A Study Towards Recent Trends, Issues and Research Challenges of Intelligent IoT Healthcare Techniques: IoMT and CIoMT

Garima Verma, Aditya Pratap Shahi, and Shiva Prakash

Abstract Present scenario deals with lots of complexities and drawbacks of healthcare systems. These systems help in transforming and providing various solutions to replace the use of traditional monitoring systems. The advanced healthcare monitoring systems are dealing with the reduced cutting cost and also they are improving the treatment methodologies of the patients. These systems gives the opportunities to the patients for online tracking of their health related data without moving to the doctor's clinic and one can easily check the related data by just sitting online. A framework is required for the combination of verification convention with a vitality proficient access control instrument. In the wake of experiencing the philosophy for validation convention and for a proficient access control system, a consolidated procedure is proposed to be received to pool the hole. This paper shows an exhaustive literature review and describing the related work done by the existing authors based on the Wireless Body Area Networks (WBANs) and the latest technologies used in connected health like CIoMT and IoMT. Through this paper; various comparisons between several parameters and techniques are being done. The new researchers will be able to get more ideas about the past researches and the emerging trends in the healthcare field based on IoT.

Keywords Internet of Things (IoT) · Internet of Medical Things (IoMT) · Internet of Healthcare Things (IoHT) · Cognitive Internet of Medical Things (CIoMT) · Comparative Study of Parameters

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1 Introduction

Internet of Things plays a very important role in providing various applications and benefits to the clients and consumers. In the current scenario, more than 1 billion users are there which are interconnected and communicate with each other. There are a lot of devices which are electronically and mechanically connected with each other for providing a better aspect of communication to the users. Internet is a technology that has somehow incorporated various devices and their technical solutions as per the needs of the users [1]. IoT has revolutionized the world with the ability to identify and track all other devices as per the requirements [2]. But at present, IoT healthcare is emerging as one of the recent challenge for the researches since it is providing new scopes and research domains for the IoT developers [3]. As predicted by the Cisco Systems, it has been told that in the upcoming years, the IoT is enlarging itself into so many other domains. But there are many drawbacks also which are considered for IoT devices like cybercrimes and hackers which harm the security of the data. More the devices which are available online, more number of chances of hacking the data. There are various types of medical devices that are available for the users like smart diagnostic tools, smart healthcare devices etc. which are providing great applications for the mobile health users all over the world [4]. From hand bracelets to home automation systems, all the frameworks need a tight security for protected data. According to the researchers, IoT threats are being increasing day by day potentially in all the domains. One of the basic issues is privacy of data. In [5], the author has given a systematic approach for the healthcare technologies using the fog network for designing devices that can be used in Internet of Medical Things. The security of the accumulated data is the main concern that the data privacy should not get loss or the individual's information should not be misused. There are several devices which are operated on this layer and various networking protocols are being used. Some of the devices are repeaters, Network Interface Cards (NICs) etc. In fact, has given the facility to extend the current IPv4, expands the current IPv4 protocol from 32 to 128 bits for every IP address which offers great flexibility for IoT world. IPv6 supports dynamic objectives of networking to achieve flexibility and reliability in a system. A comprehensive study of IoT in medical things of healthcare has been discussed [6]. Well-ordered guidelines to approve the healthcare devices are similarly a critical research zone. Usually, confirmation is cultivated through various methods, for instance, ID/mystery word, pre-shared special bits of knowledge are some examples. There are various software platforms used for the implementation of IoT devices such as Raspberry Pi [7], Arduino Uno. Figure 1 shows the various architectural frameworks of IoT Domain.

The IoT has the empowering capability to change the whole world where we are living today. The architectural work goes for planning and actualizing an IoT-mindful Smart Hospital System (SHS) having, as principle characteristic, the capacity to promptly join extraordinary, yet corresponding, advancements empowering novel functionalities. Essentially, the framework we imagine ought to have the capacity to

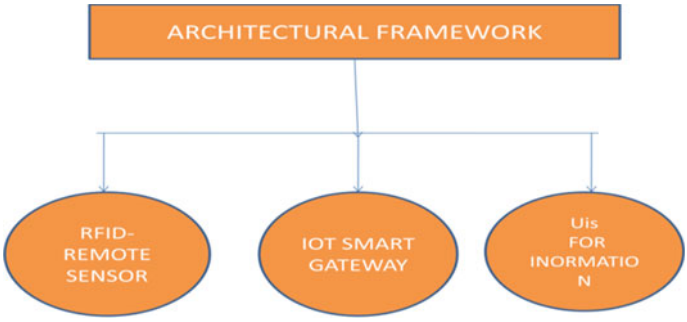

Fig. 1 Components of Healthcare Frameworks

gather, progressively, both natural conditions and patients' physiological parameters and convey them to a control focus. IoT has been a promising field since many years.

IoT presently utilizes various gadgets, administrations and conventions to accomplish a shared objective. In any case, for better coordinating of any system it should be required to use the architecture standards. In any case, the security necessities for IoT can't be accomplished by essentially putting explicit arrangements from every layer together. Indeed, it is important to consider IoT framework, overall framework and security is one of the major factor that should be considered in the IoT structure. In this manner, to improve IoT security, we additionally need some participation between various layers by planning security answers for cross layers use beating heterogeneous combination issues. This component of extraction was basically combined with the hashing techniques to avoid several assaults. The exhibited model explains the versatility and adaptability which are the highlighting concepts of this model. A lot of detailed work on diabetes diagnosis and detection using IoMT has been discussed [8].

- **IoT and related background referring to COVID-19**

Talking about the Internet of Things (IoT), it can be simply defined as the network of interconnected devices which can be incorporated in any communication network using various hardware, software, RFIDs (Radio Frequency Identification Devices) etc. or any other required components. In the current pandemic situation, whole world is fighting with this corona virus and researchers are in race of trying to develop a successful vaccine but still the vaccine is in the development phase. Doctors and researchers are still looking for a feasible solution to develop a vaccine that could somehow reduce the infection rate of this dangerous corona virus. Researchers involved in various departments like computer science, physical engineering etc. are in a continuous attempt to develop new approaches, theories, study problems for giving a successful solution to this COVID 19 pandemic. IoT is an innovative approach of implementing several kinds of healthcare systems that can easily reduce the work load of the doctors and also help in developing cost-effective methodologies for patients. At this point of time, there is a great need of such scenario where one

can easily integrate the technologies with new theories for developing best solutions for this pandemic. Talking more about IoT, it is a concept which is incorporating many other domains like artificial intelligence, machine learning, data science etc. It also helps in implementing such sort of techniques which will help in complete integration of the person who is in need of the services and the service providers.

- **Research focus**

In such problematic situation, where the whole world is fighting with the pandemic, everyone is trying to find a solution for getting out of this. On daily basis, the records of the patients infected with COVID-19 are increasing day by day. Every day, a new record of data is set breaking all other records. There is a great need of utilizing the existing facilities and technologies integrating with the Internet of Things (IoT). Moreover, IoT has already been implemented in several domains in different forms and is serving great roles in helping people with different aspects like Internet of Healthcare Things (IoHT) and Internet of Medical Things (IoMT). By using different tools and techniques of IoHT and IoMT, the number of cases can be reduced up to certain level. For example, there should be proper monitoring systems in every room of the quarantined patients so that proper care can be taken of those patients. Along with all this, various body sensors like temperature sensors, BP sensors etc. can be used for regular updates of the patients so that if some other diseases are there, they can be easily cured and timely treatment can be given to the patients.

2 Literature Review

The concept of fog computing and edge computing has somehow affected the overall technology in IoT as it has given a new approach for the researchers to work in this area. Along with this, the data generated from the healthcare industry carries major sensitive data that requires critical care and security. There are lot of developments being made on daily basis regarding the healthcare platforms for better optimization of technologies. Home care monitoring systems have emerged as one of the very helpful technological frameworks in IoT [9].

One of the recent studies [10], a framework developed using AI based technology to battle with the novel corona virus has been developed using the smartphones is discussed in this paper. A novel study [11] has discussed the design and implementation of Remote Monitoring Systems for Low Cost devices for Limb health. In [12], authors has done a detailed survey in the usability of AI in the field of IoT using Embedded NN-Techniques for developing smart mobiles devices for better computing. Further, a study discussed the pruning convolution networks for the healthcare systems in [13]. Monteiro [14] has discussed a lot of tele-treatment methods for the healthcare domains using different fog computing devices for the treatment of patients on several nodes of parameters. The healthcare systems that are being developed today are of great benefits for the patients but there are still

various loopholes on which, the researchers are working today for better design and development of such devices.

Further, G. Muhammad [15] has done the study on different smart health solutions by integrating various domains but mainly IoT and cloud computing along with a case study on it. There are numerous solutions possible for the technological advancement of healthcare problems by integrating different domains into one. In [16], a detailed discussion for developing a smart healthcare framework has been discussed using the concept of Artificial Intelligence and Edge Computing that can be implemented in the smart cities for progressive developments of areas. In [17], a smart framework has been developed for persons with voice disorder and their treatments using edge computing with cloud framework. In [18], various frameworks for checking the health status using the records of the health conditions can be seen in this work. Further, a recent approach of Body Area Networks has been discussed in which different types of studies has been done incorporating the transmission policies of the networks [19]. Pham et al. [20] have proposed a new technological framework for the designing of smart healthcare solutions using cloud based architectures (CoSHE).

Here, a comparative study has been discussed with various parameters like sensors used, fog/cloud devices, methodology used, their advantages and disadvantages. Various authors have researched on IoT fundamentals given in the Table 1.

3 Research Objective

The COVID-19 is a very challenging situation for everybody and especially for the doctors, healthcare workers, nurse staffs and many medical personnels to deal with patients and offer them services. These people are trying to serve the patients in more impactful and effective way. The paper is a comprehensive study of various tools and techniques of offering the services to the corona patients by the means of IoMT/ IoHT. Patients today are suffering from various problems like visiting the hospitals, corona testing, report monitoring and medicine purchasing. There are further more issues with regards to the COVID-19 which can be resolved more effectively and more efficiently by using the IoT healthcare approaches. These techniques can also be helpful for those patients which are quarantined at a remote place [27].

The main objective of this proposed work is to develop such a framework in which the system will consist of several layers including the physical layer, middleware layer, network layer, transport layer etc. Firstly, on the physical layer, there will be several embedded devices responsible for data collection, data transmission and data controlling. These devices will contain the sensors, transmitters, LowPAN Networks etc. Hence, this layer will perform several processes of data collection and transmission. Further, the next layer is the network layer which plays the role of transmitting the signals [28]. The signals are transmitted from the sensors to the cloudlets or cloud servers. And meanwhile, middleware layer helps in storing and collecting the data and then depositing that data into the cloud. Another function of middleware layer is that it helps in making the data available for the users who

Table 1 Comparative study of different parameters of technologies used

Authors	Contributions	Sensors Used	Fog/cloud devices used	Methodology used	Advantages	Disadvantages
Devarajan et al. [21]	Diagnosis, prediction and controlling the risk of diabetic patients based on real-time framework	BP sensors, Motion sensors, Heart sensors	No fog/ Cloud devices were provided	Used Hybrid Technique neutrosophic VIKOR methods	Efficient technique with smart sensors based operations	Difficulty in handling large samples of data
Oniga [22]	Various parameters recorded by using Arduino Microcontroller	Body specialized sensors	Arduino, System	Data was transferred into PC for further processing	Better monitoring and controlling	Cost Factor
Yakut et al. [23]	Use of ECG signals using Raspberry pi	E-Health sensors	Raspberry Pi	Raspberry Pi records the data for processing in Matlab	Faster Processing of signals	Hardware constraints and cost factors
Dubey et al. [24]	Speech Monitoring Mechanisms using PD and ECG sensors	Microphone	Intel Edison	Dynamic Time Warping (DTW) method is used for processing	Efficient Speech recognition method	Difficulty in speech conversion of data
Monteiro et al. [14]	Worked on tele-treatment techniques of patients	Microphone	Intel Edison	Numerous features was sent to the cloud server	Easy approach for tele-medicine techniques	Cost factors
Mathur et al. [11]	Temperature monitoring of residual limb	Motion sensors, thermistors	Raspberry pi, Arduino	Machine Learning is used for measuring skin temperature	Easy monitoring of sensors	Difficulty in Accessing the Sensor data quickly

(continued)

Table 1 (continued)

Authors	Contributions	Sensors Used	Fog/cloud devices used	Methodology used	Advantages	Disadvantages
Kaur et al. [7]	Worked on measuring pulse rate and temperature	Temperature and pulse rate sensors	Raspberry Pi	PANGEA platform has been used using wifi networks	Provides accurate results	Cost factor and difficult implementation
Satija et al. [25]	ECG measurement using signal quality	ECG sensors	Linux, GPU as hardware	SVM technique in machine learning along with deep learning	Better signal quality results	Design and implantation is difficult
Pham et al. [20]	Collection of Physiological signals and motion	Smartwatch and environmental sensors	arduino mega	Data transmitted from the sensors is processed at home gateway networks	Quick implementation and results	Environmental parameters are difficult to sustain
Queralta et al. [26]	Cardiovascular and diabetes monitoring	ECG, EMG	Raspberry Pi, Gateways are used	LSTM RNN networks were used for data processing	Easy monitoring and controlling	Cost factor is a limitation

are in need of that data at a particular point of instance. And at last, the application layer responsible for the final processing of data by using the data analysis and data diagnosis techniques.

4 Proposed Architecture of IoMT (Internet of Medical Things)

Now-a-days, there are a lot of complex architectures leading to tedious implementations of the recent technologies. Basically, the devices present in the IoMT architecture are connected to the cloud servers and the data is stored in the cloud and then the data is being easily accessed through the clouds [29]. There are a lot of implementations of IoMT architectures like remote monitoring of patients having serious issues related to health and treatment can be given instantly without hectic movement from one place to another. Along with various important services, the IoMT architecture offers numerous other important administrative and medical facilities [30]. Consultation of telemedicine has become easier through such implementations of IoMT architectures. These architectures are very helpful to reduce the cases in COVID-19 pandemic. There are several functions that are carried by the IoMT implementations as given below:

- IoMT architectures help in managing the data of the patients online. The patient does not have to depend on physical movement from one doctor to another.
- IoMT facilities leads to accessing of the data easily like one can use the facility of block chains.
- Helps in measuring the different parameters like robustness, efficiency, productivity etc.
- Easy identification of healthcare issues and problems.
- Patients can be easily traced simultaneously using remote monitoring
- Services will become internet based services.

Since, there are a lot of barriers in the way of accessing the health services due to increase in the number of connected medical devices, a need rises for designing the IoMT devices for various parameters like lowering the costs, efficiencies, improvement in the capabilities of managing devices etc. IoMT services has the ability to easily collect, analyze and transmit the healthcare data where required [31]. Therefore, IoMT techniques and tools are continuously transforming the way of healthcare services delivery. There is connectivity between the medical devices and the sensors being implemented in the IoMT architecture which leads to proper management and improvement in the patient's healthcare services (Figs. 2 and 3).

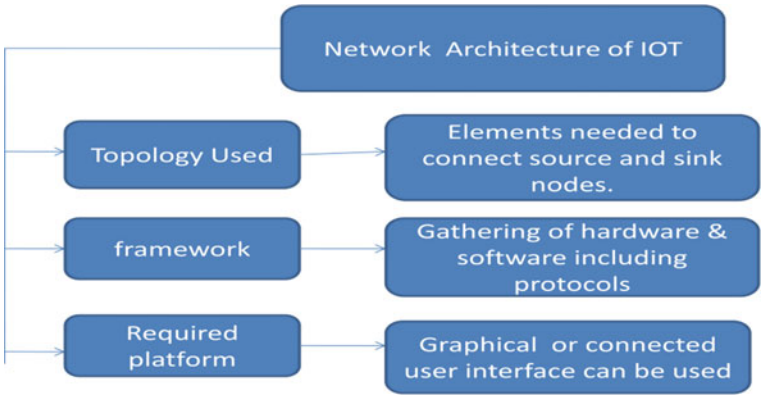

Fig. 2 Flow diagram for healthcare framework

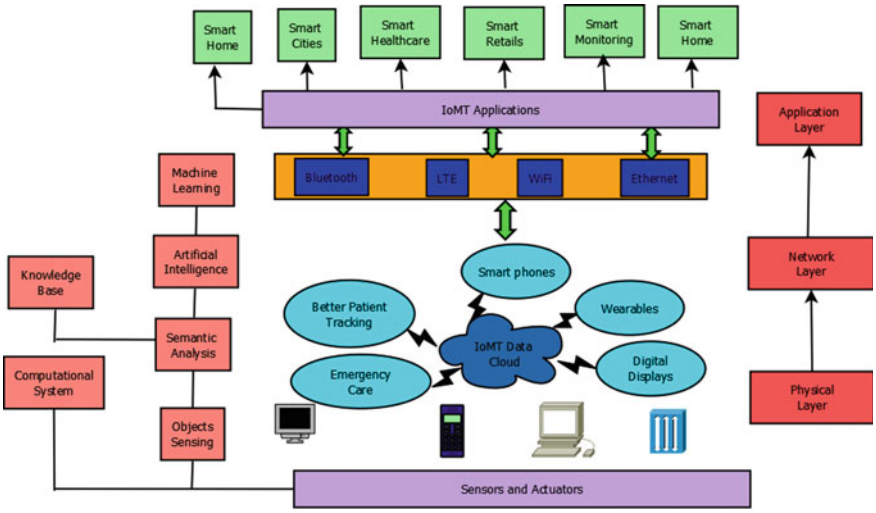

Fig. 3 Architecture of IoMT

5 CIoMT (Cognitive Internet of Medical Things)

Basically, CIoMT is a class of CIoT (Cognitive Internet of Things) made specifically for the medical industry in order to support the recent technologies in smart healthcare. The need of such technologies is to track and record the patient's real time data like diabetes check, glucose level, blood pressure level, heart rate, temperature, humidity etc. According to the current scenario of COVID-19, there is a great need of such Cognitive architectures that can tackle with corona cases. With such systems,

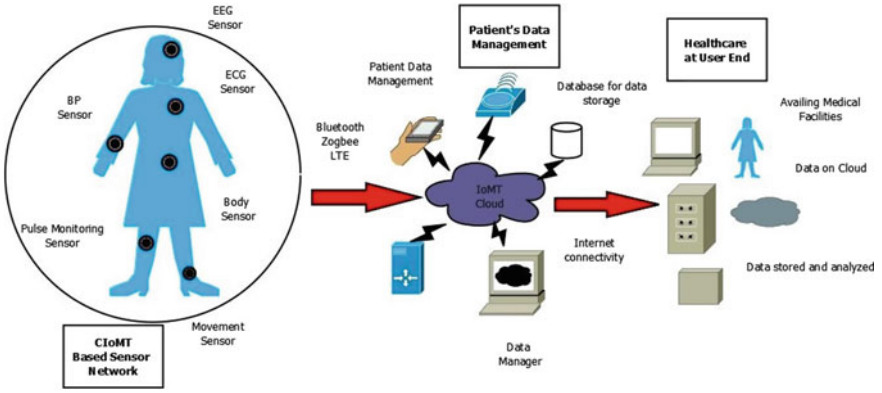

Fig. 4 Architecture of CIoMT

data tracking can become easy and monitoring of the patient can also become effective. The CIoMT technology will lead to better recording and analyzing of real-time data, surveillance, tracking, clustering, prevention and control of virus [32].

A connected medical infrastructure provides with so many features like easy data sharing, accessing o healthcare data, reporting of live data and recording them etc. Along with this, CIoMT systems will enhance the capability and robustness of the entire domain of healthcare environment. Also, patients on track mode can easily record and report their live activity and tell what they actually feel. Currently, the biggest use of CIoMT is that these systems are helpful in diagnosing the patient and their problems easily [33]. Looking upon the current pandemic situation, it is very important to pay attention to the healthcare infrastructure of the hospitals so that better facilities can be provided to the patients. It is the high time to increment and implement the IoT healthcare architectures to deal with severe problems of the patients. One of the biggest application of IoT is implementing the healthcare frameworks using blockchains. Blockchains are enabling the patients to access the patient's data from the cloud and many more facilities (Fig. 4).

It is being expected that the investment on the IoT healthcare solutions will somehow reach to $1 trillion by 2025 and it will be set on the stage for the overall high adaptability, accessibility and durability of the data. This will help in providing on-time healthcare services to the users by using the real-time scenarios of collecting the data, analyzing the data and then storing the data for the future use. Hopefully, by 2026, remote monitoring implementations will create approx. $1.15 trillion in value which will help in improving the healthcare conditions of the patients. These implementation systems will lead to develop better healthcare systems that will help to deal with chronic diseases easily. Internet of Medical Things (IoMT) has covered almost each and every part of the healthcare systems by which the medical facilities has increased up to a certain level.

Talking about the current scenario, there are approx. 3.8 million medical devices which are connected all together in order to give quick response to the healthcare

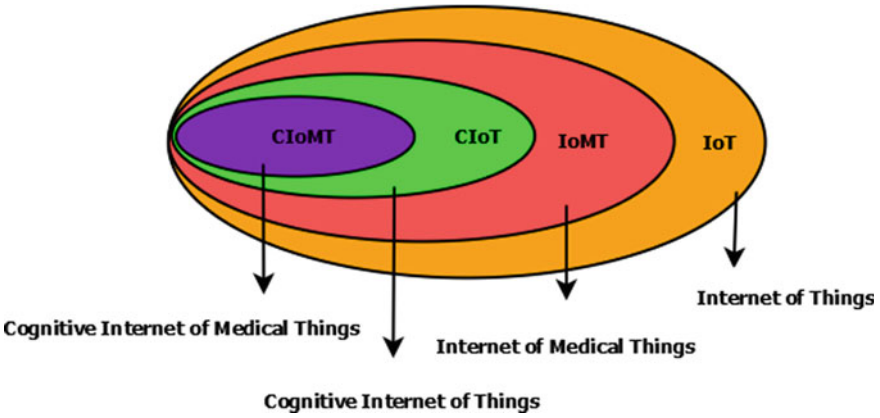

Fig. 5 Subsets of IoT

decisions. Using such cognitive architectures of medical devices, it has become very easy to monitor the activities of the patients and make decisions accordingly. Doctors and scientists are using such medical systems for better healthcare facilities which is making the patient tracking more easier and efficient [34]. CIoMT is a field of cognitive healthcare study which offers preventive care for the patients as it is somehow reducing the paper work and making the healthcare processes digital So, the areas having most critical need can be easily tracked using the IoT deployed systems. Moreover, there are more advanced devices which provide internal surveillance with embedded sensors and chip technologies allowing smart medical services. By using such smart surveillance systems, it is easier to tackle with all such situations of forgery and cheat. These devices were not available before for use but now they are available with most recent advanced embedded sensors (Fig. 5).

6 Proposed Services of IoMT

IoMT and CIoMT are the two most trending concepts for the healthcare infrastructures which are in progress to be implemented for better monitoring and tracking of the patients. There are a lot of services which are being offered by the Internet of Medical Things as discussed below:

- Smart and early diagnosis of diseases in the patients.
- Smart Tracking systems will help in proper monitoring and surveillance of the patients and will help in recording the live activities of the patients.
- It will help in better risk prediction which allows identifying the problems at a very early stage helping the easy diagnosis.
- Smart monitoring systems leads to smart tracking of patients.
- Smart wearable devices can be implemented easily.

- Smart healthcare will help to develop new system frameworks that will revolutionize the world with lots of new inventions and opportunities.

7 Research Limitations

Subsequently, there should be some pre-characterized personality of the board element or center point which can screen the association procedure of gadgets by applying cryptography and different strategies to anticipate wholesale fraud [35]. It may also ensure to facilitate various security issues and helps in better management of the network in IoT model.

- On the basis of the risks evolved, listing should be done and accordingly the devices should be deployed.
- In any IoT communication process, there are various encrypt and decrypt cycles taking place in the mechanism and these cycles are very much vulnerable to attacks and are prone to high security attacks. So, this point should be considered while designing any IoT device.
- There are many security issues which are being rectified using the communication protocols to combine with IoT security in IoT systems and to provide basic level security at each layer in the IoT model [36].

8 Conclusion

This paper basically presents about the various contributions of different authors and their respective works in the field of IoT. This paper will help in making a better comparative study and will help various new authors to develop and create a new scenario for the betterment and development of new healthcare related technologies. The paper consists of various recent concepts of healthcare like IoMT, CIoMT etc. Since, the validation of conventions gives confirmation of the client, while different assaults like secrecy, trustworthiness, revocation, and so forth are not tended to. IoT techniques play a very important role in connected health and also providing various services.

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