Healthcare-Internet of Things (H-IoT) can assist and address emerging challenges in healthcare

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Abstract

The emergence of technology correlation Internet of Things (IoT) could not be quantified on a growth perspective. The emerging technologies across the globe, in various sectors has made the life of every individual much more easier as compared to the previous days. At present the application of technologies are not limited to one particular sector, rather it is widely spread among various sectors. This is equally applicable to the healthcare sector. In this article I tried to emphasize the current challenges in healthcare sector and how the challenges can be addressed using different technologies. I conducted my review on different articles related to transformation of healthcare which has taken place since last few years and has brought a massive change in the medical sector. The best example for the same is the change from hand written prescriptions to Electronic Medical Records (EMRs). Healthcare-Internet of Things (H-IoT) has made a great contribution in bringing this transformation. H-IoT does not only have its application in one specific area of medical sector, rather it has shown its application to several areas of healthcare like – early diagnosis detection, continuous monitoring, orthopedic surgery, drug management, etc. The architecture of IoT is a three layer setup which should pass through four different stages. Even though researchers are continuously working on the transformation of healthcare using the IoT concept, still there are certain limitations in terms of data privacy when H-IoT comes into question.

Lay Summary. The wide spread reach of digital health can be structured with the impeccable use of Internet of Things (IoT). IoT in healthcare is Healthcare Internet of Things (H-IoT). As healthcare deals with huge data and there are challenges in handling of healthcare data, so to address the challenge of healthcare H-IoT is being used in the current era. It is the connectivity of several devices, where sensors are used to extract data from patient body, transmit the usefull information from the extracted data to the server using different transmission options like Wifi, this transmitted data is then made available to the medical professionals to interpret the data. The Medical professionals can read the data on their mobiles. In case of any abnormal findings in the data, an alert can be sent to the patient via wearable devices like Fitbit, millet wristbands, and Apple Watches etc. At last the medical decision making made by the healthcare professionals are shared with the patient. This technology is very much essential specifically for the elderly people who are on long term treatment of medicine. It has also shown its contribution in the areas of orthopedic by advising the patient on their regular physical exercise activity post orthopedic surgery. However, H-IoT is still at its initial stage of its application and requires further research specifically to maintain data privacy.

1. Introduction

The extensive and enormous amount of challenges in the healthcare sector across the globe demands for a massive transformation. This transformation from paternalistic treatment methodologies to digitized forms is required to address these challenges. Thus, it can be considered that healthcare is the sector, where investment is required to reduce the cost of treatment and ramp up the quality of care. To meet the challenges and demand of this sector Healthcare-Internet of Things (H-IoT) has made its contributions to several areas of healthcare industry. The Internet of Things (IoT) is the intelligent connectivity of appliances, sensors, devices and things, which can be defined as identifiable smart objects – comprising of radio-frequency identification (RFID) tags or actuators or sensors or smart phones. It is used for exchanging and connecting data with other device within the internet. In short it is a physical devices to gain efficiency, business growth and quality of life. Since last few years IoT played a crucial role into the healthcare domain to gain accuracy, productivity and

reliability. This term was first introduced by Kevin Ashton in the year 1999 [1]. In healthcare domain IoT is addressed as H-IoT which is designed with low cost sensors along with wireless communication which can provide large amount of space along with innovative service. It enables data collecting, data processing, port management along with several other innovative services.

It enables patients to get the treatment remotely instead of visiting the hospital in person at the time of emergency. The best functioning of IoT can be described as – When several sensors are attached to patient body, then it can be used to access the data which are further analyzed using relevant algorithms. These data are then transferred to the server using different transmission media like Wi-Fi. Finally the medical professionals can access this data, can plan the treatment accordingly and render the medical decisions remotely. Internet of Things (IoT) has its applications in several areas of medical sector starting from medical decision making to drug management.

Literature Review
I. Challenges to Healthcare

According to WHO, the threat towards the health issues has increased more than the past decade across the globe. Addressing these issues is one of the challenges at present with the increase in population and death rates. There are several reasons behind these issues, however healthcare data management and analysis of the same is one of the major concern. The Medical industry comprises of enormous amount of data which comes from hospitals, clinics, and several other medical sectors. As per the 2020 WHO report, there are total top 10 global causes of death, where chronic heart disease reports maximum number.
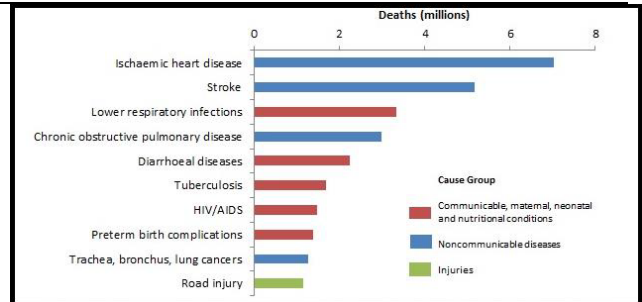

Figure 1: Top 10 global cause of death, 2020 (Source: Global health estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018)

With the increase in medicinal and health data there is also an increased demand for proper health and medical data management which in reality is out of the scope of humans to keep track of the entire data and deal with the same. Here comes the demand for technology which can manage these data, able to extract the valuable information from the collected data, analyze the same and come out with appropriate interpretation so that valuable medical decision can be made for every patient. This will finally lead to quality health service with reduced cost and time [2].

At present healthcare is undergoing a huge transformation from paternalistic method of treatment to patient-centric treatment approach. Thus an intelligent and smart healthcare technology is required that can transform several data captured and extracted from patient through physical devices to digital world. IoT plays a pivotal role in this transformation. To avoid continuous medical care, wearable sensors based monitoring via Healthcare-Internet of Things (H-IoT) is considered to be more efficient in early detection of disease and medical management.

In developing countries like India there are almost negligible in house treatment facilities. At times of emergency it becomes very difficult to reach the hospital on time and patient may take the last breadth on their way to the hospital in the ambulance. This usually happens due to lack of technological communications. Healthcare Internet of Things (H-IoT) can address this challenge by building up a smart hospital that will be connected to end to end users.

II. Application of IOT in several areas of healthcare

According to Sheth et al. (2017), in this era of digitization along with the new emerging technologies, healthcare shifted "from being driven by limited data to 360-degree, multimodal personal-public-population-physical-cyber-social big data driven "[3]. Internet of Things (IoT) is the new form that has been introduced to the world of information technology [4], [5]. It is the combination of software, sensors, electronics and networks, which together enables to build up a bridge between the physical and the digital world, thereby enabling data extraction from the human body by means of sensors, data transmission to the server by means of cloud computing and finally accessing, analyzing and interpreting the data at the healthcare professional's end. The last part of IoT that is being used at the healthcare professionals end can be done using simple Android mobiles within short period of time at minimum cost. It has been estimated that 161 million healthcare IoT devices will be into operations by the end of 2020 [6]. The number of active connections in Healthcare Internet of Things (H-IoT) is expected to increase in the near future. The current report from Statista (Figure 2) shows the total number of active connections of Internet of Things (IoT) in the healthcare sector in the European Union (EU) in 2016, 2019 and the expected rise in 2022 and 2025. It is expected that the total number of connections from 2016 to 2025 is at an expected rise in number from 0.87 million to 10.34 million connections.
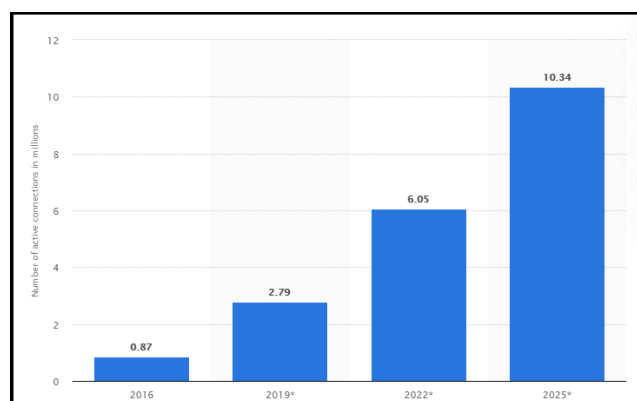
Figure 2: Number of Internet of Things (IoT) active connections in healthcare in the European Union (EU) in 2016, 2019, 2022 and 2025 in millions (Source: Statista 2020[1])

This increase demand for IoT encourages today's healthcare to set up a smart hospital to implement IoT. Internet of Things comprises of several technologies like – tracking technology, communication solutions, wired, wireless sensor identification, etc [7]. The implementations of IOT is a package of integrated devices that includes famous consumer-oriented well-being fitness trackers like - Fitbit, millet wristbands, and Apple Watches. [8].

IoT has its application in different areas of healthcare. In today's fast moving world, it is difficult for every individual to visit the physicians in person for regular health check-up. Also, taking elderly persons into consideration, it has been noticed, that they often suffers from several chronic diseases and might seek for emergency service. So to address this challenge the concept of "pervasive healthcare" was introduced [9]. Thus, with the advancement of technology in the healthcare sector, wearable devices are often used by the individuals to monitor heart rate, blood sugar level, ECG. In this case IOT can be used for the monitoring of blood pressure, oxygen saturation, heartbeat etc [10]. It can enhance early detection and diagnosis of diseases, by measuring patient's vitals along with collecting of other biometric information. In a nutshell, it can be used to address the treatment and supervision of chronic disease, fitness management.

Due to the increase in chronically ill patients specifically in case of elderly people, continuous monitoring of the patient's body along with the recommendation of diet chart and drug management is essential. The monitoring action in H-IoT is carried out with the concept of ontology and fuzzy logic [15].

Another application of IoT is Telemedicine that has been proposed by the researchers for rural areas where it is time consuming to take the patients at the time emergency to hospitals. A Mobile Care Unit (MCU) which is a wireless telemedicine system, has

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[1] https://www.statista.com/statistics/691848/iot-active-connections-in-healthcare-in-the-eu/

Published by:
http:ijesir.org

(IJESIR) International Journal of Science and Innovative Research
ISSN: 2724-3338
Vol. 01 Issue 02, December 2020

Paper id: 0100010IJESIR

been designed and implemented to monitor, manage and plan accordingly for patient's treatment in case of abnormal readings of the vitals of a patient. C# language has been used to develop the application program of MCU. The functioning of MCU is based on extracting the physiological data (vital signs), transmitting the data to the remote server via cellular network at times of emergency and internet at times of normal case for monitoring purpose. This will enable reduction in cost of using GSM/GPRS network, because cellular network will be used only at times of emergency[11].

Additionally, IoT is also helpful in controlling the traffic lights, thereby enabling the ambulance with critical patients to reach fast to the hospitals, thereby avoiding the roadblocks [12].

It is a common issue with the elderly persons as they miss to take their medications on time. As a result, full time attendance is required to monitor medical management for the patients who are on long term medications. However, I believe this issue is no more limited to elderly people rather it is a challenge for every individual in today's fast moving world. To address this challenge designing of smart pill box [16] for medicine reminder and day to day monitoring the time of taking the medicine can be resoved designing smart pill box.

IoT is not only limited to one specific area of medical industry, rather it has been incorporated into dentistry and orthopedic [13]. In case of orthopedic surgery it provides an accurate information about blood pressure, bone pain and brain activity. It plays a vital role post-surgery, where the data is captured from the patient, post-surgery and is shared with the physician, who can advise the patient accordingly for fast recovery. With the application of IoT the cost of surgery is reduced along with minimization of surgical errors. The functioning of IoT in the field of orthopedic is shown in figure 3.
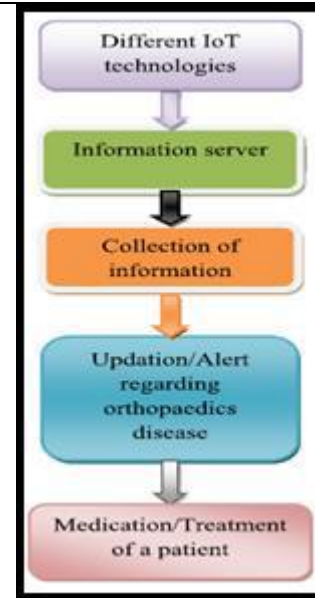

Figure 3: Process chart of IoT in orthopedics (Source: Haleem, A., et al., 2020)

III. Architecture of IoT in Healthcare

Internet of things (IoT) has enabled the movement of researchers and technologists from centralized to distributed environment. The entire business spectrum is moved towards betterment with the emerging technology of IoT. It enables connectivity between users by going beyond Machine to Machine scenarios.

The basic layer of IoT software architecture requires 3 main layers and with the absence of any of the below three layers IoT cannot be considered as a complete structure [17]. The three layers along with their functions are explained below in figure 4. To build the architecture of IoT it needs to pass through 4 stages –

Sensors and actuators
- Sensors enable data collection from the physical environment and transformation of the data into meaningful form for analysis
- Actuators conduct data analysis of the recorded data from the sensors.

Internet gateways and Data Acquisition Systems
- The digital signals that are converted from analog signals becomes readable for the applications.

- Along with signal conversion, data acquisition system and internet gateway is used at this stage.
- The aggregate data is further used for application.

Edge Information Technology

- In order to avoid issues with bandwidth of the local network and the router due to availability of huge dataset, filtering of the data is done before transmitting the data to the server.
- The informative data is converted to digital format and send to the actual system.

Data Centre and cloud

- Grading of data into necessary and unnecessary and then transferring it to various storage capabilities such as cloud, physical and data centres.
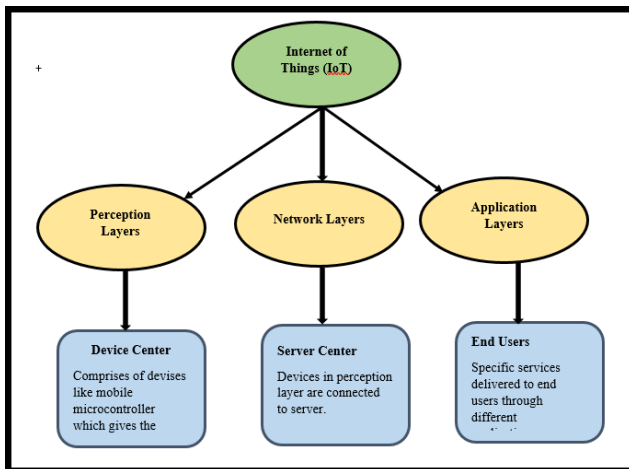

Figure 4: Process chart of IoT in orthopedics (Source: Own flowchart)

In case of healthcare major concern is with data privacy. Thus, the second stage of IoT architecture is the crucial phase where data protection can be deployed. To enhance data privacy, fast response and low latency an IoT architecture based on Fog-layers has been proposed [14]. IoT that is designed based on cloud computing has its limitations in terms of data privacy due to cost effect, availability and maintenance of enormous amount of data in case of healthcare. Therefore data extraction from Electronic Medical Records (EMRs) through cloud computation

method is a threat and to address this challenge fog enhanced IoT based application has been developed.
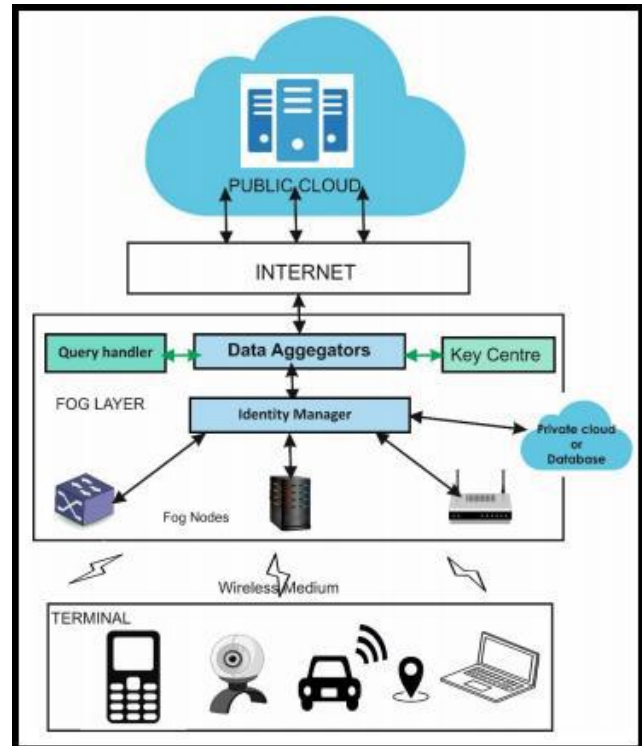

Figure 5: Proposed framework for the privacy ensured ehealthcare network (Source: Saha, R., et al., 2020)

Research gaps in IoT applications in the healthcare sector

To bring comfort to our daily life, Internet of things (IoT) is utilized to connect human lives with several technologies across the globe. In spite of its massive contribution and rapid demand in every sector there are certain limitations and gaps when healthcare is taken into consideration. Internet of Things (IoT) being a new concept, has high level of uncertainty from several aspects starting from technology, legal, economic, etc. The main challenge and concern is in terms of security, privacy and accessibility of data as cloud computing has certain limitations in terms of amount of data and cost consumption. The IoT based applications should be more user friendly, with proper instructions about the steps that needs to be followed at the time of designing the application. Usually the network used is a LAN networks which requires high set up cost. There are chances of data privacy violation as the LAN Administrator have

Published by:
http:ijesir.org

(IJESIR) International Journal of Science and Innovative Research
ISSN: 2724-3338
Vol. 01 Issue 02, December 2020

Paper id: 0100010IJESIR

access to patient's data. Additionally, at the time of data transmission, data can be lost due to lost. There should be a back-up for data retrieving in case of lost data. Thinking about the Wearable devices they are having limited power supply, so further research is required to address this challenge. Above all there is no device that can be used to check for data accuracy that are being retrieved from patient's body through sensors.

Above all, among all the stake holders in the healthcare industry, payers are also subset of healthcare. No research regarding application of H-IoT from the payers perspective has been done till date. Like-

- ✓ Financial Risk Management – Can we utilize IoT further for making hassle free cash flow to the hospitals by determining accounts that demands payment on priority basis and determine the accounts that should remain unpaid in future.
- ✓ Fraud & Abuse – There can be many fraudulence incidents in healthcare sector starting from wasteful diagnostic tests and incorrect Medical Decision Making – resulting in false claims submission and ending up with erroneous billing and payment. Can IoT play a role in avoiding these errors.

CONCLUSION

With the increase demand of technology across the globe in every sector, the researchers are showing keen interest in digitization of the healthcare industry. This sector is the most fertile soil where maximum research is required that can be carried out in collaboration between all the stake holders of healthcare industry. To find a way for the ongoing challenges of the healthcare sector, Internet of Things (IoT) has played a pivotal role in transforming hospitals to smart hospitals. Internet of Things (IoT) has enabled to reduce the communication barrier which was often noticed between healthcare professionals and patients' in paternalistic forms of treatment. This has enabled easy access to healthcare data for the medical professionals which enables to plan and render the

treatment at hours of emergency as well as on regular monitoring. Considering the real time applications of IoT in healthcare industry, there are certain challenges that should be addressed in future research. Most of the papers published on Internet of Things (IoT) either refers to particular areas of medical industry like dentistry, orthopedic, Electronic Medical Records, etc or their architectural context, which restricts their acceptance by most of the elderly patients as they are not familiar with the new technologies. The advancement in technology in the healthcare sector also restricts healthcare professionals' from adoption of IoT in medical field, which limits further investigations in this field. There are certain roadblocks to the implementation of IoT in the healthcare sector from both provider and patients' perspective. Apparent lack of data privacy is the main concern that should be addressed in further research. However, IoT is still at an infant stage in the healthcare sector, so further development is required to address the challenges in the areas of healthcare industry. Future studies evaluating the cost-effectiveness of IoT measures are required to decide whether upfront expenditure will provide value for money in the longer term.

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