Towards Know-how Mapping Using Goal Modeling

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Abstract. In organizing the knowledge in a field of study, it is common to use classification techniques to organize concepts and approaches along dimensions of interest. In technology domains, an advance often appears in the form of a new way or method for achieving an objective. This paper proposes to use goal modeling to map the means-ends knowledge ("know-how") in a domain. A know-how map highlights the structure of recognized problems and known solutions in the domain, thus facilitating gap identification and prompting new research and innovation. We contrast the proposed goal-oriented approach with a claim-oriented approach, using Web Page Ranking as a sample domain.

Keywords: Knowledge mapping, Knowledge exploration, Goal-oriented

1 Introduction

The term *know-how* is generally used to refer to knowledge about how to accomplish something effectively and efficiently. While it is widely acknowledged that a great deal of know-how is tacit, the body of literature in each technical domain reflects the cumulative store of the articulated know-how for that domain. Mapping out the conceptual structure of a body of know-how facilitates learning about the domain. Practitioners can use a map to seek out solutions to problems, and compare strengths and weaknesses of alternate solutions. Researchers can use a map to uncover gaps and guide research directions.

Our research is motivated by the observation that at the core, know-how involves means-ends relationships. Most existing approaches for mapping knowledge, such as classification [1], citation graphs [1,3], concept maps [5] and claim-oriented argumentation [6, 7] do not give special attention to the means-ends relationship. Since the means-ends relationship is also at the core of goal modeling approaches such as i*, we are interested in exploring a goal-oriented approach to mapping know-how. In our preliminary investigation, we have applied goal-modeling to map know-how from published literature in several domains. In this paper we motivate our research with a brief comparison with ScholOnto, a claim-oriented argumentation framework used to describe and debate scholarly literature [6, 7].

2 Objectives

This research aims to eventually offer a framework that:

- Provides a language to construct a map of the high-level structure of problem-solution relationships in a domain, along with strengths and weaknesses of known solutions, thus facilitating identification of knowledge gaps,
- Requires little or no special training to contribute or dispute know-how, so as to accommodate a wide range of users from novice to expert,
- Supports multiple viewpoints with differing assumptions,
- Provides guidance on possible integration of know-how from diverse sources and viewpoints,
- Supports trust management based on know-how sources and contributors, for example by identifying influential sources,
- Provides tools for knowledge acquisition – for example, semi-automated extraction of means-end structures from knowledge sources (e.g., research papers or technical reports) to be weaved into the know-how maps,
- Supports reconciliation or integration of know-how from different domains, so as to facilitate interdisciplinary understanding and collaboration.

3 Scientific Contribution

To meet the needs of a wide range of users, we face a trade-off between ease of use and expressiveness. Greater language expressiveness contributes to more sophisticated reasoning capabilities, while ease of use is essential for attracting users.

We begin our exploration by adopting a subset of an existing goal-oriented language, i* [8], as a baseline language for mapping know-how. i* goals and softgoals are used to characterize problems in terms of desired domain outcomes and properties. Alternative solution approaches are modeled as i* tasks. Tradeoffs are revealed through contributions to softgoals. Contextual assumptions are modeled as beliefs (not illustrated in this paper).

In this paper we report on one exploration of the trade-off between ease of use and expressiveness, in which we compared a rich ontological argumentation approach, ScholOnto [6, 7] with our light-weight goal-oriented approach. A ScholOnto model consists of concepts and links. A concept could be a verbal description of a problem, data, a methodology, a theory, etc. Concepts connected by links represent claims. Although ScholOnto offers link types called "addresses" and "solves" (under the "Problem-Related" category) among its fairly large number of link types (Figure 1), its focus is on argumentation on claims rather than on the structure of know-how. Figure 2 shows a ScholOnto argumentation model taken from [6, 7]. The model captures some scholarly claims that appear in a paper on Page Ranking algorithms [2].

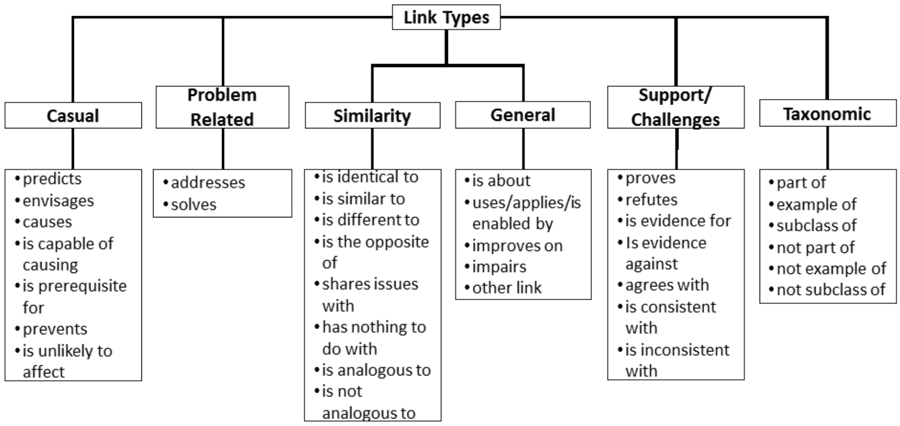

Figure 1: ScholOnto Link type Ontology [7]

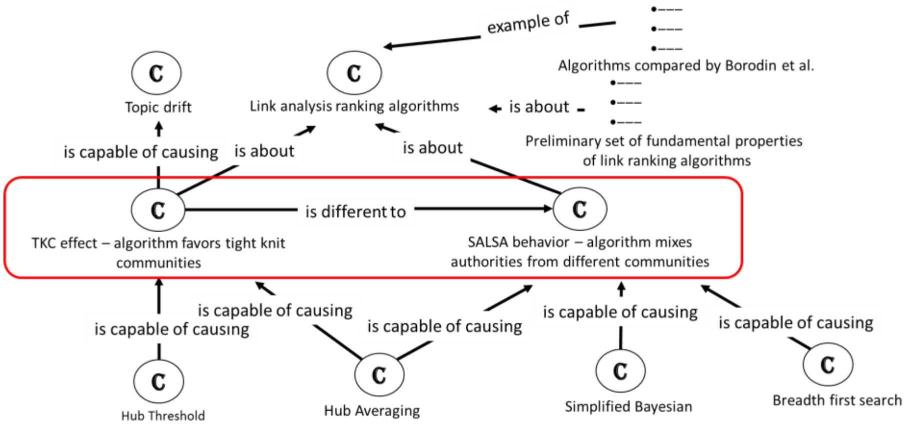

Figure 2: Argumentation Model Fragment using ScholOnto (adapted from [7])

In the study reported in [2], researchers submitted queries to different page ranking algorithms. They observed that pages that are part of tightly linked (page) communities show up higher when searched using some algorithms. They call this the Tight Knit Community (TKC) effect. Another family of algorithms favored pages drawn from different communities. This is referred to as SALSA behavior, as the search randomly goes back and forth between incoming and outgoing links of a selected pool of web pages. Authority is a measure of importance of a web page.

In Figure 2, the claim that there is a difference between these two types of behavior is expressed by the "is different to" link between the concepts "TKC effect – algorithm favors tight knit communities" and "SALSA behavior – algorithm that mixes authorities from different communities". Another claim states that a "Hub threshold" mechanism in a ranking algorithm "is capable of causing" the TKC effect. "Hub threshold" is a technique that discounts "hub" pages if they do not themselves have certain authority ranking. The TKC effect in turn is capable of causing “topic drift”, where a search term leads to unrelated results.

Figure 3: Contrasting page ranking algorithms using goals

Figure 3 shows a goal model representation of the Page Ranking analysis[1]. At the top, the goal graph indicates that the overall task of “Order page results from web query” should be addressed reliably, indicated by the quality goal “Reliable ordering.” One way to achieve this is to “Rank pages according to authority” with the following associated quality goals: reducing “topic drift” (results off the query topic), increase results that are of relevant authority, and stability of results ranking with respect to small changes in the page links. To rank pages according to authority, two families of

[1] The model includes some of the concepts included in Figure 2, as well as a few other concepts drawn directly from [2].

algorithms are identified: Graph theoretic and Bayesian. These, in turn, can be designed to include specific features such as "Page base set", "Hub Threshold" and "Hub Averaging". Each of these alternatives affects some of the higher level design (soft-) goals.

Contrasting the goal model in figure 3 with the argumentation model in figure 2, we observe that argumentation model is primarily concerned with claims and their validity. The goal model, on the other hand, is focused on possible ways or methods for achieving goals, and how alternate methods contribute differently to various quality objectives. While the two models cover roughly the same domain, the know-how goal model is better suited to support design activities, such as seeking solution to problems, comparing alternatives, and making trade-offs.

We note that although the ScholOnto ontology includes "solves" and "addresses" as link types (Figure 1), these are merely used to document such relationships as claims (potentially refutable by another author). They are not meant to support analysis of goal achievement, unlike in goal-oriented modeling frameworks such as i*.

4 Conclusion

Today, there are a number of approaches that can be used to map the knowledge structure of a domain. However, they aim to cover knowledge structures in general with no special support for means-ends relationships or problem-solution reasoning.

Unlike ScholOnto, which offers a large number of link types, we considered a light-weight approach using a small number of concepts focusing on problem-solution structures. We aim to explore to what extent this light-weight approach can already be useful for the specialized purpose of know-how mapping.

This initial investigation suggests that a goal-oriented language, with limited expressiveness focusing on means-ends and problem-solution structures, may suffice for know-how mapping. Its compact representation could contribute to ease of use (to be validated), due to its minimal set of modeling constructs.

To-date we have explored a goal-oriented conceptualization of know-how in several domains and at different levels of abstraction, including Big Data, Goal-Oriented Software Architecting, Web Data Mining, and Agent-Oriented Software Engineering and found that the minimal set of concepts used by the goal-oriented approach allows us to identify problems and their associated qualities, solutions to these problems and their evaluation following the problem qualifier properties, and thus opportunities for innovation.

5 Future Work

We will continue to investigate the appropriateness and adequacy of representing domain know-how in terms of goal model structures. For added expressiveness, we are considering the incremental overlay of conceptual structures such as beliefs, assumptions and preconditions. We will explore modular structuring approaches, such as modules and intentional actor concepts.

We will consider the use of actor boundaries as an abstraction mechanism to delineate knowledge communities (research communities and communities of practice). The aim is to provide a simplified and readily accessible view of the know-how of a domain to non-specialists, recognizing that the full details of in-depth solution considerations are of interest primarily to "insiders" of a specialist community. We are exploring how know-how mapping can help when attempting to bridge neighbouring domains, such as Requirements Engineering and Architectural Design.

We are developing guidelines and methodologies on how to approach the mapping of domains without prior knowledge of goal modeling. We need to address issues of readability and scalability of know-how maps expressed as goal-graphs. We are experimenting with tool support and visualization strategies. We plan to perform empirical studies with users to test the effectiveness of various know-how mapping approaches under different use cases, including getting acquainted with a domain using a know-how map, navigating the structure inside a know-how map, and extracting know-how from knowledge sources to add to an existing know-how map.

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