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Application of Internet of Things (IoT) on air pollution monitoring database system

Sudarsono[1,*], *Muhammad Andang* Novianta[2], *Cyrilla Indri* Parwati [3]

[1]Department of Mechanical Engineering, Institut Sains & Teknologi AKPRIND Yogyakarta - Indonesia
[2]Department of Electrical Engineering, Institut Sains & Teknologi AKPRIND Yogyakarta - Indonesia
[3]Department of Industrial Engineering, Institut Sains & Teknologi AKPRIND Yogyakarta - Indonesia

Abstract. In the present work, a database system of air pollution monitoring is developed using Internet of Things (IoT) technology. The system aims to give structural information and trace of air pollution level at particular monitoring station. The particular monitoring location (node) is connected to IoT/M2M server via GSM network using GPRS feature and display on IoT/M2M application in web form. The database on IoT/M2M contains name, description, and location of the monitoring station, Pollution index and the time when the data are taken. On IoT/M2M, the data are displayed either in a color bar graph or a line graph. The color indicated the index value of the pollution. The data can be accessed via internet on *isfuonline.info*. The system is tested at laboratory environment to detect CO, SO_2, NO_2, O_3, and PM. The test result shows that the system is worked well. Time required to transfer the monitoring data to the IoT server is about 15 minutes. Meanwhile, response time of the system is 30 minutes.

Keywords: **Internet of Things (IoT); air pollution; database system**

1 Introduction

Decreasing air quality is one of the conditions that are very harmful to human health. The source of air pollution comes from various activities including industry, transportation, offices, and housing. It is estimated that air pollution due to industrial activities and vehicles will increase 2 times in 2000 from conditions in 1990 and 10 times in 2020 [1], The Indonesian government has regulated air quality by making the Air Pollution Standard Index (ISPU) as outlined Bapedal.

Air quality monitoring activities have been carried out by various agencies on a regular basis, usually only information on air quality at that time at several points of information that have been built by the agency so that only a few people know it through an air quality information board. With the 4.0 industrial revolution, one of them is the development of IoT-based information and communication technology. IoT is a technology that can be applied to overcome the problem of monitoring an object by utilizing connections on an internet technology-based network.

Many researchers have developed air pollution monitoring technologies, such as an ozone monitoring technology [2], a NOx detector using mid-infrared coherent [3], a CO level monitor for IC engine [4], a portable ash detector [5], and a wireless SO2 and NO2 detector for IC engine [6].

The Internet of Things (IoT) is a part of future internet technology that allows humans and objects to be connected to each other. The basic idea of IoT is the widespread presence of connected objects and devices on a network and can work together with one another to provide human user services through Machine to Machine (M2M) Communications [7]. Figure 1, is a standard architecture based on ETSI (European Telecommunication Standard Institute).

Fig. 1. Standard architecture of IoT/M2M (ETSI, 2014)

Wireless Sensor Network (WSN) is a group of organized nodes into a network that can work together [8]. Each node has different capabilities. Nodes consist of components that have the ability to sense, computing, communication, actuation, and power [9]. The ability of the node component makes the WSN able to process measurements, observations and react to phenomena that exist in the environment around us. For sensing

* Corresponding author: sudarsono1574@akprind.ac.id

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purposes, there is a sensor node that can transmit data captured in the environment wirelessly to the central gateway so that data can be processed and processed further in accordance with the objectives to be achieved. WSN technology also offers various advantages compared to previously distributed systems. The advantage is in the form of wireless-based communication media, which requires small power, real-time, can change dynamically, and can reach locations that have limited access [8].

The purpose of the present research is to develop an air pollution monitoring database system based on ISPU with structured IoT technology so that output data can be easily traced and can be used as information for the public and decision makers as remediation of air polluted environments.

2 Methodology

Figure 2 shows schematic diagram of the system test where the data are acquired from the nodes. The node or station will be connected to the M2M server via the GSM network using the GPRS feature and then displayed on the IoT application in the form of a web.

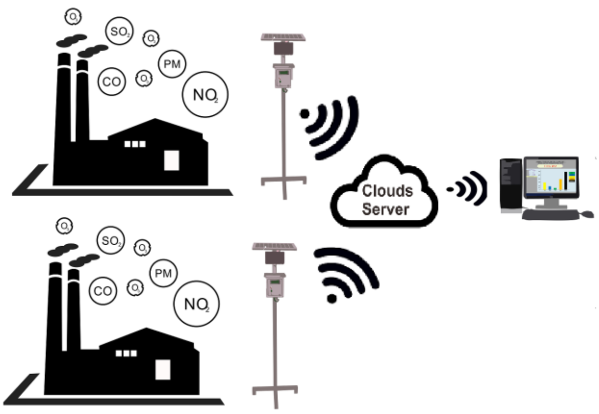

Fig. 2. Schematic diagram of the data collection

3 Results and Discussion

3.1. Design of IoT / M2M Application

IoT / M2M application design in the form of interface system design in the form of a website that displays index values of carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), and Particulate Matter (Dust) and data collection time on the sensor node. The URL address used to access the observed Index data can be accessed on the ispuonline.info page. Figure 3 shows the initial display of the website *ispuonline.info*.

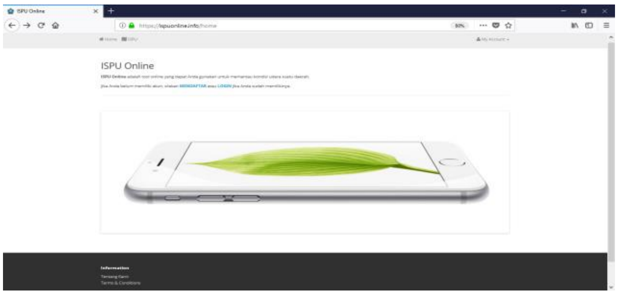

Fig. 3. Homepage of ispuonline.info

The website designed in this study consists of 3 main web services in the form of API (Application Program Interface), namely Leaflets, Charts, and Highlights.

3.1.1 Leaflet Web Service/API

Web service / API leaflet is an open-source javascript library for displaying dynamic and mobile-friendly interactive maps. The reason for using this API for IoT applications is because of its small javascript size, which is only 38KB. Figure 4 displays a program script fragment to display a map of the sensor node location.

```
<script type="text/javascript" src="catalog/view/javascript/custom/maps.js"></script>
<script type="text/javascript">
// load the map
  var mymap = L.map('mapid').setView([-2.548926, 118.0148634], 5);
  L.tileLayer('https://api.tiles.mapbox.com/v4/{id}/{z}/{x}/{y}.png?access_token=pk.evJ
    maxZoom: 18,
    attribution: 'Map data &copy; <a href="https://www.openstreetmap.org/">OpenStreetMa
      '<a href="https://creativecommons.org/licenses/by-sa/2.0/">CC-BY-SA</a>, ' +
      'Imagery © <a href="https://www.mapbox.com/">Mapbox</a>',
    id: 'mapbox.streets'
  }).addTo(mymap);

  var title = '';
  var labels = [];
  var data = [];
  var latitude = '';
  var longitude = '';
  var logged = '<?php echo $logged; ?>';

  data['field1'] = 0;
  data['field2'] = 0;
  data['field3'] = 0;
  data['field4'] = 0;
  data['field5'] = 0;
```

Fig. 4. Script of Library Leaflet

The results of the library display from the Leaflet API are dynamic, which means that the display in the browser can adapt automatically to the device used. Figure 5 presents a browser display on a desktop device.

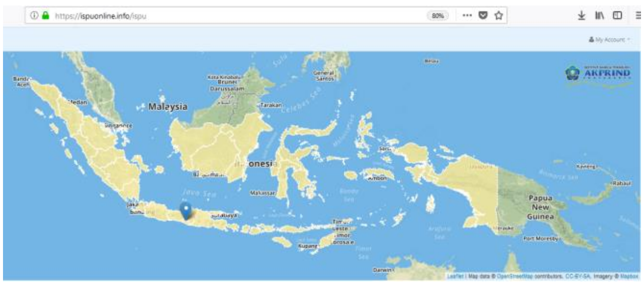

Fig. 5. Map displays on Desktop Browser

The web service leaflet also has a pop-up feature that can be used to display desired information when the cursor is directed to the desired point. The appearance of the pop-up feature that is used in the air pollution standard index monitoring website is a piece of program script to activate the popup feature in the API leaflet web service as shown in Figure 6.

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Fig. 6. Script of PopUp program

The data information displayed in this pop up is obtained from reading JSON files that are created automatically by the ThingSpeak platform. The data information consists of the station name, station description and index value of each gas sensor as shown in Figure 7.

Fig. 7. PopUp display on Website ispuonline.com

3.1.2 Bar Graph

The second component used in this IoT-based air pollution monitoring website is a bar graph. The charts are created using the ChartJs library. This library is a web service or API that is open source and easy to use. The bar graph presents the most recent air pollution index value. The library is called through the main program on the website as shown in Figure 8.

Fig. 8. Script for bar graph

To see the graph on the website ispuonline.info, users are required to register and login to ispunonline.info/login so that the account is stored in the database system. The bar graph form is dynamic with an interactive display as shown in Figure 9.

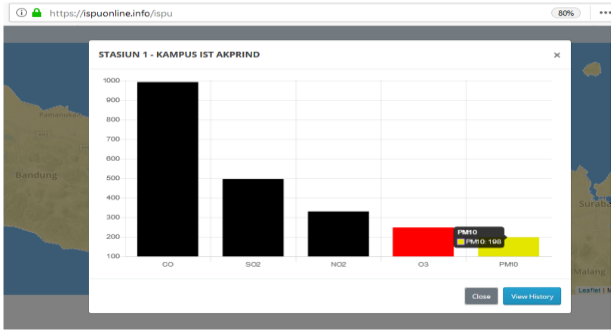

Fig. 9. Bar graph display

The bar graph color can change according to the air pollution standard index (ISPU) value in accordance to the Bapedal, KEP-107 / Kabapedal / 11/1997. The black color has an ISPU index of more than 300 ppm which means it is DANGEROUS. Meanwhile, red color has an ISPU ranging from 200 to 299 ppm which means it is VERY HARMFUL; while the yellow color has an ISPU between 101 to 199 ppm, which means it is HARMFUL.

4 Conclusion

The conclusion can be drawn from the current work are:

a. Information on monitoring standard air pollution index consisting of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and IoT / M2M-based Particulate Matter (Dust) accessible on the website with url address ispuonline.info.
b. Database on IoT / M2M server contains data of Station Name, Station Description, Station Location, index value of each sensor node as well as Time of storage of gas index value obtained.
c. The application of the results of monitoring CO, SO_2, NO_2, O_3 and dust gases on the website consists of 3 main web services in the form of API (Application Program Interface), namely location map of monitoring node, bar graph and line graph.

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