

IoT Instrumented Food and Grain Warehouse Traceability System for Farmers

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Abstract – In a developing country like India, agriculture is one of the main sectors in terms of income. Good food storage plays a very important role when it comes to food security that is affected by both food loss and food wastage. The losses can be reduced, which will automatically increase the amount of food availability. In this article, we proposed an IoT enabled monitoring system to deploy in remote areas where the accessibility is very minimum for farmers with good storage facilities to reduce food losses and increase food safety. This proposed framework monitors warehouse parameters such as temperature, humidity, CO, motion, vibration, and smoke which is highly affected to grains. The ESP32 WiFi module collects the data from the sensors and this module sends data to Node-red dashboard through MQTT broker. Multiple IoT nodes installed at a different location inside the warehouses and which will give information about the warehouse environment to the farmers through Mobile SMS and E-mail notification.

Index Terms — Agriculture, Internet of Things (IoT), ESP32, Sensors, Node-Red.

I. INTRODUCTION

Warehousing organization is the key part of the supply chain management. Warehouse in the agriculture sector is considered as the more crucial sector generally for ensuring food security. In earlier days, there been outmoded methods for storing the foods and grains which required a lot of the manual approach occasionally which is time-consuming and inefficient. Food and grains start to spoil once they are harvested. Harvested yields have to be stored in a place where the yield gets proper food security in terms of access to quality, safe, and nutritious food. One of the main factors to improve food security is to lessen food waste. A warehouse provides protection of foods from loss and damage due to excessive heat, moisture, dust, and wind. The main aim must be to maintain the crop in good condition for as long as possible. Storage of crops is one of the functions of warehousing where protection of crops and risk bearing is an essential factor. In addition, it prevents any mishaps like theft or loss.

As observed by the study of the Food and Agriculture Organization that the higher the temperature, the lower should be the moisture of the grain in order to make sure good conservation of the crops. Due to high temperature, food loses its weight slowly and in the end are shrivelled,

rotten. High moisture content leads to problems because it encourages fungal and insect problems. Lack of proper care could cost huge losses for the farmers. This makes their huge income loss.

The main objective of this work is to develop an IoT instrumented Warehouse Traceability System, which will enable farmers to have live data of temperature, moisture and other parameters at a very low cost so that the live monitoring can be done. Also, to boost the earnings of the farmers and to reduce the workforce and difficulties in storing ranches.

IoT based Agriculture Storage system is a new approach in the research area and is the whole town is talking about in past few years with various architectures and frameworks. Researchers have worked in different parameters such as Temperature Sensor, Humidity sensor, LDR, Smoke Sensor, Fire Sensor and many. Also, worked on different hardware devices and software platforms. In the past some of the researchers had done related work for warehouse monitoring which has some draw back reported below:

In 2013, S. Kaushik et al. [1] established monitoring and controlling platform in the food storage system based on ZigBee and Bluetooth. Using these modules, the PIC microcontroller sends the data. The data from the sensor unit is received and stored in a database.

H. Nigam et al. [2] have induced assistive technology which monitors indoor environmental parameters. This paper widely focused on the AQI monitoring system consisting parameters such as CO, CO₂ and other environmental parameters. The live status of toxic gas and AQI level are being monitored on Node-Red dashboard.

A. Srivastava et al. [3] have developed a framework for facilitating food monitoring for the protection of the food.. Input data from the sensor is analyzed using Raspberry Pi2. An alert message is received in an emergency over Wi-Fi by using the Tkinter module that supports GUI.

S. S. Sruthi et al. [4] utilized the technology of Thingspeak cloud for storing the data. Sensors like Luminosity, Fire/Smoke, Door Status Sensors, etc are deployed in the cold storage to sense the environment and this data can be presented to the users. WAMP is used to host the website on the local machine.

T. N. A. Kumar et al. [5] developed a system that deals with monitoring and controlling various environmental conditions in a warehouse. Sensors like temperature, humidity, smoke, load cell and LDR sensor. Renesas microcontroller the value updates to the web server through the GSM.

S. A. Khumkar et al [6] integrated the mobile application, which is used to facilitate user interaction and connect through the system. The sensor like DHT11 and IR sensor are stored in the cloud using Raspberry Pi and sent to the base station by connecting to the database using the IP address.

The structure of this paper is as follows: Section II will cover the overview of System Methodology and elaborates on the System implementation, Data Transmission. Section III describes a flowchart of the complete prototyping framework. Section IV highlights live data results. Section V will cover the conclusion and future scope.

II. SYSTEM METHODOLOGY

This section explores and justifies the development purpose of the system for using a particular research method. It also includes the process of hardware and software architecture, modules and components, interface and data for the system to satisfy the specified requirements.

A. SYSTEM OVERVIEW

The Internet of Things is an interaction between the physical and digital worlds. The application of IoT in agriculture warehouse is about empowering farmers [7]. IoT has mainly five layers namely perception, transport, processing, application, and business layers. The first three layers is used in our work as the perception layer has sensors for sensing and gathering information, the transport layer transfers the sensor data to the next layer wirelessly and the processing layer which helps to visualize the data that comes from the transport layer[8].

In this paper, the important factors such as temperature, humidity, motion , shock, CO and fire is measured and detected. With the help of IoT the live data is visualized on the dashboard using MQTT broker and it can be monitored at any time by the farmers.

The IoT nodes are designed using ESP32 and various sensors .These nodes are located in the warehouse at various location. Farmers can observe the information using mobile phone as text message and E-mail[9].

In order to achieve well-organized warehouses in an easy way, let us present the idea of setting up a warehouse, which is based on IoT.

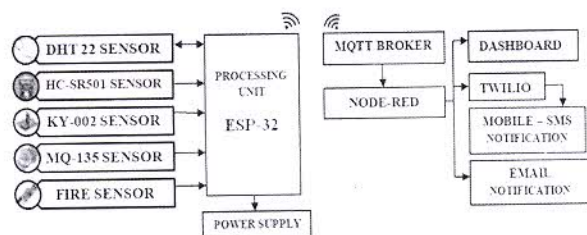


Fig. 1. Block diagram of prototyping framework

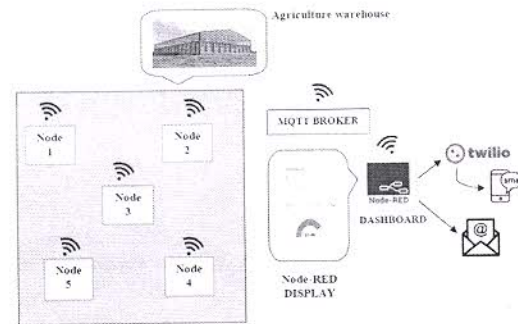


Fig. 2. Overall system Architecture.

This prototype framework is shown above consists of sensors, ESP32 WiFi Module. IoT node monitor temperature, humidity, motion, vibration and smoke in the warehouse. Micro-controller of WiFi units gather sensor data from the sensors and publish it to MQTT broker. All parameter values are displayed on Node-Red Dashboard. And measured warehouses parameter data are sent to an email and mobile SMS through MQTT Broker protocol.

B. SYSTEM IMPLEMENTATION

In this section, multiple sensors interfaced with the ESP32 WiFi module as shown in fig.3.

- 1) *Hardware Implementation:* It includes ESP32 WiFi module, DHT22, HC-SR501, KY-002, MQ-135, Fire sensors.
 - a) *DHT22 Module:* DHT22 also known as AM2302 is a temperature and humidity sensor ranges from -40 to 80. It operates in the range of 3.3V to 6V. It has +-2percentage RH (Max +-5percentage RH) accuracy for humidity and ± 0.5 Celsius for temperature. The sensor uses its own one-wire protocol for communication [10].
 - b) *HC-SR501:* This sensor has adjustable settings for delay time and sensitivity. Also, there is a jumper arrangement for a single movement and for multiple movements. The maximum sensitivity it achieves is up to 6 meters. It operates in the range of 5V to 20V. It detects motion in a 110 cone angle [11].
 - c) *KY-002:* The switch is normally open in this sensor, detecting vibration the switch is closed. It works on the voltage from 3V to 5V. It has an anti-interference ability. It connects directly to the micro-controller output I/O port. When the module detects a shock, it indicates the value of digital output [12].
 - d) *MQ-135:* We use the MQ series as it detects gasses like Carbon Monoxide (CO), LPG, Smoke, etc. In this work, we detect CO, which is produced when fuels such as gas, wood do not burn fully. Smoke from cigarettes also produces CO gas. As its poison to people who breathe it. MQ-135 has lower conductivity to clean air but when the conductivity of the gas sensor increases due to any harmful gas, the concentration of the harmful gas increases. It operates in 5V. It has to keep for preheating for over 24-48 hours [13].

- e) *Fire sensor*: Fire sensor is used to detect the presence of a fire source or any other bright light sources. In this work, this module used an Infrared Radiation Sensitive Sensor based on photo transistor. It is interfaced with ESP32 module to detect fire.
- f) *ESP32 Wi-Fi Module*: ESP32 is a low cost and low power system on chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. It is an Xtensa dual core or single core LX6 microprocessor that operated the voltage range of 2.2 to 3.6V. It has a 448Kbyte Data ROM and 512 Kbytes Data SRAM. This Wi-Fi module is connected to the DHT22, HC-SR501, KY-002, MQ-135, and Fire sensors [14].

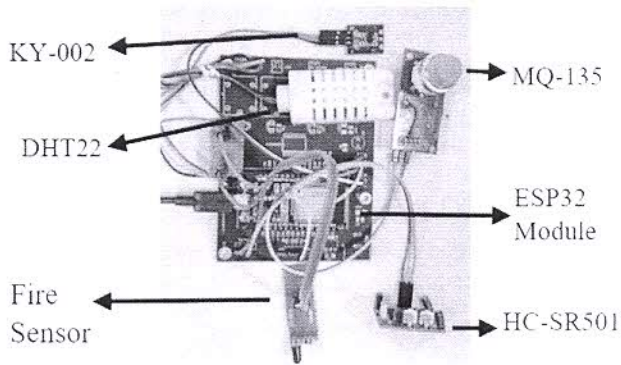


Fig. 3. All sensors interfaced with ESP32 module (IoT node).

2) *Software Implementation*: It includes Programming, Node-Red Dashboard.

- a) *ESP32 Programming*: For programming, Arduino IDE platform is used. It is an open source platform. It supports languages C and C++.
- b) *Node-Red Dashboard*: To collect and visualize data from the sensor, the Node-red dashboard is being used. Node-red used to wire up input, output in order to create flows for data handling[15]. It supports the connection in order to execute functions such as via e-mail or to services like Twilio for monitoring the data both online or offline.

C. DATA TRANSMISSION

- c) *MQTT Protocol*: It is the application layer protocol for IoT. This allows the device to send or publish data on a given topic to a server. There is an MQTT broker (Mosquitto Broker) in between publisher and subscriber. Sensor data publish to the broker or IoT device. The sensors are the publishers in the network. The broker takes data from the publisher and sends it to the device that subscribes to the sensor data.
- d) *JSON Encoding Format*: The sensor input data are serialized in JSON format. As JSON is easy for a human to read and write, we communicate over MQTT using JSON. All sensor's data of one node are combined in JSON format and send over to the MQTT broker.
- e) *Twilio*: It is a Cloud communication platform that send text message through APIs. It is easily accessible model[16].

III. FLOWCHART OF COMPLETE PROTOTYPING FRAMEWORK

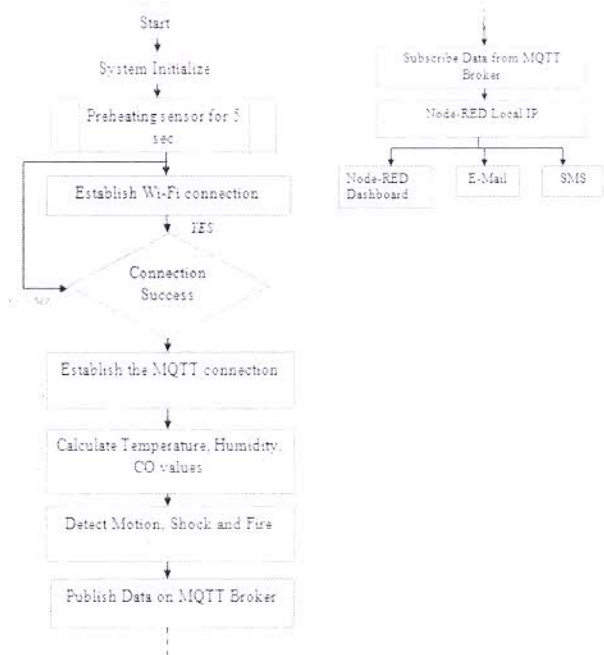


Fig. 4. Flowchart of IoT node system.

IV. RESULT AND DISCUSSION

This section includes the status of different sensors and the snapshots of the system.

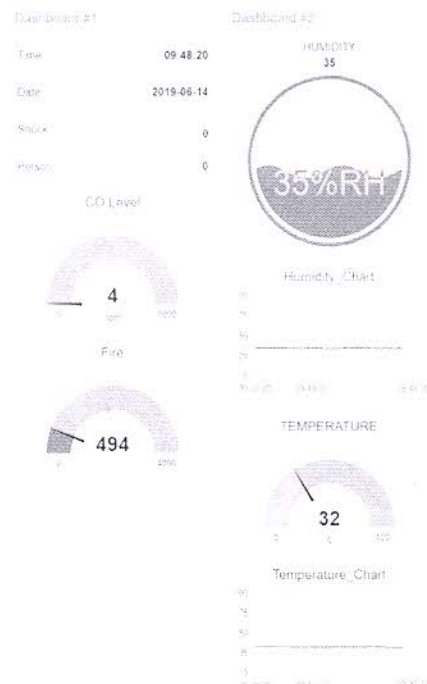


Fig. 5. Data visualize in Node-Red Dashboard.

Fig.5 Dashboard#1 shows live monitoring data including Time and Date also shows the detected value of Shock, Person in a binary format. Fire and Toxic gas like Carbon monoxide is represented in chart which gives the visual display of the amount or level. Dashboard #2 shows the measured value of Humidity and Temperature. Here, the graph chart helps to observe the changes in degree of the environment parameters.

Farmers can visualize the sensor data from any device and can trace the live data from anywhere. Furthermore, users will be notified via email and text message at an interval of every 30 min. Fig.6(a) shows the Email notification in a single string and Fig.6(b) shows the SMS notification sent via Twilio in a single string.

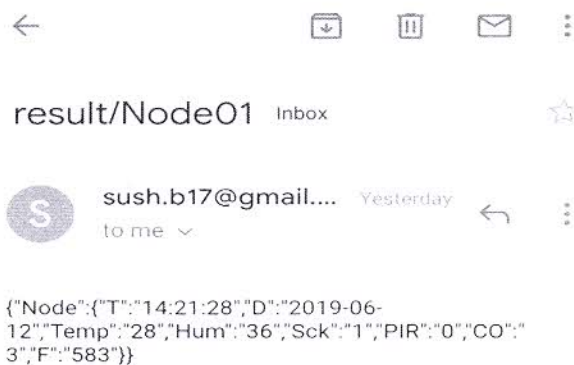


Fig.6 (a). Email Notification of the Warehouse

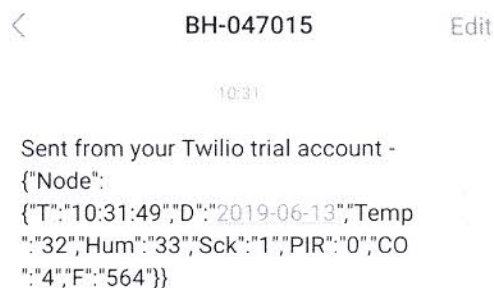


Fig. 6(b). Mobile SMS of Warehouse Environment.

V. CONCLUSION

This work demonstrates the design and implementation of monitoring platform used in the food storage system. Besides establishing a food maintenance system, it proposes a low-cost solution based on IoT. This system promotes the upgrading of the warehouse management system avoiding food waste and unnecessary economic loss. The temperature sensor is used to sense the rise in temperature. The humidity sensor is used to see the percentage of humidity present in the warehouse. On detection of harmful gas, the gas sensor helps in detecting CO inside the warehouse. On detection of

tilt or any lateral movement of the rack, the shock sensor is used. If the presence of fire flame detected, to protect grains from fire, fire sensor is being used and a notification is sent to the user. The sensors data is being displayed in the dashboard to which a user can monitor the live data results from anywhere and anytime. Dashboard parameters update automatically with the newest sensor data. Moreover, simultaneously the email is sent to the user.

VI. FUTURE WORK AND OUTCOMES

As IoT has entered in the agriculture field, this technology will be easily accessible to farmers. In the future we can use, different sensors with high sensitivity, high adaptability, and high reliability will be developed and which can be helpful to preserve the grains and vegetables. The sensors data can be stored in a database to which a user can monitor the current and the history of data from anywhere and anytime. The system can be designed for controlling food items stored in the warehouse. The device can be facilitated to collect the information of theft so that the implementation of machine learning is achieved.

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