Department of Digital Business
Journal of Artificial Intelligence and Digital Business (RIGGS)
Homepage: https://journal.ilmudata.co.id/index.php/RIGGS
Vol. 4 No. 2 (2025) pp: 2692-2700
P-ISSN: 2963-9298, e-ISSN: 2963-914X

IoT-Based RFID System for Enhancing Kindergarten Student Safety : A Case Study

Putri Elfa Mas`udia, Febiola Kireya Suekko, Nugroho Suharto
[1,2,3] Digital Telecommunication Network Study Program, Department of Electrical Engineering, Malang State Polytechnic, Malang, Indonesia
[1]putri.elfa@polinema.ac.id*,[2]febiolakireyna12@gmail.com, [3]nugroho.suharto@polinema.ac.id

Abstract

Antonius Kindergarten is one of the kindergartens whose school building is a courtyard with a higher school level, namely SDK Santa Maria, and adjacent to the highway. One of the major safety concerns is the staircase leading to the second floor of the elementary school building, which connects directly to the hallway used by kindergarten students to access the bathroom This access point poses a significant risk, as kindergarten students often ascend the stairs unsupervised, resulting in injuries or crying without being noticed by teachers or staff. There is no guard because the staircase access is in the middle of the elementary school building. Based on this background, an automatic student security monitoring system is needed by utilizing technology, namely RFID (Radio Frequency Identification) and a website as a user interface. Based on the results of the RFID reading distance test using two models of tags, bracelets, and I.D. cards at 3 points of the area (gate, front door, stairwell) and 2 points of the height of the RFID reader (1.8 meters and 1.5 meters) the farthest distance of the RFID reader reading was obtained was 5 meters (I.D. card model rails area) and 3.5 meters (front door area bracelet model). The warning alarm for kindergarten admins sounds for 5 seconds repeatedly with a pause from the minimum reading distance of the RFID reader of 0.3 seconds. The farther away the Tag is from the reader, the longer the pause is.

Keywords: *Kindergarten Students; Monitoring; Alarm; RFID; READER; TAG; MQTT; Website*

1. Introduction

Kindergarten is the initial stage of formal education and the initial stage in character formation and individual development. [1]. Kindergarten students are aged 4-6. They are characterized by a high level of curiosity and energy and a tendency to explore new environments. Consequently, the safety, security, and well-being of students is a primary concern for teachers, particularly when they are engaged in outdoor activities. Surveillance with the naked eye certainly has a high-security risk.

Antonius Kindergarten is one of the kindergartens whose school building is a one-yard building with a higher school level, namely SDK Santa Maria. The SDK Santa Maria school building consists of two floors; the 1st floor consists of grades 1 – 3 and teacher rooms and staff, while the 2nd floor only has classrooms 4 – 6 elementary schools. The kindergarten building is located on the first floor of the back area adjacent to the 3rd-grade classroom. The staircase access to the 2nd floor of the elementary school building is in the middle of the school building, with a hallway connected to the road to the kindergarten bathroom.

Kindergarten Antonius has 26 students, while SDK Santa Maria has approximately 100 students. This makes it difficult for teachers or staff of Antonius Kindergarten to supervise each student's location during recess because the break hours for kindergarten and elementary school students are simultaneous. In addition, kindergarten

students are trained to be independent and brave enough to go to the bathroom during recess. The bathroom for kindergarten students is located behind the classroom of Kindergarten A, and the bathroom hallway is connected

to the staircase access hallway on the second floor of the elementary school building. Due to high curiosity, sometimes kindergarten students go up to the second floor of the elementary school building, which is filled with elementary school students from grade 4 to grade 6. However, many kindergarten students come back injured or crying. In addition to these problems, the location of the school on the side of the highway and the absence of security guards guarding the school gate are also a problem for teachers and staff of Antonius Kindergarten in supervising kindergarten students so that they do not go out of the gate during recess hours, even though there are no food vendors in front of the school. During the observation in the school environment, it was thought to create an automatic security system with technology that can monitor and know the location of students while in the school environment to prevent students from entering dangerous areas in this problem, namely the elementary school staircase area. Research [2] In 2022, RFID technology type RC522 was obtained to monitor vocational school students and prevent students from skipping school due to a very short reading distance, namely a maximum RFID reading of 50 cm with a maximum delay of 5 seconds.

RFID *(Radio Frequency Identification*) is a wireless system that uses radio waves to automatically identify an object, animal, or human using a chip attached to it [3]. A Website is a collection of web pages or 'locations' on the Internet that store information and present it so anyone online can access it through a web browser. [4]. Based on the above problems, the system will be created and designed to monitor students directly by using RFID readers as detectors and RFID tags attached to students as transponders that transmit backscattered signals to the readers. [5]. The system communicates using TCP/IP using LAN cables for communication between RFID readers and access points and utilising the MQTT protocol for communication with websites.

Nugroho Suharto, et al, in 2020 designing and developing a new system to automatically record medical records of posyandu patients by using RFID to identify patient data, Arduino as a microcontroller, N.R.F. as data processing, and Raspberry Pi as a server. In addition, this study utilises a node containing an ultrasonic sensor and a load cell sensor to determine the height and weight of the patient. In this study, the maximum result of RFID detection was obtained at 3 cm with a maximum delay of 2.9 seconds; the data displayed on the web was in the form of toddler name, weight, and height [6]. M Sucito, et al, in 2022, study designed a warehouse management system using RFID technology to support the warehousing system in real-time and Android as an interface user. By using UHF RFID tags on goods and ID Card employees and installing an RFID Reader in each warehouse area, the system can determine the inventory of goods in the warehouse, employee attendance, and information on the location of goods and employees [7]. Research in 2023 [9], the system uses a custom RFID reader and RFID tag in the form of an RFID card that scans data that will be processed by the ESP8266 and displayed on the LCD and computer. The database uses MySQL as a hosting service that stores data and sensor values. RFID readers can read tags at a maximum distance of 6 cm with an RFID tag reading time of 0.18 seconds. The research in 2024 [10] designed an automatic attendance system using RFID technology for monitoring student attendance and Node MCU ESP8266 as a microcontroller regulating data transmission via Wi-Fi.

The interface used in this study is a website that displays information on subjects, classes, majors, school year, semesters, names of students who attend, K.B.M. dates, class entry and exit hours, and attendance data recordings that can be downloaded in Excel. The research, titled "Design and Build an IoT-Based Kindergarten Student Security System with RFID Technology (Case Study of Antonius Kindergarten Madiun City), aims to determine how to design a security system for kindergarten students using RFID, how to integrate software and hardware security systems for kindergarten students, and the quality of the reception range by RFID.

2. Research Methods

2.1 System Block Diagram

The implementation of this system is drawn in a diagram block, shown in Figure 1. The system consists of four main components: input, process, server, and output. In the input stage, RFID tag specifically passive wet inlay stickers—are used to identify students by transmitting a unique code when powered by RFID readers.

DOI: https://doi.org/10.31004/riggs.v4i2.891

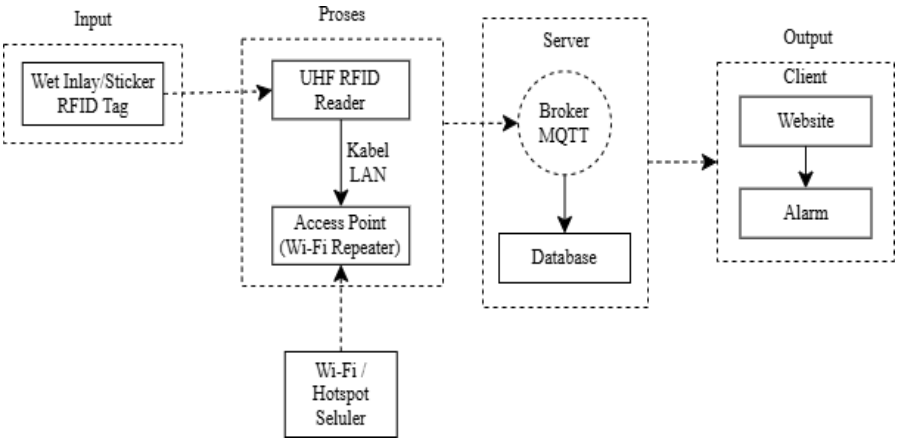

Figure 1. System Block Diagram

In the processing stage, RFID readers capture these signals and forward them to a server for interpretation. An access point functions as a Wi-Fi repeater to connect RFID readers to the server over the same TCP/IP network. On the server side, an MQTT broker facilitates communication between RFID readers and the website interface, translating tag codes and routing messages. The database stores identification results and related data for system use. The output stage includes a website interface used by teachers and staff to monitor student locations in real time, as well as an alarm system that triggers warnings when students enter restricted areas. The alarm only activates if the live monitoring page is active and the student is within the RFID reader's range.

2.2 System Design

Each student equipped with a wristband or ID card containing a unique RFID tag code is first registered in the system's database. The database stores student information such as name, student identification number (NIS), class group, and the unique code embedded in the wristband or ID card. When a student enters a dangerous area and comes within the reading range of the RFID reader, the signal captured from the RFID tag is processed and transmitted to the MQTT broker via the internet network to be translated into data. This data is then automatically displayed on the monitoring page of the admin website. At the same time, an alarm sounds like a notification and warning to teachers or school staff that a student is approaching or entering a dangerous location. Teachers or staff can view the students' information and location, enabling them to take preventive measures to avoid potential incidents. How the hardware system works is shown in Figure 2 below:

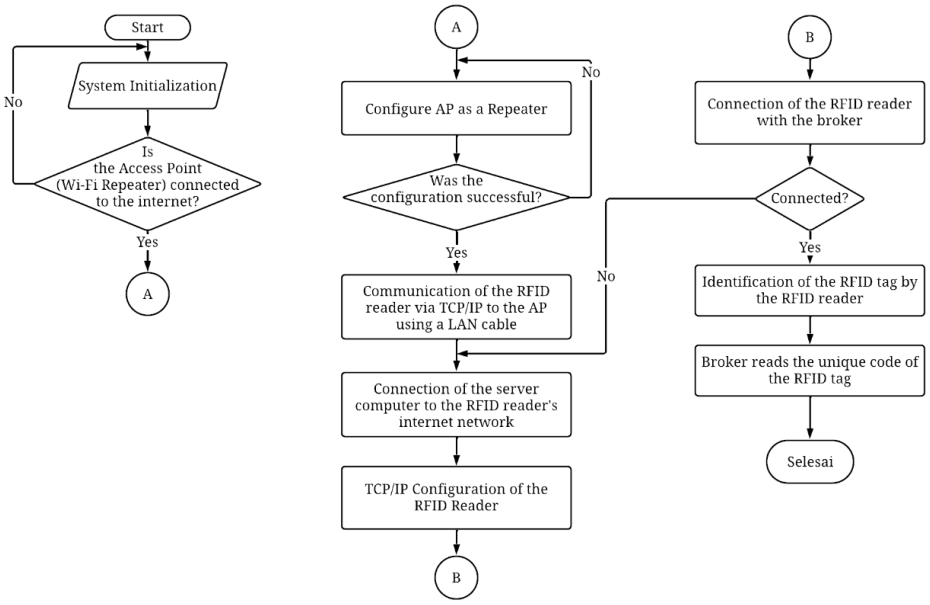

Figure 2. Flowchart Hardware.

The system process begins with an initialization phase, where all devices involved undergo system startup

DOI: https://doi.org/10.31004/riggs.v4i2.891

procedures, where all devices required are subjected to system startup procedures. Once the initialisation is complete, the access point (AP) connects to the internet network. The next configuration steps can only proceed if the AP is successfully connected. Upon connection, the AP is set up to function as a Wi-Fi repeater. Following this, the AP is linked to the RFID reader via a LAN cable to enable communication over a TCP/IP network.

If both the AP and RFID reader are properly connected, the RFID reader is then configured. Before proceeding with this step, it is essential to ensure that the internet network on the laptop matches the RFID reader's network. Configuration involves aligning the remote IP address with the IP address of the RFID reader and setting the appropriate gateway IP.

Once configured, the RFID reader communicates with the system through the MQTT protocol, which acts as a broker. This broker receives, processes, and translates the RFID tag signals into readable data, which is then transmitted to the user interface. If the broker fails to establish a connection, the RFID tag signal cannot be processed or displayed on the interface. Conversely, if the broker is connected successfully, the tag's identification code is translated and sent to the system.

To verify functionality, the RFID tag is brought near the RFID reader while the broker's terminal window is open. If the terminal does not display a unique code, it indicates a connection error between the broker and the RFID reader. However, if the terminal shows the message "Tag: [unique code]", it confirms that the connection is successful, and the system is operating as intended. This concludes the setup process.

2.3. Application Design

The flowchart below illustrates the systematic sequence of steps involved in the software's work.

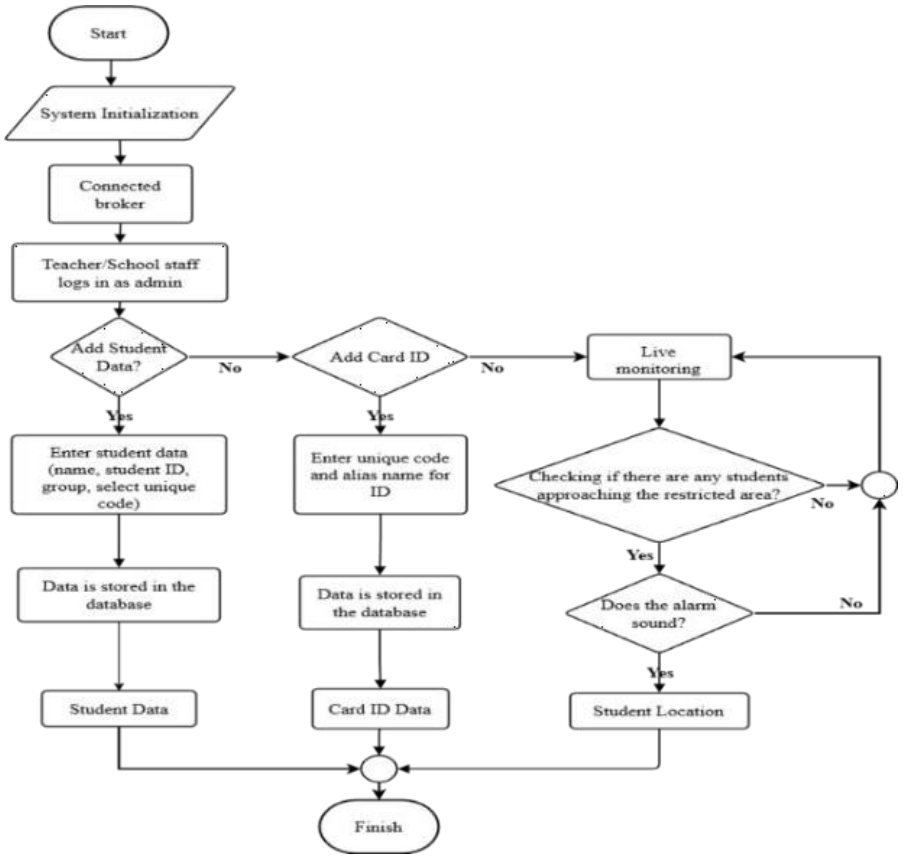

Figure 3. Flowchart Software.

The system begins with an initialization process. The MQTT broker terminal is opened to ensure a successful connection. The teacher then logs into the website as an admin and registers student data, including name, student ID (NIS), group, and the unique RFID tag code, which can be viewed from the broker terminal. Monitoring cannot begin until all students are registered.

DOI: https://doi.org/10.31004/riggs.v4i2.891

To monitor student activity, the teacher accesses the monitoring page. If no alarm or alert appears, no student is within the RFID reader's range. However, if an alarm sounds and an alert with student information appears, it indicates that a student has entered a restricted area.

The teacher can then check the student's location via the location menu to take prompt action. Once the student leaves the restricted area, the alarm stops automatically.

3. Results and Discussions

3.1 Software Design Result

The website developed in this study serves as a user interface utilized by school administrators to monitor the safety and whereabouts of kindergarten students within the school environment, particularly when students enter dangerous areas and are detected by the RFID system. The result of the website implementation is shown in Figure 4.

Figure 4. Main Menu Implementation

The monitoring menu serves as the user interface used by kindergarten administrators to track the real-time location of students. Monitoring can be performed once the MQTT server is connected to all devices, including the RFID reader, the server, and the website interface. The table on the monitoring page will continuously display the message "Waiting for Data" if no RFID tag is identified or read by the RFID reader. The student data menu is used to add and update student information, as well as to register the unique RFID tag code. The student data menu is shown in Figure 5.

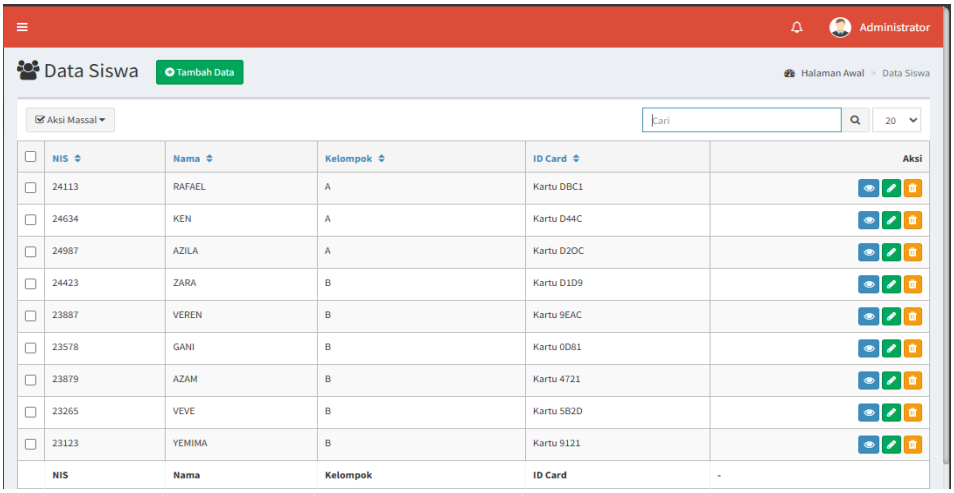

Figure 5. Student Data Page

The Student Location Page, in addition to displaying the current location of students, also functions as a history log of students who have crossed boundaries, approached, or entered hazardous areas within the RFID reader's detection range. This page presents information such as the unique tag code, student name, location, time, and status. All data displayed on the Student Location Page is automatically stored in the database.

DOI: https://doi.org/10.31004/riggs.v4i2.891

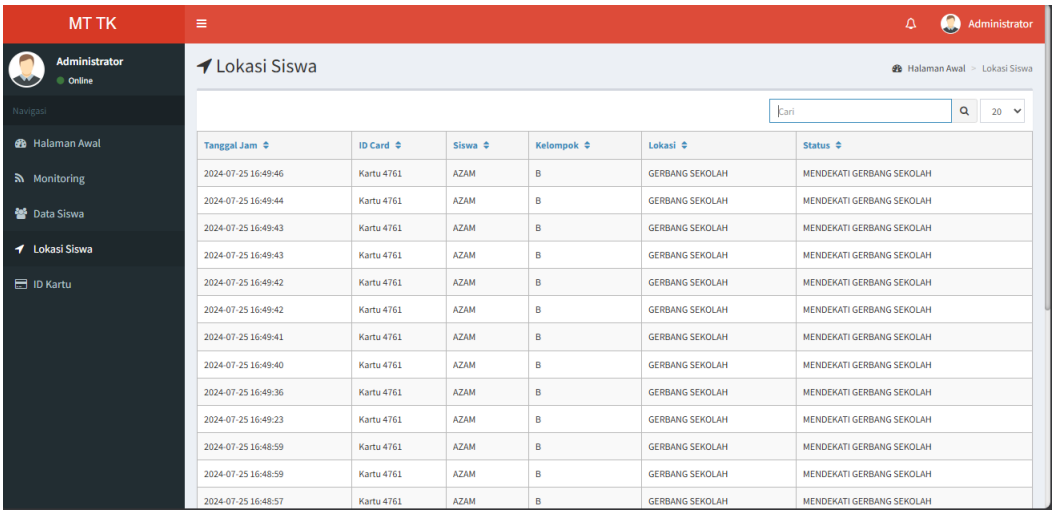

Figure 6. Student Location Page

3.2 RFID System Test Result

The testing system aims to determine the RFID's reading distance. The distance testing is conducted at three points area (gate, front door, rails), at distances of 1 to 5 meters and two height levels of 1.8 meters and 1.5 meters.

Table 1. RFID Testing Results Height 1.8 meters Gate Area

Experiment	Distance	Wristbands Tags Results	ID Card Tags Results
1	1 m	Detected, and the alarm sounded	Detected, and the alarm sounded
2	1.5 m	Detected, and the alarm sounded	Detected, and the alarm sounded
3	2 m	Detected, and the alarm sounded	Detected, and the alarm sounded
4	2.5 m	Detected, and the alarm sounded	Detected, and the alarm sounded
5	3 m	No detected, and no alarm sounded	Detected, and the alarm sounded
6	3.5 m	No detected, and no alarm sounded	Detected, and the alarm sounded
7	4 m	No detected, and no alarm sounded	No detected, and no alarm sounded
8	4,5 m	No detected, and no alarm sounded	No detected, and no alarm sounded
9	5 m	No detected, and no alarm sounded	No detected, and no alarm sounded

In Table 1, the test results show that the maximum distance the RFID reader can read is 2.5 meters, and starting from 3-5 meters, it cannot read the wristband model tag. Meanwhile, the maximum distance the RFID reader can read with the I.D. card model tag is 3.5 meters, and starting from 4-5 meters, it cannot be read

Table 2 RFID Testing Results Height 1.5 meters Front Door Area

Experiment	Distance	Wristbands Tags Results	ID Card Tags Results
1	1 m	Detected, and the alarm sounded	Detected, and the alarm sounded
2	1.5 m	Detected, and the alarm sounded	Detected, and the alarm sounded

DOI: https://doi.org/10.31004/riggs.v4i2.891

3	2 m	Detected, and the alarm sounded	Detected, and the alarm sounded
4	2.5 m	Detected, and the alarm sounded	Detected, and the alarm sounded
5	3 m	Detected, and the alarm sounded	Detected, and the alarm sounded
6	3.5 m	Detected, and the alarm sounded	Detected, and the alarm sounded
7	4 m	No detected, and no alarm sounded	Detected, and the alarm sounded
8	4,5 m	No detected, and no alarm sounded	Detected, and the alarm sounded
9	5 m	No detected, and no alarm sounded	No detected, and no alarm sounded

In Table 2, the test results show that the maximum distance for reading the RFID reader is 3.5 meters, and starting from a distance of 4-5 meters, the wristband model tag cannot be read. In comparison, the maximum distance of reading the RFID reader with the I.D. card model tag is 4.5 meters, and starting from a distance of 5 meters, it cannot be read.

Table 3 RFID Testing Results Height 1.5 meters Stairwell Area

Experiment	**Distance**	**Wristbands Tags Results**	**ID Card Tags Results**
1	1 m	Detected, and the alarm sounded	Detected, and the alarm sounded
2	1.5 m	Detected, and the alarm sounded	Detected, and the alarm sounded
3	2 m	No detected, and no alarm sounded	Detected, and the alarm sounded
4	2.5 m	No detected, and no alarm sounded	Detected, and the alarm sounded
5	3 m	No detected, and no alarm sounded	Detected, and the alarm sounded
6	3.5 m	No detected, and no alarm sounded	Detected, and the alarm sounded
7	4 m	No detected, and no alarm sounded	Detected, and the alarm sounded
8	4,5 m	No detected, and no alarm sounded	Detected, and the alarm sounded
9	5 m	No detected, and no alarm sounded	Detected, and the alarm sounded
10	5.5 m	No detected, and no alarm sounded	No detected, and no alarm sounded

In Table 3, the test results show that the maximum distance the RFID reader can read is 1.5 meters, and starting from 2-5 meters, it cannot read the wristband model tag. Meanwhile, the maximum distance the RFID reader can read with the I.D. card model tag is 5 meters, and starting from 5.5 meters, it cannot be read.

3.1. Discussion

RFID testing in the gate area, with the RFID reader positioned at a height of 1.8 meters, the maximum reading distance achieved was 2.5 meters using a wristband tag model and 3.5 meters with an I.D. card tag model. In the front door area, where the RFID reader was placed at a height of 1.5 meters, the maximum reading distances were 3.5 meters for the wristband tag and 4.5 meters for the I.D. card tag.

The number of obstacles between the RFID reader and the RFID tag influences the differences in testing results. The reading distance was shorter than the I.D. card model during testing with the wristband model. This is due to several factors: the wristband tag experiences curvature to fit the shape of the wrist, it is attached to a medium with a thickness of 1.4 mm, and it is close to a metal button. In contrast, the RFID tag used as an I.D. card is positioned straight without being attached to the I.D. card's plastic, which has a thinner thickness of 0.022 mm. The different implementations of the tags are a factor in the reader's reading distance.

DOI: https://doi.org/10.31004/riggs.v4i2.891

In addition to the differences in tag implementation, the location and height of the RFID reader also contribute to the variations in reading distance. The tests in the gate area at the height of 1.8 meters and the front door area at 1.5 meters showed a similar maximum reading distance of 1 meter for both tag models. However, in the stairwell area, which was also at a height of 1.5 meters, the maximum reading distance for both tag models were relatively far, at 3.5 meters. This is because the gate and front door areas have few obstacles of metal, thick materials, or other dense objects. In contrast, the stairwell area contains many metal items such as ladders, cabinets, stoves, and glass, which significantly reduces the reading distance of the wristband model to just 1.5 meters.

The reading distance tests were conducted alongside alarm testing to alert the admin when a student approaches a hazardous area. Based on the test results, the alarm will sound when a student equipped with an RFID tag enters the reading range of the RFID reader placed in the hazardous area. The alarm will sound for 5 seconds and will continue to sound if the Tag remains within the reading range of the RFID reader, with a reading interval of 0.3 seconds at the minimum reading distance and 0.5 seconds at the maximum reading distance, depending on the reading distance and the signal reflection from the Tag. The farther the Tag is from the minimum reading distance, the longer the alarm will sound. This is because the alarm will only activate when the RFID reader can detect the Tag and only when the Tag can receive and send signals back to the reader. As explained above, the speed of signal reception and transmission between the RFID reader and the Tag is affected by the number of obstacles present.

4. Conclusion

Based on the problem formulation, implementation, and testing results, the following conclusions can be that the Kindergarten Student Security System designed using RFID technology and Access Points can detect the location of students and provide alarm warnings to the admin when students enter hazardous or restricted areas. The RFID hardware unit successfully integrated with the software unit using the built-in software from the RFID reader and a Python program utilising the MQTT protocol. From the results of the RFID reading distance tests using two tag models, wristband and I.D. card, in the gate area with the RFID reader height of 1.8 meters, the maximum reading distances were 2.5 meters (wristband) and 3.5 meters (I.D. card). In the front door area with the RFID reader height of 1.5 meters, the maximum reading distances were 3.5 meters (wristband) and 4.5 meters (I.D. card). The RFID reader's height in the Stairwell area was 1.5 meters, and the maximum reading distances were 1.5 meters (wristband) and 5 meters (I.D. card). The alarm warning for the kindergarten admin sounds for 5 seconds repeatedly, with a delay of 0.3 seconds from the minimum reading distance of the RFID reader, and the delay increases as the distance between the Tag and the reader increases. The web monitoring system for kindergarten student security operates effectively according to the expected functionality, assisting the admin in monitoring, supervising, and determining the location of the students.

Reference

[1] R. Indonesia, "Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional," in Bagian Ketujuh Pasal 28 tentang Pendidikan Anak Usia Dini, Jakarta, Kementrian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2003, p. 42.

[2] A. T. R. T. A. Fikri Fajar Asshiddiqi, "Development of Smart Attendance Detection Based," Journal of Computer Systems and Informatics (JSON), vol. 4, pp. 204-209, 2022.

[3] N. Maghfirah, "Pengimplementasian RFID dalam Perkembangan Teknologi," Robotics and Embedded System Laboratory Teknik Komputer Universitas Andalas, 1 Januari 2021. [Online]. Available: http://reslab.sk.fti.unand.ac.id/index.php?option=com_k2&view=item&id=245:pengimplementasian-rfid-dalam-perkembangan-teknologi&Itemid=342. [Accessed 23 Juni 2024].

[4] BAKRI, "Website : Pengertian, Fungsi, Jenis, dan Cara Membuatnya," Biro Administrasi Kepegawaian, Karir, dan Informasi (BAKRI) Universitas Medan Area, 21 Agustus 2023. [Online]. Available: https://bakri.uma.ac.id/website-pengertian-fungsi-jenis-dan-cara-membuatnya/. [Accessed 26 Juni 2024].

[5] S. Amsler, "DEFINITION RFID (radio frequency identification)," TechTarget, Maret 2021. [Online]. Available: https://www.techtarget.com/iotagenda/definition/RFID-radio-frequency-identification. [Accessed 24 Juni 2024].

[6] L. D. T. A. Nugroho Suharto, "Aplikasi Teknologi RFID pada E-Rekam Medis untuk Manajemen Posyandu Berbasis Web," Jurnal Jaringan Telekomunikasi, vol. 10, pp. 197-201, 2020.

DOI: https://doi.org/10.31004/riggs.v4i2.891

[7] C. I. G. E. A. L. M Sucito, "Perancangan Prototipe Sistem Kelola Gudang Menggunakan RFID Berbasis Android," KONSTELASI: Konvergensi Teknologi dan Sistem Informasi, vol. 2, p. 10, 2022.

[8] M. I. Fauzi, M. M and I. S. S, "Rancang Bangun Sistem Monitoring Proses Belajar Mengajar (PBM) dengan RFID menggunakan Arduino Nano Berbasis Web," JITET (Jurnal Informatika dan Teknik Elektro Terapan), vol. 11, no. 3, 2023.

[9] M. U. A. Primaadi Airlangga, "Identifikasi Pasien pada Posyandu Lansia Menggunakan Rfid Card," EPiC Exact Papers in Compilation, vol. 5, pp. 1-7, 2023.

[10] Suliswaningsih, N. Dwitama and A. B. Wijaya, "Perancangan Sistem Presensi Siswa dengan RFID Berbasis IoT Menggunakan NodeMCU ESP8266," Infotekmesin, vol. 15, no. 1, pp. 15-23, 2024.

[11] Electron, "EL-UHF9424-U9-W," Electron Indonesia, [Online]. Available: https://electron.id/produk/el-uhf9424-u9-w/. [Accessed 12 Juli 2024].

[12] Electron Indonesia, "Jarak baca UHF RFID," Electron Indonesia, Tangerang.

[13] PAUD JATENG, "Membuat TP Tujuan Pembelajaran dari Elemen Jati Diri PAUD," 15 Januari 2023. [Online]. Available: https://www.paud.id/tujuan-pembelajaran-jati-diri-paud/. [Accessed 7 Mei 2024].

[14] R. Amalia, "Mengenal Bahasa Pemrograman Python," Gamelab Indonesia, 24 Agustus 2023. [Online]. Available: https://www.gamelab.id/news/2768-mengenal-bahasa-pemrograman-python. [Accessed 26 Juni 2024].

[15] Direktorat Pembinaan Pendidikan Anak Usia Dini, PETUNJUK TEKNIS PENYELENGGARAAN TAMAN KANAK-KANAK, Jakarta: Direktorat Pembinaan Pendidikan Anak Usia Dini, Direktorat Jenderal Pendidikan Anak Usia Dini dan Pendidikan Masyarakat Kementerian Pendidikan dan Kebudayaan, 2015.

DOI: https://doi.org/10.31004/riggs.v4i2.891