Evolution in Electrical and Electronic Engineering Vol. 3 No. 2 (2022) 561-568

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

IoT-Based Weather Monitoring Station for Smart City

Hezry Azhar Shahiziey Azmira[1], Tee Kian Sek[1]*

[1]Department of Electrical Engineering, Faculty of Electrical and Electronic Engineering,
University Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2022.03.02.066
Received 18 July 2021; Accepted 15 September 2022; Available online 30 October 2022

Abstract: The idea of a "smart city" seeks to connect citizens while improving city operations and services by fusing information and communication technology (ICT) with a huge number of physical devices connected to the Internet of Things (IoT) network. One of the pillars of municipal administration is weather monitoring. The term "weather" describes the erratic daily state of the atmosphere, which greatly impacts human activities and is significant in many different sectors. The market's present weather station, though, is pricy and inconvenient. The objective of this project is to develop a weather station that is straightforward, inexpensive, and connected to a cloud platform in order to offer real-time notifications for climate monitoring. As a result, it might improve the accuracy of the city's data. The Arduino Uno R3 and the ESP32-based Wi-fi module DOIT DEVKIT are the microcontrollers used in this project. The hardware in this project is separated into two categories, which are the client units and the master units. Various types of sensors are attached to the client unit, allowing all the parameters to be measured. The nine sensors linked are the temperature and humidity sensors, air quality sensors (PM 2.5 and PM 10), ultra-violet power, ultra-violet index, wind speed sensor, gas sensor, and rain sensor. The Arduino Cloud IoT platform will be used to visualize the input data after it has been sent from the client unit to the master unit. Between the client and the master unit, as a gateway, the LoRa module-equipped RF transceiver type E90-DTU (900SL30) is used. The data gathered by the sensors is then saved on the Arduino Cloud IoT platform. Using Arduino Cloud IoT, a website and mobile application was created to display real-time weather information in a graphical presentation that administrators and users could access. The surrounding weather parameters were collected by the weather sensors and the data was streamed and saved directly into the Arduino Cloud IoT platform. The data can be viewed through the Arduino Cloud IoT website and IoT Remote mobile application. The data presentation can be viewed 15 days before, 7 days before, and 1 day before instead of 1 hour and current data. Furthermore, the administrator has access to review the data collected at any moment. In analyzing the information gathered on particular locations, this initiative might be useful to some parties.

Keywords: Smart City, Weather Station, ESP32

**Corresponding author: tee@uthm.edu.my*

1. Introduction

Nowadays, the Malaysian government is focusing on the Smart City program, which aims to digitally monitor and regulate key environmental variables. A smart city is a technologically advanced metropolitan region that collects data using various electronic technologies, voice activation methods, and sensors. This includes information gathered from citizens, devices, buildings, and assets then processed and analyzed in order to monitor and manage the city.

The smart city idea combines information and communication technology (ICT) and numerous physical devices linked to the Internet of Things (IoT) network to improve the efficiency of city operations and services and connect inhabitants. Internet of Things is a network of physical objects in which electronics are incorporated, as well as software, microcontrollers and sensors that allow users to obtain timely and accurate data through services for data exchange between users or other connected devices [1]. A smart city is an urban region where several types of automated data collection are used to provide critical information for efficient asset and resource management.

As more Malaysians move to cities, cities are experiencing issues such as traffic congestion, pollution, overcrowding, flash flood, environmental degradation, and inefficient urban service delivery. Smart City is a next-generation or future-city approach to urban administration that addresses these concerns and improves the quality of life for city people [2]. There are several components in the smart city such as a smart economy, smart living, smart environment, smart people, smart government, smart mobility, and smart infrastructure [3].

1.1 Weather Station Methods and Mechanism

A smart weather monitoring system is necessary for a smart city. Weather monitoring is critical not just for identifying climate change but also for developing models that allow us to predict future environmental changes. It raises environmental awareness, prepares for extreme weather, climate, and water events, and aids decision-making in disaster prevention and mitigation. Smart weather stations are devices that can measure, and monitors many physical properties in the atmosphere, and store meteorological and environmental parameters without the need for human intervention.

In the proposed project, an IoT weather station for a smart city was developed to measure the parameters of weather. In this project, the Arduino Uno R3, and the ESP32-based Wi-fi module DOIT DEVKIT as a microcontroller is used. The Arduino Cloud IoT platform is used to visualize the input data in graphical and numerical ways. Additionally, people have access to current weather information whenever and wherever they need it.

1.2 Weather Station Overview

In Malaysia, according to MET Malaysia, there are around 400 automatic weather stations installed around the country that ability to report the data every minute to MET Malaysia [4]. Since numerous constructions and barriers have been built around the weather station, its location has become inconvenient. The obstructions will have an impact on the precision of the data. To improve data accuracy, a new weather station must be added in certain locations to determine climatic data. The main problem is that the weather stations that are available on the market are a bit expensive. This project describes a system that, like other high-priced commercial weather stations, can monitor and collect data. As a result, the researchers would like to propose a weather station that might add value to the government's monitoring of weather parameters. The key goal was to keep the weather station as basic, inexpensive, and secure as feasible in order to save the measured data. In this situation, a proposed weather station would be quite useful because it provides real-time data that varies over time. Additionally, using the Arduino Cloud IoT platform, individuals have access to up-to-date weather data whenever and wherever they need it via a website and a mobile application called Remote IoT, which can be downloaded from the Google Play Store and the Apple App Store. It is required for geographic mapping and data monitoring.

2. Methodology

2.1 Hardware Design

An overview of the system's operation is shown in Figure 1. The Master unit and Client unit are the two components that make up the hardware. A client unit is typically located outside, such as in the location where we wish to gather the data, but the Master unit is typically installed indoors, such as in a control room. The input data are gathered by the Client unit, which then transfers them to the Master unit. The acquired input data is then processed by the ESP32 and visualized by the cloud platform. Because it makes it simple, quick, and safe for makers to create connected products, researchers use the Arduino Cloud IoT platform to visualize the data. Using desktop and mobile applications, users may also keep an eye on the data.

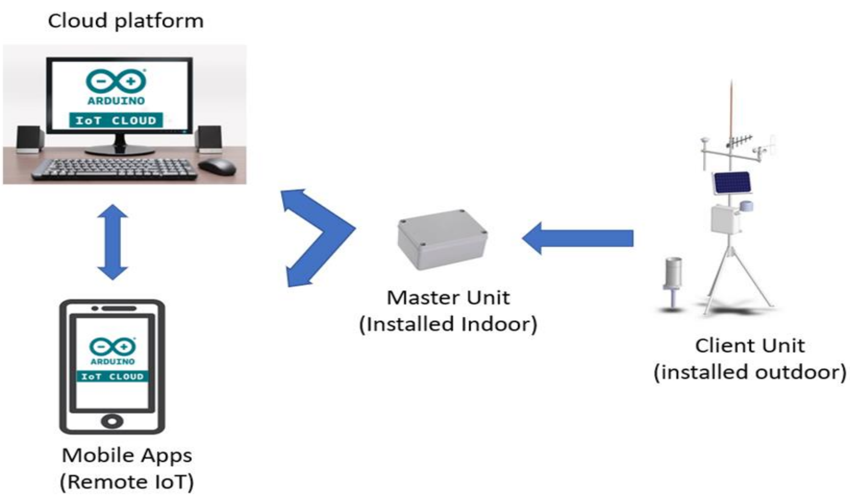


Figure 1: An overview of the system works

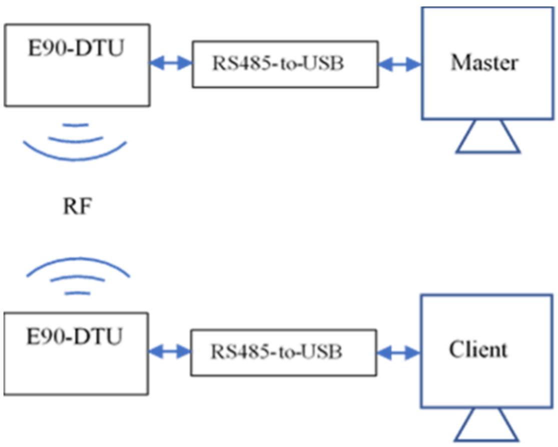


Figure 2: Block diagram of the system works

Figure 2 illustrates how data travels from the Client unit to the Master unit. The Master unit will receive the input data from the parameter sensors that were installed onto the Client unit for the subsequent procedure before visualizing it using the Arduino Cloud IoT platform. This project needs to utilize a data transceiver with a LoRa module to transfer the data from the Client unit to the Master unit due to the installation locations of the two components differ. Both the Client unit and the Master unit have the data transceiver with a LoRa module installed. The gateway for data transmission from the Client unit to the Master unit is a LoRa module. In order to link the Client unit's input data to the data transceiver, we employed an Rs485 to USB connection. Longer communication distances will be possible thanks to LoRa direct sequence spread spectrum technology, which also has strong anti-interference capabilities and a concentrated power density. Within 10 kilometers is the distance covered. Data input that receives from a data transceiver with a LoRa module is connected to the Master unit via RS485 to USB. The master unit will then receive the input data to be visualized using the Arduino Cloud IoT platform.

The client unit houses various parameter sensors. For this study, there were nine parameter sensors employed. They are the rain sensor, temperature and humidity sensor, UV power and UV index sensor, wind speed sensor, PM2.5 and PM10 air quality sensor, and gas sensor. All sensor input data is sent to a control box that houses an Arduino Uno R3 and a data transmitter with a LoRa module. The Master unit is shown in Figure 3.6. A data transceiver with a LoRa module installed in the control room will transmit the input data to the Master unit using an RF signal. On the Arduino Cloud IoT platform, the data will be shown. The master unit has a connector for quick wire connections between all the components, an ESP 32 microcontroller, a data transmitter with a LoRa module, and an RS485 radio.

2.2 Flowchart of the Weather Station

A literature review where intensive research has been done to know the components, types of a parameter used, types of platforms used, and system design by other researchers. Next, designing the weather station based on the parameters selected such as humidity and temperature, UV power and UV index, rain, wind speed, and air quality. Then, all of the gathered data were transmitted to a cloud platform where they were instantly stored and processed. After that, using a data presentation platform, the data were plotted and analyzed. Through the website and app, the graphs were presented in an appealing manner. If the requirement was not fulfilled, the system will be redesigned.

The development method for the project's workflow is outlined in Figure 3. Setting up the hardware is the first step. The Master Unit and Client Unit are the two categories into which the project's hardware is divided. While the Client is installed outdoors, the Master Unit is installed within. The testing procedure must then be carried out using the SSCOM version 5.13.1 serial terminal application. This operation was carried out by connecting the microcontroller to the computer's port using the UART to USB converter. The SSCOM apps will display the data in hexadecimal format. After the testing procedure was successful, the Arduino Cloud IoT platform needed to be set up. To guarantee that all parameter data will display in graphical form, the code must be created using the web editor of the Arduino Cloud IoT platform. The parse data procedures must be carried out to get the display data must be in decimal format. The process of converting data from one format to another is called data parsing. The setup of the program for the Arduino Cloud IoT required developers to create Things and Variables. The dashboard will then show data that were plotted using the Arduino Cloud IoT platform. After that, end users were permitted to access the weather conditions information through the mobile app and website. The Remote IoT mobile application is such a good and beneficial app for users to access weather conditions. Users can get it on the Google Play Store and Apple AppStore for free. Lastly, a trial process must be carried out to ensure that all of the stated objectives are archived.

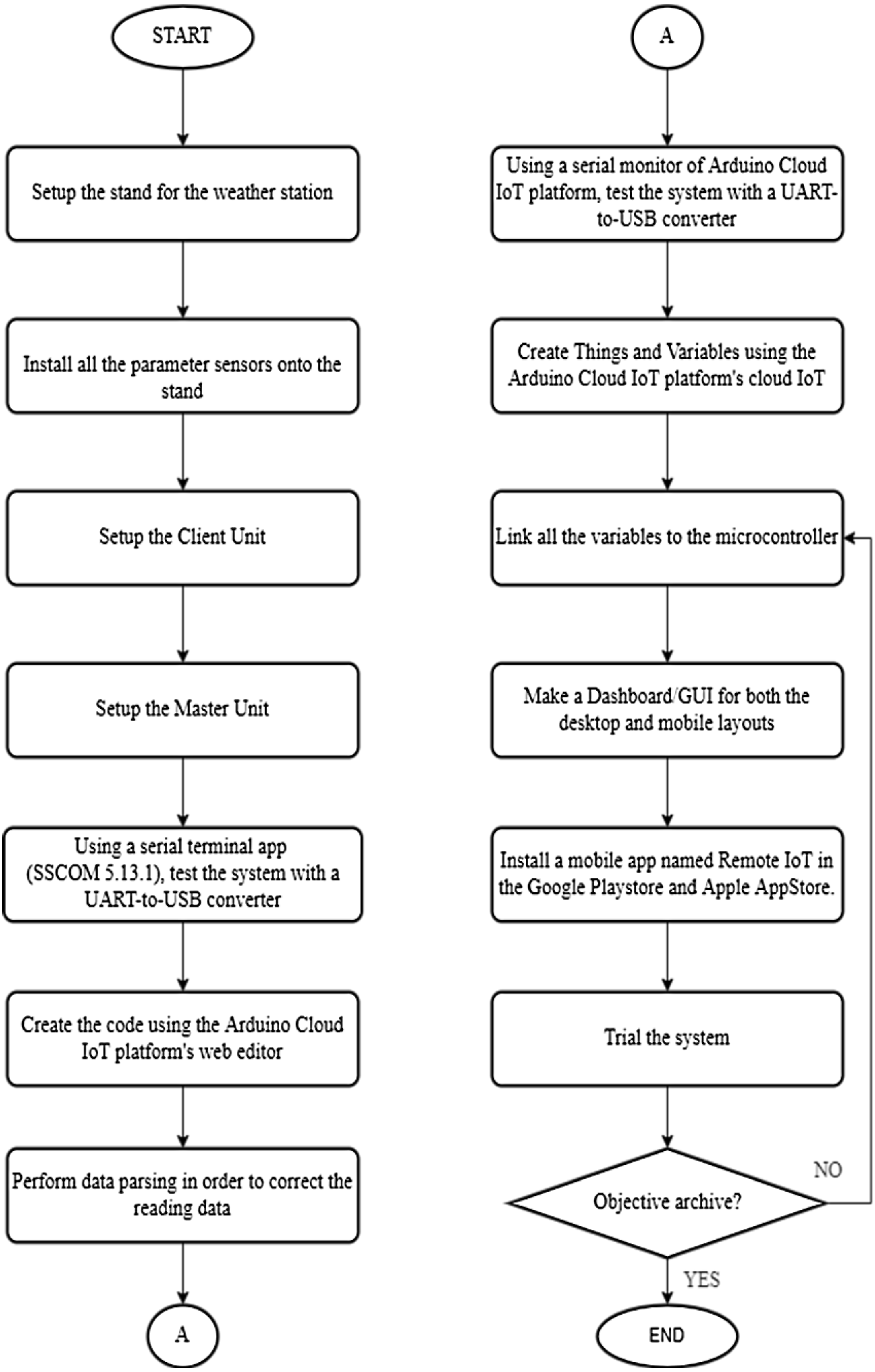


Figure 3: Flowchart of the PV Cleaning System

3. Results and Discussion

The surrounding weather parameters were collected by the weather sensors and the data were streamed and saved into the Arduino Cloud IoT platform directly. Nine parameters would be used in this project. The weather sensors were set to make a measurement every 60 seconds. The data can be viewed through the Arduino Cloud IoT website and IoT Remote for mobile applications. The data presentation can be viewed 15 days before, 7 days before, and 1 day before instead of 1 hour and current data. All the data gathered from the sensors regarding the parameters stated is displayed in the Arduino Cloud IoT platform. The collected data were presented using the Arduino Cloud IoT platform. The data were plotted and displayed in various methods such as values, and charts. The template was being edited and beautified with names of parameters and the units of parameters used in order to be presentable. This enables users to check real-time weather conditions of Parit Raja, Johor, Malaysia via web page and application. The data shown on this web page encountered a delay of twelve seconds after the sensors took measurements. Therefore, the entire process from measurement to data presentation took around one minute.

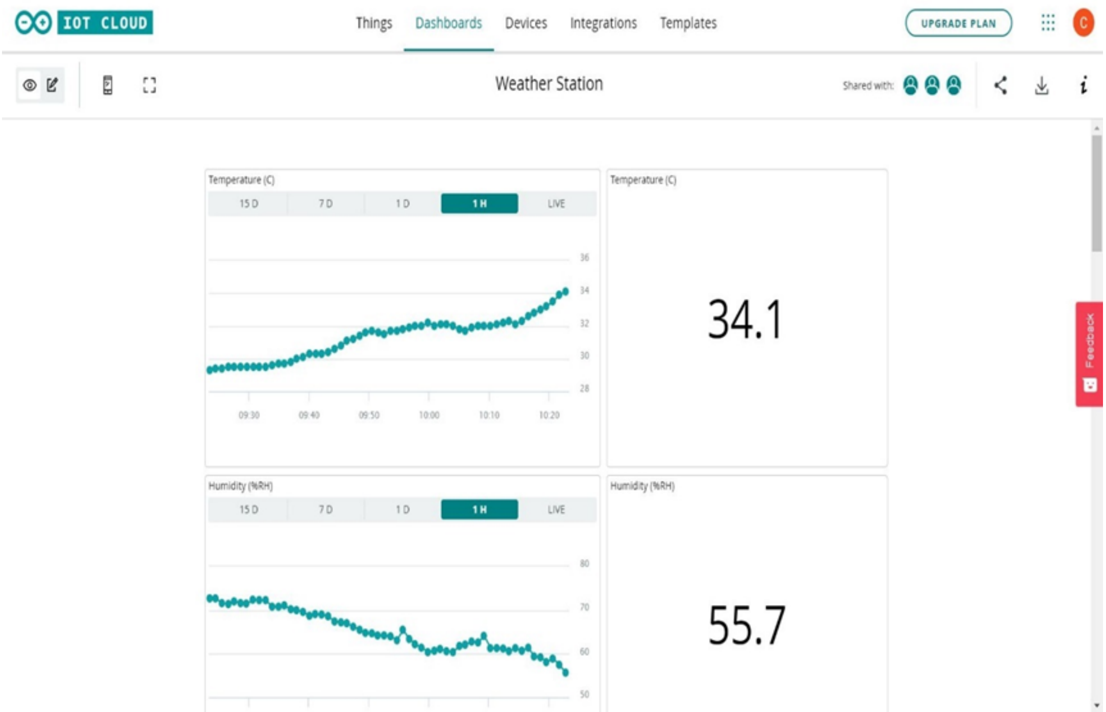


Figure 4: Presentation of data through Arduino Cloud IoT website

Users can also access weather information from an Android application created using Android Cloud IoT named IoT Remote as the user interface. This app is to be installed on the user's mobile phone which connects the users to the Arduino Cloud IoT page directly as illustrated in Figure 5 as long as the mobile Internet works regardless of the present location of the users. The app is currently available to be downloaded from the Play Store for free.

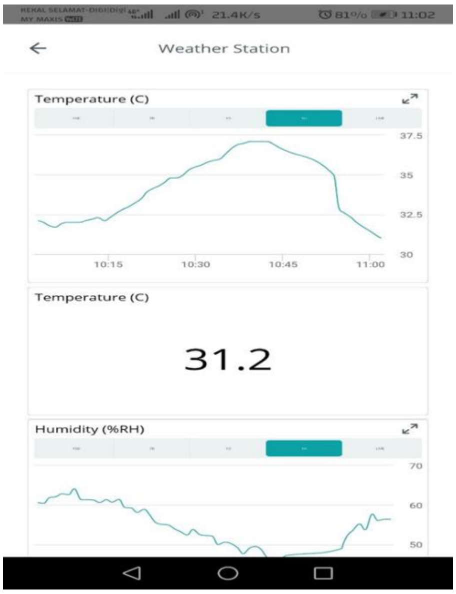
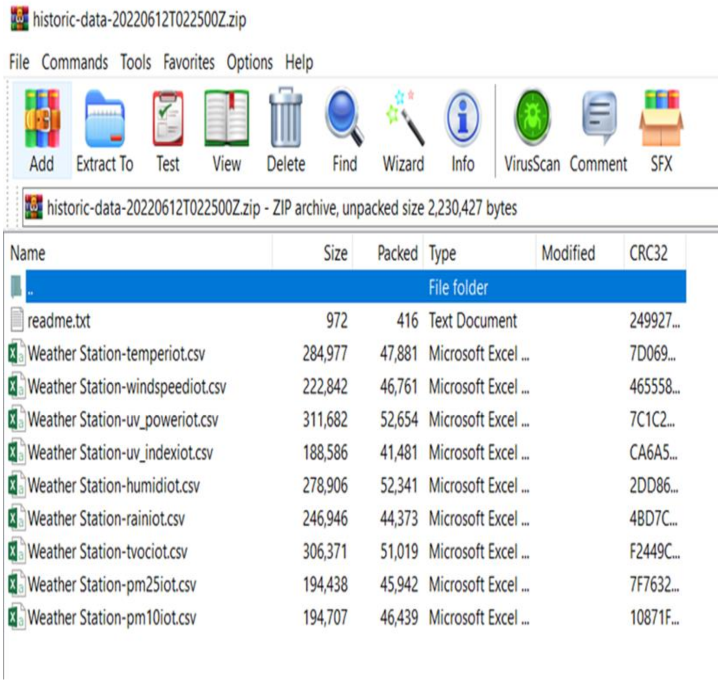


Figure 5: Mobile Interface using IoT Remote application

According to Figure 6, the administrator can download all the data using the Arduino Cloud IoT platform. You can do it by clicking the download icon on the cloud platform's user interface. The file will be sent to the registered email address.



Name	Size	Packed	Type	Modified	CRC32
..			File folder		
readme.txt	972	416	Text Document		249927...
Weather Station-temperiot.csv	284,977	47,881	Microsoft Excel ...		7D069...
Weather Station-windspeediot.csv	222,842	46,761	Microsoft Excel ...		465558...
Weather Station-uv_poweriot.csv	311,682	52,654	Microsoft Excel ...		7C1C2...
Weather Station-uv_indexiot.csv	188,586	41,481	Microsoft Excel ...		CA6A5...
Weather Station-humidiot.csv	278,906	52,341	Microsoft Excel ...		2DD86...
Weather Station-rainiot.csv	246,946	44,373	Microsoft Excel ...		4BD7C...
Weather Station-tvociot.csv	306,371	51,019	Microsoft Excel ...		F2449C...
Weather Station-pm25iot.csv	194,438	45,942	Microsoft Excel ...		7F7632...
Weather Station-pm10iot.csv	194,707	46,439	Microsoft Excel ...		10871F...

Figure 6: Data download in ZIP file format

4. Conclusion

In conclusion, smart weather systems can aid in smart city contextualization and geo-awareness efficiency. In addition, collective intelligence will improve decision-making and empower citizens. A weather station was assembled using Arduino Cloud IoT and the ESP32-based Wi-fi module, with a LoRa module as the gateway between sensors and the IoT Platform. An Arduino Cloud IoT stored all the collected weather data neatly. Thus, all the weather parameters were successfully displayed via Arduino Cloud IoT using various graphical methods which are accessible by both administrators and users. An app named IoT Remote was created by Arduino Cloud IoT which allows users to check whether data by phone with just a few buttons clicked. In a nutshell, the proposed prototype can run in a real condition and achieve the required criteria. This initiative can bring significant added value to the government in terms of obtaining correct data.

Acknowledgment

The authors would like to thank the Faculty of Electrical and Electronic Engineering for supporting the research and development of this research work. Special appreciation to the SENA Traffic System Laboratory, UTHM for providing the related facilities.

References

[1] Glória, A., Cercas, F., & Souto, N. (n.d.). Comparison of Communication Protocols for Low Cost Internet of Things Devices.

[2] Mahāwitthayālai Songkhlānakharin. College of Computing, Electrical Engineering/Electronics, C., IEEE Thailand Section, & Institute of Electrical and Electronics Engineers. (n.d.). The 17th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology : ECTI-CON 2020 : 24-27 June 2020, a virtual conference hosted by College of Computing, Prince of Songkla University

[3] Mishra, N., Singhal, P., & Kundu, S. (2020). Application of IoT products in smart cities of India. Proceedings of the 2020 9th International Conference on System Modeling and Advancement in Research Trends, SMART 2020, 155–157. https://doi.org/10.1109/SMART50582.2020.9337150

[4] Elijah, O., Rahim, S. K. A., Sittakul, V., Al-Samman, A. M., Cheffena, M., Din, J. bin, & Tharek, A. R. (2021). Effect of Weather Condition on LoRa IoT Communication Technology in a Tropical Region: Malaysia. *IEEE Access*, *9*, 72835–72843. https://doi.org/10.1109/ACCESS.2021.3080317