Goal-Models and the i* Modelling Method

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1 Introduction to Goal Oriented Requirements Engineering

Requirements engineering is according to the *International Organization for Standardization* defined as following:

> *"interdisciplinary function that mediates between the domains of the acquirer and supplier to establish and maintain the requirements to be met by the system, software or service of interest.*
>
> *NOTE: Requirements engineering is concerned with discovering, eliciting, developing, analyzing, determining verification methods, validating, communicating, documenting, and managing requirements." [4, p.6]*

Requirements engineering is therefore necessary for a successful development of a system, program etc., because it defines the requirements that are needed to meet the intended purpose of the system [8, p.33]. One way to approach requirements engineering is from a goal oriented perspective. Van Lamsweerde defines a goal as *"an objective the system under consideration should achieve."* [9, p.250]. The system in that case can be either referring to the current system or to the system-to-be, and both states of the system are of importance in the requirements engineering process. Van Lamsweerde understands a system as a composition of the environment. The system is made of active components with their own behavior [9]. The active components can be anything from human, software, institutions or devices and are called agents. And to make the loop back to the requirements: *"A goal under responsibility of a single agent in the software-to-be becomes a requirement."* [9, p.250].

It is helpful to use goals as a guideline for requirements engineering process for the following reasons [9, p.250]:

- to achieve requirements completeness,
- to avoid irrelevant requirements,
- to explain requirements to stakeholders,
- to provide a natural mechanism to structure complex requirements,
- to find alternative goal refinements,
- to manage conflicts among multiple viewpoints,
- to separate stable from unstable information,
- to use goals as a driving force.

One problem with goals is, that often they are not expressed directly, but more often indirect or informally. A possible approach to identify goals is to analyze the current system and use it as a source to identify goals. Having a closer look a the current state of the system might end up in a list of problems, and simply turning the problems around can provide in a list of goals to be achieved for the system-to-be [9, p.250f.].

There are several modelling languages that help to analyze, conceptualize and model the requirements of a system to be developed or transformed. Some of the well known goal oriented modelling languages are KAOS and i* [3, 11]. The following introduced modelling language i* (pronounced iStar) was developed by Yu [11]. It is based on the goal modelling approach, but takes it as a starting point for an agent-oriented modelling language.

2 An Agent Oriented Modelling Framework – Introduction to i* Modelling Language

2.1 i* – its idea and intention

The i* modelling language was developed by Yu [11] in his dissertation published in 1995. The framework is designed for the early-phase of the requirements engineering process. It builds upon the goal-oriented framework described above but puts a special emphasis on modelling social relations, in that sense i* is also an agent-oriented modelling framework. It is the understanding that a system should aim at improving the relationship among actors, thus in order for a system to work, the social relations have to be analyzed beforehand [12]. The early-phase of requirements engineering is characterized by understanding the motivation to create a system-to-be, why the current circumstanced do not work and what the different perspectives are on the current situation. This can be analyzed by looking at and rearranging the different social relationships involved.

The benefit of applying a social worldview is to see and understand the different kinds of intentions, dependencies, interests, reasons and many more of the different actors involved the system(-to-be). Especially vague ideas of a system-to-be, or simple desires of an actor can be easily added to such a social worldview. Additionally, applying a social worldview allows to acknowledge the fact that each actor acts (semi-)autonomously in that sense that the actor has a behaviour of himself/herself, but is also dependent on their environment and other actors involved [12].

The i* modelling framework takes upon the two above mentioned benefits of a goal and agent oriented perspective. It uses goals to describe the intentions as attributes of the different actors involved and hence can incorporate the viewpoints from several perspectives. With dependencies created between different actors, the autonomy and vulnerability of actors are also incorporated into the system modelling process. With this combination of goals and agents it is possible to recognize the possible trade-offs and opportunities of different/competing goals from several perspectives [12].

Currently the version i* 2.0 is used. The new standard was published 2016 and is under continuous development [2]. For the i* modelling language several domain specific extensions are available, thus i* can be used for many different modelling tasks in many different domains which shows the intended open nature of i* [5].

2.2 i* Notation – What can i* model?

As mentioned before, the focus of i* are the social relations between different actors involved in a system. A summary of the notation of i* can be seen in table 2.3 as well as some example models in figures 1-3 of a travel reimbursement scenario as described in [2]. Generally i* differentiates between the following model views; *Strategic Rationale, Strategic Dependency, Hybrid SD/SR* (see figures 1–3 for examples).

- *Strategic Rationale (SR):* This view shows all the links, relations, dependencies, resources etc.
- *Strategic Dependency (SD):* This view only focuses on the actors and the associations to others and their dependencies among each other including the intentional elements.
- *Hybrid SD/SR:* The hybrid view is useful, when for example not all the information about all actors is available, or the model is defined from a specific perspective.

From the perspectives of the SR and SD model view, the following section is going to describe what i* can model and for what it can possibly used for.

Strategic Dependency Model (SD): The focus of the SD model is, as its name already states, the dependencies of the different actors, how they are related to each other in terms of their dependencies to each other. The dependency relationship describes a depender, its dependee and the dependum (compare figure 2 and table 1). The focus on the dependencies allows the identification of possible vulnerabilities and opportunities resulting from the different social relations. Taking the example of the travel reimbursement scenario, the student is dependent on the travel agency to provide the booked tickets and the trip being booked, which could create a vulnerability for the student if the travel agency does not do their tasks. But this also offers the student some leisure, not to worry about the trip being booked.

Strategic Rationale Model (SR): The SR model includes all the dependencies described in the SD model and additionally shows the intentions, resources, tasks and the like of the different actors (compare figure 2). One can say that it takes a deeper look into the actors involved and elaborates their position in the system. Different tasks are decomposed into sub tasks, linking different actors together, showing how they interrelate to each other and hierarchically ordered. This could be of special interests to evaluate if there are any alternatives with respect to the interests and intents of the actors. As mentioned in the SD model in figure 1, the student is dependent on the travel agency for them to book the trip. When having a look at the SR model (see figure 2), it is possible to evaluate why involving a travelling agency is of comfort for the student: it is is quicker, it is more comfortable, but also possibly more expensive compared to booking the trip himself/herself.

2.3 Overview of the i* modelling notation as described in [2].

Group	Variations	Description
Actors	Actor	Autonomous entity, that aims at achieving his/her/its goals by exercising their know-how, in collaboration with other actors – used when distinguishing the type of actor is not relevant.
	Agent	Abstract characterization of the behavior of a social actor within some specialized context or domain of endeavor.
	Role	An actor with concrete, physical manifestations, such as human individual, an organization, or a department.
	Actor Boundary	Visualization for the actors intentionality, grouping together their intentional elements together with their relationships
Actor Association Links	Is-a	Represents the concept of generalization/specialization.
	Participates-in	Represents any kind of association, other than generalization/specialization between actors. No restrictions on type of actor linked. Source = agent, then the target is a role - represents the play relationship. Source and Target = same type - represents part-of relationship. Every actor can participate in multiple other actors.
Intentional Elements	Goal	State of affairs that the actor wants to achieve and that has clear-cut criteria of achievement.
	Quality	An attribute for which an actor desires some level of achievement. The level of achievement may be defined precisely or kept vague.
	Task	Represents actions that an actor wants to be executed, usually with the purpose of achieving some goal.
	Resource	A physical informational entity that the actor requires in order to perform a task.

Social Dependencies	Depender	The actor that depends for something (the dependum) to be provided.
	Depender Element	The intentional element within the depender's actor boundary where the dependency starts from, which explains why the dependency exists.
	Dependum	An intentional element that is the object of the dependendy. The type of the dependum specializes the semantics ot the relationship (e.g. dependum = resource - the dependee is expected to make the resource available to the depender; dependum = goal - the dependee is expected to achieve the goal, and is free to choose how).
	Dependee	The actor that should provide the dependum.
	Dependee Element	The intentional element that explains how the dependee intends to provide the dependum.

Intentional Element Links	Refinement		Links goals and tasks hierarchically. Is an n-ary relationship relating to one parent to one or more children. Parent can only be AND or OR refined, not both at the same time.
		AND	The fulfillment of all the n children makes the parent fulfilled.
		OR	Inclusive: the fulfillment of at least one child makes the parent fulfilled. Allows for one single child.
	Needed By		Links a task with a resource and it indicates that the actor needs the resource in order to execute the task.
	Contribution		Represents the effects of intentional elements on qualities, and are essential to assist analysts in the decision-making process among alternative goals or tasks. Defined as relationships from a source intentional element to a target quality.
		Make	The source provides sufficient positive evidence for the satisfaction of the target.
		Help	The source provides weak positive evidence for the satisfaction of the target.
		Hurt	multicolumnThe source provides weak evidence against the satisfaction/denial of the target.
		Break	The source provides sufficient evidence against the satisfaction/denial of the target.
	Qualification		Relates a quality to its subject (task, goal, resource). Expresses a desired quality over the execution of a task, the achievement of the goal or the provision of the resource.

2.4 Short evaluation of the i*

Although i* is widely used in the research field of requirements engineering, some recent studies show that it still has some open issues to be resolved. Yasin and Liu have evaluated a number of studies on i* [10]. Their findings show, that currently open problems dealt with in their evaluated studies of i* are concerning the scalability, clarity and the combined use of i*. Abrahão et al. have compared i* 2.0 to value@GRL concerning several aspects like usability

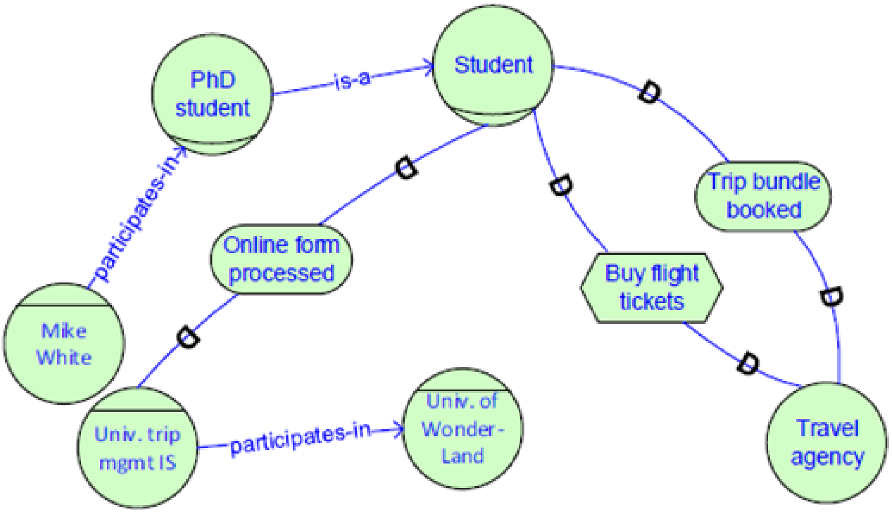

Figure 1: Strategic Dependency Model View of a travel reimbursement scenario [2].

and the achieved model quality (value@GRL is a simplified i* version) [1]. Their results show that the models created with value@GRL are significantly of better quality; the participants in the studie found value@GRL more useful; the ease of use and of value@GRL and i* and productivity of the participant (productivity = quality and time) are comparable; and last modelling time was lower for i*.

These findings show that i* seems not to be the answer to all requirements engineering questions and concerns. But never the less, i* is still very popular with the research field of goal oriented requirements engineering [6, p. 143].

3 Conclusion on goal oriented requirements engineering

Mavin et al. have done a study on the application of goal oriented requirements engineering in practice [7]. They show that though it is quite popular in the academic research field, it finds little application in industry. Most of the publications about goal oriented requirements engineering are coming from the academic field and only in some cases show a connection to the industry and actual application of it. A questionnaire done with practitioners shows that they do work with goal oriented requirements engineering, but mostly in a more general sense of goals. This underlines that there is a gap between the academic field on requirements engineering and its actual application in the field of industry. Therefore in theory goal oriented requirements engineering seems to work, but still needs to find a way into the real world.

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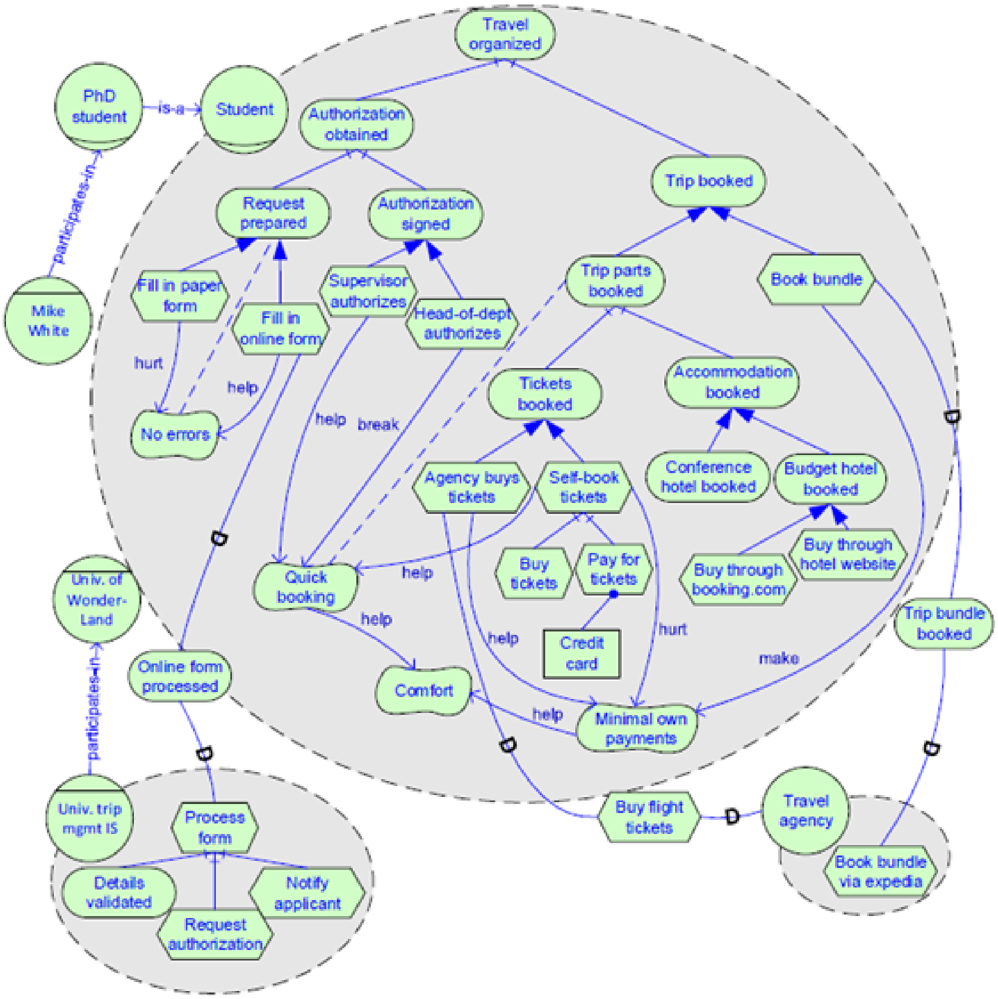

Figure 2: Strategic Relationale Model view of a travel reimbursement scenario [2].

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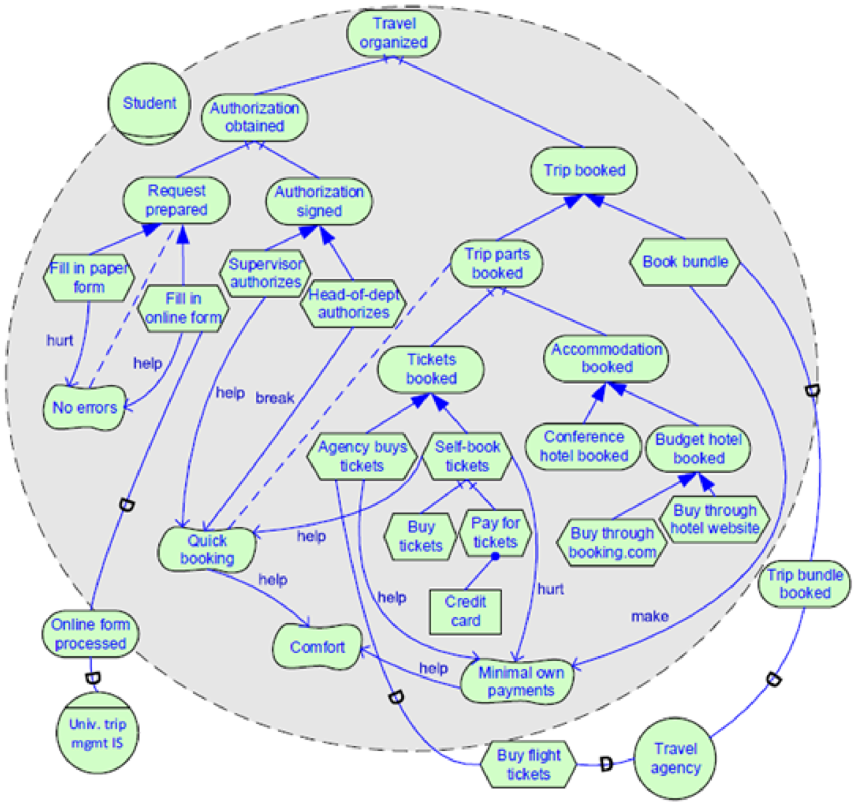

Figure 3: Hybrid SR/SD Model View a travel reimbursement scenario [2].

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