A Framework for Iterative, Interactive Analysis of Agent-Goal Models in Early Requirements Engineering

Jennifer Horkoff[1], Eric Yu[2]

[1] Department of Computer Science, [2]Faculty of Information,
University of Toronto, Canada

jenhork@cs.utoronto.ca, yu@ischool.utoronto.ca

Abstract. The early stage of domain analysis in requirements engineering is critical for understanding the stakeholders, their needs, problems, and how views of these problems differ. We advocate methods for early domain exploration which provoke iteration over captured knowledge, prompting analysts and stakeholders to review what is known, helping to guide elicitation, and facilitating early scoping and decision making. Specifically, we provide a framework to support interactive, iterative analysis over goal- and agent-oriented (agent-goal) models. The framework will allow for multiple types of analysis questions, manage alternative evaluations over a model, manage interactive results, capture model assumptions and arguments, and support iteration over all constructs. Initial case study experience shows that interactive evaluation provokes model iteration and domain exploration. Further case studies will be developed to test the benefits of framework expansions.

Keywords: Goal-and Agent-Oriented Models, Early RE, Model Analysis

1 Introduction

Early stages of domain analysis (Early RE), as characterized by Yu in [1], are critical for understanding stakeholders, their needs, inherent domain problems, and how views of these problems differ in the eyes of stakeholders. Early stages of analysis are characterized by incomplete and imprecise information. It is often hard to quantify or formalize critical success criteria such as privacy, security, employee happiness, or customer satisfaction in early stages. Early analysis involves a high-degree of stakeholder participation, not only gathering information from individuals using or affected by the proposed system, but presenting information gathered thus far, allowing validation and improved understanding in an iterative process.

If Early RE information is collected in an ad-hoc way it may be difficult to facilitate communication, convergent understanding, and, more importantly, aid the discovery of missing or misunderstood information. We advocate methods for early domain exploration which provoke iteration over captured knowledge, prompting analysts and stakeholders to review what is known, helping to guide elicitation, and facilitating early scoping and decision making.

Approaches have been introduced in order to facilitate elicitation, understanding,

and analysis when dealing with incomplete or imprecise information. For example, the Soft System Methodology is aimed at dealing with systems where objectives are difficult to clearly define and are often conflicting [2]. This approach uses rich pictures to capture the domain. Although the lack of defined syntax for such models allows for flexibility it discourages tool support, including analysis which makes explicit use of model structure and which may encourage model iteration.

Another popular approach for Early RE analysis is the application of Goal- and Agent-Oriented Models (agent-goal models), advocated in [1], where graphical models are created to represent goals and actors in the domain, including their decomposition, contributions, and side-effects. These approaches are applicable to Early RE analysis as they allow users to model fuzzy concepts (softgoals) and can provide useful views even if the models are not complete. However, domain exploration using agent-goal models often stops after a single round of modeling.

Several analysis procedures have been introduced for agent-goal models, employing methods such as the propagation of satisfaction or metrics over model constructs ([3], [4]). These procedures often require precise or specific domain information such as probabilities, costs, priorities, or quantitative estimates from "experts", difficult to acquire in early analysis stages. These approaches are typically fully-automated, "push-button"-type procedures where input is given, the procedure initiates, and an answer or results are provided. We believe that it is difficult for stakeholders to trust results produced automatically over incomplete and imprecise information, especially if the mechanism for deriving results is opaque or mysterious.

What is needed is a way to capture and analyze domain information in Early RE which specifically prompts iteration over domain knowledge, increasing the likelihood of discovering objectives, problems, and alternative remedies in the domain. We are interested in methods which allow interaction, receiving frequent input from stakeholders, but which can be enhanced by tool support. To this end we create a framework for iterative, interactive analysis of agent-goal models in early requirements engineering. Our aim is to expand the capabilities of agent-goal modeling in the following ways: allowing for multiple types of iterative analysis over models; supporting management of alternative solutions in the model; supporting management of user-entered judgments, assumptions, and rationale; supporting iteration over models and user judgments; and guiding model creation and analysis.

2 Objectives of Research

We aim to support iterative learning and understanding of a domain in the early stages of a requirements analysis project. Previous work has provided evidence that interactive qualitative forward analysis over goal models prompts users to make changes to the model, derive questions concerning the domain, and improve their understanding of the model and its subject matter [5], [6], [7]. We capitalize on these effects by extending this procedure as part of a framework supporting iterative domain exploration. Specifically, we aim to allow for analysis over incomplete and imprecise information, allow for the assessment of stakeholder objectives in light of alternatives, provoke iteration over the model and further elicitation in the domain,

and, overall, increase domain understanding among analysts and stakeholders, helping an organization learn about itself. We claim that accomplishing these objectives will help to ensure captured requirements effectively address problems in the domain, avoiding development of the "wrong" system.

3 Scientific Contributions

We outline components of our interactive framework in the following section. Some components, such as forward evaluation, have been well-described and applied in existing work, while other components are in various stages of development.

Forward Evaluation. An interactive, qualitative forward evaluation for i* models, an expansion of the procedure in [8], has been introduced and is described in [5], [6], and [7]. The procedure starts with an analysis question of the general form "How effective would a proposed solution be in meeting the desired goals?" The analysis makes use of a set of qualitative evaluation labels, assigned to intentions to express their degree of satisfaction or denial. The procedure propagates initial values iteratively from contributing elements to recipient elements through model links using defined rules. The interactive nature of the procedure applies when human judgment, based on domain knowledge, is used to combine multiple conflicting or partial values to determine the satisfaction or denial of a softgoal. An assessment is made as to whether the alternative is satisfactory, stimulating further analysis and potential model refinement. The procedure is currently implemented in the OpenOME tool [9].

Backward Evaluation. In addition to "What-if?" questions, it is useful to support "Is it possible?" questions. For example, "Is is possible for certain element(s) in the model to be satisfied? Answering these questions requires "backward" analysis, where desired values are placed on the model and the procedure works backwards (from recipient elements to contributing elements) to find alternatives in the model which produces these values. Work in [3] has implemented a fully-automated, two-value procedure for non-agent goal models using a SAT solver. We expand on this approach, adapting it to consider agent-oriented concepts, a single evaluation value for each element, and the role of human intervention, producing an iterative, interactive procedure. An initial description of the procedure can be found in [10].

Multiple Evaluations over a Single Model. Experience has indicated that it is useful to store the evaluation results of each alternative, allowing users to flip between views of the alternatives, facilitating a comparison. GRL as implemented in the jUCMNav tool currently allows users to store multiple analysis results; however these results are automatically recalculated when changes are made to the model [11].

Human Judgment Management. It is useful to revisit evaluation judgments for alternatives over a model. Users should be able to see all judgments for a particular element, either specific to an alternative, or across all alternatives.

Assumptions and Argumentation. We would like to capture information, especially domain assumptions and the rationale for evaluation decisions, as part of the modeling process. Modelers should be able to attach assumptions and arguments to parts of the model or to human judgment in evaluation. Work in [12] has used satisfaction arguments to justify the satisfaction of selected i* elements, including

domain assumptions. Our framework will capture arguments and assumptions over more model constructs, incorporating this information into evaluation.

Supporting Model Iteration. Our framework will allow users to make changes to the model, their judgments, and their textual arguments and assumptions. Whenever changes are made, the user will be shown which evaluation results are potentially affected, and will be able to interactively re-evaluate these parts of the model.

Suggested Methodology. We will guide the iterative creation and analysis of Early RE agent-goal models by providing a suggested methodology. An initial version, included in [6], [7], will be expanded to cover all framework components.

The proposed framework will advance beyond current work in several ways:

- Allowing analysis over informal, incomplete, agent-goal models in Early RE without requiring detailed or quantitative information. This goes beyond the algorithm sketch provided by the NFR Framework ([8]) by allowing users more freedom in their judgments and working over agent-oriented syntax.
- Providing interactive forward and backward analysis, letting users make decisions over partial or conflicting evidence. Our previous work in [6] allowed only a single type of analysis and had limited support for iteration.
- Unlike other forward satisfaction algorithms for agent-goal models ([3]), the algorithms are iterative, continually adapting to input provided by users.
- Presenting the partial results of the algorithm to users as they are evaluating a model, helping to promote transparency and buy-in.
- Supporting iteration over the model by showing users what analysis values may be affected by model and judgment changes.
- Providing an incremental algorithm which remembers past states and supports minimum re-evaluation after model or judgment changes.
- Other frameworks have supported management of alternatives [11], storage of assumptions or arguments [12], or supported (automatic) backward evaluation [3], this framework combines these aspects together, allowing complimentary interaction between the features and providing a single implementation.
- Focusing on the iteration and elicitation prompted by analysis through application of case studies.

4 Conclusions, Ongoing and Future Work

The forward procedure component of the framework has already been tested via several case studies, including a demonstration of the differences between proponents and opponents of Trusted Computing Technology [13], and an analysis of an online counseling in a large social service organization, with selected results reported in [14], [15], and [16]. Evaluation over models in both studies demonstrated the ability of the procedure to provoke elicitation and model iteration, as evaluation results sometimes led the modeler to further investigate sources and often to modify the model to more accurately reflect the domain.

Further studies will be performed to test the utility of backward analysis and additional framework components. We plan to use both an action research approach, using the framework to work with an organization and analyze its needs, as well as

individual studies, looking at how users analyze models with and without the framework. Study results should confirm whether the backward procedure also prompts iteration and model improvement.

Future work could investigate extending the framework with varying levels of human interaction, tabular views of model elements, assumptions or justifications, and views which allow comparisons between analysis results over alternatives.

References

1. Yu, E.: Towards Modelling and Reasoning Support for Early-Phase Requirements Engineering. In 3rd IEEE International Symposium on Requirements Engineering (RE'97), pp. 226--235. IEEE Press, New York (1997)
2. Checkland, P.: Soft systems methodology: A Thirty Year Retrospective. Systems Research and Behavioral Science 17, (S1) S11--S58 (2000)
3. Giorgini, P., Mylopoulos, J., Sebastiani, R.: Simple and Minimum-Cost Satisfiability for Goal Models. In: Persson, A., Stirna, J. (eds) CAiSE 2004. LNCS, vol. 3084, pp. 20-3-5. Springer, Heidelberg (2004)
4. Franch, X.: On the Quantitative Analysis of Agent-Oriented Models: In Dubois, E., Pohl, K. (eds) CAiSE'06. LNCS, vol. 4001, pp. 495--509. Springer, Heidelberg (2006)
5. Horkoff, J., Yu E.: A Qualitative, Interactive Evaluation Procedure for Goal- and Agent-Oriented Models. In: CAiSE Forum. CEUR Workshop Proceedings (2009)
6. Horkoff, J., Yu, E.: Evaluating Goal Achievement in Enterprise Modeling – An Interactive Procedure and Experiences. In: A. Persson, J. Stirna (Eds.), 2nd IFIP WG 8.1 Working Conference on The Practice of Enterprise Modeling (PoEM'09). LNBIP, vol. 39, pp. 145-160. Springer, Heidelberg (2009)
7. Horkoff, J., Yu, E.: Interactive Analysis of Agent-Goal Models in Enterprise Modeling. Int. J. Inf. Sys. Modeling and Design. (to appear).
8. Chung, L., Nixon, B.A., Yu, E., Mylopoulos, J.: Non-Functional Requirements in Software Engineering. Kluwer Academic Publishers, Norwell, MA (2000)
9. OpenOME, https://se.cs.toronto.edu/trac/ome/wiki
10. Horkoff, J., Yu, E.: Qualitative, Interactive, Backward Analysis of i* Models. In: 3rd International i* Workshop. pp. 43—46, CEUR-WS.org (2008)
11. Amyot, D., Ghanavati, S., Horkoff, J., Mussbacher, G., Peyton, L., Yu, E.: Evaluating Goal Models within the Goal-oriented Requirement Language. Int. Journal of Intelligent Systems (IJIS). (to appear).
12. Maiden, N.A.M., Lockerbie, J., Randall, D., Jones, S., Bush, D.: Using Satisfaction Arguments to Enhance i* Modelling of an Air Traffic Management System. In: 15th IEEE Int. Con. on Requirements Engineering (RE'07). pp.49--52. IEEE Press, New York (2007)
13. Horkoff, J., Yu, E., Liu, L.: Analyzing Trust in Technology Strategies. In: International Conference on Privacy, Security and Trust (PST 2006). pp. 21--32. (2006)
14. Easterbrook, S. M., Yu, E., Aranda, J., Fan, Y., Horkoff, J., Leica, M., Qadir, R. A.: Do Viewpoints Lead to Better Conceptual Models? An Exploratory Case Study. In: 13th IEEE International Requirements Engineering Conference (RE'05). pp. 199--208. IEEE Press, New York (2005)
15. Strohmaier, M., Yu, E., Horkoff, J., Aranda, J., Easterbrook, S.: Analyzing Knowledge Transfer Effectiveness - An Agent-Oriented Approach. In: 40th Hawaii International Conference on Systems Science (HICSS-40). pp 188b, IEEE Press, New York (2007)
16. Strohmaier, M., Horkoff, J., Yu, E., Aranda, J., Easterbrook, S.: Can Patterns improve i* Modeling? Two Exploratory Studies. In: Paech, B., Rolland, C. (eds) REFSQ'08. LNCS, vol. 5025, pp. 153--167. Springer, Heidelberg (2008)