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# Cold Supply Chain Risk Monitoring and Safety alerting System Using IoT

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## ABSTRACT

The intake of the perishable fruits and vegetablesin the human diet can contribute to reduce the risk of some chronic diseases. But unfortunately, fruits and vegetables loss rate is high among all the food produced annually and occurs at storage stage of post-harvest life cycle. The study focused on reducing the customer complaints due to cold chain segment. A cold chain is a temperature-constrained supply chain. An ideal cold chain is a continuous series of refrigerated production, stocking and supplying activities, with the help of associated equipment and logistics, which maintains the desired low temperature limits. It helps in preserving and increasing the shelf life of commodities such as frozen foods, pharmaceutical drugs, chemicals, seafood, chemicals and fresh agricultural products. Cold chain commodities are liable to rot and perishable they are always directed to the destination or end user. Reducing customer complaints in an online grocery retailer is the theme of this paper. In addition, for cold warehouses and rooms in different cold chain facilities, the personal occupational safety risk assessment is established by considering the surrounding environment and the operators' personal health status.

**Keywords:** IoT, cold chain, temperature, humidity, risk monitoring, real time, foods

## INTRODUCTION

Cold chain management has been growing in the past few decades. Unlike traditional supply chain management, the goods in cold chains, such as pharmaceutical products, chilled food and frozen food, generally a have shorter shelf life and higher sensitivity to the surrounding environment,i.e. temperature, humidity and lighting intensity. The proposed system consists of sensing module,
wireless communication technology, status prediction module and Android App module. An IOT resolution offers a powerful data-link platform with multi-sensor smart tracking devices, and highly innovative software applications, enabling us to monitor all cargo and containers across the globe in real time for maximum security, guaranteed quality and total visibility. Traditionally, supply chain transactions are completed manually, creating delays and a higher risk for recording error, which can cause differences between what was recorded and what was actually loaded. By digitizing this process using IOT, the relevant information is captured directly from the sensors placed around the products, and entered onto the platform, creating a single, shared repository that all authorized participants can access and which can only be altered with consensus from all parties.The embedded sensing devices are employed in IoT based systems to efficiently and economically gauge real- time environmental parameters in supply chain. While certain automations can be achieved through the use of IoT devices, the idea behind installing them in a supply chain is to gather the data necessary to achieve a less strenuous path from order made to a supplier, all the way to consumer. Employing a third-party provider like The Things Industries can significantly reduce the time it takes to deploy your solution. However, what you want to achieve specifically (e.g., temperature monitoring, real-time alerts, GPS tracking) is up to *your* supply chain and what *you* see as valuable. A company's supply chain stands to benefit from IoT innovations because they allow automating certain actions while preventing major incidents before they happen, and predicting consumer demand 6 to 12 months into the future without using traditional statistical model.

## LITERATURE REVIEW

Expired shelf life may cause product deterioration and contamination leading, for example, to foodborne illness. Product quality degradation is a main concern in customers' acceptance, and it should be seriously controlled in the cold chain (Ling et al., 2015) [1]

Generally defined temperature range of cold work at/below +10 to +15°C. In real-life situations, the temperature of cold chain facilities may vary from −40 to +10°C, depended on the type of inventory handled. Apart from the climatic factors, the safety and health effect of the cold conditions is also contributed by physical activity, clothing, individual constitution, and socioeconomic factors. Inappropriate risk management for cold exposure may trigger cold-related diseases and aggravate the symptoms of chronic diseases.Under the IoT environment, smart objects with integrating wireless communication technologies, sensors and actuators can connect to the internet and share their data, in order to provide real-time data acquisition in supply chain management (Wortmann and Flüchter, 2015; Yan et al., 2016) [2]

Compared with RFID technology, IoT is an expanded concept that emerged from the prerequisite of RFID foundation. The fundamental architecture of IoT consists of four layers, namely the sensing layer, gateway/network layer, management service layer and application layer (Dweekat et al., 2017; Rezaei et al., 2017) [3]

Developed a fuzzy-based risk rating system to predict accident risk on road networks based on road condition, driver-based risk and the number of pedestrians crossing the road. Hence, it is deemed to be a suitable technique to enhance ISO11979 practice by combining personal constitutions to evaluate the appropriate levels of occupational safety risk. Fuzzy logic is another promising AI technique for generating acceptable reasoning with uncertainty and vagueness by mimicking human thinking and decision-making processes. In practice, fuzzy logic has been widely applied in various scenarios. Markowski et al. (2020) [4]

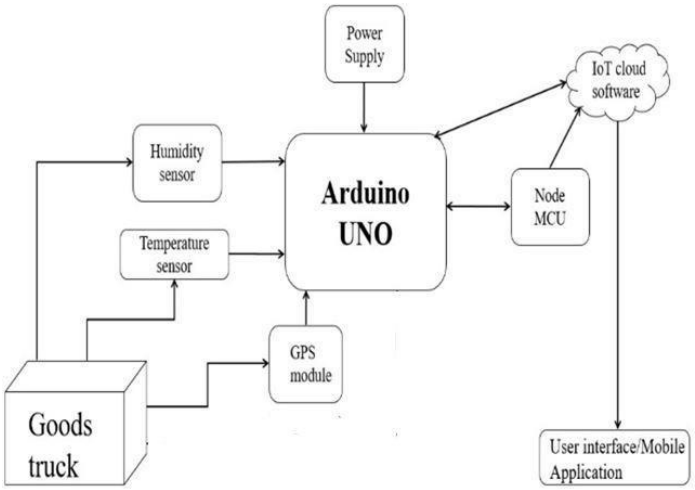
Message Queueing Telemetry Transport (MQTT) and Extensible Messaging and Presence Protocol (XMPP), on BLE links have been investigated, while the sensors in such networks can directly communicate to the internet. By doing so, the sensor network can be operated in a scalable and efficient manner with increasing interoperability and standardization (Higuera and Polo, 2011) [5]

### *Proposed System*

The temperature exertion in the cold chain was reduced by 50% which also led to decrease in customer complaints by 30%.The online retailer had been receiving an average of 5000 complaints daily and was found that more than 2000 complaints were due to the poor quality of fruits & vegetables and unacceptable temperature of the cold chain. When fresh produce is involved, it's also crucial to maintain air quality levels across parameters like carbon dioxide, oxygen, and humidity. The purpose of this paper is to propose an Internet of Things (IoT)-based risk monitoring system for controlling product quality and occupational safety risks in cold chains. Real-time product monitoring and risk assessment in personal occupational safety can be then effectively established throughout the entire cold chain. The real-time environmental monitoring ensures that the products handled within the desired conditions, namely temperature, humidity and lighting intensity so that any violation of the handling requirements is visible among all cold chain parties. The central unit is a microcontroller (Arduino UNO), and acts as the main processing unit for the entire system; it interfaces with the sensor chip at the input for receiving temperature and humidity readings and interfaces with the Wi-Fi module at the output to send the received data to the cloud over the Internet. The microcontroller polls the sensor to retrieve data and sends it over the Internet cloud for analysis. The system is equipped with a temperature and humidity sensor that continuously monitors the temperature and humidity of the carrier chamber and the monitored data is sent to a microcontroller unit which records the temperatures and sends the data at a regular interval to the communication unit. That automatically monitors real-time environmental parameters like ambient temperature, relative humidity, light intensity and concentration of CO2. Information sensing devices realize in real-time and share it using wireless technology and then transmit the information to the desktop.Data from the sensor is transmitted to the gateway and from there to the cloud and then to the desktop.

### *IoT Technology*

For the Internet of Things, the dashboard or IoT dashboard is the key HMI (Human-Machine Interface) component that organizes and presents digital information from our physical world into a simply understood display on a computer or mobile device. With the help of IoT Dashboards, users and operators can (remotely) monitor and control specific assets and processes, and depending on safety requirements, access and control an environment from anywhere in the world. IoT dashboard is one of the most important parts of an IoT project. IoT dashboards act as HMIs that present data relating to the status of a system or events.




IoT-based business solutions, organization gain the real- time visibility across the cold chain and can then take intelligent actions needed to ensure that the food product is of highest quality and delivered on time. For example, the manager of a food organisation can find out whether the product is being delivered at the right temperature or not and thus can take actions like prevent the delivery or take actions to make sure that the product is delivered at right temperature to the customer.

### *Arduino UNO*

The central hardware component of our system is the microcontroller which interfaces with other components of the system. Since the system comprises of temperature and humidity monitoring for which a single sensor interface is required and no local storage of data therefore we selected Arduino UNO microcontroller which serves our purpose well due to its simplicity, robustness and low cost [6]. Figure 1 shows a picture of Arduino UNO microcontroller used in our system [6]. This microcontroller board is based on the ATmega328P. It has 14 digital input/output.


**Fig 1: Arduino UNO**

pins, 6 analog input pins, a USB connection, 16 MHz quartz crystal, a power jack, and a reset button. It can be powered with a battery. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable.

### *GPS module*

GPS modules contain tiny processors and antennas that directly receive data sent by satellites through dedicated RF frequencies. From there, it'll receive timestamp from each visible satellite, along with other pieces of data. Unlike other GPS modules, it can do up to 5 location updates a second with

2.5m Horizontal position accuracy. The u-blox 6 positioning engine also boasts a Time-To-First-Fix (TTFF) of less than 1 second. The NEO-6M GPS module is a well-performing complete GPS receiver with a built-in 25 x 25 x 4mm ceramic antenna, which provides a strong satellite search capability.

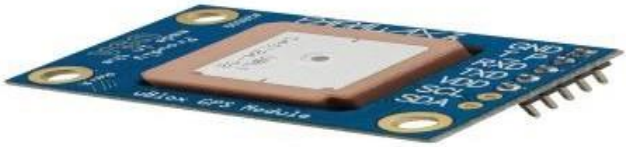


**Fig 2: GPS module**

GPS sensors are receivers with antennas that use a satellite-based navigation system with a network of 24 satellites in orbit around the earth to provide position, velocity, and timing information.

### *Sensors*

Selected temperature and humidity for environmental monitoring and preferred a single sensor with both sensing capabilities instead of separate sensors for each parameter. For this reason, we selected DHT11 composite sensor chip which gives readings for both temperature and humidity at the same time, it has high reliability andexcellentlong-term stability. It has small dimensions, low cost, good quality, fast response, strong anti-interference ability, digital signal output, and precise calibration.

**Fig 3: Temperature sensor (DS18B20)**

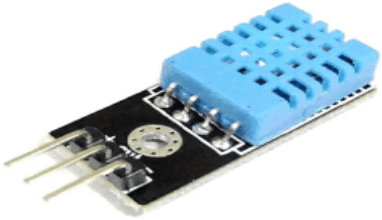


**Fig 4: Humidity sensor (DHT11)**

This sensor can measure temperatures between temperature ranges of -55 [°C] to +125 [°C] and is accurate to ± 0.5 [°C], over the range of -10[°C] to +85 [°C].It can be easily interfaced with Arduino UNO board with the help of DHT library and connecting wires. DHT composite sensor which we used in our system. It has temperature range from 0 to 50°C and humidity range from 20 to 90%RH. It has signal transmission range of 20m. To interface it with Arduino UNO, we connected the Ground and Vcc of the DHT11 sensor with the Ground and 5V of the Arduino. Then we connect the Data pin of the DHT11 to the pin 2 of the Arduino. Then we installed the DHT library and run the code for getting it started.

### *Wi-Fi Module*

In order to upload sensor readings from DHT11 to the open source cloud, Arduino UNO interfaces at the output with Wi-Fi module ESP8266. It is a low-costWi-Fi microchip with full TCP/IP stack. It works on the 3.3V that is provided by Arduino UNO in our system. The module is configured through AT commands and needs the required sequence to be used as a client. The module can work as both client and server. It gets an IP on being connected to Wi-Fi through which the module and then communicates over the Internet. After testing our ESP8266 module, we connected it with Arduino UNO and then programmed Arduino UNO to configure ESP8266 Wi-Fi module as TCP client and send data to server which is an open IoT platform to visualize and analyse live data from sensors.

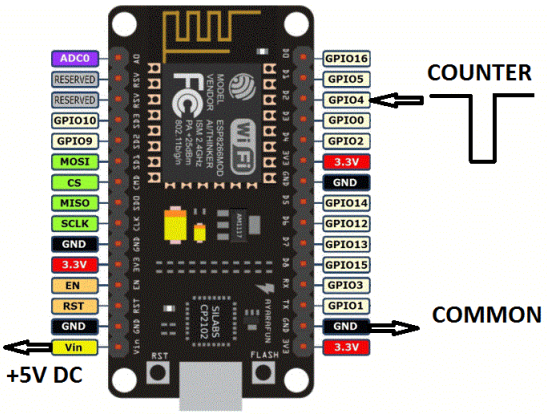
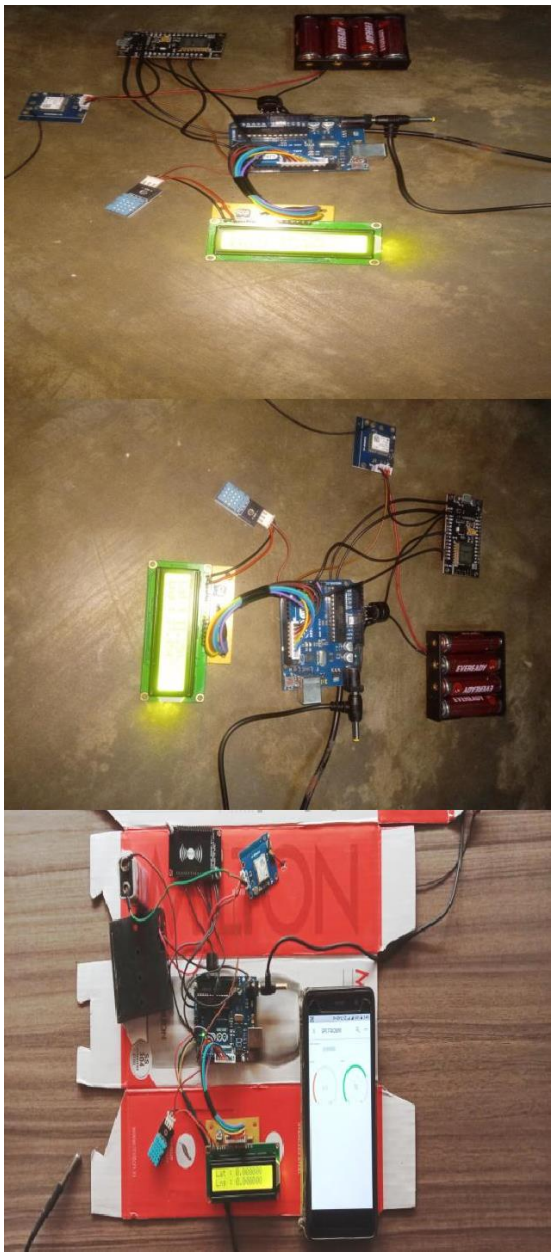



**Fig 5: Wi- Fi module**

## *Software for Initialization*

Arduino IDE was used to program the microcontroller for data retrieval from sensor and data transmission to the cloud. After the authentication phase in which the user enters login and password, the user logs in to the application to view the monitored data.initialization and configuration of hardware,and the development of Android based mobile application for user interface.

## *Prototype*



## CONCLUSION

This paper presents a cold supply chain monitoring system for real-time monitoring of temperature and humidity of surrounding environment. The sensed data is sent through Wi-Fi to the cloud where both real-time data and its graphical analyses can be viewed. An Android application is developed for the end user who can monitor the environment of the area where the hardware is deployed using a smart phone with respect to handling environmentally sensitive products in supply chains, risk management is important in preventing product loss and industrial accidents. On the one hand, there is a probability that the products will either deteriorate or be contaminated at any point in cold chain due to the fluctuation of temperature and humidity. Cold chain parties may bear unnecessary loss if visible product monitoring information is not recorded.This study provides an applicable method for improving product quality risk and occupational safety risk management in cold chains, where it also contributes to the research on cold chain monitoring and industrial safety. Furthermore, other sources of relevant data can be fine-tuned and collected for fulfilling the needs of different industries.

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