Acquiring Software Requirements As Conceptual Graphs

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1. Introduction

Eliciting and acquiring requirements is a key aspect in developing effective requirements for software systems. It is essential not only to get the right requirements, but to get them in a form that is usable throughout the software development process. This poster presentation describes a knowledge-based approach to requirements elicitation and acquisition, whereby "requirements patterns" are used to guide the process. The result of the acquisition process is a set of conceptual graphs [1], a knowledge formalism that will be used for specification, analysis and documentation of software systems.

There is a substantial "learning curve" associated with participating in a requirements elicitation process. It is becoming increasingly apparent that the requirements engineer plays the role of a knowledge engineer (KE) in establishing requirements for a software system (or indeed, any system). We therefore consider knowledge acquisition (KA) in general (as treated in the AI community) to be a crucial supporting technology for software requirements. This poster presentation will describe a general KA technique that employs direct interaction with a stakeholder. The result of the interaction is a set of conceptual graphs, suitable for integration and analysis by a variety of existing methods, among which is formal concept analysis.

The Troika process exploits the advantages of three key technologies in acquiring requirements knowledge. We have named the approach after a three-horse sled because these three technologies provide the driving force behind the approach. The three technologies are

- Conceptual graphs (CGs) for requirements knowledge representation
- Repertory grids for requirements knowledge acquisition
- Formal concept analysis (FCA) for requirements concept formation.

Conceptual graphs provide a general knowledge representation that can support requirements sharing and re-use. Repertory grids provide a psychologically-based, content-driven acquisition technique that is usable by practitioners with minimal acquisition experience. Formal concept analysis provides a relatively unbiased technique for identifying concepts.

2. Troika Approach

The Troika approach consists of a series of steps, supported by algorithms (not shown here, see [2] for details) which guide a human participant in identifying concepts and relations among those concepts. Figure 1 shows the basic steps.

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Characterize the requirement pattern type (e.g., resource-allocation, planning, etc.)
Develop initial conceptual graphs of problem structure
Repeat
    Acquire a concept for the knowledge base
    Acquire instances of that concept
    Acquire a second concept for the knowledge base
    Acquire instances of the second concept
    Acquire label for relation between the two concepts
    Acquire knowledge for relation using a repertory grid
    Build a concept lattice from the repertory grid
    Acquire any new concepts derived from the lattice
Until no new concepts are acquired.
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Figure 1. Steps of Troika acquisition.

In brief, the process consists of acquiring two concepts with instances, then acquiring relationships between the two, followed by refinement of the concepts using FCA to establish new intermediate concepts in a hierarchy. The advantage of the approach is that it does not impose any particular modeling paradigm on the acquisition process. Of course, the choice to establish concepts and relations is a modeling paradigm in itself, but we claim that it is more general and less restrictive than a conventional requirements paradigm.

The poster presentation will present a sample dialog showing how the Troika approach operates.

3. How Troika works

An important aspect of using Troika is that initial requirements patterns are asserted, in the form of a conceptual graph template. Figure 2 shows a producer/consumer pattern. The graph states: **there is some resource allocated to two consumers, each of whom possesses a constraint which controls an attribute of the other consumer**. Such a requirements pattern is used as the basis for acquisition of requirements: first, to specialize the graph so that a domain's actual consumer types, resource types, attributes and constraints can be

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identified and next to identify instances of these types that can be used for testing, illustration, validation, etc.

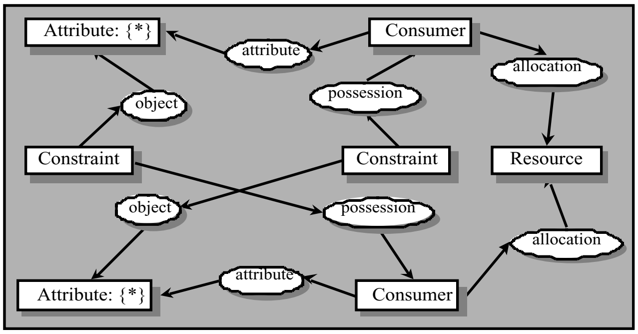

Figure 2. A producer/consumer requirements pattern.

From this initial pattern, a repertory grid can be constructed from the relations in the graph, and then a tool automatically fills in the repertory grid. Questions are posed using the participant's own terminology, which causes specialization of the initial (general) requirements pattern.

During an interactive dialog, the structure of the initial requirements pattern guides the interaction; however, the terms and relationships acquired are determined by the human participant.

After some attributes have been acquired through an iteration of the Troika algorithm, formal concept analysis is applied to determine whether there are any new (possibly unnamed) concepts that the human participant needs to elaborate. The purpose of applying formal concept analysis during the acquisition process is to help the participant establish these classes and categories based on the knowledge already obtained. This determination is made without bias on the part of the tool's design: the instances are grouped and organized entirely according to their attributes.

Based on the results of format concept analysis, new concepts can be identified. To determine their names and possible importance, the human participant must be consulted. As acquisition proceeds, the system keeps an updated copy of its current knowledge in the form of an augmented conceptual graph. Embedded in the current graph is the original requirements pattern graph, after being specialized to capture this domain's types and instances.

The Troika approach provides an automated (i.e., without additional human intervention) assistant to guide a human participant in acquiring concepts and relations within the analysis domain. Requirements patterns provide a conceptual starting point for fleshing out the attributes and details of the specific domain.

4. Current issues

The following issues are subjects of ongoing research in the Troika approach.

4.1 Selecting the right requirements pattern. We have so far identified only a few of these requirements patterns. The human participant must select one of the patterns that is closest to the kind of problem domain (or sub-domain) that he wishes to describe. Guiding the initial choice of a pattern is therefore an important future direction for this work.

4.2 Interoperability. Troika has the potential for integration with other external knowledge bases in CGIF standard form. As more and more knowledge engineers use conceptual graphs for their knowledge bases, the opportunity for re-use of pre-existing knowledge becomes real. Another benefit from using existing knowledge bases is that a wider range of requirements patterns and real-world "common sense" knowledge will be available to the acquisition process. Still another benefit can accrue from the availability of other requirements and knowledge-modeling tools that understand CGIF format.

4.3 Traceability. The Troika process is based on formal steps and produces a well-formed set of graphs with each iteration. Since the dialog and results are all accessible, there is a nice traceability through the process. When conflicts or inconsistencies are detected among the graphs, the source of each component can be identified and the problem can be clearly specified (though not explicitly solved automatically!). This record can be valuable, particularly in the multi-participant efforts which typify modern system development.

4.4 Automatic requirements document generation. We are also exploring the idea of generating a requirements specification from a conceptual graph representation of requirements. This fits in well with conceptual graphs' historical emphasis on natural language systems. This approach also has the potential to automate the tedious process of preparing documents according to various standard requirements outlines.

Bibliography

[1] J. F. Sowa, *Conceptual Structures: Information Processing in Mind and Machine*. Reading, Mass.: Addison-Wesley, 1984.

[2] H. Delugach and B. Lampkin, "Troika: Using Grids, Lattices and Graphs in Knowledge Acquisition," in *Working with Conceptual Structures: Contributions to ICCS 2000*, G. Stumme, Ed. Aachen, Germany: Shaker Verlag, 2000, pp. 201-214.

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