IoT based Temperature and Humidity monitoring Device with Location Tracking using AWS

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***Abstract*—The purpose of this project is to develop an Internet of Things (IoT) device capable of monitoring and transmitting crucial environmental data during the transportation of sensitive goods such as food and medicine. The device incorporates sensors for measuring humidity and temperature using the DHT22 sensor, light intensity using the LM393 sensor, and location information through the GPS Neo 6m module. The gathered data is then sent to the AWS IoT Core using the ESP32 microcontroller. The information is stored in AWS IoT Timestream for historical analysis, and real-time visualization is achieved through Grafana. Additionally, the project integrates a SIM800L module to receive sensor data via SMS.**

Keywords—Internet of Things, Environmental Monitoring, Real-time Data Visualization, AWS

I. Introduction

The escalating demand for the secure and efficient transportation of perishable goods, particularly food and medicine, has prompted the development of sophisticated monitoring systems. This paper introduces an innovative Internet of Things (IoT)-based Environmental Monitoring System tailored for the specific challenges posed by the transportation of sensitive goods. The primary focus is on integrating advanced sensors, including DHT22 for humidity and temperature, LM393 for light intensity, and GPS Neo 6m for location tracking, into a comprehensive solution. The system leverages the ESP32 microcontroller for data processing and communication, facilitating secure transmission to the AWS IoT Core. The gathered data is stored in AWS IoT Timestream for historical analysis, and real-time visualization is achieved through Grafana. Additionally, the integration of the SIM800L module enables data reception through SMS, providing an additional layer of communication in areas with limited network connectivity. This paper outlines the architecture, sensor integration, communication protocols, and experimental results of the developed system, showcasing its applicability in ensuring the integrity of transported goods and opening avenues for further enhancements in the field of IoT-based environmental monitoring.

II. System Architecture

The IoT-based Environmental Monitoring System is meticulously designed to provide comprehensive and reliable monitoring of environmental conditions during the transportation of perishable goods. The architecture is modular and integrates seamlessly with various sensors, communication modules, and cloud services. The key components include:

A. Sensors:

- DHT22: Measures humidity and temperature levels within the transportation container.
- LM393: Monitors light intensity to assess the exposure of sensitive goods to light.
- GPS Neo 6m: Provides accurate location data, ensuring real-time tracking of the transportation route.

B. Microcontroller:

ESP32: Serves as the central processing unit for the IoT device, responsible for collecting, processing, and transmitting sensor data. It also manages the communication protocols with both the AWS IoT Core and the SIM800L module.

C. Communicatoin Protocols:

- MQTT (Message Queuing Telemetry Transport): Facilitates secure communication between the ESP32 and the AWS IoT Core. This ensures real-time transmission of environmental data to the cloud for storage and analysis.
- SMS (Short Message Service): Implemented through the SIM800L module, enabling bidirectional communication with the IoT device using mobile devices equipped with GSM capabilities.

D. Cloud Services:

- AWS IoT Core: Acts as the central hub for securely managing communication between the IoT device and the cloud. It subscribes to MQTT topics, receives data from the ESP32, and ensures reliable data transmission.
- AWS IoT Timestream: Stores time-series data for historical analysis, providing a robust platform for long-term environmental monitoring.

E. Data Visualization:

Grafana: Enables real-time visualization of the collected data. Grafana fetches information from AWS IoT Timestream, presenting it in a user-friendly and customizable dashboard for monitoring and analysis.

F. SMS Interaction:

SIM800L Module: Enhances communication capabilities by allowing data reception through SMS. Mobile devices can send SMS commands to the IoT device, enabling remote control and monitoring.

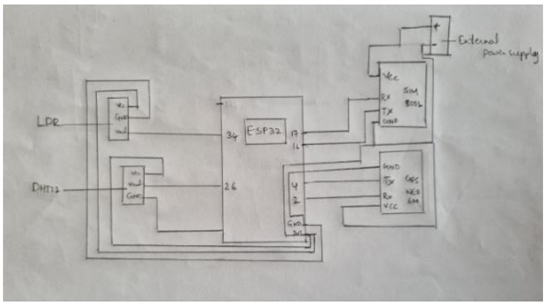
G. Application-Specific Modules:

The system is tailored for use in food and medicine transportation containers, ensuring that the monitoring parameters are finely tuned to the specific requirements of these sensitive goods.

This modular and scalable architecture allows for easy integration of additional sensors or features, making it adaptable to diverse applications within the realm of environmental monitoring in logistics and transportation. The seamless interaction between the hardware components, communication protocols, and cloud services forms the backbone of a robust and reliable IoT-based Environmental Monitoring System.

III. SENSOR INEGRATION

The integration of advanced sensors is a pivotal aspect of the IoT-based Environmental Monitoring System, ensuring accurate and real-time data acquisition to guarantee the safe transportation of sensitive goods.



A. DHT22 Sensor(Temperature and Humidity):

The DHT22 sensor plays a critical role in monitoring the humidity and temperature conditions within the transportation container. Integrated with the ESP32 microcontroller, the DHT22 sensor provides precise readings, which are then processed for transmission to the AWS IoT Core. This sensor's capability to operate within a wide range of environmental conditions makes it a reliable choice for assessing the ambient climate of the container.

B. LM393 Sensor(Light intensity)

The LM393 sensor is employed to gauge light intensity within the transportation container, ensuring that light-sensitive goods, such as pharmaceuticals, remain shielded from potentially damaging exposure. The sensor output is processed by the ESP32, and the data is incorporated into the MQTT communication protocol for transmission to the AWS IoT Core. This integration enables real-time monitoring and analysis of light conditions during transit.

C. GPS Neo 6M(Location Tracking)

For accurate real-time tracking of the transportation route, the GPS Neo 6m module provides precise location data. Integrated with the ESP32, the GPS module continuously updates the device's location, allowing for detailed route mapping and monitoring. The location data is crucial for assessing the impact of environmental conditions on goods during various stages of transit.

D.Esp32 Microcontroller

Serving as the central processing unit, the ESP32 microcontroller orchestrates the integration of sensor data. It collects, processes, and formats the information from the DHT22, LM393, and GPS Neo 6m sensors for transmission to the AWS IoT Core. The microcontroller's versatility allows for seamless communication with both MQTT and SMS, providing a comprehensive platform for data exchange.

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IV. COMMNICATION PORTOCOL

The communication paradigm within the IoT-based Environmental Monitoring System is designed for optimal efficiency and reliability. Two distinct channels have been established for seamless data transmission - MQTT for communication with the AWS IoT Core and SMS for mobile interactions.

A. MQTT Communication:

MQTT (Message Queuing Telemetry Transport) is employed for the communication between the ESP32 microcontroller and the AWS IoT Core. This lightweight and efficient protocol ensure reliable data exchange in real-time.

The ESP32 subscribes to specific MQTT topics hosted on the AWS IoT Core, facilitating the secure transmission of sensor data. Topics are organized hierarchically to streamline data flow and enhance system scalability.

Authentication and encryption mechanisms are implemented to safeguard the integrity and confidentiality of the transmitted data, adhering to the stringent security requirements of IoT applications.

B. SMS Communication:

The integration of the SIM800L module extends the system's communication capabilities by enabling data reception through SMS.

Mobile devices equipped with GSM capabilities can interact with the IoT device by sending SMS commands. These commands trigger specific responses, such as requesting the current environmental data or configuring system parameters.

The bidirectional nature of SMS communication provides an additional layer of reliability, ensuring that critical information can be transmitted even in areas with limited network connectivity.

This dual-channel communication strategy not only ensures robust connectivity but also enhances the versatility of the IoT-based Environmental Monitoring System, making it adaptable to diverse operational environments and scenarios.

V. DATA STORAGE AND VISUALIZATION

The IoT-based Environmental Monitoring System incorporates robust data storage and visualization components, allowing for both real-time insights and historical analysis of the transported goods' environmental conditions.

A. *AWS IoT Timestream (Data Storage):*

The collected sensor data is securely stored in AWS IoT Timestream, a purpose-built, serverless database designed for handling time-series data. Time-series data is organized chronologically, allowing for efficient querying and analysis over specific time intervals. AWS IoT Timestream ensures the scalability and reliability required for managing large volumes of environmental data generated during transportation.

B. *Grafana (Real-Time Visualization):*

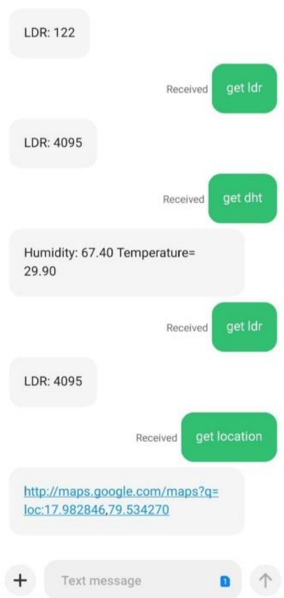
Real-time visualization of the collected data is achieved through Grafana, an open-source platform for monitoring and observability. Grafana seamlessly integrates with AWS IoT Timestream, fetching live data and presenting it in customizable dashboards. This dynamic visualization enables stakeholders to monitor environmental parameters in real time, ensuring prompt responses to any deviations from the desired conditions. Grafana's flexibility allows for the creation of intuitive and user-friendly displays, enhancing the accessibility of critical information.

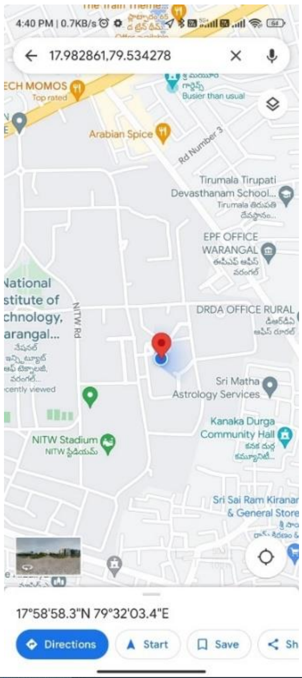
C. *Historical Analysis:*

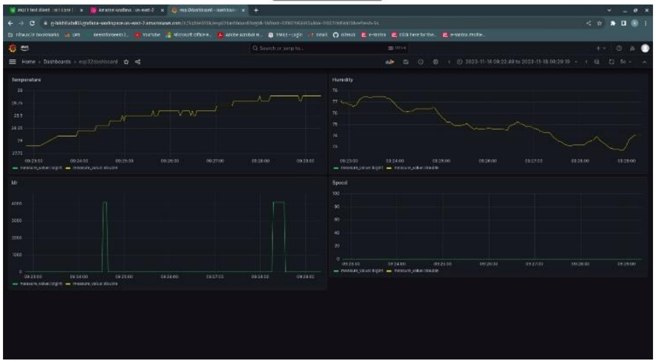
AWS IoT Timestream's storage structure facilitates historical analysis of the environmental data. By querying specific time ranges, trends, and patterns, stakeholders can gain valuable insights into the conditions encountered by sensitive goods during transportation. This historical perspective is essential for identifying areas of improvement, optimizing logistics processes, and ensuring compliance with quality standards.

The combination of AWS IoT Timestream and Grafana creates a powerful synergy for data storage and visualization within the IoT-based Environmental Monitoring System. Together, these components provide a comprehensive solution for monitoring, analysing, and ensuring the integrity of sensitive goods during transportation. Stakeholders have access to both real-time insights and historical trends, empowering them to make informed decisions and continuously optimize the transportation process.

VI. EXPERIMENTAL RESULTS







VII. APPLICATOINS AND FUTURE WORK

A. *Applications:*

The IoT-based Environmental Monitoring System, tailored for the transportation of perishable goods, finds diverse applications in ensuring the integrity and quality of sensitive products. Key applications include:

- Food Industry: Safeguarding the quality of perishable food items during transit, ensuring compliance with food safety standards, and minimizing wastage due to unfavourable environmental conditions.

- Pharmaceuticals: Maintaining optimal storage conditions for pharmaceuticals to preserve their efficacy, ensuring that medicines reach their destination in a viable state.

- Biotechnology: Facilitating the secure transportation of biological samples and materials, where maintaining specific environmental conditions is crucial for experimental integrity.

- Supply Chain Logistics: Enhancing the overall efficiency and reliability of supply chain logistics by providing real-time visibility into environmental conditions, reducing losses and ensuring product quality.

- Cold Chain Management: Optimizing cold chain logistics by monitoring and controlling temperature-sensitive goods throughout the entire distribution process.

B. *Future Work:*

The IoT-based Environmental Monitoring System lays the foundation for continuous improvements and advancements. Future work could encompass:

- Predictive Analytics: Implementing predictive analytics to anticipate and mitigate potential environmental deviations, enabling proactive intervention and further enhancing the system's reliability.

- Integration with Machine Learning: Exploring the integration of machine learning algorithms to identify patterns, anomalies, and optimization opportunities within the collected data, thereby improving the system's adaptability.

- Enhanced Power Management: Investigating innovative power management solutions to prolong the device's operational life, ensuring uninterrupted monitoring during extended transportation periods.

- Integration with Additional Sensors: Exploring the integration of additional sensors to capture a more comprehensive set of environmental parameters, providing a more nuanced understanding of the conditions during transportation.

- Global Expansion: Adapting the system to operate seamlessly in diverse geographic regions, considering variations in network connectivity, regulatory requirements, and environmental conditions.

- User Interface Enhancements: Improving the user interface for both real-time monitoring and historical analysis, making it more intuitive and user-friendly for a broader range of stakeholders.

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