A Review Paper On Routing Algorithms Through Medium Access Control Protocols of WBAN

Saurabh Dhiman
Research Scholar
Saurabhdhiman0603@gmail.com
Universal Institute of Engineering and Technology
Lalru, Mohali

Ms. Shaveta Bala
Assistant Professor
Shavetabala@ugichd.edu.in
Universal Institute of Engineering and Technology
Lalru, Mohali

Abstract - WBAN is a category of short-range wireless network technology that consists of several miniature-sized intelligent sensor devices that can be implanted in a human's body or can be worn to monitor crucial physiological data Viz. electrocardiogram (ECG), heart rate, blood pressure, and temperature, without interfering with the normal daily activities. The data measured through the sensor devices are directed to a remote medical server, where the values and parameters measured can be analyzed, for evaluating the health status of patients for decision making purposes. Directed diffusion focuses on data centering and energy efficiency of the networks such as, scalability, network lifetime, security, and reliability with application-aware and in-network processing. Now, to improve the reliability & efficiency issues of the network appropriate gradient information such as the antenna selection criterion and local information interaction can balance the load on the network. The algorithm is designed to stay aware of the network status by getting information from MAC layer, selects the intermediate nodes from source to sink based on remaining energy in the node, buffer capacity, transmission delay, and link quality. This layer provides status information of link quality or transmission errors of communication links. All these information together provides a space to the network to decide and choose the best available route to propagate data to enhance network reliability as well as energy balancing reliably.

Keywords - WBAN, Energy Consumption, ECG, MAC layer

I. INTRODUCTION

Wireless Body Area Network (WBAN) has emerged as a viable solution in real time due to sophisticated radio technologies and sensor hardware mechanisms. WBAN has attracted more and more attention in recent years because of its strong economic implications in many applications such as dynamic sign monitoring, collaboration gaming and e-health. The configuration of a typical WBAN-based framework is shown in Figure 1.

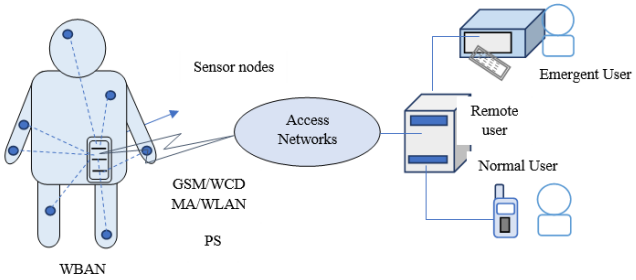

Fig. 1. General architecture of WBAN-based system

The WBAN consists of several wearable sensor motes and a Personal Server (PS) deployed on the human body. These nodes are usually arranged as a mobile network having star-topology as the coverage area of sensor motes is 2-3 meter. Therefore, sensor nodes attached to the body are capable to collect different types of physical information, and transmit them to the PS for display and processing. Personal server after detecting changes of monitoring contexts accordingly adjusts the quality of service (QoS) requirement of data transmission. On the other hand, main users such as physicians, and common people, like family members, can deliver a request to PS to replace the transfer necessitate in a proactive manner. Hence, WBAN architecture adopts the above-mentioned approach to fruitfully gather body area information without disrupting regular activities of folks.

1.1 Energy Consumption in WBAN

In the research area of WBAN, energy efficient approaches have drawn strong interest because sensor nodes needs to operate through the energy supplied in limited manner from a mini power source for example a tiny battery or an energy-harvesting architecture.The need for low energy of specific systems by virtue of the position of nodes can be implanted or equipped on the body and functions on the power-source for extended periods. Sometimes, it also uses the energy gathered from the surrounding environment. The wireless elements of a typical WSN node have been recognized to utilize the maximum portion of the energy stored in the system as the sensing data needs to be delivered wirelessly. Therefore, the largest proportion of research based on energy efficiency focuses on communication protocols that

are energy-saving. The basic objective of the Medium Access Control (MAC) protocol is to find the most optimally flexible solution of communication between sensor nodes with minimum usage of network resources due to communication between nodes. Flooding and gradient calculating consumes more power. if the transmission period of interest message takes long than load imbalance occurs and network lifetime is also reduced based on the current gradient information to achieve load balance by tracking the series of received 'information event' from different neighbors and to select a neighbor with highest priority in order to demand for path setup. It emphasizes on both MAC layer and transport layer. MAC-level reliability is essential to provide hop-by-hop error recovery for the transport layer, route discovery and maintenance.

1.2 Medium Access Control (MAC) Protocol

The radio frequency spectrum is distributed across frequency bands allocated to networking equipment. These frequencies can be implemented with time spread spectrum methods similar to frequency division multiple access (FDMA), code division multiple access (CDMA), time division multiple access (TDMA), and frequency skipping. Because of the disappearance of signal strength with remoteness, utilisation of similar resources at two places is possible, as long as there is a sufficient distance between them. The communication channel allocated in a communication system may be stationary or dynamic. In stationary mode, resources of a channel are shared over a particular link on permanent basis. In a device where multiple computing systems are interconnected wirelessly; sharing a channel across each system is quite unrealistic. Being a sub-layer of the data link of the Open Systems Interconnection (OSI) model, a major requirement of the MAC protocol is to identify and mediate access to the frame's boundaries or/and to a channel distributed by all network nodes.

The basic function of a main controller is to handle the channel for a centralized MAC protocol. Centralization makes it easier to control algorithms and designs, but it requires a star topology and generally includes more computational requirement and extra energy usage on the main controller. Mobile networks are a typical example of this scenario. On the contrary, every node in the network adopts the same approach, as they are independent of the main control from the base station; therefore, they may be suitable for communication in multiple hops. Multi-hop networks use the cluster control methods which replace the core controller's responsibility to neighbouring nodes, in order to share the additional energy used by the main controller within all sensing devices.

1.2.1 Energy Reduction Approaches in WBAN

Reducing energy consumption is a major concern in WBANS due to the limited energy of sensor nodes and extended duration of system functioning. One of the objectives of saving energy dissipation in MAC is to prolong the network service period and promote MAC protocol execution. To obtain this, various wake-up schemes, including asynchronous; Low Power Listening (LPL) or Synchronous (SYNC), Schedule Contention or TDMA are considered. All these approaches are explained in detail below:

A. Low Power listening technique: In this method, a node stays awake for minimal duration to scan for channel traffic and uses channel polling to test whether a node require to be awake for data transmission or not. This phenomenon results in reducing idle listening operation but when there is no noise in the channel. The nodes are either in a state of sleep or they can remain active to receive the data. This method is often activated and is devoid of any synchronization among nodes. The forwarding node uses a long preamble to scan the polling for the receiving node. Consequently, LPL, which is responsive to traffic levels, degrades network performance in conditions of greatly variable traffic rates including data bursts, although it is possible to optimize it efficiently for the recognized intermittent traffic rates. The main examples are Wise Mac, X-Mac and B-Mac.

i. The X-MAC leverages low energy listening like limited power transmission, ease and disruption of the RF transceiver break schedule. This protocol provides continuity of smaller initial packets: each data packet contains the receiver's address and remaining preambles. These preambles are transferred in a streamlined format at a pre-allotted time interval and the interval is enough to get a green signal from the receiver. The operation is performed rapidly at this phase to mitigate power exploited by both the sending node as well as the receiving node.

ii. Berkeley-MAC (B-MAC) uses rest/listening sequences where the node listens to the medium to transferthe packet arriving. In a case, where channel has no data to forward or there be an activity-free period, this is noticed by periodic checks by nodes with LPL method. To ensure that the received information is elapsed in time from its starting point, there is an inception time of 100ms which is added after waking up of the radio. Because all nodes are not able to transfer packets simultaneously, the rest time varies from one node to another. B-MAC does not have synchronization; instead whenever data needs to be sent the node switches to the radio state and begins forwarding a declaration. The declaration should be sufficient to

ensure that all nodes on the channel, regardless of mode, can pay attention to the signal. Afterward, the forwarding node sends the details to the receiving node, and begins packets' delivery.

iii. Wise MAC uses two communication channels: a data medium that uses TDMA and a control medium that uses Carrier Sensor Multiple Access (CSMA) to mitigate passive listening. The periodic preamble is responsible to notify the packet's receiver. If the node shows anoccupied channel, at that time it remains awake to receive the packet or goes in waiting mode until the channel is silent. The major advantage of LPL implemented in BAN is time-to-time sampling. It is useful for overflowing traffic and unscheduled traffic applications, but wearable nodes where periodic sampling depends on the energy of the power source; it becomes ineffective for less traffic. Also, the emergency traffic case is not prioritized.

B. Sensor-MAC: Sensor-Mac (S-Mac) is an example of a schedule contention MAC created to deal with the problem of wasting energy by listening and resting from time to time. When the node in lazy, it sometimes goes to sleep, which demands less energy than listening to the channel. This lowers the listening time through the means of sending the node to sleep state. In this sleep state, the sensor node must turn off its radio for saving energy. S-MAC protocol sends the synchronization data that synchronizes the sleep, wake and transmission of data packets with other nodes. The schedule includes SYNC sleeping between nearby sensing devices. A packet has a listening and sleeping period and begins with the wake time used in transferring the managed packet. This method reduces the idle listening time, applies sleep scheduling, and follows the same strategy for multi-hop WSNs. Schedule contention methods can work efficiently for body implanted systems but they do not provide a consistent measure for managing emergency traffic and demand-based events.

C. Timeout MAC and Proper MAC: T-MAC is organized into slots and on a schedule and is practically suitable for huge-traffic applications but the issue of falling asleep early can cause data loss, especially lengthy messages. In P-MAC, the system is in a hybrid state and its operation depends on listening where sluggish synchronization of sleep times causes delays in delicate systems.

D. TDMA MAC: A TDMA MAC protocol consists of the number of timeslots allocated by the main node (coordinative node) to different nodes in the network throughout network initialization. Nodes transfer and accept data from the main node within their stipulated time. Thereafter, it goes to sleep mode for the rest of the super frame: it differs from the contention scheme where nodes in the communication network remain clash-free throughout their neighbourhoods. This accomplishes effectual energy use to the extent that there is rigorous synchronization to remove timing coincidences. These timeslots are recurring in a continuous rotation called a frame: a typical example is the PB-TDMA protocol, where each TDMA frame contains a preamble, one for each individual node. There is a dedicated sub-slot and an information communication slot. The node is responsible for listening to the media during preamble and then interconnecting within the data transmission slot. These sub-slots are presented to activate the receiving node by transferring the receiving node ID of the outgoing packet. After receiving an acknowledgment from the receiving node, each node turns off its radio as there is no more data to forward .This technology removes redundant energy use of nodes. Whenever the node finds its ID in the preamble, otherwise, if the node has data to transfer, the radio is triggered.

Whenever a node moves it would be able to localize the gradient reconfiguration and could reconstruct its connection with the network. a gradient model is designed to considers residual energy of node and the numbers of hops from sink to an intermediate node, to decrease the network overhead, a mechanism is developed to make a moving node able to localize the gradient reconfiguration by messages exchange among its neighbours, and a performance analysis of gradient scheme for the increase of total number of nodes in the network. It claims an effective enhancement of directed diffusion which will provide much betterment. The scheme consists of four stages. First stage is the hierarchy construction of the nodes. In this stage, a node sends an interest message to all its neighbours. Unlike the directed diffusion, interest message will have an extra attribute named 'level'. This field is going to sort out which node is in which level. A node receiving an interest with a level N, will denote itself as in Nth level and will record the sender as its parent. Same process will go till the level N+2. Second stage is attribute establishment. In hierarchy, though there were several parents, a node will choose only one parent to transmit the real data. Unlike the directed diffusion, in this stage, this scheme is going to add an extra field in the exploratory data which will identify the data source. Third stage is the data aggregation. In this stage, the sink reinforces the interest to get the real data. With multiple sinks, each sink will have its own hierarchical tree with separate interest.

II. LITERATURE REVIEW

S. E. Pradha, et.al (2022) suggested an innovative EE (energy-efficient) MAC (Medium Access Control) protocol known asSAMAC (Scheduled Access MAC) for expanding the duration of network along with the QoS (Quality of Service) in WBAN. Castalia simulator was applied for evaluating and comparing the suggested protocol with regard to energy usage, PDR (packet delivery ratio) and E2E (end-to-end) delay. The simulation outcomes depicted the effectiveness of the suggested protocol over the traditional

protocols as it conserved the energy and QoS of WBAN (Wireless Body Area Network).

M. J. Khani, et.al (2020) introduced a compression method named UEELC (Ultra Energy Efficient Lossless Compression). This technique focused on transmitting least data to the BS (base station) that utilized least energy. For this, every input string was transformed into a shorter code via various phases. The initial phase was executed to convert every input string intothe ASCII equivalent of that string and to further transform the obtained ASCII code into its binary equivalent. The subsequent phase counted thenumber of zeros and ones in the resulting binary code to select amore optimal traverse. The final phase was executed to traverse thebinary code. The simulation outcomes demonstrated that the introduced method assisted in mitigating the energy utilized by the battery up to 2.7% in contrast to other techniques.

G. Mehmood, et.al (2020) developed an EEFT (energy-efficient fault-tolerant) system for making theWBAN (Wireless Body Area Network) more reliable. Thecooperative communication and network coding approach was implemented in this system for alleviating thechannel impairment and body fading effect. This resulted in diminishing theensued faults, BER (bit error rate), and energy usage. The developed system was considered to conduct a case study in order to monitor theremote Sepsis. Moreover, the cooperative communication was established to recognize thetracking indicators so that hospital re-admissions and death rates were lessened. Diverse parameters were considered to stimulate the developed system. The simulation results indicated that the developed system had potential for decreasing the energy usage, delay and BER which led to maximize thethroughput and reliability in network.

Q. Huang, et.al (2019) investigated a new routing algorithm called LBEE (load balance and energy efficient) that was adaptable to compute the cost value in accordance with the current traffic load and residual battery of the node. Furthermore, this algorithm was utilized to select routes having higher energy and lower load during the transmission of data and to balance the network load. The simulation results revealed that the investigated algorithm was efficient to enhance the overall life span of network, throughput and load sharing.

R. Zhang, et.al (2021) discussed about the SS (sleep scheduling) problem in EH-WBAN (Energy Harvesting-Wireless Body Area Network) for whichminimum DS (dominating set) was formulated. The method of saving the energy was integrated with the technique to harvest the energy with the objective of extending the duration of network. The NP-hardness of this issue was presented and 3 approximation algorithms were suggested for dealing with this issue. The centralized algorithm was presented in whichinformation regarding global network was utilized for discovering the maximum number of DSs and developing the minimum DS. The presented algorithm was quantified in simulation. The results validated the applicability of the presented algorithms in maximizing the duration of network and ensuring the network connectivity.

R. Zhang, et.al (2019) established a three-level SS (sleep scheduling) strategy for EH-WABNs (Energy Harvesting-Wireless Body Area Network). Initially, a sensor node was scheduled to diminish the number of sensors in an active sensor group. Subsequently, the active sensor groups were explored for executingthe alternate work in diverse frames to the maximum extent. Eventually, the level, to schedule an active sensor group, emphasized on assigning active sensor group to every frame. Moreover, the established strategy had generated a new route for mitigating the energy consumed in theEH-WBNAs.

Z. Ullah, et.al (2019) described that the major concern of WBAN (Wireless Body Area Network) technique was to utilize least energy. Thus, E-HARP (Energy-efficient Harvested-Aware clustering and cooperative Routing Protocol) was designed. To select a dynamic CH (cluster head), this protocol deployed a new multi-attribute-based method. The primary stage considered computed CF (cost factor) to choose optimum CH among the cluster members. The CF was computed on the basis of diverse metrics such as RE (residual energy) of SN (sensor node), communication link, SNR (signal-to-noise ratio) and entire energy loss. The next phase aimed at routing the datawith cooperative effort of the SN for saving the energy of node. For this, the forwarding of inadequate data packets was prohibited. NS-2 simulator was applied to conduct the experiments on the designed protocol. The experimental results exhibited that thedesigned protocol was effective to make the network stable, prolong the life span of network, mitigate the E2E (end-to-end) delay and maximize the PDR (packet delivery ratio).

W. Guo, et.al (2021) projected a KEH (kinetic energy harvesting) device for offering power for SNs (sensor nodes) and introduced an ELC (energy level classification) routing algorithm for optimizing the existence of the network, and enhancing the transmission reliability and energy efficiency. Various components such as RE (residual energy), transmission distance and link reliability of SN were utilized as the factors of the multi-objective optimal function. The projected device was implemented for adjusting theweights of these factors using the entropy method on the basis of the actual measured data. A comparative analysis was conducted on the projected device against the conventional algorithms. The results confirmed that the projected device was applicable for enhancing the duration of network and making the network energy effective.

A. T. Nururrahmah, et.al (2019) suggested a multi-hop technique with an adaptive process of selecting the forwarder nodes with the purpose of diminishing the energy consumed via node when thePDR (packet delivery ratio) was maintained. Castalia WBAN simulator, in which a realistic radio and energy model was utilized for the WBAN (Wireless Body Area Network) devices, was adopted to implement the suggested technique. The experimental outcomes demonstrated that the suggested technique outperformed the existing algorithms concerning PDR (packet delivery ratio) and energy utilization.

A. Umare, et.al (2018) discussed that the WBAN (Wireless Body Area Network) was suffered from the issue related to communicate the data effectively and the finite number of energy resources. Thus, a technique was intended for the optimization of the clustering based routing algorithm with the help of GA (Genetic Algorithm). This algorithm was useful for alleviating the energy consumed through the nodes and extending the life span of the network. The results validated the supremacy of the intended technique over the traditional algorithms as this technique prolonged the duration of network, diminish the energy utilization and maximize the throughput.

A. A. Ibrahim, et.al (2020) recommended a framework with a single BS (base station) for enhancing the way to manage the energy and QoS (Quality of Service) of the WBAN. Moreover, an algorithm was also constructed for classifying the sensed data asnormal, high-normal and critical. For this, MAC (Medium Access Control) protocol was implemented. The WEQ (Weighted Energy and QoS) algorithm was put forward for selecting the optimal path so that the normal and high normal data was forwarded. The OM Ne++ was utilized in the experimentation. The experimental results proved that the recommended framework was more efficient in comparison with others concerning duration of network and throughput.

X. Yuan, et.al (2020) introduced a TPOS (Two-Stage Potential Game based Computation Offloading Strategy) for optimizing the process of allocating the resource on the basis of task priorities and user priorities of WBANs. First of all, a system utility maximization issue related to the QoS of tasks was generated. After that, a two-stage optimization technique was deployed for dealing with the issue of mutual restriction strategies. For this, the computation complexity was lessened and the algorithm was made more feasible. The results revealed that the introducedapproach offered lower delay and consumed least energy even in heavy tasks and dense WBANs (Wireless Body Area Network) scenario.

III. CONCLUSION

WBAN is controlled by a personal server deployed on a home PC, handheld computer, smart phone, or housing gateway. This server carries out sensor fusion and first round scrutiny of physical data. This server gives graphical or audio interface to the client and sends acquired medical data to the medical server over the Internet or through the cellular network. WBAN technology confers two major benefits in contrast to the existing electronic patient monitoring frameworks. This algorithm is a better implementation of directed diffusion by saving 50% of transmission energy and it provides greater reliability. The major content which is published is based on the journals and some data is published in conferences. In future, novel approach will be proposed which improve performance of WBAN.

Future Work

The wireless body area network is the self-configuring nature due to which it has various issues like routing, security etc. In this paper various issues are reviewed which are related to routing, energy consumption, channel access etc. The author proposed various schemes to resolve issues of wireless body area network. Every technique which is proposed has its own drawbacks in terms of their outcomes. In future routing schemes needs to improve based on the reactive information. The future improvements will leads to reduction in energy consumption of the network.

IV. REFERENCES

[1]M. HajilooVakil, M. Javad Khani and Z. Shirmohammadi, "An Efficient Compression Method to Improve Energy Consumption in WBANs," 2021 7th International Conference on Web Research (ICWR), 2021, pp. 301-305

[2]N. K. Samra, R. Kaur and B. P. Kaur, "A Novel Approach for Energy Efficiency and Congestion Control in WBAN," 2019 6th International Conference on Computing for Sustainable Global Development (INDIACom), 2019

[3]A. R. Akash, M. Hossen, M. R. Hassan and M. I. Hossain, "Gateway Node-based Clustering Hierarchy for Improving Energy Efficiency of Wireless Body Area Networks," 2019 5th International Conference on Advances in Electrical Engineering (ICAEE), 2019, pp. 668-672

[4]S. Saha and D. K. Anvekar, "A poly_hop message routing approach through node and data classification for optimizing energy consumption and enhanced reliability in WBAN," 2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon), 2017, pp. 788-792

[5]M. Roy, C. Chowdhury and N. Aslam, "Designing an energy efficient WBAN routing protocol," 2017 9th

International Conference on Communication Systems and Networks (COMSNETS), 2017, pp. 298-305

[6]M. Salayma, A. Al-Dubai, I. Romdhani and Y. Nasser, "Reliability and Energy Efficiency Enhancement for Emergency-Aware Wireless Body Area Networks (WBANs)," in IEEE Transactions on Green Communications and Networking, vol. 2, no. 3, pp. 804-816, Sept. 2018

[7]Z. Hussain, H. Karvonen and J. Iinatti, "Energy efficiency evaluation of wake-up radio based MAC protocol for wireless body area networks," 2017 IEEE 17th International Conference on Ubiquitous Wireless Broadband (ICUWB), 2017, pp. 1-5

[8]Z. Askari, J. Abouei, M. Jaseemuddin and A. Anpalagan, "Energy-Efficient and Real-Time NOMA Scheduling in IoMT-Based Three-Tier WBANs," in IEEE Internet of Things Journal, vol. 8, no. 18, pp. 13975-13990, 15 Sept.15, 2021

[9]P. S. Ezhil and K. Selvaradjou, "Performance Evaluation of Energy Efficient MAC Protocol for Wireless Body Area Network," 2019 IEEE International Conference on System, Computation, Automation and Networking (ICSCAN), 2019, pp. 1-7

[10]B. Liu, Z. Yan and C. W. Chen, "Medium Access Control for Wireless Body Area Networks with QoS Provisioning and Energy Efficient Design," in IEEE Transactions on Mobile Computing, vol. 16, no. 2, pp. 422-434, 1 Feb. 2017

[11]O. Ahmed, F. Ren, A. Hawbani and Y. Al-Sharabi, "Energy Optimized Congestion Control-Based Temperature Aware Routing Algorithm for Software Defined Wireless Body Area Networks," in IEEE Access, vol. 8, pp. 41085-41099, 2020

[12]D. Chen and W. Chiu, "Collaborative Link-Aware Protocols for Energy-Efficient and QoS Wireless Body Area Networks Using Integrated Sensors," in IEEE Internet of Things Journal, vol. 5, no. 1, pp. 132-149, Feb. 2018

[13]A. Samanta and S. Misra, "Energy-Efficient and Distributed Network Management Cost Minimization in Opportunistic Wireless Body Area Networks," in IEEE Transactions on Mobile Computing, vol. 17, no. 2, pp. 376-389, 1 Feb. 2018

[14]M. Dakhel and S. Hassan, "Stable High-throughput Energy Efficiency Reliable Protocol for Wireless Body Area Networks," 2019 2nd Scientific Conference of Computer Sciences (SCCS), 2019, pp. 32-37

[15]K. Kour and S. Singh, "A Hybrid Routing Algorithm for WBAN," 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), 2021, pp. 1756-1763

[16]D. Fernandes, A. G. Ferreira, R. Abrishambaf, J. Mendes and J. Cabral, "A Low Traffic Overhead Transmission Power Control for Wireless Body Area Networks," in IEEE Sensors Journal, vol. 18, no. 3, pp. 1301-1313, 1 Feb.1, 2018

[17]D. Chen and P. Wang, "Context-Aware Optimization for Energy-Efficient and QoS Wireless Body Area Networks with Human Dynamics," 2018 26th Euromicro International Conference on Parallel, Distributed and Network-based Processing (PDP), 2018, pp. 53-59

[18]A. K. Ojelade, A. A. Ibrahim and O. Ata, "Efficient Energy and QoS Based Routing Algorithm for Wireless Body Area Network," 2021 5th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), 2021, pp. 110-115

[19]K. Masroor, V. Jeoti and M. Drieberg, "Improving the Energy Efficiency of a Wireless Body Area Network Using a Redundant Coordinator for Healthcare Applications," 2018 International Conference on Intelligent and Advanced System (ICIAS), 2018, pp. 1-5

[20]A. S. Abiodun, M. H. Anisi, I. Ali, A. Akhunzada and M. K. Khan, "Reducing Power Consumption in Wireless Body Area Networks: A Novel Data Segregation and Classification Technique," in IEEE Consumer Electronics Magazine, vol. 6, no. 4, pp. 38-47, Oct. 2017

[21]R. Singla, N. Kaur, D. Koundal, S. A. Lashari, S. Bhatia and M. K. Imam Rahmani, "Optimized Energy Efficient Secure Routing Protocol for Wireless Body Area Network," in IEEE Access, vol. 9, pp. 116745-116759, 2021

[22]F. Ullah, A. H. Abdullah, M. M. Arshad and K. N. Qureshi, "Energy efficient and delay-aware adaptive slot allocation medium access control protocol for Wireless Body Area Network," 2017 5th International Conference on Information and Communication Technology (ICoIC7), 2017, pp. 1-6

[23]S. Singh, D. Prasad, “Wireless body area network (WBAN): A review of schemes and protocols”, in Materials Today, vol. 5, no. 1, pp. 751-759, June, 2021

[24] S. E. Pradha, A. Moshika, B. Natarajan, K. Andal, G. Sambasivam and M. Shanmugam, "Scheduled Access Strategy for Improving Sensor Node Battery Life Time and

Delay Analysis of Wireless Body Area Network," in IEEE Access, vol. 10, pp. 3459-3468, 2022

[25] M. J. Khani and Z. Shirmohammadi, "UEELC: An Ultra Energy Efficient Lossless Compression Method for Wireless Body Area Networks," 2020 6th Iranian Conference on Signal Processing and Intelligent Systems (ICSPIS), 2020, pp. 1-7

[26] G. Mehmood, M. Z. Khan, S. Abbas, M. Faisal and H. U. Rahman, "An Energy-Efficient and Cooperative Fault-Tolerant Communication Approach for Wireless Body Area Network," in IEEE Access, vol. 8, pp. 69134-69147, 2020

[27] Q. Huang, J. Tan and W. Jiang, "A New Load Balancing Routing Scheme for Wireless Body Area Networks," 2019 IEEE 3rd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), 2019, pp. 866-870

[28] R. Zhang, J. Yu, Y. Guan and J. Liu, "A Dominating Set-Based Sleep Scheduling in Energy Harvesting WBANs," in IEEE Transactions on Vehicular Technology, vol. 70, no. 11, pp. 11923-11934, Nov. 2021

[29] R. Zhang, A. Nayak and J. Yu, "Sleep Scheduling in Energy Harvesting Wireless Body Area Networks," in IEEE Communications Magazine, vol. 57, no. 2, pp. 95-101, February 2019

[30] Z. Ullah et al., "Energy-Efficient Harvested-Aware Clustering and Cooperative Routing Protocol for WBAN (E-HARP)," in IEEE Access, vol. 7, pp. 100036-100050, 2019

[31] W. Guo, Z. Tang, W. Guo and T. Lu, "Efficient Routing Protocol Based on Entropy Method for WBAN with Kinetic Energy Harvesting," 2021 IEEE 4th International Conference on Electronics Technology (ICET), 2021, pp. 1115-1120

[32] A. T. Nururrahmah and W. Wibisono, "An Adaptive Multi-hop Forwarding Approach for Energy-Efficiency Communication for Wireless Body Area Networks (WBAN)," 2019 2nd International Conference of Computer and Informatics Engineering (IC2IE), 2019, pp. 99-103

[33] A. Umare and P. Ghare, "Optimization of Routing Algorithm for WBAN Using Genetic Approach," 2018 9th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2018, pp. 1-6

[34] A. A. Ibrahim, O. Bayat, O. N. Ucan and S. Salisu, "Weighted Energy and QoS based Multi-hop Transmission Routing Algorithm for WBAN," 2020 6th International Engineering Conference “Sustainable Technology and Development" (IEC), 2020

[35] X. Yuan, H. Tian, H. Wang, H. Su, J. Liu and A. Taherkordi, "Edge-Enabled WBANs for Efficient QoS Provisioning Healthcare Monitoring: A Two-Stage Potential Game-Based Computation Offloading Strategy," in IEEE Access, vol. 8, pp. 92718-92730, 2020