Knowledge-Based Standard Updates and Changes in a Testing and Certification Company: A Case Study

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Abstract: In this paper, a Knowledge-based approach for dealing with standard updates and changes is presented for a Testing, Inspection and Certification (TIC) Company. Due to the high recall rate for products produced in China, as well as frequent changes to standards and regulations and the challenge posed to the testing laboratories, they are deficient in the relevant knowledge to deal with internal technology preparation for the increasing rate of standard updates which increases the pressure on testing service providers to transform their strategic goals into achieving shorter technology development cycle times and delivering more responsive customer service to sustain their long-term competitive advantage. The system is built based on a rule-based reasoning algorithm. Since the design mechanism of the Knowledge-based System (KBS) relies on a thorough understanding of the landscape of knowledge employed in the process in order to provide a reference for incorporating the right mix of knowledge items into the system, a knowledge audit is conducted to evaluate the knowledge need of the process. A prototype KBS was developed and successfully trial implemented in a case study in a prestigious testing company. Encouraging results were obtained.

Keywords: knowledge-based system, knowledge audit, testing, certification and inspection

1. Introduction

According to the result from the Rapid Alert System for dangerous non-food products (RAPEX), which is a recall system in Europe, over 50% of recall products are produced in China and Hong Kong (HK), and the top three recall products are textiles, toys, and electronic and electrical (E&E) products. The main reasons for the higher recall rate are the fact that manufacturers may not be aware of the standard update, due to having limited knowledge resources. Even if manufacturers have information about standard updates, they have a lack of technical know-how to fulfill the requirements, and they have limited capital resources to recruit technical experts and limited resources to establish a monitoring system to cope with such frequent changes to the standards. Due to the introduction of new regulations, this leads to frequent changes of the standards. Examples can be found in improving safety legislation and standards as well as globalization of international standards leading to harmonization. It is also noted that manufacturing migration and shorter product life cycles also lead to standards being updated. This paper attempts to address the three key issues, which include a lack of knowledge retention for the repeatability of using knowledge, insufficient notification of information to clients about related projects, and the lack of a systematic way to develop the related resources in order to cope with standard updates and changes, due to a lack of good planning.

While considering the lack of a systematic research to managing the standard updates and changes, this paper studies and evaluates the existing Testing, Inspection and Certification (TIC) issues in terms of recall rate and standard update workflow, and a Knowledge-based System (KBS) is developed to manage the knowledge of standard updates and changes. Hence, a prototype KBS is developed in order to validate the feasibility of the proposed system, and it is trial implemented through a case study in a prestigious testing company as well as evaluated in respect of system performance.

2. Literature review

In this section, standard updates and the technology are reviewed. It provides an overview of the design of a knowledge-based system for technology deployment of standard update processes in the TIC industry.

2.1 Standard updates

According to the annual reports of the International Electrotechnical Commission (IEC) (2015), average standards production amounts to over 400 publications annually as shown in Table 1. This indicates the fast-moving nature of standard requirements.

Table 1: Standard production figures from year 2009 to year 2014 (Source: IEC 2015)

Year	2014	2012	2011	2010	2009
No. of technical standard production	418	402	373	459	366

2.2 Existing practice in TIC

The survey was conducted of three major leading service providers in the TIC industry in Hong Kong and found that they rely on manual handling to perform the work of technology deployment for the standard update process through email forwarding and paper document transfer. The key challenges faced by the TIC industry under the pressingly rapid rate of standard updating include: (i) manual handling of technology deployment for the standard update process, (ii) deficiency in the relevant knowledge of actions needed to deal with internal technology preparation and the content of customer notifications, (iii) risk of knowledge loss of technology deployment for the standard update process, (iv) lack of case retention of technology deployment for the standard update process.

2.3 Knowledge-based system

KBS is a knowledge automation system operated by computer programs which are capable of automating tasks and deriving advisory solutions to specific problem domains at a level comparable to domain experts with faster decision-making than could be achieved by manual handling. KBS represents problem-solving knowledge as models that can be implemented computationally while promoting consistency and reliability (Pal, 2000). It reduces the amount of processing time needed to arrive at an acceptable solution and hence prevent its delayed delivery (Carrico et al., 1989; Akerkar and Sajja, 2010). The current methodology for building KBS are classified into ten categories: rule-based systems, neural networks, fuzzy, object-oriented methodology, case-based systems, system architecture, intelligent agent systems, database methodology, modeling and ontology (Liao, 2005; Laudon and Laudon, 2002). One of the most widely used KBS is rule-based system (RBS).

The rule-based reasoning cycle of rule-based system architecture is composed of three main components which include fact database, rule base and inference engine (Buchanan and Duda, 1982; Lam, 2014; Pal, 2000). The operating process for RBS is similar to that for typical KBS, as shown in Figure 1. General rule-based reasoning (RBR) process of the RBS is that the system analyzes new problem or case faced as input factual data which is used for assessing current situation so as to find applicable rules by matching against rule base via either forward chaining and/ or backward chaining of inference engine to infer from existing pre-set IF-THEN rules from experts in the rule-base. Intermediate results are generated by chosen inference mechanism. The solution output is tested for feasibility. The process is repeated until a desired solution state is obtained (Chow et al., 2007; Iassinovski et al., 2007; Lee and Chen, 2008; Lam, 2014).

Figure 1: Mechanism of RBR Cycle (Adapted: Pal, 2000; Lam, 2014)

Information technology components of knowledge management system also facilitate case retention (Tiwana, 2000). As a result, KBS leads to gradual increase in overall inventory of knowledge (Ferns, 1995; Morales and Sucar, 1998; Pal, 2000). Validation tests are required to ensure the system built is right to meet performance requirements and expectations of users. The system is finally validated for performance evaluation judged by criteria such as completeness and relevance, as applied by business specialist users (Pal, 2000).

3. Research methodology

As shown in Figure 2, the proposed research methodology for the KBS and knowledge audit process are adapted from the infrastructure design methodology of KIPMRS developed by Cheung et al. (2014) and the Strategic Tools to Capture Critical Knowledge and Skills (STOCKS) methodology developed by Shek et al. (2008) respectively. The proposed methodology is divided into five major phases.

Phase 1 focuses on the identification of problems and objectives. In Phase 2, a knowledge audit is undertaken to prepare for the system development. Phase 3 comprises expert rule collection while Phase 4 performs structural formulation of a knowledge-based system for technology deployment planning of standard updating. In Phase 5, system implementation and evaluation are undertaken. In Phase 2, a knowledge audit method is proposed based on the Strategic Tools to Capture Critical Knowledge and Skills (STOCKS) methodology developed by Shek et al. (2008) with some major modifications for the purposes of simplification and streamlining. The customized knowledge audit process is shown in Figure 2 and consists of seven steps: Step 1 - Scope alignment and process selection, Step 2 - Task identification, Step 3 - Process owner identification, Step 4 - Face-to-face individual interviews with form filling and data validation, Step 5 - Building a knowledge inventory, Step 6 - Data analysis and result validation, and lastly Step 7 - Recommendation for knowledge-based system design.

Figure 2: Proposed methodology for knowledge-based system and knowledge audit process

4. Research results

The proposed knowledge-based system (KBS) development methodology was undertaken in a global TIC Company with more than 30,000 employees across the world located in 50 countries. The company established its Hong King office in 1996 mainly focused on electrical and electronic product testing. It conducts laboratory tests on premium appliance products, which are famous brands in the world, especially for the European market, and supports the China offices by providing useful explicit knowledge for technology deployment planning of standard updating. As shown in Figure 1, there are five phases to establish the Knowledge-based system for this case study.

4.1 Phase 1 – identify the problem

The Product Experts (PE) participate directly in the drafting of standards in various technical committees (TCs) of international standardization bodies, such as CENELEC and IEC, to empower them with the ability to interpret standards. PEs provide the technical advice and align variable technical interpretations of standard requirements across local offices upon request. PE also coordinates and transfers skills to dedicated Product Experts (dPE) in each local office, who are responsible for the implemention and deployment of standard updates or changes in their respective local office. After evaluating the existing workflow, there are five issues; the first is inefficiency of manual handling, the second is lack of knowledge retention measures, the third is difficulty in alignment of standard update procedures across branch offices, the fourth is inadequate cross-functional communication, and the last is lack of systematic methodology for technology deployment planning.

4.2 Phase 2 – system development preparation using the knowledge audit result

In this phase, the knowledge audit is conducted in seven steps (refer to Figure 2) and its result supports the Knowledge-based system establishment while the prioritized business process that supports the business objectives is the technology deployment for the standard update process. The whole auditing process in the case study company took around two months from setting the scope alignment with the company to the delivery of the audit analysis results.

4.2.1 Knowledge audit results

The details of the audit data analysis results are presented including: (i) Explicit to tacit knowledge ratio, (ii) Stakeholder analysis, (iii) Distribution of explicit knowledge, (iv) Distribution of knowledge workers, (v) Knowledge mapping, (vi) Rating of core competence, (vii) Core competence mapping, (viii) Critical implicit knowledge, and (ix) Knowledge and document mapping. The results are used in Knowledge-based System preparation, and an example of audit results can be found in Figure 3.

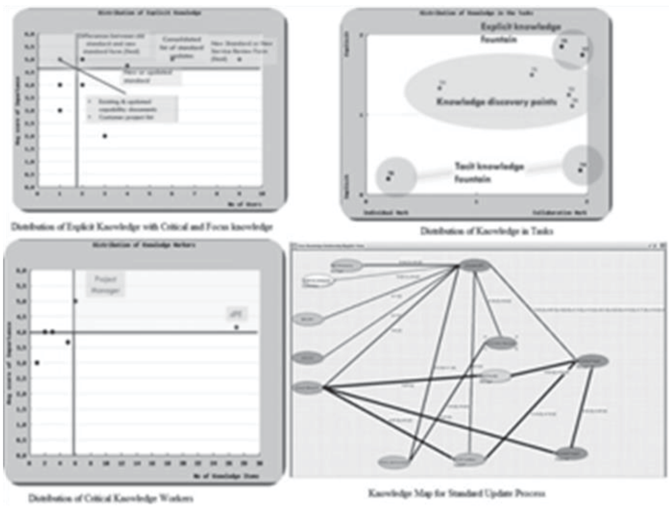

Figure 3: Example of knowledge audit results

4.2.2 System development preparation

As shown in Figure 4, a framework of the knowledge-based system design with task characteristics (knowledge discovery point, explicit knowledge fountain and tacit knowledge fountain) is matched with the corresponding critical explicit knowledge, focus explicit knowledge and critical implicit knowledge items identified in the proposed knowledge audit to be included in the system.

Figure 4: Framework of the knowledge-based system design

Task 1, Task 2 and Task 3 are found to be knowledge discovery points, which collect the expert rules to enable rule-based reasoning in the knowledge-based system. They are ‘Consolidated list of standard updates’, 'Knowledge of classification of updated standard requirements' and 'Classification of requirement change in standard updating'. Task 4 and Task 6 are found to be tacit knowledge fountains where affluent critical implicit knowledge is identified, that is, 'Technical interpretation of standard requirement' and 'Knowledge about technology deployment planning'. Task 5 and Task 7 are explicit knowledge foundations where a large portion of coded knowledge exists in the form of laboratory capability documents, which are 'Review current resource status' and 'Update internal related parties for implementation of technology deployment' tasks. Task 8 is reflected by the critical implicit knowledge items of 'advice on affected customers for project change' and 'advice on affected customers for certificate update'.

4.3 Phase 3 - expert rule collection

The expert rules collected by using questionnaires are presented according to the knowledge themes selected to be captured and codified for establishing expert rules. They are: (i) *Classification to categorize standard updates* for internal technology deployment implications, and (ii) *Classification to categorize standard updates for customer notification* of project changes and certificate updates by levels of change. The criteria of classification and corresponding implications are translated into decision tree diagram for representation of the complete set of rules in Figure 5.

Figure 5: Collected expert rules for classification to categorize standard updates for internal technology deployment implications

4.4 Phase 4 - structural formulation of knowledge-based system for technology deployment planning of standard update

The proposed model for the knowledge-based system design using the knowledge audit analysis results is shown in Figure 6. Only critical and focus explicit knowledge as well as critical implicit knowledge found from the audit analysis are selected to be included in the knowledge-based system. Knowledge items with high criticality value exhibit the highest potential for knowledge management effort to capture.

The knowledge-based system model for standard updates is developed in Figure 6. It is designed by using the knowledge audit analysis results plus user requirements in each department. At the trial run stage, the system interface is built using an Excel form builder to display the necessary data fields and the overall layout flipping across the workspaces according to the designated system logic flow in Figure 7.

Figure 6: Proposed model for knowledge-based system design using the knowledge audit results

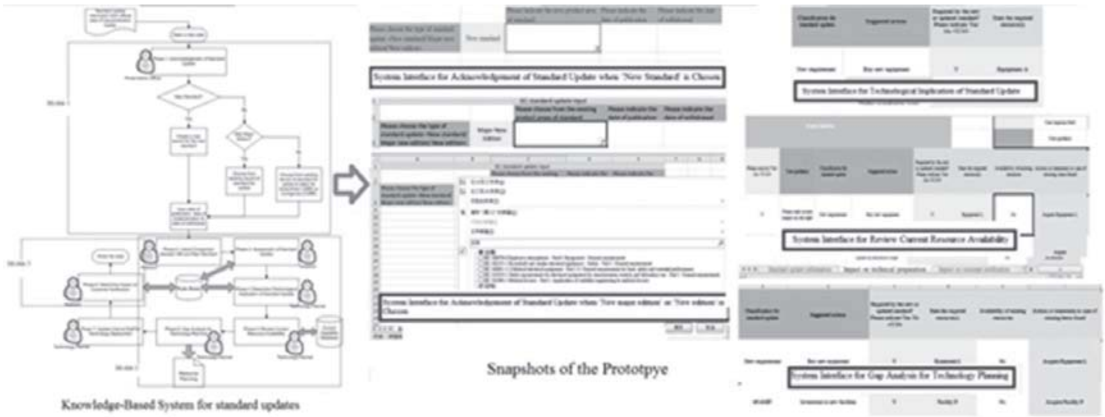

Figure 7: Knowledge-based system model of standard updates and logic flow

4.5 Phase 5 - system implementation and evaluation

System performance is evaluated with regard to usefulness and effectiveness by collecting user feedback from the case study through qestionnaires. The result in Figure 8 shows that it is generally agreed that the system is fairly useful. However, there are two areas that should be improved, which are insufficient prompt questions for elaborate condition filtering in the system and contribute to rigorous internal staff deployment for standard updating. The first is the time limitation for in-depth investigation into expert rules which prevents extraction of more sophisticated thought patterns of experts. The second is due to the system's infrastructural limitation to extend direct user participation for progress monitoring, reporting and performance feedback.

Statement(s)	Please indicate your degree of agreement with the statement(s) (5=Strongly agree; 3=Neutral; 1=Strongly Disagree)
1. The system interface is easy to use.	4
2. It is easy to understand how to input data with adequate instructions.	5
3. The input options to answer the prompt questions are valid.	4
4. There are sufficient prompt questions for elaborate condition filtering in the system.	2
5. The categorization result is shown properly and easy to read.	4
6. The results obtained are valid after finishing all questions in the system.	4
7. The data input for standard update in Module 1 of the system is useful.	3
8. The determination of technology implication of standard update in Module 2 of the system is useful.	4
9. The determination of impact on customer of standard update in Module 3 of the system is useful.	5
10. Recommendations from the system would be considered as useful to improve technology planning effectiveness.	4
11. The system can contribute to rigorous internal staff deployment for standard update.	2
12. The system can contribute to rigorous leveling of importance of standard update for customer notification.	4
13. I would like to use the system again in the future.	4

Figure 8: Evaluation result

5. Conclusions and discussion

In today's highly competitive business environment, especially in the Product Testing, Inspection and Certification (TIC) industry, fast moving standard updating poses an imminent challenge for testing laboratories in the industry to achieve effective technology planning and timely delivery of quality customer services, in light of the frequently changing standards from IEC information. However, according to the information collected through interviews, the major problems facing the industry are that there is a lack of knowledge to systematically perform technology deployment planning for standard updating so that internal staff members are fully aware of the necessary actions to be undertaken, and lack of knowledge to distinguish between levels of priority of standard updates that require customer attention so as to effectively customize the notification content for resource planning.

A framework for the development of a knowledge-based system is presented which attempts to provide a decision support capability in the formulation of the technology deployment planning strategy. It is used to support and improve the process performance in the testing laboratory. From the literature review, it is found that research related to the use of knowledge-based system method to solve the technology planning formulation problems in facilitating the resources allocation process for standard update has received relatively little attention. This research study provides a novel and feasible solution with regard to this. Analysis of special knowledge needs of testing laboratory for the technology deployment for standard update process is brought forth via knowledge audit. Unique method is proposed to analyze knowledge audit result so as to facilitate the design of the knowledge-based system and this bridges the gap between the two separate realms of knowledge. The proposed knowledge–based system methodology has been successfully implemented in a third testing laboratory. Overall performance of evaluation feedback is obtained after launching the methodology and prototype system through a case study. Positive feedback has been obtained and some areas for improvement are also identified for further enhancing the proposed knowledge-based system in actual environments.

In this paper, a knowledge-based system for standard updating has been proposed, demonstrated, and validated through a trial implementation in one of the top 5 TIC companies, and it has been proven that this system supports the decision-making process in technology planning and determination of the implications of standard updating upon customers. The Knowledge-based System makes use of rule-based reasoning (RBR) to collect expert rules and provide rule-based knowledge support in decision-making when standard updating occurs. It is recommended to be adopted by other Testing and Certification companies to improve the capability of the system by building up a hybrid knowledge-based system, which is a combination of rule-based and case-based reasoning.

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