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(ICACSIS 2014)
Hotel Ambhara, Jakarta
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Committees | Table of Contents | Author's Index | About This CD-ROM

View: 1-25 | 26-50 | 51-75 Search

View: 1-25 | 26-50 | 51-75

A

G

H

I

J

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An Analysis and Design of Frozen Shrimp Traceability System Based on Digital Business Ecosystem

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***Abstract*—Traceability system is one of the most critical requirements in logistic information systems and the supply chain risk management for both global food safety and quality assurance. Real-time documentation from the earlier stages of production process enabled the two way process of traceability. This paper presented an analysis and design for traceability system of frozen Vanname shrimp based on digital business ecosystems (DBE) model. Business Process Model Notation (BPMN 2.0) was the primary tool in analyzing the task for capturing and transferring data processing between traceable units in each layer of DBE. Business process analysis helped to understand the capturing steps as the main element within such traceability system. The results of the analysis showcased how traceability system work in digital business ecosystem which involved on dispersed stakeholders. Manual data transformation to the digital system was provided by stakeholders using digital species metaphors. The requirement for factor analysis was computed with Relief method to select the most important attribute to capture. Our evaluation showed that the proposed system was able for estimating water salinity and related hatchery parameters changing, such as broodstock ID which utilized as key code. Current results showed the readiness of application to transfer into real world operation.**

Keywords-traceability, digital business ecosystem, traceable unit, digital species

I. INTRODUCTION

Traceability is the ability to verify the history, location, or application of an item by means of documented recorded identification. Other common definitions include the capability (and implementation) of keeping track of a given set or type of information to a given degree, or the ability to chronologically interrelate uniquely identifiable entities in a way that is verifiable [1].

Traceability system could use to solve the food safety problems. The food safety context related to the efficacy of comestibles that can become the cause of diseases (bacteria, viruses, and germs) from one country to others will thus harm people's health when consumed. This condition risked the potency of rejection from importer countries. Several regulations that control food safety give requirement to the producers of comestibles to create a traceability system. This system is used to trace and track the flow of products on every supply chain mechanism in the production and its distribution processes.

The traceability system offers some benefits particularly in products with fresh and easily damaged characteristics such as vegetables, fruit, meat, milk and fish [2]. One of the efficacies of this system is that it can improve security towards food safety from the products it produced. This system enables elimination towards unqualified food products from the supply chain system as well as monitoring the environment condition that can influence the safety of products. Product certification gives significant influence in costumer confidence. Thus, traceability system is one of the requirements in ISO standard. ISO 22005 is one of the documents that regulated the design and implementation of traceability system in a feed and food supply chain [3].

Shrimp is one of the leading exports of fishery commodities. Indonesian export volume data show that 122 tons shrimp has been exported in 2012 [4]. The shrimp company has to meet the criteria in ISO standard which is regulated the traceability system to get the confidence of importers, therefore the rejection can be avoided. The traceability system is established by documenting exceptional information on every point of supply chain and process stages of product handling, thus food producers are able to give detail information on the food products. The information of the product collected by supply chain actor, then shared to another stakeholders. This process just happen when the actor become the member of business ecosystem in shrimp production. Therefore, it is required to model the process of documenting information on every point of supply chain which catalyzed by ICTs infrastructure. Several researchers have been conducted to find out the implementation of the traceability system, such as in vegetables supply chain [1], on soya beans [5] and in supply chain of aquaculture products [7].

The utilization of digital technology has formed a digital ecosystem in its business activity and therefore called as Digital Business Ecosystem (DBE). The data of documentation results can be stored in a database hence query can be conducted for the search process.

The development of traceability system on DBE base replaces all process documentation by using paper (paper based), thus resulting paperless document which benefits in the improvement in overcoming easily damaged products by recording the tracks of product quality, the improvement in product management recall, the automatic scanning, the improvement in stock management, and the decrease in both work force operational cost. The pilots traceability system based on DBE have been implemented in a private sector company which located in some sparsed Island. Their main business was on hatchery and processed food. Frozen Vanname shrimp chosen as the model because the complete process of the supply chain, start from breeding unit until the retailer or restaurant. This system's constructions were in terms of interest a company which located in some sparse location of the Indonesian archipelago. Each actor in the traceability system is a model of organism in Digital Business Ecosystem which interact each other in data capture and tracing process. Through the development of Digital Business Ecosystem, every technical phase in the process of documenting data can be conducted by using the support of ICT based infrastructure that is analogized as digital species in digital ecosystem. The technique of product search can also be represented in the form of formulation and logic of computer programming hence the digital application design is attained for the process of data documenting and searching (Fig.1).

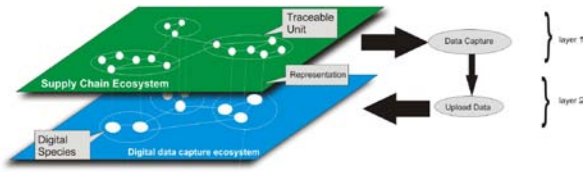

Fig 1.Structural Coupling between supply chain ecosystem and digital ecosystem in traceability system [6]

The objective of this work were to analyze the requirement and to design of traceability system. We then focus to the proposed system for frozen Vanname shrimp products and then verify and validate the traceability system to evaluate system performance.

I. REQUIREMENT ANALYSIS

A. *Business Process Analysis*

Business process in traceability system is modeled in BPMN 2.0. The Development of BPMN is conducted. It is started from the making of simple flow chart, granting information related roles, process, data and information to description, therefore it can be analyzed and simulated [8]. System analysis is conducted for parse a system be resolved into components so it the interaction between components and its environment can be seen. Results of analysis showed the capacity of the system as seen from its ability to add value from input to output [9]. Based on the business process analysis then retrieved five stakeholders who take a role in the system of traceability and divided into four structure systems.

1. Input
   This system requires data related to product, processes and product quality as main input [10]. Data related to product include its product identity code along with various identity components that support the formation of these products. Meanwhile, the data related to the process cover some of the indicators of the process that are set up on the stage of the seed production. Among them are pH of water, water salinity, survival rate, and temperature of water. The data related to the quality of the standard value according to SNI are the total plate count (TPC), the levels of lead, the levels of histamine and others. This system, however, is not documenting related data quality due to lack of infrastructure system.
2. Pre-process
   The results of identification of the data attribute are then observed and documented in the application form for a period of time during material handling process.
3. Process
   The main processes include documentation of process traceability system using an application data input of each stakeholder and tracing product process from end user stakeholder. Every stakeholder performs the process of documentation into application data input that was installed in the desktop computer on each unit of stakeholder. The process is then continued by printing the report in the form of label contains barcode of seed ID and destination pool for the process of enlargement shrimp larvae. The barcodes on the labels function as product identification that can be read using barcode scanner. Readable barcode labels subsequently can be added to the data on the next process. The barcode is printed back and imprinted on the next product label [11].
   Quantitative model in the process of documentation of the data was then factorized using Relief method. This analysis was performed to find out the most influential data attribute in traceable unit. There were some attribute data defined as variables which were analyzed by using Relief algorithm such as survive rates, average pond water temperature, pH of water and water salinity. That variable used as quality process parameter in seed production, thus the variable have to documented for complete information. Different probability of the attribute X data value calculated as follow [12]:

$$W[X] = \frac{p_{equal} \times Gini'(X)}{p_{samecl}(1 - p_{samecl})} \tag{1}$$

Where,

$$Gini'(X)=\sum_{x\in X}\left(\frac{P(V)^2}{\sum_V P(V)^2}\times\sum_C P(C|V)^2\right)-\sum_C P(C)^2 \quad (2)$$

W [X] is an approximation of the following difference of probabilities of attribute X, P_{equal} is *P*(equal value of X), P_{samecl} is *P*(same class), P(V) is probability of value, and P(C) is probable classes, P(C|V) is probability X value occurred in a certain class C.

As a system, traceability must fulfill basic architecture of Input-Process-Output components. The design of data flow which transforms inputs into outputs is represented in Fig. 2.

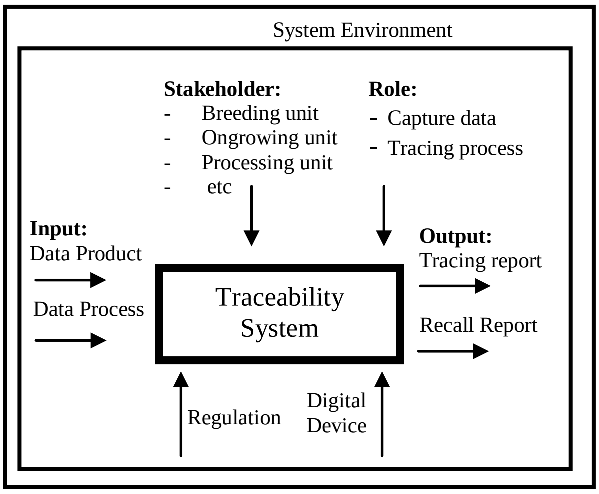

Fig 2.The design of the data flow that transforms inputs and outputs

4. Output
   The data set will store in the traceability repository include the relevant traceability data generated during the company operations [7]. Every single data will distributed to the query application by getting input product code from customer. The retailer as one of end user will get traceability reports after the process. This report answers the following typical traceability questions for instance:
   - Result of tracing data product
   - Generated recall list which contain all the needed information to contact affected customers and allow them to pull appropriate products if indicated
   - Report which identifies any of the suspect lots or unit process with nonstandard procedure

II. Computational Experiment

A computational experiment was set up to verify and validate at what extend the proposed system could fulfill the performance stakeholders required. A Java based application system in both PC-Windows 7 and Android-JellyBeans Machines was then constructed. The details are as follows

A. *Capturing Data*

Every stakeholder carried out documenting process into data input application installed on desktop computer in each stakeholder unit. As an example, in the unit of seeds provision, the documented data attribute among others were broodstock ID, seeds ID, provided feed mill supplier, water temperature of the seeds pond, pH and water salinity. The entire data attribute was documented during the activity of seeds handling process in the data application form on breeding unit. Figure of business process stage of seeds documenting data can be seen on Fig 3.

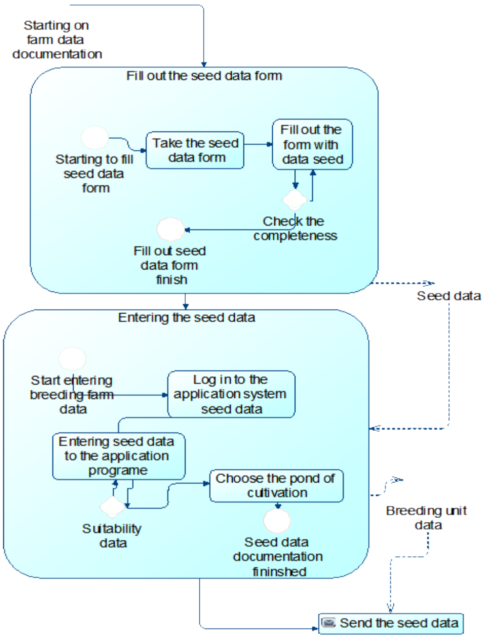

Fig 3. Business cycle of seeds data documenting process

The stage of seeds handling process ended when the seeds grow turning into larva that are ready to be transferred into raising pond in the cultivation unit. After the entire data was documented, data was inputed from the seed data form into the desktop computer. Data input application in desktop computer would save all documented data, then printed the report in the form of label with barcode from seeds ID and pond destination for the process of raising the fish larva. Data input application were illustrated in Fig 4.

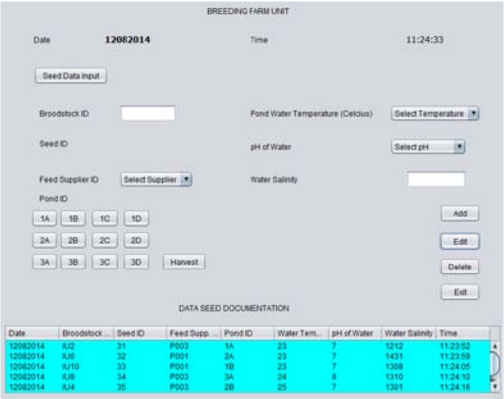

Fig 4. Application of seed data input

Every process of data input was carried out at the end of material handling process because documenting data related to production process and track record was carried out to the next stage during the material handling process. Every stakeholder carried out the same process namely data input process into desktop computers to be stored in a server. The printed barcode in label became the key for product registration handled by using barcode scanner (Fig 5). Application for other stakeholders was deployed input documented data in the next process of production.

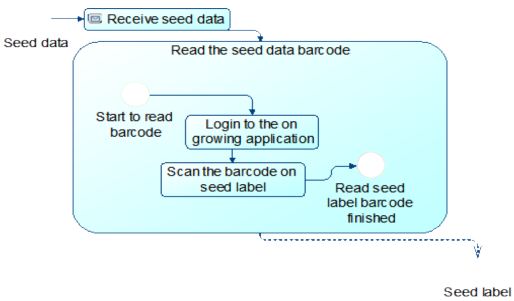

Fig 5. Stage of data reading with barcode scanner

Table I shows data in the stakeholder of seeds supply unit documented during the ongoing system. Data attributes were analyzed by using relief method to figure out the most influenced factor and required to be well documented during the process of product handling. The analyzed data attribute were numerical type showing a value. The results of factor analysis showed attribute sequence that influence the system and become the consideration in determining critical data attribute that were needed to be constantly documented. The attribute determination became a source to create security system in source code input data software so that the process of data input into server was not available until data attribute filled in. Table II shows example of relief method utilization to determine critical attribute.

TABLE I
DATA SEEDS DOCUMENTATION ON BREEDING FARM

No Index	Date	Batch number	Broodstock code	Broodstock ID	Seeds ID	Feed Supplier ID Code	Feed Supplier ID No	Feed Supplier	ID Ongrowing Pond	Survive Rates (%)	Pond Temperature (°C)	pH of Water	Water Salinity (mg/l)
0	12/08/2014	1	IU	2	31	P	003	Jordan	1A	97	23	7	1212
		2	IU	6	32	P	001	Simon	2A	97	23	7	1431
		3	IU	10	33	P	001	Simon	1B	96	23	7	1308
		4	IU	8	34	P	003	Jordan	3A	95	24	8	1310
1	13/08/2014	5	IU	4	35	P	003	Jordan	2B	97	25	7	1301
		6	IU	9	36	P	001	Simon	2C	97	24	7	1403
		7	IU	7	37	P	003	Jordan	3B	97	23	9	1100
		8	IU	1	38	P	001	Simon	1C	96	24	9	1379
2	14/08/2014	9	IU	5	39	P	003	Jordan	1D	97	25	7	1159
		10	IU	3	40	P	003	Jordan	4A	97	24	9	1191

Note: This data follow the normal distribution random hypothetical.

TABLE II
RESULTS OF FACTOR ANALYSIS WITH RELIEFF METHOD

Data Attribute	Relief Value	Rank
Survive Rate	-0,4	4
Average Pond water Temperature	-0,1	2
pH of water	-0,3	3
Water Salinity	-0,093	1

B. *Tracing data*

A database for this traceability information system was constructed for data query using three mathematic model follow as manual tracing process, such as sorting, searching and check the suitable data with similarity measurement, then arrange as source code software by using java programming. This data query application would be used by end user as one of the Stakeholders roles for tracing distributed products in customers. Figure of product tracing process at end user stakeholder is shown on Fig 6.

In this explanation, the writer described the use of the third mathematic model for the process of product tracing by using data at the stage of seeds supply. Computing stage from search mode in data query application was initiated by location searching of date data by utilizing interpolation search method with the following equation:

$$\text{Position} = \frac{\text{BC Sought-BC }[low]}{\text{BC }[high]\text{-BC }[low]} \times (\text{DI } high\text{-DI } low) + \text{DI } low \quad (3)$$

Where BC is a broodstock code, DI is a data index, BC [*high*] is the top level of BC and BC [*low*] is bottom level of BC.

Data Index of location search from Table I data uses equation model (3) was simulated in the following calculation:

Search key : 13
Data Index low : 0
Data Index high : 2

Position = $\frac{13-12}{14-12} x(2-0)+0=1$

Data discovered in index [1] dated 13/08/2014 along with other data in Tabel III.

TABLE III
DATA BASED ON TABLE I

No Index	Date	Broodstock ID Code	no	seeds ID	…	Water Salinity (mg/l)
1	13/01/2014	IU	4	35		1301
	13/01/2014	IU	9	36		1403
	13/01/2014	IU	7	37		1100
	13/01/2014	IU	1	38		1379

Based on Table I

The computing process by application enters the next stage based on broodstock ID. Before the process of data search was conducted, the broodstock ID was processed by using insertion method with the following stages:

- When i =1, x equals to Data [1] = 9 and j=0. Because data [0] = 4 and 9 > 4 thus process was continued for i=2.
- When i =2, x = Data [2] = 7 and j=1. Because data [1] = 9 and 7 < 9, thus carried out shifting to the left until data which was smaller than 7 was discovered. Results of this shifting, Data [1] = 7 and Data [2] = 9 whilst Data [0] = x = 4.
- When i =3, x = Data [3] = 1 and =2. Because Data [2] = 9 and 1 < 9, thus shifting was carried out until data which was smaller than 1 was discovered. Results of this shifting, Data [2] = 7 and Data [3] = 9 whilst Data [1] = x = 4. And so forth

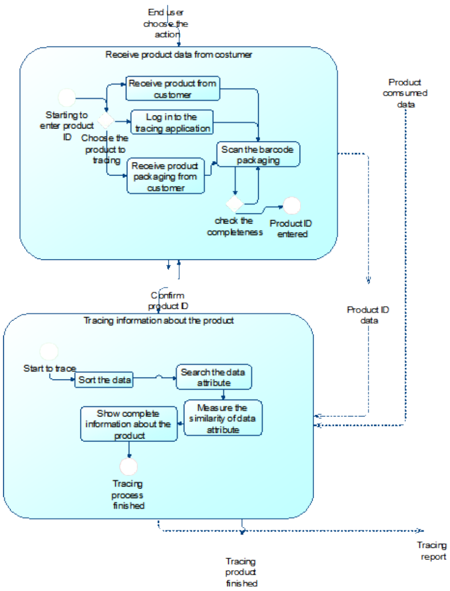

Fig 6. Stage of product tracing by end user

The searched broodstock ID was IU7. However, the code identification used in search process was numerical data. Index number was the number of data position in database arrangement. The search process was explained as follows:

Search key : 7
Data Index low : 0
Data Index high : 3

Position = $\frac{7-1}{9-1} x\,(3-0)+0=2$

Data discovered in index [2] seed ID 37 along with other data attribute among others.

TABLE IV
DATA BASED ON TABLE I

Seeds ID	Feed Supplier ID	Feed Supplier	…	Water Salinity (mg/l)
37	P003	Jordan		1100

(Based on Table 1)

After the searched data were attained, hence similarity measurement was carried out with standard data attribute using Cosine Similarity [13] as follows:

$$sim(x,y)=\frac{x^t.y}{\|x\|\|y\|}, \qquad (4)$$

Where *x* and *y* is two vectors for comparison, then ||x|| is the Euclidean norm of vector $\boldsymbol{x} = (x_1, x_2, x_3 \ldots x_p)$ which defined as:

$$\sqrt{x_1^2+x_2^2+\ldots+x_p^2} \qquad (5)$$

Standard data attribute in the form of numeric value and factual data of search results is shown in Table V.

TABLE V
STANDARD DATA ATTRIBUTE OF QUALITY REFERENCE

Attribute	Symbol	Survive rate	Average Temp (°C)	pH of Water	Water Salinity (mg/l)
standard	X1	98	25	8	1300
37	X2	97	23	9	1100

Suppose that X_1 and X_2 are thefirst two term -frequency vectors in Table 4. That is, X_1 = (98, 25, 8, 1300) and X_2 = (97, 23, 9, 1100). How similar are X1 and X2? Using Eq. (4) and (5) to compute the cosine similarity between the two vectors.

Based on the results of similarity measurement, it indicated that the parameter of seeds quality from the searched seeds ID was almost similar to the standard parameter with value of 0,999. Thus, it could claim that the seeds ID were in the standard of cultivation process.

The dataset from ongrowing unit show in Table VI. Pond ID was inter-correlated with data attribute from ongrowing process, such as feed supplier ID and other quality process for instance pH water, temperature of water, survive rates, weight and container temperature. During the harvesting days, the data of yield and transportation are collected by an application form to get data about harvest date and harvest container ID which used to. The processing stage followed the same documentation process to get information about production line of shrimp packaging and then transport to the cold storage. The dataset of processing unit showed on Table VII.

In the same case, the data were available in order to get further information about the product. The identification of data utilizes by date other ID number which get from supply chain event.

Traceability management information system provided intangible advantages for instance practicality, security and the deliverability of data for each stakeholder. The data could save, organized and emerged easier. Besides financial benefits, this system given improvement in the quality of information for management decision-making, and prevents in errors documentation processes. The operator could save the data on the data base system just by complete all field on the data software application. Each data saved with high security from lost and easy transferring to the other stakeholder by the local network among the computer. This system could provide information for increasing

Date	Pond ID
12102014	2A
	1A

Note: This data follc

TABEL VII
DATA SHRIMP DOCUMENTATION FROM PROCESSING UNIT

Date packaging	Line ID	Pond ID	Cold Storage ID	Grade (Box) @ 1000 g			Pack Temperature (°C)	Cold Storage Temperature (°C)
				A	B	C		
12102014	L1	2A	CS01	6	5	5	5	2
		2C		8	3	5	5	2
		1B		6	9	2	5	2
	L2	1A		3	5	8	5	2
		3A	CS02	6	6	2	5	2
		1C		4	4	6	5	2

customer confidence about the frozen shrimp product.

Some information included in the tracing report such as:

1. Description of the product
2. Expired date of product
3. Flow chart of the process, include :
   - Identification number of unit process or material
   - Temperature process and water pond salinity
4. Similarity value of the process with standard procedure and
5. Duration of tracing

Other report can be produced to give information about recall list with contact number of affected customers. The result of reporting can be seen on Fig 7.

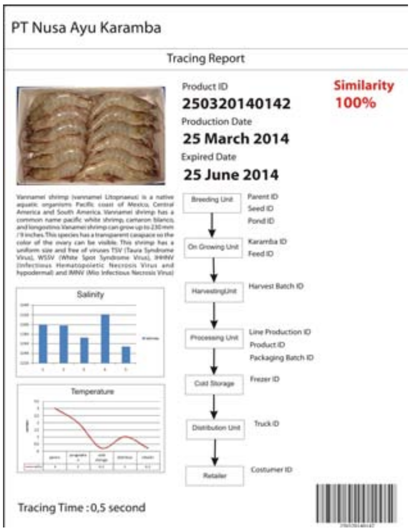

Fig 7. Report of tracing product

III. CONCLUSIONS

Based on the analysis using BPMN 2.0, it is known that there were five stakeholders taking role in traceability system. The results of critical attribute determination by using relief method determined that water salinity parameter became critical attribute that requires documentation. The results of mathematic verification model show that the model used was able to produce the expected parameter according to its purpose. The rule of sorting method could show data sorting process. Search method also proved that it could be utilized for searching data location index. Similarity measurement shows that data attributed similar with standard process, thus the value almost 1

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