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Conceptual Nuclear Decommissioning Knowledge Management System Design

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Abstract

In Taiwan, Taiwan Research Reactor (TRR) was shut down in January 1988, and a few nuclear facilities were accompanied to stop operation within Institute Nuclear Energy Research (INER). For the past a few years, INER dismantled continually its related nuclear facilities. For ensuring dismantling safety and efficiency reasons, Decommissioning Information Management System (DIMS) was developed firstly to record all activities during decommissioning project which starting with the planning, licensing, post-operation and finishing with radioactive waste management and storage. At the same time, a few assessment models also were built within DIMS; such as optimize workload model, dismantling cost assessment model and exposure dose evaluation model. Another goal of DIMS was to summarize the empirical data as the fuzzy if-then rule and apply Fuzzy logic inference engine in the planning predictions. Results indicated DIMS supported the decommissioning project rationally and the assessment models need more experiment data or projects to verify their accuracy. It is anticipated that DIMS will be an important reference base design for Taiwan decommissioning project of nuclear power plant in the future.

Besides, a lot of INER's nuclear workers approach retirement age and another important issue is efficient transfer nuclear knowledge to next generation. The artificial fuzzy-neural learning algorithm will be applied within DIMS to construct Decommissioning Knowledge Management System (DKMS) in next coming project. The paper describes DIMS architecture design, methodologies, development process and platform, the conceptual design of DKMS and some results.

1. Introduction

Decommissioning is the final phase in the lifecycle of nuclear facilities. For public health and safety reasons, a nuclear facilities need to be decommissioned at the end of its useful life. INER was planning to dismantle a lot of related facilities within INER's campus in the few years. Therefore, DIMS was developed to ensure the decommissioning project execution safety and rationally.

Like any highly technical endeavourer, the use of nuclear technology relies heavily on the accumulation of knowledge. This includes technical information in the form of scientific research, engineering analysis, design documentation, operational data, maintenance records, regulatory reviews and other documents and data. It also includes knowledge embodied in people - e.g. scientists, engineers and technicians. Effective management of nuclear knowledge thus involves ensuring the continued availability of essential reservoirs of both technical information and qualified people.

There are a lot of INER's nuclear scientists and workers will retire in the near future. In addition, in Taiwan, fewer young people are studying nuclear science, nuclear engineering and related fields at university level, and even sole university had given up their nuclear education. Therefore, transfer nuclear knowledge with efficient way becomes an important issue for INER's develop policy. DKMS was expected to deal with nuclear decommissioning knowledge acquisition, knowledge classify, knowledge storage, knowledge transform, knowledge disseminate and even knowledge discovery.

In this paper, Section 2 presents DIMS system development process and the key methodology of design. Section 3 presents the architecture of DKMS. Finally, in section 4, the conclusion and key direction for the future develop are provided.

2. DIMS system development

DIMS's main goal was collect decommissioning record and expected to be useful for the planning and execution of nuclear facility decommissioning project management and dismantling process. Therefore, all activities of decommissioning shall be recorded step by step. Following recommendation from IAEA (International Atomic Energy Agency), decommissioning project is carried out at three phases: Initial, Ongoing and Final [1]. For fulfill these principles, all related activities were grouping with system within decommissioning three phases as Fig.1 shown.

Phase / System	Initial	On going	Final
Dismantling Planning	1.Decision making 2.Cost estimate	1.Standard operation procedure 2.Risk monitoring	1.Performance report 2.Lesson learning
Exposure Dose Evaluation	1.Exposure dose planning	1. Exposure dose assurance	
Dismantling Support	1. Dismantling tool assessment	1.Dismantling development	
Health and Safety		1.Personal dose monitoring 2.Area radiation monitoring	1. Health and Safety final report
Decontamination Management	1.Decontamination method assessment	1.Decontamination executive &development	
Human resource/ Procurement	1.Organization planning 2.Staffing	1.Team work development 2.Source selection	1.Source list 2.Accounting record
Surveillance & Security		1.Vision monitoring 2. Access control	1. Video file and entrance record
Radwaste Management &Analysis		1.Radwaste categories 2.Quantitative analysis	1.Radwaste shipment report
Radwaste Storage &Final Repository			1.Radwaste acceptance criteria

Fig. 1. The activities of the decommissioning project

2.1. Requirement acquisition

For more detailed define system requirement precisely, development team referenced Standard operation procedure (SOP), regulations, and interview with nuclear knowledge workers (as Fig.2. shown). Next, based on the system requirement, object oriented analysis and structured analysis techniques were adapted to analysis data and workflow (see section 2.2). There are twenty-eight activities which contain dismantle process workflow and information needed to implement by nine systems to meet the system requirement specification.

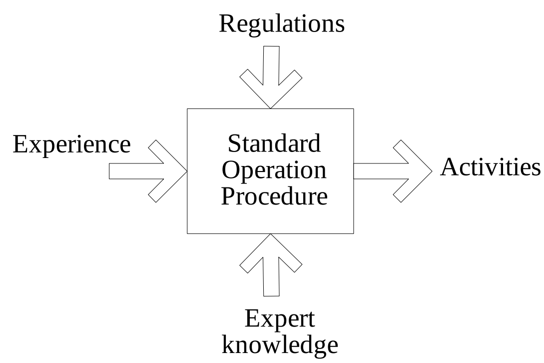

Fig. 2. Activities and requirement acquisition

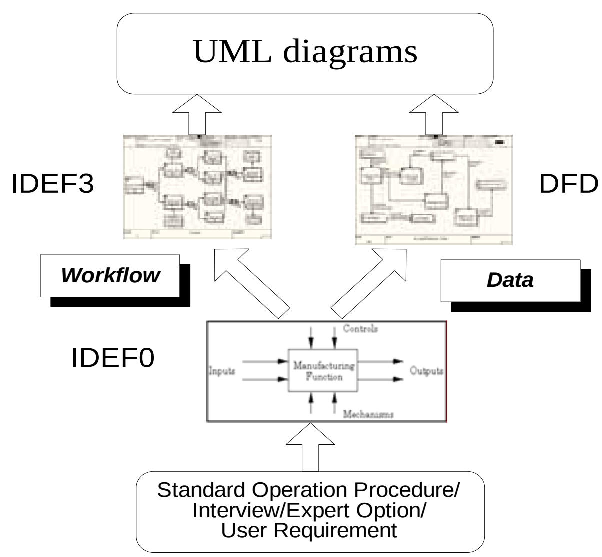

Fig. 3. System flow and data analysis diagram

2.2. System analysis

Unified Modeling Language (UML) is a widely adopted for requirement analysis and design tool in object-oriented analysis. But sometimes UML is not easy for analysis workflow-based system requirement, and users are not familiar with UML models, such as use case diagram, class diagram and dynamic diagram. Therefore, Structured Analysis and Design Technique (ex: IDEF0, IDEF3 and DFD) were adopted firstly in this project to analyze all activities of the decommissioning project. Then, transfer the results to UML diagrams for implementation use. The system analysis diagram was as Fig.3 shown.

IDEF0 stands for Integrated DEFinition Language, which is a methodology for describing, managing and improving complex processes and systems. IDFE0 models can help to organize the analysis of a system and to promote good communication between the analyst and the customer.

IDEF3 model is a process flow modeling that graphically describes and documents processes by capturing information on process flow, the relationships between processes, and important objects that are part of the process. As such, it is generally performed IDEF0 in the early phases of a project for acquire user requirement, followed by IDEF3 modeling for data collection and process modeling. DFD describes data processing functions; data used or created by the data processing system; objects and data processing tables.

2.3. Implementation

According to the UML diagrams and the system architecture of DIMS (as shown in Fig.4.), programmer's implemented nine systems with object oriented programming (OOP) tools and relational database. At the same time, a few assessment models were built in model base with Fuzzy Logic and inference engine was useful for decision-making and planning prediction in initial phase.

The activity models and data model diagrams were implemented by using AllFusion Process Modeler software. System implement platform and software development tool adopted Microsoft .NET framework and Visual Stduio.Net 2003. For the development of interactive user interface, the technology employed is Microsoft ASP-based IIS. Cost assessment model used standardized cost listing [2] and considered using parametric cost estimating [3] or Hybrid Decommissioning Cost Estimation Model next year. So far, web-based dismantling support system, surveillance and security system and Heath and safety system (see Fig.5) were completed firstly with six months and two part time software engineers in the end of 2004.

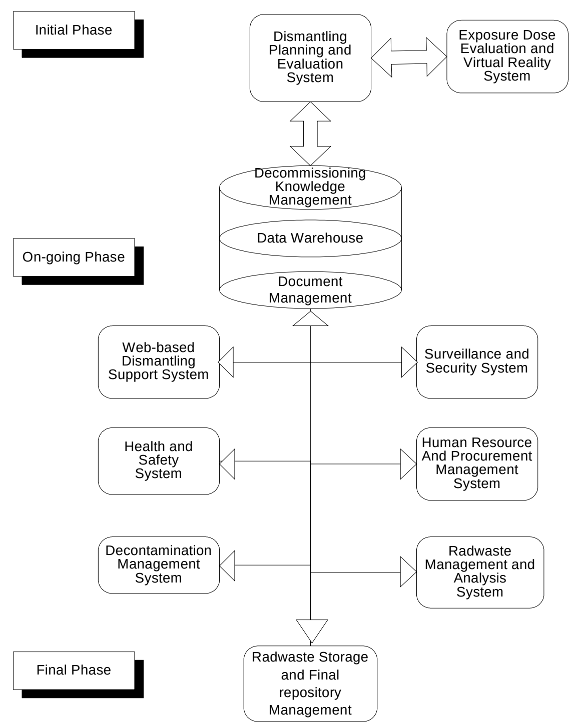

Fig.4. System architecture of DIMS

Fig. 5 User interface of health/safety system and web-based dismantling support system

3. Architecture of decommissioning knowledge management system

Knowledge Management is a discipline that provides strategy, process and technology to share and leverage information and expertise that will increase our level of understanding to more effectively solve problems and make decisions [4]. So far, results indicated DIMS could improve quality of dismantling task and storage all the decommissioning project empirical data. Therefore, based on the framework of information management system as known DKMS with the learning mechanism was proposed to management decommissioning decision-making and knowledge management.

3.1. Functional Overview

For the ability to flexibly apply tools and keep overhead to a minimum, DKMS adopted layer architecture which consisting of the knowledge and information layers as shown in Fig.6.

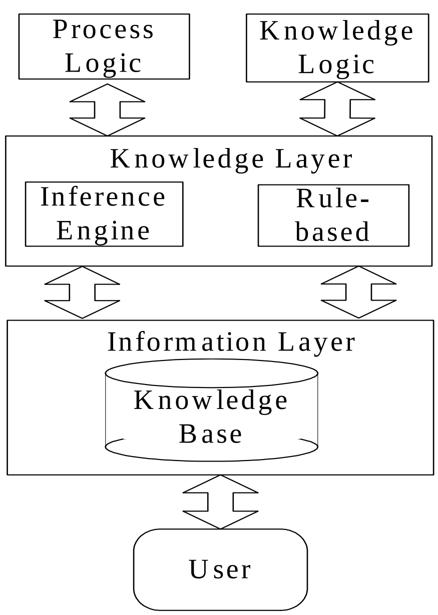

Fig. 6 Layer architecture of DKMS

The top layer- knowledge layers contain decommissioning intellectual assets and knowledge, which should be organized by an appropriate taxonomy. With the enhanced learning capability via training data, the Neuro-Fuzzy will be applied as inference engine to create and discovery knowledge. Rule-based fuzzy if-then mechanism constitutes a knowledge representation from empirical data. In other word, this layer was designed to in charge of decision-making and knowledge reasoning for decommissioning project.

The bottom layer- information layer contains all decommissioning activities information and prediction models that were implemented by DIMS. In other word, DIMS was in charge of maintaining information, capture knowledge, and classify knowledge and knowledge dissemination within knowledge management system.

3.2. Knowledge inference and decision-making

Knowledge and decision-making are closely linked. Decision-making may be broadly construed as the process of selecting from a set of options the alternatives that are most likely to lead to desired outcomes. The process entails various steps and stages that decision-makers engage in, either explicitly or implicitly [5]. A key knowledge management challenge in the context of decision-making is to surface tacit function elements that are often not apparent, but which are crucial for improving decisions and their resultant outcomes [6]. An additional need in organizations is to document the thought process behind decisions in a format that can be easily reviewed by those who wish to contribute to an ongoing decision or to understand the guiding rationale behind choices already made [7]. In addition, shared frameworks are also needed to enable double-loop learning for improving the quality of the decision-making process itself [8].

Based on these considerations, we identify the following steps that comprise the knowledge inference and decision-making process, and delineate the issues that are typically relevant during each step [9] [10].

3.2.1 Step 1: Define problems

The main objectives of this step are understanding the problems that are to be resolved, and identifying sources of knowledge. What is the situational background within which the decision or knowledge is to be needed? Is there a sense of context that provides the perspective needed for effective decision-making? Results, events, outcomes, information and such other elements impinge on our awareness and create a need for changing or improving a situation. It is important that a sense of context be provided within which the details of the process can be understood.

The outputs of this step are a specification of the context and a statement of goals. Goals and objectives are often defined in a hierarchy, in terms of multiple objectives contributing towards a parent goal. If the problem is not clear, the process is seriously handicapped by a lack of direction and focus.

3.2.2 Step 2: Conceptualization and integration of knowledge

Based on the problem definition, it is necessary to extract the knowledge, and determine the relationships between condition and if-then rule.

In many situations, this step result is a choice from among two or more options. While some options may be obvious in a given situation, the generation of non-obvious or creative options is often neglected, due to time pressures and other reasons, leading to sub-optimal decisions [11].

3.2.3. Step 3: Formulation of the knowledge model

Knowledge or process logic is typically made in this step. Consideration of risks and uncertainties is also a critical part of real world. It is often helpful to consider various hypotheses or predictions in order to identify options and to assess how they might play out under various scenarios. Neuro-Fuzzy was applied to inference uncertainties and learning schema. Facts or real data can be upgraded with a feedback loop mechanism.

3.2.4. Step 4: Select the best the option

This step pertains to the actual making of a decision, the other steps so far being preludes to this act. Selects one or more options that will best contribute, singly or in combination, to the goals or objectives that define the problem, and which are compatible with relevant factors, assumptions, reasons and other variables. The output of this step is a selection, i.e., the decision that will contribute most optimally to the goals made explicit in Step 1.

The choice of the best options in a given situation assumes that the selection has some requisite content or domain knowledge that will help them evaluate all the variables of interest and arrive at a conclusion.

3.3. Implementation consideration

DKMS has two layers need to be implemented. The information layer was built by DIMS as described above. The second layer-knowledge layer, INER develop team plan to adopt commercial software tool - FuzzyTECH 5.5 to build Fuzzy rules and Neuro-Fuzzy inference engine. For the development of interactive user interface, the Microsoft ASP-based IIS and web-based technology will be employed.

4. Conclusion

Both DIMS and DKMS are two continuous stage systems within INER's decommissioning project. DIMS was designed to be a dismantling workflow and information system for ensuring process safety and executive effectively. However, main target of DKMS is to provide a nuclear decommissioning knowledge management system for next generation.

This paper provides the concept of knowledge management system for nuclear facilities decommissioning project. In particular, we presented a conceptual design and knowledge inference process for organizing decommissioning knowledge based on the previous decommissioning information system. We have also described the architecture and design methodology of DIMS in the fist part. Results indicated DIMS supported the decommissioning project rationally and DKMS need to be realized in the near future.

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