IoT Based Real Time Warehouse Monitoring using Sparkfun ESP8266 Thing Dev and Cayenne MyDevices

Muhammad Afzal[1], Hafiz Ali Hamza Gondal[2], Muhammad Bilal Arshad[2], Moeed Shahid[2]

[1]*CTO imzlab 15-C Small Industrial Estate Lahore Road Sargodha, Punjab, Pakistan*

[2]*The University of Lahore Sargodha, Punjab, Pakistan*

Abstract:

As Internet of Things (IoT) field is growing very fast in this modern era, and new technologies are coming day by day which are creating huge impact on our life as well is in industrial area. Industrial Internet of Things (IIoT) is a subcategory of IoT. With the advancement of industry trends warehouses are becoming essential part of industry to maintain their stocks. Every product requires specific Environment i.e. temperature & humidity to maintain its life span. Currently industries are using manual methods to take readings and maintain their warehouse which are not effective. Human errors and mistakes are always possible in an environment of manual methods. These methods are not suitable for warehouses and lead to huge loss in terms of stock which creates high impact on region's economy. This paper presents the real time implementation of indoor and outdoor temperature & humidity monitoring. Our proposed system has also capability of indoor smoke monitoring of warehouse. The study focuses on the IIoT project to monitor the warehouse indoor and outdoor conditions in real time plus instant notification alert via SMS and e-mail according to thresholds. The method of analysis is performed on Sparkfun ESP8266 Thing Dev Board, NodeMCU implementation with Cayenne MyDevices Cloud. Cayenne MyDevices is a real time Cloud for IoT devices which uses Message Queuing Telemetry Transport (MQTT) Protocol to receive and send data to and from nodes. At hardware level nodes are using DHT22 (Temperature & Humidity) and MQ-2 (Smoke & Combustible gases) Sensors. Nodes will send the sensor readings to cloud via Wi-Fi network. Nodes are easily movable within the area of warehouse due to Wi-Fi mode of communication. This system will work effectively to maintain warehouse environment easily and in a systematic way. Experimental results proved that proposed system works efficiently in warehouse environment to increase the life span of products.

Keywords: Internet of things, Industrial internet of things, Sparkfun thing dev, NodeMCU, ESP8266, Cayenne Mydevices, MQTT, DHT22, Smoke Sense

**Corresponding author address:* Muhammad Afzal

CTO imzlab 15-C Small Industrial Estate Lahore Road Sargodha

+92-302-5151829, afzal.attari786@gmail.com

1. Introduction

IoT is an emerging and very fast-growing field in this modern era. IoT is also putting very huge impact on our daily life style as well as in Industrial environment. IIoT is a subcategory of IoT which deals in Industrial Process enhancements. IoT/IIoT systems are making our daily life process very fast and easy, due to this advancement there is huge business potential [1]. Warehouse in any industry works as back bone to store goods, specially food items, medicine, beverage and grain. Industry are using warehouse to store their products in warehouse for long term supplies. Different industries are using remote warehouse to store their goods. Temperature & Humidity plays very vital role in these industrial warehouses. Every product needs a specific environment to increase or maintain its storage life span [2]. Currently Industries are using Manual Temperature & Humidity reading to maintain their warehouse environment. But due to manual system many time industries face a huge loss in their stocks which results in the loss of region economy, clients and production. There is also another issue observed which Smoke Monitoring in warehouse is.

Industries are using different kind of equipment's like thermometer to detect the warehouse temperature and humidity which lakes to take real time readings. Traditional methods are time consuming and inefficient, which is not effective to critical situation for products life span. In Some warehouses it is difficult for human to visit inside and take manual readings of temperature and humidity. Such type of warehouse requires immediate actions in case of uncertain changes in temperature and humidity [3].According to above mentioned issues This paper will demonstrate the real time implementation of Warehouse Indoor/Outdoor Monitoring system which will monitor the Temperature and humidity of Warehouse as well as Indoor Smoke Monitoring, and it will use trigger functionality to send instant notifications if any value reach or cross the threshold value via SMS and Email to recipients so that owner can take necessary actions on time. Proposed system is a huge benefit for those industries which have remote warehouses. Industries will be able to monitor their remote warehouse at central place in real time without support of additional human resource. Nodes are using Wi-Fi as mode of communication to stream sensor readings to cloud which is cost effective method.

Sparkfun ESP8266 Thing Dev Board

The Board used in this system is Sparkfun ESP8266 Thing Dev for Indoor Monitoring, as shown in Fig.1 that has been designed using espressif ESP8266 System-On-Chip (SoC) including FTDI(chip used to add USB support in device) USB-to-Serial chip. This Board could be easily programmed by Arduino IDE & Arduino based C Language [6].

NodeMCU ESP8266

NodeMCU ESP8266 is an open source board as shown in Fig. 2. It was specially created for IoT platform and was introduced on Dec 2013. Its firmware based on ESP-8266 wifi SOC. The data of sensors will be send to Iot cloud server with the help of this board

DHT-22 (Temperature & Humidity) Sensor

DHT-22 is Temperature & Humidity sensor shown in Fig.3, used by both boards in Outdoor & Indoor Monitoring. It can read the temperature from -40 to +125 degrees Celsius with +-0.5 degrees accuracy. It has also capability of humidity measuring range, from 0 to 100% with 2-5% accuracy

Fig .1 Sparkfun ESP8266 Thing Dev[6]

Fig .2 NodeMCU ESP 8266 [7]

Fig .3 DHT-22 sensor [5]

MQ-2 (Smoke & combustible gases) Sensor Module

MQ-2 Module shown in in Fig.4 is used to detect the smoke and combustible gases in Indoor monitoring of warehouse. It has capability of detecting humidity measuring range, from 0 to 100% with 2-5% accuracy. It is very sensitive to these gases and give us quick alarm in case of emergency.

3-D Printed Enclosure for circuits

Custom 3-D Printed Enclosures show in Fig 5, has been designed to enclosed the components of Indoor/Outdoor circuits devices.

Fig .4 MQ-2 sensor [4]

Fig .5 3-D printed enclosure of devices

Arduino IDE

Arduino IDE is an Opensource Integrated Development Platform (IDE) to Program Different types of MCUs. which uses High Level Language syntax based on C & Java to Program MCU Boards.

Cayenne MyDevices

Cayenne MyDevices show in Fig .7 is a world first drag and drop IoT cloud platform. It provides ease of use and less development time to developers and designers in order to design of IoT prototypes [10]. Platform stores all the data and provide Web and Mobile (Android & IOS) interface to visualize the data in different ways like graphs and text.

Tinker CAD 3-D Model Design

Tinker Cad show in Fig .8 is a free, simple, easy to use web-based application for 3D design. It is used by professional, students and makers to design 3D models for visualization as well as for 3D Printing [11].

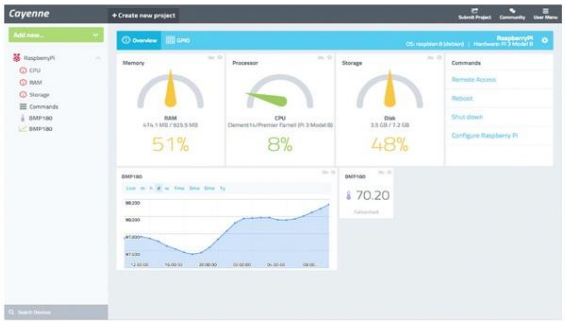


Fig .7 Cayenne MyDevices Web Interface [10]

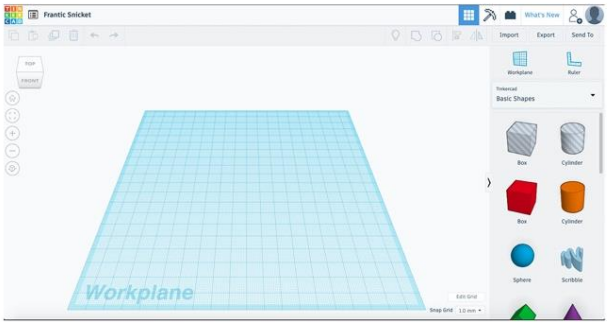


Fig .8 Tinker Cad Application Web Interfaces [11]

2. Material and Methods

System Description

High level overview of our proposed system is shown in Fig .9 which is demonstrating that sensors are connected with MCUs. Data is processed on Arduino Platform, which is simple and opensource. The System-On-Chip (SoC) ESP8266 Wi-Fi module allows MCUs to connect with Internet. MCUs will send the sensors readings to Cayenne MyDevices Cloud using MQTT Protocol. Proposed system can send the readings to cloud every second but currently our system is sending the readings with the delay of 10 seconds. Data will be sent to cloud instantly by MCUs and could be watched on Web and Mobile using Cayenne MyDevices WebApp and Mobile App.

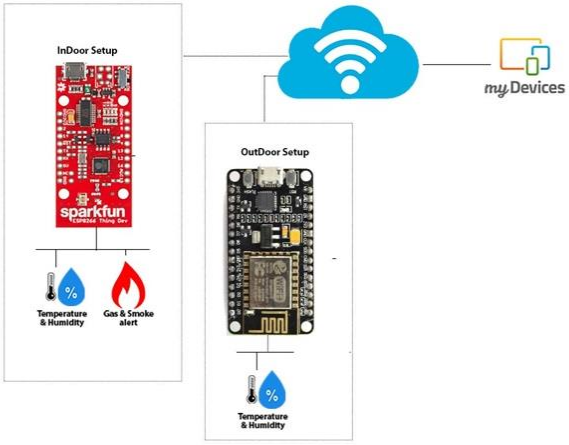


Fig .9 High Level diagram of proposed System

System Flow Chart

The working flow of our proposed system is shown in Fig .10

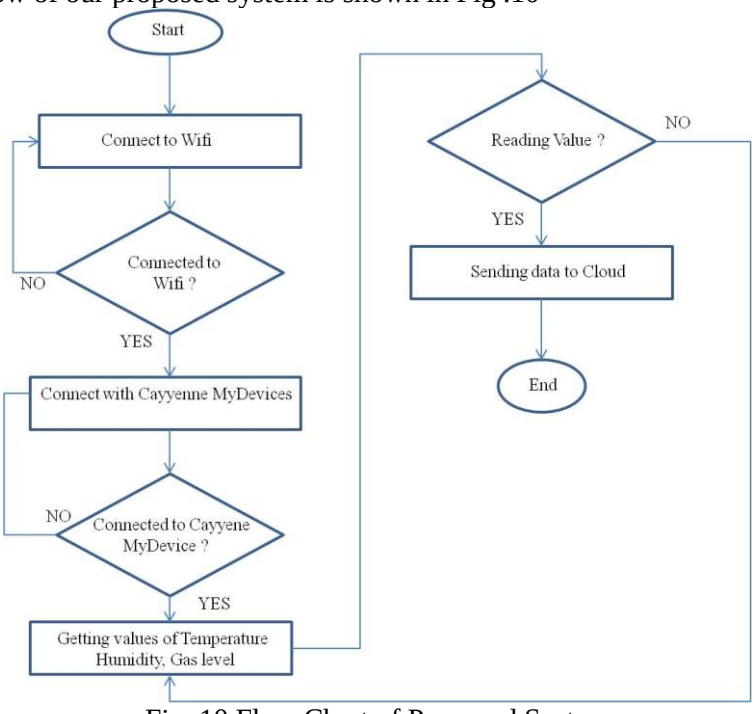


Fig. 10 Flow Chart of Proposed System

A- Sensors Pinout Diagram and specifications

Proposed system is using two sensors DHT-22 shown in Fig .3 and MQ-2 Gas Sensor show in Fig .4. DHT22 temperature range is -40 – 125 °C / ± 0.5 °C, Humidity Range 0 – 100 % / ± 2-5%. Operating Voltage Range is 3-5V [8]. Pinout Diagram is show in Fig .11

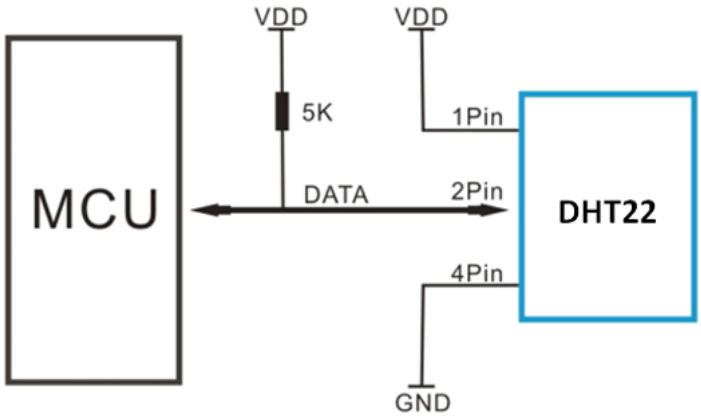


Fig .11 Pin out Diagram of DHT-22 with MCU

MQ-2 Gas Sensor Module sense the Smoke and combustible gases. Module Operates on 5V and provide Output in both Digital and Analog. Due to Digital Output it can be used as a stand-alone without any MCU Support. If System requires to fetch the values in PPM then Analog pin is used to get PPM Values. To fetch Accurate PPM values it is required to use 10K Ohm resistance while preheat duration of sensor is 20 seconds. Make sure to wait at least one minute before taking the readings from sensors[4]. Module Pinout Diagram is shown in Fig .12

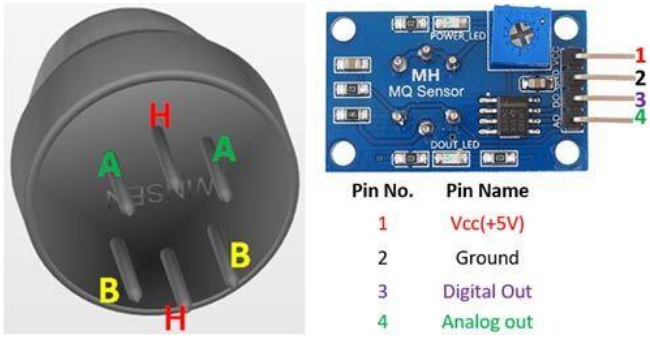


Fig. 12 Pin out Diagram of MQ-2 Sensor

B- System Circuit Diagram

Indoor Node circuit is shown in Fig .13 DHT22 (Temperature & Humidity) and MQ-2 Gas Sensor Modules are connected with Sparkfun ESP8266 Thing Dev Board. DHT22 requires Minimum 3V to operate and MQ-2 Sensor Requires 5V to Operate, for better results including 10K ohm resistance

which connects from ground to signal. Outdoor Node circuit is shown in Fig .14, NodeMCU is connected with DHT22 to fetch outdoor temperature and humidity.

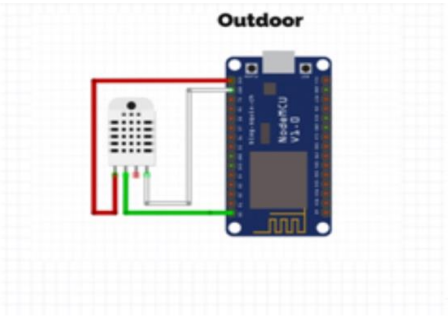


Fig .14 Outdoor Node Circuit diagram

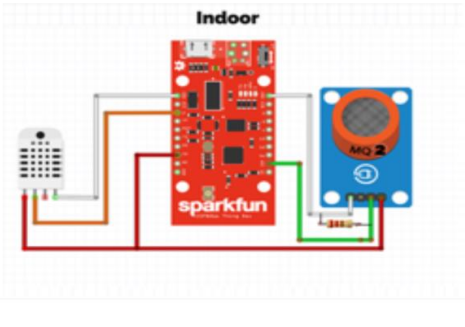


Fig .13 Indoor node Circuit diagram

C- Code of Proposed System

Wi-Fi and Cayenne MyDevices Authentication Code is shown in Fig .15, Sensors Reading and Cloud functions are shown in diagram Fig .16, which is demonstrating the delay of 10 Seconds between every reading. If there is any error in temperature and humidity reading then node will not send that data to cloud but for debug purpose it will show error on serial monitor. For gas level if value is greater than 0 then it will send the reading to cloud.

```
20
21 // WiFi network info.
22 char ssid[] = "******************";
23 char wifiPassword[] = "******************";
24
25 // Cayenne authentication info.
26 //This should be obtained from the Cayenne Dashboard.
27 char username[] = "******************";
28 char password[] = "******************";
29 char clientID[] = "******************";
```

Fig .15 Cayenne MyDevices Authentication Code

```
45  Cayenne.loop();
46  delay(10000);
47
48  sensors_event_t event;
49  dht.temperature().getEvent(&event);
50  if (isnan(event.temperature)) {
51    Serial.println("Error reading temperature!");
52  }
53  else {
54    Serial.print("Temperature: ");
55    Serial.print(event.temperature);
56    Serial.println(" *C");
57    Cayenne.celsiusWrite(0, event.temperature);
58  }
59  // Get humidity event and print its value.
60  dht.humidity().getEvent(&event);
61  if (isnan(event.relative_humidity)) {
62    Serial.println("Error reading humidity!");
63  }
64  else {
65    Serial.print("Humidity: ");
66    Serial.print(event.relative_humidity);
67    Serial.println("%");
68    Cayenne.virtualWrite(1,event.relative_humidity,"rel_hum","p");
69  }
```

```
70
71  //Read MQ-2 Gas Sensor Level
72  GasLevel=analogRead(GasModulePin);
73  if(GasLevel>0){
74    Serial.println("Gas Level=");
75    Serial.print(GasLevel);
76    Cayenne.virtualWrite(2,GasLevel);
77  }else{
78    Serial.println("Gas Level=");
79    Serial.print(GasLevel);
80    Serial.println("Unable to Take Gas Level Readings");
81  }
```

Fig .16 Sensor reading & Cloud Function

D- Cloud Trigger

Cayenne MyDevices Trigger shown in Fig. 17 and 18 which allow to create actions and alerts for your devices. Actions are used to perform device to device operations. Alerts are used to send notifications on SMS and e-mail according to conditions respectively [12].

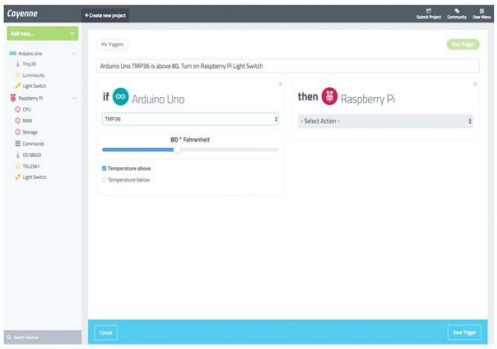


Fig .17 Trigger Action [11]

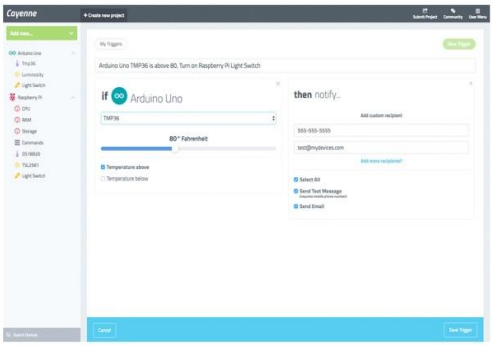
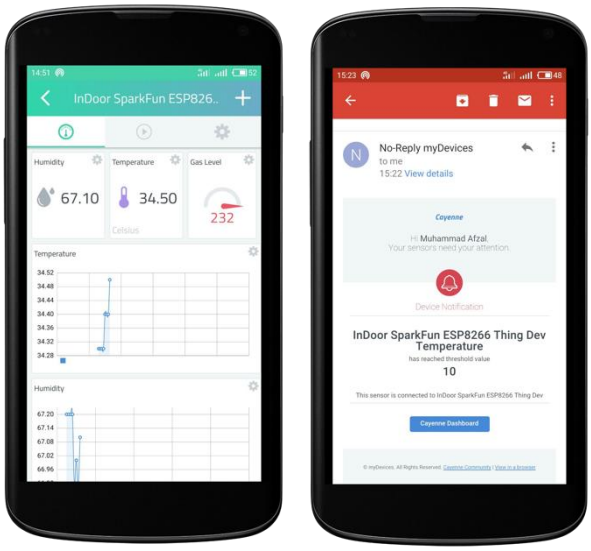


Fig. 18 Triggers Alerts [11]

3 Results and Discussion

System final Prototype is shown in Fig.19, Prototype enclosures are design in Tinker cad and printed by 3D Printer using PLA Material. Nodes are power up by 5v Mini USB Chargers. Nodes Real time data and Threshold Alert Notification is shown in Fig .20

Fig .19 Final Prototype



(a) (b)

Fig .20 (a) Real Time data (b) Threshold Alert Notification

Real time sensors readings of Outdoor and Indoor Nodes are shown in Fig .22, 23, 24, 25, 26 respectively

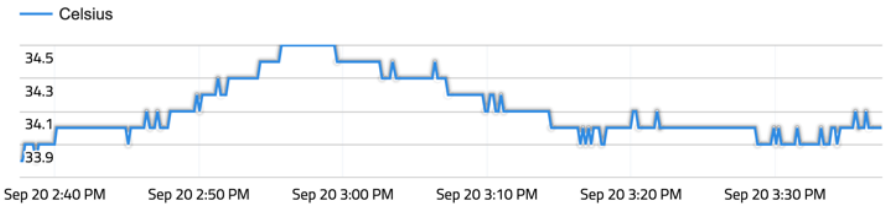


Fig. 22 Outdoor Temperature Reading

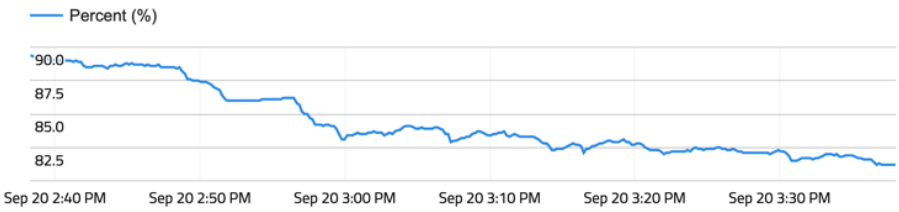


Fig .23 Outdoor Humidity Reading

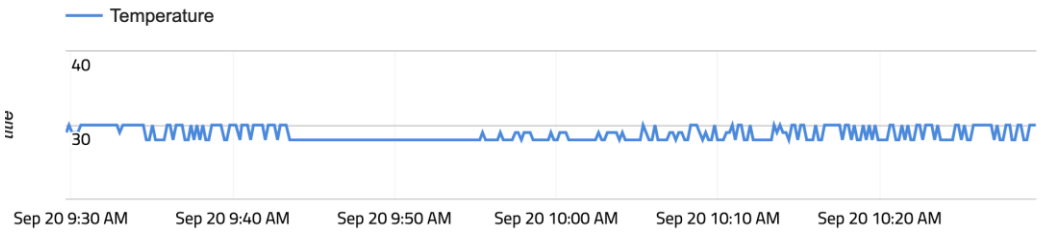


Fig. 24 Indoor Temperature Readings

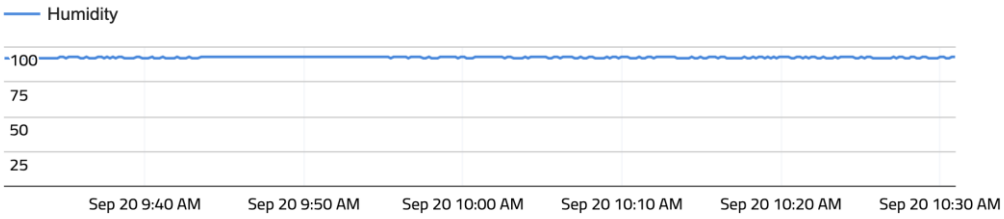


Fig .25 Indoor Humidity Readings

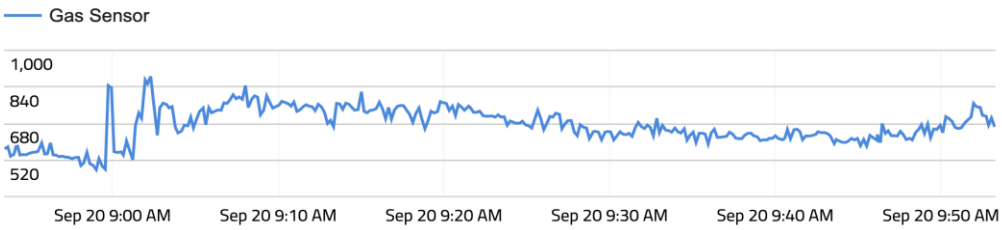


Fig .26 Indoor Gas Sensor Readings

4 Conclusion

In This Paper we proposed real time monitoring of Outdoor and Indoor Temperature, Humidity and Gas Level for warehouse. We used Sparkfun ESP8266 thing Dev Board Including DHT-22 and MQ-2 for Indoor setup and ESP8266 Including DHT-22 for Outdoor setup. Cayenne MyDevices is the cloud that we used in our system to receive and process the sensor readings. We set different threshold values for temperature and humidity and triggered events after the threshold is met. Experimental results showed that proposed system is effective for monitoring of different kind of warehouses. In proposed system we used two main sensors for monitoring of environment but in future we can use more sensors in order to increase the life span of products for warehouses.

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