Internet of Things in Smart Healthcare Systems

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ABSTRACT

Today's world is the place of modern technologies and its application. Internet of things is the most acquired feature of the modern day communications that equipped computing with sensors, microcontrollers, transceivers, and other smart communication devices. The IoT enables computing devices to transmit a large amount of data, and store it in the cloud for decision making. This data acquisition feature of IoT is also playing an important role in the medical field, by helping in creating a smart healthcare system that can help the stakeholders, in keeping them informed and aware of the patient's condition. This system also helps in monitoring the patients. In this paper, we have discussed advantages, Issues and different aspect of building a smart healthcare system. We have also discussed that which measures of IoT can be handy in healthcare and how can we get the optimal result. How can BAN and M2M communication help in health maintenance and home healthcare services by using the Internet of thing (IoT).

Keywords : Internet of Things, Smart Healthcare Systems, Healthcare

I. INTRODUCTION

As we all know a commonly used phrase "health is wealth" shows the importance of health and healthcare is our life. Healthcare is the process of preventing, diagnosing, treatment of the different medical problems causing to our health. Healthcare is an essential part of our life but unfortunately, due aging population and the rise in chronic illness our health organization are facing a lot of problems in the maintenance of the health of patients. Due to the limited number of beds, nurses, and doctors [1]. In that aspect, the hospital has begun to implement "smart beds", which can be detected when they are occupied and when the patients are trying to get up [2].

Internet of things (IoT) is the interconnection of daily used appliances where internet communication is embedded and they share their data with other devices and clouds. Sensors, Microcontrollers, and transceivers are used in IoT devices. Lots of researches

have proposed that IoT can play a vital role in the health care system, which will help ease maintenance and keeping track of the patient's condition these devices collect a large amount of data to the clouds through sensor networks.

In this paper, we have discussed Machine to machine (M2M) communication which is used in communication devices to share their collected data among connected devices in the network. These devices periodically collect data and shared it to the devices in the network. M2M communication must be capable of self-healing, self-maintenance, and configuration [3].

This paper gives a view of different dimensions of Medical Body Area Network (MBAN). MBAN is created by embedding a wireless network of wearable devices inside the human body, or placing it on the human body surface or putting it in pockets and bags to capture its required data and then forward it to cloud for decision making [4].

In this paper, we also discussed the wearable devices which are responsible for the data communication of the Internet of thing wireless body area sensor network. We also discussed the caring point of view in the context of healthcare of humans i.e. to keep track of humans and those wearable things [2], which leads to a better healthcare system.
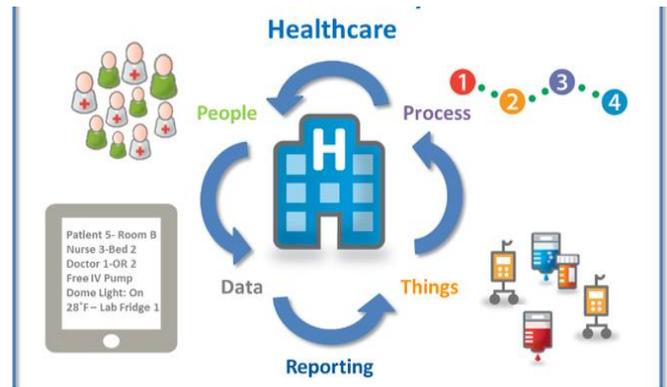
II. INTERNET OF THINGS IN HEALTHCARE

In this section we are going to discuss the Internet of Things, what are the basic measures of a healthcare system? How to embed IoT in the healthcare system? What are the main pain points in our health system that we are trying to resolve through the use of Internet of Thing in the health care system and what will be the outcomes of embedding IoT in the healthcare system?

A. Internet of Things

Internet of Things is a modern technology which deals with the interaction of things embedded with communication devices like sensors, microcontrollers, actuators, and transceivers enabling normal devices and appliances collect a large amount of data through sensors and share this data to clouds and also sharing this big data with other communication devices through M2M communication.

Internet of things gave birth to the phenomenon of collecting data with normal devices and them smartly sharing this data with other devices through Machine to Machine communication. According to [5] "the embedding of IoT in healthcare enhanced the access to care and strengthen the quality of care and finally reduced the cost of care". In [1] it is discussed that IoT can play an important role in collecting the data through sensors and providing this big data for monitoring to the stakeholders like caretakers, nurses, doctors, and healthcare centers.

Figure 1. Retrieved September 9, 2018, from kmgus: http://www.kmgus.com/blogs/healthit/index.php/2016/06/internet-of-things-for-healthcare

B. Healthcare System

As described above Healthcare means the process of preventing, diagnosing, treatment of the different medical problems causing to our health by organized professionals on behalf of certain medical care organization. These organized systems of medical care professionals are known as medical care or healthcare system.

In [6] there are certain pain points or loopholes which is causing problems in the health care system and patients are not treated as it is needed and the system is not functioning perfectly.

The following certain problems faced by local hospitals in the context of healthcare:

1. Regular Checkup Cost-- in countries like Pakistan where monthly revenue of a common person is not at a high level it becomes very difficult a common person to conduct regular medical checkup.
2. Disease Diagnosing-- has been a very large problem in health care. There are certain problems in disease diagnosing.
   a. 1st unavailability of proper medical testing machines.
   b. 2nd is the limited number of qualified staff for disease diagnosing.

c. The 3rd one is that diseases are diagnosed but not at the right time which causes lots of healthcare issues. The authors in [5], have discussed the suitability of healthcare for the right person at the right time, which give reliable results.

3. The high number of patients and the limited number of staff to deal with those patients and mismanagement of time to cure a patient.

4. Improper diet and medication for the patients due to the financial status.

The above are the appealing points that we are tried to figure out and can be solved or can be limited to some extent with the use of Internet of Things in the healthcare system. In the next session, we will discuss the IoT wearable devices, BAN and M2M communication trying to figure out how to solve these proposed issues.

III. INTERNET OF THINGS & SMART HEALTHCARE

In this section, we are going to discuss the basic measure and elements through which we can embed IoT in the healthcare system. In that aspect we will discuss 3 majors 1st The Wearable devices that is the basic part of implementing IoT is the health care system, 2nd is the Body Area Network through which the wearable devices are enabled to create a networking environment and share their collected data with clouds for decision making. 3rd one is The Machine to Machine communication that how will those wearable devices and sensor share there among them in order to give a comprehensive result in healthcare system which could be handy and beneficiary for the stakeholders like hospitals, doctors, patients, caretakers and nurses to take care of the patients in a better possible way without consuming large amount of time.

A. IoT Wearable Devices

Wearable devices are smart electronic devices that can be worn, implanted, put on as clothing or can be used as accessories.[4][8] They are embedded with sensors and microcontrollers that enable the Internet of Things to take part in the use of those wearable devices and collect data from those devices and share it to cloud.

The trends of Internet of Thing have given a whole new dimension to the thee concept of internet that means nowadays the household thing and common use things are embedded with internet that gives birth to new ideas and concepts and changing the trends of people but also the trends in industrial state, also playing an undeniable role in the industry of health [9].
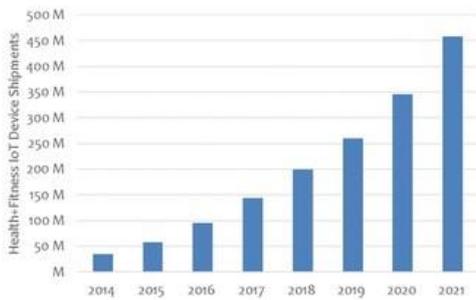
The health industries are also going towards the adaptation of Wearable IoT. The author in [9] discussed trends of the health sector as they are going from Hospital-Centered structure to Personal-Centered Structure. That means they are focusing on self-health monitoring to limit the unfavorable health conditions.

As the hospital is trying to adapt to the personal-centered health it would not be possible without the interference of IoT Wearable Devices. That can fetch the data easily to clouds and doctors and other stakeholders easily through the Internet of Things.

From [10] "Mobile Experts interviewed more than 35 companies ranging from insurance providers to hospitals, OEMs, and semiconductor suppliers to develop the information in this report. After thorough review of existing connectivity technology choices, our Experts estimate shipments and revenue based on technical and business factors".

According to the author in [10] the health industries are heading more towards the use of wearable devices and they prove it by the following trend graph as

shown in figure 2, created from data collected from 2014 onwards.

Figure 2. Retrieved September 11, 2018, from prnewswire.com :
https://www.prnewswire.com/news-releases/the-iot-wearable-market-is-looking-well-healthy-300351393.html

This graph shows the shipment of wearable device recorded during the years and show trends for the upcoming years.

From these stats, we can conclude that wearable IOT is playing an important role in the development of healthcare system and settings the new trends for IoT to be more and more embedded in the Healthcare System.

Here we will discuss some of the wearable devices that can give us better results in terms of monitoring, curing and caring for some of the very ubiquities diseases. That is hard to recover. IoT wearable devices are making the monitoring of such diseases very handy some of these diseases are discussed below.

[1]   Wearable device for Diabetes

Diabetes is a diseases caused by the uncertain level of Glucose-Oxide in the blood of a human body. This deficiency of level of Glucose-Oxide can gave birth to certain other diseases that could be contagious and can interrupt the normality of the human body. Therefore diabetes needs regular check in order to prevent it from spreading and causing more problems. According to [11] the author, Organizations have started creating prototypes of Continues Glucose Monitoring CGM systems from 1990's to check and

monitor the glucose-oxide level sensors to measure the level of glucose-oxide in the blood. That leads to control the level of glucose-oxide in human body.

After years of development nowadays we have reached the IoT solution of monitoring Glucose-Oxide level remotely. Some the modern devices used in this paradigm are the following.

a)   "LIFELEAF" A CGM Wearable

LifeLeaf is a Continues Glucose Monitoring non-invasive and non-intrusive wearable device that is developed by The Lifeplus Inc [12] that is used for monitoring and taking care of chronic diseases that are need to be checked regularly. According to [12][13][14] LifeLeaf is a Smart watch that monitors the Glucose level, Blood Pressure, Heart Rate, Respiratory Rate Cardiac Arrhythmia, Sleep apnea and Oxygen Saturation in the human body.

Figure 3 Retrieved from www.androidheadlines.com: https://www.androidheadlines.com/2018/05/lifeplus-lifeleaf-smartwatch-monitors-blood-glucose-levels.html

Working Mechanism

According to [12][13][14] LifeLeaf is a IoT based multi-sensors Smart watch with hosting novel physiological parameter extraction algorithms, which works on client(User) and cloud based hosting and AI-driven predictive analytics [12]. It user interface have a mobile application and a desktop portal. LifeLeaf uses an optical sensor technology namely Photo-Plethysmography (PPG) [15] to measure the blood volume changes in the micro vascular bed of

tissues. This sensor provides the necessary data for the cloud through IoT. The cloud contains novel parameter extracting algorithm a machine learning algorithm which works on the digital signal processing phenomena. Then the cloud send the extracted results to mobile application for showing the results on user interface.

b) E-MOSQUITO

E-Mosquito is a CGM wearable IoT based device that is like a wrist watch. According to [17] E-Mosquito was first introduced and deployed in 2007 by a team at The University of Calgary in Canada.

Figure 4. Retrieved from spectrum.ieee.org:

https://spectrum.ieee.org/the-human-os/biomedical/devices/emosquito-drinks-your-blood-to-keep-you-healthy

Working Mechanism

The idea of this device was to have a spontaneous and periodic testing of blood for glucose level. From [17] [18] the device contained piezoelectric actuators from beginning. Now the latest prototype contains Shape Memory-Alloy (SMA) actuators for biting the skin with a needle. The actuators bites the skin several time a day and gets the blood sample to the strips, the strips then transmitting the data of glucose level wirelessly to Smart phones or other related stakeholders. The strips used in this device are customized strips which can work with the very small amount of blood drops and giving the required result.

[2] Wearable for Asthma

Asthma is a well-known chronic disease caused by the infection or abnormality in lung that leads improper respiration of human body [19]. As asthma is a chronic disease it also need regular checkup and monitoring to avoid asthma attacks that can lead to severe consequences. On verge of taking care of asthma and controlling and limiting the asthma attacks Internet of Things is also playing a very important part by creating Smart Wearable that can detect asthma attacks according to the symptoms and try to avoid unfavorable conditions.

"ADAMM" AN IOT BASED WEARABLE FOR ASTHMA"

ADAMM stands for automated device for Asthma Monitoring and Management. According to the author in [20] ADAMM is a technology for Intelligent Asthma Monitoring. It's a soft, flexible, waterproof wearable Internet of Things device. Which communicates with a smart phone app and web portal using Bluetooth, Wi-Fi, and cellular connections. It attaches to the upper torso using skin-safe adhesive and tracks precursor symptoms of asthmatic attacks, including cough rate, respiration patterns, heartbeat, and body temperature.

Figure 5. Asthma-Health Care Originals. (n.d.). Retrieved from http://healthcareoriginals.com/solutions

ADAMM have the unique feature unlike other Smart wearable in the field that it collects large amount of data and deliver it to cloud and smart phones for further decision making but ADAMM also gives vibration alerts in unstable stable condition and possible occurrence of the asthma attack.

Figure 6. Asthma-Health Care Originals. (n.d.). Retrieved from
http://healthcareoriginals.com/solutions

ADAMM can be worn anywhere on the skin and we can examine different features related to our health through that wearable device. It collects the real time information to connected smart phone and web portal that come with the device. We can add different parameters according to our medical conditions and based on that specified conditions the device gives us monitored results. It also keeps track of you medication that whether you have taken it or not.

A. Body Area Network

BAN Body Area Network also referred as WBAN Wireless Body Area Network or MBAN Medical Body Area Network, BAN is a kind of Personal Area Network.

1) Body Area Network History

Body Area Network was first developed and introduced in 1990's [21], At Massachusetts Institute of Technology where a number of groups were working on PAN and to develop a network that can measure the positions of the sensors on the body and to interconnect them for communication. On the basis of those experiment they found a new network phenomena named as Body Area Network where devices or sensors could be placed on human body and they can communicate and data among each collected from the surface through a communication channel.

2) IEEE Standard For BAN

As Body Area Network is based on the phenomena of Personal Area Network and it works low-power and short-range communication technology. IEEE have kept BAN in the standard IEEE 802.15 that is defined for personal area networks and that is responsible for the short-range and low-power consuming communication.
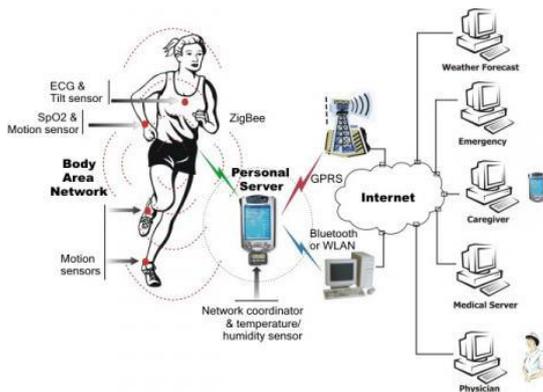
IEEE have defined a separate international standard IEEE 802.15.6 for body area network that is responsible for the communication of extremely low-power short-range devices over body area network with a data rate up to 10 Mbps to provide continues communication is the network and share data among the devices connected in the network [22]. According to the standard IEEE 802.15.6 the portable antennas on the body senses the surface change and motion of the body and provide different characteristics based on that results collected from motion of human body that is then provided to the devices in the body area network[23].

3) WBAN In Healthcare

Body area network is basically developed for sensing and collecting big data from the human body through continues monitoring that could help humans to maintain their medical condition and to prevent unfavorable events to occur regards human health.

In body area network different types of sensors like ECG sensor, Motion Sensor, Heart-rate sensor, Blood-pressure sensor, CGM sensor and some other sensors

are connected to collect data according to the condition of the human body and measure the human health condition on the basis of the collected parameters that are defined to the sensors for the collection of data. This continuously collected big data is propagated to smart-phones, web-portals and clouds for decision making and showing the conditions of human health according to the specified parameters to the sensor devices [24].

Figure 7. Wireless Body Area Networks (WBAN) | WAVES. (n.d.). Retrieved from https://www.waves.intec.ugent.be/research/wireless-body-area-networks

In this way body area network contributes to the human healthcare system and keeps us informed at personal level from our health conditions and gives us an idea that what pre-cautions should be taken to avoid unwanted and unfavorable conditions.

Body area network is providing a brilliant platform for Internet of things to be embedded in healthcare system that can easily be adapted and could be very beneficiary in the healthcare sector.

B. M2M Communication

Machine to machine communication refers to all the automated communication between elements without the interaction of human. This communication is based on things that are embedded with smart services to perform some tasks and communicate data without manual interaction of humans. M2M communication uses IEEE standard IEEE 802.15.

1) M2M Communication History

According to [26] [27] Machine to Machine communication was first introduced in early 1970's and developed afterword over the years. Firstly M2M communication was used in the industries for the communication among the machine to share their data for different purposes but nowadays its playing a very important role in the field of Internet of Things. That enable different mobile and sensor devices to collect big data from the surroundings and then share this data to other connected devices in the network that yields in the better outcome and performance of the sensor devices deployed in different area.

2) Six Pillars Of M2M

Machine to Machine communication is based on the following six pillars which are responsible for the working of M2M [26] [28] [29].

a) Remote Monitoring-- acquisition of the data from different communicating devices automatically to clouds and other devices.

b) RFID-- M2M communication use RFID electronic tags to for data collection and data storing.

c) Sensor-Networking-- M2M needs a sensor network to work with the device connected in the network with each other to communicate data and collect big data for decision making.

d) Smart-Services-- refers to the networking and monitoring of the data in such a manner that it user-centered and could be monitored easily and effectively.

e) Telematics means the combination of telecommunication and informatics that deals with the transmission of data through networks.

f) Telemetry-- The process in which data is collected to a remote point and then it is shared among the connected devices that are in need of that collected data.

3) M2M In Healthcare

Body area network is created by the combination of sensors planted on human body to collect data from different areas of the body. Then a M2M

communication is established between the sensors and smart-phones and other networking devices to transmit that collected big data to the clouds and to extract the required results from the collected data.

M2M communication is used in body area network for gathering different combination of parameters from different deployed sensors for a particular result to be shown to the user, which is a very useful application of M2M communication the field of Healthcare [30].

From [30-32] M2M is used in healthcare system because in human body there are different parameters like blood pressure, heart rate, oxygen level etc to measure for human body monitoring a single parameter cannot give us the accurate condition of the body therefore M2M communication amongst the sensors is used so that the sensors can combine their data automatically and give us the accurate condition of our body. M2M communication is playing a very important role in the communication of newly developed wearable device that are used in healthcare system for condition monitoring.

IV. CONCLUSIONS

Internet of Things is the revolution to the modern communication technology and it is contributing big time in our daily life for the goods of the humans. From this research we conclude that IoT is making a mark on the new development of Healthcare System, by developing healthcare system from hospital-centered to personal-centered means with the help of embedding IoT in the healthcare system healthcare of human beings are transferred in to their own hands. With the help of IoT wearable devices the patients itself can monitor their health condition without going to hospitals and they can be facilitated at homes.

Embedding IoT in the healthcare will also be helpful and time saving for doctors and hospitals to monitor a patient. Smart healthcare system provides a great

opportunity health sector stakeholders diagnose, monitor and cure the occurring medical condition smart and easily. The communication among wearable devices through M2M communication made the smart IoT healthcare more prominent to adapt and to be introduced the hospitals.

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