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Energy Efficient Cooperative Quality of Service (QoS) Aware Routing Protocol for Wireless Body Area Sensor Networks

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***Abstract*— *Network Wireless Body Area Network (WBAN) is a promising technology for delivering quality healthcare to its users. Low power devices attached to the body have limited battery life. Nowadays the world is moving towards an era of wireless technologies for making the life of elderly people living alone in the houses easier. The latest innovative technologies improve and facilitates the daily life of human beings especially ambient assisted living. Internet [1] of Medical Things (IoMT) revolutionized the quality of life of people living in cities as well as in the far flung areas. Under the domain of IoT and WBAN integration, which leads towards a new emerging domain in technological Health care named as IoMT. The Main focus of this Research study is to improve the Quality of Service (QoS) in the Health care data transmission. Major problems in health care data transmission. It is desirable to have energy efficient routing protocol in WBAN that maintains the required reliability value for sending data from a given node to the sink Node. In this proposed research, the researcher intends to propose two routing protocols named as Improved Quality of service Aware Routing protocol for WBAN (IM-QRP) and Energy Aware Cluster based Routing protocol for Flying Ad hoc Networks (EA-CBRP-FAN). The performance of the proposed protocols will be compared with the existing routing protocols named as QPRD [1], CO-LAEEBA [2], E-HARP [3] and EEBSR [4]. IM-QRP will primarily concentrate on the enhancement of the fundamental metrics, including Signal to Noise Ratio (SNR), Path Loss Ratio, and Residual Energy of the Sensor Nodes. The Mat Lab Simulation tool will be used to create the IM-QRP results. The Simulation results will be compared with existing routing protocol. From the simulation results the researcher will try to observe the performance of IM-QRP Routing with existing ones in order to assess which performs better. Improving simulation results will be based on numerical percentage values. Better residual energy of the Sensor Nodes, reduction in path loss ratio, improvement in packet transmission (link reliability) towards the Sink nodes and improvement in SNR will be the aim.*

Keywords*— *Wireless Body Area Network, Internet of Medical Things, Energy-efficient Routing, Quality of Service, Signal-to-Noise Ratio.

I. INTRODUCTION

1.0 Wireless Body Area Sensor Networks

Wireless body area network (WBAN) is a promising technology to provide intelligent health care services at remote locations. From the literature review, we have observed that since 2006 scientists and researchers has focused more on Quality of service Aware (QoS) energy efficient routing techniques, network topology and Medium Access Control (MAC) layers used in WBAN. QoS aware routing techniques are based on a set of protocols which can maintain the routes efficiently and are capable of exchanging the data between sensor nodes effectively

[5].

The WBAN-related healthcare applications concentrate on enhancing medical infrastructure, particularly for senior citizens living at home. WBAN uses wireless computer devices to facilitate communication all over the human body [7]. As illustrated in Figure 1.1, the WBAN architecture is divided into three sub-tiers: Tier 1 is for intra-BAN communication, Tier 2 is for inter-BAN communication, and Tier 3 is for extra-BAN communication. The various types of sensor nodes that make up Tier 1 include ECG, EEG, and EMG sensors, glucose level sensors, blood pressure and temperature sensors attached to human bodies, to name just a few. The coordinator node inside the Tier 1 is capable for processing the data received from sensor nodes and transmits this information back to sink node located inside Tier 2. Sink node located inside Tier 2 directly communicates with Tier 3. Tier 3 consists of beyond body communication-based Network infrastructure [8]. In order to establish reliable communication between multiple tiers, Link reliability should be maintained between each Tier. Link reliability is an important QoS based parameter in WBAN. Optimal Link reliability is based on Received Signal Strength Intensity (RSSI).

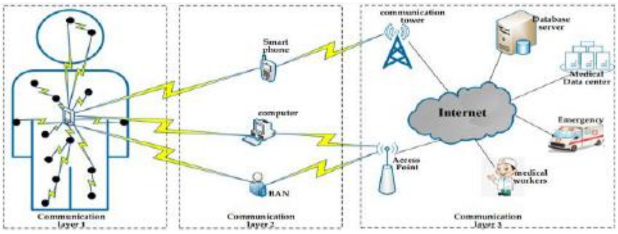

Fig 1.1: Three Tier Architecture of Wireless Body Sensor Networks [8]

A holistic healthcare system is becoming incredibly valuable as the world's population grows, the oldest, and increasingly more susceptible to health problems. Current healthcare expenditures will not be sufficient to satisfy future health needs. Indeed, most patients cannot receive treatment due to healthcare resources. Long-term hospital admissions result from financial restraints, employment obligations, and even familial responsibilities, regardless of whether their health must be examined immediately or on a short-term basis. There is much interest in developing wireless medical devices that can provide remote patient monitoring in an invisible, efficient, and cost-effective manner to receive personalised, long-term healthcare [9]. More information about wireless communication standards research in healthcare settings may be found here. International interest in WBANs (Wireless Body Area Networks) for use in healthcare applications is growing as a result of its potential to both provide healthcare infrastructure and provide individuals with cost-effective and efficient healthcare options. WBANs, or wireless body area networks, are tiny networks comprising numerous small, lightweight sensors that can be worn as intelligent patches on the body or put nearby. These artificial nodes collect various physiological data, including heart rate and blood glucose levels. WBANs allow doctors and other medical professionals to constantly monitor the health of patients at risk of medical concerns, the elderly and chronically ill, those with disabilities, and others.

If high-reliability medical communications are to be provided, sensor nodes in such networks must communicate with each other. The development of good routing protocols in WBANs is a difficult undertaking. This is large because of the unique qualities of WBANs, but not exclusively. The first step is to determine how much energy each sensor node on the network can consume. Additional challenges arise because of the necessity for real-time data in many medical applications. Body temperature, heart rate, and blood glucose level are all examples of physiological data collected by a wide variety of commercially available sensor nodes. These sensors may not give the necessary data rate or battery life due to the illness. Because of this, the appropriate technology for transmitting data from the patient's body to medical personnel is dependent on several parameters, including dependability, power consumption, latency, weight, size and pricing. The continuous monitoring of the sensors allows medical workers to maintain track of the patient's condition. As a result, because the patients are not bound in bed, they can move around [10] . Four Tier based WBAN architecture developed for the health care systems. Four-tier body area network architecture is shown in Figure 1.2.

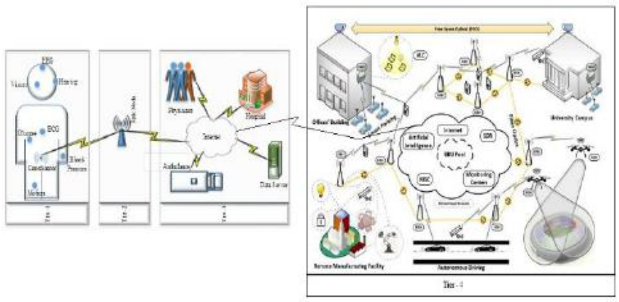

Fig 1.2: A 4-tier WBAN architecture [8]

The four-tier WBAN, which is connected to Tier 3 through the internet, adds new levels at Tier 4. Office complexes, college campuses, smart parking lots, and far-flung industrial sectors linked to the Internet of Drones make up Tier 4.

1.1 Classification of WBAN

Bio signals are detected by the WBAN detectors, which are then digitally translated and sent to an access point for further processing. Wearable sensors (on-body sensors) and implanted sensors (under-the-skin sensors) are both options (in-body sensors). Sensors are divided into two categories: those that only measure and transmit data and those that do both. The second kind, known as actuators, monitors and sends data the same way as the first, but it may also administer medication based on the data [11]. The information gathered is wirelessly forwarded to a medical server, evaluated, and saved. Depending on the system architecture and technologies used, this can be implemented in two, three, or four layers. Three layers are the most frequent architectural design for WBANs presented in the literature.

1.1.1 Intra WBAN

After PD communication, sensors communicate in Intra-WBAN. A wireless network at the first layer is unnecessary in certain existing approaches because sensors and PDs can be connected directly via wires. When using WBAN, the PD can transfer data wirelessly to a coordinator or master node, which then transmits data to an Access Point after processing, or to the PD can transmit data to an Access Point after processing (AP).

1.1.2 Inter-WBAN

Inter-WBAN refers to wireless technology communicating between the PD and AP. This layer connects WBANs to other networks that are accessible via the Internet. Ad-hoc and infrastructure-based architectures are often employed in WBAN systems for secure transmission during inter-WBAN communication.

1.1.3 Beyond-WBAN

The link between AP and the local medical centre is denoted by the Beyond-WBAN symbol. A gateway is a device that facilitates data transmission to and from medical personnel through wireless or wired networks. After receiving the data, medical workers can monitor the patients and offer required health recommendations. This layer also enables the restoration of patient medical information, which may require proper therapy.

1.2 WBAN Applications

WBANs are already being used in the military, healthcare, sports, and entertainment. WBAN applications that need specific technology aim to improve people's quality of life. The sub-sections that follow show how WBANs are used in various sectors [9].

1.2.1 Medical Applications

WBANs indeed alter the future of healthcare systems by delivering a simple, safe, trustworthy, and rapid diagnosis of ailments. WBANs can diagnose and treat life-threatening illnesses at the moment, giving the patient immediate access to vital data. The introduction of microelectronics, sensors, the Internet, and wireless network technologies into healthcare has profoundly impacted the way people live and work. In conclusion, the broad adoption of WBANs will raise the bar for healthcare systems regarding illness management, diagnosis, and treatment. In medicine, it is common practice to employ WBANs to keep tabs on vital signs such as a patient's temperature, blood pressure, and heart rate under constant surveillance. The following WBAN subcategories are applicable to medical applications.

1.2.1.1 Wearable WBAN Applications

Two types of WBANs are used in wearable medical applications. a) Management of Human Performance and b) Disability Assistance, which we'll get into a bit more detail about next. Combat Stress and Combat Readiness Assessment of Military Personnel. When soldiers are on the front lines, WBANs allows for precise tracking of their movements. An aggregation device integrated with WBANs can link cameras, biometric sensors, GPS, and wireless networking to connect with other soldiers and central monitoring units. To avoid ambushes, soldiers' ability to communicate securely is critical. WBANs may be used to regulate athletes' training schedules in both professional and amateur sports by monitoring metrics, motion capture, and therapy. All connectors and wires can be removed with WBANs, allowing the intelligence and instrumentation to be housed within the sensor nodes themselves.

1.2.1.2 Implant WBAN

This application involves implanting nodes into the human body, either beneath the epidermis or inside the circulation, to accomplish the following functions.

1.2.1.3 Diabetes Control

Diabetes afflicted around 6.4% of healthy adults globally in 2010 (a total of 285 million), with the amount expected to climb to roughly 438 million by 2030. (Almost 7.8% globally). Diabetes therapy, according to current research, is a long-term medical ailment that needs regular and extensive monitoring. WBANs may be used to test diabetes levels frequently, minimizing the risk of acute illness and allowing for ideal doses by removing the risks of blood circulation, blindness, and other complications.

1.2.1.4 Cardiovascular Illnesses

Almost 17 million people die each year from cardiovascular disease alone, a huge burden for the human health business. By utilizing appropriate healthcare, this number might be drastically lowered. For example, employing WBAN to screen for episodic occurrences and other odd scenarios might drastically reduce the number of myocardial infarction (MI) cases.

1.2.1.5 Cancer Detection

There will be a 50% increase in the number of persons dying from cancer by 2020. So, WBAN-based sensors can keep tabs on human cancer cells.

1.2.1.6 Remote-Controlled Medical Devices Based on WBANS

Ambient Assisted Living (AAL) is a home care system that uses Internet-enabled WBANs to connect to various equipment and services, including a remote medical network. Patient self-care can be extended at home using the AAL, reducing dependency on costly personal care and expenses and improving quality of life. Because of its unique combination of anticipatory functionality, contextual sensitivity, user sociality, and flexibility, the AAL has great promise to create innovative new IT systems.

1.2.2 Non-medical Applications

Among the non-medical uses of WBANs, these subcategories are:

1.2.2.1 Real-Time Streaming

Video clips shot using a mobile phone camera can be streamed in real-time (2D and 3D) and used to advertise sports products and current fashion trends in e-commerce. You can listen (with headsets) to an art explanation in a museum or bus schedule information at a stop, as well as multicasting conference calls and musical samples in an audio CD store via audio streaming via voice communication. Real-time streaming signals can be used to identify body motions, vital signs, and other bodily information from remotely operated entertainment devices.

1.2.2.2 Entertainment Application

These programs are about gaming, listening to music, social networking, and other hobbies. Audio and video recording, playback equipment, high-tech computers, and networking hardware can be combined into WBANs. In addition to gaming, these devices can be used for virtual reality (VR), tracking personal belongings, exchanging digital profiles linked to business cards, and transferring consumer electronics-related data, among other applications.

1.3 Routing Mechanism Related to WBAN

Routing is a tricky problem in WBAN due to restricted resources such as memory, compute capability, and energy infrastructure. The physical layer of sensor nodes greatly affects WBAN energy consumption through radiofrequency (RF). Furthermore, the MAC protocols can enhance the sensor network's residual energy by changing the RF component's duty cycle. Physical and MAC layer techniques that improve network connectivity do not deal with end-to-end packet delivery, address allocation systems, or route selection procedures. In this case, the network layer is the best choice for addressing these challenges, and network layer routing options must be considered in energy savings. There are several aspects to consider while building WBAN routing protocols, including the heterogeneous wireless nature (due to particular physiological data), higher energy Consumption, wider coverage area, reduced transfer dimensions, mobility, and quality of service. These factors are because WBAN transmits at a higher rate and transmits more data faster (priority-based data). According to all of the stated features, the temperature rise of implanted sensors has the greatest impact on WBAN performance. Sensor nodes might become dangerously hot due to radiation intake and energy consumption from the antenna. This damages heat-sensitive tissues and potentially causes tissue damage near sensor nodes. As a result, a WBAN routing algorithm that prevents body tissue from damage caused by a node's temperature rise requires extensive research. Data transmissions should be limited to reduce energy usage, and the proposed routing algorithm must choose the most efficient way from a list of options [12]. A network's life can be extended due to smart routing (considering temperature rise and residual energy).

1.3.1 Quality of Service (QoS) Aware Routing in WBAN

There isn't much discussion of QoS studies centered on WBAN applications in the literature. Numerous researchers have merely raised it as a concern without conducting any more research. In order to overcome channel degradation, the Researchers had tried and implemented QoS in WBAN. Due to the essential nature of the operations, the QoS concerns in WBAN require extra attention. The highest level of service is required in the functioning of a WBAN, for instance, which is used to monitor the health of an aged heart patient. QoS-Aware Wireless sensor network routing protocols have been developed, however no QoS-based standard routing method has been developed for WBAN [13]. In body area networks, routing protocols are often divided into three basic categories: temperature-based routing, cluster-based and cost-based routing. The most recent BAN network implanted on the human body is capable of sensing, processing, and storing information. Because of this, memory module, RF module, and microprocessor module are the most common sensor nodes utilized in medical applications.

Achieving QoS in WBAN is a difficult task. Received signal strength intensity (RSSI) at receiver side is the key factor in achieving QoS. The core research challenges for achieving QoS requirement in WBAN are based on following motivational factors. The researchers have described the challenges for supporting QoS requirements including bandwidth minimization, limited energy consumption, and communication delay trade-off, handling limitation in buffer size, multiple traffic support, and redundancy removal. These all factors can apply to QoS constraints in WBAN applications.

Data packet priority and wireless channel conditions are examples of QoS indicators. Node ability to function as a router and data packet priority are further examples. RSM, APIs, PQSM, and System Information Repository (SIR) are all design components (SIRM). RSM, for example, can be used with the APIs module's capabilities. The APIs module includes four sub-modules: QoS-metric selection, which takes packet success ratio, power consumption, and the end-to-end delay into account. In this sub-module, received from the user program me, data packets are sent or received. It is up to the sub-module to set the priority level for data packets. A submodule is available for request processing and service level control, providing network conditions to user applications. There are eight categories of priority. Data and control packets are defined, with packets having the greatest priority [14].

In WBAN routing mechanism the data packets do not maintain and update their routing database based on information from their neighbors. Sensor nodes cannot connect to wireless channels owing to network congestion. Therefore, PQSM alerts user applications when buffer size reaches a certain level and advises them on lowering it. A router's willingness and service level must be high to minimize packet losses. Priority is granted to data packets in the submodule for setting packet priority levels. A separate sub-module can handle request processing and service level monitoring. The priority level setting sub-module prioritizes data packets. Request processing and service-level monitoring are provided in a separate submodule. Link health is monitored by latency, average packet success ratio, and channel bandwidth via the LS table. The RW database contains all nodes that can function as a forwarding node or router.

1.3.1.1 QoS-Aware Based Routing Protocols

QoS requirements for bio-medical sensors implanted in the human body necessitated the development of the thermal-aware targeted route (TLQoS). Communication loops are also prevented, and the protocol eliminates superfluous routes with large hop counts from the sink to reduce network latency. All neighboring nodes can be selected as forwarders using a technique called "targeted." Each of the three new peering routing protocols, the Energy-aware Peering Routing Protocol (EPR), the Quality of Service (QoS)-aware Peering Routing Protocol (QPRD), and the Quality of Service (QoS)-aware Peering Routing Protocol (QPRR), uses less power than the previous protocols in their respective functions. Some protocols don't allow for energy use, while others allow it [15].

Time-sensitive information can be delivered while maintaining reliability-sensitive information, such as with the data-centric multi objective QoS aware routing protocol (DMQoS). Protocols that consider the quality of service (QoS) requirements can be utilized or selected for that network. Quality of service is a critical component in developing a trustworthy network (QoS). When QoS is dependable, packets are transmitted properly and on time. Medical information transfer in WBAN relies heavily on Quality of Service (QoS) since vital applications demand the optimum QoS. High throughput is essential to achieving a high quality of service (QoS). Packet content is directly related to throughput, while transmission latency is directly related to throughput. There must be some lag for the sake of QoS (quality of service). To help WBAN systems achieve high QoS, 5G may be an attractive solution because it will provide high data throughput, dependability, and extremely low latency.

1.3.2 QoS based Routing Challenges in WBAN

The packet priority level setting sub-module prioritizes data packets. Request processing and service level monitoring can be done in a separate sub module. The priority level setting sub module assigns importance to individual data packets. A sub module for request processing and service level control is offered. WBAN's network environment is exceedingly complicated because it is applied to the human body. Since Designing routing for the body area network is crucial because the physiological data gathered substantially influences human life and health [16].

The network's priority level setting sub module promotes data packets. There is a sub module for request processing and service level control. Dynamic topological changes in wireless transmission may be seen in body surface transfer, body transmission, and free storage transmission. It's challenging to comprehend the channel conditions. It is essential to take into account the shadows cast by human movement. As limbs move, the distance and location of nodes will shift. Given the topology's temporal fluctuation and potential issues a trustworthy routing system that responds to the dynamic topology should be designed.

WBAN includes implants that must be surgically removed and replaced. It is insufficient to only supply electricity using micro batteries. Energy efficiency design must be used at the source in addition to RF (Radio Frequency), EM (Electro-Magnetic), or energy harvesting. To maximize network lifetime, routing design must take the network's general metabolism and each node's energy efficiency into account.

The temperature of nodes: Heat produced by nodes during operation damages the body's vital tissues and organs. To prevent this kind of issue, the routing design must take node warmth into account. In order to reduce the amount of energy absorbed by the human body, sensors must retain their power efficiency [7].

When it comes to WBAN nodes, a wide variety of data is generated, and each type of data must be handled in a unique way to meet the quality of service requirements of different data types.

WBANs, as a subset of WSNs, inherit all WSN constraints. Furthermore, some special limitations and concerns associated with WBANs must be addressed. In contrast to standard WSN applications, which employ homogenous sensor nodes, WBANs use a variety of BMSNs. These BMSNs' data generating rates, energy consumption, storage capacity, and compute performance differ. Numerous types of BMSNs running at different frequencies cause interoperability concerns. The compatibility issue will be addressed using WBAN-specific data mining approaches. Similarly, the pace of data output in WBANs is high, necessitating effective data collection and processing systems [9].

The research challenges related to QoS support in WBAN routing protocols are mentioned as follows [16].

1.3.2.1 Lifetime of Biomedical Sensor Nodes

Lifetime of biomedical sensor nodes is important in healthcare applications. The tiny thermal and battery-powered sensor nodes working in ad hoc architecture offer the most value when they communicate with one another for as long as possible. How long a sensor network operates depends on how much energy the sensor nodes still have left. Residual energy is a vital component in achieving QoS [17].

1.3.2.2 Routing and Clustering Technique to be used

In the case of WBAN, routing strategy is crucial for QoS-aware, energy-efficient routing. The best routing technique for WBAN is shortest path selection across many clusters, which is applied within ad-hoc wireless infrastructure [17].

1.3.2.3 Scalability

If we were to add more sensor nodes to the network field, the routing protocol and clustering technique should be adaptable enough to be able to route data effectively from one sensor node to another within each cluster. Effective data transmission within each cluster or across numerous clusters significantly improves QoS [18].

1.3.2.4 Power Consumption Issues

The performance of the network degrades in many WBAN-based applications as the energy of the sensor nodes runs out. Recent WBAN systems have introduced QoS-based metrics to address this communication overhead [19].

1.3.2.5 Data Aggregation

The primary objective of the data aggregation method used by WBAN is to gather data from the sink node in an energy-efficient manner in order to extend the network lifetime. The QoS is greatly increased by WBAN lifecycle optimization [16].

1.3.2.6 Link Reliability in WBAN Traffic

The real time monitoring of patient depends on the patterns of data being transmitted in WBAN. Real Time monitoring of patients in hospital depends on improved link reliability. Link reliability is based on received signal strength intensity (RSSI). Improvement in RSSI is based on optimal QoS [16].

1.3.2.7 Dual and Multiple Sink Approach

Multiples sink nodes within a network may directly increase the power consumption overhead for overall network. This results in increased energy consumption which may directly effects QoS [14].

1.3.2.8 Network Topology and Dynamics

Postural movements of patient body and energy consumption of sensor nodes causes a change in network dynamics and topology, which may directly effects QoS [20].

1.3.2.9 Deployment of Sensor Nodes on Human Body

Optimal Node deployment on the human body is considered to be an important parameter in achieving QoS [21].

1.3.2.10 Types of Network Traffic

Multimedia based high data rate Network traffic during peak and low traffic periods may directly effects the QoS [22].

1.3.2.11 Un-reliable Wireless Link and Connectivity in Packet Transmission

In order to achieve QoS, it is crucial to take packet transmission reliability across sensor, relay, and sink nodes in WBAN into account [23].

1.3.2.12 Maximization in Network Traffic Load

The suggested technique can choose alternate nodes from source nodes to relay nodes and from relay nodes to sink nodes, preventing the entire energy of any one node from being depleted and extending the lifetime of the network. Network life-time extension enhances QoS [16].

1.3.2.13 Data Duplication

Data aggregation and retransmissions at sink node may results in data duplication, which may affect QoS constraints [20].

1.3.2.14 Mobility Management

The mobility of patients with in-hospital environment directly changes the QoS of network based infrastructure. The route between the sensor nodes will be distorted or changed. If the network route is broken, there is a great chance of data loss, which may also result in power consumption overhead [24].

1.3.2.15 Resource Allocation

The resource allocation plays a vital role in designing any QoS based protocol application. The resources include memory capacity of sensor nodes, the residual energy of sensor nodes and network lifetime [18].

1.3.2.16 High Temperature and Interferences

Interferences in communication and increasing temperature of the overall wireless network degrade the performance of WBAN. This situation results in data loss, communication delay and route failure. Network Communication delay degrades the performance of WBAN, which may directly effects QoS [25].

1.3.2.17 Security and Privacy

Nowadays secure data interaction and maintaining the privacy of information in healthcare environments is considered to be an integral component in maintaining QoS in WBAN [6].

Table 1.1: Tabular representation of QoS aware routing parameters

QoS-Aware Routing parameters	Description of QoS Aware Routing parameters
Link Reliability (RSSI)	Link reliability is an important parameter in achieving optimal received signal strength intensity (RSSI).
Residual energy (RE)	Residual energy of sensor nodes for prolonged life time in WBAN is an important parameter in achieving QoS.
Signal to Noise ratio (SNR)	High Signal to Noise ratio in wireless communication is an important parameter in achieving QoS.
Path Loss ratio (PLR)	Minimum path loss in WBAN routing mechanism is an important parameter to achieve QoS.
Packet loss (PL)	Packet loss is the total no of packets transmitted by sender node and eventually lost with in the network.
Effective throughput (ET)	Quantity of transported data or packets between the source and sink nodes of the relay.
Network criticality (NTC)	Parameter to determine the change in network effects its performance, related to sensitivity of the network
Network Availability	It is the measure of delay for components available within the Network.
Delay in packet transmission (DPT)	It includes the packet transmission delay and queuing delay with in the Network.
Probability in connection outage	Probability of outage of network connection at each link.

There are multiple routing challenges related to QoS support for energy efficiency in WBAN. The core challenge is the lifetime of the battery to operate the sensor nodes. Transmission power in case of WBAN is dependent on the distance from the source node to the destination node. To select the most optimal route, we can take the help from the routing protocols. Therefore, to provide reliable communication, we have to select energy efficient routing strategy. For example, Co-LEEBA routing protocol [2] is based on cooperative routing strategy in the case or normal and emergency circumstances. M-ATTEMPT is thermal-aware routing protocol, which selects the routing path based on the thermal heat of hotspot [26].

Meeting QoS requirements in WBAN is an important task. For this reason, we have identified the core parameters for maintaining QoS in reliable routing mechanism. Table 1.1 describes about the distinctive parameters identified in QoS aware routing for WBAN applications [17].

The parameters which we had discussed previously in Table 1.1, we have selected the most relevant parameters for our proposed WBAN protocol based application scenario. Path Loss Ratio, Signal to Noise Ratio, Residual Energy of Sensor Nodes, and Link Reliability (Throughput) are the selected parameters. The IM-QRP suggested technique is based on the body's postural movements in medical settings. The foundation of postural movement routing protocols is link reliability, which is determined by the quantity of packets that are successfully sent to the sink node [27]. When using wireless sensor nodes in WBAN, managing the power source or residual energy of the nodes for the longest possible period of time is a crucial aspect to take into account. In WBAN, IM-QRP offers energy-efficient routing. Prolonging the network life time by introducing the arrangement of sensor nodes, relay nodes and sink node mounted on human body improves the energy efficiency. Path loss or path attenuation in case of electromagnetic signals over human body is reduced in case of proposed protocol by improving link reliability and signal to noise ratio [14]. Therefore, the importance of the above parameters discussed are based on proposed protocol IM-QRP. Rest of the parameters are also QoS Aware but they not strongly related to our proposed protocol based on modified cost function. Table 1.2 describes about the QoS parameters based on QoS-Aware routing metrics necessary to build efficient WBAN protocol based Application. The proposed methodology is based on the primary motivating considerations listed below [7].

Table 1.2: Tabular representation of QoS metrics related to WBAN

Layered description	QoS-Aware Routing parameters	QoS Metrics	Description
Network Layer	Path loss / residual energy - sensor nodes	Network congestion & network path latency	Minimizing the network path latency and congestion may directly reduce energy consumption and path loss.
Transport Layer	Link reliability (RSSI)	Network bandwidth reliability	Achieving Network bandwidth reliability is consider to be an important matrix achieved.
Application Layer	Residual Energy of sensor nodes	Life time of the network	Maximizing the life time of BAN may directly affect QoS based matrix.
Coverage layer	Path loss	Coverage area related to WBAN	Maximizing the coverage area related to WBAN on human body may directly affect path loss.
Connectivity Layer	Link reliability and SNR	Network connectivity	Improving network connectivity may result in RSSI and SNR

1.4 Statement of Problem

QoS is considered to be an important issue in cooperative routing in WBAN. To Improve QoS, we have to achieve the maximum throughput. [28] Optimal throughput achieved in energy efficient routing protocols is based on maximum packet delivery towards the base station. Due to the multiple path losses during data transmission in WBAN. This results in increased energy consumption of sensor nodes and reduces the network lifetime [11]. Another reason for increase in communication delay is due to limited received signal strength intensity (RSSI) and minimum SNR [28].

1.5 The Purpose/Significance of the Study

The significance of the research is based on achieving the energy efficiency in routing mechanism based on improving the following factors.

- Algorithm Efficiency
- Communication Range
- Energy Efficiency in routing.

1.6 Research Objectives

- Transmission of the selected data by using cooperative low energy efficient routing technique.
- To improve the communication mechanism by maximizing the throughput by improving packet transmission ratio towards the sink node.
- To minimize the path loss ratio.
- To improve link reliability based on (RSSI) Received signal strength intensity.

1.7 Research Questions

The issues which are previously discussed degrades the overall performance of routing mechanism related to WBAN. There is a strong need for addressing these issues so that the proposed scheme will be more accurate regarding energy efficiency and reliability. The research questions related to these issues are as follows.

Research Question 1: How to improve the Quality of service (QoS) in WBAN routing Algorithm which results in minimum path loss and maximum throughput ratio?

Research Question 2: How to develop a protocol which is capable of selecting the appropriate scheduling scheme for data transmission in normal and emergency circumstances for static and moving bodies?

Research Question 3: How to maximize the Signal to noise ratio (SNR) ratio in WBAN routing mechanism and to achieve the maximum received signal strength intensity (RSSI) in a single hop and multi-hop communication?

1.8 Contribution to Knowledge (Academic Contribution)

Use of low energy efficient routing technique in order to improve the communication mechanism by maximizing the throughput by improving packet transmission ratio towards the sink node. Furthermore, it will minimize the path loss ratio in addition to improving link reliability based on (RSSI) Received signal strength intensity.

1.9 Statement of Significance (Practical Contribution)

The practical contribution is achieved by achieving algorithm efficiency, communication range and energy efficiency in routing.

1.10 Research Aims and Hypothesis

In this section, the hypothesis and the explanation for the observations are covered. We looked at WBAN's energy-efficient routing algorithms based on the following open research problems and driving forces [16].

- Transmission of the selected data by using cooperative low energy efficient routing technique.

- To improve the communication mechanism by maximizing the throughput by improving packet transmission ratio towards the sink node.
- To minimize the path loss ratio
- To improve link reliability based on (RSSI) Received signal strength intensity.

This Section presents the significance of our research study based on the critical evaluation of the literature studied during our research. Our work will be effective in successful data transmission. The existing algorithms in WBAN should be flexible and adaptable in the different regions and environments. The choice of a suitable communication protocol is essential for WBAN devices to operate as efficiently as possible. Sensing and computation require a significant amount of energy in WBAN wireless communication. For this reason, a low power cooperative energy efficient routing schemes for WBAN had been discussed in the literature review section. M-ATTEMPT [26], RE-ATTEMPT [29], IM-SIMPLE [30], and CO-LAEEBA [2] are the protocols that are most commonly mentioned in the literature review section. The preference of considering the significance of energy efficiency in routing mechanism can be made based on the following factors.

- Algorithm Efficiency
- Communication Range
- Energy Efficiency in routing

1.11 Research Methodology

The health care data will be obtained. The data will be obtained in the form of MS Office Excel Sheets. The daily patient's reports will be obtained by different Medical centers. The structure of data is based on patient's body related parameters. The comparative analysis will also be obtained on the basis of improvement of successful packet transmission ratio from source node to the Sink node.

The Real time health care data set will be very much helpful for us in identifying the patient health care condition in future. For this reason, we will choose the Ad hoc WBAN Architecture as a Model to collect Health care forecasting parameters via using Ad hoc wireless sensor Nodes.

The patient's heartbeat, pulse rate, and glucose levels are tracked in the data set. Ten nodes are distributed on a moving body in the vicinity of the head, chest, center waist, left arm, right arm, left hand, right leg, left foot, and right foot. The experimental setup will be populated by using Mat lab. Simulation results will provide the brief detail about Improvement in Received Signal Strength Intensity (RSSI), Successful packet transmission ratio, energy efficiency, improvement in SNR (Signal to Noise Ratio), maximum throughput and minimum path loss and packet drop ratio [31].

This section also provides the administration of tools related to the Research. The QoS for the proposed scheme has been discussed. The maximum number of packets that can be transmitted to the sink node will determine the QoS.

II. LITERATURE REVIEW

2.1 Introduction

WBANs mark a turning point in the fight against disease and early diagnosis. On-body, on-clothes (wearable), and embedded sensor data, including temperature, heartbeat, pH-level, blood pressure, electrocardiogram (ECG), electroencephalogram (EEG), and respiration rate, is captured by WBANs, which reduces healthcare expenditures. Bio-Medical Sensor Nodes are the name given to these sensors (BMSNs). Identifying WBANs that match the basic needs of healthcare applications, such as mobility, secure and reliable data, energy consumption and the coexistence of many sensor nodes in a relatively small space, will be one of the primary goals of this research. Understanding the protocol stack and each layer is required to understand the specific needs in medical networks. On the outside or within the body, BAN sensors can be used on the body [23] .

Any human safety approach must consider the biological effects of transmitter irradiation. The constant activity of the sensor nodes in the in-body scenario could lead to an increase in average temperature, which could damage human tissue when data is relayed or transmitted to nearby neighbors. One strategy is distributing data transmission over the network rather than relying on well-established channels. As a result, the sensors' temperature in some areas does not rise much. BAN routing algorithms can be grouped into several categories based on the aims they seek to achieve.

Because they aim to minimize local and system-wide temperatures, temperature-based routing systems fall within the first routing system category. To avoid temperature surges that could cause tissue injury and node deletion, these protocols transport data from many channels to avoid excessive temperature surges on particular sensors. However, as the number of nodes grows, these protocols' system complexity and overhead. With BAN nodes being divided into groups and each group having its own "cluster head," the data from the sensor is routed from the sink through these "cluster heads" in cluster-based routing protocols. Reduce the number of direct sensor-to-base station transmissions with these methods [32].

The exorbitant prices and extended periods of these procedures, however, greatly constrain Cluster selection. The third kind of BAN routing approach looked at in this study combines routing problems with limits on medium access. Despite high throughput, low energy consumption, and nearly constant end-to-end latency, these protocols cannot attain high performance in specific conditions due to body motion and severe route loss. Cost-effective routing protocols update their cost formula and choose the most cost-effective routes on a regular basis using cost-effective information. These protocols are tested by the massive amounts of data that must be transferred to maintain data current efficiently. As the fourth type of routing protocol, QoS-based routing protocols provide discrete modules for a wide range of QoS measures. End-to-end chain reliability is increased, latency is reduced, and packet delivery is improved. These protocols' substantial complexity is due mainly to numerous modules based on multiple Quality of Service (QoS) standards [17].

2.2 WBAN Architecture

WBAN can interface with a wide range of sensors and appliances within and outside the human body with a dedicated sensor. Components of the basic WBAN architecture are shown in the Figure 2.1. This section breaks down the network architecture into four main parts. There are several sensor nodes in the WBAN, the initial component. Inertial and biological sensors mounted on the human body make these low-cost, low-power nodes excellent for wearable and other applications. All equipment can be continuously monitored of vital factors such as heart rate, ECG, blood pressure, and the surroundings. Large-scale cable-based monitoring systems are now in use. Wearing a monitoring system's cables might be a nuisance and limit movement. Thus, WBAN can be an excellent option in this area, particularly when patients need constant control and mobility, as is the healthcare case. Following the coordination, a node is the Central Control Unit, which connects all sensor nodes to the Central Control Unit (CCU). Sending sensor data to the next segment is the CCU's responsibility. Figure 2.1 describes Architecture [33].

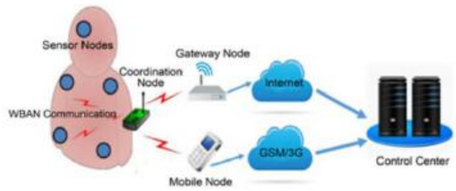

Fig 2.1 Architecture of WBAN

It's impossible to use a wireless method to monitor a person's body activity. Medical monitoring systems often use WLAN, WiFi, GSM, 3G, 4G, and WPAN (Bluetooth, ZigBee) technologies. However, short-distance communication can also be accomplished via these other methods outside of mobile phone networks. Two alternative body monitoring systems use low transmission power: Wireless Medical Telemetry Services (WMTS) and Ultra-Wide Band (UWB). As a data conduit, WBAN communication is the final component. Email and other Ethernet-based services can be run from a router or a personal computer. Users' mobile phones, PCs, and servers will all be included in the control centre, monitoring and emailing them and saving database information.

2.3 Routing Protocols in WBAN

Routing in WBAN is problematic due to a lack of memory, computing power, and energy. The physical layer of WBAN sensor nodes has a considerable impact on energy consumption due to radiofrequency (RF). It is also possible to enhance sensor node density by altering the RF component's duty cycle in the MAC protocols that use the remaining energy. However, there are still unmet needs in improving network connectivity via the MAC or physical layer and addressing systems and route optimization. Procedures of determination are not discussed. The network layer should be employed to solve this problem. Research into network layer routing methods must be addressed to conserve energy. Even though it is a subset of WSN, WBAN has its features and standards. It takes more time and effort to design an effective WBAN routing protocol than it makes a successful WSN routing approach [34].

WBAN routing protocols need to consider a number of important factors, including the heterogeneous network nature (because specific physiological data are transmitted), energy consumption (because transmission rates are increased), temperature rise (because transmissions are numerous), coverage area (because the transmission dimension is low), mobility and quality of service (because priority-based data are transmitted) for the WBAN routing protocols, among others. WBAN efficiency is negatively impacted by the temperature increase of sensors implanted in the body. WBAN performance is negatively impacted by implanted sensor temperature rise, which is the most critical aspect of all characteristics mentioned above. As a result of the absorbed radiation and the antenna's energy consumption, the temperature of a sensor node rises, possibly hurting nearby human flesh and injuring heat-sensitive portions of the body. When designing a routing algorithm that prevents human tissue from being harmed by the rise in temperature of an individual node, substantial research is necessary. Removing sensor nodes (particularly implanted sensor nodes) is not an option.

WBAN routing must also cope with energy consumption issues. Data sensing and monitoring consume less energy than the connection between devices. The suggested routing algorithm must select the optimum way from various possibilities while lowering the contact range for data transfer. Smart routing (which takes into account temperature rise and remaining power) can help extend the lifespan of the entire network [35].

2.3.1 Classification of Routing Protocols for WBAN

Over the years, several WBAN routing strategies have been put forth in the literature. Routing protocols based on postural movement awareness, QoS awareness, thermal awareness, energy awareness, cluster-based routing protocols, and cross-layered routing protocols are a few examples.

Figure 2.2 details the WBAN routing protocols, which are primarily categorised into the following groups: cluster-based routing, posture-based routing, temperature-based routing, cross-layer routing, and QoS-based routing [12].

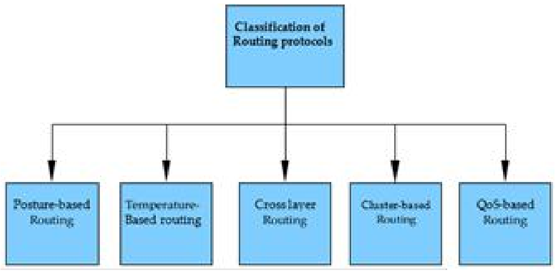

Fig 2.2. Classification of Routing Protocols in WBAN

2.3.1.1 Posture Based Routing Protocols

A proposed routing protocol for WBAN is based on postural movement [12]. By examining the network architecture of the human body in many dynamic settings, posture-based routing may construct a quick and trustworthy path. Assessment of diverse positions is vital. Every type of human movement has some degree of regularity. With this, the dynamic WBAN, which is already in use, could see a significant boost in its development. Dynamic environments alter network architecture and create a shadow effect because of the movement of the body parts. If the circumstance, which was highly passive and required a long period, arose, existing remedies could only be studied further. If the next activity in the current time slot can be predicted in advance, judgment and processing may be done in advance, particularly important for efficiently minimizing latency and boosting the data transfer rate [36].

The physical body's postural mobility influences WBAN transmission. Moving about causes many problems while trying to talk, yet it's still possible to communicate effectively. Several research studies have discovered the optimal cost function for sink routing. Table 2.1 describes about the standard Postural Movement Based routing protocols in wireless boy area networks.

Table 2.1: Postural Movement Based routing protocols

Authors	WBAN Protocol / Standard used	Strengths	Limitations
Y.Zhou et al [37]	Mobility handling Fault Tolerant based Protocol is developed.	Low delay and higher energy efficiency is achieved Used to predict heart beat rate.	Sacrifices human comfort, difficult to implement in normal daily life routines.
Y.Zhou et al [37]	Distributed Network Management routing protocol is developed which is capable to establish multiple connections in a single time unit	Minimization in network framework	More suitable for dynamic moving bodies.

It is advised to utilize the On-body store and flood routing protocol (OBSFF), which has a high energy consumption factor as a disadvantage but a superior ability to reduce packet delivery delays. An energy-efficient routing system based on postural movement is the Opportunistic Routing System (ORP) [38]. Today's QoS routing techniques are based on body posture changes within the WBAN framework. The Energy Efficient Thermal and Power-Aware Routing (ETPA) system is also recommended for identifying various postures related to the human body. When compared to current plans, the one that has been presented utilizes less energy. ETPA ensures secure and dependable routing with a maximum packet delivery delay ratio. The subsections that follow address a few particular subcategories of postural movement-based routing systems.

2.3.1.1.1 A Novel Mobility Handling Routing Protocol (MHRP)

It was designed to be a wireless, portable processing routing system for mobile devices. The method is designed to record heart rates. Seven nodes can be found on each side of the body. It's possible to create sets of nodes with symmetrical nodes in each of the three groups. It's now possible to create two fault-tolerant systems using identical but separate components. One of the design goals is to switch to a different group when the energy levels of the present working set diminish or the network topology is disrupted in order to assist reduce errors and increase data transmission reliability. The network architecture is examined by the MHRP protocol to identify the best route for four different elbow movements. The simulation results of this procedure show considerable reductions in end-to-end time, error rate, and energy consumption. It could be difficult to recognize the comfort of the body as being distinct. The human body is put under more stress even if this kind of substitution set produces consistent results [39].

2.3.1.1.2 Energy-Efficient and Distributed Network Management Cost Minimization (NCMD)

It is suggested to use a distributed opportunity routing NCMD with less network management. When used in a dynamic setting, WBAN causes significant transmission delays and higher network maintenance costs. The quality of service (QoS) measurements decline when mobile data rates increase. This study addresses network administration and QoS challenges by presenting an opportunistic transmission link creation technique in postural movement routing strategy [40].

2.3.1.2 Temperature aware routing protocols

Sensors implanted in or attached to the human body in WBAN can have an impact on the human organism. Because the transmitted fields generate a temperature rise in the node's digital circuits, antenna radiation, absorption, and interaction are essential difficulties to solve while constructing a body sensor network. Radiation has a significant effect on the human body. It may cause tissue damage if exposed to it frequently. All temperature-aware protocols strive to avoid routing over hotspots, which reduces in-body sensor node temperature rise [32].

Route selection in temperature-based routing is dependent on node temperature. The fundamental purpose of this routing strategy is to steer clear of nodes with high temperatures and create pathways that allow the nodes with high temperatures to be rapidly decreased. Because of the primary focus on security when implementing WBAN, temperature-based routing is being explored first. Although temperature-based routing was extensively investigated throughout WBAN creation, many current studies have focused on energy. As a result, the routing method based on temperature has greatly reduced the growth of WBAN. Temperature Aware routing protocols plays a vital role in QoS Aware energy efficient routing in WBAN [41]. The antenna design and its radiation are the major challenging research issues in WBAN. Since the electromagnetic radiation causes the temperature to rise. The electromagnetic radiations have a strong impact on the human body which is dangerous to the human health. The motivation behind the design of all the temperature-aware routing schemes is to reduce the temperature rise of intrabody and extra body sensor node communication. The routing path is established by using hotspots which should be avoided in most of the schemes due to high-temperature rise. The analytical comparison among different protocols reveals that the performance comparison of Least Total Route Temperature (LTRT) is much better than Thermal-Aware Routing Algorithm (TARA) due to low-temperature rise. Hotspot preventive Routing scheme (HPR) has a minimum temperature rise as compared with other schemes. The M-ATTEMPT protocol, which is ideal for heterogeneous WBAN, has demonstrated that it is one of the better thermally aware routing protocols. The M-ATTEMPT approach uses multi-hop communication. It is between the sensor nodes and sink nodes to select the most cluster heads in each round. Due of high energy costs, one hop communication is employed for emergency services. The majority of the time, packet transfer uses multi-hop communication. Unlike RE-ATTEMPT [29] protocol, M-ATTEMPT [26] protocol is thermally aware. The following describes the tabular representation of the temperature-aware routing system in Table 2.2.

Table 2.2: Tabular representation of Temperature aware routing protocols

Authors	WBAN Protocol / Standard used	Strengths	Limitations
N.javed et al [29]	M-Attempt protocol is developed	The suggested approach may investigate all feasible paths as it can identify thermal heat of hot spot throughout the routing process.	chooses the most cluster heads feasible via multi hop communication in each round.

The M-ATTEMPT [26] protocol allows for both sensor movement and human body motion. In order to potentially explore the most paths, the scheme is also capable of detecting the thermal heat of a hotspot throughout the routing process. Comparing the proposed strategy to existing ones, the proposed scheme uses the least amount of energy. When compared to multi-hop communication schemes, single hop communication schemes have a faster packet delivery ratio. The only purpose of the RE-ATTEMPT [29] system is route selection. Future considerations should also take into account route discovery and cluster head selection. In the case of current schemes, no actual framework has been created. There is currently no accurate way to distinguish between a source node, sink node, and the root node.

2.3.1.2.1Thermal-Aware Routing Algorithm (TARA)

The TARA protocol is a classic work and a pioneering effort in this area. Temperature is utilized as a single path selection criterion, with the neighbor node with the lowest temperature chosen as the next hop. As soon as a target node has had a chance to cool down, data that has been sent to it is cached and then retransmitted. If the target node waits too long, the cached data is destroyed. Using the retreat approach, data that has encountered a hotspot can be sent back toward their original path. The protocol's back-off method sparked new ideas for future research due to the protocol's back-off method [25].

A famous accomplishment in this field, the TARA technique was the first one to be a great success. Path selection is mostly based on temperature, with the lowest node on the thermometer being the next step in this method's chain. Delivered data is cached at the hotspot and deleted if the waiting time exceeds a specific threshold. It is possible to use the retreat strategy if a hotspot is encountered during data transmission and a new path must be found. There were strong results and ideas for future research based on the protocol's back-off mechanism at the time. According to our knowledge, these methods do not consider the temperature rise in the forwarding node. WBAN data transmission must be stable and fast at low temperatures. Adaptive Thermal-Conscious Routing (ATC) is a WBAN routing protocol that is supposed to be aware of thermal conditions (ATAR). For example, the ATAR aims to reduce heat generation and data transmission while prolonging the network's life span [41].

2.3.1.2.2 A New Energy-Efficient Routing Protocol (ER-ATTEMPT)

The RE-ATTEMPT protocol [29] avoids hot nodes and selects the shortest viable path with the fewest hops as an alternative. The ATTEMPT protocol does not consider the current path's inability, and the ER-ATTEMPT protocol is constructed around this premise. By exchanging HELLO messages with other nodes, the node initially finds all of the paths that it can take. The sub-optimal option ensures dependable transmission if the present transmission path is unavailable. Additionally, the ER-ATTEMPT protocol considers node positioning; it arranges nodes according to their energy levels. Relay nodes have more energy at the start, making it easier for other nodes to send data to them. With this technique, nodes generating normal data while routing can quickly find the alternative routing table's shortest path with the fewest hops. If a node generates erroneous data, the emergency transmission mode is activated. This routing system ensures that emergency data is delivered promptly and that general data is reliably transmitted.

2.3.1.2.3 Trust and Thermal Aware Routing Protocol (TTRP)

TTRP, a routing method that considers both trust and heat, was proposed by [42] . Trust and temperature were the variables that were tested in this study. Relay nodes, which receive and send information, do not engage in information collection and have more energy to convey information from other nodes in this routing strategy than in others. The TTRP protocol consists of three steps: estimation of trust, the discovery of routes, and maintenance. The routing step determines the optimal route without using hotspots or reliable nodes. To speed up the routing process, TTRP has developed a composite function.

2.3.1.2.4 A Mobility-Based Temperature-Aware Routing Protocol (MTR)

MTR, a temperature-aware routing system based on mobility, was developed by [43]. Human mobility and posture are not considered by the present temperature-based routing method. A large amount of information will be lost due to topological separation. This protocol has been streamlined and modified to solve the difficulties raised above. That's not all; it also takes advantage of the DTN network's ability to store and transport heat. As a result, topological separation-related data packet loss is no longer an issue. Body area network nodes are classified as static or dynamic per the protocol.

2.3.1.3 Crossed-Layered Routing Protocols

Network performance can be improved by employing cross-layer routing protocols, which mix several protocol layers and take advantage of each stack's unique properties. According to the research, dynamic WBANs benefit from the cross-layer technique. Layer collaboration can achieve individual service for each data type and low latency, high dependability, and energy savings. Table 2.3 describes the tabular representation of cross layered routing protocols in WBAN [12].

Table 2.3: Tabular representation of cross layered routing protocols

Authors	WBAN Protocol / Standard used	Strengths	Limitations
B.Braem et al [44]	(WASP) for Multihop WBAN	High packet transmission	No suitable for moving bodies
B. Later et al [45]	Multi hop WBAN communication is achieved	Minimum delay	Limited packet delivery ratio
A.G.Ruzzelli et al [46]	scheme (TICOSS) To improve IEEE standard	minimum utlization of energy. High packet transmission	High delay

The detailed analysis of cross layered schemes is performed which is based on CICADA and TICOSS having limited energy consumption factor. WASP has improved packet delivery ratio as compared with other schemes. CICADA scheme has a minimum delay as compared with TICOSS and WASP. Biological communication scheme (Biocom) is used to optimize the overall network performance by utilizing a minimum amount of energy and satisfactory packet delivery ratio [46].

2.3.1.3.1 A Priority-Based Cross-Layer Routing Protocol (PCLRP)

This study uses three different categories of data: emergency (EM), delay-sensitive (DS), and general (GM). Medical video is referred to as DS, general data is referred to as P3, and cycle data is referred to as GM. There are three priority-based slots for children's competition access (CCAP) and free phase (CCFP). The service is tailored to varied priority data. For EM data to be prioritized, it must compete for CCAP access. CCAP and CFP are divided into three priority-based slots based on data, and the service is adapted to the needs of each kid. To ensure that P1 data transmission is given priority, EM data must compete for access across the whole CCAP network. When it comes to ensuring that emergency data is communicated quickly, a back-off strategy based on priority and the back-off duration is set by priority is used [47].

2.3.1.3.2 A Cross-Layer Design for Optimizing Transmission Reliability, Energy Efficiency, and Lifetime (CLDO)

A combination of transmission power and relays is needed to address the problems related to Routing Mechanism in WBAN. The Researchers around the world had conducted simulation studies, which showed that a proper transmission power and packet size might guarantee reliable transmission, conserve energy, and extend network life [48]. The ideal relay can transfer data packets with low mistakes, reduce energy consumption by a significant amount, and meet acceptable latency requirements. Many theoretical inferences and stronger claims and proofs have been made as a result of this experiment.

2.3.1.3.3 Cross-Layer Retransmit Strategy (CLRS)

CLRS cross-layer retransmit protocol is proposed which is based on IEEE 802.15.6 standard [49]. Unlike prior cross-layer approaches, it was meant to retransmit data packets that failed to transport. In this experiment, when data transmission failed, separate waveforms showed up on the output waveforms of the receiving end due to collision and shadow effects. After determining the issue by analysis of data frame waveform characteristics, the MAC retransmission approach was chosen.

2.3.1.4 Cluster-Based Routing Protocols

It was motivated by WSNs to use the cluster-based routing approach. Studies suggest that clustering is better for WBANs than a standard WSN routing scheme, LEACH (Low Energy Adaptive Clustering Hierarchy). Clustering techniques can boost network robustness as the number of nodes, and their distance from each other grows. Clustering routing protocols are used to partition network nodes into groups. There is a cluster head and a number of other cluster nodes in a cluster [50]. The tabular representation of Cluster based routing protocol is mentioned in Table 2.4.

Table 2.4: Cluster Based routing protocols

Authors	WBAN Protocol / Standard used	Strengths	Limitations
A.Raza et al [51]	Cluster Based Body Area Network Protocol (CBAAP) is designed	Proposed protocol improves residual energy, network life time, throughput and residual energy.	Mathematic Model has not been designed

Consider both temperature and energy while designing a WBAN. Network life and power consumption are both reduced by using cluster-based routing. By dividing a network into smaller clusters, the network's nodes' total energy can be reduced. When found in a cluster head, these nodes are used to exchange information (CH). The CH is in charge of data transmission, collection, and aggregation. The low-energy cluster-based hierarchies and power-efficient sensor information systems' hybrid indirect transmission waste less energy when few nodes (LEACH). Since Any Body does not scale linearly with the number of nodes like LEACH, it performs better than LEACH. The cost of setting up Any Body is likewise reasonably priced [50].

2.3.1.4.1 Dual Sink Approach Using Clustering (DSCB)

One of the most significant innovations of DSCB's dual sink node routing architecture is its usage of cluster-based DSCBs [52]. There is only one sink used for routing inquiries. These tests revealed several issues, such as high failure rates of data transmission and limited coverage and a lack of flexibility in NLOS communication in dynamic environments. Shadow effects can be observed in real-world situations, and because the transmission interruption they create must wait for the shadow effect to vanish before continuing to broadcast, the delay in transmission is significant. People's lives are at danger when there is an interruption in emergency data transmission.

2.3.1.4.2 An Cluster Based Energy Efficiency Routing Protocol (CRPBA)

CRPBA, a cluster-based routing system referring to sink nodes as gateway nodes, was presented by [24]. In some cases, nodes in a network may communicate directly with the gateway or with other nodes in a cluster. At the waist and neck, there are two entrances. The protocol mandates that some critical data interface directly with the gateway node to avoid transmission delays. Data from the leader of a group of cluster members is provided to the gateway to reduce energy usage while enhancing the success rates of data transmission.

2.3.1.5 Quality of Service (QoS) Based Routing Protocols

Presently, there are some QoS aware routing schemes which are designed for WSNs, but WBAN lacks any QoS based standard. The energy-efficient peer routing protocol (EPR), which minimizes energy use while reducing network traffic load, is suggested. QoS aware peering routing protocol (QPRR) for reliability sensitive data is also proposed for WBAN. The analytical comparison is performed among EPR and QPRR. The results predict that neither any routing scheme previously discussed supports optimal energy efficient routing in emergency circumstances. Figure 2.3 describes about the classification of WBAN routing protocols based on QoS Aware Routing parameters.

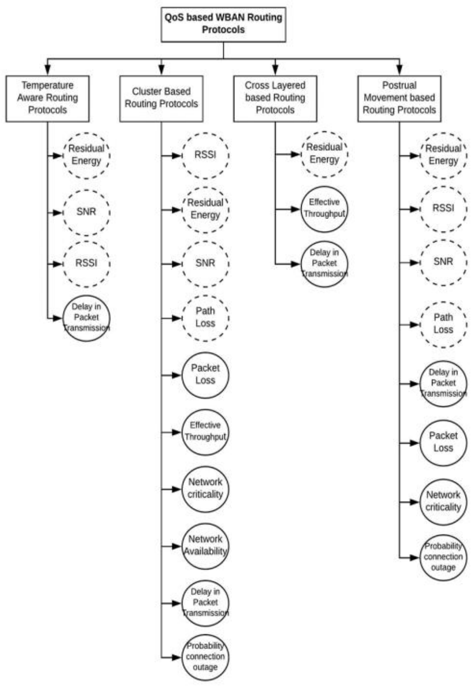

Fig 2.3: Classification of WBAN routing protocols based on QoS Aware routing parameter

Various QoS aware protocols can be deployed in WBANs, but only if considered. WBAN data formats require various levels of Quality of Service (QoS). EPR, QoS-aware peering routing protocol (QPRD), and QoS-aware peering routing protocol for reliability-sensitive data (QPRR) consume less electricity than other protocols. Some methods don't include energy use, but other ones include. As one of the most widely used protocols that consider QoS considerations, DMQoS can help reduce latency for time-sensitive data while still ensuring reliable routing for reliability-sensitive data. Some protocols do not account for energy use, whereas others do. The data-centric multi objective QoS routing protocol (DMQoS) is one of the most extensively adopted QoS protocols for data that must arrive quickly and reliably. Other QoS-aware protocols are utilized or selected depending on a given network's data type and QoS requirements.

In this regard, the data-centric multi-objective QoS-aware routing protocol (DM-QoS) is designed to reduce the delay for sensitive information. However, the proposed scheme provides the optimal routing strategy for reliable-sensitive information. The researchers had proposed the routing table construction algorithm and path selector algorithm for maintaining the quality of service in packet transmission towards the base station. WBAN and Cognitive Radio Technology (CRT) are merged to achieve efficient and reliable WBAN solution. This novel approach can lead towards a considerable improvement in energy efficiency and routing schemes.

Zahoor Energy Efficient-Quality of service aware (ZE-QoS-aware) routing scheme for communication of sensor devices in the healthcare domain is proposed. The scheme is based on high energy consumption, which is a major drawback. The protocol QoS refers to maximum packets sent towards the base station. QoS aware peer routing protocol (QPRD) for delay sensitive data in case of WBAN is designed. The protocol is capable to handle delay sentive data in WBAN.

WSN as compared with WBAN, minimum energy consumption is the major constraint to be considered. In WBAN cluster based routing schemes are proposed to reduce the energy consumption and to maximize the network lifetime. QoS based routing schemes now a days are based on cluster based routing protocols. Fault detection and discovery (FDR) is a fault tolerance based routing strategy, for alternate route selection in case of faulty or dead nodes. In a cluster-based routing strategy, the FDR parameter is based on QoS. If there are fewer sensor nodes in the cluster, hybrid indirect transmission (HIT) in WBAN uses less energy than low-energy adaptive clustering hierarchy (LEACH) and a power-efficient collecting in sensor information systems (PEGASIS). Given that the number of clusters stays constant as some sensor nodes are added, any technique in WBAN is preferable to LEACH [21]. Anybody's installation and deployment costs are significantly lower than those of other cluster-based routing techniques. Cluster-based body area protocol (CBBAP), which is based on LEACH, is created to maximize WBAN performance throughput while also having a minimal network energy footprint [51]. The tabular form of QoS-aware routing protocols in WBAN is described in Table 2.5.

Table 2.5: Tabular representation of QoS aware routing protocols

Authors	WBAN Protocol / Standard used	Strengths	Limitations
X.Liang et al [53]	(RL-QRP) Reinforcement learning based routing protocol with QoS support.	High packet delivery Ratio.	High average delay
M.A.Razaque et al [54]	(DM-QoS) Data Centric Multi objective QoS Aware routing protocols	High packet delivery ratio, minimum delay	Large network size results in high energy consumption
Z.A.Khan et al [55]	(ZE-QoS) Health care system QoS-based routing.	high ratio of packet deliveries	high level of energy use
Z.A.Khan et al [1]	(QPRD) QoS aware peer routing protocol for delay sensitive data in case of WBAN is designed	Protocl is capable to handle delay sentive data in BAN	Framework has not been designed in the proposed scheme

WBAN's resource limitations make the quality of service (QoS)-based routing all the more critical, which is a big problem. Quality of service (QoS) considerations for the WBAN include data priority and energy efficiency, connection dependability, low latency, node temperature, and data security.

2.3.1.5.1 Designing Lightweight QoS Routing Protocol (LRPD)

Delay QoS is a primary goal of the LRPD protocol developed by [56]. The protocol's objective optimization is achieved through a modular technique. Priority is given to sending data from the higher layers to the categorization module. There are two kinds of data packets: general (GP) and delay-sensitive (DSP). It is impossible to overestimate the importance of DP. After passing the GENERAL and DELAY MODULES, the queue processing module receives the DP and GP data. Low priority DP data must, however, wait until a good time to transmit it in order to prevent any transfer delays.

2.3.1.5.2 Hybrid Data-Centric Routing Protocol (HDPR)

An solution was put up in the form of HDPR, a modular data-aware hybrid routing protocol [57]. Once there, it is classified as delay-sensitive data (DSD), normal data (ND), or critical data (CD) (RSD) by the Data Classification Module (DCM). The four data priority levels are CD, DSD, RSD, and ND, with the CD being the highest and ND the lowest. The Qos perception module uses data modules to organize data. They will be routed to the appropriate module based on each module's requirements by this one. Using DSD data as an example, a delay estimation module identifies the most efficient route. As soon as the estimating module receives this data, it can then determine the optimum route. Many quality of service (QoS) metrics, such as route loss, connection dependability, latency, and temperature, are the primary focus of this protocol. One of the main advantages of this technique is that it considers the quality of service (QoS) related Routing Mechanism in case WBAN. This protocol's relay node only performs receiving and transmitting functions, reducing the acquisition node's energy consumption and increasing the network's lifespan. The Strengths of the Research work is based on improved Link reliability increasing QoS in routing mechanism. Along with the ability to send the maximum number of packets sends towards the base station. The Limitations of the research work is based on increased energy consumption of sensor network in maximum packet transmission and retransmissions.

Improved Quality of Service (IM-QRP) Aware Routing Protocol for WBAN

In the disciplines of medicine and health, wireless body area networks (WBAN) are a subset of wireless sensor networks (WSN) [58]. With WBAN, patients are liberated from wired monitoring and given access to a variety of medical services everywhere. These services include clinical medical monitoring, chronic disease monitoring, daily monitoring of the elderly or particular groups, and chronic disease monitoring. As a result, development in WBAN is gaining momentum and will soon rank among the most active research topics in the field. WBAN is a network with numerous levels that covers the complete body [59].

III. MOTIVATION AND PROPOSED SOLUTION

3.1 Motivation

Investigating various energy-efficient routing techniques is the goal of routing challenges. The issue of power usage with WBAN is among its biggest issues. Typically, WBAN uses medical sensors, which have restricted power sources. As a result, it is highly challenging to recharge or replace a sensor node that is part of the WBAN system. The processing of query queries, sending the data to nearby sensor nodes, and transmitting data are the sources of useful power usage.

In order for wireless sensor nodes to communicate data with one another, the routing protocol is essential. Energy-efficient routing protocols offer the best way to maintain a reliable path for data transport among WBAN. Due to the connectivity of sensor nodes on the human body, routing techniques used in WSN cannot be employed in WBAN directly. The mobility management paradigm, which is utilized to track patients' movements inside healthcare facilities, serves as the foundation for the patient healthcare monitoring system. The WBAN framework makes use of network communication range to offer the maximum levels of connectivity, coverage, and network lifespan. The data routing requires a lot of energy from the sensor nodes that are farthest from the sink node. These sensor nodes fail more frequently due to their high power consumption, which reduces network performance. In WBAN, fault-tolerant communication takes place at the node level. Data faults, hardware faults, and software faults are its three subcategories. The network failure can be avoided by removing the causes of errors in WBAN transmission. An ideal failure prediction system is required by the network for precise fault tolerance.

Wireless communication with contemporary technology allows users to exchange information at any time and from any location. Intelligent mobile communication networks and WLAN, or WiFi, are used in various settings, including education, health care, and industry, to allow people to engage with one another easily [10]. As the search for ubiquitous networks intensifies, so do household, business, and other information device gadgets that can connect wirelessly over short distances. The development of universal network standards and methodology has propelled it quickly into the global market. As a result, the Wireless Body Area Network subset is formed (WBAN). There are numerous ways WBAN differs from previous sensor networks (WSN). It's the mobility that separates a WBAN from a WSN. Compared to WSN, which tends to stay put, WBAN allows users to move in sync with sensor nodes that do the same thing. We can save much money on electricity by using WBAN.

WBAN sensors are therefore less expensive than WSN sensors. WBAN nodes adhere to the traditional model in terms of dependability, node complexity, and density. The particular needs of internet backbone body connections cannot be managed by WSNs. How quickly and precisely the system responds to data being sent and received between nodes, which is ultimately controlled by the routing protocols or algorithms used, is a key indicator of WBAN dependability and efficiency. As part of the data transfer from a sensor node positioned inside or on the body, wireless transceivers, which are comparable to WSNs, emit radiation.

In WBAN the sensor node is responsible for gathering vital information from the body. Sensor nodes in a WBAN system must have low average power consumption, are small, and can operate within a specific type band. Every WBAN sensor node is made up of the same hardware. Important patient data is gathered through the use of sensors. Signals gathered from the human body are typically not archived. Forceful and partly due to the loudness of other noises within the body, such as the heartbeat. An Analog to Digital (ADC) stage that can be adjusted over structures to help with advanced handling is experienced when the sensor detects a signal, strengthening it to make it more grounded and separated to eliminate undesirable sounds such as cacophony. This aids in advanced handling. After that, the digital sign is handled and inserted into the microchip. The sensors provide an inconspicuous check on a patient's health. You sing human services technology in their daily life activities. Each sensor node has all of the necessary equipment [11].

3.2 The Proposed Routing Protocol

Improved Quality of service Aware Routing Protocol (IM-QRP) for Wireless body area Network is proposed. Priority-based routing and QoS support are available to users in WBAN framework. These factors are considered when determining a node's readiness to serve as a router. Data packet priority levels and wireless channel status are also taken into consideration. QoS metrics are selected based on packet success rate, end-to-end latency, and power consumption issues [27]. Figure 3.1 depicts the proposed routing protocol's technique, which consists of four clusters

A. CONTRIBUTION AT LAYER 1

Relay-based routing Layer 1 is chosen with following main factors.

1. **Reliability:** The framework delivers at least 90% of end-

to-end packets when a route is present, even in challenging network conditions. The proposed scheme has a 99.9% packet delivery rate.

2. **Robustness:** The framework can be used in a wide range of network scenarios, including ones with dense network topologies, environments, and workloads.

3. **Effectiveness:** The framework can send packets across the wireless network in the shortest amount of time.

4. **Independence from Hardware:** The framework may run on a wide range of hardware systems.

B. CONTRIBUTION AT LAYER 2

Home automation systems make up Layer 2. An effective solution for smart houses is offered by this smart infrastructure [60]. In smart homes, we are implementing WSN solutions. Typically, Smart Homes are made for senior homeowners who live alone. Almost every household appliance and human body are equipped with sensor nodes, which may lead to the formation of an ad hoc network within a definite, predefined range. There is no established routing system for moving data between devices in smart homes [61].

The second layer of research builds on the motivational variables listed below.

1. Smart Homes use a relay-based routing scheme.

2. To efficiently send information from numerous sensor nodes to the relay node (RN).

3. Information on the health status of the elderly can be sent from one sensor node to another with the use of smart homes, which offers an effective and dependable solution.

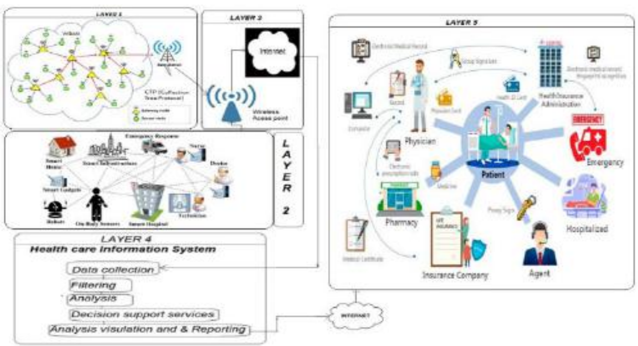

Fig 3.1 Proposed routing protocol for WBAN application

C. CONTRIBUTION AT LAYER 3

Base Station and Access Point (AS) make up Layer 3. (BS). Typically, relay-based routing is utilized for sending data to AS/BS. Relay-based routing provides a low average end-to-end delay and strong communication dependability. Data from AS/BS in Layer 3 can be properly routed using relay-based routing. A successful packet delivery ratio from Layer 3 to Layer 4 is achieved by the suggested scheme. Based on a patient's health, relay-based routing makes effective use of clustering. 150 sensors have been placed in the Layer 1 network field to support the current circumstance. By using a relay-based routing strategy, layer 3 packet loss ratio can be minimized. Data from AS/BS can be successfully forwarded through the Internet to Layer 4 via relay-based routing. The third layer of research contributions is motivated by the following criteria. Guarantees for relay-based routing.

1. QoS

2. Energy conservation

3. Maximum packet delivery ratio; 4. Minimal end-to-end delay

4. Relay-based routing can extend the life of the network and improve load balancing and scalability by detecting wireless signals.

5. For relocating doctors or nurses working in a medical context, relay-based routing offers an efficient means of data transmission and routing.

6. Relay-based routing helps Layer 3 and Layer 4 successful packet delivery rates.

The People's lifestyle data is taken from Kaggle (Kaggle, an online community of data scientists and machine learning engineers, is a subsidiary of Google. It provides a platform where users can access datasets for building AI models, share their datasets, collaborate with other experts in the field, and participate in competitions to tackle data science challenges) which is based on Table 3.1 as mentioned as follows.

Table 3.1. Sample Distribution for Disease Classification

Disease	No of samples
Heartbeat	3193
Pulse rate	927
Glucose level	660

3.2.1 Communication Flow Chart and Route Selection Algorithm of IM-QRO Routing Protocol

Figure 3.2 depicts the communication flow-chart for the QoS-aware routing strategy-based IM-QRP routing protocol.

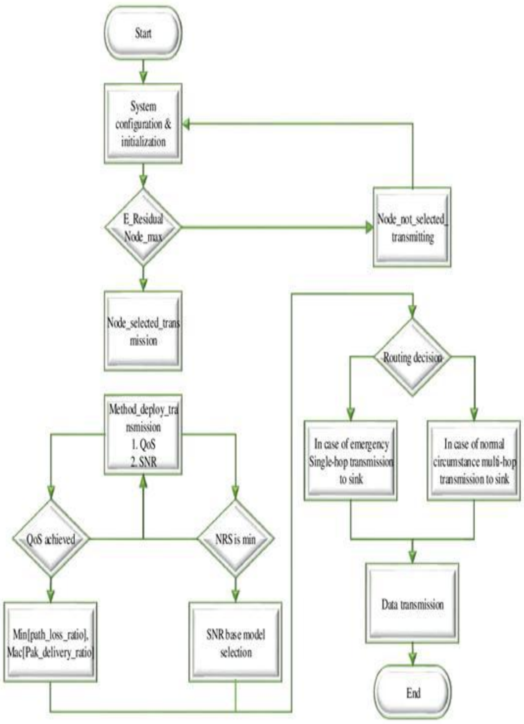

Fig 3.2. Flowchart description of IM-QRP routing protocol

The IM-QRP flowchart is shown in Figure 3.5 for both regular and emergency situations.

In WBAN communication, cooperative routing plays a key role Relay node will be added in order to establish cooperative links and lower the overhead power usage [3]. Following is a discussion of how the proposed protocol's sensor and relay nodes perform under both normal and emergency conditions.

In the case of Emergency: When sensor nodes detect heartbeat, pulse rate, glucose level, and temperature scales to the fullest extent feasible, an emergency has occurred. The sensor nodes and sink nodes exchange data directly. A single hop communication occurs when the patient's health situation is concerning.

$$sensor\_nodes \xrightarrow{sends(data)} sin\ k\ \_node \ldots \ldots \ldots .(3.1)$$

```
Initial Phase:

1. All the sensor nodes transmit test messages.
2. All the sensor nodes and relay nodes update their neighboring nodes and routes to the sink
nodes.

Routing Phase:

3. SN=sensor node
4. SN=SNk: all sensor nodes send the data to the sink node
5. For each (SNi∈SN)
6. //Routing algorithm for sensor nodes deployed on the human body
7. //Start
8. //system initialization and configuration
9. if (SNi==Recives_signal_([Residual_energy_max]) )
10.    Node_selected_transmitting( )
11. // Methods deployed for transmission to sink node
12.  L1: QoS
13.  if (SNi==(QoS_max_IM-QRP]))
14.                          [Min_path_loss_ratio_model_selection    (     )
15.+Max_link_reliability_model_selection()+
16. Max_residual_energy_model_selection() 17.+Max_SNR_model_selection()]
18.     Else
19.         Jump to L1
20.   if (routing_decision_normal_QRP)
21.         Selection_optimal_route_normal( )
22.   Transmits the data in multi-hop to sink node
23.   if (routing_decision_emergency_QRP)
24.        Selection_optimal_route_emergencyl ()
25.  Transmits the data in single-hop to sink node
26.    Else
27.       Node_not_selected_transmitting( )
28.//start again from system initialization and configuration
29.    End
30.  // Energy consumption algorithm procedure  in the selection of the optimal route
31.  NNF=Neighbouring node as a forwarder
32. all candidate nodes as neighboring forwarder node
33. REin= residual energy of sensor node i in case  of normal data transmission
34. REie= residual energy of sensor node i in case  of emergency data transmission
35.  ECNi=Energy consumption of node i
36.  switch (NNFi∈NNF)
37. case: 1
38. (In case of emergency)->REin=(REi – ECNi) Energy consumption of each sensor node in
emergency
39. case: 2
40. (In case of normal Trans)->REie = (REi – ECNi) Energy consumption of each sensor node
in  normal
41. end case
```

In the case of normal daily life: When sensor nodes detect temperature scale, pulse rate, glucose level, and heartbeat to an acceptable degree, the situation is normal. The relay node receives the data from the sensor nodes. The relay nodes cooperate with each other and maintain a close proximity to the sink node. The data is sent to the sink node by the cooperative relay node. Compared to standard sensor nodes, relay nodes use less power. When the patient's health is in good shape, a multi-hop communication situation arises.

$$SensorNode \overset{sendsdata}{\rightarrow} relayNode(co-operativeNode) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots ....(3.2)$$

$$relayNode(co-operativeNode) \xrightarrow{sends(data)} sin\ k_{node} \ldots \ldots \ldots .. (3.3)$$

3.3 Simulation and experimental results

IM-QRP is contrasted with the current routing protocols QPRD [1] and CO-LEEBA [2]. Results were obtained using MATLAB, and the classification of sensor nodes implanted on the human body is reported in Table 3.2.

Table 3.2. Classification of Sensor Nodes Mounted on a Human Body

Type of Sensor Node	Abbreviation	Functionality
Sink Node	SN	Positioned in the center of the body and able to receive data from relay and sensor nodes.
Sensor Node	S1	Assessing the patient's body's glucose levels.
Sensor Node	S2	Electro Encephalogram (EEG) sensors are used to track the signals the human brain sends out.
Sensor Node	S3	ECG (Echocardiography) is a technique for tracking heartbeat
Sensor Node	S4 & S5	The method of electromyography (EMG) for capturing muscle activity
Relay Node	R1, R2, R3, R4	Ability to cooperate with sink node and receive data from sensor nodes.

The network in Figure 3.3 employs a fixed number of nodes that are connected to the human body, but we can alter this number based on the patients' health and postural changes.

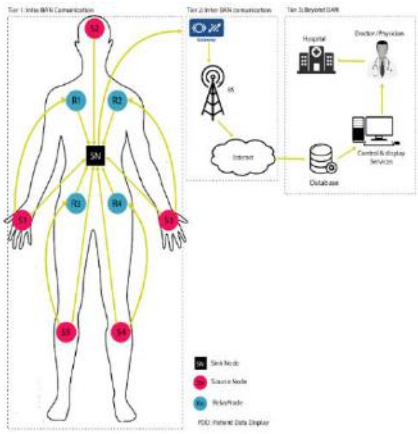

Fig 3.3. A Schematic for IM-QRP routing protocol

According to Figure 3.5, the sink node in the IM-QRP routing protocol is placed in the middle of the user's body.

According to [5] assessing vital electric sensors and their subsequent administration, including extraction, enhances the accumulation of consistent physiological indications obtained, which may provide a general estimation of the client's well-being state at any random time. The table depicts the many sensor nodes used in the WBAN system and their location (which body part they are in) and function. These are the most common types of patient vital data monitoring; however, just one or two types monitor specific symptoms in certain cases. When developing any monitoring system, it is critical to priorities sensor manufacturing quality and chip requirements to ensure that all sensors are consistent and that receiver devices can receive patient data without difficulty during transmission and receive. The following sensor nodes are classified inside Tier 1, along with the functionality of each sensor node.

Sink Node (SN) placed at the centre of the human body

Sensor Node (S1): Glucose level

Sensor Node (S2): Electro Encyplograms (EEG)

Sensor Node (S3): Electromyography (EEG)

Sensor Nodes (S4 & S5): Electromyography (EEG)

Relay Nodes (R1, R2, R3, R4)

3.3.1 Initialization phase

Table 3.3 lists the energy-related factors and the ideal values that should be employed in a Situational simulation. Due to the heterogeneous nature of the WBAN, it allows two alternative types of sensor nodes that are categorized as follows.

1. Advance nodes are further divided into (Relay nodes)

2. Additional categories of normal nodes include (Sensor nodes)

A minimum distance must exist between the sink node and the relay nodes positioned on the patient's body. To gather essential information about the patient's health status, normal energy sensor nodes are mounted at random on the patient's body.

Table 3.3. Energy parameters with Desired Values

Energy parameters	*Desired values*
$E_{initial}$ (Initial Energy)	4 millijoules
Supply voltage	2.0 volts
Frequency (f)	2.4 GHZ
$E_{Transmission-amp}$	2.0nJ/bit
$E_{Transmission-circuit}$	17nJ/bit
$E_{receiver-circuit}$	10nJ/bit
DC Current (Transmission)	10.5 Ma
DC current (Reception)	18 mA
Wavelength (λ)	0.125 m

3.3.2 Selection of next-hop in routing

Based on the IM-QRP routing protocol, the next-hop selection criteria employed in this section to select the forwarder node.

3.3.2.1 Computation of cost function for the selection of the relay node

We use the multi-hop routing strategy because it increases network throughput while consuming less energy. In an emergency, a single hop route is chosen. For each round, IM-QRP chooses a new forwarder or relay node. The sink node is aware of the ID, distance, and remaining energy of the nearby sensor and relay nodes. These presumptions make it possible for the cost function to decide if a node is a forwarder or a relay node. Equation 3.4 [13] contains the formula for determining the cost function.

$$C(F) = \frac{d(i)}{R_E(i)} \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.4)$$

Where i is the node ID, $d(i)$ is the separation between the sensor node and the sink node, and RE denotes the sensor node's residual energy.

Equation 3.5 gives the following definition of the cost function based on the optimization model used in WBAN.

$$cos\,t\_function \xrightarrow{elect\_optimized} forwarder\_node(relayNode) \ldots \ldots (3.5)$$

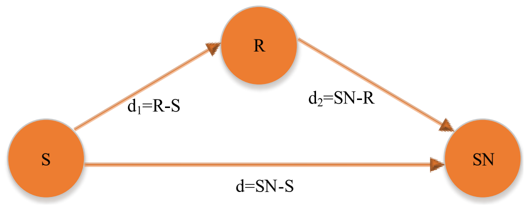

Fig 3.4. A Distance calculation for sink node

These presumptions are used to modify the cost function in both regular and emergency situations. The equations shown below provide the updated cost function. The following describes the cost function for multi-hop transmission in the situation of regular data transmission using Equation 3.6.

$$CF_n(i) = \frac{(SN-R)-(R-S)}{R_E(i)} = \frac{d_2-d_1}{R_E(i)} \ldots \ldots \ldots \ldots (3.6)$$

The Cost-based function in single-hop transmission is explained as follows in case of an emergency in Equation 3.7.

$$\mathrm{CF_E(i)} = \frac{\mathrm{(SN\text{-}S)}}{\mathrm{R_E(i)}} = \frac{\mathrm{d(i)}}{\mathrm{R_E(i)}} \ldots \ldots \ldots \ldots \ldots (3.7)$$

WBAN operates at low energy levels to prevent hotspots on the human body, and the suggested method also steers clear of high data transfer rates to prevent negative impacts [68]. Overhead power consumption rises as a severely reduces the WBAN framework's QoS. According to one body propagation model, when sent signals travel through the body, diffract around the body, and are reflected off of nearby surfaces.

Smaller wireless networks use fewer sensor nodes, a smaller network, and a shorter communication range than WBAN. Given the limited energy budgets of sensor nodes, energy efficiency is a key concern in WBAN. There is no easy way to replace or charge body sensor batteries. Even if sensors are worn, changing batteries will be cumbersome and time-consuming. On the other hand, physical wireless networks are among the most significant energy consumers [35].

Furthermore, power transfer should be maintained to a minimum to maximize network longevity. It should be noted that network apps should endure several years before being refreshed or paid. The other element is lower power usage due to less network traffic disturbance. Furthermore, radio signal specific absorption rate strongly links with radiation power density. The radiation energy is converted to heat, and if there is too much of it, the tissue will be harmed. To avoid the influence of radio waves on the human body, high transmittance is prohibited [69].

Although the communication range of the WBAN is restricted, incident electromagnetic attenuation is significant due to the lost path. Tree-based, chain-based, and cluster-based protocols are all examples of multi-jump protocols. Nodes in the first and second groups transmit data to their parent nodes, and the data is delivered step by step to the good node. As a result, the node closest to the good node consumes more energy because it must acquire network information and transport it to the well after processing. Cluster-based protocols organize nodes into multiple clusters [70].

Each cluster has a node responsible for collecting data from other nodes, compressing it, and transmitting it. As a result, clusters consume much more energy than regular nodes. Certain protocols require that the cluster change regularly to balance the energy use across the nodes. To achieve WBAN criteria, we must use multithreading when removing nodes from the hole to move the data. As a result, relay nodes may be used to increase lifespan and performance. It is worth noting that the additional relay nodes in the body can significantly improve network stability since data is transported across several alternative paths. Relay nodes are also employed in wireless sensor networks and WiFi communication. Relay nodes typically do not feel anything and only transport data. Because data transmission consumes much power, it has the potential to reduce sensor node power consumption [71].

To reduce energy consumption and boost network throughput, we favour a multi-hop routing method. In an emergency, a single-hop route is usedIM-QRP selects new forwarders and relay nodes for each cycle. The sink node is aware of the sensor node, relay node, IDs, distances, and collected energy. From this sink node, each node in the IM-QRP cost function is derived. B The link reliability in the BAN is dependent on the quality of service. SNR is another important factor to be considered in a WBAN routing strategy [3]. Now the proposed equation for cost function for energy efficient routing in WBAN is defined as follows in Equation 3.8.

$$\cos t(F) = W_1[residual\_Energy] + W_2[;ink\_reliability] + W_3[path\_loss] + W_4[SNR]$$

…..(3.8)

Where, W_1, W_2, $W_{3,}$ W_4 are weighting to provide the importance of these parameters [13]. The weights are optimized by using a genetic algorithm. The genetic algorithm based cost function performance based on fitness function with each weighted vector value assigned one is described as follows in Equation 3.9.

$$\cos t(F(performance)) = 1.[\frac{residual\_energy}{Total\_Energy}] + 1.[\frac{link\_reliability}{Max\_value\_link}] + 1.[\frac{path\_loss}{Max\_path\_Loss}] + 1.[\frac{SNR}{Max\_SNR}] \quad \text{.......(3.9)}$$

The possible weight vector range and maximum simulation time for each weighted vector are computed by using following Table 3.4.

Table 3.4: weighted sum classification

Weights	Possible weight range	Maximum simulation time (ms)
W1	0.507 … 1.90	34.01
W2	0.508 … 1.91	35.03
W3	0.509 … 1.92	36.06
W4	0.510 … 1.93	37.09

Cost function in WBAN routing mechanism, it is to be decided whether the node becomes a forwarder/relay node or not.

3.3.3 Energy consumption model based on routing mechanism

WBAN communication is divided into two forms based on the location of the radio signal: in vivo communication and in vitro communication. Vivo communication in WBAN is based on real world Telemedicine based Infrastructure. Vitro communication in WBAN is based on communication tests in real word outdoor environments including ranges calculation in meters based on frequency calculation in hertz. Body-coupled communication is a revolutionary kind of in-person communication in which the human body serves as a transmission channel [72]. The literature was searched for the best simulation technique for in vivo communication. Data collection, transmission, reception, and inactive interception consume the bulk of node power. The energy consumption of data transit causes the majority of them. Because this work focuses on inter-node communication, only sending and receiving energy utilization is addressed, leaving out data collecting and idle listening [72].

Path loss in the IM-QRP Routing protocol can happen in a variety of situations based on how the body is positioned and how close or far the sensor nodes and relay nodes are to one another. The variable that directly correlates with path loss is RSSI. When the patient positions his body differently, especially when his legs and arms have path loss, the transmission distance between sensor nodes, relay nodes, and sink nodes may increase. For IM-QRP, our proposed model allows for a little degree of route loss. The cause is related to the patient's position when the sensors on the arms and legs are close to the washbasin node deployed on the belly side of the human body. A few millimeters of minimal communication space between sensor, relay, and sink nodes may cause a minor amount of route loss on the sides of the arms, legs, and abdomen [73].

The proposed model for energy consumption is feasible [71]. The following model defines the energy consumption for transmitting and receiving k bit data:

$Etx(k,d,n)=ETXelec*k+Eamp*k*d^{n}$ ……..…(3.10)

$Erx(k) = ERXelec *k$ ………(3.11)

3.3.4 Path loss model in routing mechanism

Path loss shows the effect of route loss on discourse in WBAN. The Authors [74] had investigated and presented findings using channel route loss model to solve the issue of statistics loss or variation in scientific implants and conversation waves. The authors proposed sensor units for machine monitoring and established a server-based architecture for in vivo speech transmission channel loss. As the world's population grows, so does the demand for appropriate healthcare device features in WBAN, particularly for the elderly, who are more prone to fitness issues. Many scientists have presented services to the elderly; for example, prototype structures that use Bluetooth as a wireless physique region network (WBAN) to show location and fitness status and smartphones outfitted with accelerometers as intelligent central nodes have been used to design healthcare systems. This system gives family members and healthcare practitioners real-time access to patients' whereabouts and health status over the Internet. ZigBee is used for low-data-rate applications because it consumes less energy than Bluetooth. The most significant challenge with WBAN to date has been recorded loss or transmission corruption; new protocols or schemes are required to demonstrate the efficacy of receiving entire records without loss; the loss is caused by free-space impairment of the propagating sign (e.g. refraction), fading, absorption, and reflection, among other things. It is also determined by the distance between the transmitter and receiving antennas, the top and position of the antenna, the propagation medium, such as moist or dry air, and the antenna's rural or city location, among other factors. In the case of WBANs, the loss of the route depends on distance and frequency.

Equation 3.12 defines the Friis formula for Path Loss Model PLd, which determines the path loss between two communicating nodes depending on the distance, d, between the sensory nodes in the network field.

$$PL(d) = PL\ (d_0) + 10_n \log\left(\frac{d}{d_0}\right) \qquad (3.12)$$

Where d is the distance between the sending and receiving nodes along with the reference distance of 10 cm. PL is path loss coefficient, which varies in different environments. In physical wireless networks, in areas with a direct line of sight, between 3 and 4, while in environments with an indirect line of sight, we are between 5 and 7.4. X represents the random variable of Gauss with standard deviation σ.

Equation 3.13 can be used to compute the route loss ratio necessary for the sensor node to communicate with the sink node in an emergency.[74].

$$P_{Loss(emergency)} = \frac{PLk_{emergency)_{max}}}{PL_{max}} \qquad (3.13)$$

In an emergency, the path losses ratio factor will be as low as possible. The ratio of the shortest paths between a sensor node and a relay node, as well as between a sensor node and a sink node used in Equation 3.14

$$P_{Loss(normal)} = \frac{PLk_{normal)_{max}}}{PL_{max}} \qquad (3.14)$$

. $PL(do)$ is path loss in dB at distance d_0, and n is the path loss exponent is defined as follows in Equation 3.15.

$$PL(d_0) = 10 * \log(4\pi\ .\ d_0 f) * C \qquad (3.15)$$

Where f is the frequency of operation, and C is the speed of light. The equation gives the total path loss in Equation 3.16.

$$PL = PL\ (d) + X_6 \qquad (3.16)$$

Where X6 is the shadowing factor in dB.

In WBAN framework node failures, may occur, which results in routing path disconnection and overall network topology will change. In this regard early detection and recovery of routing path is feasible in emergency situations. Due to minimum battery life of sensor nodes, the performance of overall network degrades. In this regard IM-QRP scheme may adopt Cluster based Fault Detection and Recovery mechanism (FDR) [75] on exiting framework in Figure 1. The mathematical modeling of this scheme is based on our future work. FDR is an energy efficient routing mechanism designed for fault detection and recovery. The scheme achieves minimum packet loss by replacing faulty sensor nodes with in routing path with the newly selected alternate routing paths. Network topology is designed in such a way by mapping a virtual grid over the human body sensor network, which is capable to identify the node failure detection and its possible recovery as soon as possible in normal and emergency circumstance. FDR scheme may also achieve fault tolerance capability and enables the network to route the data on shortest path between sensor nodes, relay nodes and sink nodes. The FDR scheme may also generate a query path leading towards the faulty node. The query can be a request for information. In order to get information about the energy level of sensor nodes the request based query is generated. Agent based technique is used to implement the query path. Agent based packet is created at sink node which is traversing the entire WBAN [76]. Sink node is responsible to generate an Agent packet and Agent generates a query path towards the faulty node. The sink node is responsible for sending the Agent based packets to all its neighboring sensor nodes. The Agent based packet contains the following Information.

Message-ID: *Message identifier for agent based packet generation*

Sender-ID: *Agent packet based sender node ID*

Receiver-ID: *Agent packet based receiver node ID*

Active-node: *Active node based query path*

Stamp-time: *Calculation of time when the packet is sent by agent.*

When Agent packet is received, the sensor nodes stores the above mentioned information in Query list and returns ACK packet to the sender node. The ACK packet consists of following information

Message-ID: Message identifier for agent based packet generation

Sender-ID: Agent packet based sender node ID

Active-node: Active node based query path

Stamp-time: Calculation of time when the packet is sent by agent.

The mathematical modeling of Fault detection and discovery in case of faculty nodes and dead nodes is to be handled in our future work. At this stage we have suggested an Agent based descriptive framework for Fault tolerance and node failure in case of QoS Aware routing mechanism in WBAN.

3.4 Proposed Protocol (IM-QRP) comparison with existing Protocols

The outcomes results are based on the sensor nodes' remaining energy, the path loss ratio, the quality of service, and the SNR ratio vs 6000 rounds.

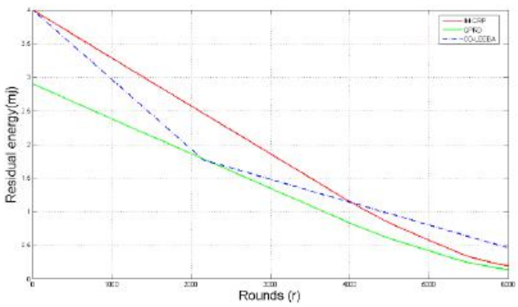

Fig 3.5. Residual energy

On the basis of residual energy for sensor nodes implanted on the human body, Figure 3.6 compares QPRD, CO-LEEBA, and the proposed IM-QRP.

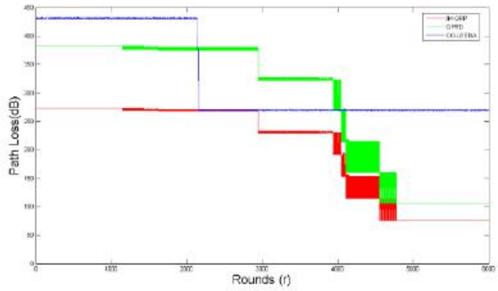

Fig 3.6. Path loss ratio

Path loss ratio has been determined for 6000 rounds in Figure 3.7. The highest route loss ratio for the CO-LEEBA system at the initial number of rounds is 440 dB.

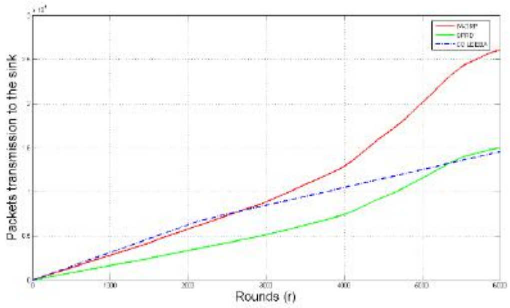

Fig 3.7. Link reliability (packet delivery ratio)

In Figure 3.8, the QoS for the suggested design is mentioned. The maximum number of packets that can be transmitted to the sink node affects QoS.

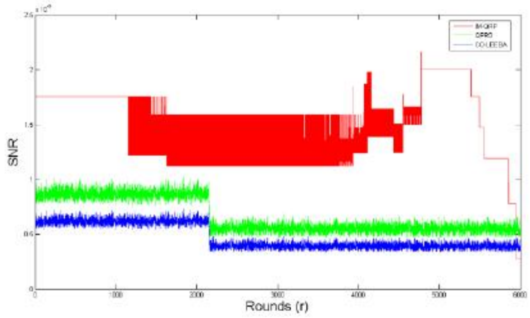

Fig 3.8. Signal to noise ratio

The proposed IM-QRP QRP's is shown in Figure 3.8. Comparing the IM-QRP to the QPRD and CO-LEEBA, the highest SNR of the IM-QRP is 2.2 * 108 dB.. Table 3.5 compares the QPRD routing protocol with the IM-QRP routing protocol.

Table 3.5: Comparison of IM-QRP with CO-LEEBA and QRPD Protocols

WBAN Routing Protocols vs Evaluation parameters	Residual Energy	Path loss	Link Reliability	SNR
Co-LEEBA	YES	YES	NO	NO
QPRD	YES	NO	YES	NO
IM-QRP	YES	YES	YES	YES

Table 3.6 provides more information on the WBAN routing protocols' comparative study. The temporal complexity of the CO-LAEEBA, QPRD, M-ATTEPT, and RE-ATTEMPT algorithms is compared to that of the IMQRP Routing Protocol Algorithm. The complexity of routing protocol algorithms varies depending on their benefits and drawbacks. Analysis of the existing protocols reveals that the M-ATTEMPT routing protocol achieves temporal complexity as Best case.

Table 3.6: Comparative Analysis of Complexity of Routing Protocols in WBAN

	Algorithms	Contributions	Limitations	Time Complexity
1.	M-ATTEMPT [39]	• Select thermal heat of hot spot during Routing Mechanism. • Temperature Aware Routing Protocol for WBAN	• Maximum power Transmissions is utilized by sending maximum number of packets directly towards the sink Node.	$O(n^2)$
2.	RE-ATTEMPT [24]	• Selects the Route for data transmission with minimum hop count and lesser delay as compared with M-ATTEMPT. • Routing Path quality is better than simple M-ATTEMPT	• Minimization in Network Life time due to increased energy consumption. • Short range transmission using IEEE 802.15.6 Standard	$O(n)$
3.	QPRD [67]	• QoS Aware Routing Protocol in WBAN. • Ensures Higher data transmission rate (maximum throughput) and limited packet drop with stable Network Traffic	• Less coverage rate and exploration • Transmission link failure can occur. •	$O(n \log n)$
4.	CO-LAEEBA [43]	• QoS Aware Routing Protocol for WBAN having minimum path Loss. • Having Low Energy Consumption and High packet delivery ratio	• Minimized Network life time, i.e. limited number of alive nodes for maximum amount of time	$O(n*m)$
5.	IM-QRP [proposed]	• Improved QoS Aware Routing protocol for WBAN. • Higher SNR, Maximum throughput, maximum residual energy of sensor nodes, Maximum number of packets transmissions, Enhanced Network life time	• Integration with 6G wireless framework is future research challenge.	$O(n)$

The suggested routing protocol by IM-QRP has a time complexity of. Time complexity is made possible thanks to reliable data transfer increases Network lifetime, including the maximum residual energy of each cluster's sensor and sink nodes. With the exception of RE-ATTEMPT, the algorithm we've suggested has a lower temporal complexity than the ones listed in Table 3.6. Our restriction is for future sixth generation (6G) wireless framework in the case of WBAN communication infrastructure, if we compare the limitations of both Re-ATTEMPT and IM-QRP.

IV. CONCLUSIONS AND FUTURE WORK

4.1 Conclusion

Many applications in WBANs are concerned about QoS Aware Routing. Patient's vital signs and physiological factors are constantly monitored in healthcare applications, which can be difficult. WBAN-driven technology is also needed to implement the data aggregation technique related to patients. WBANs-related resource constraints and a lack of relevant real-world data are the issues raised by the study's findings. Energy consumption, fault tolerance, and reliability are major concerns in current WBAN technologies. Reactive Routing Protocols can be improved by increasing the reliability of the network. High bit-error rates, packet drop ratios, and delays reduce the system's reliability [101]. WBANs' increased resiliency benefits greatly from the addition of this QoS parameter. The research objectives and major challenges have been met by developing three schemes for WBAN fault tolerance and reliability improvement.

Cluster-based routing schemes outperform non-cluster-based routing schemes in terms of network lifetime, packet delivery ratio, end-to-end delay, and path loss when node densities are high, according to simulation results. Non-clustered schemes do not take into account cooperation-based communication [102]. The data packets that each sensor node holds take center stage in cluster-based schemes.

4.2 Research Contributions

Research contributions have been summarized in this section. As a result of the literature review and the proposed solutions, this research gap has been filled. The following is a list of the contributions made by this thesis to the field of research:

The IM-QRP scheme, a new QoS-based Multi-Path Routing Protocol, has been proposed and presented in order to increase the QoS insider network. The proposed system prioritized traffic and classified paths within the network. Various matrices such as residual energy, path loss ratio, Link reliability, packet delivery ratio, and Signal to Noise Ratio are used to evaluate the proposed scheme's output. ACCORDING TO THE RESULTS, QoS-based IM-QRP has maximum residual energy after 3000 rounds. IM-proposed QRP's QoS-based QoS scheme uses the least power in comparison. The QPRD and CO-LEEABA schemes are less efficient in terms of energy usage. In the long run, it will extend the network's lifespan compared to the current one. Like the QoS-based routing protocol, its path loss ratio is reduced as compared that of QPRD and Co-LEEBA routing protocols respectively. Signal to Noise ratio for the proposed scheme is higher than existing schemes. The higher signal to noise ratio leads towards better and stable data transmission mechanism.

With the proposed cooperative network routing scheme, it was found that there was a significant improvement in packet transmission towards the Base Station. Additionally, the cooperative communication approach results in a significant power gain within the network itself. Cluster based Routing strategy and cooperation in (WBAN) has also increased FANETs energy efficiency towards maximum number of alive nodes for maximum duration of time. Objective function is also used in order to improve the performance of reactive routing protocol via using FANETs. It is possible to achieve significant improvement in the energy efficiency and minimum delay with the maximum number of sensors working together in cooperative communication with in each cluster.

4.3 Future Works

WBANs are becoming increasingly popular, particularly in healthcare applications, in the broader context. Health care technology has grown so quickly that remote patient monitoring is now feasible in smart healthcare. WBANs provide researchers with a brand-new field of study. Since WBAN is still an emerging technology, there is always room for new ideas in this era of technological advancement. It is possible to extend this research in the future to fill in the gaps that have been unearthed. Following are a few potential future paths for research in the following areas:

Real-time IoT systems can benefit from the proposed research's collaborative architecture. The system's available computing resources will be utilized in this collaborative architecture. Combining the sensing and processing capabilities of WBAN and FAN systems, the result is a novel network design that includes multiple levels. IoT-based WBAN systems, on the other hand, can use predictive resilience models for the available resources and service discovery mechanisms to make less-than-optimal decisions.

WBANs have unique characteristics such as self-healing, self-organization, fault tolerance, low duty cycle, dynamic network topologies, and flexibility. It is because of these characteristics that these networks have expanded their reach. Their wide range of applications has resulted from this. Battery power, storage capacity, computation power, data rate, and transmission range all suffer in WSNs where nodes are lacking. As a result of the sensor nodes' limited resources, these networks face a slew of difficulties. WSNs have drawn significant academic and industrial research to address these problems. As a result of the sensor nodes' resource limitations, scientists are constantly tackling new problems. At first glance, it seems that structure-based data aggregation techniques using various functions are the optimal energy management solution for WBANs. Although these techniques have some drawbacks, the possible directions for future research includes Lightweight and energy-efficient data aggregation [103], Accuracy of the aggregated data [104], Reducing packet loss ratio [105], Security and integrity of the aggregated data[106], Optimization [107], Practical implementation [108] and Challenges faced by the Internet of Vehicle (IoV) [109].

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