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A Survey Paper on Cold Storage Monitoring System using IoT

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Abstract: ***Around the world, numerous warehouses are used to store medicine, chemicals, food, and electronics, etc. These warehouses are kept under controlled cold conditions for preserving various products. In cold storage, temperature, humidity, and other parameters are recorded and monitored to meet requirements and quality assurance. Maintaining the high quality of products extensively depends on how they manage their storage temperature and transportation. There is a growing need for monitoring systems in food, pharmaceuticals, electronics, and logistics. While transporting the products from one place to another, it is observed that transports carrying products are not kept under required environment, due to this many stores have to bear the loss of both, quality as well as quantity of respective products. So, designing an IoT system that takes care of all these aspects at a low cost is the need of the hour, that can be used by small warehouses in towns and cities.***
Keywords: Temperature & Humidity sensor, Air Quality sensor, Firebase Realtime DB, ESP32 module, IFTTT, ESP32 Web-Server.

I. INTRODUCTION

Today, almost every industry requires cold storage, the most important objective of the storage is preserving the raw materials for a longer period. Cold storages are maintained at a certain range of conditions using refrigeration and dehumidification systems. The products in cold storage are kept in three different conditions that are freezer, chiller, cooler.[10] They are used to meet the storage demands of products needed at a particular temperature range.

This storage needs frequent monitoring of temperature and humidity as any fluctuation may lead to deterioration and loss of product. Cold chains are a kind of supply chain that specializes in the transport, storage, and preservation of products that are kept at a specific temperature in cold storage and needed to be transported to other places. Over the years cold chains have become the most essential part of the supply chain around the world.[8]

In the food industry, they need to preserve vegetables, fruits, meats, spices, etc. But, due to lack of technology and human ignorance temperature, humidity, air quality is not maintained according to food safety standards.[2][11][12] While storing electronic components they should be stored at proper temperature otherwise there is a chance that components may get damaged due to condensation and it should be avoided. Pharmaceuticals, healthcare, or medicinal goods are very delicate and need extra precautions if there is any problem while storing these goods or while transporting via cold chains as not all products are kept at sub-zero temperatures there must be an alarm system which helps to find out the problem in the system.[13]

So, designing an IoT system that takes care of these aspects and at a low cost is the need of the hour which can even be used by small stores in small towns and cities. In pharmaceuticals stores, the medicines, vaccines, medical kits are kept cold, clean, away from direct sunlight, a hygienic place for keeping the products in top condition but natural reasons or human negligence creates uncalled situations disrupting storages and further losses to pharmaceutical stores. A smaller, compact, energy-efficient monitoring device that can provide constant communication for real-time temperature updates, and security alerts. The system should provide real time-dashboards, and better information on the cold storage and make monitoring and management easier.

II. LITERATURE SURVEY

A. P.J. Sousa, P. Abreu and M. R. Quintas, "Modular System for Cold Storage Monitoring"

In this paper, the author describes the development of an embedded monitoring system that is suitable for cold-storage. The system provides sensor data of temperature, humidity, power consumption, and detection of door position. This system was developed for cold storage that monitors the conditions of products like food, biological samples, or medicines. The system uses modular architecture using both cables and wireless communication for logging and alarm generation systems. The data is collected in CSV format and later plotted using MATLAB. Analysis of data provides information about the significant variations in storage [1].

B. Ting Lu and Zeliang Liu, "Temperature Control System of Cold Storage"

Cold storage uses cooling facilities to maintain the proper humidity and temperature of warehouses and is used for the storage of agriculture and livestock products. In this paper, the author has proposed a design based on the STC89S52 microcontroller and uses the DS18B20 sensor to detect the current temperature of cold storage and also provides the LCD Display which shows the current values of the storage system. If the measurement value is above or below the limit value the system will alarm and then stops the actuator from making the temperature quickly reach the preset range. The system saves the results of values in the database [2].

C. Asif Bin Karim, Md Zahid Hassan, Md Masum Akanda, Avijit Mallik, "Monitoring food storage humidity and temperature data using IoT"

In the food industry, cold storage is a necessity and the main objective behind this kind of storage is to preserve the raw foods for a certain time. But due to lack of technology and ignorance in the system raw foods are not maintained well. In this paper, the author proposed a system based on IoT to monitor the real-time data of temperature and humidity using sensor DHT11 with ESP8266 NodeMCU module. NodeMCU is a cheap alternative for Arduino and provides Wi-fi capabilities. The data from the warehouse can be viewed on ThingSpeak cloud service that gives a dashboard with all real-time values. This IoT system focuses on controlling electronic devices remotely and also to monitor devices around the world [3].

D. José Ramírez-Faz, Luis Manuel Fernández-Ahumada, Elvira Fernández-Ahumada, Rafael López-Luque, "Monitoring of Temperature in Retail Refrigerated Cabinets Applying IoT Over Open-Source Hardware and Software"

The control of refrigeration in the food industry is rudimentary in all stages and implementation of IoT based solution is a revolution in the food industry. In this paper, the author proposed a low-cost IoT solution based on the use of ESP8266 Wi-fi with a DS18B20 temperature sensor. The system uses the ThingSpeak IoT platform for storing and processing data in the cloud. An alarm system is present if any abnormality is detected in cold storage it can be notified to cold storage operations rooms [4].

E. Bindu J, Nikitha, Namitha M, Pradeep H" WSN based Online Parameter Monitoring in Cold Storage Warehouses in Cloud using IOT concepts"

In this paper, the author proposes a wireless sensor network-based monitoring system for cold storage warehouses by using IoT to ensure the food products are not decayed due to an increase in temperature and humidity. The system uses the PIC18 microcontroller and ESP8266 module to send data through Wi-fi. All the parameters are then monitored simultaneously to represent data on the web page to keep track of cold storage and for data analysis. The system provides an android app that is used to monitor the real-time condition of cold storage [5].

F. Yi-ping CHEN, and Jian WANG," A Corn Warehouse Monitoring System Based on IoT"

In this paper, the author proposes a warehouse management system based on IoT that provides a real-time condition of products to reduce waste and improve quality. This system uses Zigbee protocol and the real-time data from the warehouse is monitored on a GUI application in which all the parameters are shown [6].

III.LIMITATIONS OF EXISTING SYSTEMS

A. In paper [1], the system is developed with two micro-controller unit that use Microchip's MLA to manage touch-screen and second controller use Mi-Wi protocol for wireless communications instead of Wi-fi, data can't be monitored in real-time as it saves data in CSV format and there is no alarm system for a situation if any anomaly occurs.

B. In paper [2], the author uses the STC89S52 controller in place of a more powerful and efficient microcontroller, which uses only one parameter i.e., temperature for monitoring which is less secured while monitoring cold storage. Also, real-time data can be seen on the LCD module only which is not efficient.

C. In paper [3], the system uses Node-MCU which has slower Wi-fi and fewer GPIO pins, DHT11 sensor works only in the range of 0-50*C. So Cold storage having a temperature less than 0*C in that device will not work. Only two parameters are considered i.e. temperature and humidity but some cold storages need ambient air quality for storages and need to be monitored.

D. In paper [4], this system uses Node-MCU and for storing and processing data it uses the ThingSpeak cloud platform which is a paid service for commercial use. Parameters like air quality, light level are some parameters that are becoming fundamental for monitoring cold storage.

E. In paper [5], the author uses a PIC18 microcontroller with a Wi-fi module which increases the cost of the system as there are alternatives available for these controllers. Other parameters like CO2, smoke, light needed to be monitored for making the system efficient.

F. In paper [6], the system described here uses Zigbee which has a short-range, low data, and low transmission rate and also is prone to attack from unauthorized people. Also, Zigbee is not free to use, and this increases the price of the system.

IV. PROPOSED SYSTEM

As per the above-done survey, the existing systems use either old micro-controllers or use fewer parameters for monitoring the cold storage. So, building a low-cost and compact solution is the need of the hour which then can be used by even small or larger cold storage warehouse keepers to make their system secure and efficient.

Here, we proposed a system as shown in fig 1, that uses an ESP32 micro-controller unit that is faster, better than Node-MCU in terms of performance. For measuring the temperature, we use DHT22 which measures both temperature and humidity in the range of -40 *C to 125 *C. For measuring other parameters like air-quality we selected the MQ135 sensor for measuring and detecting NH3, NOx, CO2, smoke, etc. in most cold storage systems they use ammonia-based refrigerants if any leakage occurs it can't be detected by naked eyes so the use of this sensor is must. LDR sensor is used to check the light intensity in the cold storages where some products are required to be kept at certain light intensity for a longer duration. Cold storages also need highly effective fire protection as due to low temperatures, dry atmosphere, high airflows, and the presence of highly combustible materials, fires can spread quickly in cold storage rooms/warehouses for that we also included a flame detector sensor to detect the presence of flame.

In this system, we use ESP32 Web-Server to see real-time values of cold storage in form of a dashboard on web pages that are accessible in WLAN (Wireless Local Area Network) on any device connected to Wi-fi. In ESP32 we use SPIFFS (SPI Flash File System) in which we can store HTML & CSS files. It is specifically designed for low ram usage and is highly configurable. ESP32 has dual cores which allow two tasks to perform parallelly by this we can perform tasks smoothly and efficiently than other microcontrollers.[14] For the alarm system if any abnormality is found in cold storage then it uses IFTTT webhooks which is a web-based service that allows users to create a chain of conditional statements triggered by changes and then it performs task designated to it[15], in this case when temperature or any other parameter goes less or more than the threshold it will send an email to the user specifying about an anomaly in it.

The Dashboard consists of current real-time values and different graphs that show the values of every sensor data by using Chart.js library, it is accessible from any device connected in WLAN. Data from ESP32 is then needed to be stored in the real-time database which can later be used for analysis for that we use the Firebase Real-time database, the data is pushed directly into the database parallelly as it uses the other core of ESP32 for this function. The system also has an LCD display for seeing the current values of the cold storage. The proposed system architecture for cold storage is shown in fig 1.

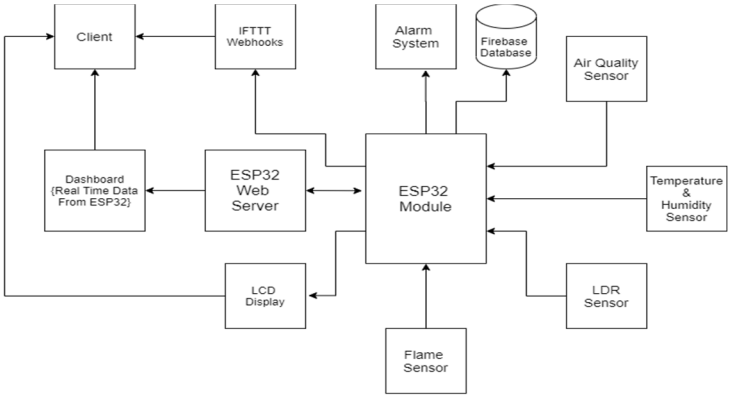

Fig 1. Cold Storage Monitoring System Architecture

V. CONCLUSIONS

Thus, a survey on cold storage systems shows various processes that are used in the industry. This proposed system overcomes the disadvantages of the existing systems by making it efficient, low-cost, and compact to monitor the parameters of cold storage. The system's principal objective is to achieve compactness and making the system user-friendly which then can be used even by small cold storage warehouse keepers at a low price and provide great quality of the product which monitors the storage effectively.

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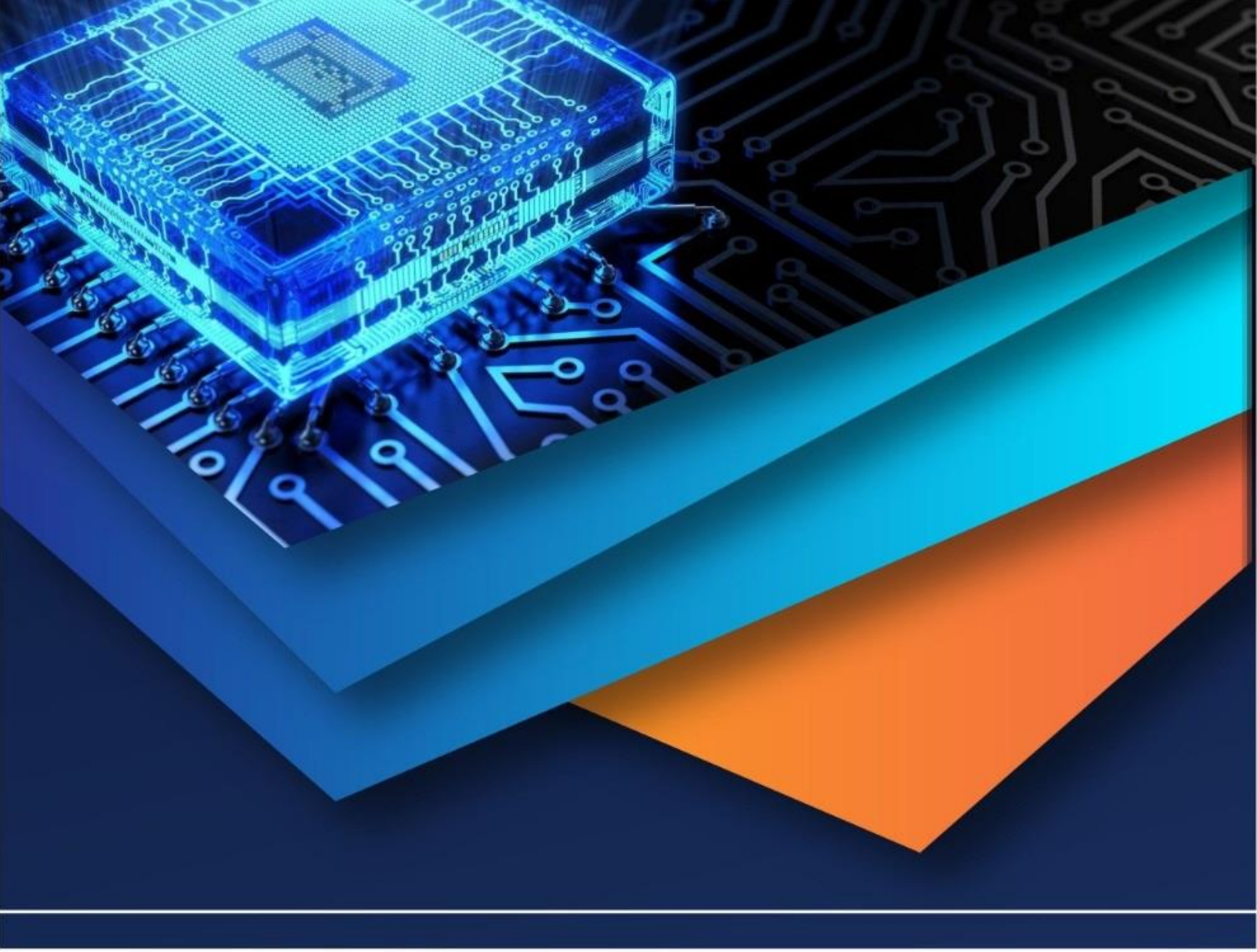

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