Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(11):556-561

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Critical criteria when implementing electronic chain traceability in a fish supply chain

Hui Li*[1,2], Hu Yun[1,3] and Jun Shi[2]

[1]*Department of Computer Engineering, Huai Hai Institute of Technology, Lianyungang*
[2]*School of Information and Electrical Engineering, China University of Mining and Technology*
[3]*Department of Computer Science and Technology, Nanjing University, Nanjing*

ABSTRACT

In order to enhance product quality management in fresh fish supply chains through improved logistics management and ensured traceability effectiveness, we investigate and discuss the underlying nature of the requirements traceability problem. We introduce the distinction between pre-requirements specification (pre-RS) traceability and post-requirements specification (post-RS) traceability, to demonstrate why an all-encompassing solution to the problem is unlikely, and to provide a framework through which to understand its multifaceted nature.

Key words: Fresh, Supply chain, Traceability, Criteria

INTRODUCTION

Global demand and consumption of fresh fish have increased, for instance a significant growth in fresh fish market has been observed during recent years. The world production of fresh seafood has gradually grown from about 45.4 million tons in 1998 to 54.6 million tons in 2007.

Increasing global market competition requires companies to be able to deliver appropriate products and services to the market faster, at the lower possible cost. Company should be able to formulate the best strategy to face the competition. In order to formulate the best strategy, the company should design good supply chain [1]. Supply chain is defined as an integrated process and flow of supply chain's members, starting from raw materials until the final product and covered the customer's need [1-6]. Good supply chain can be determined by measuring the performance using the appropriate performance measurement tools [7].

Some scholars propose performance measurement systems (PMS) on supply chain. Different approaches are used in developing the model, such as designing PMS by used hybrid DEMATEL and AHP [8], balance scorecard (BSC)[9-10]. Previous measurement systems are developed based on general characteristic of supply chain. However, it is important to use specific performance measurement tools that are suitable to the supply chain characteristics [11]-[12]. In this paper, we propose a performance measurement system for sea fishery supply chain. Sea fishery supply chain has specific characteristics that are different from other supply chains. Those characteristics are perishable, highly dependence on nature, seasonal, required special transportation and storage condition, and there are product safety issues. These characteristics would affect the performance of the supply chain.

The purpose of PMS is to evaluate and to determine the best strategy to improve the supply chain. It is important to select appropriate PMS according to the characteristic of the supply chain [8-12]. Good PMS should meet the following criteria; inclusiveness, universality, measurability, and consistency.

Some PMS models have been developed. Various methods are proposed, starting from the use of cost as indicators, involving both financial and non-financial aspects, and the more complicated model that try to include the entire stakeholders on supply chain. Cost minimization uses cost as a single indicator to measure performance of the supply chain. This model is simple to use but disregard the stakeholders involvement and uncertainty factors in supply chain.

[11] Considers the complexity of supply chain in two industries; automotive industry and pharmaceutical industry. This work provides analisys on company's strategic viewed by the criteria of well-designed of PMS (currently used PMS). The criteria of well-designed of PMS are a comprehensive approach, process-based, aligned with strategy, a dynamic system, balanced approach, a managerial tool, cover strategic, tactical and operational level, provide a forward looking (leading) perspective, tool for improvement, provide drill-down functionality, handling conflicting objectives, simple, comparability, relevant metrics. It is done by analysing and discussing how the criteria are applied on different companies. Thus, the drawback of company's strategic can be acknowledged, hence it can be used for preliminary step to improve the supply chain although it is not detail and specific.

[6] Propose a framework using a systematic approach to improve the iterative key performance indicators (KPIs) accomplishment in a supply chain context. It uses a process-oriented SCOR model to identify the basic performance measures and the KPIs. The proposed framework quantitatively analyzes the interdependent relationships among a set of KPIs. It enables to identify the crucial KPI accomplishment costs and propose performance improvement strategies for decision-makers in a supply chain.

[13] Tries to determine the PMS used by selected Philippine manufacturing companies to monitor the effectiveness of their supply chain operations. A literature review is conducted to determine the supply chain performance measures. Survey method to the industry is used to discuss the relevance and applicability of the PMS. This study also tries to find the effect of supply chain management strategies on performance.

Due to the complexity of supply chain, various indicators have been proposed to measure its performance. [8] Proposed a multiple criteria decision making (MCDM) tool to solve the problem of various parameters. MCDM enables the complexity to be defined and calculated properly. Analytical Hierarchy Process (AHP) and DEMATEL are the popular MCDM approaches for prioritizing various attributes. [8] Proposed a new methodology which is a combination of AHP and DEMATEL to rank various parameters affecting the performance of the supply chain. DEMATEL is used as it describes the relationship between the indicators, while AHP used to integrate indicators from entire aspects of supply chain.

There is also SCOR (Supply Chain Operation Reference) built by Supply Chain Council on 1996. SCOR is process-oriented of PMS, which are Plan, Source, Make, Deliver, and Return so it can cover the whole process on supply chain. The indicators determined by toolkit on each process. Although it is determined on each process, SCOR do not have the same indicators, because the indicators would be selected, screened and united. If the previous models are performance measurement for common case, but then adopted for supply chain performance, SCOR (Supply Chain Operation Reference) is developed as a specific performance measurement system for supply chain. SCOR consider more on the aspects in supply chain. SCOR measure the supply chain performance based on process-oriented on supply chain, which is Plan, Source, Make, Deliver, and Return [4]. This framework just focused on certain point, it cannot improve supply chain entirely [14]. It involves the process form upstream to downstream; therefore it cannot give the optimal result specifically. However, it includes entire process in supply chain, and tries not to pass any process in supply chain.

[7] developed PMS for agri-food supply chain, especially tomato industry. It measures the supply chain based on efficiency, flexibility, food quality, and responsiveness. Entire stakeholders on tomato industry are involved. The performance is total performance from each stakeholder.

Although agri-food supply chain [7] has similar characteristics with sea fishery supply chain, but it has differences. The dependence of agri-food supply chain on nature can be controlled because agri-food especially tomato can be cultivated, but in sea fishery industry, it is highly dependence on nature and uncontrolled. Further, sea fishery industries in Indonesia mostly is Small and Medium Enterprises (SMEs). In Indonesia, 99,91% companies are SMEs, thus SMEs have significant contribution to the nation. SME has some unique characteristics such as limited capital, limited technology, difficulty adoption to change, but has high contribution to the nation [15].

EXPERIMENTAL SECTION

Traceability has emerged as an important concept in food safety since the breakout of the Bovince Spongiform Encephalopathy(BSE) and dioxin crised in Europe in the last decade. In the fields of animal health and food safety, various definitions of traceability can be found, both in legal and standard texts. Traceability is defined by the International Organization for Standardization(ISO) as "the ability to trace the history, application or location of that which is under consideration". The ability to trace the product information within a company is referred to as internal traceability; while chain traceability is the ability to trace the product information through the links in a supply chain, or the product information a company gets and gives away.

Traceability can be divided into tracing and tracking. Tracing is the ability to find the origin, attributes, or history of a particular traceable item or product form given criteria, through records, upstream in the supply chain; used to find the source of the problem. Tracking is the ability, at every point of the chain, to find the products' localization from given criteria; used in case of product recall and to find the cause of the problem.

Benefits-incentives for food traceability

Food traceability has been perceived and proven to bring social and industrial benefits. From the public or social point of view, good traceability practice in food supply chains reduces risks and costs associated with outbreaks of food borne diseases, e.g. reduce their occurrence magnitude and possible health impact, reduce or avoid medical costs, reduce labor productivity losses, or reduce safety costs arising from a widespread food borne illness. Furthermore, readily verifiable traceability information can reduce the costs for consumers in verifying the information associated with food quality.

From the industrial perspective, traceability can result in the following benefits:
(1) Market benefits: By implementing traceability, actors of supply chains are able to comply with laws and regulations of the markets and to meet the demands of their customers, which in turn will help them to retain and extend their markets. In addition, traceability helps to expand sales of high-value products or products with credence attributes. Traceability is also found to be beneficial in terms of reducing costs associated with maintaining or enhancing consumer or market confidence in a product.
(2) Benefits form recall saving: Implementation of traceability is considered as a measure to save costs associated with product recalls due to improved recall management efficiency
(3) Benefits from reduction of liability claims and lawsuits: Another economic reason for adopting traceability systems is to reduce liability risks associated with unsafe food problems which are the penalties, loss of trade, damage to reputation, or loss of a brand name that may result.
(4) Benefits from process improvements: Traceability, particularly electronic-based, has the potential to improve supply chain and company management, increase production and process efficiency, improve planning and lower cost of distribution systems. Sharing traceability information along with other relevant information throughout the value chain, e.g. in the food cod industry, could improve the catch management and production planning, as well as optimize yields and overall profits.

Type of traceability systems

Information transfer in traceability can be conducted by several technologies which apply different media and infrastructure. The simplest type of traceability systems is paper-based. Bar codes are also commonly used and radio frequency identification (RFID) is a more recent medium. Besides there are other potential media such as vision systems, dot peening and laser etching. A summary is presented in Table 1.

Table 1. Advantages and limitation of various traceability system types

Type of traceability system	Advantages	Limitations
1.Paper-based	Low cost	Potential illegibility, transposition, language barriers, fading, fading and other physical damage
2.Barcode-based	A substantial amount of information can be contained in the bar code Relatively inexpensive Globally accepted	Need printer and reader/scanner Line-of-sight access to the bar code is required for scanning
3.RFID-based	Line of sight to the tag is not required Multiple tags can be read virtually simultaneously Labor cost savings No manual screening, variable memory Tag memory can be rewritten or appended	May be too expensive for low cost commodities Tags may interfere with recycling and biodegradation processes Radio interference

It is worth noting that the type of media for transmitting information is totally independent from the type and quality of information conveyed, meaning that using an advanced medium such as RFID does not guarantee effective traceability if the information is lacking standardization allowing interoperable exchanges of relevant information along the chain.

Traceability effectiveness

Effectiveness of a traceability system is considered as its ability to collect the necessary information. In general, current traceability regulations

In general, current traceability regulations and standards stipulate one-up-one-down model for traceability. Therefore relevant data must be collected, kept and shared by all the participants in the food supply chain to accomplish this.

Three basic elements of chain traceability are:

Product, party and location identification: Every food component form harvest, form farm or sea, and through every stage of its transformation or packaging to a finished consumer product must be uniquely identified at ach stage of transformation or possession and these identifiers must be linked.

Recording of information: Effective traceability requires standardizing the information that needs to be recorded through each step of the food supply chain. It is required that linkages are maintained, allowing a product to be traced through the supply chain. Each time a lot number is changed, the original and resulting lot numbers must be recorded. If a lot number is unchanged, but the product moves between facilities, this must be recorded in order to follow the path of the product.

Linking of information: Each business operator must transfer information about the identified lot or product group to the nest partner in the supply chain or to a central data based or registry to enable information retrieval when necessary. This is to ensure a continuous flow of traceability information.

RESULTS AND DISCUSSION

Analysis of the requirements traceability problem

Numerous techniques have been used for providing RT(Requirements Traceability), including: key phrase dependencies [16]; RT matrices [17]; matrix sequences [18]; hypertext; integration documents; assumption-based truth maintenance networks [19]; and constraint networks [20]. These differ in the quantity and diversity of information they can trace between, in the number of interconnections they can control between information, and in the extent to which they can maintain RT when faced with ongoing changes to requirements.

Additionally, some form of RT can result from using certain languages, models, and methods for development. This is particularly exemplified by: the Requirements Statement Language [21]; process entity-relationship models; the Planning and Design Methodology [22]; formal methods; and Quality Function Deployment. The quality of the resulting RT, however, depends on the rigid adherence to pre-specified procedures and notations for development.

Despite a growth in specialized tools, and inflated claims of RT functionality from tool vendors, their use is not as widespread in practice as the importance of RT would suggest. RT problems even remain cited where they are used.

A framework for addressing the problem

To provide a framework in which to locate and address the fundamental cause of RT problems, we first need to establish some shared and working definitions.

- *"**Pre-RS traceability**,* which is concerned with those aspects of a requirement's life prior to its inclusion in the RS (requirement production)."
- *"**Post-RS traceability**,* which is concerned with those aspects of a requirement's life that result from its inclusion in the RS (requirement deployment)."

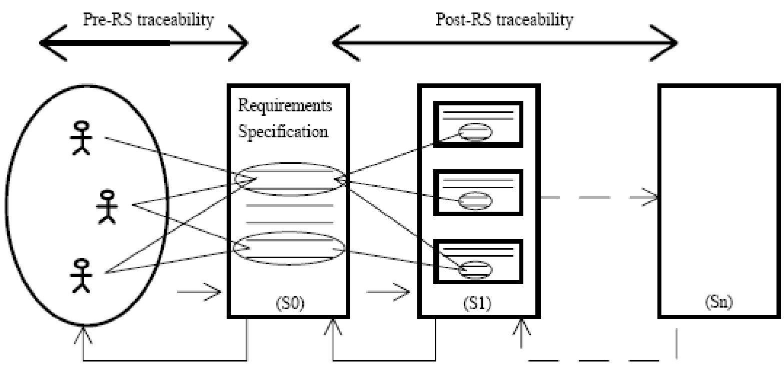

Figure 1: Two basic types of requirements traceability

Figure 1 shows the typical setting of RT to illustrate these definitions. Note how requirements knowledge is distributed and merged in successive representations; note also the added complication of iteration and change propagation.

Forwards and backwards RT are clearly essential. However, we emphasize the pre-RS and post-RS separation, because RT problems in practice were found to centre around a current lack of distinction here. Although both these types of RT are needed, it is crucial to understand their subtle differences, as each type imposes its own distinct requirements on potential support.

The main differences involve the information they deal with and the problems they can assist. Post-RS traceability depends on the ability to trace requirements from, and back to, a baseline (the RS), through a succession of artifacts in which they are distributed. Changes to the baseline need to be re-propagated through this chain. Pre-RS traceability depends on the ability to trace requirements from, and back to, their originating statement(s), through the process of requirements production and refinement, in which statements from diverse sources are eventually integrated into a single requirement in the RS. Changes in the process need to be re-worked into the RS. Changes to the RS need to be carried out with reference to this process, so they can be instigated and propagated from their

Support for pre-RS & post-RS traceability
Existing support mainly provides post-RS traceability. Any problems here are an artifact of informal development methods. These can be eliminated by formal development settings, which automatically transform an RS into an executable, and replay transformations following change [23]. In contrast, the issues that pre-RS traceability are to deal with are neither well understood nor fully supported. Post-RS traceability support is not suitable. This generally treats an RS as a black-box, with little to show that the requirements are in fact the end product of a complex and on-going process. Rigid commitment to categories for recording information also make it difficult to represent this process and to account for the dynamic nature of the sources and environment from which requirements are drawn. It has been argued that pre-RS traceability problems will remain, irrespective of formal treatment, as this aspect of a requirement's life is inherently paradigm-independent [23].

CONCLUSION

From the results of antibacterial and antifungal activity, it can be concluded that the compounds bearing isatin, and furan rings are more potent than the remaining compounds. They showed comparatively good antibacterial as well as antifungal activity.

Identifying applications for traceability and benefits of traceable information in seafood supply chains is a clear area for further studies. There is also a need to increase knowledge of preferable granularity levels for traceable units by carrying out real industry studies.

We have illustrated the multifaceted nature of the so-called "requirements traceability problem" that many practitioners claim to experience. We have shown why little real progress has been made here, and how this can only be achieved if based on a thorough understanding of the actual problem. We have distinguished between pre-RS and post-RS traceability, demonstrated how advances in the former are needed and offer most opportunity, and made suggestions for progress here.

Acknowledgment
A Project Funded by the Priority Academic Program Development of Jiangsu Higher Education Institutions. The research is supported by the Natural Science Foundation of Jiangsu Province Nos. 13KJB520002, and the key project of science and technology plan from Lianyungang City, No. CG1214.

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