Extension and integration of i* models with ontologies

Blanca Vazquez[1,2], Hugo Estrada[1], Alicia Martinez[2], Mirko Morandini[3], and Anna Perini[3]

[1] Fund Information and Documentation for the industry - INFOTEC, Mexico
{blanca.vazquez, hugo.estrada}@infotec.com.mx
[2] National Center of Research and Technological Development - CENIDET, Mexico
{blancavazquez11c, amartinez}@cenidet.edu.mx
[3] Bruno Kessler Foundation - IRST, Center for Information Technology - FBK, Italy
{morandini,perini}@fbk.eu

Abstract. Currently, i* is one of the most well founded organizational modelling techniques. Its main feature is the expressibility to represent intentional social relations among stakeholders. In i* models, each modeling component is described explicitly through text labels. However, the process of labeling model elements is usually an activity which is not rigorous and not well documented for designers. Performing the labeling with freedom and subjectivity often results in unclear labels that are not helpful for interoperability and the understanding of the model semantics. In this paper, we deal with this problems by extending i* models with ontologies. Taking advantage of an ontological definition of concepts and well-defined relationships, we improve the unambiguous interpretation of labels and thus interoperability, reuse and machine-readability of a model. A guided process and tool support for the integration of i* models with an ontology are described in this paper.

Keywords: conceptual modeling, iStar, semantic annotation, ontology.

1 Introduction

The i* framework is a goal-oriented and agent-oriented modeling framework. It provides the needed infrastructure to model concepts such as actors, roles and agents, and to reason about them. Nowadays, many research projects exist that use the i* in different applications domain on early requirements engineering, business process design and system requirements [2]. The i* framework defines two key models at different level of abstraction: the Strategic Dependency and the Strategic Rationale model. A set of modeling primitives defines the model components and the relationships among them, where each business element is labeled according to its description. This labeling is usually the only reference in the model to indicate, to the analyst, the meaning of a specific model element.

However, the absence of guidelines or good-practices to label business elements usually leads to the subjectivity, resulting in ambiguous labels that make the models difficult to understand for both the analysts and the target audience.

Furthermore, the amount of information that can be encoded in a human readable label is necessarily limited. Thus, the interpretation of an organizational model can become inevitably complex. Moreover, the machine-readability of a model remains quite limited.

In the remainder of this paper we present an approach to extend i* models with semantic annotations taken of general or domain ontologies. This allows us the standardization of concepts, clarifying the labels that describe an element and also it permits to improve the analysis of existing models. Section 3.1 describes a set of semantic suggestions to guide the process of model annotation based on domain and general ontologies. Section 3.2 describes a tool-supported approach for combining the i* model (in its ontological representation [6]) with the ontology used for the annotation.

2 Objectives of the research

As first objective of this work, we propose the extension of i* models with concepts taken from an ontology in order to address the above-mentioned ambiguity issues that emerge from the labeling of organizational models.The enrichment of models with well-defined concepts allows us to clarify the labels that describe an element to improve the analysis of existing models. Starting from this, as a second objective, we try to explore the possibilities given by a (tool-supported) ontological representation of the annotated i* model joined with an ontology.

To address our first objective, we extend i* models with annotations from a well-defined ontology. The extension process consists of three steps *(i)* we describe a set of suggestions applicable to ontologies, these suggestions are the key to annotate the i* models; *(ii)* we propose an extension of the iStarML [3] model interchange format to represent the annotated model in a validated language, and *(iii)* we provide tool support for annotation, by extending the model export plug-in for *iStarML* of the jUCMNav i* modeling tool.

To address our second objective, we translate the i* model into an ontology [6],and we join this ontology with a general or domain ontology used in the annotation process. In this ontology, the model annotations provide a formal link between concepts and the instances of the model and thus collocate the model in the domain in an unambiguous way. Our approach can also be applied to models described in Tropos [1] and Service-oriented i* [4].

3 Scientific contributions

The core of our contribution is the extension of i* models with semantic annotations taken of ontologies. The top of Fig. 1 presents the proposed approach and the bottom side presents an example of this approach.

3.1 Model Annotation Process.

This process is composed by three main steps.

Step 1. Semantic annotation suggestions. To annotate model elements with concepts from an ontology, we first define guidelines, in the form of a set of semantic annotation suggestions. An ontology represents knowledge as concepts and relationships between them. Specifically, general ontologies such as DOLCE

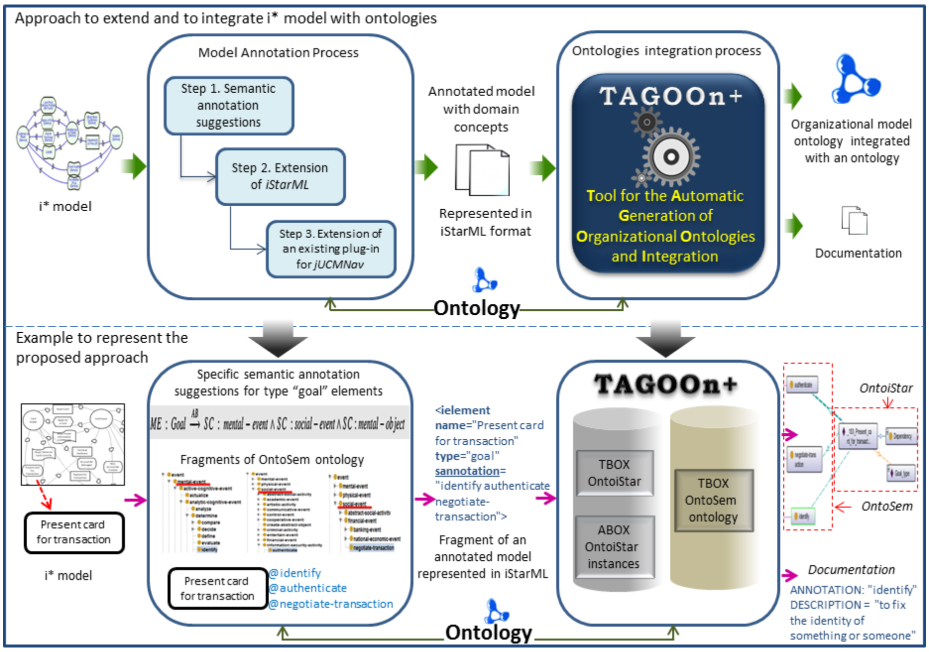

Fig. 1. Proposed approach to extend and integrate i* models and an example.

and UFO describes general concepts like space, time, matter, event, etc. [5], while the domain ontologies describe a vocabulary related to a limited domain (e.g., healthcare). In this work we use the *OntoSem* ontology [7]. OntoSem is a general ontology developed with a focus on practical application, basing on the root concepts of *object*, *event* and *property*.

To develop the suggestions, a semantic analysis of the primitives in i* and its variants was carried out. We analysed and compared the definitions among primitives of the same type (e.g., *goal*), in order to identify the differences and similarities among them, obtaining a single definition for each primitive. Next, analysing the structure of general and domain ontologies we tried to find matches between the obtained definition of the primitives and the concepts and relationships of the ontologies, with the goal to formally establish the relation of each obtained definition with ontology concepts. We provide a set of general semantic annotation suggestions (Table 1) and a set of specific semantic annotation suggestions (Table 2). The general suggestions are applicable to any general ontologies, while the specific suggestions are applicable to the OntoSem ontology and its extensions.

We illustrate the annotation process with two shorts examples. Let's assume that a goal element labeled *"Get credit"* is annotated using a domain ontology on financial operations. Using the general suggestions for elements of type *"goal"*(Table 1), the goal *"Get credit"* can be annotated with *"Financing"* and *"Credit request"*. Now, let's assume that a goal element is labeled *"Present card for transaction"* (bottom side of Fig. 1) using OntoSem and the suggestions for elements of type *"goal"* (Table 2), where *"ME"* means *Model Element*, "$\xrightarrow{AB}$" means *can be annotated* and *"SC"* means *SuperConcept*, this element could be annotated with *"Negotiate transaction"*, *"Authenticate"* and *"Identify"*. The idea is to first follow the semantic suggestions, then to go in-deep in the selected ontology and to find out the most appropriate concept for each model element, in a manual process. This approach could be used with different ontologies independently of the model domain thanks to the semantic annotation suggestions.

Table 1. General semantic annotation suggestions applicable to domain ontologies [8]

Primitive	Suggestion
Actor	An actor (including the actor types) should be mapped into domain concepts that describe an organization, agent, tangible entity, or intangible entity.
Goal	A goal should be mapped into domain concepts that describe a clear and precise condition, interest or desire.
Softgoal	A softgoal should be mapped into domain concepts that describe an interest or desires not clear-cut satisfaction criteria.
Task	A task should be mapped into domain concepts that describe a concrete action or activity.
Resource	A resource should be mapped into domain concepts that represent a physical object or informational entity.

Step 2. Extension of iStarML. To provide a format for interoperability between *iStar* modelling tools and dialects, we extend the iStarML model interchange format, adding an XML attribute called *sannotation*. This attribute stores the semantic annotations for each model element, with the syntax *sannotation* =*"concept*$_1$ *concept*$_2$*...concept*$_n$*"*.

Step 3. Extension of an existing plug-in for jUCMNAv. To use semantic annotation in practice, we use the popular iStar modeller jUCMNav, adding the annotations with the symbol "@". We extended an existing plug-in for jUCMNAv to generate the iStarML files containing the annotations.

3.2 Ontologies integration process

We provide a tool-supported process for joining annotated i* models with general or domain ontologies. First, an organizational ontology is created from an i* model by following the approach presented by Najera et al. [6]. Starting from models iStarML format, models are transformed to an OWL-based representation in the metaontology *OntoiStar*, defined for representing the i* metamodel. We propose to combine the *OntoiStar*-based ontology of an i* model with a domain or general ontology. The two ontologies will have two joint points: on one side, the foundational concepts used in both ontologies, and, on the other side, the strong connection created by the semantic annotation of the model elements with concepts provided by the selected ontology.

We enhanced the TAGOOn tool (*Tool for the Automatic Generation of Organizational Ontologies*) provided by [6] to achieve our objective. The resulting tool, called **TAGOOn+**, takes as inputs the semantically annotated iStarML model and the selected ontology in OWL format (see bottom side of Fig. 1).

Taking an i* model (M_{iStar}), TAGOOn+ creates its ontological representation (O_M) by using the functionalities provided by the original TAGOOn tool,

Table 2. Examples of specific semantic annotation suggestions for *model elements* (ME) using OntoSem *super-concepts* (SC), for OntoSem and its extensions [8]

Merging axioms	Intuitive meaning
$ME : Actor \xrightarrow{AB} SC : object$	A model element of type actor can be annotated only with (can represent only) the super-concept *object*.
$ME : Goal \xrightarrow{AB} SC : mental\text{–}event \wedge SC : social\text{–}event \wedge SC : mental\text{–}object$	A model element of type goal can be annotated only with (can represent only) the super-concepts mental-event, social-event and mental-object.
$ME : SoftGoal \xrightarrow{AB} SC : abstract\text{–}object$	A model element of type softgoal can be annotated only with (can represent only) the super-concept abstract-object.
$ME : Task \xrightarrow{AB} SC : active\text{–}cognitive\text{–}event \wedge SC : social\text{–}event \wedge SC : physical\text{–}event$	A model element of type task can be annotated only with (can represent only) the super-concepts active-cognitive-event, social-event and physical-event.
$ME : Resource \xrightarrow{AB} SC : physical\text{–}object \wedge SC : mental\text{–}object$	A model element of type resource can be annotated only with (can represent only) the super-concepts physical-object and mental-object.

instantiating each model element to an individual in O_M. Next, it analyzes the selected ontology (O_D) to obtain the hierarchy and description of each concept. O_M and O_D are joined, determining if an individual element was annotated with concepts (classes of the selected ontology). If an element is related with one or more concepts, a relation of type *is-a* is created between the concept in O_D and the instantiation of the model element in O_M. The obtained combined ontology (O_I) thus integrates the domain knowledge of O_D and the organizational and intentional perspective provided by M_{iStar}. For instance, a model element M_E is annotated with the concept C_1 from an ontology O_1. After the integration, the M_E is an individual element I_E that presents a relation of type *is-a* with C_1. The resulting ontology in OWL format can be visualized and edited with the popular Protègè ontology editor. In Figure 1 (bottom right side) fragments of OntoSem and i* models are visualized, both integrated into a single ontology.

Depending on the properties of the domain or general ontology used, Protègè reasoning engines offer consistency checking, inference and classification. Moreover, TAGOOn+ can create a text document that describes each element of the model with its semantic annotation and its description taken from the selected ontology. The documentation can be useful for achieving a better understanding of the i* model, for sharing and reuse.

Our approach has been used to annotate models that described a farm systems, a generic card-based payment system, and the processes to register students at a postgraduate institution [8]. In all these case, the annotations were validated by domain experts. The semantic annotations were helpful to discover hidden relationships, to collaborate with experts, to improve the understanding of the model and to eliminate ambiguity in labeling and thus to facilitate knowledge sharing.

4 Conclusions

In this paper we presented an overview of our approach to extend i* models with concepts taken from ontologies. A set of semantic suggestions guide the annotation of i* models were presented. A model with semantic annotations from an ontology is clear for humans and accessible to machines. Moreover, it can help improving the labeling quality in particular for models that evolve for a long time or that need to be read or edited by various analysts and stakeholders with a different background. Joining the model (in its ontological representation) with a generic or domain ontology, depending on the properties and axioms defined in the ontology adopted, the obtained joint ontology could be checked for consistency and completeness. We provide tool support for the complete process and tested it with available *iStar* models and ontologies obtained from web repositories. The benefits of extending an i* model with annotations would be, first, to facilitate the analysis and understanding of a model proving a clear model supported for domain concepts and second, as our approach is based on iStarML, we permit the interoperability among i* variants through domain concepts.

5 Ongoing and future work

At the present time, we are focusing on extending i* by describing its elements with generic concepts. As a future work we attempt to use natural language processing techniques for the annotation of each model element. In this way, semi-automatic suggestions will be provided to annotate the model. Moreover, we consider that a concept that integrates different model elements could represent new business services to the organization. These new functionalities can be useful to delineate new business services, and to improve the understandability and expressiveness of a model, thus giving a necessary condition for model reuse.

Finally, an empirical study and the modelling of real-world systems would be needed to give practical and statistical evidence to the efficiency of the approach.

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