Information Systems 53 (2015) 346–362

Contents lists available at ScienceDirect

Information Systems

journal homepage: www.elsevier.com/locate/infosys

Metrics for measuring complexity and completeness for social goal models

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ARTICLE INFO

Article history:
Received 3 October 2014
Received in revised form
23 February 2015
Accepted 23 March 2015
Available online 30 April 2015

Keywords:
Goal-oriented requirements models
*i**
Software metrics
Model assessment

ABSTRACT

Goal-oriented Requirements Engineering approaches have become popular in the Requirements Engineering community as they provide expressive modelling languages for requirements elicitation and analysis. However, as a common challenge, such approaches are still struggling when it comes to managing the accidental complexity of their models. Furthermore, those models might be incomplete, resulting in insufficient information for proper understanding and implementation. In this paper, we provide a set of metrics, which are formally specified and have tool support, to measure and analyse complexity and completeness of goal models, in particular social goal models (e.g. *i**). Concerning complexity, the aim is to identify refactoring opportunities to improve the modularity of those models, and consequently reduce their accidental complexity. With respect to completeness, the goal is to automatically detect model incompleteness. We evaluate these metrics by applying them to a set of well-known system models from industry and academia. Our results suggest refactoring opportunities in the evaluated models, and provide a timely feedback mechanism for requirements engineers on how close they are to completing their models.

1. Introduction

Goal-oriented Requirements Engineering (GORE) has a great impact and importance in the Requirements Engineering community, helping in identifying, organising, and structuring requirements, as well as in exploring and evaluating alternative solutions to a problem [1]. There are two types of GORE models: models that only capture goals and their refinements (e.g. KAOS [2]), or models that capture the actors behind the goals and the way they deal with them through refinement and delegation (e.g. . *i** [3] and GRL [4]). Earlier work (by the authors) focused on the KAOS goal model [5]. In this work, we motivate and propose metrics for social goal models, such as those used in *i**.

When modelling real-world systems with a GORE approach, the models can quickly become very complex. A common challenge for the GORE approaches is to manage the complexity of their models. While real-world problems have an unavoidable essential complexity, we need to minimise, as much as possible, the accidental complexity introduced by the way we model those problems [6].

A possible way of minimising accidental complexity of a model is to improve its modularity. In particular, this can be achieved by identifying model refactoring opportunities. In this paper, we focus on the *i** framework, and how we can manage the accidental complexity of *i** models. In order to identify refactoring opportunities for these models, we define a metrics suite for assessing their complexity and the complexity of the elements defined in them. Collecting such metrics on several different models is a necessary step to establish a typical usage profile of the modelling mechanisms.

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http://dx.doi.org/10.1016/j.is.2015.03.006

In practice, this profile is built using descriptive statistics analysis on the metrics collected from different model elements. For example, the number of goals and tasks for a system agent may indicate whether this agent holds too many responsibilities in the system. This can hint the modeller for a refactoring opportunity where this agent should in fact be decomposed into several sub-agents.

Another challenge for the GORE approaches is that resulting models might be incomplete, which results in lack of information for its proper understanding and implementation. Eliciting requirements for these systems is typically performed in a stepwise manner. The requirements engineer begins by modelling the higher-level elements, and then decompose them into less abstract elements. In this refinement process, it is useful to have a measure of completeness and a timely feedback mechanism, which can help requirements engineers to realise how close they are to completing their models. In this paper, we focus on how we can automatically detect *i** models incompleteness. We define a metrics suite for assessing their completeness and the completeness of the elements defined in them.

The objective of this paper is to provide a metrics suite, along with corresponding tool support, targeted to the measurement and analysis of complexity and completeness of social goal models (in this paper, *i** models). The goal is the identification of refactoring opportunities to improve the modularity of those models, and automatically detect social goal models incompleteness. The identification of such opportunities can be useful during the development of the system, where a better modularisation can lead to a sounder distribution of responsibilities among the system components. If performed in a timely fashion, this is likely to contribute to relevant costs savings through the reduction of the model's accidental complexity. Refactoring opportunities identification is also an asset in the context of preventive maintenance, as a facilitator for future requirements changes. Regarding models' completeness, measuring the current status of a model, and its level of completeness at a given time, can help in calculating the estimated effort required to finish the modelling process.

Our metrics suite is integrated in an Eclipse-based *i** editor, so that metrics can be computed during the requirements modelling process, whenever the requirements engineer requests them. The metrics are defined using the Object Constraint Language (OCL) [7] upon the *i** meta-model. This makes our metrics set easily extensible, as improving the metrics set can be done by adding new OCL metrics definitions to the ones presented in this paper.

In [5], we proposed and validated a metrics suite for evaluating the completeness and complexity of KAOS goal models, formally specified (using OCL) and incorporated in a KAOS modelling tool. The metrics suite was evaluated with several real-world case studies. The work described in this paper shares a common approach to metrics definition and tool implementation. However, the goals and structure of the KAOS approach are significantly different from those of social goal models. While KAOS builds on concepts such as goals and refinements, the metrics proposed in this paper are specific to a set of modelling constructs, e.g. actors, goals, refinements, and delegations, commonly present in social goal models. In particular, *i** has a modularity mechanism – the actor's boundaries – which is not present in KAOS, that paves the way for a significantly different approach to modularity, by encapsulating model elements within the actors boundaries. This is reflected in the choice of relevant complexity metrics. Actor's boundaries are a key mechanism in the metrics suite proposed in this paper. Our goal is to use these metrics to leverage the modularity of *i** models. This paper extends our previous work in [8] by enhancing the initial set of complexity metrics and adding a full set of completeness metrics.

The rest of the paper is organised as follows. Section 2 describes background information on the *i** framework. Section 3 describes the metrics set, defined using the Goal-Question-Metrics approach, and a concrete example of its application to a real-world model. Section 4 reports the evaluation process, including a presentation of the models, the results obtained by applying the metrics on those models, and a discussion on the results. Section 5 discusses the related work. Section 6 draws some conclusions and points out directions for future work. While the paper is self-contained, additional information such as the complete *i** meta-model, and the detailed specification of auxiliary metrics can be found in this paper's companion site (CS).[1]

2. The *i** approach

The *i** [3] approach was developed for modelling and reasoning about organisational environments and their information systems. It focuses on the concept of intentional actor. Actors in their organisational environment are viewed as having intentional properties such as goals, beliefs, abilities and commitments. *i** has two main modelling components: the Strategic Dependency (SD) model and the Strategic Rationale (SR) model. The SD model describes the dependency relationships among the actors in an organisational context. In this model, an actor (called depender) depends on another actor (called dependee) to achieve goals and softgoals, to perform tasks and to obtain resources. The SR model provides a more detailed level of modelling than the SD model, since it focuses on the modelling of intentional elements and relationships internal to actors. Intentional elements (goals, softgoals, tasks, resources and beliefs) are related by means-end or decomposition links. Means-end links are used to link goals (ends) to tasks (means) in order to specify alternative ways to achieve goals. Decomposition links are used to decompose tasks. A task can be decomposed into four types of elements: a sub-goal, a sub-task, a resource, and/or a softgoal. Apart from these two links, there are the contribution links, which can be positive or negative.

In this work we are particularly interested in assessing the complexity and the completeness of *i** models. To support this, we needed a flexible platform upon which we could define our metrics set. To the best of our knowledge, none of the existing *i** tools provide adequate support for a

[1] https://sites.google.com/site/miguelgoulaofct/is2015companion.