CONSTRUCTING WEB ONTOLOGIES INFORMED BY SEMANTIC ANALYSIS METHOD

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Abstract: In the context of the Semantic Web (SW) research, recent proposals have explored new approaches for a more precise representation of the meanings. These proposals attempt to model the information in a more adequate way, and, at the same time to be compatible with the SW standards. This paper proposes heuristics for deriving an initial Web ontology (WO) from Ontology Charts (OCs) produced by the Semantic Analysis Method (SAM).

1 INTRODUCTION

There is a growing need for methods, techniques and tools to better represent the semantic aspects of the information available in Web systems. The first initiatives taken by Berners-Lee *et al.* (2001) already aimed at creating a Web that also takes into account the meanings of information and not just its structure and protocols. Nevertheless, recent studies point out that there are still various limitations and problems regarding technologies coming from the SW initiative (*e.g.*, Reis *et al.,* 2010).

Modelling approaches for WOs that uses the (SAM) (Liu, 2000) as a starting point may provide a more precise representation of the semantics. This approach proposed here enables to incorporate into SW ontologies, concerns and possible representations arising from a Semiotic perspective (Reis *et al.,* 2010).

Assuming that the Semiotic approach contributes with improvements in business modelling, it is plausible to have both: the Organizational Semiotic (OS) (Liu, 2000) methods with a different and valuable view of the social context, and a WO described in Web Ontology Language (OWL) that is an interoperable SW Standard. As semantic refers to meanings, and meanings are socially created by humans, we expect to create a more faithful computer ontology considering an information system with a more abstract conceptual model that can capture the behaviour of the involved agents.

In order to use the outcome of SAM (*i.e.* the OC) with languages that describe WOs, it is necessary to create a procedure that makes possible and explicit the construction of OWL models from OC. The objective of this paper is to propose heuristics to perform this construction. The relations between the models are mapped, and one model supports the construction of the other. The paper is organized as follows: Section 2 presents the Theoretical and Methodogical Background; Section 3 describes the heuristics proposed to create WOs aided by SAM; Section 3 concludes and points out future works.

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2 THEORETICAL AND METHODOLOGICAL BACKGROUND

This section firstly presents an overview of the main concepts of SAM; then some characteristics and properties of WOs are presented.

2.1 Semantic Analysis Method

In SAM "The World" is socially constructed by the actions of agents, on the basis of what is offered by the physical world itself. The SAM assists users or problem-owners in eliciting and representing their meanings in a formal and precise model. In SAM, the analyst in the role of facilitator specifies the required system functions in an OC - a graphic representation of a conceptual model. The OC maps the vocabulary and the temporal relationships between the percepts that those words represent and describes a view of responsible agents in the focal domain and their pattern of behaviour named affordances (Liu, 2000).

Affordance, the concept introduced by Gibson (1977) can be used to express the invariant repertories of behaviour of an organism made available by some combined structure of the organism and its environment. In SAM, the concept introduced by Gibson was extended by Stamper (1993) to include invariants of behaviour in the social world; affordances are social constructs in a certain social context (Liu, 2000).

Agent is a special kind of affordance, which can be defined as something that has responsible behaviour. Agents are affordances that can take responsibility both for their own actions and the actions of others. An agent can be an individual person, a cultural group, a language community, a society, etc.

Ontological dependency is formed when an affordance is only possible if certain other affordances are available. We say that the affordance "A" is ontological dependent on the affordance "B" to mean that "A" exists only when "B" does; *e.g.*: for a person to be able to stumble, he/she must first walk; thus there exist an ontological dependency between to stumble and to walk.

Determiners are properties which are variants of quality and quantity that differentiate one instance from another. Determiner are attributes that enable one to describe an agent or an affordance;

Specialization, agents and affordances can be placed in generic-specific structures depending on whether they possess shared or different properties;

Whole-part, an agent or affordance can be part of other agent or affordance. The part also owns all the ontological dependencies from the whole;

Role-Name, an agent can have a specific role depending on the affordance it has.

2.2 Web Ontology

The term ontology in Computer Science is often used to refer to the semantic understanding (a conceptual framework of knowledge) shared by individuals participating in a given knowledge domain. An ontology is used to formally specify the concepts and relationships that characterize a certain body of knowledge (domain). The formal nature of ontologies makes them amenable to machine-readability and provides a well-defined semantics for the defined terms (Kalyanpur *et al.*, 2004).

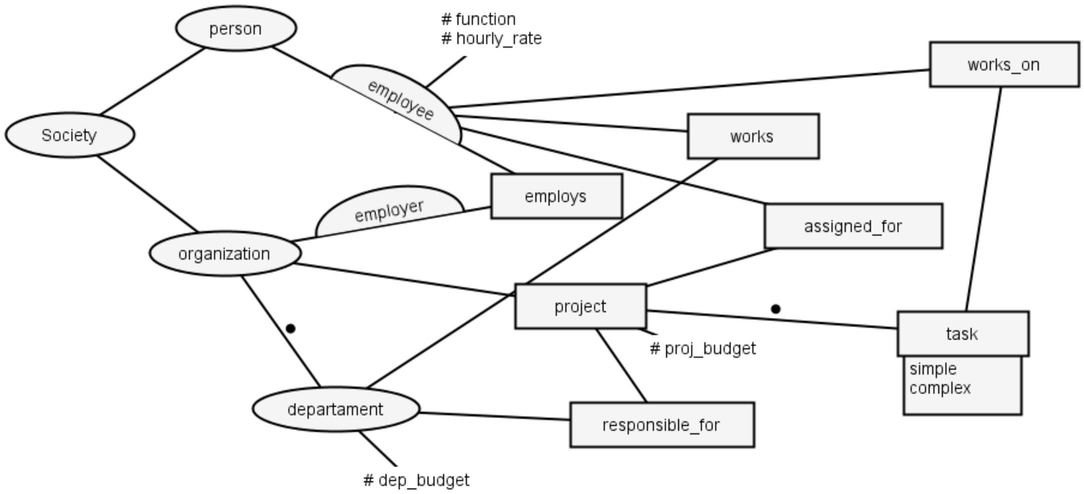

Figure 1: Ontology Chart for project management (adapted from Liu, 2000:79).

A WO is usually described by computational languages based on logic for knowledge representation and inference. According to the SW architecture proposed by Berners-Lee *et al.* (2001), the ontology description languages are related to other Web languages such as Extensible Markup Language (XML), Resource Description Framework (RDF) and RDF Schema (RDFS). In order to address interoperability problems and to define a universal paradigm for web-based exchange of ontological information, the World Wide Web Consortium (W3C) created the OWL which became a W3C Recommendation (W3C, 2004). Using OWL as a common language, knowledge experts and application developers can create, modify, link and import ontologies in a distributed environment. OWL is an important piece of the future vision of the Web, the SW.

3 HEURISTICS TO BUILD OWL ONTOLOGY INFORMED BY SAM

The first step of our approach is the application of SAM in the context under study. An OC is created to be the source model for the transformation to OWL code. In order to accomplish that, a set of specific heuristics must be followed to derive an initial OWL ontology. The proposed heuristics are based on the basic principles proposed by Liu (2000) and also by Bonacin *et al.* (2004). They have proposed a set of heuristics to construct Unified Model Language (UML) diagrams from OC; those heuristics were adapted to our purpose since there are conceptual and practical differences between UML and OWL. The OWL differs from UML in their proposals and some key concepts such as methods and composition. It is important to mention that by applying the proposed heuristics does not guarantee an equivalent ontology in OWL, and even the transposition of all its properties; instead, it represents some support to the analyst during the modeling process. We assume that the analyst should be in charge of evaluating the results and determining the priorities (*e.g.* fidelity, maintenance, reuse, and so on) over the modelling processes.

The proposed heuristics were classified following the concepts from SAM such as: affordances, agents, determiners, role-name, whole-part, specialization and ontological dependence. Figure 1 shows an example of an OC used to didactically exemplify the approach with the proposed heuristics. The heuristics with examples from the OC of Figure 1 are presented as follows:

Affordances – During the SAM the world is mainly modelled by the identification of social constructions (affordances), while in the OWL the world is modelled by the identification of classes and individuals in the world. The presence of an affordance in the OC suggests a class to be modelled into the OWL ontology. For instance, considering Figure 1, by the SAM perspective, a "*project*" is an affordance of the society, and by the perspective of WOs it can be a class with attributes. If the affordance named "*project*" was represented in the OC, this suggests that there is a class in the context, and probably it is possible to refer to it using the "*project*" name. Based on the procedure of extracting names of classes from nouns, affordances that are nouns can be mapped to classes in OWL (*i.e.* affordances that suggest entities will be classes in OWL). However, not all affordances are nouns, for example the affordance "*employ*" which is a verb. The affordances named as verbs will be mapped to object properties in OWL. Thereby the affordance "*employ*" will not be a class in OWL, but it will be an object property named "*employ*".

Agents – The heuristic suggest that all the agents represented in the OC can be mapped as classes in OWL and as sub-classes of a class called "*Agent*". This is carried out to identify the agents into the OWL ontology, so all agents from the OC would inherit the possible characteristics and properties from the class "*Agent"*. Thus, agents such as "*person*", "*organization*", "*department*" presented in Figure 1 will be classes into the OWL ontology.

Determiners – The closest OWL concept to a determiner is data property, which should be connected to the appropriated class. As in the example of Figure 1, the "*function"* determiner will be a data property in OWL and its domain will be set with the class "*employee*"; while the "*dep_budget"* determiner will be mapped to the agent "*department*", then this data property domain will be the "*department*" class.

Role-Name – In OC the role-name is always connected to an agent. Hence from OC to OWL role-names will be mapped as sub-classes of the OWL classes that represent the agent in the left side of the role-name. For instance, considering Figure 1, the role-name "*employee*" will be mapped to a class in OWL, and this class will be a sub-class of the class named "*person*"; the same applies to the role-name "*employer*". The relation between the role-name with the affordance in its right side can be better visualized in the transformation rule that may implements this heuristic.

Whole-Part – There are two situations of whole-part relation. First: when both the source affordance and the target affordance are nouns, the affordances or agents are mapped to classes; then an object property called "*partOf"* can be created, and the target class will be a restriction of this source class. For example, in Figure 1, the class agent "*department*", mapped as a class in OWL will be part of the agent "*organization*", also mapped as a class into OWL. In the second situation, both affordances are verbs, so based on the affordance heuristic described, both will be object properties in OWL. Therefore, the target affordance will be mapped to sub-property of the source affordance, which is also an object property. Moreover, since there is not part without the whole, when there is a whole-part relationship there is also an ontological dependence between the affordance of the whole and the part.

Specialization – The specialization can be used in agents, affordances or role-names; the specialization relation between the generic and the more specific type can happen between nouns and also between verbs, as in whole-part relation. When the more generic affordance type is an action and it is mapped to an object property, then the more specific affordance will be mapped to sub-property of the object property in the OWL that represents the more generic affordance. Nevertheless, when the more generic affordance type is an entity (*i.e.* an OWL class), and consequently is mapped to a class in OWL, the more specific affordances will be mapped to classes in OWL and they will be sub-classes of the more generic class. The situation when the more specific affordances are verbs is an exception in the OC.

Ontological Dependence – This relation between affordances is the most common in the OC modeling. When an object cannot exist without other, an association between classes can be modelled into OWL. For example, the ontological dependence that exists between the affordances "*society*" and "*person*" in Figure 1 suggests an association between then in OWL. For that, creating an object property named "*depends_on*", the source affordance can be mapped to the range of this property, and the target affordance is mapped to domain of this property. Considering Figure 1, the affordance "*project*" is ontologically dependent on the affordance "*organization*"; thus the transformation will create an object property stating that "*project*" depends on "*organization*". There is a temporal relation between the ontological dependence of two affordances; so an affordance that depends on other will just exist while the other exists. Nevertheless, just using the object property as proposed in this heuristic is not enough to fully represent the concept of ontological dependence of SAM into OWL. Rules described in Semantic Web Rule Language may be used to represent it.

4 CONCLUSIONS

The SW evolution depends on methods and solutions that can adequately represent the knowledge presented in Web applications content. Heuristics to support the creation of a WO described in OWL from the outcomes of the SAM were presented with this proposal. The solution brings opportunities to improve the semantic models used in the existing SW applications. Next steps are the construction of tools to implement the proposed heuristics as transformation rules and the conduction of practical experiments illustrating the application of this approach.

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