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A Framework for Intention-Driven Requirements Engineering of Innovative Software Products

Mauri Leppänen and Juha Lamminen and Pertti Saariluoma

Abstract Requirements engineering is highly challenging particularly when designing innovative software products. This is so because there are no corresponding products, ultimate needs of actors are difficult to capture, the products may have unforeseeable impacts on the actors' behavior, and it is hard to find out how value-added and competitive the product actually is. In this paper, we propose a novel framework for intention-driven requirements engineering of innovative software products, which combines technological, social and business viewpoints. We illustrate its use with a short example related to the domain of web mapping services and augmented reality.

1 Introduction

Requirements engineering (RE) is the most challenging discipline in the systems development lifecycle. Requirements are often ambiguous, incomplete, redundant and contradictory, due to stakeholders' divergent perspectives, terminology, and interests [14]. They are frequently changing because stakeholders are not able to say what they really need. Requirements engineering also involves reluctant participation, misperception and disagreement. Many RE languages and frameworks have been proposed to help making requirements more precise, complete, and consistent [20, 3]). These techniques are mainly targeted to late-phase requirements engineering, and less attention has been given to consider how the desired software product would meet personal or business goals, and why the product is needed.

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The emergence of novel IC technologies has created new possibilities to add value through innovative products and services. Realizing this potential requires creativity and innovative acts across the whole product design lifecycle. *Innovation* means a multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace [1].

Requirements engineering is particularly challenging when it concerns the design of an innovative software product. First, there is no corresponding product from which to learn. Second, a new product may affect, in an unforeseen manner, ways of how actors behave and business is run. Third, it is hard to discover how value-added and competitive the product-to-be would actually be, and for whom, among the networked companies. These challenges have been tried to be met by moving the focus onto early phase RE [31,32], by developing goal-oriented approaches [4, 6, 15], and by crafting creativity techniques [9, 22] for requirements engineering. Nevertheless, the situation is still unsatisfying.

We argue that in RE of innovative products creativity should be a built-in, all-bracing property, the intentions of human and business actors have to be taken as the basis for all the RE activities, and the way of requirements engineering should be tailored based on the situation at hand (cf. customer-driven vs. market-driven vs. technology-driven). We suggest a novel framework for RE of innovative software products, which aims to satisfy the abovementioned demands. The framework combines the technological, social and business viewpoints. It is aimed to be used for analyzing and comparing existing RE methods in terms of how they address, emphasize, and integrate creativeness and the three viewpoints. It also provides a basis for considerations of how to enhance existing RE methods.

The paper is organized as follows. In Section 2 we describe the framework, and in Section 3 we illustrate it with a small example. In Section 4, a short literature review of relevant literature is presented. Section 5 concludes with the summary.

2 Framework for Requirements Engineering

We define *requirements engineering* (RE) as a creative process in which stakeholders and designers work together to create and concretize ideas for a new product [18, 19]. We build our RE framework on four concepts: innovation, user-centressnes, goal-orientedness, and multi-viewpoint. First, the overall structure of the framework is designed to boost the capturing and elicitation of new ideas for software products. Second, the RE process starts with finding out the intentions and needs of users, and users are expected to have an active role in the RE process. Third, goals provide rationale for requirements that operationalize them and help detect and manage conflicts among the requirements [15]. Fourth, requirements engineering is considered from the business, social, and technology viewpoints. The focus of the first viewpoint is on value creation, distribution and consumption (cf. [8]). Social viewpoint concerns members of communities and their

social relationships. Technology viewpoint is applied to bring forward and discuss new technological innovations.

The RE framework is composed of five interrelated RE activities: envisioning, user profiling, business context analysis, social context analysis, and goal setting (see Figure 1). In the following, the activities are described in more detail.

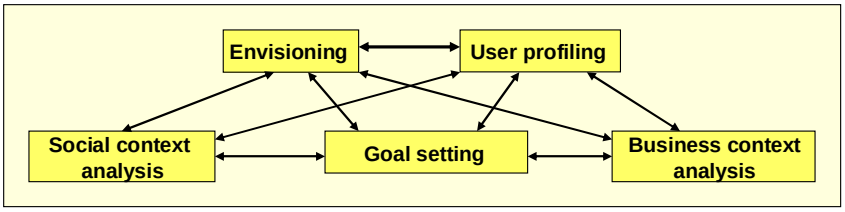

Fig. 1. Framework for Requirements Engineering

2.1 Envisioning

Envisioning means innovative and creative action aiming at evoking and eliciting ideas for new products and/or new ways of using the products. Product design often starts with a vague desire, concept, or image of something new. Work is done, through innovative techniques [9, 20], to elaborate it towards a more concrete vision. To ensure its feasibility, the vision should be shared within the community and be translatable into reality. Creativity is a key factor to successful envisioning. It is the interplay between the ability and process by which an individual or group produces a product that is both novel and useful within some social or business context [25]. *Technical innovations* improve existing features or facilitate the introduction of completely new features. *Need innovations* happen when a hidden need is found or an existing need is abstracted into a more profound need (cf. [12]). *Business innovations* help companies increase their profits through the use of a new product and by re-engineering their business processes.

Envisioning can be driven by technology, business, or human needs. In the first case, a new IT intensive product is first invented and then an attempt is made to find out contexts in which its features could be utilized [16]. In the second case, the focus is on searching “enablers” for innovative business solutions [32]. In the third case, a social context is analyzed to understand what profound needs the human actors have, and to figure out how the needs could be satisfied through a new product. Our RE framework support all of these approaches. There is a large range of creative models and techniques available for envisioning [9, 22].

2.2 User profiling

User profiling aims at distinguishing user categories and characterizing them in terms of relevant features. Typically, the features include psychological characteristics (e.g., attitude, motivation), knowledge and experience (e.g. typing skill, task experience), job and task characteristics (e.g. frequency of use), and physical characteristics (e.g. color blindness) [21]. Characteristics can be concretized and combined by attaching them to personas, or fictional people [5]. Early personas are sketches that are later elaborated toward more detailed characters. Personas should not replace active user participation.

Data for user profiling is collected through interviews and/or user profile questionnaires, and indirectly from marketing personnel [20]. As new products built upon emerging technologies seldom have existing counterparts, it is important also to gather information about the users' subjective opinions and preconceptions regarding their future (cf. cultural probes [7]).

2.3 Business context analysis

If the product is to act as an "enabler" for innovative business solutions, not just as a means of automating well-established business processes, one has to obtain a deep understanding about the domain. This means learning about the interests, priorities and abilities of various business players. Also, to ensure that the idea of a new product will really add value, it is necessary to analyze its profitability. The purpose of *business context analysis* is to model the context, objectives, and processes of the business entity for which a new software product is to be designed, in order to better understand its ICT needs and potentials. A business context means a web of networked companies and/or organizations that are established to provide goods and/or services to consumers.

There are several approaches and models for business context analysis (e.g., business process models, workflow models, cultural models). We do not propose any new approach, but utilize two of them that are particularly suitable for early-phase requirements engineering. They are the e^3 value approach [8] and the i* framework [31, 32, 33].

In the e^3 value approach [8], a business context is viewed from a commercial perspective. It is seen as a multi-actor network in which economic value is created, distributed and consumed through a software product. An innovative idea means to find new economic value propositions that are yet unknown to the market and significantly change the way a company does business [8]. The e^3 value approach, as it is integrated into our RE framework, starts from an innovative idea resulting from envisioning. Based on this, a baseline model is constructed. The model shows business actors, value activities and value objects, as well as concepts related to value exchange through the distribution of value objects among

the business actors [8]. Construction of the model may yield more new ideas which can be iteratively elaborated through envisioning and perhaps through social context analysis. Based on the improved understanding of the business context and a clearer conception of the economic value of a new innovative idea, it is possible elicit goal statements for the product and its use.

In the i* framework [33], early requirements are assumed to involve actors who depend on each other for goals to be achieved, task to be performed, and resources to be furnished. The goals are analyzed and elaborated into functional and non-functional requirements of the product-to-be. The key concept is actor. Organizational actors are viewed as having intentional properties such as goals, beliefs, abilities and commitments. Actors are strategic in the sense that they are concerned about opportunities and vulnerabilities, and seek rearrangements of their environments that would better serve their interests [33]. The i* framework includes the strategic dependency (SD) model and the strategic rational (SR) model. The former is used for describing the dependency relationship among various actors in the business context. The latter is used to describe stakeholder interests and concerns, and how they might be addressed by various configurations of products and environments [32].

Both of these approaches emphasize the importance of understanding the business context, motivations and rationales (the "Whys"). The way of executing business context analysis depends on the situation at hand. For instance, if economic value is important, an e^3 value model is first constructed. The approaches can also be used to analyze the "eco-systems" of competitors and combine the results with information got from market analysis, in order to contemplate the competitiveness of the product.

2.4 Social context analysis

The purpose of *social context analysis* is to make sense of the motives and actions of the members in a given social community. A *social community* means a group of people who share common characteristics or interest and is perceived or perceiving itself as distinct in some respects from the larger society with which it exists [29]. Communities can be established based on family or friendship relationships, ideological views, hobbies, work, etc. Novel IC technologies (e.g. Facebook, Twitter, LinkedIn, Bebo, and MySpace) have substantially helped establishing new communities and networking within and between them.

Resulted from the first iterations in envisioning and user profiling, there exist preliminary conceptions about the relevant contexts and actors. Here, these conceptions are elaborated and analyzed. Within a family, for instance, the actors are the father, the mother, and children, and possibly grand parents and other relatives [10]. The next step is to recognize the intentions of the human actors. The purpose

is to analyze the underlying rationale and purpose of what people are doing: what are they trying to achieve, and why are they trying to achieve it?

During social context analysis, problems are uncovered and analyzed to find out whether ICT in some form could support social actions. The analysis may result in more elaborated ideas on a desired product, or it may lead to the conclusion that no product is needed. Another approach is to start with considering how an existing technology, perhaps in a new form and/or in a novel manner, could be utilized by the community. In parallel to the work in goal setting, work here continues with describing actions the actors are doing to reach their intentions and goals. Features of the product are outlined, and user tasks are modeled and analyzed to help discover main functionalities and qualities of the product. There are various models and techniques that can be used to describe user tasks in the social context: e.g., scenarios, (essential) use cases, use case templates, task decomposition trees, and work flow models.

2.5 Goal setting

Goal setting means the activity by which human and business actors' intentions are captured and refined into goals and ultimately specific, preferably measurable, requirements for a new product. An *intention* is a mental state of the actor, which motivates and regulates actions [3]. During this process, the goals and requirements are discussed, negotiated, formalized and prioritized. At its best, the requirements become concise, feasible, precise, complete, consistent and verifiable. As our focus is on early requirements engineering, we do not discuss formalization.

A *goal* is the reason for which something is done, made, used etc. Goals can be formulated at different levels of abstraction, ranging from high-level, motivational and strategic concerns to low-level, technical concerns [14]. From the business viewpoint, goals are objectives of the business organization, which guide decisions at various levels. From the human actor's viewpoint, goals are conditions or states of affairs that the actor would like to achieve. The lower-level goals concern objectives related to the concrete use of a product. A *requirement* specifies properties (functional, structural, physical, etc.) of the product-to-be [17]. A *feature* is a property of the product. It is first a design feature, then an implementation feature, and finally a usage feature (see Figure 2).

Goals are elicited, elaborated and analyzed in parallel to social context analysis and business context analysis. If the product is aimed for a social community, intentions and actions of the members give the starting point for elicitation. If the product is to be designed for business, business goals of and relationships between the business actors provide a basis for goal elicitation. In case the product has some features analogical to existing products, problems and deficiencies encountered in their use can be negated and used as anti-goals for the product-to-be.

Goals can also be got from marketing groups, technical support groups, and derived from competitive analysis.

Once goals have been identified, they are refined progressively into lower-level goals until they involve the use of the product. This process is done by asking the HOW questions. Another approach is to derive more abstract goals from those already identified by asking WHY these goals exist. This way it may be possible to refine them and find their sub-goals that were originally left undetected [15]. The goals and requirements can be described in AND/OR trees or networks. As all the goals and requirements cannot be satisfied, some priorization is necessary (for priorization techniques see [11]).

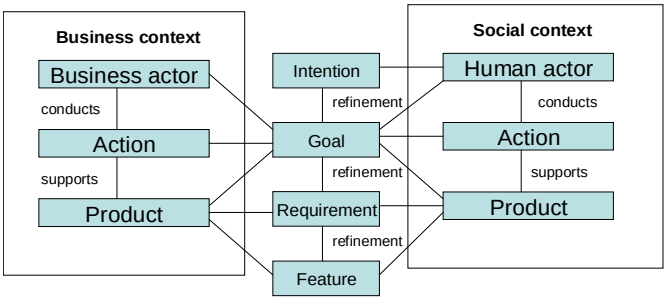

Fig. 2. Main concepts of the framework

3 Example

In this section, we illustrate the RE framework with a hypothetical example. Let us suppose that we are designing a new product to help tourists and start with the following vague ideas: planning trips should be fun, experiences during trips should be enriched, and networking with and communication between people with the same interests should be encouraging. The product is to be built upon three novel technologies: location-based services (LBS), distributed geographic information systems (GIS), and augmented reality (AR).

Most LBS offer basic navigation and routing services (cf. GoogleLatitude). We are especially interested in web map services (cf. Google Maps, Yahoo! Maps, Microsoft Virtual Earth, MapQuest, ArcWeb) in the form of distributed GIS that enhance the accessibility and dissemination of geographical capabilities and knowledge to internet users [28]. AR facilitates overlying labels or other virtual information over the real world objects (e.g. scene, building) observed through a camera attached to a computer, thus helping information contextualization and localization [30].

In the following, we describe how the activities of our framework can be applied to innovate the novel software product. Our case mainly applies technology-driven approach to RE. Due to the space limit, the description is very indicative. Intentions and goals are not discussed separately (cf. Goal setting) but mentioned in connection with the other activities.

Envisioning. We seek innovative solutions from three perspectives: technology, social and business. For finding technology innovations, we first recognize that there already exists a wide range of web mapping products. Our task is to invent a product with new features which make it desirable and competitive. We decide to build upon three promising concepts: geoportal, online annotation editing, and collaboration support. *Geoportals* are websites providing entries to geographical content on the Web [27]. Through them it is possible to provide tourists with a large assortment of existing web map functionalities and services [28]. Today, only a few augmented reality (AR) applications allow the *online creation and editing of annotations* [30]. When AR becomes popular on mainstream devices, there will be a large group of users who will be able to add content. This potential we want to exploit. We believe that with online annotation techniques an explosion of user created content, similar to the increase of online context with Web 2.0 applications, will be experienced [30]. Thereupon, the emergence of new forms of *social networking and cooperation* related to traveling can be also expected.

User profiling. The World Tourism Organization defines tourists as persons who "travel to and stay in places outside their usual environment for more than twenty-four (24) hours […] for leisure, business and other purposes [...]" . A tourist wants to obtain new experiences (e.g. roads with hairpin bends), learn exotic cultures or new things, or raise his/her social status (cf. visits in glamorous places). Tourists differ from each other in pre-knowledge, motivational, psychological, educational and physical terms. These differences should be taken into account in the functionality and interaction design of the product-to-be.

Social context analysis. We consider the context of traveling in three stages: trip planning, travelling and retrospective recalling and discussions of the experiences. The way a trip is planned depends on the motives of a human actor. Here, we assume that tourists are mainly interested in attractions. They want to know, among others, which kinds of places and attractions there are, how to reach them, where to have lunch and accommodation. Trip planning should also be fun, not stressful as it is usually. In addition to searching information related to geographical objects through common web service functionalities, tourists want to make their personalized maps and/or geotags. Because travelers plan less and less ahead of a trip and engage in more on-route and in-destination planning, there is a need to support “ad-hoc decisions” on restaurants or attractions. Tourists want also to be active members of social communities. Therefore, they should be facilitated to search for other travelers with similar profiles, interests and travel experiences, and their personalized maps (social bookmarking) [27].

During the trip, a tourist needs many kinds of guidance, not only that provided by GPS navigators. To offer a tourist richer experiences from places and attractions, the product should provide virtual information, attached with objects seen in

the real world. This way, they can "see", for instance, how the building that is now in ruins looked like in the past. Tourists also want alternative viewpoints from which to look at objects around them. For example, it should be possible to select "eyeglasses" through which (s)he is provided with virtual information related to architecture, history, sport, or culinary art in the certain place. Tourists want also to include location related items (hotels, attractions, monuments, restaurants) on their personal maps and enrich them with feedback and experience of the places.

To refresh memories and share experiences with people, the product should allow to create new networks based on geographical routes and location-items (map networking [27]), and to use them for communication on interesting topics.

Business context analysis. The product connects a wide range of stakeholders, including tourists and their social networks, tourist bureaus, restaurants, pizzerias, hotels, museums, art galleries, etc. In this multi-actor network, economic value is created, distributed and consumed through the software product [8]. There is a large variety of ways of how tourism companies can exploit a product like ours in their business [27]: localized exploitation, internal integration, business process redesign, business network redesign, and business scope redefinition. Companies can generate greater business benefits when they increase their level of exploitation. The product-to-be should provide a large range of options for exploitation. Next, we only give some examples of them.

Map networking transforms a trip planning process to a more collaborative and social decision making process where social networks with other travelers are incorporated into value chains and become co-creators and co-producers of travel services [27]. A hotel's website does not only allow customers to search for, contribute and read user-generated content, but the hotel can also use this content for developing its new services [27]. Virtual information attached to places and attractions in web maps enables a tourism business update their information even on an hourly basis and provide, for example, a special deal for the day if the restaurant is short of customers or a hotel is having a low occupancy rate [24].

To recognize the involved stakeholders and to examine their complex value-added relationships, we should build an e^3 model [8]. The model shows, among others, key tourism business actors, value activities and value objects. In addition, to elaborate goals, beliefs, abilities and commitments of the business actors and strategic dependencies between them, we may find the strategic dependency (SD) model and the strategic rational (SR) model [32] useful.

Concluding from business context analysis, we can state that the product-to-be should provide tourist companies with new opportunities to redesign their operations, internally and/or externally, and to develop new collaborative business models by involving new partners and/or users-customers into their value chains and systems.

4 Related work

There are a large number of studies on innovation and creativity in requirements engineering (RE). Nguen and Shanks [23] present a theoretical framework for understanding creativity in RE. Kauppinen et al. [12] identify three main opportunities for innovations: discovering hidden user and customer needs, inventing new product features, and supporting feature development. Maiden et al. [19] present a scenario-driven RE process, called RESCUE, that integrates human activity modeling, system goal modeling, and creativity techniques. Maiden et al. [18] apply theories from cognitive science to build creative models and working methods in air traffic management domain. Grube et al. [9] propose a framework to select creativity techniques for requirements elicitation. Gordijn et al. [8] consider RE from business perspective and distinguish three stakeholder-type related viewpoints: value , business process and information system viewpoints.

There is also a wide range of studies on goal-oriented approach to RE. Chung et al. [4] present a goal-based framework for clarifying and prioritizing non-functional requirements. The KAOS methodology [6] contains a rich set of formal analysis techniques and three types of models: goal model, object model, and operation model. i* [31, 32] is an agent-oriented modeling framework that supports the modeling activities before the system requirements are formulated. Shibaoka et al. [26] proposes a method called GOORE which deploys a domain ontology to support goal decomposition. There are also some goal-oriented requirements engineering methods, such as AWARE, AGORA, and Tropos.

We have strongly exploited earlier research on innovation to make creativity an all-bracing property of the framework. Our approach borrows ideas from goal-oriented approaches but goes further by emphasizing the importance of the human actors' intentions as the starting point for requirements engineering. Business context analysis has been built on [8] and [31, 32]. The RE research has also yielded multiple generic conceptual and functional frameworks for requirements engineering, such as those by IEEE, ISO and [13]. These are, however, mainly lifecycle-based, whereas our framework is focus-based. It shows which you should particularly focus on in requirements engineering.

In summary, our framework integrates creativity and the derivation of requirements from the intentions of human actors (cf. social context) and the goals of business actors (cf. business context).

5 Summary and Conclusions

We are experiencing challenging times in today's software product design. Real business potential is only gained from radically novel products, not from making improvements in existing products. A growing portion of products is directed to so-called consumer markets (cf. social media software, game industry), for which

it is typical that nobody knows how a new product should be like. In this situation, it is not enough to ask what is needed but why it is needed. This can only be done by deriving requirements from the intentions of human and business actors.

We have suggested a new intention-driven framework which combines the technological, social and business viewpoints for requirements engineering of innovative software products. It is composed of five activities: envisioning, user profiling, social context analysis, business context analysis, and goal setting. The framework can be used to analyze and compare existing RE methods in terms of how they address and integrate creativeness, user-centredness, business view, and goal-orientness. It also provides a basis for considerations of how to enhance existing RE methods, in order to make them better meet today's challenges. The framework equally applies to software product design for consumer markets as well as for company use. In the former, social context analysis is emphasized whereas in the latter business context and social context (within a company) are evenly important.

Our next step is to elaborate the framework to address, in more detail, interaction requirements engineering, especially regarding user experience, which is important to social media and other novel application domains. It is also important to pay attention to the so-called micro-innovation processes, i.e., thought processes, concepts and design thinking paradigms, which actually create new ideas of the products, and develop innovation techniques based on them. Thirdly, future research is needed to tailor the activities of the framework to be part of agile methods whose popularity is growing fast in practice.

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