Merging of IoT and WSN for Real-Time Air Condition Monitoring Systems Towards Medan Smart City

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Abstract. Lots use of motorbike and car vehicles, industrial gas disposal, cigarette smoke and also forest fires cause high levels of air pollution in the city of Medan, North Sumatra, Indonesia. Based on these problems, an air condition monitoring device was built with the concept of low cost and low power, with a wireless sensor network (WSN) architecture from end device hardware, data collecting, data processing in gateway, and data visualization. IRIS hardware platforms are used in this system, whereas the communication between base station and gateway via internet networking. Therefore, people can monitor the air condition results by real-time through a website-based application or an android smartphone.

1. Introduction

Based on data from the American Environmental Protection Agency on the level of air pollution in all cities in the world, Medan is ranked as the fourth most polluted city. This is due to the large number of motorized vehicles and the disposal of industrial gas, cigarette smoke and forest fires, causing high levels of air pollution in the city of Medan (BPS RI, 2018) [1]. Nowadays, there have been many studies done in WSN technology that are used to monitor environmental health conditions and the efficiency of battery power consumption. In this study describes a survey of WSN technology applied in environmental monitoring systems, such as agricultural monitoring, habitat monitoring, shelter monitoring, greenhouse monitoring, fire monitoring, etc.[2]. Other research, proposes a design and implementation for monitoring WSN-based environmental health conditions using an open-source hardware platform, such as Raspberry Pi and Arduino Microcontroller. This system uses temperature and humidity sensors to detect and monitor temperature and humidity values. For communication using the Xbee module with the standard 802.15.4 protocol[3][4]. Other research, they propose environmental health monitoring by using several sensors such as monitoring water level, barometric pressure, ambient temperature, atmospheric humidity, wind...
direction, wind speed and rainfall [5]. Internet of Things (IoT) is a technology that is widely used for applications such as shelters, measuring ECG in real time, agriculture [6], and so on. Much communication is used in monitoring environmental conditions, for example using Bluetooth, Xbee, Wi-Fi, LoRa, and so on [7]. Based on these problems, this paper proposes WSN architecture from end device hardware, data collection, data processing at the gateway and data visualization. In this system, hardware IRIS platform is used, where communication between the base station and the gateway is via the internet. So, users can monitor the results of air conditions in real-time through web-based applications or android smartphones. In this study also, we built a monitoring tool for low cost and low power environmental conditions.

2. Literature Review

2.1. Block Diagram

Each node in the WSN consists of sensors, microcontroller devices, radio transceiver devices that provide wireless communication and batteries that are used as energy sources for the node itself. A permanent additional power can be added that aims to convert energy from external sources (such as the sun, heat, wind, and kinetic energy) into electrical energy to charge traditional resources such as batteries. Figure 1 shows the WSN block diagram that will be used in this study.

![Block Diagram](image)

**Figure 1. Block Diagram**

2.2. End Devices

Sensor nodes are small, inexpensive devices with limited battery and computing power that are used in an area to monitor the environment. Sensor nodes are devices that have the capacity to collect sensor information from the environment, process information and communicate with other nodes. Sensor nodes have the ability to collect sensor information, sense, process data, and communicate with each other. This is a large number of inexpensive, small, low-power communication devices. The main components of the sensor node are the microcontroller, transceiver, external memory, power source and one or more sensors. Network nodes with components for sensing, data processing and communication. A sensor node is a type of transducer that uses one type of energy, a kind of signal, and converts it into readings for information transfer purposes. Figure 2 shows the block diagram of the sensor node that will be created.

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**Figure 2. Sensor Node Block Diagram**
2.3. Gateway
In this study, we use Raspbian as an operating system that is obtained free of charge on the Raspberry website. There are several packages installed, such as php5 package, MySQL database, open-jdk library, rxtx library for reading microcontroller ports, NetBeans, python. Then the 32 GB memory card is used as a data storage media sensor, operating systems and packages contained in the OS. Figure 3 shows the gateway used in this research. Data obtained from the measurement of air conditions in the end device sensor will be sent to the gateway using Xbee 802.15.4 communication. The data will be processed using a java program by using the rxtx library to open a port, then coding for data storage to a MySQL database. To display information about air conditions, we provide a web or mobile application that can be accessed in real-time and social media such as Facebook and Twitter.

2.4. Cloud
The cloud that we use in this research is to buy domains and hosting that are sold in Indonesia. Data from the gateway will be synchronized with the Database cloud which must be connected to the internet. All information about air conditions can be accessed by users through websites and / or mobile applications and social media such as Facebook and Twitter.

3. Method
In this study, we use 3 sensor nodes to measure air conditions in real-time. Each sensor node consists of a microcontroller, temperature, humidity and carbon dioxide (CO2) sensors, Zigbee 802.15.4, the power used to run the microcontroller. All sensor data will be sent to the gateway continuously, then the data will be stored in a MySQL database that has been provided at the gateway. Furthermore, data stored in the local database will be synchronized to the cloud. In the cloud, we prepare a data-base for online storage. The goal is that users can access air conditions in real time through the website and / or smartphone application, we also develop information on social media such as Facebook and Twitter. Figure 3 shows the topology used in this study.
4. Results

In this experiment, we measured air conditions in real time. All data obtained from the end device will be sent to the gateway, and synchronization will be continued to the cloud using the internet network. Figure 4 is displayed on the front page of the website for monitoring air conditions.

For software and hardware specifications used are shown in Table 1.

| End device          | Gateway               | User                  |
|---------------------|-----------------------|-----------------------|
| Mikrokontroller Atmega328P | Raspberry pi, operation system Raspian, php5, database | CPU core i3, memory 8GB, ssd 256GB |
| Arduino Uno r3, Flash Memori 32kb, temperature, humidity, CO2 sensors, Xbee, battery | MySQL, apache, rxtx, java netbeans, mozilla firefox, python, memory 32 GB | |

Figure 3. Topology Air Condition Monitoring

Figure 4. Dashboard Monitoring Air Condition
Figure 4 above, data will be sent to the gateway every 30 seconds. All data will be displayed on the web page in graphical form. On the dashboard page above, the measurement data obtained temperature values of 31 °C, humidity 62% and CO2 334 ppm. This is done at 09.00 am to 17.00 at the laboratory. Users can see a graph of each sensor data in real-time by clicking on temperature, humidity and CO2, a graph will appear as shown in Figure 5-7 below.
Furthermore, we also tested xbee 802.15.4 communication between end devices and gateways. Table 2 shows the results of the experiment.

| No | distance (meter) | Status  |
|----|------------------|---------|
| 1  | 10               | Success |
| 2  | 20               | Success |
| 3  | 30               | Success |
| 4  | 40               | Success |
| 5  | 50               | Success |
| 6  | 60               | Success |
| 7  | 70               | Failed  |
| 8  | 80               | Failed  |
| 9  | 90               | Failed  |
| 10 | 100              | Failed  |

From the Table 2 test above, we conducted the test in the open. At the time of testing, we conducted testing with a distance of 10-100 meters. At a distance of 10-60 meters the sensor data packet is successfully sent to the gateway. While at a distance of 70-100 meters the data fails to be sent to the gateway, this is because the range of XBee delivery is limited, but it is also affected by other noise. Figure 8 shows the sensor access data via a mobile phone application.

In the cloud, testing is carried out for sending data from the gateway to the cloud using the internet network. In this test, we observe the data transmission time at the gateway with the data receiver time in the cloud. The test results are obtained in Table 3.
Table 3. Testing Time of Sending Sensor Data

| No | Time delay (gateway to cloud) / second |
|----|--------------------------------------|
| 1  | 1                                    |
| 2  | 0                                    |
| 3  | 0                                    |
| 4  | 0                                    |
| 5  | 1                                    |
| 6  | 1                                    |
| 7  | 0                                    |
| 8  | 0                                    |
| 9  | 0                                    |
| 10 | 1                                    |

From the test results above, we observed a time delay by observing the 10 data that entered the cloud. From 10 incoming data, the average delay of 1s is 40% while the corresponding time is 60%. This is due to internet network factors, so data comes in a little slowly.

5. Conclusion
There are limitation for data transmission and time delay. According to measuring, in range of 60 m has successful sent to the gateway. After that, data packet is not sent by successful. Repeater is needed to re-strengthen signal of devices to gateway.

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