Internet of Things in Healthcare, A Literature Review

Conference Paper · November 2021

DOI: 10.1109/ICTAI53825.2021.9673369

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Suhail Javed Quraishi
Department of CSE-AIT
Chandigarh University
Chandigarh, India
suhail.e11364@cumail.in

Humra Yusuf
Department of CSE
Invertis University
Bareilly, India

***Abstract*— Over the last few decades, extensive research has been consigned to the study of various technologies such as information technologies in order to strengthen the existing ones. One such field is the Internet of things (IoT). In recent times, internet of things has been a ground-breaking technology in almost all sectors of human life. IoT holds the tendency to make available both value-added services and mainstream services in all fields. Healthcare sector is one such area. IoT for healthcare tends to keep doctors and professionals more watchful and connected with the patients proactively. For the overall development of a nation, healthcare is the main service center. It is clear that technology cannot help to eradicate the issues related to health completely but it can make access to healthcare easier. In today's scenario where healthcare has been drastically despoiled, IoT has completely changed the perspective of traditional healthcare methods. IoT tends to play a crucial role in providing better and improved services. Real-time monitoring of the data via smart devices use to transfer collected health data to a physician. Patient health observation and monitoring, emergency proceedings, remote inspection, and observation are some vital analyses that can be made with the launch of the Internet of Things in the respected sector. The standpoint of the paper is to summarize the applications of IoT in the field of the healthcare field.**

Keywords*— *Information technologies, IoT, Healthcare, Sensors, Remote inspection.

I. INTRODUCTION

The term IoT is not unknown for now. The IoT or internet of things is referred to many of physical devices around the globe that are connected to the internet, all gathering and sharing data. With the introduction of the super-cheap computer chips and ubiquity of wireless networks, it has now become possible to make anything, from any small chip to any bigger device. IoT basically is defined as the connection of many embedded devices supplied with internet connectivity. These devices share data with each other and with people on a broader scale. The IoT is turning the structure of the world smarter and responsive thus consequently combining the digital and the physical world. There is a disparity between internet and internet of things. It can be clearly said that Internet of things is smarter than the internet as it connects the different devices, analyses it and make decisions. Technically anything can be converted into a smart device by connecting it to the internet connection for exchange of data.

The emergence of idea of internet of things took place 17 years back. Kelvin Ashton, however in 1999 gave us the term "internet of things" during his work in Procter & Gamble. The progress however at that time was slow because the chips at that time were huge and bulky. It was not possible to embed the chips to the basic objects. Slowly and eventually with the progress in the technology IoT emerged out to be an essential sector in human lives.

Tagging Radio Frequency Identification (RFID) tags to costly equipment was the first application of IoT. This was done to keep a record of their location. Since then, cost of tagging sensors and connection to internet in basic home commodities has eventually fall. Many of the experts claim that adding tags and internet connection to basic commodities will be as cheap as 10 cents.

There is numerous application of IoT. It has been successfully developing its roots in the healthcare field so far. It aims at providing well organized and much effective services to the patients. Healthcare applications of IoT have potentially able to offer comprehensive patient care. Monitoring of the patients health has become much organized and empowers physicians to provide the best of healthcare. IoT eases things not only for the patients but also for the physicians. A huge pool of data of the history of a patient treatment can help a doctor/physician to give a detailed description of their health before starting a thorough treatment. Through IoT patients are connected to the sensors and the necessary health data and information is transferred to the health-control unit. With this, concept of 'virtual hospital' can be better understood as IoT aims at providing services at remote areas. Providing healthcare has not remained only limited to clinical centres. IoT here act as a boon for those people who regularly cannot head up to a clinic/hospital for regular check-ups. Fig. 1, illustrates the various areas of healthcare where IoT is paving its way.

Through IoT decision making in healthcare field has been improved drastically. The physician can take an effective decision regarding patient's health by considering the history of his health data. The main motive of IoT is to modernize the healthcare sector with new technologies. Some of the parameters that IoT has covered are monitoring the health condition, change in interaction, data collection, observing health condition, determining new techniques for disease

prevention and self- care. IoT extremely enhances the nature of health-care by constant consideration and lesser mistakes thereby bringing down the cost of self-care. Today, IoT has affected every aspect of the business platform. The main motive of IoT is to empower the objects for the connection anywhere at any time. The IoT is the new evolution of internet. It aims at building a smart world with smarter areas of health facilities.

Fig. 1. IoT implementation in the healthcare

IoT, with no doubt faces different hurdles and challenges when implemented in health-care sector. One of the hurdle that IoT overcomes in the healthcare sector is of safety and violence. Sometimes violence can be seen within the staff of a hospital, but sometimes there are life threatening acts done by the patient's family against the staff or patient. CCTV cameras help to keep a record of movement of all the people inside a healthcare centre. Also biometric sensors can be used to identify the aggressions or anxiety of the visitors or the staff members.

Healthcare methods based on the technology of IoT, has benefited in improving the treatment methods and improving patient health. In the present scenario IoT has been the focus of many researches. But introducing it into the developing countries where common public in still not aware of these advance technologies, is a big challenge. IoT aims at making healthcare better with the upcoming time. There are millions of patient worldwide who are handled on medical technology products. From surgical and endoscopic products to patient handling and orthopaedics to neuro technology and more, innovation has always been at the forefront. The work of various firms in this field has been a big boost for everyone. The cloud enables security and helps strike it to connect to and have real time data. The IoT enables to really capture and access data continuously which allows to quickly respond to the need of the different products that are in this field to make them better. This real time data is also accessible by the patient themselves. This collected data allows predicting any maintenance issue before it really happens. It also enables the end users such as surgeons, physicians and doctors to better control the usage of the actual instruments in the operating room. This all positively affect patient's outcomes. Ultimately this all helps in providing better quality of life for more people.

II. IoT ARCHITECTURE

In this section, the basic architecture of an IoT device is explained. Fig. 2 demonstrates an IoT device architecture having four layers. The base layer consists of IoT devices like sensors with the ability to sense, compute and connect other devices. The second layer is the IoT gateway or aggregation layer. This layer significantly aggregates data from various sensors. These two layers form the definition engine. In order to set the rules for data aggregation next layer is based on cloud. It is called the processing engine or event processing layer. It has numerous algorithms and data processing elements that are ultimately displayed on a dashboard. This layer basically process the data obtained from the sensors layer. The last layer is called the application layer or API management layer. It acts as an interface between third party application and infrastructure. This entire landscape is supported by device managers and identity and access managers which are useful for security of the architecture.

Fig. 2. IoT Device Architecture

III. RELATED LITERATURE

IoT for healthcare field has been path-breaking technology. This has been possible with the help of so many back end technologies working up together to achieve a desired goal. A lot of work has already been done in this area and a lot of it is needed to be done. We here, throw light on the major areas of healthcare sector which are already implemented with IOT.

P. Chatterjee et al.[5], in the paper discuss about the implementation of IoT in healthcare field in the cardiovascular diseases. In this area IoT focuses on connecting all the medical entities together in order to get the efficient analysis. Through this, the information of all the entities can be shared on a common platform through all the smart inter-connected devices. Here, the centre point was to make a decision-support system to examine the amount of possibility a person have for cardiovascular disease. Along this, some parameters such as age, gender, diabetic problems, cholesterol level, smoking habits etc. were took in consideration. A survey of 600 people is conducted along with mentioned physiological parameters. The Framingham's score along with the other physiological parameters of a person, is embedded in the reference engine gives us the risk score of that person. It can be clearly seen that how the physiological parameters impact on diagnosing risk of any particular disease.

S. Sheikh et al.[9], in the paper focuses on the healthcare monitoring system using IoT. Certain arrangements of the

raspberry pi, graphic card and memory with internet connected to them, so that they can safely catch and share the data. This collected data is forwarded to the physician through remote network who can intelligently make a decision regarding the patient's health. This all process eliminates the physical visits of the patients to the clinics. A model is proposed in which all the sensors were connected to raspberry-pi processor. Database is responsible for storing the collected data which is on the cloud. This stored data on the cloud is displayed on a web page by guarded security person. Also, in case of any emergency the doctors are sent an alert accordingly. The different sensors used in the model were temperature sensor, ECG sensor, raspberry-pi etc.

S. K. Routnay et al.[10], in their paper discussed about the use of narrowband IoT. Narrowband IoT is a version of IoT which is simpler and cost effective. NBIoT or narrowband IoT uses smaller number of quantity of resources that is why it is most preferable solution. Further in the paper issues and problems related to use of NBIot is discussed. Narrowband IoT has been proposed as a possible solution for the applications linked to healthcare. It is a leaner and thinner translation of IoT. NBIoT has low power wide area (LPWA) coverage capabilities because of which it is mostly attracted in different applications. Applying this technology to the existing system will not only reduce the cost but is also effective in providing the better health services. One possible field where NBIoT can be used as an alternative to the technology is healthcare. NBIoT is an easy technology for detecting the alterations in the performance of human body functions.

TABLE I. RESEARCH WORKS ON IOT FOR HEALTHCARE

Paper	Aim	Technology	Accuracy	Highlights
[5]	To detect and cure cardiovascular diseases with the help of IoT	Use of Framingham score for the detection of disease.	Was nearly successful in diagnosing the disease.	Easy risk assessment. Cost effective
[9]	To propose a scalable and flexible healthcare monitoring system.	Use of raspberry-pi for the analysis.	Had future scope. All sensors were connected to the raspberry-pi which makes the proposed system much more accurate.	Easily accessible.
[10]	To propose a cost effective and much simpler IoT healthcare system using narrowband IoT.	Use of microcontrollers inside the sensors. And use of mobile application to transfer the data.	Due to deficiency in the technology total accuracy cannot be achieved.	Remote monitoring became easier. Provided better services.
[11]	To propose a remote prescription and i-home healthcare based on IoT.	Use of sensors on the patient body to monitor the data and use of raspberry-pi.	Improves efficiency and make it much more accurate.	Minimizes hospital visits. Monitor even smallest changes of the patient body.
[17]	To discuss the ongoing advances in the engineering field to in order to improve the healthcare architecture system	Use of various sensors such as ECG sensors, temperature sensors, heart rate sensors to	The paper provides the complete overview of the advances made till date.	Data could be easily accessible to the doctors whenever they require it.
[12]	To build a mobile based healthcare application using IoT and cloud computing.	Monitoring ECG waves using mobile based application. Use of microcontroller and signal processing for ECG waves.	Use of the data can be done by the physicians for a longer period of time and for further analysis.	Use of IOIO microcontroller, signal processing, and communication protocols, efficient and secure mechanism for large file transfer.
[22]	To detect voice pathology with the help of IoT	Representation of voice signal using the local binary pattern(LBP) on a mel-spectrum representation of voice signal	Using smart devices such as microphone, the scalability can be increased	The research involves health IoT-based monitoring framework
[23]	To encrypt IoT messages using IoT group key and share it with the patient	Privacy preserving framework which is based on IoT healthcare data	The flexibility and the scalability of the proposal can be further increased	This proposal work upon on securing the confidential health data of patients.
[24]	To process the ECG data of the patients suffering from cardiovascular diseases	To monitor the ECG, glucose and body temperature of the patients	The proposal required good battery health of the devices that is worn by the patients	Size of data has to be reduced.

S. Lavanya et al.[11], in their paper proposed a model which helps both patients and the doctors. The time can be saved as the patient doesn't have to visit the clinic to the physician for his regular treatment. The health data of the patient is stored on the cloud which helps in giving more proper and efficient services. In the paper, ihome health-IoT system is proposed which is home centric healthcare platform. For the daily medication management the smart sensors are

attached to human body for physiological monitoring. A raspberry-pi processor is used which is an incredible piece of hardware. It is so because of the amalgamation of the features of conventional computer and an embedded machine.

I. Singh et al.[17], proposed a paper where the recent progression in IoT based human services structure. Sensors like ECG sensor, temperature sensors and heart rate sensors have been used to build up the planned framework. In the software architecture of the model a complete path of the patient's data is described as how the data from the cloud server reaches to the doctor, who further takes the necessary actions.

Junaid Mohammed et al.[12], focuses on building a mobile based application for the healthcare domain which uses the technology of IoT and cloud computing. They build "ECG Android Application". In the app the data is uploaded to user private centralized cloud from the patient's end. This data is retrieved from the physician's end for doing the further analysis. Their paper revolves around describing the fundamental theories of IoT. Whole paper gives a detailed description as how ECG waves are studied with the help of an android app. The infrastructure given in this paper can be applied to other healthcare related application also. Table I summarizes few of the previous works in the field of usage of IoT for healthcare

IV. Challenges and Limitations

IoT has been paving its way rapidly in the field of healthcare. But there are numerous challenges which still needed to be overcome in order to achieve cent percent accuracy and success. Some of the few challenges are high power utilization, accessibility of fewer resources and security issue because of the use of many devices. Also continuous use of wearable sensors can make the patient uncomfortable. The data transferred to the doctors may contain a lot of noises. Also, many devices and signals are used in a single network; it may increase the power consumption. Cloud computing is used alongside to store the data of number of user and devices it increases the complexity of the system. Another most important challenge to IoT is of security. Inside one frame of network numbers of devices are deployed. These devices are vulnerable to attack. Because of the low resource constraints these devices are not suitable to apply techniques of encryption. However in the recent times, work has been carrying out in order to reduce these limitations and challenges. As with the advancement in the work of IoT there are certain challenges which increase. Devices used in a network of IoT are large in number so the amount of data produces in very large. This data may become an issue sometimes. Sometimes, this data is interrupted and may lose. Thus, proper strategies are taken to keep these hurdles away from a secure and proper network of IoT. Some of the big issues with the IoT in healthcare sector is how to integrate the new devices with a system that may have not been updated in several years. Further challenge is that the data that has been collected is valid or not. So, doing research studies take time. So, as the technology is coming out and it's continuously advancing, by the time research is completed there may be something better already coming out.

Also, making sure that people's health information is properly protected is a really important thing. Then comes the human factors of getting people to adopt the technology.

V. Conclusion and Future Development

The main and focused goal of IoT for healthcare is to provide better and advanced services in healthcare sector. IoT has contributed in transforming the healthcare facilities. From clinics and hospital to the home IoT has been a boon for the elderly patients. It has reduced the headache of regularly visiting the healthcare centre. IoT has remarkably contributed in increasing lifespan of the people. However, some challenges and limitations still reside in the respected area. For achieving secure and fully developed services further works have been carrying out.

Even after so much advancement in the field of healthcare, wearable sensors still is a major issue of discomfort for some patients. This is an important issue as comfort is a major concern. Another holdup issue for the sensor devices is that, they require continuous power supply. The solution can be use of rechargeable batteries. But, recharging regularly may cause burden over the patient. A sustainable solution is using sensor device which uses low power consumption and which can be charged over solar energy. The main threat to the IoT for healthcare is that all the data is shared over internet thus making it open to be used by the attackers. In order to maintain the privacy of the patients there should be proper authentication check over every step. All the network is wireless and low power supply devices cannot be implemented with complex security programs. So, much research is required to be done in the field of security for IoT for healthcare.

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