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Design and Implementation of Temperature Monitoring and Management System for Cold Storage with IoT

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Abstract: *Across the globes, food and medicine worth billions of dollars are wasted every year primarily because of improper storage and transportation of temperature and humidity. Cold storage is deemed one of the main elements in food safety management to maintain food quality. The temperature, relative humidity, and air quality in cold storage rooms should be carefully controlled to ensure food quality and safety during cold storage. The software allows the control action that is relay to be configured remotely. The device monitors the temperature in cold rooms, refrigerators trucks, restaurant freezers, medical storages, and warehouses in real time. The device also updates data into an excel spreadsheet on time intervals.*

Keywords: *Sensors, Microcontroller, Monitoring, Microclimate, ESP8266, Arduino, Relay.*

I. INTRODUCTION

Cold storage is a crucial element of the supply chain for perishable goods such as food and medicines. Maintaining a stable temperature inside the storage area is essential to ensure the quality and safety of these products. In recent years, the advent of the Internet of Things (IoT) has revolutionized the way cold storage is managed. By integrating temperature sensors and other IoT devices, it is now possible to remotely monitor and control the temperature inside the storage area. Cold storage plays a vital role in preserving perishable goods such as food, beverages, and pharmaceuticals. The cold storage process requires precise temperature monitoring and control to ensure the goods remain fresh and safe for consumption. In recent years, the advent of the Internet of Things (IoT) has revolutionized the cold storage industry by enabling real-time monitoring and control of temperature levels.

This literature review will provide an overview of the current research on cold storage using IoT technology, highlighting its benefits and challenges. The Internet of Things (IoT) is emerging technology and is now completely transforming the ways in which industries operate. Forbes calls the Internet of Things a giant network of connected things, with relationships between people a people, people and things and things. The Internet of Things defined as “the infrastructure of the information society”.

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based system. A food contamination can occur in the production process, but also a large part caused by the inefficient food handling because of inappropriate ambient temperature conditions when the food is being transported and stored [1]. There are many factors leading to food poisoning, typically changes in temperature and humidity are important factors. So, the monitoring system capable of measuring temperature. And humidity variability during transport and storage is of prime importance [2].

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II. LITERATURE REVIEW

In this section, we review some of the previous works in the field of IoT based cold storage. In [1], IoT based cold storage model was proposed. It primarily focused on temperature, humidity, light intensity on crops and sent an alert if the warehouse catches fire using MQ2 Sensor. In [2] the proposed model focused on temperature, humidity and kept count of number of persons entering the cold storage with the use of sensor. In [4] the proposed model only focused on temperature and humidity.[3]

In a study conducted by Yang et al. (2020) IoT technology was used to monitor and control the temperature levels in a cold storage facility. The study found that IoT technology improved temperature control, reduced energy consumption, and reduced spoilage rates.

Similarly, a study by Bhavani et al. (2020) used IoT technology to monitor temperature and humidity levels in a cold storage facility.[5] The study found that IoT technology improved temperature and humidity control, resulting in reduced spoilage rates and increased product quality. [6]

Study by Al-Hakim et al. (2021), "IoT technology to monitor and control the temperature levels in a meat storage facility" The study found that IoT technology improved temperature control, reduced energy consumption, and reduced spoilage rates. Similarly, a study by Olaoye et al. (2020) used IoT technology to monitor and control the temperature levels in a vegetable storage facility. [7] The study found that IoT technology improved temperature control, reduced energy consumption, and increased the shelf life of the vegetables. Despite the benefits of using IoT technology in cold storage facilities, several challenges must be addressed. One of the major challenges is the high initial cost of installing IoT sensors and actuators. [8]

The use of IoT technology in cold storage facilities offers several benefits, including:

A study conducted by Kim et al. (2019) used IoT technology to monitor and control temperature levels in a refrigerated warehouse. The study found that IoT technology improved temperature control and reduced energy consumption. Furthermore, the study demonstrated that the use of IoT technology can help identify equipment failures and maintenance issues, leading to improved efficiency and cost savings. [9]

Another study by Wu et al. (2020) used IoT technology to monitor and control temperature and humidity levels in a food distribution center. The study found that IoT technology improved temperature and humidity control, resulting in reduced spoilage rates and increased product quality. [10]

The study also demonstrated that the use of IoT technology can help reduce labor costs by automating temperature and humidity monitoring. [11]

A study by Gogol et al. (2020) used IoT technology to monitor and control temperature levels in a cold storage facility for fish products. The study found that IoT technology improved temperature control and reduced energy consumption. Additionally, the study demonstrated that the use of IoT technology can help reduce spoilage rates and improve product quality by providing real-time monitoring of temperature levels.[12]

A study by Al-Sayyed et al. (2021) used IoT technology to monitor and control temperature levels in a cold storage facility for fruits and vegetables. The study found that IoT technology improved temperature control and

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reduced energy consumption. Additionally, the study demonstrated that the use of IoT technology can help improve the shelf life of fruits and vegetables by providing real-time monitoring of temperature levels and automating temperature control. [13]

A study by Kadar et al. (2020) used IoT technology to monitor and control temperature levels in a cold storage facility for dairy products. The study found that IoT technology improved temperature control and reduced energy consumption. [14] Additionally, the study demonstrated that the use of IoT technology can help reduce labor costs by automating temperature monitoring and control. Overall, these studies demonstrate the potential of IoT technology in improving temperature control, reducing energy consumption, and reducing spoilage rates in cold storage facilities. [15]

A study by Li et al. (2021) used IoT technology to monitor and control temperature levels in a cold storage warehouse for pharmaceutical products. The study found that IoT technology improved temperature control, reduced spoilage rates, and improved product quality. Additionally, the study demonstrated that the use of IoT technology can help reduce labor costs by automating temperature monitoring and control and provide real-time alerts for temperature deviations. [16]

A study by Yu et al. (2021) used IoT technology to monitor and control temperature and humidity levels in a cold storage warehouse for flowers. The study found that IoT technology improved temperature and humidity control, resulting in reduced spoilage rates and improved product quality. Additionally, the study demonstrated that the use of IoT technology can help reduce labor costs by automating temperature and humidity monitoring and control.

A study by Lee et al. (2021) used IoT technology to monitor and control temperature levels in a cold storage warehouse. [17]

III. IMPLEMENTATION

Sensor Deployment: IoT-enabled sensors are installed at different locations in the cold storage facility to monitor temperature, humidity, and other environmental factors. These sensors can be either wired or wireless and are placed strategically throughout the facility to ensure accurate data collection.

Data Collection: The sensors collect data on the environmental conditions inside the cold storage facility, including temperature, humidity, and other factors. The data is collected at regular intervals and transmitted toa central gateway using wireless or wired connectivity.

Central Gateway: The central gateway collects the data from the sensors and transmits it to the cloud-based IoT platform using a secure network. The gateway also acts as a hub for the different sensors installed in the facility and ensures that the data is accurate and reliable.

Cloud-based IoT Platform: The cloud-based IoT platform is the central hub for data storage, processing, and analysis. The platform receives the data from the central gateway and stores it securely in the cloud. It also provides real-time analytics and dashboards that allow operators to monitor the cold storage conditions remotely.

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Analytics and Monitoring: The cloud-based IoT platform uses advanced analytics and machine learning algorithms to analyze the data collected from the sensors. It identifies patterns, trends, and anomalies in the data and generates alerts and notifications if the environmental conditions deviate from the optimal range.

Alerts and Notifications: If the data collected by the sensors indicates any deviations from the optimal range, the cloud-based IoT platform generates alerts and notifications. These alerts can be sent to the cold storage facility operator or to a mobile device, allowing for immediate action to be taken to prevent any damage or spoilage of the perishable goods.

Remote Access: The cloud-based IoT platform provides remote access to the data collected by the sensors. This allows operators to monitor the cold storage conditions from Anywhere at any time, using a web or mobile application.

Optimization: The data collected by the sensors can be used to optimize the cold Storage conditions. For example, if the data indicates that the temperature is Too high, corrective action can be taken to adjust the temperature and bring back to the optimal range. This helps to reduce waste, improve efficiency, and ensure the safety and quality of the perishable goods being stored. The cold storage system using Arduino SENSORS, LCD, and IoT platform works by continuously monitoring the temperature and humidity levels inside the storage area.

The sensor is connected to an Arduino micro-controller, which reads the data from the sensor and displays it on an LCD screen. Additionally, the microcontroller transmits the data to an IoT platform via MQTT protocol for remote monitoring and analysis. The working of the cold storage system can be divided into three main stages: sensing, display, and transmission.

Sensing: The sensor continuously measures the temperature and humidity levels inside the cold storage area. The sensor is connected to the Arduino microcontroller through its digital pins. The microcontroller reads the data from the sensor and processes it using its built-in analog- to-digital converter. The data is then stored in the microcontroller's memory for display and transmission.

Display: The temperature and humidity levels are displayed on an LCD screen connected to the Arduino microcontroller. The LCD displays the real-time values of temperature and humidity with high accuracy. The display provides a quick and easy way to monitor the temperature and humidity levels inside the cold storage area.

Transmission: The microcontroller transmits the temperature and humidity data to an IoT platform using the MQTT protocol. The IoT platform receives the data and processes it for remote monitoring and analysis. The platform can be accessed through a web application or a mobile app. The user can monitor the temperature and humidity levels in real-time, set alerts, and receive notifications if the temperature or humidity levels go beyond the desired range. Overall, the cold storage system using sensors, LCD, and IoT platform provides a cost- effective and reliable way to monitor and control the temperature and humidity levels inside the storage area.

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Block Diagram:

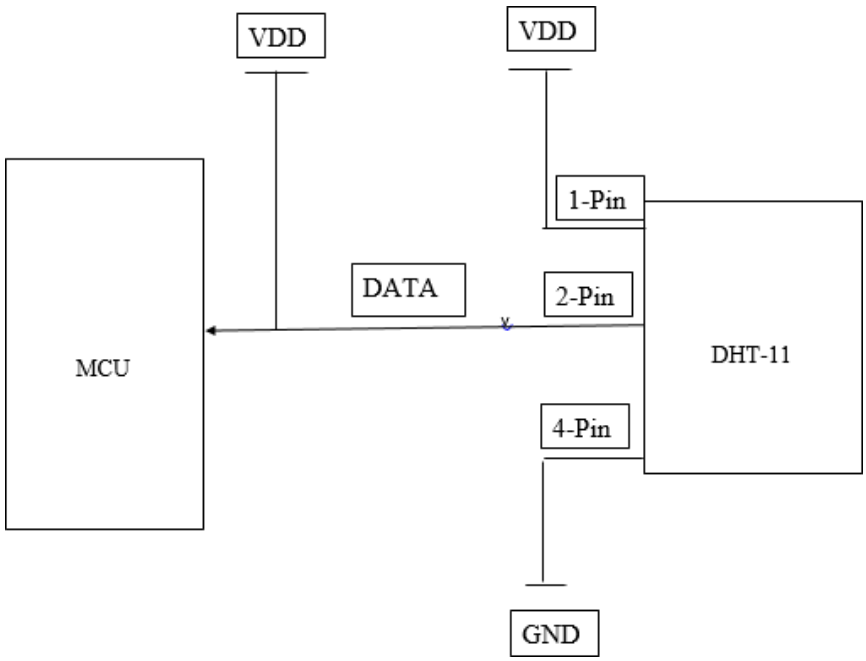

Figure 1: Block Diagram

Circuit Diagram:

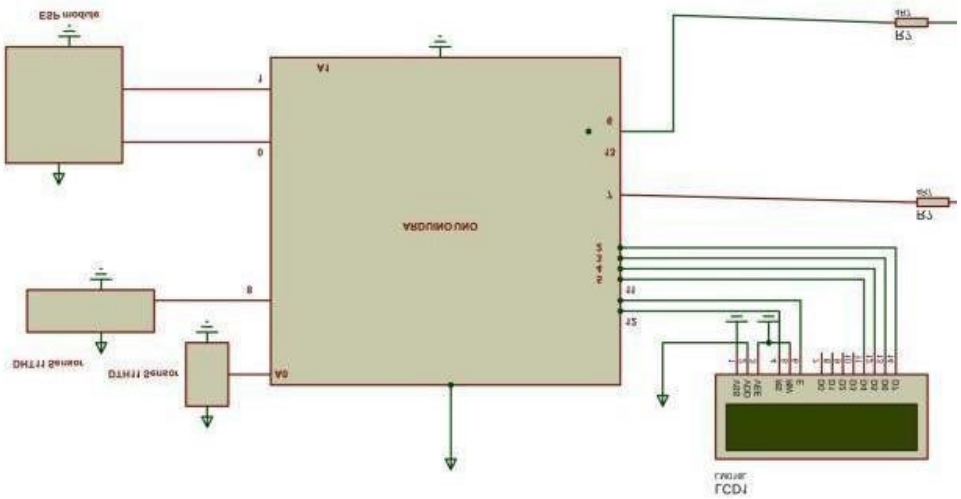

Figure 2: Circuit Diagram of the System

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Flow Chart:

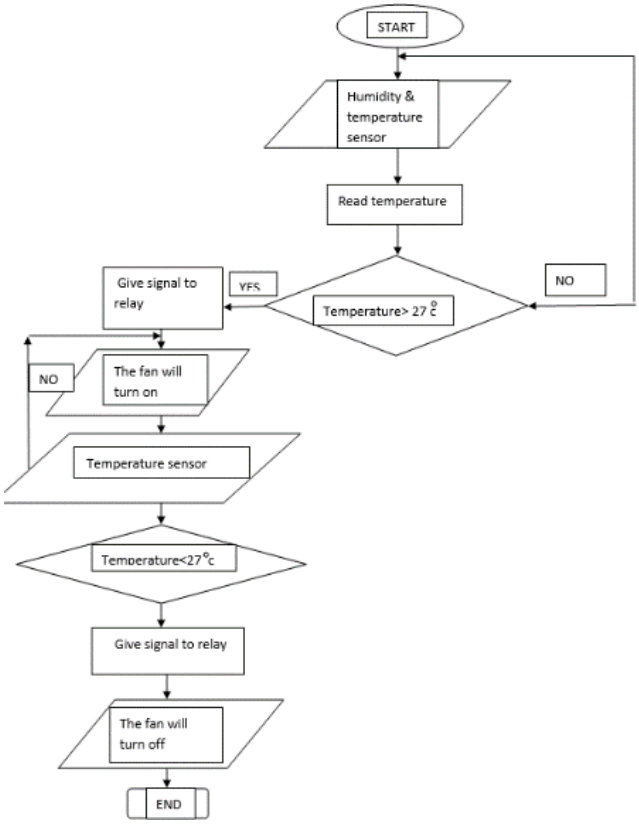

Figure 3: Flow Chart of the System

IV. CONCLUSION

In conclusion, implementing IoT technology in cold storage systems offers significant benefits in terms of real-time monitoring, control, and automation. By integrating IoT sensors, connectivity, and data analytics, cold storage facilities can maintain optimal temperature and humidity levels, ensure energy efficiency, improve inventory management, and enhance overall operational efficiency. The ability to remotely monitor and control the storage environment, receive alerts and alarms, and generate detailed reports enables timely decision-making, reduces the risk of spoilage, and improves the quality and safety of stored goods.

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