Original Article

A Review Approach to Modeling, Analysis, and Design Framework for Wireless Sensor Network Health Monitoring Systems

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Abstract

According to the results of the survey on Modeling, Analysis, and Design Framework for Wireless Sensor Network Health Monitoring Systems, the current study is written. Wireless Sensor Networks (WSNs) are fast emerging as a key enabling technology for a diverse variety of applications across a wide range of industries and disciplines. Recent breakthroughs in wireless sensor networks (WSN) have made it feasible to deploy extensive health monitoring in both the home care and hospital sectors, thanks to recent advances in wireless sensor networks. As a result of technological developments in sensors, power-efficient integrated circuits, and wireless communication, it is now feasible to design physiological sensor nodes that are compact and lightweight, low in cost, and capable of giving real-time information. Depending on their design, these nodes are capable of detecting, processing, and sending one or more vital signals, among other things. As a side benefit, they may be used to monitor one's health via wireless personal area networks (WPANs) or wireless body sensor networks, among other applications (WBSNs). Many studies have been undertaken and/or are currently being conducted in an effort to develop WBSNs that are flexible, reliable, secure, real-time, and power-efficient, with the goal of using them in healthcare applications. WBSNs are a kind of wireless backhaul network (WBSN).

Keywords-WNS, WBSNs, WPANs, Health Care Application, Hospital Environments.

I.INTRODUCTION

Wireless sensor networks (WSNs) are being utilized in a wide range of applications today, including health monitoring, industrial automation, military operations, building automation, agriculture, environmental monitoring, and multimedia, to name a few. Recently, there has been a great deal of debate on how they may be employed in the healthcare industry, specifically. Researchers in both academia and industry are interested in the design and development of wearable biomedical sensor systems for health monitoring, with the latter focusing a particular emphasis on the former.

Increasingly sophisticated medical technology has contributed to the population's increasing age. Almost every country on the planet is seeing rapid aging of its population. The significant increase in the number of old people will be the primary driver of the increase in the cost of healthcare services in the future. Patients-friendly medical equipment at a reasonable price is a challenging challenge for medical service providers to solve in order to deliver high-quality health care to their patients. The deployment of body sensor networks (BSNs) to enable continuous real-time health monitoring has the potential to significantly improve patient care, according to researchers. Patients may benefit from this advantage since it allows them to be treated in a timely way before a potentially deadly event happens. This advantage entails continually monitoring the status of patients and notifying both the patients and medical specialists of any anomalies that arise.

Based on the figure below, business service networks (BSNs) are comprised of a number of dispersed network devices, which may contain sensor units, and which collect and analyze data while also connecting with other devices through a radio frequency channel. With the help of this wearable health monitoring gadget, it is possible to monitor changes in a patient's vital signs and support them in maintaining their optimal health state. Patients who are outfitted with wireless medical sensors for continuous monitoring may be able to notify their doctors, hospitals, and other medical institutions if they observe any odd changes in their condition. It is possible that this will be very useful and even lifesaving if a patient has a heart attack or needs post-operative care.

When it comes to healthcare applications, wearable BSNs have the potential to play a significant role. In spite of this, owing to the delicate nature of medical applications, it is necessary to guarantee that the correct physical information is sent without any data loss, mistakes, or delays from start to finish. Additional considerations include the need for sensor nodes that are small, light, and use little power in order for patients to keep enough mobility while also minimizing the cost of healthcare services. It is necessary to address all of these issues prior to implementing a wireless healthcare network in a real-life environment. Unwired physiological data monitoring systems use radio waves to communicate real-time vital sign data from wearable biomedical sensor devices to a central controller, which then processes the data. Wearing wireless gadgets that detect physiological abnormalities and transmit the data collected to their physicians in real-time will be possible in the near future for patients.

Wireless health monitoring systems, as compared to wired healthcare equipment, provide a number of significant advantages over the latter. Most importantly, individuals no longer have to waste time waiting to see a physician when they need one. As an added bonus, the deployment of wireless healthcare systems outside of the hospital may assist care providers in saving money on healthcare expenditures by lowering their overhead costs. Furthermore, it allows many patients to continue working while being under the observation of their doctor, which is a significant advantage. A medical emergency may be signaled by such systems in two ways: first, if certain vital indicators change dramatically, such as if the heart rate rises above the normal range, medical personnel may be informed.

Having a heart attack is defined as the abrupt death of heart muscle caused by a blood clot blocking the flow of oxygen to the heart muscle. Blood flow to the heart muscle must be returned to normal within 20 to 40 minutes, or else permanent death of the heart muscle would begin to take place. Given the abrupt nature with which heart attacks strike elderly or hospitalized individuals, constant and real-time monitoring of heart rates might undoubtedly save their lives.

Currently, the majority of heartbeat monitors, such as electrocardiography (ECG), are exclusively accessible in certain situations, such as hospitals and doctor's offices, and are not readily available to the public. They need the implantation of a large number of wired electrodes on the patient's skin. Heartbeats are frequently checked with stethoscopes by medical professionals to ensure that they are normal in patients. Unfortunately, when it comes to heart monitoring technologies, they are severely limited in their capabilities. As previously said, in the case of an unexpected heart attack, it is vitally important to continuously check the pulse to ensure that it does not stop. However, given the current state of connected medical equipment, this is almost impossible to accomplish. Wireless health monitoring gadgets, when compared to traditional wired healthcare equipment, clearly provide a number of unique advantages over the former. Wireless sensor networks for healthcare purposes are shown in Figure 1. In order to send data collected by the sensor nodes to the base station, the coordinator or the PDA/cell phone, which is connected to other networks through a wired or wireless connection, radio frequency channels (RF channels) are used. Managing and monitoring the entire network in real-time is the responsibility of a server. Wireless communication methods such as Wi-Fi, Bluetooth, ZigBee, Ultra-Wideband (UWB), and cellular networks are used in the application, depending on the specifications. Among these technologies, Wi-Fi is the most widely adopted.

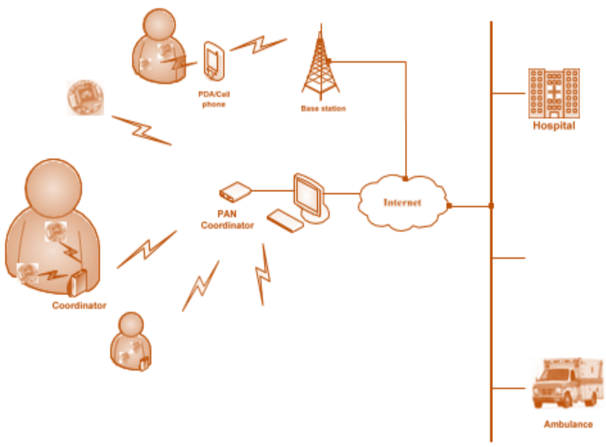

Figure 1. A typical wireless sensor network infrastructure for healthcare applications.

II. LITERATURE SURVEY

In this section, some specific applications that have been developed or are being researched for health monitoring purposes are discussed.

Abawajy, J. H., & Hassan, M. M. (2017)"prompted active research in the development of solutions that enable healthcare providers to remotely monitor and evaluate the health of patients in the comfort of their residences.Existing attempts, on the other hand, are limited in terms of their flexibility, quantifiability, and energy potency. In their opinion, the construction of a pervasive patient health observation (PPHM) system is unquestionable. PPHM is built on cloud computing and the Internet of Things technologies that are seamlessly linked together. A case study for the period observation of a patient with symptom failure using an ECG is offered in order to demonstrate the suitability of the proposed PPHM infrastructure for the patient population[1].Testing has proven that the proposed PPHM infrastructure is a highly adaptable, scalable, and energy-efficient remote patient health observation system for monitoring the health of patients"[1].

Abdelgawad, A., &Yelamarthi, K. (2017)"proposed the Structural Health Monitoring (SHM) platform embedded with IoT to detect the size and location of damage in structures.The recommended platform is comprised of a Wi-Fi module, a Raspberry Pi, an Analog-Digital Converter (ADC), a Digital Analog Converter (DAC), a buffer, and piezoelectric

(PZT) sensors, among other components. As a pair, the piezoelectric sensors are mounted to the framework of the structure. The data from piezoelectric sensors will be used to identify the size and location of the damage, which will be determined using a mathematical model that has been proposed. An evaluation of the extent and location of any structural damage will be carried out using the proposed mathematical model, which would be implemented on a Raspberry Pi and then sent over the Internet. This information will be retained and made available to you from any mobile device you may have. Validation of the system was placed on a real testbed in the lab"[2].

Aktas, F., Ceken, C., &Erdemli, Y. E. (2018) "built a new IoT-based healthcare framework associated with Wireless body area networks (WBANs) and radio frequency identification (RFID) technologies for hospital information systems.A software program called Riverbed Modeler was utilized to develop and simulate the desired framework. The findings show that the proposed energy-aware system fulfills the Quality of Service (QoS) standards of the ISO/IEEE 11073 standard in terms of data rate and latency. It is also shown that the proposed framework may quickly materialize multiple case studies in hospital information systems by constructing a time-saving simulation environment, which is a significant time-saver"[3].

Ali, A., &Alshmrany, S. (2019)"defined the autonomous system of sensors and a framework was proposed to measure various vital signs for monitoring purposes.The proposed system is capable of monitoring the human body's vital indicators, including blood pressure, heart rate, temperature, and other parameters. It is the IoT that allows the sensor system to communicate with the base controller. There, the data is compared to the patient's history, and an alert is issued to the relevant department. Following a review of the patient's medical history, the expert will make a determination, and the rescue team will be despatched to save the patient who has crossed the border into the United States. Because the proposed system is capable of identifying the patient's health well before a heart attack occurs, the information will be critical in the case of a heart attack. In their study, they provide a thorough examination of the proposed healthcare framework's effectiveness and efficiency. According to the findings of the research, the proposed system, which includes hardware components for the purpose of monitoring and regulating the patient while under the care of the rescue team, might be implemented"[4].

Almahdi, E. M., et al. (2019)"presented comprehensive insights into mobile patient monitoring systems (MPMSs) from evaluation and benchmarking aspects on the basis of two critical directions. The current MPMS evaluation criteria, which are based on the architectural components of MPMSs, as well as potential solutions, are discussed. According to the findings of this research, multiple assessment criteria, criterion importance, unmeasurable criteria, and data variation are all essential considerations in MPMS benchmarking practices. A multicriteria decision-making (MCDM) analytic methodology is offered as a strategy for overcoming these issues from the perspective of methodological considerations. This methodological feature includes a framework for benchmarking MPMSs that is based on MCDM, which allows users to rank and choose the best MPMS from a pool of accessible MPMSs. The benchmarking methodology is described in four steps. Phase 1: Introduction Following that, the procedures for pre-processing and identification are described. The best-worst method (BWM) is used to calculate weight, and the next section explains how to do so. The VIKOR technique is used to develop a benchmark framework. Finally, the framework that has been proposed is put to the test"[5].

Almarashdeh, I., et al. (2018) "presented an expert system for Elderly Health Care (EHC) at an elderly home tailored for the specific needs of the Elderly. Specifically, the proposed EHC aims to provide an integrated and interdisciplinary system for utilizing communication technology and information to address the genuine health needs of the elderly, particularly those who are at high risk due to social and geographic isolation, as well as specific chronic conditions. In the proposed EHC, individualized treatment solutions for chronic disorders such as high body temperature (BT), high blood pressure (BP), and high heart rate are provided (HR). The operations and architecture of the proposed EHC are based on a server and three primary clients, one of which is for the elderly and the other two of which are for the nurses and doctors who provide care for them. The proposed EHC model is described in detail in order to illustrate the usage and effectiveness of the expert system"[6].

Babar, M., et.al. (2018)"proposed a healthcare architecture that is based on an analysis of energy harvesting for health monitoring sensors and the realization of Big Data analytics in healthcare. A comprehensive conceptual framework for energy harvesting for health monitoring devices is provided by the proposed architecture, which also allows for data processing and decision management in the healthcare industry. It is proposed that the architecture be divided into three layers: (1) energy harvesting and data production; (2) data pre-processing; and (3) data processing and applications. This system recommends the employment of energy-harvesting-based IoT in the healthcare sector, with an emphasis on patient safety. The system also includes smart health monitoring and planning capabilities, among other things. They tested the proposed architecture using consistent datasets on the Hadoop server that were limited by the threshold limits that were defined (TLVs). According to the findings of the study, the proposed design offers immediate and considerable value in the area of smart health"[7].

Bhuiyan, M. Z. A., et.al. (2015)"designed a dependable distributed WSN framework for SHM (called DependSHM) and then examined its ability to cope with sensor faults and constraints. In their research, they revealed evidence that faulty sensors in a structural system might influence the consequences of a health event (such as injury) without being noticed. They call attention to an unknown but fascinating fact: the truly measured signals produced by one or more faulty sensors may cause an undamaged site to be identified as damaged (false positive), or a damaged site to be diagnosed as undamaged (false negative), depending on the situation (false negative). Other problems, such as sensor bonding difficulties and precision degrading as a result of amplification gain, bias, drift, or noise, may also contribute to this. This paper describes a distributed automated approach known as DependSHM for detecting such issues, and we present an online signal reconstruction algorithm for recovering from an inaccurate diagnosis. They evaluate the

effectiveness of DependSHM via extensive simulations and the deployment of a WSN prototype system"[8].
Deng, C., Guo, R., et al. (2018)"proposed a long lifetime of WSNs, data cleansing algorithms for energy-savingin order to achieve reliable and accurate data acquisition while ensuring low energy consumption. As a result of the low energy consumption of communications, the cleaning algorithms are computationally light and energy-efficient in local sensors due to their minimal computing requirements. Dynamic voltage scaling and dynamic power management are used in order to minimize energy consumption without compromising overall system performance. It is proposed as a low-power protocol for sink node communication at the network level in their work. In order to monitor the health of a Cyber-Physical Machine Tool, this system is being developed (a typical example of CPPS). Experiments have shown that the proposed energy-saving data purification approach delivers high-performance and effective monitoring, which is in line with the conclusions of the studies"[9].
Dey, N., et al. (2017)"presented a home-based wireless ECG monitoring system using Zigbee technology. This kind of system may be used to monitor patients in their homes, in addition to providing frequent physician monitoring to ensure correct healthcare is provided, allowing people to remain in their homes for a longer amount of time. Many physiological signals can be continuously tracked by health monitoring systems, and these signals may subsequently be evaluated and interpreted by trained professionals. The features and downsides of these devices may restrict the wearer's ability to move while monitoring vital signs. Real-time monitoring devices record, measure and monitor the electrical activity of the heart while maintaining the consumer's comfort and convenience. However, although Zigbee devices may offer a low-power, small-size, and low-cost alternative for monitoring the ECG signal in the home, such systems are typically built in isolation, without taking into consideration existing home control networks or smart home solutions. Initially, they provide an overview of current technology before moving on to the fundamental ideas and contents of wireless ECG monitoring devices. Aspects such as models of the ECG signal as well as power consumption estimates are also discussed. There is also a discussion of issues and perspectives on the future. After much deliberation, they came to the conclusion that mass-market health monitoring systems will only become widespread if they are used in combination with home environmental monitoring and control systems"[10].
El Zouka, H. A., & Hosni, M. M. (2021)"proposed integrating artificial intelligence technology, such as neural networks and fuzzy systems in a secure healthcare monitoring system in order to enable the system to work as a smart healthcare model that decides the priority by itself depending on the collected health parameters from the sensor nodes. For example, the proposed model includes a trusted environment for collecting authenticated physiological data from a patient's body, which is then sent to Azure IoT Hub via the GSM module, where raw data is converted into linguistic representation using a logic-based algorithm trained in the fuzzy-based inference system (FBIS) in order to determine the patient's condition. A consequence of this is that the proposed system allows for patient monitoring that is consistent in its accuracy, security, and timeliness"[11].
El-Rashidy, N., et al. (2020)"proposed a convolutional neural network-based deep learning model for COVID-19 detection based on patients' X-ray scan images and transfer learning. In comparison to the current state of the art, the proposed model yielded promising results (i.e., the accuracy of 97.95 percent and specificity of 98.85 percent). They believe that our technique is a useful tool, and they anticipate that its use will result in considerable reductions in COVID-19 proliferation and healthcare expenses"[12].
Fu, H., Khodaei, et al. (2018)"designed, implemented, and experimentally evaluated impact detection in composite airframesfor a low-power high-response wireless structural health monitoring system (WSHMS). In order to reduce system power consumption when no impact happens while yet offering outstanding performance when an impact does, an event-triggered technique is utilized. This method is used since impacts are uncommon, unexpected, and temporary. Every aspect of the system, including its responsiveness, robustness, and energy efficiency, is taken into consideration and modeled. Depending on the system requirements and functionalities, modules such as filtering, impact sensing, local processing, and wireless transmission are developed. The technology was implemented via the use of a printed circuit board. A typical response time of around 12 seconds is achieved with an average current of less than 1 milliampere when the impact activity is less than 0.1 percent. The gadget is particularly resistant to ambient vibration noises and has the ability to accurately and rapidly collect the input channels of numerous sensors (up to 24 channels). It is shown that a low-latency, energy-aware WSHMS may be used for impact detection of composite structural elements. There is a variety of Internet of Things applications where it may be used to monitor other unusual, random, and ephemeral occurrences"[13].
Ghayvat, H., Pandya, S., & Patel, A. (2020)"suggested the AAL-based system, an acoustics sensing system capable of dissecting, recognizing, and distinguishing distinct auditory events that occur in day-to-day living circumstances, allowing not only individuals but also healthcare professionals to continually monitor the state of each individual. For preventive healthcare, this system solely analyses background acoustics linked to activities of daily living (ADL). To fill a research gap, the research makes a unique contribution based on prototype creation, audio signal processing methods, and deep learning algorithms"[14].
Gogate, U., & Bakal, J. W. (2016)"studied that WSN-based healthcare applications are gaining popularity across the world due to advantages like flexibility, portability, and the convenience of ongoing patient monitoring. The primary objective of such a system is remote monitoring of the patient, both within and outside the hospital room and in the intensive care unit"[15].
Hameed, R. T., et al. (2016)"developed an experimental model based on sensors for monitoring and assessing the health status of patients. e-Health sensor shield, which is connected to a cloud platform that gathers sensor data, serves as the foundation for the framework. In addition to collecting data from a glucometer, airflow sensors, and patient posture, the sensors transmit data to a cloud storage platform through a microcontroller and an Ethernet gateway. Those who have

access to the data collected on the cloud platform may use it for further processing, such as the investigation of certain connections between recorded parameters and patient health” [16].

Harbouche, A., et al. (2017)“offered a flexible design for a preventative health care system. Because of its heterogeneous node design, the proposed system can perform daily continuous monitoring as well as targeted control operations on demand. They devised a model to describe the global behavior of the WBSN, which they then tested. They proposed a model-driven engineering (MDE) strategy to deal with the derivation of each node's behavior in the WBSN from the global behavior of the WBSN, which is a critical aspect of this study's methodology. With the help of this approach, developers may construct a system design from the global specification of demand. Prior to deployment, it is important to examine and validate that the produced behaviors are consistent with the requirements of the design. However, formal techniques may be useful to software engineers at different points of the software development life cycle in order to test the logical soundness of concurrent software. In the field of concurrent systems, model-checking is one of the most powerful formal methodologies for assessing the logical correctness of concurrent systems. It was discovered that a model checking approach based on a model transformation may be used to verify the autonomously generated behavior of a WBSN for health monitoring in their research. The purpose of this model-driven method is to improve the performance and quality of service of the system by determining if the derived system runs correctly in accordance with its global specification. As an alternative to thinking about the system as a whole, this method enables the developer to reason about a model of the whole global system”[17].

Hassan, M. K., et al. (2018) “developed an intelligent hybrid context-aware model for patients under observation at home that uses both local and cloud-based components in a hybrid architecture. The cloud-based component of the concept makes it simpler to store and manage the huge amounts of data generated by ambient assisted living devices, which are used to monitor chronic disease patients in their homes, especially the elderly, and which generate massive amounts of data. In the event of an internet outage or other difficulties in the cloud system, the local part of the model will continue to maintain track of the patients. A context-aware methodology is used in the proposed model to evaluate the real-time health status of a patient by concurrently monitoring physiological data, environmental situations, and patient actions. Experimental results from a case study on patients with blood pressure difficulties demonstrate the effectiveness of our proposed approach for monitoring patients and consistently identifying crises in imbalanced datasets”[18].

Hayajneh, T., et al. (2016)“aided in identifying the most difficult security vulnerabilities in existing remote patient monitoring authentication techniques and proposes a lightweight public-key-based authentication mechanism for MSNs. In MSNs, nodes are divided into two categories: sensors that collect data on the human body and actuators that respond to commands from medical staff and carry out the instructions. A critical security risk is the authentication of these instructions since any alteration might have disastrous consequences. According to the authors, the recommended protocol is based on the Rabin authentication algorithm, which has been improved in their research to optimize the signature signing method, making it suitable for MSN applications that need quick response times. They utilized Tmote Sky motes to create the Rabin algorithm with different hardware settings and also constructed the algorithm on an FPGA to analyze the design and performance of the algorithm. This allowed them to show the usefulness of the Rabin algorithm. For the purpose of developing and testing the proposed protocol, the MIRACL (Multiprecision Integer and Rational Arithmetic C/C++) package is also used. The findings suggest that medical experts may transmit commands to MSN nodes that are safe, direct, fast, and authenticated, according to the study” [19].

Hu, J., Wu, K., & Liang, W. (2019)“presented a fog-assisted healthcare monitoring platform based on Internet Protocol Version 6 (IPv6). This structure is composed of three layers: the body-sensing layer, the fog layer, and the cloud layer. As part of its mission to gather and analyze time-sensitive data, the fog computing node in the fog layer works in tandem with the body sensing layer to generate physiological data. The fog layer delivers physiological data to a cloud computing node in the cloud layer so that it may be further processed there. It is a mobile intelligent device that connects fog computing nodes and supports consumers in anticipating the severity of a potential illness in the future. When developing the suggested framework, researchers employed advanced methods such as IPv6-based network architecture, a cloud–fog resource scheduling algorithm that is based on time thresholds, and a chronic disease classification model that is based on cascaded deep learning. For the purpose of evaluating the validity of the framework, health data from 45 people were collected in a systematic manner during a 30-day period. According to the results, the proposed chronic disease classification model has a high degree of accuracy when it comes to determining the severity of a potential ailment. The response time is also much less than it would be in an IPv4-based cloud-assisted system”[20].

Huang, H., et al. (2017)“built a healthcare system (HES) architecture that gathers medical data from wireless body area networks (WBANs), transfers it across a vast wireless sensor network infrastructure, and then publishes it via a gateway into wireless personal-area networks. Aside from key distribution and data transport mechanisms using send-receive models, HES features homomorphic encryption based on a matrix scheme for privacy, as well as an expert system capable of autonomously evaluating scrambled medical data and offering feedback on the findings. When compared to existing systems or methodologies, the security, privacy, and better performance of HES are shown via theoretical and experimental evaluations. Last but not least, the viability of a prototype implementation of the HES is looked into further”[21].

Huynh, D. T., & Chen, M. (2016) “developed a ZigBee-based energy-saving solution for WBAN using the Healthcare Monitoring System. They particularly exploited the ZigBee protocol in beacon-enable mode to obtain the adaptive duty cycle in order to do this. Because of this, energy consumption in idle mode, as well as the total energy consumption of sensors, is lowered, resulting in increased network lifespan. A long-term Healthcare Monitoring System, according to the results of OPNET Modeler's simulations, may benefit from reducing WBAN energy usage while preserving QoS in terms of network performance (e.g., average end-to-end latency and network throughput)"[22].

Jaiswal, K., et al. (2018)"presented an approach that uses a Raspberry Pi and a Docker container to automate the challenge of collecting, delivering, and analyzing crucial data from patients. As a result, wherever the patient goes, the doctor can diagnose and observe medical conditions"[23].

Jangra, P., & Gupta, M. (2018)"developed an IoT-based smart healthcare monitoring system that computes biological signals in real-time for real-time patient supervision. The proposed multilayered architecture increases the value of biosensor-based data collecting and aggregation while also facilitating the development of a real-time, efficient decision support system in the case of an emergency" [24].

Kajornkasirat, S., et al. (2018)"developed a Smart Health Monitoring System with the Internet of Things (IoT). The proposed multilayered architecture increases the value of biosensor-based data collecting and aggregation while also facilitating the development of a real-time, efficient decision support system in the case of an emergency"[25].

King, R. C., et al. (2017)"studied the review of data fusion approaches and algorithms for interpreting wearable sensor data in the context of health monitoring applications The use of these approaches in healthcare, including activity and ambulatory monitoring, gait analysis, fall detection, and biometric monitoring, is then outlined. A snapshot of existing commercially available sensors, concentrating on their sensing capacity, is also presented, along with a remark on the gaps that must be overcome to bring research to market[26].

Lamonaca, F., et al. (2018)studied thedifferent types of Structural Health Monitoring (SHM) used to identify, detect and characterize the degradation and damage of all types of engineering structures, highlighting their benefits, and their improvement obtained thanks to the application of IoT paradigm. The Internet of Things (IoT) concept connects common things to the Internet in order to provide them with connectivity. In the presence of billions of connected devices dispersed throughout the world, each with the ability to acquire and elaborate data, new scenarios for the development of new data acquisition systems and methods for the automatic management of such big data open up, enabling the development of new digital services. In recent years, the field of structural health monitoring (SHM) has emerged as a new area of Internet of Things application, and the systems developed within this framework have shown promising results"[27].

Li, S., Zhang, B., et al. (2020) "proposedfog-assisted Computational Efficient Wearable sensor networks (FCE-WSN) in health monitoring systems for sports athletes using IoT. When participating in physical activity, a wearable device that allows for continuous real-time monitoring of the heart rate, breathing frequency, and movement cadence was tested. Furthermore, the sensor data is relayed to the IoT-connection system Ethernet module, and the Authorized Individual may utilize the data to track the athletes' health through the internet, according to the manufacturer. The analytical model for the wearable device and its application, in addition, illustrates how computing resource costs may be lowered while still meeting health needs for access to medical data that is stored in a fog and cloud distribution environment. Their technique of assessment makes use of a queue to estimate the minimum computer resources necessary to fulfill the Service Level Agreement (SLA) requirements (for both fog and cloud nodes). Following the completion of the tests, it was discovered that the recommended technique is user-friendly, reliable, and cost-effective when put into practice on a regular basis"[28].

Mahmud, M. S., et al. (2017)"presented the design and prototype of a wireless health monitoring system using mobile phone accessories. In order to assess real-time electrocardiogram (ECG) and heart rate monitoring, the researchers used a smartphone cover. With the increasing number of cardiac patients throughout the globe, its design may be used to detect heart abnormalities at an earlier stage in the disease process. Contrary to the majority of previous techniques, which use an optical sensor to monitor heart rate, they attach dry electrodes to the phone's shell in order to record real-time ECG readings. An ECG signal obtained by a smartphone application may be saved and analyzed in real-time for prognosis and diagnosis using a smartphone application. With the proposed hardware approach, a single chip microcontroller (RFduino) that is integrated with Bluetooth low energy results in a lower size and longer battery life, as opposed to the previous system. It was decided to put the "smart case" idea to the test in a laboratory environment. For testing purposes, they also constructed a 3-D printed smartphone cover to see whether the technology was viable. The results revealed that the proposed system is on par with medical-grade equipment in terms of performance"[29].

Manogaran, G., et al. (2018)"proposed a new architecture for the implementation of IoT to store and process scalable sensor data (big data) for health care applications. Two of the most essential sub-architectures of the proposed architecture are Meta Fog-Redirection (MF-R) and Grouping and Choosing (GC) architectures, respectively. In order to collect and store sensor data produced by a variety of sensor devices, the MF-R architecture makes use of big data technologies such as Apache Pig and Apache HBase, which are both open-source projects. The proposed GC architecture is being used to ensure the integration of fog computing with cloud computing services. In addition to key management services and data categorization operations, this architecture incorporates other security features (Sensitive, Critical, and Normal). The system makes use of a MapReduce-based prediction model in order to forecast cardiac diseases. Several performance evaluation metrics, including throughput, sensitivity, and accuracy, as well as the f-measure, are computed in order to illustrate the effectiveness of both the proposed architecture and the prediction model"[30].

Mohammed, K. I., et al. (2019)"introduced a comprehensive and inclusive review on the prioritization of patients with MCDs in telemedicine applications. As well as patient prioritization in telemedicine, the paper highlights the problems and unsolved issues associated with this practice. The following are the results of the research: (1) The limitations and challenges associated with prioritizing current patients who have MCDs are reviewed and highlighted in detail. (2) An assessment of the academic literature revealed that there was no accurate method for remote prioritization on a large scale of patients with MCDs. (3) The development of a new multiple-criteria decision-making theory is urgently required in order to address the current issues in the prioritization of MCD patients"[31].

Ozer, E., & Feng, M. Q. (2019)"proposed a methodology and architecture for a cyber-physical system (CPS) that builds a bridge finite element model (FEM) using vibration data from smartphone WSNs and centralized/distributed computational capabilities, then analyses structural reliability using updated FEMs. It is possible to determine the modal frequencies of an existing bridge by analyzing structural vibration data acquired from smartphones and stored on a server. Because there are no design drawings or supporting paperwork, just field data, and observations, the FEM of the bridge is written with errors in the structural mass, stiffness, and boundary conditions. The reason for this is that there are no design drawings or supporting documentation (BCs). The baseline FEM is then updated by lowering the error between the findings of the crowdsourcing-based modal identification and the results of the FEM analysis, resulting in the creation of 2700 FEMs entirely on the fly. As an additional step, bridge response time history simulations are carried out using 151 strong ground motion recordings from databases in order to estimate the displacement demand distribution. Finally, the structural dependability of the bridge is determined by comparing it to performance standards that have been established. Through the integration of the cyber (FEM analysis) and physical (bridge structure and observed vibration characteristics) worlds, this crowdsourcing-based CPS has the potential to be a powerful tool for supporting swift, remote, autonomous, and objective infrastructure-related decision-making. Their study, which is based on structural engineering and structural health and safety management, provides a fresh picture of the impending Fourth Industrial Revolution"[32].

Pirbhulal, S., et al. (2019)"developed a biometric-based security framework for resource-constrained wearable health monitoring systems by extracting heartbeats from ECG signals. It has been discovered that time-domain-based biometric features play a vital role in increasing security on the Internet of Things-based medical applications. Furthermore, a resource optimization technique based on utility function is presented for clinical information transmission via the Internet of Medical Things (IoMT). The ECG signals of 40 healthy adults were employed in this experiment, which took place in a lab environment and made use of a publicly accessible database called e-physionet to gather information. It was discovered via experiments that the proposed framework (0.0068ms and 0.196 microJoule/Byte) uses less processing time and energy than the Alarm-net (0.0128ms and 0.351 microJoule/Byte) and BSN-care (0.0175ms and 0.53 microJoule/Byte) frameworks. Furthermore, the findings demonstrate that the biometric key generation method not only creates random and unique keys, but it also allows for a trade-off between security and resource efficiency to be made. Therefore, it is possible to conclude that the proposed architecture for real-time healthcare applications is both socially and economically beneficial"[33].

Rajan Jeyaraj, P., & Nadar, E. R. S. (2019)"worked on a unique Internet of Things (IoT) application-based physiological signal monitoring system to develop e-healthcare systems. The proposed system was implemented using a Deep Neural Network-based accurate Signal Prediction and Estimation approach, which was developed by the author. In order to prototype the proposed system as an advanced electronics component, an intelligent sensor for signal measurement and a National Instruments myRIO for smart data collection are used in conjunction with a National Instruments myRIO. The Smart-Monitor, which is being developed as a consumer device, is equipped with an intelligent sensor. We were able to collect four physiological signal prediction accuracies for two individuals, which allowed us to test the suggested Smart-Monitor system. The average accuracy of the prototype experimental set-up was 97.2 percent, according to the results of the study. This indicates that the automated system that has been proposed is trustworthy and capable of providing precise monitoring. Based on the experimental results, they conclude that the suggested system is capable of providing dependable help as well as an accurate single prediction" [34].

Rajaram, M. L., et al. (2016)"built a WSN modeling framework that might be used in conjunction with a hardware prototype to track the structural health of bridges, monuments, and skyscrapers MATLAB/Simulink is used to create the simulation framework. Cyclic redundancy checks (CRC) and a transmission error rate calculator are used to assess the simulation framework's data integrity" [35].

Saba, T., Haseeb, K., et al. (2020)"developed different systems based on low-powered biosensor nodes employing Wireless Body Area Network (WBAN) to monitor the medical state of patients; nevertheless, preventing increasing energy consumption and communication costs are demanding and intriguing concerns. Patient data distribution to distant centres is slowed due to an imbalance in energy consumption between biosensor nodes, imposing an additional burden on the medical system as a result. Furthermore, since the patient's sensitive data is exchanged through an unprotected internet connection, it is vulnerable to security breaches. This has resulted in another significant research topic for medical applications: data privacy and integrity in the face of hostile traffic. Researchers at the University of California, San Diego are working on developing a proposed secure and energy-efficient framework for e-healthcare that makes use of the Internet of Medical Things (IoMT). The primary goal of this framework is to reduce communication overhead and energy consumption between biosensors while transmitting healthcare data in a convenient manner. On the other hand, it protects patients' medical data from unauthentic and malicious nodes to improve network privacy and integrity. As shown by the simulation results, the proposed framework outperforms the previous state of the art systems on a number of metrics, including network throughput by 18 percent, packet loss rate by 44 percent, end-to-end latency by 26 percent, energy consumption by 29 percent, and link breaches by 48 percent"[36].

Sakr, S., &Elgammal, A. (2016)"defined and discussed some of the major challenges in the healthcare systems which can be effectively tackled by the recent advancement in ICT technologies. They are particularly interested in sensing technologies, cloud computing, the internet of things, and big data analytics systems as emerging technologies that have been made possible by significant advancements in various aspects such as network communication speed, computational capabilities, data storage capacities, all of which provide various advantages and characteristics that can help improve the efficiency and effectiveness of health-care delivery. Moreover, they go through the architectural components of our proposed framework for big data analytics services, SmartHealth, and discuss its many applications in the healthcare industry”[37].

Shahzad, A., et al. (2018)“employed Telemonitoring which remotely monitors the health of patients that are located not in common places, such as hospitals or medical centers. Wearable medical sensors, such as electrocardiography sensors, blood pressure sensors, and glucometers, have been widely used to obtain real-time information from remote patients; as a result, the medical information is further transmitted via the Internet to allow for medical diagnosis and treatment to be administered to the patients. Similar to other IT industries, the medical industry has made significant strides in safeguarding patients from a range of chronic diseases, and patient medical information may now be accessed remotely over Wi-Fi and cellular networks. Furthermore, cloud computing technologies have made medical systems more efficient and scalable in terms of processing, such as storage and access, to medical information while requiring fewer development resources. Furthermore, their study is an augmentation that makes use of the modeling of private cloud computing to track and monitor real-time medical information that is contained inside a predetermined geographical area. The bounded telemonitoring system, which is a private cloud-based environment for patient health monitoring, is intended to collect real-time medical information from patients who resided within the medical center's perimeter, within medical wards, and outside medical wards, according to the manufacturer. A fresh wireless sensor network scenario is being developed and created in order to keep or monitor the health information of patients throughout the day, 24 hours a day, seven days a week. In addition to providing a new, safe viewpoint on medical information access, their study paves the path for future improvements to the healthcare system”[38].

Shaikh, S., et al. (2017)“achieved efficient transmission of data from source (patients) to destination (Doctors) through data aggregation and data dissemination. It is the collection or gathering of information in order to enhance the energy efficiency, while data dissemination is the routing of information via a sensor network in order to reduce the amount of time it takes for data to travel from its source to its destination” [39].

Soh, P. J., et al. (2015) “evaluated the most recent breakthroughs in body-worn wireless health-monitoring systems, as well as their existing obstacles and limits, and discussed future prospects for such wearable devices in these applications. In recent years, wearable health-monitoring devices have gained in popularity, particularly since they allow for the noninvasive detection of critical human functions. The utilization of a variety of body-worn sensors, in addition to standard single-heartbeat or sweat sensors, which have just lately been commercially available, may create an effective health-monitoring system. Combined information obtained from such systems may be conveyed promptly to any health-monitoring specialists in the case of an emergency, or it can be documented and assessed as part of preventive health measures. Nodes that are attached to the human body, on the other hand, must be used with care since they may interfere with the patient's usual movements. This is particularly problematic since the interaction of electromagnetic waves is affected by the patient's motions, the distance between the patient and the closest base station, the operating environment, and a variety of other variables. Whenever the nodes need extra on-body space, impose an additional weight, or are not sufficiently conformal to the patient's body, further obstacles to their deployment develop. On the hardware design side, the sensing and communication functions of the electronic node must be constructed from certain materials in order to reduce reliability problems and damage caused by frequent or strong movements. At long last, and maybe most crucially, the electromagnetic safety level of such systems, which is determined by their individual absorption rates, must be considered (SARs)”[40].

Souri, A., et al. (2020)“proposed an IoT-based student healthcare monitoring model to continuously check student vital signs and detect biological and behavioral changes via smart healthcare technologies. Important data is collected by Internet of Things devices, and it is evaluated using machine learning approaches to detect possible threats linked with students' physiological and behavioral changes, as described in this paper. Using the data from the trials, it was discovered that the proposed model is both efficient and accurate in detecting the circumstances of the students. After assessing the proposed model, the support vector machine achieved the highest accuracy of 99.1 percent, which is an acceptable result for our objectives. The data showed that the strategies of the decision tree, random forest, and multilayer perceptron neural network were all outperformed”[41].

Srinivas, J., et al. (2018)“proposed a new cloud-based user authentication scheme for secure authentication of medical data. Following successful mutual authentication, both the user and the wearable sensor node create a secret session key that is shared between them. This key is used to establish secure connections in the future. Based on formal security analysis, the widely used Real-Or-Random (ROR) model and the widely accepted Automated Validation of Internet Security Protocols and Applications (AVISPA) tool, which is based on formal security verification, demonstrate that the proposed scheme protects against active attacks while also providing session-key security. An informal evaluation of the proposed system is conducted in order to show its resilience to other known attacks. Furthermore, they carried out a complete comparison of communication and computation costs, as well as security and functionality aspects, in order to establish its usefulness in comparison to other existing systems in this area, which they found to be lacking”[42].

Uddin, M. A., et al. (2018)“proposed a tier-based End to End architecture for continuous patient monitoring that has a patient-centric agent (PCA) as its centerpiece. When data from body area sensors must be securely saved, the PCA is in charge of a blockchain component that is controlled by the PCA. When a PCA-based architecture is used, a lightweight communication protocol is implemented to ensure data security across many segments of a continuous, real-time patient monitoring system. Storage of data on a personal blockchain, which allows for data sharing among healthcare professionals and incorporation into electronic health records while retaining anonymity, is part of the design concept. This version of the blockchain has been modified for RPM, and it now allows the PCA to choose a Miner to reduce computational effort, as well as manage multiple blockchains for the same patient. It has also been replaced with a prefix tree to reduce energy consumption and incorporate secure transaction payments. According to the findings of simulations, the PCA-based End to End architecture increases security and privacy in the RPM environment”[43].

Vedaei, S. S., et al. (2020)“presented a potential application of the Internet of Things (IoT) in healthcare and physical distance monitoring for pandemic situations. The proposed platform is comprised of a lightweight and low-cost Internet of Things (IoT) node, a smartphone application (app), and fog-based Machine Learning (ML) tools for data analysis and diagnosis. The Internet of Things node analyses health indicators such as body temperature, cough rate, respiration rate, and blood oxygen saturation, and then sends updates to the smartphone app, which displays the user's current health condition. To prevent virus spread, the program urges the user to maintain a physical distance of 2 meters (or 6 feet) between him or herself and the computer. To further enhance real-time infection prediction, a Fuzzy Mamdani algorithm (which runs on the fog server) takes into consideration environmental hazards as well as user-health parameters to predict the likelihood of infection spreading in real-time. The concept of a virtual zone communicates environmental threats while also providing up-to-date information for diverse locales. To establish a connection between an Internet of Things (IoT) node and a fog server, two alternatives are considered: 4G/5G/WiFi or LoRa, which may be used depending on ambient circumstances. The required energy consumption and bandwidth (BW) for a variety of event scenarios are evaluated and compared. The COVID-SAFE design may be able to assist lower the risk of coronavirus infection”[44].

Wang, P., et al. (2015)“proposed a generic sensor network design framework using a detectability measure while accounting for uncertainties in material properties and geometric tolerances. All three contributions to their work include the definition of a detectability measure to quantify the diagnostic/prognostic performance of a given sensor network, the development of detectability analysis methods based on physics-based simulation and health state classification, and the formulation of a generic sensor network design optimization problem as mixed-integer nonlinear programming. Genetic algorithms were utilized to solve the difficulty of optimizing the architecture of sensor networks in this study. Because of continual vibration, a power transformer system with a loosening core and winding joints is used to demonstrate the effectiveness of the proposed approach”[45].

Wang, S. L., et al. (2016)“suggested a system uses a cloud computing environment to develop a mobile web for a customized health information service, which includes two health information recommendation service functions: a collaborative recommender and a physiological indicator-based recommender. When predicting the trajectory of a moving object, they developed a hybrid predictive model that integrates the Grey Theory and the Markov chain, among other things. When faults are tracked down, the cost of tracing them down is reduced, while simultaneously increasing the longevity of the network. According to the findings of the experiment on usability, subjects provide positive responses to the system's usability evaluation categories of satisfaction, expectation-confirmation, perceived trust, perceived utility, and perceived worth”[46].

Wang, T., et al. (2018)“proposed BigReduce, a cloud-based health monitoring application with an IoT framework that could cover most of the key infrastructures of a smart city under an umbrella and provide event monitoring. In order to reduce the burden of huge data processing at the BS while also improving the quality of event detection, they employ BigReduce to merge real-time data processing and intelligent decision-making abilities into a single system. Particularly noteworthy are two distinct health event monitoring systems that may be implemented locally by an IoT sensor: one is a big data reduction approach, and the other is a decision-making system. It is their belief that BigReduce will provide great outcomes in terms of data reduction, energy cost reduction, and the quality of monitoring data”[47].

Wang, X., & Cai, S. (2020)“proposed a secure healthcare monitoring framework integrating NDN-based IoT with edge cloud. It makes use of the capabilities of NDN to speed up the retrieval of medical data, and it employs ciphertext and signatures to guarantee that medical data is transferred securely. The framework is subjected to statistical evaluation. According to the results, when compared to the old technique, the framework reduces medical data retrieval latency and cost by about 28 percent and 52 percent, respectively”[48].

Xu, B., Xu, et al. (2017)“designed a framework of an m-Health monitoring system based on a cloud computing platform (Cloud-MHMS) to implement pervasive health monitoring. Additionally, the Cloud Storage and Multiple Tenants Access Control Layer, the Healthcare Data Annotation Layer, and the Healthcare Data Analysis Layer are referred to as framework modules. In order to protect patient confidentiality, a multiple tenant access strategy is implemented at the data storage layer. When it comes to the data annotation layer, linked open data is utilized to semantically improve the interoperability of health data. When applied to the data analysis layer, the process mining algorithm and similarity calculation technique may be used to aid in the development of individualized treatment plans for each patient. Each of these three modules collaborates to carry out the three fundamental functions of health monitoring: storage of data, processing of data, and analysis of data. Finally, they investigate the use of our architecture in the monitoring of antimicrobial medicine consumption in order toillustrate the applicability of our technology in the analysis of personal healthcare data”[49].

Xu, K., Li, Y., & Ren, F. (2016)“proposed a general framework that utilizes CS and online dictionary learning (ODL) together. While learning dictionaries are less densely packed than predetermined dictionaries, they do carry distinguishing features of the original signal, which results in a sparser representation of the data. Accordingly, as compared to prior attempts, the compression ratio is greatly improved by a factor of 2 to 4. The proposed design also offloads pre-processing from sensor nodes to the server node, resulting in even significant reductions in hardware costs prior to dictionary learning. Because it is data-driven, the paradigm that has been proposed has the potential to be applied to a broad range of physiological indicators” [50].

In conclusion, based on the literature review, we can infer that much research has been undertaken and/or is currently being conducted in an effort to develop WBSNs that are flexible; reliable; secure; real-time; and energy-efficient, with the goal of using them in healthcare applications. We are concentrating our efforts on the many components of health monitoring. The sound transmission of a heartbeat will be compared to various smaller data packet transmissions in order to determine their effectiveness. The findings of theoretical analysis and simulation may be utilized to estimate and build high-performance health monitoring systems, which are currently under development.

III. PROPOSED METHODOLOGY

Figure 2 displays a PAN coordinator establishing a network that is not equipped with beacons for communication. A coordinator with a single PAN ID connects network devices desiring to get access to the PAN by broadcasting their IP addresses to other network devices on the same network. The scanning phase, whether active or passive, is the initial stage in the association process. Using this scanning technique inside a PAN zone, a device may identify those coordinators who are sending a beacon frame, allowing the device to locate them. As previously indicated, the beacon request instruction is not required for the passive scan process to be successful. The end device is the one that initiates an active scan. During the active scan, a channel is selected and a BeaconRequest instruction is sent to the broadcast address (0xFFFF) and the broadcast PAN ID associated with that channel is received (0xFFFF). An end device then watches that channel to see whether any coordinators have sent out beacons on that particular channel. Once the predetermined time period on that channel has elapsed, the end device looks for a new channel and sends the BeaconRequest command to the network once again, completing the cycle. In order for this method to be deemed active, it is required to scan all available channels first. Once the scan is complete, the MAC broadcasts a MAC MLME SCAN CNF message that contains all of the PAN information that was acquired during the scanning process.

The higher-level layer of the device checks the PAN descriptors and selects a coordinator based on the information. After agreeing on a coordinating partner, nodes send an Association request frame to the coordinator for processing. When the information has been sent, it is delivered to the currently connected node that is reliant on the network address produced by the network protocol and is dependent on the currently connected node's network address. Here, the coordinator arranges for the node to which the connection is being established to be assigned a short address by the coordinator. Based on the outcomes of these operations, the PAN coordinator may be able to estimate the number of devices that are linked with it. A number of communication packet characteristics are communicated between a coordinator and nodes throughout the course of the communication process between them, and the former may be able to identify the latter based on these characteristics. It is feasible to ascertain the address parameter of each device based on the values of the MLME ASSOCIATE and MCPS DATA process parameter values. It is possible for a coordinator to make reasonable judgments about the health of the network since it knows how many nodes have joined it. Figure 3 displays our proposed scenario, in which some nodes request that a beacon be transmitted to them in order to join the PAN, as shown in the text. A beacon frame containing network status information is sent by the coordinator in response, as shown in Figure 3. The beacon frame is controlled by the Frame Control Field (FCF), which is illustrated in Figure 3.

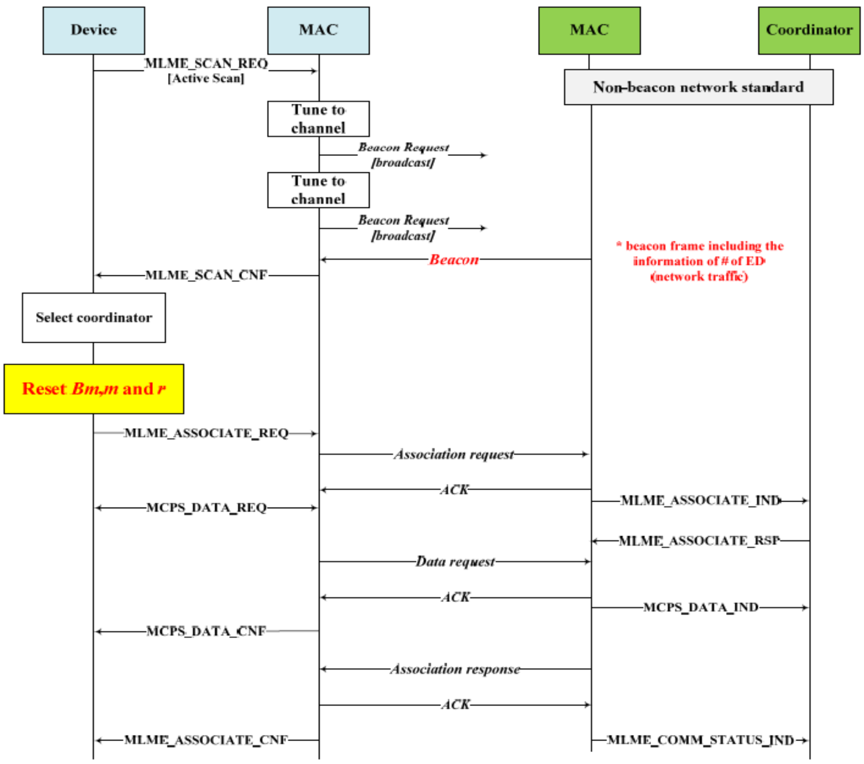

Figure 2. Modified association network flow for priority data transmission

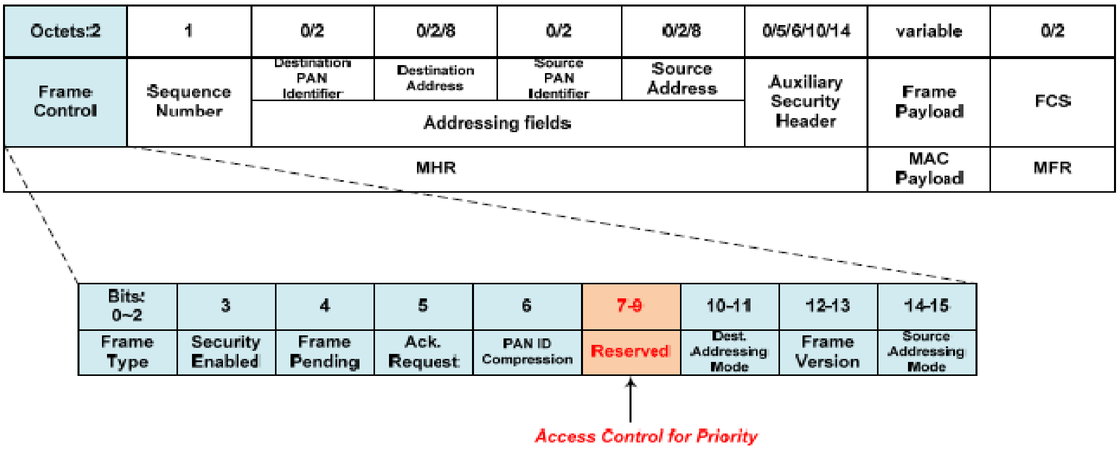

Figure 3. Frame Control Field (FCF)

Table 1. Reserved Fields in FCF

Command Frame	Nodes in PAN
0x001	$N < 5$
0x010	$5 \leq N < 10$
0x011	$10 \leq N$

If the existing network has a large size, i.e. N > 10, or if there are a large number of network devices already in the PAN, the device will stop associating with the current coordinator and look for another. According to the device, MAC settings are reset to the default value if the number of previously connected devices is more than 5, but less than 10 when the device detects this condition. It is assumed that the value is less than 5, in which case the device configures adaptive MAC settings for the connection.

VI. CONCLUSION

In conclusion, based on the literature review, we can infer that much research has been undertaken and/or is currently being conducted in an effort to develop WBSNs that are flexible; reliable; secure; real-time; and energy-efficient, with the goal of using them in healthcare applications. We are concentrating our efforts on the many components of health monitoring. The sound transmission of a heartbeat will be compared to various smaller data packet transmissions in order to determine their effectiveness. The findings of theoretical analysis and simulation may be utilized to estimate and build high-performance health monitoring systems, which are currently under development.

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