UML for Ontology Modelling and Interoperability

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Abstract. The Semantic Web vision aims to integrate and convert the vast amount of information available on the Internet into a machine-understandable network. The objective is to promote knowledge sharing and reusability. Ontologies form a global pool of reusable, shared knowledge resources. Ontology languages, like RDFS, DAML or the W3C recommended OWL, make the knowledge base machine or platform independent. However, ontology use outside the realm of ontology experts is still limited. There is a need to facilitate integration and interoperability of existing knowledge bases. Knowledge modelling and representation methodology also needs to be language independent, easy to understand and share. In this paper, we propose the use of UML conceptual models as knowledge modelling and representation language for ontology. This paper illustrates the ease of interoperability and integration between ontologies built on UML conceptual models, through case studies involving INCOTERMS and Multi Tier Contract Ontology (MTCO).

1. Introduction

Semantics has been defined as "the study of meaning in language, i.e., the study of the relationship between linguistic expressions and reality" in the domain of conceptual modelling [1]. Thus the Semantic Web [18] vision of building an enriched network of information and knowledge requires existing knowledge bases to be translated in to semantic knowledge resources. This migration from existing knowledge bases to semantic knowledge base, viz, ontology, has few obstacles to overcome. Primarily, knowledge base users and domain experts cannot be expected to learn new knowledge representation formalisms or ontology languages like RDFS [9], DAML+OIL [8] and OWL [16]. Given that ontology engineering tools and languages are still in their infancy, any standard and globally accepted representation guideline is not yet feasible. Secondly, knowledge represented in machine understandable formats is not necessarily human understandable. Thirdly, the translation from existing knowledge bases to ontology needs to be simple, reusable and interoperable. That is semantic knowledge needs to be modelled in a form which is machine understandable yet supports human understanding, use modelling approaches that is widely accepted, and the knowledge representation should be flexible, reusable and it should be able to interoperate with other knowledge bases. This paper proposes the use of an accepted standard like UML for ontology modelling. Thus the solution for facilitating easy understanding and interoperability between ontologies is to model and capture the knowledge in a language that already has a vast global acceptance, namely OMG's UML [19]. UML has a large number of users in the information systems domain due to its graphical, easy to understand features. In this paper, we propose the use of UML conceptual models as an intermediate ontology to aid easy interoperability, sharing and reuse. The paper demonstrates the integration feasibility through a set of case studies in the realm of business contract management.

A *Multi-Tier Contract Ontology* (*MTCO*) has been proposed by the authors in [2,3,4] to capture and model the different aspects of a legal business contract ranging from the generic, abstract concepts in an *Upper Level Core Contract Ontology* to a specific contract type in a *Specific Domain Level Contract Ontology*, down to a highly specialised conceptual model in a *Template Level Contract Ontology*. The framework has been proposed to be structured, reusable, flexible and extensible semantic representation of contracts. ICC [6] 's Contract Model for International Sale of Commercial Goods [14] has been modelled as specific domain level contract ontology. Another international standard legal term for delivery, the INCOTERMS [5], has been modelled as a separate ontology. This paper illustrates how importing or including the relevant parts of the two conceptual models may merge the two ontologies.

The rest of this paper is structured as follows. Section 2 discusses the suitability of UML conceptual models as ontology. In section 3, we present conceptual models for INCOTERMS, an overview of the sale of goods contract ontology and a discussion of how the two may be merged together. Finally, the paper concludes and summarizes in section 4.

2. UML Conceptual Models as Ontology

Gruber [10] defines, 'An Ontology is a specialization of a conceptualisation'. We agree with the idea presented in [5], that a conceptual modelling language would be able express semantic relations and appropriate integrity constraints which help ensure that instances of objects and property values are semantically "valid". From a conceptual model representation one may generate graphical models for visualization (*e.g.*, UML diagrams), XML schemas, DTDs, RDFS, DAML+OIL and so forth as illustrated in [3].

Two of the main issues of knowledge representation are interoperability and reusability. Knowledge represented in a specific language or format should be interoperable or interpretable with other knowledge bases. Also, knowledge resources should be readily reusable outside its intended application domain. The key to resolve both issues is 'semantics', that is modelling and capturing the meanings rather than representing knowledge in syntax and specifications. Conceptual Modelling is the first step to capture the semantics of any world artefact. In Conceptual Modelling [5], the **object** is the basic modelling construct around which all other modelling constructs are defined. Like any real world object, all conceptual model objects have characteristics and are related to each other through various kinds of associations or relationships.

Coming back to our problem of interoperability of knowledge bases as well as migration from existing knowledge bases to ontology, we propose the use of UML conceptual models as an intermediary ontology before representing in machine-readable formats. We suggest the use of UML class diagrams to capture the semantics of the real world domain being modelled. Behavioural characteristics may be modelled using activity-state diagrams, sequence diagrams and choreography as required. Existing knowledge bases need to be translated in to semantic UML conceptual models.

Advantages of UML as an ontology modelling language has been proposed by Cranefield [12], Hart, Baclawski et al in [13].Cranefield in [12] has proposed mappings to transform UML ontology models in to RDF and to generate Java classes from UML using XSLT.

Baclawski has compared the advantages and disadvantages of UML as an ontology modelling language over other ontology language specifications like RDFS, DAML. In [13], Baclawski has proposed extensions to UML to facilitate mappings between DAML and UML and has been adopted by us. Falkovych [15] has built on Baclawski's proposals and he has further extended the UML mappings to DAML.

3. UML Conceptual Modelling Case Studies

In this section we illustrate the use of UML conceptual models as 'interpreter' to facilitate the interoperability of two ontologies describing the legal business contract domain. Three different perspectives, the business process domain, the legal judiciary domain and the information systems domain influence the contract knowledge domain.

Sale of Goods business contracts form the domain of interest for our knowledge models. Detailed conceptual models for the same have been discussed in [7]. We chose to analyze and model the contractual knowledge from a recommended standard of contract patterns like the ICC's INCOTERMS as another case study to evaluate the extendibility of the MTCO, the ease of reusability and integration with other ontology.

INCOTERMS form a part of the vast contractual knowledge contained in a typical sale of goods contract, like that recommended by ICC International Sale of Commercial Goods. These are internationally accepted and standardized patterns for delivery terms agreed between the parties involved in a sale of goods business transaction. The INCOTERMS clearly outline the obligations, roles and responsibilities of various actions and counter actions of both the Seller and the Buyer.

Some of the main concepts are summarized in the generic outline for INCOTERMS as in figure 1 below:

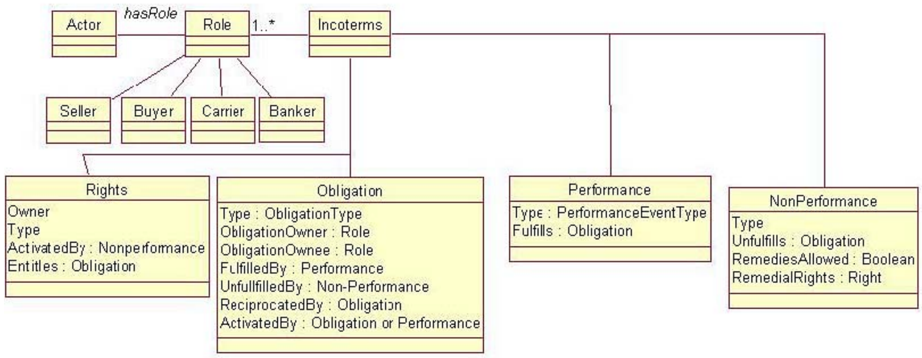

Figura 1 : Some Generic Concepts of INCOTERMS

We see that the main concepts involved are common to sale of goods contracts like *actor*, *role*, *obligation*, *right*, *goods*, *performance and non-performance*. The Specific Domain Level Contract Ontology in MTCO [3] includes Sale of Goods Contract Ontology conceptual model. A typical sale of goods contract specialises *consideration* to be *goods*, the *roles* to be *buyer* and *seller*. The primary obligation involved is the *obligation to deliver* and the *obligation to pay* for the *seller* and the *buyer* respectively.

The INCOTERMS describe extensively the specifics involved in the actual contractual process of *delivery*. Also other secondary obligations are described, like the *obligation to load*, *Obligation to Package*, *Obligation for Customs Clearance* and so forth. Thus, the proposed INCOTERMS conceptual models are an effective extension to the Sale of Goods Contract conceptual models. But, the INCOTERMS may be used as an individual ontology by itself too.

In the extract for INCOTERMS model presented above we see that some of the inter-relationships like that between *obligation* and *performance*, *FulfilledBy* has been modelled as a data type property association. This has been done only for illustrative purposes in this paper due space constraints. It represents an association between the UML class *obligation* and *performance* that would indicate the actual semantic relationship of an object relationship as proposed by Baclawski [13].

From the Sale of Goods Contract Ontology, we see that *DeliveryTerms* form a mandatory part of any sale and purchase contract. The INCOTERMS on the other hand deal exlusively with obligations and performances expected under delivery of purchased goods. Thus, the INCOTERMS may be used directly as a part of the Sale of Goods Contract Ontology. The *DeliveryTerms* may refer to the INCOTERMS code to be used like EXW for ex-works and the concept may be directly integrated to the EX-Works conceptual models. Thus, we may get all the additional information regarding the obligations involved under that particular delivery term. In this case study, the INCOTERMS ontology could be directly integrated in to the Sale of Goods Contract ontology. The primary obligation *ObligationToDeliver* in the sale of goods contract ontology can be seen to be constituted of secondary obligations like *ObligationToDeliver*, *ObligationToLoad*, *ObligationToExportClearance* etc. Similarly performance of *delivery* can be seen to be comprised of manufacture *goods to confor-*

mity, *pack goods*, *load goods*, *and hand over documents* etc from the INCOTERMS ontology.

From the above illustrations, we see that the INCOTERMS ontology may be merged with the sale of goods contract ontology through the identified common concepts or concepts which are semantically similar. The case studies have demonstrated that though individual ontologies may be represented in different ontology languages (for machine readability, inferencing etc), they may be integrated easily through a common medium of representations, namely UML conceptual models. The transformation and integration mappings may be carried out through the use of ontology editor tools like Protégé 2000[7].

We see that implementations depend a lot on the tools chosen and are bound by the limitations of the tools. But, the feasibility of transforming the UML conceptual models into other formal specifications has been successfully validated. At the same time the usefulness of UML models in integration, mapping of ontologies has also been vindicated. Though, we agree that more work needs to be carried out in standardising transformation, and integration methodologies and rules. But we are confident that ongoing efforts will succeed in resolving the remaining open issues.

4. Conclusion

In this paper we have proposed the use of UML conceptual models as an intermediary ontology to solve the issues as stated earlier:

- *No Standard for Ontology Representation Language*: Use of UML (class diagrams for static, structural concepts, activity diagrams for behaviour) for ontology representation solves this issue as UML is widely accepted and has a growing audience.
- *Formal Ontology Specification not Human-Understandable*: Ontology languages like DAML, RDFS, KIF may be machine-readable but they are not human understandable outside the domain of ontology experts. UML on the other hand is easy to understand due to its graphical nature.
- *Heterogeneous Knowledge Bases need to Interoperate, Integrate, Reuse*: Existing knowledge bases as well as ontologies using different specification languages need to be able to reuse each other as well be interoperable as required. In this paper, we have proposed the use of intermediary ontology using UML conceptual models as a solution to this issue.

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