The Design of Traceability Information System of Smart Packaging-Based Product Supply Chain to Improve A Competitiveness of Apple Processed Agro-Industry

Faizatul Amalia\textsuperscript{1}, Miftakhurrizal Kurniawan\textsuperscript{2}, Danang Triagus Setiyawan\textsuperscript{3}
\textsuperscript{1,2,3}Fakultas Ilmu Komputer, Universitas Brawijaya
\{faiz_amalia, miftakhurrizal, danangtriagus\}@ub.ac.id

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Abstract. Agricultural food products are various. Apple is one of the agricultural product which is popular in Malang. There are many processed products from apple. However, there is a problem of food security concerning on the agricultural processed products. The food security consists of the information of nutrition contained in it, expired period, and the supply of healthy food. Therefore, it is required a traceability system that gives a guarantee about product authenticity and entrusted information about the food products. Lack of good information and infrastructure will hamper the formation of an effective traceability system that has not been considered even considered to require high costs, especially for some Small and Medium Enterprises (SME) producers. In general, producers and consumers need an information system that can provide food information effectively and efficiently. In general, producers and consumers need an information system that can provide food information effectively and efficiently. The design concept uses object oriented methods using United Modeling Language (UML), which consists of: Use Case Diagrams, Sequence diagrams and Class Diagrams. The design results were tested using Requirement Traceability Matrix (RTM) and the value of Response for a Class (RFC). Based on this test, it is produced that the RTM can be traced to all artifacts that have been made and the average RFC value is 5.17 meaning the RFC value is between 1 to 69, so that the RFC between 1 to 69 then the coupling is adaptable.

Keywords: traceability, smart packaging, waterfall.

1 Introduction

Trade in food products and agricultural products is expected to increase continually. Changes in the trade environment have led to growth in global production networks. This has caused the supply chain structure to develop towards increasing fragmentation and complexity in many companies and the global reach of the agribusiness supply chain. The number of actors involved, unpredictable supplies, and perishable food increasingly increases the need for quality and safety guarantees in relation to products and production processes and to ensure traceability in food security measures.

In developed countries traceability has become an obligation. Traceability is a system to track all forms of food in all stages, namely production, process and distribution including for import and retail processes [1]. Food safety issues arising from mad cow disease, genetically modified meat [2], outbreaks of bird flu have caused these regulations to be formed with adequate enforcement. In addition to food safety issues, the traceability system also guarantees product authenticity and provides reliable information. On the other hand, in some developing countries there are still challenges to realize the system, especially in the type of fresh or perishable food. Lack of good
information and infrastructure will obstruct the formation of an effective traceability system that has not been considered even considered to have high costs by some producers. Regulation on traceability must be realized and producers and food companies in developing countries must consistently implement the system which will certainly be useful primarily as a quality control and also a guarantee for consumers.

Apple of Malang is known as the agricultural production from Malang Regency, East Java. The area is an apple plantation which has become an icon of the Greater Malang area, including Malang City, Malang Regency, and Batu City. The centers of Indonesian apples are only in Poncokusumo, Malang Regency, Nongkojajar, Pasuruan Regency, and Bumiaji, Batu City. As time goes by, the future of apples is getting gloomier. Farmers are frustrated by the invasion of imported apples, shrinking land, and falling prices. These problems were then resolved by the socialization of apple planting technology to farmers in Gubugklakah, Wringinom, Pandansari, Sumberejo, and Poncokusumo by the Secretary of the Regional Research and Development Agency (BPPD) of Malang Regency. So there was an increase from the original land of only 370 ha become 384 ha in 2017 [3]. Along with this, local apple sales have also increased due to information on bacterial in imported apples [4].

Specifically, the purpose of this research is to study the supply chain traceability process, design a supply chain traceability information system based on smart packaging products, and build a supply chain traceability model for apple processed agro-industry products.

2 RESEARCH METHODOLOGY

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 [5]. 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:

a. 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).

b. 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.

c. 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.

d. Testing Phase
Testing focuses on software in a logical and functional way and ensures that all parts have been tested. This is done to minimize errors and ensure the output produced is as needed.

Provide sufficient detail methods to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

3 REQUIREMENT ANALYSIS

Based on results of interviews and observations, there are actors who will use this system. The identification of these actors can be seen in Table 1 below:

| No. | Actors     | Description                                                                 |
|-----|------------|-----------------------------------------------------------------------------|
| 1   | Buyers     | People who will make purchases on processed apple products                   |
| 2   | Shop/ Staffs | Business owners who can perform all functions performed by staffs, create staff accounts, make discounts, update stock and make financial reports |
| 3   | Admin      | An application service provider that can create store/staff and buyer accounts and validate apple product payments by buyers. |
4 Proses Bisnis

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 [6]. 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.

**Figure 1** Business Process As Is of Product Order

### 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 2 below.

| No. | Codes of Needs | 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 |
### Use Case Diagram

Use case diagrams illustrate what can be done by the system and who can use the capabilities of the system [7]. 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.

![Use Case Diagram](image)

**Figure 2** Use Case Diagram Traceability System

### 5 DESIGN

#### Sequence Diagram

Sequence diagram is used for diagrams that illustrate dynamic collaboration between a 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.

Static models that describe the structure and description of classes and their relationships between classes. In this system class diagram can be seen in Figure 4.
3.6 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 table below:

### Table 3 Check Field Column Algorithm

#### Algorithm checkKolomIsian

**Declaration:**
- Boolean $\rightarrow$ nilaiHasil
- String $\rightarrow$ inputNamaProduk, inputHargaProduk, inputNominalSatuan, inputDeskripsiProduk

**Description:**
- Input :inputNamaProduk, inputHargaProduk, inputNominalSatuan, inputDeskripsiProduk
- Process:
  1. Variable description is nilaiHasil
  2. Checking the condition of the value from its variable
  3. Saving the false value in the variable of nilaiHasil if there is null value and true value as vice versa
  4. Getting the return value from nilaiHasil variable
- Output: value of nilaiHasil variable
Interface Design System
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.

a. Produk Admin

6 TESTING AND ANALYSIS
Requirements Traceability Matrix (RTM) is a tool used to determine the needs of software development in the testing phase. 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 5 Requirement Traceability Matrix

| Artifacts          | 1 | 2 | 3 | 4 | 5 |
|--------------------|---|---|---|---|---|
| Use Case           |   |   |   |   |   |
| 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

Analysis results:
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 [8].

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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.

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 [9].

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 sil and all methods in the item information class. Table of RFC values in the controller class as below:

| 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.

Analysis Results:

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 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.

7 CONCLUSIONS

Based on the process of elicitation of needs, there are three actors namely admin, shop / staff and buyers with twelve functional system requirements and one non-functional requirement namely availability to be designed. Defining this need is done by interviewing, observing and questionnaires given to several stakeholders in the city of Malang and Batu City as producers of apples. The needs analysis process results in design with an object-based approach. The running processes are modeled using business processes as is and to be. The results of this design produce use case diagrams, sequence diagrams, class diagrams, package diagrams and database design created by the preparation of meta data. The results of this design are then tested using traceability matrix which functions to test the tracking needs with the design has been fulfilled. Based on this test, it is produced that the RTM can be traced to all artifacts that have been made and the average RFC value is 5.17 meaning the RFC value is between 1 to 69, so that the RFC between 1 to 69 then the coupling is adaptable.
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