JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 4879-4887
https://publishoa.com
ISSN: 1309-3452

Survey of Energy-Efficient Routing Protocol for Managing Data Quality in Wireless Body Area Networks

Hiba A. Tarish [1, a)], Alaa Q. Raheema[1, b)] and Mostafa Musa Jaber [2, c)]

[1]*Civil Engineering Department,University of Technology,Baghdad, Iraq.*

[2]*Medical Instruments Engineering Techniques,AL-Frarahidi University , Baghdad,10021,Iraq*

[a)]Correspondingauthor:*hiba.A.tarish@uotechnology.edu.iq*
[b)] *40345@uotechnology.edu.iq*

[c)] *mustafa.musa@duc.edu.iq*

Received 2022 March 15; **Revised** 2022 April 20; **Accepted** 2022 May 10.

Abstract. In wireless body area networks, wearable devices are used to make the medical data transmission process help avoid emergencies. The gathered medical data need to be transmitted in a quality manner because it consists of several critical and emergency information. The data transmission is influenced by several intermediated attackers, which damages the data quality and causes security issues. So, this paper analyses the different author's works, opinions, and frameworks to get the knowledge for effective data transmission process in body area networks. The optimised data transmission process checks several quality factors like transmission time, energy, and path. According to these factors, several discussions are performed to reduce the delay, maintain network quality, and maintain network lifetime. The advantages and disadvantages of various routing protocols are discussed to finalise the efficiency of the existing research methods.

Keywords: Wireless body area network, Low energy, Routing protocol, Data transmission, Data quality.

INTRODUCTION

Wireless body area networks (WBAN) [1] have several elements such as actuators, nodes, and sensors designed to place on the human body to capture their health information. The WBAN elements are resistant to interference, reliable, low energy consumption, and able to transmit the data at high speed [2]. Initially, the sensor devices were designed at the Massachusetts Institute of Technology with respective hypothesis settings. Later, the devices are designed to transmit the data by increasing the bandwidth and minimising the energy consumption and computation prices. The WBAN utilises the IEEE 802.15.6 technologies [3] that share the data using short-range wireless devices to communicate effectively. This wireless technology device transfers the data nearer to the human body. Communication is performed in two ways such as in-body and out-body communication [4]. In-body contact [5], sensor devices are placed inside the human body, a medical implant communication system. The on-body communication [6] is created between the wearable devices composed of several sensor nodes. The Ultra-wideband (UWB) [7] and industrial scientific and medical (ISM) [8] communication is performed via the on-body communication process. Then the various WBAN network architecture is illustrated in figure 1.

The WBAN network is created by various power resources, processing units, and memory power to communicate effectively. The designed sensor network batteries are limited from small to high because they should consume minimum energy to maintain the network lifetime [9]. Wearable devices are widely utilised in medical applications, and several sensitive information is transferred. Therefore, network lifetime should manage to reduce unwanted information loss. The network should satisfy low power, self-healing, interoperability, low latency, and security for every wireless communication [10]. These factors are incorporated by developing an effective WBAN architecture. The structure consists of the WBAN part, central control unit (CCU), and Communication and control centre. Each piece belongs to the health data [11] collection and transmission process. The WBAN part composes several sensor nodes that collect the data by satisfying the mobility factor widely utilised in patient monitoring. The gathered health information was

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 4879-4887
https://publishoa.com
ISSN: 1309-3452
coordinated with the CCU to transmit the data to the health centre. During the communication process, gateways are used to reach the destination. The gathered data stored for future use in the control centres enhance decision-making.

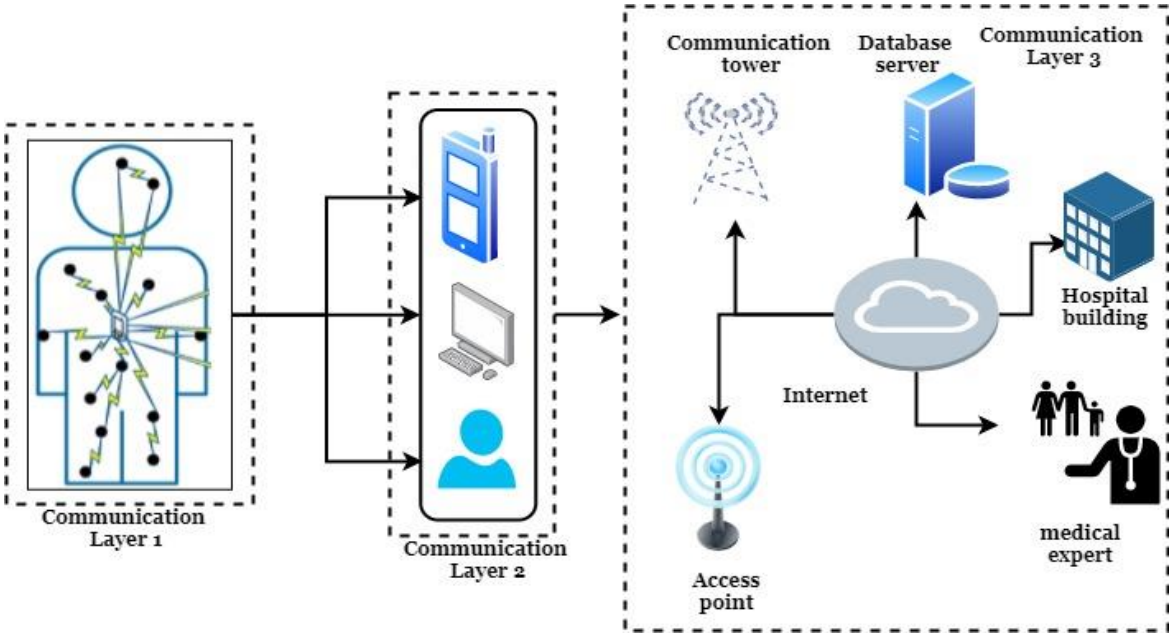

FIGURE 1: WBAN network architecture.

The transmitted data should be responsible for making the clinical analysis and decision. Therefore, the data quality should be maintained until complete data transmissions [12]. The data quality and originality are maintained by examining each node, energy level, and selected optimised paths. The selected routes [13] are responsible for accomplishing this task. Exiting techniques effectively work on data transmission, although network overheads and transmission delays are still significant. Therefore, this study analyses various researchers' opinions, frameworks, existing methodologies, and templates to understand the routing protocols in the body area networks. The researchers utilisedifferent methods, including clustering, neighbouring node, and geographical location identification processes. These analyses are more helpful in understanding the clear view of an effective data transmission process with minimum computation complexity.Then the rest of the paper is organised as follows; section 1 discusses the general discussion of wireless body area networks and their research gaps. Section 2 analyses the various researchers' opinions, studies, methodologies, and frameworks to understand the effective routing protocols with respective advantages and disadvantages. Section 3 summarises the overall work.

SURVEY OF VARIOUS ROUTING PROTOCOLS IN SENSOR NETWORKS

Elhoseny et al., 2020 [14] apply the intelligent energy-efficient multihop clustering routing protocol for transmitting data in sensor networks. This paper manages the battery, computation power, transmission bandwidth, and storage while transferring data. These issues are solved by applying the particle swarm optimisation method and selecting the clustering centre. According to the cluster head, a route has been detected by examining the node energy level, and this process helps maintain the network lifetime and energy level.

Qu et al., 2019 [15] create reliable data transmission process using an energy-efficient routing protocol in body sensor networks. This system intends to solve the multihop routing and energy consumption issues. The transmission process uses efficient bandwidth and residual energy parameters to maintain data quality. The next hop is selected according to these parameters to improve the overall data transmission efficiency.

Kaur et al., 2017 [16] recommend cost and anenergy-effective routing protocol to improve the data transmission in sensor networks. This work uses the genetic algorithm with protocol to solve the multi-objective cost optimisation problem. The selection of nodes and genetic operator performance effectively minimises path loss and reliability issues. Further, the data transmission is improved by computing the distance between the sensor nodes, and the computation identifies the shortest path between source and destination with minimum energy consumption.

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 4879-4887
https://publishoa.com
ISSN: 1309-3452

Fu et al., 2020 [17] discuss the fusion multipath routing protocol to broadcast data in the sensor networks. The main aim of this system is to manage the harsh environment and routing survivability issues by applying an effective routing protocol. The data transmission decisions are handled according to the residual network energy and representing the environment, and these parameters help minimise latency, high energy consumption, and survivability. In addition to this, the selected path can transmit the emergency data in anoptimised manner.

Hassan et al., 2017 [18] introduce cloud technologies in sensor networks for effective data sharing in healthcare systems. The network uses the perception, network, cloud computing and application layers to broadcast the information. A content-centric network is integrated with this process to improve data transmission ability. This process minimises packet loss and improves the data transmission rate.

Peng et al., 2017 [19] introduce a chaotic compressive sensing approach to resolve sensor networks' security and energy-saving problem. This process uses the matrix generation process that maintains the data security and saves the storage for further transmission. In addition, the method ensures the quality and feasibility and maintains the energy. This system ensures the minimum 10-16 sensitive and relative error rates while encrypting and decrypting the data.

Samanta et al., 2018 [20]analysed cooperative scheduling of the dynamic connectivity in body sensor networks to manage the data quality. This system intends to reduce traffic overload and maximise throughput while transmitting data. The scheduling protocol can address the quality of services and connectivity problems by investigating the path and link reliability. In addition, the game-theoretic algorithm is incorporated into the scheduling process to enhance the QoS services.

Kiani et al., 2017 [21] apply a reinforcement routing algorithm to broadcast the data in the wireless sensor networks. The collected health information is transmitted to the destination by computing the best route from source to destination. Here, a clustering algorithm is applied to form the clusters to predict the shortest route in 1000*1000 meters with 600 simulation time.

Shen et al., 2017 [22] introduced the centroid-related routing protocol to transmit IoT data in sensor networks by managing energy factors. This system aims to maintain robustness and network lifetime by forming effective clusters. The clusters are created by analysing local nodes, and the cluster centres are chosen in a rotating manner. Afterwards, cluster members are adapted to the cluster head to reduce energy consumption. This process helps manage the network characteristics while transmitting data long-distance.

A reliable, energy and stable network for wireless body area sensor networks is suggested in [31]. Two of the eight sensor nodes employed are recording crucial data. These two sensors deliver data directly to the sink instead of participating in multi-hopping. Six new sensors are calculated to function as a forwarder node. After aggregating the sensor data, forwarder nodes deliver it to the sink. Multi-hopping is used to shorten data transfer distances and store energy.

Amjad et al., 2017[23] recommend a clustering routing protocol to manage the QoS in sensor networks. This system overcomes the delay, time-critical, bandwidth and QoS issues while transmitting data in the sensor networks. The heterogeneously clustering algorithm decides the paths for standard and critical data by examining the energy level and node characteristics. This process minimises the delay and effectively manages the network stability. In addition to these methods, several researchers focus on the supervised and unsupervised techniques [24], [25], [26] [27],[28],[29] and [30] to improve the overall data transmission in sensor networks. The way of utilising machine learning techniques in wireless body sensor networks is illustrated in figure 2.

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 4879-4887
https://publishoa.com
ISSN: 1309-3452

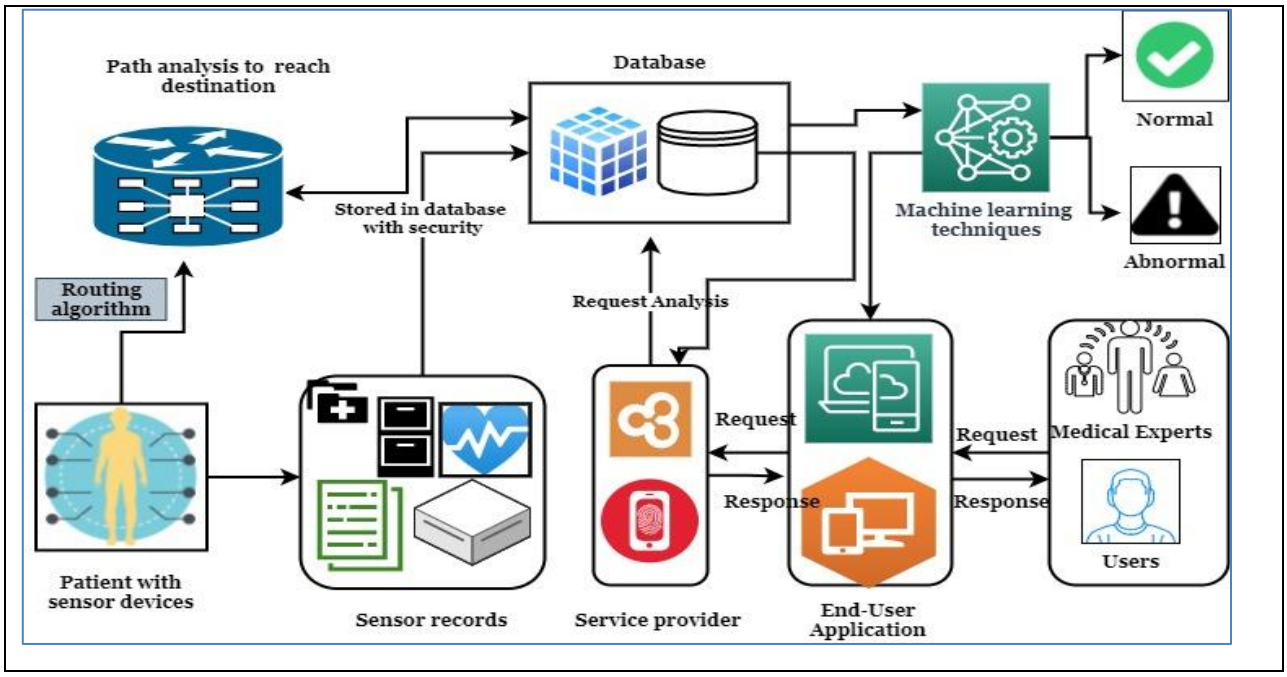

FIGURE 2: Machine learning techniques influenced in wireless sensor networks.

TABLE 1: Summary of quality data transmission in wireless body area networks.

S. No	Author	Method	Addressed Problem definition	Dataset/ Tools	Efficiency	Advantages	Limitations
1	Elhoseny et al., 2020 [14]	Intelligent Energy-Efficient Multihop Clustering Routing Protocol	Failure to consider the transmission bandwidth and storage while transferring data.	NS-2	Ability to transfer data to 2056 rounds	The system can maintain the maximum residual energy and enhance the network lifetime	Formulation cluster head consumes high computation time
2	Qu et al., 2019 [15]	energy-efficient routing protocol	Addressing the multihop routing and energy-efficient problem	NS2	More than 90%	Manage the reliability of data transmission and minimise the high energy consumption	Limited data quality while transmitting priority data
3	Kaur et al., 2017 [16]	Geneticallyoptimised cost and energy-effective routing protocol	Fails to concentrate on multi-objective cost problems	NS2	83.7% to 94.7%	Reliability and shortest path detection are performed with minimum computation complexities	We need to concentrate on network cross-layer interactions and accountability in the complex scenario
4	Fu et al.,	Environment	Difficult to address	Matlab	Average	Improves the	Only

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 4879-4887
https://publishoa.com
ISSN: 1309-3452

	2019 [17]	-fusion multihop routing protocol	the harsh environment data transmission	simulator	network degree=6.2 and the selected optimal number of paths =3	packet delivery rate, reduces the latency and high energy consumption in a harsh environment	theoretical analysis is handled; it needs to create an effective decision-making model to improve the data transmission.
5	Hassan et al., 2017 [18]	Content-centering network with cloud sensor routing protocol	Quality requirements and flexibility issues fail to address	OPNET simulator	Saves network lifetime up to 75%	Managing data quality and security and improving the packet delivery rate.	The scalability of the network system needs to be addressed
6	Peng et al., 2017 [19]	chaotic compressive sensing	Addressing the security and energy factor issues	Matlab	10^{-16} sensitive and minimum relative error rate	Ensuring the data security and minimum energy consumption while transmitting data	Mobility and scalability of the system should manage in a different scenario.
7	Samanta et al., 2018 [20]	A game theoretic-based cooperative scheduling algorithm	Addressing the quality of services and connectivity problem	Matlab	-	Able to maximise the network throughput and minimise the network overload effectively.	Fails to consider the link quality dynamic behaviour, security and privacy issues should be considered.
8	Kiani et al., 2017 [21]	The clustering-based reinforcement routing algorithm	Minimising data transmission time and improving the packet delivery rate	Matlab	-	It reduces the packet delivery time and delays with minimum energy consumption	Reliability and consistency should be improved.
9	Shen et al., 2017 [22]	A centroid-related energy-	Fail to address the protocol robustness and network	NS-2	Ability to sustain 720 rounds with	Consuming low energy while	Failure to concentrate on the

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 4879-4887
https://publishoa.com
ISSN: 1309-3452

		efficient routing algorithm	lifetime		the maximum delivery rate	transmitting data ata long distance also ensure a high packet delivery rate.	multihop routing protocol
10	Amjad et al., 2017[23]	heterogeneously clustering routing algorithm	Needs to overcome the network stability and sensitive delay issues	Matlab	2750 rounds are processed and sustain maximum energy level	Minimise the delay sensitivity, tolerance in a critical situation, balancing load and flexibility.	Need to support the energy harvesting feature to improve the network lifetime.
11	Mosavvar et al., 2019 [24]	Fireflies algorithm with the cluster-based routing algorithm	Consuming more power and reducing network lifetime	Matlab	-	Reducing the communication overhead and increasing the packet delivery rate	Failure to concentrate on heterogeneous-based sensor networks.
12	Muzammal et al., 2020 [25]	Data fusion-based ensemble approach	Inconsistency results in health data analysis	Matlab	98% of accuracy	Ensures the quality and reliability of data analysis	Multi-objective optimisation and errorclassification is still challenging task.
13	Kumar et al. 2021 [26]	Improved Satin Bowerbird Optimization - deep convolution neural networks	Difficulties in false information and adversary detail identification	Matlab	-	Maintains the residual energy and successfully detects the false information	Complexity while solving a multi-objective problem
14	Alarifi et al., 2019 [27]	Adaptive neural network	Energy consumption and data gathering accuracy are still a significant issue	NS2	Delay-8.44m, Residual energy-51.15% higher, lifetime-29.27% higher, request failure-0.08	Minimise the node failure and path loss and effectively maintain the residual network energy.	Need to concentrate on the network overheads and apply an effective learning process to improve the

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 4879-4887
https://publishoa.com
ISSN: 1309-3452

							network lifetime further.
15	Belavadi et al., 2020 [28]	Long short term-recurrent neural networks	Difficult to maintain scalability while transferring air quality data in sensor networks	Matlab	Detection accuracy improved up to 20%	Maximise the scalability and improve the detection rate	Sensitive data analysis should require additional efforts
16	Ayadi et al., 2017 [29]	Outlier detection techniques	Fails to concentrate on features selection approach in outlier detection	Matlab	-	Maximum detection accuracy	Reliability and consistency should be improved
17	Bangotra et al., 2020 [30]	Intelligent opportunity routing protocol	Difficulties in selecting relay nodes	Matlab	-	Effectively maintains the residual energy by selecting optimised relay nodes	Secure data transactions must be incorporated

PROBLEM DEFINITION

The researcher's analysis shows that wireless sensor networks are effectively involved in different applications like medical, battle, remote patient monitoring etc. During the data collection and transmission process, the system phases several difficulties like security, reliability, consistency, accuracy, flexibility, scalability, packet loss, delivery rate, latency etc. The researchers introduced various methodologies such as clustering approaches, routing protocols, neural networks, and energy management techniques.

However, the wireless sensor system should consider the following issues before creating the sensor-based data collection and transmission process.

- To maximise the data transmission rate and residual energy management process.
- To minimise the latency and packet loss rate while transmitting data
- To reduce the network overhead and control overheads.
- To manage the data security and trust while broadcasting data to the third party
- Manage the network lifetime to sustain the network reliability and scalability.

CONCLUSION

Thus, the paper analyzing the various researcher's opinions, surveys, methodologies, frameworks and processing methodologies in wireless sensor networks. The researchers use the routing methodologies that help to identify the shortest path between source and destination with minimum computation complexity. In addition, clustering methodologies are introduced to reduce energy consumption while broadcasting data. Along with this, machine learning techniques are discussed to ensure the abnormal or anomaly data involvement in the sensor data collection and process. In addition, security techniques are discussed to manage the sensitive information and trust between the service requester and provider in sensor networks. Therefore, this study helps to understand the advantages and disadvantages

of each method to improve further research analysis. In future, an improved algorithm has been proposed to reduce the delay, maintain network quality, and maintain network lifetime.

REFERENCES

1. Hasan, Khalid, Kamanashis Biswas, Khandakar Ahmed, Nazmus S. Nafi, and MdSaiful Islam. "A comprehensive review of wireless body area network." Journal of Network and Computer Applications 143 (2019): 178-198.
2. Ghias, Zohreh, and Avid Avokh. "Towards energy-and interference-aware health monitoring by using WBANs in medicine services." Biomedical Signal Processing and Control 73 (2022): 103403.
3. Cicioğlu, Murtaza, and Ali Calhan. "Performance analysis of IEEE 802.15. 6 for underground disaster cases." Computer Standards & Interfaces 66 (2019): 103364.
4. Zeinelabedeen, Wael, and RasimeUyguroglu. "A study on health care monitoring of femoral shaft fracture healing by using implanted antenna for wireless in-to-out body channel communication." Journal of Electromagnetic Waves and Applications (2021): 1-21.
5. Vasisht, Deepak, Guo Zhang, Omid Abari, Hsiao-Ming Lu, Jacob Flanz, and Dina Katabi. "In-body backscatter communication and localisation." In Proceedings of the 2018 Conference of the ACM Special Interest Group on Data Communication, pp. 132-146. 2018.
6. Benaissa, Said, LeenVerloock, Denys Nikolayev, Margot Deruyck, Gunter Vermeeren, Luc Martens, F. A. M. Tuyttens, Bart Sonck, David Plets, and Wout Joseph. "Joint Antenna-Channel Modelling for in-to-out-Body Propagation of Dairy Cows at 868 MHz." In 2020 14th European Conference on Antennas and Propagation (EuCAP), pp. 1-4. IEEE, 2020.
7. Lituma-Guartan, Rafael A., Josue B. Benavides-Aucapiña, Danilo F. Poveda-Pulla, Luis F. Guerrero-Vasquez, and Paul A. Chasi-Pesantez. "A novel Hybrid fractal antenna design for ultra-wideband application." In 2018 IEEE 10th Latin-American Conference on Communications (LATINCOM), pp. 1-5. IEEE, 2018.
8. Sanchez-Montero, Rocio, Pablo-Luis Lopez-Espi, Cristina Alen-Cordero, and Juan-Antonio Martinez-Rojas. "Bend and moisture effects on the performance of a U-shaped slotted wearable antenna for off-body communications in an Industrial Scientific Medical (ISM) 2.4 GHz band." Sensors 19, no. 8 (2019): 1804.
9. Liu, Xiaoming, Yu Guo, Wen Li, Min Hua, and Enjie Ding. "A complete feasible and nodes-grouped scheduling algorithm for wireless rechargeable sensor networks in tunnels." Sensors 18, no. 10 (2018): 3410.
10. Montori, Federico, Luca Bedogni, Marco Di Felice, and Luciano Bononi. "Machine-to-machine wireless communication technologies for the Internet of Things: Taxonomy, comparison and open issues." Pervasive and Mobile Computing 50 (2018): 56-81.
11. Abidi, Bahae, AbdelillahJilbab, and El Haziti Mohamed. "Wireless body area network for health monitoring." Journal of medical engineering & technology 43, no. 2 (2019): 124-132.
12. Thabit, Ahmed A., Mahmoud Shuker Mahmoud, Ahmed Alkhayyat, and Qammer H. Abbasi. "Energy harvesting Internet of Things health-based paradigm: Towards outage probability reduction through inter–wireless body area network cooperation." International Journal of Distributed Sensor Networks 15, no. 10 (2019): 1550147719879870.
13. Khanna, Aakriti, Vaibhav Chaudhary, and Sindhu Hak Gupta. "Design and analysis of energy efficient wireless body area network (WBAN) for health monitoring." In Transactions on computational science XXXIII, pp. 25-39. Springer, Berlin, Heidelberg, 2018.
14. Elhoseny, Mohamed, R. SundarRajan, Mohammad Hammoudeh, K. Shankar, and Omar Aldabbas. "Swarm intelligence–based energy efficient clustering with multihop routing protocol for sustainable wireless sensor networks." International Journal of Distributed Sensor Networks 16, no. 9 (2020): 1550147720949133.
15. Qu, Yating, Guoqiang Zheng, Honghai Wu, Baofeng Ji, and Huahong Ma. "An energy-efficient routing protocol for reliable data transmission in wireless body area networks." Sensors 19, no. 19 (2019): 4238.
16. Kaur, Navneet, and Sukhwinder Singh. "Optimised cost effective and energy efficient routing protocol for wireless body area networks." Ad Hoc Networks 61 (2017): 65-84.
17. Fu, Xiuwen, Giancarlo Fortino, Pasquale Pace, GianlucaAloi, and Wenfeng Li. "Environment-fusion multipath routing protocol for wireless sensor networks." Information Fusion 53 (2020): 4-19.
18. Hassan, Mohammad Mehedi, Kai Lin, Xuejun Yue, and Jiafu Wan. "A multimedia healthcare data sharing approach through cloud-based body area network." Future Generation Computer Systems 66 (2017): 48-58.

19. Peng, Haipeng, Ye Tian, Jürgen Kurths, Lixiang Li, Yixian Yang, and Daoshun Wang. "Secure and energy-efficient data transmission system based on chaotic compressive sensing in body-to-body networks." IEEE transactions on biomedical circuits and systems 11, no. 3 (2017): 558-573.
20. Samanta, Amit, and SudipMisra. "Dynamic connectivity establishment and cooperative scheduling for QoS-aware wireless body area networks." IEEE Transactions on Mobile Computing 17, no. 12 (2018): 2775-2788.
21. Kiani, Farzad. "Reinforcement learning based routing protocol for wireless body sensor networks." In 2017 IEEE 7th international symposium on cloud and service computing (SC2), pp. 71-78. IEEE, 2017.
22. Shen, Jian, Anxi Wang, Chen Wang, Patrick CK Hung, and Chin-Feng Lai. "An efficient centroid-based routing protocol for energy management in WSN-assisted IoT." Ieee Access 5 (2017): 18469-18479.
23. Amjad, Muhammad, Muhammad Khalil Afzal, Tariq Umer, and Byung-Seo Kim. "QoS-aware and heterogeneously clustered routing protocol for wireless sensor networks." IEEE Access 5 (2017): 10250-10262.
24. Mosavvar, Islam, and Ali Ghaffari. "Data aggregation in wireless sensor networks using firefly algorithm." Wireless Personal Communications 104, no. 1 (2019): 307-324.
25. Muzammal, Muhammad, RomanaTalat, Ali Hassan Sodhro, and Sandeep Pirbhulal. "A multi-sensor data fusion enabled ensemble approach for medical data from body sensor networks." Information Fusion 53 (2020): 155-164.
26. Kumar, Mohit, Priya Mukherjee, KavitaVerma, SahilVerma, and Danda B. Rawat. "Improved Deep Convolutional Neural Network based Malicious Node Detection and Energy-Efficient Data Transmission in Wireless Sensor Networks." IEEE Transactions on Network Science and Engineering (2021).
27. Alarifi, Abdulaziz, and Amr Tolba. "Optimising the network energy of cloud assisted internet of things by using the adaptive neural learning approach in wireless sensor networks." Computers in Industry 106 (2019): 133-141.
28. Belavadi, Sagar V., SreenidhiRajagopal, R. Ranjani, and Rajasekar Mohan. "Air quality forecasting using LSTM RNN and wireless sensor networks." Procedia Computer Science 170 (2020): 241-248.
29. Ayadi, Aya, OussamaGhorbel, Abdulfattah M. Obeid, and Mohamed Abid. "Outlier detection approaches for wireless sensor networks: A survey." Computer Networks 129 (2017): 319-333.
30. Bangotra, Deep Kumar, Yashwant Singh, Arvind Selwal, Nagesh Kumar, Pradeep Kumar Singh, and Wei-Chiang Hong. "An intelligent opportunistic routing algorithm for wireless sensor networks and its application towards e-healthcare." Sensors 20, no. 14 (2020): 3887.
31. Khan, R. A., Mohammadani, K. H., Soomro, A. A., Hussain, J., Khan, S., Arain, T. H., & Zafar, H. (2018). An energy efficient routing protocol for wireless body area sensor networks. Wireless Personal Communications, 99(4), 1443-1454.