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Implementation of temperature and humidity monitoring system in wooden warehouse based on distance and access location assessment

Yuvina[1], Bakti Viyata Sundawa[2], Bayu Setiawan[3], Abdullah[4]
[1,2,3,4]Electrical Engineering Department, Politeknik Negeri Medan, Medan, Indonesia

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ABSTRACT

Indonesia is the largest furniture exporter in the world. This business will continue to grow because Indonesia has abundant wood raw materials. These wood raw materials must be stored in a good wooden warehouse because the bad warehouse conditions will cause physical damage to the wood. This study designed a temperature and humidity monitoring system in a miniature wooden warehouse based on Internet of Things (IoT) technology. The test location was carried out at 5 locations. The length of test time i.e. 8 hours. Based on testing, data are displayed in app.microthings.id website for access location of Medan Selayang, the max. temperature was 26.4°C and the max. humidity was 68.8%. For access location of Medan Baru on Berdikari road, the max. temperature was 26.4°C and the max. humidity was 68.8%. For access location of Medan Johor, the max. temperature was 25.4°C and the max. humidity 68.1%. For access location of Medan Baru on Jamin Ginting Road, the max. temperature was 25.1°C and the max. humidity was 68.3%. For access location of Medan Baru on Universitas road, the max. temperature was 24.7°C and the max. humidity was 69%. These data are compared to data from A-TH3 sensor. There is the difference and latency between them. The highest of latency occured in Medan Johor District about 10 second.

Corresponding Author:

Bakti Viyata Sundawa,
Electrical Engineering Department,
Politeknik Negeri Medan,
Almamater road, no.1 USU, Medan, North Sumatera, 20155, Indonesia.
Email: baktisundawa@polmed.ac.id

1. INTRODUCTION

Indonesia is the largest furniture exporter in the world. The trade value reached USD 1.91 billion on 2020 (Saputro, 2022)(Janice Carysa Siahaya, 2022). This business will continue to grow because Indonesia has abundant wood raw materials (Hakiki & Jakaria, 2023)(PURWANTO et al., 2019).

These wood raw materials must be stored in a good wooden warehouse. Bad warehouse conditions will cause physical damage to the wood, such as drying, cracking, discoloration, weathering, fungal degradation, and then quality of the wood will decrease. In addition, there are pest attacks that can damage the wood structure and potential fire

hazards. Losses caused by poor timber storage can cause significant losses of 2%-7% of the timber's quality value (McConnell et al., 2019).

In addition, Wood raw materials specifically have certain characteristics (de FARIA et al., 2020)(Lopes et al., 2023)(Maiti et al., 2016). Many factors will determine the quality of wood such as temperature and humidity in the wooden warehouse (Kittang & Bye, 2023)(Park et al., 2022). The ideal temperature and humidity for timber storage is 24°C-26°C and 65%-75% (Yuvina et al., 2024). The condition of the wooden warehouse must be dry and free from rain (Lemaire-Paul & Foruzanmehr, 2023). They must be have air ventilation (Krugly et al., 2022)(Kuptz & Hartmann, 2021). If these conditions are not met, so that will have an impact on the durability and weathering of the wood (Özgenç et al., 2022)(Brun, 2023)(Jirouš-Rajković & Miklečić, 2021). For this reason, the condition of the wooden warehouse must be well regulated so that the supply of wood raw materials maintains its quality.

Wood inventory management is one of the most important factors in the furniture business (Ermawati, 2020)(Shanmugapriya, 2023). Wood raw materials cannot be imported instantly because it is related to environmental preservation (Khademibami & Bobadilha, 2022)(Candelier & Dibdiakova, 2021). The inventory management is needed which control the wood raw material supply chain. It is useful for the furniture craftsmen can prepare customer orders on time. Inventory management consists of the type of inventory, the amount of inventory, the location of the place, and the condition of the inventory warehouse (Salih et al., 2023)(Becerra et al., 2022)(Inegbedion et al., 2019).

Based on the description above, this research will design a temperature and humidity monitoring system in a wooden warehouse (Saini et al., 2020)(Serhani et al., 2020). The wooden warehouse is made in miniature and equipped with temperature and humidity sensors, data sending devices equipped with LoRa networks and the internet. Each measurement data can be sent to the cloud server. The users can access temperature and humidity in real-time. This system uses IoT technology so that users or warehouse owners can control and supervise the warehouse remotely (Xu et al., 2022)(Ding et al., 2020)(Pathmudi et al., 2023). This research will focus on distance and access location assessment. The results of the temperature and humidity data on the user side will be compared with A-TH3 temperature and humidity sensor which installed in the miniature warehouse.

2. RESEARCH METHOD

This research uses a sensor device that can detect temperature and humidity in the room. This sensor was equipped with a transmission system. Every temperature and humidity data was successfully detected by the sensor. The data was directly sent to the wireless RS485 LoRa Node. Wireless RS485 LoRa Node was a device that sends measurement data to LoRa Gateway S281 as an IoT gateway. Next, LoRa Gateway S281 as an interface to the cloud server. This device was equipped with a SIM Card as a data package for internet access. The cloud server functions as a storage medium for temperature and humidity measurement data that can be accessed by users.

In this study using app.microthings.id as a cloud server. It was a platform or application that focuses on managing and analyzing cloud-based IoT (Internet of Things) data. Here are some features and functions that are usually found on cloud-based IoT platforms such as data collection, data analytics, devices management, real-time monitoring, alert and notificaton, and integration. The process is shown as flowchart in Figure 1 and all of component was illustrated with a block diagram as in Figure 2.

The testing was carried out in 5 (five) locations or districts, namely: Medan Johor, Medan Baru (Berdikari Road), Medan Baru (Jamin Ginting Road), Medan Baru (Universitas Road), and Medan Selayang. The selection of these locations is due to road conditions with the existing population and vehicle density. This is done because this

research will test the robustness of the monitoring system when there are many GSM signal interference locations such as humans and vehicles. In this study, we will calculate the latency in app.microthings.id monitoring againts the A-TH3 sensor placed in a miniature wooden warehouse. The specification of A-TH3 sensor is shown in Table 1. The parameters are the access distance between the access location to the miniature wood warehouse, and the value of latency between the temperature and humidity measurements in app.microthings.id application with the A-TH3 sensor placed in the miniature wood warehouse.

The placement of the wooden warehouse miniature in the Telecommunication Engineering Laboratory. These locations to find out how far the monitoring access distance from the wooden warehouse. This research uses the GSM network. This network can reach almost all regions in Indonesia, so that temperature and humidity parameter can be monitored by online access and the values can be seen on the website in real-time.

Based on previous research, the ideal temperature in the warehouse is 24^{o}C-25^{o}C and the humidity in the warehouse is 65%-75%. The temperature and humidity measurement data were adjusted to the ideal requirements for wooden warehouse. By monitoring system, the temperature and humidity parameter in the warehouse can be detected in real-time. The temperature and relative humidity parameter were measured in the miniature warehouse at a certain time. The miniature warehouse was placed in an air-conditioned room because the temperature in the miniature warehouse follows the temperature of the surrounding environment.

Table 1. A-TH3 sensor specification

No.	Feature	Measurable data
1	Power supply	DC 10-30V
2	Precision	±0.4oC, ±2%RH ±0.5oC, ±3%RH
3	Transmitter circuit operating temperature:	40℃~+60℃, 0%RH~80%RH
4	Probe operating temperature:	40℃~+120℃, default: -40℃~+80℃
5	Probe working humidity:	0%RH-100%RH
6	Resolution:	0.1℃, 0.1%RH
7	Refresh time:	Temperature ≤0.1℃/y, humidity ≤1%RH/y
8	Response time:	Temperature ≤15s(1m/s), humidity ≤4s(1m/s)
9	Output signal:	RS485/0-5v/0-10v/4-20ma/WIFI

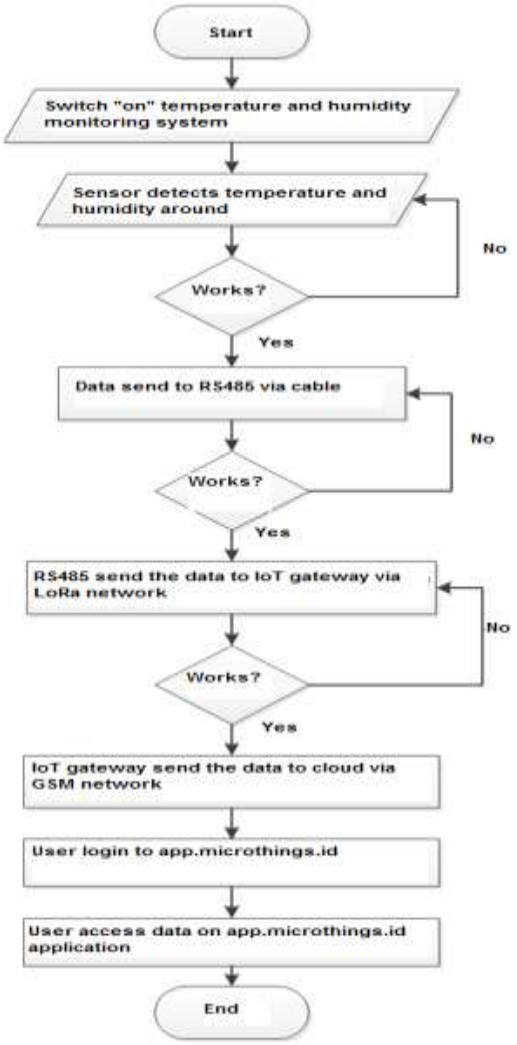


Figure 1. Flowchart of the system

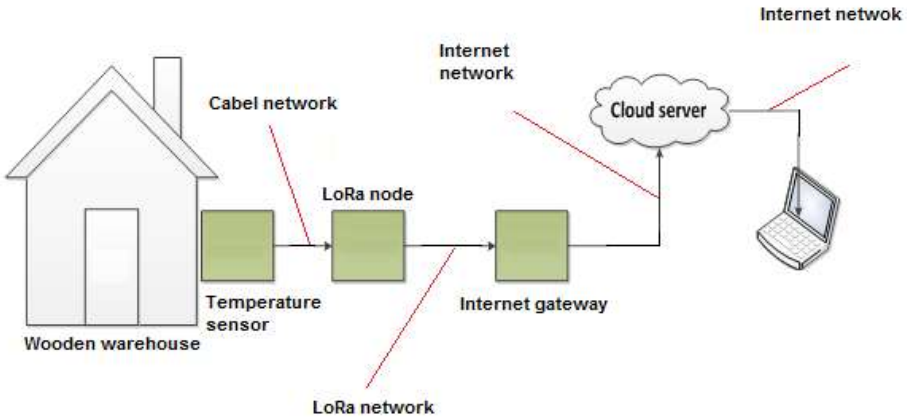


Figure 2. Block diagram of the system

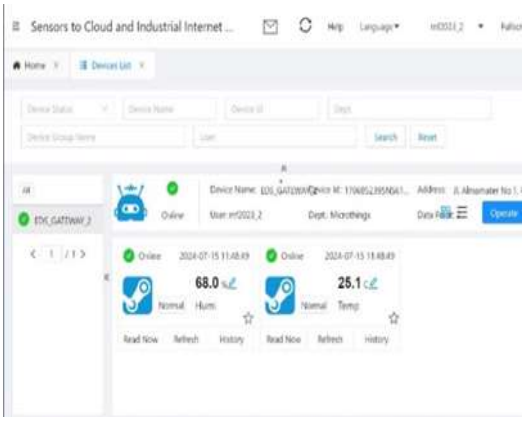
3. RESULTS AND DISCUSSIONS

The test location was carried out at 5 locations, namely in Medan Selayang District, Medan Johor District, Medan Baru District for 3 locations. For more details can be seen in Table 2. which contains the name of the monitoring location, monitoring distance from the device, and test results in the form of a display from the website by app.microthings.id.

The length of test time i.e. 8 hours. Based on testing, for the location of Medan Selayang, the max. temperature was 26.4°C and the max. humidity was 68.8%. For location of Medan Baru on Berdikari road, the max. temperature was 26.4°C and the max. humidity was 68.8%. For the location of Medan Johor, the max. temperature was 25.4°C and the max. humidity 68.1%. For the location of Medan Baru on Jamin Ginting Road, the max. temperature was 25.1°C and the max. humidity was 68.3%. For the location of Medan Baru on Universitas road, the max. temperature was 24.7°C and the max. humidity was 69%. The data was measured in real-time, then depicted in the form of measurement graphs as shown in Figure 3 to Figure 4.

Comparison data between app.microthings.id and A-TH3 sensor can be seen in Table 3 and the image of A-TH3 sensor can be seen in Figure 5. There are some latency between them. The latency is caused by the stability of network in access time. Research locations are placed on crowded road. There is more vehicles and human. This is done to know the impact of network signal stability, latency and environmental external factors. The highest of latency occured in Medan Johor District. This location is more community residences, more community activities and vehicle crossroad. The latency is 10 second.

Table 2. Testing results

Access location	Distance to the tools	Measurable data
 Medan Selayang District	 3.5 Km	 Temperature : 25.1°C Humidity : 68.0%
		

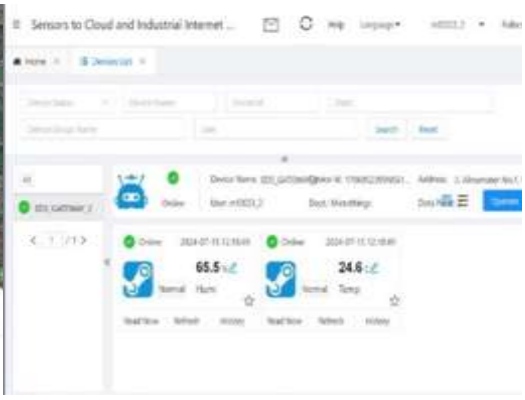
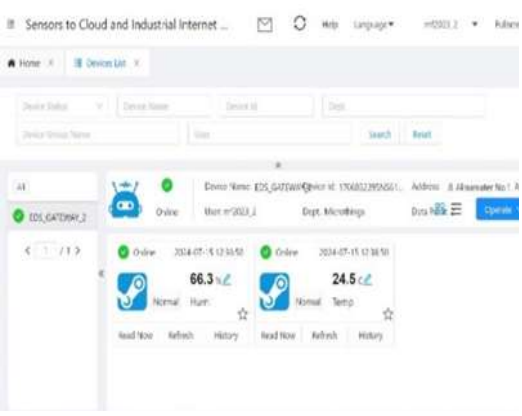
Medan Baru District	3.7 Km	Temperature : 25.1°C Humidity : 68.0%
		
Medan Johor District	4.3 Km	Temperature : 24.6°C Humidity : 65.5%
		
Medan Baru District	2.7 Km	Temperature : 24.5°C Humidity : 66.3%
		
Medan Baru District	850 meters	Temperature : 24.7°C Humidity : 69.0%

Figure 3. Graphic of humidity on location of Medan Johor by app.microthings.id

Figure 4. Graphic of temperature on location of Medan Baru (Jamin Ginting Road) by app.microthings.id

Figure 5. A-TH3 temperature and humidity sensor

Table 3. Comparison data between app.microthings.id and A-TH3 sensor

Access location	Data on app.microthings.id		Data on A-TH3 sensor		Latency (sec)
	Max. temperature (°C) and time	Max. humidity (%RH) and time	Max. Temperature (°C) and time	Max. humidity (%RH) and time	
Medan Selayang District	26.4°C (10:30:10 WIB)	68.8% (10:40:15 WIB)	26.1°C (10:30:05 WIB)	68.5% (10:40:10 WIB)	5
Medan Baru District (Berdikari Road)	26.4°C (10:30:10 WIB)	68.8% (10:40:25 WIB)	26.2°C (10:30:05 WIB)	68.6% (10:40:20 WIB)	5
Medan Johor District	25.2°C (11:20:20 WIB)	68.1% (11:40:10 WIB)	25.0°C (11:20:10 WIB)	67.9% (11:40:00 WIB)	10
Medan Baru District (Jamin Ginting Road)	25.1°C (11:10:05 WIB)	68.3% (11:10:05 WIB)	25.1°C (11:10:00 WIB)	68.1% (11:10:00 WIB)	5
Medan Baru District (Universitas Road)	24.7°C (13:30:45 WIB)	69% (13:30:45 WIB)	24.7°C (13:30:40 WIB)	68.7% (13:30:40 WIB)	5

4. CONCLUSION

This study produces a temperature and humidity monitoring system in a miniature wooden warehouse. The test results of temperature and humidity monitoring are affected by environmental conditions and network stability at the access location. The access location is densely populated and vehicles that affected to existing access network. There are latency caused by network signal stability, data transmission, and external environmental factors. This study has limitations, such as the test results are still in the form of miniature wooden warehouses. It can be improved to inventory management systems such as RFID scanned, and QR barcode inventory. The system can be carried out in further research in the FIFO system (first in first out). Finally, the monitoring system is to keep the quality of wood to ensure that furniture business is still sustainable.

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