Building Ontology for Adaptive Collaboration in a Dynamic Environment

ADEPEJU A. ADIGUN[1] and MICHAEL O. KOLAWOLE[2]

[1]Department of Information and Communication Technology
College of Science, Engineering and Technology
Osun State University, Osogbo, Nigeria

[2]Department of Electrical and Electronics Engineering
School of Engineering and Engineering Technology
Federal University of Technology, Akure, Nigeria

Abstract
Building new knowledge-based systems usually involves constructing or modelling new knowledge bases systems. Current knowledge modelling methodologies tend to focus on the subsystem, viewing domain knowledge as strongly dependent on the particular task at hand. Recently, however, the potential value of task-independent knowledge bases (or "ontologies") suitable to large-scale integration has been underlined in many ways. This article examined three broad methods for building ontologies and uses one of them to build ontology for adaptive collaboration in a dynamic environment for knowledge sharing.

Keywords: *Ontology, knowledge-based systems, collaborative, adaptive and modelling*

1. Introduction

In the tradition of AI (artificial intelligence), knowledge is defined in a strictly functional way; that is, whatever can be ascribed to a participant, such that participant's behavior can be computed according to the principle of rationality [1]. For instance:

i. If another participant is able to ascribe to some existing participants goal.
ii. If the same participant sees that this goal is going about achieving his/her goals in systematic or rational fashion; then the participant ascribes knowledge to it.

The relevant evaluative criterion for knowledge base is functional utility, utility in relation to the goals ascribed to the participant's idea. As the content of a knowledge base refers to an objective reality instead of a participant's "mind", it seems clear that according to the modelling view; knowledge is much more related to the classical notion of truth intended as correspondence to the real world, and less dependent on the particular way an intelligent agent pursues its goals. More exactly, the modeling activity must establish a correspondence between a knowledge base and the collaborators: the participant's behavior that is the problem solving collaborators and their environment that is the problem domain. However, current knowledge modelling methodologies tend to focus on the former subsystem, viewing domain knowledge as strongly dependent on the particular task at hand. A further reason for considering domain analysis as a task-independent activity comes from communication concerns. We are often dealing with different communities of diverse participants who must interact and communicate in different ways and in relation to widely different sorts of tasks.

Sharing Effort has underlined the opportunity of increasing the quality of formalized bodies of knowledge in such a way that it is possible to share and reuse at least parts of the ideas for a variety of different purposes. Within such a perspective, knowledge can in principle acquire a value per se. The more shareable, we might say, the better and truth in the classical sense is a sort of infinite shareability [12]. For this knowledge to be shared and reused, information imbedded in the knowledge must be characterized by uniform terms so that the user of such information must understand the same concept as others would. One of the methods that quantify the "common understanding" concepts is called ontology. The concept of ontology has expanded

from its humble beginning in Philosophy into Computer Science.
The study of *ontology*, intended as a branch of philosophy dealing with the *a priori* nature of reality, can be of benefit to the knowledge-construction process in yielding high-value knowledge bases. Ontological issues have recently gained some popularity due to the knowledge sharing initiative [6] [9] [10]; it should be noticed, however, that in the knowledge sharing community the term "ontology" tends to be used more to denote the content of a particular (top-level) knowledge base rather than to indicate a scientific discipline or a methodology. Nominally, ontology is seen as the systematic, formal, axiomatic development of the logic of all forms and modes of being [2] [3]. Therefore, what ontology is concerned in is not so much the bare existence of certain individuals, but rather the rigorous description of their forms. In practice, ontology can be intended as the theory of a priori distinctions among the entities of the world and the meta-level categories used to model the world [4] [13] [14]. Curiously, there is no single knowledge representation that is best for all problems, nor is there likely to be one. Accordingly, in many cases, sharing and reusing knowledge will involve translating from one representation to another. This article studies three broad methods for building ontologies and uses one of them to develop semantic ontology model for adaptive collaboration in a dynamic environment for knowledge sharing.

2. Methodology

2.1 Ontology Building Methodologies

Several methodologies for building ontology have been proposed in the literature. Detailed comparative analyses of these methodologies are provided in [6]. These methodologies vary in the steps and tasks a practitioner should perform when building ontology [7]. These methodologies are broadly typified by:

(i) Uschold and King [11]

This methodology prescribed five stages for ontology development, namely:

a. Define the purpose.
b. Building the ontology by:
    - Capturing the ontology
    - Coding
    - Reusing possible existing ontologies
c. Evaluation.
d. Documentation.

(ii) Fox and Grüninger [8]

Essentially, the Fox and Grüninger [8] enterprise model is a computational representation of the structure, activities, processes, information, people, behaviour, goals and constraints of a business, government or other enterprise. It can be both descriptive and definitional—spanning what is and what should be. This model prescribed five stages for ontology development, namely:

(a) Write scenarios
(b) Formulation of informal competency questions.
(c) Specifying formal terminology for ontology
(d) Formulation of formal competency questions using the terminology of the ontology.
(e) Set benchmarks to see if the ontology is complete

(iii) Bernaras et al. [5]

This approach to developing ontologies is conditioned by applications development. So, every time an application is built, the ontology that represents the knowledge required for the application is built. This ontology can be developed by reusing others and can also be integrated into the ontologies of later applications. This approach prescribed three stages for ontology development namely:

Steps:

(a) Specification of the application
(b) Preliminary design based on relevant top-level ontological categories
(c) Ontology refinement and structuring

2.2 Building an Ontology for Adaptive Collaboration in a Dynamic Environment

The Fox and Grüninger [8] method is adopted to build this system, which involves building a logical model of the knowledge that is to be

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specified by means of the ontology. This model is not constructed directly. First, an informal description is made of the specifications to be met by the ontology and then this description is formalized accordingly following these Steps:

(a) Write scenarios

(b) Formulation of informal competency questions.

(c) Specifying formal terminology for ontology

(d) Formulation of formal competency questions using the terminology of the ontology.

(e) Set benchmarks to see if the ontology is complete.

Step a: Write scenarios in form of questionnaires:

1) What are the analyses of system configuration for computer setup?
2) Highlight the procedures of coupling a system using MIDI (Musical Instrument Digital Interface) for example.
3) Enumerate the differences between coupled system and brand new one.
4) State the advantages of one over other.
5) Point out the relationships between troubleshooting and repair in computer system.
6) Give us the best option of solving computer problem on MIDI.
7) Reasons for selecting that option as the best.
8) What is your conclusion about MIDI using computer setup?

Step b: Formulation of informal competency questions.

Name:
Age:
Sex:
Faculty:
Department:
Course of Studies:
Level:
GSM Number:

Step c: Specify formal terminology for ontology.

First order logic is notoriously neutral with respect to ontological choices. This is one of its strengths, which shows the power of general ideas like **completeness** and **soundness**.

<u>Sound Or Truth-Preserving</u>
This is an inference algorithm that derives only sentences or derivations produce only entailed sentence, e.g.

i is sound if whenever $KB \vdash_i \alpha$, it is also true that $KB \models \alpha$

<u>Completeness</u>
This is an inference algorithm that derives all sentences or derivations can produce all entailed sentences, *e.g.*

i is complete if whenever $KB \models \alpha$, it is also true that $KB \vdash_i \alpha$

Proof of completeness

(a) Forward Chaining (FC) derives every atomic sentence that is entailed by *KB*
(b) FC reaches a fixed point where no new atomic sentences are derived
(c) Consider the final state as a model *m*, assigning true/false to symbols
(d) Every clause in the original *KB* is true in m a_1 … a_k b
(e) Hence *m* is a model of *KB*
(f) If $KB \models q$, q is true in every model of *KB*, including *m*

The models of a logical language are the formal structures that constitute the possible worlds under consideration. The **domain** of a model is the set of objects it contains. These objects are sometimes called **domain elements**.

where

m is a model of a sentence α
if α is true in *m*
M(α) is the set of all models of α
then
KB $\models$ α iff *M(KB)* *M*(α)

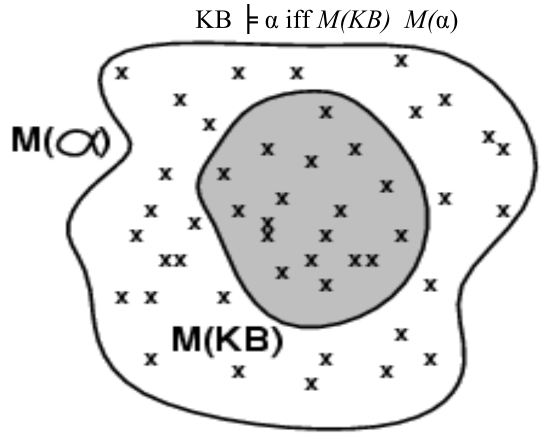

Fig. 1: Specifying Formal Terminology for Ontology.

Step d: Formulation of formal competency questions using the terminology of the ontology.

The **Central work (**KB**)** containing

"Reasons for selecting that option as the best for your environment and Describe the effect of sharing interest in the **Central work (**KB**)**"

entails

"Either the Reasons for selecting that option as the best for your environment or the Describe the effect of sharing interest in the **Central work (**KB**)**"

Step e: Set benchmarks to see if the ontology is complete

KB = Central work
α = participant

Entailment ($\models$) is the relation between a sentence and another sentence that follows from it.

Therefore, $KB \models \alpha$

Knowledge base KB entails sentence α if and only if α is true in all worlds where KB is true that is **Central work (**KB**)** entails **participant (**α**)** if and only if **participant(**α**)** true in all environment where **Central work(**KB**)** is true. The participants A, B, C, D, E, F were working differently as a collaborators in a different environment sharing information within the same environment of **KB (**Central work**).** Extraction of common goals from each participant (use of intersection) to form another sentence α in a model M for the proof of **soundness** that is

i is sound if whenever $KB \vdash_i \alpha$,
it is also true that $KB \models \alpha$

Therefore, **intersection**(i) is sound if whenever **participant(**α) can be derived from **Central work(**KB**)** by procedure **intersection(**i)**,** it is also true that **Central work(**KB**)** entails **participant(**α**)** if and only if **participant(**α**)** is true in all worlds where **Central work(**KB**)** is true**.** Joining them together as a system (use of union) to form a new sentence α in a model M for the proof of **completeness** that is

i is complete if whenever $KB \models \alpha$, it is also true that $KB \vdash_i \alpha$

Therefore, **union**(i) is complete if whenever **Central work(**KB**)** is entails **all participant(**α**)**, it is also true that **participant(**α) can be derived from **Central work(**KB**)** by procedure **union(**i).

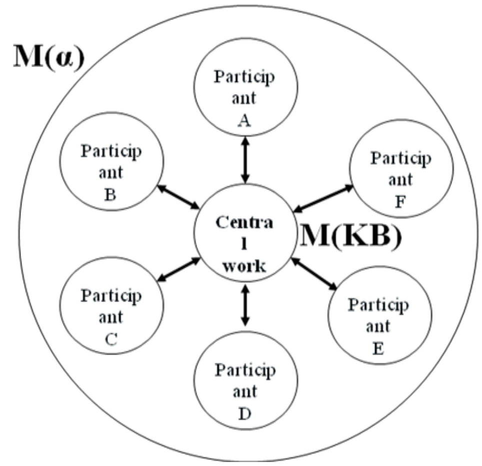

Fig. 2: Set benchmarks to see if the Ontology is complete.

3. Results

A previous participation is an input to other participations. Specific formal terminologies for questions were used to define scenarios followed by formulation of informal competence questions. Benchmarks were used to see if questions were completely answered. The ontology structured the questions and enabled participants to revisit the scenarios if questions have not been completed. Eight questions were formulated to test the ontology for information sharing. Questions were not stereotyped to a particular model but to the participant choice. Question one consists of two or more answers; Questions two, three, four, five, six and seven contain eight solutions; while question eight has only one answer from each participant in the central work. Questions were terminated at the end of third visit whether or not a participant attempted all the questions or not. Analysis of each competency question was performed and the main concepts' domains of the developed model, which are semantically related to the questions, were enumerated. This demonstrates that ontology for adaptive collaboration, in a dynamic environment, assisted participants to achieve greater levels of performance with information sharing from other collaborators, as well as helped in sharing ideas across the period of collaboration.

4. Conclusions

Ontologies are consensual representations of a domain of discourse and the backbone of the future Semantic Web. Presently, only a fraction of Web users can take part in the process of building ontologies. In this study, ontology integrating Fox and Grüninger [8] method has been developed, as a data modelling technique that allows definition and analysis of data requirements needed to support the adaptive collaboration in a dynamic environment allowing for information sharing platform, as well as for problem solving. More studies are continuing ensuring robustness of the model, as well as reducing entry barriers for the participation of users in the creation and maintenance of ontologies, and describe our future prototype.

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Adepeju A. Adigun earns BSc (Ilorin, 2000), MSc (Ibadan, 2006) and MPhil (Ibadan, 2011) in Computer Science. A Lecturer at the Osun State University, Osogbo, Nigeria and she is currently undertaking PhD at the University of Ibadan. Her research interests include adaptive and distributed computer systems, information security design, system education and adaptive collaboration in dynamic environment. She has seven publications on various topics including information security, adaptive collaboration in dynamic environment, building ontologies for adaptive collaboration in reputable journals and in national and international conference proceedings. She is a member of Computer Professionals Registration Council of Nigeria and Nigeria Computer Society. The *Strategic Institute for National Resources and Human Development* honored Mrs. Adigun for her case study initiative.

Michael O. Kolawole earns BEng (VU, 1986) and PhD (UNSW, 2000) in electrical engineering, and Master of Environmental

Studies, MEnvSt (Adelaide, 1989). Concurrently Professor of Electrical Engineering (Communications) at the Federal University of Technology, Akure Nigeria and Director Jolade Consulting Company, Melbourne Australia (www.jolade.com.au). Michael is a chartered engineer, who has received a number of distinguished awards for his research excellence; holds 2 patents, and has overseen a number of operational innovations. Michael is the author of three books: (i) *Satellite Communication Engineering*. New York: Marcel Dekker, 2002; (ii) *Radar Systems, Peak Detection and Tracking,* Oxford: Elsevier, 2003; and (iii) *A course in telecommunication engineering*, New Delhi: S Chand, 2009. Michael has consulted widely and published extensively in his areas of expertise. He enjoys reading, walking, cycling and playing clarinet and saxophone, and composing, arranging, and listening to classical and contemporary music.