Ontological Foundations for Agent-Oriented Organizational Modeling

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Abstract. This paper reports on our work on three complementary directions, aimed at developing: (i) a theoretical framework named UFO (Unified Foundational Ontology) for (re) design, evaluation and integration of conceptual modeling grammars and models; (ii) the ARKnowD agent-oriented software engineering methodology to develop knowledge-centered systems and processes; and (iii) methodological contributions to business process modeling and reengineering. The aforementioned theoretical framework is in the basis of our work. Here, we describe our research agenda, along with its main scientific contributions and future directions.

1 Introduction

Using agents as human abstractions is motivated by the fact that, for specific problems, such as software engineering and business process modeling, agents may aid the analyst to abstract away from some of the problems related to human complexity, and focus on the important issues that impact the specific *goals, beliefs* and *tasks* of agents of the domain. This often leads to a clear understanding of the current situation, which is essential for the proposal of an appropriate solution. In the consideration of these cognitive and social concepts lies the strength of Tropos/i*, which comprehend the analysis of agent's motivations, tasks, applied resources, and so on. In the past few years, we have often run into situations in which goal analysis is shown to be relevant in understanding the problem domain. This includes grasping the wants and needs of Knowledge Management users [1] and visualizing business process models in different abstraction levels, allowing the elicitation of different sets of business and system requirements.

Although presenting clear benefits, it is a fact that the adoption of the agent-oriented paradigm remains elusive in software engineering and business process modeling practice. We claim that part of the adoption problem lies with the fact that cognitive and social concepts underlying agents are subjective and complex for the average practitioner. Specifically, although there are many efforts related to the topic in the areas of philosophy, cognitive sciences and computer science, a uniform and well-founded semantic view on these concepts is currently lacking.

Our proposal for such a semantic view lies in a Foundational Ontology named the Unified Foundational Ontology (UFO) [2]. This ontology has been successfully used to evaluate and interoperate two prominent agent-oriented languages, namely, TROPOS and AORML. The combination of these two languages is the core of the ARKnowD methodology [1], specifically targeted at developing Knowledge Management systems. UFO is now being applied to guide the integration of Tropos/i* to organizational modeling languages focused on the process modeling viewpoint (e.g., ARIS-EPC). This integration allows for establishing a principled link between the composition structure of business goals, on one side, and business events and activities, on the other. This integration enables us to address some important issues in business process modeling, such as goal-driven evolution of processes, and reasoning about processes on different levels of granularity.

2   Objectives

Our research agenda can be summarized as follows. Our first objective is to investigate the ontological nature of the social entities underlying the agent-oriented modeling paradigm. By doing this with the help of an interdisciplinary approach, we aim at defining a ***stable and sound formal theory*** which can be used as a foundation for agent concepts. Having this theory at hand, we intend to contribute to uncovering the concepts and viewpoints which are sufficient and necessary for creating ***agent-oriented organizational models*** in specific concern areas. In particular, we are interested in the areas of Knowledge Management and Business Process Modeling. Thus, a second objective of our research is to contribute to the *language and methodology unification efforts* of the agent community. Finally, we intend to apply the languages and methodologies which are the outcome of our evaluation, (re)design and unification processes in ***industrial case studies***. These case studies shall work as testbed and possibly empirical support both for these languages/methodologies as well as for their underlying ontological concepts. In the next section of this paper, we elaborate on these objectives discussing the scientific contributions of our work to the TROPOS/i* community. Our ongoing and future in these three research lines are elaborated in section 4.

3   Scientific Contributions

3.1   Ontological Foundations for Agent-oriented Modeling

In recent years, there has been a growing interest in the application of Foundational Ontologies, i.e., formal ontological theories in the philosophical sense, for providing real-world semantics for conceptual modeling languages, and theoretically sound foundations and methodological guidelines for evaluating and improving the individual models produced using these languages. In a number of

publications (e.g., [2][3][1][4][5]), we developed a Foundational Ontology named the Unified Foundational Ontology (UFO).

In the past years, UFO has been tested as a theoretical framework to evaluate, (re)design and integrate concepts from many different conceptual modeling languages (e.g. UML [2]), reference models (e.g., RM-ODP [6]) and domain ontologies (e.g., the ODE Process Ontology [5]). Particularly in line with this workshop, UFO has been successfully employed to evaluate, propose modifications and provide real-world semantics to TROPOS/i* modeling constructs. Moreover, it has been used to promote the integration of TROPOS/i* with the AORML modeling language [1]. This result is the core of the ARKnowD methodology mentioned in section 3.2 and fits well with the on-going effort of the agent-oriented community towards a unification of existing modeling languages and methodologies. Motivated by our interest in Tropos/i*, our research has recently focused on the concept of goal, aiming at disambiguating its definition, discussing its different manifestations, and clarifying its relation to other important agent-related concepts [4].

3.2   Agent-oriented Knowledge Management

In [1][7][8], we propose the ARKnowD methodology to develop Knowledge Management systems. ARKnowD is an integrated agent-oriented methodology, which represents as agents all humans, organizations and information systems of the domain. This enables the analyst to understand their relations and interactions, guiding him on finding appropriate solutions to target the idiosyncrasies of that particular environment. Note that 'system' is defined as a *general set of interacting entities*, including but not being restricted to that of information system. This opens the possibility to consider several outcomes resulting from the application of our methodology, such as: changing organizational structures, modifying business processes, and adopting technological or non-technological tools.

One of the main principles of ARKnowD is the realization that there is no silver bullet when pursuing an agent-oriented engineering methodology, so the best approach is combining existing work according to the given domain or situation. This allows us to benefit from these works' modeling concepts and viewpoints, besides reusing modeling tools and other related developments. As previously mentioned, ARKnowD results of the integration of two modeling languages which are used in different phases of the agent-oriented development processes, namely, TROPOS/i* (for requirements engineering and architectural design) and AORML (for detailed design). Moreover, ARKnowD applies Constructivist theories as a theoretical background to guide the proposal of Knowledge Management solutions.

3.3   Business Process Modeling and (Re)Design

Business Process Modeling is about the description of sequence of business activities carried out in organizations in order to make them explicit. Hence, these processes can be effectively analyzed, communicated and used as knowledge assets

of documented enterprise practices and activities. Together with modeling, Business Process Engineering also evokes two other areas of concern, namely *process evolution (or reengineering)* and *process abstraction (granularity)*. Reengineering is about the modification of current enterprise processes in order to make their results better fit to organizational strategies and goals. In a different perspective, it is important that the same business process and its composing activities can be seen in different levels of granularity in different phases of the process of analysis and (re)design, or for the sake of carrying out different problem solving tasks. For example, in a situation in which parts of an existing process are unstable, the designer may choose to increase the abstraction level of the existing process model before attempting at producing a redesigned model. The same can be the case for the transition between a conceptual model to an implementation model, i.e., for instance, one may choose to implement as a workflow specification a more abstract version of the initial conceptual model.

In our research program, the establishment of systematic relations between these aforementioned concern areas is made through the use of the UFO framework. In a nutshell, this is accomplished via the formal understanding of the semantic ties between, on one side, a viewpoint focused on the temporal ordering and compositional structure of processes and, on the other side, a viewpoint focused on the compositional structure of goals and the relations between goals and alternative activities that can fulfill those goals.

4   Ongoing and Future Work

In our first line of work, we intend to continue with the development of the ontological theories that constitute UFO. Moreover, as result of these developments, we expect to be able to provide real-world semantics to further agent-oriented and organizational concepts as well as contribute to the principled unification of additional agent-oriented modeling languages.

In our second line of work, currently, our efforts are focused on experimenting with the methodology in the health care domain. This is being pursued in the context of a project entitled Constructivist Knowledge Management in Health Care [9], funded by FAPES (Fundação de Apoio à Ciência e Tecnologia do Espírito Santo). The project proposes the analysis of the public health care sector in the state of Espírito Santo, with the main goal of enhancing the knowledge and information flow within the involved organizations.

Finally, in our third line of research, besides continuing with the analysis and integration of the process evolution (reengineering) and process abstraction (granulariry) concern areas, our current and near future activities in this area can be summarized as follows. Firstly, in the same spirit of section 3.2, we are producing an integrated modeling language that covers the aforementioned viewpoints by integrating TROPOS/i* (goal modeling viewpoint) with ARIS-EPC (temporal ordering viewpoint). Additionally, we are currently applying this integrated modeling language in industrial cases within the Petroleum and Gas industry [10].

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