generate an alert to remind them [94].

6. Arduino and ESP8266 Integration: The IoT system incorporates an Arduino microcontroller board with built-in Wi-Fi connectivity. The Arduino board controls the LED indicators on the medication box and triggers a buzzer if the incorrect compartment is opened.

7. Data Transmission to the Hospital Website: The Arduino microcontroller uses the ESP8266 Wi-Fi module to transmit the collected data from the medication box to the hospital website. The data includes information about medication adherence, such as timestamps of medication intake and any instances of non-adherence.

8. Monitoring and Support from Healthcare Providers: Healthcare providers can access the data collected by the medication adherence system through the hospital website. They can monitor patients' adherence patterns, identify any issues or trends, and intervene when necessary to address non-adherence.

By leveraging IoT and WSN technologies, medication adherence monitoring systems aim to improve medication compliance, especially in populations prone to non-adherence, such as older adults with chronic conditions. These systems provide patients with real-time monitoring, reminders, and support, enhancing their adherence to medication regimens and reducing the risks associated with medication non-adherence.

7. ADVANTAGES OF ADVANCED WSN HEALTHCARE BASED ON IOT

The Internet of Things is rapidly acquiring traction in all facets of society, including medicine. In brief, the technologies enable multiple interconnected devices to communicate and exchange data. Presently, many Internet of Things-related techniques are being utilized in medical services, as well as optimism for the future. The IoT continues to develop whenever technologies evolve and become more complex and sophisticated. The advantages of IoT-based healthcare systems are depicted in Figure 15.

- Monitoring and reporting simultaneously: In medical care, wireless network surveillance can save the lives of patients suffering from cardiovascular disease, diabetes, or respiratory problems. Using authentic health analysis facilitated by intelligent medical care connected devices and a mobile application, the networked system can monitor healthcare and other vital medical information and transmit it to a healthcare professional via a cell phone internet connection. The IoT device captures and transmits health-related data, including hypertension, oxygenation, glucose levels, body weight, and electrocardiography. Such information is stored on the internet and can be transmitted to an appropriate authority, such as a clinician, a financial institution, a medical organization that collaborates with others, or an experienced professional, who can access the data from anywhere, at any time, and using any device.

- Node-to-node connectivity and cost-effectiveness The Internet of Things can simplify the patient outcome process with medical mobility solutions, other technological advancements, and next-generation medical centres. Advanced medical technology enables standardization, machine-to-machine (M2M) connections, data exchange, and data transmission, thereby enhancing the efficiency of quality medical services. By connecting technologies such as Bluetooth connectivity, ZigBee, Z-wave, Wi-Fi, and other current technologies and innovating new treatment methods, healthcare professionals can profoundly alter how physicians identify disease and disorders in patients.

- Assortment of data analysis: When real-time implementations of medical instruments transmit large datasets quickly, retrieving and managing the data is difficult when cloud connectivity is unavailable. Risky for healthcare professionals is collecting and evaluating information from numerous equipment and channels. IoT-based healthcare systems can collect, transmit, and evaluate data in real-time, reducing the need for fundamental data storage. This is possible online, but only the anticipated outputs and accompanying graphics are visible to suppliers.

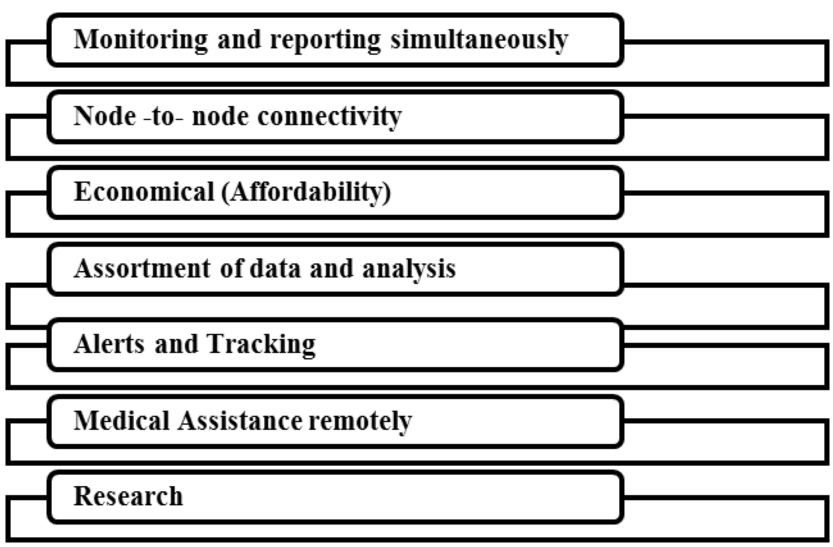

Figure 15 Several Advantages of Healthcare Based on IoT Systems [95]

- Tracking and alerts: In a life-threatening situation, prompt notification is necessary. A healthcare IoT sensor collects vital data and transmits it to clinicians in real time, permitting monitoring and alerting individuals about critical components via smartphone platforms and other connected devices. Regardless of time or location, reporting and notification provide a reliable assessment of the patient's condition. Additionally, it assists in making informed decisions and providing prompt medical care. As a result, IoT provides real-time alerts, monitoring, and tracking, allowing for hands-on interventions and enhancements in precision, appropriate medical involvement, and overall patient healthcare service outcome.

- Medical assistance remotely: Individuals can alert a physician millions of kilometres afar using sophisticated

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mobile applications during an emergency. Physicians can monitor patients and diagnose maladies using medical transportation solutions while on the move. Moreover, many public healthcare channels plan to construct apparatus that can administer medications based on participants' prescriptions and disease-related data available through connected devices. As a result, the IoT will improve patient outcomes in medicine. Consequently, Social Security and Medicare expenses will decrease.

8. QUANTITATIVE PERFORMANCE ANALYSIS

Numerous studies on efficient wireless sensor network communication have been conducted in preparation for implementing IoT-based advanced healthcare systems. In this section, several existing methods of IoT-based healthcare WSNs, such as SAB-UAS (Secure and anonymous biometric-based user authentication scheme) [22], SPRP (Secured routing protocol for delay-tolerant networks) [47], HMS (Health monitoring system) [27, 96] , SDN-based (Software defined networking) edge computing, EPPDA (Efficient privacy-preserving data aggregation) [97], LSDA (Lightweight secure data aggregation) [97], etc., are compared. The comparison of various techniques is based on dissimilar performance metrics of healthcare IoT-based wireless sensor systems. Network throughput, packet delivery ratio, end-to-end (E2E) delay, and end-to-end (E2E) delay are the performance metrics used for comparison analysis. E2D is the time for messages to travel from the initial to the final node. Various IoT-based healthcare systems are contrasted and graphically represented in Figure 16. The reference [96] is assumed to represent the maximum end-to-end latency. The packet delivery ratio (PDR) is the ratio of total packet delivery to total transmissions sent in a network from a source to a destination point.

The references [98] and [99] require significant time to transport payloads from one node to the next. Figure 17 is a graphical representation of the various methods of an E2D-based healthcare system. The energy consumption of a sensor node is determined by averaging the node's power consumption throughout its implementation. Figure 18 is a graphical representation of various healthcare system methodologies based on their energy consumption. The throughput of a network [97] is the rate at which data is transmitted over a transmission medium. Figure 19 depicts the throughput of extant methods in the healthcare system.

The superior results achieved by certain methods in IoT-based healthcare WSNs can be attributed to various innovative features or improvements they offer. Here are some possible innovations or features that could contribute to better results:

Secure and anonymous biometric-based user authentication scheme (SAB-UAS): This method focuses on ensuring secure and anonymous user authentication, which is crucial for maintaining privacy and security in healthcare systems. By employing biometric-based authentication techniques, such as fingerprint or iris recognition, SAB-UAS enhances the system's overall security, preventing unauthorized access and protecting sensitive healthcare data.

Secured routing protocol for delay-tolerant networks (SPRP): SPRP addresses the challenges of delay-tolerant networks in healthcare WSNs. It incorporates robust security mechanisms to protect data transmission and routing protocols, ensuring secure and reliable communication. SPRP improves healthcare applications' overall performance and effectiveness by mitigating network delays and vulnerabilities.

Health monitoring system (HMS): HMS introduces a comprehensive system for monitoring and managing patients' health conditions. It integrates various sensors and devices to collect real-time health data, such as vital signs and transmits this data wirelessly to a central server for analysis. As a result, the HMS enables remote monitoring, early detection of health issues, and timely intervention, improving the quality of care and patient outcomes.

Software-defined networking (SDN)-based edge computing: This approach leverages the capabilities of SDN and edge computing to optimize data processing and communication in healthcare WSNs. By offloading computation tasks to edge devices, SDN-based edge computing reduces latency, improves response times, and enhances the network's overall efficiency. In addition, it enables real-time data analysis, decision-making, and resource allocation at the network edge, leading to improved performance and scalability.

Efficient privacy-preserving data aggregation (EPPDA) and lightweight, secure data aggregation (LSDA): These methods focus on preserving the privacy and security of aggregated data in healthcare WSNs. They employ advanced encryption and privacy-preserving techniques to protect sensitive patient information during data aggregation and transmission. EPPDA and LSDA enhance patient confidentiality and prevent unauthorized access to sensitive healthcare data by providing robust data security.

These innovative features contribute to the superior performance of the respective methods, such as improved network throughput, high packet delivery ratio, reduced end-to-end delay, and efficient energy consumption. In addition, these methods offer enhanced functionality, security, and reliability in IoT-based healthcare WSNs by addressing specific challenges and incorporating advanced techniques.

Afterwards, we will conduct a comparative analysis to identify existing issues and propose a hybrid routing protocol to improve performance metrics and features such as network performance, optimal route search, and network transmission rate. Finally, we will analyze several methods to address these problems and propose solutions in our research.

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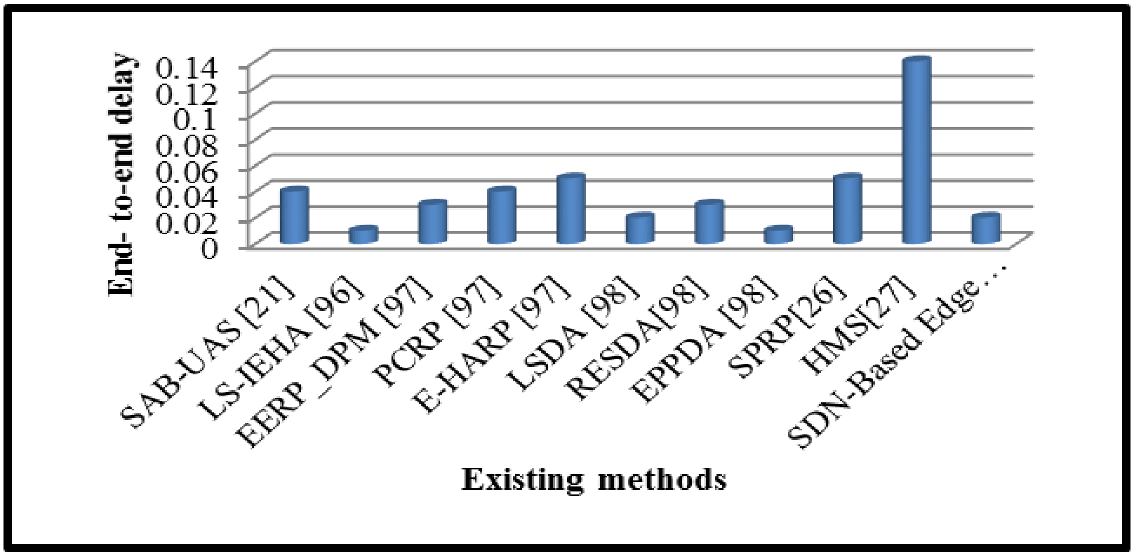

Figure 16 Comparison Analysis with Different Routing Methods: End-to-End Delay (E2D)

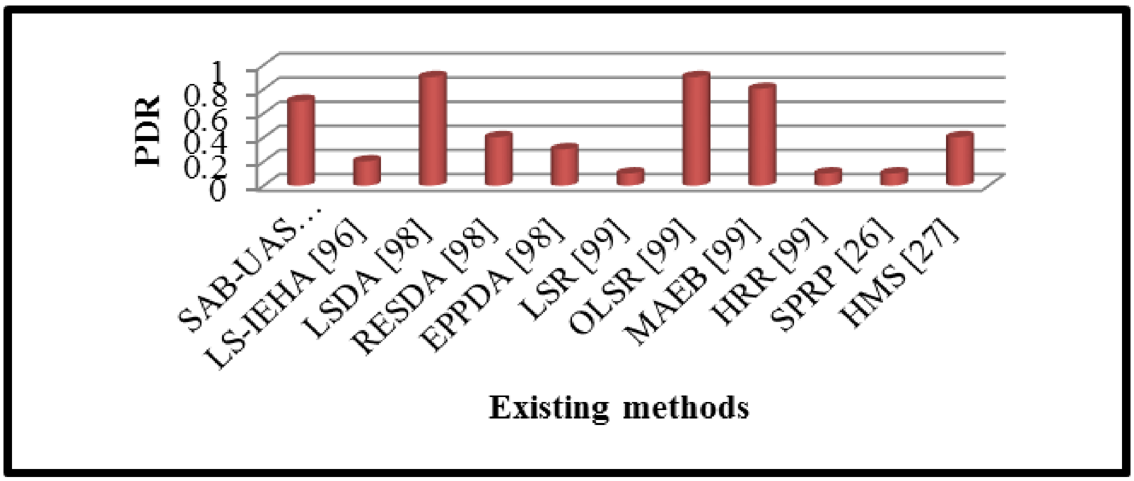

Figure 17 Comparison Analysis with Different Routing Methods: Packet Delivery Ratio (PDR)

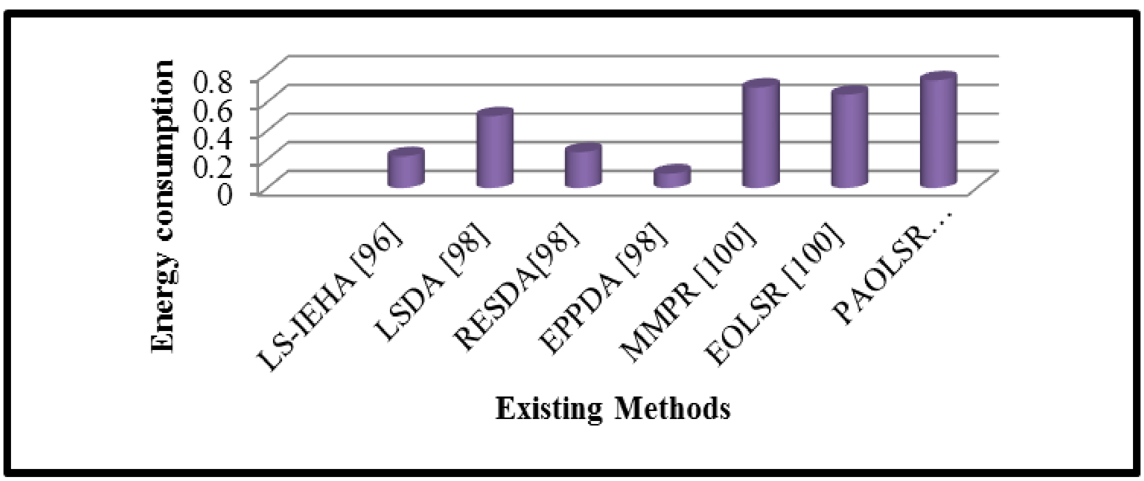

Figure 18 Comparison Analysis with Different Routing Methods: EC (Energy Consumption)

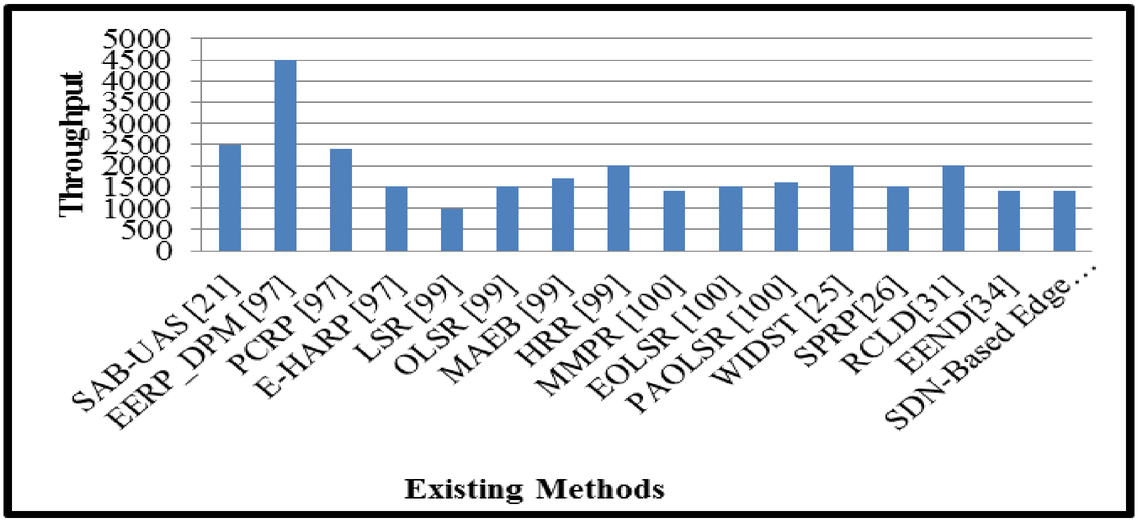

Figure 19 Comparison Analysis with Different Routing Methods: NT (Network Throughput)

9. CONCLUSION AND FUTURE SCOPE

IoT is a minimal-power connection system for intelligent devices. Several WSN-based intelligent applications employ IoT. In this paper, the framework of healthcare based on IoT WSN is elaborated. Numerous user research benefits and the most appropriate application domains have been identified. A comparative analysis of extant healthcare systems and methodologies is conducted. In this work, a comparison table of the strengths and weaknesses of existing methods is illustrated. Each methodology has distinct inadequacies, such as lengthy computation times, data aggregation, sluggish data transmission, security issues, etc. RPs are indispensable for wireless sensor networks. Using our taxonomy, the current protocols classify various classifications of RPs for IoT-based healthcare systems, such as route establishment, following hop selection, application type, network topology, etc.. There are protocols with high scalability and protocols with low scalability. This paper uses distinct comparison tables to compare several protocols based on various parameters. The graphical representation of various routing strategies according to throughput, PDR, E2D, and energy consumption. The current result analysis demonstrates that the different protocols of healthcare based on IoT wireless sensor systems, such as SAB-UAS [22], SPRP [47], HMS [27], LS-IEHA [99], SDN-based edge computing [97], LSDA [97], etc., are compared and increase the network lifetime compared to other methods, which led us to conclude that the use of intelligent methods increases the network lifetime and ensures improved coverage in the sensing domain. Additional enhancements will focus on modifying one of the routings mentioned above techniques so that the modified RP reduces energy consumption and delay[100]. We will conduct a comparative analysis to identify existing problems and propose a hybrid routing protocol to enhance performance metrics and features such as network performance, optimal route search, and network transmission rate.

ABBREVIATIONS

The following abbreviations are used in this review article.

AB	Arduino board
ACQUIRE	Active query forwarding in the sensor network
ALO	Antlion optimization algorithm
AMS	Asthma Monitoring system
AODV	Adhoc on-demand vector routing
BDIT	Blockchain decentralized Interoperable trust platform
BEENISH	Balanced Energy Efficient Network Integrated Super Heterogeneous Protocol
BP	Blood pressure, Body pulse
BPM	Blood Pressure Monitoring
BS	Body sensors, Base station
BT	Body temperature
CBRR	Contention-based beaconless real-time routing protocol
CCS	Concentric clustering scheme
CDR	Composite decision rule
CDMRIB	Compressed Sensing-Based Protocol for Interfering Data Recovery

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CDP	Customer data platforms
CDS-RULE-K	connected dominating set protocol
CH	Cluster head
CM	Central monitor
CO	Computational Overhead
CODAR	Congestion and delay-aware routing protocol
COLLECT	Collaborative event decision and tracking
CS	Control system
CT	Computational Time
DES	Data encryption standard
DEEC	Distributed Energy Efficient Clustering
DIT	Decentralised Interoperable Trust
EAQR	An energy-efficient ACO-based QoS routing algorithm
E2D	End-to-end delay
ECG	electrocardiography
EECDS	Energy efficient connected dominating set (EECDS) protocol
EEDP	Efficient event detection protocol
EELA	Energy-efficient and latency-aware routing protocol
EELER	Energy efficient low latency express routing protocol
EEOR	Energy Efficient Opportunistic Routing
EERP	Energy Enhanced Routing Protocol
EHR	Electronic health record
EMG	electromyography
EPPDA	An efficient privacy-preserving data aggregation mechanism
ERP	Event reliability protocol
ESEERP	enhanced smart-energy-efficient routing protocol
ESfl	Event-Sensing fidelity level
EQSR	Energy Efficient and QoS-aware multipath routing protocol
ETX	Expected transmission count

GA	Genetic Algorithm
GCS	Game theory-based clustering scheme
GLM	Glucose level monitoring
GS	Ground station
HB	Heartbeat
HDPR	Hybrid data-centric routing protocol
HGMR	Hierarchical geographical routing protocol
HMS	Health monitoring system
HIP-DEX	Host uniqueness protocol diet exchange key algorithm
HPC	High-performance computing
HS	Healthcare system
IETF	Internet-Engineering Task Force
IQAR	Information quality aware routing
IOT	Internet of things
LEACH	Low energy adaptive clustering hierarchy
LMDSG	Lamport Merkle Digital Signature Generation
LONG QT	the heart's electrical activity as graphed on an electrocardiogram
LRPD	Light-weight QoS routing protocol
LS-IEHA	Lightweight secure-improved energy hierarchy aggregation
LSDA	Lightweight Secure Data Aggregation
Mi	Myocardial infarction
MAC	Media access control
MAE	mean absolute error
MC	Medical care
MIN-HOP	Minimum hop routing protocol
ML	Machine learning
MS	Monitoring system
NB-IOT	Narrow band-Internet of things
NL	Network layer
NT	Network throughput
OMLRP	On-demand multi-hop look ahead real-time routing protocol

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ORP	Opportunistic routing protocol
PATH	Power-aware two hop
PC	Power consumption
PDR	Packet delay ratio
PEGASIS	Power-based efficient gathering sensor information system protocol
PEW	Path energy weight
PSO	Particle Swarm Optimization
RFID	Radio Frequency Identification
RIIGRP	Reliable Intra and Inter Gateway Routing Protocol
RoFGSN	Routing on fingerprint gradient in a sensor network
RMSE	Root Mean Square Error
RPL	Routing Protocol for Low-Power and Lossy Networks
RP	Routing protocol
RREP	Route Reply
RREQ	Route Request
RRRTP	Reliable robust real-time protocol
RSSI	Received Signal Strength Indicator
RT2	Real-time and reliable transport
SAB-UAS	Secure and anonymous biometric-based user authentication scheme
SC	Smart card
SDR	Simple decision rule
SDN	Software Defined Networking
SHA1	Secure Hash Algorithm
SGEAR	Sub-game energy-aware routing
SFO	Sailfish optimization
SHM	Structural health monitoring
SIIGRP	Secure inter and intra-gateway routing protocol
SMESRT	Simultaneous multiple events sink reliable transport protocol
SPIN	Sensor protocol for information vs negotiation
SPRP	Secured routing protocol for delay-tolerant networks
SN	Sensor node
TA	Trust authority
TOSSIM	TinyOS sensor network
TTDD	Two-tier data dissemination
UAV	Unmanned aerial vehicle
WBAN	Wireless body area network
WBTEEN	Well balanced threshold sensitive energy efficient sensor network
WSN	Wireless sensor network

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