

# Internet of Things (IoT) and E-Healthcare System – A Short Review on Challenges

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## Abstract

The Internet of Things (IoT) connects smart objects and devices, which provides large amount of data to be stored than analyzed for processing. IoT devices are useful in different categories from remote monitoring of industrial environment to industrial automation. Furthermore, healthcare applications are mainly showing interest towards IoT devices because of cost reduction, user-friendly and improve the quality-of-life of patients. The existing IoT-driven healthcare applications, analyzed and still there is a need for innovative technology-based solutions to face the challenges in medical environment. In particular, wearable and implantable devices with IoT architectures, investigated for data-transmission process. The usage of IoT in e-healthcare has tremendously increased in many areas such as to maintain vital equipment, monitor patient care, monitor medical assets, track equipment usage etc. Wearable IoT interlinks body-worn sensor devices to the medical environment; the physicians can monitor the health condition of patients remotely. Implantable devices aid in replacing the biological part of the human body, which damaged. Developing wearable and implantable body area network is significantly challenging due to miniaturization of sensors, integration of Integrated Circuits (ICs), less energy consumption, body-worn antennas, non-invasive wearable structures etc. This article provides the overall ecosystem of IoT based E-healthcare systems and its relevant components.

**Keywords:** IoT, e-healthcare, sensor devices, wearables, implantables<sup>?</sup>.

## Introduction

In the starting of 21st century, no one predicted the immense impact of IoT in our daily life. Nowadays, the things have changed drastically with the exponential growth of IoT sensor devices. IoT connects heterogeneous objects to the internet, which permit data exchange rapidly never exists before [1]. An IoT device that interconnects different kinds of objects wirelessly to a network and transmits data seamlessly and it is perceive as the “things” in IoT. Large number of entities connected with the network in IoT based infrastructure that enables easy and effective communication. The embedded technology assists internal as well as external communication in order to make further decisions [2]. The ‘thing’ in IoT can be an automobile with built-in-sensors or a human with a heart monitor, i.e. once the objects are assigned with IP addresses and those are capable of gathering and transferring data with little or without any human intervention. IoT devices include thermostats, light bulbs, door locks, cars, fridges, wearable such as smart clothes, smart watches, implantable like pacemakers and RFID. The trend behind IoT is all about functioning in concert of users in businesses, industry, or at home.

The recent achievements in IT industry significantly improved the intelligence and communication and the devices with which we are interacting around. E-healthcare system plays a vital role as a dedicated ecosystem for medical treatment and supervision. It is obvious that the requirement of novel technologies is essential to permit the inter-communication between heterogeneous devices via internet. Healthcare services and medical supervision provisioning is about to change the entire world of innovative technologies. Various automation devices include intelligent sensors, regulators, actuators, PLCs exchanges data in order to direct control functionalities or monitor on a large-scale system. Devices do not exhibit autonomous behavior and the intelligent sensor be fixed in building automation system, secured e-health system as well. Such device activated as an individual “thing” under the defined access control policy. IoT provides appropriate solution in various domains such as traffic congestion, industrial sector, emergency services, logistics, waste management, smart cities, and e-healthcare.

## Overview of IoT in e-Healthcare system

Sharp alertness about health and fitness is the significant factor that drives healthcare users’ attention towards IoT devices that removes the fear of frequent hospital visits and expensive physician. The healthcare consumers in the medical industry is growing rapidly that the total market being lead to revamped. Business models need to restructure to cope up with the growing influence of huge number of healthcare customers [3]. Recently, the recent survey states that the extraordinary growth in the usage of IoT devices such as wearable and implantable devices. With the ‘Internet of Things’ users can have the control of their health in a personalized way and the major strength lies in data analysis and for decision-making. The diagnosed information gathered using electronic medical annals, imaging tools, monitors, hand-held devices improves the decision-making process of physicians to play an active role in maintaining the patient’s health.

IoT-based personalized review of person’s health will become very common at the end of the decade. Healthcare users would be more comfortable with appropriate plans to defend against diseases and intelligent devices would assist them to maintain their health. With the data generated by IoT devices, the significant decisions made instantly to improve the patient’s health. The challenge of healthcare industry is not lies in developing new devices, technologies, although the great attention is required for e-healthcare users. The number of smart connected devices aimed to improve the person’s health

and the related environment with the intellectual usage of data. Such devices can track the environmental air quality and the doctors' can provide the consultation for the patients remotely [4]. In particular, there are three main qualities to certify the sensor equipped "thing" to become a part of IoT healthcare.

- ✓ First, the device should sense and collect the data about the surroundings, such as humidity, temperature, light as well in the case of pulse rate / blood oxygen monitoring, blood glucose monitoring, electro cardiogram monitoring, etc.
- ✓ Second, the device should be acting autonomous in communicating the gathered data to the central coordinator automatically or with any other device or if meets any condition [5].
- ✓ At last, it should be in an active mode until the process is completed. For instance, if patients' blood pressure or blood sugar levels are at critical, alert information should triggered out for immediate action.

Irregular heart rate of a patient stimulates an alert message to the cardiologist and the patient informed to proceed with the prescribed treatment immediately. Miniaturized implanted device or skin patch monitor's blood sugar, skin temperature and alerts the insulin pump to regulate the dosage [6]. This kind of monitoring assists not only to maintain the health status, but also enables the physician's advice before the condition becomes critical. Sensors in patients those who are suffer from heart related issues help to track the heart rhythm continuously. The blood pressure, healthcare medical devices like CTs and MRIs, oxygen saturation levels can also be tracked remotely [7]. Patient's movement tracked efficiently with Radio-Frequency Identification [RFID] technology, sensor devices and process analytics done for identifying and monitoring the optimal process flow.

Nowadays, human health predominantly influenced by behavioral as well as environmental factors like smoking, polluted city etc. IoT assist in understanding the patient's life style and it has the potential to strengthen the predictive analytics. According to Gartner's Hype Cycle of Emerging Technologies report, another 10 years are required for the full usage of IoT in e-healthcare system. Body sensors combined with Arduino and RaspberryPi boards to manipulate collected data from heterogeneous networks. IoT based e-healthcare systems are design to gather biometric information and it assists in monitoring the patient for current status or medical diagnosis can be performed using android application, web services and multi-protocol unit.

### **Architecture of IOT in Healthcare**

IoT is a network of connected physical devices and objects, which help to sense, analyze, and control remote devices. A conceptual framework introduced for connecting the edge computing devices to enable the communication among wearable sensors and smart devices seamlessly. IoT applications are highly dependent on the middleware layer in IoT architecture for information processing. Some IoT applications are smart health, smart grid, smart city, smart home, smart agriculture, intelligent transportation, etc. The fundamental IoT architecture framed with three layers comprises of perception, network and application layers. Then, extended to have more layered architectures and it includes middleware and business layer.

1. **Perception layer:** The perception layer describes about the sensor devices and physical objects. The sensor device in the perception layer identifies and senses the object and gathers information about the object. Based on the sensor type, the gathered information can be about temperature, motion, orientation, humidity, vibration, location, acceleration, chemical changes, etc. The information then transmitted to the next layer for processing. If a lady is wearing a set of smart earrings in her ears and it assists in detecting the condition of different parts of the body and locates the position of the lady. Perception layer transmits the gathered information by the earring to the network layer for processing [8].
2. **Perception layer:** Also termed as, "Transmission Layer" and its major task is to connect different servers, smart objects and network devices. It transmits the sensor data, which is collect from sensor devices. The transmission medium can be the technologies such as infrared, Bluetooth, ZigBee, Wi-Fi, UMTS, and 3G. Then the information transmitted from the network layer to the middleware layer. Network layer combines the information received from both earring and forward the same to the processing layer.
3. **Middlewave Layer:** It is the main "processing layer", which stores, analyses the large amount of information received from the network layer. It has the responsibility for the database connectivity and service management. Since it is the middle layer, provides number of services to the lower layers. It is connect with big data, cloud computing, and databases for processing the huge amount of data. Information, which is collect by earrings is analyzed and to verify the body temperature of human. If there is any dissimilarity with the normal temperature, then it is report to the corresponding entity and intimated to the patient.
4. **Application Layer:** The significant role of this layer to deliver application oriented services to the end users. This layer communicates directly with the end user by enabling application layer protocols. If the information collected from lady's earrings inform that she is having fever and the concerned lady can be communicated with the application layer. This layer communicates with the person by passing a notification about fever to the smart phone.

5. **Business Layer:** The business layer controls the entire IoT eco-system with well-constructed efficient business models. It assists the end user to make decisions for further actions. For instance, if a person suffering from fever then the nearby clinics or hospitals would suggested by displaying the details.

### Wearable devices

Wearable devices can be fix to the human body in items such as bracelets, pendants, badges, wristwatches, T-shirts, smart rings, glasses, fitness trackers and other accessories for the global gain of health benefits [9]. A wearable device in close contact with the user is capable of tracking illness, wellness of a person and the collected information transmitted to the centralized hub station for analysis. Wearable devices comprise of three components such as sensors, computing architecture and displays. Wearable gadgets are able to provide biological information such as calories burned, steps walked, heart rate, blood pressure, and time spent exercising, etc. [10]. There is a huge impact on these devices and it is quite powerful which gains good attention in tracking user's physical health.

Some wearable devices as listed below:

- ✓ **Pulse Oximetry:** The device helps to measure the oxygen saturation level in a human body, tracks the difference in the blood level of skin related to cardiac cycle. Particularly, a pulse oximeter is attach to a finger or an earlobe, which consists of photodetector and Light-Emitting Diodes (LEDs). It quantifies the amount of infrared, the red light that is send to or reverted by the human body. The difference between the absorption level and the oxygenated to deoxygenated hemoglobin level assists in measuring the oxygen saturation level. The periodic signal termed as PhotoPlethysmoGraph (PPG), which is use to locate the heart rate.
- ✓ **Electrocardiography (ECG):** A waveform that tracks the heart functioning persistently and provides the information with respect to time. Hence, ECG measurements based on wireless sensor devices are prominently suitable for ambulatory applications.
- ✓ **Blood Pressure:** It helps to measure the force exerted due to the blood circulation on blood vessels. These types of sensors fitted around the wrist and systolic, diastolic readings measured by using oscillometric method.
- ✓ **Electromyography (EMG):** It is the study of muscle functioning by monitoring the electrical signals exercised by the muscle. EMG is the spatio-temporal summation of all electrical signals. Hence, the EMG signal provides an effective means of tracking the human muscle activities.
- ✓ **Electroencephalography (EEG):** Electroencephalography (EEG) is the depiction of human brain activities. Wireless Intelligent Sensor (WISE) is a micro-controller based system and introduced for EEG signal acquisition applications for data acquisition, wireless communication, analog-signal conditioning, and low-level real-time signal processing.

### Implantable devices

Implant devices that are implant under the skin of the human body and it help in repairing the part or the entire biological structure [11]. Nowadays, implants normally used for various purposes such as neural prosthetics, orthopedics, cardiovascular stent, artificial pacemaker, defibrillator, dental fillings and crowns, drug delivery system, cochlear implants, etc. [12]. The outer layer of implantable devices can be made of any biomedical material such as apatite, silicone, titanium, and the material should be select based on the requirement of the human body part. The materials used for implant devices can be of ceramics, metals, and polymers. Some implantable devices listed as below:

- ✓ **Glucose Monitoring:** The process accomplished by implanting the sensor device with the multilayered membrane in the abdominal tissue. Body glucose level can tracked for every 30s and the data transmission happened for every 5 minutes. If the sensors are implanted and the glucose level can be controlled by providing the varying amount of insulin.
- ✓ **Implantable Neural Stimulators:** These types of neural stimulators direct the electrical impulses into the human's spinal cord or the brain to provide the treatment for chronic pain.

### Conclusion

E-healthcare system provides a technological framework that uses wearable and implantable health sensors to facilitate monitoring various factors such as health, wellness, behavior and other chronic information for the benefit of individual's everyday quality of life. The main objective of this article is to investigate how IoT can be associated with wearable and implantable devices in healthcare system. The wearable and implantable gadgets will surely revolutionize the smart technologies that are quite familiar nowadays and in near future. The sensors needs to be design in a precise way to be easily wearable and less power consumption. The clinical information gathered from the sensor devices need to preserve in

a secured data-warehouse. Promoting IoT devices will accelerate the adoption of e-healthcare system on a wider scale. The technologies for e-healthcare system should be safe, consistent, effective, flexible, power-efficient, and patient-centric. Moreover, designing IoT devices for upcoming e-healthcare system is challenging which determines the success of IoT based e-healthcare system.

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## 10 examples of the Internet of Things in healthcare

The next decade may well see a revolution in the treatment and diagnosis of disease. The Internet of Things (IoT) has opened up a world of possibilities in medicine: when connected to the internet, ordinary medical devices can collect invaluable additional data, give extra insight into symptoms and trends, enable remote care, and generally give patients more control over their lives and treatment. Here are 10 examples of IoT in healthcare that demonstrate what medicine is becoming capable of thanks to technology.

<https://econsultancy.com/internet-of-things-healthcare/>

### India's health with AI, machine learning, and smart apps

From medical tourism to telemedicine, India's healthcare sector has been expanding at a healthy double-digit rate to include newer and better services powered by new-age technologies. The problem, however, is not availability, but access to these services. For every 1,000 people, the number of physicians in India stands at 0.7 (less than 1), a metric that places the country way behind the global average of 1.5 physicians per 1,000 people. And then, there are only 0.7 beds per 1,000 people, compared to the World Health Organisation's (WHO) recommendation of 3.5. These findings from the Deloitte and CII's 'Medical Technology, Shaping Healthcare For All In India' report highlight the grim reality of healthcare in the country. But, more importantly, it stresses on the challenges that people across the length and breadth of India – including rural parts and cities other than the Tier I – face when it comes to the access to “quality and affordable” healthcare. On the flipside, India's healthcare space is expected to grow at 23 percent CAGR to a \$280 billion market by 2020. And with the 'Digital India' initiative, the government has been bolstering all efforts towards bridging the gap in healthtech, an area where Indian startups already have a momentum. On the heels of World Health Day, we take a look at five such startups making healthcare efficient and affordable for us.

<https://yourstory.com/2019/04/startups-monitoring-india-health-machine-learning>

### A guide to healthcare IoT possibilities and obstacles

This essential guide will look at some of the current applications of healthcare IoT, including how it's being used in one Boston hospital to keep track of newborns in the NICU. Next, the guide explores some of the challenges of IoT in healthcare, such as the need to manage multiple connected devices and a lack of interoperability with EHR systems. Finally, this guide will posit the future of healthcare IoT, including how physicians can turn IoT data into actions.

<https://searchhealthit.techtarget.com/essentialguide/A-guide-to-healthcare-IoT-possibilities-and-obstacles>