Using GORO to provide ontological interpretations of iStar constructs*

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Abstract. *i** is the most popular goal modeling language and, therefore, has several dialects that can interpret its concepts in different ways. *iStar* 2.0 was designed to lessen the misinterpretation problems of its constructs. Concepts can be well-defined in the language but, if not used properly, the produced models may become inconsistent. An ontology can be used to verify and help the construction of correct and consistent models. GORO is an ontology about GORE that was built based on different goal modeling languages. This paper interprets some *iStar*'s constructs and proposes some discussions in the light of GORO.

Keywords: i* · iStar · GORE · Ontology

1 Introduction

Due to the popularity of *iStar*, different extensions have been proposed, leading to different interpretation of its constructs. This led the community to propose iStar 2.0 [2] in order to unify and simplify the language [2]. However, some simplifications may cause exactly the same misinterpretation problem as before. Let us take the example of the **refinement link**, created to replace the **means-end** and **decomposition** links. This new link allows different interpretations given that it connects different pairs of elements and, for each pair, the relationship entails distinct semantics.

Hence, when analyzing models produced using *iStar*, it is possible to identify inconsistencies that are not related to misconstructions of the language, but to improper use of its constructs, due to misunderstandings regarding its constructs' semantics. Moreover, we argue that a syntactic analysis of the language is not enough. We need a deeper understanding of the constructs with a well

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founded artifact that provides a common and unique interpretation of concepts: an ontology.

Several interpretations are given to the *iStar* constructs, which lead to models with multiple meanings and confusion among beginners. This motivated us to analyze the definitions of the language elements in the light of a well-founded ontology.

One of the main focuses of ontologies is to provide a non-ambiguous conceptualization of a specific domain. As a consequence, modeling languages that are created with support of an ontology will have a very precise definition of its constructs. Indeed, giving an ontological interpretation of modeling language constructs has been recognized as a good practice in modeling language development [3], and it is also intended in the *iStar* 2.0 proposal.

In this paper, we propose the use of the Goal Oriented Requirements Ontology (GORO) [7, 1] as a tool to semantically analyze and interpret the constructs of the *iStar* language. We use GORO as a reference model and a well founded basis for (1) making explicit the ontological commitments of the *iStar* language; (2) defining (ontological) real-world semantics for their underlying concepts; and (3) providing guidelines for the correct use of these concepts.

To put it more precisely, in this paper, we provide possible interpretations of some *iStar*'s constructs in the light of GORO. By analyzing different interpretations of constructs, we seek to solidify the definitions of concepts in a consensual manner. Thus, this paper intends to raise discussions about some constructs, namely: (i) the Refinement Link; (ii) the Task/Goal refinement interpretation given the different modeling phases to which they belong; and (iii) the Role element definition and its relation with intentionality.

The remainder of the paper is organized as follows: Section 2 presents a brief theoretical background on GORO. Section 3 proposes the ontological interpretation of some *iStar*'s constructs based on GORO, also presenting some modeling guidelines based on such interpretation. Finally, Section 4 concludes this paper.

2 Goal Oriented Requirements Ontology

Due to the large number of languages proposed since the first GORE approach emerged [6], many concepts became dubiously interpreted and it became increasingly difficult to delimit the scope of the GORE field. Thus, the need for an artifact that deals with this domain was perceived. In this context, the Goal Oriented Requirements Ontology (GORO) [7, 1] was proposed. GORO is an ontology based on UFO [3] and was built to be used as an interlanguage between GORE languages and also to be used as an instrument of consensual conceptualization of GORE elements.

The Goal Oriented Requirements Ontology (GORO) [7, 1] was proposed aiming at providing formal semantics to the concepts of GORE and serving as a common vocabulary for this domain. Moreover, the ontology can be used as basis for analysis and construction of languages and as a interlanguage between different GORE approaches. GORO is based on UFO [3] and was built to be

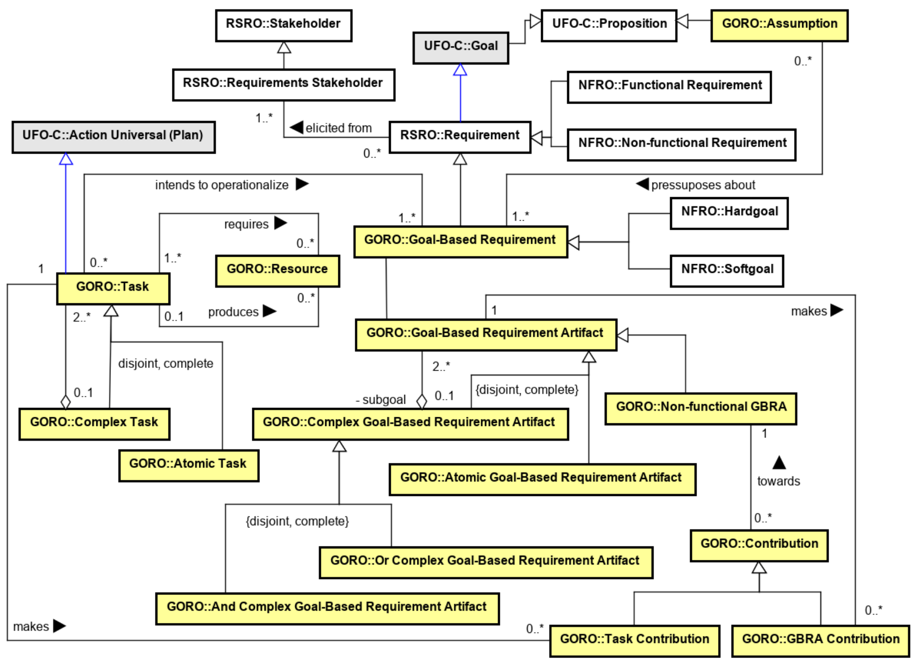

Fig. 1: The Goal Oriented Requirements Ontology

used as an interlanguage between GORE languages and also to be used as an instrument of consensual conceptualization of GORE elements.

Figure 1 presents an excerpt of GORO. The ontology focuses on the concept of Goal and defines it as a Mental Moment, which is a mental property existentially dependent on a single individual. A Goal in GORO can assume four types of classifications, according to [5]: Functional Hardgoal, Non-functional Hardgoal, Functional Softgoal and Non-functional Softgoal. A Goal-Based Requirement Artifact (GBRA) (a documented requirement) *describes* a Goal-Based Requirement (a requirement that exists only in the stakeholder's mind). A GBRA can be an Atomic GBRA or a Complex GBRA. The latter defines a Goal that is decomposed into smaller ones, either using *AND Refinements* (AND Complex GBRA), implying that the supergoal will only be achieved if all of its subgoals are; or in *OR Refinements* (OR Complex GBRA), implying that a goal is considered satisfied when at least one of its subgoals is satisfied.

A Task is a subtype of Action Universal (Plan), which is a specific way to do something. In this context, a Task describes a process that a stakeholder wants to follow in order to achieve a Goal. A Task can be an Atomic Task or a Complex Task. A Complex Task can be broken down into other Tasks, whereas an Atomic Task cannot. A Task can *require* and/or *produce* a Resource.

Assumptions are domain properties expected to be true in a specific context (the context in which a Goal is expected to be achieved). Assumptions are classified according to [8]. Contributions are positive/negative total/partial relationships, which relates a Goal or Task with a Non-functional GBRA.

We emphasize that the entire process of building GORO and mapping constructs of GORE languages to GORO (including both versions of $i*$/iStar) was carried out with the support of a group of domain specialists, as described in [1]. The iStar constructs definition was extracted from the literature ([2]) and then mapped to GORO concepts only after the agreement of at least 80% of the group. The group is made up of five academic professionals with considerable experience in the field. Table 1 shows the iStar to GORO concepts mapping.

Table 1: iStar to GORO concepts mapping.

GORO Construct	**iStar Construct**	**GORO Construct**	**iStar Construct**
Requirements Stakeholder	Actor, Agent, Role	Resource	Resource
Functional Requirement Hardgoal	Goal	AND GBRA	AND-Refinement
Functional Requirement Softgoal	Quality	OR GBRA	OR-Refinement, Qualification
Task	Task	Contribution	Make, Help, Hurt, Break

3 Ontological Interpretation of *iStar* Constructs

This section discusses the interpretation of different concepts of *iStar* and is divided in three parts. Subsection 3.1 describes the multiple semantics of the Refinement Link, while subsections 3.2 and 3.3 propose open discussion topics about the Task/Goal refinement and the Role element, respectively. We use sans serif and *slanted* to represent concepts and relations of GORO, respectively, and **boldface** for iStar constructs.

3.1 The Refinement Link

With the aim of alleviating the complexity of the language and thus facilitate its adoption, *iStar* proposes gathering multiple relations between goals and tasks in just one relation called **refinement link**, which can be of two types: **AND** or **OR**. Indeed, this choice simplifies the language's syntax; however, this can also lead to confusion regarding semantics. In *iStar*, a **goal** can be (AND/OR) refined in **goals** and **tasks**. Also, **tasks** can be (AND/OR) refined in **goals** and **tasks**. With GORO, we can explore the very nature of all these relations.

The *iStar* **AND refinement** between **goals** is interpreted as GORO's And Complex GBRA, which represents a complex Goal (an implicit concept derived from Goal-Based Requirement, analogous to And Complex GBRA) *decomposed* in sub-parts (sub-goals). Being Goal a Proposition, it is possible to separate it in different parts that, together, compose the original ($G \iff G_1 \wedge G_2 \wedge G_3 \wedge \ldots Gn$). That means, G is satisfied by exactly those situations which satisfy $G_1 \ldots G_n$ conjunctively and, so, satisfying all subgoals implies satisfying the supergoal.

Moreover, the **OR refinement** element in *iStar* can be used to represent GORO's Or Complex GBRA indicating alternatives, in which Goals are not broken down in sub-parts but in alternative Goals in which a situation that satisfies each of them (separately) also satisfies the main goal. Hence, considering $S(G)$ as a situation that satisfies G: $S(G) \iff S(G_1) \vee S(G_2) \vee \ldots \vee S(G_n)$.

The *iStar* **refinement link** can also be used to refine a **goal** into **tasks**. If the **goal** is OR refined into **tasks**, then the child **task** is a particular way for achieving the parent **goal**. In GORO, these relations can be interpreted as the *intends to operationalize* relation between a Task and a Goal. This relation denotes that the successful execution of a Task — i.e., the action of executing this specific process — will interfere in the reality, producing a post-situation that may *satisfy* the Goal. However, if a **goal** is AND refined into **tasks**, the child **tasks** are sub-tasks that must all be executed to achieve the **goal**. In this case, there is an implicit Complex Task that *intends to operationalize* the Goal and is OR refined in the child **tasks**, as explained next.

Regarding **task decomposition/refinement**, *iStar* **tasks** can also be refined in other **tasks**. When OR refined, the child **task** represents a specific way to execute the parent **task**, whereas when AND refined, the child **task** is a set of steps that need to be performed in order to complete the parent **task**. In GORO, Tasks can be Complex Tasks or Atomic Tasks. The former can have subparts that, when executed together, achieve the whole Task. The *iStar* **AND refinement** of **tasks** is in agreement with GORO's concept of Task decomposition, whereas the OR refinement of **tasks** is not covered in GORO. We do not consider OR refined **tasks** in GORO as we propose a different approach for this type of modeling: if a **task** has alternative ways of being achieved, then it is actually a Goal and hence, its **subtasks** are Tasks that *intend to operationalize* such Goal. Consequently, a **task** that is OR refined into other **tasks** should be modeled as a **goal** that can be achieved by performing different **tasks**.

In *iStar*, it is also possible to refine **tasks** into **goals**. This specific type of refinement will be discussed in Subsection 3.2.

iStar **refinements** have different meanings depending on the elements they connect. Ontologically speaking, grouping different semantics into one syntax leads to construct overload, which may cause these elements to be misinterpreted by modelers. Nevertheless, we here try to minimize the impact of this issue, by providing explicit ontological interpretation (i.e., ontological commitment) of the languages' constructs. We firmly believe that such interpretation helps clarifying the meaning of its construct, and ultimately lead to better *iStar* models.

3.2 The Task/Goal Refinement

In *iStar*, a **task** can also be refined in **goals**. GORO does not predict this kind of relation. As GORO defines, Goals are the propositional content of an intention to achieve a specific situation (state of affairs) in reality. This means that Goals refer to desired situations in reality. On the other hand, Tasks describes specific processes executed with some intention.

A possible interpretation is to consider that **goals** that are children of a **task** refer to the post-situation brought about in the reality after that **task**'s execution. However, it is our belief that being **goals** and **tasks** of different ontological nature, the trade-off of allowing such refinement is not a positive one, possibly leading to much confusion. After all, how can a process (i.e., a Task be decomposed into propositions (i.e., Goals)?

Yu [9] argues that the refinement between **goals** and **tasks** is a way to capture the transition between the problem domain (**goal**) and the solution domain (**task**). In addition, according to him, refining a **task** into a **goal** would be natural in the analysis and modeling cycle, which generally iterates between these two domains. However, by ontologically analyzing these concepts, the relationship between a **task** and a **goal** is not a **"refinement"**. Rather, the aformetioned possible interpretation proposes that the task analysis may motivate the "emergence" of new goals, possibly better characterized in different models, created for the different analysis' cycles.

3.3 The Role Element

iStar propose **actors** as active and autonomous entities that aim to achieve their goals and may be further classified as **roles** or **agents**. In GORO, an **actor** corresponds to the Requirement Stakeholder Kind concept. A **role**, in its turn, is interpreted as a Requirement Stakeholder Role. The distinction between a *kind* and a *role*, according to UFO, is that a kind represents essential properties of objects (they are also termed rigid or static types [3]), whereas a role represents contingent or accidental properties of objects (termed anti-rigid types [3]).

As stated before, GORO interprets a Goal as the propositional content of an intention, which is a mental property existentially dependent on a single individual. Thus, a Goal is related to an individual Requirements Stakeholder. However, being a type, a **role** represents expected behavior patterns of several individuals. To explain that, we resort to the ontological clarification made by Guizzardi et al. [4]: "(...) a physical role is characterized by social moment types, which describe the set of general commitments and general claims that a physical agent playing a particular role has" (p. 559). Thus, we interpret the **goals** of a **role** as commitments to execute Goals of those particular types. By analogy, similar interpretations may be inferred to **role**'s **tasks** and **resources**. So, expressing Goals of Roles may not represent the particular goals of individuals that will assume that role, but general goals that they are expected to achieve.

4 Conclusion and Future Works

Among the various GORE modeling languages, *iStar* has been one of the most popular ones, further leveraging the GORE field. Therefore, conceptually standardizing all concepts common to this field becomes an increasingly important need. This is the goal of *iStar* 2.0. This standard can be considerably improved with the support of ontologies, such as GORO, making explicit the semantics behind the language's constructs. In addition, ontologies can be used to guide users in adopting best practices in *iStar* modeling, thus preventing modelers from creating inconsistent, low-quality models. We emphasize that an ontological analysis is not intended to limit or restrict the use of a language, but to provide a well-founded and unambiguous interpretation of its concepts.

In this paper, we propose an ontological interpretation for *iStar* role, we argue that agent is not a necessary concept, and we explain why it is not a good idea to refine tasks into goals. Moreover, we presented different ontological interpretations of the *iStar*'s **refinement link**. We acknowledge that this element groups different semantics in order to reduce the complexity of the language. However, we emphasize the need to find a balance between simplification and loss of meaning. We understand that this is a hard task and that the line that defines a good balance between both sides is thin. Therefore, the use of an ontology to mitigate the risk of having the language's construct misunderstood and misused may be a suitable approach.

We are currently using GORO to analyze a greater number of languages, also facilitating their interoperability. In addition, GORO can be used to solidify GORE concepts, so that they can be properly used, thus allowing new adepts to learn GORE in a simpler and faster way.

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