Wireless Networks based Smart Medical Monitoring System

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ABSTRACT

Wireless Sensor Network (WSN) innovations are rapidly becoming a significant area of research in the healthcare industry due to their potential to support sustainable personal health development. These networks enable continuous monitoring of vital health parameters, offering critical assistance to physicians for accurate diagnosis and enhanced patient care. This paper explores the development and impact of emerging handheld smart medical monitoring systems that leverage WSN-based applications. These systems consist of various physiological sensors, wireless transmission units, and processing modules. Once the data is collected, it is transmitted to the patient's smartphone, which acts as an intermediary platform. From there, the data is shared with medical professionals through dedicated smartphone apps or stand-alone systems. These specialists can remotely access the patient's health information and, based on the analysis, recommend appropriate treatments or medications. This innovative architecture minimizes the need for frequent in-person doctor visits, particularly for patients requiring regular health status tracking. By automating data collection and remote reporting, WSN-based health monitoring enhances healthcare efficiency, reduces patient burden, and promotes timely medical intervention. Overall, these systems offer a cost-effective and scalable approach to personal health management, aligning with the global goals of sustainable and technology-driven healthcare solutions.

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1. INTRODUCTION

The Wireless Sensor Network (WSN) [1] is a network of independent sensor devices installed at specific places to track and capture information like vibration, radio signals, temperature, pressure, etc., [2]. In several businesses and civilian uses, WSNs could be used, like tracking and regulation of pharmaceutical systems, healthcare uses, ecosystem tracking, smart devices, and several others [3]. Medical services are particularly difficult today. Individuals' need for any continuing health services is rising each day. There are so many more problems facing medical professionals. In the medical profession, this presents important concerns that should be discussed effectively. Systematic evaluations of the present situation must be used in analytical thinking to form a functioning framework that addresses the satisfactory amount of challenges that are to be encountered in the future [4]. This sort of approach can be provided by medical WSNs [5].

It has also seen the development of Wireless Sensor Networks, supported by technical advances in low-power networked devices and sensors in medical research. Automated sensors that track ecological, environmental parameters such as climate, pressure, vibration, etc., are provided by WSNs. Using Wireless Sensor Networks, smart medical sensor device prototypes are still designed. The main objective of our framework is to collect WSN-based information about particular health monitoring and include doctors with consistent data and measuring that might be used to track the evaluation of health monitoring via wireless communications. This will be used with systematic reviews to aid in spreading out behavior changes and to communicate effective intervention and treatment with personal representatives. Instead, certain schemes are effective ways of examining the conditions in quantitative value. Figure 1 shows the block diagram of a smart healthcare monitoring system.

In reality, it is beneficial for a patient to be responsible to observe the specific health condition, everywhere it is, with portable mobile health care tracking devices [6]. As a result, the amount of wearable equipment for health tracking and related illnesses is expected to increase significantly, particularly in remote areas. On the other hand, the immense economic demand guarantees the resulting in the growth of these products. Different wearable systems were used effectively. For example, Georgia Tech [7], that soldiers can conveniently and safely wear, is a basic form as a "wearable mother-board" in the US army to track a range of critical variables via a belt. To test a comprehensive electrocardiogram (ECG) achieved with unipolar pre-cordial causes, an intelligent shirt [2] has several electrodes on the chest. Besides, they build semi-conducting foam blocks that cover this void between the individual and the intelligent tee. These programs are primarily targeted at tracking a patient's health and people who live in extreme conditions as well. A Development Unit current study guided by Haahr [8] also dedicated itself to a long-term wireless medical tracking device with lesser energy usage. To monitor physiological signals, it is stated that they might have constructed diffraction medical imaging sensors embedded in a ring-shaped photodiode [9] and digital patch.

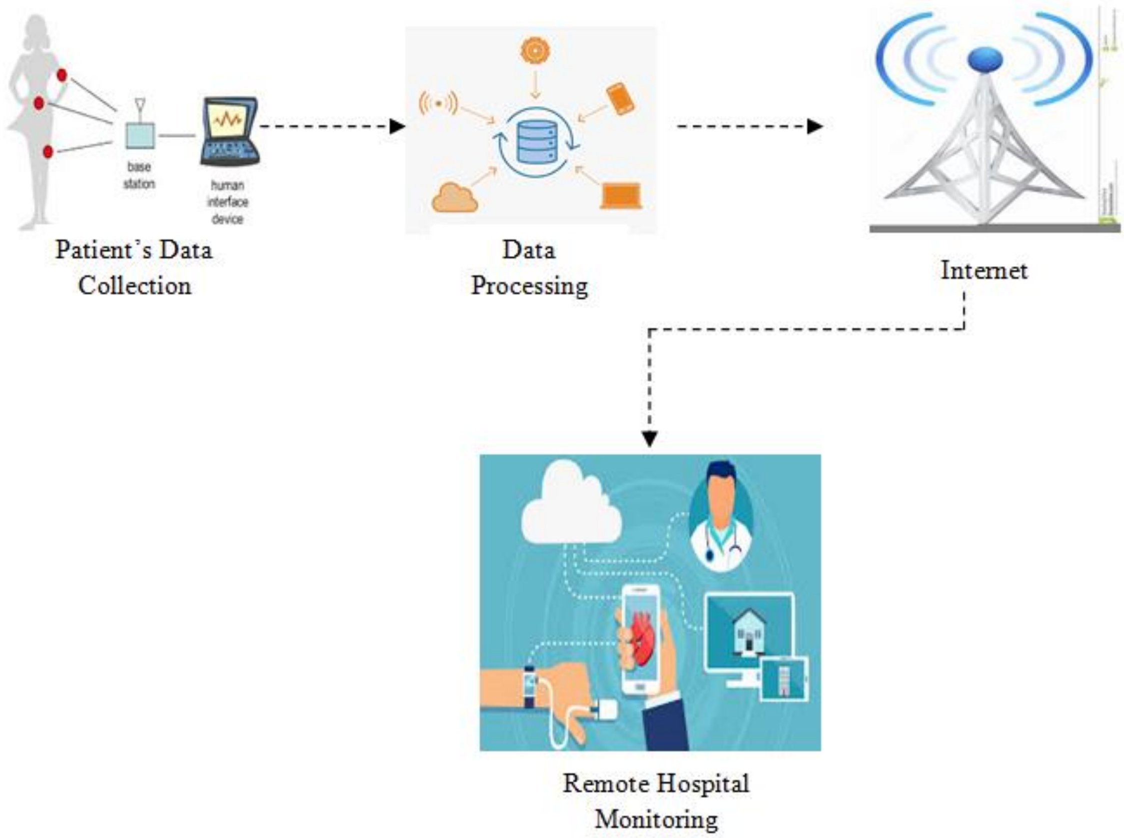

Figure 1. Block Diagram of Smart Healthcare Monitoring System

In specific, the Smart Medical Monitoring System consists of three broad range of multiple kinds of lightweight smart or artificial implant sensors and transmitting systems from the first component. For example, for biomedical parameters including HR, blood pressure, breathing rate, body temperature, oxygen saturation, and ECG, Bluetooth is intended to relay physiological data to the sensor module. The second phase is a device that consists of a wireless communication interface for a data processing device to retrieve or transmit successful data. The last part is a health monitoring center that is used mostly to include relief and security support. Smart Medical Monitoring System seems to have a wide range of advantages that are common in the smartphone market.

Benefits are referred to as follows:
a. Real-time Tracking
b. Geographic Versatility
c. Quick to diagnose
d. Smart Characteristics
e. Human characteristics
f. Protection and continuity
g. Extremely low expense and energy
h. Background-awareness

In this study, the current production and innovation status of smart, low-cost non - intrusive devices for tracking impact in medical circumstances were established. In this framework, a very important development of many multinational initiatives and consumer goods have also been presented and evaluated. For portable wireless medical and health tracking systems dependent on capturing different sensors, various recognized short-range wireless connectivity protocols were reviewed and analyzed. The analysis offers an incisive analysis of the rapid growth of the wearable health-tracking method.

2. LITERATURE REVIEW

The Wireless Sensor Network (WSN) [11] is a system of independent sensor nodes solutions provided at established sites for environmental monitoring collection purposes, like electromagnetic waves, vibration, temperature, etc. Wireless sensor network innovations are said to be one of the main scientific fields in the information technology and healthcare technology sectors to become advanced sufficient to be used to improve the standard of living. With continual surveillance, the omnipresent healthcare networks offer qualitative analysis knowledge and activating processes towards suspicious circumstances. This minimizes the use of providers and encourages a productive life for the mentally disturbed and needs to live. The integration of wireless sensor networks is effectively beginning to be implemented at an increased level. It is optimistic to think that life will emerge from technologically available wireless communication networks.

Many other problems, including low power, minimal computing, content limitations, and maintenance of the product, compactness and fault tolerance, optimization, protection, and conflict and legislative criteria should also be recognized when evaluating health care implementation using wireless sensor networks. Our framework will aim to solve these efficiency metrics that have to be solved through the use of WSN to incorporate health care programs. Wireless Sensor Network medical tracking nodes are capable of biomedical detectors, which are custom-built instruments, sampling patient-worn sensors, and passing the results via a wireless network. There should also be a back - end database that holds medical data and only shows it to authorized GUI users.

Mobile connectivity is the biggest problem now, where consumers cannot interact with smart handheld devices and have to be relying on the place to get help from the doctor, consulting him for a prescription each time. A study has been detailed in the implementation of wearable IoT in healthcare [12], several of the technologies have all been marketed and accepted in the market. Current programs also concentrate on supporting persons who have trouble preserving functional independence. Smartphones and tablets have been the hub of mobile technology and connectivity of our everyday lives over the past few decades [13]. Smartphones provide better functionality and innovations, together with the advent of multiple inbuilt sensors, which have been considered to fundamentally change a variety of socioeconomic fields in the upcoming years. These included social networking, control of the atmosphere and monitoring, health care and education, and travel. Several different sensors, including a GPS, microphone, transmitter, shutter, light sensors, trackpad, and optical compass, have been provided to the current smart device [14]. To contribute, WiFi, 3G/4G/5G, and wireless device are installed in a large number of smart devices, facilitating communication and knowledge exchange with other devices. Analysis of mobile phone-based medical networks has derived growing interest in recent years and numerous solutions were developed.

For environmental detection devices, cell phones are widely used, acting primarily as transmitted sensors. The author Pigadas et al.[15], for instance, introduce an Android phone-based software that collects GPS technology, infrared sensor information, and data from such a range of embedded devices but instead communicates this data to a different access point. When dangerous conditions are observed, alerts may be defined and distributed. Similarly, Pirani et al.[16] is also a smartphone-based Android framework aimed at monitoring restless actions, leveraging knowledge about the location and meaning. A core aspect of this design seems to be that the sequence of actions of the consumer could be trained from a theoretical decision framework. Furthermore, it is possible to include verbal reminders to direct users to a known location or call caregivers.

For several decades, remote health control is being suggested and investigated [17]. The basic technology used to capture a range of health-related information, like ECGs and heartbeats, are detectors and wearable devices. Using a mobile phone as a networking gateway, which captures transmitted signals with or without subsequent analysis, but instead communicates them to the corresponding health center or a data analysis database, is a common approach for healthcare monitoring. The Body Area Network (BAN), which consists of a variety of integrated smart sensing instruments for capturing a variety of medical criteria, like ECG, EEG, blood pressure, and body temperature, is also a major aspect. Via different network infrastructures like ZigBee, Bluetooth, and WiFi, these sensor devices are organized. Sensor nodes, nevertheless, are also equipped with minimal memory and storage power, so sensor data is usually transferred to a different computing network, in which smartphones are widely accepted.

To gather biomedical data from patients, homogenous wireless wearable instruments have been developed, including EMG, ECG, EEG, blood pressure, body temptation, pulse oximeter, blood sugar, and sweat monitor [18]. A traditional approach is to use a mobile phone or tablet as the data analysis portion, due to the reduced computational power of the sensing systems, which may not be capable of manipulating all the sensor information. The smartphone or tablet will perform a range of functions, such as the retrieval of actual data, the representation of data for consumers, and the transfer of data to other network infrastructure [19]. Nevertheless, software running continuously is also needed for these devices, which would also impact the regular usage of cell phones. As cloud infrastructure has recently advanced, the collected information could be sent remotely to a cloud server [20]; registered people can download data from any Internet-enabled computer from anywhere at any time [21]. For example, Pigadas et al. [15] propose an ECG monitoring scheme based on the IoT-cloud, where detected information is represented remotely via WiFi to the database component.

Technologies for allowing vast quantities of medical sensors to be included in emergency relief were also strongly connected to our activities. The SMART [22], AID-N [23], and WiiSARD [24] groups are from many sponsored research to ensure emerging technology for disaster relief through the US national institute of health. Multiple sensor models are being used by the Support-N group, and the SMART community has produced a smaller number-based EKG [25] which is broadly comparable to the model. An experimental sensor tool for analysis built on an 802.11-equipped PDA was also produced by the WiiSARD community, however, its scale and power specifications make it inefficient for actual clinical usage. The wizard and SMART architectures plan for a database controller to gather and transmit all sensor information, a strategy with clear requirements of redundancy and usability. It must not be conscious of every information revealed, detailing the processes of coordination, routing, exploration, or data query used by several programs.

3. WIRELESS SENSOR HEALTHCARE MONITORING SYSTEM

Software update models are required for the pharmaceutical applications of sensing devices. Multi smaller number-based medical sensors that we have built are stated in this chapter: a smaller number-based pulse oximeter, a two-lead electrocardiograph, and a unique movement-analysis sensor board.

A. Pulse oximeter

The pulse oximeter has been in use since it's developed in the early 1970s as a healthcare clinical instrument. To accurately measure two main clinical care measures, this non-invasive technique was included: heart rate and blood oxygen saturation. These criteria provide vital details, especially in situations where the use of immediate medical attention can be demonstrated by a dynamic change in heart rate or a decrease in blood oxygen supply. Much until the patient experiences side effects, the pulse oximeter may offer early notice of the development of hypoperfusion. Figure 2 shows the Structure of the Pulse Oximeter.

The application of infrared and near-infrared radiation into arteries near the skin is involved in pulse oximetry. A silicone framework that slides over the index finger or earlobe is usually integrated with pulse oximeters. There is a series of LEDs in the framework on each internal surface and a semiconductor-based sensor alongside this. The respiratory rate intensity could be determined by calculating the energy absorbed by hemoglobin in the blood at two separate ranges. Moreover, as blood flows compress and widen with the patient's heartbeat, pulse rate could be estimated by the sequence of optical emission over distance. Using normal optical signal processing methods, calculating heart rate and blood oxygen supply from the light propagation sound waves is being carried out.

Figure 2. Pulse oximeter

B. Electrocardiograph

To assess the heart's electrical activity, various types of electrocardiograph (EKG or ECG) are widely used in clinical and emergency treatment. A most prominent characteristic of ECG includes the attachment of twelve to fifteen contributes through elastic suction cups to the stomach, arms, and right ankle of a person. A brief analysis of the heart's electrical activity between multiple brands of electrodes is captured by the system. A special and accurate image of the heart activity, an independent echo of the electrical signals of the heart as they have been carried out via healthy tissue, is given by every couple of leads. To detect a broad variety of cardiac arrhythmias, and also due to myocardial ischemia and embolism, an advanced physician may easily be read generic ECG identification.

Table 1. Sensor Response time Comparison table

Sensor Type	Average Response Time (ms)	Accuracy (%)
Pulse Oximeter	250	98.5
ECG (Electrocardiogram)	150	97.2
Motion Sensor	120	94.8

This Table 1 shows that ECG sensors have a fast response time ideal for real-time monitoring. Pulse oximeters, though slightly slower, offer high accuracy, while motion sensors are fastest but slightly less precise.

Moreover, abnormal or sporadic heart problems can not be detectable because normal Electrocardiographic signatures reflect just a brief sample of health information. Some hospitals now use continuing Electrocardiogram sensor data to monitor patients in critical condition to resolve this flaw. This includes using a second- or third-electrode Electrocardiogram to measure the heart function of a patient for an infinite amount of time. The intensified heartbeats are either visualized on a monitor or written on a tape dispenser next to the side at all times of the patient. If there would be a risk that a client has heart complications, like atrial fibrillation, which arises continuously, sometimes just once or twice a day, a doctor might prescribe regular supervision. The Continuous data recorder could also be important as a way to notify health care workers of the primary indicators of a patient's health worsening. ECG programs function by collecting and enhancing the electronic pulses produced by every heart muscle contraction and relaxation. Public networks usually have one or two modulation amps with the key advantages of high-frequency noise reduction and signal amplification. In comparison, some machines can provide specialized circuits for data analysis to improve tracing efficiency.

Figure 3. Electrocardiograph

The Structure of an Electrocardiograph is shown in Figure 3. Most Electrocardiographic devices are sold as "compact," both regular and systematic, but it will not affect that they are compact and easy to navigate. Several other instruments receive electricity from an electrical circuit and are strong enough to be placed on a machine and rolled through one place on to another.

C. Motion Analysis Sensor Board

Sensor networks could be used, in addition to conventional physiological parameter tracking, in complex human trials that may need advanced equipment to capture physiological data of concern. For two conditions including motion tracking, they are collaborating with researchers at the Spaulding Recovery Clinic in Boston to build wearable technologies. The one works on surgery patients post-stroke physiotherapy, whereas the other seeks to assess the efficacy of Parkinson's therapies. Both experiments need extensive data on muscle function and body movement to be captured. In certain different parts of the brain, strokes are a type of brain injury caused either by brain swelling or by an immediate loss of blood. The operation of a portion of the brain is momentarily or completely interrupted in this case. In response to speech difficulties and inability to maintain a feeling of control, a recovered stroke victim can suffer decreased mobility and limitation of one half of the body.

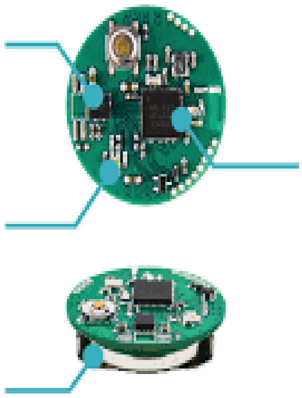

Figure 4. Motion Analysis Sensor Board

A wireless digital multimeter held in a waist brace is used for conventional motion-capture processes; a variety of wires connect from the brace two separate sensors mounted on the body parts of concern. Figure 4 shows the structure of the Motion Analysis Sensor Board. Simply, the need for wireless smart technologies could dramatically enhance the collecting of data and allow a person to wear sensors for a long time as the heavy data recorder and leads would be discarded. For software metrics findings in the area, several kinds of sensors are widely applied: accelerometers, gyroscopes, and electro-myographic surface electrodes [26, 27]. The direction and rotation of every part of the body are measured by triaxial sensors. Gyroscopes evaluate angular speed which is used to reliably assess limb orientation in conjunction with accelerometer data [28]. Electro-myographic Signals electrode catches the electromagnetic current produced before a skeletal muscle by hyperpolarization areas moving along the muscle. The Electromyographic data's root means the square cost is slightly equal to the strong effect of the muscle that is tracked. The study of the dynamics of Electromyographic operation will thus contribute to the recognition and features of muscle tasks [29].

4. PERFORMANCE EVALUATION

An initial analysis of the highly customized device operating on an enclosed testbed of 25 MicaZ motes, spread across two functions of their software engineering built environment, is provided in this section. While its role of every network is set, behind a broad variety of interaction requirements and data speeds, this test platform gives us the ability to calculate connectivity speed and efficiency. It also discusses observations that illustrate the use of pharmaceutical and medical with mobile processors. The aim of testing CodeBlue is to verify its general effectiveness and optimization with different channels that send and receive. It also wants to investigate the effects of implementing the performance of higher frequencies. Our findings are encouraging and demonstrate that with moderate data speeds, work more efficiently and ADMR extraordinary benefits service provider levels. Moreover, with increased data speeds, radio spectrum congestion is a significant concern, meaning that this is also a key priority for future opportunities.

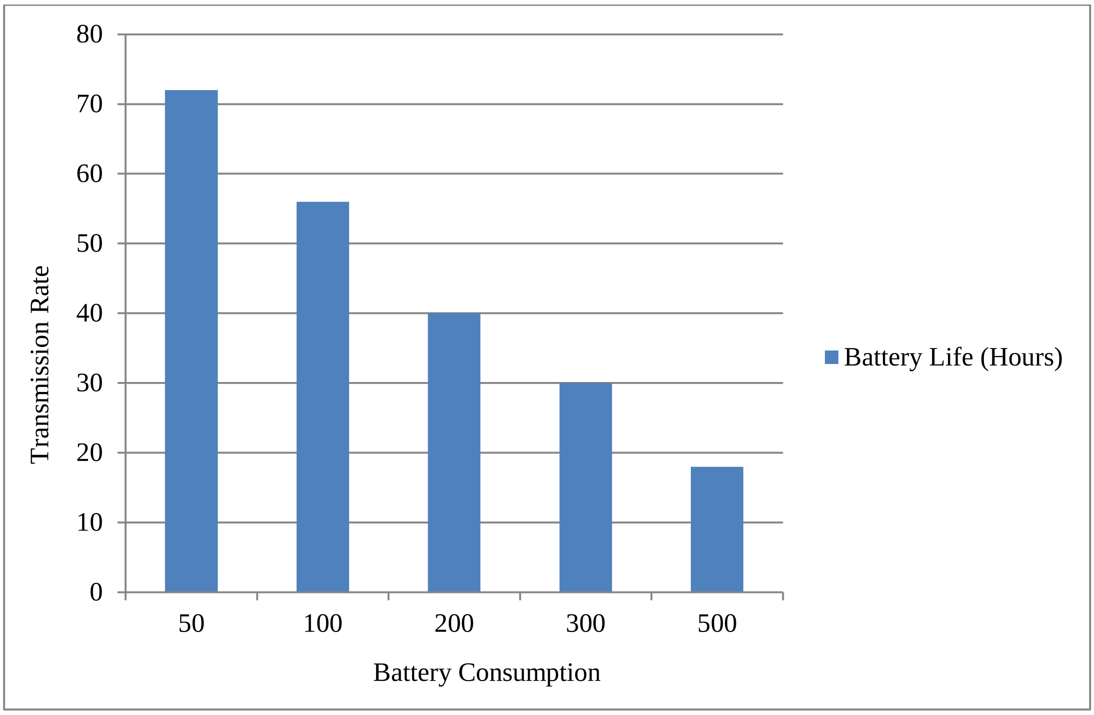

Figure 5. Battery Consumption vs. Data Transmission Rate

Figure 5 depicts a Web-based framework is supported by our high dielectric constant network system testbed that allows users to analyze schedule and execute tasks on the test platform. The device also transmits information through a TCP socket to and from the serial interface of each module, enabling us to regulate and track the whole system from a single computer. A Java-based operator has been introduced to give signals to highly customized nodes for response authorization, data receipt, statistics retrieval, and so on. This configuration continued to be a little more simple, makes it simple to run experiments without trying to reconfigure the sensors every period with several system criteria.

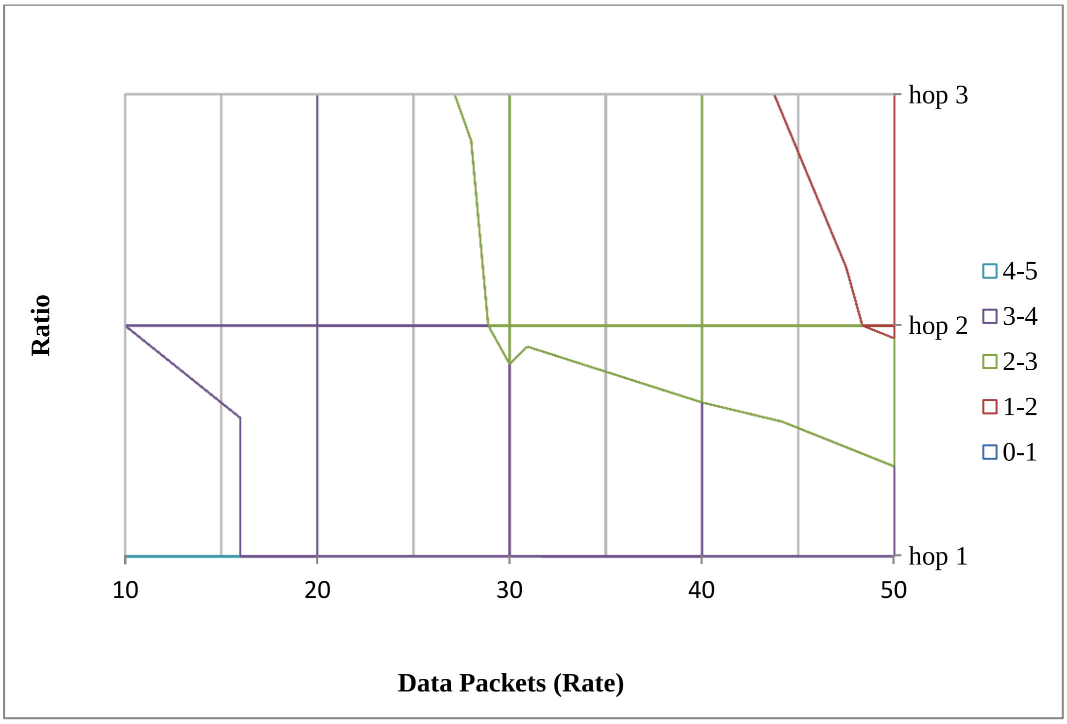

Figure 6. The result in the processing ratio of rapidly increasing connection speed and hop.

Figure 6 depicts the packet receipt ratio (amount of incoming signals calculated by the total of packets received) for various sets of senders as shown in Figure 5. Certain nodes will be used as the sender in several instances, while the receiving node is distinct. To specify the number of wireless hops across the ADMR route, receivers are chosen. Confirm this, since ADMR connections are complex, the number of hops changes that have occurred. In healthcare environments in which the health care provider is next to the patient, the single-hop situation may be very prominent.

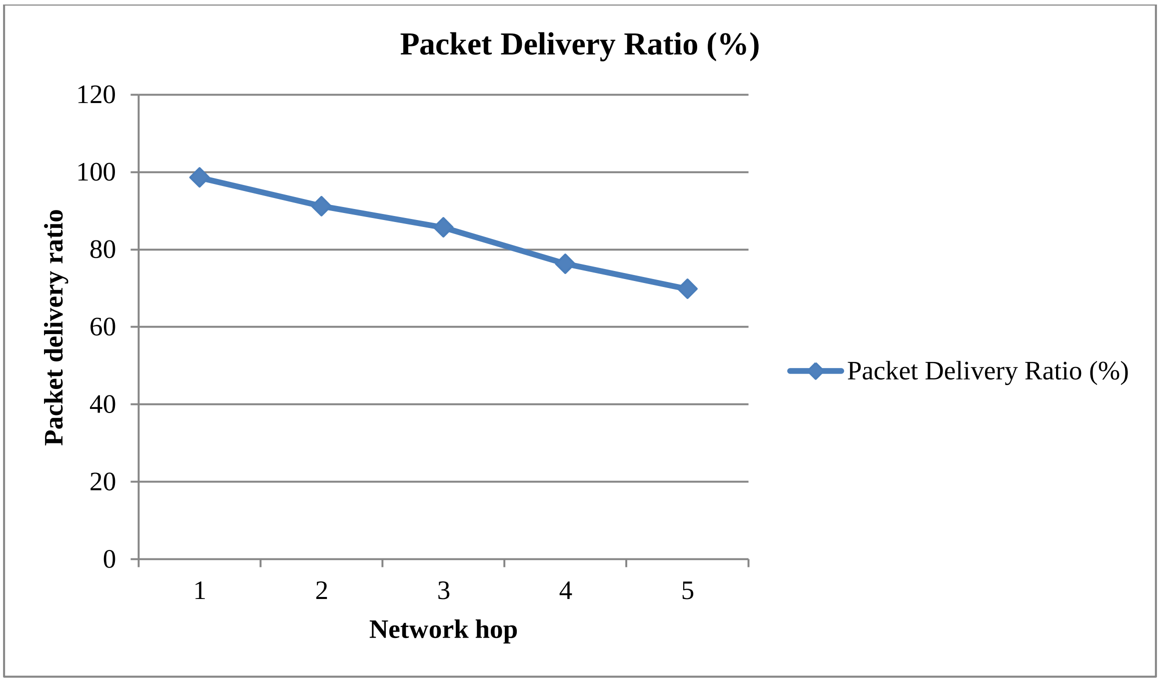

Figure 7. Effect of Hop Count on Packet Delivery Ratio (PDR)

Figure 7 highlights that as the hop count increases in a wireless network, the reliability of data delivery (PDR) decreases. For medical applications, ensuring fewer hops can improve system performance. As the figure demonstrates, except with large data speeds, the reception quality is much stronger in the single-hop scenario. The receipt ratio decreases significantly for multi-hop situations. It happens in the following ways. Second, in multi-hop, transmitting networks should interact with both the transmission and distribution providers for connectivity, reducing the amount of transmission capacity of every device. Enhanced communication terms of risk assessment each node to filled packet queues, ultimately causing the packets to decrease. Secondly, it showed that changing the volume of disrupting traffic has a detrimental effect on their key technological transmission levels, even though no packets are lowered. This is difficult to determine due to interactions triggered by hidden-terminal impacts.

Table 2. Sensor vs. Detected Vital Parameters

Sensor Type	Heart Rate	Blood Oxygen	ECG	Movement	Temperature
Pulse Oximeter	□	□	□	□	□
ECG Device	□	□	□	□	□
Motion Sensor Board	□	□	□	□	□

Table 2 depicts that Each sensor module specializes in tracking specific health parameters. A composite system using multiple sensor types ensures broader health coverage and precision.

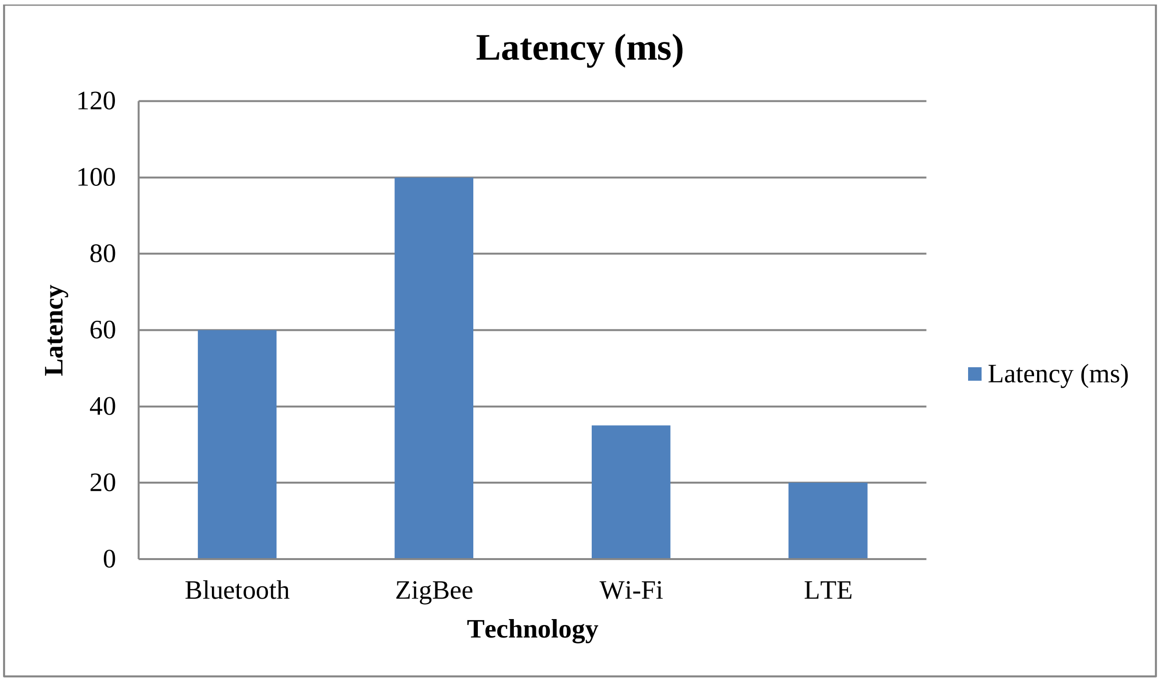

Figure 8. Latency Comparison of Communication Technologies

Figure 8 depticts that Wi-Fi and LTE offer the lowest latency, making them preferable for urgent medical transmissions. However, Bluetooth and ZigBee are power-efficient for long-term use.

5. CONCLUSION

A basic requirement for adaptive frameworks is something for real-time wellness and movement identification with wearable sensors. The measurement of medical health criteria using Wireless Sensor Networks is also not a revolutionary concept, and also this paper mainly focused on the provides a variety of different variables such as heart rates, ECG, and Blood Pressure Tracking in a simple integrated device that presents to the patient as a single machine when communicated with the Android mobile framework that provides doctors with greater usability. The technology will remove the issues found in the control system relying on physical and traditional equipment as the need for real-time data control rises due to the growth in medical conditions that would contain personal information. The sensor-based medical device enables medical patients to securely evaluate their health history with the correct details at the proper moment. The framework may reduce the threat of consulting a specialist any time for diagnosis and would allow physicians' licensed patients to easily receive care.

REFERENCES

[1] Chauhan, J., & Bojewar, S. (2016, August). Sensor networks based healthcare monitoring system. In 2016 International Conference on Inventive Computation Technologies (ICICT) (Vol. 2, pp. 1-6). IEEE.
[2] Akyildiz, I. F., & Vuran, M. C. (2010). Wireless sensor networks (Vol. 4). John Wiley & Sons.
[3] Schmitt, C. (2013). Secure data transmission in wireless sensor networks. Techn. Univ. München, Lehrstuhl Netzarchitekturen und Netzdienste.
[4] Chauhan, J., & Bojewar, S. (2016, August). Sensor networks based healthcare monitoring system. In 2016 International Conference on Inventive Computation Technologies (ICICT) (Vol. 2, pp. 1-6). IEEE.
[5] Sahaa, S., & Tomar, S. K. (2013). Issues in transmitting physical health information in m-healthcare. International Journal of Current Engineering and Technology, 3(2), 411-413.

[6] Liang, T., & Yuan, Y. J. (2016). Wearable medical monitoring systems based on wireless networks: A review. IEEE Sensors Journal, 16(23), 8186-8199.
[7] Harms, H. (2011). Body posture detection using non-tight fitting garments (Doctoral dissertation, ETH Zurich).
[8] Haahr, R. G., Duun, S. B., Toft, M. H., Belhage, B., Larsen, J., Birkelund, K., & Thomsen, E. V. (2011). An electronic patch for wearable health monitoring by reflectance pulse oximetry. IEEE Transactions on Biomedical Circuits and Systems, 6(1), 45-53.
[9] Duun, S. B., Haahr, R. G., Birkelund, K., & Thomsen, E. V. (2009). A ring-shaped photodiode is designed for use in a reflectance pulse oximetry sensor in wireless health monitoring applications. IEEE Sensors Journal, 10(2), 261-268.
[10] Teng, X. F., Zhang, Y. T., Poon, C. C., & Bonato, P. (2008). Wearable medical systems for p-health. IEEE reviews in biomedical engineering, 1, 62-74.
[11] Shnayder, V., Chen, B. R., Lorincz, K., Fulford-Jones, T. R., & Welsh, M. (2005). Sensor networks for medical care.
[12] Wan, J., Al-awlaqi, M. A., Li, M., O’Grady, M., Gu, X., Wang, J., & Cao, N. (2018). Wearable IoT enabled real-time health monitoring system. EURASIP Journal on Wireless Communications and Networking, 2018(1), 298.
[13] Pal, A., Visvanathan, A., Choudhury, A. D., & Sinha, A. (2014, March). Improved heart rate detection using smartphones. In Proceedings of the 29th Annual ACM Symposium on Applied Computing (pp. 8-13).
[14] Dubey, D., Amritphale, A., Sawhney, A., Amritphale, N., Dubey, P., & Pandey, A. (2014). Smartphone applications as a source of information on stroke. Journal of Stroke, 16(2), 86.
[15] Pigadas, V., Doukas, C., Plagianakos, V. P., & Maglogiannis, I. (2011, May). Enabling constant monitoring of chronic patients using android smartphones. In Proceedings of the 4th International Conference on PErvasive Technologies Related to Assistive Environments (pp. 1-2).
[16] Wan, J., Al-awlaqi, M. A., Li, M., O’Grady, M., Gu, X., Wang, J., & Cao, N. (2018). Wearable IoT enabled real-time health monitoring system. EURASIP Journal on Wireless Communications and Networking, 2018(1), 298.
[17] Kafalı, Ö., Bromuri, S., Sindelar, M., van der Weide, T., Aguilar Pelaez, E., Schaechtle, U., ... & Stathis, K. (2013). Commodity 12: A smart e-health environment for diabetes management. Journal of Ambient Intelligence and Smart Environments, 5(5), 479-502.
[18] Verma, P., & Sood, S. K. (2018). Cloud-centric IoT based disease diagnosis healthcare framework. Journal of Parallel and Distributed Computing, 116, 27-38.
[19] Sareen, S., Sood, S. K., & Gupta, S. K. (2018). IoT-based cloud framework to control the Ebola virus outbreak. Journal of Ambient Intelligence and Humanized Computing, 9(3), 459-476.
[20] Xia, Z., Xiong, N. N., Vasilakos, A. V., & Sun, X. (2017). EPCBIR: An efficient and privacy-preserving content-based image retrieval scheme in cloud computing. Information Sciences, 387, 195-204.
[21] Xiong, N., Han, W., & Vandenberg, A. (2012). Green cloud computing schemes based on networks: a survey. It Communications, 6(18), 3294-3300.
[22] L. Ohno-Machado et al. SMART: Scalable Medical Alert Response Technology. http://smart.csail.mit.edu/.
[23] D. White et al. AID-N: Advanced Health and Disaster Aid Network. https://secwww.jhuapl.edu/aidn/.
[24] L. Lenert et al. WiiSARD: Wireless Internet Information System for Medical Response in Disasters. https://wiisard.org.
[25] Shih, E., Bychkovsky, V., Curtis, D., & Guttag, J. (2004, November). Continuous medical monitoring using wireless microsensors. In Proceedings of the 2nd international conference on Embedded networked sensor systems (pp. 310-310).
[26] Mathie, M. J., Coster, A. C., Lovell, N. H., & Celler, B. G. (2004). Accelerometry: providing an integrated, practical method for long-term, ambulatory monitoring of human movement. Physiological measurement, 25(2), R1.
[27] Bonato, P., Mork, P. J., Sherrill, D. M., & Westgaard, R. H. (2003). Data mining of motor patterns recorded with wearable technology. IEEE engineering in medicine and biology magazine, 22(3), 110-119.

[28] Giansanti, D., Macellari, V., Maccioni, G., & Cappozzo, A. (2003). Is it feasible to reconstruct body segment 3-D position and orientation using accelerometric data?. IEEE transactions on biomedical engineering, 50(4), 476-483.
[29] Bonato, P., Hughes, R., Sherrill, D., Black-Schaffer, R., Akay, M., Knorr, B., & Stein, J. (2004). Using wearable sensors to assess the quality of movement after stroke. Proceedings of the 65th Annual Assembly American Academy of Physical Medicine and Rehabilitation 2004.