Strategies for collaboration and resource sharing in building intelligent digital libraries

- Not everything is technical : Lessons from Korean Research Memory (KRM) Project

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1. The Korean Research Memory in Korea Research Foundation

Korea Research Foundation (KRF) is a government agency under the Ministry of Education, Science and Technology that perform research support and management for researchers in research institutions like universities. Its Korean Research Memory (KRM) is a system that collects the research outputs in humanities, social sciences, and arts and sportsciences into a database to serve expert researchers, such as graduate students and above.

The foundation's research funding budget is about 350 million US dollars in the year of 2008, supporting more than 5000 research projects to produce significant outputs. KRM system was designed from the need to manage and share systematically the research outputs or raw data obtained or created during the projects, which had been lost and abandoned after the research. Therefore, the main items that KRM system wants to collect are raw data such as sound recordings, photographs, video, numeric data, rare documents, relics, and folklore materials, and this characteristic makes KRM different from other systems which center research outputs.

To establish KRM system, the foundation after conducting a pilot test in 2006, formed database working groups for 7 areas in January 2007 (philosophy-religion, history, social science, pedagogy, Western language and literature, Korean-Eastern language and literature, arts-sports), targeting universitys and other research institutions to construct the information system (Table 1). KRM system had officially began its service on August 31, 2007.

Table 1 : Management status of annual DB construction of KRM (unit: 1 Mill. ₩)

Classification		Year of 2006	2007	2008	2009
Budget	DB Construction	1,690	2,530	2,470	1,470
	System Construction	2,110	1,470	1,330	530
	Budget Total	3,800	4,000	3,800	2,000
Supported Budget per Division		Within 400	Within 400	Within 400	Within 400
Number of DB Construction Divisions		7	9	8	9
Project Period		10 months	7 months	8 months	1 year

The roles of the DB Construction Division are as follows: 1. To collect data of outputs from research projects that were supported under the Academic Research Promotion Project; 2. To collect data from general research studies which were found to have high academic value; 3. To digitize and input the metadata, as well as to inspect the collected data; 4. To construct a DB of term data registry in the fields of humanaties, social sciences, and arts and sport science; 5. To secure copyright agreements for the entire collection of data etc.

The DB Construction Division has 1 senior research engineer, approx. 20 members who are regular research engineers and doctoral-degree associate research engineers, and another group of approx. 20 research assistants currently engaged in Master's and Ph.D. programs. The senior research engineer is responsible for the general operation and management of the project, while the regular research engineers are collecting and screening data according to their respective professional backgrounds. The associate research engineers are the core part of the division. Based on their professional understanding, the associate engineers make an overall configuration regarding the value, content, specialty and reference compared to existing data, to finally construct a database of especially high quality. The research assistants build up the metadata. As they input the data, based on their special knowledge, they take great care to use exact and proper subject terminology, subject classification, and term data registry. Their other duty is to create links between data by deciding the paths to be performed during each project, as well as to inspect the relations between the data. As of April 30, 2009, KRM has 95,806 datasets from 11,810 research projects (Table 2).

Table 2 : Data sets of KRM (April, 2009)

	Books	Reports	Statistics	Journal articles	Rare/ old documents	Rare/old books	Photos / images	Videos	Sound recordings	Web-sites	Newspaper Artide	Sheet/ leaf materials	Total
Metadata	2,017	9,276	913	21,169	7,407	1,632	3,571	1,224	879	93	2,248	6,070	**68,380**
Full-text	1,788	10,162	3,298	19,229	10,272	4,190	62,276	6,217	346,925	1,211	3,976	26,262	**495,806**

2. KRM Database

2.1 Structure of KRM database

KRM system consists of three sub-systems: KRM database, open archive system and term data registry. The most important one is KRM database based on FRBR concept model, so in this study, the structure of KRM database and its search screen shots are discussed.

2.1.1 FRBR concept model introduction

The foundation's research projects often make various different types of research outputs from a single project and the file types and the numbers of files created vary from one to several hundreds or thousands. Therefore, the existing cataloging approach that describes bibliographic information by identification of the content and the media of information, has a structural limitation in describing the complicated structure of research outputs in various types and media.

To solve this problem, KRM system adopted FRBR (Functional Requirements for Bibliographic Records) model which can freely represent the conceptual aspect and the physical aspect of information resource and suggests hierarchical network structure as metadata structure that can describe the relationships among each material properly.

The most distinctive characteristic of FRBR model is that it divides bibliographic information into 4 objects, Work, Expression, Manifestation, and Item to present hierarchical cataloging structure. It also makes it easy to establish relationship for each

level and strengthens the relationship due to the easy vertical and horizontal transfer.

There are three purposes in the introduction of FRBR model into KRM.

First, users can choose the exact version of materials they want and access to all the levels of bibliographic objects by providing hierarchical cataloging in logical level. Second, it enables the retrieval of all the related research outputs based on the definition of its relationships by creating catalogues with link structure.

Third, users can move to the other information they want directly because it strengthens the linking functions to all the possible linked information and changes the search procedure from the current linear structure to the network structure.

2.1.2 Application of FRBR conceptual model

To achieve KRM system's objectives, three approaches suggested in FRBR model were applied.

First, for the hierarchical cataloging at a logical level, the research output information which is stored in the database was defined by Work, Expression, Manifestation, and Item as suggested in FRBR Group 1. This allows identifying individual objects independently to differentiate creative intellectual contents from media information and to enable access to each object.

Second, for the link-based cataloging, considering research projects as Work, the top level, this system introduced link structures of research outputs vertically and horizontally by identification numbers assigned to each research project, which is a Work. This enables to retrieve all the research outputs produced by research projects in group and retrieve all the research outputs related to a specific research output according to the relationship defined.

Third, for the link function of all possible linking to all the information, the system introduced a bridge structure between Group 1 and its actors defined in Group 2, connecting to the integrated researcher information database and the institution information database. It also connects to the research area classification and the data registry system, which is Group 3 in FRBR model. These links make it possible to access to all the research outputs by a specific researcher or by an institution as well as to those related to a specific subject element.

2.1.2.1 Introduction of hierarchical cataloging structure

Figure 1 shows the applied FRBR model in KRM which includes FRBR's Group 1, Work, Expression, Manifestation, and Item. KRM's corresponding objects to Work, Expression, Manifestation, and Item are the following.

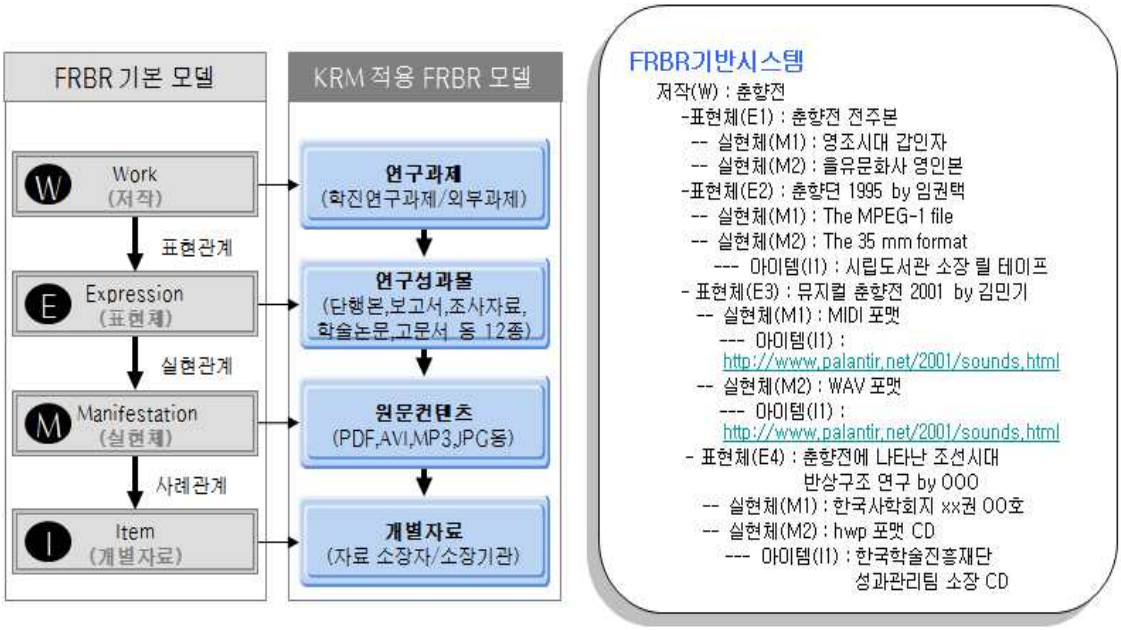

Figure 1 : FRBR application to KRM

(1) Work: Research Project

The concept of Work in FRBR is an abstract object having originality intellectually or artistically. In the KRM system, the concept of Work as an abstract object of intellectual or artistic research outputs and individual research projects are considered as Work. Each research project contains abstract conceptual information about the research and it has a unique identification number which can be a linking device between research outputs so that all the research outputs from the project can center on it. The subject concept of research activities, an abstract object of intellectual or artistic research outputs, is included in Group 2 and Group 3 connecting to research area classification and data registry.

(2) Expression: Research Outputs

The concept of Expression in FRBR is intellectual or artistic realization of a Work. KRM system define the concept of Expression as all the research outputs from a research project and it includes 12 types of resources: reports, journal papers, monographs, newspaper articles, sheet/leaf materials, rare/old documents, rare/old books, videos, photos/images, sound recordings, statistics, and web sites. It also separate metadata formats for each type of Expression. KRM referred to national and international metadata sets to derive metadata formats for each type of materials. They include Dublin Core, KERIS' Scholarly Object Metadata Set (SOIMS), Korea University's MODS (Metadata Object Description Schema) and METS (Metadata Encoding and Transmission Standard), TTA's groupstandard metadata for registered type, and others.

While KRM decided types of materials in Expression, the same ambiguity issues regarding the definition of Expression and Manifestation and the borders among individual objects, which have been raised as problems in FRBR model. For example, among the types of resources, reports, journal papers and monographs should have been categorized as Manifestation because they are considered as media-based according the definition of FRBR model, but KRM classified them as independent Expression objects.

The reason for the mixture of Expression and Manifestation in KRM is that reports, journal papers and monographs are considered as major resource types and generally expected to be together with other resource types like videos, photos/images and sound recording, which are Expression objects.

(3) Manifestation: Full Text

The concept of Manifestation in FRBR is physical realization of Expression. In KRM, it is a file in which a research output is converted into digital media and saved. The file formats were decided by media types: PDF for text, AVI for video, MP3 for sound, JPG for image and SAV for statistics. In KRM, it is a principle to handle individual file unit enabling independent identification of Manifestation files, but in the case of many files with different serial numbers but still with the same content, it provides a meaningful layer to group files even inside Manifestation objects to avoid duplicating input of repeated values.

(4) Items

The concept of Item in FRBR is a single physical object item among many resources. KRM's Item is defined as individual objects of physical data in research outputs, includes geographic information and holding information of physical data/resource. Table 3 summarized the objects in Group 1 applied to KRM so far.

Table 3 : Objects in Group 1 applied to KRM

	Work	Expression	Manifestation	Item
FRBR Concept	Intellectually & Artistically unique creation; abstract objects	Choosing of a work & artistically materialize	Artistical materials becoming physical	Singular physical object among datas
KRM Application	Research Subjects supported by KRF or other organizations	Results produced through research	Research results digitally converted & saved file	Research results' genuine data about individual objects
Targetting objects	KRF Research Subjects Outside Research Subjects	Reports Journal Papers Monographs Newspaper Articles Sheet/leaf materials Rare/old books Videos Photos/images Sound recordings Statistics Websites	PDF JPG AVI MP3 (Etc.)	Actual data's location information Actual data's storage information Data copy information
Service Title	Research subject	Research result	Original contents	(Individual data)

2.1.2.2 Introduction of link device among research outputs

For a consistent linkage in bibliographic relationships of Work, a stable link device is required. KRM took a simple but unique research project number that has no other forms as its link device.

And at the horizontal structure at the same layer, it allows retrieval applied by relationship types suggested in Dublin Core. At the same layer relationship, 6 types of relationships are possible: previous work, later work, whole of, part of, revision, and related.

Figure 2 shows that all the Expression and all the Manifestation from two research

projects are centering on their research project via the link device numbered 001 and 002 which are their research project number. It also shows that, via A type relationship, even if they are not from the same research project, related research outputs for a specific one can be retrieved based on the defined relationship among them.

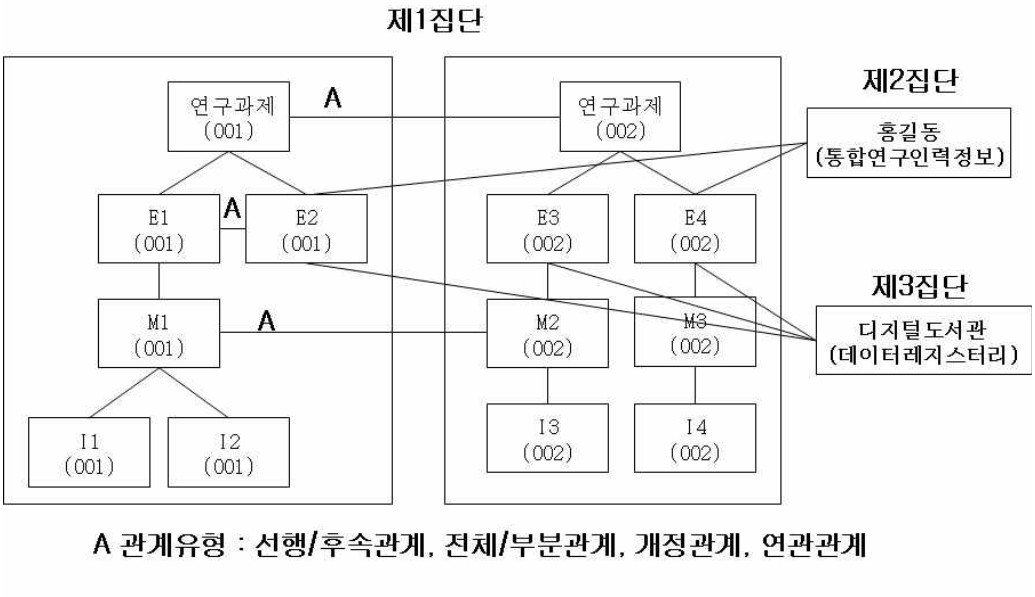

Figure 2: Inter-relationship structure of KRM

2.1.2.3 Group 2 and Group 3 Relationship : linking to reference database

For Group 2 and Group 3, FRBR model merely suggest Group 2 is Group 1's actor and Group 3 is Group 1's subject relationship, not mentioning about the reference function of them. To apply Group 2 as Group 1's actor, KRM made links to integrated researcher information database and institutional information database created by Korea Research Foundation as the reference database. As a result, it is possible to access to all the research outputs by a specific researcher or a specific institution. To apply the subject relationship such as concepts, objects, events, and places in Group 3, KRM made links to Korea Research Foundation's research area classification and data registry system established in 2007, which enables to retrieve all the research outputs related to a specific subject element.

Figure 2 shows that Expression E2's author Hong, Gildong is linked to the integrated researcher information database to show Expression E4 which is an output from the same author's another research project. It also shows that a subject term of Expression E2, digital libraries is linked to data registry system to retrieve Expression E3 and E4

which are from other research projects.

2.2 Example of KRM Search

2.2.1 KRM search concept

Figure 3 is a concept map showing how to search research outputs from a research project titled Digital Cultural Map Development of Joseon Dynasty and Its Application. It also shows how to retrieve its principal investigators, related other research projects and relationships with other research outputs based on the linking system.

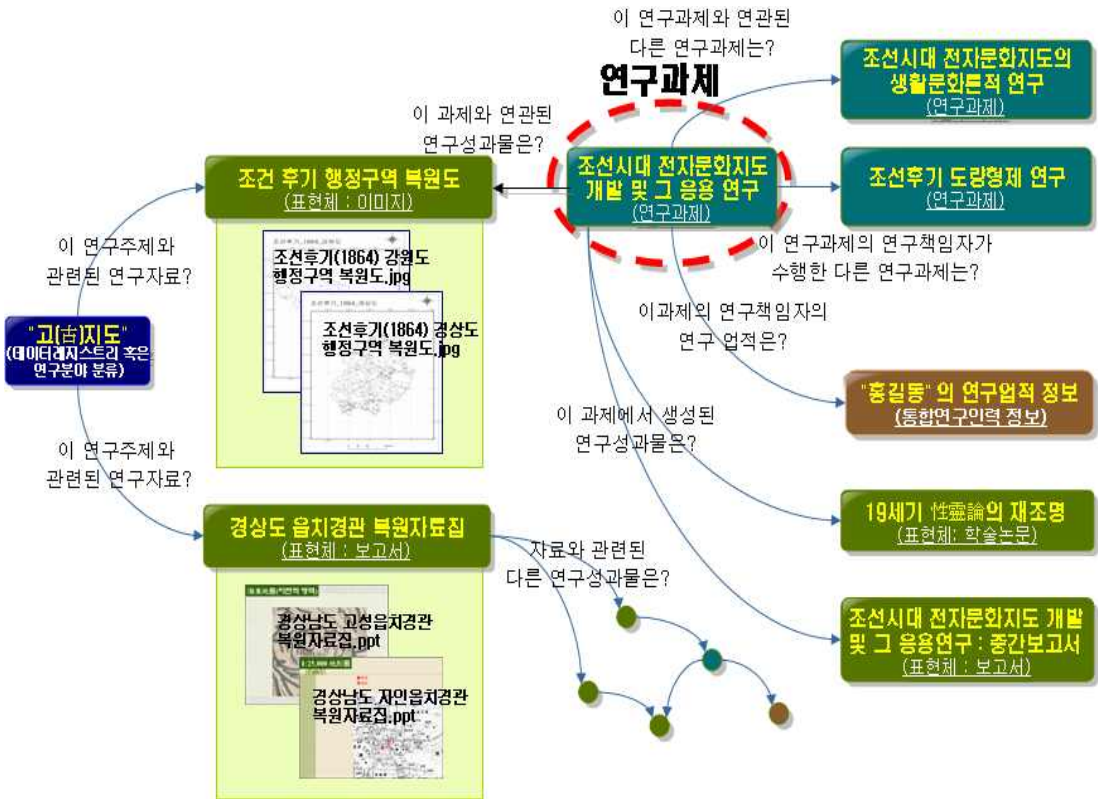

Figure 3 : KRM search concept

2.2.2 Screen shots of KRM database search

Figure 4 is a screen shot of KRM research output retrieval system resulted from a

query, Renaissance. If you click Shakespeare and Renaissance Discourse of Madness among the results to show the summary of the research project, it shows not only simple summary but also the fact that there are 8 Expressions (research outputs) and 640 full texts which are Manifestations.

In addition, each numbered menu has a link for direct access. KRM system enables users to access to three layers of information (research project, research outputs, and full texts) from any material.

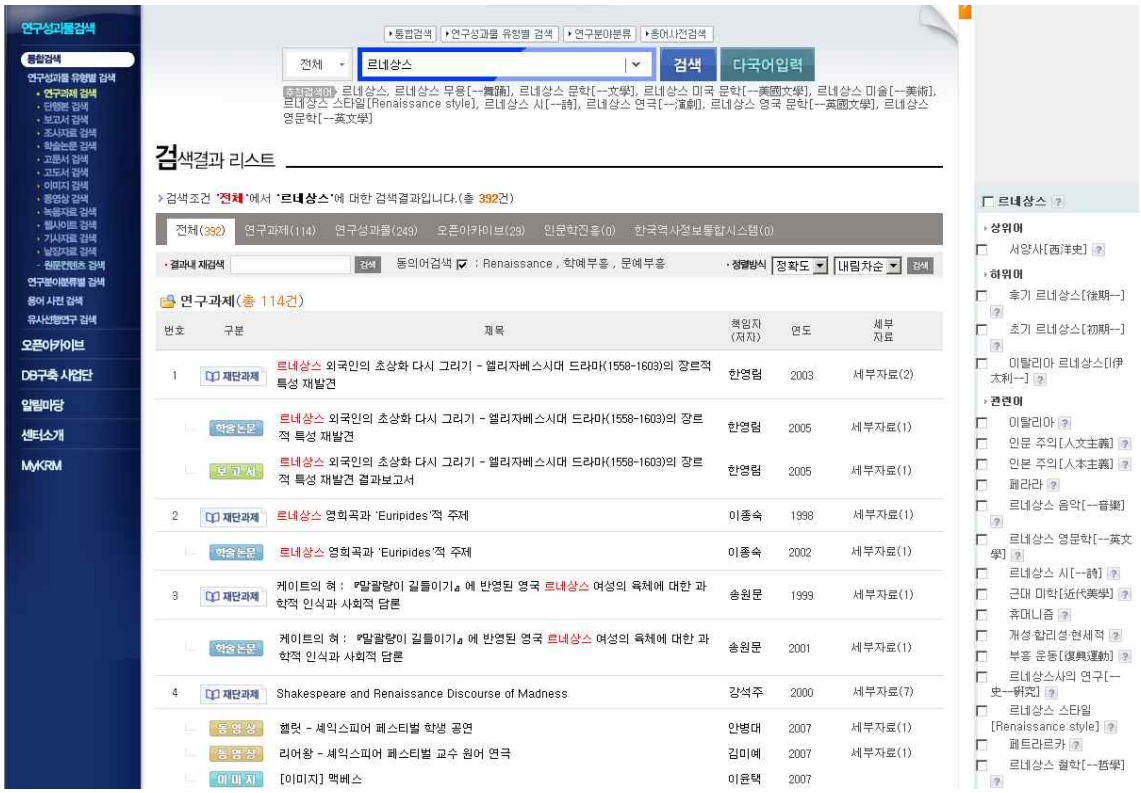

Figure 4 : Search result of 'Renaissance' in KRM

Figure 5 is a screen shot of the detailed view of the research project, Shakespeare and Renaissance Discourse of Madness. Author, institution, subject classification, subject terms have links respectively to allow viewing all the information regarding the author, the institution, and the subject matter. Below the detailed view of research project, it displays research outputs (Expression), full text (Manifestation) and related research projects.

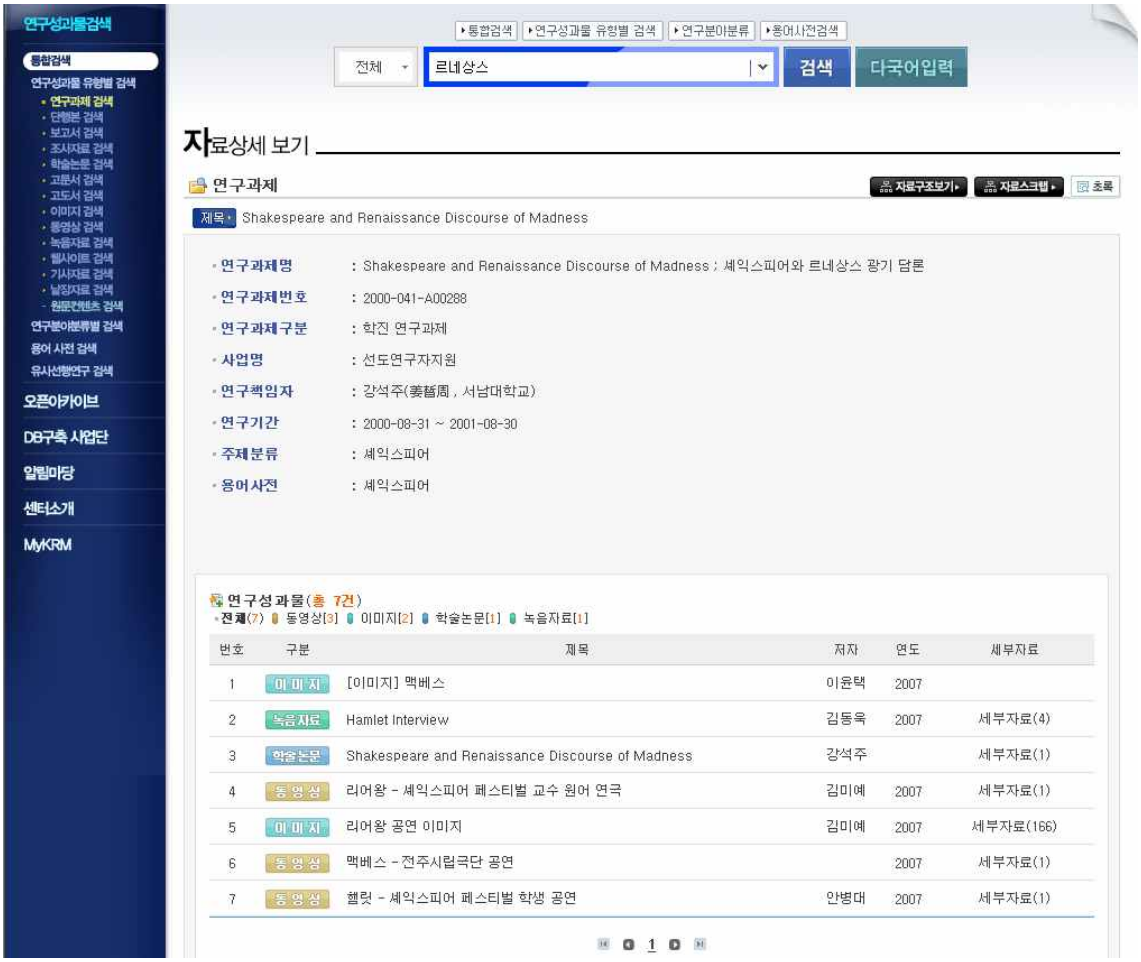

Figure 5 : Details on research subject

From the research outputs, if you choose [photo/image] King Lear Image, the detailed information of Expression appears like Figure 6. The upper screen of Figure 6 describes the detailed information about the photo image and the lower screen shows the actual contents of Manifestation.

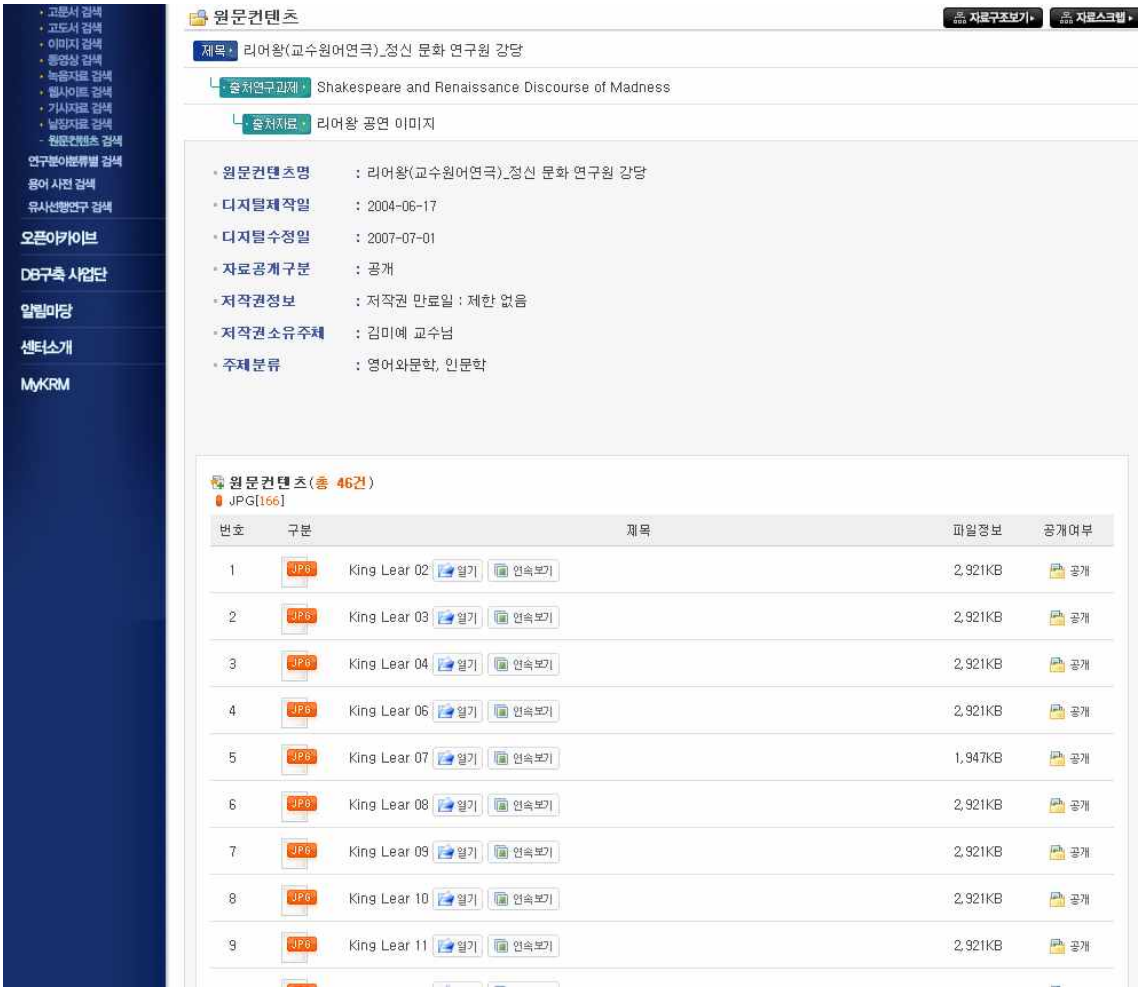

Figure 6 : 'Expression Photo/Image' information

3. KRM Ontology

The ontology system of KRM is constructed in order to support semantic relationships, as well as semantic search of research results from KRM database. From 2006 to present, this system has been in construction, with consideration of culture and society terminology selection (See Annex for further details), data registry design, construction system development, terminology creation, relation to KRM research study metadata, etc. The design and construction project proceeded in steps in order to allow the traditional thesaurus and the structure of the terminology data registry to be extended to a formal ontology system.

Table 4: Construction steps of KRM ontology

Semi-informal Ontology		Semi-formal Ontology		Formal Ontology
Traditional Thesaurus		Ontological Thesaurus		Practical use of Thesaurus on Facet Concept
Controlled Vocabulary BT, NT, and RT Concept	⇒	Thesaurus on Extended Facet Concept	⇒	Design to examine the class, relationship, function, axiom and instance, and to apply search systems, etc (Knowledge Base)
		Step 1, 2 Term Data Registry		Step 3 Ontology in fields of humanities, social sciences, arts, and sport sciences

3.1 Design of KRM ontology

Based on the ISO 2788, ANSI/NISO Z39.19 Standards, as well as on class, property, instance and relationships that are able to express the ontology, terms with conceptual specialty are classified as “Classes”, categorized, and afterwards sorted according to their conceptual properties. The relationship between the terms is linked with the relation property and concept property, in order to finally build up the knowledge system.

Table 5: Design of KRM ontology

Term Property	Concept Class	Relationship
▪ Of the terms: – Name in Korean, Chinese Characters, and other foreign languages – Definition – Footnote – Spheres per scholar and subject ▪ 7 Related properties for term definitions	▪ Name Class (10) Substantial Class (7) Abstract Class (15) : 3 Categories, 32 Classes : Approx. 160 Sub Classes ▪ Subdivided Class Conceptual Properties (83) ▪ Definition of Restriction Rule and Property Type ▪ To be extended / Further Extension Available	▪ Basic Relationship: Equal (Use, UF), Hierarchy (BT, NT), Connection (RT) ▪ Extended Relationship: 3 types of Relationships of Hierarchy (Subordination, Entire/Portion, Concept Case) – 14 relationships / 7 types of Relationship of Connection (Concept, Function, Physic, Space, Time, Antonym, Conceptual Property) – 63 relationships ▪ Construction of Relationship + Relationship Facet to extend the meanings

The concepts are roughly divided into Term Property, Class (Concept Property),

and Relationship (Relationship Property). First, except the 10 classes in the Name category, subject terms that are not proper nouns are divided into abstract category and substantial category, and then concreted to 22 classes. Therefore, from 32 classes a total of 82 concept properties are deducted. In addition, according to Relationship, 20 Extended Relationships are suggested, for further consideration in case describing detailed relationships and extending the existing type of Conceptual Relationship (Figure 7).

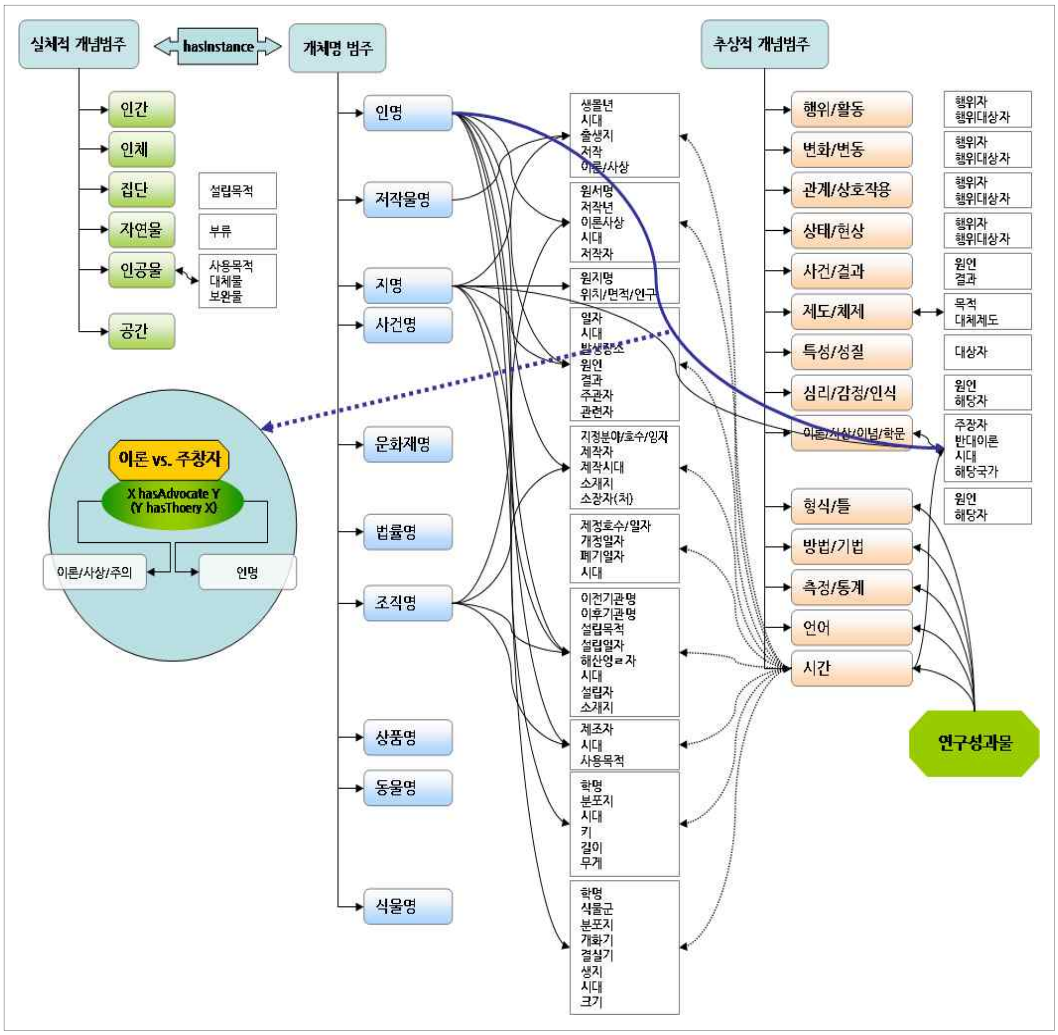

Figure 7: Classes and conceptual properties of KRM ontology

Conceptual Properties and Extended Relationship for the description of a concept are defined using standardized Semantic Relationship predicates such as “is A”, “has Purpose”. The restriction rules of each domain and range are also noted. Throughout this process, the constructed Conceptual Relationship is designed to be automatically converted to a basic triple structure (object, property and

value), in order to make it possible to conduct a Deducting Search via Syllogism written by Web Ontology Language (OWL) (Table 6, Figure 8-1 and 8-2).

Table 6: Deduction examples of semantic relationship in KRM

Is theoretically a related person with (Z, Q) => Work (X) ∧ has Theory (X, Y) ∧ Author (X, Z) ∧ Person Name (Z) ∧ Person Name (Q) ∧ has Theory (Q, Y)	If: X is Work Class, X has Y as Theory Property Value, X has Z as Author Property Value, Z and Q are in Person Name Class, Q has Y as Theory Property Value, => Z and Q are related persons in theoretical context

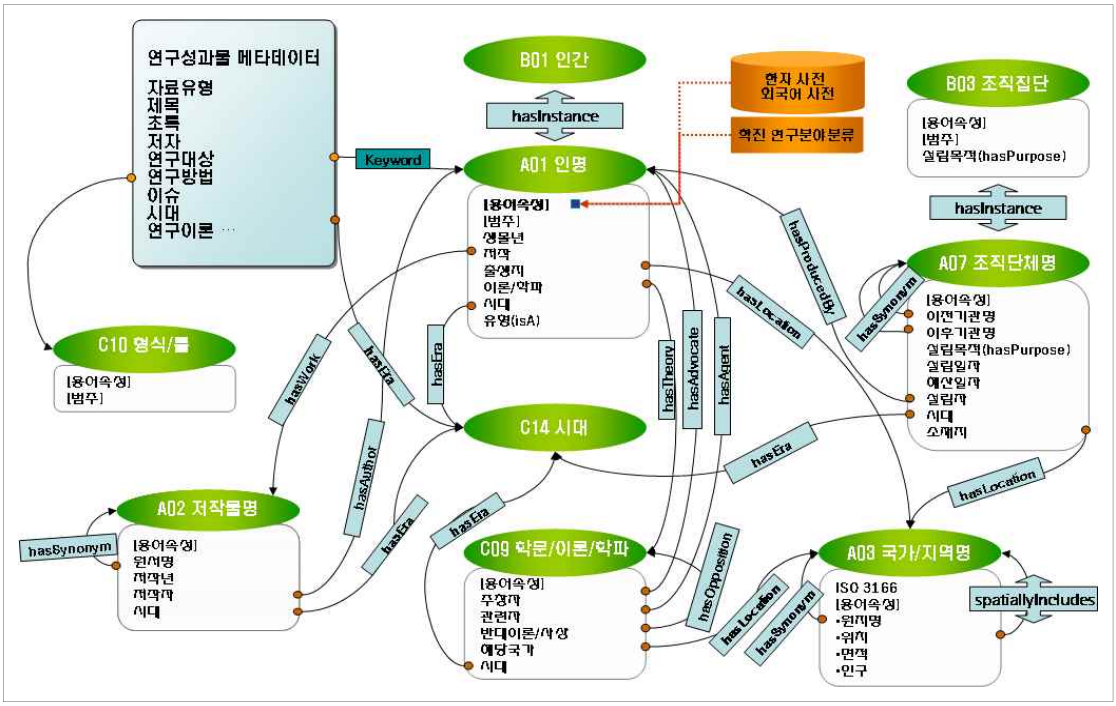

Figure 8-1: Example of relationship and construction of KRM ontology

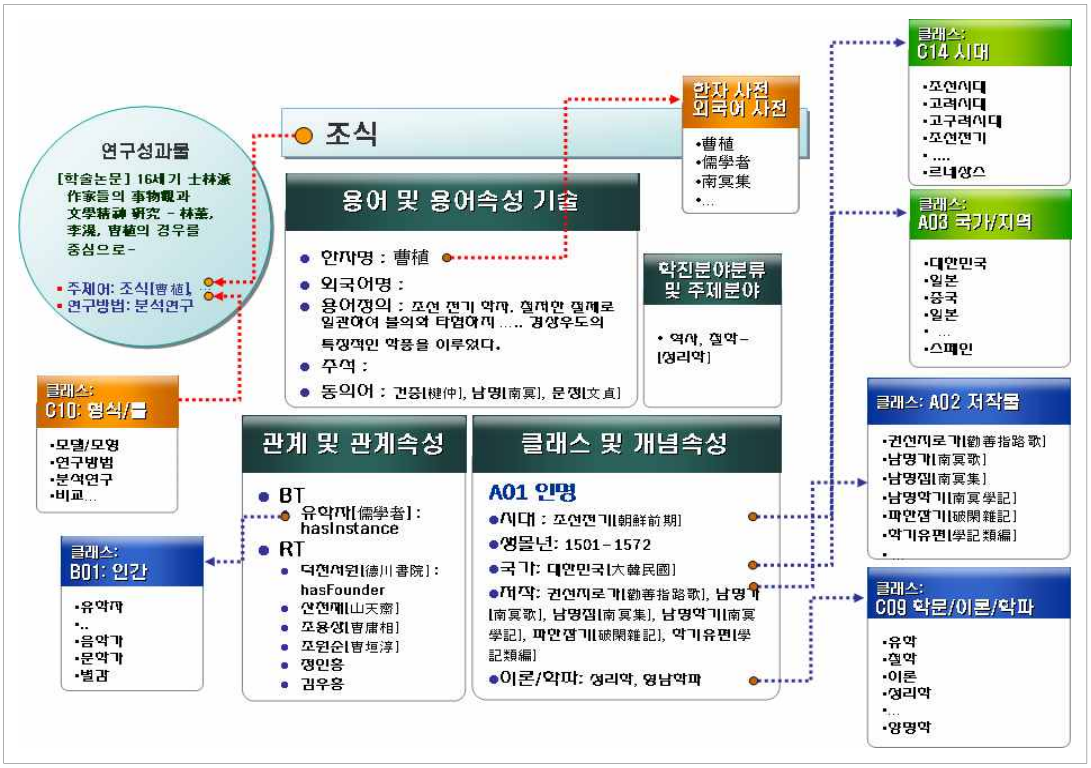

Figure 8-2: Example of relationship and construction of KRM ontology

3.2 Terminology construction project

From the first project, 15,334 terminologies from the fields of humanities, arts, and Sport science were constructed. The second project constructed 15,042 terminologies from Society and Science, as well as 15,042 from a classified table of the Research Promotion study field. Lastly, from the third project, a revision was conducted of the previously constructed (approx. 30,000 terminologies), according to the type of Class and Relationship, which was the result of the Analysis Study. As for the present, March 2009, the total number of terminologies registered in the construction system is 74,573, while the number of Relationship Setups which include Conceptual Properties, Relationship Properties, and Fields Setup, etc. is approx. 168,700. The target terminologies for construction were basically selected to be an index from planning documents of supported tasks, uncontrolled subject terms that were put in the construction of the KRM research result DB, and terms from classified tables of academic research promotion fields. However, according to the level of importance, specialists in different subjects were engaged for the selections and additional works. In the first and second projects, 10 to 15 thesaurus construction specialists were engaged in the construction of the elementary group of Terms in the field of humanities, arts and

sport science which mostly reflected the design of the Term Data Registry. The third project managed 4 divisions in humanities, 3 divisions in the social science Field, 1 in the arts and sport science field to organize 3 to 7 sub-divisions following to their own majors and professional background, and to classify, refine, examine, and formally construct the approx. 30,000 terminologies.

Table 7: Status of term construction project

	The 1st Construction Project	The 2nd Construction Project	The 3rd Construction Project
Target Fields	▪ Fields of humanities, arts, and sport science	▪ Fields of social science (Except. Pedagogy)	▪ Revision of constructed terms from first and second projects ▪ Additional construction of social sciences: pedagogy field
Project Periods	From March 2007 to October 2007 (8 months)	From December 2007 to June 2008 (7 months)	Form July 2008 to March 2009 (9 months)
Target Terms	▪ (Humanities) Report of the Supported Tasks 2002-2004: KRM Metadata Input Uncontrolled Subject Terms ▪ (Arts and Sport Science) Index from Planning document of Supported Tasks 2001-2005 ▪ 618 terms from Classified Tables of Academic Fields by Foundations of Culture, Art and Athletics	▪ (Social Sciences) Uncontrolled subject terms put in construction of research study output DB ▪ Total 3,606 terms from Classified Tables of Academic Fields by the Foundation ▪ Referred to Technical Terms Dictionary, Other Dictionaries Published by the Foundation	▪ (Pedagogy) Uncontrolled subjects put in construction of research study output DB ▪ Approx. 1500 terms referred to Technical Terms Dictionary, Other Dictionaries Published by the Foundation ▪ Revised approx. 26,000 subjects class terms applying the new type classes
Const. Terms	15,334	15,042	31,592(Revised)/1,500(New)
Add. Terms	11,655	14,362	7,144

The concept of academic terms is never fixed, but being endlessly changed according to additional relationships between the terms, changes and additions by the terms themselves, changes of Ontology design, and additional

relationships of research study outputs. In this context, the term construction continually repeated a routine of Term Selection → Construction → Examination and Inspection, though the construction is supposed to proceed by steps, to be controlled by the construction rules (Figure 9).

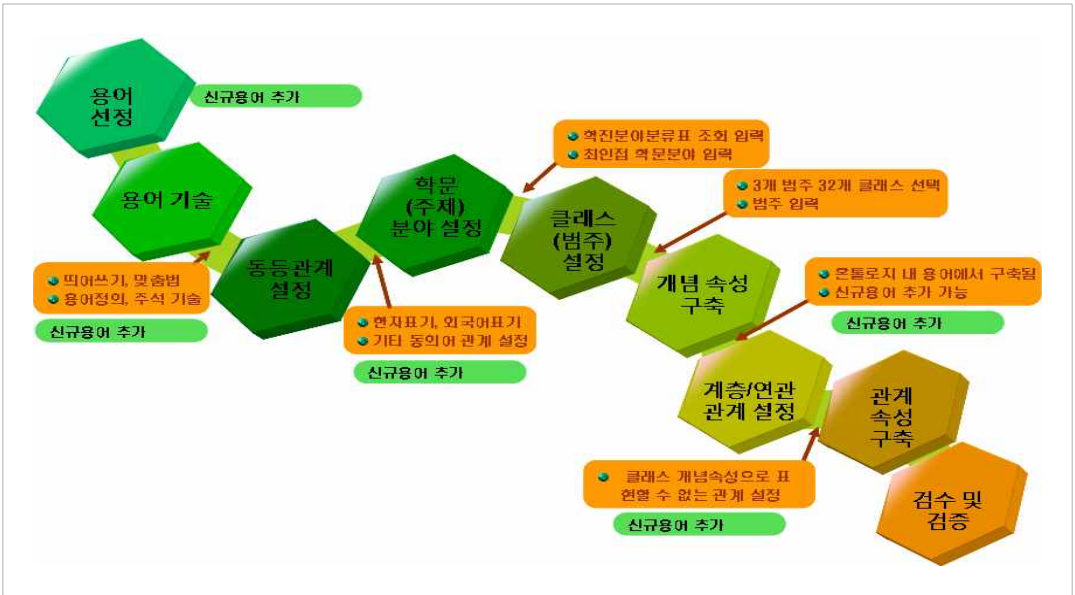

Figure 9: Construction process of KRM ontology

3.3 Construction tool development

As OnomaWork-K, the construction tool used in the first and second projects was restricted to support construction of ontology in the fields of humanities, social sciences, arts, and sport science, in the third project, we developed our own construction tool which enables Class, Relationship, and Automatic (Extending) Code Creation. It is also available to practically use for KRM DB construction and integrated search via its Open API system (Figure 10).

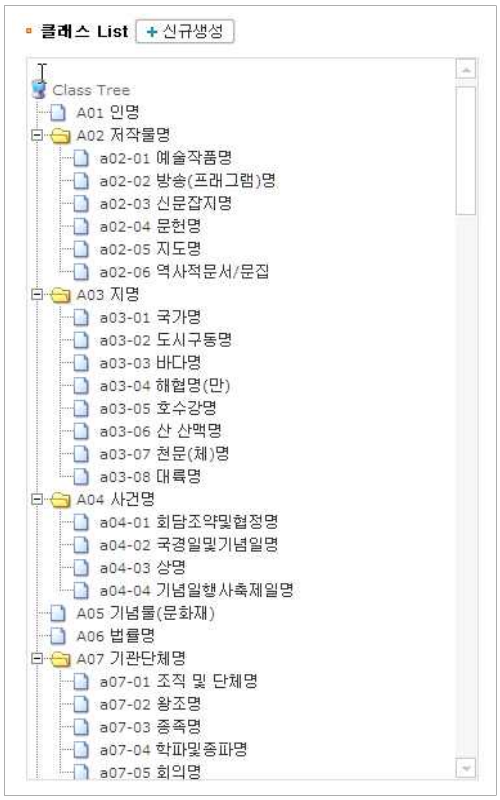

Figure 10: Input screen on construction tool

4. Conclusion

KRM system applied FRBR concept model to establish a research outputs database for expert researchers, supporting vertical and horizontal movements freely among related materials and enabling dynamic multi-dimensional retrieval in a network structure. Applying FRBR concept model and making hierarchical catalogues at logical level, KRM system allows users to choose the exact desirable version of material and to access to all levels of bibliographic objects. In addition, by making link-based catalogues, it enables retrieval for all the related research outputs based on defined relationships. It also strengthens the linkage to all the connectable information and change the retrieval procedure from the previous linear structure to the network structure to allow users to move directly to the information they want.

The 8 DB Construction Divisions in 7 different fields have 1 senior research engineer, approx. 20 members who are regular research engineers and doctoral-degree associate research engineers, and another group of approx. 20 research assistants currently engaged in Master's and Ph.D. programs. The senior research engineer and the regular research engineers are full-time university professors. The associate research engineers are the core part of the division, making the overall configuration regarding the value, content, specialty and reference compared to existing data, based on their professional understanding, to construct a database of especially high quality. The research assistants build up the metadata. As they input the data, based on their special knowledge, they take great care to use exact and proper subject names, subject classification, and term data registry. Their other duty is to create links between data by deciding the paths performed and to be performed during each project, as well as to inspect the relations between the two.

In order to support advanced search for meanings and their relationships in research study outputs, we constructed a system that can be extended to formal Ontology, based on the traditional thesaurus and the structure of term data registry. It has been designed with concepts divided into term property, class (conceptual property), and relationship (relationship property). The concepts were divided into to 32 classes and deducted into 82 conceptual properties. Also, approx. 20 extended relationships were suggested for consideration in case of describing detailed relationship and extending the existing type of conceptual

relationships.

30,376 terminologies in the fields of hmanities, social Sciences, and art and sport science were constructed according to the designed structure of the term data registry. At present, the total number of terminologies registered on the construction system is 74,573, while the number of relationships which include Conceptual Properties, Relationship Properties, and Fields Setup, etc. is approx. 168,700.

10 to 15 thesaurus construction specialists were put into the construction of the elementary group of Terms in fields of humanities, social sciences, reflecting the design of the Term Data Registry. 4 divisions in the humainties, 3 divisions in the social science field, 1 in the Art and Athletics field were organized into 3 to 7 sub-divisions following their own majors and professional backgrounds, and to classify, refine, examine, and to formally construct the approx. 30,000 terminologies.

KRM service is in early stage still, so how much users are satisfied with the cataloging structure based on FRBR model and the new interface screen and how much it affects the retrieval effectiveness are not clearly evaluated. The tasks before KRM are the thorough evaluation and analysis with which users' information seeking behavior and preferences to be carefully examined and the functions and the interface can be developed to meet users' needs.

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