Higher School of Communication of Tunis

Cloud of Things Scope Statement

Smart House Monitoring System

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1 Concept

In today's interconnected world, the concept of a "smart house" has gained significant traction. The Internet of Things (IoT) is transforming how people interact with their living environments, providing the ability to monitor, control, and automate various home functions from a distance. Smart home technology offers convenience, efficiency, and enhanced security, making homes safer and more responsive to the needs of their occupants.

This project introduces a comprehensive IoT-based smart house monitoring system, powered by a Raspberry Pi. The system is designed to oversee key household elements such as lighting, water usage, and security. By integrating sensors, alarms, and computer vision, the system aims to create a connected and intelligent home environment.

1.1 Problematic

The primary challenge addressed by this project is the lack of centralized home monitoring and security in many modern homes. Without a dedicated system to oversee utility usage and security, homeowners are often unable to detect unusual events—such as unauthorized intrusions—when away from home, leaving their property and belongings vulnerable.

1.2 Context of the Project

This smart house monitoring system targets homeowners who seek a practical and efficient solution for managing household resources and enhancing home security. It aims to utilize IoT technologies to create a responsive, automated, and user-friendly home environment.

1.3 Ambitions

1.3.1 Project Goal

The primary goal of this project is to develop a smart house monitoring system that allows homeowners to remotely monitor and control household conditions and security, providing peace of mind and resource efficiency.

1.3.2 Key Objectives

- **Resource Management:** Monitor household parameters, such as lighting and water usage, to promote efficient resource management.
- **Enhanced Security:** Use an integrated alarm system and computer vision to detect unauthorized persons when the homeowner is absent.
- **Location-Based Services (LBS):** Leverage LBS to avoid unnecessary notifications by activating alerts only when the homeowner is not within a designated proximity to the house.

By fulfilling these objectives, the system aims to provide an adaptable, cost-effective solution that enhances both convenience and security for homeowners.

2 Target Audience

This smart house monitoring system is perfect for homeowners who want smart tech in their living spaces. It provides remote security alerts, helps manage resources like water and electricity, and is ideal for landlords managing multiple properties. Easy to install in both new and existing homes, it meets the needs of those prioritizing security, convenience, and efficiency.

3 Equipment

After conducting research, we have identified the following elements as necessary for the smart home system:

Equipment	**Description**
Raspberry Pi 4 (8GB)	Central controller for managing sensor data and processing commands.
ESP32CAM	Provides computer vision for security monitoring.
DHT22 Temperature Sensors (2)	Measure indoor temperature and humidity.
Gas Sensor	Detects gas leaks or hazardous fumes.
Proximity Sensors (3)	Detect movement or presence around entry points.
Relays	Control high-power devices, such as lights and appliances.
LEDs	Visual indicators for system statuses and alerts.
RFID and Keypad	Secure access control for authorized users.
LCD Display	Shows real-time information for user reference.
Water Flow Sensors (3)	Monitor water usage in various areas.
Servo Motors	Control locks, blinds, or other movable parts.

Table 1: List of necessary equipment for the smart house monitoring system

4 Functionalities

4.1 Sensor Data Acquisition

The following sensors acquire and monitor key data within the home:

- **DHT22 Temperature Sensors:** Monitor indoor temperature and humidity levels.
- **Gas Sensor:** Detects hazardous gas levels for safety alerts.
- **Proximity Sensors:** Detect motion around entry points to enhance security.
- **Water Flow Sensors:** Track water usage to manage consumption.

- **RFID and Keypad:** Allow secure access control for authorized users.

4.2 Mobile App Development

A user-friendly mobile app developed with Progressive Web Application (PWA) technology provides cross-platform accessibility, allowing homeowners to remotely monitor and control home systems. **User Dashboard**

- Provides a centralized dashboard to view real-time sensor data and manage home functions.
- Displays vital information such as temperature, humidity, gas levels, water flow, and security status.
- Sends an alert notification if an unusual or unauthorized person is detected by the security system, allowing homeowners to take immediate action.

4.3 Machine learning integration

4.3.1 Model development

The goal is to develop a compact and efficient object detection model tailored to identify persons within live video feeds from an ESP32-CAM installed in the smart home environment. The model will perform person detection to enable automated alerts and responses when human presence is identified. Leveraging a lightweight architecture like YOLOv5, the model will balance accuracy and real-time performance, ensuring reliable detection even with the limited resources of the ESP32-CAM setup.

4.3.2 MLOps Implementation

An MLOps pipeline will streamline the ongoing training, deployment, and monitoring of the object detection model. Key features include:

- **Automated Training and Deployment:** The MLOps framework will periodically train and update the model with relevant data, deploying it to ensure real-time detection capabilities on the ESP32-CAM.
- **Performance Monitoring:** Automated monitoring will track the model's accuracy and detect performance drift, ensuring reliable person detection across different conditions.
- **Alerts and Notifications:** Upon detecting a person, the model will trigger alerts and predefined actions to enhance home security.
- **Data Management:** MLOps will support secure data versioning and tracking, aiding in model improvements while maintaining data privacy.

- **Optimization and Feedback:** Ongoing model tuning and user feedback will refine detection accuracy, optimizing the ESP32-CAM's limited resources for consistent, effective performance.

This MLOps framework will maintain the efficiency, security, and adaptability of the detection model, aligning with the smart home's automation and safety needs.

5 Technologies choice

To implement the various components of this smart home monitoring system, multiple technologies and frameworks will be utilized. These technologies are organized into three main categories: Backend, Middleware, and Frontend.

5.1 Backend

The backend of this system relies on several technologies to handle communication between IoT components, data storage, and data management:

- **MQTT (Message Queuing Telemetry Transport):**

  MQTT is a lightweight messaging protocol specifically designed for communication between Internet of Things (IoT) components. It uses a publish-subscribe model, requiring an MQTT broker to manage and route messages.

- **MongoDB:**

  MongoDB is a NoSQL, document-oriented database used for storing all project-related data. This includes sensor data as well as user information for the application.

- **HiveMQ:**

  HiveMQ is an MQTT broker optimized for IoT, enabling secure, real-time communication between devices in a smart home. It supports scalable data transfer, secure protocols (TLS/SSL), and efficient handling of sensor data, making it ideal for managing and routing information in your monitoring system.

5.2 Middleware

The middleware serves as a bridge between the backend and frontend, ensuring secure communication and efficient API management:

- **Jakarta Enterprise Edition:**

  Jakarta Enterprise Edition is a Java-based framework for developing APIs, enabling communication between multiple applications. Its high level of security makes it suitable for IoT projects, as it protects sensitive data and ensures secure interactions.

- **WildFly:**

  WildFly, formerly known as JBoss Application Server, is a lightweight, free, and open-source Java Enterprise Edition (Java EE) application server developed by Red Hat. Written in Java and released under the GNU LGPL license, it provides the necessary infrastructure for running Java-based web applications and can operate on any operating system with a Java Virtual Machine, making it ideal for managing and hosting our middleware layer.

5.3 Frontend

The frontend will be developed as a Progressive Web Application (PWA), allowing users to access the system seamlessly across various platforms. This includes:

- **Progressive Web Application (PWA):** The frontend will utilize PWA technologies to create a responsive and reliable user experience across mobile and desktop devices. This approach combines the best of web and mobile apps, ensuring fast loading times and offline capabilities.

5.4 Iot integration

- **Flogo:**

  Flogo is an open-source framework that provides a lightweight and easy-to-use platform for building microservices, particularly in IoT environments. It will be used to manage the flow of sensor data and facilitate data processing within the system.

6 Architecture

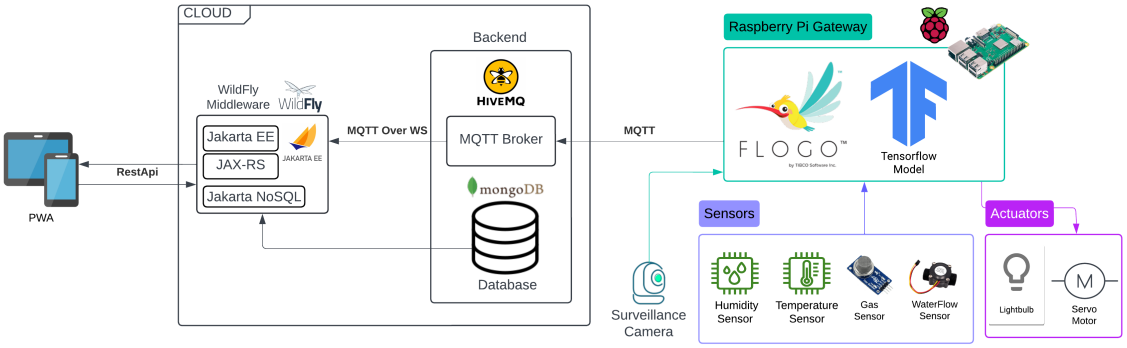

Figure 1: Architecture

The diagram above describes the main architecture of the Smart House Monitoring System which is mainly composed by Backend, Middleware and Frontend.

7 Timeline and tasks

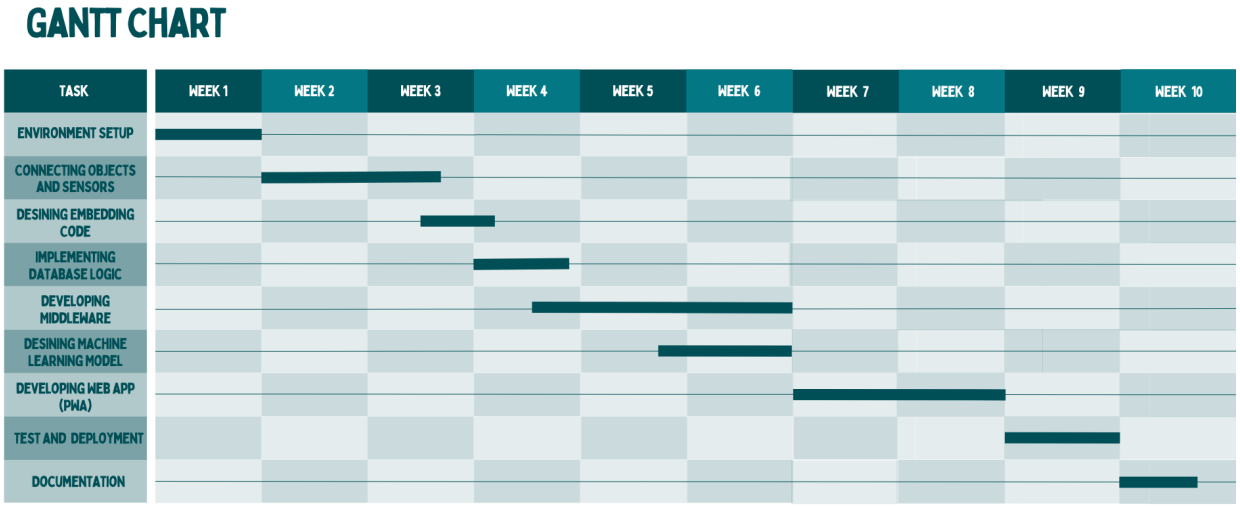

Figure 2: Gantt Diagram.

The Gantt diagram, which enables the project's progress to be graphically represented, is shown in the explanation above. It makes it possible to visually illustrate the project's progress and the length of each process.

8 Limitations

As we develop our smart house monitoring system, it's crucial to anticipate and address several potential challenges that may arise during implementation:

- **Internet Connectivity Interruptions:** The system relies on continuous internet connectivity for real-time monitoring and remote control. In cases of connectivity issues or outages, remote access and timely alerts for security or environmental changes may not be achievable.
- **Sensor Data Accuracy:** The accuracy of the system may be impacted by occasional false alarms or inaccuracies in sensor data, which could lead to unnecessary alerts or missed detections of critical events.
- **Proximity of IoT Devices:** The effectiveness of the system's data collection and identification may be affected if IoT devices are placed too closely. Nearby devices might interfere with each other's readings, potentially impacting data accuracy and responsiveness.
- **Sensor Placement and Thresholds:** Proper sensor placement and well-defined thresholds are critical to avoid misinterpretations. Inaccurate placement or incorrect

threshold settings for parameters like gas levels, water flow, or proximity detection may lead to false alarms or missed alerts.

- **Data Volume and Processing:** The system may need to handle and process significant volumes of data from multiple sensors and devices in real time. Efficient data processing is essential for maintaining system performance and ensuring prompt responses to critical events.

9 Business study

The Business Study section provides an overall view of our project's business model and marketing policy.

9.1 Business Model Canvas (BMC)

The Business Model Canvas serves as a visual representation of our project's main aspects, such as value proposition, customer segmentation, channels, cost structure, revenue stream, and more. The BMC is depicted in the figure below:

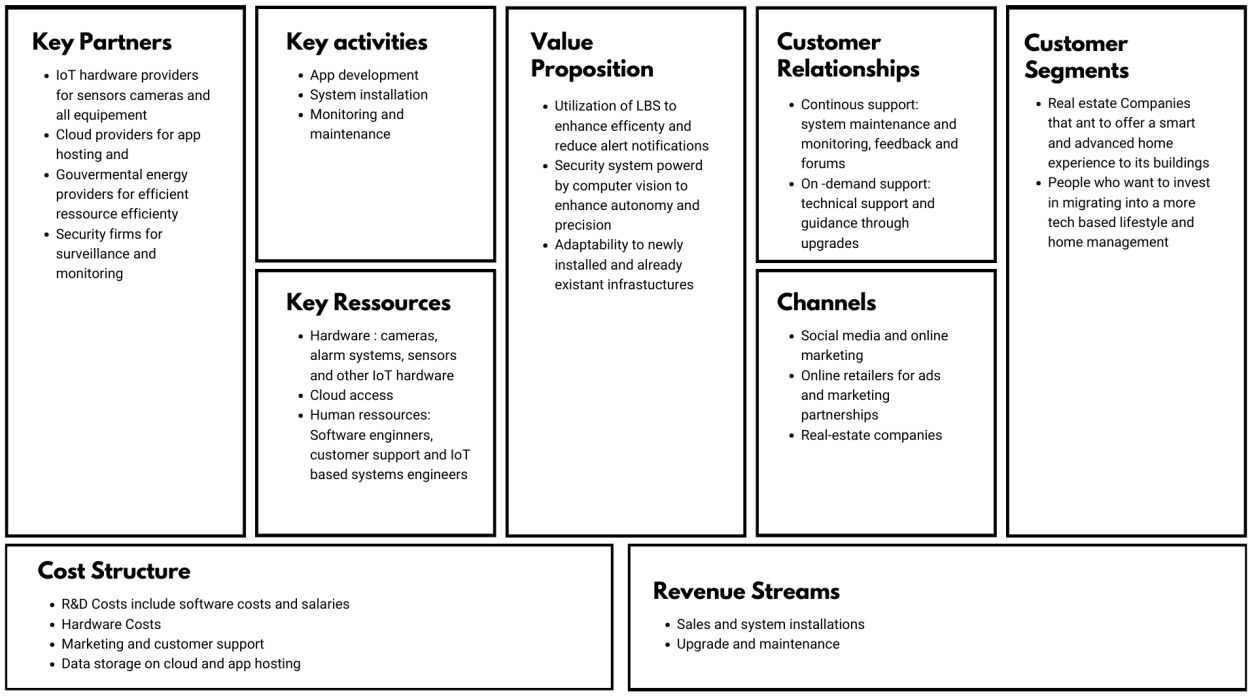

Figure 3: Business Model Canvas

9.2 SWOT Analysis

The SWOT analysis highlights the Smart House Monitoring System's strengths in affordability, functionality, and customization, making it appealing for tech-savvy homeowners. However, setup challenges for non-tech users may hinder adoption. With rising demand for eco-friendly home automation and potential partnerships, the project has strong growth prospects. Yet, it must navigate intense competition, privacy concerns, and security regulations to sustain its market position.

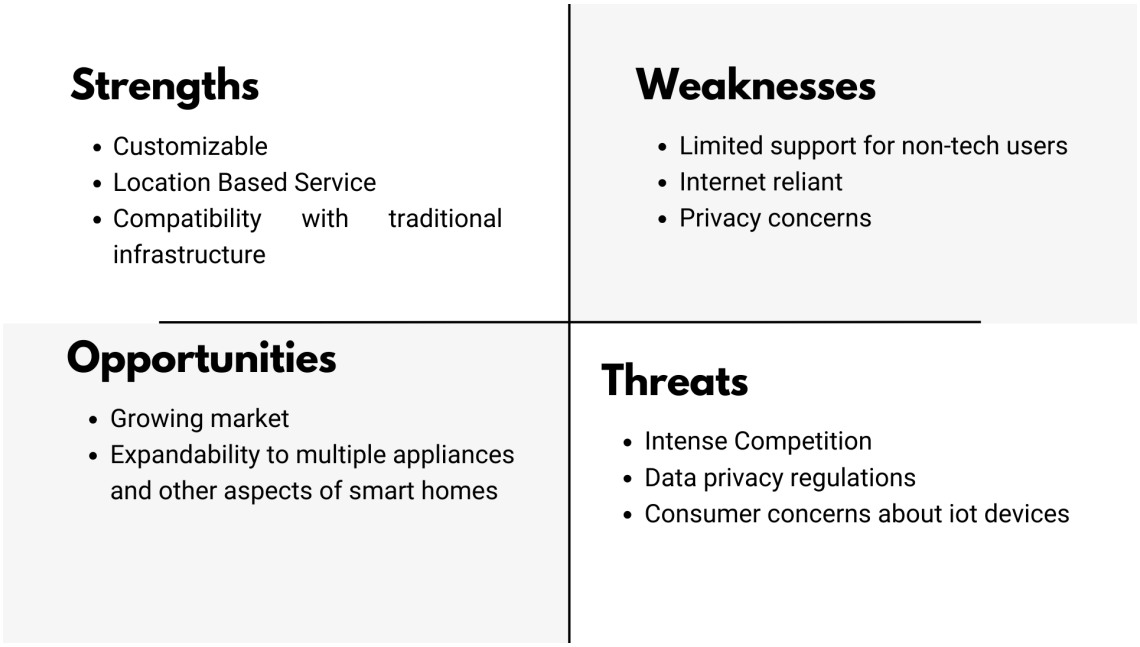

Figure 4: SWOT Analysis

9.3 Marketing policy

Our marketing policy is focused on delivering value to our customers while maintaining a strong market presence.

The 4P analysis positions this health monitoring system as a robust and user-friendly solution, utilizing IoT components for seamless health tracking. Its sophisticated features, such as Location-Based Services (LBS) and continual improvement through MLOps, make it ideal for both individual users and healthcare institutions. Competitive pricing and customizable packages, along with warranties and after-sales support, add value for users. Promotion leverages digital marketing, partnerships with healthcare providers, and collaborative advertising to maximize outreach, while a web and mobile platform ensures convenient access to health data, making it a practical and accessible choice in health monitoring.

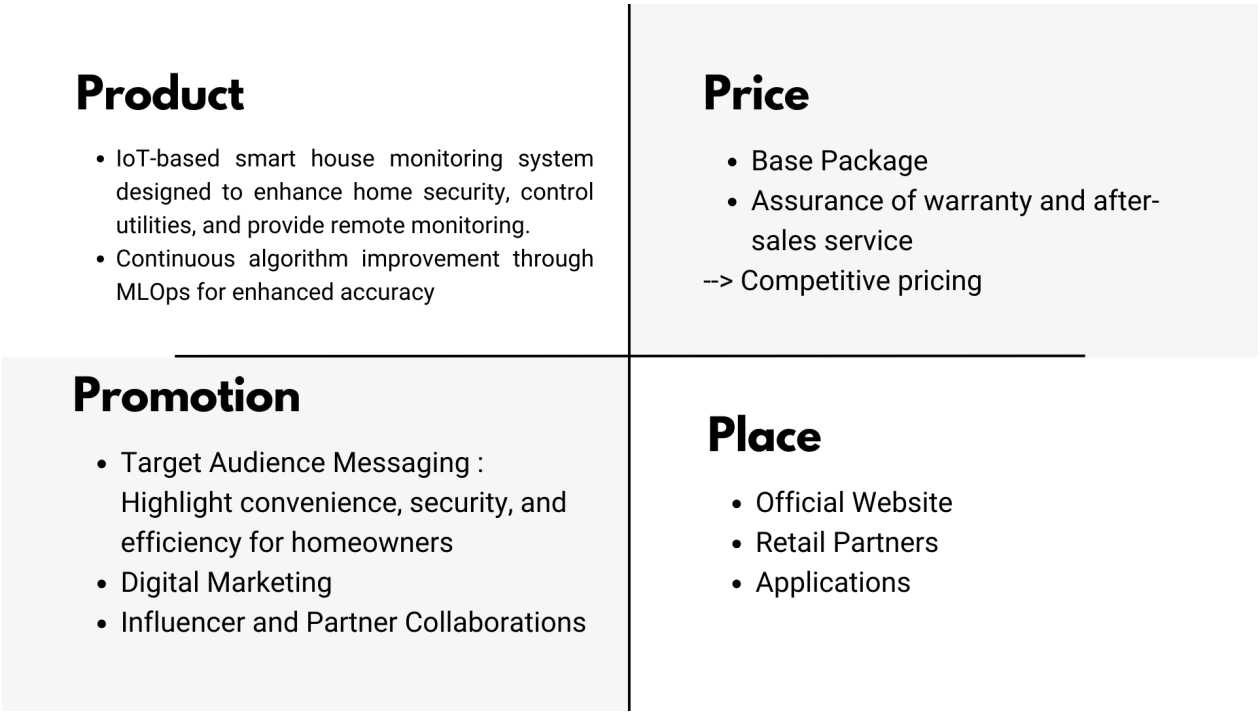

Figure 5: 4P Matrix

10 Constraints

The realization of all parts of the Smart House monitoring system must be achieved no later than 5 January 2025.

11 Deliverables

- Conceptual Document: This document presents in a detailed and structured manner the specifications and the services to be provided.
- Source code of the various project components on GitHub
- Technical documentation: A README.md file in GitHub detailing all the needed steps to launch the application.
- Prototype/simulation of the intelligent Smart House monitoring system.
- Demonstration Video: An mp4 format video that contains a demonstration of the proposed solution.