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Developing A Supply Chain Of Apple Processed Product Traceability Information System Based On Smart Packaging And Digital Business Ecosystems

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Abstract. Apples are one of the fruits that much post-harvest processing can do. Apples can be processed into drinks or snacks. The need for information about nutritional content is needed by consumers. Therefore, a traceability information system is needed that can enable consumers to know the nutritional content involved. This research uses the Waterfall model information system development method and the Unified modeling language (UML). This method allows for the sequential development of information systems. The results of this research will be in the form of an information system that has been tested using the Requirement Traceability Matrix (RTM) and Response for a Class (RFC) method. The resulting Response for a Class (RFC) value is 5.17, meaning that this information system will be easy to adapt later.

1 Introduction

Food safety assurance is a major problem faced by many people in the world today. There are so many food products that have chemical content that exceeds the standard, unclear product expiration time, inappropriate nutritional content, and disease outbreaks transmitted by animals such as the case of the Coronavirus which is endemic today. Consumers will experience difficulties because of the lack of access to information related to food products. The packaging that currently only contains the amount of information that is felt is still very lacking. Many food products are still not equipped with information on expiration dates and nutritional content. To minimize food safety risks, consumers need to carry out traceability activities for the products they consume. Traceability (traceability) is the ability to present information related to the history and movement of an item/object through each stage of the production and distribution process. This system requires that supply chain actors know who supplies the company and to whom the products are delivered so that each actor has access to information both upstream and downstream [1] [2].

Through the traceability system, the company can identify product lots and their relationship with the batch of raw materials, process, and product delivery, so there is no need to withdraw all product lots produced. Besides, the traceability system also gives the company a competitive advantage through the ability to document product characteristics [3]. The benefits that arise from this Traceability system can be a reason for companies to implement a Traceability system and are not only driven by compliance with regulations imposed by several importing countries. One of the biggest challenges in developing a traceability system is how to exchange data between supply chain actors and present information in a standard format [4] [5]. For this purpose, the traceability system requires the support of information technology (IT) based devices to support the process of collecting, storing/ and accessing data. The development of

information technology has been able to encourage changes in manual (paper-based) documentation to become digital. The digital business ecosystem (DBE) is a representation of a business ecosystem where every business actor interacts with each other in a digital environment [6] [7] [8].

The previous researches have been related to this research such as Development of Tracking And Tracing Models in Distribution Processes to Support Agricultural Product Quality [9]; Mapping of Supply Chain Activities in Building Traceability Systems in the Apple Cider Industry produces a mapping of supply chain activities according to their business process areas based on SCOR [10]; Traceability model in the fish meal industry as a form of implementing a new strategy to support the supply chain [11]. Then the last is Traceability in the Cocoa Supply Chain: An Indonesian Context examines the traceability of the chocolate supply chain in general in Indonesia [12].

This study aims to provide convenience and certainty for consumers to perform a traceability system using an information system. In addition, the existence of this information system makes it easy to make transactions online. It is also useful for companies to be able to control inventory in each store quickly and precisely.

2 Research Methods

In this study, the design method that will be used is OOAD (Object-Oriented Analysis and Design). The choice of this method is because the application designed focuses on defining classes and the way they work together to produce the needs of apple entrepreneurs. Besides Waterfall is a method that has long existed [13]. The waterfall model is often also called a linear sequential model or classic life cycle. This model provides a sequential or sequential software life cycle approach consisting of the following steps:

1. Software Requirement Analysis Phase
   At this stage, the developer defines the boundaries of activities, analyzes user needs, and performs the initial design of the software (architectural design and use case).
2. Design Stage
   This stage is more focused on system architecture planning. This stage also detects whether the desired system architecture can be created or not.
3. Coding
   Implementation of the software design that has been made is conducted at this stage. The results at this stage are programs with designs that have been created with predetermined designs.
4. Testing Phase
   Testing focuses on software logically and functionally and ensures that all parts have been tested. This is done to minimize errors and ensure the output produced is as needed.

3 Results and Discussion

The waterfall method can detail information system components to the lowest level [13]. Kurniawan [14] only researches the design stage, while this research adds more detailed information system supporting components. Based on the waterfall method used, the sequence of completion of this study includes:

1. Requirement Analysis

This traceability information system will later be designed based on smart packaging, consumers if they want information related to nutritional content or availability of stock in stores, they can simply scan the QR code that has been listed on the packaging using a gadget. Besides, this traceability information system will be designed based on the digital business ecosystem. In its implementation, there will be minimal paper usage and even zero paper usage. All users simply place their documents in the cloud system that has been designed. Based on results of interviews and observations, there are actors who will use this system. Based on the results of interviews and observations, several

actors play a role in the operation of this information system including customers, shops/distributors, manufacturers, and admins.

1.1. Business process

The business process will model how an activity is carried out by the relevant actors which makes it easy to explain the procedure so that it is easy to understand [14]. Business processes will be created using BPM or Business Process Modeling Notation (BPMN). The business process that is made includes the main activities with a state before the system or commonly called BPM as is and after the system or BPM to be. Business processes that apply before the system applies conventional concepts in managing and obtaining information. After the system is in place, each actor can manage and obtain information on smart packaging-based product supply chains easily and in real time.

In the Figure 1 below, the actors consist of Shop / staff and buyers. The process begins with the buyer choosing an apple processed product and placing an order, if the stock runs out, the buyer is advised to choose an apple processed item again. When successful, the Store / Staff process will be continued and record the order. When the order is ready, the staff will give the goods to the buyer and the buyer pays for the number of items that have been ordered. Then the staff processes whether there is change or not, if there is a change it will be processed if not then the process is complete. The business process will be designed using Business Process Modeling Notation (BPMN).

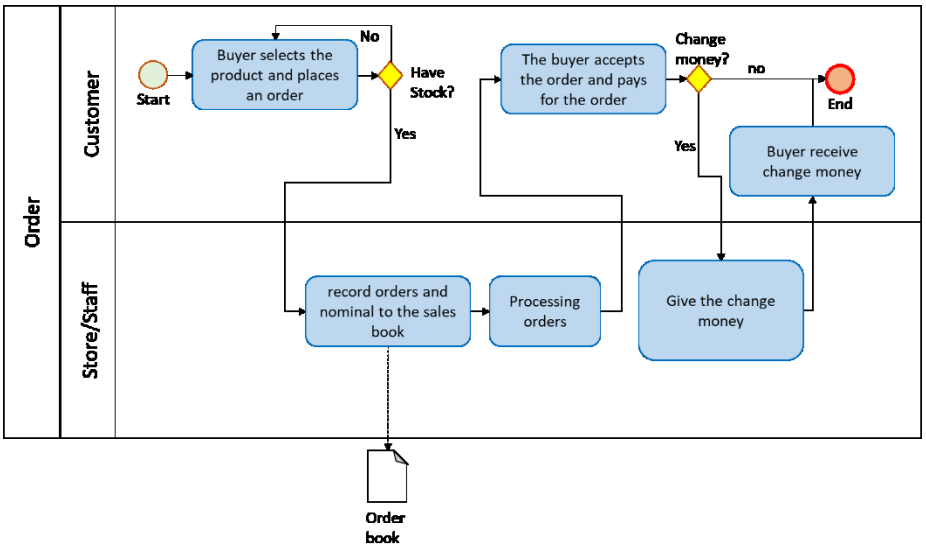

Figure 1 Business Process As Is of Product Order

1.2 Functional needs

Based on the needs elicitation stage, eighteen functional system requirements are obtained. But in this article, nine functional requirements are listed. A list of functional requirements can be seen in table 1 below.

Table 1 Functional Needs

No.	Codes of Needs System	Needs Description
1	SRS-SB-F-1	The system can provide log-in functions for buyers, shop / staff, admin
2	SRS-SB-F-2	The system can provide log-out functions for buyers, shop / staff, admin
3	SRS-SB-F-3	The system can provide a list function for buyers
4	SRS-SB-F-4	The system can record the order history on the buyer
5	SRS-SB-F-5	The system can schedule goods on goods that will come out
6	SRS-SB-F-6	The system can record items that are often requested by the buyer
7	SRS-SB-F-7	The system can record item information
8	SRS-SB-F-8	The system can provide functions to serve the purchase of goods
9	SRS-SB-F-9	The system can provide functions to serve the delivery of goods

1.3 Use Case Diagram

Use case diagrams illustrate what can be done by the system and who can use the capabilities of the system [15]. The presence of use case diagrams will facilitate understanding of how users and systems interact. Use case diagrams for this system can be seen in Figure 2 below.

Figure 2 Use Case Diagram Traceability System

2. Design

The design model of this traceability information system will be based on the following diagram:

2.1. Sequence Diagram

Sequence diagram is used for diagrams that illustrate dynamic collaboration between number of objects. Its purpose is to indicate the sequence of messages sent between objects as well as interactions between objects. In this system the sequence diagram can be seen in Figure 3.

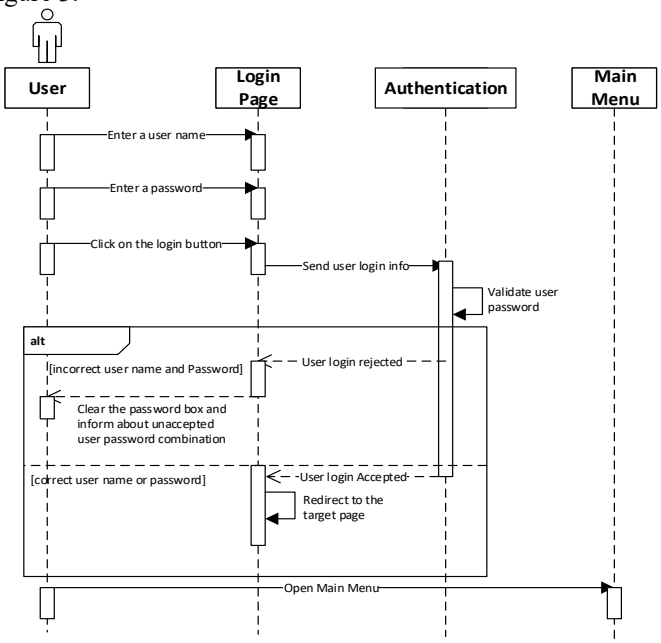

Figure 3 Sequence diagram of open main menu

2.2. Class diagram

Static models that describe the structure and description of classes and their relationships between classes [16]. In this system class diagram can be seen in Figure 4.

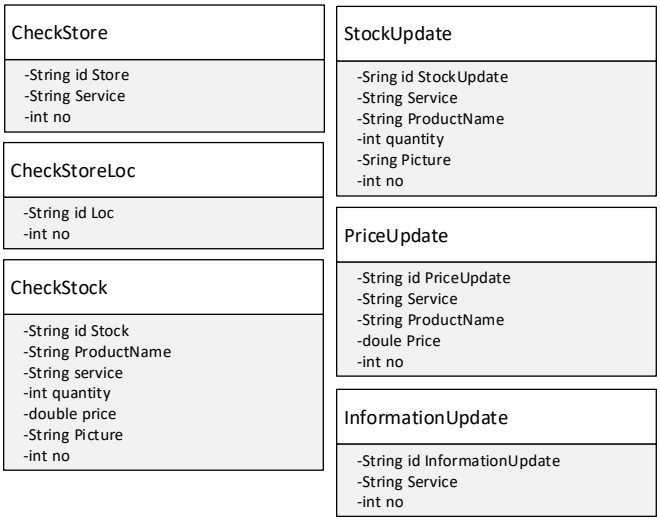

Figure 4 Class Diagram of Product Order

3. Algorithm Design

The check column algorithm is a useful algorithm for checking the input data column whether it is filled correctly or not. The implementation of the algorithm for checking the fields is explained in the figure below:

Check Field Coulmn Algorithm
Declaration:
1. Boolean → nilaiHasil
2. String → inputNamaProduk, inputHargaProduk, inputNominalSatuan, inputDeskripsiProduk

Description:
3. Input:inputNamaProduk, inputHargaProduk, inputNominalSatuan, inputDeskripsiProduk
4. Process:
1. Declaration of the value of the result variable
2. Check the condition where the variable value from the edit text is empty or not
3. Storing the value of false if the value of one variable is empty and the value of true if it is not empty in the value variable
4. Get the return value from the Result value

- Output: variable value Result value

Figure 5 Check Field Column Algorithm

This interface design shows several sample interfaces such as login page interface, admin page interface, admin product page interface, product detail interface, product add page, edit and delete pages, order queue list page, order detail page, Customer Data page, Data page shop, Store Details page, Add Store page, Admin Data page, Daily Bookkeeping page, Monthly Bookkeeping page, Annual Bookkeeping page, Shop / Staff Home page, Shop / Staff Product page, Store / Staff Product Details page and Sign up page. The interface design will be accompanied by pictures and menus of each component on the page. Figure 6 is the interface design in this traceability system as an Administrator system.

Figure 6 Realtioship between interface

4. Testing And Analysis

The testing and analysis process of this study uses several methods including:

4.1. Requirements Traceability Matrix (RTM)

Requirements Traceability Matrix (RTM) is a tool used to determine the needs of software development in the testing phase [14]. RTM is useful to verify whether these needs have been met or not. This RTM is in the form of a list of needs that can later

facilitate testing. This matrix connects the requirements at the highest level, design specifications, testing requirements, and coding.

Tabel 2 Requirement Traceability Matrix

Artifacts Use Case	1	2	3	4	5
Login	1	0	0	0	0
Logout	0	1	0	0	0
Purchase of goods	0	0	1	0	0
upload payment receipt	0	0	0	1	0
Payment validation	0	0	0	0	1

Description:

1. Class, *sequence diagram* login
2. Class, *sequence diagram* logout
3. Class, *sequence diagram* pembelian barang
4. Class, *sequence diagram* upload bukti bayar
5. Class, *sequence diagram* validasi pembayaran

Each column and row in the traceability matrix has a value of 1, which means that all use cases can be traced to all artifacts that have been made. Use cases are effective because all use cases produce artifacts by line and no use case loses the source of artifacts or comes from requirements according to column [17].

4.2. Quality Testing

Quality testing is conducted to determine the design that has been made to have a level of adaptation to change (adaptability), a level of ease of understanding (understandability), dependency between modules (cohesion), the relationship between functions in one high or low module (coupling). Testing is done by calculating (Coupling Between Object Classes) CBO, (Response for a Class) RFC, (Lack of cohesion in methods) LCOM1 metrics, and (Lack of cohesion in methods2) LCOM2 metrics. But in this study CBO, LCOM1 and LCOM2 tests were not carried out, because this research was in the design stage.

4.3. Response for a Class (RFC)

RFC calculation is conducted to measure the level of adaptability and coupling, as well as the understandability of the class. The level of adaptability if using the RFC metric will be shown with values 1-69 are Adaptable, 70-100 are Fairly Adaptable, and> 100 are Poorly Adaptable [18].

The RFC value on item information is 6, because the class has 6 methods, which are a combination of methods that are called by other methods in the class and all methods in the item information class. Table of RFC values in the controller class as below:

Table 3 RFC Values on Class Controller

Nama Class controller	**Nilai RFC**
Login	6
Make discount provisions	6
Payment validation	5
Upload of payment receipt	4
Create a store/staff account	4
Record information of goods	6
TOTAL	31

The table above explains the RFC value for each controller class. After the RFC value for each class is obtained, the average RFC value for each controller class is 31/6 = 5.17.

The average RFC value is 5.17, meaning the RFC value is between 1 to 69, so the RFC is between 1 and 69, then coupling = adaptable or means the relationship between modules is very easy to adapt when there is a change in the system (high adaptability value). The fewer functions or lower RFC values, the easier it is to do testing and debug classes because they have low complexity.

3. CONCLUSIONS

This research has succeeded in implementing the information system based on the software design. This information system can accommodate the needs of each stakeholder especially in tracing the apple processed product. Manufacturers can easily check the stock availability of each store. Meanwhile, consumers can find information related to the food products they buy to check more detailed data related to the production process and other information. The results of system verification and validation show that the system can fulfill its functionality and can produce output as expected.

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