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A Review on Internet of Things for Health Care

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Abstract
The Internet of Things (IoT) is a new conventional technology reforming the regular way of existing into smart living. Smart industries, energy saving, smart transportation, smart cities and smart homes are few applications of IoT. The Internet of Things is one such transformation with a huge variety of smart systems, intelligent devices and sensors. One of the most efficient applications of IoT is advancement of healthcare systems. The goal of a proficient IoT healthcare system is to make available a real-time remote monitoring system of patient health conditions and to enhance the quality of life. The core attention of IoT enabled healthcare services is to offer a better user experience at minimal cost and enhance the quality of life and build devices smarter. The Internet of things in healthcare provides connectivity to the medical systems available that are connected to the network remotely to treat the diseases. IoT enables smart healthcare systems in the medical field, generally with smart functionality of sensors, network and a server. This paper investigates how IoT can be efficiently used in healthcare, few healthcare applications which are revolutionizing in space and challenges faced while using IoT in the healthcare system.

Keywords: Internet of things, Healthcare, Sensors, Remote monitoring.

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I. INTRODUCTION

Health is one of the important concepts in the growth and well-being of humans, also in the terms of technology. Monitoring patients' health is one of the major concerns. To provide a smarter way of monitoring health, the Internet of things (IoT) enabled health monitoring system is one solution for it.

Internet of Things (IoT) has been extensively recognized as a solution to relieve the pressure in the healthcare domain. A significant amount of such study looks at observing patients remotely. Few applications to talk about- Healthcare monitoring system which is used to take a constant care of the heartbeat of the patient. Treating patients remotely helps to monitor and observe patients all time which benefits in providing a better treatment. Similarly many other IoT systems are implemented for healthcare. Applications like smart health-care systems can be designed to create an IoT environment to monitor a patient's basic health along with room condition. This system uses sensors to record the data from the hospital environment through room temperature sensor, CO sensor, and CO2 sensor, thereby helping health-care.

IoT is assisting people in rural areas who normally neglect any kind of health issues like body temperature, heartbeat etc. To avoid this, patients are provided with smart sensors to monitor them from their place of stay usually located remotely would be a practical solution to save money. The other way is medication tracking systems which track the medicine taken by the patients remotely and help them to take those medications on time by alerting patients. Chronic disease management is one of the major applications used in healthcare. People with chronic disease can monitor their health distantly and more efficiently. In general the role of IoT in healthcare can easily automate the workflow of patient care and improve the health of patients. All these IoT systems help to gather information from patients and send it to health professionals via application and alert the patient through SMS. This paper discusses the various research, Architecture to show how the internet of things in healthcare functions and also revolutionizing applications of healthcare domain with respect to IoT.

II. LITERATURE SURVEY

Various IoT solutions for health monitoring systems have recently been modeled. Nazir et al. has proposed a protocol on how healthcare systems in IoT can be monitored using mobile applications [1, 11]. Compactness, IP connection, low-power consumption, and security are all features that m-health brings to the IoT.

Islam et al. presents the state-of-the-art network architectures, applications, and industry trends in IoT-enabled health care solutions, as well as improvements in IoT-based health care technology [2, 12-14]. In

addition, considering health-care the study examined several IoT security and privacy characteristics such as security criteria, attack taxonomies and threat models.

Sathya et al. proposed a health monitoring system where patients were given wearable sensors that can measure ECG, electromyography (EMG) muscle activity, temperature, sweating, respiration rate, and blood glucose levels [3, 10,11].The system is accountable for data transfer and conversion of patient records from any place to the health center with precision and security. The concentrator, may be a smart phone used to control the sensors in the IoT system over the Internet.

Rashmika explained that The Internet of Things (IoT) has a significant influence on the field of health care [4]. IoT aids healthcare in improving current features by enabling patient administration, medical records management, medical emergency management, treatment management, and other services, all of which contribute to the overall quality of healthcare applications.

Shubham et al. proposed a system comprising a variety of medical equipment, such as sensors and web-based or mobile-based applications that interact via network-connected devices and assist in the monitoring and recording of patients' health data and medical information [5, 8, 9, and 15]. The former is performed by connecting the Raspberry Pi to the database using the MySQL db module, whilst the latter is performed by combining the Raspberry Pi with the GSM module and the web interface.

Damain et al. presented indoor and outdoor information systems based on the Internet of Things (IoT) [6]. The developed approach used three-axis accelerometer and magnetometer, thresholding, PDR and decision trees method. As a result, a Design Methodology (DM) is needed, which looks at the design goal from the standpoint of contracting authorities, stakeholders and possible users.

Ashlesha et al. proposed an IoT based health care monitoring system composed of a body sensor network [7]. Patients may be monitored utilizing a collection of tiny powered and lightweight wireless sensor nodes utilizing the body sensor network (BSN) technology, which is one of the key technologies of IoT advancements in healthcare. The Raspberry Pi microprocessor is combined with a Wireless Body Area Sensor Network in the suggested system. Temperature sensor, blood pressure sensor, and heart beat sensor are the sensors employed here. Sensors are put on the human body to assist monitor health conditions without interfering with the patients' regular routines, and these health-related metrics are subsequently transferred to a physician's server using long-range wireless technology. Table 1 represents summary of IoT enabled applications and findings in Medical field. Studies

Table 1: Summary of Applications and Findings

AUTHOR / YEAR OF PUBLICATION	METHODOLOGY/ TECHNOLOGY	APPLICATIONS	FINDINGS
Shah Nazir, Yasir Ali 2019	SLR Protocol methodology, GSM.	Smart hospital	Result analysis of m-health using mobile computing provides various applications for management of health.
S.M.Riazul Islam 2015	Wireless Sensor Network (6LoWPAN), IoTnet, GSM.	Smart hospital	Technological solutions have been provided to enhance healthcare and make the system more efficient.
M.Sathya, S.Madhan, K.Jayanthi 2018	Wireless Sensor Network, Cloudlet Processing.	Remote Monitoring System	Usage of compact sensors with IoT in remote health monitoring made huge impact on patients making their life easier.
Rashmika Madushan 2020	RFID, Wireless Sensor Network.	Remote Monitoring System, Medication Management	Current technology helps in resolving the challenges in healthcare and provides better solutions for development of healthcare.
Shubham Banka 2018	Raspberry Pi, data mining techniques.	Remote Monitoring System	System monitors the health condition using sensors and Raspberry Pi uses a data aggregator to collect data from patients.
Damian Dziak, Bartosz Jachimczyk 2017	Pedestrian dead reckoning and decision tree algorithm.	Remote health monitoring system	End result of the developed design is built on IMU, with an integral accelerometer to propose a home care monitoring system.
Ashlesha.Patil, Dr.S.R.Suralkar 2017	BSN based Using Raspberry Pi.	Remote Monitoring System	Using web based concepts in healthcare resolves issues and improves security in systems.
Sudha.V, Shaziya Banu A 2018	Arduino, Body sensors.	Remote health monitoring system	A well-equipped model with features is developed where doctors can examine patients remotely.

Prajoona Valsalan 2020	Arduino, WI-FI module, Room humidity Sensor.	Room and patient monitoring system	Information collected from patients is stored and processed in the cloud this reduces hospital visits for the documents and patients can be monitored by a doctor being stayed remotely.
Md. Milon Islam, Ashikur Rahman 2020	ESP32, Sensors, Web Server	Hospital Management	Smart health care system monitors the basic essential parameters of patients like body temperature, heart rate, and calculates the hospital room condition like the level of CO2, CO gases and room humidity.
Jie Wang, Ning Cao 2018	WISE Cloud, BASN technology	Wearables	A wearable helps the patient to monitor their health condition and also WISE cloud helps to store and access the information from the cloud.
K.Hari Kishore, D.Pavan Kumar 2019	Ardunio, Smart cloud, GSM.	Remote health monitoring system	System can be implemented in general wards of hospitals to assist patients, understand its utilization and performance. The system can minimize the adverse emergency of a patient with heart disease.
R. Alekya, Neelima Devi Boddeti 2020	Wireless sensor network, Coap, 6LoWPAN, REST	Cluster Condition health application	Helps better to provide people with healthcare at any time in any region by eliminating geography, time and other barriers while increasing their coverage and efficiency at the same time. IoT health revolution is a reality and thus fair, affordable care provides high-quality care to people.
Stephanie B Baker, Wei Xiang 2017	Secure cloud, WBAN, Photoplethysmographic pulse sensor, RF array module.	Review on all applications	Various healthcare systems are proposed using IoT which can be applied in general conditions. Wearables are one of the most significant technologies. Technology like data storage, cloud are the best means of storing the information in healthcare.
J.V.Alamelu, A.Mythili 2017	Wireless sensor network, cloud with sensor network.	Remote Monitoring System	System acquires pulse rate signals using a cloud platform. Results demonstrated the evaluation for its performance in the context of energy.

III. DISCUSSION

A. IOT-Internet of Things Architecture

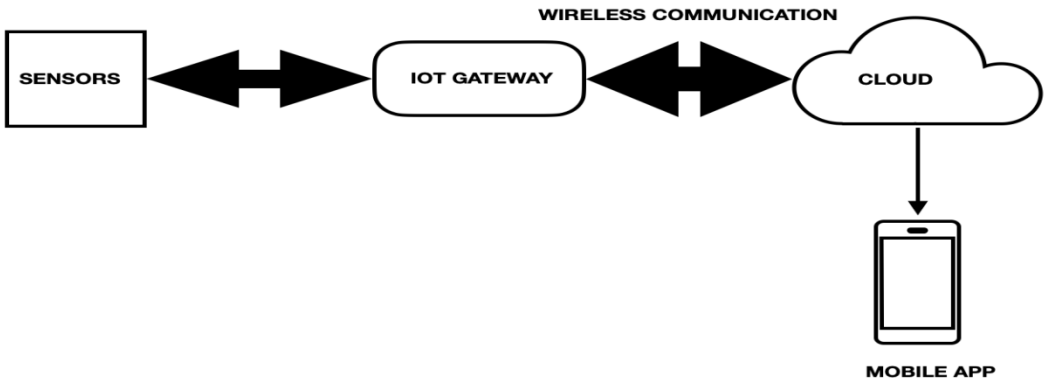

Fig 1: IoT Architecture

Figure 1 illustrates architecture of IoT and its working components.

1. Sensors:

IoT is a collection of one or more sensors. Sensors recognize data from the atmosphere. Sensors will detect a comprehensive variety of information like running machine, Environment/Weather conditions, Location and

human body. For example, temperature sensors sense temperature from the room. The data detected by the sensor is sent to the connectivity device, namely the gateway.

2. IoT Gateway:

IoT gateway provides a way to access the internet with things/devices which we need to interact with. Server and the devices interact with each other through gateways. Data is collected from the sensors by gateway and then transmitted to the infrastructure usually a cloud server.

3. Cloud server:

Data is stored & processed within the cloud server i.e. in data centers. Processed data is used to perform acute operations that enable all our devices to be Smart. All diagnosis and decision making happens in the cloud server and then transmitted to the user mobile.

4. Mobile applications:

Mobile applications are used to monitor and control the medical devices by end users. These applications collect the processed information from the cloud server and display it on smartphones, tablets etc.

Information sent to the user mobiles through these apps will be in the form of bars, graphs, and in a pi-diagram displayed to the user in a user- friendly way.

Using mobile applications, commands can be sent to sensors to modify the values, like change the temperature of air conditioner and many more.

B. IoT in Health Care Architecture

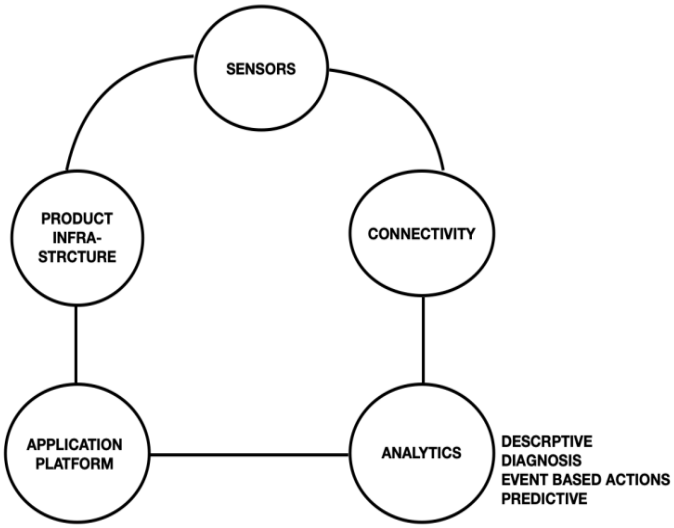

Fig 2: System Architecture of Heath Care

Figure 2 illustrates the architecture of Heath Care systems

IoT Architecture with respect to healthcare changes according to the design, Figure 2 demonstrates a usual working of IoT in the healthcare domain.

Product Infrastructure: IoT product infrastructure refers to software or hardware component that read the sensors signals and display them to a particular device. For example, pulse rate monitoring devices or an IoT software.

Sensors: IoT in healthcare has diverse sensors devices such as fluid level sensor, electrocardiogram, thermometer, pulse-oximeter, sphygmomanometer (blood pressure) that read the current patient situation (data).

Connectivity: IoT system delivers better connectivity (using Bluetooth, WiFi, etc.) of devices or sensors to read the data.

Analytics: Healthcare system investigates the data from sensors and associates to get healthy parameters of the patient and on the basis of their analyzed data the patient health is upgraded. Analytics has four stages namely, descriptive, diagnosis, event-based action and prediction.

Application Platform: Mobile applications help in transferring the health information with details to the health professionals from patient devices and vice versa.

IV. APPLICATIONS OF HEALTH CARE

A. Remote Monitoring System

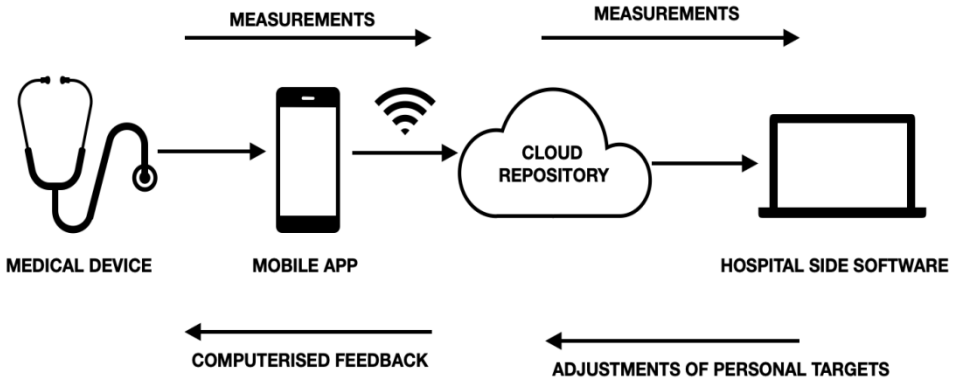

Fig 3: Remote Monitoring System

Remote Monitoring system is depicted in figure 3. Remote monitoring is one such application of healthcare which helps to treat the patient from the remote environment, where there's no need for the patient to run for the hospital or any emergency care.

Patients just have to make use of IoT devices to get access. IoT devices like oximeters, blood pressure monitors etc. are a few devices of remote monitoring systems.

The end user makes use of these devices to check their health condition, the measured values of the patient is sent to the cloud server through the mobile application. In turn the data stored in the cloud is processed and sent to the hospital professionals. The communication is done through personal or telephone talks.

B. Devices of Remote Monitoring System

CGM: Continuous Glucose Monitor or CGM device is implanted in diabetic patient arms which help them to monitor their glucose level.

Smart Insulin Pens: IoT enabled device keeps a track of time, amount and type of insulin injected. Diabetic patients can also keep a track of dosage of insulin and analyze how much dose of insulin may affect their sugar level.

Ingestible Sensors: These are sensors that are used for treating mental disorders. These sensors get activated through the wearable patch. Patch transfers the data to the application where the users can monitor activity level, ingestion data, and mood of the patient.

C. Medical Management

Few patients who are not directly observed by their doctors or are being monitored in a remote environment fail to take medication prescribed by their doctor, as a result of which their treatment does not yield the anticipated results. IoT-enabled solutions agree monitoring of such patients from distant locations and send them reminders to make sure they follow medical advice of dosage and frequent intake of medication.

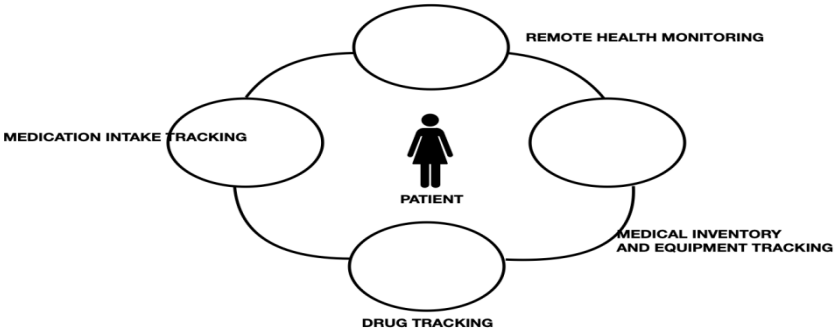

Fig 4: Medical Management System

People can remotely take their medications. Medical management systems in figure 4 provides various ways of tracking such as medical inventory and equipment tracking which helps patients to use their equipment remotely and that will be monitored by health professionals. Drug tracking is one system where patients can track the type of medicine and their dosages. Medication tracking helps patients to know their dosages and also the system alerts the user to take medication on time if they have missed one.

IoT Devices for Medical Management

- **Smart Bottles:** A Smart Pill bottle is given to patients along with their medication. The bottle reminds the patient on missed doses through a message to the cell phone and tracks medication constancy of the patient.
- **Plug-and-Play Platform:** An IoT enabled plug-and-play platform for doctors allows them to contact patients and confirm those patients follow to their advice on medication dosage. Sensor-embedded platform allows patients to be monitored from a remote location and, in several cases, minimizes the cost of treatment. This enables for a better assessment of the patient.

D. Chronic Disease Management

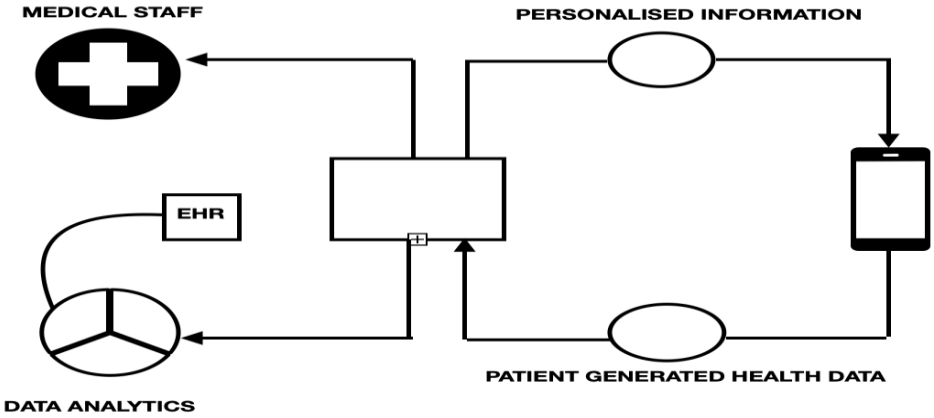

Fig 5: Chronic Disease Management System

Wearables and network-enabled medical devices transfer user data directly to the patient health repository. It is more convenient-to-use and affordable. IoT devices are being used to continuously monitor the blood pressure, heartbeat, sugar levels and other vital stats in chronically-ill patients. Chronic disease management system in figure 5 helps a chronically-ill patients to monitor their health using the system. The patient is given an IoT-based device which helps them to measure their health. The analyzed data is sent to the health professional device via the system.

IoT Devices Used To Manage Chronic Diseases

- **Connected Inhalers:** Using this device some of the Respiratory disorders will be treated. Disorders such as chronic bronchitis which affect people. This sensor will be attached to an inhaler which tracks the rate of rescue medication of patients. This sensor will send the data to mobile data and this data is being analyzed and then the doctor or the user receive notification about what might be the reason for their symptoms.
- **Automated Device for Asthma Monitoring and Management:** ADAMM is an IoT-enabled wearable that identifies the symptoms of an asthma attack in advance and informs the wearer and his designated caretaker of the attack. This allows the patient to handle the situation before it gets worse.

The device also detects and tracks the use of an inhaler; it allows patients to record their voice and track their behaviors and feelings through an IoT application. This device also helps the patient to set reminders and track their medication schedule.

V. CHALLENGES IN IOT FOR HEALTHCARE

- **Data Security and Privacy**: Some of the most significant challenges that are faced by IoT in healthcare are privacy and security. IoT permitted devices hold real time data, but lack in data protocols. Hence data will be stored in IoT permitted devices inclined to data theft and are vulnerable to hackers to fetch the

health information. This results in misuse of devices and allows criminals to create fake ID's for selling and buying drugs fraudulently.

- **Data Overload and Accuracy**: Due to the un-similarity of data and communication protocols, it quite difficult to collect data. As IoT devices collect the data in bulk for analysis, data has to be divided in chunks without overloading the data to get a better accuracy.
- **Cost**: One of the major challenges is cost, while planning to develop an IoT system in health management. Prices are fully worth it if it works efficiently to save one life. Hence one has to pay out a notable amount of money in resources for building an IoT application.

VI. CONCLUSION

IoT has several applications in diverse areas. IoT usage has the potential to provide possible solutions for any remote tracking system especially in the field of health monitoring systems. IoT enabled devices are emerging to make the life of the people smarter and easier. Our study discusses applications of IoT in the healthcare domain. IoT has the potential to improve the healthcare system. Several systems are being modeled and researchers are finding new technologies for development of healthcare. Further study and development can be focused aiming at the benefits of IoT to make healthcare efficient and successful. Though IoT in healthcare has many challenges, there is always a way out to overcome those drawbacks.

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