E-health in Internet of Things (IoT) in Real-Time Scenario

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Abstract Internet of things (IoT) has drawn much attention in recent years, and it has a very significant role in the IT industry. The IoT helps to modernize the healthcare system with promising technologies and economic prospects. This paper presents working of IoT in e-health, IoT-based technologies, and communication range in the e-health sector. Furthermore, this paper also analyzed the IoT security and privacy in e-health, security risk which is involved in the e-health and the real-time application which is used in health care. The IoT application is the utmost necessary part of daily life, and it is used in almost every sector of human and industry activity. Communication standards of IoT will be provided along with some real-time applications.

Keywords Internet of things · Health care · E-health · Real-time tracking location · Virtual health · MIoT

1 Introduction

Augmented The internet of things (IoT) ensures to changes our livelihood to make them simpler, efficient and most importantly smart. This paper aims to provide information on e-health IoT universe in a different perspective and also reflects the importance of this kind of technology in the medical sector. IoT technologies are rapidly increased in terms of device installation, this trend shows that IoT became the most important part in the e-health sector, and also, we can rely on that with no hesitation [1–6].

IoT comes in as the interfacing stage for all the particular elements associated with a common social insurance framework. Besides it supplies the unobtrusive and installed intensity of processing which separates the information from nature and

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trades it commonly for a universal data framework, making it continuous for an omnipresent smart framework. As we know that the world technology is growing much rapidly and intelligently in every sector like industries and business, the main reason of growing technology is because of revolution of the Internet of things as we know that is IoT. The global market of IoT in e-health alone is 26.34 billion dollars in 2016 and expected to reach [7–13].

The global market of IoT may reach 148.76 billion dollars approximately in the year 2025. The healthcare IoT also called the Internet of medical and things (IOMT) provides many facilities like smart medical care, improved public health care and saves thousands of lives across the world, and nowadays, health care in IoT is playing a very vital role in everyone's life. Internet of things also includes many components of a healthcare system such as data collection which works as the collection of real-time data comprises IoT-driven sensors to gather ongoing checking information from smart sensors, the another component is big data which really became an important component of IoT health care in recent times, and any smart devices that are connected with users or patient and generate related data about the personal health and send back to the cloud will be a part of the IoT (Fig. 1).

The last component is data analysis, the mechanism of the data analysis articulation by machine learning, to acquire relevant data from past stored result data machine learning is a key component in the health care.

All components have their own role and process in health care and also played a very important role in e-health care [14–17]. There are also many fundamental areas where the e-health is used such as health records data, diagnosis, post-medical phase, and monitoring of data.

This paper is categorized into seven chapters. Section 1 deals with introductory part of e-health in IoT, whereas Sect. 2 is related work. Section 3 deals with IoT leading a smart medical revolution. In the next Sects. 4 and 5, communication standards of e-health and challenging issues are discussed. In Sect. 6, communication

Fig. 1 E-health in IoT [2]

standards of IoT are provided. In next Sect. 7, real-time applications are discussed. In the last, conclusion of the work is discussed.

2 Literature Review

This section deals with the work done by various researchers in this specific domain to date. Scarpato et al. [1] discussed about the cloud environments that help to share and collect data directly from the devices with the using of IoT, and it is also providing a vast amount of data or input to be stored and mechanism of the data analytics process. Because of healthcare application, there is an increased in life expectancy of patients. This paper also showed the privacy and security during the sharing of real-time data. Xang et al. [18] discussed that, in recent years, IoT technology draws much attention because of its promising alleviation of the strain on health care, and thus, this paper presented overall suitability for a sensor-based IoT health care system. Challenges that healthcare IoT faces include security and privacy.

Sharma and Lohan [19] discussed about object detection in IoT field and in surveillance system alongside with methods, applicational areas, challenges, and advantages of IoT technology in surveillance system. Devendan et al. [14] discussed that IoT is a connecting network interfacing thing which has naming, detecting, and processing capacity. IoT helps to alter the data from the physical world to the digital world. The IoT has a variety of application domains, and IoT in health care is gone for engaging individuals to live more beneficial life by using smart gadgets. This paper presents couple of uses of IoT in rural health care and approaches to improve essential health needs of the creating countries and innovation utilized in IoT. Sharma et.al [15] discussed about e-health system alongside with challenges in implementing IoT in medical department. Sebestyen et al. [20] discussed and break down the effect of 'IoT—Internet of Things' on the structure of new e-health arrangements. The authors expected to illustrate that the communication models, conventions, and advances advanced under the IoT idea have an incredible potential in the usage of Internet-based healthcare frameworks.

Azzawi et.al. discussed (IoT) ascends as an incredible area where capable gadgets and sensors can interface and trade data over the Internet. The significance of IoT gadgets and information can be basic, so security limitations are required to safeguard the IoT information from intruders; verification is one of fundamental and imperative intends to affirm information protection and security.

3 IoT Leading a Smart Medical Revolution

Here are the means by which IoT is realizing an intelligent medicinal revolution, changing the e-health industry incredibly. Some of the important are listed below.

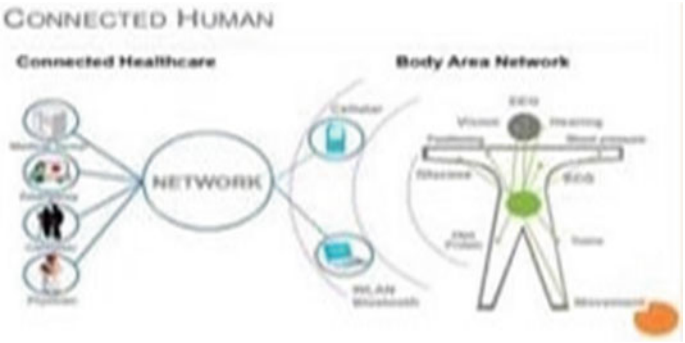

Fig. 2 IoT for E-health system project concept [24]

- *Telehealth*: The another name of telehealth is remote patient monitoring system. This technology is used in a such a way that the health care is provided to the patient who are in a distance. The telehealth is beneficial in many ways such as it increases the access of patients, improves the real-time data analysis, and also, it is cost effective. The working of remote patient monitoring system: The patient is connected to the monitoring system, and vitals are recorded through probes. The tablet sends life and recorded data to the cloud using WI-FI [21–23].
- *Real-Time Tracking Location (RTLS)*: The real-time location tracking uses the technology of the location sensor which is attached or connected to the device and people. Nowadays, health care is likely to be 52%, and the organization uses the real-time location services in their daily lives to improve their healthcare result and status within the patient. RTLS also comprehends ordinary difficulties by following important resources, staff, and patients on virtual maps, helping emergency clinic representatives and directors save time (Fig. 2).

- *E-health Application*: The introduction of e-health application creates many possibilities, and because of this application, the health care is very easily accessible to everyone [17]. Some of the healthcare groups developed mobile application to start round the clock message passing with the patients and users and also increase the healthcare awareness among them (Fig. 3).

- Virtual health assistant—Virtual health assistant helps the health care system in many ways, most of the hospitals installed chat-based and virtual-based assistant in their organization which helps their medical staff or administrator to enhance the result and produce a better outcome, and it also increases the patient experience [26, 27] (Fig. 4).

Fig. 3 Healthcare app development [25]

Fig. 4 Virtual health assistant

4 Communication Standards of E-health in IoT

In the health care in IoT, the communication area is related to it and is divided into two categories. The first is short-range communication, and the second is long-range communication. In advancing of e-health in IoT, we used the wireless body area network (WBAN) to communicate between the two devices that are connected to the Internet of things. Firstly, we have to know what is WBAN, so basically, it is a wireless network of wearable computing device that connected to a cloud network and also in or around the human body to exchange of data and also serve the variety of application. Both communication standards are equally necessary in e-health in IoT [28].

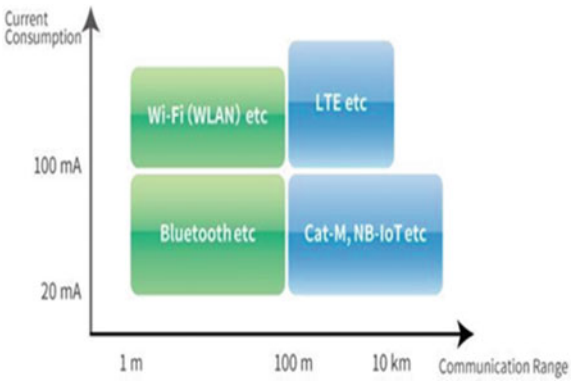

Fig. 5 Range and consumption scale of SRM [32]

1. *Short-Range Communication*: The short-range communication application of network technologies is growing very rapidly in recent years, short-range communication also helps to expand network easily, because in this type of communication, we do not need predefined and wired infrastructure or framework. In the short-range communication, new sensor and input devices can easily be configured and easily joined or connected [29–31].
2. *The Bluetooth low energy*: It is also known as Bluetooth 4.0, it is introduced in 2010, and with the introduction of the Bluetooth 4.0, there is a rapid increase in wearable devices mostly in the fitness sector, i.e., flue band, Fitbit, flex, and shine. Star topology technique is used by BLE which results often in the best for the healthcare application and devices and that is why sensor does not communicate with each other directly. The range of BLE is 150–1570 m in widely open area, and high data rate is 1 MBPS (Fig. 5).

3. *Long-Range Communication*: The reason of the higher success of e-health in IoT is because of the introduction of the long-range communication standards, and it is also very suitable for the IoT applications. LPWA is a subset of the long-range communication definitive [30]. In general, the LRC has the long reach of communication as compared to the traditional communication such as the Bluetooth or WI-FI. Long-range communication has another advantage and is that it supports the 3G network that they are intended to help short blasts of information rarely [26, 32, 33]. This is appropriate for a vast number of social insurance applications. The most famous or important standard of long-range communication is SigFox. The description of SigFox is given below:

For, e.g., SigFox—SigFox provides just a limited number of functionality, but it is expanded very vast as compared to any other communication standards. The SigFox base framework is very similar to the cellular—antenna mount on tower, and SigFox uses the star topology which is suitable for healthcare devices.

5 IoT E-health Challenging Issues

This is a rapid growth of IoT in e-health, and there are many challenges that rise which must be addressed carefully before it reaches out of our zone. Some of the important e-health open challenges are listed below:

- *Cross Domain*: In IoT e-health, many fields intersect with each other at some point, and some of the fields are bio-engineering, embed system, network design, and data analysis. Therefore, to maintain that level of framework structure and also the design verification requires a very vast amount of knowledge in that field.
- *Heterogeneous*: IoT measures the cyber and physical world, and because of that, it includes the hardware and software component. Thus, it is important to give detailed or proper consideration to interfacing and compatibility of such an all-encompassing framework. Of associated gadgets, arrange segments, calculation frameworks that must deal with information volume, assortment, speed, and accuracy [34].
- *Data Management*: In health care, IoT tackles the data management challenges in recent times because of the increasing number of patients which are connected to the IoT e-health. The data is taken from the human body via wearable devices or sensor from which human is connected so that device sends the real-time data, but human body constantly changes and so the data of an individual, and thus, it becomes very difficult to maintain a very large amount of ongoing flux data.
- *Scalability*: In order to design a human services Internet of things on a very scaled-down, every client should have direct access to healthcare administrations from convenient gadgets, for example, cell phones. These administrations will require them very own sensors particularly for information gathering, alongside secure focal servers for dealing with client requests [28, 35].
- *Human-factor engineering and interfaces*: *T*he interface between front-end advancements, for example, sensors, PCs, tablets, and other cell phones gives one of the quickest difficulties for IoT e-health improvement. End clients will be required to self-train so as to utilize the gadgets effectively. Also, a large number of the gadgets will be conveyed in remote areas; old populaces specifically will be probably the most remarkable IoT clients, featuring a reasonable requirement for e-health frameworks that can be conveyed basically and self-sufficiently (Fig. 6).

- Another big challenge is device update needs to be managed effectively as well security patches to firmware and software will have a number of challenges. Also, over the air updates may not be possible with all kind of IoT devices. Many a times, the device owners may also not show much interest in applying an update to the system.
- The communication channel through which data is going from cloud devices or vice versa also needs to be secure and also uses the transport encryption to adopt standards like TLS.

Fig. 6 Challenges in e-health sector [3]

Security and the Privacy Issue on the Medical Internet of Things (MIoT)

MIoT is subdivided into three layers which are the perception layer, network layer, and the another is application layer, and all these layers perform their specific task, such as to collect healthcare real-time data from different types of devices is a work of perception layer, the network is subdivided into wired and wireless system and middleware which mechanize and send the data or input which is taken by perception layer, it also ensures the privacy and security, and the third layer is application layer that unified the healthcare information resources to provide personalized medical services. Following are the security and the privacy issues on the medical Internet of things:

(1) *Data Usability*: Data usability is to guarantee that information or information frameworks can be utilized by approved clients. Enormous information brings incredible advantages as well as vital difficulties, for example, wrong information and nonstandard information.
(2) *Data Integrity*: Data integrity, or 'data quality,' alludes to the way toward keeping up the precision, reliability, and consistency of data over its whole 'life-cycle.' Applied to health, this can incorporate (yet is not restricted to) keeping up the exactness of patient's personal health, details, summary, and many more that are very credential to the patients.
(3) *Data Auditing:* Review of medical data is a successful way to screen the utilization of assets and a typical measure for finding and following unusual occasions. Also, cloud service organizations more often play entrusted roles, which require sensible auditing techniques [27].
(4) *Patient information privacy*: The data of the patient's or users can be divided into two categories, one is normal record, and the another is sensitive records which include patient's mental status, infectious diseases, drug addiction,

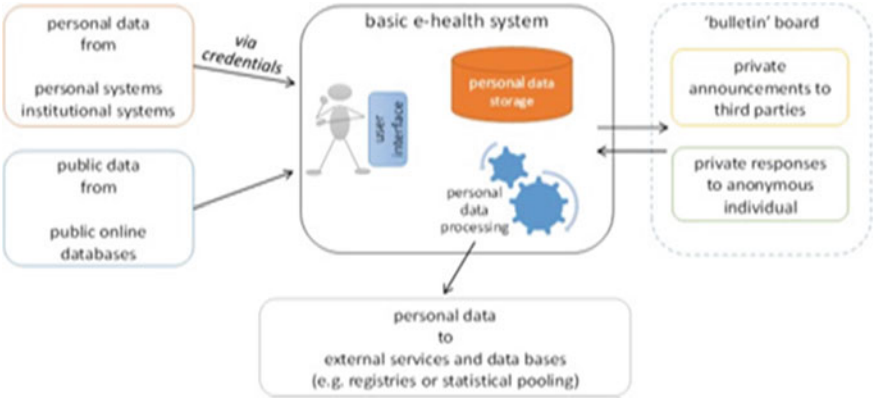

Fig. 7 Basic privacy and security of e-health system [36]

genetic information, and personal identification data. So, we have to make sure that any unauthorized users do not get these types of information or neither the data can be modified (Fig. 7).

6 Real-Time Applications / System Components of E-health Sensor

In healthcare system, sensory devices play a very important role, and because of that devices, we can easily detect or know any problem within the patients and user, these devices are shown the real-time data of the patients which helps to easily overcome the problem [37,38]. Some real-time application/sensory devices are as follows

- *ECG electrodes*—An ECG cathode is a gadget connected to the skin on specific pieces of a patient's body —by and large the arms, legs, and chest—during an electrocardiogram methodology. It recognizes electrical driving forces delivered each time the heart pulsates. The number and situation of anodes on the body can change, yet the capacity continues as before [37]. The power that an anode recognizes is transmitted by means of this wire to a machine, which makes an interpretation of the power into wavy lines recorded on a bit of paper. The ECG records, in an extraordinary detail, are utilized to analyze a wide scope of heart conditions.
- Blood pressure (BP) sensor—It is a smart device that helps to measure the pressure of the blood in arteries which pumped in our body through heart when our heart thumps, it contracts and pushes blood, and due to this, a pressure arises on the arteries. BP is recorded as two numbers, one is systolic pressure (sp), and another is diastolic pressure (dp). Moreover, a regular circulatory strain sensor can store 80 estimations data with time and date [28].

Fig. 8 Sensor devices in health care [19]

- Pulse oximetry sensors—Heartbeat oximetry measures the level of oxygen in the blood. Like heartbeat, blood oxygen level is positively not a basic sign, however that as it might, fills in as a pointer of respiratory limit and can help in diagnosis of particular conditions, for instance, hypoxia (low oxygen including the body's tissues) [35]. All things considered, and beat oximetry is an essential augmentation to a general medicinal service observing system. By getting PPG signals, beat oximetry measures the blood oxygen [38] (Fig. 8).

7 Conclusion and Future Work

In this paper, we analyzed that the emergency department part is embracing the IoT very rapidly. This exponential development of the wearable gadgets, capable advancements, and cloud-based information logical techniques are giving new era of healthcare system frameworks. Despite, the extensive number of applications of IoT in medicine numerous issues is as yet open, and they need ingenious answers to be solved. This paper presents advances in IoT-based future healthcare or medical services for different use case scenarios, explores the ongoing and developing communication technologies and standards in IoT. The security issues are also involved in the e-health sector, and it is very crucial to take some important

measure before any big adversity. This paper also discussed some real-time application/sensor devices which are used in the e-health sector, and due to this, there is a big improvement in healthcare sector.

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