



A Study of Internet of Medical Things (IoMT) Used in Pandemic Covid-19 For Healthcare Monitoring Services

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Abstract: Before Internet of things, visit or meet a doctor is based on the appointments, by tele and text communication and also interaction with patient and doctors are limited. IoMT enables medical devices remote monitoring, unleash the possibility for patients to keep safe and healthy, also made easy for physicians to deliver excellent care for patients. The capability of IoT or IoMT in infectious disease control a network of interconnected systems and Artificial intelligence, Data analytics and using omnipresent connectivity in all these networks based upon real time data can help to provide an early warning system to restraint the spread of Pandemic like situation (Covid-19 corona virus, Ebola virus, Hanta Virus etc.) and it also help in healthcare monitoring and treatment services.

Keywords: *Internet of Medical Things (IoMT), Internet of Things (IoT), Medical Internet of Things (mIoT), LAN (Local Area Network), NFC (Near Field Communication), RFID (Radio Frequency Identification).*

1. Introduction

The main form of communication on the internet is human to human communication by text messages or emails. But its sure thing that in nearby future any object will be identify by a unique way of ids and references and every object or device is connected to each other, that's the main concept of IoT. Beside human-to-human communication when object and devices become expand from human-human interaction to human-device communication, it become Internet of things [1,4]. To mix the physical world with the information world we use these technologies where we realize real time data and based upon that data capable devices will be performed. Mobile phone is the best tool which can be properly used to take all the benefits of IoT solutions and technology. It gives more flexible and calculated platform for transmitting real time data compared to web apps, like in this Covid-19 Corona Virus situation, mobile app launched by Indian government named "Arogya Setu" app will be used as a real time data platform for IoT solutions [5]. To use that data, we facilitate the healthcare services in hotspot regions or most affected areas, mobile apps used in various departments also facilitate with the data and use remote control of other gadgets to provide services in that areas, like drone surveillance, information gathering and alert issues etc. Internet of things are now trending in technology era and it has rapidly growing and found relevance in various sectors [5,11].

For any type of connectivity like infrared, Bluetooth, Wi-Fi, LAN etc., to share the information we need a network of physical devices, sensors, objects which operated on software's and digital machines, that network is based on Internet of Things (IoT) [1,11]. The thing in IoT is basically an object or man-made device which we can use whether with some sort of connectivity or we assign certain IP addresses to that device and this exchange data or real time data according some prescribed or predetermined rules of Internet [13]. The IoT solutions are found in various fields like healthcare, retail, agriculture, vehicles, sensors and so on.

2. Internet of Medical Things

As we know Internet of Things is collaboration of many devices, appliances worldwide and all similar sharing data or real time data through the internet. The work automation and smartness (in devices) is the major key factor in IoT. The endless level of autonomous "smartness", by increasing them the ability of intelligence process and data analyzation allow them to interact with any manual process [13]. It means at global scale; internet is being more effective and active in physical environment. Few examples are like, with a smartphone app you can switch on the light bulb, fan and AC. Another element is web connected streetlights, traffic lights, Thermostats and motion sensors are major applications of Internet of Things (IoT) [1,4].

From last few years, Medical devices which are web connected or operated by some apps are become more popular among healthcare providers and hospitals. Just as we look at statistics as shown in figure 1, among 3 companies out of 5, i.e., approx. 60%, companies have installed Internet of things devices named as IoMT [6,8]. As consider particular application, nearly 73% of healthcare firms use IoT/IoMT as monitoring and maintenance services. Patients health report will be monitor by mobile apps as medical devices connected through internet. For business purpose, 7 out of 8 companies i.e., 87% are currently make strategies for the use of IoT with plan to imply systems or devices by coming few years [8,9]. Patient monitors system comprises 63% of the total current healthcare services by IoT/ IoMT. By report of the 2016 Allied market research, the healthcare industries who adopt Internet of Medical Things (IoMT), the team or firm projected at the growth rate of 13% i.e., Compound Annual growth rate (CAGR).

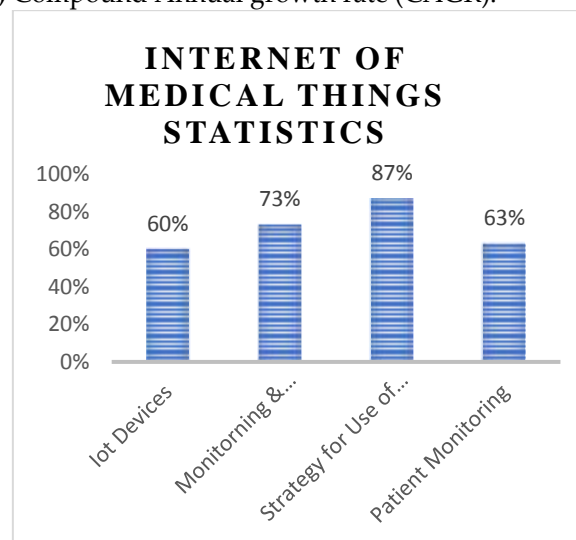


Fig 1: Internet of Medical Things (IoMT) Statistics

Source: WHO data, Ray Parker, readwrite .com

As by 2030, as population increase the number of senior citizens is also increased, and in India we have huge numbers of peoples who has age 60+ by then. As since life expectancy is generally increasing, so healthcare devices, its cost and numbers are also increasing. As we know medical staff and healthcare

service providers will also be required at a large scale [6,7]. To solve such situation Internet of Medical Things (IoMT) is a solution. IoMT will make it easier to control cost. The medical devices connected with web access or internet, will monitor heart activity, health parameters, heart rate, blood pressure etc within other systems and also keep track of the patients and their routines like, quantities of sleep and activities done by patient for each day [6, 9].

Currently a pandemic disease Covid-19, in such case to monitor the activities of infected persons or patients will be taken care by these technologies. IoMT devices will do monitoring services [7,10]. Sometimes patients or Elderly patients neglect to take medication or forget to take medication at particular instant of time, so IoMT is able to send and record the status of patient activity and send reminder to the patient and also to the healthcare service provider like doctor or nurse. Wearable IoMT devices make possible to take precautions and monitoring the day-to-day movement of the patient and send out or notify an alert if anything wrong or miscalculation happen during diagnosis [7, 10]. Real time data or statistical data will be increasing day by day with every perspective of life, and to segregate and use that data for prediction is much more complex task. As Covid-19 case, in India data can be provided by Arogya Setu app, which is real time data. Based upon that data we use medical IoT (mIoT or IoMT), to take a necessary and precautionary actions for the future [11,12]. As Internet of Medical Things, in coming years pharmaceutical companies or healthcare services will have an access on patients via vast amount of data which include various medical parameters such as blood pressure, ECG, respiratory rate, sleep patterns, pulse heart rates, diabetes, cancer patients. All this information will be retrieved or collected by medical devices, sensors which are connected to web and access data as per devices or app configurations. These technologies will be previously adapted by athletes and sport persons to check the physical patterns of sportspersons.

IoMT include remote patient diagnosis and monitoring of people with long term or chronic disease conditions, by patient mHealth devices, (like wrist band to calculate heart rate, no of steps count etc.) which send information to the medical staff or patients [13]. As in case of IoT and due to more advancement in IoT field by NFCs (Near Field Communication) or RFIDs (Radio Frequency Identifications) the applications of IoMT are increased and allows devices to share the information's with other devices which are connected through web or internet [2]. As we provide RFIDs to the medical equipment's or medical supplies at hospitals or medical centers, so hospital staff and related persons remain aware of the number of quantities in stock and take precautionary steps at time. Also, the type of treatment where patient has to travel to hospital and physician's office whenever they have small medical test or taking a report, that kind of treatments can be done easily using IoMT devices or equipment's [11]. Apart from monitoring patient's health, IoMT has many other applications which can be used in real time scenario. By tag the devices with sensors or IoT we use for real time tracking record and real time location of medical equipment's like, wheelchairs, oxygen pumps or cylinders, ECGs, status of ventilator beds, nebulizers, defibrillators and other monitoring equipment's. As the Covid-19 situation is arises, using Arogya Setu app the real time data will be collected, and the medical facilities or equipment's can be assigned immediately to the most infected or affected areas, also the team of doctors or medical staffs also deploy at different locations by consider real time data provided by mobile apps and IoMT Devices are provided at such locations [12]. As we know the infection is major concern in this type of situations and it is also a major concerning factor in hospitals also, for that situations IoT enabled hygiene monitoring devices are very helpful for prevent patients from the infection. IoT devices are also help is asset management like inventory control in pharmacy stores, the temperature control, humidity and environmental parameters monitoring etc.

3. Methodology and Techniques

The basic key concepts of IoT were defined in many terms, but when we consider the majority key concepts the first will come in mind that is hardware or devices. As shown in figure 2, To control the physical world or to interconnected all devices with attached sensors and actuators, we achieve the first basic concept of Internet of things, where devices or objects are connected with mobile apps. Second, we consider Networking and Cloud integration, to manage huge network and its real time data, or network design its

management is the other major key factor in IoT [1,2]. IoT devices are embedded devices and a prototype which uses microcontroller platforms such as Arduino, Printed circuit boards etc which can be implemented at later stages [2, 4]. IoT devices are more exposed to security parameters, so this is major concern issue. Security in IoT is built-in or default at every step of design of the system or network, and should be not updated or added afterwards. Critical issues related to the security of IoT are data ethics, liability of data, copyrights and its privacy [2,5].

Allot appropriate authentication to the users or devices and most important wherever or whenever required data encryption should be done. Next important step is Data analyzation and Machine learning or Artificial Intelligence.



Figure 2: Key Concepts of Internet of Things

Source: <https://medium.com/@sciforce>.

Due to the multiplication or increase in data, the better application, algorithms to such data, also the improvement is storage capability and power capacities of devices, Artificial Intelligence become the key factor in Internet of things [2,5]. Same parameters can also be used in the medical internet of things (IoMT).

4. Implementation and Application Area

With the growth of the healthcare services, the specific IoT devices and Medical IoT devices have great opportunities to cover the maximum application area in society. The huge amount of the data is generated by IoT devices and it can be useful for taking further precautionary steps to improve health of the society. For effective healthcare services medical IoT or IoMT has basic architecture comprises of four stages [11]. All stages are connected in such a way that data is analyzed and processed at any stage and give the better reference to the nest stage or simply say give alert to take necessary action for further stages. First step is to collect data, it consists of setup of devices or gadgets which are interconnected devices that include detectors, monitors, sensors and actuators, camera systems, servo mechanism motors etc. Like in Covid-19 situation all health data will be collected as mobile app Arogya Setu, which is a real time data. So another step include conversion, Usually data which is collected from many gadgets, sensors or other devices are in continuous form or analog form, which has to be distributed and converted to the digital form for further data processing [5,6]. After conversion that digital data is pre-processed, standardized and further data moved to the data center or cloud. Then in last step, final data is analyzed and arranged at required level. Advanced analytics and diagnoses involve, and after data is ready it enables to take actionable decisions by

effective way in many application areas such as technology, medical fields etc. IoT redefines healthcare facilities by ensure better care, protection, improved treatment outcomes, improve patient experience in context of healthcare facilities and reduce the cost of patients and facilities required for medical field. The major advantages of IoT in healthcare services includes various factors like cost reduction, faster disease diagnosis, Proactive treatment, improved treatment, Drugs and Equipment management and error reduction [7,9]. In real time scenario if we enable to use patient monitoring system, it reduces the unnecessary costs like visit to doctors, admit to hospitals and take appointments in hospitals etc. Also, it is also useful for physician as he/she track the activities of patients like, medicine taken, sleep pattern, basic health readings like temperature, blood pressure, heart rate etc., so physician get evidence-based information at real time and it brings absolute transparency [10]. Real time data and continuous monitoring of patients and effective areas will help in diagnosis disease and infection at early stage or even before the disease develops based upon the symptoms. As we know Covid-19 didn't diagnoses at early stage in major countries like Italy, Spain, America and China. So, in India we use real time data based on mobile app name Arogya Setu, and by following major key techniques of medical Internet of Things we can reduce the risk of infection at early stage [11,14]. Also, in that case the medical equipment's, medical supplies and drugs/medicine is a major concern. As we know there is shortage of face masks and hand sanitizers at early stage of Covid-19. Such issues can be resolved using IoMT, where each equipment and medicines are provided by unique identification numbers, so that we track the data and all things are available in stocks [12]. Also, by apply IoT system, chances of errors are also reduced due to effective decision making which is based on real time data.

5. IoMT Covid-19 and Preventing future outbreak

The World Health Organization (WHO) has declared a Pandemic stage and global health emergency due to rise in the number of infected persons due to Covid-19 Corona Virus from Wuhan, China [3,19]. As of now, total 213 countries will be affected by this infections and data of conformed cases are increased day by day throughout world. As the statistics show by WHO, the following few graphs are shown below in figure 3. The active cases categorized as a patient with mild conditions, serious or critical conditions [3]. Whereas, closed cases consist recovered or discharges cases, and deaths of patients. To prevent the future outbreak or curb the spread of Covid-19, medical IoT plays an important role. As IoT, Internet of things is a network of systems which is interconnected through internet or web, and also advances in data analytics (in this case we take real time data based on mobile application named Arogya Setu), artificial intelligence and the various number of connectivity sources, all key features of IoT combine together will provide a early warning system through connected devices and medical equipment's so that necessary precautionary actions will be taken at time and prevent the spread of infectious disease [14, 19].

Two cases arise here, whether make sensors that would detect viruses which is based on the previous history or references like pandemic situation e.g., Ebola virus, Hanta virus etc. Or whether create a network to provide services, resources, medical healthcare's and equipment's is such situations (or in affected areas) through the use of sensors and networks [15,17]. The solution for this situation will be a collaboration of enterprises, cities and national governments which collectively create a global platform and a massive network of sensors to detect and prevent this type of situations.

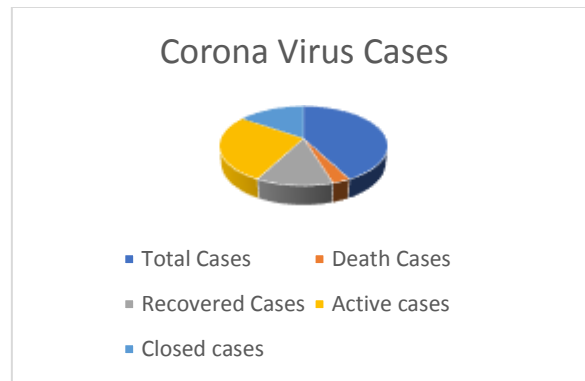


Figure 3: Covid-19 Corona Virus cases throughout World

Source: <https://www.worldometers.info/coronavirus/>

Like the first step in any pandemic disease is to detect the infection or simply say to stop or control any infectious disease the first step is detection [17,19]. As shown in figure 4, positive cases worldwide, show statistics of various countries of major effects of viruses. The data or real time data is the major key factor for the detection of the disease.

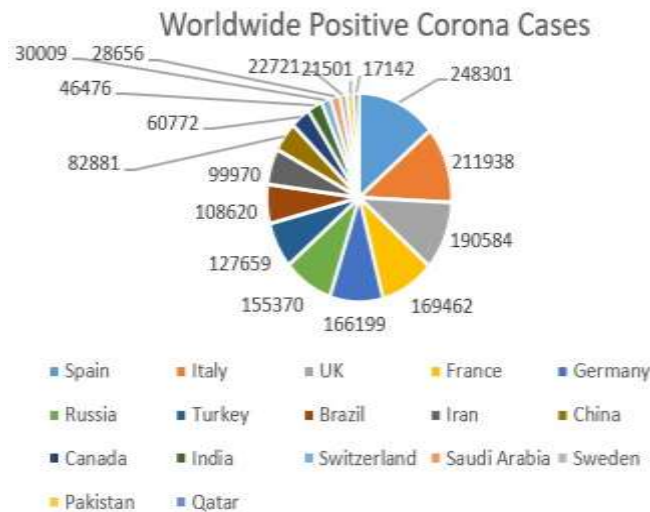


Figure 4: Covid-19 Corona Virus- List of +ve Cases Country Wise.

Source: <https://www.worldometers.info/coronavirus/>

In recent years, world has encountered so many threats and pandemic crisis such as SARS, Zika Virus, Ebola and now Covid-19 corona virus [15,17]. For the future health issues and crisis, we need a better digital infrastructure so that we deal with this type of situations in future. Better integration of IoT system and Artificial Intelligence solutions together response to public health and safety on priority basis. And real time data will be analyzed which is related to the movement of persons which is based on wearable devices, the pattern of transmission of disease and also monitoring the health patterns of the people to cure and prevent the future outbreaks [15] As shown in figure 5, to fight such pandemic situation big data analytics should be taken an important part. For prediction, detection, its response and recovery all data should be available and take necessary actions. To implement this facility through IoT, a global sensor of networks is required which implement wide area IoT solutions (i.e. Video Surveillance), and detect persons with facial recognition and its locations, by using surveillance cameras we trace, identify and monitor people that may have affected or not by virus or disease, also through medical IoT we also send medical facility or equipment at that infected area with the help of devices only [16].



Figure 5: Big data to fight pandemic situation

If we add more layer in IoT solutions then it would also track every individual infected person and keep record of its activities. So, it's the basic key factors and leverages of IoT which is combination of AI, Sensors and devices [18]. There are two possibilities where we can restrain the expansion of coronavirus. As every infected person is monitoring and see their activities whether they go through customs, airports, border crossing and whether in streets or in public place [19,20]. And also provide other IoT system where mobile apps or medical devices help with AI sensors to help with targeted quarantines and quick treatment to diminish the spread of coronavirus or any infected virus. As till the various factors are come forward about Covid-19 which can be further used as data and by analyzing that data we will find a particular IoT or medical IoT system to prevent further outbreak. The majority keys factors are, symptoms of a coronavirus, the incubation time period is between 2 to 14 days so we can detect the health of patient on daily basis and keep record of that for further implementations and precautions [19]. Furthermore, according to WHO, the attack rate or transmissibility of a virus indicated by its reproductive number, R_0 , which will show average number of peoples to which a single person will affect the others or transmit the virus. For common flu and cold R_0 is 1.3, and the Virus like SARS its value is 2.0. The R_0 value of the Covid-19 corona virus is between 1.4 to 2.5. So, based upon these parameters we also collect data and make a IoT system to take precautions and measurement of this infectious virus [16].

5. Conclusion

The Covid-19 Coronavirus is a major issue and it also provide a new start up for development and necessity of digital infrastructure for detect, control, analyses, predict and prevent the future by taking necessary steps, so that these pandemic diseases should be stopped and controlled before spread, and people are not affected by taking precautionary action within time. Using the real time data by mobile apps, using devices gadgets, the artificial intelligence, cloud, IoT and medical IoT, these all are collaborated used and create a room for industries to develop a better system to tackle such situation and provide a better life, medical facilities, good healthcare services to people in future. In coming years, the use of smartphones, the apps and m-devices i.e. devices operated using mobiles and apps, will be the future of Internet of things and medical Internet of things [16,20]. According to the global market, the medical IoT services will be increased by 26% in coming decades, and healthcare services and technologies are using network technologies. The IoMT (Medical Internet of Things) consist of smart and health devices, include wearable and medical monitors, which use strict healthcare for patients on the body, in the home, community or hospital/clinic settings, based on real time locations, telehealth and other medical services.

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