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Internet of medical things: Architecture, applications, benefits and challenges

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Abstract---Internet of Medical Things (IOMT) is playing critical role in healthcare business to boost the accuracy, reliability and efficiency of electronic equipment. Researchers are working towards a computerized healthcare system by integrating the existing medical resources and healthcare services. As IOT converging different sectors but our emphasis is connected to research contribution of IOT in healthcare domain. This study covers the peoples contribution of IOT in healthcare sector, application and future problems of IOT in term of medical services in healthcare. We do expect that our study will be valuable for academics and practitioners in the area, allowing them to comprehend the tremendous potential of IoT in medical domain and identification of important problems in IOMT. This investigation would also allow the academics to comprehend applications of IOT in

healthcare area. This input would allow the academics to comprehend the prior contribution of IOT in healthcare business.

Keywords---IoMT, architecture, sensor, actuator, patients, hospital, communication.

Introduction

The Internet of Medical Things (IoMT) is the collection of medical equipment and applications that link to healthcare IT systems over online computer networks. Medical equipment connected with Wi-Fi provide the machine-to-machine communication that is the cornerstone of IoMT. IoMT devices connect to cloud platforms like as Amazon Web Services, on which recorded data may be stored and analyzed. IoMT is also known as healthcare IoT. Examples of IoMT include remote patient monitoring of persons with chronic or long-term diseases; tracking patient prescription orders and the whereabouts of patients admitted to hospitals; and patients' wearable mHealth devices, which may provide information to carers. Infusion pumps that link to analytics dashboards and hospital beds outfitted with sensors that assess patients' vital signs are medical equipment that can be converted to or implemented as IoMT technology. As is the case with the larger Internet of Things (IoT), there are now more possible applications of IoMT than before because many consumer mobile devices are built with Near Field Communication (NFC) radio frequency identification (RFID) tags that allow the devices to share information with IT systems. RFID tags may also be put on medical equipment and supplies so that hospital workers can keep informed of the quantity they have in store. The technique of employing IoMT devices to remotely monitor patients in their homes is also known as telemedicine.

This form of care saves individuals from going to a hospital or physician's office everytime they have a medical query or change in their health. The security of sensitive data such as protected health information governed by the Health Insurance Portability and Accountability Act — that flows through the IoMT is a rising issue for healthcare providers. Internet of things is not a new idea but it is popular issue in the globe. This is not amazing that throughout the globe, 18.2 billion devices are linked utilizing internet of things (iot) (iot). This lists all categories of iot throughout the globe. Basically iot is the internetworking of electronic devices to allow interchange of data between devices for particular domain applications. This notion of internetworking in internet of things (iot) makes human life more simpler than previously. According to WHO, Pakistan is confronting health challenges and our life expectancy in 2015 for men is 64.5 and for females it is 67.3 years. This has attracted our attention on iot and more over iot is most promising option for health care business since it lets patients to control their own sickness and obtain aid in most emergency scenario through mobile. It is projected that the demand for personal healthcare apps would expand substantially. In the conventional medical method, the quality and size of medical care can't match the requirements of patients.

It is of major relevance to create a set of family oriented remote medical monitoring system based on mobile Internet. Generally, the provision of

healthcare services via mobile devices is termed m- health, which is used to evaluate, record, transmit and store health information from many resources, including sensors and other biomedical acquisition systems [1]. M-health provides an intuitive answer to an issue typically encountered in the medical field: how to get the relevant information when and when required in highly dynamic and scattered healthcare organisations. These health apps may instruct diverse sort of viewers such as guardians of patients, patients themselves, physicians, nurses and healthy peoples too. These m health give better medical services, efficiency , greater efficacy of health plan and services therefore this minimise the expense of health maintenance.

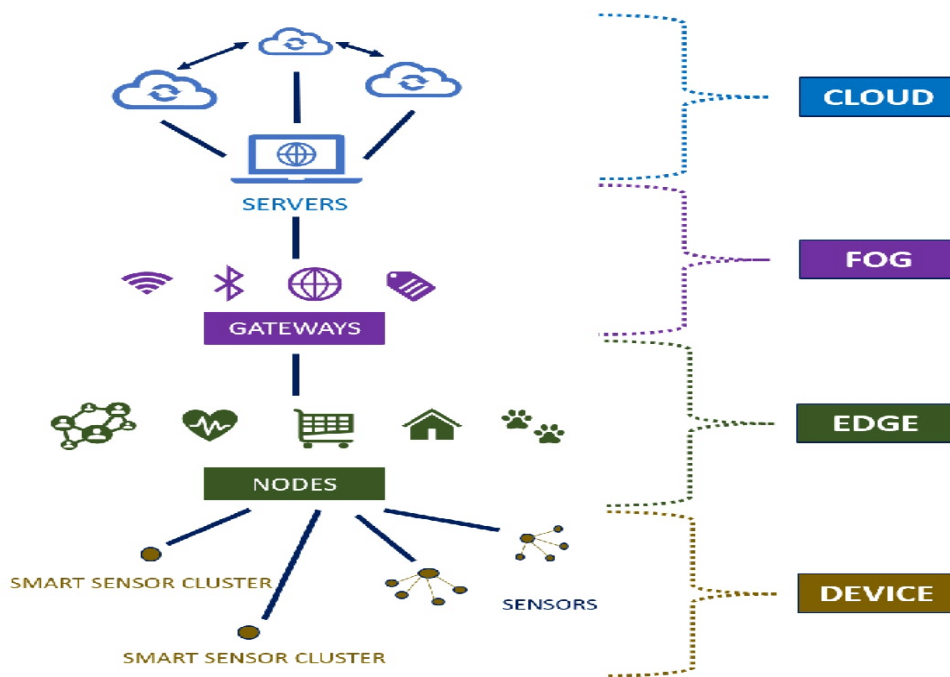


Figure 1. Communication of IOT

Figure.1. above illustrates how iot interacts with other network components. Patients, doctors, and the rest of the network are all linked. In the databases, physicians and clinical staff have access to all of the patients' medical records. Medical treatments and drugs may be readily tailored to meet the requirements of patients with this mobile health service. The patient's whole care is taken care of by the iot-based system, which is able to adapt to the patient's state and establish settings depending on their ailment. Using this method, we may be certain of both the patient's current and future health. Based on the study done by several iot researchers [2], we will focus on the applications, advantages, and potential problems of IoT in this article. As the title suggests, the primary goal of this article is to provide readers a general overview on the Internet of Things (IoT), as well as a look at the many types of applications that it has enabled. As a dashboard for medical caretakers, most IoT systems make use of a user interface that allows them to manipulate, visualise, and analyse data. In the literature, there is a lot of

information on the advancement of the IoT system in healthcare monitoring, control, security and privacy. As a result of these achievements, IoT in the healthcare industry has a bright future. However, the key worry when building an IoT device is the maintenance of quality of service matrices that include privacy, security, cost, dependability, and availability of information exchange. Many nations have implemented new technologies and legislation in order to increase the employment of IoT in healthcare systems. As a result, medical researchers now have a more promising area to investigate.

Literature Survey

When it comes to healthcare equipment, the authors of [3] have proposed a design that incorporates IEEE 11073 Service/DIM and CoAP. Using CoAP, they were able to compare the speeds of HTTP with the 11073 DIM protocol. CoAP and HTTP were also compared in terms of packet abundance in a single transaction, packet loss rates, and syntax utilising JSON and XML. Finally, they came to the conclusion that, compared to HTTP, CoAP can only transfer a small number of packets. XML is not superior than JSON when it comes to using resources, according to the experts. To quantify patient posture, the author of [4] presented a method based on the body weight of the patient exerting pressure on a specifically built mattress. Cohen's Coefficient, with a value of 0.866, indicates a high level of detection accuracy, which he uses to back up his work. He also mentioned that the goal of this effort was to lower storage requirements and computational costs. According to [5], the author's medical nursing system is built on IoT architecture and transmits data through 2G-3G, WSN, RFID and sensors as well as ZigBee, Wi-fi, and Bluetooth. His technology also makes it possible to accurately supply medications. Rehabilitative systems were designed using a combination of SOA methodologies and IoT technology, optimization approaches for resource allocation and an ontology for diagnostics in [6]. His presentation also included a strategy for developing rehabilitation systems utilising IoT technology. Two essential elements are discussed in the paper: rehabilitation construction and domain information sharing ease. m2m (machine to machine) and 5G technologies are discussed in connection with m-health in [7]. New technologies, in his opinion, will offer doors to m-health solutions [5].

A low-cost, IoT-based medical sensing gadget was presented in [8] to keep track of patients' physiological state. His study focuses mostly on the transmission and synchronisation of communications. A time-saving approach is used to ensure that successive messages are separated and that specific health care nodes' queue sizes are measured to prevent concordance. As the IoT's scope has expanded, [9] creator has come up with an idea for maintaining the IoT application's data. For his study, he used a semantic method, and provided a cloud-based concept that provides essential capabilities to assist in individual diagnosis across the network. Patient monitoring systems have been known to have detection issues, as discussed by one of the authors' researchers in [10]. A solution to the problem of poor detection accuracy and noise in signals is presented in this work. A major solution for launching services based on Internet of Things and data engineering principles was presented by the author in [11]. [12] presents a method for automatically monitoring an autistic patient using sensors tailored to the patient's needs. Sensor readings from a pompous individual's brain

impulses are monitored and tracked by this system.[16]

An algorithm CAD for the identification of abnormalities in renal ultrasonic image files using FPGA was proposed by the author in [13]. There are two stages in the research process: the LUT (look up table) stage and the SVM (support vector machine) stage. An FPGA-based kintex-7 is used to implement the previously mentioned technique. The author of [14] has presented a novel framework for medical healthcare monitoring, which is based on cloud computing and is specifically developed for implementation of healthcare monitoring in this framework. Modules that implement this framework are also covered in the article. Using the internet of things and cloud computing, the author of [15] aims to create an android application for healthcare. An android app platform for wave ECG monitoring is also discussed [19]. The authors of [16] laboured to create a new tool in response to the rising popularity of the internet of things and its growing need. Using a band known as a "smart health band," researchers in the field of m-health are able to maintain tabs on a patient's heart rate to monitor their overall health. A unique message will be sent to his family or a friend based on this value. IoT-based smart hospital design was described in [17] by the author's Researcher in order to create a more effective healthcare system. This new hospital system will aid in the management of data from the previous one. In [18], the authors describe how early detection of life-threatening conditions may be very useful to the patient. He said that iot is facilitating society by supplying remote healthcare services. A methodology is also described in this study, as are the applications, problems, and evaluations of all existing work linked to iot in the medical or healthcare area. He also attempted to improve the quality and efficiency of healthcare through his study.

Architecture of IoMT

Using the IoT framework for healthcare applications helps to connect the benefits of IoT technology and cloud computing with the medical industry. Various sensors and medical equipment transmit patient data to a healthcare network, which is outlined in the protocol. Healthcare IoT topology refers to how various IoT healthcare components are organised and interconnected in a healthcare context. As shown in Figure 2, a simple HIoT system consists of a publisher, broker, and a subscriber. Sensors and other medical equipment that are linked to the publisher's network may capture a patient's important information either individually or concurrently. Blood pressure, heart rate, temperature, oxygen saturation, electrocardiograms, electroencephalograms, electromyograms, and the like are examples of the kinds of data that may be collected.

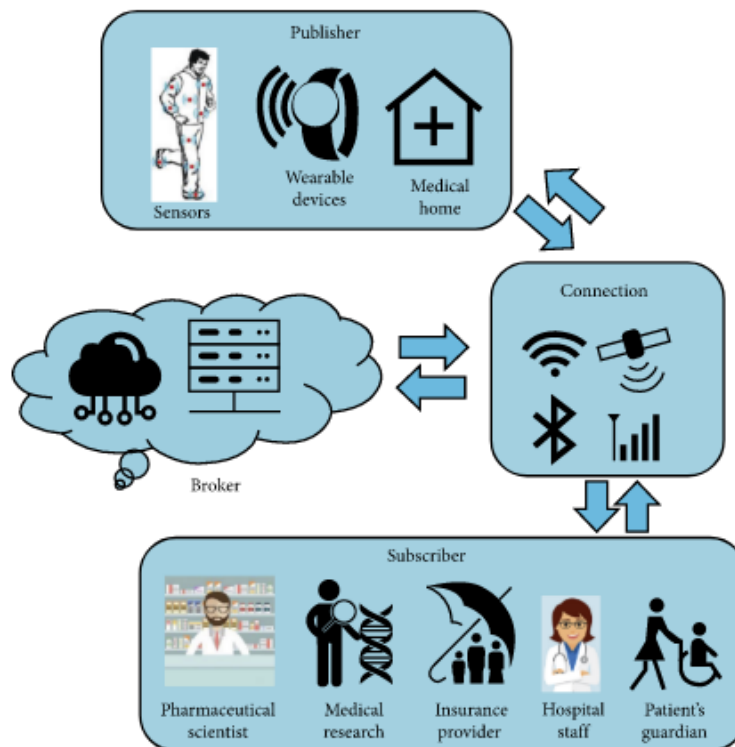


Figure 2. Architecture of Internet of Medical Things

A broker may get this information from the publisher at any time over a network. The broker is in charge of processing and archiving the data they've obtained. As a last step, the subscriber has access to and may see the patient's data on their smartphone, computer, tablet, etc. Using this data, the publisher may provide feedback to the patient if they see any abnormalities in their health. Each component of the IoT network and cloud in the healthcare network is allocated to a particular function as part of the HIoT integration[19]. A universal HIoT structure is impossible since the architecture of an HIoT varies depending on the healthcare need and application. HIoT systems have undergone several structural alterations in the past [20]. When developing a new IoT-based healthcare system for real-time patient monitoring, it is critical to list down all relevant actions connected to the intended health application. The IoT system's success will be determined by how well it meets the needs of healthcare practitioners. The architecture of the diagnostic technique must follow medical norms and stages since each illness requires a complicated sequence of healthcare activities.

Applications of IoT In Healthcare

It was previously impossible for physicians to do real-time analysis of a patient's condition because of the lack of IoT technology. As a result, healthcare facilities can now serve more people at a time, while yet maintaining high quality and keeping costs low. There are several benefits to using big data and cloud computing to improve patient-doctor communication. As a consequence, patients were able to devote more time and energy to their recovery while also saving

money. Health and fitness management, illness diagnosis, personal care for children and the elderly, and chronic disease monitoring are all examples of HIoT applications that have been influenced by the Internet of Things (IoT) in recent years. For a better understanding of these apps, they have been broken down into two main categories: services and applications. There are two types of HIoT devices: those that are being developed for the purpose of building an HIoT device, and those that are being utilised for healthcare purposes. It has been explained in depth in the following sections how HIoT services and applications may benefit your business. The wide range of applications for IoT in numerous fields makes it a highly anticipated development for a wide range of people. A variety of healthcare-related uses exist for it. In healthcare, the Internet of Things (IoT) is being used to great effect.



Figure 3. Applications of IoT In Healthcare

The Internet of Things (IoT) has also brought a number of wearables and technologies that have improved the lives of patients. Listed below are the many gadgets.

- **Hearables:** New-age hearing devices known as "Hearables" have dramatically changed the way persons with hearing loss interact with the outside world. Hearables of days are Bluetooth-compatible, allowing you to keep them in sync with your smartphone. Real-world sounds may be filtered, equalised, and layered on top of one other. The best illustration of this is Doppler Labs.
- **Ingestible sensors:** Ingestible sensors are definitely a modern-science miracle. These are pill-sized sensors which monitor the drug in our body and informs us if it finds any anomalies in our bodies. These sensors may be a godsend for a diabetic patient as would aid in reducing symptoms and offer an early warning for important health concerns. Proteus Digital Health is one such example.
- **Moodables:** Moodables are mood boosting gadgets which aid in increasing our mood throughout the day. It may seem like science fiction, but it's not far from reality. Thync and Halo Neurosciences are already working on it and has made remarkable progress. Moodables are head-mounted wearables that provide low-intensity electricity to the brain which increases our mood.

- **Computer vision technology:** Computer vision technology together with AI has given birth to drone technology which tries to replicate visual perception and consequently decision making based on it. Drones like Skydio employ computer vision technology to identify obstacles and to maneuver around them. This technology may also be utilized for visually impaired persons to navigate effectively.
- **Healthcare charting:** A doctor's manual labour during patient charting is greatly reduced by IoT devices such as Audemix. Powered by voice instructions, the device collects and stores the patient's information. Having all of the patient's information in one place makes it easier to review. It frees up around 15 hours of work every week for physicians.
- **Insulin Pens and Smart CGM:** These gadgets keep track of blood glucose levels in real time and send that information to a smartphone app for analysis. Devices that monitor glucose levels may be used by diabetics to communicate with their doctors and other medical workers.
- **Ingestible Sensors:** To assist patients swallow prescribed medicine, medical sensors emit small signals to wearable receivers on the body, which in turn relay data to a specific smartphone app for each patient.
- **Smart video pills:** A patient's intestines are examined by a smart pill in order to provide a clear image of the patient. A wearable gadget that is linked with medical applications may then receive the images. An additional benefit of smart tablets is that they allow you to see the digestive system and colon from outside the body.

Challenges of IoT in healthcare

We came up with a short list of important iot problems after doing some preliminary study. As long as these hurdles are overcome, we think that we can raise iot standards in medical care by using this technology. The Internet of Things (IoT) has the potential to improve the quality and reliability of medical health care services. As a result of the Internet of Things, internet communication has undergone a radical transformation. This has had a significant impact on the development of many difficult fields, but none more so than medicine and health care technology. As a result, it's imperative that technology bridges the gap between physicians, patients, and healthcare providers. Using IoT, medical professionals and hospital employees may do their duties more efficiently and effectively while also saving time and effort.

- **Data security & privacy:** Data security and privacy are two of the biggest issues that the Internet of Things (IoT) presents in healthcare. Internet of Things (IoT) security devices collect and send real-time data Most IoT devices, on the other hand, are devoid of standard data protocols and security measures. Aside from that, electronic device data ownership regulations are rather ambiguous. Cybercriminals are able to break into the system and steal Personal Health Information (PHI) from both patients and physicians because of these characteristics. For the purpose of purchasing pharmaceuticals and medical equipment that they may resell, cybercriminals can utilise patient electronic health records as a resource. The patient's insurance claim might potentially be fraudulently filed by hackers.

- **Integration: multiple devices & protocols:** The introduction of IoT in healthcare is further hampered by the integration of different devices. There's a problem since device makers haven't agreed on a standard for communication protocols and protocols. It's difficult to aggregate data when different devices have different communication protocols even though they're all linked. The lack of standardisation in the protocols used by connected devices slows down the whole process and limits the use of IoT in healthcare.
- **Data overload & accuracy:** There are several communication protocols and standards in use, making data aggregation a challenge. Despite this, IoT devices continue to amass vast amounts of data. The information obtained from IoT devices is critical. It's difficult for physicians to extract meaningful insights from the vast amounts of data that are now available, which in turn impacts their ability to make sound decisions. Patient safety will be compromised as a result. Furthermore, as more and more gadgets are linked together and generate ever-increasing amounts of data, this problem is only increasing.
- **Cost:** Surprised by the inclusion of costs in the challenges? Although I'm sure most of you are, the truth is that the Internet of Things hasn't yet made healthcare accessible to the average person at a reasonable price. The rise in healthcare expenditures is a cause for concern for everyone, but it is particularly so for nations like the United States and Europe. As a result, "Medical Tourism" has emerged, when individuals with life-threatening illnesses go to underdeveloped countries and get treatment for a fraction of the expense they would in the United States. As a concept, the Internet of Things (IoT) in healthcare is intriguing and promising. Aside from this, though, it hasn't addressed the issue of money. For IoT app development to be a success, the stakeholders must make it cost-effective, or it will stay out of the reach of everyone save the most well-heeled individuals.

IoT In healthcare and its Benefits

IoT healthcare facilities may be described as a collection of ubiquitous computing that mostly interacts with external operations. Health care systems that use the Internet of Things (IoT) capture a wide range of patient data and get inputs from physicians and other medical experts. The finest example of this is continuous glucose monitoring for insulin pens. All of these gadgets are capable of exchanging information and taking action that might potentially save a life. Doctors would be able to take action based on the data collected by an IoT healthcare gadget once it has been sent to the cloud. From this, we may conclude that IoT in healthcare has the potential to enhance patient health, as well as the efficiency of healthcare workers and hospital procedures. With any new technology, there are both benefits and downsides, and the Internet of Things (IoT) is no exception.

The following table provides a summary of the most important iot advantages. iot, on the other hand, is very useful in the field of medical health care. The Internet of Things (IoT) and its associated applications and technologies have altered the world into something only humans in the 1990s could have imagined. Due to Iot, there has been a revolution in internet communication. This contributes greatly to many tough sectors, but most importantly in medical things. As a result, it's

imperative that technology bridges the gap between physicians, patients, and healthcare providers. Using IoT, medical professionals and hospital employees may do their duties more efficiently and effectively while also saving time and effort. These advantages were hand-picked based on the contributions of several IoT researchers from a variety of sources. We chose articles from reputable sources like ACM, IEEE, and Elsevier based on criteria for acceptance and rejection. We've covered the most current advantages of IoT in the healthcare environment. Since IoT is a rapidly developing sector, it was critical to document the advantages of IoT in medical care. The goal was to identify the advantages of IoT in the healthcare industry.

Based on the study done by several IoT experts in this research paper, we have focused on the uses, future problems, and advantages of the Internet of Things (IoT). We only looked at medical healthcare-related apps. The majority of the applications are from works published in 2016 or before. There are a lot of obstacles to overcome, but we've narrowed it down to a few key ones in the IoT healthcare file, which are described in depth in section III. As long as these hurdles are overcome, we think that we can raise IoT standards in medical care by using this technology. In the sphere of medical health care, IoT has the potential to provide more dependable and superior services. Because of this, we may argue that IoT-based applications and systems have converted the reality into an imagined world that humans of the 1990s imagined. In order for physicians and medical workers to perform more efficiently and intelligently, IoT provides them with the tools they need.

Conclusion

Sensors on an IoT device may interact with the real environment and transmit data to the Internet. All of these IoT-based healthcare devices can interact with one other and perform vital steps that might save a patient's life. This essential information would be sent to the cloud by IoT healthcare equipment once they had collected passive data. IoT-based health care services not only benefit patients' health and provide assistance when needed, but they also increase the productivity of healthcare workers and streamline the processes of healthcare companies. An overview of Internet of Things (IoT) services and technology in healthcare is presented in this study. Research problems have been recognised, and it is projected that these trends will become key research focuses in the next years. Some of the most promising areas for future application research have been identified, as well as the most relevant application domains. Research in the area may benefit greatly from our findings, which we think will assist academics and practitioners better comprehend IoT's vast possibilities in medicine while also highlighting some of the industry's greatest obstacles. In addition, this study will assist academics better understand how IOT might be used in the healthcare industry.

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