IOT Driven Healthcare System for Remote Monitoring of Patients

Neelam Dahiya
Associate Professor
Govt. P.G. College, Sector-9, Gurugram
Gurugram University
Email: dahiyaneedahiya@gmail.com

Reference to this paper should be made as follows:

Neelam Dahiya

"IOT Driven Healthcare System for Remote Monitoring of Patients",

Voyager: Vol. XII, 2022
Article No. 06
pp.40-48

Abstract

One of the most difficult objectives for today's society is to increase the effectiveness of the healthcare system. Modern healthcare is being redesigned by the Internet of Things (IOT), which enables remote sensing and control of items. Wearable sensors are used to manage and keep track of patient's physiological data. Costs should be decreased, life quality should improve, and the user experience should be improved thanks to this system. According to WHO standards, 60% of India's population suffers from chronic and cardiovascular diseases.This technique relieves the patient's burden of having to contact the doctor each time an ECG, temperature, or blood oxygen level check is required. Real-time data gathered on the cloud platform might be used by doctors and hospitals to offer quick and effective solutions. The scope of IOT application areas can be expanded to include remote monitoring and healthcare. This study proposes, builds, and conducts various tests to evaluate a remote monitoring system for patients at home in IOT contexts.A protocol conversion system between ISO/IEEE 11073 protocol and oneM2M protocol, as well as a Multiclass Q-learning scheduling algorithm based on the urgency of delivering biological data to medical personnel, are proposed in order to make it work in IOT environments. Additionally, two security schemes—the separate storage plan of data in portions and the Buddy-ACK authorization method—are suggested for the protection of patients' privacy.The experiment on the built-in system demonstrated that it functioned well and that Multiclass Q-learning excelled Multiclass Based Dynamic Priority in terms of performance. Additionally, we discovered that the Multiclass Based Dynamic Priority algorithm's throughputs grow with decreases in the rising ratio, whereas the throughputs of the Multiclass Q-learning scheduling algorithm increase practically linearly as the measurement duration increases.The system was successfully tested, and it was *discovered that the Multiclass Q-learning scheduling algorithm outperforms the Multiclass Based Dynamic Priority scheduling algorithm. We also discovered that the Multiclass Q-learning scheduling algorithm's throughputs improve practically linearly as measurement time increases, whereas the Multiclass Based Dynamic Priority algorithm's throughputs increase with decreasing rising ratios.Also, in this paper, we highlight the challenges in the implementation of the IOT health monitoring system in the real world.*

Keywords

IOT, cloud, healthcare, wearable sensors, remote monitoring, protocol conversion, Medical Devices.

Introduction

A new technology called the Internet of Things (IOT) uses the internet to connect actual physical objects. In smart cities, healthcare, logistics, and industrial control, the IOT offer a variety of applications. The primary use of the IOT in the healthcare sector is the remote monitoring of patient's physiological indicators. The adoption of wearable technology gives seniors more freedom to keep an eye on their health at home while reducing hospital-acquired infections. According to WHOM, many people die due to chronic and cardiovascular diseases. IOT provides immediate access to doctors and hospitals by measuring and processing the vital signs of patients. This helps in reducing the mortal rate caused due to heart failures and strokes. Biomedical sensors measure the human body's heartbeat, blood pressure, pulse and ECG. In this study, we use the Intel Edison as an IOT device to process a patient's vital parameters. The concept of IOT (Internet of Things) which allows smart objects to communicate with each other or with a user , has become increasingly popular.We can get considerably more information and control things much more smoothly with an IOT than we ever could previously. Metering, traffic management, smart houses, and building management are a few domains where the IOT concept can be used. The items could be meters, home appliances, sensors, or other similar gadgets. In recent years, research into patient remote monitoring has grown significantly. There haven't been a lot of studies done on IOT-based remote monitoring, though.We can now simply and smoothly control items with an IOT, and we can get a lot more information than ever before. Many fields, including metering, traffic management, smart homes, and building management, can benefit from the IOT concept. The objects may be sensors, household appliances, meters, or other comparable equipment. A very important field of research in recent years has been patient remote monitoring. However, there hasn't been a lot of research on IOT-based remote monitoring. Medical staff can monitor their patients at home much more simply than ever before with the aid of an IOT system by getting a variety of biological data from PHDs that the patients are connected to. In this study, PHDs are viewed as objects in the IOT system, and the technology will make it possible for medical staff to be informed of emergency situations involving their patients more swiftly than ever before. In this work, the oneM2M (one Machine-to-Machine) communication protocol, an international communication protocol standard for IOT systems, is used to propose and build the IOT monitoring system.

To make the patient-at-home monitoring system more desirable and operable on ordinary IOT networks, we consider the following issues in this paper.

- **Scheduling/communication of multiclass data**

Due to the diversity of PHDs and their biology, each item of data needs to be categorized according to the urgency of its transmission because many different PHDs and their biomedical data are communicated to medical staff. Higher grades are given to data deliveries that are more urgent. For instance, falling detector data are given a higher class since they need to be sent more quickly than medication dispenser data. The highest class should be used to categorize alarm conditions. For instance, aberrant ECG data are given more quickly than normal ECG data because they are allocated to a higher class.

- **Communication protocol conversion**

Because PHDs and IOT systems utilize different standard communication protocols, a communication protocol conversion process is required in order to use PHDs as objects in an IOT system based on the oneM2M protocol. In other words, the one M2M protocol is a global standard for the IOT system under consideration in this research, whereas the ISO/IEEE 11073 protocol is a global standard for Ph. D. communication.

- **Strict authorization**

Because the biomedical data a Ph.D. obtains may pertain to a patient's privacy, the information must be handled in a way that keeps it from being disclosed to unauthorized parties. Two security techniques are suggested in this study. The biological information about a patient that a Ph.D. collects is first saved in the IOT server in segments rather than as a whole. In this study, the data are divided into two pieces and kept separately in the IOT server. Additionally, the IOT authentication server, not the IOT server, houses the separation data. This implies that in order to access the data, a user must simultaneously access both the IOT server and the IOT authentication server.

Related Work

By 2025, IOT-based healthcare applications will have a significant impact on the world economy. IOT has many uses in the healthcare industry, including glucose level sensing, which uses non-invasive methods to test blood sugar levels. Temperature transmission and recording are carried out via body temperature sensors. Oxygen level monitoring uses a noninvasive method to assess the blood's proportion of oxygen. Home monitoring is a technique that health systems can use to collaborate with doctors and patients more closely. Many elderly people are thought to have chronic ailments and could benefit from telemedicine treatments. The complexity and cost of the current remote monitoring options are higher. In comparison to conventional delivery approaches, a more recent improved option is less expensive. In comparison to conventional delivery approaches, a more recent improved option is less expensive. The system uses medical sensors to gather the patient's vital signs, such as heart rate, blood pressure, pulse oximetry, and body temperature. The work in this study did not incorporate real-time ECG signals. The primary controller for processing and analyzing the data is Adriano Yun. The application programming interface (API) is then used to upload the data through WLAN to the cloud. Doctors can use the internet server to verify the patient's medical information and to send remarks to the patient. The data will be temporarily kept in the memory card if the device loses its WLAN connection. Once the connection is established, the system will synchronize the data with the server. Lee et al. proposed a smartphone-based remote patient monitoring system [5]. A smartphone application (app) is used in this system. To discuss the course of therapy, the patient can use a smartphone to video conference with the doctor. The patient's video data is being secured by this system in conjunction with Skype's AES-style encryption. Real-time mode is not supported by this system. The patient must manually submit the vital signs that have been obtained to the server.

In the operating rooms, there are many monitoring devices that show the patient's physiological data. However, there are times when the doctor is not accessible in case of an emergency, and the information cannot be remotely communicated with other qualified medical professionals and the patient's family. The currently available options are bulky, expensive, and require numerous wires. A number of communication protocols used between the gateway and cloud include HTTP, COAP, MQTT, and XMPP. HTTP is not perfect for IOT because it is not offering predictable latency and it depends on polling to detect state changes.

A comparison among these protocols is shown in the following table.

Table I: Comparison of Different IOT Protocols MQTT COAP XMPP

MQTT	**COOP**	**XMPP**
Based on OASIS Standard	Based on the CORE IETF Group	Based on Internet official protocol standards
One-to-one, many-to-one, one-to-many Communication.	One to one Communication	One-to-one or multiuser Communication.
Lightweight Publish-subscribe model.	Client-Server Model.	Client-Server Model
M2M, memory-constrained devices.	M2M applications, smart energy and building automation	VOIP, Gaming, IoT applications.

Explanation of these Components

Biomedical Sensors: Proposed solution uses the following bio-medical sensors. The vital parameters include temperature, pulse and ECG These wearable sensors are easy to wear on a patient's body without disturbing his/her daily routine. The data from sensors is wirelessly transmitted to the IOT device.

Temperature Sensor: This sensor measures the body temperature. Body temperature recognizes characteristic changes in the body that are caused due to many diseases.

Pulse Sensor: A pulse sensor is used when a patient's oxygenation is unstable. A situation includes emergency and intensive care, and operation recovery. The sensor determines the need for an oxygen supplement.

ECG Sensor: The ECG sensor measures the muscular and electrical functions of the heart. By analyzing the exact waveform pattern, we can identify electrolyte imbalances, rhythm, disturbances and conduction abnormalities

Bio-Medical Sensors: The following bio-medical sensors are used in the proposed solution. Temperature, pulse, and ECG are among the vital signs. These discreet wearable sensors are simple to apply to the patient's body and won't interfere with regular activities. Sensor data is wirelessly transferred to an IOT device.

Body temperature is measured by this sensor, which monitors temperature. Body temperature can identify distinctive bodily alterations brought on by a variety of disorders.

Cloud: Cloud is a network or internet which is present at remote locations. It provides services over networks on public networks or on private networks. There are different applications running on the cloud such as e-mail and customer relationship management. Cloud computing manipulates, configures and accesses the application online. Cloud has unlimited storage capacity.

Experiment Setup

Two tests had been put up in actual networking setups to test the performance of the suggested system in various settings. In a local area network or private network, the first experiment is set up (LAN). The proposed system, database system, and PCs are all linked to the same access point as seen in Figure 1. supposing the hospital patients are furnished with the suggested system. The internal server houses the ECG data that have been collected. ECG data is viewed by doctors in real-time or on demand from their offices. Figure 2 illustrates how the second experiment is set up in the public network or Wide Area Network (WAN). Considering the suggested system is linked to the household WiFi.The cloud server receives the real-time ECG data collection via the internet. Through their own mobile cellular network, doctors can view the patient's real-time ECG by connecting to a cloud server. The number of packet losses and the average jitter delay is used to gauge how well the proposed system performs. At Adriano Serial Monitor and Web Server, the real-time ECG signal was seen. The AD8232 sensor's real-time ECG signal is what is shown on the Adriano Serial Monitor as an ECG signal. The MQTT broker will broadcast this ECG signal for archival in the database system and display it on the web server.

Challenges, Limitations and Future Scope

In the last few years, the healthcare industry has witnessed remarkable technological development and its application in solving healthcare-related issues. This has significantly improved the healthcare services, which have now been brought to the fingertip. With the application of smart sensors, cloud computing, and communication technologies, IoT has successfully revolutionized the healthcare industry. Like other technologies, IOT also has certain challenges and issues that provide potential scope for future research.

Some of the issues have been discussed in the subsequent section.

Cost of Servicing and Upkeep: The HIOT-based gadgets would occasionally need to be updated due to the quick improvements in technology. Every OOT-based system uses several linked medical equipment and sensors. This entails expensive upkeep, service, and upgrades that could have an effect on both the company's and the end-users' finances. Consequently, it is necessary to include sensors that can be operated with less expensive maintenance.

Power Requirements: The majority of HIOT devices are battery-operated. The battery cannot be easily replaced once a sensor has been installed. Consequently, such a system was powered by a high-power battery. But right now, scientists all across the world are working to create medical equipment that can provide its own power. Integrating IOT systems with renewable energy systems could be one of these solutions. To a certain extent, these technologies can contribute to easing the world's energy dilemma.

Standardization: In the healthcare sector, many different suppliers produce a wide variety of goods. The majority of these items assert that the design process adheres to accepted guidelines and procedures. There isn't enough validity, though. In order to standardize these HIoT devices based on communication protocols, data aggregation, and gateway interfaces, a dedicated group needs to be established. It is also important to give careful consideration to the standardization and validation of the electronic medical records (EMRs) that the HIoT devices record. The European Telecommunications Standards Institute (ETSI), the Internet Protocol for Smart Objects (IPSO), the Information Technology and Innovation Foundation (IETF), and other organizations and standardization bodies can work with the researchers to build the working groups for the standardization of the devices.

Security and privacy: The concept of real-time monitoring has changed as a result of cloud computing integration. However, this has also increased the susceptibility of healthcare networks to cyber-attacks. This could result in the improper handling of sensitive patient data and have an impact on the therapeutic process. Multiple preventive steps must be performed while developing a system in order to protect a HIOT system from this malicious attack. In order to protect themselves from attacks, the medical and sensing equipment connected to a HIOT network must assess and use identity authentication, secure booting, fault tolerance, authorization management, whitelisting, password encryption, and secure pairing protocols. Similarly to this, message integrity verification methods and protected routing procedures must be incorporated with network protocols like Wi-Fi, Bluetooth, Zigbee, and others. Since the Internet of Things is a connected network where every user is connected to a server, any flaw in the security services of the IOT could jeopardize patient privacy. This could be resolved by incorporating sophisticated and secure algorithms and cryptographic techniques into a more secure environment.

Scalability: A medical device's capacity to adapt to environmental changes is referred to as scalability. A system with greater scalability operates without hiccups and effectively utilizes the available resources. Therefore, creating a device that is more scalable is essential. This increases a system's effectiveness for both current and future purposes. A HIOT system is a network of connected sensors, actuators, and medical equipment that exchange information over the Internet. A HIOT system's inability to scale due to the unpredictability of its connected devices must therefore be effectively handled.

Identification: Healthcare workers manage numerous patients and carers at once. Similarly to this, a patient sees many doctors when he has several health problems. To minimize confusion and preserve the efficient operation of the healthcare system, it is important to interchange the identities of the patient, carer, and doctors among one another within a single treatment process.\

Self-Configuration: By integrating a feature like manual configuration, IOT devices must provide consumers additional power. The users will be able to adjust the system parameters in response to application demands and shifting environmental conditions thanks to this.

Continuous Monitoring: Several medical conditions, such as those involving chronic illnesses, heart conditions, etc., call for ongoing patient monitoring while they are receiving therapy. The IOT device must be effective at performing real-time monitoring in such circumstances.

Examining New Illnesses: With the quick development of mobile technology, more and more healthcare apps are being added daily. Although there are many mobile apps for healthcare applications, there are still just a few disorders for which these apps were created. Therefore, it is necessary to incorporate more disorders that were either disregarded or given insufficient attention in the past. This will broaden the range of HIOT applications.

Investigating New Illnesses: Every day, more and more healthcare apps are being added because of the explosive rise of mobile technology. Although there are many mobile apps for healthcare applications, the diseases for which these apps were created are relatively few. Thus, it is necessary to incorporate more illnesses that were previously either disregarded or given insufficient attention. The variety of HIOT applications will increase as a result.

Impact on the environment: It is necessary to combine numerous biomedical sensors with semiconductor-rich devices in order to construct a HIOT system. Earth metals and other hazardous materials are mostly used in the fabrication and production processes. This can have a negative impact on the environment. Therefore, a suitable regulatory agency must be established to oversee and manage the production of the sensors. Additionally, more studies must be done on creating sensors from biodegradable materials.

Both private and public networks have been used to test the real-time patient monitoring system that has been built. The real-time ECG signal was successfully shown online and stored in the cloud server. The experiment's findings demonstrate that neither package loss nor package mistakes occur when sending ECG packages across public or private networks. The hospital can use the suggested system. Without having to visit the wards, doctors or nurses can view the ECG signal of any patient at any time, anywhere through a computer or smartphone. Particularly for patients coming from suburban or rural locations, this technique is able to cut down on travel time and expenses. Internet thanks to the real-time patient monitoring technology that has been developed. The proposed approach has the ability to raise the standard of medical care offered across the country. Future work could include incorporating an ECG self-interpretation algorithm into the system to enable alarm generation and detection of aberrant ECG signals. More e-health sensors can be added to this system to collect more different health parameters. To enhance the performance of the suggested system, research is also needed to decrease jitter delay and eliminate noise signals.

The current review looked into a variety of HIOT system elements. This article has covered in detail the architecture of a HIOT system, its components, and how these components communicate with one another. The existing healthcare services where IoT-based solutions have been investigated are also included in this study.

The IOT technology has assisted healthcare practitioners in monitoring and diagnosing a variety of health concerns, measuring a variety of health factors, and providing diagnostic facilities at remote places by utilizing these principles. As a result, the healthcare sector has changed from being primarily focused on hospitals to being more patient-centric. The different uses of the HIOT system and their current trends have also been covered. The difficulties and problems related to the development, production, and application of the HIOT system have also been provided. These difficulties will serve as the foundation for upcoming development and research priorities. For readers who want to not only start their research but also develop it in the field, a thorough up-to-date knowledge on HIOT devices has also been offered.

Through a number of tests, a planned, built, and tested remote monitoring solution for patients at home in IOT environments. The system was built with multiple layers to accommodate the enormous demand for PHDs (Personal Healthcare Devices).

The large population of elderly people makes it impossible for them to receive regular medical care. By carefully monitoring, recording, and summarising the health trends recorded by physiological and environmental sensors, this IOT-based system not only offers an accurate diagnostic of the user's state but also a solution that detects and avoids health episodes. Utilizing Intel Edison enables multitasking and uses little power. Both doctors who are overburdened with patients and patients in rural areas who have limited access to medical services can benefit from this method.

References

1. Chaouchi, H. (2018). The Internet of Things: Connecting Objects to the Web; Wiley: Hoboken, NJ, USA.
2. Hoeller, J., Tsiatsis, V., Mulligan, C., Karnouskos, S., Avesand, S., Boyle, D. (2017). From the Machine-to-Machine to the Internet of Things: Introduction to a New Age Intelligence; Elsevier: Amsterdam, The Netherlands.
3. Kearns, W.D., Nams, V.O., Fozard, J.L. (2010). Tortuosity in Movement Paths Is Related to Cognitive Impairment Wireless Fractal Estimation in Assisted Living Facility Residents. Meth. Inf. Med. 49. Pg. **592–598.** [CrossRef] [PubMed].
4. Chen, H., Kalish, M.C., Pagán, J.A. (2014). Telehealth and Hospitalizations for Medicare Home Healthcare Patients. Am. J. Manag. Care. 17. Pg. **224–230.**
5. . Kearns, W.D., Fozard, J.L., Becker, M., Jasiewicz, J.M., Craighead, J.D., Holtsclaw, L., Dion, C. (2012). Path Tortuosity in Everyday Movements of Elderly Persons Increases Fall Prediction beyond Knowledge of Fall History, Medication Use, and Standardized Gait and Balance Assessments. J. Am. Med. Dir. Assoc. 13. 665.e7–665.e13. [CrossRef] [PubMed].