Re:SCN: A Web–based Report Management System with RFID–Based Vehicle Monitoring for Villa Belen

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Abstract

In the Digital Age, technology has come a long way thanks to the innovations in the world of Information and Communications Technology, however, it is a slow transition as some establishments are still lacking when it comes to the application of Information Technology. In this paper, the researchers developed the system to address the problems that are faced by the subdivision. The system organizes and receives reports that are submitted by the residents along with recording vehicles who are entering and exiting the premises. The researchers used Likert Scale to determine and gauge the data inferred from their survey results while Trial and Error method is used to measure the effectiveness of the RFID function of the system. The system was successfully implemented in the target community in which it received positive feedback and results, thus accomplishing the thesis' intended objective in which to assist the residents and help resolve the logistical problems of the subdivision and also enhance the overall security of the subdivision. With these findings and results, we believe that this study opens the potential for a variety of future studies and research such as crime prediction, crime awareness, crime frequency, and other similar topics.

Keywords
Information Technology; RFID; Subdivision; Gated Community; Security.

1. Introduction
In the Digital Age where information can be found with a tap of a button, technology has become a daily part of our lives because of its uses and availability. However, technology, as always, marches on in terms of innovation and progress because without innovation, there would be no progress and without progress, stagnation will happen. When stagnation occurs, the pursuit of knowledge will be affected, and efficiency will be reduced. This is the case for many installations here in the Philippines, who are yet to switch to digital when it comes to information storage. Digital storage is effective in terms of capability and efficiency by reducing errors and being accessible to the user always, not only that but it makes information gathering fast and precise along with swift delivery of proper results, which would be useful in a subdivision, a gated community, much to the benefit of the people within as according to Bhat (2019), people look for ways to improve their living experience both in basic and wealthy necessities and aspects. Gated communities or Subdivisions in the Philippines are often common in the urban areas where the affluent and wealthy can afford to purchase the houses or vacant lots within. They are often chosen as good places to live in because of the lingering sense of safety and security found behind the walls. Furthermore, as stated by Li, et al. (2021). Gated communities have gained increasing popularity for their perceived effectiveness in access control and their exclusion of 'suspicious' and 'threatening' outsiders. Gated communities in the Philippines are also called subdivisions and to define a subdivision, it is a plot of land that was divided into smaller pieces for development and residence. The purpose of the RE: SCN with RFID is to address the logistical problems that the community tend to face, by providing an efficient way of tracking, recording, and managing information that is needed by the administrators and to decrease the response time when it comes to handling the problems that are reported by the residents or similar tenants within the community. The system is applicable for use by the administrators in the subdivision, which can help for direct reports. Since this is computerized, this will help us accomplish the tasks efficiently, track and retrieve data while maintaining reliability and accuracy, reduce human errors and processing time and provide secure information storage.

1.1 Objectives

The general objective of the study is to design and develop Re:SCN system that will help both the residents and officials with communication-related problems for the target subdivision and to improve the logistics of the reports. The researchers decided to use a web application for the development of the system which will be used as the main system that will hold the overall reports that will be passed to the elected secretary of those in charge of the subdivision. The researchers also decided to implement the feature of a RFID system to RE: SCN that can be beneficial to the subdivision because it can help with the security by tracking those vehicles that are entering and exiting the subdivision premises.

The following are the study's specific objectives:
- To develop a module that will deal with the logistic problems through the use of Re:SCN application.
- To design a module that will handle and lessen the response time rate of reported incidents at the target subdivision.
- To develop and enhance the security in the subdivision.
- To develop a better management system that is needed by the elected officials.

2. Literature Review

a) Gated Communities and Sense of Community: A Review on the Social Features of Gated Communities

Gated communities in the Philippines are often common in the urban areas where the affluent and wealthy can afford to purchase the houses or vacant lots within. They are often chosen as good places to live in because of the lingering sense of safety and security found behind the walls. This in turn, is stated by Li, et al. (2021). Gated communities have gained increasing popularity for their perceived effectiveness in access control and their exclusion of 'suspicious' and 'threatening' outsiders. Furthermore, according to Rafiemanzelat (2016), creating the sense of community is known as the capability of the gated communities themselves. However, these communities tend to be the target of crimes such as burglary, thievery, etc.

b) Elements of security for a gated and guarded community in the context of smart living.

Most housing communities prefer a highly secure and technologically advanced guarding system and these are often common in the richer and advanced areas of the city. According to Syed et al.(2021) Smart Cities have come out as a major initiative by various governments in making cities more navigable and welcoming to the expected population increase and providing city dwellers a better living experience and it is further proven as according to Salah and Ayad (2018), choosing a residential location is not only limited to the definition of the connections with the urban environment but it also influences the whole family life, their activity, wellbeing, social life, work, and education.

c) Residential Homes adopting Modern Technology

Housing communities that embrace this type of modern technology affect the lives of the resident living there, offering them a more convenient and secured neighborhood, using technology like Artificial intelligence, IoT, and the like, offers them features that standard home community does not provide and it will improve the quality and value in the future. According to Bhat (2019), people look for ways to improve their living experience both in basic and wealthy necessities and aspects. The experience of residents living in this type of community is based on their contentment in the system and the scenario they encounter living in this type of residential home.

d) Smart Home Security

According to Lazakidou et al. (2014), it is imperative to know the significance of the concept of Smart Home and its' architectural model to recognize the factors and source of risk of security breaches or attacks. As such, it must contribute to maintaining the safety of residents by preventing as many threats as possible, accurately detecting threats that do occur, and responding quickly and effectively to them. (Dahmen, et al. 2017)

e) Smart City Development and Residents' Well-Being

As technology marches on and our very homes start adapting to the advent of technology, it is imperative to know on how our surroundings will be affected. The term 'Smart City' is often used in modern technology discussions. Modern technology is an advancement from old technology and its impact on modern life is boundless, it deals with infrastructure, transportation, information, communication, and availability for the residence. To develop a "smart

city" in this Digital Age is to rely on ICT along with a high degree of security and confidentiality as stated by Lin, et al. (2019) to secure the well-being and satisfaction of the residents.

f) IoT-School Attendance System Using RFID Technology

Nowadays, schools are using RFID technology in monitoring both students and staff attendance. The traditional way of taking attendance inside the class comes at the estimate of the time teaching–learning. This RFID Technology is an effective means in recording attendance which will not hinder students learning. This change will not only help the professors in monitoring student attendance, this will also allow the parents to keep track of their child's attendance in school via e-mail or SMS notification. This IoT way of taking attendance may also be used as a means of reducing student dropout rate. According to Foutsitzi (2019), as of recent, ICT have been used to incorporate educational domain and it has a total influence on studying results. Papadakis et al. found that ICT introduced new approach in teaching and learning on a vast proportion. ICT have become a tool in teaching-learning by introducing alternative ways such as e-books. Companies and institutions can gain a lot in terms of opportunities and improvements with the use of IoT. Zhu et al. (2016) found that smart learning environments through IoT presents opportunities such as achieving appropriate knowledge, self-learning and self-motivation. With the reason stated above, students, parents, and faculties will experience the benefit of RFID system implementation in education.

g) The impact of technological innovation on building a sustainable city

Introducing technological innovation is essential in providing a sustainable future for urban areas with a rapid incline in population. To develop this maintainable city, the use of this technological innovation will be implemented. With regards to sustainability, technological innovation has changed its efficiency and benevolence and has changed the daily life of people by making it easier. Energy-saving, pollution prevention, waste recycling, is a must in developing a sustainable city. The expected result of this is a "Smart City" or a city that has the advent of technology and innovation pass through it and one of its main components is ICT itself which is a huge influence to innovation as according to Hicran. (2017)

h) RFID - Radio Frequency Identification Technology

RFID, which stands for Radio Frequency Identification Technology is an automatic identification technology that tags objects for easier identification, tracking and managing. Implemented well, it has the potential to reduce the congestion of user traffic, conserve time that can be used for other activities and even secure items efficiently. (Singh and Mahajan 2017).
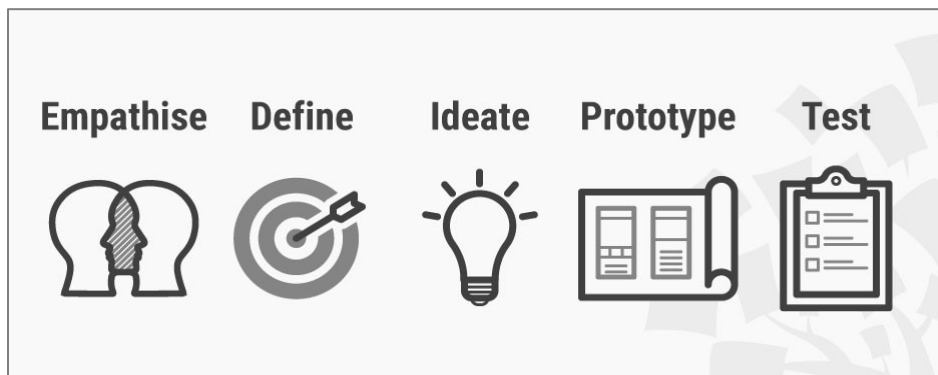
3. Methods

Figure 1. Design Thinking Methodology

Design Thinking as shown in Figure 1, is the methodology used by the researchers in this research because it makes use of intuition, imagination and experiences to tailor the end product based on what the client needs. It is a five (5) stage cognitive, strategic and practical process design methodology which provides a solution-based approach to solving problems. This methodology is more in line on the field of Information Technology because this method allows the researchers and designers to better understand the problem by putting themselves in the place of our client and thus allowing us to construct a system that will surpass the needs of our client. We used quantitative and experimental approach because it is the most applicable in determining if the prototype will work as expected and

planned. This research study will gather data through trial and error. The experiment proper will proceed through the following steps:

- **Step 1** – Program the Arduino with the following information:
    a. Vehicle Owner's name
    b. Driver's House Number
    c. Vehicle Registration number
    d. Head of the House Contact Number
- **Step 2 –** Register the data into the Arduino.
- **Step 3** – Connect LCD monitor and pin the ESP8266, RFID and GSM module in the open pins of the Arduino.

The testing of the prototype begins once the setup is finished. The testing will make use of the trial-and-error method. The research will try several times and record these data to test the probability of the research's prototype. For the RE: SCN website, we made use of qualitative approach in developing the application because the system is tailored to suit the needs of the subdivision which is an effective security system that handles the inquiries of the residents. The study of the web-side will gather data through survey of the respondents.

 The experiment proper follows the procedures as described below.

- **Step 1** – Program the application with the following information:
    a. Resident Name
    b. Incident Location
    c. Incident Type
    d. Incident Status
    e. Incident Remarks
    f. Date of Incident
    g. Date of Report
    h. Date Resolved
    - **Step 1.1 – for Guests**
        a. Guest's Name
        b. Purpose of Visit
        c. Contact Number.
        d. Family to Visit
        e. Plate Number
        f. Time In and Time Out
- **Step 2** – Register the data in the application.
- **Step 3** – Install the application into the computer.

The researchers tested the prototype application after finishing the setup. This is done in order to find errors and anomalies while at the same time gathering data on how the application will run in a certain environment. The respondents in question, are the residents of Villa Belen South Subdivision and the criteria for acceptable respondents is as long as they are residents of the subdivision. The total population of the subdivision is estimated to be around 214 households. To clarify the definition of being a resident of Villa Belen South, for as long as they own a property or a lot within the premises of the subdivision, the criteria for the valid respondents is fulfilled, making them valid for participation. The study encompasses the subdivision of Villa Belen South, located in Angeles City, Pampanga. For this study, we made use of non-probability sampling, specifically Convenience sampling. Through this method, we selected our respondents based on their availability and willingness to participate. Before sending them the survey form and website link, we first asked them if they were willing to answer and take part in our research. The respondents are residents and officers from the locale of our study, Villa Belen. With this method, we gathered 32 willing participants.

Input	Process	Output

Knowledge requirement
• Basic knowledge in manipulating end devices.
• Knowledge in the C programming language for both Arduino and Web-App.
• Awareness in the rules and policies of the targeted subdivision.
Technical requirements
• Continuous power supply
• Internet connectivity
• Pentium 4 CPU and 4 Gigagbyte RAM
	• Design Thinking
	  1. Empathize
	  2. Define
	  3. Ideate
	  4. Prototype
	  5. Test
	• Gathering of Data by Survey, FURPS Model and Likert Scale.
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Figure 1. Project Framework

Figure 1 depicts our project framework which is the guideline on the methodology of our system.

4. Data Collection

The instruments used in the gathering of data for the study is with the use of surveys and questionnaires, followed by trial-and-error methods to ensure that the data we receive is accurate and precise. Surveys and Questionnaires was used by the researchers because we believe that this instrumentation will obtain more data than any other instruments, furthermore, the data that is gathered with this method are easier to analyze and compare as they are based on the respondent's experiences within the subdivision, on how the security of the premises can be enhanced. Trial and error methods was used to gather data for us to improve the product. In their improved product, we performed 11 trials, we first used RFID as their vehicle permit. Then, we input Arduino and programed it. Commanding the 'Time-out' and 'Time-in' for the records of the vehicles going outside. After it, we connected the Arduino to the LCD and GSM module to send message to the head of their house that their vehicle went outside and inside the subdivision. We also made use of the FURPS Model to classify, determine and validate the necessary features and quality attributes of the system that the client requires. This model is suitable for software development because it allows the developers to understand and empathize with what the client needs for the system.

4.1 FURPS MODEL

1. **Functionality** – the device will function whenever the RFID scanner detects a vehicle that is entering or exiting the subdivision, it will then show a notification to the system. The function of the web-app is to process the reports that are sent by the residents.

2. **Usability** – the main users of the system and device are the residents and the ones in charge of the security. The use of the device and system will increase the efficiency of the current security of the subdivision because it improves the communication between the administrators and the residents.

3. **Reliability** – the reliability of the RFID device is accurate because it immediately sends a notification to the system from the moment a registered vehicle enters or exits the subdivision. For the web-app, the reports are quickly received by the system to be processed by the administrators.

4. **Performance** – the developers were considerate in constructing the system to be more user friendly and simple to use. The system overall is designed for the user first to make sure that they will not have any difficulties in using the system itself.

5. **Supportability** – the device and app doesn't need advanced systems to work, a simple computer can suffice.

In gathering the needed data, the researchers used a mix of quantitative and qualitative approaches because they are the most applicable in determining if the prototype will work as expected and planned by the researchers. As Information Technology professionals, the analysis of the data is through the use of Narrative Analysis method because I.T (Information Technology) is based on what are the specifications and requirements of the clients, and so

the data which is received through qualitative approach and in turn, through the use of surveys and questionnaires, we believe that this data is useful and informative. As mentioned before, the methodology used here will be Design Thinking because in analyzing the data that was gathered, the researchers can place themselves in the perspectives of the respondents to better understand the problem. Furthermore, with the use of this methodology, the researchers can formulate their own solutions on how to enhance the current security system of Villa Belen South in order to improve its efficiency and effectiveness. Primary data is the only type of data used in the development of the RFID with GSM which the researchers used to gather data.

Table 1. Likert Scale

Score	Corresponding Rank	Rate
4.50 – 5.00	Very Satisfied	5
3.50 – 4.49	Satisfied	4
2.50 – 3.49	Neutral	3
1.50 – 2.49	Unsatisfied	2
1.00 – 1.49	Very Unsatisfied	1

Also, Likert Scale was utilized to analyze the data and information that was gathered from the respondents by gathering the tallies of the questions from the surveys as indicated in Table 1. The Likert Scale that the researchers use, specifies the level of agreements into five points in order: (5) Very Satisfied, (4) Satisfied, (3) Neutral, (2) Unsatisfied, (1) Very Unsatisfied.

5. Results and Discussion

Table 2. Card Owner 1 Test

Module	Function
RFID Tag (Vehicle Card Owner 1)	Scan
RFID Scanner	Scanned
GREEN LED	Lit
Serial Monitor	Display (Access Granted)
GSM (SMS function)	Message Sent
Servo Motor	Access Granted

Table 3. Card Owner 2 Test

Module	Function
RFID Tag (Vehicle Card Owner 2)	Scan
RFID Scanner	Scanned
GREEN LED	Lit
Serial Monitor	Display (Access Granted)
GSM (SMS function)	Message Sent
Servo Motor	Access Granted

Table 4. Visitor Tag Test

Module	Function
RFID Tag (VISITOR TAG)	Scan
RFID Scanner	Scanned
GREEN LED	Lit
Serial Monitor	Display (Access Granted)
GSM (SMS function)	No SMS function for Visitors

Servo Motor	Access Granted

Table 5. Unregistered Tag Test

Module	Function
RFID Tag (UNREGISTERED TAG)	Scan
RFID Scanner	Scanned
RED LED	Lit
Serial Monitor	Access Denied
GSM (SMS function)	Access Denied
Servo Motor	Access Denied

The result of the prototype's probability was tested using the trial-and-error method. The prototype was tested eleven times with the use of a simple diorama, to see if it functions based on the researchers' expected output. When the researchers started the test run, they received consistent results as all of the trials from the prototype gave a 100% success rate because the results met the researcher's intended outcome and output. The prototype, as shown in Table 2, managed to read a resident's RFID card when scanned and the barrier opened as a result, and the resident received a SMS notification afterwards. Another trial, which is depicted in Table 3, made use of another resident's RFID card in which the result was the same as Table 2. The prototype also successfully read a visitor's RFID card, with the barrier opening afterwards, however, no SMS message was sent to the visitor as shown in Table 4. Finally, Table 5 shows that the system denied unregistered RFID tags with the Red LED activating as a result, unlike the previous trials where the Green LED activated when registered RFID tags are scanned. With these consistent outcomes from the test run, the researchers believe that the prototype would be of great benefit in monitoring the entry and exit of vehicles and overall improve the security of the subdivision.

5.2 Survey Results

For our statistical evaluation of the web application, the tool that we used is the FURPS model with the use of a five-point agreement Likert Scale and with this method, we managed to gather data from 32 willing participants. And detailed here, are the results from said evaluation.
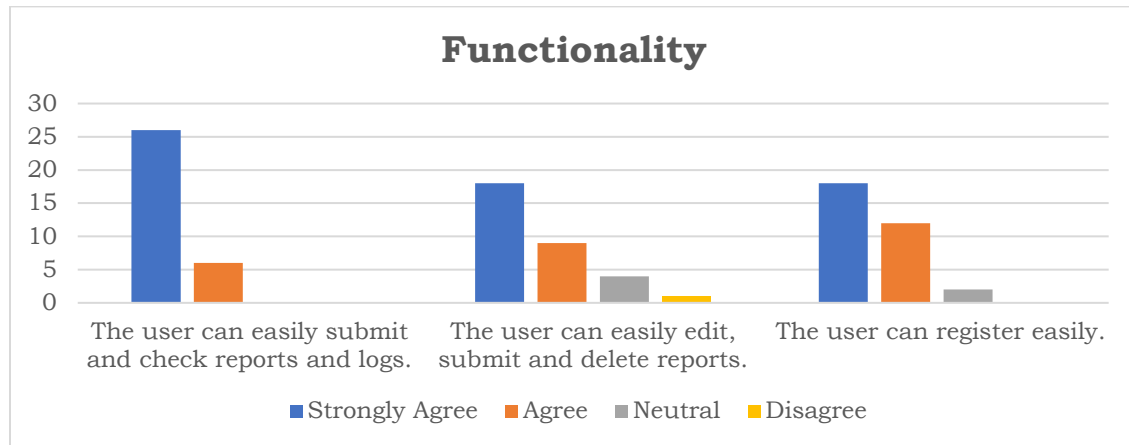

Figure 2. Functionality

Figure 2 shows the result of the evaluations to the website functionality questions. For the first criteria, it received a score of 26 Strongly Agree and 6 Agree rating as the users can submit and check reports without difficulty. The second criteria received 18 Strongly Agree, 9 Agree, 4 Neutral and 1 Disagree. For the third criteria, it received 18 Strongly Agree, 12 Agree and 2 Neutral ratings from the users.
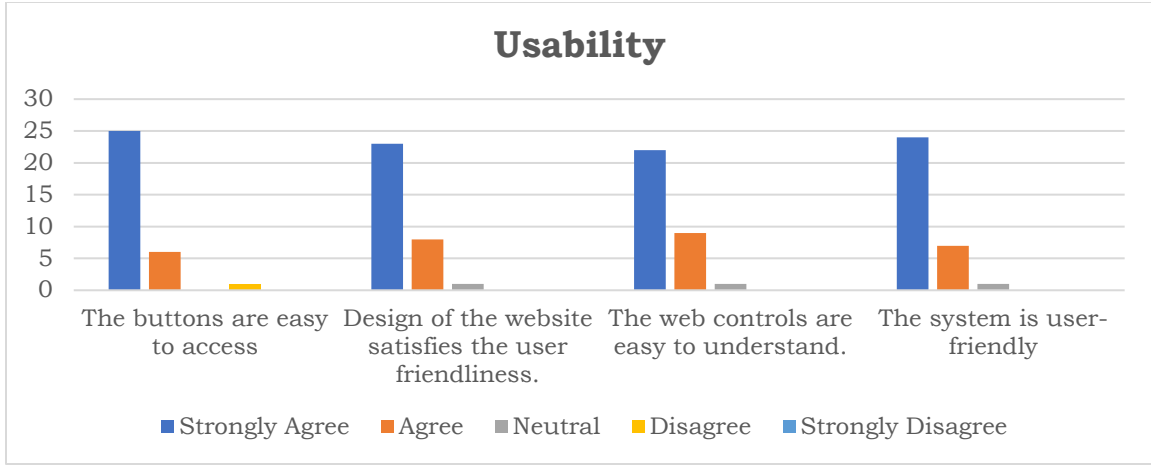
Figure 3. Usability

Figure 3 displays the result of the evaluations pertaining to the usability of the website. The first criteria received 25 Strongly Agree, 6 Agree rating and 1 Disagree rating. The second criteria received 23 Strongly Agree, 8 Agree rating. and 1 Neutral rating. For the third criteria, it received 22 Strongly Agree and 9 Agree. Because some people are not adept in using devices such as computers, one Neutral rating was incurred. Fourth criteria incurred 24 Strongly Agree, 7 Agree and 1 Neutral rating because of the similar reason stated before where some users are not well-versed in using gadgets such as computers.
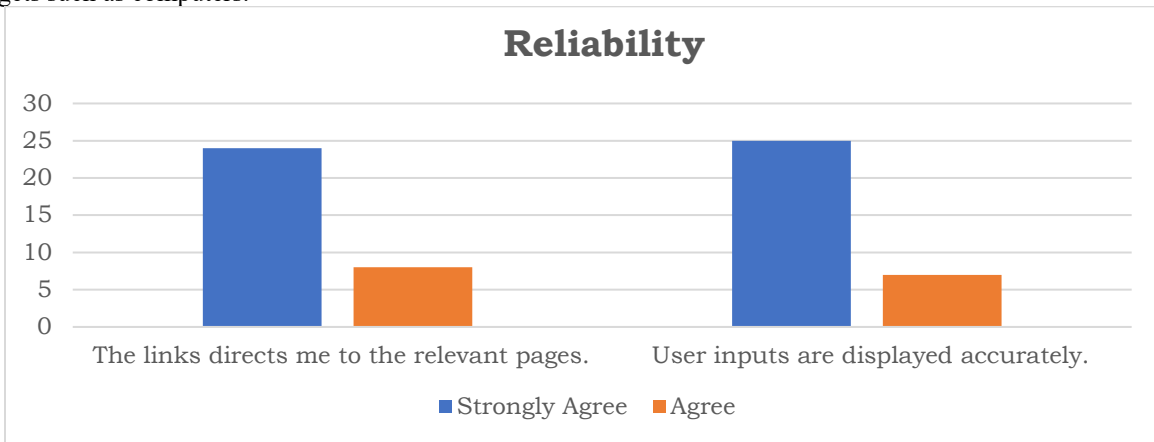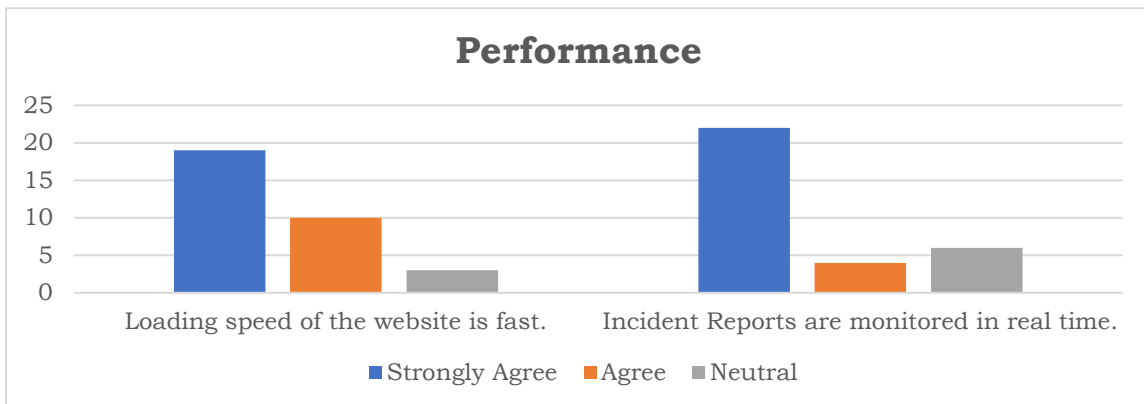

Figure 4. Reliability

Figure 5. Performance

Figure 4 shows the result of the evaluations to the website reliability questions. Since the application directs the user to the relevant pages, the first criteria received 24 Strongly Agree and 8 Agree ratings. The second criteria received 25 Strongly Agree and 7 Agree ratings because the website displayed the correct information and input to the user accurately.

Figure 5 shows the result of the evaluations to the website performance questions. The first criteria received 19 Strongly Agree and 10 Agree rating because the website can load seamlessly while 3 users submitted a Neutral rating because not every user has the same device used to access the website and that their device has low specifications. The second criteria received 22 Strongly Agree and 4 Agree rating because the users can easily monitor and be up to date to their incident reports. 6 users submitted a Neutral rating because the website needs to be connected to the internet for the reports to be monitored in real-time.
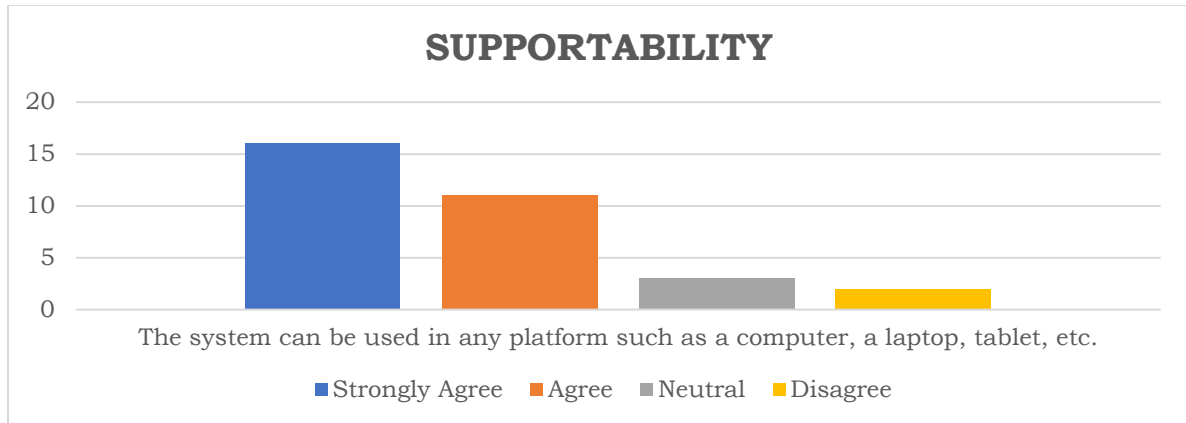

Figure 6. Supportability

Figure 6 illustrates the result of the evaluations regarding the website supportability question. The criteria received 16 Strongly Agree and 11 Agree rating because they are able to use the application on any platform such as a laptop, tablet, etc. while 3 users submitted a Neutral rating. Since the system has its limitations such as its compatibility with outdated platforms, 2 users disagreed.

5.3 Proposed Improvements
After doing this study, the researchers strongly recommend the following improvements for future research and studies:

Web Application
1. Users can upload a picture of the problem that they reported.
2. Alarm notification for urgent subdivision emergencies.
3. Add the RFID registration and cancellation process.
4. Mobile application for the system itself.

Arduino-Side
1. SMS Notification for Admins to determine the remaining load prepaid balance.
2. UPS or Backup power supply for the desktop where the Arduino software is installed.
3. Proximity sensor for the approaching vehicle to avoid collisions with the barrier.
4. Real Time Clock module to accurately gauge the time for the SMS.

6. Conclusion
Since the dawn of the Digital Age, innovation is the key word for change and change is our counter to stagnation, which many installations here in the Philippines suffer from. Many installations are still using analog or manual methods to store data and while efficient at first, becomes limited in the long run because on how vulnerable the physical data is to tamper and damage while in storage, not only that but the retrieval of data can be slow which complicates matters when the data is needed as soon as possible, especially when the report is requested by a government agency. The researchers developed and successfully implemented an Incident Report System with RFID

functionality for Vehicles with the goal to design a system that will help both the residents and officials with communication-related problems for the target subdivision and to improve the logistics of the reports along with the security of the subdivision. Arduino microcontroller, GSM, RFID reader and ESP8266 Wi-Fi module are used for the hardware portion and programmed with the Arduino IDE.

To conclude, the result of the study proves that the system helps resolve the logistical problems of the subdivision by providing a safe storage of reports generated by the residents, along with faster response time for the submitted reports from the residents of the subdivision, and it is demonstrated and proven that the Arduino RFID feature has the capability to enhance the overall security of the subdivision by monitoring individuals that are going in and out of the premises. Furthermore, the data received through this system has many potentials to be used in a variety of future studies and research such as crime predictions, crime awareness, crime frequency, and other similar topics. The study is also upgradeable and with that, the researchers recommended some additional features such as alarm notification for urgent subdivision emergencies, adding a RFID registration and cancellation process, proximity sensor for the approaching vehicle to avoid collisions with the barrier. and a real time clock module to accurately gauge the time for the SMS.

7. References

Rafie Manzelat, Reihaneh., Gated Communities and Sense of Community: A Review on the Social Features of Gated Communities. *International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering*. 10. 671 - 676. 2016.

Li L, Wan WX, He S. The Heightened 'Security Zone' Function of Gated Communities during the COVID-19 Pandemic and the Changing Housing Market Dynamic: Evidence from Beijing, China. *Land*. https://doi.org/10.3390/land10090983. 10(9):983. 2021;

Lin C, Zhao G, Yu C, Wu YJ. Smart City Development and Residents' Well-Being. Sustainability. https://doi.org/10.3390/su11030676. 11(3):676. 2019;

Syed, Abbas & Sierra-Sosa, Daniel & Kumar, Anup & Elmaghraby, Adel. IoT in Smart Cities: A Survey of Technologies, Practices and Challenges. Smart Cities. 4. 10.3390/smartcities4020024. 429-475. 2021

Salah, Nesma & Ayad, Hany. Why people choose gated communities: A case study of Alexandria metropolitan area. *Alexandria Engineering Journal*. 57. 10.1016/j.aej.2017.10.008. 2018

Bhat, N. Smart Living: Here's How IoT and AI are Set to Revolutionize the Way We Live and Work. Retrieved February 21, 2021, from https://www.entrepreneur.com/article/339348. 2019

Foutsitzi, S., Asteriadis, S., & Caridakis, G. An overview of Affective Models and ICT in Education. *2019 10th International Conference on Information, Intelligence, Systems and Applications* (IISA). https://doi.org/10.1109/iisa.2019.8900783. 2019

Zhu, Z., Yu, M. & Riezebos, P. A research framework of smart education. Smart Learn. Environ. 3, 4. https://doi.org/10.1186/s40561-016-0026-2 2016

Hamza Çelikyay, Hicran. The Studies Through Smart Cities Model: The Case of Istanbul. *International Journal of Research in Business and Social Science* (2147-4478). 6. 149. 10.20525/ijrbs.v6i1.713. 2017

Singh, Neeraj Kumar Mr. and Mahajan, Preeti, "Application of Radio Frequency Identification Technology in libraries and information centres: An Indian perspective". *Library Philosophy and Practice* (e-journal). 1614. 2017

Biographies

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