Towards a Socio-technical Ontology Engineering Methodology

Dana Indra Sensuse¹, Mesnan Silalahi², Indra Budi³
Laboratorium e-Government, Fakult of Computer Science, University of Indonesia
Kampus Depok-UI, Indonesia
¹dana@cs.ui.ac.id; ²mesnans@yahoo.com; ³indra@cs.ui.ac.id

Received 4 December 2013; Accepted 15 January 2014; Published 8 August 2014 © 2014 Science and Engineering Publishing Company

Abstract

The development of the semantic web technology has enabled the integration of existing systems and resources. The implementation can be seen such as in the Linked Open Data initiatives, semantic search and semantic web portal. Ontology has been playing the crucial role for the implementation of the semantic web technology, but the development of ontology itself has lagged behind. Methodologies have been developed for ontology engineering, but most of them focused on the technical rather than the socio-technical aspect. Only a few has approached socio-technically but only partially. This article will describe aspects towards a socio-technical approach in ontology engineering methodology more comprehensively. This approach is important because of the complexity and the social nature of the ontology building process. A comparative study will expose the plus and minus points of methods used within the existing methodologies from the socio-technical point of view. Then a workbench will be proposed that take socio-technical aspect within the ontology engineering methodology into account.

Keywords

Ontology, Ontology Engineering; Methodologies; Socio-technical Approach

Introduction

Knowledge is considered the most important asset for organizations and knowledge management has become an important issue nowadays. There are many knowledge based and information systems developed and implemented for the effective and efficient operations of an organization. One of the problems encountered during the implementation was the difficulty in searching an accurate information and/or the right knowledge. The cause of the problem was identified as the data segmentation within islands of information. In general this problem was caused by the low level of the interoperability. The key to the development of the interoperability is through the development of the ontology. Ontologies have long been argued as one approach for capturing and representing domain knowledge. Currently the information presented on the internet has very limited semantic values and is not machine understandable hence not processable. The data are heterogenous with various structures and formats. To have semantic value the data have to be annotated with ontology which has specifications for the concepts used and relations between the concepts. The development of semantic web has driven the ontology building in many domains. In order to ensure that the ontology will be used widely there must be a consensus within the related parties. And to reach a consensus effectively there is a need in the approach to the ontology engineering methodology that take into account socio-technical aspects. The socio-technical approach is needed because of the complexity in the ontology building process. This paper tries to answer the question and key factors in the socio-technical approach along the ontology lifecycle and how to operationalize the socio-technical approach effectively in the ontology engineering processes.

The socio-technical approach had been inserted into some of the existing methodologies in ontology engineering, but the methodologies have approached it partially. In this paper a methodological model will be proposed with a comprehensive socio-technical approach. The social aspect will be considered in balance with the technical aspect through the phases of the ontology building process, from planning phase to implementation and evaluation phase. This will include the considerations of the social aspects in the methods, techniques and tools of the proposed
methodology.

![FIG. 1 THE PHASES OF A SOCIO-TECHNICAL APPROACH IN ONTOLOGY ENGINEERING](image)

**Semantic Web Application**

The semantic web architecture proposed in (Berners Lee, et al, 2001) contains ontology sublayer which plays an important role in semantic web implementation. With the availability of an ontology we can give meaning to the data representation on a webpage. Within the semantic web architecture, the data will be stored in the RDF (Resource Description Framework) files. On top of it, the semantic value (ontology) is given by the OWL (Web Ontology Language) sublayer. OWL is the official standard of W3C used for ontology building with various levels of expressivity.

![FIG. 2 THE SEMANTIC WEB ARCHITECTURE](image)

In the development of a semantic web application, e.g. the semantic search application, there are various ways to integrate data from various source locations. This integration has to be carried out because of the heterogeneity of the data source formats. One of the approaches is hybrid ontology integration whereby there will be a local ontology for each data source which represents the schema of the local database. Then there will be a global ontology whereby all the local ontologies mapped into, that will be used as an entry point for designing query strategy-for searching. The semantic search is supported by SPARQL engine as the standard in query syntaxes in semantic web application.

**Methodologies in Ontology Engineering**

Various methods and methodologies had been proposed in conducting the ontology engineering. These various attempts were carried out in order to make the ontology building process running effectively and efficiently. Informally there are two approaches in the ontology building methods i.e the top-down approach that is heavyweight and mostly is carried out by large parties. The other is a bottom-up approach that is lightweight and usually is carried out by many related parties that later could be merged. In general, there are three main activities in building an ontology (Tempich et al, 2006): ontology management, ontology development that covers the domain analysis, conceptualization and implementation, and the support and maintenance of the ontology. A state of the art in the ontology methodology such as the METHONTLOGY (Gómez-Pérez et al., 2003) describes the ontology building processes, activities, and tasks in details. This methodology has been known widely but not the use. ONIONS (ONTologic Integration Of Naive Sources) is a methodology that describes various methods to integrate sources of information (ontology network) with the emphasis on the domain ontology. OTK (On-To-Knowledge) (Staab et al., 2001) was developed with the approach using the common sense found on other methodologies. DILIGENT (Tempich et al., 2004) build an argumentation framework in modeling ontology engineering supported by wiki based tools. UPON (United Process for ONtologies) uses a UML base approach with use cases and has incremental and iterative characteristics. Below is a list of the plus and minus points of some important methodologies.

**A Socio-Technical Approach**

According to Studer, et al (1998) ontology is defined as: “A formal explicit specification of a shared conceptualization of a domain of interest”. From that definition we can infer the characteristics of an ontology as formal, explicit, and conceptual specification of a domain. We can thus say that an ontology has to be built based on a consensus of the stakeholders and the related parties and is implicitly meant the wide acceptability. The true value of the ontology itself is, when it is shared and used publicly. In fact the development of an ontology is more and
<table>
<thead>
<tr>
<th>Methodology name &amp; Author</th>
<th>Plus points</th>
<th>Minus Points</th>
</tr>
</thead>
</table>
| • OTK, Staab et al.       | • Cover the whole lifecycle  
• Use of ontology pattern  
• Contains strict rules for update/insert/delete ontology  
• Integrate participants early in the process to identify use case and competency questions  
• Rather detailed in building ontology from scratch  
• Propose ontology learning | • Too formal for small scale application.  
• Focus depend on the application (enterprise ontology)  
• Not address the collaboration aspect.  
• Target User are ontology engineers |
| • Enterprise Ontology  
• Uschold & King (1995) | • Application independent  
• Middle-out strategy in identifying concept. | • Not proposing a feasibility study or prototyping.  
• No clear description on the techniques and activities.  
• Not proposing a lifecycle. |
| • TOVE  
• Grüninger & Fox (1995) | • Proposes identifying intuitively the main motivating scenarios | • No clear division in the phases.  
• The activities as well as the techniques used not described into details.  
• No selection process in life-cycle model  
• Domain limited in business. |
| • METHONTOLOGY  
• Gomez Perez et al. | • Very detailed process  
• Application independent.  
• Adoption of middle-out strategy.  
• An evolved prototype.  
• A mature methodology  
• Contain whole lifecycle  
• Has an integrating part.  
• Based on IEEE standard for software development. | • Details in predevelopment process not sufficient  
• Too complex for small scale application  
• Ontology reuse in the end development phase.  
• Lifecycle model does not respect any usage-oriented aspects  
• Not address collaboration.  
• Target users are ontology engineers |
| • SENSUS | • Addressing the distributive setting  
• Ontology Reuse | • A top-down approach  
• Not mention the lifecycle  
• Not too detailed  
• No particular technique in details. |
| • Ontology 101  
• Noy & McGuinness | • Address the naming convention  
• Based on best practices  
• Iterative process  
• Has an integrating part in begin phase | • Has some missing part of the whole lifecycle (evaluation and implementation) |
| • HOLSAPPLE  
• Holsapple & Joshi | • Collaborative building process.  
• Focus on reaching consensus.  
• Iterative process | • Only specify the effort on reaching a consensus |
| • DILIGENT  
• Tempich et al. | • Focus on the collaboration process  
• Based on the good argumentation to reach consensus.  
• Iterative process  
• Distributive environment setting  
• The approach focused on the human  
• Targeted for domain experts and end-user  
• Start using the ontology early in the process  
• A centralised approach by introducing a control board | • No proposal for activity in the specification of the ontology requirements  
• No proposal for reusing and reengineering knowledge resources to speed the process.  
• The balance of the control board not addressed. |
| • HCOME | • A distributive environment  
• The approach focused on the human | • The supporting tool is not clear |
| • DOGMA  
• Mustafa Jarrar, Robert Meersman | • Separate clearly the base facts in domain (lexons) from constraints, rules, identification, derivation to improve reuse  
• A collaborative approach | • Centralised approach. |

TABEL 1: MINUS AND PLUS POINTS OF SOME EXISTING METHODOLOGIES.

more a complex social process rather than a technical design activity (Kings & Davies, 2009). Mika (2005) stated that the creation and maintenance of ontology is purely a social activity. To understand the social existence is crucial in understanding how the ontology evolutes and accepted. Thus there are still a lot of
things to investigate in ontology engineering, such as the socio-technical context in order to develop a methodology that will enhance the successful implementation of the developed ontology. The low level of success in system implementation and the use of ontology in particular, has driven the development of the socio-technical model in the information system in general and in the field of ontology engineering in particular. In general, this approach is aimed to a greater acceptability and to smoothen the consensus building. According to Cherns (1987) there are ten principles to the socio-technical approach in system development, i.e: compactibility, minimum critical specification, variance control, location boundary, information flow, power and authority, multifunctional, support conguerncy, transitional organisation and incompleteness principle. These principles can be taken into account for modeling the ontology development. In the field of information system development, Mumford (1983) developed an ETHICS model to look for a socio-technical solution of problems in the implementation of an information system. This model focused on the participatory mechanism of the stakeholders. This approach ensures the feedback that will expose the user requirements which eventually ensure the acceptability. Below is the list of some methodology with the focus on-technical aspect aiming to automating the ontology building process and the partially socio-technical approach that focused on some aspect of a social approach to enhance the success of the ontology building process.

<table>
<thead>
<tr>
<th>Focus</th>
<th>Name</th>
<th>Characteristics</th>
<th>Ontology</th>
<th>Central Actor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Merging/Integration</td>
<td>Pinto et al, KACTUS, ONION</td>
<td>The split between the static and the dynamic parts</td>
<td>Centralized</td>
<td>Knowledge Engineer</td>
</tr>
<tr>
<td>Layered (n-tier)</td>
<td>DOCMA</td>
<td></td>
<td></td>
<td>Knowledge Engineer</td>
</tr>
<tr>
<td>Learning</td>
<td>Ontolearn</td>
<td></td>
<td></td>
<td>Knowledge Engineer</td>
</tr>
<tr>
<td>Rapid Development</td>
<td>ROD</td>
<td></td>
<td></td>
<td>Knowledge Engineer</td>
</tr>
<tr>
<td>Comprehensive</td>
<td>METHONT-OLOGY</td>
<td>Based on SE methodology, very detailed</td>
<td>Static Ontology</td>
<td>Knowledge Engineer</td>
</tr>
<tr>
<td>Common Sense</td>
<td>OTK</td>
<td>based on UP and UML</td>
<td>Large Scale Domain Ontology</td>
<td>Knowledge Engineer</td>
</tr>
<tr>
<td>Partly Socio-technical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argumentation Based</td>
<td>DILIGENT</td>
<td>Distributive setting, More Role for Domain Expert</td>
<td>Dynamic Domain Ontology</td>
<td>Control Board in Consensus Building</td>
</tr>
<tr>
<td>Human Centered</td>
<td>HCOME/HCOME</td>
<td>Nominal Group Technique</td>
<td>Decentralized</td>
<td>Knowledge Worker</td>
</tr>
<tr>
<td>Consensus</td>
<td>HOLSAPPLE</td>
<td>First Initial Ontology developed further with Delphi Method</td>
<td>Static Ontology, centralized</td>
<td>Knowledge Engineer</td>
</tr>
<tr>
<td>Inter-organisational</td>
<td>DOGMA-MESS</td>
<td>Database like inspiered architecture</td>
<td>Dynamic</td>
<td>Domain Expert</td>
</tr>
</tbody>
</table>

**Research Methodology**

The proposed methodological model will approach the ontology engineering from the point view of socio-technical design. The model will take into account the existing best practices in software engineering as well as in ontology engineering. Fig.2 describes the proposed components for input in the development of the methodology. The methods that will be applied in the design model will take into account concepts in meta-design, concepts in virtual workgroup collaboration, and the argumentation model in consensus building. In the planning phase account will be taken on how to handle the seeds of the ontology design such as the goal and intention of the ontology, and the planning and the user requirement elicitation in complex system.

**FIG 3. INPUT FOR THE METHODOLOGY DEVELOPMENT**

The tool is web based which is build for supporting the socio-technical approach that has the functionalities for: the capabilities for supporting collaboration with a user-friendliness in inserting
people to participation, contribute, put arguments and voting (or some other conflict resolution mechanism) and/or for just to put comments. Furthermore the communication channel will be built on various methods such as mailing list, blogs, chatting, short messages, or a functionality to shouting. More importantly is the integration with tools for the core functionalities such as ontology editing, ontology browsing and ontology visualization. Furthermore accounts have to be taken on the supporting features such as documentation and tracking ontology versions history.

Below is the list of some of the tools that are reviewed before integrating into the proposed workbench. The tools selected will be integrated within the portal. The portal is based on a CMS software that supports the semantic web application (such as Drupal) and has capabilities for extention and adaptability such as integration with the more powerful existing tools for ontology editing, ontology browsing and ontology visualization.

![Image of reviewed tools for socio-technical ontology engineering](image)

**FIG. 6 REVIEWED TOOLS FOR THE SOCIO-TECHNICAL ONTOLOGY ENGINEERING**

**Conclusions**

The socio-technical approach has been proposed to be comprehensively used as a basis in developing a methodology for the ontology engineering. This methodology is proposed based on the partially socio-technical approaches that have been tempted in order to increase acceptability of the new system in general and the ontology in particular. This will eventually boost the wider use of the ontology and eventually can contribute to the higher interoperability of the exiting systems and data sources. By including the methods, tasks, and tools that have the socio-technical characteristics from past results in ontology engineering methodology development, it will add socio-technical value of the new proposed methodology. This methodology has a modular property in which the new methods, tasks or tools can later be added to fully covered the whole range of the ontology engineering process with the socio-technical value.

**ACKNOWLEDGMENT**

We thank the Ministry of Education of Republic of Indonesia for supporting this research within the scheme of BOPTN 2013.

**REFERENCES**


Tharam Dillon, Elizabeth Chang, Maja Hadzic, Pornpit Wongthongtham (2008) “Differentiating Conceptual Modelling from Data Modelling, Knowledge Modelling and Ontology Modelling and a Notation for Ontology Modelling”, Wollongong, Australia.


Dana I. Sensus received his B.Sc in Soil Science from Bogor Agricultural University (Indonesia, 1985), M.LIS from Dalhousie University (Canada, 1994), and Ph.D in Information Studies from University of Toronto (Canada, 2004). Now he works as a teaching staff in Faculty of Computer Science, University of Indonesia, and Head of e-Government Laboratory. His research interests include E-Government, Knowledge Management, and Information Systems.

Mesnan Silalahi received his M.Sc in Materials Science from TU Delft, Netherland, (1994) and Magister in Information Technology from University of Indonesia (Indonesia, 2007). He is now taking his Ph.D in Computer Science (University of Indonesia). He works as a researcher at the Indonesian Institute of Sciences. His research interest includes Ontology Engineering, Semantic Web and Knowledge Management.

Indra Budi received the Doctoral degree in Computer Science in 2008 from University of Indonesia. Currently, he is an academic staff at the University of Indonesia. His
research interest includes Information Extraction, Natural Language Processing, Named Entity Recognition and Information Retrieval. He was the first PIC of Content Development Activity, Program B Fasilkom UI, Grant from DIKTI in 2004 and involved in Program CISA Review Course in 2004.