Supporting *i**-Based Context Models Construction through the DHARMA Ontology

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Abstract. The construction of enterprise context models, fundamental tool to design of modern information systems, is usually a cumbersome task to lead, largely due to the gap of communication between the administrative staff and technical consultants in charge of its construction. In order to make this task easier previous works encouraging the reuse of *i** context elements through the implementation and use of catalogs has been proposed. In this paper, we make use of semantic technologies to exploit such catalog, storing its content in a semantic repository. To support this idea, we have created the DHARMA ontology following the guidelines proposed by NeOn methodology, integrating different domains and their vocabularies.

Keywords: DHARMA Method, ontology network, iStar, iStar catalog.

1 Introduction

Modern Enterprises rely in Information Systems (IS) designed to manage the increasing complexity of the interactions between their operations and context. Enterprise Architecture (EA) [1] is a widely accepted approach for architecting IS, starting from the business strategy to its implementation, allowing the identification of the IS Architecture. In order to support this process, the DHARMA Method [2] has been proposed, which allows the discovering of Enterprise IS Architectures starting from the construction of Context Models (CM) expressed in *i** notation.

We have applied this method in many industrial cases, discovering repetitive elements and therefore a pattern catalog [3], which can be used as template to ease the construction of CM. Despite of its practical interest, the catalog presents some typical limitations of syntactic artifacts, including the difficulty to perform queries in natural language, the identification of synonyms and antonyms, etc.; due these limitations, in this work we propose the extension of the DHARMA ontology, which integrates different domains and their corresponding vocabularies needed to support all activities of the DHARMA method. The structure of the resulting semantic repository will improve the search of elements and the construction of CM expressed in *i** notation.

This paper is organized as follows. Section 2 presents a background and its related works, section 3 describes the design of the DHARMA ontology; section 4 shows its implementation. Section 5 presents some results and validations of the resulting ontology and finally, section 6 exposes some conclusions and future works.

2 Background and Related Works

This section summarizes previous concepts required to understand the scope of the proposal, we briefly describe the NeOn methodology to support the creation of the ontology network and we also present the DHARMA Method and its activities.

2.1 NeOn Methodology

NeOn Methodology guides the life cycle of an ontology network, which is a collection of interconnected and interrelated ontologies[4]. It is focused in the reuse of existing resources within the domain of interest and also supports the dynamic evolution of the ontology network. NeOn offers i) nine scenarios focused in the reuse of ontological and non-ontological resources, their reengineering and fusion; ii) a glossary of processes and activities involved in the development of an ontology network; and iii) methodological guidelines to support various processes and activities. This methodology is also supported by a tool (NeOn toolkit), which provides some methods and software complements to manage the knowledge enclosed by each scenario [4].

2.2 The DHARMA Method

The DHARMA Method (Discovering Hybrid ARchitectures by Modelling Actors) [2] allows the definition of Systems Architecture (SA) by modelling the organization and its environment using the *i** framework. This method is sustained in i) Porter's five market forces [5], designed to reason about potential strategies and to help with the analysis of the influence of context forces; ii) Porter's Value Chain, which encompasses primary and support activities. The DHARMA Method is structured by four activities:

Activity 1: Modelling the Enterprise Context. The organization and its strategy are carefully analyzed, to identify its role inside the context. As result, social dependencies are identified and included in the organization CM.

Activity 2: Modelling the Environment of the System. This activity proposes the introduction of an IS to-be inside the organization and analyzes its impact over the elements identified in activity 1.

Activity 3: Decomposition of system goals and identification of system actors. System dependencies in the CM are analyzed and decomposed into a hierarchy of goals required to satisfy them. The result of this activity is a set of SR diagrams.

Activity 4: Identification of System Architecture. Finally, goals included in previous SR models are analyzed and systematically grouped into System Actors (SA) representing atomic domains.

2.3 Related Works

In [6], authors present a meta-model based in ontologies to support the *i** framework, called OntoiStar, which integrates models representing the *i** model through the use of ontologies. In [7], authors introduce a methodology for the integration of ontological models of the *i** framework and its variants, this methodology lead the authors to the definition of a new extended ontology, called OntoiStar+.

Based on the need to perform a semantic analysis of the DHARMA Method, authors in [8] developed an ontology network called DHARMA, by extending OntoiStar+, adding some vocabularies to include concepts of interest for activities 1 and 2 of the DHARMA Method; in this proposal, we aim to complete that extension, adding vocabularies to include concepts for activities 3 and 4, and besides, extend OntoiStar+ ontology to include concepts of the iStar 2.0 standard [9]. As result, we will get a complete ontology network that covers the four activities of the DHARMA method, including concepts related to iStar 2.0 standard.

3 Design of the DHARMA Ontology Network

This section describes the steps performed to design the DHARMA ontology network, following the guidelines proposed in NeOn methodology. This methodology proposes 9 scenarios to create an ontology network [10]. Due to the nature of this project, scenarios 1 (*From specification to implementation*), 3 (*Reusing ontological resources*) and 8 (*Restructuring ontological resources*) will be implemented.

Scenario 1: From specification to implementation. In this scenario, functional and non-functional requirements were identified. Functional requirements regarding to activities 1 and 2 of the DHARMA method were presented in [8] and were identified through Competency Questions (CQ); Table 1 shows functional requirements for activities 3 and 4 of the DHARMA method, and new concepts included in iStar 2.0.

Table 1. Excerpt of DHARMA Ontology Requirements Specification

Ontology Requirements Specification – Competence Question Groups
CQG1. Actor Relationship (2 PC)
CQ1. Which are the types of relationship between actors? Partipates_In, Is_A
CQ2. Which are the types of relationship between Participates_In relations? Part_Of, Plays
CQG2. Actor (2 PC)
CQ3. Which are the types of Actors? Agent, Role
CQ4. Which are instances of a type of Actor? Hardware, Software, Human, Organization
CQG3. Intentional Element (IE) (2 PC)
CQ5. Which are IE types? Goal, Task, Resources, Quality
CQ6. Which is the category of an IE? Maintenance, Process, Query, Transaction
CQG4. Intentional Element Relationship (3 PC)
CQ7. How can two IEs be linked? Refinement, NeededBy, Qualification, Contribution
CQ8. Which are the types of relationship between Refinement links? and/or-refinement
CQ9. Which are the types of Contribution links? Make, Help, Hurt, Break

Scenario 3: Reusing Ontological Resources – Methodological guidelines for ontology reuse. This scenario describes the activities performed in order to reuse ontological declarations.

Activity 1: Search of ontologies. To cover the requirements defined in scenario 1, five modular ontologies satisfying the requirements were found: OntoiStar, OntoiStar+, Offer-job [11], Classification [11] and ValueChain. These ontologies conceptualize knowledge regarding to Organizations, Actors, Dependencies, Usability, Organizational Areas and Socio-technical relationships.

Activity 2: Evaluation of ontologies declaration. After contrasting the ontologies mentioned in previous paragraph and the stablished requirements, it can be concluded that Offer-job and Classification ontologies will satisfy concepts of Organization, OntoiStar and OntoiStar+ will model concepts of the *i** notation, answering questions related to socio-technical requirements, and ValueChain ontology will be used to satisfy requirements related to organizational areas.

Activity 3: Selection of ontologies declaration. Offer-job, Classification and ValueChain ontologies are used entirety in the ontology network, as they satisfy requirements analyzed in previous activity. As mentioned in section 2.3, OntoiStar+ is an extension of OntoiStar, so, we decided to use OntoiStar+ in our ontology network. For concepts regarding to the DHARMA method activities and functional requirement presented in Table 1 we will perform an enrichment process, which will be presented in section 4.

Activity 4: Integration of ontologies declaration. Based in the guidelines stablished in [13], two integration models for the creation of the ontology network will be performed: Reuse of ontologies as they are defined (applicable to OntoiStar+ and ValueChain ontologies) and Ontological reengineering (applicable to Offer-job and Classification ontologies as they include irrelevant definitions for the DHARMA method).

Activity 5: Local inconsistences detection. Offer-job and classification ontologies include a third ontology called Region to define the language, weather and geographical region, as this information is irrelevant for the DHARMA network ontology, we have decided to delete it.

Scenario 8: Restructuring ontological resources. Explained in section 4.

4 Extension of the DHARMA Ontology Network

In this section, we will describe the enrichment process of the DHARMA ontology, using scenario 8 *Restructuring ontological resources* based in requirements CQG2, CQG3 and CQG4 (see Table 1). NeOn Toolkit and Protégé were used to extend the DHARMA ontology network. Figure 1 shows the resulting network, where Classification**,** Ofer-job, ValueChain and OntoiStar are ontological resources, while DHARMA and iStar 2.0 represent knowledge from external sources that have been conceptualized into the ontology network. Text over each link describes the relationship between concepts. As an example, let's consider the relationship "*has organization industry*" link, which has as source *Organization* concept (from classification ontology) and target *Industry* concept (from Offer-job ontology).

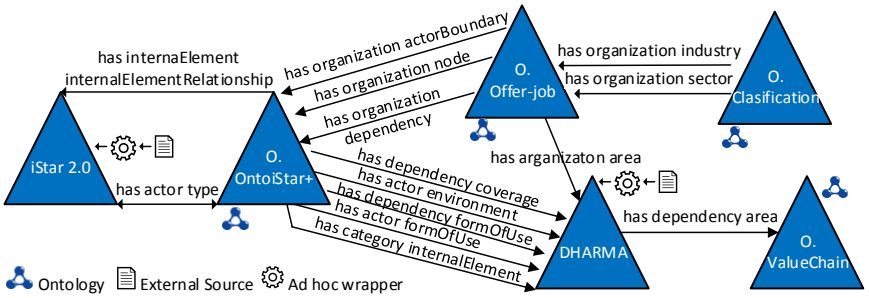

Fig. 1. DHARMA Ontology Network

The process to transform concepts into ontological constructors is based in the 5 transformation rules exposed in [6], where, i)each concept, concept relation and enumeration class is represented as a class in OWL [12]; ii) each enumeration element is represented as a class instance in OWL; iii) each class property is represented through axioms in OWL; iv) each association is represented as an object property in OWL; v) each enumeration and primitive data are represented as a data property in OWL.

5 Results and Validation

The DHARMA ontology network is composed by 4 ontologies (OntoiStar+, Offer-job, Classification and ValueChain), additional concepts of the DHARMA method and iStar 2.0. The resulting ontology has a total of 856 *classes*, 72 *Data Properties*, 175 Object Properties and 20 *Annotation properties.* The URI of the DHARMA ontology is *http://www.ucuenca.edu.ec/ontologies/DHARMA.owl#*.

The ontology was validated by annotating different CM analyzed in [13]. Due to the complexity of creating a semantic repository, this work presents a brief evaluation. The following example shows an SPARQL [14] query answering the questions included in CQG2 (see Table 1). Table 2 shows the result for an actor (UC) where variables *type* and *name* are concepts from DHARMA ontology and *instance* is a concept from OntoiStar+ ontology (and specified in iStar 2.0).

```
PREFIX dharma: <http://www.ucuenca.edu.ec/ontologies/DHARMA.owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?type, ?instance WHERE {
dharma:Actor/UC a ?instanceC. ?dharma:Actor/UC rdfs:label ?name.
dharma:Actor/UC dharma:has_Actor_TypeActor_source_ref ?typeC.
?instanceC rdfs:label ?instance.  ?typeC rdfs:label ?type.}
```

Table 2. SPARQL Query

Variable	Result	Ontology
Name	UC	http://www.ucuenca.edu.ec/ontologies/DHARMA.owl#
Type	Organization	http://www.ucuenca.edu.ec/ontologies/DHARMA.owl#
Instance	Agent	http://www.cenidet.edu.mx/OntoiStar.owl

6 Conclusions and Future Work

Ontologies are valuable elements to support the IS modelling process, providing a knowledge base of the information stored, facilitating its reuse. In this work, we have presented the development of the DHARMA Ontology Network, which conceptualizes the knowledge provided by the DHARMA Method, aiming to define the EA of an organization, and making use of the *i** notation.

Applying NeOn methodology, we have extended an ontology network aiming to encompass the different domains involved in the construction of CM, by reusing different ontologies and enriching them. Finally, the evaluation and results were presented. As future work, we aim to use reasoners and synonym suggestion modules in order to infer and generate new IS starting from the knowledge provided by the catalog instantiated using the DHARMA ontology. Also, we want to enlarge the ontology to cover aspects related to structural metrics of the resulting *i** context model [15][16].

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