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On Supporting a Meta-design Approach in Socio-Technical Ontology Engineering

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Abstract**—**Many studies have revealed the fact of the complexity of ontology building process. Therefore there is a need for a new approach which one of that addresses the socio-technical aspects in the collaboration to reach a consensus. Meta-design approach is considered applicable as a method in the methodological model of socio-technical ontology engineering. Principles in the meta-design framework are applied in the construction phases of the ontology. A web portal is developed to support the meta-design principles requirements. To validate the methodological model semantic web applications were developed and integrated in the portal and also used as a way to show the usefulness of the ontology. The knowledge based system will be filled with data of Indonesian medicinal plants. By showing the usefulness of the developed ontology in a semantic web application, we motivate all stakeholders to participate in the development of knowledge based system of medicinal plants in Indonesia.

Keywords**—**Socio-technical, meta-design, ontology engineering methodology, semantic web application.

I. Introduction

ONTOLOGY has been started to be used widely as the knowledge representation technique because of its ability to identify class or concept, property and relationship within a domain of discourse. Ontology is the key in the development of semantic web application. However, ontology development itself undergone many obstacles in its development. Previous research has revealed the fact that building ontology is a complex process that a new approach is needed with regard to collaborative work efforts toward consensus. The development of ontology is heavy and complex because it includes the development of knowledge models that involves many stakeholders and requires careful preparation to smoothen the social process. Ontology development requires consensus within the meaning of common shared concepts. Various methodologies have been developed to create ontology with the purpose to provide easy and systematic guide in building ontology efficiently. However, many of the proposed methodology only focused on the constructing process and the technical evolution of ontology. This results in the low outcome of the developed ontology from the expected benefit. And the ontologies that have been published are not based on consensus, so they are unreliable and are not reused extensively. The result of observation made by [19] states that most of the existing ontology engineering practices does not follow the principles of a methodology. To bridge the gap between social and technology, identification of common needs must be considered as a social activity and includes all stakeholders in the search for ontological agreement that will support mutual needs. Socio-technical approach may have been partially used in several existing methodologies. In this study, a methodology for ontology engineering is developed with a socio-technical approach which covers the whole life-cycle. The study includes the development of a socio-technical workbench that has functionalities in order to support the principles in the meta-design framework. This paper will describe the development of a model in the design and implementation of ontology using the meta-design framework. Meta-design is deemed an appropriate framework in an attempt to build a model of a methodology in ontology engineering with a socio-technical approach. Socio-technical approach emphasizes provision of greater opportunities for all stakeholders to participate in the development of a system. But to obtain broad participation it needs the ability to show to the stakeholders the usefulness that can be gained from these efforts. In our context the concept of meta-design is about how a system and its environment are built by the designer as well as how to involve domain experts. Changes that occur as well as the evolution of the system can be carried out by the domain experts. Meta-design aims to plan, evaluate and incorporate some changes that may occur at use-time based on evolution model. Adapting [8], meta-design relates to domain experts involvement in the design process where they can be a meta-designers and can make changes at this stage of the evolution of the ontology. In the traditional system development, the focus would be specific solutions for the problems while on meta-design the issue is the creation of a solutions space. This solution space must be created in order to support a culture of participation [14] and the evolution of the ontology [10].

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II. Related Works and Motivation

Reference [18] conducted a study comparing tools in building ontology for environment in a human centered engineering. The functionalities are such as: a hierarchy of concepts, properties, instant concept hierarchy, ontology comments, ratings, asynchronous editing in ontology modules, a personal space, historical change, discussion, chat, content insert with integrated browser, and a web interface. These functionalities are developed in line with the growing demands in the engineering ontology. Reference [6] did some comparisons against multiple tools by taking into account functionality such as support for IBIS models in constructing arguments, ontology editing support, and the provenance link. Some of ontology engineering methodology that emphasizes the collaborative aspects such as DILIGENT [3] uses the wiki technology as a web-based tool which is then integrated with the ontology editor and visualization (such as KAON) as a tool to facilitate comprehension of the developed ontology. This wiki based tool is primarily aimed to support broad collaboration in building ontology. Wiki is also used to support the development of an ontology engineering methodology with a human-centered approach in [16], [17]. This tool is used to support web community-driven collaborative ontology engineering tasks and as an argumentation support tool. In our view, tool support for collaboration should include providing access to the same ontology for distributed users and the annotations from various users as a way to reach a consensus. The tools provided will also need to provide increasingly complex functionality such as supporting an efficient discussion that can accelerates the convergence to a decision [6]. As far as the authors knew, none of the existing tools have special support in building consensus. Some of the tools provide supports for rating and voting. However, it should be noted that a rating without a comment and explanation attached to it will not be useful. Another issue that arises is the need for sophisticated tool to facilitate understanding of the ontology. One of the widely used tools for the construction of ontology which closely covers the needed functionality is Protégé [2]. Protege has extension for a web based tool called WebProtege. But so far most of the existing tools only support the design and implementation of the ontology. They do not support all of the activities in the life-cycle of ontology development [5]. Our research seeks solution to support domain experts in building capabilities to become a meta-designer in the ontology building process. This can be achieved by providing tools that support human-problem interaction, support under-design for emergent behavior, enable legitimate peripheral participation, share control, promote mutual learning and support, reward and recognize contributions as well as foster reflective communities.

III. Semantic Web Application

As previously described, there is a necessity of a semantic web application in order to be able to demonstrate the usefulness of the ontology that has been built as well as to evaluate the ontology. The development of ontology based knowledge querying application can be carried out using Jena programming framework [1] or Corese framework [4]. Class (concept), property, and individuals (instances) are created using WebProtégé [2]. Jena is a Java based web semantic programming framework, aims to provide a consistent programming interface for ontology based application development [1]. Corese aimed at the rapid development of a semantic web based interface to ontology and the RDF data. In Jena, ontology models are created through the Model Factory, while in Corese it is embedded in its API called Semtags. Like Jena, Corese can also be used to setup the inference rules and to setup queries on the ontology database. Both tools support SPARQL as a Query Language that can query RDF graphs via pattern matching. The language's features include basic conjunctive patterns, value filters and optional patterns. Thus using SPARQL it is possible to retrieve more specific and semantically related resources. Using these technologies we can develop a semantic web application that based on the feedback of and requirements of domain experts, problems owner or the broader context of the implementation. The ability to be able to demonstrate the usefulness and to provide a solution of the current problems, will impact on the wider applicability and commitment to sustainable development. Types of applications in semantic web are such as semantic search and linked data. Semantic search seeks to improve search accuracy by understanding the contextual meaning of terms as they appear in the searchable data space to generate more relevant results. Semantic search systems consider various points including context of search, variation of words, synonyms, generalized and specialized queries, concept matching and natural language queries to provide relevant search results. Semantic search can be regarded as a set of techniques for retrieving knowledge from richly structured data sources like ontology as found on the semantic web. Such technologies enable the formal articulation of domain knowledge at a high level of expressiveness and could enable the user to specify his needs in more detail at query time. Application of semantic web linked data is a best practice efforts made in entering data to the web in an effort to enhance the current web. The basis of this application development is the establishment of a data format RDF (Resource Description Framework), a framework that describes the web through a model of expressive metadata (RDFS and OWL) and other sources that have been addressed (URI).

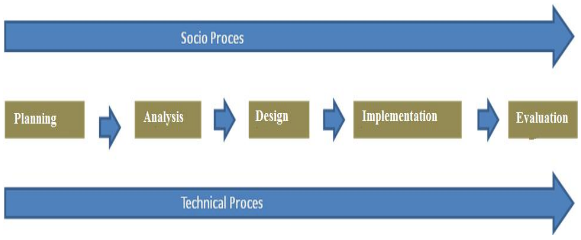

Fig. 1 The phases of a socio-technical approach in ontology engineering

IV. Meta-Design Framework in Socio-Technical Ontology Engineering

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 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 life-cycle and how to operationalize the socio-technical approach effectively in the ontology engineering design process. The socio-technical approach had been inserted into some of the existing methodologies in ontology engineering, but they have approached it partially. In our study a methodological model is proposed with a comprehensive socio-technical approach. The social aspect is considered in balance with the technical aspect along the phases of the ontology building process, from the planning phase to the implementation and evaluation phase as can be seen in Fig. 1. This will include considerations of the social aspects in the methods, techniques and tools of the proposed methodology.

Operationalization of the design, implementation and evaluation phase in the socio-technical ontology engineering model is carried out with the principles of meta-design conceptual framework. The processes in the engineering of Indonesian medicinal ontology will be based on the key concepts of meta-design adapted from [14]. The objective of meta-design is to create socio-technical environments that empower stakeholders to engage in informed participation and to eventually become a designer [12], [15]. The tools that were used to support the engineering process could be integrated from the web-based collaborative tool such as WebProtege, Semantic Media Wiki as well as the content management software such as Drupal [7]. With the Drupal CMS software we can build capabilities in supporting a collaborative annotation and communication on the building process while actively engineer the ontology. With Drupal we launched a community portal for knowledge sharing and supporting collaborative ontology editing and also to create learning environments as is required in meta-design framework [9], [11]. The knowledge model and ontology design can also be evaluated by developing a knowledge-based system based on the database model. This system requires conversion of ontology design to relational database. The advantage of this method is the expertise which has long been established in the traditional web database application development.

The data that has been published about medicinal plants in Indonesia are generally divided into three categories: (a) data that has been structured in a database, (b) data that has been structured and classified but still represented in HTML format, and (c) data that is still unstructured but contains in-depth description of a specific medicinal plant whereby the information will be very useful if it can be easily accessed. In general, in this study several data sources that contain structured data are converted into RDF format with reference to developed ontology of Indonesian medicinal plants. Then the data is used in the implementation of semantic search application and linked data application. Future development of a more enhanced application of intelligent system will provide the use recommendation of medicinal plant by entering data particular to the user. We envisioned to further develope the application that can provide recommendations on the suitability of species of medicinal plants that can be cultivated somewhere in the region of Indonesia, based on geographical location, climatic and soil structure of the region.

The data that have been identified and collected will be used as the sources of RDF data. The results obtained are multiple pieces of data on medicinal plants of Indonesia from herbal database of University of Indonesia (approximately 1600 species of plants), the simplicia database of medicinal plants from the Faculty of Pharmacy, Sanata Dharma University, and the data of Indonesian medicinal plants from the database of National Agency of Drug and Food Control (BPOM), as many as 900 species. This ontology also describes the economic aspects as well as aspects of plant cultivation. The data collected was also regarding the production and economic value of some types of mass-produced Indonesian medicinal plants. The data was collected from Ministry of Agriculture. The data is then converted into the RDF format. These data will be used in semantic search application built in java architecture with interfaces using Java Server Pages (JSP) and in an application of linked data. The design process is described as in Fig. 2. The first part of the design process includes the development of an appropriate work environment and then the development of initial ontology.

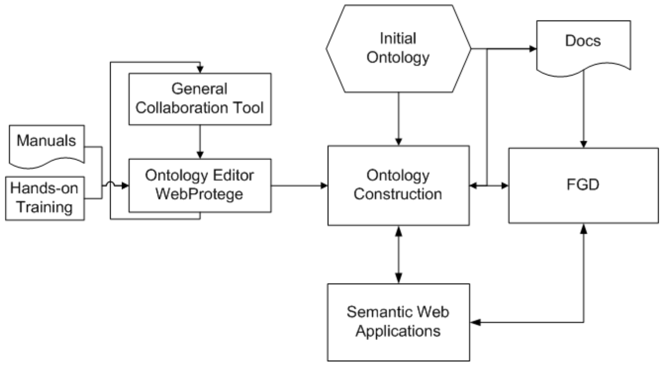

Fig. 2 A socio-technical approach in ontology construction

TABLE I
KEY CONCEPT IN THE META-DESIGN FRAMEWORK AND THE DERIVATION TO SOCIO-TECHNICAL DESIGN IN ONTOLOGY ENGINEERING

Meta-design key concepts in [13]	Derivation of a socio-technical design in ontology engineering environment
Support Human-Problem Interaction	(a) development of a knowledge repository and, (b) user manual, (c) feedback of design output (d) feedback on collaboration, (e) provision of initial design solutions
Under-design for Emergent Behavior	(a) availability of initial ontology as a seed at the start (b) possibility to partition large ontology, (c) separate verification and storage of ontology design fragments, (d) sharing of ontology fragments
Enable Legitimate Peripheral Participation	(a) involvement of other domain experts, (b) allowance of incomplete processes to be completed by others, (c) possibility of merging process fragments of others into a process
Share Control	(a) access permissions (b) preservation of privacy (c) concurrency awareness and control to avoid ontology editing conflicts
Promote Mutual Learning and Support	knowledge sharing through knowledge based system, recommendation lists, comments, blogs, FAQs and forum discussion
Reward and Recognize Contributions	(a) assign specific tasks and feedback on outcome and contributions, (b) visible labeling of feedback (implicit or explicit) on design process
Foster Reflective Communities	(a) facilities for collaboration and communication among domain-experts and other stakeholders, (b) functionality of social networking platforms like voting, rating, and tagging

An initial ontology is built as a starting material which would be further developed collaboratively. This ontology will then be assessed in a face-to-face interaction among domain experts in a focus group discussion. An effective and rich process can be pursued through this inter-active process when it is well prepared. In addition, through a face-to-face interaction it is easier to build trust among stakeholders. Ontology that has been built will be implemented in a semantic web application. For this purpose we develop a semantic web-based search application as well as an application of linked data. The semantic web search application is built using Corese framework. In general, the features that already exist in this software can be integrated with other software tools to complement the functionality necessary for the purpose of supporting meta-design principles in the context of collaborative work and the context of domain expert empowerment. Below is described the key concept within the meta-design framework and how we apply these concepts in supporting the ontology construction. Table I lists the derivation of key concepts in the meta-design framework adapted from the work in [8].

Based on these key concepts, the design process of the ontology takes into account at least some of the key features derived from the meta-design key concepts.

- Support Human-Problem Interaction

The focus on the problem domain and the task of a domain expert are done by making a check-list of the functionality necessary to perform the job. Functionality such as help system as well as lines of communication with systems developers are prepared.

- Under-design for Emergent Behavior

We start at building a simple ontology as a seed to start working collaboratively with domain experts. In the design process a tool is required that enables domain experts to modify parts of design definitions, to verify and to store these fragments of a process separately, and also to share them with others. They can also store the design locally and work further on this local design, that might suit his local need and then to share. Domain experts should be able to decompose the design problem into smaller design elements and combine them with other elements. Concerning reusing design elements, such a design modeling tool might also consider data given from other domain experts as an additional component for designing process. For these purposes the WebProtege has been installed and a training session are facilitated to Domain Experts.

- Enable Legitimate Peripheral Participation

We support this concept by using a web-based software tool WebProtege which has functionality to organize the participation of all stakeholders (community of practice). WebProtege has collaboration features such as sharing and permissions, threaded notes and discussions, watches and email notifications [2]. Because the software is a web-based ontology editor, it can also be used in a broad context by customizing or open certain restrictions of the functionalities. In a broader scope, the community of interest can provide input in a simpler form through the features such as forum discussion that is contained in the web portal built based on Drupal. Optionally the participation of stakeholders can also be supported using the functionality commonly found in wiki-based tools such as link-based web page titles, on the fly web page creation as well as a flat structured content. This functionality can be integrated within the linked data application. Ability to configure user-interface design as well as the representation of diverse stakeholders gives any entrances to participate in the design process, for example in articulating issues in the design and in providing or seeking the proposed solution. Wiki can be configured to only allow a formal process through forms and validation mechanisms, but can also be configured for simple things like to be able to allow a textual description

- Share Control

In the context of constructing the ontology formally, the use of a web based ontology editor WebProtege has made these requirements supportable: (a) access permissions in different roles (b) preservation of privacy (c) concurrency awareness and control to avoid editing conflicts. This tool supports also the informal construction of the ontology through functionalities such as: giving access to put comments that can be used to buid argumentations.

- Promote Mutual Learning and Support

This can be achieved by building a system that support individuals to share their experiences and express their opinions to a problem lies in the development of ontology. The system must be pursued in order to share knowledge among domain experts, as well as in peer-group, namely the practitioners and problems owner, as well as in the wider community. For a broader learning goal a knowledge base can be developed that is published by using a wiki-based tool. Wiki technology has many usages in establishing a community-based knowledge base. With this technology we can seek definition of a concept that is not separated from the discussion and arguments building. This binding will shape the intension of the concept, since the history of a conceptualization is a valuable part of the respective definition.

- Reward and Recognize Contributions

To motivate domain experts to actively participating in the design process is basically done by rewarding and recognizing contributions. Rewarding and recognizing is established by labeling each ideas, comments, feedback, arguments which is visible with the name of the contributor. A statistic of participant’s input can be made in the front page of the web portal as a way for recognizing contribution.

- Foster Reflective Communities

In doing ontology design, the environment should include facility for collaboration and communication so that the domain experts can build a shared understanding among them and to build and sustain a community of designers. This aspect is of particular relevance for process modeling, as several stakeholders from different areas are involved into the processes. Typical functionalities of social networking platforms to support this goal are like sharing, rating, tagging, and commenting process model, that will enable collaboration and communication between stakeholders and in a broader context can be utilized for collective intelligence in order to solve complex design problems.

V. CONCLUSION

The aim of this paper is to show the position of the meta-design approach in constructing ontology in ontology engineering methodology with a socio-technical approach. By setting up the necessary tools in socio-technical environments as well as pay attention to the key concepts contained in the meta-design framework, we designed an ontology of Indonesian medicinal plants, which involves domain experts as well as practitioners and academics. With this approach the goal to be achieved is the creation of a socio-technical environment that inspires broad participation of all stakeholders related to the use of data, information and knowledge of Indonesian medicinal plants. Meta-design approach requires thorough preparation associated with the complexity of the work in ontology building. Therefore, some aspects of the work needs to be prepared to expedite the process of ontology design, such as the need to build the initial ontology (seeds model) and held several methods of collaboration and interaction within the process such as the use of web-based tools. The phase of planning and analysis has been investigated associated with building the initial ontology before the kick-off meeting with domain experts. The next phases still need to be studied further within the on-going basis of the Indonesian medicinal plants ontology development to prove the reliability of the proposed ontology engineering methodology.

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