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IoT Based Weather Monitoring System for Effective Analytics

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Abstract*: *Internet of Things (IoT) is adding value to products and applications in the recent years. The connectivity of the IoT devices over the network has widely reduced the power consumption, robustness and connectivity to access data over the network. IoT is powering many frontiers of industries and is seen as a promising technology to take Big Data Analytics to a level higher. Weather monitoring system as a module is an issue among IoT research community and it has been widely addressed. A new weather monitoring system is developed using various sensors connecting to Raspberry Pi. The implementation and data visualization on the data collected are discussed in this paper in detail. Weather parameters like temperature, humidity, PM 2.5 and PM 10 concentrations and Air Quality Index (AQI) are monitored and visualized in graphical means using the Raspberry Pi as server and data accessed over the intranet or internet in a specified subnet or world wide web. The data visualization is provided as result and proves to be a robust framework for analyzing weather parameters in any geographical location studying the effect of smog and PM 2.5 concentration.

Index Terms*: *Weather Monitoring System, IoT, Raspberry Pi, PM 2.5.

I. INTRODUCTION

Internet of Things is a novel paradigm combining telecommunications [1] and any kind of device or applications using sensors, tags, microcontrollers and ARM processors. This paper proposes an implementation of weather monitoring system using Internet of Things (IoT). A raspberry pi based implementation is proposed to monitor PM2.5, PM 10, temperature, humidity and the air quality index (AQI) of the Particulate Matter pollutants available. Internet of Things is playing a leading role in providing solutions to many applications with the support of software, internet and embedded systems. There are various IoT devices available in the market ranging from micro controllers to microprocessors. The microprocessors in IoT are normally ARM processors like Raspberry Pi and Intel Edison. There are many technologies developed for weather monitoring using IoT devices and are discussed in section II. In countries like India [2], China [3] and Thailand [4] smog is a natural phenomenon affecting human lifestyle and daily routine of those cities. The implementation done in this paper is based on the heath issues faced by the people in Thailand [5]. Studies have been done to analyze the PM 2.5 concentrations in Thailand for more than a decade [6], [7] from all over Thailand. The data analyzed by [8] states that the predictive analytics of PM 2.5 in Bangkok, Thailand using linear regression says that the parameters of various parameters of timestamp, temperature and humidity are responsible for the concentration of PM 2.5. The data of PM 2.5 was taken from Berkeley Earth database and temperature and other weather parameters are populated using API connectivity to a local weather station in Weather Channel. The data is not populated from the same geographic location. To address these issues, an IoT based weather monitoring system is designed and developed at Thai-Nichi Institute of Technology. The implementation details and the data analysis based visualization are discussed in detail in this paper. The literatures studied on the existing techniques, methodologies and simulations are surveyed in section II. Section III discusses about the implementation and data visualizations of the proposed architecture, followed by discussions in the section IV.

II. RELATED WORK

Weather Monitoring System has been done extensively using IoT devices in the past. The wide range of literatures discussed provide information like a survey. The existing technologies are developed using microcontrollers like Arduino, Node MCU etc and ARM processors like Raspberry Pi. The implementation proposed in [9] shows that a Raspberry Pi based weather monitoring system is developed using pollution sensors. Apart from temperature, pressure and humidity, carbon monoxide concentration is also monitored. This is not purely Raspberry Pi based implementation, but a combination of Pi and Arduino Nano. An IoT node based framework was proposed by [10]. This methodology uses PM 2.5 sensor and monitor it periodically and stores in a cloud server. A raspberry Pi based weather monitoring system is proposed in [11]. This gets basic parameters like temperature, humidity and few other parameters. A weather monitoring system for agriculture was developed by [12] using Node MCU. This uses a temperature and humidity sensor and soil moisture sensor for monitoring weather with respect to agriculture. A higher resilience based weather monitoring system using microcontroller was developed by [13]. This was done mainly to target under developed and developing economies. This used temperature, humidity and rain gauge systems to obtain data in real time. A data logger based weather monitoring system is proposed by [14] using a microcontroller uses temperature, humidity, light and CO sensors. There are many weather monitoring systems proposed using simulation as in [15], [16], [17] using Labview based interfaces.

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Since weather in tropical countries like India, China and Thailand are heavily affected by air pollutants, there are some studies done on the IoT implementation using pollution monitor sensors also. The method proposed in [18] states the post processing of pollution data and weather monitoring systems to predict the weather.

III. PROPOSED METHODOLOGY

The detailed architecture of the system implementation is given in fig 1 below. It shows the hardware connected to the raspberry Pi and the software used in managing the data collected using the sensors. The scope of this framework is to store the data in a cloud server but the implementation reports in the availability of data over the intranet of a specified subnet. Data collected is made available to download in CSV format and the latest weather data in JSON format is made available to share data online over the network. The software implementation of this proposed system is available in GitHub and it can be accessed from the link http://www.github.com/ferdinjoe

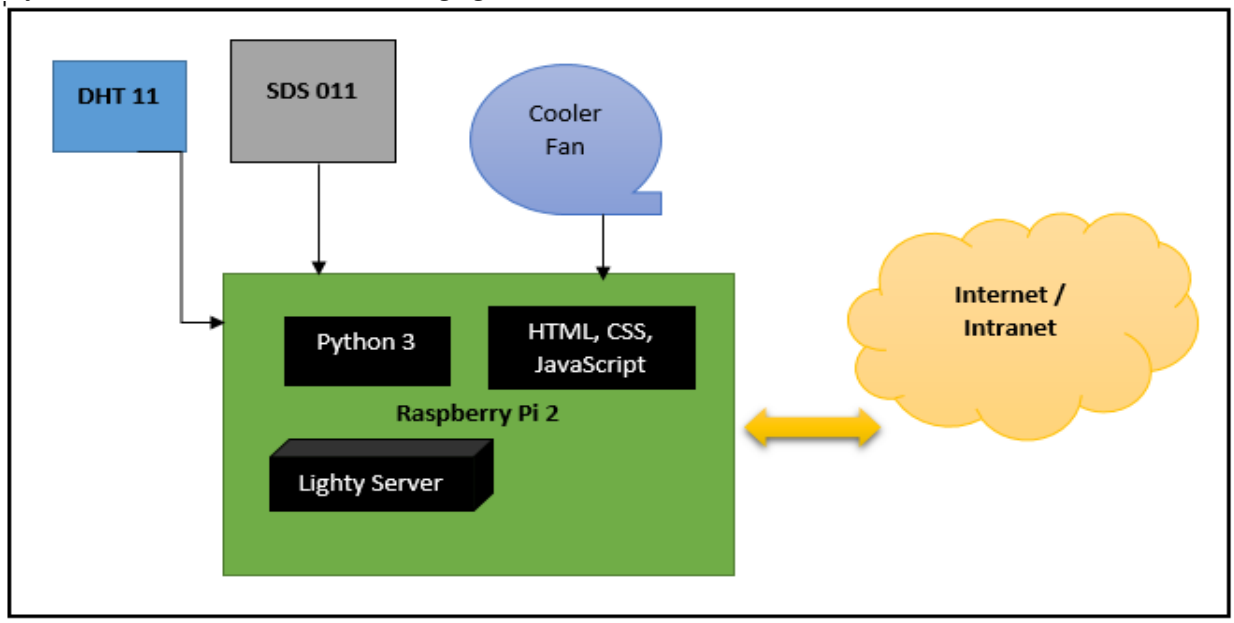

Fig 1: Architecture of Proposed System

The weather parameters measured using the proposed system's implementation are given in table 1.

S.No	Parameter	Hardware
1	Temperature	DHT 11 sensor [19]
2	Humidity	DHT 11 sensor
3	PM 2.5 concentration	SDS 011 sensor
4	PM 10 concentration	SDS 011 sensor
5	Air Quality Index	SDS 011 sensor

Table 1: Sensors' specifications

The sensors and cooling fan are connected to Raspberry Pi's input terminals as per the specifications below. Raspberry Pi 2 is used in the implementation. The GPIO pin configuration listed is BOARD interface values in table 2. BCM values are used in the python code used in the implementation. The circuit diagram is provided in the fig 6. The pin configuration of various sensors and their interfacing with the Raspberry Pi are given in Table 2. The pin configuration is chosen as per the author's own preference and it can be changed as per the requirements.

S. No	Device/Sensor	Device interface	Raspberry Pi's interface
1	DHT 11 Sensor	Vcc	Pin 1
		GND	Pin 9
		Signal	Pin 7
2	Cooling Fan	Vcc	Pin 4
		GND	Pin 6
3	SDS 011	USB interface	Any of the 4 USB ports
4	RJ 45 Connector	LAN	RJ 45 port

Table 2: Raspberry Pi interface specification

Raspbian Jesse OS is used to support the hardware and software connected to the Raspberry Pi. TeamViewer for IoT devices is used for remote access of the Pi. Python is used to code for interfacing the sensors, extraction and storing of data from the sensors. DHT 11 sensor is accessed using Adafruit library [20] available in GitHub. SDS 011 is also accessed using the serial port interfacing of python. Since the device is set to run 24x7, a cooling fan is attached to the Pi to emanate the heat generated by the sensors and Pi. This cooling fan is of 0.12A power and works well with 5V power source. In addition to this cooling fan, SDS 011 sensor also has a fan to maintain the ideal working temperature of the device. Python code is written to run the sensors once an hour continuously until an interrupt is given. The temperature and humidity from DHT 11, PM 2.5 and PM 10 from SDS 011 are obtained and stored in a JSON file and appended as a record to a CSV file in the root directory of the lighty web server. Lighty web server is a light weight web server framework for ARM devices like Raspberry Pi and has support to most of the tools used in web technology.

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Fig 2 shows the final design and implementation of the system.

A web based interface is designed as in fig 5 using HTML, CSS and JavaScript to generate reports from the sensor data populated in the JSON and CSV files. Dimple JS library [21] is used to generate data visualization. This web interface is made available to anyone who can access a specific subnet of the intranet. Fig 3 and 4 shows the data visualization . The experiments were conducted in an intranet based IP. This can be made public, if the data storage is provided with a public IP.

Fig 2: Implementation of the system

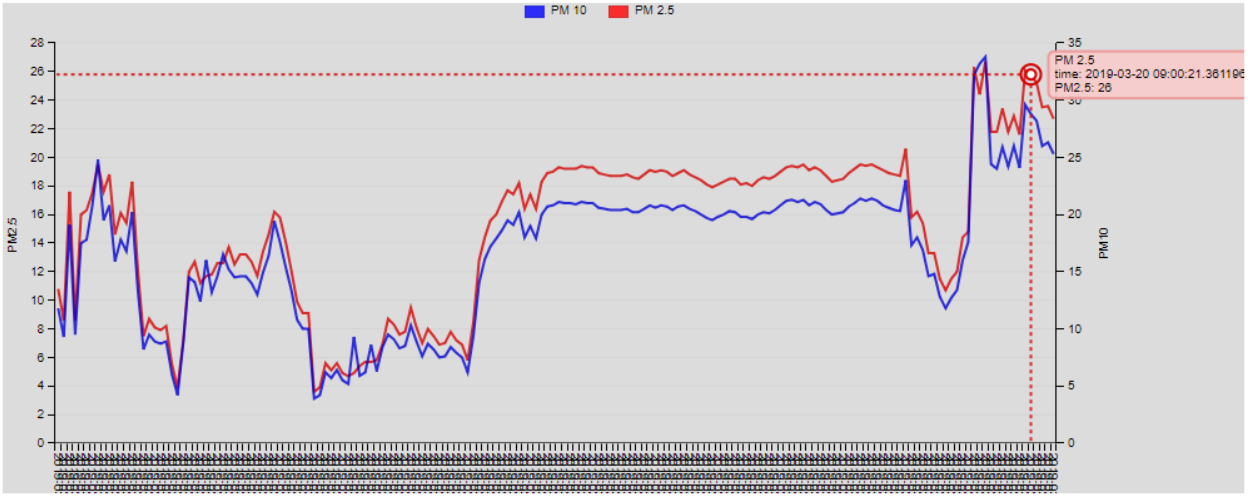

Fig 3: Trends of PM 2.5 and PM 10 recorded in the system

Fig 4: Trends of Temperature and Humidity recorded in the system

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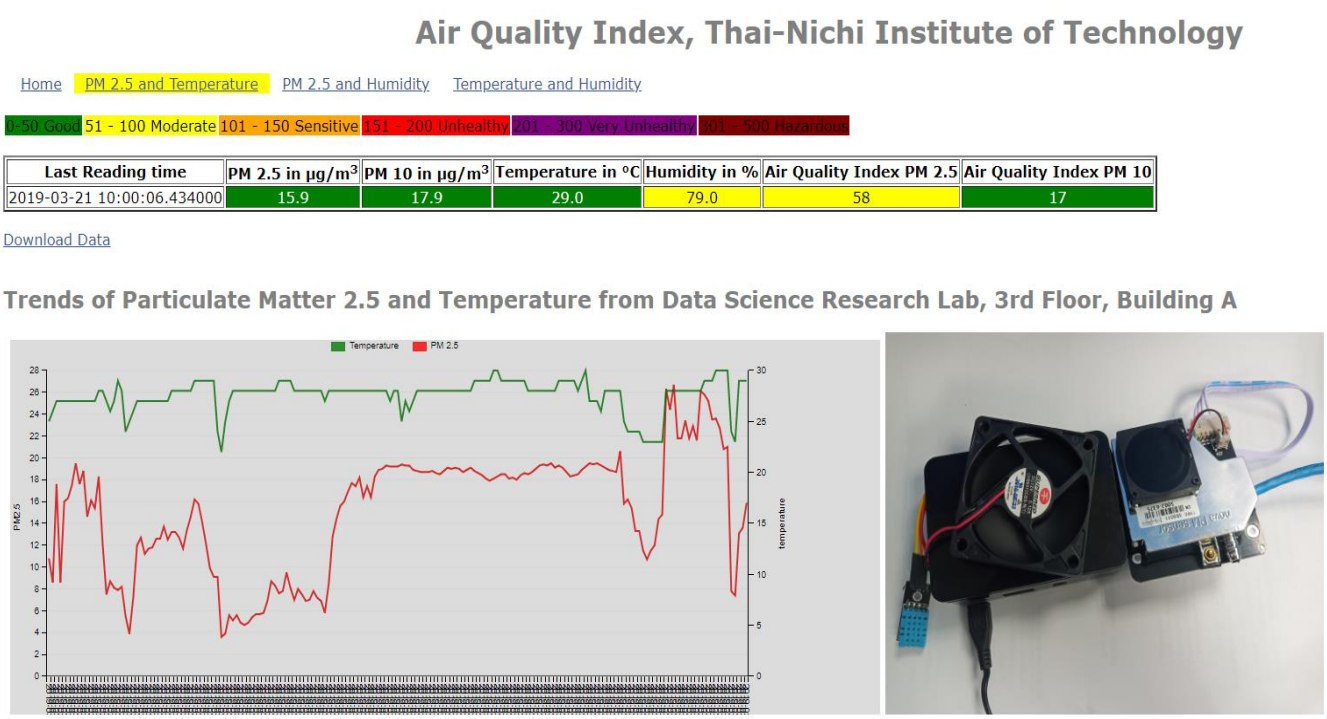

Fig 5: Web Interface created to generate trends of various weather parameters

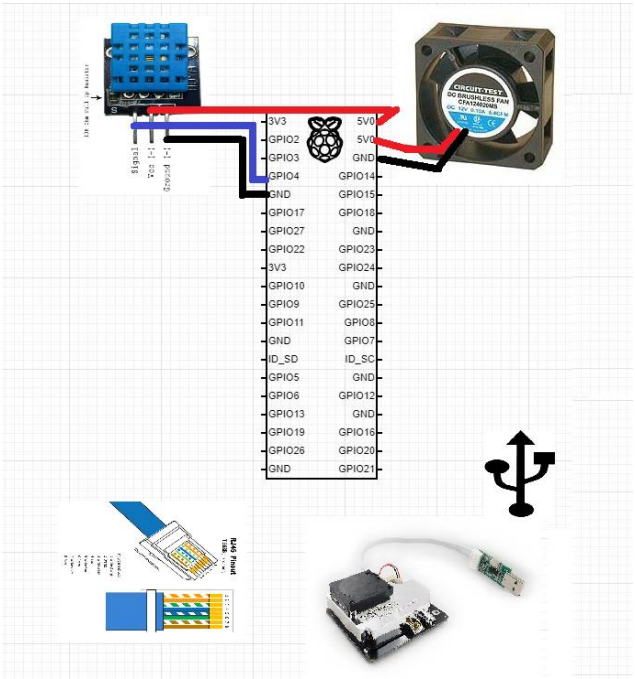

Fig 6: Circuit Diagram of sensors connected to Raspberry Pi

IV. CONCLUSION

The implementation of weather monitoring system using Raspberry Pi is done as per the specifications above and the data insights are generated in web based portal. The access to this data is available in the intranet with the current level of implementation and it could be made public when the data is made to store in cloud servers or other sources in the internet. This proposed system is the most compact unit for measuring weather parameters in regions suffering from the PM 2.5 pollution. This device in multiple nodes can be connected to the internet from various locations of study. This connectivity will aid the user to monitor the weather metrics corresponding to pollution over a centralized data analytics server.

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