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Internet of Things Based Environment Monitoring System Using ESP8266 and Arduino Uno

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Abstract

Internet of things is already recognized next revolutionary technology which connects devices together and makes system smarter. Physical quality generating data and these systems are designed to monitor and send further to cloud to make adequate application. In this paper cloud assisted humidly and temperature monitored system is designed. Monitored data will be used to activate some actions such as controlling subsequent devices. The system incorporated with Arduino Uno, DHT 11 Sensor and ESP8266 Wi-Fi module. Data transmitted to IOT service cloud ThingSpeak to further analyzed and stored.

Keywords- Internet of Things, Cloud Computing, Wireless Module ESP8266

Introduction

Today internet is easily accessible to most of the population of world. And with the increase in accessibility of the internet and advancement in the technology, Internet of Things (IoT) has emerged as one of the hot research topic with infinite opportunities and is penetrating in all applications areas like consumer electronics, health care, industrial automation, smart homes, public administration, mobile healthcare, smart grids, intelligent energy management, traffic management and many others. But as with the other technologies, IoT also comes with its own design challenges and security issues.Gas leakage, intensity of light, temperature, humidity and sea level measured by sensors and sent to cloud wirelessly using Arduino Uno [1]. Authors [2] proposed system based upon LPC2148 microcontroller to monitor environmental conditions, data sent to cloud but proposed system will be more costly and complex comparison to Arduino Uno. In [3], authors proposed real time weather monitoring system using Raspberry Pi using Python scripting. Authors presented Arduino based weather monitoring system using Arduino IDE [4]. Authors [5] proposed WSN network for environment monitoring system using Arduino and RaspberryPi.Xbee module takes data from different sensors and sends it to Raspberry Pi. In [7] authors proposed smart wardrobe system by monitoring external environmental changes and predict the clothes according to user requirement, moreover Pi camera is used to detect the level of cloth status.

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1. ESP8266 Wi-Fi Module

ESP8266EX integrated with antenna switches, RF, power amplifier, low noise amplifier, filters and power management modules. Due to minimum size of Printed Circuit Board it allows minimum external circuit because of all modules availability in board. Advance version of Tensilica's L106 Diamond series controller is used. It is having 32 bit processor which is good for Wi-Fi functions to design embedded system. GPIOs can be used to interface external sensors and actuators. For various applications software development kit provides ample of sample codes. Sleep mode to wake-up mode, less power operations, spur cancellation and signal interference mitigation enables by Espresif Systems Smart Connectivity Platform.

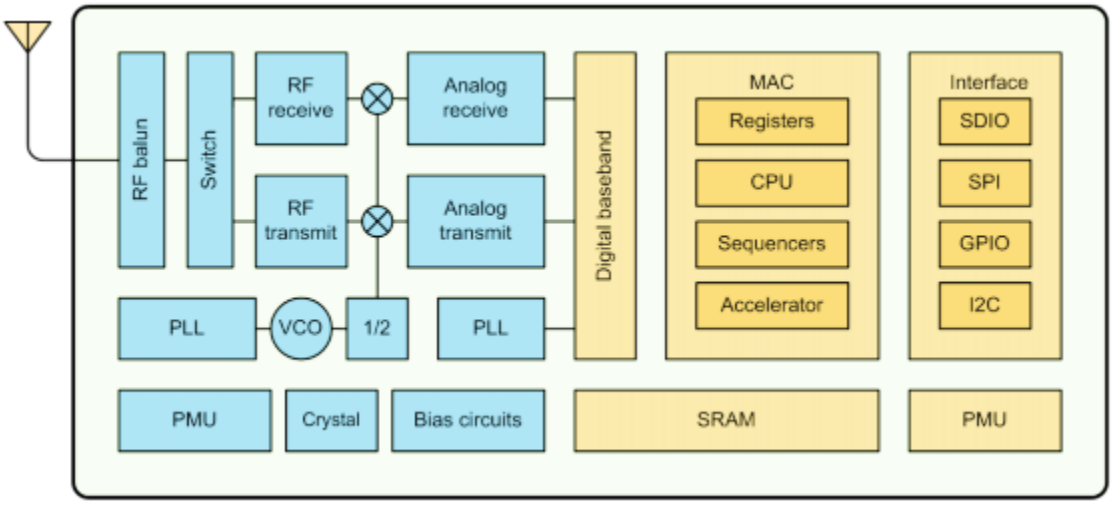

Fig. 1 Block Diagram of ESP8266X Series

The ESP8266 is a system on chip self-contained Wi-Fi module, which included TCP/IP protocol stack that provide wings to any microcontroller to connect with WiFi community. ESP8266 module is capable to set it as access point or station point.In access point mode it can create hotspot and in station point mode it can connect as Wi-Fi. Using this modes data can be fetch and upload over internet in any cloud services. Data can be fetched or upload using API's, thus makes it smarter module. It can be programmed through any microcontroller but using Arduino IDE it makes user friendlier. The ESP8266 module required 3.3V, more than this module will damage. Multiple ways are there one can be to program by using the FTDI board that supports 3.3V or design voltage divider circuit that could provide at least 500mA current. Effective one controller is the LM317 to setup an ideal match.

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Categories	Items	Parameters
Wi-Fi	Standard	CCC / FCC / CE / TELEC / SRRC
	Protocols	802.11 b/g/n
	Frequency Range	2.4 G ~ 2.5 G (2400 M ~ 2483.5 M)
	Tx power	802.11 b: +20 dBm
		802.11 g: +17 dBm
		802.11 n: +14 dBm
	Rx Sensitivity	802.11 b: -91 dbm (11 Mbps)
		802.11 g: -75 dbm (54 Mbps)
		802.11 n: -72 dbm (MCS7)
	Antenna	PCB trace, external, IPEX connector, ceramic chip
Hardware	Peripheral interface	UART / SDIO / SPI / I2C / I2S / IR Remote Control
		GPIO / PWM
	Operating voltage	3.0 V ~ 3.6 V
	Operating current	Average: 80mA
	Operating temperature range	-40 ℃ ~ 125 ℃
	Storage temperature range	-40 ℃ ~ 125 ℃
	Package size	QFN32-pin (5 mm x 5 mm)
	External interface	N/A
Software	Wi-Fi mode	station / softAP / SoftAP + station
	Security	WPA / WPA2
	Encryption	WEP / TKIP / AES
	Firmware upgrade	UART Download / OTA (via network)
	Software development	SDK for customised development / cloud server development
	Network Protocols	IPv4, TCP / UDP / HTTP / FTP
	User configuration	AT Instruction Set, Cloud Server, Android/ iOS App

Table1. Wi-Fi, Hardware and Software Limit of ESP8266X Modules Series

Above tables shows different categories of ESP8266X series modulus working capacity. Modules come with efficient frequency range followed by good sensitivity of Tx and Rx channels. It works and in less power and have well working conditions in different temperature range. WPA/WPA2 security patches make it more reliable to use in different applications.

1.2 ESP8266 Pin Details

The ESP8266 has also General Purpose Input/output pins. It can use as digital input to read the external data or as digital output to send either 0 or 1. Pin no.1 connected to the ground. Pin no.2 which is Tx pin connected to Rx pin of any microcontroller or it can be used as simple GPIO pin when not in use as Tx pin. Pin no 3, GPIO 2 will be used as simple GPIO pin. Pin no 4, CH_PD it is used to enable the chip.

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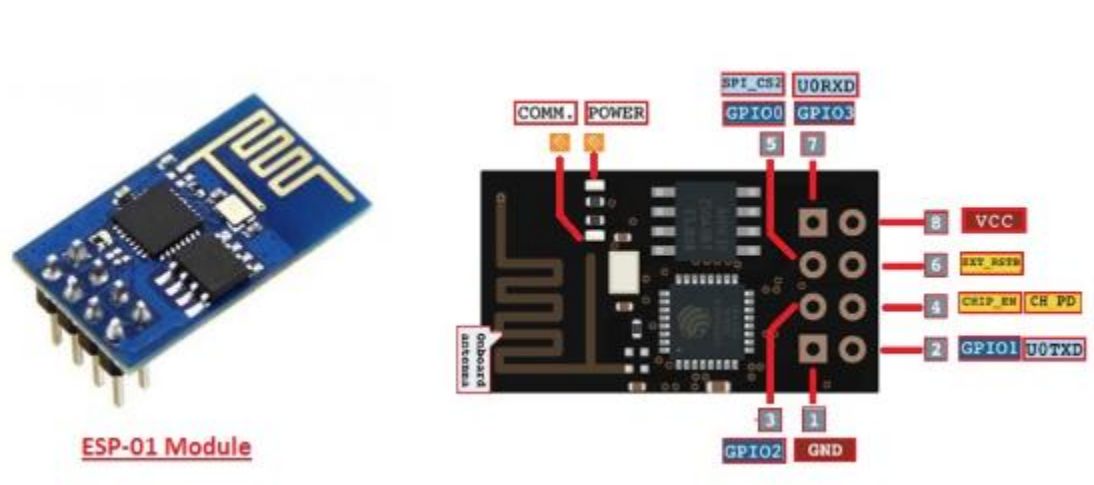

Fig 2. Pin Diagram of ESP8266 Module

Pin no 5, GPIO 0 will be used as simple general purpose input/output pin. Pin no 6, is used to reset the module. . Pin no 7, Rx pin connected to Tx pin of any microcontroller or it can be used as simple general purpose input/output pin when not in use as Rx pin. Pin no 8, is used as power supply pin which required maximum 3.3V.

2. Arduino

Open source software and hardware supports by Arduino, moreover single board microcontroller are used to design embedded systems. These products are under licensed of GNU Lesser General Publice License or the GNU General Public License.Arduino development boards equipped with different type of General Purpose Input Output pins. Those GPIO's can be used to connect analog or digital sensor, expansion shields and actuators. The board use serial communication interfaces included USB which are used to load programs from computer. Arduino provides open source IDE to make sketch.

Arduino boards subsist of an AVR microcontroller (ATmega8, ATmega 328, ATmega2560) with different amount of memory, I/O pins and features. Mostly boards use female headers to connect add-on shields, include 5v regulator and a 16 MHz crystal oscillator.Arduino comes pre-programmed with optibootbootloader.

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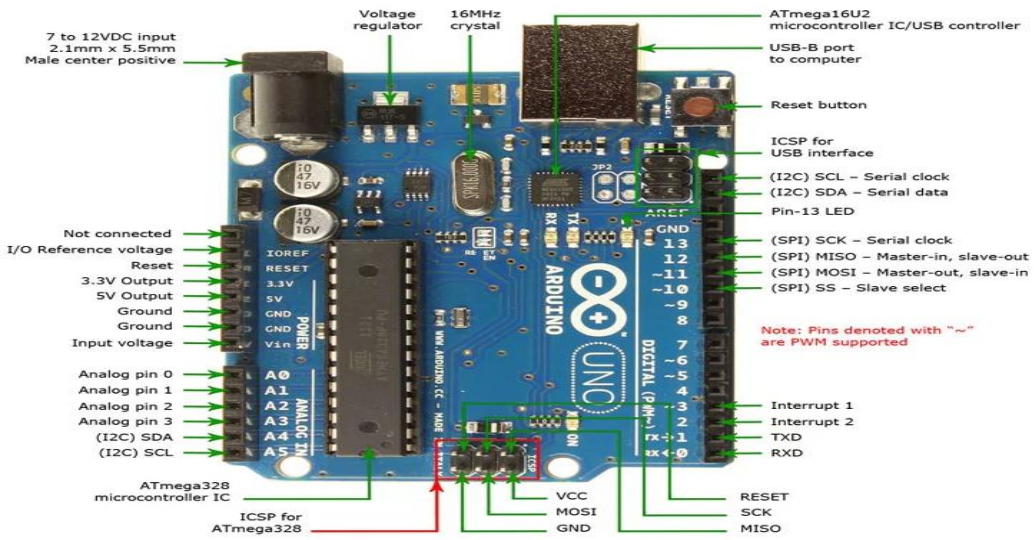

Fig. 3Arduino Uno

3. Testing Of ESP8266 Module Using Arduino

3.1 AT Commands

The following AT commands should bein use at minimum to test ESP8266 Module. As it follows strong supports of AT commands and can be further tested by using data sheet of ESP8266 Module. It is also suggested to test attention commands initially which are going to be used in main program. In order to test here bare minimum code of Arduino is used and following are connection made.

Arduino	ESP8266
TX	TX
RX	RX
3.3 V	VCC
3.3 V	CH_PD
GND	GND

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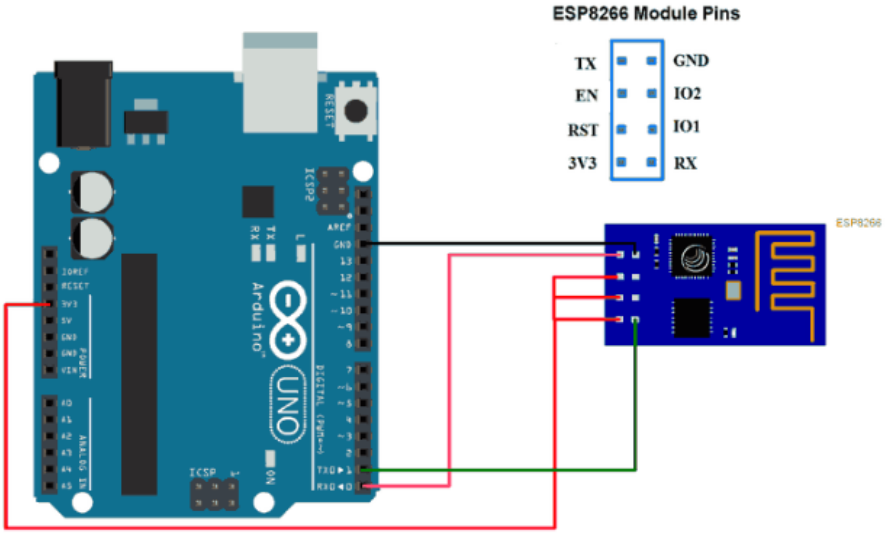

Fig 4.AT Commands Testing Connection between ESP8266 and Arduino

Following code should upload on the Arduino Uno after removing the connection of TX and RX pin.

```
void setup()
 {
}
void loop()
 {
}
```

AT – This attention command will give acknowledgement if module is properly connected. Module will reply as term OK.

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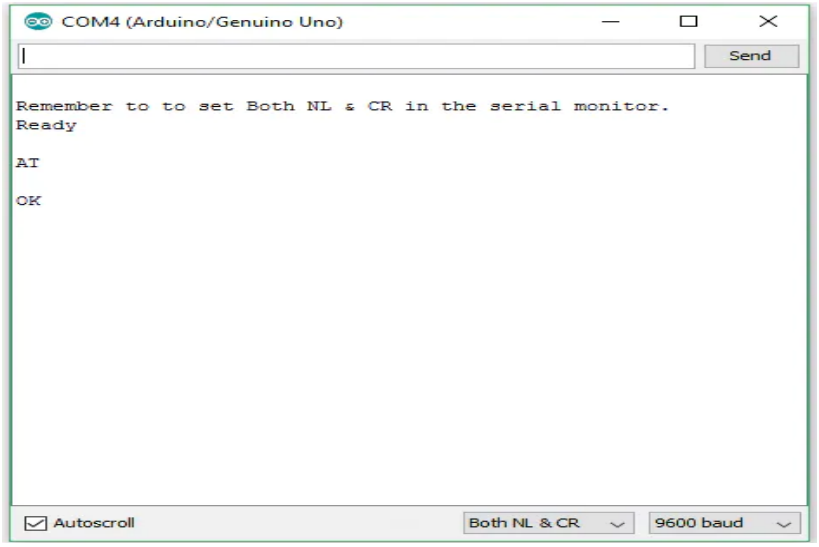

Fig.6 Serial Monitor Output Details of AT command

AT+RST – This attention command will reset the ESP8266 module. It should be always in practice to make module reset before using it.

AT+GMR – This attention command willprovide version of firmware installed on Wi-Fi module.

AT+CWMODE – This attention command will be used to select the modes It can be selected as station mode or access mode.

AT+CWLAP – This attention command will at least discovered the access points and availability of security level, mac address and strength of signal.

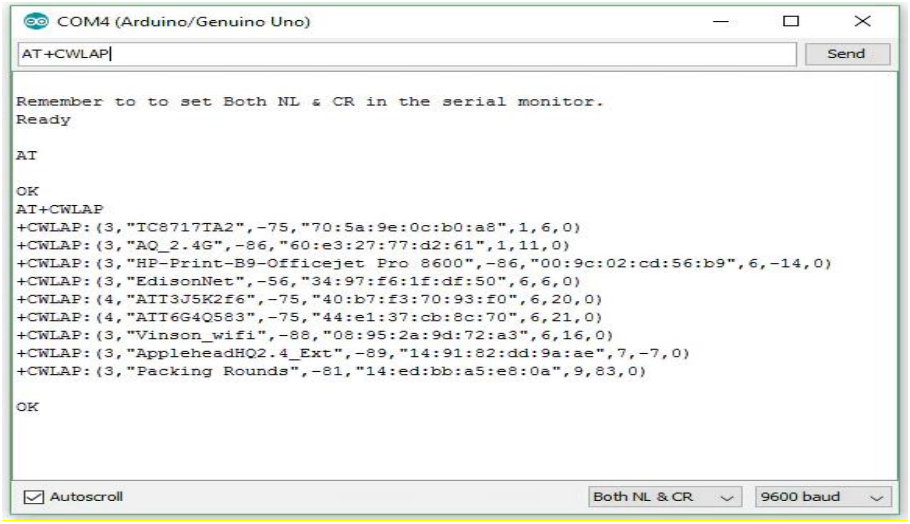

Fig.7 Serial Monitor Output Details of AT + CWLAP command

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AT+CWJAP=”SSID”,”PASSWORD” This attention command will connect with provided SSID.

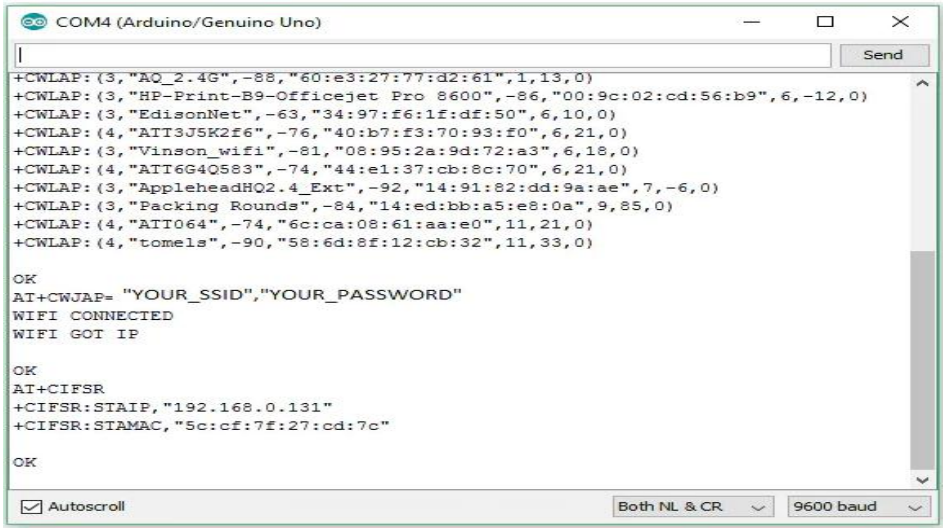

Fig.8 Serial Monitor Output Details of AT +CWJAP command

AT+CIFSR – This attention command will show the ESP8266 module obtained IP address.

4.1 Temperature and Humidity Data to cloud

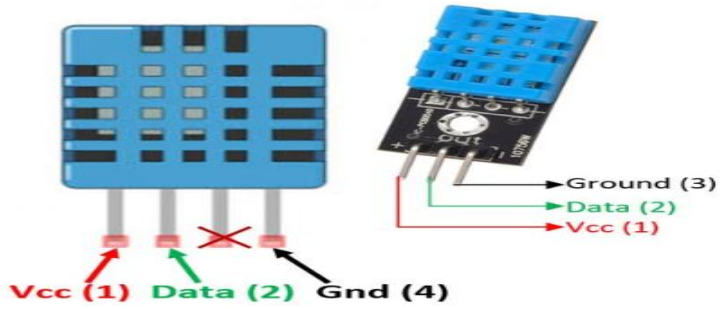

Fig 8 Pin Diagram of DHT11 Sensor

There are two types of pin package available for DHT11 sensor. If the module have three pins then filtering capacitor and pull up registor are inbuit whereas in four pin it should be connected externally as per requirement. The sensor have calibrated and dedicated NTC for measerment of temperature and send data serially of temeprature and humidity to microcontroller.

4.1.1ArduinoSktech to upload data on Thingspeak

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```
#include <SoftwareSerial.h>
#include "DHT.h"
#define DHTPIN 7                          // Digital Pin 7
#define DHTTYPE DHT11                     // DHT Type is DHT11 not DHT22
String apiKey = "API KEY ";               // Edit Channel Write API key
String  Name = "SSID";                    //  Edit SSID
String PSWD = "WIFIPASS";                 // Write Wi-Fi Password
SoftwareSerialser(2, 3);                  // RX, TX
int i=1;
DHT dht(DHTPIN, DHTTYPE);                 // Pin and Type of DHT (7,11)
void setup()
 {
Serial.begin(115200);                     //  baud rate
ser.begin(115200);
ser.println("AT+RST");                    // Reset ESP8266
dht.begin();                      // Initialize  DHT11 sensor
char inv ='"';
String cmd = "AT+CWJAP";
cmd+= "=";
cmd+= inv;
cmd+= Name;
cmd+= inv;
cmd+= ",";
cmd+= inv;
cmd+= PSWD;
```

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```
cmd+= inv;
ser.println(cmd);
 }
void loop()
{
int humidity =  dht.readHumidity();                    // Command to Read Humidity Value
int temperature = dht.readTemperature();               // Command to Read Temperature Value
 String state1=String(humidity);                  // Convert it to string
 String state2=String(temperature);
 String cmd = "AT+CIPSTART=\"TCP\",\"";                 // Build TCP connection
cmd += "184.106.153.149";                        // IP address of Thingspeak
cmd += "\",80";                             // port 80
ser.println(cmd);
Serial.println(cmd);
if(ser.find("Error"))
{
Serial.println("AT+CIPSTART error");
return;
 }
String getStr = "GET /update?api_key=";
getStr += apiKey;
getStr +="&field1=";
getStr += String(state1);                          // Value of Humidity
getStr +="&field2=";
getStr += String(state2);                          // Value of Temperature
```

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```
getStr += "\r\n\r\n";
cmd = "AT+CIPSEND=";
cmd += String(getStr.length());                    // Total Length of data
ser.println(cmd);
Serial.println(cmd);
if(ser.find(">"))
{
ser.print(getStr);
Serial.print(getStr);
 }
else
{
ser.println("AT+CIPCLOSE");                        // closing connection
Serial.println("AT+CIPCLOSE");
 }
delay(1000);                                       // Update after every 15 seconds
}
```

5. Conclusion and Results

This paper presents real time cloud assisted environmental monitoring system. Surrounding environment sensed data sent to cloud using ESP8266 Wi-Fi module. Thingspeak application can be used to see the real time status of deployed hardware in smart phone. This system further modified which can control some actuators using Humidity and Temperature data.

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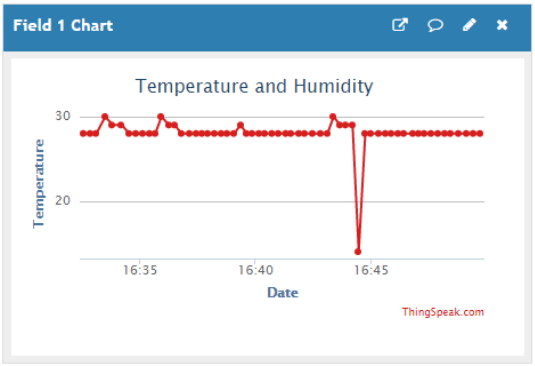
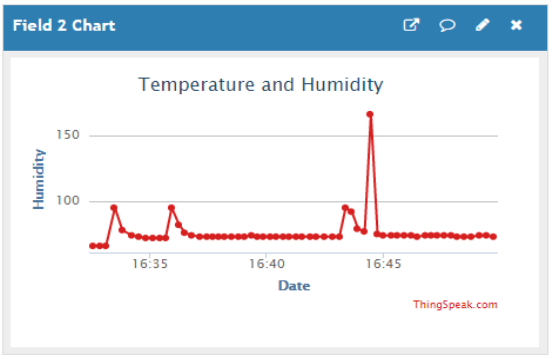


a) Temperature Data



b) Humidity Data

Analysis tools like classifications, clustering, association and so on used for extracting the knowledge from the prepared data. Association rules are if and else statements used to find the relationships between humidity and temperature.Above are the results of sensors in Thingspeak cloud.This paper is important step to understand the working and attention commands of ESP8266 module and to implement IOT applications.

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