Using i^* for Transformational Creativity in Requirements Engineering*

Sushma Rayasam and Nan Niu

Department of EECS, University of Cincinnati
Cincinnati, OH, USA 45221
rayasasa@mail.uc.edu, nan.niu@uc.edu

Abstract. Requirements engineering (RE) techniques that promote creativity can lead to product innovation and business competitiveness. To investigate the role of i^* in creative RE, we report a study involving nine analysts who generate creative requirements for the meeting scheduler in a transformational way. Our results reveal the interdependency of exploratory creativity and transformational creativity, and uncover tasks as starting points for creative goal modeling. Our work also offers process insights which can guide the development of automated support for transformational creativity in RE.

1 Introduction

In today's tech-savvy world, it is crucial for companies to leverage innovation and creativity to come up with products which will sustain the test of time. The importance of creativity in requirements engineering (RE) is recognized and specially emphasized for developing software-intensive systems which address critical business challenges and which are in highly competitive contexts [6].

Creativity, in general, is the ability of an individual or a group to think of new and useful ideas; however, because creativity plays a role in many fields (e.g., business, arts, etc.), defining creativity can be context-dependent. Creativity in RE, according to Maiden *et al.* [7], is the capture of requirements that are both novel and appropriate. Maiden *et al.* [7] also distinguish between creativity and innovation by relating innovation to downstream software development, that is, implementation of creative requirements leads to system innovation.

Current creativity techniques tend to rely heavily on expert facilitation and manual effort. An example is the creativity workshop where stakeholders are asked to perform brainstorming and creative thinking during requirements elicitation [6]. Manual work often results in undocumented rationales behind the produced requirements, making the creativity process less systematic.

Goal models, such as i^* [12], offer structure which can provoke systematic creative exploration and enable a wide variety of analyses (e.g., [4]). As will be surveyed in Section 2, researchers have developed creativity methods to support

RE. Most contemporary support is of *exploratory* nature aiming to traverse a space of possibilities. Support for *combinational* creativity in RE also emerges recently, attempting to make unfamiliar connections between familiar possibilities. Less supported is *transformational* creativity which challenges the constraints on the search space and seeks new ideas in different domains or paradigms.

In this paper, we report a preliminary study on how human analysts perform transformational creativity using i^* models. Specifically, we recruited 9 upper-division computer science students and asked them to individually generate creative requirements of the meeting scheduler i^* models in a transformative way. Our research goal is to uncover the patterns used and the challenges faced by the analysts. Our observations and lessons learned can contribute to a more systematic process, along with the identification of potential automated support, of transformational creativity in RE. In what follows, we review related work in Section 2. Section 3 presents our study design, Section 4 analyzes the results, and finally, Section 5 concludes the paper.

2 Background and Related Work

RE, framed as a creative problem solving process, plays a key role in product innovation and system sustainability [7]. Being novel and being appropriate are intrinsic to creativity [3]. Creativity in RE can be categorized into three groups on the basis of the techniques and heuristics employed [3]. The first is *exploratory creativity* obtained by traversing a search space of partial and complete possibilities. Techniques, such as brainstorming, snowballing, and serial association, can be used. Operating on the KAOS goal models, Lutz *et al.* [5] perform analysis to explore requirements in a space defined by obstacles for a safety-critical, autonomous system.

The second is *combinational creativity* that is performed by making unfamiliar connections between objects in the same search space. Random and fixed stimuli are two techniques through which combinational creativity can be achieved [3]. Bhowmik *et al.* [1, 2] leverage topic modeling to identify concepts familiar to stakeholder groups and exploit part-of-speech tagging to automatically generate unfamiliar combinations.

The third, and the highest form of creativity according to Boden [3], is *transformational creativity* which can be achieved by changing the rules that govern and structure the conceptual space. Compared to exploratory creativity and combinational creativity, less (automated) support for transformational creativity exists. An exception is the semantic service search & composition (S^3C) tool developed by Zachos and Maiden [13] that retrieves Web services in domains analogical to a current requirements problem. Even the S^3C tool does not fully take advantage of the structural information embedded in goal models. We argue that more structure (e.g., overview of the current problem domain, dependencies within the domain, etc.) is needed to facilitate transformational creativity in RE. Next we describe the research design to investigate the use of i^* for transformational creativity.

Table 1. Excerpt of existing modeling constructs (see [11] for the complete version)

Actor	Goal	Softgoal	Task	Resource
Mtg. Initiator (7)	Mtg. Be Scheduled (14)	Low Effort (10)	Attend Mtg. (4)	Details (3)
Mtg. Scheduler (5)	Agreeable Mtg. Date (4)	Quick (4)	Organize Mtg. (3)	Proposed Date (2)
Mtg. Participant (5)	Solicit Response (4)	Accuracy of Constraints (4)	Determine Mtg. Date (3)	Agreement (2)
Important Participant (5)	Collect Timetables (4)	Collection Effort (3)	Participate in Mtg. (3)	Facilities Confirmed Room (1)
...	...	...	...	...

3 Study Design

Our main research objective is to examine how human analysts use i^* to perform transformative creativity, paying special attention to the structural elements of i^* in creative RE. We set out to uncover the commonly used strategies and to identify areas where additional support can be provided to facilitate creative goal modeling. To accomplish the objective, we chose participant observation as our research method. To recruit participants, we sent e-mail invitations to the upper-division students (juniors, seniors, Master's, and Ph.D.s) in our department who have already learned or practiced goal modeling (i^*, KAOS, or other forms deemed as appropriate by the respondents). We regarded having industrial experiences as desired but not as mandatory. Nine participants (3 females and 6 males; 4 seniors and 5 graduates) were recruited to voluntarily take part in our study, all of whom knew goal modeling from their educational backgrounds. Five participants reported 1 to 4 years of software development experience in industry, though none had used goal modeling in their industrial projects.

We selected the meeting scheduler i^* models for the participants to perform transformational creativity. Our rationale is three-fold. First, meeting scheduler is a common problem scenario, allowing the participants to readily gain familiarity and practice creativity. Second, meeting scheduler serves as a canonical example in goal modeling, making it relatively easy for us to depict the current domain by consulting to the relevant literature. Third, meeting scheduler is framed in the early-RE phase [12] in which business goals and alternatives are still explored. We therefore consider the early-RE phase is where the requirements tend to be most creative.

We prepared 3 types of materials to help participants begin the transformational creativity task: (1) thirteen references from the literature containing meeting scheduler in i^* notations; (2) three representative graphical models; and (3) existing modeling constructs sorted by their frequencies of occurrence. All the materials are available in [11]. The 13 references range from a conference presentation to a dozen peer-reviewed papers. We identified them by manually searching the proceedings of the RE conference and i^* workshop series, and by following the references cited in relevant papers.

We then chose 3 graphical models — 1 strategic dependency model and 2 strategic rationale models — to illustrate the goal-modeling constructs and their relationships [11]. Finally, we extracted the structural elements from the 13 references, grouped those elements by their types (actor, goal, softball, task, and resource), and ranked the elements by number of appearances. Table 1 shows an excerpt of the extraction results. We expect our prepared materials (references,

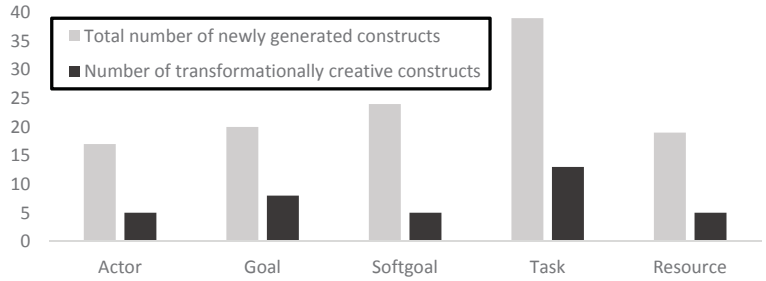


Fig. 1. Modeling constructs grouped by i^* categories.

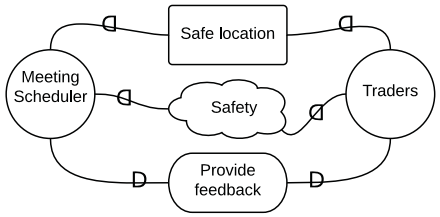
graphical models, and extracted constructs) to act as a depiction of the current i^* meeting scheduler domain — a baseline that the participant-analyst can use to conduct transformational creativity.

4 Results and Analysis

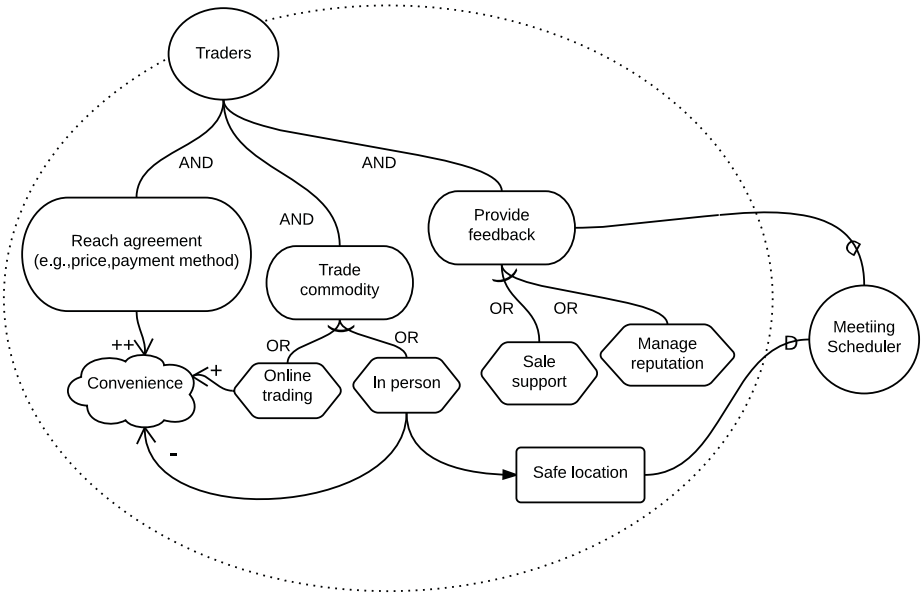
From the i^* models generated, we identified *new* constructs to be those that had not appeared in the literature. This was done via a manual comparison with the complete version of Table 1 [11]. We further judged whether a new construct is transformationally creative. The judgments were drawn based on *how* the constructs were generated; specifically, if a new domain (e.g., catering) was behind a newly generated construct, then the construct was regarded as *transformationally creative*. Figure 1 compares these numbers.

Several observations can be made from Figure 1. First, although a total of 119 new i^* constructs were generated, the transformationally creative ones accounted for a small portion (30.2%). A closer inspection revealed that a majority constructs were of *exploratory* nature, that is, they were identified by surfacing the possible elements within the *same* meeting scheduling domain. Examples resulted from exploratory creativity include the actor "Meeting Secretary" and the softgoal "Quick Supply". This suggests that exploratory creativity is not only easier to conduct, but potentially a precondition for transformational creativity. In another word, the analyst would need to explore the current domain before transforming to a new one. Second, softgoals are less likely to be transformationally creative ($\frac{5}{24} = 20.8\%$) than other i^* modeling types (32.3% on average). We speculate a main reason is that a typical domain has about a dozen softgoals significant to software architecture [10] and these softgoals already appear in existing i^* models. Another reason is due to softgoal's terminological interference [9], e.g., different modelers use the same term to label different softgoals. Third, the participants in our study produced the greatest number of tasks (39), among which 1/3 were creative in a transformational manner. The rich set of tasks not only helps to manage softgoal's terminological interference [8], but also represents a common starting point for transformational creativity.

In addition to the structural analyses, we examined the newly generated i^* constructs based on the semantics. A majority of the constructs could be grouped into 3 semantic clusters: remote participants (e.g., video conferencing, virtual



(a) strategic dependency



(b) strategic rationale

Fig. 2. Sample transformationally creative i^* models.

meeting), services (e.g., technology, food, transportation), and pre/post work (e.g., document sharing and distributing). As mentioned earlier, these modeling elements fall into the meeting scheduler domain and therefore their identification counts more as exploratory creativity than transformational creativity.

One of the most transformationally creative i^* models in our study linked meeting scheduling with online trading. For illustration, Figure 2 shows strategic dependency (SD) and strategic rationale (SR) models. According to the analyst, the key was to identify some *bridging node* to enable domain transformation. In this case, the "safety" (softgoal) "safe location" (resource) concerns helped connect meeting to the trading domain. Further modeling the core constructs in trading (the new domain) not only required temporary ignorance of meeting scheduling (the current domain), but also facilitated discovery of new transformative relationships. For instance, "provide feedback" of Figure 2b could be used by the traders (meeting participants who do transactions instead of just attending) to influence meeting scheduling (e.g., having a new requirement for reputation management). Our work thus indicates a process: identifying bridging node $\rightarrow$ modeling new domain $\rightarrow$ refining transformative relationship, through which automated support can be developed.

5 Summary

Our study is designed to better understand how i^* is used for transformational creativity in RE. The results show that transformational creativity intertwines with (and possibly requires) exploratory creativity, and that tasks (as opposed to softgoals) serve as common starting points for transformational creativity. In addition, some concrete process insights (e.g., connecting new domain via bridging node) are obtained that could direct automated tool development.

Future work can be carried out in several avenues to overcome the limitations of our preliminary study. First, involving more diverse and heterogeneous participants will uncover more patterns used and struggled faced in creative goal modeling. Second, different ways of depicting (visualizing) the current domain can be researched and compared. Finally, measures and metrics could be defined to help guide the (transformationally) creative RE process.

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