

# Air Pollution Monitoring and Alarming System via Internet of Things

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**Abstract.** Air quality is the most tremendous thing for the life of people. According to a severe situation of air quality in Thailand, air pollution emerges from an internal combustion engine, construction, different transportation, forest fires, industrial production and so on. These lead to a health's problem, especially coronary heart disease and severe acute respiratory syndrome. For this reason, researchers have a notion to apply information technology to monitor and alarm state of air quality in a hazardous area.

Internet of Things (IoT) is a network of smart sensors that can control and monitor things from anywhere over wireless communication and internet. Therefore, this research aims to propose air pollution monitoring and the alarming system powered by the internet of things technology. The smart box has been developed as a prototype to measure the level of air quality, dust, temperature, and humidity. It comprises of two important units including a microcontroller and related sensors. Data from sensors is collected and sent to the IoT cloud server over a wireless network. The Blynk mobile application is used to monitor and display real-time related data through the digital dashboard. Moreover, Blynk application is selected as a real-time notification system to the user provided that air pollution is greater than the standard level.

The research results indicated that the developed smart box and mobile application can monitor and alarm the level of air quality effectively. Also, it is suitable to implement and apply in a smart city for the near future.

years, Thailand have faced air pollution problem affecting health of a large number of people. Air is the necessary factor of human body being and life. Bangkok is the capital city of Thailand where people more than 8 millions [1] living crowded with high density of population.

In January 2019, Bangkok had problem of hazardous particulate matter of small dust covering Bangkok area as shown in Fig. 1. Moreover, the particulate matter has spread into many large areas and provinces around Bangkok, for example, Nakhon-Pathom, Nonthaburi, Pathum-Thani, Samut-Prakan and Samut-Sakhon. These problems caused schools in Bangkok close many days which affect many students.

Air Quality Index (AQI) in January 2019 for Bangkok was measured at 165 that was over the safe standard threshold and is unhealthy towards respiratory tract of people as presented in Fig. 2. AQI is the number for reporting data of air quality and air pollution situation to public in each area to show air quality level whether it affects health or not and how to react to avoid health effect in the form that easy to understand for the general people. It is international form that is world-wide used in many countries which is sometimes called differently. AQI can be measured from calculating amount of 5 types of dirty air which are Ozone (O<sub>3</sub>), Nitrogen dioxide (NO<sub>2</sub>), Carbon monoxide (CO), and Sulfur dioxide (SO<sub>2</sub>), particulate matter of 10 micrometers less in diameter (PM<sub>10</sub>), and particulate matter of 2.5 micrometers less in diameter (PM<sub>2.5</sub>).

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## 1. Introduction

In the present, Thailand is being categorized into developing country group which caused rapidly changes of economy, culture, and environment. During many past



Fig. 1: Air pollution in Bangkok [2]

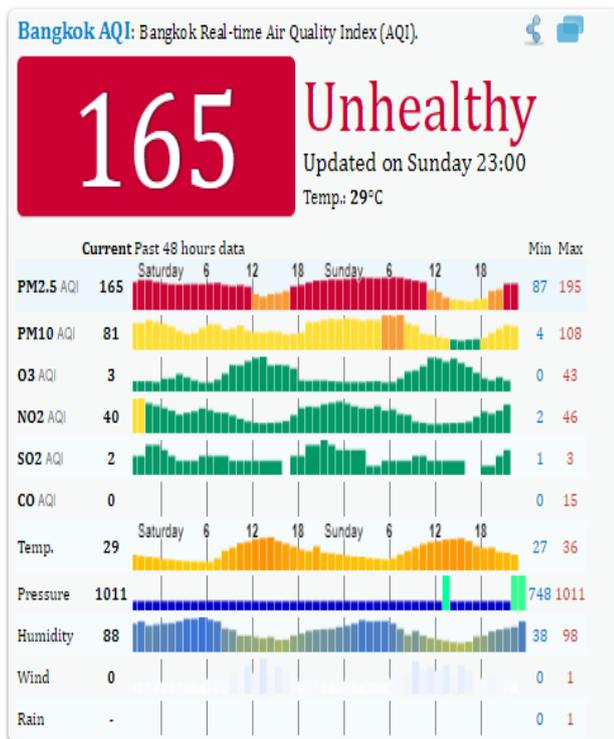


Fig. 2: AQI in Bangkok on January, 2019 [3]

PM2.5 is the particulate matter which has diameter less than 2.5 micrometers [4], and cannot be seen by the eyes. Though it is a tiny dust, it can be expanded together and spread to cover a large area in the air, floating in the atmosphere with the large amount which finally produces smog. PM2.5 is particulate matter 20 times smaller than a hair which can be penetrated the nasal hair to the lungs. Some of them can enter through alveoli wall to capillaries, float to bloodstream, and spread over our body. Moreover, it stimulates free radicals which can increase the risk of cancer. PM2.5 (particle matter smaller than 2.5 micron) is smaller than 3% of hair diameter. It is occurred mainly from engine combustion, construction, agriculture, industrial factory, and power plant that are the factors causing particulate matter in the air.

Internet of things (IoT) is the concept of bringing the internet to connect to other devices and making those devices to be able to receive and transfer data through internet network. IoT has been applied to many functions, for example, public health, transportation, agriculture, and industrial factory. Internet of things can be separated into 3 main parts which are end node or things that microcontroller board and environmental sensors are collected together to send data to the second part which is IoT cloud service. This second part will be the broker to keep database and send data to user. Internet of things is the technology that can track air quality in real time through smart sensor network which is installed in the desired area to monitor air quality. Also, it can warn when the AQI is over the safe standard and dangerous for health. IoT has been used to follow up air

pollution and can fetch data real-time [5], so we can reach the data quickly all the time. Moreover, IoT was used to bring data to analyze and find the factors affecting air pollution [6].

In this case study, from air quality problem that is directly affect people's health as mentioned above, researchers study and develop breathe box to be the tool measuring AQI in living place with tools installed in each room of the house that data can be shown via smart phone.

## 2. Internet of Things

In 1998, Kevin Ashton introduced the term "Internet of Things" [7] to describe the network connecting objects in the physical world to the Internet. IoT communication systems can be divided into 2 main groups [8] : 1) short-distance communication network with a proximity range of less than 10 meters such as Near-field Communication (NFC), Radio Frequency Identification (RFID), Bluetooth, Zigbee, and Wi-Fi that are used to track products and building access, and 2) wireless neighborhood area network with a range of more than 1,000 meters. Wireless neighborhood area network can be further divided into 2 groups: 1) licensed spectrum such as NB-IoT, LTE, and WCDMA that must be granted permission from the government and operated by licensed companies, and 2) unlicensed spectrum such as LoRa and SIGFOX. Each group can be utilized as appropriate.

IoT has been increasingly used in smart life. It is applied in smart home platforms to control home devices and appliances from remote locations such as automatic door opening and closing system, motion detection sensor, intruder alarm system, automatic power on/off system, and remote home monitoring. In smart city platforms, IoT is used to manage an urban public transportation system and control energy and environmental management systems through smart sensor network. In smart health care systems, it is used to regularly monitor and collect patients' information necessary for medical analysis and providing emergency medical assistance.

## 3. System Design and Implementation

### 3.1 Internet of Things Architecture

Internet of Things architecture is composed of the following 3 main layers as follow:

- Device layer is the layer of physical things or Breathe Box, where a microcontroller and sensor are installed.
- Network layer is the layer of network connectivity or Blynk server.
- Service layer is the layer that displays data to users through Blynk application on smart phone. Blynk is used to display real-time data that are sent from the Breathe Box on a digital dashboard.

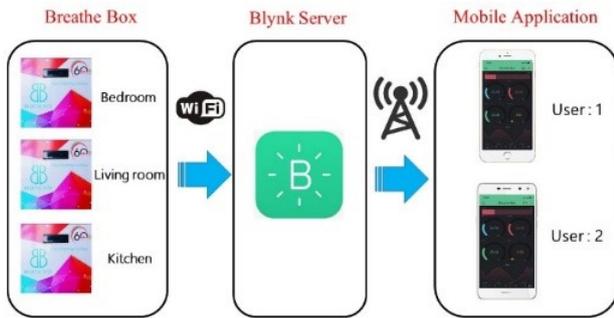


Fig. 3: Breathe box IoT architecture

### 3.2 Breathe Box Design

The first process of Breathe Box is designed by 3D computer program. Size and shape will be designed to suit the actual size and shape in order to find out the actual physical of Breathe Box and the pint to drill for installation of microcontroller and sensor. It assists the researcher to see the model to modify before actual building as shown in Fig. 4. The size of Breathe Box 6.5x20x20 centimeters.

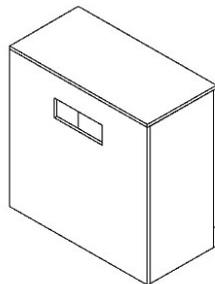


Fig. 4: Breathe Box design

### 3.3 Prototype Implement

After completing of design by computer program, it builds prototype by acrylic plastic, cut that match model size and then assemble.

### 3.4 Microcontroller

Node MCU ESP8266 is microcontroller that select by the researcher because it has the advantage of being able to send data via wireless communication up to IoT cloud service. NodeMCU is an open source IoT platform. ESP8266 was developed by Espressif systems Company Limited in China, in 2014. ESP8266 is a microcontroller with a 160 MHz single-core CPU, a 32-bit reduced instruction set computer (RISC), IEEE802.11b/g/n 2.4 GHz Wi-Fi, and +19.5 dBm output at the antenna.



Fig. 5: Node MCU ESP8266 [9]

## 3.5 Sensor

### 3.5.1 Dust Sensor

Sensirion SPS30 SENS-3073 is sensor that use to measure dust in this research. The sensor can measure dust by laser in both mass concentration of PM1, PM2.5, PM4 and PM10. The advantage is that it can work continually around 8 hours without cleaning of filter. The general features that are Supply voltage 4.5 volt to 5.5 volt, Supply current 55mA, Interface I2C and UART, operating temperature in the range of -10 to 60 Celsius, dimension 40.6 x 40.6x12.2 mm, as can be seen in Fig. 6.



Fig. 6: Sensirion SPS30 sensor

### 3.5.2 Temperature and Humidity Sensor

The temperature and humidity sensor that the researcher choose was DHT 22 or AM2302. The feature for working is digital signal output, resolution or sensitivity humidity 0.1%RH; temperature 0.1 Celsius. Working voltage: DC 3.3-6 Volt. It is sensitive to the temperature in the range of -40 to 80°C. This sensor is also sensitive to humidity in the range 0 - 100% with 2 - 5% accuracy. Dimension 28mm X 12mm X 10mm [10]. It appears in the Fig 7.



Fig. 7: DHT 22 or AM 2302 sensor

### 3.6 Programming

Arduino Integrated Development Environment (Arduino IDE) is an open source software that is used to write a programming code to control Node MCU ESP8266 microcontrollers. Arduino IDE can be downloaded and installed for free. The C/C++ programming language was used in this research.

### 3.7 Blynk

Blynk is application for smart phone. It designed to communicate with the microcontroller via network and receive the data wirelessly. Blynk is an IoT cloud platform that supports both iOS and Android. Blynk digital dashboard is an electronic interface that aggregates and visualizes data from multiple sources and allow you to monitor your real-time information. It benefits for management information systems. The advantage of Blynk that the researcher select was that Blynk can share data to several user. For example, a house installs a Breathe Box, but it can share data to all members in family who install Blynk application on smart phone. They can reach data from Breathe Box. According to creation of digital dashboard, it only selects widget from widget box, then dragging and dropping widgets in the location of digital dashboard that user creates.

## 4. Results

The results of air pollution monitoring can be displayed on a smartphone via Blynk. The invented Breathe Box is composed of sensor measuring amount of PM, sensor measuring temperature and humidity. The unit monitored from sensors will show the amount of PM1, PM2.5, PM4, PM10, temperature, and humidity from 3 rooms of the house which are bedroom, living room, and kitchen in real time via Blynk application in a smartphone.

### 4.1 Breathe Box

Role model of monitoring air quality station in this research was designed to be a small box for portable and proper to be used in the house. Air vents at the base and the

back of the box was made to allow air to float through the box including sensors as follows; 1. Sensors measuring amount of PM1, PM2.5, PM4, PM10 which is intensity of AQI; 2. Sensors measuring temperature and humidity in the air. As show in Fig. 8.



Fig. 8: Breathe Box prototype

### 4.2 Dust Monitoring via Blynk

The display presenting data result of particulate matter in the air can show 4 indexes which are PM1, PM2.5, PM4, PM10, temperature and humidity in Gauge form when there is any change of dust amount in the air with real-time displaying. As show in Fig. 9.



Fig. 9 Dust Real-Time Monitoring

### 4.3 Multiple Room Monitoring

This research measured air quality of each room in the house by placing air quality monitor station in daily routine rooms which are 1. Bedrooms, 2. Kitchen, and 3. Living room to be able to know air quality of each room in the house in real time. As show in Fig. 10.

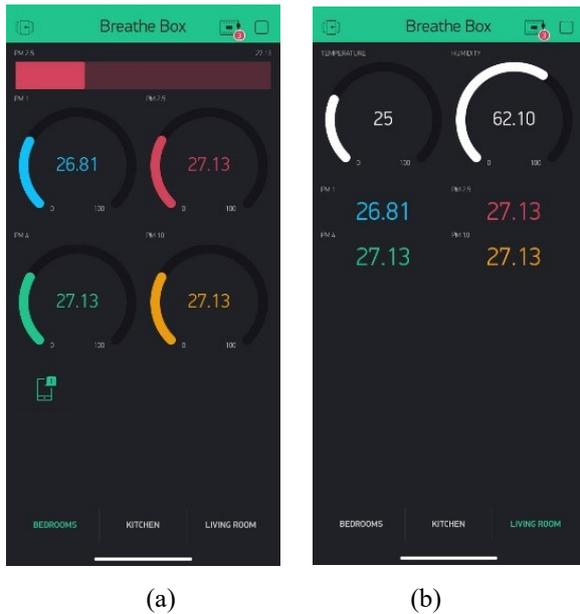


Fig. 10: Dust real-time monitoring: (a) bedroom and (b) living room

#### 4.4 Alarming system

In case of very high dust in the air was captured, the system will warn with the data. In this research, it will show the warning message when very high pollution occurred as “High pollution! Force signal active”. As shown in Fig. 11.

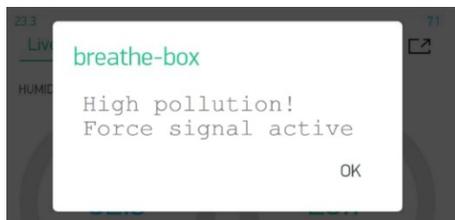


Fig. 11: Alarming screen on smart phone

#### 5. Conclusions

The research focused on applying the IoT to monitor the dust via Blynk application on a smart phone. The purpose of creating small dust monitor station by designing as a box is to be easy for using and portable. In the air quality monitor station box consists of measuring sensors as follow; 1. Sensor measuring amount of PM1, PM2.5, PM4, PM10, 2. Sensor measuring temperature and humidity in the air to show the air quality in the house and living place. After Breathe box measures air quality, it will transfer data to be able to monitor air condition in real time by using Blynk application in smartphone. The researchers can configure forms of display results of current air quality. The warning in case of high pollution air affecting health and living is captured can be further developed to measure air condition as desired.

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