Door Security System Using Radio Frequency Identification Technology for Colegio De Sebastian Computer Laboratory

Reynaldo L De Asis [1], Kennedy V Rodriguez[1], Joefil C Jocson[1], Ryan John L de Lara[1]

[1]*Graduate School, Doctor of Philosophy in Engineering Management, Nueva Ecija University of Science and Technology (NEUST), Nueva Ecija, Philippines.*

Corresponding Author: ledesma0906@gmail.com

Abstract: Security has been a common issue for many years. Most establishments used the conventional access system in recording the person who is entering the facility. This conventional system may result to breach due to its low security. Nowadays, technology continues to grow gradually, that it is now being implemented to automate different system processes. The door access and monitoring system have been part of the vital growth of technologies across the globe. The study mainly aims to develop an RFID door lock system by utilizing and integrating different existing technology that could give accurate date and time record, storing data logs. It also includes the design, development, testing, and evaluation of the system. To meet the objectives of the study, the researcher used the developmental method and prototyping model. Parts of these methods include the building and testing stages, and a redraft of the developed system. The researcher started by requirement analysis. The different technologies to be integrated to the system were determined based from their functionalities. Each module was tested during the construction of the system. The modules include the RFID which will be the main means of access to the system, the RTC module for providing a real-time clock and the date needed in the data logging operation, the SD card module for the real-time storage and access of data, the LCD to serve as the user interface, the Arduino as the main microcontroller, the relay module as the electromagnetic switch, and the electric rim lock as the main security lock device. After the completion of the system, it was evaluated based from different criteria which are challenge-response, keys derived or permanent, lock location, read range, and key update. From the results of the evaluation, the developed RFID Door Lock System improved the security of a conventional door lock by utilizing and integrating open-source technology. Based on the findings and conclusions of the study the following are hereby recommended for the improvement of the project: To integrate Solar Power Technology to adapt green energy and minimized power interruption of the system. RFID microchip implant to the human body.

Key Words: — ***Arduino, Door Lock, Prototyping, RFID, Security.***

I. INTRODUCTION

Security and property have been common issues for many years. Due to low security, the conventional system is the only way to record the person who is entering the facility. An unauthorized person can access enter the facility without permission [1]. Nowadays, security becomes the most significant issue anywhere in the world. This resulted to the security of everything becoming of higher importance in recent years [2]. Technology has a big impact on our day to day living. It became an important facet of every person in society. Almost everything is being run by technology: may it be in the fields of business, education, and health and access control in various places.

The door access and monitoring system have been part of the vital growth of technologies across the globe. Year 1960 was the first time that electronic door access control system is practiced to eliminate problems with regards to the lost keys which give way to allow and restrict the access of someone, and to be able to generate reports on people's "comings and goings"

Manuscript revised April 27, 2023; accepted April 28, 2023. Date of publication April 30, 2023.

This paper available online at www.ijprse.com

ISSN (Online): 2582-7898; SJIF: 5.59

or simply the monitoring of the transaction of the particular area. Prevention is better than cure, through innovation we can prevent crimes such as burglary. The availability of open-source technology is now the way on fast-growing innovations, inventions, and people now are embracing the new trend of the Internet of Things (IoT). One of the common technology available in the market is Radio Frequency Identification (RFID) that can enhance the security of a facility. It is easy to integrate into any open-source technology. RFID is an inexpensive technology that enables wireless data transmission. This technology is used in the standardization of industries. RFID can be applied in attendance monitoring, inventory detection, asset tracking, people tracking, access application control, and the most common is its implementation in the digital security system [3]. An RFID system has three main components. These are the RFID tag serving as the transponder, the reader which is a transponder and a database or a back-end application system. RFID tags are composed of an integrated circuit and an antenna. These components are responsible for transmitting the data gathered to the RFID reader, which is also called an interrogator. Then, the reader converts the radio waves received to a data in a more usable form. Information received from the tags is transferred afterward through an interface to a host computer system for communications. The data gathered is stored in a database. This can also be analyzed at a later time. RFID tags are usually made from a kind of plastic of high durability. The tag is sandwiched between the layers of this kind of plastic. There are different shapes and sizes of RFID tags available. These tags are also classified as either passive or active. Passive tags are the most widely used tags since they are smaller and less expensive to be utilized. They must be "powered up" by the RFID reader before transmitting data. Unlike passive tags, active RFID tags have a built-in power supply [4].

This paper aims to integrate Arduino as the main controller used in the system. Arduino is an open-source platform used in electronics. It is based on a user-friendly hardware, a flexible microcontroller, and an integrated development environment. It can be integrated to different kinds of sensors to read and control the data. Its simplicity and extensibility to use have led to the development of many software libraries and hardware extensions in addition to its great success and adoption by users [5].

The general problem of the study is: "How RFID door lock system may be developed utilizing and integrating different existing technology?"

The study also sought to answers the following questions:

1.How may the RFID door lock system be designed?

2.What technology may be used for the following functionalities

2.1. Accurate date and time record

2.2. Storing data logs

2.3. RFID reader model

2.4. Microcontroller as the main controller

2.5. Displaying notification for the user, and

2.6. Solenoid door lock to strengthen the security?

3. How may the RFID door lock system be developed?

4. How may security of the RFID door lock system be tested in terms of the following criteria

3.1 challenge-response

3.2 keys derived or permanent

3.5 read range and

3.6 key update?

The collection of related literature and studies, resources, ideas, methods and instruments for the developed project were gathered. These related works are guides and reference to solve the current problems and to determine the capability of the devices, design, and methodology used during the development. Theory of Safety and Security. [6] believes that analyzing the current situation is the basis for solving security problems and choosing the appropriate security methods, measures, and resources. The researcher spent hours in a company and observed the needs of security enhancement. Through this research, the researcher came up with the right measure and resources to use in developing a technology that can address this problem. Theory of Radio-Frequency Identification. [7] believes that the application of RFID technology may have the potential in boosting the efficiency of operations in different industrial fields. It may also contribute in enhancing the asset visibility and traceability, and in minimizing the use of manual processes. This can lead to the reduction operation costs and provision of useful data for business analytics. The researcher had utilized the RFID technology for it is low cost, easy-to-use and can enhance the security of an establishment from a manual door lock to an electronic door lock. Industries have switched to RFID technology in their procedures. This made an impact in the improvement in data accuracy, operational efficiencies, logistics enhancements, and other process improvements. Prototyping theory. Prototyping can be considered as the heart of the innovation process, engineers and designers both use the prototyping method, but their perspective on prototyping differs based on their background. The engineer focuses on the features and functions of the prototype and needed specific

objectives. On the other hand, designers used prototyping to investigate new possibilities and open to a variety of materials and tools. The researcher used the prototyping method to address the problem presented. Prototyping method deals in requirements gathering, designing, building, refining, and engineering product as an output. As an engineer, the researcher focused on the specific features and functions of the developed system. [8] introduced a security system with a built-in automatic sensing. It is equipped with an RFID card tagging system and a fingerprint-sensing biometric security system to maintain the security in accessing a place by authorized persons. RFID reader and fingerprint sensing device serves as automated security locker. The RFID tag and an authorized ratified finger are considered as keys of the locker. When access is verified and granted entity, the door bar opens using a servo mechanism system connected to the door bar. Otherwise, no action is taken if the entity is considered as invalid or unauthorized by the sensing system. The researcher used the RFID reader as the sensor for the RFID tag as the key to the door lock. The researcher believes the RFID technology would be enough to enhance the security of the door. Instead of using a servo mechanism to unlock the door, the researcher used a solenoid lock were if the access is granted an induction coil will release the pin lock for the door to open. [9] an anti-theft system for the car security using RFID. The system combines the Arduino Uno microcontroller and RFID technology. The initial design was simulated using Proteus software in validating the Arduino electronic circuit. There is a serial communication linking the RFID and the Arduino. An immobilizer was utilized to give assurance in stopping the car engine if other strategies fail. This was integrated as another security strategy. The system was built considering cost-effectiveness and operational efficiency. The researcher used Arduino Mega as the main controller of the system; it is linked to the RFID receiver. Both technologies communicate through serial communication. The system was designed for the door instead of car anti-theft as mentioned above. Arduino is considered as a very flexible micro-controller and development environment with many applications. It is not only used in controlling devices, but it extended its application in reading data from all kinds of sensors that can be integrated to it. Its simplicity and extensibility to use have led to the development of many software libraries and hardware extensions in addition to its great success and adoption by users. It has now also wired and wireless communication with the Internet. Arduino is the ideal hardware platform available for experimenting with the world of the Internet of Things due to it becoming open-source [5]. Home safety is still considered as a critical issue in the metropolitan city as well as in the sub-urban area. This is specifically for people who give much activity outside the home. The community needs proven strategies in enhancing and assuring the security system and monitoring the house environment from distance. designed and developed a home security and monitoring in a single system. They utilized the Internet of Things (IoT) technology and combined an Arduino-nano and NodeMCU ESP8266 as the controller. The home security system they developed also included an RFID reader and numerical code in unlocking the door and in sending email notifications to the users. The monitoring system used a PIR sensor in detecting the intruder and a DHT-22 sensor in sensing the temperature and humidity inside the room. It also utilized a rain sensor for rain detection, a fire sensor in determining a stove's fire, and LDR sensors in monitor the light condition inside the house. Moreover, the researchers set up light bulbs in the house. They also used solenoid valves as actuators. The study succeeded in the overall monitoring of the house condition and controlling the lights distantly using a smartphone application with the aid of the internet. As mentioned, Arduino is much recommended in developing projects for it is easy to integrate into different types of sensors, electronic devices, and even to connect on the internet. Different libraries for different devices are available for easy programming. Since the developed system deals with different modules, the researcher is confident in using Arduino. 16x2 LCD was added for the Arduino-based LPG gas monitoring system to display the data from different sensors. Also, LCD has been applied for various reasons: cost-efficient, it can display numbers, characters, and graphics rather than LED which was limited to numbers and characters [10]. In another article, the authors stated the advantages of the LCD module. It is said that it is compatible with many applications. A much basic module and is frequently used in different devices and circuits. The reason why it has been chosen because they are economical, easy to program, no limitation in displaying special and custom characters, animations [11]. Displaying messages is important for users to be informed. Therefore, using an LCD that displays a notification from the system device served as a guide to the user to be aware of how the system device respond to each command. The developed system needs a visual output that will display if the RFID tag tapped on the RFID receiver was authorized (registered) or unauthorized (unregistered) to open the door. Any electronic device needs to have feedback for the user in every use or transaction.

This network consists of three sensors serving as communication nodes (i.e., slave nodes) sending their measured data samples to a master node (SD card). Other components of the system are real-time clock; media memory card (MMC); liquid crystal display, virtual terminal, and many other devices that are integrated to form the complete system. Also, two power supply sources are provided [12]. SD cards can be used for data storage and data logging. Examples include data stored on digital cameras or mobile phones and data logging to record information from sensors. Micro SD cards have storage capacity of 2GB of data when formatted in FAT32 (File Allocation Table) format. The micro-SD card has an operational voltage rating of 3.3V. This means that only micro-SD card modules with a 5V to 3.3V voltage level shifter chip and a 3.3V voltage regulator can be interfaced to the Arduino 5V supply [13].

Since the developed system is not computer-based and it's microcontroller-based, it needs an external memory module to record all its data logging. One of the main features of the developed system is to record every authorized user. Data log history includes Employee ID number. RFID serial number, date and time of the transaction. [14]. A microcontroller-based digital clock using Real Time Clock (DS1307), this system was constructed using a PIC microcontroller that displays current time and date in an LCD. In this paper, the RTC module has a backup button cell battery of 3v in case that the system was shut down or in standby mode, the time and date are still up-to-date. The developed system must be up-to-date and time accurate. Using the RTC module this feature can be achieved. The researcher chooses clocked by 32.768 kHz, the Maxim DS1307 is one of the popular I2C 8-pins RTC chip available on the market, equipped with Automatic Power-Fail Detect and Switch (Vergara, and Villaruz, 2014). RTC and Arduino are connected through I2C Bus to make it simpler in connection, and since libraries related to RTC and Arduino are available on the internet it is also easy for programming. The Inter-IC Control (I2C) Bus is a Serial communication standard developed by Philips decades ago. The main purpose of this is to connect all peripherals to the computing device in one data line and synchronized clock [15]. Developed a digital security to store all the information of the user to the computer. When a registered user comes to the entry point and puts the tag into the reader, the system checks whether it is a registered user or imposter. If the user is registered one then the tab information is matched with the user information stored in the system. The door gives access to the entry of the user after successful authentication. It also closes automatically when the specified time interval is reached. The check-in information is also stored in the database with date and time when the door was accessed. A log is also generated by the system according to check-in information. The disadvantage of this developed system is that it is a computer-based Door Lock System. The capability of the whole computer was being limited to just opening the door, reading RFID, registering and deleting RFID information. The use of the computer was not maximized. The developed system is microcontroller-based and no computer intervention upon its implementation, it is cheaper but still can do such task. [16] Automated Classroom Magnetic Door Lock with Attendance Monitoring System using Radio Frequency Identification (RFID) Technology was developed. Their objective is to design a device consists of hardware and software. The software used is Microsoft Visual Studio 2015 Community Edition and its MySQL Local Database. The hard ware devices are Gizduino v.5 for RFID Technology, Arduino which controls the Electromagnetic Lock devices to give security in each door of the classroom, and LCD for log status display. The study implemented a system to record the attendance of the teacher and students. Also, the system can record a log history for security purposes. The study aims to prevent students from entering and using the classroom facilities that leads to unnecessary electricity consumption. By using the attendance monitoring system, they can easily monitor the attendance of the teacher that would also allow them to view and print records. In the mentioned study, their system was consisting of a computer where the database uses, Arduino, and Gizduino. There is a redundant technology in the said study, Arduino and Gizduino are the same. It is just that Gizduino is a Filipino-made Arduino version. The researcher is aiming to develop a system without a computer system to make it cheaper without compromising security. Single Arduino would be enough to run the whole system. [16] The study was entitled Automated Classroom Magnetic Door Lock with Attendance Monitoring System Using Radio Frequency Identification was developed to automate mainly the attendance monitoring system of teachers and students of the Notre Dame of Tacurong College and to provide classroom security and maintenance access. The main objective of the study was to develop an Arduino and Visual Studio 2015-based attendance monitoring system that accepts Radio Frequency Identification Tag data and a set of numeric codes for the room security password. The Radio Frequency Identification or RFID enabled the system to capture and record the late and absences of both teachers and students while the set of numeric codes gave the school personnel access to classrooms to perform security and maintenance without using

the RFID tag and RFID reader. In the aforementioned study, they used RFID for the attendance of the students, and keypad for a numerical password on unlocking the door for the maintenance personnel, which are both can be achieved by simply using RFID technology. The main purpose is security and data logging which is included in the features of the developed study of the researcher.

II. METHODOLOGY

The design of the study defines the study type and sub-type, research questions, and experimental framework. The researcher used two different research methods to offer an appropriate solution to the problems inherent in the existing system

Developmental research is an advanced method of the simple instructional development. It has been defined as the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness. Developmental research is specifically significant in the field of instructional technology. The most common types of developmental research involve situations in which the product-development process is analyzed and described, and the final product is evaluated [17].

Another statement of [18], whether the research is conducted either before or after the development of the actual product is better than simulated or idealized.

The researcher used the prototyping model to show the building, testing, stage and a redraft of the developed system. The researcher gathered all the requirements such as journals and online references that support the study and analyzed the component needed such as Arduino Mega, RFID Scanner, relays, RTC module, and SD card module. After the requirements gathering and analysis, designing the prototype was the next step. The requirements in the first phase must be considered. From time to time, the changes given by the experts were applied and the refinement of the prototype was conducted. This was a continuous process until the device is ready to use.

This model has an advantage for a huge and complex project. Rather than the waterfall model that cannot be changed unless you go back from the previous stage when an error occurred, the prototype model has a redraft until the desired goal is achieved. Hence, the errors can be easily identified [19].

The advantage of the prototyping model is it can be documented, evaluated, simple that can easily be understood compare to other models [20].

Requirements. A prototyping model starts with requirement analysis. In this phase, the requirements of the system are defined in detail. During the process, the users of the system are interviewed to know what their expectation from the system is.

Quick design. The second phase is a preliminary design or a quick design. In this stage, a simple design of the system is created. However, it is not a complete design. It gives a brief idea of the system to the user. The quick design helps in developing the prototype.

Build a Prototype. In this phase, an actual prototype is designed based on the information gathered from a quick design. It is a small working model of the required system.

Evaluation. In this stage, the proposed system is presented to the evaluators for an initial evaluation. It helps to find out the strength and weaknesses of the working model. Comments and suggestions are collected from the customer and provided to the developer.

Refining prototype. If the user is not satisfied with the current prototype, refinement of the prototype is needed according to the user's feedback and suggestions. This phase will not over until all the requirements specified by the user are met. Once the user is satisfied with the developed prototype, a final system is developed based on the approved final prototype.

Implement Product and Maintain. Once the final system is developed based on the final prototype, it is thoroughly tested and deployed for production. The system undergoes routine maintenance to minimize downtime and to prevent large-scale failures.

The weighted scores and its equivalent description were used to analyze the computed mean of each criterion as shown below.

Mean Value Score

Scale	Ranges	Descriptive Rating
4	4.00-3.26	Strongly Agree
3	2.51-3.25	Agree
2	1.76-2.5	Disagree
1	1.0-1.75	Strongly Disagree

III. RESULTS AND DISCUSSION

The flowchart of the system device is shown in Figure 1. The program will start by tagging the RFID, if the ID matched on the authorized IDs it will display Authorized access. The electrical lock will open, the time, date, and ID number will be saved on the SD card.

The physical architecture of the proposed system in Figure 2 shows the representation of the physical connection. LCD, RTC, SD Card Module, and Relay Module are connected to

Arduino. The electrical door lock is connected through the relay module.

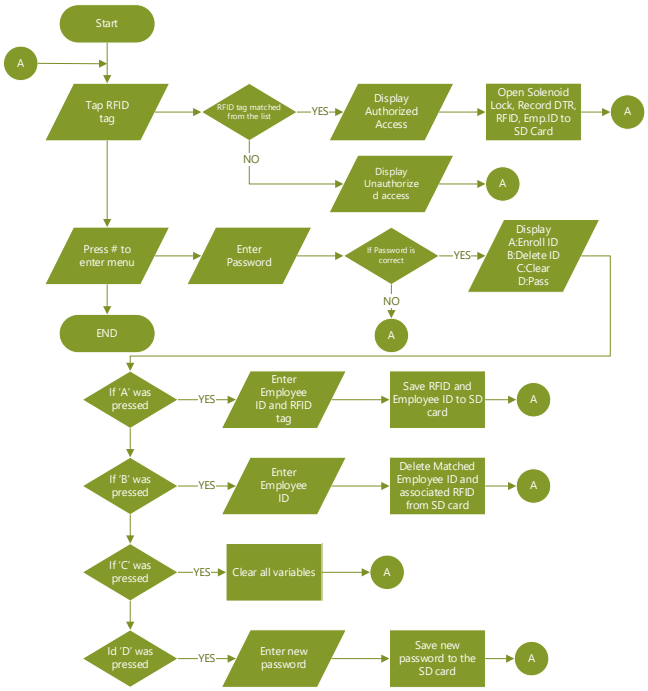

Fig.1. Flowchart of the RFID Door Lock System

In this part shows the testing results of ten registered and ten unregistered RFID tags used to access the RFID Door Lock System. Each tag has an identification number that unique to each other. Registered RFID tags must show a 100% accessibility rate of opening the door, and it must all reject the unregistered RFID tags. Symbol (√) indicates that the door opened and symbol (×) indicates that the door did not open.

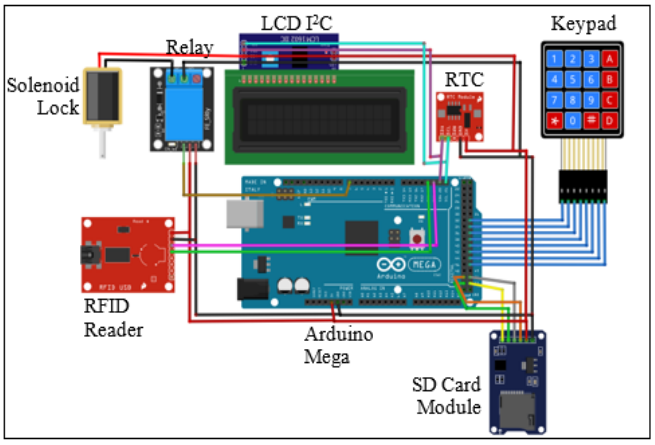

Fig.2. Architecture of the RFID Door Lock System

Table.1. Presents the Result of Registered RFID Tags Accessibility Test

RFID Tag Number	Number of Access Attempt	Attempts to open the door		
		1st	2nd	3rd
0004184010	3	√	√	√
0004173725	3	√	√	√
0004155407	3	√	√	√
0005865817	3	√	√	√
0004177208	3	√	√	√
0004155472	3	√	√	√
0005841484	3	√	√	√
0004188402	3	√	√	√
0004184031	3	√	√	√
0004156047	3	√	√	√

In Table 1, ten registered RFID tags was used to test if the door lock will respond, each tag has three attempt and the result shows 100% success rate on opening the electronic door lock on 1st, 2nd and 3rd attempt.

Table.2. Presents the Result of Unregistered RFID Tags Accessibility Test

RFID Tag Number	Number of Access Attempt	Attempts to open the door		
		1st	2nd	3rd
0012031796	3	×	×	×
0006570414	3	×	×	×
0011972564	3	×	×	×
0004323726	3	×	×	×
0004366157	3	×	×	×
0006558650	3	×	×	×
0006559461	3	×	×	×
0004594621	3	×	×	×
0004551716	3	×	×	×
0004345901	3	×	×	×

In Table 2, ten unregistered RFID tags was used to test if the door lock will respond, each tag has three attempt and the result shows 0% success rate on opening the electronic door lock on 1st, 2nd and 3rd attempt.

Table.3. Presents the Result of Registered RFID Tags Read-Range Test

RFID Tag Number	Number of Access Attempt	Read-Range in (cm)	
		Minimum Range	Maximum Range
0007323280	3	0	5.5 cm
0007320101	3	0	5.5 cm
0007323298	3	0	6.0 cm
0007323292	3	0	6.2 cm
0007323282	3	0	5.4 cm
0007314652	3	0	6.0 cm
0007314654	3	0	5.5 cm
0007320119	3	0	6.5 cm
0007320103	3	0	6.0 cm
0007323276	3	0	5.6 cm

In Table 3, Read-range test was conducted using ten RFID tag. This test is to measure the minimum and maximum distance where the RFID reader can reach its signal. The significance of this test is that having short read-range is the higher the security of the RFID door lock.

Table.4. Presents the Frequency Distribution and Descriptive Measures in the evaluation of the developed RFID Door Lock System in terms of Challenge-response.

Items	Responses				Mean	Descriptive interpretation
	4	3	2	1		
1. The communication between the RFID tag and RFID receiver cannot be hack.	19	1	0	0	3.95	Strongly Agree
2. It will not accept unregistered RFID tag.	20	0	0	0	4.0	Strongly Agree

In Table 4, the respondents strongly agreed that the RFID door lock system cannot be hack and cannot be access by unregistered RFID tag or access by unauthorized person.

In Table 5, the respondents strongly agreed that the communication between the RFID reader and tag is difficult to listen in case there is a hacker trying to duplicate the communication during transaction. Also, the respondents strongly agreed that the door lock will not accidentally open in case a RFID tag holder passed by near the system.

Table.5. Presents the Frequency Distribution and Descriptive Measures in the evaluation of the developed RFID Door Lock System in terms of Read range.

Items	Responses				Mean	Descriptive interpretation
	4	3	2	1		
1. The read range between the RFID tag and the reader is close range for the radio signal be difficult to listen in case there is a hacker trying to duplicate the communication during transaction.	15	5	0	0	3.75	Strongly Agree
2. The door lock will not accidentally open in case a RFID tag holder passed by near the system.	20	0	0	0	4.0	Strongly Agree

Table.6. Presents the Frequency Distribution and Descriptive Measures in the evaluation of the developed RFID Door Lock System in terms of Key-update.

Items	Responses				Mean	Descriptive interpretation
	4	3	2	1		
1. Enrolling and Deleting RFID tags must be done offline for stronger security.	20	0	0	11	4.0	Strongly Agree
2. Enrolling and Deleting RFID tags should be done by Authorized person only.	17	3	0	0	3.85	Strongly Agree

In Table 6, the respondents strongly agreed that the RFID door lock system has a higher security because enrolling and deleting RFID tags must be done offline, and must done by Authorized person only.

IV. CONCLUSION

The system was successfully developed and achieved its desired. From the results of the evaluation, the developed RFID Door Lock System improved the security of a conventional door lock by utilizing and integrating open-source technology.

REFERENCES

[1]. Maato, J., Mwangi, E., & Karimi, P. M. (2017) A low-cost computer-based fingerprint security system for restricted access control automation using LabVIEW. International Journal of Computer Applications: 0975-8887. Volume 163

[2]. Nehete, P. R., Chaudhari, J. P., Pachpande, S. R., & Rane, K. P. (2016). Literature survey on door lock security systems. International Journal of Computer Applications, 153(2), 13-18.

[3]. Verma, G. K., & Tripathi, P. (2010). A digital security system with door lock system using RFID technology. International Journal of Computer Applications, 5(11),

[4]. Huang, Y. C. (2009, August). Secure Access Control Scheme of RFID System Application. In 2009 Fifth International Conference on Information Assurance and Security (Vol. 1, pp. 525-528). IEEE.

[5]. Kumar, N. S., Vuayalakshmi, B., Prarthana, R. J., & Shankar, A. (2016, November). IOT based smart garbage alert system using Arduino UNO. In 2016 IEEE Region 10 Conference (TENCON) (pp. 1028-1034). IEEE.

[6]. Ludek Lukas (2016). Theoretical Sources for a Theory of Safety and Security. In SECURWARE 2016: The Tenth International Conference on Emerging Security Information, Systems and Technologies (pp 146). IARIA.

[7]. Kasemsap, K. (2017). Internet of Things and security perspectives: Current issues and trends. In Security breaches and threat prevention in the Internet of Things (pp. 19-45). IGI Global.

[8]. Komol, M. M. R., Podder, A. K., Ali, M. N., & Ansary, S. M. (2018). RFID and Finger Print Based Dual Security System: A Robust Secured Control to Access Through Door Lock Operation. American Journal of Embedded Systems and Applications, 6(1), 15-22.

[9]. Eze, P. C., Achebe, P. N., Jeremiah, L., & Ageh, T. A. (2018). Anti-Theft System for Car Security using RFID.

[10]. Naik, R., Reddy, P., Kishore, S., & Reddy, K. (2016). Arduino based LPG gas monitoring & automatic cylinder booking with alert system. IOSR Journal of Electronics and Communication Engineering (IOSR-JECE). Volume 11, Issue 04. ISSN: 2278-8735.

[11]. Mishra, K. B., Munshi, A. M., Dhuldhar, N. S., & Dahake, R. R. (2017). Wireless rash driving detection system with SMS sending facility and obstacle detection system. International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT). Volume 3, Issue 2, ISSN: 2454-132X.

[12]. Abba, S., & Nyam, I. M. (2018). Design and Evaluation of a Low-Cost and Flexible Data Acquisition System Using Sensor Network for Smart Homes. Sensors & Transducers, 227(11), 73-81.

[13]. Cameron, N. (2019). SD Card Module. In Arduino Applied (pp. 219-236). Apress, Berkeley, CA.

[14]. Samanta, A. G. (2014). Interfacing Of PIC 18F252 Microcontroller with Real Time Clock via I2C Protocol. Journal of Engineering Research and Applications, 4(7), 152-156.

[15]. Flynn, J. M. (1997). Understanding and using the I2C bus. Embedded Systems Programming, 10(12), 52-71.

[16]. Automated classroom magnetic door lock with attendance monitoring system using RFID by James Paul S. Bernardo, Christopher King D. Garcia, Federico J. Pagmanoja III, and Michael F. Roque.

[17]. Richey, R. C. Developmental Research: The Definition and Scope. NOTE. 1,045 p.; For the individually papers, see ED 368 341 and IR 016 709-783. For the 1993 proceedings, see ED, 713.

[18]. Richey, R. C., & Klein, J. D. (2005). Developmental research methods: Creating knowledge from instructional design and development practice. Journal of Computing in higher Education, 16(2), 23-38.

[19]. Saxena, A., & Upadhyay, P. (2016). Waterfall vs. prototype: Comparative study of sdlc. Imperial Journal of Interdisciplinary Research (IJIR), 2(6), 1012-1015.

[20]. Rai, P., & Dhir, S. (2014). Impact of different methodologies in software development process. International Journal of Computer Science and Information Technologies, 5(2), 1112-1116.