Standardization of Spent Nuclear Fuel Information Management Using Semantic Web

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1. Introduction

Recently, 20 light water reactors and 4 heavy water reactors in Korea generated a total of 750 tons of Spent Nuclear Fuel (SNF) every year [1]. At the Wolseong Nuclear Power Plant (NPP), one of the domestic NPPs, the amount of SNF in At Reactor (AR) storage's capacity has already saturated [2]. SNF is a high-level waste, which requires long-term management because it has a nuclide emitting alpha rays with more than 20 years of half-life [1]. To manage and dispose of the SNF in Korea, the regulatory body is trying to build Away From Reactor (AFR) storage facilities and final disposal facilities in the country. Institutions relevant to SNF management will demand an SNF information DataBase (DB) to perform this management and disposal.

The process from Uranium mining to the restoration of its natural state is called a "nuclear fuel cycle", and Figure 1 shows its process [3]. The process shows that there are various stages before the disposal of SNF. Fuel goes through this process and generates a lot of data required for SNF management.

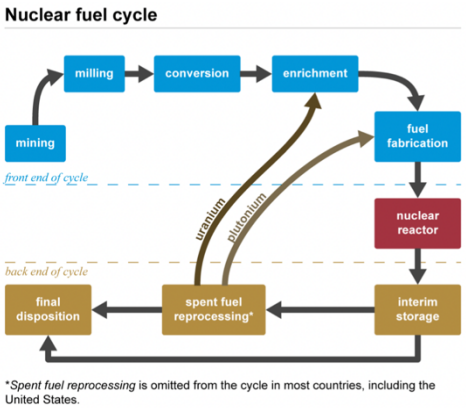

Fig 1. Nuclear Fuel Cycle [3].

Institutions should manage meticulously and for a long period due to the nature of SNF data, and this management requires more than 100 years of operation and maintenance. To satisfy this long-term and meticulously management, the quality of work should not be degraded even after a change in personnel, such as a change in the worker of the institution after several decades. Therefore, even if future generations do not go through special documents or data, it is necessary to standardize the SNF information to the extent that they could recognize and understand it. Namely, DB structure and contents should have a standard structure and terminology for easy recognition by all relevant communities.

We would like to introduce a new DB model using Semantic Web technology to meet the above-mentioned standard. The meaning of the Web here is a mass of data bundles in which is an entanglement of various information.

2. Methodology

In section 2, we describe the existing DB, what needs improvement in the existing DB, and a brief definition of Semantic Web and Ontology. Finally, we describe how to apply this system to SNF information DB.

2.1 Structure of DB

The Existing DB structure lists data simply according to categories. In other words, the existing DB has a deployment method in which several inferior data under the superior data are listed according to the DB writing criteria. Figure 2 shows the existing DB structure.

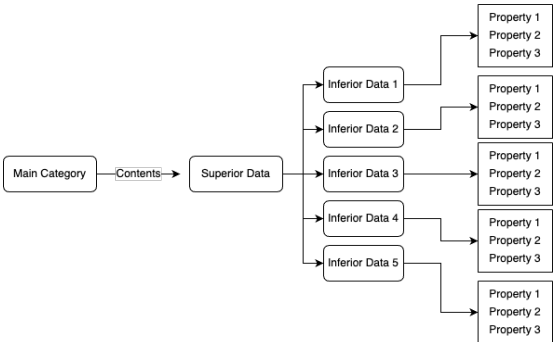

Fig 2. Existing DB structure

As shown in Figure 2, the existing DB spreads all inferior data equally within superior data. However, in this spreading, each inferior data also has another inferior information such as its information or property. For instance, if inferior data is fuel, inferior data will have a fuel's information or property under itself (e.g., physical property, specification, special consideration). Eventually, this structure is not suitable for information management because it increases the amount of data to be managed. Moreover, if a user wanted to find the desired property in DB, he/she would search all data within inferior data until the desired target is found.

At the same time, all inferior data have common characteristics because they are informed about the same superior data. However, users could not recognize them at once due to this structure. Users should look for all data within the superior data to recognize common characteristics.

As a result, the existing DB structure needs improvement because it causes a challenge of searching too much data to get the information.

In Addition, since an institution could construct a DB that fits its internal purpose, it is necessary to consider the situation in which the information handling method and terminology differ from other institutions. This is another reason why standardization of structure and terminology is necessary for DB.

To solute these problems, an improved DB model is required, and it should be standardized to prevent conflicts between institutions and transfer the knowledge to future generations. Hence, this paper proposes a new DB standard structure using Semantic Web Technology.

2.2 Semantic Web Technology

We select Semantic Web technology as a key to overcoming the problems of existing DB. It is a new technology that computers, as well as humans, can recognize the structure, the meaning of data, and the process. In the traditional web, humans only could understand the meaning and relationships between the information, but Semantic Web could make it possible that systems to understand underlying information. Therefore, Semantic Web is suitable for a type of information management model that does not need to be managed by humans.

To construct the information system, Semantic Web uses the knowledge expression system called Ontology [4]. By constructing Ontology for SNF management, the DB constructor could remove problems of the existing DB. An ontology consists of 4 factors such as class, instance, property, and relation.

Table 1. Ontology's Four Factors [5].

Term	Mean	Example
Class	Concept of thing	Nuclear Fuel
Instance	An individual entity	PLUS 7
Property	A specific feature of class or instance	Length of Fuel Pin
Relation	Relationship between classes or instances or class and instance	PLUS 7 is supplied to OPR1000 and APR1400 and is related to OPR1000 and APR1400.

We already know that "nuclear fuel" is a concept of thing used for nuclear power plants in the real world. In Table 1, PLUS 7 is an improved type of fuel developed by KEPCO Nuclear Fuel Co., Ltd (KNFC). In other words, PLUS 7 is an individual entity. Nuclear fuel has several properties and one of the properties is "length of fuel pin". APR1400 and OPR1000 use PLUS 7 as the main fuel. So, PLUS 7 gets the relationship with APR1400 and OPR1000.

Figure 3 shows the structure of the Ontology. However, in Figure 3, there is no expression of the relationship between data. The main category has a class (superior data), and the class has some properties (properties 1, 2, 3). These properties indicate the class's features. All inferior classes (inferior data) have common characteristics (e.g., properties 1, 2, and 3). Thanks to this simple structure, the amount of data to be managed is decreased when building a DB with data of the size shown in Figure 2. Through this improvement, users could easily recognize and understand contents in DB and common characteristics of superior data.

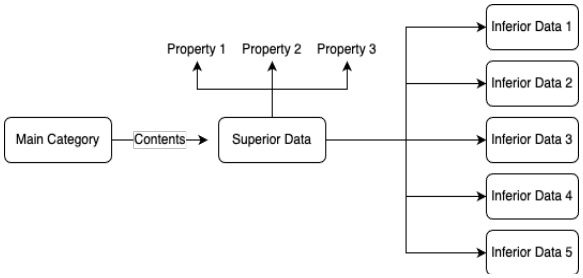

Fig 3. Ontology Structure

2.3 Application

For the application of Semantic Web technique, we use an Ontology constructing program named Topbraid Composer. Topbraid Composer is the most famous tool to be used to model Ontology. It has been widely used all over the world due to its high reliability. By using this program, we construct a sample web to demonstrate the concept of Ontology.

We construct a DB structure such as Figure 3, and Figure 4 shows that it is the hierarchy. When this hierarchy is applied to SNF DB, "integer" properties become physical properties about SNF such as fuel's length, weight, or density. "String" property becomes a description of SNF information such as special consideration or fuel manufacturer. However, keep in mind that this is just a conceptual explanation for the application of Semantic Web technology.

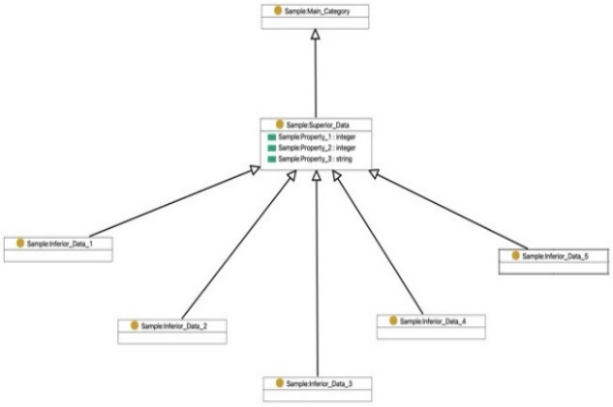

Fig 4. Ontology implementation using Topbraid Composer

As the amount of data is increased and contents become more specialized, the DB structure shape becomes more hierarchical and more complex rather

than in Figure 4. In addition, each data could get a relationship with other data through constructed Ontology. In order not to make an error in these in-depth approaches, we always should consider the data's features and procedure of SNF management.

While adhering to the method of this paper, we proceed to standardize SNF DB based on Semantic Web technology.

3. Conclusions

By changing the existing DB to the Ontology structure, we expect to solve the problems of the existing DB. And this new model based on Semantic Web technology, which overcomes problems, is suitable for the SNF information management DB that is huge and requires accuracy. As time goes by, institutions for SNF management will need continuity about SNF management and will increase the amount of data. To meet them, we believe that the application of Semantic Web technology will be mandatory more than ever.

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