

# IoT, an Emerging Technology for Next Generation Medical Devices in Support of Cardiac Health Care – A Comprehensive Review

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## ABSTRACT

Cardiac diseases are the major causes of death in both developed and developing nations. As per WHO, it is estimated around 17.9 million people died due to cardiovascular diseases which accounts for 31% of all global deaths every year. More than 75% deaths occur in middle and low income countries. Globally, the main reason for the fatality of cardiac patients is Stroke and Heart attack, secondly the unavailability of doctors and insufficiency of hospitals with proper infrastructure in remote areas. Around the world, only few cardiologists are available, especially in developing countries like India; around 64 million peoples are suffering from different types of cardiac diseases with just about 4000 cardiologist. The ratio between the availability of cardiologist and cardiac patients varies significantly, which leads to alternative measures to monitor the patients from their respective places to prevent the death. In recent days Internet of Things (IoT) is the most innovative technologies that revolutionize the health care sector by providing modern medical devices for diagnosing, monitoring and treating patients with several diseases. IoT help the people who are at higher risk of getting diseases and make them to live a healthy life. This review paper is aimed to explore the benefits, applications and challenges of IoT based medical devices which are designed to diagnose and monitor the cardiovascular diseases and also give an insight about the overwhelming superiority of IoT in solving the problems arising due to heart diseases by expanding the medical resources and its availability.

**Keywords:** Cardiovascular diseases, healthcare, IoT, medical devices.

## 1. INTRODUCTION

Cardiovascular diseases are disorder of blood vessels and heart which includes rheumatic heart disease, coronary heart disease, cerebrovascular disease etc. The major cause for sudden cardiac arrest is drop in oxygen levels in blood which causes damage to cardiovascular system and rise the blood pressure. From the current report from WHO, it is observed that every year around 17.5 million people died due to cardiovascular diseases. The percentage of people with heart diseases differs geographically, that is around 1 to 5% in rural areas and 2 to 11% in urban areas, with an increase of 300% over past 30 years. It is clearly understood that people living in urban areas are mostly affected by cardiovascular diseases which may be due to various environmental factors, life style etc., [1].

Globally, large numbers of people are affected with cardiovascular diseases, which may cause serious health consequences either directly or indirectly such as heart attack, congestive heart failure, arrhythmia, kidney failure and stroke [2, 3]. Either delay in the treatment or unsuitability of the treatment of the diseases and abnormalities may cause danger to the patients. Hence, there arises a need to observe and report the condition of patients' health regularly to health care centres or doctors on time. To overcome these issues continuous health monitoring devices are considered as good solution.

The modern health care system provides individuals with superior health care services in a reasonable cost at anywhere anytime by changing the conventional approach to patient friendly approach. In conventional approach the health care professionals play a vital role in diagnosing the diseases and treating the patients by visiting the health care centres. The main problem in this approach is the availability of doctors in health care centres and long period of patient's admission to hospital. To solve these problems, patient friendly approach has been designed and received. In patient friendly approach, the patients get to know their health conditions by active participation in disease diagnosis, its prevention and treatment at anytime and anywhere. This approach is more user friendly, reliable and readily accessible individual monitoring system to lead an effective and healthy life. [4].

Internet technology has reformed the human life by endowing with advanced facility of both software and hardware such as sensors, processors, transmitters, receivers etc., in the field of communication to connect people or devices ubiquitously at any instance. A new concept of technology expanding the services of Internet is Internet of Things, an emerging field that gains fame in everyday life in health care [5]. Internet of things (IoT) is a system or process interlinked between computing devices, objects, digital and mechanical machines, people and animals and other internet devices which are provided with unique codes to collect and exchange data [1].

IoT transfer the data through the network without the assistance of humans. An object in IoT can be an individual or animal with a biochip or monitoring implant or other substances with IP address which have the ability to transfer the data through network connection [6]. In general IoT act as a catalyst and plays a significant role in monitoring the health conditions, agriculture, environment, transportation and building management using smart wearable devices, biochips, microchips, sensors and smart grids [7].

The wireless communications require no need of active participation of patients. Individuals or patients can be monitored by sensors in passive form [6]. Network devices, such as wireless sensor, wearable sensor, implanted sensors either on the body or in living environments, gather information to evaluate the mental and physical condition of the individual by collecting the blood pressure, body temperature and sugar level etc., IoT shows its ability to solve most of the problems and difficulties in health care systems. It also helps to improve the quality of health care services by offering remote monitoring and notifications. But conveying the collected data to health care monitors to make accurate decision and advising the patient is the most challenging task in IoT technology [7].

The most relevant areas of research for heart problems is by reviewing the clinical reports of cardiac diseases and implementing the technologies for detecting the real time abnormalities. Plenty of research work and surveys are conducted to find the real key factors for heart diseases. The studies reveals that environmental factors, blood pressure, obesity, increased lipid levels, living habits such as lack of exercise, smoking and food habits etc., increases the risk of cardiovascular diseases [8-11].

Early detection of these risk factors helps the patients to recover faster. Now a day's through the interlinking of health care systems with the artificial intelligence, the abnormalities of the diseases can be easily detected in earlier stage and facilitates the treatment of the disease faster. This review paper gives an insight about the usage and benefits of IoT devices in support of cardiac health care.

## **IOT FOR MONITORING BLOOD PRESSURE AND ECG**

Yan Fang *et al.*, (2016) designed an early warning system under mobile environment for cardiovascular patients. This system is designed in such a way that it collects the current activity and key indicators of the patients by wearable sensors (Blood pressure, ECG, Body temperature, location etc..) and by patients themselves (Blood lipids, body fat percentage etc..) before and after intake of food. Once the mobile terminal starts its work, mass of data will stream into heterogeneous and multi-sources. Here preprocessing of the data takes place and it will be uploaded to the server for analysis and storage. The collected data will be used in three different parts, i.e., first for detecting the abnormalities by on time monitoring the indicators and analyzing the data based on knowledge base predetermined cases, secondly for evaluating the health risk and providing early warning to the patients and finally obtaining common and personal knowledge for cardiovascular diseases. The system principle takes advantages of both off-line knowledge mining and on-line analyzing. Here the procedure for early warning of cardiovascular diseases is proposed using two methods that is knowledge engineering and data mining. This two-tire platform transfers the data between multi-users and also provides a timely alarm for patients with cardiovascular diseases [12].

Chao Lia *et al.*, (2017) developed a heart disease monitoring system based on IoT technology for healthcare service. This device is designed in such a way to monitor the physical signs of the patients like ECG, blood pressure, peripheral capillary oxygen saturation (SpO<sub>2</sub>) and environmental factors continuously by wearable or mobile devices. Four operation modes of data monitoring system are designed for data transmission. They are (i) real-time continuous transmission for all data for high risk patients, (ii) continuous transmission in special periods, and (iii) event triggered transmission for middle risk patients and (iv) transmission on patients' demand for low risk patients. This monitoring system is aimed to assist remote health care professionals to be aware about health status of patients and to reveal the real conditions [13].

## **HEART BEAT MONITORING AND HEART ATTACK DETECTION SYSTEM**

Now a day's, there is an increase in the number of heart diseases with the main risk of heart attack. A model was designed by means of a sensor device for monitoring the heart rate by using heart beat sensing method. This method is user friendly, the users and concerned ones can monitor the patient heart beat even at home and give an alert to doctors over internet. The sensors are interfaced with a microcontroller which allows the checking of heart beat. Patients and users can set the levels of upper and lower limit of heart beat, if the heart rate crosses the limit the device send an alert to doctors and users to predict the present situation. The device is also helpful in detecting the heart attacks by monitoring the heart rate and the person can be saved immediately from anywhere on time [14].

Ponugumatla Kalyan and Gowri Shankar Sharma (2017) proposed an IoT based heart disease prediction and monitoring system using raspberry pi 3 and Arduino. An AD8232 heart rate sensor module is used to interface with the Arduino board which communicates in sequence with the raspberry pi board. Python software is used to control the system and to store the data in cloud form using Wi-Fi and HTML. This offers safety and facility for retrieving the sensor data and for monitoring the patient heart condition at anywhere and anytime over mobile phone or internet. This web-based ECG system is used to display the real-time ECG signal, heart rate of a patient along with GPS Location and allows monitoring the heart condition for diagnosing different heart diseases. This monitoring system is very useful for the patients to monitor the small changes in the health condition and to report the doctors for treatment [15].

## **WEARABLE HEALTH MONITORING SYSTEM**

Wearable health monitoring system based on IoT technology was designed by Rashmi *et*

al., in 2017. This system makes use of a flexible sensor attached to the yarn as a conductive material to notify the information of the patient's health and stores the data in cloud for easy access. The proposed system makes the patient to be detached from equipments and offer around the clock monitoring of patients health, provide self test application which avoid physician intervention. This pervasive approach uses a small wearable ECG sensor and mobile phone to collect the symptoms of user's and also to detect the onset of a heart attack by investigating the ECG recordings. Any small changes in the skin caused by heart muscle during heartbeat, abnormal rhythms due to conductive tissue damage or electrolyte imbalance can be easily detected and amplified to detect cardiac arrest. Thus the new system of Smart clothing with built-in sensors assists in tracking and gathering the variability in heart rate in timely basis to provide prospect for early warning [1]

Due to increase in the incidence of sudden heart attack, smart wearable devices gaining fame in monitoring the individual health conditions. In another study, a multisensory device was developed using smart IoT technology which can collect body area sensor information to provide early symptoms of cardiac arrest with low power consumption transferring channel between smart phone and smart IoT devices (pulse sensor and temperature sensor). This system provides patient with the better understanding of ECG in noninvasive manner and also finds application in multiple areas such as behavior change detection for patients with several disabilities [16]

## **IOT FOR ARRHYTHMIA**

Arrhythmia, an irregular heart beat is the most commonly occurring cardiovascular diseases. Patient with this condition need immediate hospitalization and requires regular monitoring of heart beats to study the abnormalities and to provide insights and suggestion for treatment. This study describes about the system in which the heart rate is calculated using pulse sensor in cardiac patients. A sensor system developed for this purpose reads the ECG of the patients and intelligently predicts the arrhythmia. Music of appropriate musical ragas is played from the patient's smart phone based on the ranges of heart rate which automatically controls the arrhythmia condition temporarily. This system has remote monitoring feature which would be useful for the healthcare centers that does not have sufficient facility for admitting and monitoring the patients. This specialized feature will allow the monitoring of patients from their place either at homes or anywhere, in their comfort level. The regular heart checkups will be monitored by the system and not by the health care professionals and reduces the time and money in spending to doctors. This system of monitoring is cost effective than smart sensor devices and heart rate monitors [17].

## **BENEFITS OF IOT IN HEALTH CARE**

The IoT technology is a new game changing and life enhancing system in health care services across the world. The benefits of IoT in health care sectors are remote monitoring of patients, preventive healthcare, healthcare automation, provides electronic healthcare records and hospital information management. It also provides medical assistance with simultaneous reporting and monitoring of patients, end-to-end connectivity and affordability, data assortment and analysis and offer quick tracking and alert notifications. Telemedicine and remote patient monitoring system with smart sensor devices and smart phone allows the patient to carry out the scheduled test, transfer the data to health care professionals and to improve the treatment efficiency during emergency condition [18].

## **Challenges of Iot**

### **1. Privacy and Security Issues**

Most significant threats of IoT are data privacy and security. IoT system captures the data

And transfers it to the connected users on time. But, most of the devices lack standards and protocols and also possess uncertainty concerning the regulation of data ownership. These issues make the data extremely susceptible to misuse by the cyber criminals.

## **2. Scalability**

Integration of multiple devices is an obstacle for healthcare sector to implement the IoT system. Since the manufactures have not attained the agreements regarding the communication protocol and standard, the connection of several devices results in hindrance of data aggregation process, non uniformity of the devices connected to the protocol and reduces the efficiency of the IoT in healthcare and reduces the scope of scalability.

## **3. Data Overload and Accuracy**

IoT can collect, store and transfer huge amount of data but due to hindrance in the data aggregation process by the use of different communication protocols, there is difficult for doctors to get an insight into it and in due course it affects the eminence of decision making [19]

### **Applications of IoT in Health Care [20]**

- Reduce the time
- Able to track the condition of patients, by staff, doctors, relatives and by patient itself
- Improve in the drug management system and medicine adherence
- Guaranteed availability of critical hardware
- Better and Improved patient experience
- Reduction in the waste and errors
- Better outcomes of treatment
- Immediate medical assistance
- Early identification of chronic diseases

## **CONCLUSION**

Globally, good health is the prime challenge for human race. As per WHO, the fundamental right for every human being is attaining a good health. In this modernized world, now a days, all the individuals enthusiastically take part in collecting the reports and reviewing it regularly by using several technology to monitor their health conditions. A new and fast budding technology in health care is IoT, in which the whole thing (objects and devices) is interconnected to the internet for communication of the interlinked things. IoT is a boon to health care sectors in both developing and developed countries by providing effective health monitoring systems in most affordable cost. Using IoT technology, better treatment options are suggested by the health care sectors in emergency and also very useful for elderly persons to monitor their health condition in their comfort zone. Even though IoT has wider areas of applications and provide cost effective systems, the main challenges in using IoT are data security, privacy and loss of accuracy at some point of time due to hackers, which has to be rectified by designing the devices with high standards and protocols in near future for better usage of technology by individuals in and around the world for monitoring their health condition.

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### Conflict of Interest

None of the authors have any conflicts of interest to declare.

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