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SWAD-Europe Deliverable 6.4: Using Modelling Methods to Build Semantic Web Applications - Survey

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The impact of the Semantic Web has been realised by other scientific communities. Modelling techniques used by the software engineering and the knowledge engineering communities are currently adapted for the Semantic Web.

The Software Engineering community, and the industry in general, has adopted UML as a de-facto standard for software modelling. Therefore, initial work on modelling Semantic Web applications has been centred on UML, notably [4, 6, 12].

The work of Baclawski et al [4] is focused on developing tools for developing ontologies in UML. They have established similarities and differences between UML and DAML, and show how they can be mapped to each other. To handle the difference between the notions of UML Association and DAML Property, they propose to extend the UML meta-model by enriching the Meta-Object Facility (MOF) specification with the notions of Property and Restriction. They claim that their ideas can be applied to other knowledge representation languages such as semantic network and concept graph approaches.

In [12], Falkovych et al review transformational approaches to establishing connections between UML and web-based ontology languages. It analyses one of the main obstacle for establishing the mapping between UML and ontology representation languages: the notion of Property. A Property is a first-class modelling element in all web-based knowledge representation languages; whilst a Property is somehow equivalent to the UML Association notion, an Association cannot exist without explicit connection to classes.

The work of Cranefield [6] presents a mapping to produce Java classes and an RDF schema from an ontology represented as a UML class diagram and encoded using XMI. It is also tackled the representation of representation of incomplete knowledge.

One of the seminal areas has been formal methods. Well-known specification languages such as Z [19] and Alloy [14] as well as algebraic specification languages such as OBJ [13] have been used for the Semantic Web.

Z is a formal specification language well suited to model system data and state, developed at Oxford University. It is based on ZF set theory and first-order predicate logic. In [11], Dong shows how to use Z to capture Semantic Web requirements such as ontology and service functionalities. It develops a set of transformation rules to project Z models to DAML ontology automatically. This work is further extended in [9] to transform ontologies back into Z models. One important aspect of his work is the possibility to detect and remove possible ontology flaws with the assistance of Z proof tools such as Z/EVES [16].

Alloy is a structural modelling language, based on first-order logic, for expressing complex structural constraints and behaviour, developed at MIT. In [10] is shown how to develop semantic models for DAML+OIL in Alloy and systematic transformation rules that can translate DAML+OIL ontology to Alloy automatically. With the assistance of the Alloy Analyzer, the consistency of ontology can be checked automatically and different kinds of reasoning tasks can be supported. Since Alloy is based on relations, it suits well to express the relations between Web resources.

In [15] is shown how to transform software component specifications written in CafeOBJ into OWL. CafeOBJ is a specification language successor of OBJ, based on algebraic specification and equational rewriting logic. CafeOBJ specifications are executable and their combination with OWL allows one to find them based on properties that require reasoning about the specification semantics.

Close-related to the Semantic Web is the Web of Trust. Formal techniques are starting to be used for modelling and verifying trust properties in the Web. For instance, the on-going work presented by Butler in [5] highlights the advantages of using the B formal method [1] and associated tools such as model checkers and test case validation to verify trust properties in ubiquitous systems.

Knowledge engineering techniques have also been influential in the development of the Semantic Web. One of the main areas has been Problem Solving Methods (PSMs). PSMs are software components that can be assembled with domain knowledge bases to create application systems. Knowledge-based methodologies such as CommonKADS [17] or MIKE [3] consider PSMs as essential structures for controlling the methodological activities that must be carried out to build expertise models.

In [7], Crubezy and Musen analyses the relation between problem-solving methods and ontologies. They propose a methodology in which domain knowledge bases and problem-solving methods are described as ontologies that can be reused in different applications. Their approach has been further applied to the Internet Reasoning Service [8], a web-based front-end which provides online problem-solving resources.

As part of the work undertaken in SWAD-Europe, Arenas and Matthews describe how to apply CommonKADS to the development of Semantic Web applications [2]. They revise the ITtalk Web Portal case study [18], showing how domain specific knowledge can be modelled by reusing well-known ontologies such as FOAF and RDFiCal, as well as specifying CommonKADS PSMs as Web services described in OWL-S.

The above review shows how the different scientific communities are interested in applying current techniques to build Semantic Web applications. Although promising results have been obtained so far, it is needed much work to made them more accessible to the public in general. We hope the work presented here encourage members of other communities to adapt existing techniques to the case of the Semantic Web.

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