

# IoT based Smart Healthcare Monitoring Systems: A Review

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**Abstract**— IoT devices are becoming very useful in today's world. In today's era IoT devices are increasing and it has a huge impact in healthcare. It can provide early detection of health problems and can reduce the cost of medical care. The healthcare monitoring system is required for a patient who needs to be monitored 24 X 7. The IoT based health monitoring system can monitor the vital health parameters of a person at all times. It can help patients in the case of emergency by providing immediate health consultation from the doctor available at a distant location. Further, IoT based smart systems enable remote monitoring of the patient by the guardian/ family member which is considered as one of the major advantages to save the precious human life. This paper provides an overview of various IoT based health monitoring systems. The comparison of various healthcare devices has also been presented by taking into consideration the important healthcare parameters.

**Keywords**— *Health monitoring, heart monitoring devices, IoT, healthcare, medical services*

## I. INTRODUCTION

In this era of information technology (IT) everything is going to be IT-dependent. In the future world, everything is going to be equipped with the newest technology which can enlighten the world in the form of the Internet of Things (IoT). IoT is the field of information technology which is widely used in many areas of industries, smart cities, to make everything intelligent, efficient, and useful for human life [1]. The healthcare system still majorly functions in offline mode. Many researchers are working in healthcare domain to integrate the healthcare technology with IoT and cloud systems so that the health facilities can be made available from anywhere and anytime. Researchers working in IoT and for healthcare domain and designing different IoT devices. The healthcare area is making progress with the help of IT. Many devices are in the market which helps the person to monitor their health parameters. Some of the devices are heart monitoring, Diabetes tester, Oxygen level checker. Smart watches are leading in this area as this device can measure heart

rate, oxygen level, and it guides towards keeping a good health regime.

Nowadays, there is a lot of research going on in the IoT, cloud, wireless sensor networks which has led to the innovations in various smart applications that are helpful in daily life. Intelligent cities, homes, cars, health monitoring systems etc. are examples of IoT [2]. Health monitoring is playing an important role in the field of healthcare. Healthcare is always improving with IoT devices because of IoT capabilities and tools which help in monitoring the health of people in real time [3]. IoT devices can monitor the data from wireless sensors and IoT devices receive information about the human body like blood pressure, heart/pulse rate, body temperature [4]. The healthcare dependency is rapidly increasing to make the services of IoT better in terms of quality, access and cost [5]. The IoT can help and ease the life of patients and doctors. The IoT devices can track, monitor and record the patient's health, vital medical information which can help patients and doctors to take necessary precautions in the real time and in case of emergency [6].

The Health Monitoring systems are the IoT based devices which can measure the various vital parameters of the patients. The fig. 1 shows working of IoT based health monitoring system. The parameters on which these system works are heart rate, blood pressure, temperature ECG, disease prediction etc. These devices read the natural frequencies produced by the human body. These frequencies are measured to gather data and to perform analysis. Thereafter, the analysis is performed on the collected health related and prediction can be made about the patient's health condition.

The paper is organized as follows: section II provides an in-depth review of the previous research work done in the IoT based health monitoring system. In section III provides a comparative view and discussion of various reviewed works on the basis of important health parameters. Section IV finally concludes.

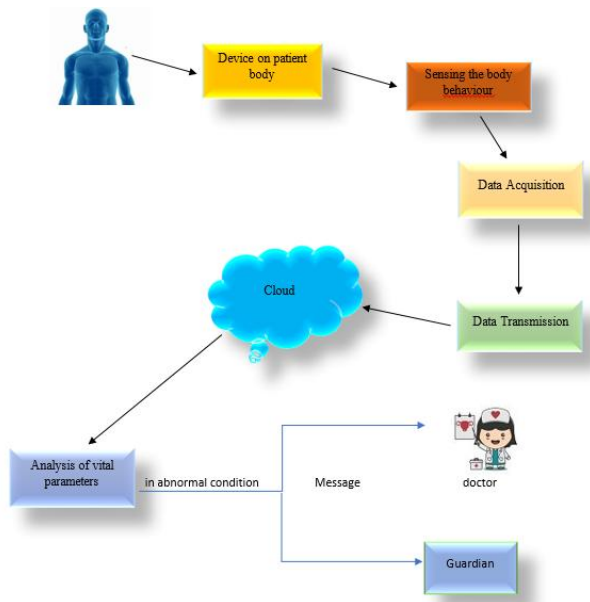


Fig. 1: Working of the IoT based Health Monitoring System

## II. LITERATURE REVIEW OF IOT BASED HEALTH MONITORING SYSTEMS

In [2], the authors proposed a healthcare system with various distributed systems which analyse information gathered from the patient body and make communication in real time by storing data on cloud. This paper implements IoT based health monitoring system for hospitals using Zigbee mesh protocol. It can monitor mental state of patients. It enhances merits of monitoring of patients and reduces the cost of healthcare and analysis. The hardware components used in this device are Intel galileo generation 2 board, Arduino board, XB24-B, XBEE S2 modules, XBEE S2 adapter, LM35 temperature sensor. In [3], the authors proposed a remote- controlled monitoring system with Raspberry Pi. The device is designed for continuously monitoring of vital parameters of patients like the ECG (Electrocardiogram). The data is stored in database that can be seen through a website and this data can only be accessed by authorised persons. The primary method is to update the data and if any abnormality occurs then the alert is sent to the doctor. The parameters are ECG, heart rate. In [4], the authors developed a healthcare system with smart monitoring of personnel and biomedical services. The proposed smart healthcare system for hospitals works with many different technologies like RFID, wireless sensors and smart mobile. These technologies work together with the help of CoAP/6LoWPAN/ REST protocols. The system gathers data from environment and patient physiological via low powered hybrid technologies. The data is sent to the data centres where with a smart mobile application a user can access data with the help of REST services. The parameters on which the author has worked is biomedical services. In [5], the author proposed a device to check on person's health and monitor it. It helps in monitoring the pulse rate, temperature, blood pressure,

and real time patient monitoring system. It eliminates the manual data collection, stores, and delivers the data on the cloud. It gathers real time data and provides high quality of service to users. It seamlessly gathers the data, shares information with each other and stores the info to analyse the data. The parameters on which the author has proposed his work is pulse rate, temperature, blood pressure. In [6], the authors proposed the model by which users can improve their health issues, minimize their risk, and reduce the cost of health monitoring by collecting, recording, analysing and sharing large amounts of data in real time. With the help of this model, users didn't have to go to the doctors physically for problems like blood pressure, heart rate and temperature. The smart healthcare applications facilitate the patient by providing help through doctor so that health services can be made available the user anywhere at any-time in the case of an emergency. The model works on the parameters like health monitoring, heart rate, temperature and ECG. In [7] proposed a method where ECG monitoring is done by using IoT techniques. It gathers the data from IoT device and with the help of internet it transmits the date to cloud. The proposed system utilizes HTTP and MQTT protocols to provide visuals to the doctors. This monitoring system consists of three parts: ECG monitoring, IoT cloud and GUI (Graphical user interface) and utilizes Zigbee model. The algorithms used in these devices are Marshall-Hash Algorithm (MHA), Advanced Encryption Standards (AES), Chaotic Fruit fly Optimization Algorithm (CFOA). The parameters on which the authors have proposed this work are ECG monitoring and health monitoring. In [8], an architectural review of smart IoT based healthcare monitoring device is used for better healthcare for the patients. With this system body temperature and vital parameters of the patient can be measured. The data is transferred to the microcontroller ATMEL89552 and micro controller transfers that data to the MYSQL server. The server manages the data and provides accessibility to the user. If data is abnormal then patients get notification and the caretakers will also get emergency messages for the same. The parameters considered in this work are healthcare, body temperature and heart rate. In [9] the emphasis is made on the the usage of why and how the smart health monitoring systems and tools is an important aspect in today's scenario. This proposed approach gives the patient restorative personality. The health monitoring system is structured to work on particular viewpoints and it makes decisions on the basis of data gathered from the source. The parameters are pulse rate, heart rate, medical services, In [10], proposed a healthcare monitoring system which aims to give medical services without physical contact with doctors. This paper introduced a device with IoT which is a platform for new devices and applications with the help of Raspberry Pi controller, the generic health monitoring. It monitor's heart health and stores the data on the cloud, it can be seen in the form of a graph. The major parameter taken into consideration is heart rate. In [11] proposed a reliable monitoring system for patients so that the doctors can monitor their patients by using the system made by IoT at home or at the

hospitals. The device is mobile based application consists of sensors, data, acquisition unit, Arduino. The heart rate, temperature and EEG can be monitored by this device. In [12] the authors proposed a monitoring device which helps the doctor and user to monitor the health of a person easily with low cost. The device is made using raspberry pi on the IoT platform. There are two ways to connect and operate a raspberry pi system. One is direct connection with peripherals and one is through the software called putty. If any anomaly is detected by the system in the health of a person then the message will be sent to the doctor and user. The power consumption of the device is very low. The parameters on which the author has worked are pulse monitoring, blood pressure, temperature, respiration, ECG. In [13] proposed a framework for remote monitoring of ECG signals which allows monitoring in real time [13]. The data is transmitted over the internet to the medical institution. This data can also be stored on cloud for future reference. The framework provides monitoring without any special machinery. The patient uses the mobile electrocardiograph and the readings are transmitted to the medical institution instantly. The parameters on which the author has worked here are remote sensing, telemedicine electrocardiography.

In [14] SHA 512 is used for security which is an IoT centred deep learning modified neural network for monitoring the health of heart patients. The gathered data is securely transmitted to the cloud by using encryption. Thereafter the data is analysed, if found abnormal then in case of the emergency the information is transferred to the doctor and guardian. The parameters considered in this work are heart disease, healthcare monitoring. In [15], authors proposed a framework based on the resource description utilisation. In this work the resource description framework (RDF) graph is used to illustrate the data and semantic queries for reconfiguration. For rule management mechanism the semantic IoT gateway is used and it enables the rule configuration which is made to satisfy the user requirements. Finally, comparison is performed with the solution which uses ontology in real time monitoring systems. In [16] the author proposed a device with the combination of the hardware components. In implementation phase the components are assembled together. These sensors are connected with ESP-32. All sensors are connected to  $V_{cc}$  and GND pin ESP-32. Similarly, all the components are connected. This is basically a device which will monitor the heart beat/pulse rate of a person in real time. The parameters on which the author has worked are patient's health, basic health, room temperature condition in real time. Error rate is less than 5%. In recent past there has been a lot of tremendous research going on in the wireless sensor networks, IoT, cloud which has led to the innovations in various smart applications however there still exists various challenges need to be explored further [17-31].

### III. COMPARISON AND DISCUSSION OF IoT BASED HEALTH MONITORING SYSTEMS

This paper discusses various IoT based healthcare devices. These devices are very helpful for the patients and the doctors. Most of the existing health monitoring devices are IoT based and developed using Arduino/Raspberry Pi, to monitor the patient's health in real time so that proper treatment to the heart patients can be given on-time. There exist various research gaps in the available IoT based health monitoring systems. The existing heart rate monitoring systems majorly measures pulse rate and heart rate a major parameter.

There are various other vital parameters which has not been taken into consideration such as oxygen level, sugar level (low or high), Blood pressure (BP) (Low or high). Few monitoring devices have added features like BP and temperature. But the problem still exists that a person can't wear different devices at the same time. BP is measured in few health monitoring devices but it is not considered as major factor for health condition whereas BP (either high or low) can also lead to a life-threatening situation because BP can affect the heart rate of the person. Health monitoring system lacks to consider the situation when a person falls without any movement. Hence, this can be another critical and emergency which must be considered by a smart health monitoring system so that immediate help and health support can be provided. Existing systems also lacks in data aggregation of the monitoring device since the monitoring is done in real time and it should be stored on the cloud so that later on the collected data can be analysed to know the emergency situations in a patient's profile. Table I shows the comparison of various IOT based health monitoring systems on the basis of various health parameters taken into consideration by researchers.

TABLE I: COMPARISON OF VARIOUS IOT BASED HEALTH MONITORING SYSTEMS

Ref. no.	Heart rate/ Pulse rate	Healthcare Monitoring	BP	Medical Services	Temper ature	ECG	Ambient Technology	Disease Prediction	Remote Sensing	Tele Medicine	Phycological state
[2]	-	√	-	-	-	-	-	-	-	-	√
[3]	-	√	-	-	-	√	-	-	-	-	-
[4]	-	√	-	-	√	-	-	-	-	-	-
[5]	√	√	√	-	-	-	-	-	-	-	-
[6]	√	√	-	√	√	√	-	-	-	-	-
[7]	-	√	-	-	-	√	-	-	-	-	-
[8]	-	√	-	-	-	-	√	-	-	-	-
[9]	√	-	-	√	-	-	-	-	-	-	-
[10]	√	√	-	-	-	-	-	-	-	-	-
[11]	-	√	-	-	-	√	-	-	-	-	-
[12]	√	-	√	-	√	√	-	-	-	-	-
[13]	-	-	-	-	-	√	-	-	√	√	-
[16]	-	√	-	-	√	-	-	-	-	-	-

#### IV. CONCLUSION AND FUTURE SCOPE

This paper provides a review of various IoT based health monitoring systems. The paper also provides a comparison of various healthcare devices taking into consideration the important healthcare parameters. It is concluded from this review that all these devices are focused on monitoring heart rate as vital parameter. However, there are many other important parameters which has major impact on a person's health condition which include BP (Low or high), sugar level, and oxygen level. Therefore, it is recommended for that these parameters must be taken into consideration while designing an IoT based smart healthcare monitoring system so that the precious human life can be saved.

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