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INTERNET OF THINGS BASED HEALTH MONITORING SYSTEM : OPPORTUNITIES AND CHALLENGES

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Abstract: Internet of Things (IoT) is a new and fast growing technology in which everything (smart objects and smart devices) are connected to the internet for effective communication between these connected things. Internet of things serves as a catalyst for the healthcare and plays very important role in wide range of healthcare monitoring applications. Networked sensors devices, either worn on the body or embedded in living environments, make possible the gathering of rich information to evaluate physical and mental health condition of the patient by collecting body temperature, blood pressure, sugar level etc. Communicating this collected information to the doctor, making accurate decision on the data collected and notifying the patient is the challenging task in the Internet of things. In this paper author focus on review of IoT based Healthcare System and outline about Opportunities and Challenges for Internet of Things based Patient Health Monitoring System.

Keywords: Healthcare; Internet of Things; Wireless Sensor Network; Body Area Network

I. INTRODUCTION

We are living in Internet age where every physical object may be connected to each other for sharing information purpose. Due to enhanced wireless technologies like 6LoWPAN, Wi-Fi, Bluetooth & ZigBee, many things or objects around us have the ability to exchange information automatically. This network of things or objects that are connected to each other via Internet, local area network or Wireless Sensor Networks is called Internet of Things(IoT). IoT is made of two words one is Internet and second is The Things. Internet is network of networks that are connected world widely via some standard protocols. Things refers to any Physical Object that may be involved in connectivity. IoT uses many technologies like Radio Frequency Identification(RFID) tag, Sensors, Actuators and Smart phone and cloud computing support etc. By using IoT, we can connect anything, can access any service and useful information of any object from anywhere and anytime [1].

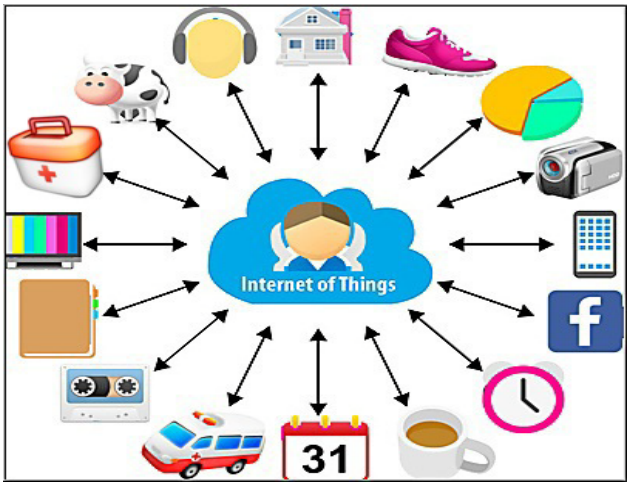

Figure 1: Internet Of Things (IoT)

II. ECONOMIC IMPACT OF IOT

Many new technologies like micro-electromechanical systems (MEMS), wireless sensor technologies and internet have promote the development of IoT at a rapid speed. we have available sensor devices at a economical prize. Market analysts estimate that near about 25 billion IoT devices would be installed by 2020 and the IoT market would extent around 2.1 trillion by 2025[2]. According to a report by marketresearch.com market of internet of things in health care is expected to reach $117 billion by 2020[3.].McKinsey Global Institute has presented a report “the internet of things: mapping the value beyond the hype” in June 2015 predicted that IoT market will reach up to $11.1 trillion per year in 2025[4].The Gartner group predicts that up to 26 billion of IoT devices will be connected to the Internet by 2020. Intechno Consulting estimates that IoT application market will create up to 180 billion of Euros worldwide [6].

III. IOT APPLICATION AREAS

Near Field Communication (NFC), Radio frequency Identification (RFID), Machine-to-Machine Communication (M2M) & Vehicle-to-Vehicle Communication (V2V) are the technologies by which IoT is being implemented exponentially. It is assumed that more than 50 billion IoT devices will be connected through internet by 2020. It is going to change human life, working style, entertaining ways and many more [7]. IoT have many Applications Areas and domain of these application are increasing day by day.

Figure 2: IoT Application Areas

There are ample of applications of IoT as follow:

- Smart Cities
- Building & Home automation
- Environmental Monitoring
- Automotive Industry
- Smart Retail
- Smart Agriculture
- Smart Industry
- Energy Management
- Healthcare Monitoring

IV. IoT AND HEALTHCARE MONITORING

Healthcare is one of the sector in which IoT technology is flourishing . According to Forbes magazine IoT market in healthcare industry will be more than $117 Billion by 2020[3] and According to P&S Market Research report, there will be a compound annual growth rate (CAGR) of 37.6% in the healthcare Internet of Things industry between the years 2015 and 2020. IoT have the capability to reduce human dependent healthcare.

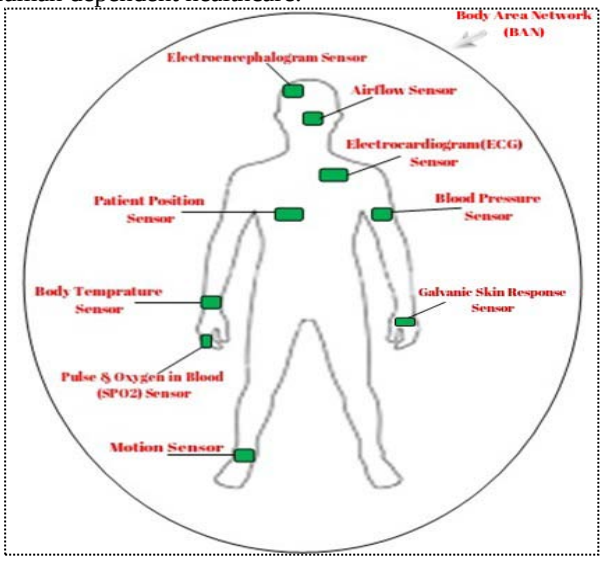

Figure 3: Body Area Networks

IoT wearable devices (medical sensors) records patient health related information like blood pressure, body temperature and breathing pattern etc. This data will be delivered to concern hospital or caretaker for further action.

A. Medical Sensors and Wearable used in IoT based Healthcare Monitoring

Due to improved wireless communication, medical sensor and data analysis techniques, now it is possible to monitor health condition remotely by using them as wearable technology. These Sensors and wearable devices can be included into many accessories like garments, wrist bands, eyeglasses socks, hats, shoes, and other devices such as smart phones, headphones and wristwatches.

Medical sensors can be categories into two categories: on body contact sensors and Peripheral Non-contact sensors. on body contact sensors can be further divided into two categories :

- Monitoring sensors for physiological behavior (ECG, EMG, EEG), chemical (sweat, glucose, saliva) optical (Oximetry, tissue properties),
- Therapeutic sensor for medication (drug delivery patches),stimulation (chronic pain relief) and emergency(defibrillator).

Peripheral Non-contact sensors can be further divided into three categories:

- Monitoring fitness & wellness by measuring motion(physical activity, calorie count), location(GPS, indoor localization)
- Behavioral monitoring of Activity(fall, sleep, exercise), Emotion(anxiety, stress, depression) and Diet(calorie intake, eating habits) and
- Rehabilitation by speech(language development) and camera (technology for blinds)[8].

Medical Sensors and Wearable devices can be used in following application of healthcare[9]:

- Vital sign monitoring in hospitals
- At-home and mobile aging
- Assistance with motor and sensory decline
- Large-scale in-field medical and behavioral studies

B. IoT Applications in Health Monitoring

IoT could have various applications in medical industry for improving the quality of life, saving lives and reduce treatment cost. By using IoT based technologies, medical industry can improve the ability of the healthcare system in minimizing human error, simplifying the treatment process and quality of life for caregiver as well patient. IoT based monitoring system can help doctors in treatments and predict a symptom before starting diagnosis. Monitoring system can also alarm in medical emergency situations like falling of old age patient ,patient has abnormal behavior as in the intensive care unit (ICU).There are many IoT based healthcare use cases/application area as follows[10]:

i. Health Monitoring
ii. Personal Fitness Monitoring
iii. Chronic Disease Monitoring
iv. Safety Monitoring
v. Medication Monitoring
vi. Home Rehabilitation
vii. Real Time Location Tracking

1) Health Monitoring

Medical sensors and wearable devices can capture vital health sign for health monitoring and personal fitness program. sensors can capture blood pressure, blood glucose, weight, ECG, heart rate and body temperature etc to monitor pediatric and aged person [11].

2) Personal Fitness Monitoring

This class of sensor application is for those who want to stay fit and health. Sensors can track personal fitness / progress of fitness level also. individual can track and record many parameters to check his/her performance and workout routine. sensor are used here are weight measuring sensors, activity monitors sensors like walking time counter, step counter, speed counter, calorie counter and heart rate and blood pressure measuring sensors.

3) Chronic Diseas Monitoring

Millions of people are suffering from Chronic diseases like cancer ,diabetes, asthma, heart diseases, sleep disorders and arthritis. special care is need in such kind of disease. It required disease specific diet and treatment plans. By using physiological sensors like ECG(electrocardiogram), EMG(Electromyography) and EEG(electroencephalogram) with activity monitor sensors like step counter, speed counter, calorie counter etc can be used for early detection of symptoms and adverse changes in a patient's health condition that will cause to early and timely medical treatments.

4) Safety Monitoring

There are many sensors and wearable devices are available to improve healthcare system for aged and pediatric population. sensor for fall detection, epileptic seizures detection and heart attacks symptom detection can be used for safety monitoring of patient. these sensor have a push button that send alarm signals to caregivers or family members.

5) Medication Management

It is general human tendency of noncompliance of medication prescribed by physicians. this may cause threat to patient health as well financial loss. IoT based an intelligent packaging method for medicine boxes can be used for medication management. This packaging method have controlled sealing which is based on delaminating materials and that is controlled by wireless communications[12].

6) Home Rehabilitation

IoT based healthcare has the potential to improve rehabilitation. IoT based Sensing technology with Virtual Reality environments and augmented feedback systems can be used for home-based rehabilitation system for aging population. IoT based technologies can be used for remote consultation also[13].

7) Real Time Location Tracking

Through IoT Patient and equipment used for treatments tracking is possible. By using RFID tag health care providers can track real time location, assigned physician and progress of treatment etc. Medical equipment and devices like defibrillators, ECG machines, spirometry and nebulizers etc can be tagged with sensors and tracked easily with IoT [14].

V. TECHNOLOGIES BEHIND IoT BASED HEALTHCARE MONITORING

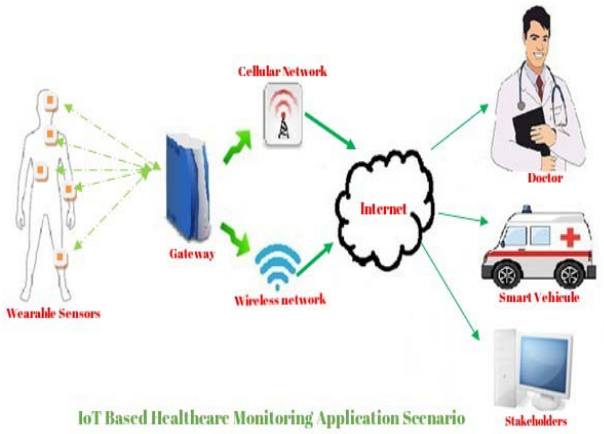

Figure 4:IoT in healthcare

IoT is an emerging technology where all (living & non living) objects are connect through Internet for data sharing and controlling remotely.

Heterogeneous technologies are combined together to enable IoT applications. IoT in healthcare uses the combination of RFID technology, Sensors Networks, wireless Communication Technology & Embedded System Technology[14]. Physical health information gathered by sensor are transmitted to middleware/ gateway. Gateway can handle multiple technologies and multiple sensors together. it analysis and aggregate this health data and send it internet where connected healthcare service provider and stockholders use this information and take actions accordingly.

VI. BENEFITS OF USING IoT IN HEALTHCARE:

A. Reduction in treatment cost:

Internet of Things based healthcare provides 24/7 and real time patient monitoring. It will definitely reduce unnecessary hospitals visits and transportation cost too. patient can have doctor advice through online video streaming at their home and only on critical situation patient may reach to hospitals only. IoT based healthcare monitoring can reduce insurance premiums as well patient working leave for health checkup.

B. Reduction in human error:

In IoT based healthcare monitoring Physical health information like blood pressure, sugar level etc is collected vary accurately by sensors and corresponding decisions is taken by big data analytics technique. it helps in minimizing human errors.

C. Remove geographical barriers:

Any patient can take medical advice from any corner of the world because Physicians and patient are connected globally via internet.

D. Minimum paperwork and documentation:

Internet of Things based Internet healthcare monitoring support green technology and minimize paperwork and documentation.

E. Early detection of chronic disorders:

Using Big data analytics and data mining techniques on Physical health information that is generated by medical sensor, it is possible to predict chronic disorders in early stage and treatment can be done before it become incurable[16].

F. Enhanced Drug Management:

It is vast challenge to make and manage drugs for health industry. By using RFID (Radio-frequency Identification) technology in drug supply chain management this industry can have better drug management for producers, supplier and consumers also. It will reduce loss because of thief, lost and miss management of drugs.

G. Immediate medical attention:

IoT based medical devices can alarm healthcare provider or family members in case of medical emergency like rise in blood pressure or fall of a senior family member.

H. Better outcomes of treatment:

24/7 health monitoring and evidence based treatment decisions will help to cure diseases on timely basis. It will increase treatment outcomes in result.

VII. CHALLENGES AND ISSUES

Every emerging technology have some challenges. IoT based Healthcare Monitoring also have some bottlenecks and challenges too. Some of them are as follows:.

A. Security & Privacy Issues

Healthcare devices and applications captures private healthcare information and these devices are connected to internet for anytime, anywhere access. So it may attract hacker to steal private information. Private health information must be used after patient authorization. According to the official breach reports from 2009 to mid-April 2013 presents 51% of total the security risks is theft of laptop or medical device for healthcare[15].

Data security in healthcare should address the following challenges[13]:

- Physical security of health devices
- Providing secure routing for data communication
- Providing data transparency in cloud computing environment.
- Maximum security with minimum resource consumption

In IoT Based healthcare patient health information is collected from various medical sensors and wearable devices. medical devices have to connect to other devices and multiple users for data gathering. There are thousands of vendors who manufacture devices without following any standard rules and regulations for compatible interfaces and protocols for inter device communication. So data captured by these device are not visible to other devices. This cause interoperability issues. Because of lack of interoperability, data from different IoT devices may remain locked in each individual system and lose its potential value and increase system integration cost.

B. Device Designing issue

IoT devices used in healthcare are tiny sensors those have low computing power processors, low storage capacity and limited battery power. IoT devices are mobile in nature too and internet connected. Wearable devices have to connect different networks to provide health information to caregivers. Developing a IoT devices that have higher computing power, more storage capacity, high battery power and mobility complaint security is still a research challenge.

C. Scalability

In coming days improved medical device will came into market. Billions of IoT devices will connected to the network that will produce large amount of health data. The amount of data that have to be store and processed will also increase exponentially. This will cause a big data problem for healthcare. The system which stores and analyses these information from the IoT devices needs to be scalable. Data collected from connected IoT devices needs big data analytics to making better treatment plan and cloud storage for storing for future. As number of IoT devices is increasing, it is becoming difficult to generate knowledge and insights from this data.

D. Trust

Information generated and delivered by medical devices are prone to security attacks. information might appear to be correct but it could be infected or corrupted by virus malware during data transmission. hackers may use this information to harm individual because on the basis of information generated by these sensor, caregiver take decision and makes treatment plan. So this corrupted information can cause life and death decisions. How then we can trust the treatment based on medical sensors data? This is a big challenge in IoT based health monitoring.

VIII. CONCLUSION

Internet of things technology is in its starting face but it have potential to impact human healthcare and associated market at a massive scale. Due to high speed internet access and advanced sensor technology it is possible to track human and other objects. Researcher have start to discover many technological solutions to improve healthcare system. This paper offers deeper insights of Internet of things based healthcare applications ,enabling technologies , current challenges and issues of healthcare.

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