# A Framework for Semantic Checking of Information Systems

Gonçalo Alves<sup>1</sup>, João Sarraipa<sup>1</sup>, João P. M. da Silva<sup>2</sup> and Ricardo Jardim-Gonçalves<sup>1</sup>

<sup>1</sup>CTS, UNINOVA, Dep.<sup>o</sup> de Eng.<sup>a</sup> Electrotécnica, Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa, Caparica, Portugal

g.alves@campus.fct.unl.pt,jfss@uninova.pt,rg@uninova.pt

<sup>2</sup>CT2M, Department of Mechanical Engineering, University of Minho, Guimarães, Portugal jpmas@dem.uminho.pt

**Abstract.** In this day and age, enterprises often find that their business benefits greatly if they collaborate with others in order to be more competitive and productive. However these collaborations often come with some costs since the worldwide diversity of communities has led to the development of various knowledge representation elements, namely ontologies that, in most cases, are not semantically equivalent. Even after solving once the establishment of a semantic alignment with other systems, they do not keep unchanged. Consequently, they need to check regularly its semantic alignment. Therefore, to aid in the resolution of this semantic interoperability problem, the authors propose a framework that intends to provide generic solutions and a mean to validate the semantic consistency of ontologies in various scenarios, thus maintaining the interoperability state between the enrolled systems.

**Keywords:** Semantic Interoperability, Ontology Validation, Consistency Checking.

## 1 Introduction

Nowadays, in an increasingly global business environment, several companies have found that to make themselves more competitive and productive they had to collaborate with others, if they are to compete with the larger organizations [1]. However the same globalization in the professional field that led to the collaboration between companies, also led to the development of various knowledge representation elements, such as ontologies, that are not semantically coincident [2]. Thus interoperability problems appeared when these different systems try to exchange or share information with one another. After having established seamless communication and semanticalignment between systems it was identified the necessity of having "something" that allows companies to track their semantic evolution to keep the consistency and validity of their knowledge representation elements. To this effect, an interoperability framework that provides a set of assumptions, concepts, values and practices (methods & tools) [3] and that contemplates several scenarios for the semantic checking is a possible solution to the semantic interoperability maintenance.

## 2 Semantic Checking Framework

The proposed framework main purpose is to provide generic guidelines for the semantic checking of a knowledge base. It was defined based on the three types of ontology consistency suggested by Li et al. in [4] that are single ontology, composite ontologies and multiple ontologies. It is complemented by the knowledge mapping types described by Agostinho et al. in [5] that are the structural and conceptual mapping types. Agostinho et al. in [5], further propose a 5-tuple mapping expression that is used to formalize morphisms between model elements and to minimize inconsistencies. However, imperfect mappings can lead to semantic mismatches which can be lossy, when losses of information are recorded or lossless when no information loss is recorded. The proposed framework (**Table 1**)shows the main characteristics that an ontology based information system should comply to maintain semantic consistency.

Table 1. - Semantic Checking Framework

	Single Ontology	Composite Ontologies	Multiple Ontologies
Structural	1.Automatic reasoning	3. Automatic reasoning;	5.Ad hoc synchronization;
		Automatic synchronization	Automatic reasoning
Conceptual	2.Human action plus automatic reasoning	4.Human action plus auto-	6.Human action plus automatic
		matic reasoning;	reasoning;
		Automatic synchronization	Ad hoc synchronization

The framework is composed of 6 items. Items 1 and 2 refer to scenarios where only a single ontology is involved. For item 1, a simple reasoning process suffices to verify the structural consistency of the ontology. In addition, item 2, also requires human action. This is because the user needs to create instances of the concepts to test if after running the reasoner such concepts are well positioned in the ontology. Items 3 and 4 of the framework denote cases where the knowledge base aggregates various ontologies. On item 3, in addition to an automatic reasoning process, an automatic synchronization mechanism is also required. Since composite ontologies are composed of two or more ontologies merged together, if a structural change occurs in one of the ontologies, then this change needs to be reflected in all the elements. On the other hand, item 4 additionally requires human interaction to the automatic reasoning and synchronization processes. Here, the user also needs to create instances with the same objective mentioned for the item 2. Moreover in this case, the concepts need to be well represented in the merged ontology to avoid repetitions and that is why the synchronization and reasoning are both required. Finally, items 5 and 6 of the framework are applicable in scenarios where multiple but separate ontologies are involved. In item 5, besides having an automatic reasoning process, an ad hoc synchronization process is also required, in order to align the knowledge represented in the various components. This means that any changes that occur in a certain element of the system must also be reflected in all the other components. Since these types of systems can be very complex, knowing the synchronization process facilitates the further semantic checking. In entry 6 it is also needed human intervention, by the same reasons as in the other conceptual checking items. It is needed to create instances and then execute the reasoner to check its conceptual definition. To accomplish the communication checking between ontologies it is also needed to know its particular synchronization process o then execute modifications in one side that could be reflected in the other side.

## **3** Use Case Demonstration

The use case demonstration refers to item 6 of the framework and features a scenario between a bolt manufacturer and retailer. To be able to collaborate with one another it was decided to follow the MENTOR methodology [5] to build a reference ontology to serve as a mediator to their interactions. Here the semantic interoperability problems derive from the different definitions of involved concepts in this domain. After identifying these differences both the manufacturer and the retailer need to come to a consensus regarding those terms and definitions by adopting reference ones. Upon reaching the reference terms and definitions, mappings between each term of the entities with the adopted references ones are established. Based on these elements, a reference ontology was built, along with the ontologies of the manufacturer and retailer (Fig.1).

Thing     V topObjectProperty     OBoitt     WhatMax Diameter     Olameter     Olameter     Olameter     Ohing Diameter     Ohing Diameter	Thing TepObjectProperty Bolt2 TopObjectProperty TopObjectProperty Topotector Topotector Topotector	Orang O	
Retailer Ontology	Manufacturer Ontology	Reference Ontology	

Fig.1. Used Ontologies

To verify the consistency of the involved concepts, instances were created in the "Thing" class of the retailer, manufacturer and reference ontologies and a set of rules that aim to represent the mappings between the concepts were defined. These instances were created there to ensure that by reasoning the system puts them in their corresponding classes, ensuring the conceptual consistency of the system. Fig.2 (a) shows the retailer and reference ontologies with the created instances inferred to their proper classes (both "b" and "b1" concepts were inferred to "Bolt" and "Bolt1").

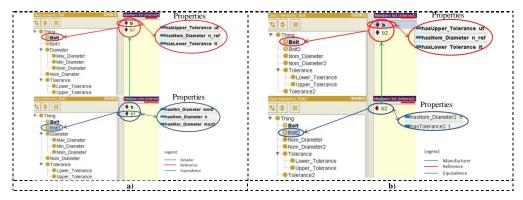


Fig.2.After Reasoning Example: a) Retailer - Reference; b) Manufacturer Reference

Contrarily to the previous example, in Fig.2 (b) it is possible to observe some loss of information because although both instances ("b" and "b2") are represented within the reference ontology, the same cannot be said regarding the manufacturer's ontology since only "b2" is represented. This is because of the "Tolerance" definitions represented by each of the ontologies. While the reference ontology distinguishes between "Upper and Lower Tolerances", the manufacturers only define a single tolerance, assuming an equal value for "Upper" and "Lower". This means that if different values for the "Upper and Lower Tolerances" are defined in the reference ontology then a conflict is created. Since the manufacturers' ontology does not have such distinction, therefore will not know which value is the correct one, leading to possible inconsistencies in the knowledge representation.

## 4 Conclusions and Future Work

The proposed framework was developed with the idea to provide general guidelines to various contexts and situations, allowing organizations to effectively assess if their knowledge representation elements still semantic consistent. Following such guidelines it was possible to assess the semantic consistency of the involved ontologies on a small case study scenario that comprises a bolt retailer and a manufacturer. The authors have also been able to validate items 1 and 2 of the framework, as well as item 5, where a prototype of an ad-hoc synchronization tool has been developed o this case between a wiki and an ontology. In conclusion, the proposed framework could prove to be a valuable asset in helping in the semantic checking of knowledge repositories. In terms of future work, the authors are working on developing scenarios regarding composite ontologies.

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