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Full Length Research Paper

A reference model of RFID-enabled application for traceability of foods production and distribution

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This paper employs architecture of integrated information system (ARIS) as the holistic modeling methodology for analyzing step-by-step processes and radio frequency identification (RFID) as the tracking device for recording all procedures in logistics. The major purpose of this study is to establish an information traceability system on agricultural product for coordination and quality control over production, distribution, and consumption. The proposed model incorporates EPCglobal Network™ standards to generate, integrate, and disseminate the comprehensive records of paddy rice among farmers, distributors, inspectors, and consumers.

Key words: Radio frequency identification (RFID), architecture of integrated information system (ARIS).

INTRODUCTION

Researchers have continuously developed and designed RFID-enabled applications in different industries (Chen and Chen, 2006; Domdouzis, 2007; Wang et al., 2008; Yin et al., 2009; Wen, 2010). Many studies either have proposed RFID applications in libraries, museums, health care, and tracking system in supply chain or provide empirical evidence to concentrate on the acceptance or adoption of RFID (Wu et al., 2006; Reyes et al., 2007; Hossain and Prybutok, 2008; Leimeister et al., 2009; Sari, 2010). However, to the best knowledge of the authors, only a paucity of experimental research has focused on the traceability system in the paddy rice industry. To fill this gap, the current study attempts to propose to what extent managers may utilize this concept to establish better traceability coordination. So as such, this study recommends the postulated models based on RFID-enabled application and architecture of integrated information system (ARIS).

LITERATURE REVIEW

Radio frequency identification

RFID refers to a technology that utilizes radio waves for transferring data from an electronic tag (that is, RFID tag attached on an object) to an individual in order to identify and/or trace the object (Auto-ID Center, 2011). RFID tags basically consist of a transponder that is electronically programmed with unique data. The 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 has been utilized in several perspectives, such as logistics resource administration (Poon et al., 2009), supply chain/production management (Wang et al., 2008; Yin et al., 2009) and traffic supervision (Wen, 2010).

Architecture of integrated information system (ARIS)

ARIS is a conceptual framework for enterprise modeling (Scheer, 2001). As shown in Figure 1, ARIS is classified into 4 dimensions: 1) organization, 2) function, 3) data, and 4) control views. First, organization view portrays the executive vision of an enterprise. Second, function view describes the decomposition structures and function modules of information systems, such as enterprise resource planning system (ERP) and advanced planning and scheduling system (APS). Third, data view presents the data schema that accrued or required in the enterprise's operation process. Finally, control view

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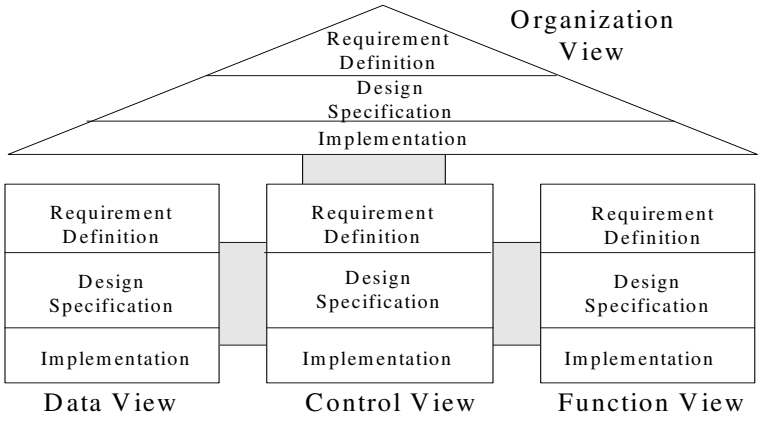

Figure 1. ARIS Methodology framework concept (Scheer, 2001).

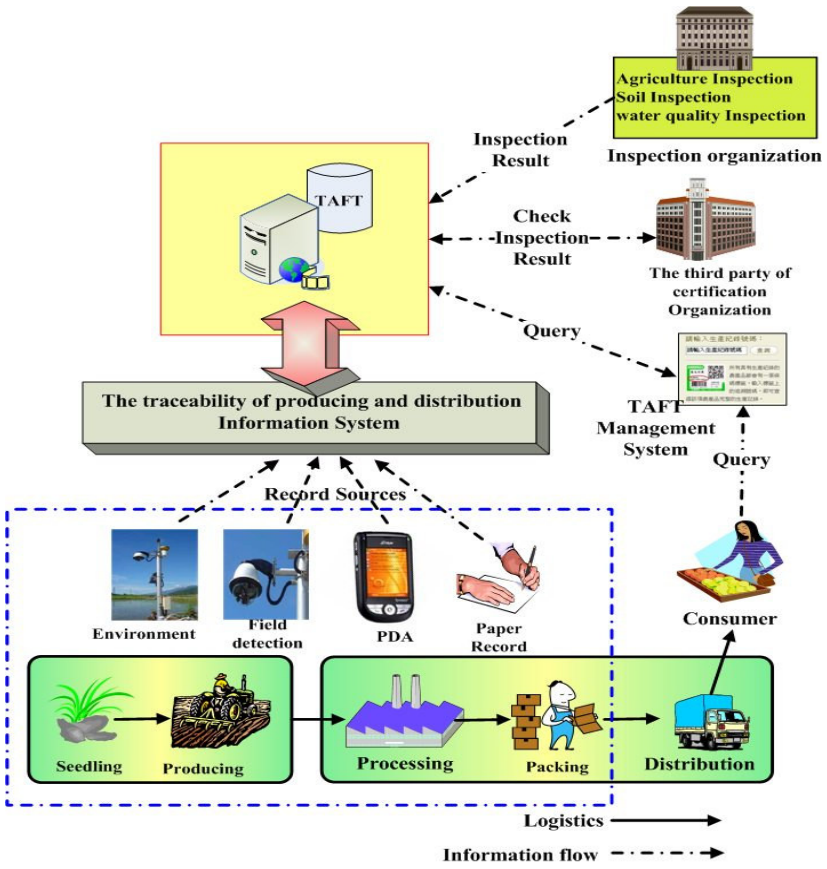

Figure 2. The environment of traceability system for production and distribution.

integrates the other three dimensions of function, data, and organization views for coordination. On the other hand, each dimension of ARIS has 3 stages of processes: 1) requirement definition, 2) design specification, and 3) implementation. Empirically, ARIS has been applied in a number of recent studies (Juan and Ou-Yang, 2005; Ou-Yang and Hon, 2006; Chang et al., 2007).

TRACEABILITY SYSTEM

Figure 2 illustrates the environment of traceability for production and distribution in paddy rice industry in Taiwan. As shown in Figure 2, the interrelationships among production (that is, seedling, fertilization, processing, and packaging), distribution, consumers, Agricultural Inspection Bureau, TAFT (Taiwan Agricultural and Food

Traceability), Certification Organization, and record sources (that is, PDA, field detection) are demonstrated. Regarding the construction of traceability system, many factors must conform to the TGAP (Taiwan Good Agriculture Practice) regulated by the Council of Agriculture (COA). These factors are as follows: soil and water quality in the planting environment, characteristics of seedling, fertilization, disease/pest control, and cultivation. All of these records are documented in Taiwan Agriculture and Food Traceability (TAFT) database. Moreover, the agricultural products need to be randomly selected and examined by the inspection organizations. Further, certification organizations occasionally check the inspection results in order to understand whether these outcomes meet the standards.

RFID + ARIS model for traceability system

In order to establish a RFID + ARIS based traceability system, we provide some guidelines:

1. To build a comprehensive information flow among production, distribution, consumption, and inspection;
2. To replace the barcode tracking method with the RFID technique, so as to create a cross-industry information connection structure through EPCglobal Network™. RFID serves as a medium for inquiry;
3. To set the control frequency on a daily and/or event basis for every activity among production, distribution, consumption, and inspection in order to keep an evidence of fluctuation/variance for any potential outcome in the future; and
4. To establish a systematic step-by-step working agenda, based on ARIS, among production, distribution, consumption, and inspection for coordination.

From the seedling procedure, every unit of paddy field is given a RFID with tracking number for keeping cultivation records. Moreover, the fertilization for every unit of paddy field shall be tested. Irrigation and quality of soil shall be controlled. Farmers must join the certification organizations in order to make sure that their daily working activities comply with the requirements. Figure 3 demonstrates the RFID + ARIS model for paddy rice production procedures, such as harvest, grains storage (that is, temperature and humidity), pest control, milling process, quality control as well as inspection, and packaging, etc. Thus, rice is packaged in the regulated size and attached a RFID with a tracking number. Subsequently, rice packs are delivered to a distribution center. Figure 4 demonstrates the RFID + ARIS model for rice packs distribution procedures, such as arrival, departure, delivery, and sales.

Accordingly, the RFID carries all information about production, inspection, and distribution for inquiry. Based on the suggestions provided earlier, Figure 5 refers to the postulated framework of the traceability system that is a more detailed form of Figure 2. As shown in Figure 5, with EPCglobal Network™, the information circulation starts from the production and processing procedure and stops at consumers' inquiry. From the beginning, the information output includes the records of seedling procedure, farming development, rice processing, and production inspection. As soon as manufacturers attach RFID tags to rice packs in the processing procedure, rice packs simultaneously register in EPC and ONS (Object Name Service). For the records of distribution, event registry is responsible for the stock's in-and-out proceedings. Consumer inquiry has the ability to understand every portion of history for the RFID rice packs.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Conclusions

The major purpose of this study is to establish an information traceability system on agricultural product for coordination and quality control over production, distribution, and consumption. As a result, this paper provides a framework for cross-industrial intelligence integration and the conclusions are as follows:

(1) Regarding the quality control over the rice production process, transit stations should be established in order to examine that operation procedures match the pre-requisite standards. If any mismatch exists, the production process should terminate;
(2) This study adopts the ARIS guidance pattern to keep different types of output records respectively. In other words, supervisors understand farmers' production situations proactively rather than passively. Every step's cause-and-effect relationship is well documented for assessment;
(3) Operation procedures are confirmed on both daily basis and event basis. The purpose of this approach is to make sure that the production, as well as distribution, environment have minimum variance and maximum consistency; and
(4) By the implementation of EPCglobal Network™, this new traceability system incorporates and disseminates intelligence among production, distribution, inspection, sales, and consumers.

Future research

First, this study chooses paddy rice in the farming industry as the research object. Future study can employ this model on other agricultural products and explore the

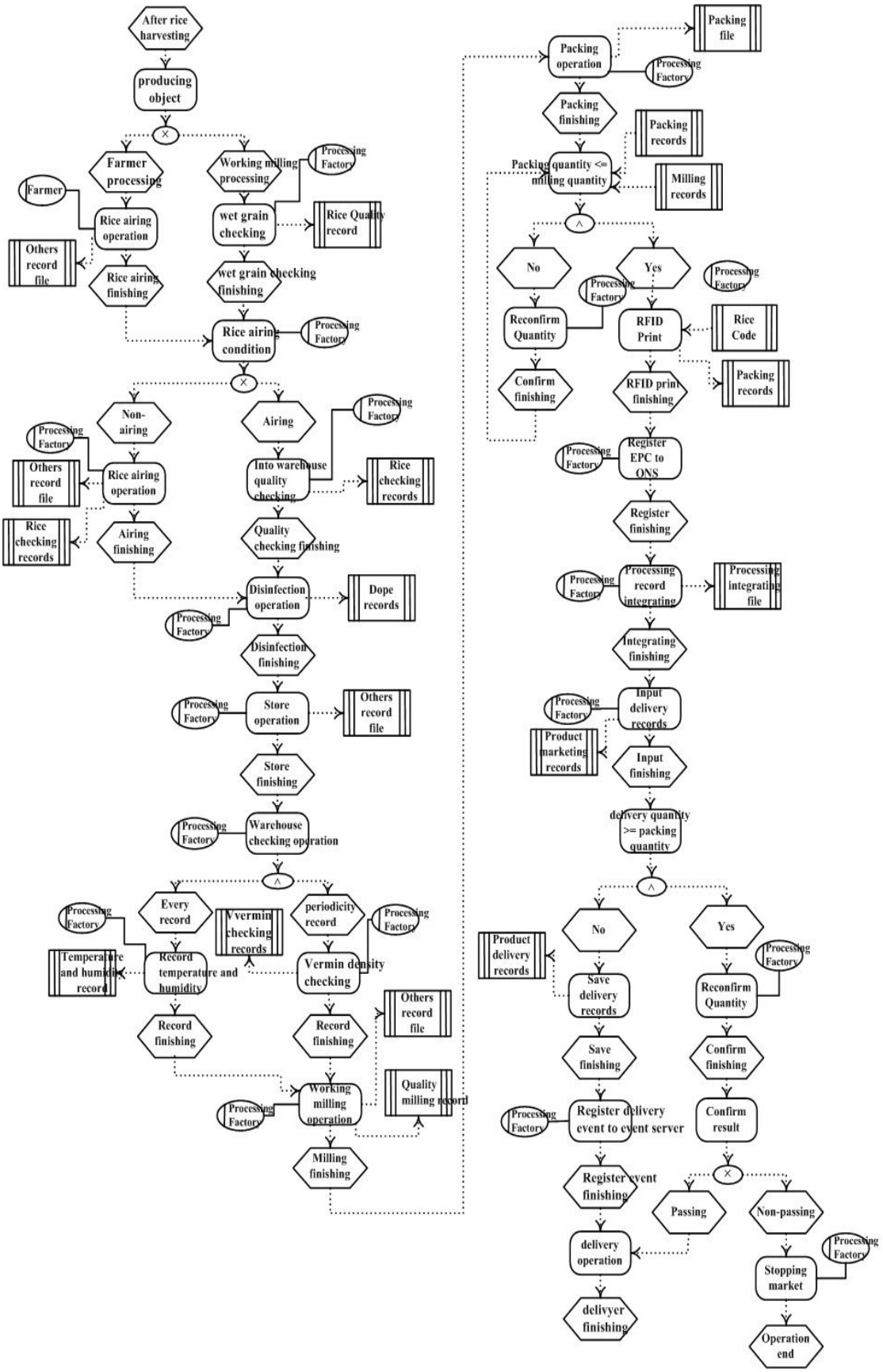

Figure 3. Production procedures.

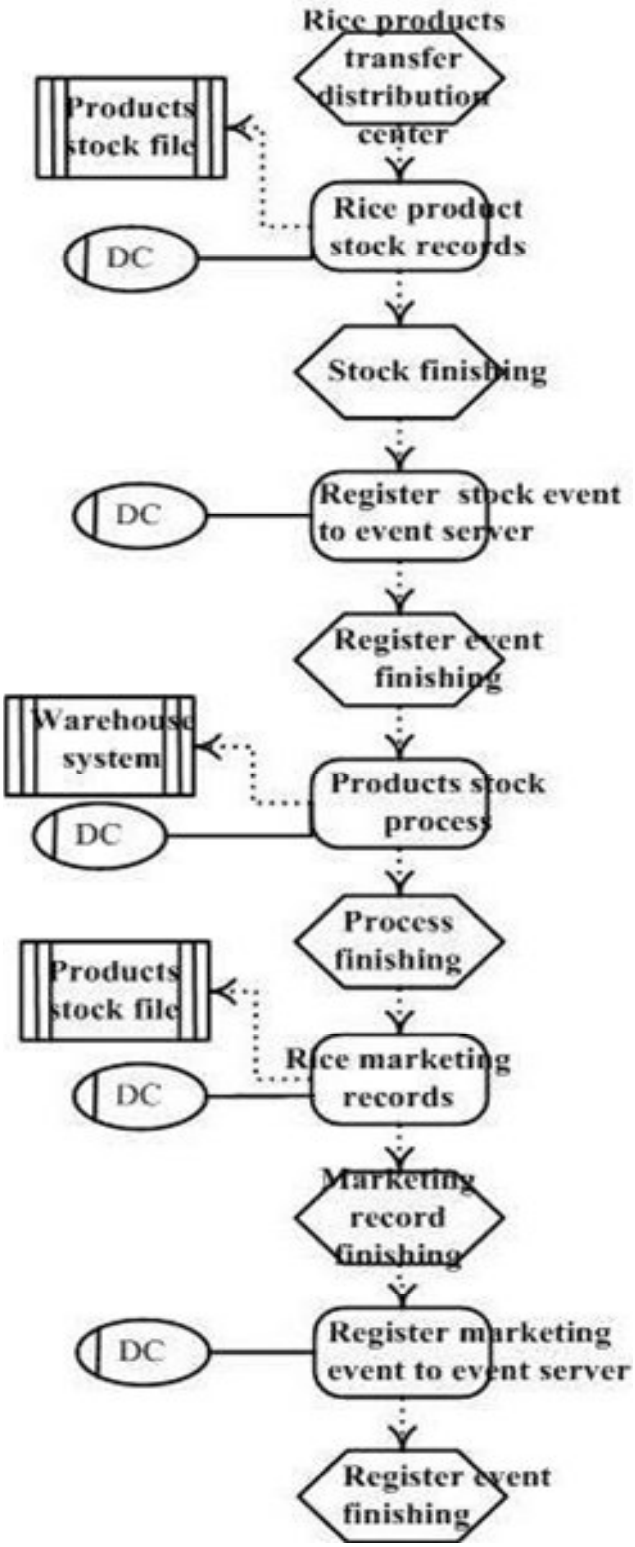

Figure 4. Distribution procedures.

differences along with various practices. Second, this model can be utilized in other industries to discover any significant improvement(s) on quality control and consumers' understanding about the specific product.

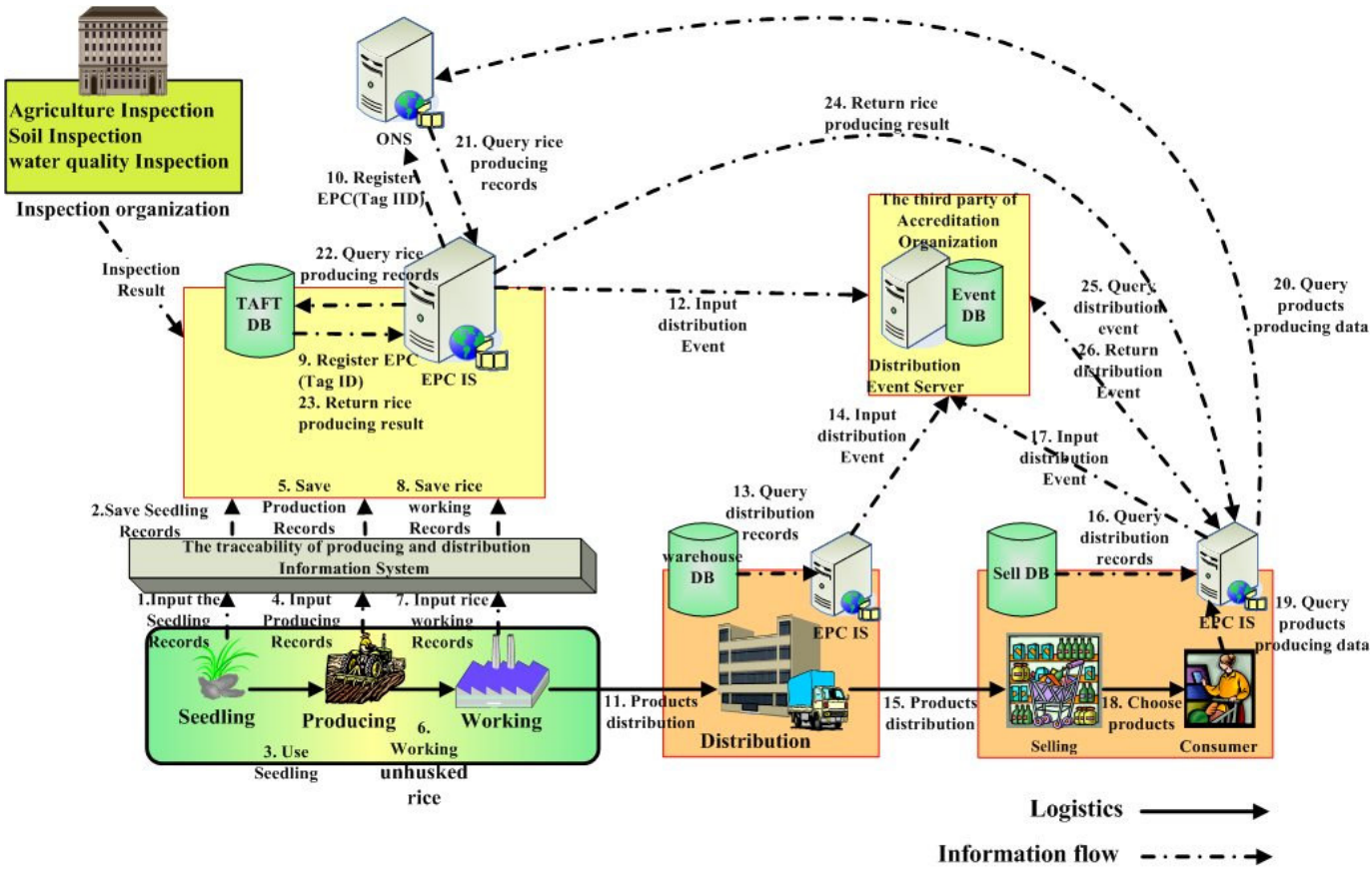

Figure 5. The postulated framework of the traceability system.

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