



## An IoT Equipped Hospital Model: A New Approach for E-governance Healthcare Framework

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### ABSTRACT

Internet of things (IoT) is an emerging technology that helps in reducing the human efforts. IoT refers to the physical objects connected to each other over the internet. In reference to the healthcare sector various equipment and gadgets like a thermometer, ECG, blood pressure measuring machine, heart rate monitor etc. are interconnected via various sensors. People are becoming more inclined towards the use of the Internet of things. The growing elderly population and the increase in chronic diseases generate a need for the healthcare sector to find ways to provide services at the convenience of the patient. Many people in India do not have access to proper medical services due to which the health of these people suffers. Nowadays the government is taking so many initiatives to support and provide help to the people living in the rural area. This paper proposes a model e-governance healthcare framework of IoT equipped hospital that helps in treating critical healthcare requirements.

**Keywords:** Internet of things, Healthcare framework, Sensors, Cloud storage, E-governance, Gramin chikitsa seva kendras (GCSK,) Wireless building lighting control (WBLC)

### INTRODUCTION

Health is what makes or breaks an economy which is why good healthcare is equal to a good economy. An efficient and reliable healthcare system is an important factor in establishing a good economy. Bad or poor health leads to inefficiency in work which results in various problems in economic balance. Health is the right of every individual. Provision of effective healthcare facilities to each citizen of the country is the responsibility of government and is an important process in e-governance framework.

In a country like India where there is social and economic inequality, health is a major concern. People living in rural areas are not even aware of the basic and primary healthcare services. Villages constitute a huge part of Indian economy and they are not provided with the primary medical facilities. According to the 2011 census, 68.84% of the total population of India is living in villages but the condition of healthcare and medical services has not met the expectations and requirements [1]. Rural areas face the problem of primary healthcare services shortage. Out of the primary healthcare sectors available 8% do not have doctors or any medical staff, 39% do not have lab technicians and 18% do not even have a pharmacist [1]. This makes the need for new and innovative technology an urgent and dire need to provide better healthcare services to rural India.

Internet of things (IoT) is an ever-growing technology that helps in connecting anything and everything over the internet. It aims at collecting data from various sources with high accuracy and less time. IoT enables collection and exchange of data which can be stored and later be used for analysis, measurement, and reference by experts. It helps in making the world a better place and improves the quality of life. Information and communication technology can be effectively used to improve the healthcare system in rural areas.

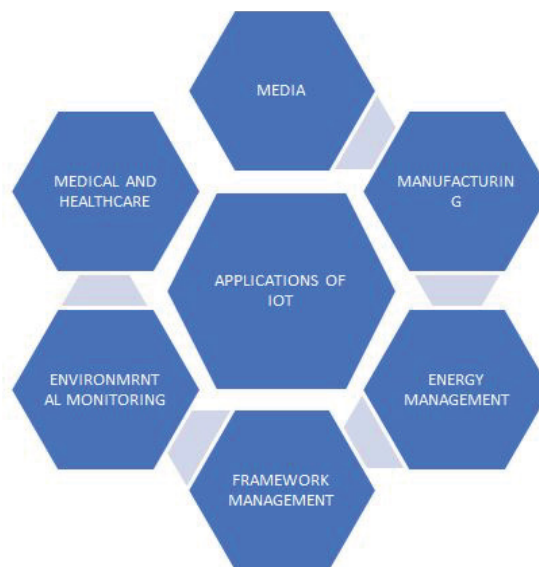
In India where it is geographical and population inequality, it is difficult to provide the medical services to everyone everywhere, but the use of IoT has made it possible. IoT can be implemented in any industry, may it be environment, manufacturing or framework. IoT has helped in reducing human efforts in providing various services to people. With more and more advancement in the technologies, there has been a decline in the health of the people due to a busy lifestyle and stressful environment. As we know that a healthy population is the back bone of any developing nation

and the majority of the population in India lives in rural areas, it is necessary to improve the healthcare conditions in these areas. Nowadays the healthcare sector is using IoT to provide better and more accurate medical help. IoT makes it possible to provide the medical facilities and services at the patient's convenience, without being wired to heavy and big machines.

The paper is organized as follows: Section II covers a literature review of research done in telemedicine, RFID, wearables, Swasthya slate, IoT etc. In Section III a model framework of IoT equipped hospital is proposed. Finally, in Section IV we have discussed the outcomes of the paper and how it would affect the healthcare system.

### Literature Review

IoT has a number of applications in various domains such as energy management, framework management, environmental monitoring and healthcare [2] (Figure 1).



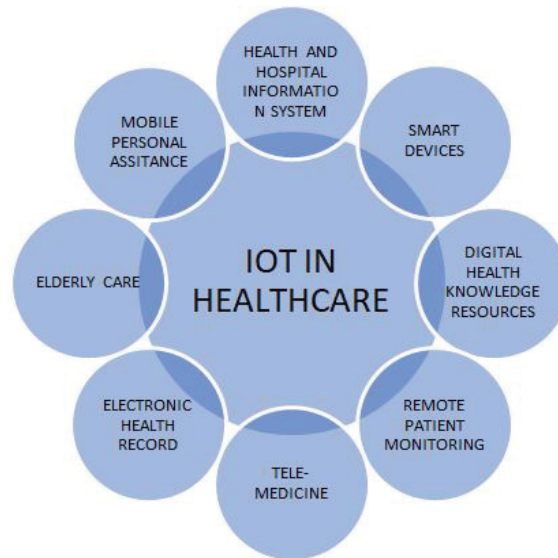
**Figure 1 Various applications of IOT**

An environment monitoring system uses various sensors to collect data about the air quality, temperature, humidity, and earthquake detection, processes it through raspberry pi, uploads the data to the server and the data is then converted into meaningful information [3]. The earthquake detection function helps in saving many lives. This system can help in alerting the user according to the change in temperature and air quality for early precaution.

A Wireless building lighting control is used for controlling lighting in a building [4]. The lighting system is connected to an automation system and controls the intensity and usage of the lights. A smart garbage monitoring system uses sensors to detect the amount of garbage collected [5]. A sensor is attached to the head of the garbage can. When the garbage fills up to a particular level, the sensors generate an alert and the garbage collecting assistant collects the garbage. A smart wheelchair equipped with body sensors helps to know about the person's body temperature and heart rate condition and his movements within the premises [6]. It also consists of a panic button, which can be used during any problem. It can be controlled through eyeball movement, joystick control, gesture control, and audio control. Telemedicine is an application of information and communication technology that uses a combination of hardware and software for the exchange of information [7]. It is also useful in training people in the medical field in a remote location over the internet.

Telemedicine plays an important role in our daily life. Combining the IOT technology and the telemedicine helps to bring health quality under control [8]. RFID (radio frequency identification) technology is used to store and transfer data, stored in a tag attached to an object, using radio frequency wave. Equipping various devices with RFID technology helps in uniquely identifying them and this can act as an information retriever [9,10]. Electronic Medical Record (EMR) is a digital version of medical records on paper, which provides quick and easy access to health care information remotely, at anytime and anyplace [11]. Integration of RFID technology and EMR enables more secure

and accurate measure and analysis of data collected by the sensors [11]. Cloud computing, wearables, and sensors have proved to be of great help in providing better medical services (Figure 2).



**Figure 2 IoT in healthcare**

The data collected by the wearable sensors such as the temperature, heartbeat, etc. is stored on the cloud and can be viewed by both doctor and patient anytime. An IoT health monitoring system helps to alert the patient whenever needed based on the data collected by the sensor [9,12]. Use of smart sensors in a robust healthcare monitoring system helps to generate raw data and send it to the database server for the data to be further analysed and maintained for medical experts [2,13]. A doctor can use sensors to diagnose patients at remote locations, such as in the ambulance on the way to the hospital or anyplace else, and access their medical record using cloud service [14]. With the use of multiple body area sensors, data can be collected from multiple body parts and stored on the cloud for further analysis and can be viewed on a smartphone by both, the doctor and the patient [15]. Swasthya slate is an example of portable technology that has helped in providing medical assistance in various areas where it was not available [16,17]. The tests performed through Swasthya slate give instant results. The patient does not need to visit different places to get a test done. Tele-monitoring information system refers to an information system that can remotely monitor the user's physical condition and physiological parameters. Smartphones give an advantage over other technologies, such as portability, continuous internet connectivity, running complex applications and almost every doctor carries one in his pocket [18]. Smartphones help in monitoring body vitals through the data collected via sensors being displayed on an android application [19].

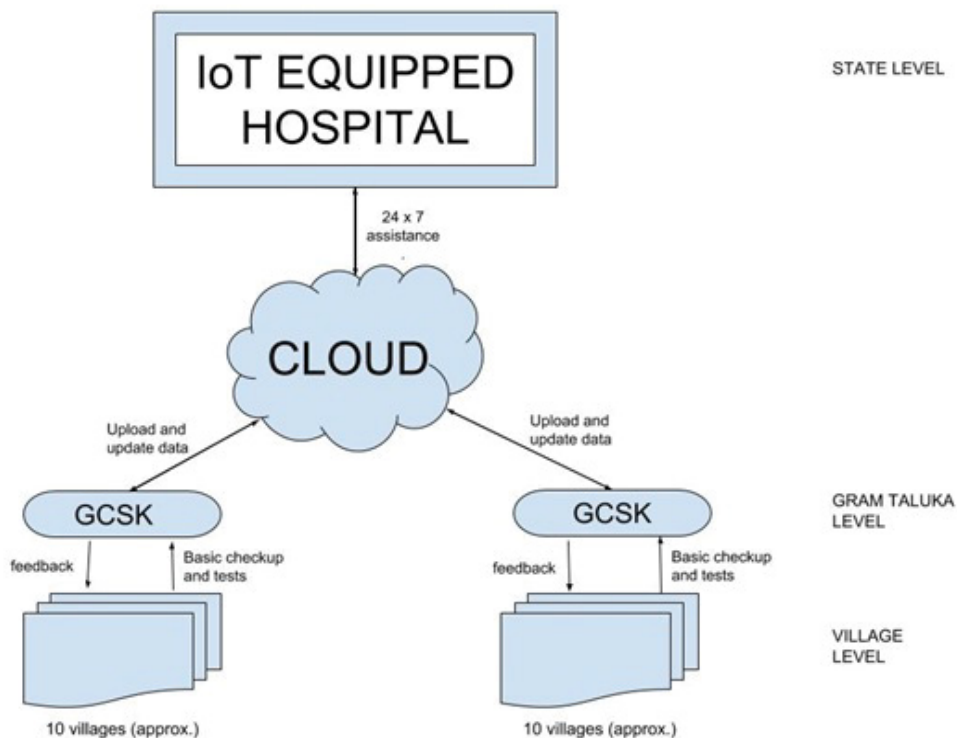
iMed box is used to provide the patients with medicine at the prescribed time [20,21]. It can be used when the patient is not feeling well and needs some medicine. The patient needs to plug the sensors on the iMed patch attached on his fingertip. This sensor would send the data to the doctor who will then prescribe some medicine based on the data received from the sensor. The prescribed medicine would dispense out of the iMed box and the patient would consume that. Smart beds help in monitoring a patient while sleeping [22]. It helps in collecting the data of a human body during sleep and detects a problem, if any. Washable smart clothing consists of various body area sensors that incorporate various connected devices and cloud service [23].

### **Proposed Model**

While reading the researches done by various researchers in IoT in health care and various other sectors, an idea got stuck in the head which is presented in the form of a model. This paper proposes a model framework of IoT equipped hospital that projects the most advanced healthcare centre at the state level which supports all GCSK.

Figure 3 illustrates a bottom-up approach, where there were 3 levels-village levels, gram taluka level, and state level. Village level refers to the rural area where proper medical facilities and services are not available. Garam taluka level consists of GCSK that aid minimum 10 villages. Any person who has a problem contacts the doctor present at

GCSK. The doctor collects all the data related to the patient and his problem and stores it in a smartcard and a database is maintained. Here, the patient is provided the basic primary healthcare services and treatment with the help of Swasthya slate. If the doctor present at GCSK cannot treat the disease, then he takes assistance from the senior doctor at the state level via video conference. If the disease is critical and cannot be treated at gram taluka level, the patient is sent to the IoT equipped hospital where he is provided proper medical assistance. The telemedicine ambulance present at the regional hospital is called for transporting the patient from the village level to IoT equipped hospital. When the patient reaches the regional hospital, the doctors are already prepared for the treatment and all the arrangements are taken care of. The doctors at the hospital already have the patient's medical history and the recent medical report of the disease as it shares a common database with GCSK via the cloud. The doctors at the IoT equipped hospital can also access the patient's information from the smartcard issued to the patient at GCSK.



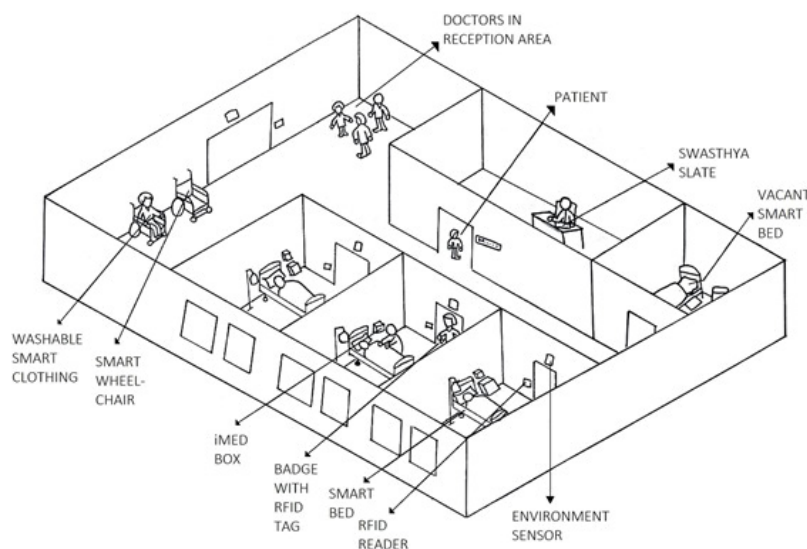
**Figure 3 A bottom-up approach**

The first sub-point of this section discusses the infrastructure and the benefits of the IoT equipped a hospital for the environment and the second sub-point covers patient care management and benefits to the patient.

**Infrastructure:** While constructing the IoT equipped hospital, sensors are placed in various places for management. Each sensor has a battery and a wireless transmitting device to alert the maintenance engineer. A model framework of IoT equipped hospital is illustrated in Figure 4.

- Environment management: Sensors fixed in the building during construction, provide data related to the air quality, temperature, humidity, light level, earthquake detection, etc., that are further processed to convert the data into meaningful information
- Water management: The sensors help in improving the efficiency of the water distribution network of the hospital. They help in reducing the wastage of water due to leakage through early prediction
- Garbage management: Smart garbage monitoring system is used in each room. The sensor on the head of the dustbin alerts the garbage collecting assistant or the nursing station helper when it becomes full and the assistant collects the garbage. This reduces the human efforts of checking the dustbin again and again. The cleanliness and hygiene are maintained using this smart garbage monitoring system

- Smart wheelchairs and stretchers: When an injured person arrives at the hospital, a stretcher equipped with body sensors are used to know about the person's condition on the way to his treatment. This saves the time of the doctor from testing his condition first and then doing the treatment. Smart wheelchairs are also used to monitor the patient's movement within the premises
- Telemedicine ambulance: If the condition of the person is too bad to be treated in this hospital, he is then sent to a hospital equipped with advanced medical facilities through telemedicine ambulance. This ambulance is equipped with medical equipment that helps in the basic treatment of the patient on the way to the hospital. The person providing service inside the ambulance is continuously connected to the officials in the hospital
- RFID technology: RFID readers are installed at various places such as the entrance of the patient room, the room where medicines are kept, etc. for safety purposes. Doctors, nurses and other staff members are provided with RFID tags that are read while entering a room and the data is sent to the respective database. This helps in maintaining a safe and secure place for the patient
- WBLC: Wireless building lighting control is used to control the light intensive in the room for the patient's convenience and power saving. After a fixed time, the lights go dim and after some time they are switched off in the hospital so that patient can sleep peacefully



**Figure 4 A model framework of IoT equipped the hospital**

**Patient care management:** Architecture of the model framework of IoT equipped hospital is shown in Figure 5. All the technologies used are connected over the internet. The data collected through the sensors and other technologies are sent to the physicians as well as the medical assistants, who monitor the patient and the environment.

The physician, after analyzing the information received, sends feedback. Physicians use the android app on their smartphone to monitor the patient. If any unusual change in the health of the patient is seen, the physician is alerted and he visits the patient for a check-up. All the data is uploaded and stored on the cloud storage from where the senior doctors can monitor the patients (Figure 5).

- Swasthya slate: Swasthya means health, soundness, and wellbeing. The basic tests are done through Swasthya slate. It provides instant results and advice, which helps in better and fast treatment
- RFID technology and EMR: Integration of RFID technology and EMR is used to keep the data of a patient at one place. The timely availability of the patient's record helps in improving the quality of health delivery
- Information system: Information system is used to record data related to the patient's admission, registration, payments, patient care management and managing the reports

- Smart beds and washable clothing: For the patients admitted in the hospital, smart beds and washable smart clothing are used to monitor the patient. If the patient's health needs attention, an alert is generated and the doctors arrive to examine them
- Smart-med box: The patients need to take the prescribed medicine at the prescribed time. To provide the patients with medicine at the prescribed time, Smart-Med box is used. It can also be used when the patient is not feeling good and needs some medicine. The patient needs to plug the sensors on the Smart-Med patch attached on his fingertip. This sensor sends the data to the doctor and the doctor prescribes some medicine on the basis of the data sent by the sensor. The prescribed medicine dispenses out of the Smart-Med box and the patient consumes it

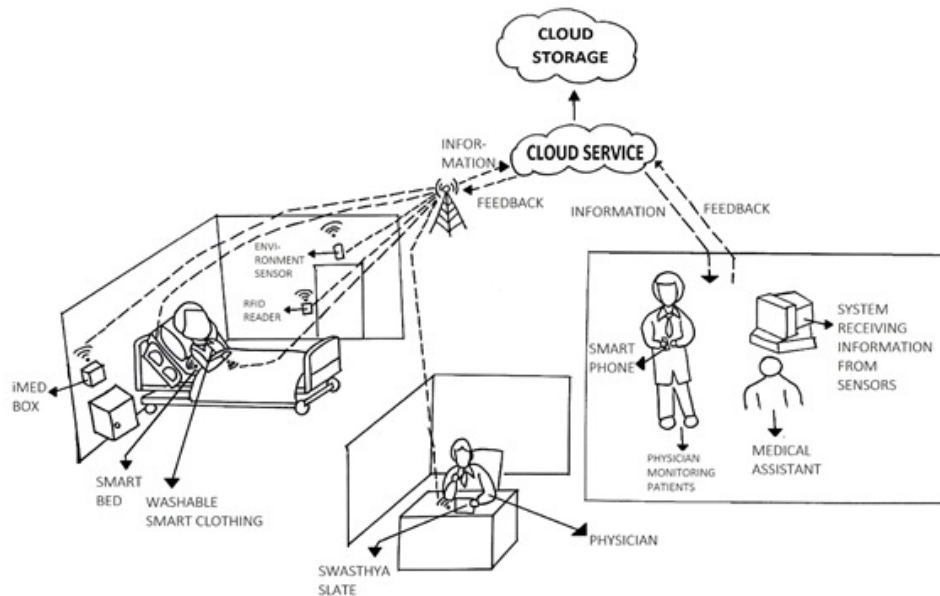


Figure 5 An architecture of the model framework of IoT equipped hospital

## CONCLUSION

Healthcare sector has become more inclined towards the use of IoT. There are several regions in India that face problems like road blockage for a particular period of time every day, transportation problem etc. The proposed model framework of IoT equipped hospital will be of great help during such time as it can provide immediate help and has 24 × 7 connectivity with the state region hospital over the internet.

Since independence, the well-being of the farmers has been the focus of India. The government has taken so many steps for the betterment of the villagers through various programs like PMGDisha and digital India. About 68.84% of the total population in India lives in villages that are the back bone of the economy and the nation. The Indian economy is based on the villages, but the villagers have mere availability of and knowledge about the medical facilities and services. The government should take initiative to provide medical facilities and services to villagers in the best way possible.

## DECLARATIONS

### Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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