

# Requirement analysis for the one-stop logistics management of fresh agricultural products

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**Abstract.** Issues and concerns for food safety, agro-processing, and the environmental and ecological impact of food production have been attracted many research interests. Traceability and logistics management of fresh agricultural products is faced with the technological challenges including food product label and identification, activity/process characterization, information systems for the supply chain, i.e., from farm to table. Application of one-stop logistics service focuses on the whole supply chain process integration for fresh agricultural products is studied. A collaborative research project for the supply and logistics of fresh agricultural products in Tianjin was performed. Requirement analysis for the one-stop logistics management information system is studied. The model-driven business transformation, an approach uses formal models to explicitly define the structure and behavior of a business, is applied for the review and analysis process. Specific requirements for the logistic management solutions are proposed. Development of this research is crucial for the solution of one-stop logistics management information system integration platform for fresh agricultural products.

## 1. Introduction

The heightened awareness of food-related safety issues among food consumers drives the demand for more information about the vertical food supply chain about the origin and handling of the basic commodities and food products generated and consumed throughout the world. Developments of agro-food industries are facing global challenges that can only be supported by information technologies. The major IT development lines, the support potential of their integration, organizational requirements for the utilization, and possible consequences for the future organization of the agro-food sector were reviewed [1]. Traceability is an essential subsystem of quality management, and must be managed by setting up a traceability system, which keeps the data tracking of product routes and of selected attributes. A traceability system can consist two elements, the routes of the product, path along which products can be identified throughout the manufacturing, distribution and retail procedures, and the extent of traceability wanted [2]. Food traceability requires that all stakeholders within the food supply chain, including agriculture and feed producers, food manufacturers, retailers, etc., must be able to identify the source of all raw materials and ingredients to whom the products have been sold. The food companies must apply identification systems and data handling procedures and these must be integrated into their quality management system. The sector encompassing information technology (IT) centers ought to find a reasonable compromise between the simple, step by step passing of traceable unit IDs for the neighboring actors, and the accumulated enormously huge databases of the actors. The traceability system is to provide services for the supply chain actors on cooperative basis of the mutual



interests [3]. In addition, the IT centers must support the supply chain and value chain management, as well as the work of the authorities that are responsible for the human health. Opara [4] reviewed the concepts of supply chain management and traceability in agriculture and highlighted the technological challenges, including food product label and identification, activity/process characterization, information systems for data capture, analysis, storage and communication, and the integration of the overall traceable supply chain in implementing traceable agricultural supply chains. Wang et al. [5] addressed that the values on traceability can be integrated with the supply chain management processes to manage the business process and improve its performance. Bosona and Gebresenbet [6] summarized the literature review on the food traceability issues. The definition, driving forces, barriers, benefits, traceability technologies, improvements, and performances of food traceability system had been discussed. It was pointed out that the development of full chain food traceability system is quite complex in nature, and a deeper understanding of real processes from different perspectives such as economic, legal, technological, and social issues are essential. Consequently, studies on the integration of traceability activities with food logistics activities, the linkage between traceability system and food manufacturer, standardization of data capturing and communication protocol for different drivers, and performance evaluation frameworks for food traceability system need to be focused.

A new model and prototype of a new Farm Information Management System, which meets the changing requirements for advising managers with formal instructions, recommended guidelines and documentation requirements for various decision making processes, was developed [7, 8]. As achieving end-to-end traceability across the supply chain is quite a challenge from a technical, a co-ordination and a cost perspective, Kelepouris et al. [9] suggested a radio frequency identification (RFID) technology and outlined both information data model and system architecture that made traceability feasible and easily deployable across a supply chain. Based on an integration of alphanumeric codes and RFID technology, the traceability system for Parmigiano Reggiano (the famous Italian cheese) was developed [10]. Manthou et al. [11] provided empirical insights regarding the use of Internet-based applications in the agri-food supply chain by focusing on the Greek fruit canning sector. The companies' perceptions regarding perceived benefits, constrained factors and motivation factors towards the use of Internet-based applications were studied. A PDA-based Record-keeping and Decision-support System for traceability in cucumber production was developed on Windows Mobile platform invoking a Geographic Information System (GIS) control [12]. Two agricultural production enterprises were chosen as case study to evaluate the system and the results show that the efficiency of production record-keeping and decision-support is improved by the simple and friendly system. The state-of-the-art review in the recent advancements of food processing and packaging industry in the fields of smart packaging and materials, automation and control technology, standards, and their application scenarios, and production management principles and their improvements was proposed [13].

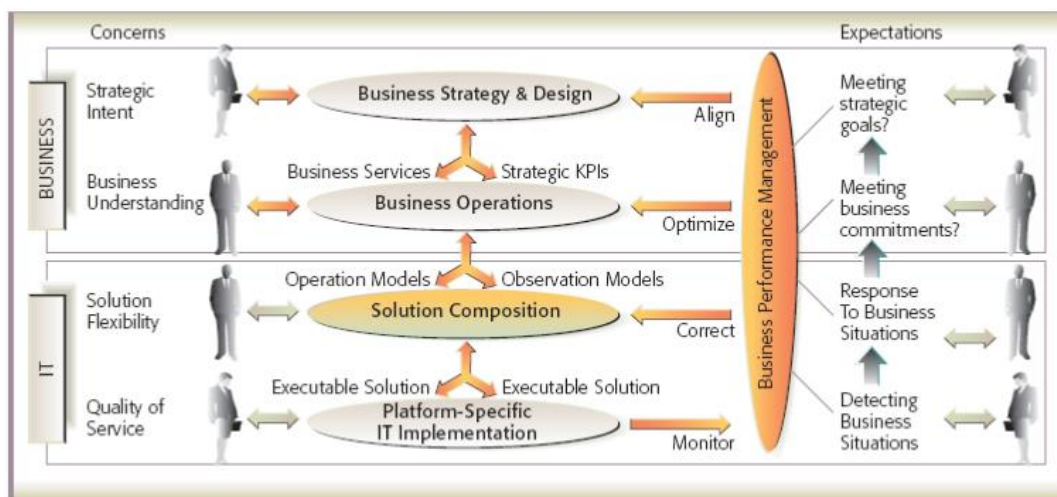
The logistics and information flow play an important role in the fresh agricultural products supply chain. The purpose of this research is to further provide a complete study on the issues and solutions for the one-stop logistics service management of fresh agricultural products. A full life-cycle business-to-technology method, model-driven business transformation MDBT, is both a business transformation methodology and a set of innovative technologies that allow business strategies to be realized by choreographing workflow tools and human activities. MDBT uses formal models to explicitly define the structure and behavior of a business component. Kumaran et al [14] presented a new approach to IT service workflow automation and a new generation of service-delivery management systems based on the model-driven transformational approach and service-oriented architecture. The MDBT approach is applied to propose an integrated solution. Development of this research is crucial for the solution of information and logistics management in fresh agricultural products supply chain business.

## **2. Model-Driven Business Transformation Approach**

Model-driven business transformation, MDBT developed by IBM research, uses formal models to explicitly define the structure and behavior of a business component. These models can be employed to monitor, analyze, and improve its performance, and leverages these models in the construction of its IT systems. Each layer constitutes a different level of abstraction, performs a well-defined function, and has a different audience. The strategy layer defines the goals and objectives of the business system. The operation layer describes the operations performed by the business system to achieve the goals. The

composition layer is an abstraction of the computational elements for the business operations. The implementation layer specifies how the computational elements are implemented on IT platform. Figure 1 shows the MDBT framework, including the separation of concerns, connections between model layers, and the closed-loop architecture using the business process modeling component.

In the MDBT approach, the transformation process begins with the identification of the strategic goals and objectives of the business component. This leads to a set of initiatives that support these goals. These initiatives determine the definition, analysis, optimization, and implementation of the business operations of the organization such that the strategic goals can be achieved. Formal definition of the business operations and the operational KPIs (key performance indicators) is the next step of transformation process which was referred as the business operation model. A business operation model is different from the more familiar workflow models. A business operation model, on the other hand, defines the key business artifacts and the operations performed on these artifacts. The third step of solution composition in MDBT is the judicious use of technology to support the execution of business operations. This involves the generation of a platform-independent solution composition model and the realization of this model on a specific software platform. The final step in MDBT is to create an implementation of the IT solution on a specific IT platform. Once the solution is deployed, business owners can monitor and analyze business performance using KPIs and continuously improve the models, both at the business and IT levels, based on this performance analysis.



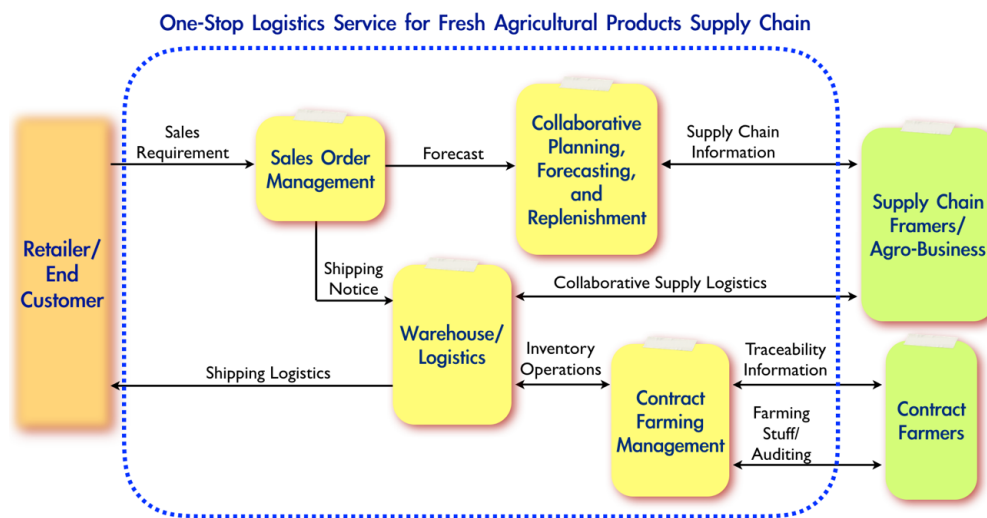
**Figure 1.** Model-driven business transformation framework, from [14]

### 3. Solution Analysis for One-Stop Logistics Service

The infrastructure of fresh agricultural products logistics supply chain management services can be summarized as shown in Fig. 2. The solid lines stand for the logistic flow of the products, and the dashed lines are the required information flow to assure the food safety. As indicated in Fig. 2, the traceability information is required during the farming process of the agricultural products. The process and ingredient information is necessary if the products are sent to the food industry for more process. The logistics information during the transportation and storage for the supply chain stages must ensure the completeness of the traceability management. By applying MDBT approach, the definition of goals and objectives should be firstly analyzed in strategy layer. As the project team reviewed the current fresh agricultural products supply chain in Tianjin, the first two issues are the product loss during the logistics procedure and cost (and/or effectiveness) of the cold chain logistics. The objectives are consequently to improve the effectiveness and efficiency for fresh agricultural products logistics management. One-stop supply chain management service is an integrated model of the logistics services. The fresh agricultural products are characterized by perishability, timeliness and regional nature, with intensive information requirements during the whole supply chain procedures. One-stop logistics service system is studied to reduce logistics cost, facilitate logistics efficiency, and promote the logistics development of fresh agricultural products.







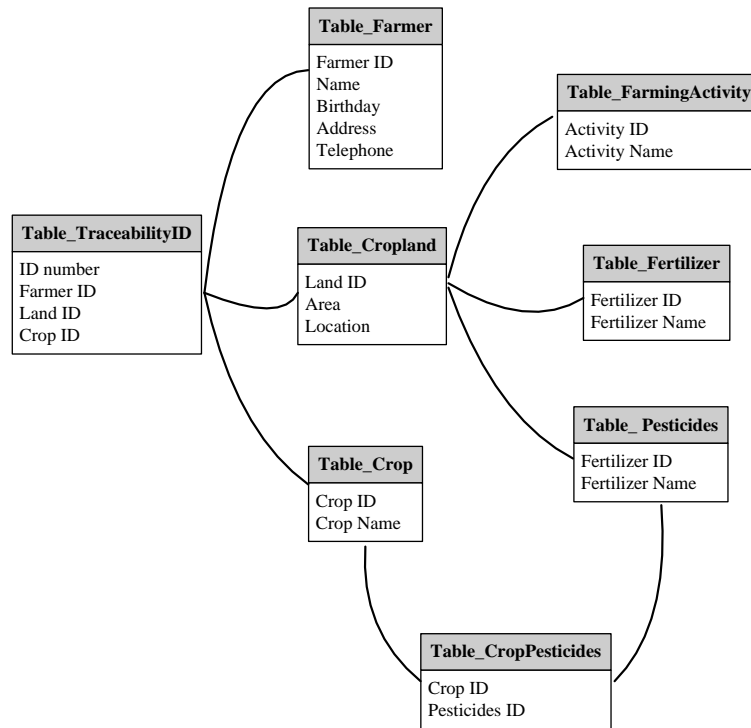
**Figure 3.** System integration architecture for the one-stop information management platform for traceability and logistics management of the fresh agricultural products supply chain.

### 3.1. Functional Analysis for the One-Stop Logistics Service

The one-stop logistics service system not only coordinate the links between the various nodes, but also help to make accurate estimation on the customers' needs through effective information analysis. The cold chain logistics companies should provide procurement, distribution, logistics and other value-added services to meet customers' demand. The requirement of the one-stop logistics service can be summarized as:

- One-stop procurement service can achieve the purpose of door-to-door procurement. It is much more complex for fresh agricultural products because of the storage conditions and variety in the combinations and substitute of product types. One-stop procurement service provides the opportunity for industries to obtain all procurement from their supplier to utilize the operation effectiveness.
- Constructing a one-stop distribution channel is to integrate different supply chain services platforms based on the satisfaction of customer needs. A win-win situation can be reached that the brand owners can reach more customers, and the customers can have more choices of product resources.
- The logistics management under the One-stop supply chain service platform cannot become possible without the collection, analysis, processing and timely update of the supply chain data. Information of the products, financial, and logistics can be collected through proper information system design. One should note that the main challenge is the information integration of the all venders in the supply chain.
- Food traceability can usually be found by attaching a 2-dimensional label, QR (quick response) code is the usual case, on the package of the food or agro-products. A mobile farming information system to collect the farming data and directly transmitted to the traceability system by cell phone and two dimensional codes was proposed in [15]. The basic traceability information is consisted of the farmer, cropland, and crop planted. All the farming activities are performed on the cropland. All the required farming operations are encoded into QR codes and every farming operation is transformed into distinct QR code label. As the usage of pesticide is critical for the pesticide residual can be harmful to human, the relationship of allowable pesticide for crop is constructed to guarantee that safety of pesticide usage. The main information entities and their relationships of the traceability information system are shown in Fig. 4. The basic traceability information is consisted of the farmer, cropland, and crop planted. All the farming activities are performed on the cropland. The farming activities can be divided into three categories: the farming operations for all kind of crops like seeding and pruning without the need of further attribute records; the fertilizing operations which the fertilizer and amount used need to be recorded; and the disease prevention operations with the use and records of pesticides. All the required operations are encoded into QR codes and every farming operation is transformed into

distinct QR code label. Different fertilizers and pesticides are all encoded into distinct QR code. By scanning the proper QR code, the farmer can easily upload the operation messages into the data collection system.



**Figure 4.** Main database entities for the mobile traceability data collection system, from [15]

### 3.2. Supporting System for The One-Stop Logistics Service

The support systems of one-stop supply chain logistics service platform for fresh agricultural products include cold chain logistics enterprise, information technology, logistics network, corporate reputation and professional team. The logistics service network provides an important foundation, such as the layout of distribution network, cold storage facilities, and information network, for one-stop supply chain services. Considering the complexity of the fresh agricultural products supply chain, high-quality and professional staff team is vital for the one-stop supply chain services. The operation team that is adaptive to the changing market and customer requirements is crucial to develop the logistics service platform. Effective project management is indispensable for the system design and implementation of the project consists of design, analysis, simulation, and verification of information systems. Industries must keep abreast on controlling logistics risk and improving the effectiveness and efficiency of logistics enterprises and customer service. The replenishment (CPFR) is the major solution to overcome the highly uncertain property of the supply and demand for fresh agricultural products. The key requirements for the system shown in Fig. 3 can be summarized as followed:

- CPFR for the fresh agricultural products supply chain with the considerations of the farming production and the market requirements for proper farming control and products dispatching is necessary to minimize the unbalance of the supply-and-demand of fresh agricultural products.
- Detail analysis for the traceability information of contract and supply farmers is necessary to assure the software systems can achieve properly the control and traceability purpose.
- The warehouse management of fresh agricultural products is quite different from the general grocery items. The storage condition, labeling, and packing need to be carefully reviewed.
- The integrated platform consists of different venders of the supply chain, the effective interface definition and communication protocol design are crucial for the success of the information systems.

### 3.3. Strengthen the One-Stop Logistics Information Service

Considering the specific characteristics of the fresh agricultural products, effective professional staff team, that is adaptive to the market changing, customer requirements, and the operational process to the last mile of customer, is vital to support the one-stop supply chain service. An efficient team assessment management to ensure the successful implementation of one-stop service system is necessary. Venders in the fresh agricultural products supply chain are usually located far away from food industries, retailer, and customers. Transportation of fresh agricultural products can be summarized in two manners. The first type is transported directly by the food industries (or agricultural corporations). The other is to be delivered by the third-party services such as DHL. The quality of transportation and fresh agricultural products must be controlled and guaranteed during transportation. The cold chain logistics is hence become inevitable. As to provide and integrate the logistics information, the cold chain logistics vehicle need to be upgraded with information accession and transmission. Some suggestions to strengthen the one-stop service information platform are listed:

- It is a great challenge to share information and reduce fluctuations among the different corporations in the fresh agriculture product supply chain. The fresh cold chain related enterprises should re-coordinate to achieve risk-sharing and benefit-sharing. Detailed contract should be compromised to encourage the supply chain members to work with the occurrence of unexpected events.

- Solution enhancement of the one-stop logistics service can be divided into two aspects: the hardware and software solutions. Hardware solutions should be designed to cope with that integrate various types of equipment involved in material flow including transportation, handling, and storage.

- Software solution is to provide an efficient one-stop logistics management platform system for the integration of complex logistics information including the products receiving and recording, warehouse entrance check and record, transportation management, and storage management of automatic storage location assignment, load/unload to storage location, lot split, and inventory check.

### 4. Summary and Conclusion

The fresh agricultural products supply chain is reviewed and the one-stop logistics management requirements are studied based on the project experience in Tianjin. Because of the importance food safety and the complex business characteristics through the food supply chain, the MDBT approach to provide a service-oriented-architecture solution is proposed in this paper. Three major considerations for the one-stop logistics management platform, including the functional analysis, supporting system, and strengthen for the one-stop logistics service, are suggested. With the proposed functional requirements, the results of this paper can be fruitful for the further design of the fresh agricultural products logistics information management systems.

### 5. Acknowledgment

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