OperA+: a Model for Context-aware Organizational Interactions in Virtual Organizations

(Extended Abstract)

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1. INTRODUCTION

Virtual organizations are complex, dynamic and unpredictable environments where independent organizations work together for some collective goals. To ensure that the goals are achieved in a predicable way, regulating structures should be represented explicitly and independently from the acting components at different abstraction levels, which on the one hand enables stakeholders with different value orientations to communicate their organizational knowledge and analyze the overall setup, and on the other hand, makes sure that the integrated interaction processes are performed in a secure and smooth way.

Agent-based organizational models provide a good basis for the design and analysis of such regulating structures since organizational interactions in virtual organizations can be well described as agent interactions in regulated multi-agent systems. Instead of starting from scratch, our research is based on an existing agent-based organizational modeling framework OperA [1] and dedicates to modeling organizational interactions in virtual organizations.

The new framework is named OperA+ and improves organizational modeling from two perspectives. On the one hand, the conformity requested by solution designers is ensured by adopting the idea of compositionality and contextualization in the organizational design of agent societies including social structure, normative structure and interaction structure. On the other hand, the autonomy desired by actors/agents can be guaranteed by the multi-level organizational design and evaluations from the perspective of agent operations. Finally, a balance between conformity and autonomy can be achieved in a context-aware organizational model.

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2. RESEARCH OBJECTIVE

The objective of this research is to build an agent-based organization modeling framework with a suite of methods that enables (1) design and analysis of the relations and capabilities of roles in a virtual organization at different abstraction levels in terms of objective decomposition, (2) design and verification of the normative structures in a virtual organization which not only expresses sets of regulations from each organization but also helps to check the consistencies between them, (3) design and simulation of the interaction processes in a virtual organization which provides guidelines to help actors to achieve their collective objectives. Furthermore, we introduce the notion of context in the framework which not only adds modularity and flexibility to organizational models but also provides control mechanisms to switch between different contextual states as a response to external changes. To evaluate our proposal, we have applied the framework to several case studies from the domain of international trade and railway systems [4, 7, 5].

3. OPERA+

Figure 1 shows the architecture of the proposed modeling framework OperA+. It expands the organizational modeling in two directions that enable analysis and decision making in different situations where interactions are performed at multiple levels towards the collective goals. One direction adds details to organizational models from abstract (business values) to concrete (operational details). The other direction identifies the multiple application environments (i.e., contexts) of an organizational model and elaborates these into sets of contextual specifications according to the specific requirements of the refined contexts. The two directions together provide a contextual link between organizational values and implementation details.

At the strategy level, the top-level objective of a system refers to an application domain determined by situational variables which concern but do not restrict to individuality, activity, location, time, and relation [8]. Contexts indicate system responses (states) to various situational conditions by enabling different organizational models, which decompose the top-level objective into a set of sub domains.

For each context, a normative structure [3] is built to specify the (un)desired behavior envisioned by an organization. To verify the normative specification, we also propose computational methods for compliance and consistency checking [4]. Furthermore, in accordance with the normative structure, an interaction structure is presented to give more de-

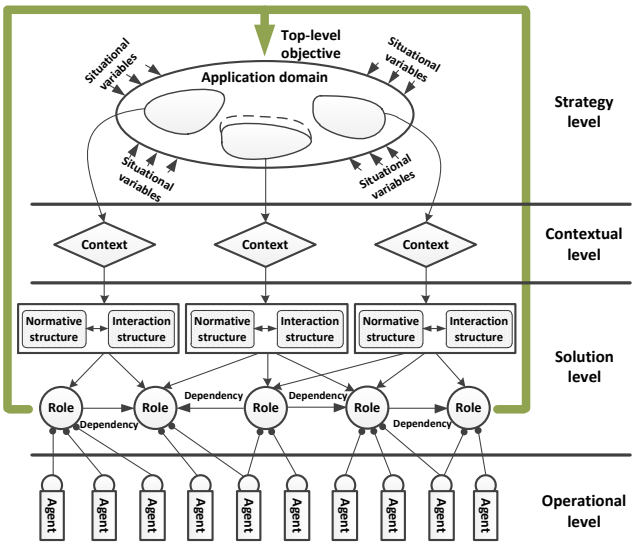

Figure 1: Modeling Framework.

tailed guidelines of interaction processes. Both the normative structure and the interaction structure are imposed on a set of roles. A role identifies the activities and services necessary to achieve society objectives and enables to abstract from the individuals that will eventually perform the role [1]. As a result, a solution to achieve the top-level objectives in a certain context is specified. Moreover, an objective of a role at the solution level can again be decomposed into more specific components, which facilitates a modular way of organization modeling.

The purpose of the organizational design is to specify a mechanism to coordinate the behavior of the operational agents that enables the system to achieve its top-level objective in dynamic settings. Only by an exact match between organizational roles and operational agents, such a system behavior will be realized. Thus, at the operational level, eligible (external) agents will participate in the system and enact the roles that are assigned to them.

4. RESEARCH APPROACH

This research is based on multiplicity principles, which is useful to gain rich insight in complex socio-technical problems. The principles involve using multiple theories as basis for the theoretical framework, collecting data on multiple levels of analysis, using multiple methods, and performing multiple, longitudinal measurements. Following the design science framework proposed in [2], this research consists of three research cycles.

The **relevance cycle** bridges the research with specific application domains that not only provide specific requirements but also criteria for the evaluation of the research results. In this research, the application domains are virtual organizations such as international trade systems and railway systems in which a set of independent organizations are involved, while the criteria are flexibility, robustness and reusability of the organizational design. An important question is, does the designed methodology improve the collaborations between multiple organizations in virtual organizations and how can this improvement be measured?

The **rigor cycle** provides a knowledge base to the research and connects theoretical foundations with the research activities. It is essential to study the state-of-the-art and up-to-date literatures and make sure that the results of the research have scientific contributions. In our research, a main observation is that organizations and their collaborations with each other under sets of regulations can be modeled as a multi-agent system (MAS) where intelligent agents enacting different roles coexist within a set of norms. Therefore, MAS related theories and methodologies provide potential supports for this research such as agent organization models, agent-based simulation, normative multi-agent systems. On the other hand, the specific characteristics of this research requires advanced methodologies such as requirements engineering, context modeling, concurrent system modeling and verification, which in turn will contribute to MAS.

The central **design cycle** iterates between the core activities of developing and evaluating the design artifacts and the processes of the research. The output must also be returned into the empirical foundation for refining the design until it well fits the research objective and the specific requirements of the application domains. The design artifacts in this research are the OperA+ framework with a suite of methods for modeling organizational interactions and verifying the organizational design. To evaluate the artifacts, for instance, we have performed several case studies to analyze the contexts and embedded organizational interactions in international trade systems and railway systems [5, 7, 6]. Regrading the normative structure, we studied the European international trading legislation which is used to evaluate the proposed normative structure and the mechanism of norm compliance checking [3, 4]. Besides, based on the organizational models, we also implemented agent-based simulations for further analysis [6].

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