REVIEW OF IOT-ENABLED PATIENT HEALTHCARE MONITORING SYSTEMS

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ABSTRACT:

The main concept of IoT (Internet of Things) in healthcare is that doctors can watch over patients from anywhere, even when they're not in the hospital. Wearable devices pick up lots of information, such as heart rate, blood pressure, oxygen levels, body temperature, and ECG readings that show the heart's electrical activity. All this data connects through networks and cloud services, which likely cuts costs in the long run and makes checking on patients easier. I suppose patients enjoy the sense of always being looked after. In this paper, we looked at various IoT systems, with a focus on sensors, how they share information, how they handle the data, and ways to keep things secure to prevent issues.

From reviewing the studies, we noticed common trends, like the types of sensors that are often used. For the future, systems might become smarter and more dependable, and they could grow or expand more easily. This could be helpful for students or researchers who want to create medical gadgets.

KEYWORDS:

Internet of Things (IoT), Patient Monitoring, Smart Healthcare, Wearable Sensors.

INTRODUCTION:

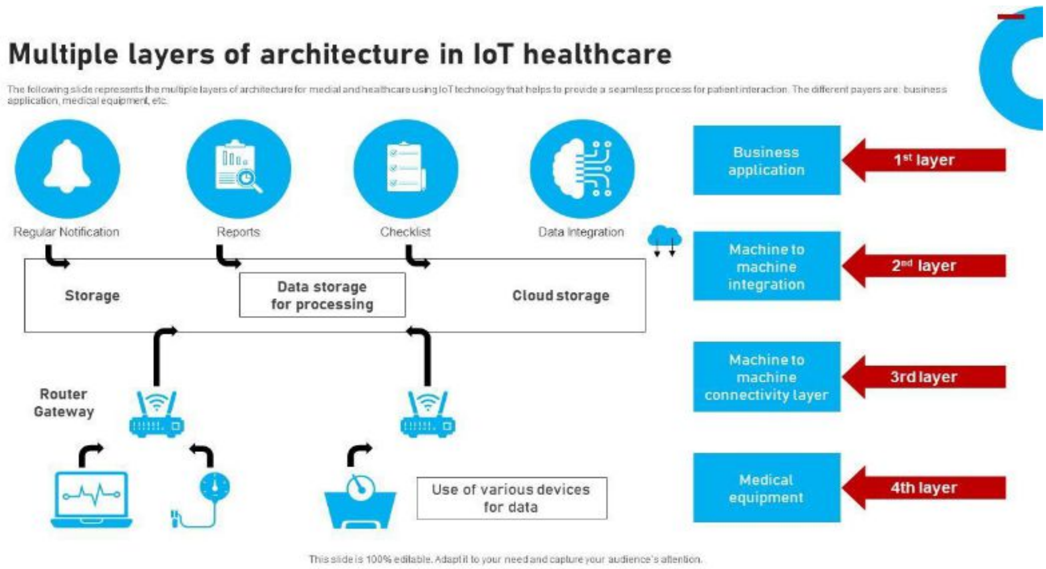
Digital technology has transformed how healthcare works, thanks to smart and connected medical systems. A key part of this is the Internet of Things (IoT), which links up different "things" like devices, sensors, and apps through the internet. This setup helps deliver higher-quality care and eases the burden on old-fashioned healthcare setups.

IoT systems for tracking patient health offer many advantages, but they also face several challenges that make them hard to put into practice. These include problems with keeping data secure and private, getting different devices to work together smoothly, managing battery life in wearable sensors, handling the growth of cloud systems, and ensuring reliable instant communication. To tackle these issues, a deep look at the latest research and tech is essential.

The goal of this paper is to give a complete overview of IoT systems for patient health monitoring by doing a systematic review of the newest studies. It covers system design, sensor tech, and communication methods; compares current approaches; and talks about unsolved problems plus ideas for future research. This work will help researchers, professionals, and students in smart healthcare and IoT medical tools.

SYSTEM ARCHITECTURE:

The setup of IoT systems for tracking patient health is built to allow ongoing collection, sending, handling, and display of health information. A standard IoT healthcare design uses layers to make sure it can grow, stay dependable, and manage data well. It usually has four key parts:



The layers involved in IoT architecture are:

1. Sensing Layer:

- The actual gadgets that collect health information.
- **Examples:** Wearable sensors, smartwatches, etc.

2. Transmission Layer:

- The actual gadgets that collect health information.
- **Technologies:** Bluetooth Low Energy (BLE), Wi-Fi, 5G, etc.

3. Processing Layer:

- Handles data right where it's gathered.
- **Purpose:** It checks quick info to cut down on delays.

4. Application Layer:

- Offers services directly to the end-users.
- **Services:** Tailored health apps, remote patient monitoring, etc.

SENSORS AND DEVICES:

Most patient health monitoring systems rely on a mix of biomedical sensors and smart gadgets to keep collecting data about a person's body functions and daily habits. This is done through wearable, portable, or implanted devices, which are essential for remote medical checks and constant health monitoring.

1. **Physiological Sensors:**

Physiological sensor devices often include heart rate monitors, which provide data about the pulse rate of an individual and may be able to help in the early detection of various types of cardiovascular disease. In addition, body temperature monitors can help with identifying a fever or an infection. A blood pressure monitor is also commonly used for monitoring individuals who have been diagnosed with high blood pressure (hypertension) and other cardiovascular-related conditions. Additionally, ECG (electrocardiogram) sensors are designed to record the electrical impulses generated by the heart muscle. The information obtained from this type of sensor is very valuable in diagnosing and managing a wide variety of cardiac diseases. Finally, pulse oximetry (SpO2) sensors measure the level of oxygen being transported in the blood. This type of sensor is especially useful when monitoring patients who require supplemental oxygen and/or those who are critically ill.

2. **Wearable Devices:**

Due to a combination of user comfort and portability, wearable devices are the most common form of IoT-based healthcare technology utilised by consumers. Wearable devices, including smart watches, fitness bands, smart clothing, and chest straps, have become capable of utilising multiple sensors to monitor a range of physiological parameters simultaneously. As a result, these devices allow continuous, non-invasive monitoring of patients in their daily lives and are typically used for elderly care, chronic condition management, and post-operative care.

3. **Environmental and Motion Sensors:**

Beyond physiological sensing, many IoT-based healthcare systems include other types of sensors (motion and environment). In addition, the use of environmental sensors (humidity, ambient air quality and ambient temperature) can be used to determine the environmental factors affecting a patient's health.

4. **Implantable and Medical Devices:**

These advanced IoT systems can also be made up of many implantable devices that monitor and treat a variety of conditions, including heart rhythm (pacemaker), blood sugar levels (glucose monitors) and diabetes (smart insulin pumps). Although these types of devices provide both continuous and precise monitoring and treatment, they have very specific requirements in terms of their design, including security, reliability and efficiency with respect to energy consumption.

TABLE 1:

Sensors and devices used in IoT-based Patient Health Care Monitoring Systems.

Sensor/Device	Health Parameter Monitored	Device Type
Heart Rate Sensor	Heartbeat	Wearable
Temperature Sensor	Body Temperature	Portable
Glucose Sensor	Blood Glucose Level	Implantable
Accelerometer	Body Movement Activity	Wearable
Gyroscope	Orientation and Posture	Wearable
Smartwatch	Multi-Parameter Sensing	Wearable
Respiration Sensor	Breathing Rate	Wearable
EEG Sensor	Brain Activity	Medical Device

REVIEW LITERATURE:

[1] An IoT-Aware Architecture for Smart Healthcare Systems:

It focused on patient identification, monitoring, and system interoperability in healthcare environments.

[2] The Internet of Things for Health Care: A Comprehensive Survey:

The authors presented a detailed survey on IoT applications in healthcare, discussing sensing devices, communication protocols, and healthcare services. Security and privacy issues were identified as major challenges.

[3] Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions:

This work introduced a general IoT architecture and discussed its application in healthcare monitoring. It highlighted the role of cloud computing in processing large-scale sensor data.

[4] Exploiting Smart e-Health Gateways at the Edge of Healthcare IoT:

The paper proposed an edge/fog computing-based healthcare monitoring system to reduce latency and improve real-time performance in IoT healthcare applications.

[5] BSN-Care: A Secure IoT-Based Healthcare System Using Body Sensor Networks:

This study introduced a secure IoT healthcare framework using body sensor networks. Authentication and encryption techniques were used to protect sensitive patient data.

[6] Wearable Technology for IoT-Based Healthcare Monitoring: A Survey:

This survey reviewed wearable sensors and devices used in IoT healthcare monitoring systems and discussed challenges related to energy efficiency and data reliability.

COMPARISION:

TABLE 2

Comparison of Real IoT-based Patient Healthcare Monitoring Systems (with IEEE sources)

Reference (IEEE)	Year	System	Sensors	Connectivity	Key Features
Portable and Real-Time IoT-Based Healthcare Monitoring System for Daily Medical Applications	2022	Daily healthcare monitoring	Wearable sensors	IoT	Portable system, real-time
HOT Watch: IoT-Based Wearable Health Monitoring System	2024	Wearable smart watch IoT	Temperature, SpO_2, ECG	Bluetooth	High-accuracy real-time health tracking
Remote Patient Monitoring System with Wearable IoT Devices and Biosensors for Vital Signs	2025	Real-time monitoring with wearables	Multiple biosensors	IoT devices	Wearable sensing + real-time remote monitoring

COMMUNICATION TECHNOLOGIES:

Communication technologies are important to the operation of the Internet of Things (IoT) for patient health care monitoring through the ability to provide continuous and timely transfer of physiological sensor information collected from the various sensors and medical devices to healthcare professionals. Selection of appropriate communication technologies is based on several key criteria, including: data rate, transmission distance, energy efficiency, latency and the application's requirements. A variety of both short- and long-distance wireless communication technologies are utilised in the development of smart health care systems.

1. **Short-Range Communication Technology:**

Bluetooth and Bluetooth Low Energy (BLE) are used by a lot of wearable health monitors because they consume little energy and easily connect to phones. In particular, BLE is well-suited for ongoing monitoring of your physiological characteristics (i.e., your pulse and how active you have been). Wi-Fi is most often used at home or in hospitals since Wi-Fi has much higher data transmission speeds than other technologies, including the transmission of large medical data (e.g., an electrocardiogram signal). However, Wi-Fi will use more power than BLE.

ZigBee is a low-power wireless technology that is also used in body-area networks and in the communication among sensors in healthcare sensor networks. ZigBee can be configured in a mesh configuration; mesh configurations help increase the reliability and scalability of a network in a confined space (like an inpatient room).

2. **Long-Range Communication Technology:**

Due to their range capabilities and low power requirements, both Narrowband IoT (NB-IoT) and LoRa WAN have become very popular for a variety of wide-area healthcare use cases (for example, remote/rural patient monitoring). While these two options will support the periodic transmission of vital signs, they both have relatively limited bandwidth. The high bandwidth and low latency offered by cellular technologies (such as 4G LTE & 5G) make cellular a better option for real-time and life-threatening health care use cases (e.g. telemedicine).

3. **Emerged Communication Technology:**

The growth of smart health care has drawn increased interest toward 5G-Enabled IoT as it provides ultra-low latency, high reliability, and supports the connection of large numbers of devices.

Selecting the most suitable technology for communications will ensure that data is transmitted efficiently, securely, and reliably within an IoT-based system for patient health care monitoring.

CHALLENGES:

1. **Patient Information Safety And Security:**

The use of Internet of Things (IoT) in the field of healthcare involves storing and transmitting private patient information through cloud-based wireless networks. One of the biggest challenges facing this form of healthcare delivery is how to ensure the security of all patient information from unauthorised users, including hackers.

2. Battery Life and Power Consumption:

Wearable and implantable devices used in healthcare are typically powered by batteries, which limit their power consumption. The frequent need for the devices to transmit data and sense changes in patients can shorten the battery life and make them less reliable and less convenient for the patient.

3. Performance In Handling Increasing Amounts Of Data:

Because the number of devices being connected to the internet is increasing, IoT-based healthcare systems must be able to process an increasing volume of data while still performing reliably. This can create scalability issues for cloud-based systems that can include limits on bandwidth and storage space.

FUTURE DIRECTIONS:

1. Using Artificial Intelligence To Monitor Health:

Using artificial intelligence (AI) and machine learning (ML) techniques can help monitor diseases, detect anomalies, and deliver personalised health care.

2. Edge Computing For Real-Time Processing:

To eliminate the delays caused by sending data through the cloud or to a remote server, future healthcare systems are likely to use edge computing to perform real-time processing and to eliminate the delay caused by sending data to the cloud.

3. Blockchain-Based Secure Sharing Of Patient Information:

A blockchain-based system would allow for secure sharing of patient information between providers, hospitals, and other entities by allowing for a decentralised method of data sharing that is tamper-proof and provides greater trust and data integrity than current systems.

4. Developing Standards For The Integration Of Devices:

Developing a set of universal standards for developing devices for healthcare would help to ensure that devices made by different manufacturers could communicate with each other and share data seamlessly.

CONCLUSION:

Healthcare accessibility, disease detection at an early stage and patient care were shown to be improved with a significant reduction in the cost of operation and the load on healthcare infrastructures through the use of IoT-based remote health monitoring systems. The contribution of wearable sensors, cloud and edge computing, and high-speed communications to smart healthcare has been significant. However, there are many issues currently impacting the large-scale deployment of smart healthcare systems, such as data security and privacy, the ability to communicate between systems (interoperability), energy consumption by devices, scalability, and the reliability of data generated by devices.

Additionally, this study established some important research gaps and directed researchers to possible future areas of research, including, but not limited to, AI, edge computing, blockchain-based security solutions, and next generation communications technologies like 5G. About the research gaps established in this study, the authors believe addressing the various challenges associated with them, along with continued exploration into new technologies, is essential to developing more intelligent, secure, and dependable health monitoring systems.

This survey should serve as a resource for researchers, developers, and healthcare professionals interested in understanding current trends, the challenges facing the field, and the potential opportunities related to IoT-based patient health monitoring systems.

This study provides a solid foundation for additional research and development in the area of smart healthcare applications.

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REFERENCES:

[1] L. Catarinucci, D. De Donno, L. Mainetti, L. Palano, L. Patrono, M. L. Stefanizzi, and L. Tarricone, “An IoT-Aware Architecture for Smart Healthcare Systems,” *IEEE Internet of Things Journal*, vol. 2, no. 6, pp. 515–526, Dec. 2015.

[2] A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, “Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications,” *IEEE Communications Surveys & Tutorials*, vol. 17, no. 4, pp. 2347–2376, Fourthquarter 2015.

[3] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, “Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions,” *Future Generation Computer Systems*, vol. 29, no. 7, pp. 1645–1660, Sept. 2013.

[4] M. M. Islam, M. R. Islam, N. Hasan, M. M. Kabir, and S. M. R. Islam, “Wearable Technology for IoT-Based Healthcare Monitoring: A Survey,” *IEEE Access*, vol. 7, pp. 133394–133418, 2019.

[5] S. M. Riazul Islam, D. Kwak, M. H. Kabir, M. Hossain, and K.-S. Kwak, "The Internet of Things for Health Care: A Comprehensive Survey," *IEEE Access*, vol. 3, pp. 678–708, 2015.

[6] P. Kumar and H.-J. Lee, "Security Issues in Healthcare Applications Using Wireless Medical Sensor Networks: A Survey," *Sensors*, vol. 12, no. 1, pp. 55–91, 2012.

[7] Y. Yang, X. Zheng, W. Guo, X. Liu, and V. Chang, "Privacy-Preserving Smart IoT-Based Healthcare Big Data Storage and Self-Adaptive Access Control System," *Information Sciences*, vol. 479, pp. 567–592, Apr. 2019.

[8] A. Rahmani, T. N. Gia, B. Negash, et al., "Exploiting Smart e-Health Gateways at the Edge of Healthcare Internet-of-Things: A Fog Computing Approach," *Future Generation Computer Systems*, vol. 78, pp. 641–658, Jan. 2018.

[9] M. Chen, Y. Ma, J. Song, C.-F. Lai, and B. Hu, "Smart Clothing: Connecting Human with Clouds and Big Data for Sustainable Health Monitoring," *Mobile Networks and Applications*, vol. 21, no. 5, pp. 825–845, Oct. 2016.

[10] K. Ashton, "That 'Internet of Things' Thing," *RFID Journal*, pp. 97–114, June 2009.

[11] M. Hassanalieragh, A. Page, T. Soyata, et al., "Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-Based Processing: Opportunities and Challenges," *IEEE International Conference on Services Computing*, pp. 285–292, 2015.

[12] P. Gope and T. Hwang, "BSN-Care: A Secure IoT-Based Modern Healthcare System Using Body Sensor Network," *IEEE Sensors Journal*, vol. 16, no. 5, pp. 1368–1376, Mar. 2016.