Implementation of Self-service Petrol Stations based RFID Technology

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***Abstract*—**Present-day, everything is digital. The entire fuel pump has a design capable of displaying the tasks of operating the pump, driving the display, measuring the flow rate, and turning off the pump. However, most petrol stations still operate manually with labor. Cash is still acceptable at the counter to fill petrol. Thus, this paper proposes the automation of petrol bunks using RFID technology as an intelligent solution to this phenomenon. Stratified sampling and questionnaires will be used to gather the information for this research. In the end, the petrol stations are expected to minimize labor by applying RFID technology. The technology for automating petrol pumps also expected less time to operate, more efficient, and deployed anywhere. It is also recommended to enhance the system's security in future research.

Index Terms – RFID, Self-Service, SST

1. Introduction

Nowadays, petroleum is the most valuable creation among nature. Petroleum is the most widely used commodity, and individuals must use them wisely to survive. A petrol station is a store that uses bowsers to sell lubricants and fuel. It is used to fill up vehicles with petrol. As the usage of vehicles increases day by day, a petrol station becomes one of the essential industries in daily life. However, a petrol station requires an operator to replenish the petrol. Clients require an operator to fill their cars with fuel in a petrol station and conduct payment transactions. Most petrol stations are run manually. Nevertheless, it needs more workforce and is time-consuming (Jogi et al., 2021).

By adopting this proposed solution, all of the present system issues may be resolved. In this system, the users are provided with RFID-tagged user cards. It eliminates the need for station attendants. The users will be dealing with an RFID reader to build a self-service petrol station using RFID technology.

2. Literature Review

2.1 Research Domain

2.1.1 Radio Frequency Identification (RFID) Technology

Radio Frequency Identification (RFID) is a wireless communication technology that captures data associated with various identification properties such as serial numbers, position, color, and purchase date of entities carrying RFID labels (Chetouane, 2015). There are three main components of RFID technology: RFID reader, RFID tag, and a host computer or middleware.

Figure 1: Relationship between RFID Tag, Reader, and Host Computer (Diyari Qadir Mohammed, 2021)

Figure 1 shows the relationship between RFID tag, reader, and host computer. The data capture process occurs when an RFID tag exchanges electromagnetic waves with an RFID reader. In detail, an RFID label comprises two parts: a small chip on one side and an antenna on the other. The chip stores and manages information, whereas the antenna is primarily used to send and receive data. Furthermore, the chip is used to store an ID and certain other associated information such as kind and color. When the RFID reader is brought close enough to the RFID chip, it sends signals at a predetermined frequency to read the tag. The information collected is transmitted to the RFID reader then forwarded to the host computer connected to the RFID reader. The host computer then manages the whole system by aggregating RFID data, filtering RFID data, and interacting with other supply chain information systems (Diyari Qadir Mohammed, 2021).

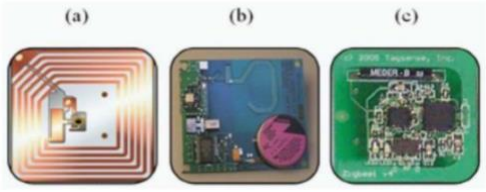

Figure 2: Types of RFIG tags: (a) Passive, (b) Semi-Passive, (c) Active (Diyari Qadir Mohammed, 2021)

Figure 2 shows the types of RFIG tags used nowadays: passive, semi-passive, and active. The most frequently used type is the passive RFID tag. It is powered by electromagnetic energy radiated from RFID reader antennas via backscattering. A passive tag cannot send out its own radio waves, and its data storage and computing capabilities are limited. It can only be read at a short range of 0.6 to 3 meters. A semi-passive tag communicates in the same method as the other passive tags. On the other hand, an active tag is powered by a long-life onboard battery that provides enough energy for independent communication over a longer distance of about 90 meters (Chetouane, 2015).

Table 1: Operating Frequency of RFID

Frequency Range	Frequencies	Passive Read Distance	Examples of Application
Low Frequency (LF)	120-140 kHz	10-20 cm	Used to deposit, withdraw, and control assets
High Frequency (HF)	13.56 MHz	10-20 cm	asset-tracking applications, contactless credit cards, and ID badges
Ultra-High Frequency (UHF)	868-928 MHz	3 meters	supply chain management applications

Table 1 depicts the four most common frequencies used in RFID technology. Different RFID systems use different radio frequencies. To be more specific, the read distance, power requirements, and performance of each radio frequency differ. Thus, the frequency chosen depends on the application (Parkash et al., 2012).

According to the research conducted by University de Moncton, RFID is most commonly used in the manufacturing sector, such as production monitoring and control and supply chain management. RFID is also used to make complex systems easier to control and manage, such as recycling, bookstore inventory control, patient flow management in health care facilities, and airport baggage routing and handling (Chetouane, 2015).

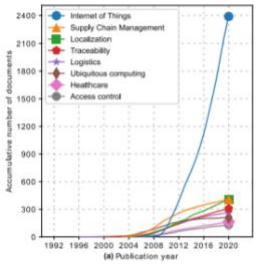

Figure 3: Top Applications, and Number of Publications by year (Munoz-Ausecha et al., 2021)

Another research conducted by MDPI shows that most RFID technology documents related to the Internet of Things (IoT) are embedded in recent years, followed by supply chain management, localization, traceability, and other applications (Munoz-Ausecha et al., 2021). The growing number of these applications documents demonstrates RFID systems' ability to improve operational efficiency and lower costs. Thus, it can be concluded that integrating RFID technology into the existing fuel dispensing system would be a great way to manage the petrol stations effectively.

2.1.2 Self-service

Self-service is an old concept that has held up well over time. A better example of self-service is a customer serving himself rather than relying on others when visiting a restaurant or attending a wedding. However, with the advancement of technology, the world has been transformed from complexities to simplicity. The concept of self-service has now evolved into a new and exciting Self-Service Technology (SST). SST is a new type of marketplace transaction in which no physical interaction between the client and the service provider is necessary, and the customer must do self-service tasks. SST is defined as a service or benefit that service providers give by implementing technology so that customers can conduct the service or portions of the service themselves (Shahid Amin et al., 2019).

For many clients, the perceived benefits of executing the transaction themselves are the driving force behind choosing self-service. Self-service helps clients be more efficient in a transaction, which is mentioned by most of the customers. According to

the journal from the University of North Carolina, one of the top reasons buyers opted to forsake a full-service option and purchase online was efficiency. It was also shown that some clients prefer self-service since it needs little to no interaction with others, emphasizing the transaction's efficiency (Collier & Barnes, 2015).

Another research conducted by the ITM University Gwalior indicated that consumers prefer SST for various reasons, including cost savings, convenience, faster service, and ease of use. SST allows businesses to frequently open about 24 hours a day, seven days a week, rather than typical working hours. Customers have full control over the service and do not feel rushed or pushed. On the other hand, firms seek SST for a variety of reasons. Examples of businesses implementing SST include customer demand, cost reduction, improved service levels, customer satisfaction, the need for new distribution methods, and gaining a competitive advantage (Shahid Amin et al., 2019).

Figure 4: Self-service Banking

One of the most common industries adopting the self-service concept is the banking industry. SST is highly feasible because information processing is critical to banks and other financial intermediaries' activities. Self-service banking, which uses SSTs in banking, has improved the banking industry and boosted client demand and satisfaction. Self-service banking encompasses telephone and internet banking, EFTPOS (Electronic Funds Transfer Point of Sale) terminals, and ATMs designed to meet customers' requirements and convenience. Self-service and information technology may significantly lower the expenses of processing and transferring data. Not only that, developing alternative distribution channels improves the effectiveness and efficiency of financial institutions and their ability to maintain their current client base. New consumers may be drawn to a bank that offers services through alternative distribution channels (Shahid Amin et al., 2019).

However, self-service is not extensively used in Malaysia. Malaysians are familiar with a limited number of self-service ideas, such as ATM banking, photography, and restaurants (Zain & Idris, 2015). Therefore, establishing a self-service petrol station in Malaysia will be a great way for Malaysians to get familiar with SST. It will surely benefit citizens and businesses, as proven by the research mentioned above.

2.1.3 Self-service Petrol Stations

A self-service petrol station was introduced in the early 1947s. It was implemented at a Urich Oil station in Los Angeles in 1947. It is estimated that only one percent of petrol stations offered self-service pumps in 1969. In the early years, self-service petrol stations were distinguished because the consumers performed the tasks individually. They fill the gas tanks, wash the windshields, inflate the tires, and inspect and apply oil to the vehicles. Attendants are on hand to change money and sell extra services like lubrication and extras, notably tires. Self-service petrol stations require fewer workers. Hence, it decreased labor expenses and allowed for a lower fuel price for the consumer (Basker et al., 2017).

However, the most common criticism about self-service petrol stations is that they pose a risk of fire and explosion. Customers are more prone than attendants to smoke while filling the petrol. It is also claimed that the driver is untrained to notice essential repairs and flaws in the motor or other working parts. It will result in a hazard if a skilled attendant does not inspect his vehicle. Furthermore, individuals may refuse to wash the windshield and therefore fail to preserve their driving eyesight (PAS, 2020).

Not only that, it is frequently stated that excessive traffic congestion at the stations may develop, making accidents more likely. According to the research, a reduction in employees will result in a deterioration in station cleanliness. Even the staff would lose their jobs (PAS, 1950).

Based on the previous research conducted by the Yokohama National University, user acceptability of self-service fuel stations was positive (33%), slightly positive (49%), slightly negative (13%), and negative (6%). The usage of self-service petrol stations was rated positively by nearly 80% of respondents (Hienuki et al., 2021).

To summarize, it is critical to have a thorough understanding of the self-refueling process and faith in the technology used to disseminate self-service gas stations. Self-service petrol stations are suggested to create awareness among the citizens. It will improve when individuals grow more acquainted with the technology. To establish a self-service fuel station, future research must enhance the manner of presenting information and the substance of the information.

2.2 Similar System

2.2.1 Petron's Self-service Fuel Pumps

Figure 5: Petron's Self-service Fuel Pumps

Payments Network Malaysia Sdn Bhd (PayNet) and Petron established a partnership in January 2020 to accept ATM card payments at Petron self-service petrol stations. Petron decided to launch "FUEL-YoooH MyDebit Je with your ATM Card!" at Petron petrol stations to foster a cashless environment. Customers may use their ATM cards at the gas pumps for an even smoother, faster, more seamless, and efficient payment process (Payments Network Malaysia, 2020).

2.2.2 Shell's Pay and Pump

Figure 6: Shell's Pay and Pump

Shell Pay at Pump is a mobile fuel payment service that allows customers to pay for gas from their car using their phones. It is accessible at most Shell stations. From the comfort of their vehicle, consumers had to input and confirm the pump number. It accepts various payment options, such as Apple Pay, Android Pay, and PayPal. Individuals can begin filling the gas tank after the system displays the "Start Fueling" notification (Shell, 2022).

2.2.3 Comparison Table

System/Technology	Petron's self-service fuel pumps	Shell's Pay and Pump
Automated fuel dispensing system	/	/
ATM	/	
Mobile application		/
RFID		

Table 2: Similar Systems Comparison Table

Table 2 above shows systems that have similar features and functions with the proposed system of this research. The technologies taken into consideration are the Automated fuel dispensing system, ATM, Mobile application, and RFID. Two similar systems offer a self-service petrol station with a cashless environment. Petron's self-service fuel pumps provided an automated fuel dispensing system by implementing an ATM, whereas Shell's Pay and Pump allow users to pay with their mobile phones. However, a worker is still available in the petrol stations to collect money in case of those who do not have an ATM card and mobile phones. There has been no automated fuel dispensing system based on RFID before. Thus, this research proposes building a self-service petrol station based on RFID Technology. With the system proposed, it will minimize the labor and increase the efficiency of the petrol stations which brings benefits to the users too.

3. Problem Statement

In this day and age, vehicle usage is on the rise (P. Anjali et al., 2020). A study from the National Defence University of Malaysia shed some light on the subject preferences of transportation among 1000 citizens in Malaysia. It turns out that nearly 71.8% of the people used their own vehicles, while 28.2% used public transport (Azhar et al., 2021). Personal driving has become one of the fastest-growing modes of transportation. In relation, fuel dispensing at the petrol stations to fill all these vehicles is fraught with complications.

The petrol stations have been physically managed. In most petrol stations, communication is done on a one-on-one basis. A microcontroller controls the electrical supply, triggers the screen, and performs all operations in almost every petrol station (P. Anjali et al., 2020). However, a person is still required to collect the money. There is a possibility of numerous human errors. The drivers sometimes have to pay more due to a lack of small money change. As a result, these fueling stations consume more time and demand more labor (Dasthagiraiah et al., 2019).

4. Research Aims and Objectives

Aim: This research aims to propose a self-service petrol station by implementing an automatic fuel dispensing system

The objectives of the research were:

- To implement an RFID based fuel dispensing system in the petrol stations
- To deduct the respective money of petrol dispensed from user card automatically
- To enable real-time tracking of fuel filling

5. Research Significance

The findings of this research would bring benefits to the drivers and petrol stations. The existing fuel dispensing system consumes a longer time and more labor. Implementing an automated fuel dispensing system based on RFID technology will increase the efficiency of petrol stations. The use of RFID technology reduced the time consumption and manpower at the petrol stations. The security of citizens who use the automated fuel dispensing system will be guaranteed as there is no involvement of workers. Robbery of the petrol is also avoided. This research helps to maintain the accuracy and reliability of the quantity of dispensed fuel. Thus, an automated fuel dispensing system will be found to solve and help the complications of petrol stations in the future.

6. Methodology

This research will use quantitative methods to address the research's primary goals. The result obtained is easy to summarize, compare, and generalize since the researcher utilized the quantitative data types in the data analysis. The targeted respondents, sampling technique, and data collection method used were discussed in this section.

6.1 Targeted Respondent

The targeted respondents for this research are drivers with a car or motorcycle license between 18 to 55 years old who used petrol stations in Malaysia. The number of respondents is limited to 100 individuals.

6.2 Sampling Method

This research is designed to use probability sampling. Each sample has an equal chance of being picked in probability sampling. A probability sample, in other words, is one in which each element of the population has a known non-zero chance of selection (Nayeem Showkat & Parveen, 2017).

To be more specific, this research will be using stratified sampling. Stratified sampling is a sampling method that divides a population into smaller groups called strata. The strata are constructed based on shared qualities or characteristics among the participants. A random sample from each stratum is taken in a number proportional to the stratum's size compared to the population. These stratum subsets are then combined to generate a random sample (Taherdoost, 2016).

It can be said that stratified sampling is the most suitable sampling method for this research. In this scenario, the population can be divided into strata subgroups based on their age. The sample is then drawn from each stratum systematically to ensure adequate representation of each stratum. By carrying out stratified sampling, it allows the research conducted to make generalizations from the sample to the population. This is a major advantage because such generalizations are more likely to be considered to have external validity. Stratified sampling also improves the quality and precision of data (Sharma, 2017).

6.3 Data Collection Method

The main tool for gaining information in this research is a questionnaire. A questionnaire is a research tool that consists of a series of questions and other prompts designed to collect data from respondents. Questionnaires allow the researcher to decide on the sample and the types of questions. Not only that, but questionnaires also enable the researcher to gather large amounts of data from a large number of people in a short amount of time and for a low cost (Syed, 2016). In this dissertation, each respondent was asked to answer the same set of questions, which was mixed to avoid bias. Initially, the survey design was coded and mixed up based on uniform structures from specific topics. As a result, the survey yielded valuable information required to meet the dissertation's objectives. A five-item Likert scale was used to create the questionnaires. Each statement was rated on a five-point Likert scale, with one indicating "strongly disagree" and five indicating "strongly agree." The responses were tallied to give each measure a score.

7. Overview of the Proposed System

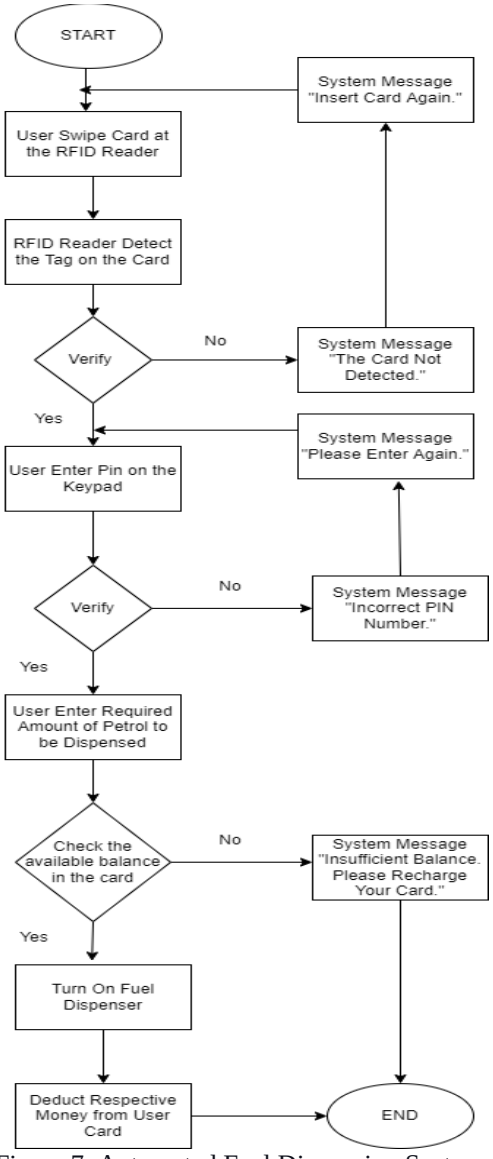

Figure 7: Automated Fuel Dispensing System Flowchart

Figure 7 shows the process involved when a user intends to fill petrol at petrol stations which implemented the automated fuel dispensing system. The users only get to fill petrol after verifying the RFID Tag, PIN, and if the card has sufficient balance.

8. Conclusion

In conclusion, this RFID-based self-service petrol station system is a versatile technology that saves people time and cost. The structure of this self-service petrol station is reused in various industries and real-time appliances. The proposed system will directly disburse the correct amount of fuel required by the customer's needs, reducing fuel abuse. In addition, if an unauthorized customer tries to swipe anyone's card, the RFID framework rejects the card, making this scheme completely secure. An automated fuel dispensing system based on RFID per user and labels must always be excellent to achieve the best possible presentation.

References

[1] Azhar, N. H., Mohd Zahari, H., Ismail, A., Baker, R., & Mohd Saudi, N. S. (2021). FACTORS CONTRIBUTING TO CONTINUED USAGE OF OWN VEHICLE. *Journal of Southwest Jiaotong University*, *56*(6), pp. 98. doi:http://jsju.org/index.php/journal/article/view/1074/0

[2] Basker, E., Foster, L., & Klimek, S. (2017). Customer-employee substitution: Evidence from gasoline stations. *Journal of Economics & Management Strategy*, 26(4), pp. 876-896. doi: https://doi.org/10.1111/jems.12215

[3] Chetouane, F. (2015). An Overview on RFID Technology Instruction and Application. *International Federation of Automatic Control(IFAC)-PapersOnLine*, *48*(3), pp. 382–387. doi: https://doi.org/10.1016/j.ifacol.2015.06.111

[4] Collier, J., & Barnes, D. (2015). *Self-service delight: Exploring the hedonic aspects of self-service*. Journal of Business Research, 68(5), pp. 986-993. doi:https://doi.org/10.1016/j.jbusres.2014.09.036.

[5] Dasthagiraiah, A., Suma, S., Reshma, S., Prasad, S., & Vignesh, C. (2019). *RFID Based Self-service Petrol Station*. Journal of Emerging Technologies and Innovative Research (JETIR), *6(4)*, pp. 262-267. doi:https://www.jetir.org/papers/JETIRBC06042.pdf

[6] Diyari Qadir Mohammed. (2021). *Radio Frequency Identification (RFID) A General Overview*. Computer Engineering Department/ Eastern Mediterranean University,

[7] doi:https://www.researchgate.net/publication/357434939_Radio_Frequency_Identification_RFID_A_General_Overview#pf6

[8] Hienuki, S., Hirayama, M., Hirayama, Y., Kamada, H., Kasai, N., Shibutani, T., & Otaki, T. (2021). Public acceptance for the implementation of hydrogen self-refueling stations. *International Journal of Hydrogen Energy*, *46*(72), pp. 35739–35749. doi:https://doi.org/10.1016/j.ijhydene.2021.08.115

[9] Jogi, N., Bille, N., Ramakanth, Y., Golla Gaduputi, J., Gowri, M., Raja, A., & Sindhwani, M. (2021). *EasyChair Preprint Smart Petrol Pump Using RFID & GSM Technology*. doi:https://easychair.org/publications/preprint_open/TQRt

[10] Munoz-Ausecha, C.; Ruiz-Rosero, J.; Ramirez-Gonzalez, G. (2021). RFID Applications and Security Review. Computation 2021, 9(69), pp. 4. doi:https://doi.org/10.3390/computation9060069

[11] Nayeem Showkat, & Parveen, H. (2017). *Non-Probability and Probability Sampling*. https://www.researchgate.net/publication/319066480_Non-Probability_and_Probability_Sampling

[12] P. Anjali, G. Navya Jyothi, & Srikanth Yalabaka. (2020). *Self Service Automated Petrol Pump Using Fingerprint Based RFID Technology*. Journal of Mechanics Of Continua and Mathematical Science, 15(6), pp 82-88. doi:https://www.researchgate.net/publication/350877239_SELF_SERVICE_AUTOMATED_PETROL_PUMP_USING_FINGERPRINT_BASED_RFID_TECHNOLOGY

[13] Parkash, D., Kundu, T., & Preet Kaur. (2012). *The RFID Technology and Its Applications: A REVIEW*.

International Journal of Electronics, Communication & Instrumentation Engineering

[14] PAS. (1950). *Self-Service Gasoline Stations*. American Planning Association. doi:https://www.planning.org/pas/reports/report15.htm

[15] Payments Network Malaysia. (2020). *Petron is the First Petrol Chain to accept MyDebit & ATM Cards at Petrol Pumps without Blocking RM200 FUEL-YoooH MyDebit Je with your ATM Card!* https://www.paynet.my/press-release/2020/Press-Release-MyDebit-Campaign-with-Petron.pdf

[16] Research and Development (IJECIERD), 2(3), pp. 109-120. doi:https://www.researchgate.net/publication/232575248_THE_RFID_TECHNOLOGY_AND_ITS_APPLICATIONS_A_REVIEW

[17] Shahid Amin, Keshav Kansana, Aditya Tripathi, & Jahangir Malik. (2019). *Understanding Self Service Technologies*. Studium Press LLC USA, pp. 136-144. doi:https://www.researchgate.net/publication/335684773_Understanding_Self_Service_Technologies

[18] Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research*, *3*(7), pp. 749–752. doi:https://www.allresearchjournal.com/archives/2017/vol3issue7/PartK/3-7-69-542.pdf

[19] Shell. (2022). *What is Pay at Pump and how can it benefit me?* https://support.shell.com/hc/en-gb/articles/115005993789-What-is-Pay-at-Pump-and-how-can-it-benefit-me-

[20] Syed. (2016, July 10). *Methods of Data Collection*. https://www.researchgate.net/publication/325846997_METHODS_OF_DATA_COLLECTION

[21] Taherdoost, H. (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. *SSRN Electronic Journal*, *5*(2), pp. 18–27. doi: https://doi.org/10.2139/ssrn.3205035

[22] Zain, O. M., & Idris, M. A. (2015). Self-service Petrol Station in Malaysia: The Perception Prior to its Implementation. Developments in Marketing Science: Proceedings of the Academy of Marketing Science, pp. 463–466. doi:https://doi.org/10.1007/978-3-319-17320-7_122