MFRC522 RFID Technology Implementation for Conventional Merchant with Cashless Payment System

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Abstract. This article discusses how technological innovation develops to support conventional merchants by implementing RFID for a fast and easy payment solution. This payment uses a contactless smart card as a medium for electronic money or e-Money. This e-Money card can be obtained through a cashier available at merchants and e-Money balance can also be topped up by registering the card first. This cashless machine uses Arduino UNO as a microprocessor, MFRC522, Micro SD Module and 16x02 LCD Display. This cashless machine does not require internet to access the database and can also be used immediately without problems. This cashless machine can work within a range of 3cm for e-Money card detection with the fastest response time of 0.1s and takes a long time to process a balance of 1.4s. This machine is equipped with a menu variant selection at merchants using a serial monitor display integrated on the Arduino UNO.

Keywords: RFID; contactless smart card; arduino UNO; e-Money payment.

1. Introduction

Conventional merchants in this digital era are increasingly, especially for several big cities in Indonesia [9]. Not infrequently, some merchants are dominated by millennials who tend to be 'experience seekers' and consumptive. However, sometimes the large number of visitors made the merchant's condition not conducive and it tended to feel that merchant operations were very slow, especially at the cashier. To overcome this, merchants often install cashier support applications to facilitate operations from input to calculating customer transactions. However, the cashier application is not equipped with an electronic payment so that the payment method still uses cash and the application is still internet based, which if there is too much visitor traffic it can interfere with the connection from the application. These weaknesses and shortcomings can be solved by using RFID as an e-ticketing system.

RFID which stands for Radio Frequency Identification is an identification method by utilizing radio transmission frequencies equipped with an RFID label or transponder to store and retrieve data remotely [1]. The RFID label consists of a silicon microchip and antenna.
RFID labels or tags can be classified into:
1. Active tags are tags that require a power supply obtained from the battery
2. Passive tags are tags whose power supply is obtained from the field generated by the RFID reader. An RFID system can consist of several components, such as tags, tag readers, tag programming stations, circulation readers, sorting equipment and inventory tag sticks.

Islahuddin [3] stated that Radio Frequency Identification (RFID) is a general term used to describe a system capable of transmitting the identity (in the form of a unique number) of an object wirelessly using radio waves. RFID itself is enabling technology, which means that this technology cannot stand alone to provide benefits to companies, but companies can build applications that use RFID to get benefits.

The RFID is a system that sends data from a portable device called a tag, reads it by an RFID reader, then processes it by a computer that has prepared the baseline data. The data transmitted and transmitted earlier can contain a variety of information. Along with its development, RFID technology can be used for everyday life. Recently, High frequency (13.56 Mhz) RFID tags are often used in libraries or bookstores, pallet tracking, building access control, baggage tracking on airplanes and apparel item tracking. Even American Express Blue credit cards currently contain high frequency RFID tags.

Electronics Payment System is a payment system that uses internet as communication media. Many companies provide both buyers and sellers with guarantees of the security of electronic transactions. To ensure the security of these transactions, companies that act as intermediaries will work with a number of banking institutions to start facilitating safe, fast and practical e-payments [4]. From many practices, electronic money is very efficient in its use [8]. In addition to being used as an electronic ticket, the identity stored on the smart card memory also allows smart card users to use it on various other functions [6].

Electronic ticketing systems are generally developed by online methods. However, the internet connections sometimes have problems. Compared to previous studies, the novelty of this research is to apply offline methods to make the transaction process faster without relying on an internet connection. With the proposed system, the user authentication and electronic payment systems do not require data from the server. Instead, they use the data stored on the contactless smart card memory. Thus, the time required for transactions is more efficient.

2. System Description
2.1 Cashless Machine

Before using electronic payment services, conventional merchant visitors ask for an e-Money card to the cashier to register and fill in the balance according to purchase requirements so that it can be used and can save purchase history.

This electronics payment is a solution to dealing with traffic congestion at the cashier because you have to make refunds and calculate the amount of purchases. It is also simpler and many times faster than using conventional receipt paper [5].

It is undeniable that this electronics payment makes payments easier and solves the dense queue of visitors and even overcomes human errors at the cashier itself.
Card registration is done by reading the UID and then writing the merchant password code into the specified sector, this password code is the key to being able to transact at a cashless machine so that the card that does not have a password code [10] cannot make transactions even though the card has a sufficient amount of balance.

![Flowchart writing code registration](image)

**Figure 1.** Flowchart writing code registration [7]

Figure 1 shows the flowchart for writing merchant code registration into the e-Money card. The card type used is Mifare Classic 1K in accordance to the ISO / IEC 14443 A. Mifare Classic 1K is divided into 16 sectors and each sector is protected by two different keys, called key A and key B. Each sector consists of three blocks of data and one trailer blocks; each block contains 16 bytes.
2.2 Authentication and Payment System

The cashless machine used for conventional merchants uses Arduino UNO as a microprocessor, RFID MFRC522 as input before being processed by Arduino UNO and forwarded to 16x02 LCD and SD card Module for history data logger. This cashless machine does not use the internet as a server, so operations will remain smooth without problems when the traffic starts to get heavy. Here is picture 2 which shows the hardware design of this cashless machine.

![Cashless machine hardware design](image)

**Figure 2. Cashless machine hardware design**

![Cashless Machine Flowchart System](image)

**Figure 3. Cashless Machine Flowchart System**
Authentication is the process to validate the user at the time of entering the system, to confirm that the person is truly authentic [2].

Figure 3 shows a flowchart the algorithm of payment system. The first process is to attach the e-Money card to the MFRC522 RFID then the RFID will start reading the UID and merchant password code. If the password code from the merchant cannot be read, the process will go directly to the final chart so that the display will return to standby mode. If the merchant password code is read successfully, then proceed with the next process, namely authenticating code A and the visitor can process the purchase transaction. After making the final transaction, Arduino will start reading again the balance on the e-Money card. If the balance is not sufficient, there will be a notification of a failed transaction, but if the balance meets the purchase amount, the transaction is successful and the final balance notification will be displayed on the 16x02 lcd and the purchase history will be stored on the SD card.

3. Result and Discussion
3.1 Evaluation of Contactless Payment System

The implementation for payment solutions at conventional merchants has been successfully developed using Arduino UNO and MFRC522. Figure 4 is an LCD display when in standby mode and Figure 5 shows an LCD display when an e-Money card is held near the RFID.

![Figure 4. Standby Mode](image)

![Figure 5. LCD display when E-Money is near the RFID Cashless Machine](image)

The machine will process the data / balance on the e-Money card, then it will display some information such as the UID, name and balance amount on the card.

RFID testing in detecting e-Money cards / RFID tags by attaching the e-Money card to RFID to get the optimum distance results for RFID to work according to the procedure. The test is carried out with an initial distance of 1 cm to a distance where RFID cannot detect the e-Money card. The results can be seen in Figure 6.
Apart from distance testing, what must be considered in RFID control is delay time and processing time. Delay time is the RFID response time to the e-Money card inserted into the module, while the process time is the time needed to process the balance including reading and writing on the card. Measurement of delay time and process time is using a stopwatch.

For the 3 cases in Figure 7 above, the response time to the e-Money card has the same time in the range 0.1 - 0.2 s at a distance of 1 - 3 cm. At a distance of more than 3 cm the RFID begins to not respond to e-Money cards and cannot process card reads. This RFID response speed is not affected by the three cases above and the response time is influenced by the accuracy of the e-Money card in the RFID module.
Figure 8. Chart RFID Response Time to E-Money Card

Figure 8 below shows the time to process e-Money data on a cashless machine. The length of time for this process is influenced by the amount of balance and access of the card, whether it is registered or not. Figure 9 shows the process time of a cashless machine.

| Case Type          | Time to process data in E-Money Machine (s) |
|--------------------|-------------------------------------------|
|                    | 1 Cm | 2 Cm | 3 Cm | 4 Cm |
|                    | Fastest | Longest | Fastest | Longest | Fastest | Longest |
| Enough Balance     | 1.4  | 2    | 1.4  | 2    | 1.4  | 2     |
| Not Enough Balance | 0.5  | 0.5  | 0.5  | 0.5  | 0.5  | 0.5   |
| Not Registered Card| 0.3  | 0.3  | 0.3  | 0.3  | 0.3  | 0.3   |

**Figure 9. Process Time**

In Figure 10 it is shown that for the amount of balance it affects the performance of data processing with the fastest time of 1.4s and for large balances it takes 2s. Meanwhile, for insufficient balance, the process time is 0.5s and for unregistered cards it only takes 0.3s.
Figure 10. Chart Time to Process Data in Machine

3.2 System Overall Evaluation

The next test is the interface test, the serial monitor. This monitor series functions for interfacing menu variants at merchants and for top up menu selection (balance filling), refund (withdrawing balance into cash) and purchases.

Figure 11. Display Serial Monitor
Figure 11 Shows the monitor serial there is a command "T" for top up, "R" for refund and "B" for purchases. Figure xx shows a purchase case using a cashless machine.

![Table 1](image)

**Figure 12.** Data logger stored on SD Card

Figure 12 above shows that every purchase, top up and refund is stored on the SD card in real time as a transaction history which will be settled by merchant employees.

4. Conclusion

This research on the implementation of MFRC522 for conventional merchants using Arduino UNO can run well by referring to the existing theory and operational system of the merchant. The method used in this payment system is to convert the decimal value to the balance value which is converted and input into the sector on the RFID tag. By prioritizing ease and speed in processing data, Arduino UNO can work well in accessing and controlling RFID.

The test results on the RFID tag / e-Money card which were tested 30 times at a distance of 1 to 3 cm got a 100% percentage result without any errors, but with a distance of more than 3 cm there will be an error that you cannot detect the e-Money card. At a distance of 1-3cm RFID can respond to e-Money cards at 0.1s time with 1.4s of data processing. With a serial monitor as a menu variant selection at merchants, it is very easy for orders and payments at conventional merchants.

Future work in this research can use hardware that has better specifications and add several supporting modules to realize a more ideal payment operation.

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