Constructing the Process Models for the Traceability of Rice Production and Distribution

Huei-Huang CHEN
Department of Information Management, Tatung University
No.40, Sec. 3, Chungshan North Road, Taipei, 104, Taiwan

Shih-Chih CHEN
Department of Information Management, Tatung University
No.40, Sec. 3, Chungshan North Road, Taipei, 104, Taiwan

ABSTRACT

With the convenient transportation and global economic liberalization, countries could have many kinds of food sources. Under such circumstances, production and distribution processes track capability of foods became the foundation of food safety. We need an information system to provide trustworthy identification of food in the process from farms to tables with transparent information for food supply processes.

Architecture of Integrated Information System (ARIS) is a methodology for analyzing processes and taking a holistic view of process design, management, work flow, and application processing. ARIS uses a modeling language known as Event-driven Process Chains (EPC), which is an important aspect of the ARIS-model. EPC is the center of the House of ARIS and connects all other views, as well as describes the dynamics of the business process. On the other hand, based on the conceptual description, ARIS can model and structure Business Process Models. Furthermore, ARIS House has been developed to implement business models in information system. Different from other process description tools, the eEPC could integrate other views from organization, function and process to construct integrated system planning process, and serve as reference model of APS operation. This study attempted to construct the production and sales processes of rice for traceability in Taiwan Good Agricultural Practice (TGAP) released by the Council of Agriculture. We developed the information of rice producing and distribution in each process for traceability. Rice producing and distribution processes were modeled with the method of ARIS.

This study chooses the traceability of production and distribution as research topic because of the emphasis on the control over the agricultural products' production processes and the information connection of the traceability of agricultural products among industries. With regard to the control over production processes, it is to ensure the security of each operation procedure and to confirm the products from every operation procedure to implement the control over input and output. We adopted EPCglobal Network™ standards to integrate the records from production processes to distribution processes of rice to reveal complete producing and distribution process information. Finally, we construct reference processes of rice source tracking for the foundation of food safety.

Keywords: RFID (Radio Frequency Identification), Architecture of Integrated Information System (ARIS), Event-driven Process Chain (EPC)

1. INTRODUCTION

With development of convenient communication and global economy freedom, countries influenced by many kinds of food sources value gradually the safety and health of food. The way of recognition of food source and knowing production situation of the food became one of the conditions of food safety. Such system provided trustworthy identification of food in the process from farm to table with transparent information for food supply process. This study is focus on rice as the research object of the traceability of the production and distribution process because rice is one of the main food provisions in Taiwan. Rice foodstuffs in Taiwan are not only subsistence crops but with the advantages for selling to other countries. Thus, recording rice's production process in detail can ensure consumers' confidence in buying it and elevate Taiwan's rice competitiveness among countries as well. In addition, another advantage is that rice contains the characteristic of dividing products into packages. This study is to discuss the current management and control of rice's production process from the perspective of enterprise process, to provide process for improvements and suggestions, to address more complete framework of recording production and distribution information, and to meet the products' needs for recording all activities from production to distribution. This study is to use eEPC (Extended Event-Process Chain) from ARIS (Architecture of Integrated Information Systems) to describe rice's relationships among organization, function, and control in production and distribution to bring up the reference model of production and distribution process. Moreover, this study is carried out by EPCglobal Network™ to establish a cross-industry distribution recording platform framework.

This study is mainly on rice in Taiwan's agriculture as the research object and employs ARIS method as the tool for constructing the process model for the traceability of rice

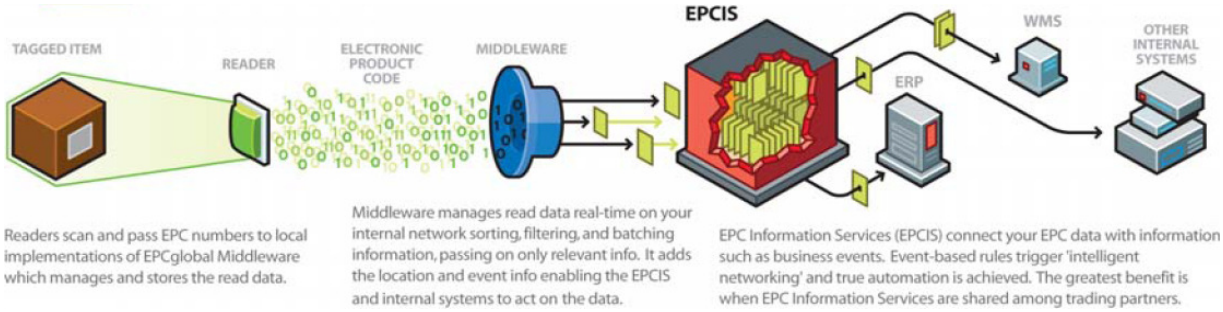

Figure 1- RFID System Framework

production and distribution. The data is from information collected and organized from concerned areas and from interviews with people concerned in the field of the traceability of rice production and distribution. Consequently, this study uses collected information and practices to conduct rice production and distribution process model construction until the reference model matches the Good Agricultural Practice (GAP). Finally, this study addresses a cross-industry framework of production and distribution information circulation by EPCglobal Network™.

2. RFID

RFID tags basically consist of a transponder that is electronically programmed with unique data. Data is read/written on the tag through an antenna or a coil by a transceiver (with a decoder), which is connected to a host computer. RFID functional components are shown in Figure 1. Furthermore, EPCglobal Network is a set of technologies that enable immediate, automatic identification and sharing of information on identifiable items in the supply chain.

3. TRACEABILITY OF RICE PRODUCTION AND DISTRIBUTION

3.1 The environment of information traceability of agricultural production

In the process of constructing the traceability of agricultural products' production and distribution, many factors need to be considered on the basis of the TGAP regulated by the Council of Agriculture (COA). They are soil and water quality in their growing environment as well as the fertilizing and control over diseases and pests during the production process. Standardized production operation in TGAP contains the following cultivation items: operation contents, fertilizing data, control materials, and control target. By using media like paper, field detection system and PDA, TGAP records agricultural products' production process one by one in accordance with the practices and writes those records in Taiwan Agriculture and Food Traceability (TAFT) database via the traceability of production and distribution information system. In the environment of information on production and distribution, the pesticides, soil and water quality of the process of production records in the agricultural products are inspected by the inspection organizations. Producers take their own samples to apply for inspection to the concerned organizations. Inspection organizations would when proceed inspection procedures. The third party, an accreditation organization, will irregularly carry out inspection according to different inspection applications and decide whether the inspection meet the standards. In such a way, consumers can understand the agricultural products' production process records via agriculture and food traceability management system. The environment of the traceability of production and distribution and data flow is shown as Figure 2.

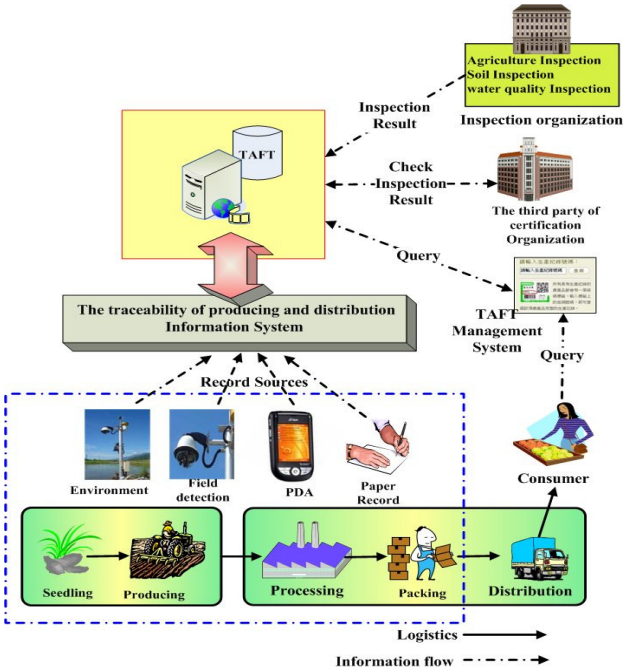

Figure 2 The environment of the traceability of production and distribution

3.2 Process for the traceability of rice production and distribution

In the process of rice production, the traceability of rice production and distribution uses the tracing number for inquiry. In the seedling procedure, rice is given a tracing number. In the farming and rice processing procedures, the tracing number follows with the records. When inquiring the traceability of production and distribution, one-dimension barcode and two-dimension barcode serve as the media for inquiry. The

construction process model for the rice production and working is made up of function view in ARIS, production process records, and risk management plan.

In the beginning of the seedling procedure, the certificate of the seed sources should be provided to start recording the seedling production and the rice cultivating and seedling hardening registration form is used as the recording evidence. Before cultivating rice, the fertilizer for farming should be tested through the soil fertility inspection to make farmers know how to utilize the fertilizer. In addition, water quality, soil sources, and their inspections need to be recorded. After that, whether the farmers join the certification organizations needs to be judged. Those farmers who join the certification organizations should cultivate according to standards and record their cultivation processes. The cultivation recording begins with establishing the field registration form to ensure which organization each farmer belongs to. Thus, the field registration form records the production process on farms until the cultivation is complete.

After harvesting rice, processing factories have to establish rice unloading registration form when sending rice to process. The registration form records the processing process until the processing finishes. In the process of packaging, rice is packaged into regulated size and stuck with the tracing number. Finally, allocating the products completes the construction of traceability of rice production and distribution.

4. TO-BE PROCESS MODEL FOR THE TRACEABILITY OF PRODUCTION AND DISTRIBUTION

For the improvements of the procedures as described above, here are some guidelines:

1. To extend the production procedure to the distribution procedure and the selling procedure makes the information about the traceability of production and distribution more complete.
2. To change the information about the traceability of production and distribution from un-industry to cross-industry, to improve the barcode tracing method to the RFID technique, and to do cross-industry information connection through EPCglobal Network™.
3. In the production process like the farming procedure, adjust the control frequency to daily records and event records. For those may endanger the rice cultivation, they need to be recorded daily in order to observe the changing levels of the dangerous factors in the process of rice production, whereas other conditions are recorded according to the things exactly happened at that time.
4. For the agricultural products in the procedures of seedling, farming and processing, check point needs to be established for the sources of agricultural products and for the transfer to another operation procedure in order to ensure the quality of the transfer of agricultural products.

As shown in Figure 3, after harvesting the wet grain and putting them into the warehouse is the storage process. After the storage process, the records in the internal environment of the warehouse contain the records of temperature and humidity and records of pest density. Temperature and humidity should be recorded daily to understand the changes of humidity in the warehouse because this kind of record has a great influence on rice quality. For the vermin density, the growing speed of the pests in the warehouse should be recorded weekly to prevent the rice pests. After the milling process, rice needs to be packaged. The amount of rice packages in the process of rice packaging and those in the rice quality records after the milling process need to be confirmed to ensure the amount of rice packages matches those in the milling process. If not, reconfirmation is required. If the amount matched, RFID barcode is printed on the rice packages and log in the RFID information address to ONS (Object Name Service) After this, data in the rice processing needs to be collected. When delivering goods, the amounts of goods delivery and the amounts of packages are under control if they are consistent. If their amounts are consistent, the delivering records are saved and allowed to deliver the goods and log in delivering goods to the distribution-event server. This is the rice processing procedure.

After packaged rice delivers to the logistic center, the logistic center takes records of the stocks in the warehouse data and log in the stock records to the distribution-event server. When delivering goods, it follows the same procedure as shown in Figure 4. Likewise, rice delivery and rice selling follow the same procedure. At the selling exhibition, exhibition activities of the packaged rice include selling and inquiry. For rice selling, selling exhibition has to record the selling records of packaged rice; for rice inquiry, recording information about packaged rice's four procedures: seedling, farming, processing and distribution displays.

Based on EPCglobal Network™, Figure 5 is the information circulation framework of the traceability of rice production and distribution. It contains three aspects of recording information: production, distribution and selling and constructs are complete information about rice production and selling. As shown in Figure 5, the information circulation begins with the production and processing procedure and ends in consumers' inquiry. In the procedure of production and processing, the information output includes the records of seedling procedure, farming procedure, rice processing and production inspection. When packaged rice is stuck with RFID in the processing procedure, rice has to register EPC to ONS. For the records of distribution, event registry is responsible for the stock in-and-out records. When consumers inquiry, event register server will feedback information on distribution records to the machine for consumers inquiry. For the records of products production, ONS will first inquire the location of the production records and then the server that saves the records would feedback related production information. The forms of the records of the production process for inquiry are shown as Table 1; the forms of the records of production and distribution are shown as Table 2.

5. CONCLUSIONS AND SUGGESTIONS FOR FUTURE STUDY

5.1 Conclusions

This study chooses the traceability of production and

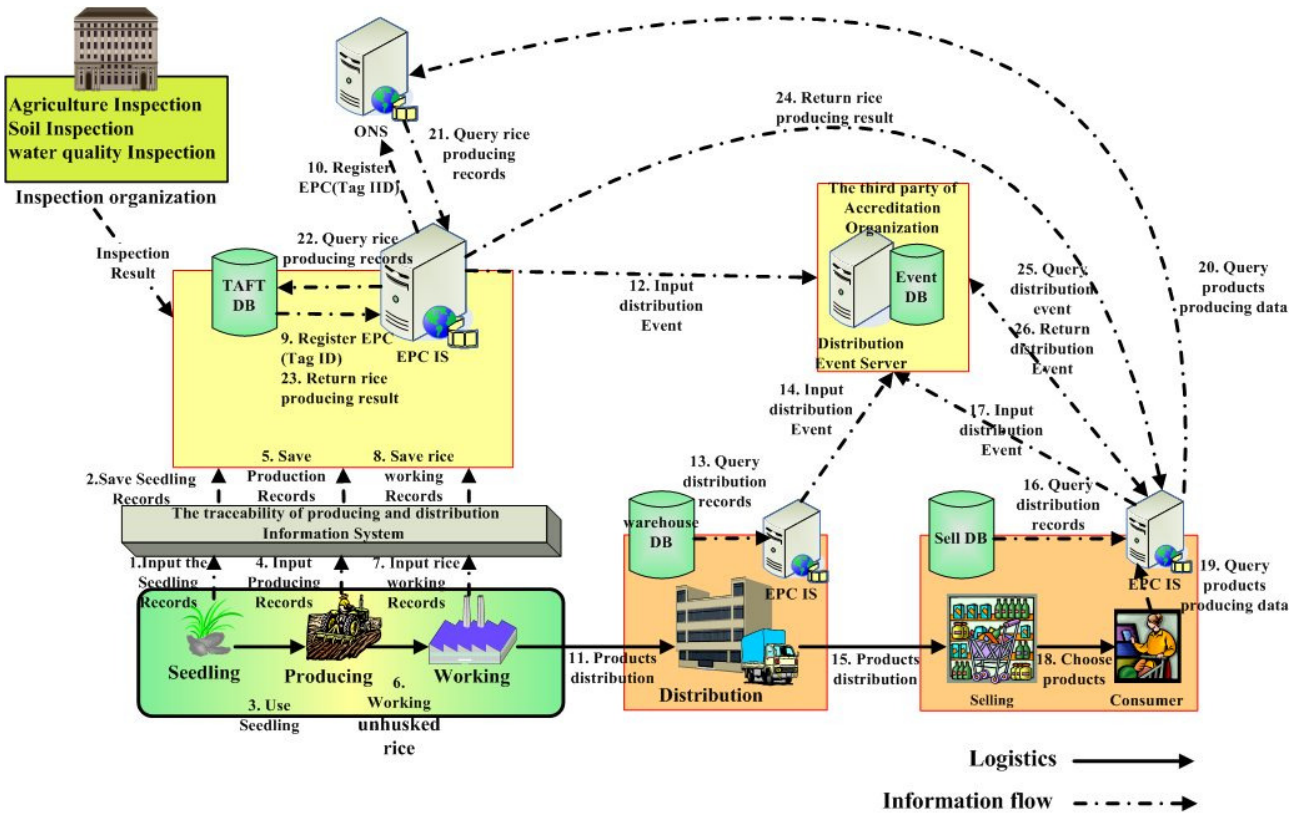

Figure 5- The information framework for the traceability of rice production and distribution

distribution as topic because of the emphasis on the control over the agricultural products' production process and the information connection of the traceability of agricultural products among industries. With regard to the control over production process, it is to ensure the sources of every operation procedure and to confirm the products from every operation procedure to implement the control over input and output. However, in the process of obtaining information about the production and distribution, it is just related to the agriculture industry, it needs the cross-industrial integration to perform the follow-up information circulation in the traceability information records. The research results in this study are summarized as follows:

1. For the control over the rice production process, inspection and check control of the production transferring station should be established in every production process to ensure if the input and output in every transferring operation procedure match the production standards. The inspection and check become stricter, thus if there is any mismatch to the standards, the production process terminates.
2. This study adopts the guidance pattern to keep different types of output records respectively. In terms of the function of the guidance pattern, it can distinguish the quality of records precisely, make supervisors understand farmers' production situations actively in the future rather than wait production record results passively, assist supervisors individually in understanding the curving changes of the production control conditions of farmers in the areas of the recording data of pesticides, fertilizer, water quality and soil, and further provide farmers with the cross analysis of the data difference to conduct more effective sampling inspections and reference for product improvements.
3. For the plan for the improvements of the operation procedures, recording time is separated into action event and regular records to decrease the influences caused by the external environment. Only using the action event recording mode is easy to ignore the effects of the external environment on the production process. Water quality and soil are the most important external factors that affect agricultural products' production process. Thus, daily or regular inspection is needed to understand the changes of the agricultural products to ensure that they grow in a stable environment within standardization.
4. In the establishment of the improvement for the traceability of rice production and distribution, the information output contains a wide range of information from production to selling among industries and information is kept by different industries. Through EPCglobal Network^{TM}, it can integrate different stages of production and distribution information to elevate the communication ability of product information and to provide a platform for tracing product information among industries.

5.2 Suggestions for future study

This study provides research scholars with the following research suggestions and reference for future study. First, this study chooses rice as the research object in the agriculture

industry. Future study can employ this model to the production and distribution process in other kinds of agricultural products and explore the differences based on different practices. Second, this study adopts the ARIS methodology for constructing the process model for agricultural products production and distribution. Future study can use this process toward the plan for the system implementation, which means using the tool of UML implementation view to analyze. Finally, this study extends the production and distribution process from the production and processing procedures to the selling procedure and adopts simple processing products as the research object. Research scholars can discuss deeper about the information connection of complex processing products of the traceability of production and distribution.

6. REFERENCES

[1] AUTO-ID Center, "EPC™ Tag Data Standards Version 1.1 Rev.1.24", **MIT AUTO-ID CENTER**, pp. 12-17., Apr. 01, 2004.

[2] EPCglobal Inc. (2004). The EPCglobal Network and The Global Data Synchronization Network: Understanding the Information & the Information Networks, http://www.epcglobalinc.org/news/position_papers.html. (Access date: 2006/10/20).

[3] Finkenzeller, K. (2003). **RFID handbook: Fundamentals and applications in contactless smart cards and identification** (2nd ed.). New York: John Wiley & Sons.

[4] Good Agricultural Practice, http://www.nri.org/NRET/SPCDR/Introduction/introduction.htm (Access date: 2006/10/25).

[5] GS1, The Global Traceability Standard,**GS1**,2006

[6] Harrison, M. (2004). White Paper-EPC Information Service-Data Model and Queries, http://interval.hu-berlin.de/deutsch/rfid/IT_Infrastruktur/CAM-AUTOID-WH025.pdf., Auto-ID Center.

[7] Mealling, M. (2003). "Auto-ID Object Name Service (ONS) 1.0," http://develop.autoidcenter.org/TR/2003/WD-ons-1.0-20030930.pdf.

[8] Porter, M. E., **Competitive Advantage**, The Free Press, New York., 1985.

[9] Scheer, August-Wilhelm, **ARIS-Business Process Frameworks**, Springer, Germany, 1998.

[10] Scheer, August-Wilhelm , et al, **Business Process Excellence**, Springer, Germany, 2002.

[11] Scheer, August-Wilhelm , et al., **Business Process Automation**, Springer, Germany, 2004.

[12] Scheer, August-Wilhelm , **Business Process Modelling with ARIS**, Springer, Great Britain, 2001.

[13] Shih-Chih Chen and Huei-Huang Chen, "**Implementation and Application of RFID EPC Information Service for Forward and Reverse Logistics**," The Journal of Global Business Management, ISSN 1817-3179, Vol. 2, No. 2, pp. 259-267, 2006.

[14] Taiwan Agriculture and Food Traceability System, http://taft.coa.gov.tw/index.asp, (Access date:2007/04/19).

[15] TAIWAN RICE INFORMATION SYSTEM (TRIS), http://tris.tari.gov.tw:8080/default.jsp, (Access date: 2007/4/20).

[16] Wismans, M.G., "Identification and registration of animals in the European Union," *Computers and* **Electronics in Agriculture**, Volume: 24, Issue: 1-2, pp. 99 – 108, November 1999.

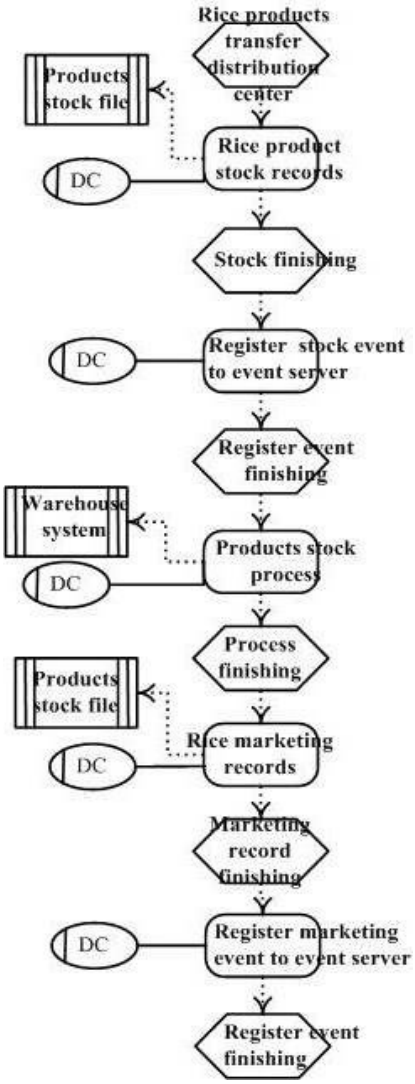

Figure 4- Distribution process

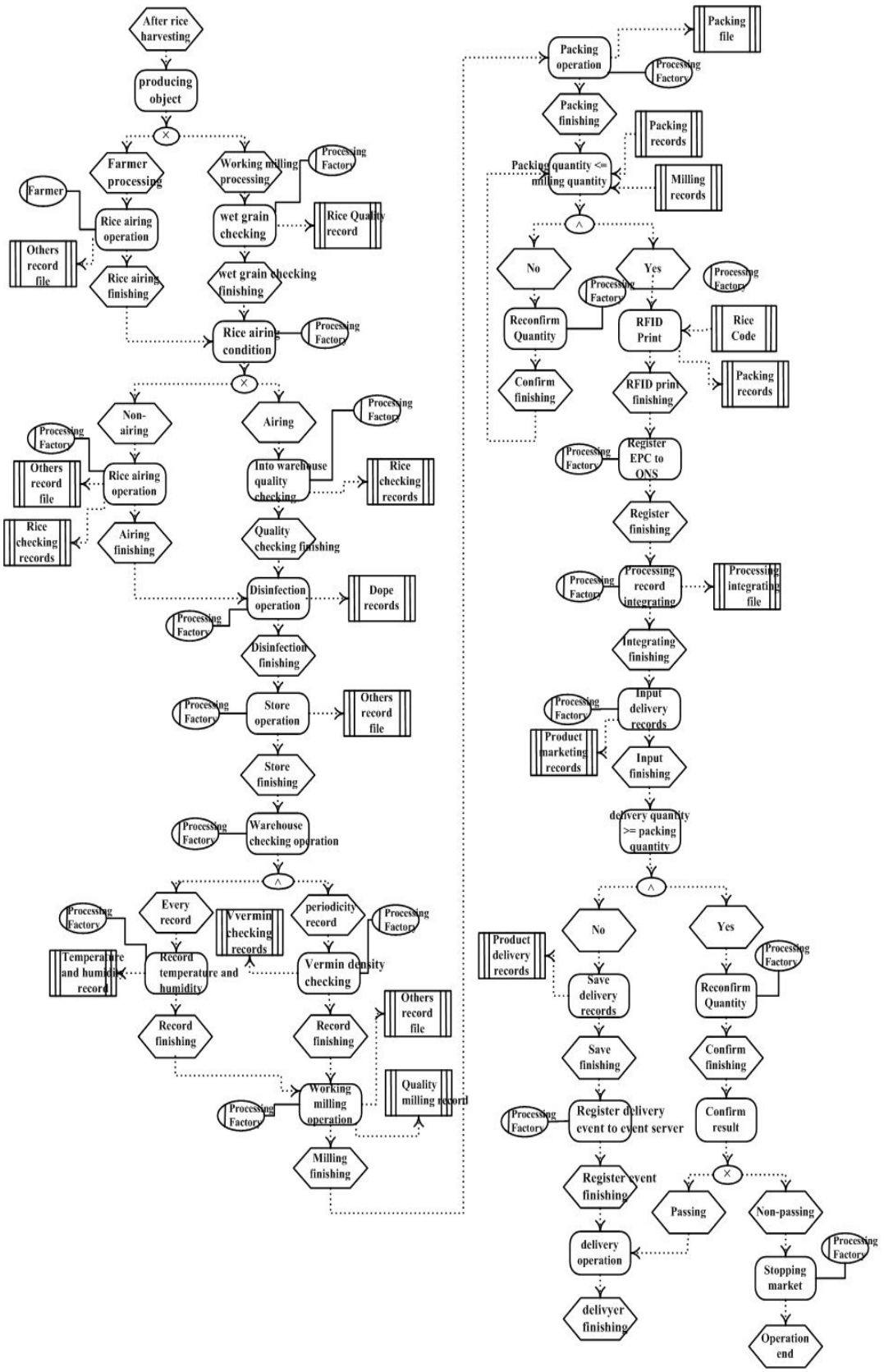
After rice harvesting
producing object
Farmer processing
Working milling processing
Processing Factory
Farmer
Rice airing operation
wet grain checking
Rice Quality record
Others record file
Rice airing finishing
wet grain checking finishing
Rice airing condition
Processing Factory
Non-airing
Airing
Processing Factory
Processing Factory
Others record file
Rice airing operation
Into warehouse quality checking
Rice checking records
Rice checking records
Airing finishing
Quality checking finishing
Disinfection operation
Dope records
Processing Factory
Disinfection finishing
Processing Factory
Store operation
Others record file
Store finishing
Processing Factory
Warehouse checking operation
Every record
periodicity record
Processing Factory
Processing Factory
Vvermin checking records
Temperature and humidity record
Record temperature and humidity
Vermin density checking
Record finishing
Record finishing
Others record file
Working milling operation
Quality milling record
Processing Factory
Milling finishing
Packing operation
Packing file
Processing Factory
Packing finishing
Packing records
Packing quantity <= milling quantity
Milling records
No
Yes
Processing Factory
Processing Factory
Reconfirm Quantity
RFID Print
Rice Code
Confirm finishing
RFID print finishing
Packing records
Processing Factory
Register EPC to ONS
Register finishing
Processing Factory
Processing record integrating
Processing integrating file
Integrating finishing
Processing Factory
Input delivery records
Product marketing records
Input finishing
delivery quantity >= packing quantity
No
Yes
Product delivery records
Processing Factory
Save delivery records
Reconfirm Quantity
Save finishing
Confirm finishing
Processing Factory
Register delivery event to event server
Confirm result
Register event finishing
Passing
Non-passing
delivery operation
Stopping market
Processing Factory
delivyer finishing
Operation end

Figure 3- Rice processing procedure