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# An IoT-based Smart Health Monitoring System with Hybrid Conversational Assistance

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***Abstract*— IoMT systems prevent frequent visits to doctors and meetings between patients and medical professionals. This end-to-end health monitoring system aims at offering monitoring of patients on their will along with consultant support and bringing up the adaptive conversational assistant as well. With a layered IoT architecture that restrictively balances between on-device signal pre-processing at the network edge with robust cloud-based analytics and hybrid assistance services, the system will collect continuous vital physiological data. The architecture provides threshold-based, role-based dashboards and to achieve sensor fidelity, data flow integrity and real-time responsiveness a prototype implementation was designed and experimentally confirmed, as well as an efficient proof of the automated warning feature. Having already initial data on its real-time functionality, our work delivers a working, configurable architecture of a health monitoring system based on an IoT and meets the stringent healthcare requirements of both latency and privacy. Our approach will help strengthen the trust of the patients and also aligns with the proposed system of modern healthcare in providing the remote patient monitoring with the hybrid conversational assistance.**

***Index Terms*— Internet of Medical Things (IoMT), Remote Patient Monitoring (RPM), Biomedical Sensors, Real-Time Health Data, Intelligent Healthcare Systems.**

## I. INTRODUCTION

The contemporary healthcare paradigm is associated with a shift toward a proactive environment as opposed to traditional treatment. This transition emphasizes on the early detection of any anomaly, will maintain the continuous monitoring of the vitals, and can help provide preventive care rather than episodic, reactive medical interventions. Internet of Medical Things (IoMT) allows constant, real-time health monitoring through sensors that ensure the measurement of patient information. By enabling uninterrupted data acquisition from patients in non-clinical environments, IoMT technologies help bridge the gap between patients and healthcare providers. Close observation of these vital signs and issuing emergency notifications in case of abnormal decreases or unexpected increases will ensure early medical intervention and, thus, lead to the prevention of complications, thanks to IoMT systems [1, 2, 3]. As a result, the patient outcomes can be significantly improved by providing the security and proper provisions to use the system while simultaneously reducing the burden on healthcare infrastructure.

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The feature relies on accessible hardware, including low-power microcontrollers (such as the ESP32) with built-in non-invasive biomedical sensors to measure life signs such as body temperature, oxygen saturation in the blood (SpO2), and heart rate [4]. These components are widely available and are cost-effective also they are energy-efficient as they run on low-power and on scheduled operation cycles, making them suitable for large-scale and long-term deployment. A hybrid processing system takes in data effectively through lightweight protocols such as MQTT [5]. Although a cloud-based database is solely used in safe and centralized data storage and access, this architecture purposely applies network advantage to low-latency, emergency event processing [6]. Such a hybrid edge–cloud system approach will help ensure responsiveness during critical events and reliability.

As soon as data is transformed into actionable insights on user-friendly dashboards that will accredit the patients and the consultants, the real potential of continuous biological data is realized [2, 7]. Clear visualization of trends enables informed decision-making and will help people know how their daily lifestyle is affecting their results. Furthermore, adaptive and hybrid conversational AI integration is also becoming an attractive instrument to enhance patient engagement through regular health advice and initial symptom triage [8]. Nonetheless, data security, compatibility of devices, and scalability of the systems require strict solutions because of ethical and regulatory environment [9].

## II. LITERATURE REVIEW

The rapid growth of IoMT has triggered a significant volume of research that is aimed at improving health care delivery. To contextualize the proposed system in the context of the current state-of-the-art developments, this review analyses recent literature focusing on architectural design, sensing developments, the purpose of generative artificial intelligence and essential non-functional requirements.

### *A. IoMT System Architectures*

The contemporary IoMT systems have the tendency to adopt a kind of layered architecture, which at times extends beyond the three-layered basic model to the complex data flow [10]. In architecture, there is a prevailing trend of judicial location of edge nodes to filter real-time data and identify anomaly as a way of alleviating network delay [6].

This combined approach is necessary to effectively trade-off the computational throughput demands of real time health monitoring and its demanding low-latency goals, where cloud will be the primary location in the long-term data storage and system-wide synchronization services [11].

### *B. Improvement in the realm of sensing and data acquisition*

This paper demonstrates that the presented health monitoring system relies on low-cost and easy to obtain components that could be interesting in practice in the context of deploying an IoMT solution. The system will include an ESP32 microcontroller and sensors to receive parameters such as heart rate, SpO2 and body temperature [12].

### *C. Interactive Hybrid Conversational Architecture*

The future of IoMT is the use of Generative AI to revitalize patient engagement. Beyond analytics, an hybrid conversational architecture using Large Language Model, Retrieval-Augmented Generation-based using the WHO and other clinical guidelines for source-based answers and a FAQ-bot for general queries. Such architecture enables source-grounded responses, minimizes hallucinations, and optimizes efficiency by pathing queries based on the requirement of the user. These dynamic systems help in initial triage of symptoms, tailored health education, and general care advice [8,17,18,19].

### *D. Research Gaps*

The common thread of the literature that has been reviewed is that there is recurring missing piece that is the absence of cohesive platforms that can succeed in integrating a proven, low-cost hardware stack with a hybrid edge-cloud solution integrated with user-friendly patient interface with state-of-the-art Conversational GenAI services [7]. The following gaps in knowledge will be addressed in this paper, which will help fill them:

The available hardware stack [12, 13] would be compatible with the hybrid edge cloud model that is based on a centralized cloud database to store data safely and streamline data flow [6, 11] and creating a role-based user-centric dashboard [7] and Integrating a holistic, integrated patient assistance through the implementation of an adaptive Generative AI orchestration chatbot [17, 18, 19].

## III. METHODOLOGY

### *A. System Design and Architecture:*

A three-layer architecture is used in the system's construction to maintain its flexibility and organization. Each component of the project can be updated and managed more easily with this design.

- Perception Layer (The Sensors): Information is gathered at this layer. It contains hardware that collects data in real time, such as SpO2, pulse & body temperature.
- Network Layer: This layer serves as the link between our primary server and the sensors. It sends the data over the network safely and dependably using effective communication protocols like MQTT.
- Application Layer (User Interface): The user interacts with this layer at the top. It contains the web dashboard for viewing real-time health insights and interacting with the provided two-way assistance, adaptive conservational assistance and the consultant as well.

### *B. Hardware and Software Components*

Hardware:

- NodeMCU ESP8266 - Microcontroller that will be used to acquire data and connect to the Wi-Fi.
- MAX30100/30102 Sensor - Heart rate (BPM) and blood oxygen saturation (SpO2), non-invasive.
- DHT11/DS18B20 Temperature sensor - A temperature sensor that will sense the temperature.
- SSD1306(OLED display): To check the prototype reading in real-time.

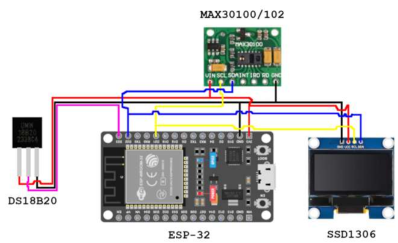


Figure 1: Hardware Setup For Data Collection

*Software Components*

The system will be developed on the basis of modern scalable frameworks:

- Embedded Firmware – Drives NodeMCU and reads data from the sensors and transmitting it using the Wi-Fi transmission.
- Backend & Data Storage: The FastAPI (Python) server validates and handles data. Data is safely stored in a cloud-based database (MongoDB Atlas) to synchronize the data. Socket.io for one-on-one chat support. An adaptive hybrid conversational chat assistant Using LLMs and Retrieval-Augmented Generation.
- Web Application: The frontend single paged application, role-based dashboard. The data visualization is done through the Chart.js library, which visualizes real-time time-series trends.

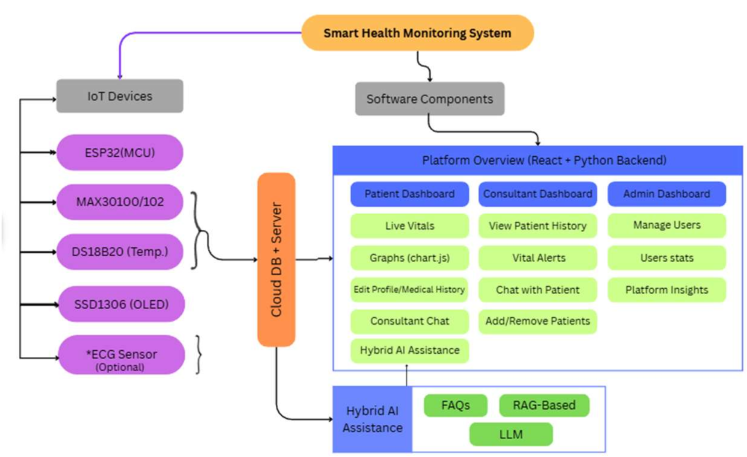


Figure 2: Overall Overview of the Platform

### C. Data Flow and Workflow

The end-to-end workflow has low-latency engineering:

- Data Acquisition: The ESP32( NODEMCU) will collect physiological data via sensors attached to it.
- Transmission & Pre-processing: Raw data is encapsulated and transmitted using Wi-Fi to the cloud storage after processing it on the local edge.
- Processing & Archival: The server back-end verifies the data and stores the data in the cloud database.
- Visualization & Interaction: React dashboard continuously updates processed data as charting in real-time. A built-in conversational interface is aimed to be used as guidance and triage.

## IV. Implementation and Analysis Of Results

The design of the IoMT health monitoring system prototype was adequately tested, and it confirmed its overall end-to-end functionality and offered essential insights.

### A. Hardware and Data Acquisition

To begin with we ensured that our hardware is sound. The NodeMCU ESP32 was compatible with the MAX30102 and DB18B20 sensors, and it was fairly reliable in receiving a continuous stream of data on the heart rate, SpO2, and temperature. Our sample readings reproducibly obtained were consistent and true and indicated that the fundamental data acquisition component of our system is healthy and prepared.

TABLE I: READINGS FROM HEALTH SENSORS

| *Reading No.* | *Temperature (°C)* | *Heart Rate (BPM)* | *$SpO_2$ (%)* |
|---|---|---|---|
| 1 | 37.29 | 89 | 95 |
| 2 | 36.74 | 65 | 97 |
| 3 | 37.41 | 73 | 98 |
| 4 | 36.88 | 95 | 99 |
| 5 | 36.85 | 89 | 99 |
| 6 | 37.01 | 75 | 98 |
| 7 | 36.98 | 77 | 98 |
| 8 | 37.13 | 72 | 95 |
| 9 | 37.10 | 88 | 96 |
| 10 | 36.64 | 91 | 95 |

### B. Real-time Data Graphs

Visualizations that are user-friendly are important in identifying abnormality in the trends of health data quickly and identify deviation to trends to then implement a prompt clinical or patient self-management response. The implementation is an effective way of showing that this system is effective in tracking longitudinal trends, and alerts based on abnormality.


Figure 3: Real Time Graphs from the Sensor Data

### C. Hybrid Conversational Assistance Model

An adaptive conversational assistance & consultant chat were also implemented. The system was able to simply switch between the FAQs, RAG & LLM-Model based on the user requirement, and reducing the exploitation of a single resource. A consultant chat support (socket.io) was also added, which provides two-way health assistance, based on the user requirements.

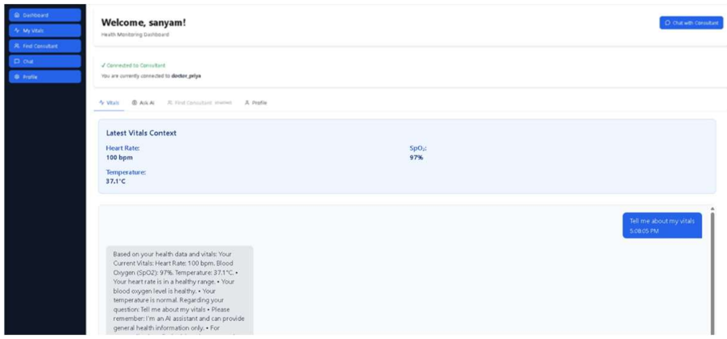


Figure 4: Conversational Dashboard Overview

## V. Conclusion

The given paper provided a general end-to-end IoMT model of efficient patient monitoring and managed to provide a viable alternative to the usual episodic healthcare provision. Because of this reason, a low-cost multi-layered system that was able to record critical physiological signals reliably was designed, developed, and empirically validated. We confirmed the hybrid architecture which considers the low-latency local and edge-based pre-processing of biosignals and securely storing them in the cloud database. The fidelity and stability of the low-cost hardware stack (NodeMCU ESP8266, MAX30102, DS18B20) was confirmed with the help of empirical testing, which indicated the ability to continuously acquire data. This data pipeline was effective and provided almost real-time visualization of data on a responsive React-based dashboard, which validated the feasibility of the system as a live monitoring and trend analysis system. It is worth noting that the prototype indicated the significance of user-centered design, which demonstrated that even a lightweight, responsive, and intuitive interface is a necessary requirement to guarantee a true clinical interpretability and useful self-management of the patient. Altogether, the given project represents a viable, proven design of available IoMT implementation that can satisfy fundamental needs in relation to real-time functionality and usability. This system's transition into a more matured platform, can help patients to save time and money by reducing their travel time and making routine check-up more cost friendly, particular if they live in non-metro cities, sub-urban cities or rural areas, with an adaptive hybrid conversational model providing guidance based on general biological facts and clinical guidelines around their biomedical data and daily lifestyle.

## References


[1] A. D. H. Al-Mugheed and N. A. Bayaga, "From periodic to continuous: A systematic review of remote patient monitoring architectures and applications," IEEE Access, vol. 9, pp. 154562– 154583, 2021.

[2] S. A. G. S. Bhatti, "The role of the internet of medical things (IoMT) in the provision of telemedicine and remote patient monitoring services," Journal of Medical Systems, vol. 46, no. 10, p. 74, Sep. 2022.

[3] A. T. Asyhari and M. H. H. Adnan, "An ESP32-based Health Monitoring System for Realtime Data Acquisition and Analysis," 2021 IEEE 11th Annual Computing and Communication Workshop and Conference (CCWC), NV, USA, 2021, pp. 0586-0591.

[4] S. Tuli, N. Tuli, S. Wander, and M. S. Gill, "HealthFog: An ensemble deep learning based Smart Healthcare System for Automatic Diagnosis of Heart Diseases in integrated IoT and fog computing environments," Future Generation Computer Systems, vol. 104, pp. 187-200, Mar. 2020.

[5] L. D. R. Goyal and N. S. Gill, "Empowering patients through interactive dashboards for remote health monitoring: A usability study," Health Informatics Journal, vol. 27, no. 1, p. 146045822199047, Jan. 2021.

[6] L. L. R. K. Nadikattu, "The crucial role of conversational AI in healthcare," International Journal of Engineering and Management Research, vol. 10, no. 6, pp. 78-86, Dec. 2020.

[7] R. M. El-Hady and M. F. Abdel-Fattah, "Internet of Medical Things (IoMT): A review of security and privacy strategies, challenges and future prospects," Journal of King Saud University - Computer and Information Sciences, vol. 35, no. 8, Part A, pp. 58-75, Sep. 2023.

[8] S. H. S. Arshad, M. A. M. Azmi, N. E. A. Khalid, N. F. M. Azmi, and N. M. Z. Hashim, "Internet of Medical Things (IoMT): A review of architectural approaches, security and privacy issues," IOP Conference Series: Materials Science and Engineering, vol. 1092, no. 1, p. 012040, Mar. 2021.

[9] M. A. Mohammed, K. H. Abdulkareem, S. A. Al-Waisy, S. A. Mostafa, M. Al-Andoli, S. A. Khaleefah, and A. A. Ibrahim, "A review of the internet of things (IoT) and its applications in the smart city," Journal of Advances in Vehicular Systems, vol. 2020, Article ID 6568245, 2020.

[10] M. S. Islam, M. S. Islam, M. R. Karim, and M. R. Islam, "IoT-based health monitoring system using ESP32," Journal of Electrical and Computer Engineering, vol. 2021, Article ID 5519532, 2021.
[11] A. Anjum, N. U. R. Khan, and M. A. Usman, "A wearable multi-sensor armband for realtime stress monitoring," IEEE Sensors Journal, vol. 22, no. 14, pp. 14467-14476, Jul. 2022.
[12] A. Al-Naji, S. M. Ali, and J. A. Chahl, "A machine learning approach for personalized patient risk stratification in remote health monitoring," Journal of Medical Systems, vol. 47, no. 1, p. 34, Mar. 2023.
[13] P. K. Singh, P. K. Sharma, and D. S. Kim, "A lightweight and secure authentication scheme for IoT-based healthcare," IEEE Access, vol. 8, pp. 229670-229683, 2020.
[14] Kalra, A., & Chhokar, R. L. (2016, September). A Hybrid approach using sobel and canny operator for digital image edge detection. In 2016 international conference on microelectronics and telecommunication engineering (ICMETE) (pp. 305-310). IEEE.
[15] Negi, P. S., Garg, A., & Lal, R. (2020, January). Intrusion detection and prevention using honeypot network for cloud security. In 2020 10th International Conference on Cloud Computing, Data Science & Engineering (Confluence) (pp. 129-132). IEEE.
[16] Pathak, S., Aggarwal, H., Sharma, L., & Lal, R. (2025, April). Semantic vector space model for text classification using progressive learning network algorithm. In AIP Conference Proceedings (Vol. 3283, No. 1, p. 040030). AIP Publishing LLC.
[17] Rizvi, N. H., Sharma, A., Panesar, A., & Lal, R. (2024, March). Analysing Various CNNs for Image Caption Generation. In International Conference on Innovations in Cybersecurity and Data Science Proceedings of ICICDS (pp. 651-659). Singapore: Springer Nature Singapore.
[18] Lal, R., & Sharma, S. K. (2023, August). Recommender Process Based on Trust-Distrust Factor for Signed Social Networks. In International conference on soft computing for problem solving (pp. 225-235). Singapore: Springer Nature Singapore.
[19] Dargan, J., Puri, A., & Lal, R. (2022). Security and privacy in cloud-/edge-/fog-based schemes. In Blockchain Applications for Healthcare Informatics (pp. 351-371). Academic Press.
[20] Negi, P.S., Pawar, R., Lal, R.: Vision-based real-time human–computer interaction on hand gesture recognition. In: Micro-Electronics and Telecommunication Engineering: Proceedings of 3rd ICMETE, pp. 499–507 (2020).
[21] MAX30100: Pulse Oximeter and Heart-Rate Sensor IC for Wearable Health Data Sheet (Rev.0)
[22] DS18B20: Programmable Resolution 1-Wire Digital Thermometer Data Sheet (Rev.6)