Building RDF-Schema Based Knowledge Map for Knowledge Management Systems

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Abstract

This paper attempts to implement the semantic web paradigm, which enables the semantic search of knowledge and information on the web environment, by adopting RDF, RDF-schema and Dublin core data element structure in the process of building knowledge map. Since the RDF, RDF-schema, and Dublin core data element structure comply with the XML grammar, we have greater convenience and flexibility in representing knowledge into XML document format.

Representing knowledge following the RDF-schema and the Dublin core structure enables the well-formed and semantic description of knowledge, facilitating the representation of knowledge into the frame format.

I. Introduction

The application and utilization of knowledge management systems for strategic advantage is prevailing in the realm of modern business. However, the current state of knowledge management technique is still in the primitive stage. We experience a lot of difficulties in extracting and storing useful knowledge from formal/informal knowledge sources. We also have difficulties in searching and retrieving knowledge that has the closest semantic resemblance to the intended knowledge query.

The current practices of knowledge map representation in many of the business organizations mostly deploy the organization chart, directory structure, or idea map structure.

While XML has made a significant contribution to the representation of meta-knowledge and to the extension of expressive power of knowledge documents, we still suffer in retrieving knowledge if we don't use the exact tag names that match those defined in the XML-DTD and XML-schema. Semantic search of the XML documents is also impossible unless we have a support by an extensive ontology knowledge base.

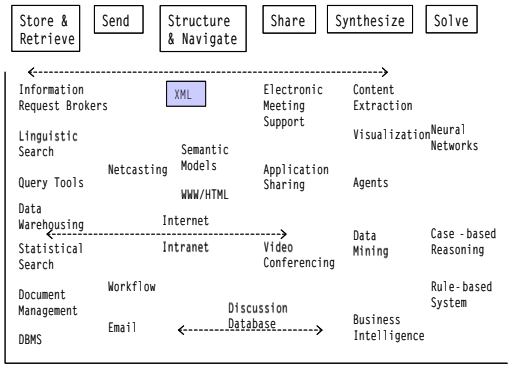
This paper intends to introduce a methodology for building RDF-schema based knowledge map with a view to contribute a small part in realizing our vision for the ‘semantic web.’

II. The backgrounds

2.1 Technological components of KMS

Gartner Group[1] explained knowledge management process consists of six stages: store & retrieve, send, structure & navigate, share, synthesize, and solve. Fig. 1 shows the maturity level of the various technologies mapped along the KMS process stages.

The XML technology, marked with shaded box in fig. 1, is regarded as a standard language that will integrate the next generation applications. It has all the necessary features to express, transmit, and retrieve knowledge. In this respect, XML technology is considered a crucial component in building the knowledge management systems.



<Fig.1> KMS process and technology map

2.2 The knowledge map

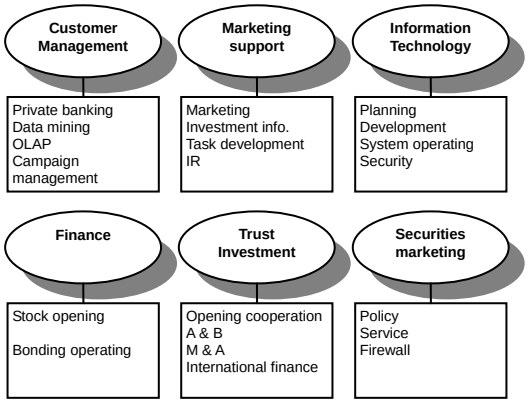
Myaeng et. al.[3] define the knowledge map as a diagram that represents the knowledge elements and their relationships expressed in an easy to understand graphical form, which are obtained through the defining, analyzing, and classifying tasks of the knowledge used in the business processes.

Pele[4] explained knowledge map in two terms: 1) maps of technology and 2) maps of technology management knowledge. He also classified knowledge mapping into four types: 1) mapping by synthesis of words, 2) chronological mapping, 3) cognitive mapping, and 4) conceptual mapping.

Grey[2] stated that knowledge map is useful for summary of the organizational outcomes, to indicate the source of knowledge, to show the flow of knowledge, and to represent the point of loss and termination of knowledge.

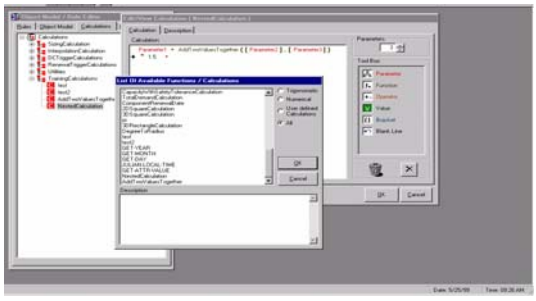
Knowledge map is a useful guide to find out where we can obtain the necessary information to perform a new task or project, whom to contact, and how to do it.

In order to develop a knowledge map, we need to define the tasks performed by the employees, and identify what kind of knowledge is used, how they are acquired, etc.



<Fig. 2> Knowledge map : organization chart style.

(Microsoft Consulting, 2002)



<Fig. 3> Knowledge map: directory tree style

Yon[6] introduced FVT(from via to) method for building knowledge maps. This method follows six stages: 1) define knowledge 2) define the processes 3) analyze the processes 4) extract and classify knowledge 5) profile the knowledge

6) build link between knowledge. Fig. 2 and 3 are two representative examples of knowledge maps, one in organization chart form and the other in directory tree style. Idea map style knowledge map is another alternative.

2.3 XML and knowledge management

Tim Berners Lee coined the term "semantic web" to indicate the direction for the next generation web technology[9]. This indicates that the next revolution in information technology lies in the development of technology that enables the exchange of information with semantic connotations. XML is a candidate tool that can materialize the vision of semantic web.

XML is now the open standard for documents on the internet and is widely adopted by many companies. It provides the framework for maintaining consistency between applications and between data. It allows us to share data between systems without redesigning the databases and therefore, there's no need to rewrite or modify existing application programs.

With XML, we can embed semantic properties inside the documents by utilizing the structural information and by assigning meaning to the tags. This in turn enables us to retrieve only the necessary portion of the documents, and recompose a completely new document by the appropriate combination and reorganization of the pieces of documents retrieved from here and there. This is an important feature for the advanced research in knowledge management systems.

2.4 XML schema

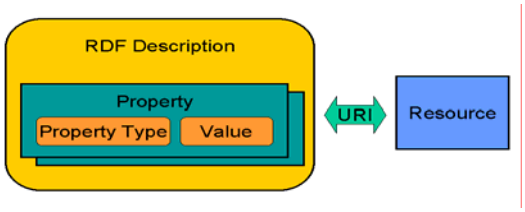
While XML is a standard language designed to represent and transmit structured documents on the web, *XML DTD*(document type definition) and *XML schema* are the means to define the rules and methods for organizing the XML documents, and are used to test the validity of the XML documents.

W3C defines XML-schema as the organization of database that is derived from the data modeling. XML-schemas can be used alone and is an XML document structure. It supports a richer set of data types than DTD, rendering greater utility.

III. RDF, RDF-schema, and Dublin core

RDF(resource description framework) is a standard for processing metadata, and provides interoperability between applications. RDF data model is a simple model that describes the relationships between web resources in terms of their properties and values.

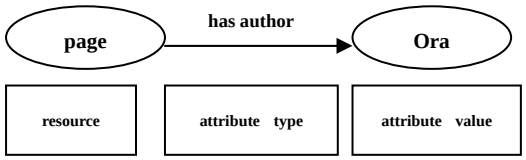
In order to describe about specific resources(e.g., book, web pages, people, etc.) we need to use the characteristics(e.g., author, subject, size, etc.) of the resources that can deliver specific meaning. RDF-schema enables the declaration of these characteristics. Whereas the DTD and XML-schema defines the restrictions on the XML documents, RDF-schema provides information as to how to interpret the documents written along the RDF data model[7, 9].



<Fig. 4> RDF knowledge representation model

The RDF grammar is based on XML. The basic architecture of RDF data model is comprised of three elements: resource, property type, and property value[5]. Fig. 4 shows an RDF data model of

knowledge representation. Fig. 5 is an RDF data model representation of the sentence “The author of the page is Ora.”



<Fig. 5> An example of RDF data model

The resource in RDF data model implicates all kinds of objects that have URI. It can be an entire knowledge document or some part of it, or it can be an object that is not even accessible through internet. A resource may have many attribute types and values.

RDF is a model derived from the knowledge representation approach. However, it differs from the existing knowledge representation techniques in the sense that it does not stipulate the inference methods. Anyhow, it does not suffice with RDF by itself to meet the objective of the ‘semantic web.’

3.1 The syntax of RDF-schema

DTD has a fixed way of declaring the elements of XML documents. But XML-schema has an extended set of declaring elements[8]. Since RDF-schema follows the XML grammar, it has similar grammar structure and defining method. Fig. 6 is a sample RDF expression.

```
……
element name "RDF">
  <complexType>
    <sequence>
   lement ref="rdf:Description" minQccurs="unbounded"/>
</sequence>
</complexType>
</element>
……
```

<Fig. 6> A sample RDF expression

Fig. 7 shows the method of declaring elements using the <element> tag and the detailed attributes of the elements. With RDF-schema, we can use the various attributes of the <element> tag to declare the element name(name=’RDF’), the element reference (ref=”description”), minimum and maximum number of occurrences of the tag, etc.

```
<element "ref=rdf:Description" minOccurs="0" maxOccurs="unbounded"/>
```

<Fig. 7> Declaring elements in RDF format

3.2 Dublin core

Dublin core has been developed to facilitate the retrieval of digital resources. It has been designed with the special emphasis upon simplicity and flexibility so that the authors of web resources may be able to describe the resources for themselves. 13 data elements were proposed at the first meeting in Ohio in 1995. Later in 1997 the Dublin core has been extended to include a total of 15 data elements. They are *title, creator, subject, description, publisher, contributor, type, date, format, identifier, source, language, relation, coverage, and rights.*

Dublin core focuses more on the semantic definition rather than on the syntax or structure. It is intended to minimize the constraints that may occur under special circumstances, and to enable the conceptual approaches to developments.

XML is extensible and enables the representation of a complicated structure. In this regard, when we represent metadata using Dublin core, XML statements can be written to the RDF model[13]. Hence the Dublin core elements and the RDF syntax are mutually complementary. Dublin core affects the RDF statements in the semantic perspective, and in turn RDF

clearly exemplifies the importance of Dublin core as the basic data model.

We need to notice the fact that resources on the internet have been represented individually, each resource using its own metadata definition. This practice has resulted in representing the same type of resources in many different formats, making it difficult to access the resources that contain the same subject or content through the network.

3.3 Representing Dublin core elements using RDF

Fig. 8 is the representation of the Dublin core basic data elements using RDF[10,11,12]. Fig. 9 is an example for defining the broad terms and narrow terms using RDF-schema. In this example, the narrow term 'Author' of the data element 'Creator' in Dublin core has been declared following the RDF-schema. The narrow terms declared this way can be written independent of the broad terms and can be reused.

```
.....

<element name = "any" abstract="true">
  <complexType mixed="true">
    <sequence minOccurs="0" maxOccurs="unbounded">
                <any processContents="lax"/>
    </sequence>
    <attribute ref="xml:lang" use="optional"/>
    <attribute ref="rdf:resource" use="optional"/>
  </complexType>
</element>
<element name = "title" substitutionGroup="dc:any"/>
<element name = "creator" substitutionGroup="dc:any"/>
<element name = "subject" substitutionGroup="dc:any"/>
<element name = "description" substitutionGroup="dc:any"/>
<element name = "contributor" substitutionGroup="dc:any"/>
<element name = "date" substitutionGroup="dc:any"/>
.....
```

<Fig. 8> Syntax showing the representation of Dublin core basic data elements using RDF

```
<?xml version="1.0"?>
  <rdf:RDF
    xmllns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmllns:rdf="http://www.w3.org/2000/01/rdf-schema#">
    <rdf:Description ID="bill of order">
    <rdf:type rdf:resource="http://www.w3.org/TR/WD-rdf-
        syntax#Property"/>
    <rdf:subPropertyOf resource=
        "http://purl.org/metadata/dubin_core#Title"/>
    <rdf:lable>bill of order</rdfs:lable>
    <rdfs:comment> The document of writing orders</rdfs:comment>
  </rdf:Description>
</rdf:RDF>
```

<Fig. 9> Defining the broad terms and narrow terms using RDF-schema.

IV. RDF-schema based knowledge map

Fig. 10 shows the RDF representation of the sentence "The author of the page is Ora."(refer to fig. 5) following the XML grammar.

```
<description about=http://www.w3.org/test/page author="Ora"/>
```

<Fig. 10> RDF expression following XML grammar

However, notice that the attribute type 'Author' may be interpreted differently depending on the applications. To resolve this problem, RDF uses *XML namespace* to clearly define the meaning of the attributes. This enables the consistent input and exchange of metadata. Fig. 11 is the RDF expression using XML namespace.

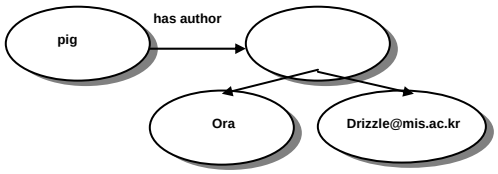
```
<?xml version="1.0"?>
 <Description
    xmls="http://www.w3.org/TR/WD-rdf-syntax#
    xmls:s="http://docs.r.us.com/bibliography-info

       about="http://www.w3.org/test/page"
       s:author="http://www.w3.org/staff/Ora"/>
```

<Fig. 11> RDF expression using XML namespace.

If we want to describe more details of an attribute, we can use a more sophisticated attribute structure as is shown in fig. 12. This example shows that the *name* of the document creator is Ora, and has an e-mail account drizzle@mis.skku.ac.kr.

XML allows arbitrary document structure but it does not define the meaning of the structure. Therefore, XML has nothing to do with interpreting the documents. While RDF is used to represent knowledge at the semantic level, XML is used to define the data structure at the syntactic level. Hence they are complementary to each other. In this paper, we have exploited this complementary relationship to build the knowledge map.



<Fig. 12> Adding more information to the RDF model

<Table 1> Comparison of XML and RDF

	XML	RDF
Function	Support syntactic analysis	Support semantic analysis
Model	Ordered tree	Object relationship

4.1 The knowledge map generation process

In this paper, we propose a six-step process for generating a knowledge map.

Step 1) Select the target knowledge domain

Step 2) Define the business process in RDF

The first two steps deal with the knowledge map generation for machine recognition. An RDF-schema is defined after these two steps(see Fig 13).

Step 3) Draw the business process diagram(see Fig 14).

Step 4) Extract knowledge(explicit and tacit)

At this stage, the knowledge related with the business process is described in RDF terms and becomes ready for expansion into the semantic web(see Fig 15).

Step 5) Fill out the knowledge Statement

Knowledge statement is essential for the RDF-based knowledge map to be used as meta-knowledge. Dublin core data elements are used at this stage for the specification of meta-knowledge(see Table 2).

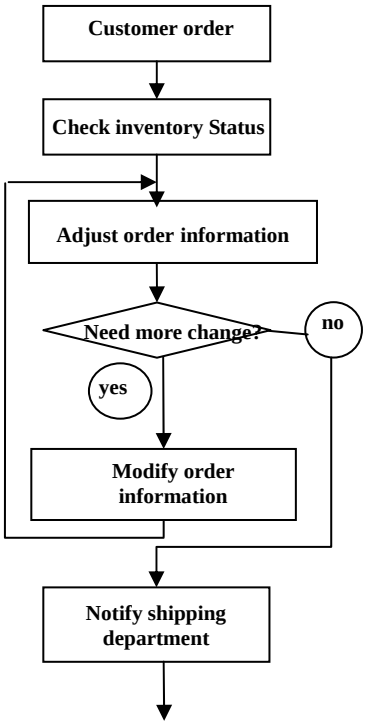
Step 6) Link the associated knowledge objects

(see Fig 16)

This task is necessary to convert the knowledge specifications into knowledge map, possibly in frame format. When the steps 5 and 6 are complete, the knowledge map is created and ready to assist knowledge workers. Human users can easily configure the relationships between knowledge objects by reviewing the knowledge map.

```
<?xml version="1.0"?>
<rdf:RDF
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
<rdf:Description ID="bill of order">
    <rdf:type rdf:resource="http://www.w3.org/TR/WD-rdf-
syntax#Property"/>
    <rdfs:subPropertyOf resource="http://mis.skku.ac.kr/metadata/
      dublin_core#Title"/>
    <rdfs:label>Order statement</rdfs:label>
    <rdfs:comment> Document contains order information
</rdfs:comment>
    </rdf:Description>
</rdf:RDF>
```

<Fig 13> RDF-schema of a customer order



<Fig 14> Process diagram for customer order processing

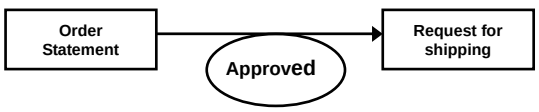
```
<?xml version="1.0"?>
  <rdf:RDF xmls=http://www.w3.org/TR/WD–rdf–syntax#"
    xmls:s=http://mis.skku.ac.kr/schema/">

<rdf:RDF>
  <rdf:Description about="http://mis.skku.ac.kr/doc/id_5089">
   <s:Creator rdf:resource="http://mis.skku.ac.kr/
      person/id_6207">
   <s:Name>Doug Choi<s:Name>
   <s:Email>Dougchoi@mis.skku.ac.kr</s:Email>
   <s:Tel>031-290-7597</s:Tel>
   <s:Title>Order statement</s:Title>
   <s:Date>2002-01-14</s:Date>
   <s:Publisher>Sales_team</s:Publisher>
    … … …
    … … …
  </rdf:Description>
<rdf:RDF>
```

<Fig 15> RDF expression of order statement

<Table 2> A knowledge statement using Dublin core

	Dublin core Element set	Attribute value
Contents	Title	Order statement, Request for shipping
	Subject	Order processing, Customer claim, Shipping
	Description	Delayed shipping notice, Delayed delivery notice, Documentations on order processing
	Source	Business team, Delivery team, Customer support team
	Language	Korean, English
	Relation	Request for authorization, Approved
	Coverage	Warehouse No.1, Warehouse No.2
Intellectual property rights	Creator	David Allen, Steve Ahrens, Mark Williams, Tom Hazel
	Publisher	Planning team, Business team, Shipping team, Customer support team
	Contributor	Tim Lee, Paul Murray, Doug Choi
	Right	Planning team manager, Delivery team manager
Physical specification	Date	yyyy-mm-dd
	Data type	Document, Know-how
	Format	HTML, text, doc, PDF, voice
	Identifier	Order No., Invoice No., Employee ID.
Additional specification	User_add	Know-how, Contents

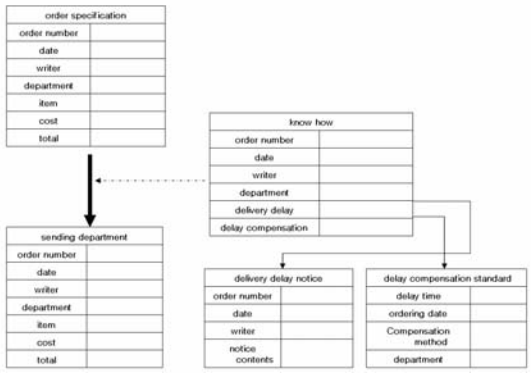


<Fig 16> Relationship between knowledge documents

4.2 Frame representation of a knowledge map

So far, we have discussed the basics of building a knowledge map based on the RDF-schema. Now we present an example so that the readers may have a solid grasp of the RDF-schema based knowledge map, for which we have deployed a frame representation. A frame is a data structure that contains the data and operational information associated with an object. The frame representation is somewhat more complicated than other knowledge representation methods but it provides a more effective and meaningful means for knowledge retrieval.

Proper linking of the RDF-schema based frames, which are representations of the knowledge elements of an organization, produces a knowledge map which enables the construction of the knowledge management systems that allows the semantic search of knowledge on the Web. Fig 17 is a frame representation of the knowledge map pertaining to the order-processing task of an organization. It illustrates that the knowledge map users can grasp the organizational details of the knowledge elements associated with the order-processing activities. The links between the objects exemplifies how the semantic search is enabled when we follow the links between the knowledge elements.



<Fig. 17> Frame representation of the RDF-schema-based knowledge map

V. Epilogue

This research has been originated from the motivation to lay a bridge from knowledge map to semantic web. A knowledge map built on the basis of RDF-schema has been proven to provide the extensibility toward the semantic web.

By utilizing the Dublin core data elements as the RDF-schema, consistency in knowledge representation has been secured, and semantic search and retrieval of the required knowledge has been made easier and more effective.

Since the frame representation of the knowledge map shows the detailed organization of the knowledge elements of objects involved with an incumbent task or process, we may lose the overall picture of an entire organization or a company that is offered by the organizational chart style knowledge map. However, since the frame representation of the knowledge map enables the semantic search of required knowledge, users can be freed from the routine operation of stepping through the organization chart or the directory tree diagram to retrieve the required knowledge.

References

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