Multipath Routing for Healthcare Monitoring in Wireless Body Area Sensor Networks

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***Abstract* — In the realm of healthcare monitors (HMS), the significance of Wireless Body Area Sensor Networks (WBASN) cannot be overstated, as they play a pivotal role in collecting critical physiological data from battery-powered sensor nodes. The challenge lies in achieving a delicate equilibrium between low power consumption and mobility to ensure sustained, continuous, and reliable communication among these nodes. Several factors contribute to increased energy consumption, such as packet replay, protocol collisions, excessive control message sending, idle listening, and suboptimal route selection. To address these challenges, this paper proposes an innovative strategy known as Region-Based Greene Multipath Routing (REMR). The fundamental concept involves the partitioning of the entire sensor array into clusters, each containing multiple Cluster Representatives (CRs). These CRs play a crucial role in routing packets across clusters. The REMR approach conducts a meticulous assessment of the energy requirements for each potential route during the route selection process, favoring the one with the lowest energy consumption. Additionally, the suggested method takes into account factors like enhanced throughput, packet delivery ratio, and end-to-end latency to optimize packet routing. In summary, the REMR method employs an energy-efficient protocol and adaptive scheduling to judiciously segment a sensor network into clusters, thereby selecting the most energy-effective channels. The primary objective is to reduce control overhead, energy usage, packet incidents, and unnecessary idle listening, ultimately enhancing the overall performance of radio-frequency body area sensors utilized in health monitoring systems.**

Index Terms*— *Multipath Routing, Healthcare Monitoring, Wireless Body Area Sensor Networks, Region-Based Greene Multipath Routing (REMR), Cluster Representatives (Crs), Energy Efficiency, RFID Technology, Probabilistic Minimalism, NS3 Simulation, AODV Comparison, Experimental Results, Dependability, Data Transfer, Energy Consumption and Routing Protocol.

I. INTRODUCTION (HEADING 1)

Patients who are not bedridden thanks to Health Monitoring Networks (HMS) are able to move within a designated range of their monitor or base station, which improves their quality of life. HMS are essential in increasing the identification of emergency circumstances. While sensor nodes usually have little battery backup, the center station is a powerful device with specialised energy resources. Since communication accounts for the majority of a sensor node's energy usage, periodic sensor unavailability poses a danger to the dependability of the system and might result in unreported medical problems.

Energy-efficient routing protocols are necessary for WBAN-based systems in order to save energy consumption, provide dependable remote monitoring, and efficiently distribute the demand on processing and network transmission. Reducing superfluous transmission and applying compression may greatly improve battery life and network performance. With the use of methods including clustering, frame length optimisation, SDN-based routing, pooled routing, and energy-aware routing, existing technologies aim to increase WBAN availability. But to increase WBAN's coverage area while extending battery life, the best strategy is multi-hop routing, which uses hop-to-hop relay to prevent using too much transmission power.

In resource-constrained situations, the suggested method presents workload allocation and network optimisation techniques to sustain node life. A multi-hop communication strategy is used to minimise energy consumption and preserve signal strength across long distances in order to accomplish network optimisation. Relay points for devices with low energy resources might be nodes with suitable battery levels. An algorithm is used for data processing, allocating data-aggregation jobs to certain head nodes based on variables such distance behind the base station, processing capacity, and battery life left.

With the introduction of wireless bodies-area networks (WBANs), the field of remote healthcare has undergone a paradigm change. Wearable actuators and embedded sensors in garments have allowed for continuous patient monitoring. The constraints of conventional bed-bound patient monitoring have been exceeded by this technical advancement in conjunction with Health Management Systems (HMS). Patients may now walk freely within a certain radius of a base station or central monitor. It is impossible to overestimate the importance of efficient in terms of energy routing protocols in the ever-changing world of healthcare. Although base stations are equipped with specific energy resources, the difficulty is in guaranteeing the durability of sensor nodes that are powered by batteries (figure 1). These nodes' main weakness is that they use a lot of energy while communicating, which increases the possibility of intermittent unavailability. Unrecorded medical situations may follow, requiring the creation of plans that ensure the dependability of the whole monitoring system in addition to energy conservation.

Up to now, several approaches like as clustering, frame length optimization, software- defined network (SDN)-based routing techniques, aggregating routing, and energy-aware routes have been utilized in attempts to improve the effectiveness of WBANs. However, a clever strategy like multi-hop routing is needed for the WBAN coverage area to be expanded, which is essential for wider healthcare applications. Over transmission power may be avoided by using hop-to-hop relay systems, which guarantees the best possible trade-off between energy use and system dependability.

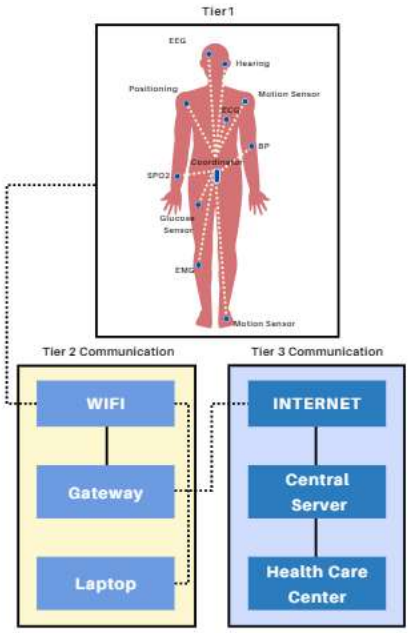

Figure 1: Approach Of The System

II. Literature Review

A clustering process that forms clusters in close proximity is suggested in [1] to extend the batteries of medical implants. This method compares outcomes with pure ALOHA and is based on an altered form of the low-energy adaptive clumping hierarchy (LEACH). While disaster data are promptly delivered to the sink node, non-critical occurrence data is pooled. Nevertheless, important routing characteristics that are required to prove the distinctive quality of the suggested scheme are absent from the assessment. The authors of [2] propose an optimisation technique to enhance network utility by improving delivery probability in the presence of bad channel conditions. They do this by quantitatively analysing the link between various elements. The necessity for further analysis of different routing algorithms for improved QoS and energy economy is underlined, even with equivalent performance.

An energy-effective routing protocol & QoS traffic supervision mechanism are realised by the introduction of the ERQTM scheme by N. Samarji et al. [3]. In order to minimise routing time, the suggested approach prioritises the transmission of emergency data by choosing an ideal head of clustering based on several QoS parameters. Improvements in network stability, longevity, residual fuel, throughput, and end-to-end latency are shown as compared to alternative priority-based methods.

Using a generalised gamma distribution, a robust optimisation approach is presented in [7] for power conservation in energy-constrained sensors. For greater energy economy, the authors recommend transmission in lower packet sizes. For an energy-efficient combining information approach in WBAN, Laya et al. [8] use bee swarm optimisation, which maximises energy efficiency by lowering retransmission and managing packet congestion.

An green cooperative routing strategy for homogeneous sensor networks is presented by Hung et al. [9], showing a substantial increase in sensor lifespan over previous approaches. The FL-EE-NC protocol performs better than other horizontal energy-efficient routing protocols in terms of network lifespan and energy consumption efficiency, according to research by Fathima et al. [10].

HajilooVakile and collaborators [11] use an efficient data compression method to address energy usage in WBAN. For medical data, a modified Huffman algorithm is used, which uses less energy than NIS. The authors of [12] suggest a wireless body area network's energy-efficient transmission power management that adjusts transmission power in response to base station feedback.

In [13], a cooperative routing method for wireless monitoring devices that balances energy efficiency and dependability is described. In order to achieve energy-efficient data delivery despite sacrificing link dependability, Zhao et al. [14] provide a green region-based routing algorithm for low-power sluggish networks (RPL).

In order to save energy via cooperative communication, a cooperative transmission technique for body-area nets (BANs) for health monitoring is proposed in [15]. With an energy-efficient directed algorithm that takes into account remaining energy metrics and anticipated transmission count (ETX), Chang et al. [16] enhance the RPL routing protocol (figure 2). The authors of [17] address problems like collision regulation and idle listening while proposing medium-range access management for WBAN in QoS provisioning an energy-efficient architecture.

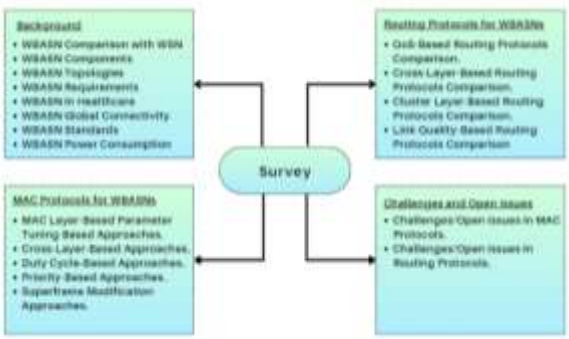

Figure 2: Technical Survey of The System

In [18], a body sensor network patient monitoring energy-efficient routing technique is presented. This algorithm solves a multi-objective optimisation issue for dependable and efficient data transfer. Anycast Q-routing in WSNs is suggested by Khianjoom et al. [19] for healthcare monitoring, effectively routing data to the closest sink.

In [20], an energy-efficient WBAN-based HMS solution is proposed, which minimises energy usage by carefully controlling packet transmission. Cloud-enabled body area wireless networks (WBANs) for ubiquitous healthcare are presented by Wan et al. [21], combining WBANs with smartphone cloud computing. Last but not least, [22] addresses problems using an ad hoc mode as a multipath routing method to improve the mobility of health care provider observation based on WBAN.

The literature study highlights the need for enhancements in conventional unicast routing protocols, especially for the unique needs of WBASN, and highlights the focus on energy saving methods in current systems. It is emphasised how a multipath route protocol might facilitate mobility in WBASN.

III. PROPOSED METHODOLOGY

We examine the architecture, stages, and essential elements of a new Region-Based Energy-Efficient Multi-path Routing (REMR) algorithm in detail, which makes it a viable option for mobile body area networks (WBANs) used for healthcare monitoring. The REMR algorithm uses smart clusters of nodes called Cluster Representatives (CRs) to deliver low-energy, dependable, and efficient routing. RFID technology is also used for improved security as energy efficiency [39].

Overview:

A strategic technique for routing with multiple paths in WBANs is introduced by the REMR algorithm, which is seen in Figure 1. The network is organised into clusters, each of which has a number of nodes acting as CRs. These CRs are essential for routing packets via different clusters and choosing the least energy-intensive routes. Cluster formation depending on energy levels at distances of the central station (BS).

Selection of Cluster Representatives:

As the central controller, the BS chooses CRs according to their energy and closeness. As intermediate clusters, several nodes are selected to provide different routes and use less energy during network propagate and route finding (figure 3). Energy efficiency is given priority in the algorithm's selection criteria, preventing too aggressive control signals.

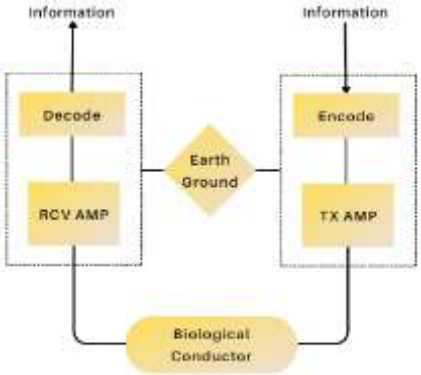

Figure 3: Workflow Methodology of The System

Using RFID to Improve Security:

Using RFID technology to improve security as well as energy efficiency is a key component of REMR. Each CR takes RFID signal strength into account in addition to distance and energy. RFID IDs are essential for organising data from nodes, tags, and sensors. Through the establishment of secure routes of communication and maintenance of data integrity, the RFID identifiers provide the BS with secret information.

RFID Tag and Identifier Administration:

RFID identifiers provide every tag a unique ID, making it easier to identify tags when they return to a given area. RFID IDs and the BS produce and exchange secret keys. The technique guarantees a system that is both efficient and safe, with RFID identifiers only exchanging minimum amounts of sensitive data with CRs. In the event of mobility, the distinct keys aid in the identification of tags through different RFID identifiers.

Reliability in Region Selection via Probabilistic Minimalism:

Probabilistic minimalism, or PM, is the foundation upon which the REMR algorithm selects trustworthy areas. The circular zone (Cr(x, y)) is prioritised over the round region (Re(x, y)) because it interacts with more tags and sensors, forming reliable relationships and facilitating energy-efficient routing. By balancing the consideration of both areas, the probabilistic minimalism method optimises for both dependability and energy efficiency.

Tracking using coordinates of x, y:

It proves to be a formidable challenge to precisely monitor the positioning of tags or nodes within Wireless Body Area Networks (WBANs). Therefore, the Region-Based Energy-effective Multipath Routing (REMR) algorithm strategically leverages Bayesian principles for inference. This innovative method enables the proactive anticipation of object positions by calculating joint probability distributions encompassing both x and y coordinates.

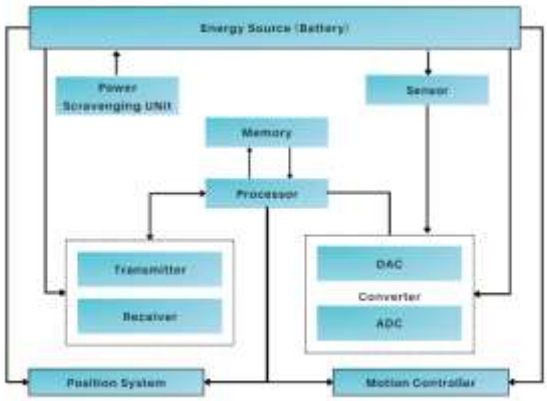

Figure 4: Implementation Of The System

The utilization of this advanced tracking technology significantly enhances the accuracy of data transfer and elevates the overall efficacy of medical surveillance systems. REMR, operating as the Region-Based Energy-effective Multipath Routing algorithm, represents a comprehensive paradigm for healthcare monitoring within wireless band networks (figure 4). It adeptly tackles critical issues related to energy consumption, reliability, and security by meticulously partitioning the network into clusters, selecting Cluster Heads (CRs) based on energy levels and distances, implementing Radio-Frequency Identification (RFID) technology to fortify security, and employing a probabilistic minimalism approach for region selection.

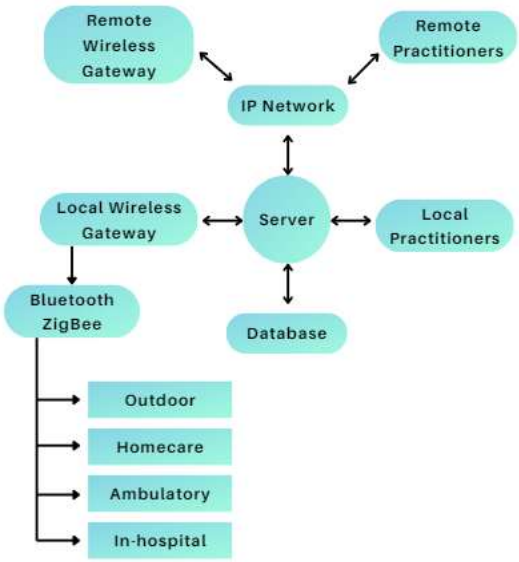

Figure 5: Working Methodology of The System

The algorithm unfolds in three distinct stages, ensuring a systematic approach to data transfer, route maintenance, and route discovery. In the context of the escalating reliance on wireless technology for healthcare monitoring (figure 5), REMR emerges as an inventive and distinctive solution for secure and efficient data routing in WBANs.

IV. RESULTS AND DISCUSSIONS

Setup for an Experiment

A clustered strategy was used to perform a series of experiments in NS3 to test the suggested REMR. In a wireless situation, two clusters were formed, and our method was evaluated with different settings in conjunction with the advertisement hoc on-demand displacement matrix (AODV) [23]. The simulation parameters used in the setting of the experiment are listed in Table 1. In order to demonstrate the innovation of the suggested region-based multipath navigation in conserving electricity via an enhanced overlay technique, AODV was selected for comparison investigation.

Outcomes

In the area of energy usage, the REMR fared better than the AODV. Notably, at one particular moment in the experiment, AODV kept using a substantial quantity of energy whereas REMR's energy usage stabilized.

V. CONCLUSION

VI. Wireless Physical Area Sensor Networks (WBASNs), which are linked to the Health Tracking System (HMS) and gather patient medical data, are essential to the healthcare industry. Despite their importance, there are obstacles to efficiently sending data between sites, which calls for the creation of a protocol for routing information that guarantees dependable data transfer while using the least amount of energy. The Region-Based Energy-Efficient Multi-path Routing Algorithm (REMR), a revolutionary multipath routing protocol, is presented in this study. Throughput, packet-delivery ratio, energy consumption, end-to-end latency, and throughput all surpass AODV according to comparative study.

VII. In an NS3 setup with a customised two-cluster architecture, the REMR protocol was tested. The dependability of REMR was repeatedly confirmed by the test findings, which came from several experiments. In order to improve outcomes even further, the suggested strategy will be extended in the future to include access control mechanisms and channel modelling. The purpose of this update is to make the REMR protocol more widely applicable in cases where WBASN connection with federated a cloudlet with Internet-of-things (IoT) architecture is involved.

REFERENCES

[1] Usman, M.; Qaraqe, M.; Asghar, M.R.; Ansari, I.S. Energy Efficient Wireless Body Area Networks: Proximity-based Clustering in Medical Implants. In Proceedings of the 8th IEEE International Conference on Communications and Networking (ComNet), Hammamet, Tunisia, 27–30 October 2020; pp. 1–5.

[2] Sun, G.; Luo, L.; Wang, K.; Yu, H. Toward Improving QoS and Energy Efficiency in Wireless Body Area Networks. IEEE Syst. J. 2021, 15, 865–876. [CrossRef]

[3] Samarji, N.; Salamah, M. ERQTM: Energy-Efficient Routing and QoS-Supported Traffic Management Scheme for SDWBANs. IEEE Sens. J. 2021, 21, 16328–16339. [CrossRef]

[4] Hussain, S.; Ullah, S.S.; Uddin, M.; Iqbal, J.; Chen, C.L. A comprehensive survey on signcryption security mechanisms in wireless body area networks. Sensors 2022, 22, 1072. [CrossRef]

[5] Rajawat, A.S.; Goyal, S.; Bedi, P.; Verma, C.; Safirescu, C.O.; Mihaltan, T.C. Sensors Energy Optimization for Renewable Energy-Based WBANs on Sporadic Elder Movements. Sensors 2022, 22, 5654. [CrossRef] [PubMed]

[6] Behera, T.M.; Samal, U.C.; Mohapatra, S.K.; Khan, M.S.; Appasani, B.; Bizon, N.; Thounthong, P. Energy-Efficient Routing Protocols for Wireless Sensor Networks: Architectures, Strategies, and Performance. Electronics 2022, 11, 2282. [CrossRef]

[7] Amjad, O.; Bedeer, E.; Abu Ali, N.; Ikki, S. Robust Energy Efficiency Optimization Algorithm for Health Monitoring System with Wireless Body Area Networks. IEEE Commun. Lett. 2020, 24, 1142–1145. [CrossRef]

[8] Liya, B.; Arun, S. Energy Efficient Data Aggregation in Wireless Ban Area Network Using Bee Swarm Optimisation. In Proceedings of the 7th IEEE International Conference for Convergence in Technology (I2CT), Mumbai, India, 7–9 April 2022; pp. 1–6.

[9] Hung, L.L.; Leu, F.Y.; Tsai, K.L.; Ko, C.Y. Energy-Efficient Cooperative Routing Scheme for Heterogeneous Wireless Sensor Networks. IEEE Access 2020, 8, 56321–56332. [CrossRef]

[10] Fathima Shemim, K.; Witkowski, U. Energy Efficient Clustering Protocols for WSN: Performance Analysis of FL-EE-NC with LEACH, K Means-LEACH, LEACH-FL and FL-EE/D using NS-2. In Proceedings of the 32nd International Conference on Microelectronics (ICM), Aqaba, Jordan, 14–17 December 2020; pp. 1–5.

[11] Alhussen, A., Vinoth, N., Jenis, M.R.A. et al. Development of Weighted Ensemble Deep Learning Network for Surface Roughness Prediction and Flank Wear Measurement. J. of Materi Eng and Perform (2024). https://doi.org/10.1007/s11665-024-09726-7

[12] J. Karthikeyan, S. Tong Chong, R. Vasanthan, N. T J, P. Shanmuga Sundari and V. C. Devi, "Construction and Implementation of English Translation Simulation Training Classroom Based on Deep Learning," 2023 Second International Conference On Smart Technologies For Smart Nation (SmartTechCon), Singapore, Singapore, 2023, pp. 716-719, doi: 10.1109/SmartTechCon57526.2023.10391666

[13] T. Vinoth, R. Arivalahan, K. Madhanamohan, V. Dilliganesh, A. Kannappan; A drowsiness detection using smart sensors during driving and smart message alert system to avoid accidents. AIP Conf. Proc. 3 October 2022; 2519 (1): 040015. https://doi.org/10.1063/5.0112049

[14] T. J. Nandhini and K. Thinakaran, "SIFT algorithm-based Object detection and tracking in the video image," 2023 Fifth International Conference on Electrical, Computer and Communication Technologies (ICECCT), Erode, India, 2023, pp. 1-4, doi: 10.1109/ICECCT56650.2023.10179720

[15] A Ambikapathy, Jyotiraditya Sandilya, Ankit Tiwari, Gajendra Singh, Lochan Varshney"Analysis of Object Following Robot Module Using Android, Arduino and Open CV, Raspberry Pi with OpenCV and Color Based Vision Recognition"Advances in Power Systems and Energy Management: Select Proceedings of ETAEERE 2020, 2021, 365-377, Springer singapore.

[16] A.Ambikapathy,Gajendra Signh and PrabhakarTiwari "Multi- level (13) inverter for Grid connected PV system with PID controller International journal of control theory and Applications, ISSN 0974-5572,vol 10, issue 6, 215-222, 2017.

[17] Aggarwal, A., Mittal, R., Gupta, S., Mittal, A. "Internet of things driven perceived value co-creation in smart cities of the future: a PLS-SEM based predictive model." Journal of Computational and Theoretical Nanoscience 16.9 (2019): 4053-4058.

[18] Singh, J.P., Chand, P.K., Mittal, A., Aggarwal, A. "High-performance work system and organizational citizenship behaviour at the shop floor." Benchmarking: An International Journal 27.4 (2020): 1369-1398.

[19] Shalender, Kumar, and Rajesh Kumar Yadav. "Strategic flexibility, manager personality, and firm performance: The case of Indian Automobile Industry." Global Journal of Flexible Systems Management 20 (2019): 77-90.

[20] Peng, Y.; Peng, L. A cooperative transmission strategy for body-area networks in healthcare systems. IEEE Access 2016, 4, 9155–9162. [CrossRef]

[21] Khianjoom, S.; Usaha, W. Anycast Q-routing in wireless sensor networks for healthcare monitoring. In Proceedings of the 11th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), Nakhon Ratchasima, Thailand, 14–17 May 2014; pp. 1–6.

[22] Huynh, D.T.; Chen, M. An energy efficiency solution for WBAN in healthcare monitoring system. In Proceedings of the 3rd International Conference on Systems and Informatics (ICSAI), Shanghai, China, 19–21 November 2016; pp. 685–690.

[23] Wan, J.; Zou, C.; Ullah, S.; Lai, C.F.; Zhou, M.; Wang, X. Cloud-enabled wireless body area networks for pervasive healthcare. IEEE Netw. 2013, 27, 56–61. [CrossRef]

[24] A Framework of AI and IoT-based Metaverse Technologies in Healthcare Domain

[25] Sindhusaranya, B., Yamini, R., Manimekalai Dr, M. A. P., & Geetha Dr, K. (2023). Federated Learning and Blockchain-Enabled Privacy-Preserving Healthcare 5.0 System: A Comprehensive Approach to Fraud Prevention and Security in IoMT. Journal of Internet Services and Information Security, 13(4), 199-209.