Creativity and Conceptual Modeling for Requirements Engineering

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Abstract. Creativity techniques have been applied to Requirements Engineering (RE) in order to find novel requirements, facilitating system and business innovation. Creativity has typically been applied to RE as part of an intensive, often multi-day workshop. Ideas are generated and recorded in a free-form, manual fashion, with much guidance from experienced human facilitators. Although this format has been successful, economic, time, and geographical pressures make this intensive process less feasible. The free-form representation of creative output (text and informal diagrams) provides flexibility in order to support creative thought, but the output of this form is not able to take advantage of much of the (semi-) automated analysis developed for RE, including trade-off analysis. In this work we address two major challenges 1) the limitations of existing creativity RE workshops, particularly their costliness and need for expert guidance, and 2) capturing creative output in a structured form, better amenable to (semi-) automated analysis and downstream development. We address these as part of a 2-3 year project focusing on integrating RE creativity techniques with conceptual modeling techniques such as goal modeling, with a focus on developing online, distributed creative support tools for RE.

1 Introduction

Recent work has made the link between creativity techniques and RE (e.g., [1–6]), arguing that existing approaches treat the RE process as essentially a problem of scoping and understanding activity, while effective requirement elicitation and analysis should focus instead on problem discovery and problem solving. Finding the "right" requirements is not about capturing stakeholder requirements, but is instead about helping stakeholders to discover requirements they were not aware of, solving problems they did not know they had. RE techniques should facilitate the creative processes needed to develop innovative products - a key factor in keeping competitive.

Although creativity techniques are key to generating ideas which evolve into novel requirements and innovative systems, they rely heavily on expert facilitation and manual effort. Methods which produce creative ideas are typically not tool-supported. Creativity technique outputs are typically captured using text, storyboards, use case descriptions, or other lightly-structured formats. As such, it is difficult to apply systematic RE analysis methods which help to select amongst alternative requirements, designs, or ideas. It is also challenging to translate creativity outputs into more structure specification formats, necessary for downstream development.

In this paper we outline ideas, initial progress, and plans for a recently-funded multi-year research project. The project was initially aimed at exploiting the synergies between creativity techniques and goal-oriented modeling for RE, but our focus has broadened to generally making better use of conceptual models in creative RE activities as part of online tool support. In this way, we aim to reduce reliance on creativity experts and expensive workshops, capturing creative ideas in a more structured form, taking better advantage of existing RE analysis techniques. Furthermore, the structure of conceptual models capturing creative ideas can be used to support a more systematic generation of creative ideas. For example, existing goal model analysis techniques (e.g., [7]) can be applied to support creative analysis (transformational, exploratory, combinatorial) by exploring the removal of captured assumptions, automatically suggesting new model connections, and evaluating the effectiveness of elicited ideas in terms of system and user goals.

Our aim is, in part, to understand the synergies between conceptual models used for RE and creativity techniques. We begin to explore this area by conducting and describing results of an exploratory experiment evaluating the combination of goal models and creativity triggers.

The overarching challenge of this work is to complement “irrational”, free-form creativity with “logical”, decomposition-based models, without over compromising the advantages provided by each technique. The overall objective is to improve RE practice, ensuring system innovation while meeting user needs.

In the rest of this paper, Sec. 2 provides background on creativity in RE, identifies challenges, and describes an example RE model analysis technique. Sec. 3 gives an overview of our proposed approach, including a high-level description of the intended tool support, examples of how conceptual models can feed into creativity techniques, and a brief description of our exploratory experiment and results. Sec. 4 concludes the paper and discusses future plans.

2 Background

In this section we provide background on creativity in RE and give an example of the type of model analysis which can be used as part of creative RE elicitation.

2.1 Creativity in RE

In [1], Maiden et al. adopt existing definitions of creativity to define creative requirements as those that are both novel and appropriate (useful). Creativity can be transformational, changing boundary rules to consider transformative ideas, possibly in another paradigm [8], exploratory, exploring a space of possibilities, or combinatorial, combining together creative output.

Several papers provide further classifications and guidance for creativity in RE. Nguyen et al. consider how five established elements of creativity (product, process, people, domain, and context) affect the application of creativity to RE [2]. Mahaux et al. examine the changing meaning of creativity in different contexts in order to guide selection of creativity techniques for a given RE project [3]. Further work emphasizes the role of collaboration in RE creativity, proposing a list of factors influencing collaborative creativity, e.g., values, and subject matter expertise [4]. Although guidance provided by these papers is useful, the output of our proposal aims to be more concrete – an integrated, tool supported framework for goal-oriented creativity.

Several papers have reported experience applying creativity techniques in an RE workshop setting as part of the RESCUE process (e.g., [5]). This approach has been applied in settings such as Air Traffic Control, work-integrated learning (APOSDLE), and food traceability. Workshops typically involve several stages, each of which can be mapped to a particular type of creativity: Round Robin (exploratory), Scoping (transformational), Creativity Triggers (exploratory), Constraints (transformational), Ideas from presented design features (exploratory), and Storyboarding (combinatorial). Inputs to workshops included use cases, context, and rich picture models. Workshop outputs included collages using pictures, storyboards, idea cards placed on pin boards, and mock-ups. Outputs were converted, primarily by analysts, into lists of ideas, requirements, and/or use cases.

The multi-day, in-person workshops, although effective, are costly, both in money and time. Workshop facilitation requires specific soft skills, difficult to capture and transfer. It is critical to develop effective tools which provide semi-automated support for creative tasks. Limited tool support is available, typically focusing on supporting a particular creative activity, e.g., mind maps, composition of document pieces (see [1] for a summary). Tools to guide participants in an overall creative process – candidates to replace the workshop structure – are lacking.

2.2 RE Conceptual Model Analysis

Once requirements knowledge is captured in a structured format, this knowledge can be analyzed (reasoned over, evaluated) in order to support improved RE understanding and decision making. We turn to qualitative, interactive goal model analysis as a concrete example, particularly applicable to creativity activities due to its high level of abstraction and deliberate incorporation of user input.

Goal models (e.g., *i** [9]) capture stakeholder goals, refining goals into more detailed goals, or into operational tasks or requirements. The *i** framework, for example, allows for a high-level representation using goals, softgoals (without clear-cut criteria), tasks, resources, and actors (system agents and stakeholders), along with task decomposition, means-ends alternatives, social dependencies, and softgoal contributions. Qualitative evaluation over *i** models allows users to explore the level of goal achievement, asking “what if?” and “is this possible?” questions [7]. Semi-automated procedures use the underlying formal semantics of the model to propagate qualitative labels representing goal (task, resource) satisfaction (and conversely, denial) throughout the model. For example, in Fig. 1 (purple and green text can be ignored for now), we show a small *i** model capturing the APOSDLE work-integrated learning case. Here we ask “what if we have commission funding, but the user does not learn quickly?”. We see that the primary softgoals of the system are only partially achieved (more details in [7]). In the next section we outline how this type of model analysis can be used to support creativity in RE.

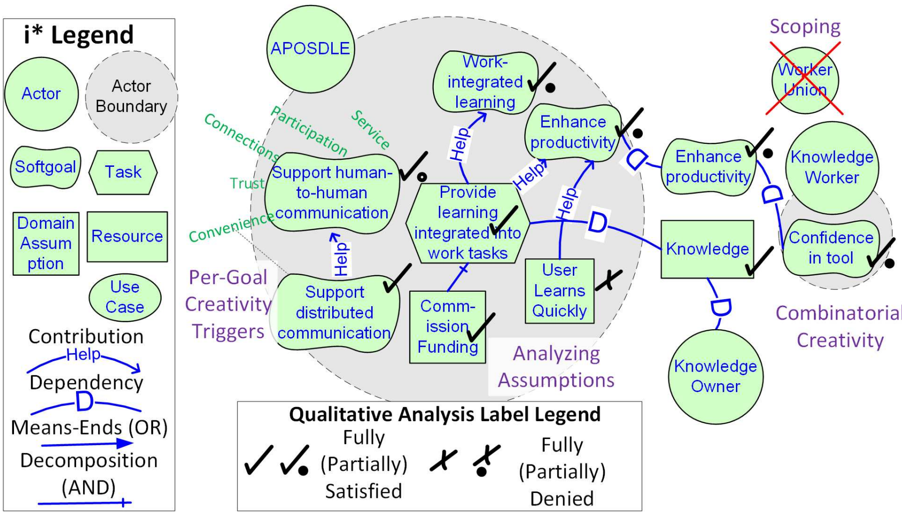

Fig. 1. Example Goal Model (i*) from the APOSDLE Work-Integrated Learning Case showing Example Qualitative Analysis Results

3 Proposed Approach: Creativity and Conceptual Modeling

In this section we give an overview of our planned approach, including tool support and process, an example of how existing model analysis can be used to support creativity, and details about an exploratory study examining the combination of goal modeling and creativity.

3.1 Tooling and Process Overview

We envision a tooling platform, ideally usable in an online, distributed manner, providing methodological guidance through various creativity techniques, connecting to a series of interconnected and continuously evolving conceptual models. We provide a high-level conceptualization of our tooling vision in Fig. 2. On the left hand side we provide a rough mock-up of the creativity activity view. Here, icons are used to represent various creativity activities, such as analogies and role play. These activities are organized roughly following the creativity conceptualization used by the in-person workshops, following a process of divergence and convergence through activities aimed for preparation, transformation, exploration, combination, and evaluation. Users will be guided through the suggested activities, with a few next possible activities, determined using the preceding activities and the amount of progress made in generating ideas. As-yet-unavailable activities are greyed out. Activities will link to either guided instructions, or to external or integrated creativity tools such as BrightSparks (http://brightsparks.city.ac.uk/) or implementations of specific RE-focused activity methods such as in [6]. Consideration must be made as to which activities can be performed individually, or which must be performed in a group setting, and whether these activities can be performed asynchronously.

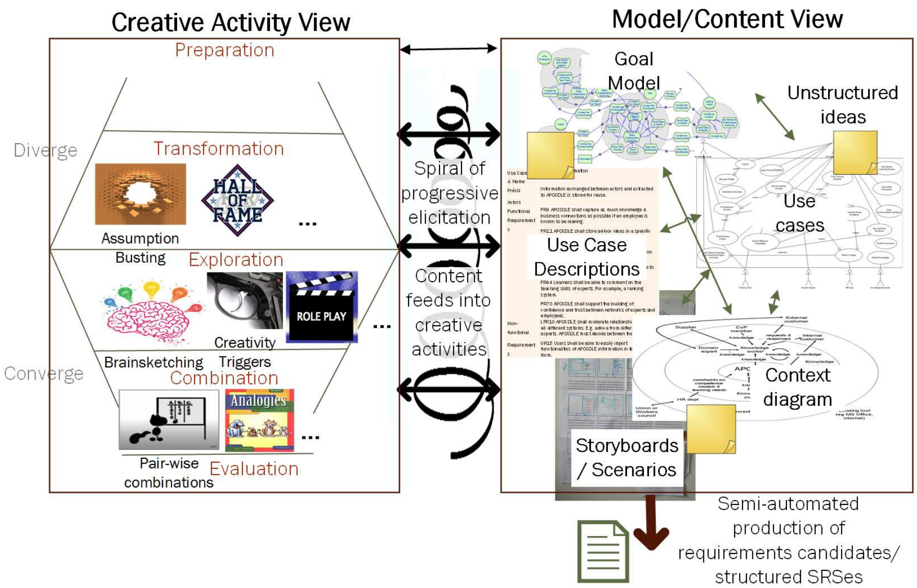

Fig. 2. Conceptual Summary of Distributed, Online, Model-Based, Creative Requirements Elicitation Tool Support

On the right, we see the model/content view. Users can switch between the selection of activities and views of several, interconnected models and other representations. At this point, we include the models/representations used as part of the physical workshops as well as goal modeling. Additional/alternative representations could be used. Following conventions in the physical workshops, creative process may start with an input of pre-existing seed models. Model content is added and changed as a result of the creativity activities. For example, a free writing exercise may elicit an interesting new scenario, captured as a new use case, with a corresponding textual description, bringing to light new goals and goal connections for addition to the goal model, and may be later selected for exploration in a visual storyboard. Although users are encouraged to capture their ideas using model constructs, they can be allowed to quickly capture ideas using digital post-it notes added to the models, with encouragement to incorporate these ideas into the model proper when possible.

After an iterative process of creative activities and modeling, resulting model content can be processed automatically to form candidate textual requirements or structured Software Requirement Specifications (SRS), feeding into downstream development.

3.2 Creativity and Model Analysis

As an example of a back-edge (right to left) in Fig. 2, we illustrate how the structured knowledge captured in goal models can facilitate further creativity. On the left of Fig. 1, we see an example of applying creativity triggers (in green) to a particular softgoal.

In this case, considering the convenience trigger in regards to “Support-human-to-human communication” provokes a new idea which results in a new softgoal, “Support distributed communication”. Constraint analysis can be captured via the addition and removal of domain assumptions (rectangles). Scoping activities can be explored by including or excluding certain actors or responsibilities (tasks). Combinatorial creativity can be facilitated by suggesting new combinations between actors or elements, for example, what if the APSODLE actor depended on the Knowledge Owner instead of the Knowledge Worker? Finally, analysis as described in Sec. 2.2 can be applied to evaluate creative ideas as captured in the model (a bottom-left activity of Fig. 2). Future work will explore more possibilities, including effective tool support.

3.3 Exploratory Study: Creativity and Goal Modeling

We have performed an initial, exploratory study in order to understand potential synergies between creativity techniques and conceptual modelling for RE. As experience has been recorded with models such as use cases and context diagrams, we focused this study on the use of goal models – new to creativity. Although our study was exploratory in nature, we were guided by several questions, including: a) Should goal modeling be performed before or after creativity techniques? b) Can goal models effectively capture creative ideas? c) Does the structure of the models impede creative thought?

In order to begin exploring the space, we have performed nine one-hour sessions with small groups of 1-4 students, primarily graduate students, all of whom have some coursework experience with goal (i*) models. Sessions involved a total of 23 participants, studying a range of Information System-related topics, including Business Analysis and Design, Software Engineering, Information and Technology, Business Systems, and Business Computing.

In the sessions, student were given a toy scenario, then were asked to sketch a goal model and come up with creative ideas guided by selected creativity triggers. Five groups performed goal modeling then creative thinking, while the other four groups did the reverse. Participants reflected on the process via a short survey, including the ordering of activities and potential synergies between modeling and creative thought.

Results indicate that goal modeling was generally better received before creative thinking – performing a creative activity straight off, without the shared domain exploration provided by modeling, was often difficult. However, results for this question were strongly influenced by the ordering of the activities in the study. Almost all participants indicated that if they had to do the activity again, they would perform both creativity and goal modeling; there was a general agreement that these activities work well together. Participants were often able to express their creative ideas in terms of the model, e.g., adding new actors or softgoals. However, due to the limited time allotted for the experiment, most groups did not have time to actually make these changes. Goal modeling did not appear to over-constrain creative thought, but gave group members a common understand by which to ground their ideas.

These results lead us to believe that these activities should be intertwined, as is shown to some degree by the left-right arrows in Fig. 2, perhaps starting with some modeling to support shared understanding, then moving into rounds of creativity techniques, with outputs incorporated back into the model(s). We will use the insights gained as part of this study to help shape our tooling.

4 Conclusions and Future Work

We have provided an overview of a project aiming to enhance creativity techniques as applied to RE using tooling with a conceptual modeling foundation. Developed tools should be, as much as possible, online and distributed, helping to avoid costly, in-person workshops. We aim to make creative RE elicitation more accessible while taking advantage of existing work facilitating RE analysis. Obviously, plans are in an early stage and much conceptual and implementation work must be done. Future plans include application of the resulting ideas and toolset to industrial examples.

Acknowledgments

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