

# Internet of Medical Things

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**Abstract:** *Medical services are crucial to the social business and prosperity of any nation. Healthcare is one of the fields which are constantly developing new solutions that are essential for society. One of those latest solutions is the Internet of medical things. IoMT is the technology that connects the medical devices to the healthcare IT systems. With the rapid development of IoMT, clinical work is becoming increasingly intelligent, meticulous, efficient, and cost-effective. This paper provides a brief introduction to IoMT.*

**Key Words:** *Internet of medical things (IoMT), healthcare IoT, medical Internet of things*

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## I. INTRODUCTION

We are living in a connected world, where more and more devices have to be connected and communicate. This trend has led to the emergence of Internet of Things (IoT). IoT is a network of physical objects and it connects over 25 billion things or physical objects, with the ability to communicate over wired or wireless communication media. The objects may be mobile, smart, addressable, and minuscule devices or people or animals. It connects all items to the Internet through radio frequency identification (RFID) and other sensing equipment. RFID is a non-contact automatic identification technology and is illustrated in Figure 1 [1]. Other communication technologies such as wireless fidelity (Wi-Fi), Bluetooth, ZigBee, and Low-Power Wireless Personal Area Networks (LoWPAN) are often used in IoT.

The major features of an IoT system include [2]: (1) interconnection of “things” (e.g, wearables), (2) connection of “things” to the Internet (intranet or extranet); (3) uniquely identifiable “things” (e.g, RFID tag); (4) ubiquity (a network that is available anywhere and anytime); (5) sensing/actuation capability (e.g, sensor network); (6) embedded intelligence (e.g, artificial intelligence, machine learning); (7) interoperable communication capability; (8) self-configurability; and (9) programmability. Characteristically, IoT will make everything in our lives “smart.” IoT has the potential to accurately track people, equipment, or even service animals and analyze the data captured. IoT has offered an incredible array of benefits in different platforms such as IIoT and IoMT. It is used in different fields such as the industry, power grid, transportation, logistics, smart cities, and agriculture [3].

## II. CONCEPT OF IOMT

People have realized that health is not only one of the goals which social development pursues, but also the basic condition of promoting the economic development. With the rise in human population and medical expenditure, affordable healthcare has become crucial. To maintain healthy life, it is essential to follow human body’s vital signals. IoT is a powerful platform where sensors can connect and data is viewed over the Internet. Among the applications of IoTs, the Internet of Medical Things (IoMTs) consist of the group of medical devices connected to Internet. IoMT is global infrastructure consisting of the collection of medical devices and applications that are interconnected through the Internet. IoT devices in the medical industry such as sensors can have numerous applications including heart rate monitors, blood pressure monitors, and endoscopic capsules. With the rapid development of IoT, IoMT is gaining popularity. IoMT differs from general IoT not just in terms of usage, but also in design.

The Internet of medical things (IoMT), also known as healthcare IoT, connects patients and healthcare providers via the Web with an objective to experience complete restoration of quality-of-life with minimal doctor’s office time. IoMT system includes wearable devices, remote patient monitoring, sensor-enabled hospital beds and infusion pumps, medication-tracking systems, medical supply and equipment inventory tracking, smart watches, contact lenses, etc. IoMT is enabled by a number of technologies such sensor networks, IoT connectivity, and artificial Intelligence (AI). It is a system where devices are connected to each other and can communicate through the Internet. It is optimized for better health in faster and easier environment. A typical IoMT is shown in Figure 2 [4].

## III. APPLICATIONS

Some applications of IoMT include the following.

- *Remote Monitoring:* IoMT is an enabler for remote monitoring for those in hard-to-reach locations. Patient monitoring can be done in hospitals and clinics. The IoMT employs accelerometer sensor, visual sensor, temperature sensor, carbon dioxide sensor, ECG/EEG/EMG sensor, pressure sensor, gyroscope sensor, blood oxygen saturation sensor, humidity sensor, respiration sensor, and blood pressure sensor to observe and monitor the patient's health in a continuous manner [5]. MRIs, X-ray machines, CT scanners, and other equipment can be remotely monitored. Real-time monitoring can save lives in event of a medical emergency like heart failure, diabetes, asthma attacks, etc.
- *Telemedicine:* Telemedicine literally means "healing at a distance." It is now regarded as the use of information and telecommunication technology (ICT) to provide patients with healthcare at a distance. It is a new fascinating development that enhances the level of medical services. Telemedicine holds the promise of significant changes within the healthcare industry since it offers an opportunity to attract and retain consumers.
- *Wearable Devices:* IoT has introduced several wearables devices which have made lives of patients comfortable. Advances in biosensor technology make possible wearable smart devices that monitor the user's health. On-the-body IoMT sensors give patients freedom, while maintaining close watch on their health conditions. Wearables devices have been developed greatly and are considered reliable tools for long-term health monitoring systems. They have matured into products being worn by patients, transmitting data to physicians and thereby allowing doctors to monitor vital signs in real time.
- *Home Medication:* Monitoring and managing medications, ensuring that patient's dose correctly and on schedule is important. Smart home medication dispensers automatically upload data to the cloud when medication is not taken. These devices can also store medication at proper temperatures to ensure viability.
- *Research:* Much of current medical research relies on resources lacking critical real-world information. Research IoMT can be used for research purposes. IoMT has a great impact in the field of medical research.

Other applications of IoMT include personalized care, cancer treatment, ambient assisted living, medical smart contact lenses, ingestible sensors, smart inhaler, insulin delivery, glucose monitor,

#### IV. BENEFITS

The Internet of medical things (IoMT) has opened up a world of possibilities in medicine. When connected to the Internet, ordinary medical devices can collect useful data, enable remote care, monitor patients' conditions, and generally give patients more control over their treatment. The benefits of introducing IoMT are vast and include the following [6]:

- *Objective Reporting:* Because the devices can record and report on actual activity at the level of the nervous system, we no longer have to rely solely on subjective patient reports.
- *Lower Cost:* The IoT in medical field results in the reduction in healthcare cost since doctors need not meet the patients physically.
- *Local Activity Recording:* Device recording capabilities allow for the collection of data which will vastly improve our understanding of the mechanism of action of these chronic diseases.
- *Automation:* The automation of device and therapy records decreases human error or fraudulent reporting.
- *Precision Medicine:* The IoT technology gives precise data and avoids human error. Targeted stimulation is designed for an individual patient while decreasing negative side effects
- *Adaptability:* Because our systems are built on a feedback loop, the system iterates on that feedback and adjusts for improved patient outcomes.

#### V. CHALLENGES

As with any other technology, we also have the downside of IoMT. Due to the critical nature of health-related systems, the IoMT still faces numerous challenges, which may slow down the development of new digital medicines. The challenges include [7]:

- *High Infrastructure Cost:* The cost of building the IoMT infrastructure is enormous. Dedicated IT health networks, blockchains, and cloud platforms are all necessary. The initial cost for setting up such systems is significant.
- *Cybersecurity:* This is a concern in the medical field since it is vital to protect all sensitive information. This is perhaps the major reason the industry would be taking a little more time adopting the technology. IoMT interconnectivity leaves medical devices vulnerable to cybersecurity breaches [8]. IoMT users must adhere to security and privacy policies to ensure that patient data remains confidential and secure. The increasing number of connected medical devices present additional risks for data security. Cybercriminals can misuse patient's data

to create fake or file a fraudulent Insurance claim in patient's name. Blockchain technology offers the only framework robust enough to meet IoMT security challenges.

- *Lack of Standardization:* The lack of standardization among IoMT manufacturers is a problem. Devices from different manufacturers are often not interoperable. As a heterogeneous network system, the interconnection of different IoMT components is a main problem that needs to be solved.
- *Computation Power:* IoMT devices have limited computation power. If a patient is using implanted medical devices, it is not easy to recharge or replace the devices immediately. Biosensors are small devices with limited energy; if the devices do not wisely utilize the energy, they may drain and become inactive [9].

## VI. CONCLUSION

In the face of growing medical needs, the construction and development of community medical Internet of things is imminent. The Internet of medical things is about interconnected medical devices that are accessible over the Internet. The purpose of IoMT systems is not to replace healthcare providers, but eliminate waste. In the long term, deployment of IoT in healthcare can improve productivity, enhance quality of life, and contribute to poverty alleviation [10].

Industry leaders, such as Philips, GE Healthcare, and Medtronic, are currently investing in IoMT technology. With IoT establishing itself in modern life, IoMT is the future of healthcare. More information about IoMT can be found in book in [11].

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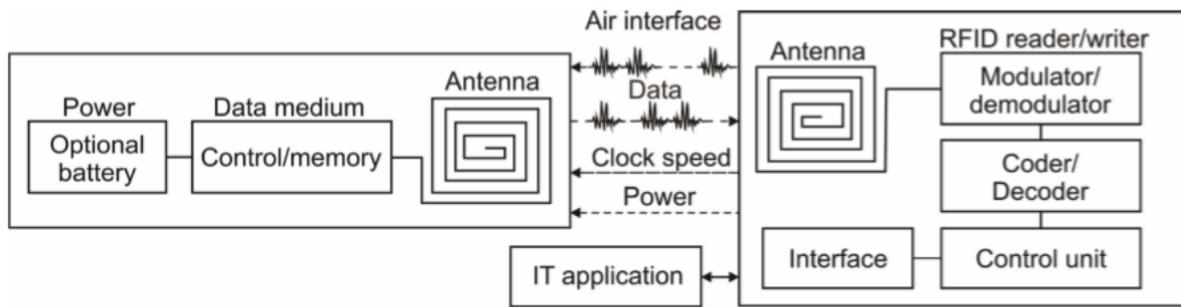


Figure 1 RFID technology [1].

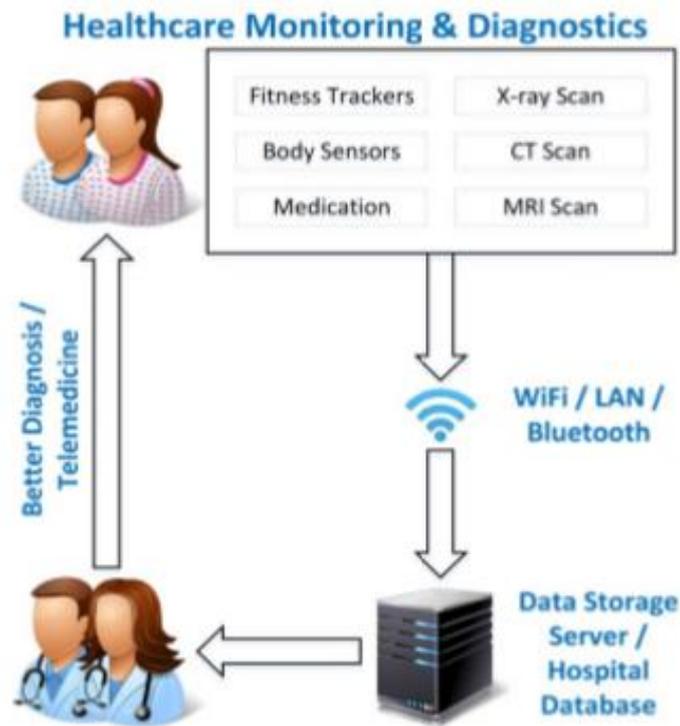


Figure 2 A typical IoMT [4].