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IOT-Based Container Tracking and Environmental Monitoring System Using Arduino UNO

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KEYWORDS

IoT; Arduino UNO; GPS tracking; environmental monitoring; supply chain.

ABSTRACT

The rapid expansion of global logistics and supply chain networks has created a strong demand for intelligent monitoring and tracking systems. Traditional container monitoring methods often lack real-time visibility and efficiency, leading to potential cargo damage and operational delays.This research presents the design and development of an Internet of Things (IoT) based container tracking and environmental monitoring system using Arduino UNO. The system integrates various sensors such as temperature, humidity (DHT11), and gas sensors to continuously monitor environmental conditions inside the container. Additionally, a gps module is used to provide real-time location tracking.

I. INTRODUCTION

The rapid growth of global trade and logistics has significantly incfresed the dependence on container-based transportation systems for the movement of goods across long distances. Ensuring the safety, quality, and security of these goods during transit has become a critical challenge, particularly for perishable items, pharmaceuticals, and hazardous materials. Traditional monitoring systems are often manual, inefficient, and lack real-time visibility, which can result in product damage, financial losses, and delayed responses to emergencies [1].

With the advancement of the Intrenet of Things (IoT), it has become possible to develop intelligent systems capable of real-time monitoring and tracking. IoT rechnology enables seamless integration of sensors, communication modules, and processing units to collect and transmit data continuously. This improves operational efficiency and supports better decision-making in logistics and supply chain management [2].

Several studies have highlighted the importance of IoT based monitoring systems in modern logistics. Smart container systems equipped with sensors can monitor environmental parameters such as temperature and humidity and provide real-time updates to users[1]. Additionally, IoT enabled tracking systems can ensure safe transportation by continuously monitoring both environmental conditions and container location [3]. These systems also generate alerts when abnormal conditions occur, thereby reducing risks associated with cargo damage [2].

The proposed system focuses on developing an IoT based container tracking and environmental monitoring solution using Arduino UNO. The system integrates sensors to monitor temperature, humidity, and gas levels inside the container, along with a GPS module for real-time location tracking. The collected data is processed by the controller and transmitted to a remote server, allowing users to monitor conditions from anywhere. Furthermore, alert mechanisms are incorporated to notify users when environmental parameters exceed predefined thresholds.

By providing real-time insights and automated alerts, the proposed system aims to enhance cargo safety, improve transparency, and optimize logistics operations. This work demonstrates how IoT and embedded systems can be effectively utilized to build a reliable, scalable, and cost-effectively utilized to build a reliable, scalable, and cost-efficient solution for modern supply chain challeneges.

2. LITERATURE SURVEY

Therapid development of IoT technologies has led to significant advancements in container tracking and environmental monitoring systems. Various researchers have proposed intelligent solutions to improve logistics efficiency, cargo safety, and real time monitoring capabilities.

Harshitha K and Suhas M K (2022) proposed a smart container system that monitors environmental parameters such as temperature and humidity while also providing real time location tracking [1]. Their system utilizes IoT technology to send continuous data updates to the cloud and generate alerts when abnormal conditions are detected. This approach enhances safety and improves decision making in logistics operations.

K. Salah et al.(2020) introduced an IoT enabled shipping container system designed to monitor environmental conditions and track location simultaneously [2]. Their work emphasizes real time data transmission and alert mechanisms, which help ensure the safe transportation of goods. The system demonstrates how IoT can improves operational efficiency and reduce risks in supply chain management.

Jabeena Shaik et al.(2023) developed an IoT based container monitoring system that focuses on tracking both environmental conditions and container location [3]. The system continuously updates data related to temperature and air quality, ensuring safe and reliable transportation. Their research highlights the importance of continuous monitoring in preventing cargo damage.

T. Lakshmi Narayana et al. (2024) presented a real-time environmental monitoring system using IoT sensors [4]. Their study focuses on collecting environmental data and transmitting it to remote users for analysis. The system improves decision-making by providing accurate and timely information about environmental conditions.

Suprava Ranjan Laha et al.(2022) provided a comprehensive review of IoT based environmental monitoring systems [5]. Their work discusses various sensor technologies and cloud-based platforms used for continuous monitoring. The study highlights the role of IoT in achieving accurate, scalable, and efficient monitoring solutions.

It is evident that IoT-based systems play a crucial role in enhancing container monitoring and tracking. However, there is still a need for cost effective, scalable, and integrated solutions that combine environmental monitoring with real-time tracking. The proposed system aims to address these gaps by developing a comprehensive IoT-based container monitoring system using Arduino UNO.

3. EXISTING METHOD

In traditional logistics systems, container monitoring is primarily carried out using manual inspection methods or basic tracking technologies. These methods rely on periodic checks rather than continuous monitoring, making them inefficient in detecting real-time changes in environmental conditions. Ad a result, sensitive goods such as food products, pharmaceuticals, and hazardous materials are highly vulnerable to damage during transportation. The lack of real-time visibility often leads to delayed responses in critical situations, causing financial losses and reduced operational efficiency [1].

The introduction of IoT, several systems have been developed to improve container monitoring. Existing IoT based methods typically use sensors to measure environmental parameters such as temperature, humidity, and gas levels. These systems transmit data to cloud platforms, allowing remote monitoring and analysis. For instance, smart container systems provide real-time updates and generate alerts when abnormal conditions occur, thereby enhancing safety and reliability [2].

Some existing approaches also integrate GPS modules to track the real-time location of containers. This enables logistics providers to monitor both environmental conditions and movement simultaneously. Such systems improve transparency and help in better decision making throughout the supply chain [3].

However, despite these advancements, many existing systems face limitations such as high cost, complex implementation, and lack of scalability. Some solutions require expensive hardware or sophisticated infrastructure, making them unsuitable for small and medium scale applications. Additionally, certain systems focus only on environmental monitoring without integrating location tracking, or vice versa, resulting in incomplete solutions [4].

The reliability issues such as network dependency and delayed data transmission can affect system performance. In some cases, alert mechanisms are not efficient enough to provide immediate notifications, which reduces the effectiveness of the monitoring system [5]. There is a need for a cost-effective, integrated, and scalable solution that combines real-time environmental monitoring with accurate location tracking. The proposed system aims to overcome these limitations by providing a comprehensive IoT based container monitoring solution using Arduino UNO.

4. PROPOSED METHODOLOGY

The proposed system presents an IoT based container tracking and environmental monitoring solution using Arduino UNO. The main objective of this methodology is to provide continuous monitoring of environmental conditions along with real time location tracking, thereby improving the safety and efficiency of logistics operations.

The system is designed by integrating multiple hardware components such as sensors, communication modules, and a microcontroller. Environmental parameters including temperature, humidity,and gas concentration are continuously monitored using sensors like DHT11and gas sensor. These sensors collect real time data from inside the contaomer and send it to the srduino UNO for processing.

The Arduino UNO acts as the central processing unit of the system. It receives input data from all sensors, analyzes the values, and determines whether the conditions are within safe limits. If any parameter exceeds the predefined threshold, the system activates alert mechanisms such as a relay controlled fan or notification system to maintain safe conditions [1].

To enable real time tracking, a GPS module is incorporated into the system. This module continuously provides location data of the container, which is processed by the Arduino and transmitted along with environmental data. This ensures that both the condition and position of the container can be monitored simultaneously [2].

For remote monitoring, an IoT communication module is used to send the collected data to a cloud platform or web interface. Users can access this data from anywhere, allowing them to monitor container conditions in real time. Additionally, alerts are generated and sent to users when abnormal conditions such as temperature fluctuations or gas leakage are detected [3].

A local display unit (LCD) is also included in the system to provide on site visualization of sensor readings. This helps inquick monitoring without the need for external devices. The system is powered using a regulated power supply circuit that ensures stable operation of all components.

The proposed methodology integrates sensing, processing, communication, and control mechanisms into a single system. This approach provides a cost effective, scalable, and reliable solution for smart container monitoring. By combining environmental monitoring with real-time tracking, the system overcomes the limitations of existing methods and enhances the overall efficiency of logistics management [4].

BLOCK DIAGRAM & WORKING SYSTEM

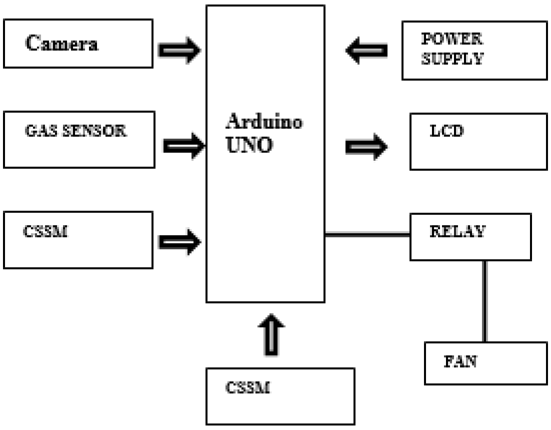

Fig 4.1: BLOCK DIAGRAM

Working System:

The proposed IoT-based container tracking and environmental monitoring system operates through the integration of sensors, a microcontroller, and communication modules to provide real time monitoring and control. The working of the system is continuous and automated, ensuring efficient data collection, processing and transmission.Initially, the system is powered by a regulated power supply, which provides a stable voltage to all components. Once powered, the sensors begin collecting environmental data from inside the container. The DHT11 sensor measures temperature and humidity, while the gas sensor detects the presence of harmful gases. These sensor values are continuously transmitted to the Arduino UNO for processing [1].

The Arduino UNO acts as the central controller of the system. It reads the sensor data at regular intervals and compares the values with predefined threshold limits. If they environmental conditions remain within the safe range, the system continues normal operation. However, if any abnormal condition such as high temperature, excessive humidity, or gas leakage is detected, the system immediately triggers an alert mechanism [2].

The alert mechanism is implemented using relay module connected to external devices such as a fan. When abnormal conditions are detected, the replay is activated, which in turn controls the fan or other devices to regulate the environment inside the container. This helps in maintaining safe conditions and preventing damage to the goods [3].

Simultaneously, a GPS module continuously tracks the real-time location of the container. The location data is combined with the environmental data and sent to the Arduino controller. This combined information is then transmitted to a remote server or cloud platform using IoT communication module such as ESP8266[4].

Users can acess this data remotely through a web or mobile interface, allowing them to monitor both environmental conditions and container location in real time. Additionally, notifications or alerts are sent to users whenever abnormal conditions are detected, enabling quick response and corrective actions [5].

For local monitoring, an LCD display is integrated into the system. It shows real time values of temperature, humidity, gas levels, and system status. This allows on interpersonal to easily observe the system performance without requiring external devices. The working system ensures continuous monitoring, real-time tracking, and automatic response to environmental changes. This improves cargo safety, reduces risks, and enhances the efficiency of logistics operations.

5. RESULTS AND OUTCOMES

The proposed IoT-based container tracking and environmental monitoring system was successfully designed and implemented using Arduino UNO and various sensors. The system demonstrated effective performance in continuously monitroing environmental parameters such as temperature, humidity, and gas levels inside the container.

During operation, the sensors accurately collected real-time data and transmitted it to the Arduino controller for processing. The system was able to detect variations in environmental conditions and compare them with predefined threshold values. Whenever abnormal conditions such as temperature rise or gas leakage were identified, the system respondeed immediately by activating alert mechanisms, ensuring timely corrective action [1].

The integration of the GPS module enabled precise real time tracking of the containers location. This feature allowed users to monitor both environmental conditionas and movement simultaneously, thereby improving transparency in logistics operations. The data collected from sensors and GPS was successfully transmitted to a remote platform using the IoT communication module, enabling remote access and monitoring [2].

The LCD display provided clear and real-time visualization of system parameters, making it easier for on-site personnel to observe the system status. The relay-based control system effectively operated external devices such as fans to regulate environmental conditions within the container [3].

The overall system proved to be reliable, cost-effective, and efficent for real-time monitoring applications. It reduced the need for manual inspection and minimized the risk of cargo damage by providng continuous monitoring and instant alerts. Additionally, the system improved decision-making by providing accurate and timely information about container conditions[4].

The outcomes of this research highlight that the integration of IoT with embedded systems can significatly enhance logistics management. The proposed solution is scalable and can extended for advanced applications such as smart supply chains and cold storgae monitoring systems [5].

6. CONCLUSION

AN IoT based container tracking and environmental monitoring system using Arduino UNO has been successfully designed and implemented. The system effectively integrates sensors, a microcontroller, and communication modules to provide continuous monitoring of environmental parameters such as temperature, humidity, and gas levels, along with real-time location tracking.

The proposed system addresses the limitations of traditional monitoring methods by enabling real time data collection, remote accessibility, and automated alert mechanisms. The inclusion of a GPS module enhances transparency by allowing users to track the movement of containers, while the IoT platform ensures that data can be accessed from anywhere at any time [1].

The results demonstrate that the system is capable of detecting abnormal conditions and responding promptly through alert mechanisms and control actions. This helps in preventing potential damage to goods, especially in the case of sensitive and perishable items. Additionally, the use of cost effective components such as Arduino UNO and ESP8266 makes the system affordable and suitable for practical deployment [2].

The proposed solution improves cargo safety, enhances operational efficiency, and supports better decision making in logistics and supply chain management. The system is scalable and can be further enhanced with advanced technologies such as artificial intelligence, cloud analytics,and mobile applications for improved performance and usability [3]. The research highlights the potential of IoT and embedded systems in transforming traditional logistics into smart and intelligent systems, paving the way for future advancements in smart transportation and supply chain solution.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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