



أسبوع المستقبل الدولي الرابع للاستدامة
4th International Al-Mustaqbal
Sustainability Week 2026



Secure and Efficient Remote Healthcare: A Lightweight Blockchain and Fog-Enabled Patient Monitoring System

Supervisor

Assist. Prof. Dr. Saad Mutashar

Students

- Wisam Ali Nuri
- Ghadir Ashraf Jalil
- Hussein Ali Jassem
- Saif Marwan Abdel Wahab
- Atheer Hassan Mar'i
- Hussein Karim Rakan
- Ali Bassam Hussein

SDGs



Abstract

This study proposes a novel patient monitoring system leveraging fog computing and blockchain technology to address limitations of traditional cloud-based approaches. The system utilizes an ESP32 microcontroller with biomedical sensors for vital sign tracking and transmits data to a fog node for real-time visualization and analysis.

Intelligent event detection, such as fall recognition, is facilitated by simulated accelerometer data. A private blockchain module ensures data integrity through SHA-256 hashing, providing tamper-proof audit trails. Evaluations demonstrate significant performance improvements over cloud-only systems, including reduced latency, bandwidth usage, and enhanced security. The framework's scalability and cost-effectiveness make it a promising solution for advancing real-time digital healthcare services.

Methods & Design

1. System Architecture

- Four-layer architecture:
 - **Patient Layer:** ESP32 microcontroller with biomedical sensors (heart rate, temperature, accelerometer).
 - **Fog Layer:** Local fog node for real-time data processing, visualization, and event detection (e.g., fall).
 - **Blockchain Layer:** Private blockchain using SHA-256 hashing to ensure data integrity and tamper-proof audit trails.
 - **Cloud Layer:** Optional long-term storage and backup.

2. Workflow

1. Sensors capture vital signs and movement data.
2. ESP32 transmits data to the fog node via MQTT/HTTP.
3. Fog node processes data in real time:
 - Displays health metrics on a local dashboard.
 - Detects anomalies (fall, abnormal vitals).
4. Hash of each data record is stored on the private blockchain.
5. Alerts are sent to caregivers if an event is detected.
6. All transactions are logged immutably for auditing.

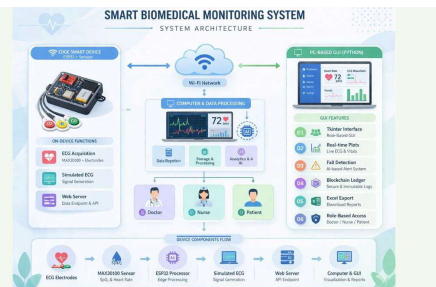
Results

- **Latency:** Reduced from 300–500 ms (cloud-only) to 50–100 ms with fog processing.
- **Bandwidth Usage:** Decreased by approximately 40% due to local data filtering and processing at the fog node.
- **Event Detection Delay:** Improved from >2 seconds to <0.5 seconds, enabling faster emergency responses.
- **Data Integrity:** Achieved tamper-proof audit trails via SHA-256 hashing on a private blockchain, eliminating the risks of centralized data storage.



Discussion

- **Low latency & real-time response** via fog computing, ideal for emergencies like fall detection.
- **Bandwidth efficiency** through local processing, reducing cloud dependency and costs.
- **Security & trust** with private blockchain ensuring data integrity and immutable audit trails.
- **Scalability** via modular fog nodes deployable across locations.
- **Limitations:** Simulated sensor data used; real-world validation needed. Blockchain overhead may grow; lightweight consensus could be explored.
- **Comparison:** Outperforms cloud-only models in latency and bandwidth, extending prior work (Quy et al., 2022).



References

1. Quy, V.K., Hau, N.V., Anh, D.V. et al. Smart healthcare IoT applications based on fog computing: architecture, applications and challenges. *Complex Intell. Syst.* 8, 3805–3815 (2022).
2. Mahmud, R., Ramamohanarao, K., & Buyya, R. (2020). Latency-aware application module management for fog computing environments. *ACM Transactions on Internet Technology*, Vol. 19, No. 1, Article 9. Publication date: November 2018.
3. Ana Reyna, Cristian Martín, Jaime Chen, Enrique Soler, Manuel Díaz, On blockchain and its integration with IoT

