

AI-IOT Powered CVD Prediction System

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Abstract -The CARE - Health Monitoring Portal is an integrated IoT-based healthcare solution designed to bridge the gap between real-time patient monitoring and clinical intervention. Built on a modern React/Vite frontend and a Firebase serverless backend, the system provides a robust platform for tracking vital signs and managing patient care. The core of the system utilizes an ESP32 microcontroller interfaced with an AD8232 ECG sensor to capture heart electrical activity, which is pushed directly to a real-time Firestore database. The application features dual-role access: patients can monitor their own health metrics and medication schedules, while doctors benefit from a centralized administrative dashboard featuring React-Leaflet maps for geospatial tracking of patient status and nearby hospital infrastructure. By automating data collection and providing instant visualization, CARE reduces response times for critical health events and streamlines medication adherence.

Index Terms— IoT-Based Healthcare, Real-Time Health Monitoring, ESP32, AD8232 ECG Sensor, Firebase, React Dashboard, Patient Monitoring System, Telemedicine

1. INTRODUCTION

In the contemporary healthcare landscape, the demand for remote monitoring systems has surged due to the increasing prevalence of chronic conditions and the need for decentralized care. The CARE Portal addresses these challenges by creating a seamless ecosystem where hardware sensors and web technologies converge. The system leverages the high-performance capabilities of the Vite build tool for the frontend, ensuring a fast and responsive user experience. Firebase serves as the backend infrastructure, providing secure authentication and a NoSQL database that supports real-time synchronization via WebSockets (onSnapshot). This allows for "Live" health tracking—where a heart rate spike detected by the ESP32 on a patient's wearable

device is reflected on a doctor's dashboard in milliseconds without requiring a page refresh. This project represents a comprehensive approach to modern telemedicine, combining hardware engineering, real-time database management, and interactive GIS (Geographic Information Systems) mapping

2. OBJECTIVES

The primary objectives of the CARE portal are:

1. To establish direct IoT integration between ESP32 and Firebase Firestore.
2. To implement secure role-based authentication for doctors and patients.
3. To provide real-time ECG monitoring and visualization dashboards.
4. To integrate geospatial mapping for patient and hospital tracking.
5. To implement automated daily medication tracking with reset functionality.

3. LITERATURE REVIEW

Recent advancements in Internet of Things (IoT), cloud computing, and web technologies have significantly influenced the healthcare sector. Many researchers have proposed remote health monitoring systems using wearable sensors and microcontrollers to continuously track patient vital parameters such as heart rate, temperature, and oxygen saturation.

IoT-based healthcare systems commonly use microcontrollers like ESP8266 or ESP32 integrated with biomedical sensors. These systems transmit physiological data to cloud platforms where doctors can monitor patients remotely. Cloud databases such as Firebase, AWS IoT, and ThingSpeak have been widely used for real-time data storage and visualization.

Several studies emphasize real-time monitoring using WebSockets and push-based communication rather than traditional pull-based systems. Modern web frameworks like React have also been adopted to build interactive dashboards for healthcare applications.

However, many existing systems focus either only on sensor monitoring or only on web-based dashboards. Few systems integrate IoT hardware, secure cloud authentication, real-time database synchronization, and geospatial visualization in a unified architecture.

The CARE Health Monitoring Portal addresses this gap by combining:

1. ESP32-based ECG sensing
2. Firebase real-time cloud services
3. Role-based authentication
4. React-based dashboards
5. Geospatial visualization using React-Leaflet

This integrated approach ensures real-time health tracking, secure access, and faster emergency response.

4.METHODOLOGY

The CARE Health Monitoring Portal follows a layered IoT architecture consisting of four layers:

- 1.Perception Layer (IoT Hardware)
- 2.Transport Layer (Network)
- 3.Service Layer (Cloud – Firebase)
- 4.Application Layer (React Web Portal)

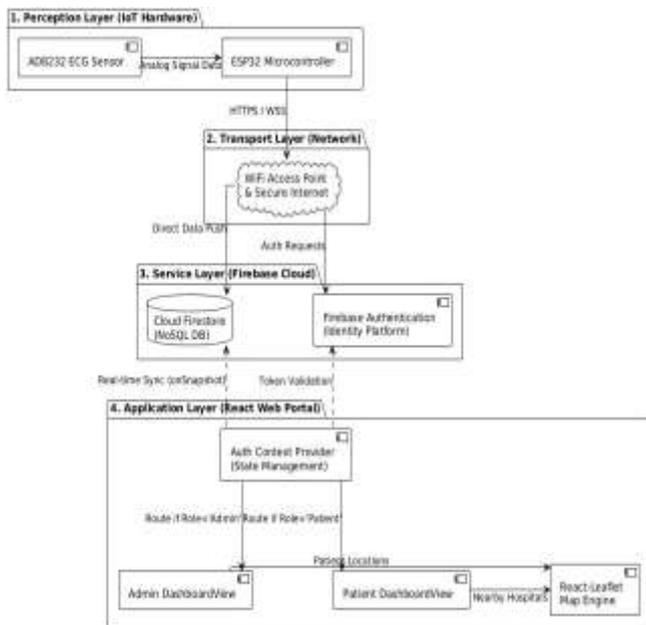


Fig. 1- System architecture

Step 1: Data Acquisition

The AD8232 ECG sensor captures heart electrical signals from the patient. These analog signals are sent to the ESP32 microcontroller.

Step 2: Data Processing

The ESP32 processes the ECG waveform, calculates heart rate, detects abnormal spikes, and converts analog signals into digital data.

Step 3: Data Transmission

Using WiFi, the ESP32 securely pushes processed data to Firebase Firestore via HTTPS.

Step 4: Cloud Processing

Firebase Authentication validates users and manages secure login sessions. Firestore stores ECG status, medication logs, and patient location data.

Step 5: Real-Time Synchronization

The React application uses Firestore onSnapshot listeners to receive live updates without refreshing the page.

Step 6: Visualization

The dashboard displays:

- I. ECG status
- II. Medication compliance
- III. Patient location on interactive map

This structured methodology ensures security, scalability, and real-time monitoring.

5.IMPLEMENTATION

The implementation of the CARE system is divided into hardware and software components.

1.Hardware Implementation

- i. AD8232 ECG sensor is connected to the ESP32 analog input pins.
- ii. ECG electrodes are attached to the patient’s body to capture heart signals.
- iii. ESP32 converts analog ECG signals into digital values.
- iv. WiFi module inside ESP32 connects to the internet and sends data to Firebase.

The ESP32 continuously monitors heart signals and updates status such as:

1. Normal
2. Elevated
3. Critical

2.Cloud Implementation (Firebase)

Firebase Authentication handles login and role verify.

Firestore database stores:

- 1) Patient profile
- 2) ECG status
- 3) Medication logs
- 4) Geo-location points

Real-time synchronization is implemented using Firestore's onSnapshot feature, ensuring live updates.

3.Web Application Implementation (React + Vite)

React Context API manages authentication state.

Role-based routing directs:

- i. Admin → Admin Dashboard
- ii. Patient → Patient Dashboard

Admin Dashboard:

- i. View all patients
- ii. Monitor critical alerts
- iii. View map with patient locations

Patient Dashboard:

- i. View personal ECG data
- ii. Track medication intake
- iii. Contact doctor

6.CONCLUSION

The CARE - Health Monitoring Portal successfully demonstrates the synergy between IoT hardware and modern cloud-native web applications. By utilizing the ESP32 and AD8232 ECG sensor, the system provides a continuous stream of vital health data directly to a Firebase Firestore backend, bypassing the need for complex intermediate servers. The implementation of a React/Vite frontend ensures that both doctors and patients have access to a high-performance, real-time interface for health management.

The project achieves its primary goal of reducing the latency between a critical health event and medical awareness. The integration of React-Leaflet adds a vital geospatial layer, transforming raw data into actionable insights by visualizing patient locations in relation to medical infrastructure. Ultimately, CARE serves as a

scalable prototype for future telemedicine platforms, prioritizing speed, data integrity, and user-centric design.

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