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An Analysis on the Modelling Techniques in Building Knowledge Repositories

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Abstract: Knowledge models take up their role in representing the knowledge and building the knowledge repositories. The operations of the existing knowledge management systems require the repositories to accommodate modelled knowledge that enables knowledge transformations in the decision support systems. This paper gives an analysis on three knowledge modelling techniques to build the knowledge repositories for knowledge management systems. Three knowledge modelling techniques are studied with real time case studies and illustrations. The implications of the work, the prevailing open ended issues and future research works with regard to new techniques conclude this work on knowledge modelling.

Key words: Knowledge management · Knowledge modelling · Knowledge engineering

INTRODUCTION

Organizations competing in the global market must manage, protect and operate its asset, the knowledge that it has gained from past experiences and learning. The experience is codified to knowledge repositories as knowledge and managed, enabling decision making. Hence, knowledge management (KM) has been the essential tool that drives organizations to success in their operational platforms [1, 2]. Data is the essential raw material for the creation of information; it can be quantitative or qualitative [3]. Information result from interpretation and processing of data. Identification of patterns of information in the information base leads to generation of knowledge. Knowledge acquired from various sources is put up into knowledge bases forming the basis for future progress. A knowledge repository is a system that continuously captures and analyses the knowledge assets of an organization. It is a dynamic system where people can query and work with both structured and unstructured information in order to preserve and retrieve organizational knowledge and facilitate collaborative working. Many techniques are available to build such knowledge repositories. Earlier works, proposed techniques for processing, codifying and refining of information to populate knowledge repositories which serves as a management tool in KMS [3-6].

Knowledge Management-An Overview: Wilson defines knowledge as ‘What I know’ and knowledge management as ‘Organizing What I know’ [5]. Knowledge is categorized into two: tacit and explicit knowledge. Knowledge that could not be expressed explicitly is termed as tacit knowledge. Knowledge that can be easily represented, easily observed is termed as explicit knowledge. Tacit knowledge can be converted to explicit through externalization and from explicit to tacit through Internalization. Conversions from tacit to tacit, is through socialization and explicit to explicit is through combination [1]. A study on the KM literature states that the process of building a knowledge repository for KMS involves these four primary steps. Knowledge Creation or Acquisition, Knowledge Modelling, Knowledge representation and Knowledge storage.

Knowledge acquisition is about extracting knowledge from sources of expertise information back and transferring it to a knowledge base [7]. Acquisition of explicit knowledge is straightforward and it can be got from reports and statistics. Further knowledge can be acquired through Socialization and Combination resulting in hybrid knowledge [1, 7-9]. An important aspect of knowledge acquisition is the use of knowledge modelling, as a way of structuring, acquiring and validating knowledge and storing knowledge for future use. Knowledge models are structured representations of knowledge using symbols to represent pieces of

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knowledge and relationship between them. A model is an intellectual construct in artefact form that provides an abstract, highly formalised, often visual, yet simplified representation of a phenomenon and its interactions [10]. Earlier works in knowledge modelling broadly classifies knowledge models into three: mathematical models, descriptive models and graphical models [9-11]. In the following section we present a detailed analysis into the three knowledge modelling techniques that are used in knowledge engineering techniques in building knowledge repositories for knowledge management systems [12].

The Knowledge Models: "*A model is a simplification of reality*". Much of the academic literature deals with high level abstractions which are presented as knowledge management models, but are actually models of knowledge. Sun states that modelling of knowledge should be performed based on the issue in keeping the KM activities [7, 10]. These knowledge models presented here are preferred for their simplicity and their applicability in wider scope.

Object Structure Model (OSM): The OS modelling environment is an object-based ontology with knowledge acquisition activities that are widely used for domain modelling [2, 9, 11]. At its core, OSM implements a rich set of knowledge-modelling structures and actions that support the creation, visualization and manipulation of ontologies in various representation formats. OSM ontology will consist of classes, slots, facets and axioms. Slots describe properties or attributes of classes. Facets describe constraints associated with a slot. Additional constraints to a relation can be specified with Axioms. An OSM knowledge base includes the ontology and individual instances of classes with specific values for slots [11]. Slots express the properties of classes and instances, such as name of an employee. There exist two types of slots which can be attached to a frame: template slot and own slot. An own slot describes properties of an object represented by that frame (an individual or a class). Template slots describe properties that an instance of a class can possess.

A way to specify *constraints* on allowed slot values is through facets. The number of values that can be associated with a slot, restrictions on the value of the slot can be specified using Facets. For example, maximum intake of students in a class can be added as a constraint to a class named CLASS. A class can acquire own slots only by being an instance of a metaclass that has those slots as template slots.

To be a functional model, a knowledge base in OSM is proposed to be developed in the following sequence [9, 2]. First, concepts and their relationships are defined based on the ontology. Second, the domain experts enter their knowledge of the domain area using the domain-specific knowledge acquisition tool. Finally, problem-solving techniques are used to answer questions and problems of the domain using the knowledge base [5].

Building OSM knowledge base: Concepts and their relationships are to be defined first. The following classes may be identified for building the knowledge repository of the given domain: *Department, Staff, Student, Subject, Result, Feedback* [from staff & students], *Examination tricks.*

- The existing relationships among the given concepts can be framed as follows: Each Department comprises staff & students. The functional responsibilities of each domain are called concepts and their interlinking association is called relationships.
- The specification of domain knowledge. This is the operational area of knowledge experts in the relevant domain. In our example, Analysis of results is done by the experts by undergoing a deep study on the results and the feedback got from staff & students. A report generated by the experts stating reasons for all the dimensions of the published results is entered into the knowledge repository using knowledge acquisition tools supported by OSM.
- The acquired knowledge derived in the previous two steps is used in crucial problem solving techniques. The domain knowledge specific to the stated problem is incorporated into the process of decision making.

Knowledge Structure Model (KSM): KSM supports building and reusing knowledge models which are required by knowledge management systems in building knowledge repositories. KM literature [8, 9] show that to formulate a knowledge model in KSM, three perspectives are defined: (1) the knowledge-area perspective (2) the task perspective and (3) the vocabulary perspective [5].

The Knowledge Area Perspective: A knowledge area identifies a body of expertise that explains a certain problem-solving behavior of an intelligent agent [8]. It gives support to develop the operational version of a model with reusable software knowledge-based

Table 1: Illustration of Knowledge area in Teaching Analysis

Knowledge area	Goal	Input	Output
Staff attendance report generation	measure the punctuality of staff	timetable, entries made in the register proposed course plan,	an estimate of the attendance of the staff
Syllabus coverage report generation	measure of the class usage by the staff	actual plan, reason stated	an estimate of the class usage by the staff
Motivation report generation	measure the motivation provided by the staff	Feedback got from student	Level of interest created by the staff member in the subject

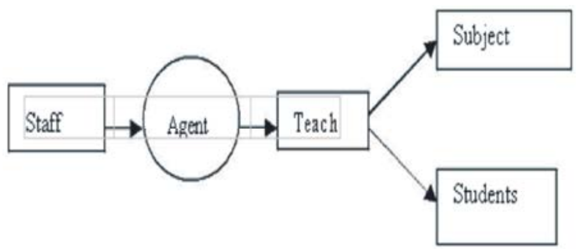

Fig 1: Conceptual graph for the given relation

components, called *primitives of representation* that contains inference methods to different knowledge representation formalism [9]. The knowledge models are built in KSM with top down approach, retaining the hierarchical structure, with sub knowledge areas and so on. The leaf nodes are *primary knowledge area* and corresponds to an elementary module that may be directly operationalized. A unit in KSM is created with two parts: (1) its knowledge, represented as a set of component sub-areas of knowledge and (2) its functionality, represented by a set of tasks (and their corresponding methods) [4].

The Task Perspective: This presents a functional description for each task using a tree of task-method-subtasks. A *task* defines a goal to achieve (with a set of inputs and a set of outputs) and the *method* describes how to carry out the task [8]. The problem-solving methods are represented with two main parts: the data flow section that defines the data connection between tasks and the control flow section that uses rules to establish the execution order of tasks. Each knowledge area is represented with three factors.

Knowledge Area = $<A, K, T>$

where A is the area associated to the knowledge unit, K is the set of subareas in which A is decomposed into and T is the set of tasks provided by A. Encapsulation of the components associated to a knowledge area is supported by this representation [13].

The Vocabulary Perspective: This is formulated with a set of components called conceptual vocabularies. A conceptual vocabulary defines a basic terminology used by several knowledge areas. Cuena describes conceptual vocabulary as ‘it allows the developer to define a common terminology which can be used by different primary knowledge areas’ [4]. One of the direct advantages of the use of vocabularies is that they provide a common location where concepts are defined. The knowledge modelling of the same problem domain *Result Analysis* using KSM needs the conceptual vocabulary to be built up first and then the hierarchy of knowledge areas, which make use of the conceptual vocabulary, is to be built next. Hierarchy of knowledge areas needs to be built as the next step towards building of knowledge repository. Table 1. Illustrates the Teaching analysis case study [12].

The identified list of tasks make up the knowledge base of the given problem domain and the knowledge base thus created is utilized in generating answers for the problem solving questions and thus supporting decision making.

Conceptual Graphs (CG): Conceptual graph, according to John S. Fowa, [13] is “A finite, connected, undirected, bipartite graph with nodes of one type called *concepts* and nodes of the other type called *conceptual relations.* A conceptual graph may consist of a single concept, but it cannot have conceptual relations with unattached links” [14]. The advantage of using conceptual graphs is that they are very closer to natural language and they expertise in representing the knowledge in its expected form. It is a representation of part of knowledge under a canon or an ontology where canon is a framework for knowledge organization and ontology is a subset of a canon dealing with a particular subject domain [15]. Conceptual graphs address in terms of *concepts* and its *attributes*. A concept can be an entity, event or an action [13]. Every concept has its own attributes and is instantiated with *Instances*. The formation of conceptual graphs is as follows:

Table 2: Features of the knowledge modelling techniques

Features	OSM	KSM	CG
Knowledge Engineering		a	
OO Approaches	a		
Platform	a	a	a
independencies Knowledge transformations	Explicit to explicit Tacit to explicit	Explicit to explicit Tacit to explicit	Explicit to explicit, Implicit to explicit
Modelling language			a
Application domain	Legal, engineering,business, institutions and sciences	Engineering, business, process improvement,software design and development	Engineering, institutions, mathematics and sciences, design and development

- Every *arc a* of *g* is a pair (*r,c*) consisting of a conceptual relation *r* and a concept *c* in *g*. The arc *a* is said to *belong* to *r*; it is said *link r* to *c*; but it does not belong to *c*.
- A conceptual graph *g* may have concepts that are not linked to any conceptual relation; but every arc that belongs to any conceptual relation *r* in *g* must link *r* to exactly one concept *c* in *g*.

Every concept has a *concept type* t and a *referent r*. The referent of a concept is specified by a *quantifier*, a *designator*, or a *descriptor*. Quantifier may be existential or defined. A designator may be literal or an individual marker or a name. A descriptor is again a conceptual graph defining the referent.

For example Staff teaches the students a given subject gives a triadic relation with the relation *teach.*

Figure 1. illustrates a conceptual graph for the given theme. Teach is the relation, connecting three concepts Staff, Students and Subject. The Conceptual graph takes up another form as *conceptual graph interchange form* (CGIF) which is intended for transmitting CGs across networks and between IT systems that use different internal representations. The above said example can be represented with CGIF as

[Staff]←(Agent)←[Teach]→[Students][Subject]

The other keywords related to conceptual graphs are lambda expression, context, co-reference set and modules. The above CG can be stated with the lambda expression as [Staff: λ_1]←(Agent)←[Teach]→[Students: λ_2][Subject: λ_3]

where λ_1, λ_2 and λ_3 are instances of Staff, Students and Subjects respectively.

The formation rules of conceptual graphs eliminate nonsensical things but allow conceivable, nonexistent things [13, 14]. Also it represents a knowledge model that avoids redundancy of knowledge and gives a complete and a consistent representation of a knowledge unit.

Implications and Future Issues: Knowledge modelling is one of the key areas of challenge knowledge workers face in building knowledge repositories of any knowledge management systems. Wilson in [5] states that knowledge representation or modelling should be done intelligently in a way human brain organizes the acquired knowledge. Probably, it is inferred that acquired information are perceived as objects and relations in OSM and as a structure of knowledge, task and vocabulary in KSM and mathematically in CG. The two primary category of knowledge, tacit and explicit, are acquired, modelled for representation, shared and deployed [3, 9, 10]. These activities of KM systems have several open-ended issues which are worth considering for research. The transformations of knowledge, from explicit to tacit and vice-versa and from explicit to explicit, are required in every knowledge manipulation.

Certain KM literatures argue that knowledge transformations do not happen in knowledge modelling [3-5, 8, 10]. But it is speculated that the primary role and goal of knowledge modelling systems are that they manipulate information, raw data, explicit knowledge and in some extreme cases even tacit knowledge, where all of these are transformed to explicit knowledge in the knowledge repositories [1]. In this paper, the way of modelling knowledge is alone dealt in detail with three modelling techniques for building knowledge repositories. OSM supports object oriented programming approach with its class concepts. It captures explicit form of knowledge from information banks and data banks in the form of objects and their associations [11]. KSM deals with the notion of knowledge unit based task oriented approach for the formulation of structured knowledge models [8]. Conceptual graphs differ totally from the modelling techniques discussed earlier in its perpetual support for natural language representation [13-15]. Table 2 consists of the specific features of the knowledge modelling techniques discussed earlier.

The future issues pertaining to this research analysis are: 1) Representing tacit knowledge in the form of explicit knowledge including assertions, associated concepts and mappings, 2) Identification and extraction knowledge domains in relevance to notions, attributes, relations and organization of knowledge unit in related knowledge beds, 3) Physical storage and retrieval of knowledge units in the databases, OSM in object relational databases, KSM and CG in intelligent database systems and 4) An implementation of a modelling tool that captures, models and deploys knowledge in the knowledge repositories.

The issues will be considered in the further research study of KM and modelling techniques.

CONCLUSION

This paper presents the modelling techniques in its explicit form. Though the argument prevails in the KM community that a quantitative and a qualitative research for explicit and tacit knowledge modelling in needed, the knowledge users and the workers are still ignorant in considering the activities of knowledge management in their functional domain [1, 7]. It is often considered as a waste of time, effort, money and other resources [3, 7]. And for that reason, only a handful of research papers in knowledge management systems and knowledge modelling exist to till date. David [6] blames the software development organizations for their negligence in providing real time data to the research community. This results in lack of research in that part of knowledge management and ultimately organizations land in jeopardy.

Still, apart from these realtime functional chores, this paper deals a lot with the knowledge modelling techniques. The three techniques have different approaches in their own specific functional area. The OSM deals with a simple approach to modelling and handling of the knowledge, KSM has a higher level of complexity in representing knowledge. CG has the highest level of complexity in handling the knowledge that was acquired through the explicit knowledge bases or information bases or data banks. This paper serves as the first step in the activity chart of knowledge management system. It also serves as a footing in the aid of further analysis and study into the wider domain of knowledge management.

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