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Cloud of Things Scope Statement

Smart Health Monitoring System

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Chapter 1

Concept

The concept of this project is to design and implement a Smart Health Monitoring System based on Cloud of Things technologies. The system integrates IoT-enabled wearable sensors to continuously track vital signs such as heartbeat, body temperature, and blood pressure. Collected data is securely transmitted to the cloud, where it can be stored, processed, and made accessible to healthcare professionals and caregivers.

In addition to real-time monitoring, the project introduces an artificial intelligence component that enhances the system's ability to detect and predict critical health events. Two possible applications are considered:

- **Fall Detection:** Using computer vision and machine learning algorithms to detect when a patient falls, and automatically sending an alert with the patient's GPS location.
- **Heart Attack Prediction:** Leveraging monitored vital signs and predictive models to identify early indicators of heart attacks, triggering timely alerts and location sharing for rapid intervention.

By combining IoT, cloud technologies, and machine learning, this system aims to improve patient safety, provide continuous health insights, and enable rapid emergency response.

1.1 Problematic

Healthcare systems today face several challenges. Patients with chronic illnesses or conditions requiring continuous observation often lack access to reliable monitoring outside of clinical environments. Traditional solutions are expensive, limited in scope, and unable to provide real-time feedback to healthcare professionals.

Moreover, emergencies such as falls or heart attacks are often detected too late, delaying treatment and endangering patient lives. Medical staff are also burdened with increasing patient loads, making personalized monitoring difficult to maintain.

There is therefore a pressing need for smart systems that can continuously track vital signs, apply predictive models to anticipate emergencies, and immediately notify caregivers with accurate patient data and location.

1.2 Context of the Project

This project is situated at the intersection of Internet of Things (IoT), cloud computing, and artificial intelligence. Recent advances in wearable sensors and mobile connectivity make it possible to capture vital health data outside of hospitals. At the same time, cloud services provide the scalability, storage, and computational power necessary to process and analyze this data in real time.

The integration of machine learning into health monitoring opens the door to not only detecting anomalies but also predicting critical health conditions before they become life-threatening. Within this technological context, our project demonstrates how Cloud of Things can enable smarter, more responsive healthcare solutions.

1.3 Ambitions

The ambitions of this project are to:

- Improve patient safety and quality of life by enabling continuous, non-intrusive monitoring of vital signs.
- Provide healthcare professionals with timely, accurate, and actionable insights through cloud-based dashboards.
- Reduce the workload on medical staff by automating data collection and emergency alerts.
- Integrate GPS-enabled notifications to ensure rapid assistance in case of falls or cardiac emergencies.
- Explore the potential of machine learning in healthcare by implementing either a fall detection system or a heart attack prediction model, with the flexibility to evolve as the project progresses.

Through these ambitions, the project seeks to demonstrate how the combination of IoT, cloud, and AI technologies can transform traditional healthcare monitoring into a proactive, intelligent, and life-saving system.

Chapter 2

Target Audience

The Smart Health Monitoring System is intended for two main groups:

- **Healthcare professionals:** Doctors, nurses, and caregivers who require continuous access to accurate patient health data in order to provide timely diagnoses, interventions, and follow-up care.
- **Families with elderly members:** Individuals who want to ensure the safety and wellbeing of older relatives at home by monitoring their vital signs remotely and receiving immediate alerts in case of falls or health emergencies.

By addressing both professional and personal needs, the system provides a reliable solution for continuous health monitoring and emergency response.

Chapter 3

Equipment

The following equipment list is temporary and may evolve as the project progresses. It represents the initial hardware components considered for implementing the Smart Health Monitoring System.

Equipment	**Description**
ESP32-CAM / AI Camera	Used for image capture or AI-based monitoring tasks, and as a possible component for fall detection.
Raspberry Pi 4 / 5	Serves as the central processing and communication unit, handling sensor data aggregation and cloud connectivity.
MAX30100 (Heart Rate + SpO_2 Sensor)	Measures pulse rate and blood oxygen saturation levels in real time.
DS18B20 (Temperature Sensor)	Provides accurate body temperature measurements through wearable integration.
MPS20N0040D (Blood Pressure Sensor)	Monitors blood pressure levels, contributing to the detection of abnormal cardiovascular patterns.

Chapter 4

Functionalities

4.1 Sensor Data Acquisition

The system continuously collects vital health data using the integrated sensors. These include:

- Heart rate and blood oxygen levels via the MAX30100 sensor,
- Body temperature using the DS18B20 sensor,
- Blood pressure measurements with the MPS20N0040D sensor,
- Environmental and situational awareness through the AI camera (or ESP32-CAM),
- Optional motion detection using a PIR sensor to activate the camera only when needed.

The raw data is processed locally on the Raspberry Pi for efficiency, and transmitted securely to the backend for storage and analysis.

4.2 Mobile Application Development

A mobile application will be developed as a Progressive Web App (PWA) combined with a Single Page Application (SPA). This will serve as the main user dashboard for both healthcare professionals and families monitoring elders at home.

The app will provide the following functionalities:

- Real-time visualization of health vitals (heartbeat, SpO2, body temperature, blood pressure),
- Notifications and alerts in case of abnormal readings or critical events,
- GPS-based alert system in case of a fall detection or potential heart attack event,
- User-friendly interface accessible from smartphones, tablets, or desktop browsers without requiring installation.

4.3 Machine Learning Integration

Model Development

The goal is to develop a compact and efficient machine learning model tailored to analyze vital signs and/or video data from the ESP32-CAM (or AI CAM) and wearable sensors installed in a bracelet. Depending on the chosen approach, the model will perform:

- **Fall Detection:** Analyzing video or motion sensor data to automatically detect falls and trigger immediate alerts.
- **Heart Attack Prediction:** Using real-time vital sign data (heart rate, SpO2, blood pressure) to predict potential cardiac events and notify caregivers promptly.

The model will leverage lightweight architectures suitable for embedded devices or edge computing, ensuring real-time performance and reliable detection even with the limited resources of the ESP32-CAM or local processing unit.

MLOps Implementation

An MLOps pipeline will streamline the training, deployment, and monitoring of the predictive models. Key features include:

- **Automated Training and Deployment:** The MLOps framework will periodically train and update the model with new sensor data, deploying updates to ensure accurate predictions in real time.
- **Performance Monitoring:** Continuous monitoring will track the model's accuracy and detect performance drift, maintaining reliability for fall detection or heart attack prediction.
- **Alerts and Notifications:** Upon detecting a fall or a critical health event, the system will trigger immediate alerts to caregivers, including GPS location if available.
- **Data Management:** Secure data versioning and tracking will support model improvements while ensuring patient privacy and compliance with health data regulations.
- **Optimization and Feedback:** Ongoing model tuning, informed by user feedback and real-world usage, will refine prediction accuracy and optimize the performance for the limited resources of the local processing hardware.

This MLOps framework will maintain the efficiency, security, and adaptability of the health monitoring models, ensuring timely detection of emergencies and enhancing the overall safety of patients monitored at home.