SIGNIFICANCE OF ONTOLOGY FOR DESIGNING STAKEHOLDER-ORIENTED APPLICATIONS

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Abstract: *Ontology provides formal explicit description of problem domains that contribute to structuring system solution. Over the past decades various applications have been developed using ontology technique for providing various user access benefits.This makes the ontology as one of the prominent techniques specially to systemize problem domains. In this paper, we describe importance of ontology development through our experience that has been gathered in two user-oriented applications development projects. The projects were designed to address issues related to user access and understandability on developed systems, in which we promote unique significance of ontology specially for developing system solution. Findings from our studies suggest that ontology enables provisions to reflect user's common understandbility for developing stakeholder oriented applications that trun to miximuse various user benefits.*

Keywords: *Ontology, User-oriented applications, DSS, Design research*

INTRODUCTION

Ontology defines a formal explicit description of concepts using basic terms and relationships as well as the rules for systemizing or modelling problem domains (Lambrix and Edberg, 2003; Noy and McGuinness, 2001). Ontology is defined as "... *an explicit specification of a conceptualization*" (Gruber 1993, p.199). The use of ontology for conceptual modeling are well-recognisied (Liddle et al., 2003) in that focus goes to extend definitions of relationships and concepts from the problem domain that are the prime aspects to enhance reusibity and sharing knowledge. Thes capacities (reusability and sharability) are of paramount importance to develop formal specifications of systems that are based on terms and relations outlined from the specific problem area. As such the ontology approaches have been used to build explicit understanding on the structure of complex problems in system design such as in bioinformatics (Baker et al., 1999; Lambrix and Edberg, 2003), World Wide Web design (Crampes and Ranwez, 2000; Liddle et al., 2003; Sunagawa et al., 2003), medical informatics (Gennari et al., 2002; Musen 1998). Therefore, it would be an important research aspect to identifying significance of

ontology for systemizing problem space in different domains to maximizing provisions of developing user-oriented applications.

Several recent studies have been illustrated the significance of using ontology technique specially for promoting user benefits. Some examples: 1) Chen et al. (2013) for personalised knowledge searching; 2) Liu et al. (2012) for Chinese text classifications; and 3) Velardi et al. (2013) for taxonomy induction. For better knowledge management, Euzenat (2002) discussed the advantages of the semantic ontology extending capabilities of the web with formalised knowledge and data processing for computer applications. Euzenat (2002) identified the need for mixing human-readable and structured data so humans can understand and use semantic data produced from computer applications. Haghighi et al. (2013) introduced important requirements of domain ontology development for the better use of domain knowledge for informed decision making. Uren et al. (2006) investigated the semantic annotation and how it may recognise the requirements of businesses and therefore better reflection on system design are ensured. The study of Haghighi et al. (2013) showed the value for ontology tools to fully address the needs of managing knowledge in organisations. The developed domain ontology-based approach by Haghighi et al. (2013) is functional for the aim of planning and managing domain knowledge for developing a decision support systems (DSS) solution. This represents its applicability of ontology across other domains for systemizing the problem space, for promoting through the benefits for end users.

In this paper we describe the applications of ontology in two different problem domains: rural businesses and higher education domains. For the rural business domain, problems are assosciated with numerous changing situations and sensitive to common vocabulary. Therefore situation-oriented terminology or system components are of paramount important for system design consideration. In this case, our attempt was to outline a knowledge sharing and reusable system model using ontology for developing an effective decision support mechanism, which we successfully achieved. In our second case, the main aim was to improve an existing electronic documents and records management systems (EDRMS) in the education domain. Our expectations were to mainly employ ontology for effectively enhancing searchability and navigability while users retrieve, store, process and preserve documents and other forms of digital record. We successfully replaced the keyword-based searching that were used in the existing EDRMS.

In both system design projects, ontology has been used to address issues of system being very static and does not meet any of the demands of context sensitivity within the target knowledge domain. This limitation results from vocabulary inconsistencies in the domain that led to mismatches between the desires and content of a system's knowledge repository.Our developments focus on developing a combined knowledge repository in order to address the inconsistencies in the domain, so users can have better access and understandability to their own systems for assisting in their every day operations. Noy and McGuinness (2001) described the importance of ontology development as sharing common understanding of the structure of information among users and developers; enabling reuse of domain knowledge; making the problem domain knowledge explicit; separating domain knowledge from operational knowledge; and analysing the domain knowledge for application development.In this paper, we contribute to the conceptual

discussion by Noy and McGuinness (2001), elaborating views that are more practical and established through our practical experiences.

The following section describes a background on the key significance of ontology, in particular for system development. The section after that will present a detail on the methodology used for ontology development in both projects. The following section after that describes the key design aspects that provides key benefits to the target users. Finally the discussion and conclusion section present a summary and overall applicability of the research reported in the paper.

BACKGROUND OF THE STUDY

The main aim of the paper is to describe the unique significance of ontology specially to develop information systems (IS) solution. In the paper we focus on a subset of the IS class called DSS and in that our emphasis goes on the personal DSS and knowledge-based DSS solutions. Arnott and Pervan (2008) separated DSS soutions types as personal DSS, group support systems; negotiation support systems, intelligent decision, knowledge management (KM) based DSS, data warehousing and enterprise reporting systems. Arnott and Pervan (2008) defined the personal DSS solution as small-scale systems that are designed for end users such as managers in order for their information support. This type of DSS applications is important in practice for the end users' everyday operations. Also, the KM based DSS is defined as the systems that support with decision making by assisting knowledge storage, retrieval, transfer, and application for their management (Arnott and Pervan, 2008). Through our approach, ontology helps improve such DSS system solutions through applying shared and common understanding of the knowledge domain (Haghighi et al., 2013). Staab et al. (2001) described that ontologies enable aggregation and use of knowledge items and sub-processes and provide a way to move from a document-oriented view of knowledge management to a content-oriented view. It implies that through ontology the shared understanding of any problem domain can be used as a unifying framework to address the domain problems (e.g. for developing a solution).

The main objective of a domain ontology is "*to reduce the conceptual and terminological confusion among the members of a virtual community of users (for example, tourist operators, commercial enterprises, medical practitioners) who need to share electronic documents and information of various kinds*" (Navigli and Velardi, 2004, p. 151). This definition has been supported by several recent studies in the context of their domain ontology construction (Chen et al., 2013). Theoretically, Semantic Web systems enable much more complex and precise queries to be formulated and executed than is possible with more traditional keyword-based approaches (Abrahams, 2006). For sustainable record management, semantic ontology holds potential to be employed for generating more context-specific and systematic record management approach for an individual's effective decision making (Bruemmer, 1991); Daniels, 2009; Joo and Lee, 2009).

Uschold and Gruninger (1996) argued that ontology needs to be developed by identifying a set of relevant concepts with a common vocabulary (of end users) and its definitions for a common and shared understanding of the domain interest. At the same time, limited studies focused on a problem ontology development that goes with the problem-specific nature of ontology constructs (Chandra and Tumanyan, 2007). However, the

significance of integrating a specific domain ontology into system design has in the past been well accepted within the perspective of decision support systems development (Miah, Kerr, Gammack, 2006; Miah, 2009; Musen et al., 1996; Ceccaroni et al., 2004). This is for the reason that it enhances information retrieval and improves accessibility of data, meta-data and its further description to support users with complicated decision-making (Ceccaroni et al., 2004; Dzemydiene and Kažemikaitiene, 2005).

As Arnott and Pervan (2008) defined the knowledge management-based DSS *"support(s) decision making by aiding knowledge storage, retrieval, transfer and application by supporting individual and organizational memory and inter-group knowledge access"* (Arnott and Pervan, 2008, p. 658). EDRMS can be classified as KM based DSS, AS the definition captures some of the aspects and nature of EDRMS defined by National Archives of Australia (NAA) and International Records Management Trust (IRMT), which highlights the role of EDRMS in managing knowledge storage in an organisation. According to the NAA, an EDRMS is .... *"a software application that manages a range of digital information, including word-processed documents, spreadsheets, emails, images and scanned documents. An EDRMS can combine both document management and records management functionality"* .

METHODOLOGY

We used similar methodology in both design projects to develop system solutions that may provide improved user access and other relevant benefits. The development of a ontology involves a complex process of knowledge acquisition through domain independent principles of the methodology. Most of the ontology development principles offered in methodologies are relatively similar. For instance Uschold et al. (1996) proposed a methodology that sets out steps such as purpose identification, building ontology, evaluation, and documentation. This methodology is similar to the traditional system development approach, which is not involved with any knowledge acquisition and conceptualisation activities that can be applied into our ontology development. Similarly, Staab and Studer (2001) described a methodology for an ontology based knowledge management system, which has followed five major steps. These steps are a feasibility study, ontology commencement, refinement, evaluation and maintenance. Another methodology for task based ontology development reported by Mizoguchi et al. (1995) involved four different phases. These are the extraction of task units, organisation of task activities, analysis of task structure and organization of domain concepts. This implies that scope and purpose identification for ontology development has been skipped or assumed to be completed previously. The above-mentioned literature indicates that these methodologies commonly start from the step for identification goals/purpose of the ontology and the need for domain knowledge acquisition. However, this can only happen after a significant amount of knowledge is acquired (Lopez et al., 1999). We engaged an approach called METHONTOLOGY (Fernandez et al., 1997) for ontology development, which advocates the use of a structured informal representation to support the ontology development (Bally et al., 2004).

The following diagram (figure 1) represents the set of activities for our ontology development.

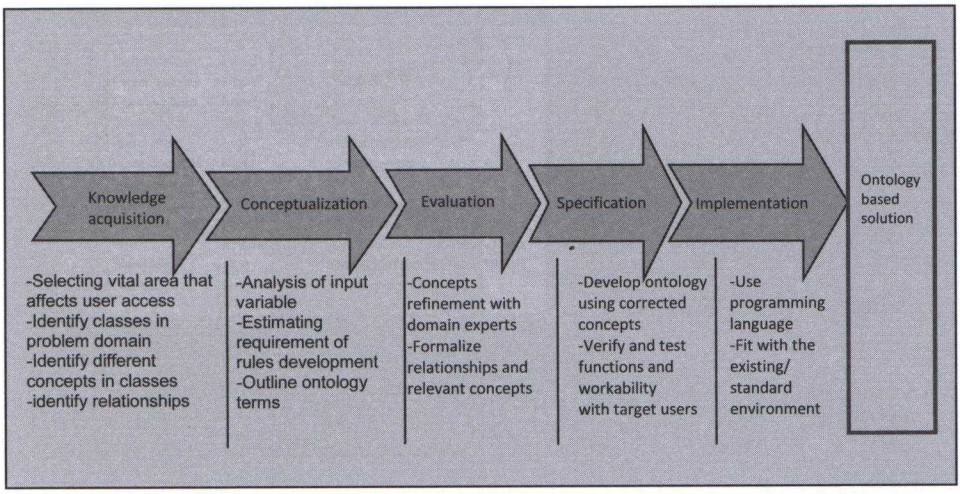

Fig. 1: Adapted Methodology for Developing Ontology.

ONTOLOGY CONSTRUCTION

As mentioned earlier the first ontology we developed for a personal DSS development in that rural business users are the target users. To model the domain knowledge, a generic knowledge repository was of paramount function to add-up all knowledge components that enable reasoning (parameters, factors and their relations). Such a structure can be re-used in other rural domains for the DSS applications. Ontologies are domain specific, and domain experts can be involved in interpreting and understanding the domain knowledge before any actual development occurs for the end users. In this case, both users such as end user and domain experts could be engaged in the DSS development processes. Figure 2 shows the developed structure of the knowledge in the ontology.

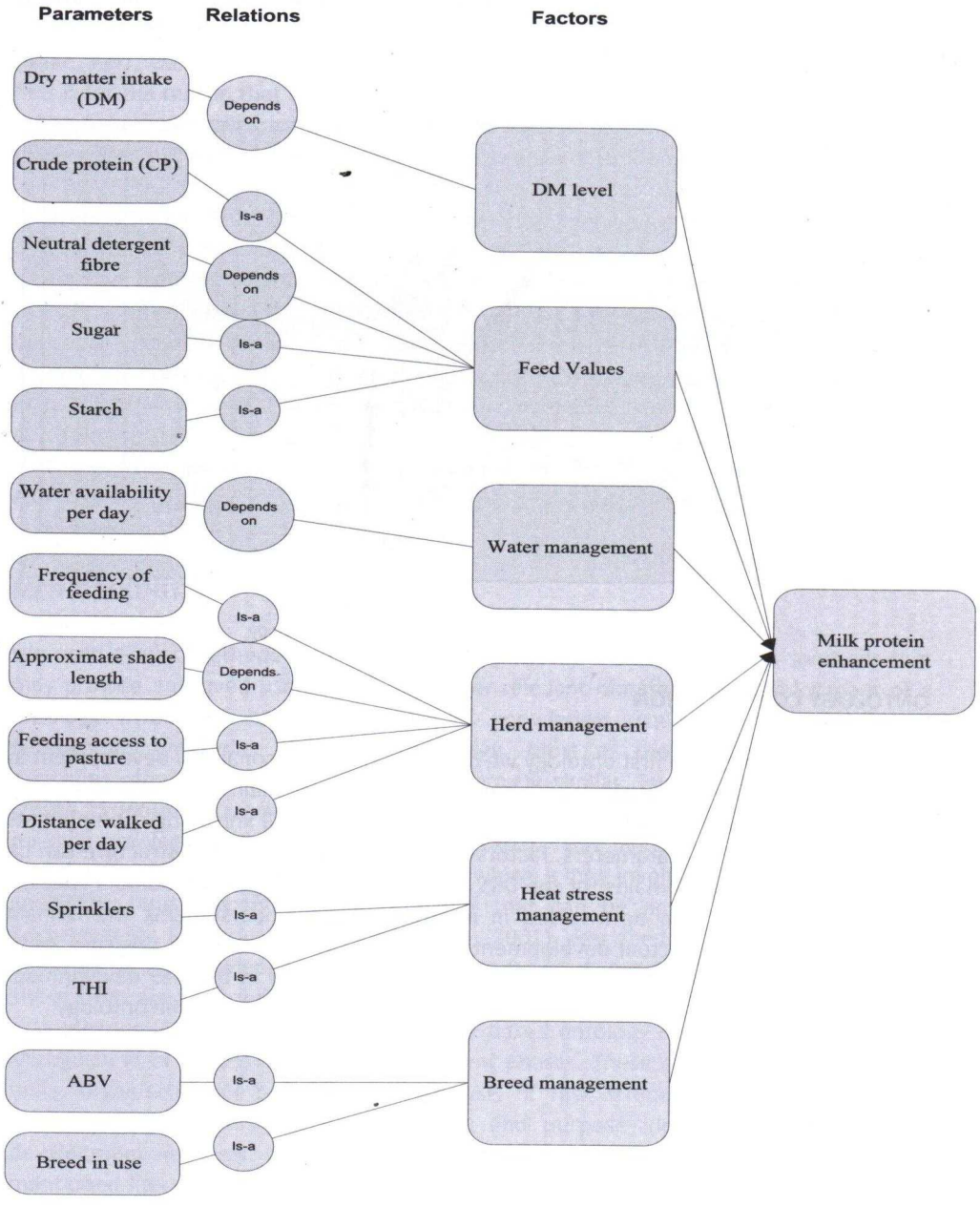

Figure 2: Ontology Development in Rural Industry

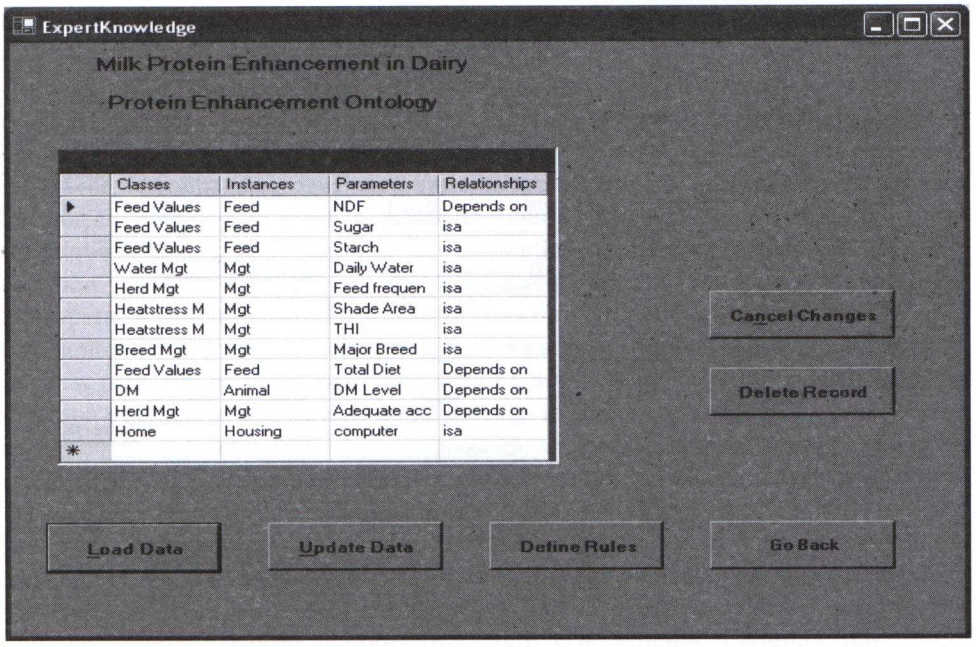

Figure 3: System Captured of the Prototype Ontology in Rural Industry

In the second case, the ontology was implemented through the concepts (classes), subclasses, properties and associated relationships of the problem domain in education. There are four main key concepts in the final structure of ontology, which defined (see figure 4). As part of the ontology description we also outlied more details such as the definition of terms used and relationships related to the proposed ontology approach. These definitions were very important to the stakeholders to learn and understand the ontology, in order to simplify the nivagation and searching processes. Furthermore, they assist the ontology developers to understand what a term was intended to mean and the design purposes.

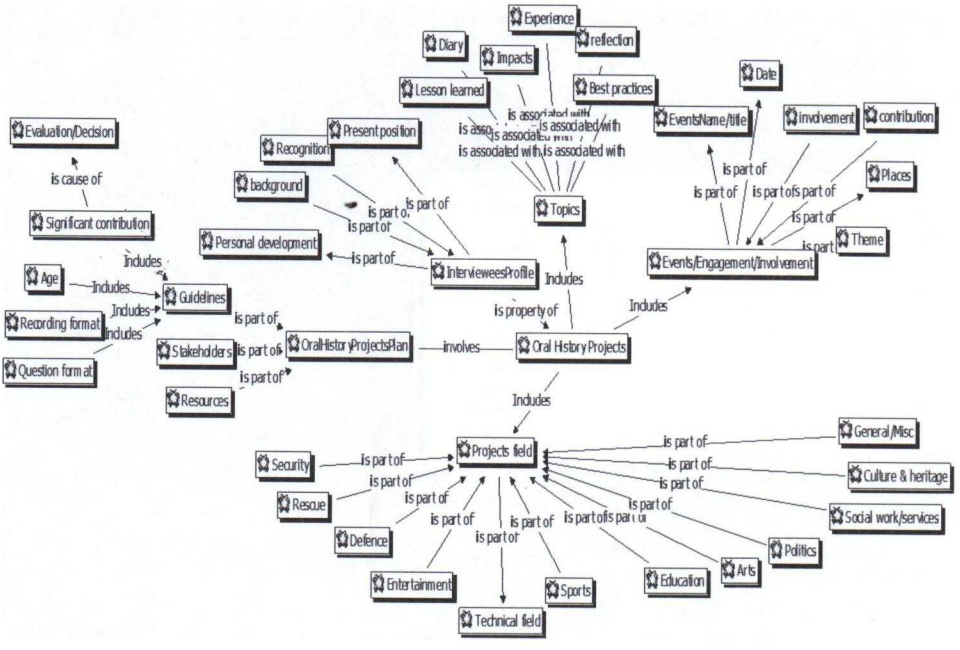

Figure 4: The Final Domain Ontology in Education Domain

There are many tools to visualise the ontology such as Atlas.ti, Protégé and Nvivo. We used Atlas.ti in both cases because the tool is user friendly, easy to use and has the ability to effectively visualise and represent our ontologies. A prototype of the improved KM based DSS system (Main window can be seen at figure 5 below) integrating the semantic domain ontology was developed in which several taxonomies were included for better searchability, as discussed earlier.

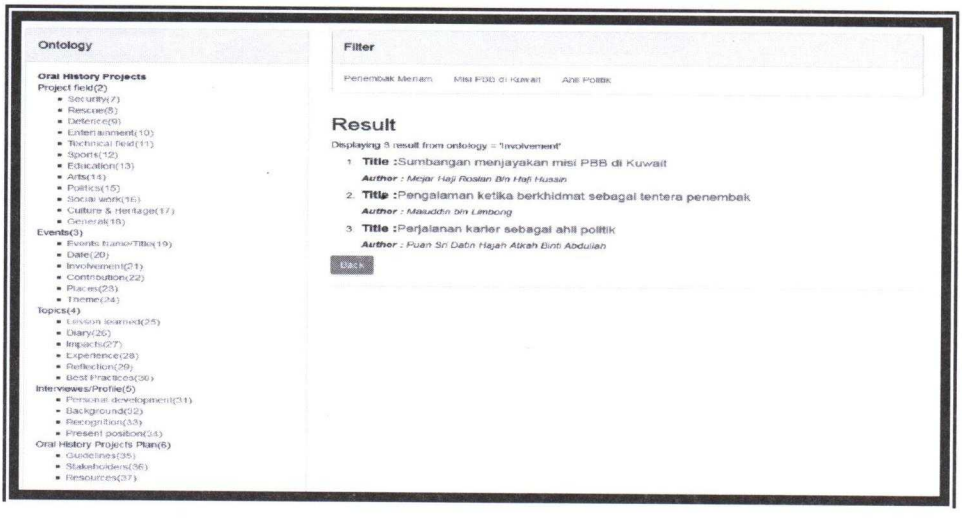

Figure 5: Main Window of the Ontology Based System in Education Domain

DISCUSSION AND SUMMARY

The main aim of the paper is to describe unique significance of ontology for stakeholder oriented application developments, demonstrating key value of structuring problem domain using ontology. Our two cases have shown how problem components are to be structured for enhancing developed systems' accessibility. The ontology development became a recognised approach in system development (Hyland-Wood et al., 2006) as the technique is able to provide a basis for application development that could provide a common understanding for a solution model that is reusable, sharable and interoperable. We have practically justified this through our two design cases. Over the past limited number of research has addressed issues of DSS design through ontology. In our first case, the ontology addressed the DSS developments in rural industries, in the direction of personal DSS classes, by simplifying technological constraints which appear as rigid options to end-users. Technological constraints were there because of a great range of changing decision requirements and the need for use various rules of thumb and traditional approaches could handle such complexity. Sharing and reusable provisions for end-users were imposed for the benefits of users. In the scond case, in the existing EDRMS, the searching was based on keywords that bring mismatches between user need and the content of the database. In the direction of KM based DSS the ontology offerd advanced features that were user oriented therefore the system developed out of it was much more effective.

Our effort goes to the direction of conceptual study by Noy and McGuinness (2001) in that the importance of ontology development has been described. The authors theoriticaly outlined the key benefits of using ontology such as: sharing common understanding of the structure of information among users and developers; enabling reuse of domain knowledge; making the problem domain knowledge explicit; separating domain knowledge from operational knowledge; and analysing the domain knowledge for application development.We extended the study as we practically defined these benefits of using ontology. We therefore would argue that ontology can provide a basis for application development that could offer a common understanding for developing stakeholder-oriented solution model that is reusable, sharable and interoperable.

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