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Prasant Kumar Pattnaik
Mangal Sain
Ahmed A. Al-Absi *Editors*

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Strategic Foresight, Security Challenges and Innovation (SMARTCYBER 2023)

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Preface

The 3rd International Conference on Smart Computing and Cyber Security—Strategic Foresight, Security Challenges and Innovation (SMARTCYBER 2023) took place in Kyungdong University Global Campus, Gosung, Gangwondo, South Korea, during June 28–29, 2023. It was hosted by the Department of Smart Computing, Kyungdong University, Global Campus, South Korea.

The SMARTCYBER is a premier international open forum for scientists, researchers, and technocrats in academia as well as in industries from different parts of the world to present, interact, and exchange the state of the art of concepts, prototypes, innovative research ideas in several diversified fields. The primary focus of the conference is to foster new and original research ideas and results in the five board tracks: Smart Computing Concepts, Models, Algorithms, and Applications, Smart Embedded Systems, Bio-Inspired Models in Information Processing, Technology, and Security. This is an exciting and emerging interdisciplinary area in which a wide range of theory and methodologies are being investigated and developed to tackle complex and challenging real world problems. The conference includes invited keynote talks and oral paper presentations from both academia and industry to initiate and ignite our young minds in the meadow of momentous research and thereby enrich their existing knowledge.

SMARTCYBER 2023 received a total of 152 submissions. Each submission was reviewed by at least three Program Committee members. The committee decided to accept 50 full papers. Papers were accepted on the basis of technical merit, presentation, and relevance to the conference. SMARTCYBER 2023 was enriched by the lectures and insights given by the following seven distinguished invited speakers: Professor Prasant Kumar Pattnaik, School of Computer Engineering, Kalinga Institute of Industrial Technology, Dr. Hind R'Bigui, Digital Enterprise Department, Nsoft Co., Ltd. Consultant, Solution Architect and Senior Research Engineer, Dr. James Aich S, CEO Mindzchain Co. Ltd, South Korea, Professor Mangal Sain, Dongseo University, South Korea, and Prof. Ahmed A. Al-Absi, Kyungdong University Global Campus, South Korea. We thank the invited speakers for sharing the enthusiasm for research and accepting our invitation to share their expertise as well as contributing papers for inclusion in the proceedings. SMARTCYBER 2023 has been able to maintain standards in terms of the quality of papers due to the contribution made by many stakeholders.

We are thankful to the Program Chair Prof. Baseem Al-athwari, Publication Chair Prof. MD Nur Alam, Organizing Chairs: Prof. Jay Sarraf, Prof. Chinyere Grace Kennedy, Prof. Khadak Singh Bhandari, and Zubaer Ibna Mannan for their guidance and valuable inputs.

We are grateful to Prof. John Lee, President of Kyungdong University (KDU) Global, South Korea and Honorary General Chair, SMARTCYBER 2023, for his constant support and providing the infrastructure and resources to organize the conference. We are thankful to Professor Sasmita Rani Samanta, Vice-Chancellor, KIIT Deemed to be University, India, Honorary General Chair, SMARTCYBER 2023 for providing all the support for the conference.

Thanks are due to the Program and Technical Committee members for their guidance related to the conference. We would also like to thank the Technical Program Committee, Publicity Chairs, Organising Committee, Finance Chairs, and Web Management Chair who have made an invaluable contribution to the conference. We acknowledge the contribution of EasyChair in enabling an efficient and effective way in the management of paper submissions, reviews, and preparation of proceedings. Finally, we thank all the authors and participants for their enthusiastic support. We are very much thankful to entire team of Springer Nature for timely support and help. We sincerely hope that you find the book to be of value in the pursuit of academic and professional excellence.

Bhubaneswar, India — Prasant Kumar Pattnaik
Busan, Korea (Republic of) — Mangal Sain
Goseong-gun, Korea (Republic of) — Ahmed A. Al-Absi

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Editors and Contributors

About the Editors

Prasant Kumar Pattnaik Ph.D. (Computer Science), Fellow IETE, Senior Member IEEE is a professor at the School of Computer Engineering, KIIT Deemed University, Bhubaneswar. He has more than a decade of teaching and research experience and awarded half dozen of Ph.D. Dr. Pattnaik has published numbers of research papers in peer-reviewed international journals and conferences and filed many patents. He also edited book volumes in Springer and IGI Global Publication. His areas of interest include mobile computing, cloud computing, cyber security, intelligent systems and brain computer interface. He is one of the associate editors of *Journal of Intelligent and Fuzzy Systems*, IOS Press and *Intelligent Systems* Book Series Editor of CRC Press, Taylor Francis Group.

Mangal Sain received the Master of Application degree from India in 2003 and the Ph.D. degree in computer science from Dongseo University, Busan, South Korea, in 2011. Since 2011, he has been an associate professor with the Department of Information and Communication Engineering, Dongseo University, Busan, South Korea. He has published over 40 international publications. His current research interests include wireless sensor network, middleware, cloud computing, embedded system, and Internet of Things. He is a member of TIIS and has participated as a TPC member in several international conferences.

Ahmed A. Al-Absi was awarded his Ph.D. from Dongseo University, South Korea, and is currently an associate professor and head of Information Technology (Smart Computing) Department and Business Administration at Kyungdong University–Global Campus, South Korea. His research interests have been concentrated on data science based on data analytics, big data, Hadoop, cloud computing, IoT, VANET, deep learning, database systems, distributed systems, parallel computing, high-performance computing, and bioinformatics.

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Distributed Wireless Sensor Network in IoT Hydroponic Monitoring System

Arbi Haza Nasution, Rian Pratama, and Winda Monika

Abstract Parameters like air temperature, air humidity, and air pressure are necessary for the plantation sector, especially hydroponics because air temperature and air humidity can affect the growth of hydroponic plants. Data regarding air temperature and air humidity must be monitored in order to maintain the quality of the hydroponic plants. However, it will be difficult to digitally cover a massive hydroponic plantation. Therefore, a tool is needed that is able to retrieve air temperature and humidity data from several distributed adjacent places or places that are not covered by Wi-Fi so that the data retrieval can be carried out practically and efficiently. The use of radio frequency networks is an alternative and solution for sending data over short or long distances. The nRF24L01 radio frequency module is a module with a relatively cheap price and low current consumption. The experiment shows that our proposed distributed wireless sensor network model is applicable to transferring data efficiently from the distributed microcontroller clients (sensor nodes) to the microcontroller gateway (the central node). The maximum distance of the nRF24L01 PA LNA radio module is 321.8 m and the maximum distance of the nRF24L01 radio module is 7.35 m to maintain a stable data transfer. The designed architecture is successfully implemented and executed to transmit air temperature and humidity data and other required data between the sensor nodes and the central node. The maximum number of characters that can be sent and received by the nRF24L01 radio module is 28 characters.

Keywords Hydroponic · Internet of Things · Distributed sensor network · Wireless sensor network

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1 Introduction

The world of the Internet is increasingly developing and the use of information technology tools in offices, industry, and agencies provides added value to data processing. Automation systems have been implemented in almost all fields of work aimed at facilitating human work [1–3]. Land in urban areas is filled with housing and buildings, so it becomes narrow to grow vegetables. Hydroponics is a method of cultivating plants using a mineral solution in water without soil [4]. Hydroponic vegetable cultivation in urban areas is a solution to the limited land problem. Data regarding air temperature, air humidity, and air pressure are needed in the plantation sector [5], especially hydroponics because air temperature and air humidity can affect the growth of hydroponic plants. Data regarding air temperature and air humidity must be monitored in order to maintain the quality of the hydroponic plants. However, it will be difficult to digitally cover a massive hydroponic plantation. Therefore, a tool is needed that is able to retrieve air temperature and humidity data from several distributed adjacent places or places that are not covered by Wi-Fi so that the data retrieval can be carried out practically in terms of sending data from the distributed microcontroller clients (sensor nodes) to the microcontroller gateway (the central node) and efficiently in terms of cost. The tool is also capable of performing automation and monitoring simultaneously [6].

Sending sensor data using radio frequency will be more practical than using cables, and more efficient than using the Global System for Mobile Communications (GSM) module or Wi-Fi module. Because a hydroponic site requires many sensor nodes, the use of cables is impractical, the use of the GSM module as a medium for transmitting data is inefficient because the GSM module is vulnerable to not being connected to the network, while the use of Wi-Fi for many hydroponic plantations is not efficient as providing hotspots in several places is relatively more expensive. The use of the GSM module is vulnerable to illegibility because the International Mobile Equipment Identity (IMEI) is not registered and the use of the Wi-Fi module by adding an access point at each hydroponic location so that the Wi-Fi is reachable by the microcontroller is relatively more expensive than using radio frequency.

The use of radio frequency networks is an alternative and solution for sending data over short or long distances. The radio frequency used in this study is 2.4 GHz, because this frequency is free to use in Indonesia according to "Regulation of the Minister of Communication and Informatics No. 28 of 2015" [7]. Radio frequency is a better alternative than cable, GSM, and Wi-Fi media in way that the microcontrollers and sensors can be moved as needed.

Previous studies showed that nRF24L01 module is suitable for hydroponic application that requires high-speed data transmission, the nRF24L01 module supports higher data rates compared to LoRaWAN. The nRF24L01 module can achieve data rates up to 2 Mbps, while LoRaWAN prioritizes long-range communication and offers lower data transfer rates in the range of a few hundred to a few thousand bits per second. Moreover, nRF24L01 modules support mesh networking, allowing for multi-hop communication between sensor nodes. Furthermore, nRF24L01 radio frequency module is a module with a relatively cheap price and low current consumption [8].

This research aims to propose a distributed wireless sensor network model using nRF24L01 radio frequency module applicable to transferring data efficiently from the distributed microcontroller clients (sensor nodes) to the microcontroller gateway (the central node).

2 Literature Study

In this section, we conduct a literature study on hydroponics and distributed wireless sensor networks.

2.1 Hydroponics

Hydroponics is a method of cultivating plants using mineral solutions in water without soil [5]. Hydroponics (hydroponic) comes from the Greek words *hydro* which means water and *phonos* which means work. Hydroponics is also known as soilless culture or cultivation of plants without soil [9]. The water requirement for hydroponic plants is less than the water requirements for cultivation using soil media. Hydroponics uses water more efficiently, so it is very suitable for areas that have a limited water supply. In other words, hydroponics means the cultivation of plants that utilize water without using soil as a planting medium or soilless.

Many factors determine success in hydroponic vegetable cultivation. Some of them include nutrients, planting media, oxygen, and water [5]. Other research also shows that air temperature, air humidity, and air pressure are very necessary in the plantation sector [10].

The nutrients in question are nutrient solutions commonly called AB Mix fertilizers. The water in question is the level of acidity and wetness of water or commonly called pH. A pH is the degree of acidity used to express the level of acidity or wetness possessed by a solution. Total Dissolved Solid (TDS) is an indicator of the number of dissolved substances or particles in the water. The unit used to calculate TDS is ppm.

2.2 Distributed Wireless Sensor Network

Wireless Sensor Network (WSN) is a technology that collaborates wireless networks with sensor technology to monitor the physical condition of the environment [11]. WSN can be applied to various objects, including in the fields of industry, health, military, agriculture, etc. WSN consists of sensor nodes and base stations, where the sensor nodes measure (sensing) the physical environment; including temperature, humidity, gas levels, etc., while the base station collects data from the results of sensing by the sensor nodes. Network topologies that can be utilized for WSN are star and mesh [12]. WSN is generally used to carry out surveillance of an area that is difficult to reach by humans. Moreover, microcontroller based WSN devices are generally used to reduce costs. In this study, we show how WSN can be applied to agriculture, specifically, monitoring hydroponic plants in order to save time and increase the accuracy of the data obtained (manual monitoring by the naked eye prone to human error) [12, 13].

If a centralized architecture is used in a sensor network and the central node fails, then the entire network will collapse, however, the reliability of the sensor network can be increased by using a distributed control architecture. Previous study [14] propose a distributed localization method based on anchor nodes selection and particle filter optimization. According to the proportional relation between localization error and uncertainty propagation, anchor nodes are selected optimally in real-time during the movement of mobile nodes. The result shows that the method effectively improves the localization accuracy and the robustness of the distributed system. Typically, wireless sensor networks (WSNs) use limited-capacity batteries that cannot be recharged or replaced. In general, designing an energy-efficient routing protocol has a significant impact on prolonging the network lifetime. Another study [15] introduced a novel distributed 2-hop cluster-routing protocol (D2CRP) to achieve energy efficiency in WSNs. In the cluster formation phase, each node obtains the information of its neighbor nodes within the 2-hop range to form the 2-hop cluster in a fully distributed manner. The transmission distance and residual energy are jointly considered to determine the energy-efficient cluster head (CH) in each 2-hop cluster. After the CH is generated, each member node can transmit packets to its 1-hop neighbor or the CH directly.

3 Methodology

In this section, we describe the experiment design and Internet of Things (IoT) architecture.

3.1 Experiment Design

Due to the limitation of budget, we focus on taking two crucial parameters in hydroponics monitoring, i.e., air temperature and humidity data. Considering the prices of pH and TDS sensors which are quite expensive, as proof of concept, we also limit this study to five distributed microcontroller clients (sensor nodes) and one microcontroller gateway (the central node). The range of hydroponic water temperature values is 26–31 °C. If the water temperature is above 31 °C, then the cooler or water pump will turn on and if the temperature is below 31 °C the cooler or water pump will be off. Due to the limitation of budget, the cooler or water pump was replaced with a fan.

We experimented with 5 hydroponics in different locations. The system uses the distributed system concept as shown in Fig. 1 where hydroponic A sends data to hydroponic B, after the data are received then hydroponic B is forwarding data of hydroponic A along with his own data to hydroponic C, after data is received hydroponic C is then forwarding data of hydroponics A and B along with his own data to the central node. Finally, after the data are received, data of hydroponics A, B, and C are sent via Wi-Fi to the cloud. Using the distributed system concept, every sensor node will send its data along with forwarded data from neighboring sensor nodes until the data reach the cloud via the central node. In the cloud, the processing layer filters the data before storing the data to ensure no duplicate or broken data.

Figure 2 depicts how the process of sending sensor data, where a sensor node sends data to reachable neighbors until the cumulative data reaches the central node and being sent to the cloud. After the data are processed, the central node will send a response to the reachable sensor nodes to do some action (for example, turning the fan on/off), and the propagation is continued until all related sensor nodes are reached. In Fig. 2, nodes C and D are assumed to be unreachable by the radio frequency (for example, 5 km apart).

Each node is distinguished by a different address to avoid data collisions, where the address is defined by the node names A–F. The address is in the form of a channel, where the channel is based on a datasheet of up to 125 channels. The topology used in this study is the mesh topology.

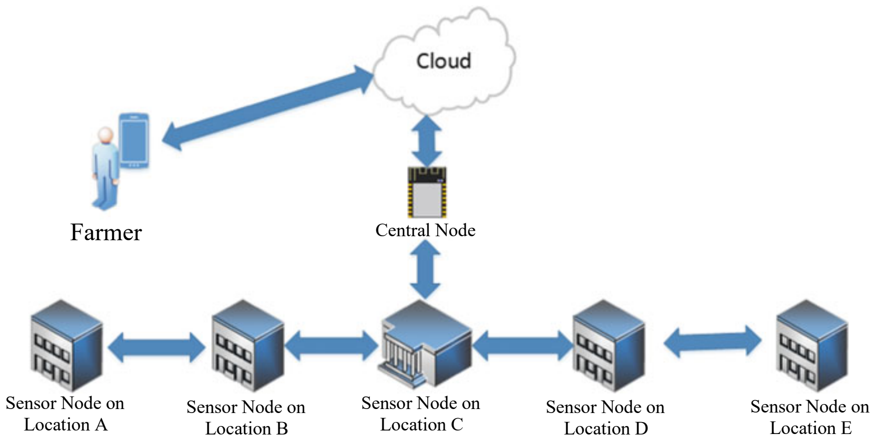


Fig. 1 Distributed wireless sensor network architecture for hydroponics monitoring system

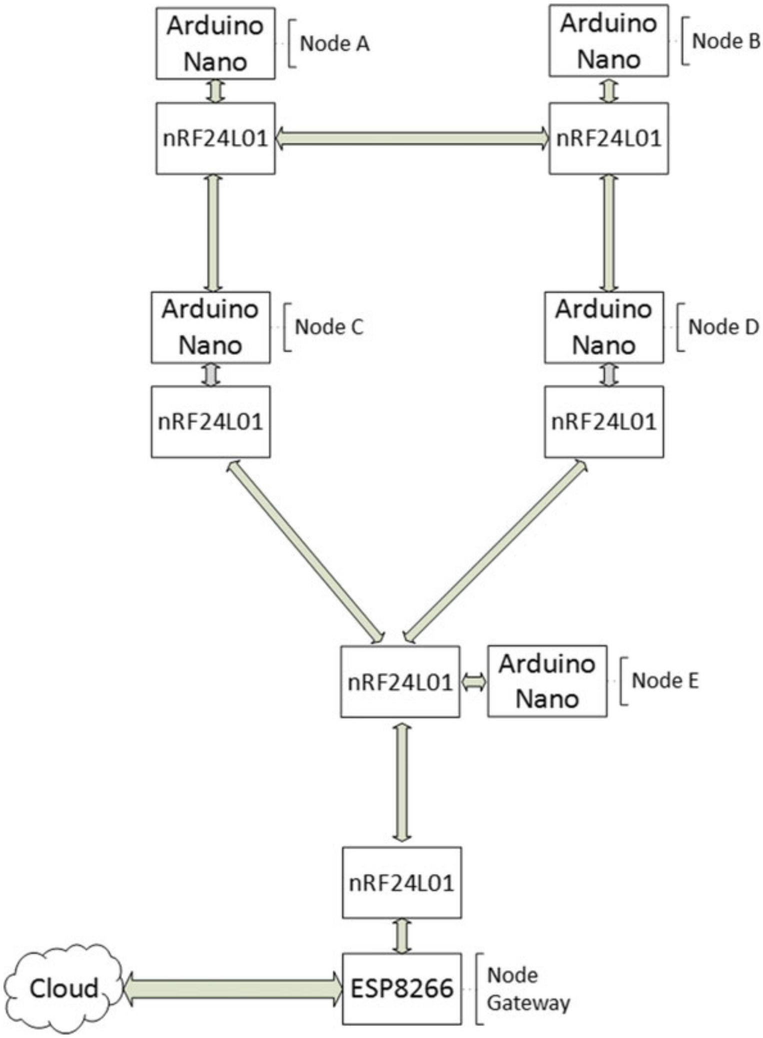


Fig. 2 Mesh topology for distributed wireless sensor network architecture

Each sensor node sends data in the form of a string, in which the string data is a collection of data from the source node and the traversed node(s) including sensors data, time status, and relay status as shown in Fig. 3.

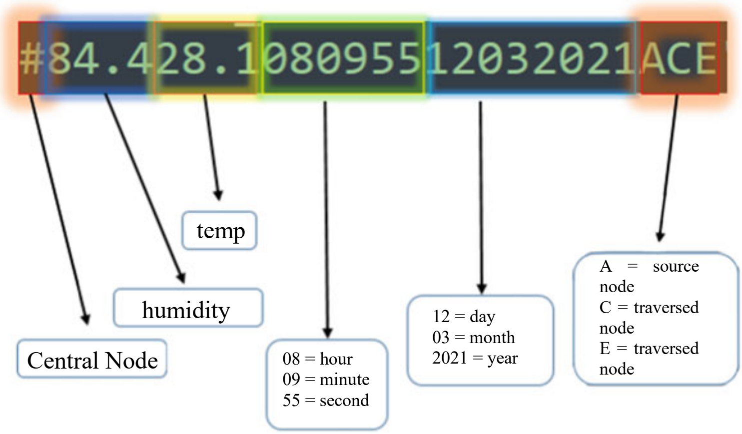


Fig. 3 Data model

3.2 Internet of Things (IoT) Architecture

Internet of Things (IoT) architecture consists of Perception Layer, Transport Layer, Processing Layer and Application Layer. In the perception layer, Arduino Nano, a microcontroller board based on the ATmega328P-AU is used. The Arduino Nano has 14 digital input/output pins (6 of which can be used as PWM outputs) and 7 analog inputs. Arduino Nano is suitable to be used in the agriculture domain due to its small size. Integrated into the Arduino Nano, a DHT-22 or AM2302 is a temperature and humidity sensor with an output in the form of a digital signal with conversion and calculations performed by an integrated 8-bit MCU. The sensor has an accurate calibration with compensation for the adjustment of room temperature with the coefficient values stored in the integrated OTP memory. The DHT22 sensor has a wide temperature and humidity measurement range, DHT22 is able to transmit the output signal through a cable up to 20 m so it is suitable for placement anywhere, but if the cable is longer than 2 m a 0.33 μF buffer capacitor must be added between pin 1 (VCC) to pin 4 (GND). There is only one actuator in the microcontroller, which is a fan. The hardware design for the sensor node is shown in Fig. 4.

In the transport layer, there are two communication modules integrated into the Arduino Nano, which are the nRF24L01 radio frequency module for sending data between sensor nodes and from sensor nodes to the central node, and the ESP8266 Wi-Fi module for sending data from the central node to the server as shown in Fig. 5. The nRF24L01 radio module is a module that can be used to send and receive data using a 2.4 GHz radio frequency. The nRF24L01 radio module uses an onboard antenna, however, this module has a short-range radius. For a farther radius, the nRF24L01 PA LNA module with a chip or IC (integrated circuit) and external antenna can be used.

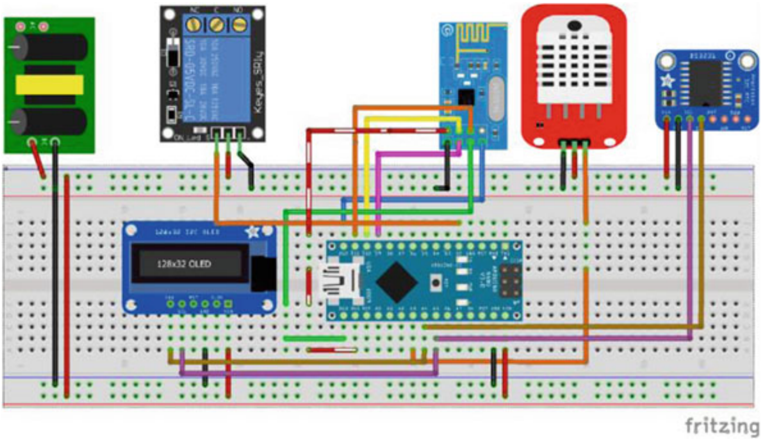


Fig. 4 Hardware design for sensor node

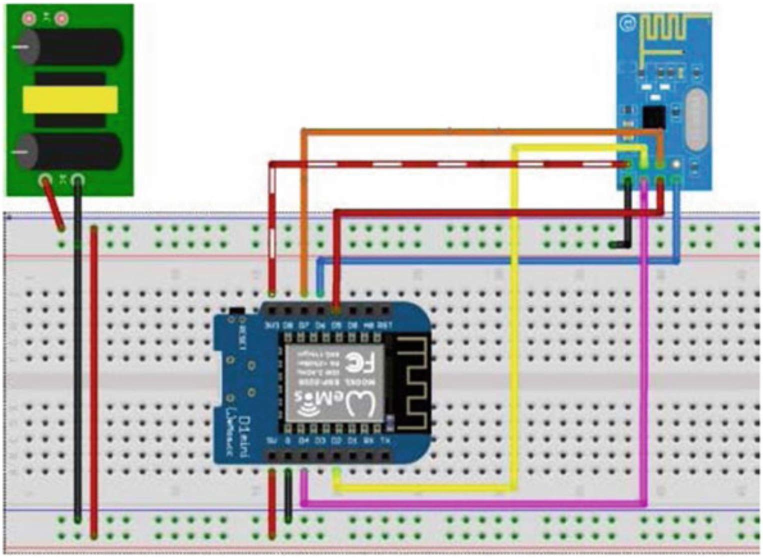


Fig. 5 Hardware design for central node

Finally, in the processing layer, the data are filtered and stored and in the application layer, the user can monitor the air temperature and humidity data via web application and telegram bot.

4 Result

Functional evaluation is carried out to determine the performance of the distributed wireless sensor network in IoT hydroponic monitoring system which is divided into two evaluations: evaluation of the sensor nodes and evaluation of the central node.

4.1 Evaluation Result for Sensor Node

Functional evaluation of the microcontroller sensor node is done by looking at the OLED I2C LCD display which shows the reading status of the nRF24L01 radio module and the DHT22 module, and further checks the actuator based on the response. Figure 6 shows an implementation in the field where the sensor node is placed in a tightly closed plastic container so that it is not exposed to rainwater. The experiment result shows that the sensor node managed to send and receive data from and to the nearest sensor nodes until the data reached the central node, then the central node redistributed the response for the actuator to the sensor nodes, and finally, the sensor nodes turned on or off the fan even in heavy rain or sweltering heat.

To evaluate the nRF24L01 module and the nRF24L01 PA LNA module, two sensor nodes are placed at different distances. A manual meter and Google maps are used to measure the distance between the two sensor nodes as shown in Fig. 7.

Fig. 6 Evaluation of sensor node

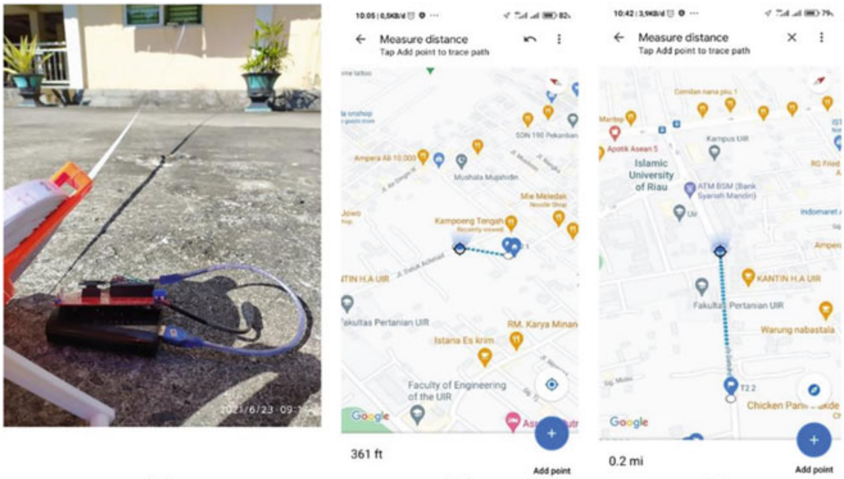


Fig. 7 Evaluation of sensor node (nRF24L01 radio frequency coverage)

The evaluation results of the nRF24L01 module show that within 7.35 m, the data transfers are stable as shown in Fig. 7a. The evaluation results of the nRF24L01 PA LNA module show that within 110 m, the data transfers are stable between two sensor nodes despite being blocked by trees as shown in Fig. 7b. However, without obstructions, the data transfers are stable between two sensor nodes within 321.8 m.

4.2 *Evaluation Result for Central Node*

Functional evaluation of the microcontroller central node is done by looking at the serial monitor and the database. The serial monitor shows what processes and what data enter the central node which are also stored in the database. Figure 8 shows a central node implemented in the form of a printed circuit board (PCB).

The experiment result shows that the central node managed to receive data from the nearest sensor nodes, then the central node redistributed the response for the actuator

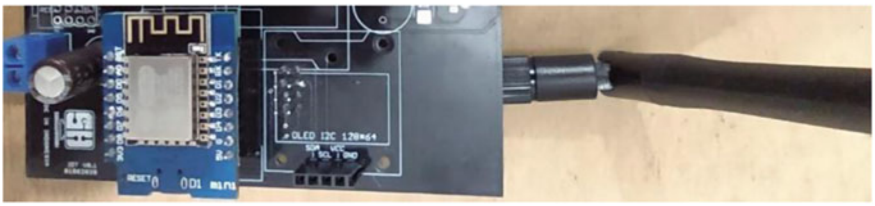
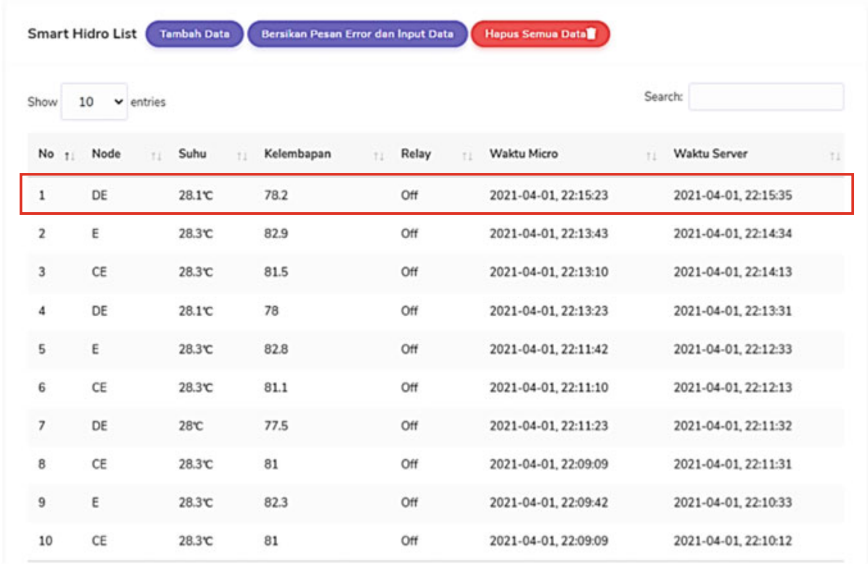


Fig. 8 Evaluation of the central node



Smart Hidro List | Tambah Data | Bersikan Pesan Error dan Input Data | Hapus Semua Data

Show 10 entries

Search:

No	Node	Suhu	Kelembapan	Relay	Waktu Micro	Waktu Server
1	DE	28.1℃	78.2	Off	2021-04-01, 22:15:23	2021-04-01, 22:15:35
2	E	28.3℃	82.9	Off	2021-04-01, 22:13:43	2021-04-01, 22:14:34
3	CE	28.3℃	81.5	Off	2021-04-01, 22:13:10	2021-04-01, 22:14:13
4	DE	28.1℃	78	Off	2021-04-01, 22:13:23	2021-04-01, 22:13:31
5	E	28.3℃	82.8	Off	2021-04-01, 22:11:42	2021-04-01, 22:12:33
6	CE	28.3℃	81.1	Off	2021-04-01, 22:11:10	2021-04-01, 22:12:13
7	DE	28℃	77.5	Off	2021-04-01, 22:11:23	2021-04-01, 22:11:32
8	CE	28.3℃	81	Off	2021-04-01, 22:09:09	2021-04-01, 22:11:31
9	E	28.3℃	82.3	Off	2021-04-01, 22:09:42	2021-04-01, 22:10:33
10	CE	28.3℃	81	Off	2021-04-01, 22:09:09	2021-04-01, 22:10:12

Fig. 9 Smart hydro web-based application interface

to the sensor nodes. Both the serial monitor, and the database show a successful data transfer between the central node (Node E as shown in Fig. 2) and the nearest sensor nodes. Figure 9 shows the successful data transfer of temperature (*suhu*) and humidity (*kelembapan*) from sensor node D to central node E.

5 Conclusion

Based on the experiment conducted on the use of radio frequency in monitoring the Internet of Things-based hydroponic system, several conclusions can be drawn. The utilization of radio frequency monitoring of the Internet of Things-based hydroponic system is very useful in sending sensor data wirelessly without using the internet between the sensor nodes toward the central node. The maximum distance of the nRF24L01 PA LNA radio module is 321.8 m, and the maximum distance of the nRF24L01 radio module is 7.35 m in order to maintain a stable data transfer. The designed architecture is successfully implemented and executed to transmit air temperature and humidity data and other required data between the sensor nodes and the central node. The maximum number of characters that can be sent and received by the nRF24L01 radio module is 28 characters.

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