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Design of RFID Smart Locker for Marketplace Systems

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Abstract: Technology to support online marketplace systems have been developed where one of its functions is to bridge the transaction process that occurs between sellers and buyers. Existing online marketplaces generally utilize the services of third parties such as expedition couriers to deliver the goods. There would be a shortcoming when buyers and sellers do not have the right time to conduct transactions directly. The problem of waiting time for a handover of goods in a marketplace system in a local area, such as a university, can be solved by an automatic locker system. The purpose of this research is to produce a design of RFID smart locker that can be utilized as a storage medium for goods that is integrated with an online marketplace system. The results showed a design of online marketplace software that is integrated with a smart locker equipped with a microcontroller and RFID reader to validate a transaction. This system can handle buying and selling transactions between sellers and buyers that have been registered on the marketplace server. Based on the testing results, the access control system using RFID is in accordance with the objective, i.e. only RFID tags that belong to users who already have transactions can access the locker.
Keywords: locker, marketplace, RFID

I. INTRODUCTION

The trend of using online shops or online marketplaces is increasing. Today many new online marketplaces are emerging that increase the number of online marketplace in e-commerce businesses. Some online stores or marketplaces in Indonesia include Lazada, Tokopedia, Bukalapak, Elevenia, and Shopee. If an online store is considered as one shop as a seller, in an online marketplace there are several sellers. This trend confirms that customer behavior has been changed and many companies have seen opportunities from the e-commerce business [1].

Technology to support the online marketplace where one of its functions is to bridge the transaction process that occurs between sellers and buyers. RFID (Radio Frequency Identification) is the development of wireless technology that replaces barcode. Radio Frequency Identification (RFID) technology has great potential for the advancement of commercial activities. RFID uses a chip that can be detected at a certain range by an RFID reader. For example, RFID can be the next generation barcode that can be used to automate inventory control will provide many conveniences and can streamline transactions that occur [2].

A research was conducted that explains the utilization of RFID technology with Raspberry Pi on a prototype of storage box which is applied as a deposit box, where only by using an RFID tag card people can access the deposit box [3]. In another study, an RFID system is used as personal identification security on a room access system. The existence of this system is intended to maintain the security and privacy of the room from someone who has no authority to enter the room. Electric keys are specially designed using solenoid components, when there is electricity, the solenoid will have a magnetic field to attract the iron core which keeps the condition unlocked [4]. There was also a study in a university that optimizes student identity cards and employee identity cards using RFID technology as an authentication tool to access all university system services. To achieve these objectives, the RFID card must be connected to an RFID listener application as an authentication framework before use by other applications in the university information system [5].

University is one of the potential markets for the development of an online marketplace. This is an opportunity to utilize technology to support the online marketplace in it. One of them is to facilitate the transaction process that occurs between the seller and buyer. The existing online marketplace generally utilizes the services of third parties as expedition couriers to deliver the traded goods. Transactions can also be done directly if the location of the seller and buyer is not too far away. For the application of the marketplace in university, it is actually possible to make a transaction directly in the campus area. However, the seller and buyer must agree on the time and place to meet.

The problem of waiting time for the handover of goods in the marketplace system in a university can be solved by an automatic locker system. There are many techniques by which this automatic locker system can be implemented. In this study, RFID tags are used to identify user information such as user IDs and locker

numbers to validate transactions. This RFID tag, when read by an RFID reader, will automatically give access to open and close the locker key. Thus, security is guaranteed and transaction waiting times are drastically reduced [6].

The purpose of this study is to produce a website-based online marketplace that is integrated with lockers as a storage medium for goods using a microcontroller, namely Arduino Uno. RFID is used to read the id of the user and detect transactions carried out. Therefore, the benefits expected from this research are:

1. Practically, it can be a media for sales transactions between sellers and buyers to overcome the problem of meeting the handover of goods between sellers and buyers and making safer, easier and more efficient transactions in higher education environments through the online marketplace.
2. Scientifically, contribute to the application of the concept of marketplace, microcontroller, and Client-Server in the field of Education.

II. THEORETICAL BACKGROUND

1.1. Online Marketplace

E-commerce is an online sales activity or the ability to transact online. This includes retail, online banking and shopping - which involves transactions where buyers actually buy and shop [7]. Some of the reasons why people start moving from shopping offline to online are because of the convenience provided by shopping online. Increased e-commerce also affects the concept of the online shop itself that continues to grow. Online marketplace, one of the concepts of an online shop where there are many sellers who sell there, has actually been defined long ago. An e-marketplace or online marketplace is defined as an inter-organizational information system that allows buyers and suppliers to participate in exchanging information about prices and products offered [8]. Companies that operate the system are referred to as intermediaries where market participants are buyers and sellers, independent third parties, or a consortium of companies. One of the main features available in the online marketplace today is the use of reviews and ratings as a tool to increase customer interest and trust.

1.2. RFID Component Systems

Radio Frequency Identification (RFID) is a technology used to identify objects through radio frequency transmission [5]. RFID can be programmed to receive, store and transmit data stored in it. Some of the advantages of using RFID are: gathering information accurately and quickly, automated processes, increasing supply chain visibility, reducing inventory loss and shrinkage and increasing productivity.

RFID tag is a small object that can be attached to an item or product. RFID tag contains an antenna that allows the chip to send identification information to the RFID reader. Figure 1 below describes the RFID tag that contains the antenna and chip.

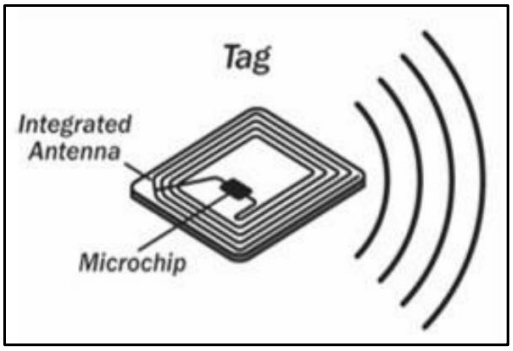

Figure 1 RFID Tag

There are three types of RFID tags: passive tags, active tags and semi-passive tags. Passive tags depend on the radio frequency energy that is transferred by the RFID reader. Whereas Active tag uses internal power sources, such as batteries to continuously flow through electricity tags and radio communication circuits the frequency. Semi-passive tags use internal resources to monitor conditions environment, but requires radio frequency energy that is transferred by the RFID reader. So semi-passive tags are similar to passive tags but there are internal resources for them to complete other functions and can extend the tag signal range. RFID tags and RFID readers must be set to the same frequency to communicate. In general, RFID frequencies consist of low frequencies (around 125 KHz), high frequencies (13.56 MHz) and ultra-high-frequency or UHF (860-960 MHz).

RFID reader is a radio frequency transmitter and receiver, which is controlled by microprocessor or digital signal processor. RFID reader using an antenna, capturing data from the tag then sends the data to the

computer for processing. There are two types of RFID readers: Fixed and Portable. The RFID reader consists of a radio frequency module (transmitter and receiver), a control unit and clutch elements for transponders. In addition many RFID readers are also equipped with additional interface (RS 232, RS 485) that allows it to forward the data it receives to another system such as computer or microcontroller [9].

Middleware Software used for communication between RFID readers that send information from RFID tags for certain purposes, such as collecting, filtering, and setting certain rules that are received from RFID readers. The middleware is built on a host computer for the purpose of tracking inventory, asset management, or other types of applications. As explained above, there are three main components of an RFID system, namely: a tag containing an antenna to transmit data, a reader as a radio frequency transmitter and receiver, and a middleware to regulate communication between the reader and the host computer [10].

III. PROPOSED SYSTEM

3.1. Design of Marketplace System

As a typical marketplace system, initially sellers can register their product first, then buyers can choose their desired product. Furthermore, buyers can process the payment with the balance left on their account. The system will check the buyer's balance and if there is adequate balance on the account, the transaction process will be validated and then recorded by the system. On the next stage, the system will check the availability of the lockers for the placement of items purchased. The system also sends transaction notifications and the locker numbers to the seller so that the seller can prepare the item to be stored in the predetermined locker.

To place the item into a locker, the seller must tap his RFID reader on the locker. The system then will validate the seller's identity based on the marketplace transaction data, then the system will provide access to the open the locker if the identity and transaction are valid. After that, the seller can put the item into the locker. Once the item the locker is closed and locked again, the system will send a notification to the buyer that the item is ready and can be picked up in the predetermined locker. After the buyer receives a notification, the buyer can take the product item by tapping his RFID card to the specified locker. The system will validate the validity of the buyer's identity based on transaction data as well as when the seller will place product items. After the buyer's identity is declared valid by the system, the buyer will take the product item he bought and provide confirmation to the system that the item has been taken. Furthermore, the system continues the notification of receipt of goods to the seller and the seller's balance increases according to the nominal value of the transaction.

3.2. Design of RFID Smart Locker

The locker will be equipped with RFID technology for authentication method. The initial condition of the locker is locked. If users tap an RFID card on the RFID reader on the locker, then users and locker data will be sent to the server. The server will validate the data. If it is valid then the server will send code 1, otherwise, if it is invalid, the server will send code 0. This code 1 will send a command to unlock the locker, while code 0 will give a warning that there is no access granted to open the locker. After the locker is unlocked, then the user who acts as a seller can put the goods. If the user acts as a buyer, then that person can take the purchased item. After the item is placed /or taken in the locker, the user can close the locker and it will be locked automatically again. The workflow of RFID-based automatic lockers can be seen more clearly in Figure 2.

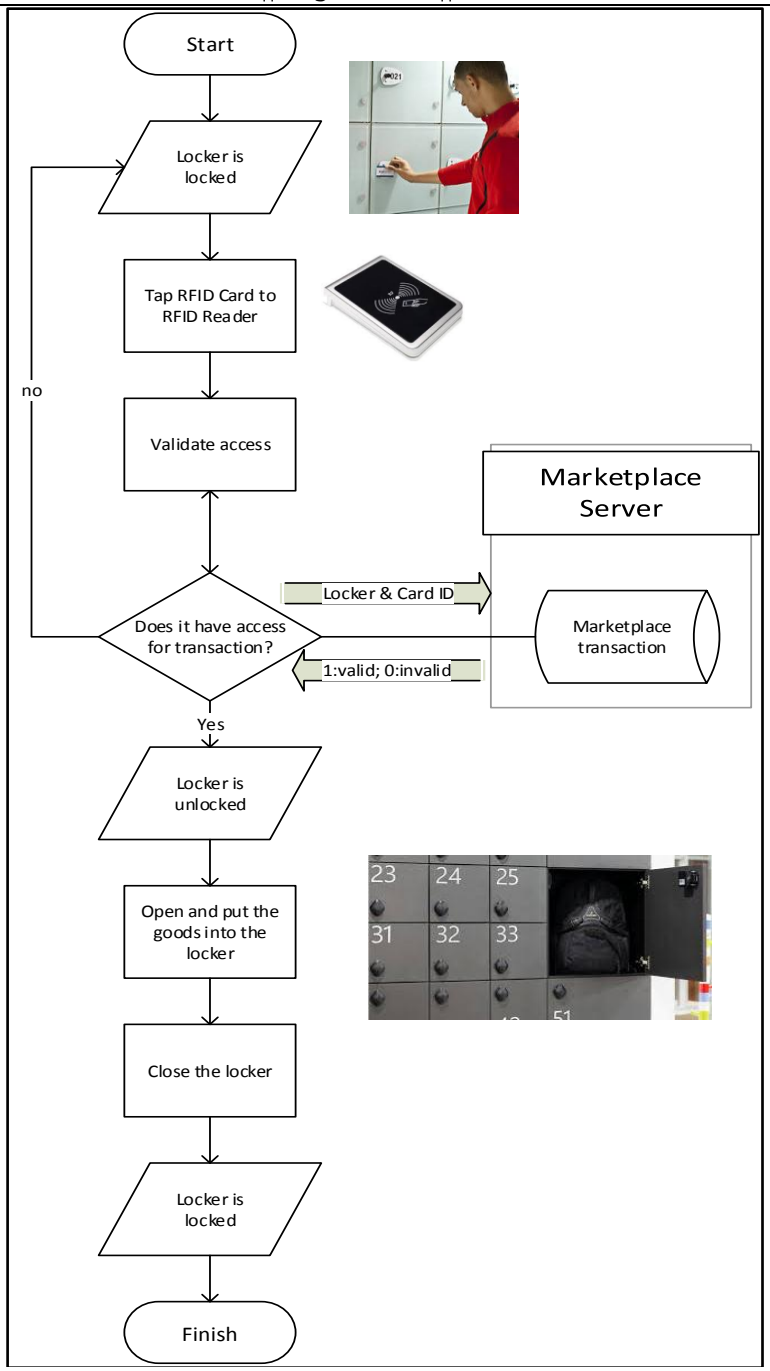

Figure 2 RFID Smart Locker Workflow

3.3. Use Case Diagram

Figure 3 shows a use case system diagram model that shows the functionality of the marketplace system. The use case system diagram consists of actors, buyers, sellers, and marketplace admins. Buyers can use the order, payment and registration features of the application. The seller can take advantage of the feature view list of items and register when first accessing the application. Admin can manage sellers and buyers and make shipments.

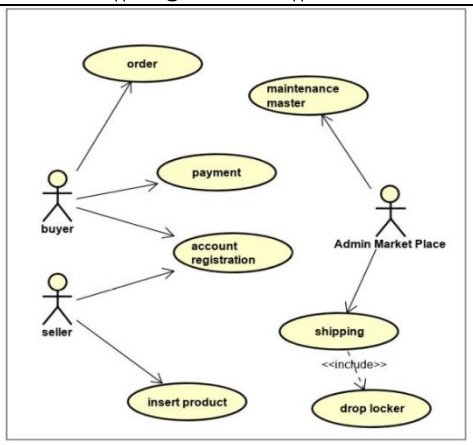

Figure 3Use Case Diagram

3.3. Sequence Diagram

Based on the use case above, a sequence diagram was created to shows the interaction of objects that exist in the system. Objects are divided into three, namely object boundary, entity, and control.The process starts with the buyer selecting the product until the buyer is successful in storing the product to be ordered in the basket. Figure 4 shows the sequence diagram of users selecting the product. Figure 5 shows the sequence diagram of users doing a transaction. Figure 6 shows the sequence diagram of sellers sending a product by putting it into the locker. Figure 7 shows the sequence diagram of users receiving a product by taking it from the locker.

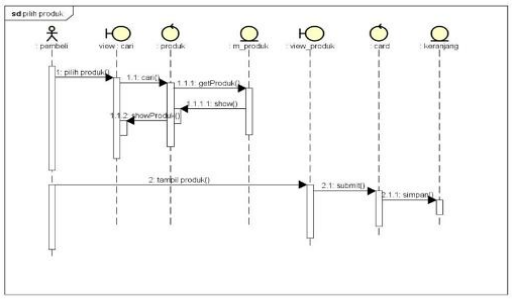

Figure 4 Sequence Diagram (selecting product)

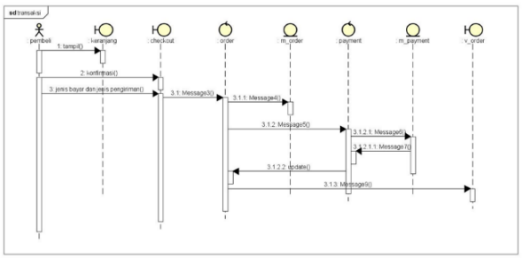

Figure 5 Sequence Diagram (transaction)

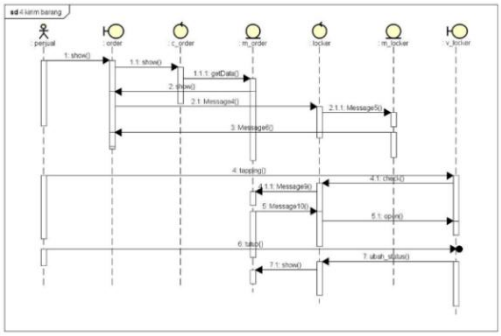

Figure 6 Sequence Diagram (sending product)

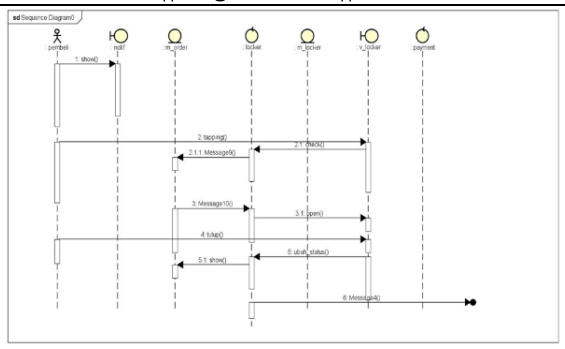

Figure 7 Sequence Diagram (receiving product)

IV. RESULTS

In the implementation phase, an online marketplace was built with the PHP programming language and MySQL database. In addition, locker integrated with RFID technology was also be made to support the marketplace system. Once created, the online marketplace and RFID locker system were tested using the black-box testing method, meaning that the focus of testing was on the functionality of the system and how the RFID locker works.

In general, the most common RFID is the one with a USB interface. Thus, to provide an RFID based locker, a modified RFID reader must be created with a microcontroller and Ethernet module, which is referred to as custom RFID reader. This custom RFID reader made to address the requirement of an RFID reader that can be directly connected to computer networks and communicate with the server and other devices.

The design of the system and the microcontroller module can be seen in figure 8. This design consists of a microcontroller module consisting of an Arduino Uno module, Ethernet module, relay module, and optocoupler input. The microcontroller is connected to an LCD to display the status of each locker door. Marketplace system that is installed on a cloud server that is connected to the network has a public IP address that can be accessed through the internet network. Radio Frequency Identification (RFID) uses chips that can be detected in a certain range by RFID readers. RFID tags are used to identify user information such as user IDs and locker numbers to validate transactions.

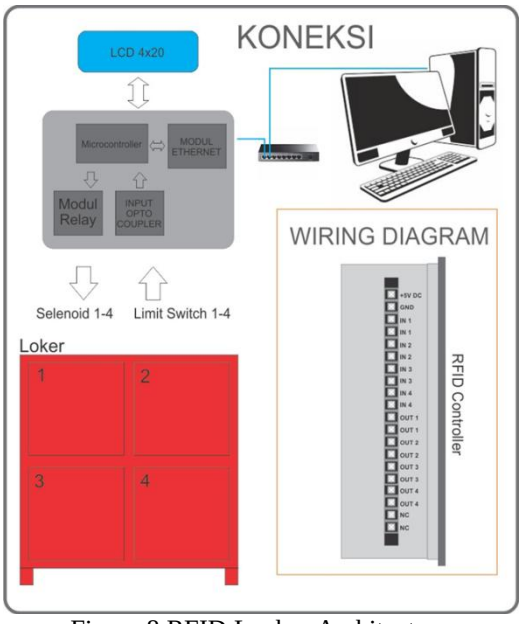

Figure 8 RFID Locker Architecture

A prototype of an RFID Locker was built for the testing purpose. This locker was designed with 4 doors on it, thus it can accommodate up to four transactions at the same time. At the top of it, we put a box that contains the microcontroller and RFID reader. An LED display is also installed to shows the information about the locker status. Each time a user taps an RFID card, the LED display shows the locker door number that is opened or closed. The prototype of the RFID smart locker can be seen in figure 9.

Figure 9 RFID Locker Prototype

Testing was conducted to find out whether the system worked as the expected objective. In this test case, some scenarios are prepared to see the response from the RFID smart locker. The test result can be seen in table 1.

Table 1. Test results

No.	Scenario	Action	Response
1.	Accessing the locker using an RFID card that has not been registered into the system.	User taps an unregistered RFID card.	"No access granted" (locker is still locked)
2.	Accessing the locker using a registered RFID card, but the user has not made any transaction on the marketplace.	User taps a registered RFID card without making any transaction before.	"No access granted" (locker is still locked)
3.	Accessing the locker using a registered RFID card, after the user made a transaction as a seller.	User acts as a seller and registered an item to be sold on the marketplace. After the item was sold, the seller tap the RFID card.	"Locker X is open, Please put the item into locker X"
4.	Accessing the locker using a registered RFID card, and user already has a transaction. The item has been put into the locker.	User acts as a buyer and bought an item from the marketplace. User tried to tap the RFID card after the item was delivered.	"Locker X is open, Please take the item from locker X"
5.	Accessing the locker using a registered RFID card, and user already has a transaction, but the seller has not put the item into the locker yet.	User acts as a buyer and bought an item from the marketplace. User tried to tap the RFID card before the item was delivered.	"Item is not ready yet"

From the testing results, it can be concluded that RFID tags can be validated with RFID reader and microcontroller system. Validation can determine whether the user has access to the locker or not. The response from the locker system can be seen on the LED display that has been integrated with the microcontroller system.

V. CONCLUSION

Based on the results and testing, some points that can be concluded from this study are:

1. This research produces an online marketplace system that is integrated with a smart locker using microcontroller and RFID to read the user's identity. This system is to help carry out buying and selling transactions between sellers and buyers that have been registered with the marketplace server.
2. This research produces an integrated system design between the website marketplace and a locker using a

microcontroller module that allows communication between buyers and sellers that can be used for buying and selling transactions in universities.

Further testing needs to be done to prove whether the online marketplace transaction using RFID smart locker has worked as desired by the user and has a positive impact on buyers and sellers in a sales transaction. The future work of this study is to provide a questionnaire survey asking whether this system actually facilitate the marketplace transaction.

VI. ACKNOWLEDGEMENTS

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