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Air pollution monitoring system using LoRa modul as transceiver system

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Abstract

Air pollution is a disaster that can indirectly interfere with human health, Indonesia is the third highest country in the world that has pollution levels, one of the types of pollution that threatens public health is the increase of CO, NO_2 and SO_2 level in the air. With the increasing level of air pollution in the city, it requires a device that can monitor air pollution in a real time. By integrating air sensor and Raspberry Pi as data processor and using LoRa module as transceiver module, then the process of transmitting data from transmitter to receiver can be done directly without connected internet. In a test, the system can transmit intensity data information by wireless system on Line Of Sight (LOS) scemes at a maximum distance of 1.7 Km and Non Line Of Sight (NLOS) scheme at a distance of 400 meters with a average delay is 2 second.

Keywords: *air pollution, line of sight, LoRa module, non line of sight*

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1. Introduction

The clean air is the most important part of human living [1, 2]. Based on WHO data, in 2014 nearly half of the world's urban population is exposed to air pollution 2.5 times above WHO safety standards [3]. The clean air will support human healthy, the type of air that directly affects human healthy are CO_2, NO_2 and H_2S [4], accordingly the level intensity of that must be considered. Increasing the number of motor vehicles in a city has contributed considerably to the decrease of air quality in a city, especially if coupled with the burning of the forest, the community activities of a city will be disrupted [5]. In addition, air pollution will also directly interfere with environmental conditions and indirectly can disrupt the global economy [6]. Because of these problems, it is necessary to do an air quality monitoring in real time to prevent the level of air pollution is getting worse [1], [7].

The rapid development of network and internet technology has supported the growth of the Internet of Things in the World. With the Internet of Things, every sensor and actuator will connect to an object, so that information from each object can be communicated to third parties through internet network technology. And for the future the performance of the Internet of Things (IoT) will depend on the efficiency of the device's power usage and the maximum distance between transmitter and receiver. This caused a lot of research using IoT technology in order to monitor air quality so that the measured air intensity value can be accessed by various parties [8].

Several studies have discussed the process of direct air monitoring. The air monitoring process utilizes an array of gas sensors comprising eight sensors, an Arduino board device, an ATMega 2560 microcontroller successfully measuring changes in Hydrogen gas, butane gas, CO gas and H2S gas on a highway [9]. But in that research, the measured data can not be sent to the third partyes. Other research about air monitoring is the process of air monitoring using Arduino and gadgets as data transmission medium [10]. In this research, the measurable data can be directly observed through the gadget. Due to the data transmission process using Bluetooth technology, the observation distance is less than 10 meters from the data center. The other research is using wireless sensor networks (WSN) technology in the process of air pollution data transmission [11]. In this technology, the system consists of target, node sensors and base station controller (BSC). With parameters measured CO_2, CO, temperature and

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humidity. Using the JN139 microcontroller as the sensor node controller, which is integrated with an IEEE 802.15.4 and Zigbee applications, so that data is sent to the receiver is capable of traveling long distances through the addition of repeaters. And the other reseach about air monitoring system is air monitoring system based on wireless sensor network (WSN) with *Tree-like Mesh topology* using Zigbee device and General Packet Radio Services (GPRS) as data transfer protocol [12]. In this research, the system can measure the intensity of CO and the delivery of test data with a good performance because have low of delay and low packet loss. Because this system uses the GPRS protocol in its data transmission then the system must be connected to the internet network that provides additional fee in the data connection. From some of these studies indicate that the distance between transmitter and receiver and the need for internet conection are the major problem in the data communication system, so it takes a new technology that can transmit measurement data in a long distance without connecting to the internet to improve performancy system. So the use of Low Power Wide Area Network (LPWAN) technology using LoRa as a transceiver medium is expected to overcome the distance problem in transmit data testing, another advantage of LoRa is the low use of power when transmitting information [13-17]. The life span of LoRa batteries is around 10 years [18]. With some of the advantages possessed by LoRa, this system can support IoT communication infrastructure [19, 20].

LoRa/GPS HAT is an expansion module can be integrated with Raspberry-Pi to develop the associated LoRaWAN solutions. This module is based on the transceiver SX1276/SX1278. LoRa/GPS HAT equipped with GPS based on MTK L80 MT3339 designed specifically for applications that use GPS with connected via the serial port for the Raspberry-Pi as timing-application or common application that requires GPS information. Sending and receiving of data contained on spread spectrum module has remote as well as the strength of the high interference with minimum power consumption, and can achieve high sensivitas up to 148 dBm with an affordable cost. Sensivitas high combined with integrated +20 dBm so it can be optimized for applications that require the range and endurance. This module can calculate and predict data automatically using orbit ephemeris (transmitted on satellite data receiver GPS contains a GPS satellite position and time information that applies only to a few hours) that are stored in the memory internal flash, so that LoRa/GPS HAT can fix position quickly even at the level of the signal with low power consumption. With technology Always Locate LoRa/GPS HAT can adjust on/off time adjustment to achieve a balance between the accuracy of the position and power consumption according to the environment and conditions of motion. GPS antenna function supports automatic switching function. It is able to achieve internal patch antenna between displacement and external active antenna. In addition, during the transition process will continue to position.

If the module of LoRa is integrated with air sensor quality, signal radio frequency modules connected to LoRa sends information form of ambient air substances content by sending the information in real-time to retrieve data coordinates from the GPS which is then sent through the module radio signal communication using LoRa, and Raspberry-Pi3 as transmitter and receiver microcontroller with his programming language.

2. Research Method

Development of air monitoring system based on LoRa as transceiver use three sensors are MQ-7 for detection CO [21], MQ-135 for detection NO_2 [22] and MQ-136 for detection SO_2 [23]. Processing data sensor using Raspberry–Pi and the Data experiment is transmitted to user using LoRa Module. The topology air monitoring system is shown in Figure 1.

Figure 1 shows the construction of the system of Monitoring air quality. At the beginning of the initialization tool that is intended to be able to make sure all the connected devices and under normal conditions. Then, the entire sensor data to send on Raspberry Pi receiver to be processed with the conversion of the value of the unit of which refer to the datasheet of each gas sensor to get value in the form of ppm (part per million). The process is considered completed after the output conversion results managed to send the results of air quality conditions in the environment, which provided the materials experiment. In this system uses LoRa as data transceiver. System can transmit data experience to user without connecting to the internet network. The air monitoring system shown in Figure 2.

Figure 2 shows a LoRa-based air monitoring system. Some parameters tested are GPS data coordinate test with latitude, longitude and altitude, the gas sensor data with output value of ppm with variation of transmission distance of both data from the transmitter side to the receiver side. For data communication between transmitters and receivers use the Line of Sight (LoS) and Non-Line of Sight (NLoS) scenarios by performing four testing of distance variations. While to test the performance of system use measurement of delay value at the time of delivery data from LoRa Transmitter to LoRa receiver. Line of sight is the propagation of radio's wave are clear from obstacle [24], while the non line of sight in the propagation of radio's wave are the process of transmitting radio wave signals where between the transmitter and receiver has obstruction [25].

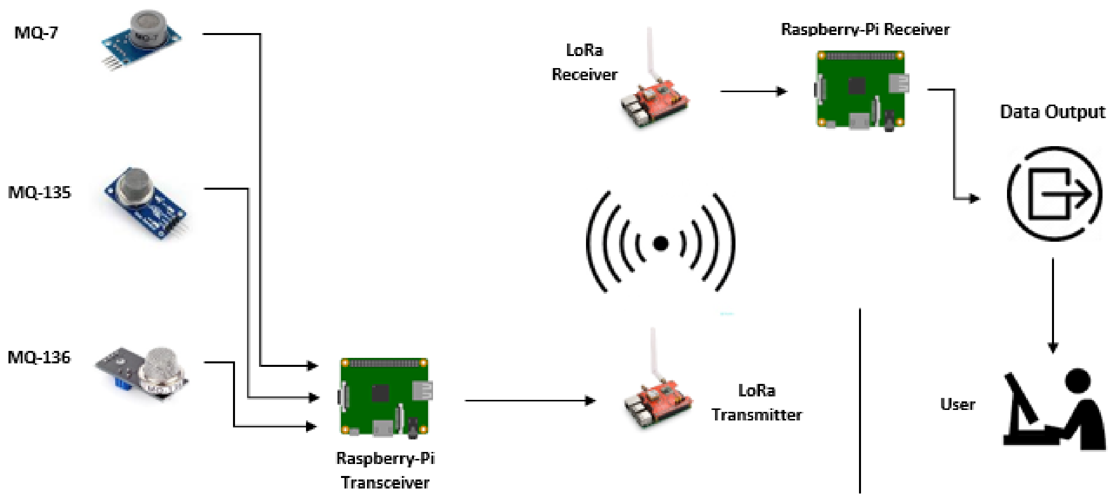


Figure 1. Topology of the air monitoring system based on LoRa

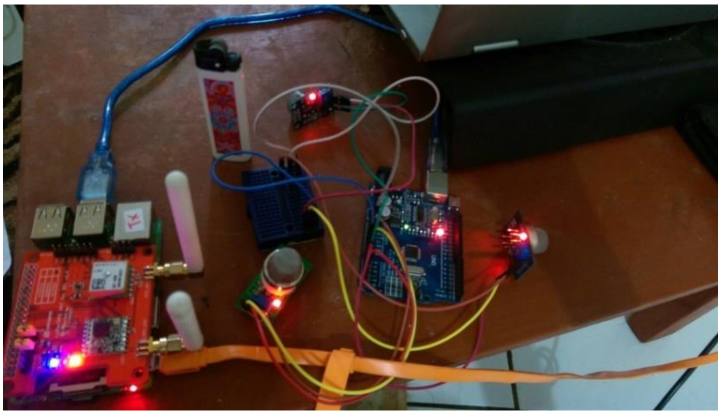
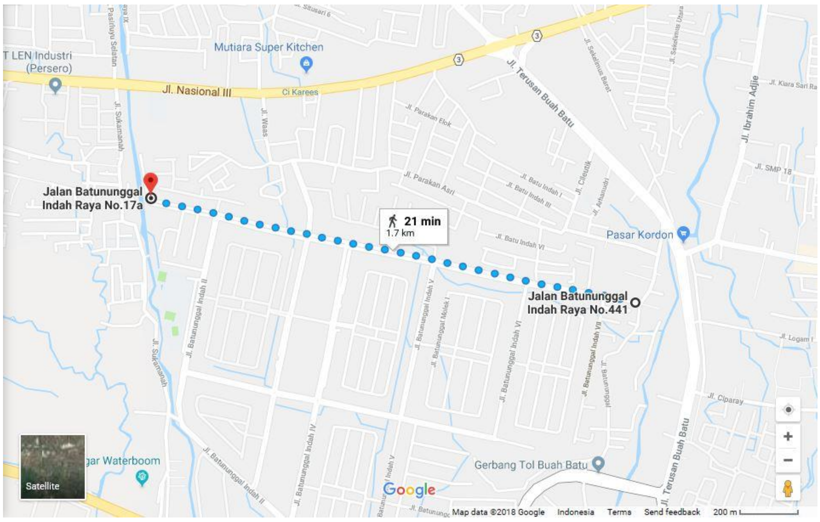
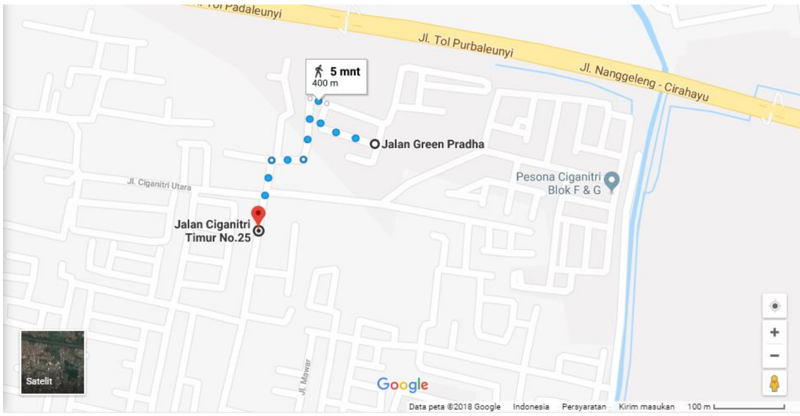


Figure 2. Air monitoring system based on LoRa transceiver

The measurement of the air intensity using LOS scenario is done in Batununggal, West Java as and NLOS scenario is done in Bojongsoang, West Java. The maps of any scenario are shown in Figure 3 (a) and Figure 3 (b). Figure 4 shows the display of data communication between the transmitter and receiver using the LoRa module with a distance of 100 m in the NLOS scenario. The figure shows that the frequency used for the LoRa module is 915 MHz with the average power intensity used is -92dB. This picture shows that the LoRa receiver module can receive GPS information related to the location of air pollution and the intensity of CO, NO_2 and SO_2 in real time. Figure 5 shows the time needed by the receiver to receive data sent by the receiver. The time needed for sending data with the NLOS scenario at a distance of 100 m is 4.56 second.

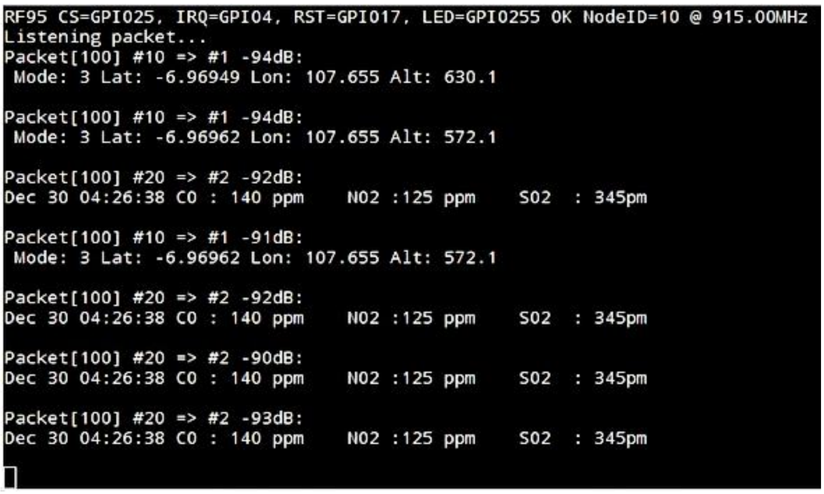


(a)



(b)

Figure 3. (a) The map for air monitoring system using LOS scenario, and (b) The map for air monitoring system using NLOS scenario



```
RF95 CS=GPIO25, IRQ=GPIO4, RST=GPIO17, LED=GPIO255 OK NodeID=10 @ 915.00MHz
Listening packet...
Packet[100] #10 => #1 -94dB:
 Mode: 3 Lat: -6.96949 Lon: 107.655 Alt: 630.1

Packet[100] #10 => #1 -94dB:
 Mode: 3 Lat: -6.96962 Lon: 107.655 Alt: 572.1

Packet[100] #20 => #2 -92dB:
Dec 30 04:26:38 CO : 140 ppm    NO2 :125 ppm    SO2  : 345pm

Packet[100] #10 => #1 -91dB:
 Mode: 3 Lat: -6.96962 Lon: 107.655 Alt: 572.1

Packet[100] #20 => #2 -92dB:
Dec 30 04:26:38 CO : 140 ppm    NO2 :125 ppm    SO2  : 345pm

Packet[100] #20 => #2 -90dB:
Dec 30 04:26:38 CO : 140 ppm    NO2 :125 ppm    SO2  : 345pm

Packet[100] #20 => #2 -93dB:
Dec 30 04:26:38 CO : 140 ppm    NO2 :125 ppm    SO2  : 345pm
```

Figure 4. The result of communication data in LoRa receiver for distance of 100 m for NLOS Scenario

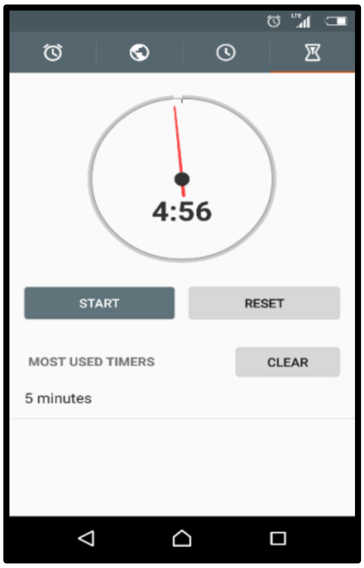


Figure 5. Delay of data communication in air monitoring system for NLOS Scenario

3. Results and Discussion

The testing process is done with two schemes, namely testing with the scheme of Line Of Sight (LOS). LOS is a condition where LoRa Transmitter and Receiver are free from obstacle. And the second scheme is Non Line Of Sight (NLOS). Table 1 shows the test results to determine the maximum distance of air sensor data transmission using LoRa module with LOS scheme.

Table 1. Information of Data Location dan Sensors

Distance	Location	Testing Time (WIB)	Delay	Coordinates Point TX			Sensor Gas (ppm)			Conclusion
				Latitude	*Longitude*	*Altitude*	CO	NO_2	SO_2	
300 M	Batununggal	20.12	2-3 Sec.	-6.95495	107.631	683.7	140	125	345	Location and data of sensors are captured
500 M	Batununggal	20.38	2 Sec.	-6.95495	107.631	683.7	140	125	345	Location and data of sensors are captured
800 M	Batununggal	20.55	5 Sec.	-6.95495	107.631	683.7	140	125	345	Location and data of sensors are captured
1 KM	Batununggal	22.43	19 Sec.	-6.95575	107.635	694.4	-	-	-	Data of location only
1.3 KM	Batununggal	21.17	1 - 3 Sec.	-6.95575	107.635	694.4	-	-	-	GPS Coordinates Only
1.5 KM	Batununggal	21.32	4 - 20 Sec.	-6.96761	107.655	683.4	-	-	-	GPS Coordinates Only
1.7 KM	Batununggal	23.02	3- 7 Sec.	-	-	-	-	-	-	Does not get any data

Table 1 shows the receiver can read location data and gas intensity of a location at 800 m transmitter and receiver distance. While at a distance from 1 Km, the receiver can only read location information transmitted by Transmitter. And the system can not read the information the receiver transmits for the maximum distance of transmitter and receiver at a distance of 1.7 Km. The maximum distance of using LoRa/GPS HAT with the LOS scenario is 2 KM [26]. Furthermore the fastest data delivery time Range is at a distance of 1.3 KM variation of testing with the acceptance of the data with GPS coordinates and it only took about 1-3 seconds. Table 2 shows data information that is transmitted by LoRa Transmitter by NLOS scheme.

Table 2. Tabel of Data by NLOS

Distance	Location	Testing Time (WIB)	Delay	Coordinates Point TX			Sensor Gas (ppm)			Conclusion
				Latitude	Longitude	Altitude	CO	NO_2	SO_2	
100 M	Housing of Pradha Ciganitri	00.27	3 - 5 Sec.	-6.97035	107.654	668.0	153	129	372	Both Data obtained
200 M	Housing of Pradha Ciganitri	00.40	2 - 3 Sec.	-6.97135	107.659	668.7	149	132	348	Both Data obtained
350 M	Housing of Pradha Ciganitri	01.07	5 - 12 Sec.	-6.97561	107.667	669.2	140	125	345	Both Data obtained
400 M	Housing of Pradha Ciganitri	01.38	3 - 8 Sec.	-6.96761	107.688	669.7	140	-	-	GPS data is received, the data of the sensor only CO

Table 2 shows the fastest data delivery time range be on testing with the variation of the distance of 200 M overall admissions data only took about 2-3 seconds and the variation distance 400 M receiver can receive both data for monitoring of CO, but NO_2 and SO_2 having packet loss.

4. Conclusion

Air monitoring system and data communication using radio frequency communication media on LoRa/GPS HAT can be made by integrating GPS, air sensor and LoRa module, the data results that transmit from transmitter to the receiver are in the form of the data in the GPS coordinates. While the output of air sensor in the ppm value. The second delivery of data can be done at a distance of approximately 1.7 Kilometres in the absence of obstacles and 400 metres in the presence of obstacles. The future research is integrating air monitoring system using LoRa communication with web application.

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