SE4IoT - SOFTWARE ENGINEERING FOR INTERNET OF THINGS

SMART HOME AUTOMATED CONTROL AND MONITORING SYSTEM

Github Repository:
https://github.com/Twiggiermaen21/Smart-Home-Automated-Control-And-Monitoring-System-IoT.git

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Introduction

Smart homes represent the next leap forward in how we live, blending technology and convenience to create intelligent, interconnected living spaces. At the heart of this innovation lies the ability to automate everyday tasks, making life more efficient, secure, and comfortable.

With smart home technologies, you can:

- Automate lighting that adjusts to your presence.
- Control heating systems that learn your ideal temperature.
- Enhance security with systems that monitor your home in real-time.

These features seamlessly respond to sensor data and your preferences, all while being managed effortlessly from your smartphone. Whether you're aiming for greater energy efficiency, enhanced safety, or a touch of futuristic convenience, smart homes offer endless possibilities to personalize your living environment and elevate your lifestyle.

Project Scope

This project focuses on developing a comprehensive IoT-enabled smart home system that integrates advanced components for lighting, heating/cooling, and security management. The aim is to deliver enhanced convenience, and safety for households while leveraging real-time monitoring, control, and automation.

Objective

- Develop and deploy an IoT-based smart home system that integrates lighting, heating/cooling, and security functionalities, ensuring a safe and comfortable living environment.
- Provide a user-friendly platform for homeowners to monitor and control their smart home systems remotely.

Project Deliverables

- **Installation of IoT Sensors:** Deploy sensors to monitor occupancy, light levels, temperature, humidity, air quality, and security across key areas of the home.
- **Real-Time Data Collection and Automation:** Enable continuous monitoring and automated responses for lighting, climate control, and security.
- **Automated Alerts:** Set up notifications for unusual activity, environmental hazards (e.g., smoke), or system anomalies.
- **User-Friendly Dashboard:** Provide an intuitive interface for homeowners to control devices, track energy usage, and review system performance remotely or on-site.

Exclusions

- Maintenance of Infrastructure: The project excludes maintenance or repairs of physical infrastructure, such as pipelines, HVAC systems, or building structures.

Potential Use Cases

Scenario 1: Evening Automation

- Lights turn on automatically at dusk and adjust brightness based on room occupancy.
- Heating adjusts to maintain a comfortable temperature based on the user's geofenced location.

Scenario 2: Vacation Mode

- Smart locks and sensors ensure the home is secure.
- Lights and blinds simulate occupancy for added security.

Scenario 3: Emergency Alerts

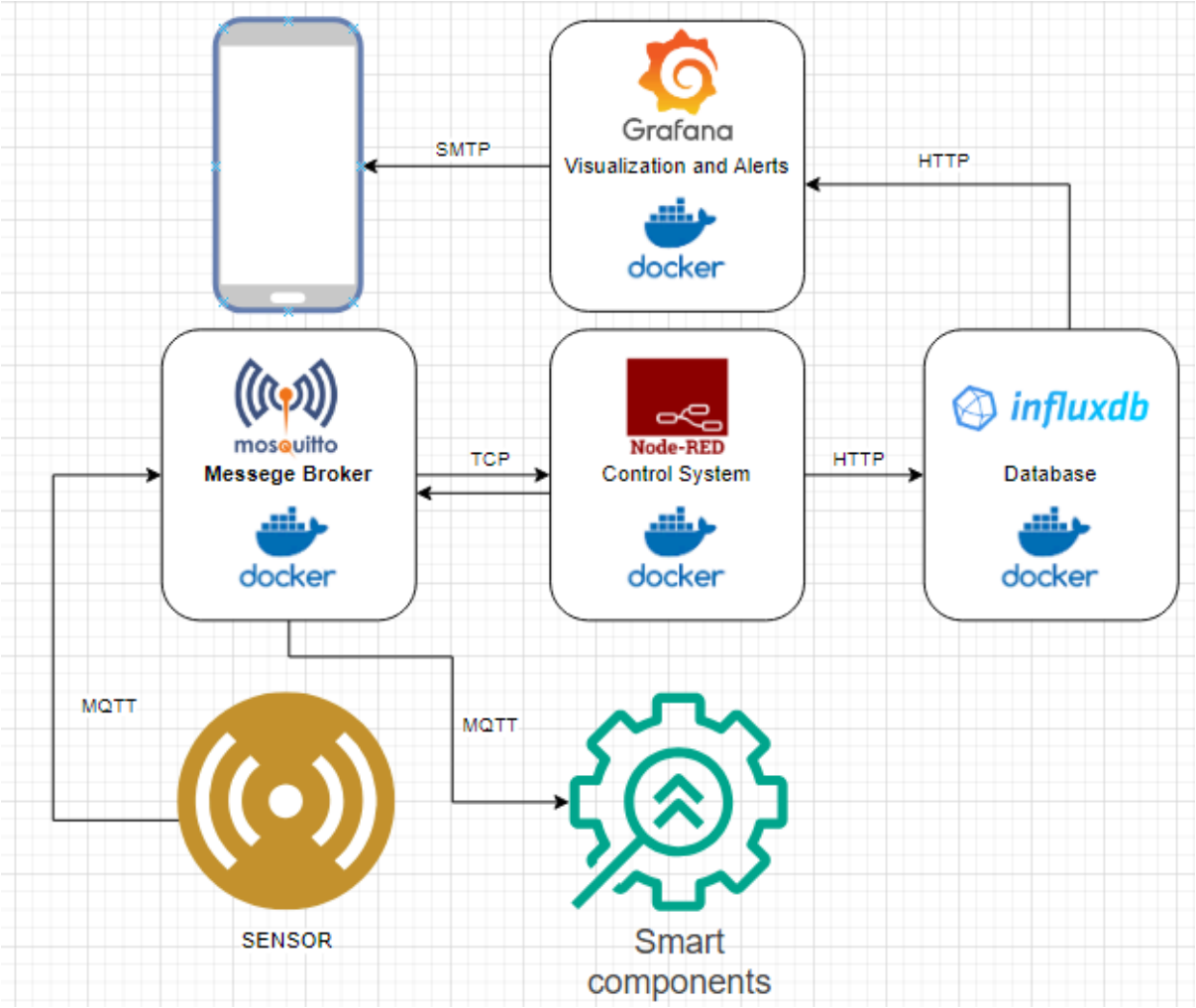
- Smoke detectors alert the homeowner and trigger safety protocols (e.g., unlock doors, turn on lights).
- Cameras stream live footage to assist in monitoring the situation.

Success Metrics

- Energy Efficiency: Reduction in energy bills due to optimized lighting and HVAC usage.
- Response Time: Time taken for alerts and automated responses during security or safety events.
- User Satisfaction: Positive feedback from homeowners regarding system usability and reliability.

System Architecture

The diagram below shows our IoT Smart Home Automated Control And Monitoring System.



Components of the Smart Home System

The system contains several types of sensors depending on the category it belongs to. Each sensor is going to sense data which are going to be used to work with the actuators. The smart components will perform actions depending on the thresholds and sensed values. Sensors are connected to the hubs which process the data and eventually communicate with the smart components.

Smart Lighting System

Sensor	**Function**	**Area**
Light sensor	Measures the amount of light outside of the house	Outside
Occupancy sensor	Detects room presence	Every room

Heating and Cooling System

Sensor	**Function**	**Area**
Humidity sensor	Tracks humidity levels to adjust air conditioning or dehumidifiers	Every room
Occupancy sensor	Detects room presence	Every room
Temperature sensor	Measures indoor/outdoor temperature for climate control	Inside/outside
Air quality sensor	Monitors levels of pollutants like CO2 or VOCs	Every room

Smart Security System

Sensor	Function	Area
Smoke detector	Detects smoke for early fire warning	Every room
Motion sensor	Detects movement at the main entrance	Main entrance
Carbon monoxide sensor	Detects dangerous levels of carbon monoxide	Kitchen

Smart components

Smart component	Function
Electric window blinds	Automatically adjust blinds to manage sunlight, reduce glare or maintain privacy based on the outside light
Dehumidifier	Activates when indoor humidity exceeds a preset threshold to maintain comfort and prevent mold growth
Smart boiler	Remote monitoring and scheduling of water/space heating
Smart light bulbs, LED strips	Controls brightness, color and mood of the lighting
Camera	Streams live video or recognizes faces to enhance security. Can also alert when unusual activity occurs
Electric window opener	Opens or closes windows based on the air quality or the carbon monoxide levels
Radiators and floor heaters	Heats the house to maintain comfort
Air conditioner	Cools the rooms based on the temperature and humidity data.

Software

1. Database Management
    - Purpose: To store and manage data collected from sensors, devices, and user inputs.
    - Responsibilities:
        - Collecting sensor data (e.g., temperature, humidity, motion) for historical analysis.
        - Storing user preferences, schedules, and system configurations.
        - Maintaining event logs for security-related activities (e.g., door openings, motion detection).
2. Visualization Dashboard
    - Purpose: To provide users with tools to monitor, control, and configure smart home systems.
    - Responsibilities:
        - Displaying real-time data, such as temperature, light levels.
        - Allowing users to adjust settings (e.g., light brightness, thermostat temperature, security alarms).
    - Visualizing trends and analytics, such as energy consumption patterns or air quality over time.

3. Data Processing
    - Purpose: To analyze raw data from sensors and generate actionable insights or automated actions.
    - Responsibilities:
        - Real-time data processing (e.g., motion detection, temperature thresholds).
        - Applying algorithms to learn user habits (e.g., optimal temperature or lighting patterns).
        - Predicting conditions based on historical data, such as detecting anomalies in security.
4. Control Software
    - Purpose: To send commands to smart devices in response to user actions, schedules, or automated triggers.
    - Responsibilities:
        - Communicating with IoT devices using protocols like MQTT or HTTP REST API.
        - Ensuring commands are executed correctly (e.g., turning on lights, adjusting temperature).
        - Managing fallback mechanisms in case of device communication issues.
5. Notification and Alert System

- Purpose: To inform users about significant events or anomalies in the smart home.
- Responsibilities:

- Sending alerts for security threats (e.g., door/window opening).
- Warning about risks (e.g., smoke detection, high CO levels, water leaks).
- Providing routine updates (e.g., maintenance reminders, energy-saving tips).

Functional Requirements

1. **Data Collection:**
   IoT sensors monitor various environmental parameters and system states, such as room temperature, motion, light intensity, and air quality.
2. **Data Transmission:**
   Sensor data is transmitted to a central hub or cloud platform using IoT communication protocols like Zigbee, Z-Wave, Wi-Fi, or Bluetooth.
3. **Data Processing:**
   A middleware processes the data to enable automation, such as adjusting heating based on occupancy or dimming lights according to ambient brightness.
4. **Notifications:**
   Alerts and notifications are sent to homeowners for events such as security breaches, fire alarms, or abnormal temperature or humidity levels.
5. **Visualization:**
   A comprehensive dashboard allows users to view real-time and historical data about lighting, heating, cooling, and security systems, with options for trend analysis and usage insights.
6. **Control Signals:**
   Commands are sent from the system to devices such as smart thermostats, cameras, locks, or lights to execute automated actions or user-defined instructions.

Non-Functional Requirements

1. **Performance:**
   The system must ensure near-instant response for critical functions like security alerts and lighting control, with latency below 1 second for key operations.
2. **Scalability:**
   Capable of integrating multiple devices and sensors across large homes or commercial properties, with support for additional components as needed.
3. **Reliability:**
   The system is built to be highly dependable, ensuring smooth operation almost all the time. Backup mechanisms are included to maintain functionality during power or network interruptions, providing continuous and reliable performance.
4. **Security:**
   Ensure strong encryption and secure communication between devices and the platform to prevent unauthorized access or data breaches.
5. **Energy Efficiency:**
   Use low-power IoT devices and optimize automation algorithms to reduce energy consumption and extend battery life.

6. **User-Friendly Design:**
   Provide intuitive interfaces on mobile apps and dashboards, ensuring accessibility for users of varying technical proficiency.
7. **Compliance:**
   Adhere to local and international safety and security standards for home automation systems.

REFERENCES

1. https://www.techtarget.com/iotagenda/definition/smart-home-or-building
2. https://www.customcontrols.co.uk/blog/benefits-smart-home-system/