Goal-oriented Contextual Requirements Analysis in the Presence of Digital Stakeholders

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Abstract. Deriving from diverse and vastly growing sources, digital data is emerging as the essential resource to organizations, enabling them to by enlarging their body of knowledge advance in highly demanding business situations and markets. The means enabling holistic reasoning and modeling business constellations including varieties of digital sources of data, and the ranges of different contexts covering those data are therefore a challenge in the modelling community. In this paper, we analyze the use of the core i* language for supporting modeling of context-dependent business environments where the contexts' data is provided by digital actors. We have defined the mappings from the main concepts for the domain of the investigation (such as digital sources, context and capability) to the elements of the i* 2.0. We illustrated our proposal by applying it on the service concerning roads maintenance.

Keywords: i*, Requirements, Context, Capability

1 Introduction

Digitizing business services is becoming a fundamental necessity. In many domains, there are opportunities to derive better decisions by collecting and analyzing data from diverse digital sources, such as web sites, mobile devices, social media and IoT, such as in healthcare for accurate diagnosis, or for weather forecasting, maintenance of industrial tools, energy consumption, transport, etc.

Traditionally, the Requirements Engineering (RE) discipline has been stakeholder-driven, i.e. existing methods for elicitation of the requirements for embedded or information systems rely on business organizations and individual stakeholders as the main sources of information [1]. Tremendously increasing digital data sources, in their versatile forms, facilitate a heightened level of awareness about business and individual environments and conditions, which therefore promote them to be considered as new types of active requirements' sources.

In this context, a challenge concerns lack of the methods and tools for supporting reasoning about system requirements in a way that would enable domain experts and developers to mutually understand and communicate these requirements for

improvements of existing software solutions or for development of new ones. One commonly discussed approach proposes to elicit motivations behind business models using organizational goals [2].

In this position paper, we concisely analyze the use of the i* goal modeling technique as a tool to support modeling and visualization of situational business environments encompassing constellations of pervading physical and digital actors, with the aim of elicitation of high-level system requirements capturing the data resources provided by these actors, as well as the desired functionality related to these data. Owing to i*'s ability for modeling the dependency links between different entities, we have found the technique as also applicable for discovering new digital actors (sources) in situations when goals and needed data resources are explicated.

The rest of the paper is organized as follows. Section 2 outlines a brief background to data and context-driven requirements engineering. Section 3 presents the theoretical proposal and illustrates it on the case concerning roads maintenance. A discussion and concluding remarks are given in section 4.

2 Data and Context-driven Requirements Engineering

Today's organizations operate in dynamically changing situational environments (contexts). Having a continuous access to relevant, accurate and usable data is therefore highly important for organizations, but in turn, it leads also to the requirements to improve their information systems to be able to benefit from new and often changed and updated data [3]. One methodological approach for dealing with dynamic business contexts implemented by the means of information systems is Capability Driven Development, CDD [4]. It is a methodology developed to support continuous delivery of business capabilities (i.e. functions [5]) by being able to capture and take advantage of changes in business context. The success of a business and IS infrastructure is therefore highly tight to the ability to entirely fetching the relevant surrounding business context and where digital data from IoT, mobile devices, websites and other play a highly significant role as versatile, precise, accurate and scalable information sources.

Goal-oriented approaches for analyzing contexts related to system development are well elaborated in [4] and [6]. Differently from them, the aim of this small study is to analyze the usability of the i* modeling language [7] (in particular, i* 2.0 [8]) for enabling a core understanding and integration of the goals and available resources of, in a varying context business constellation, involved physical and digital actors, for enabling needed system capabilities.

3 A Requirements Analysis Framework using i*

In this section, we describe a lightweight i* framework for analyzing context-driven requirements were the contexts' data is obtained from digital sources.

As for the notion, for the purpose of this study, we consider i* 2.0 and its main elements: Actor, Intentional elements and Dependency as the main archetypes. Actors

are autonomous entities aiming at achieving their goals in collaboration with other actors; they could be further refined to roles (actors with domain behaviors) or agents (actors with concrete physical manifestations). Goals, qualities, tasks and resources are the intentional elements used for modeling the things wanted by actors. Dependencies represent social relationships between actors in the way that one actor depends on another actor for something that can be a resource, a task, a goal or a quality. The i* language distinguishes two types of model views: Strategic Dependency (SD) model showing the actors and the dependencies between them, and Strategic Relational (SR) Model presenting a detailed view of the intentions of involved actors.

The scope of this paper is to analyze how i* be used for modelling context-based business environments in the presence of digital devices that provide resources to fulfill the context-based goals. Thereby, we consider a business environment where a User obtains the services of a System (IS) to fulfill his/her context-related resource requirements or goals. The System that provides Services, has a set of context-based goals and obtains data (resource) required to fulfill such goals from different types of Digital Sources. As such the analysis would concern the possible mappings between the concepts in the domain as described above and the i* 2.0 elements.

As a brief presentation of the framework usage, the figure below illustrates how User (role) is for the fulfillment of his/her goal "Traffic info provided", dependent through an online Service (agent) for obtaining "Traffic related data" (resource) from digital sources (actor, which can be refined further to a concrete source, i.e. agent).

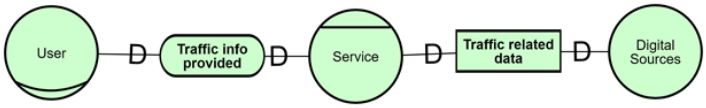

Fig. 1: i* Strategic Dependency model for an automated traffic service

In Table 1 below, we summarize the mappings from the concepts in the domain of our concern to the i* 2.0 modelling language.

Table 1 – Mapping rules

From	**To**	**Description**
Concept	***i* element***	
User	Role	Abstract characterization of People or organization types in the need for some contextual data resources.
Service	Agent (System)	An automated service realizing the requirements for the resources through its goals and capabilities.
Digital source	Agent	A mobile device, a website, or IoT that fulfills the goals related to a particular context of the Service agent by its data resource(s).
Data	Resource	Information provided by a digital source.

Relationship between Service and Digital source	Resource Dependency from Digital source (Agent) to Service (Agent)	Service is dependent on Digital source for Data (resource) to fulfill the service's context-dependent goals
Goal	Goal	A clear-cut desired condition of a role or an agent.
Business Context	Quality	A state (condition) of a business pertinent to User, further referring/associated to goals of Service.
Capability	Task	A function of Service utilizing data resources, to be developed and implemented.

To illustrate the guidelines for use of the proposed framework, we consider the case of road maintenance under different weather circumstances (contexts) such as snowy, icy and frosty road conditions, road damages, traffic disturbances, etc.

Step 1: Identify people and organizations having needs for the service

Driver is dependent on Road Service for a usable road conditions, such as "Snow is cleared", "Road is not slippery" (goals), as well as for the information regarding traffic disturbances such as road construction details, traffic signal failures, objects disturbing flow of traffic on roads (resource); this is summarized in Fig. 2 below.

Step2: Identify contexts for which Service capabilities are required.

Following [4] and [6] and Table 1, a context of interest can be defined as a condition characterizing a situation pertinent to business users and therefore relevant to some goals of the actor under concern. Following this, table 2 below summarizes the identified contexts (represented as Quality in Fig. 2), related goals of the Road Service agent, and needed capabilities (represented as tasks in Fig. 2).

Table 2: Contexts relevant for Road Service

Context	Description
Traffic disturbance	Depending on different types of traffic disturbances such as road constructions, traffic signal failures, objects on road disturbing the flow of traffic, service agent should be capable of delivering the required capabilities (tasks in Fig. 2)).
Icy conditions	Depending on the different temperature levels at the road surface, the service agent should have the ability to carry out the capabilities required to eliminate slippery conditions on roads (Fig. 2)
Snowy conditions	Based on weather forecasts the service agent should be in a position to give precise details to maintain road network free of snow (Fig. 2).

Step3: Based on the required capabilities of the service agent, determine digital sources needed to deliver such capabilities.

Requirements for data resources of the identified capabilities (tasks) are analyzed to determine the desired data resources and further the digital sources able to provide these resources. Here the modeler should consider the required capabilities to link them to the available devices, or introduce new sources by considering the resource requirements. Additionally, the modeler can compose several digital sources to get aggregated information. In table below and in Fig.2, we summarize the analysis of the data resource dependencies of the Service agent (i.e. its tasks/capabilities).

Table 3: Resource dependencies for Road Service

Task	Resource	Digital Source
Update traffic info	Construction details – construction related work details are often published to inform the disturbances to the normal traffic flow	Handheld construction details reporter source
Report traffic signal failures	Traffic light failure info – traffic light failure information is published to inform the drivers about failures of automatic traffic management in road networks	Traffic light with the ability of detecting any possible alterations to its proper functioning and reporting that to the Service agent
Analyze weather data, Collect temperature, and Predict road condition	Weather data, Weather forecast, Road condition and Temperature – Weather data is required to forecast different weather conditions. The surface level temperature at road networks is useful to determine icy conditions on roads	Composite Traffic camera or Weather and temperature sensor and Weather data analyzer – The traffic cameras can aggregate the functionalities of capturing weather information around road networks. Specialized weather and temperature sensors be used similarly. Weather data analyzer having the is used to forecast snowy conditions.
Report object details	Object data – objects on the road disturbing flow of traffic	Composite Traffic camera

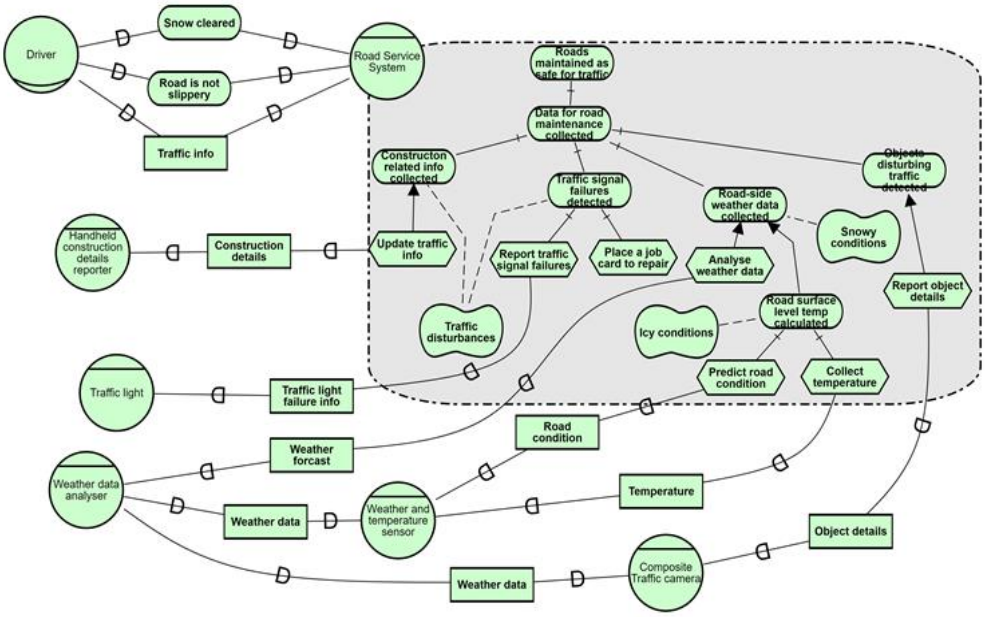

Fig. 2. i* Strategic Rational Model for the road maintenance service, with identified data resource dependencies to digital sources for required service capabilities (tasks).

A brief discussion of the presented results, conclusions, and the plans for further work are presented in the next section.

4 Discussion, Conclusions and Future Work

In this paper we have analyzed how the i* modeling language can be used to simply and holistically model context-dependent business environments where the contexts' data required for business capabilities is provided by digital actors. We have defined the mappings from the main concepts for the domain of the investigation (such as digital sources, context, capability) to the elements of the i* 2.0. Further, we have by means of step-wised guidelines illustrated the use of the proposal on the case of the road maintenance.

The motivation behind this study lies in the fact that the success of today's organizations highly rely to their ability for gathering different data from their surroundings, and where the requirements for data accuracy, amount and the pace of processing are constantly increasing. The i* modeling language provides the ability to in a single view describe and integrate the relevant domain concepts for enabling further development of information systems (services) capable to support different business contexts. An important consideration in this domain of study refers to system's behavior at run-time. Using the i* technique, it is possible to define relevant business contexts, needed data sources and capabilities, however, additional design is

needed to support switching of system's capabilities for different contexts that are changing over time. This challenge is for example explored by the CDD methodology [4], which supports monitoring of the contexts by processing their data and handling of capability adjustments when the monitoring indicates such changes in the context requiring another capability.

For the near future work, we plan to investigate the integration of the emphasized strengths of the i* technique in the domain of system's requirements analysis with the needed information for system's run-time management for context adjustments.

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