

An Agent-Based Approach to Designing VO

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INTRODUCTION

Large advances and rapid changes in informatics, telecommunication, and groupware technologies added to rapid increases in information spread, knowledge sharing, and communication speed, enable people/groups/organizations feel “closer” to each other, not only by belonging to this “small wired village” but also by sharing virtually and almost permanently huge amounts of data and information; time and distance scales shrunk. Therefore, new forms of organizations are emerging to collaborate at international levels more effectively and efficiently. The networked organization and the virtual ones are such examples.

In general, *organization* refers to a formal group of people with one or more shared goals (Organization, 2006). In sociology, organization is understood as planned, coordinated, and purposeful action of human beings in order to construct or compile a common tangible or intangible product or service. An *organization* is defined by the elements that are part of it, its communication, its autonomy, and its rules of action, compared to outside events (Organization, 2006). Organizations have been defined for decades as consisting of *structure* and *process* (Parsons, 1960; quoted in McKelvey, 1999). McMillan (2002) defines an organization’s structure as the architecture both visible and invisible which connects and weaves together all aspects of an organization’s activities so that it functions as a complete *dynamic entity*. By coordinated and planned cooperation of elements, the organization is able to solve tasks that lie beyond the abilities of the single elements (Organization, 2006).

In *networked organizations* independent people and groups act as independent nodes, link across boundaries, to work together for a common purpose; it has multiple leaders, lots of voluntary links, and interacting levels (Lipnack & Stamps, 1994). A *virtual organization* is an organization existing as a corporate, not-for-profit, educational, or otherwise productive entity that does not have a central geographical location and exists

solely through telecommunication tools (Virtual Organization, 2006).

Whatever the organization form is, it involves various heterogeneous networks of people (individuals and groups) and connecting technologies and where the whole members work to achieve a common objective. Teams are important units of organizational work (Espinoza, 2001). Understanding how groups work and how communication artifacts can help team collaboration and performance can help organizations design.

Organizations can be studied as *large complex highly volatile systems* whose behavior affects and is affected by the environment in which they operate (Prietula, Carley, & Gasser, 1998).

Complex systems refer to systems that are composed of a large number of parts that interact in a non-simple way and where the whole is more than the sum of the parts (Simon, 1969) and that does not have pure superposition of phenomena and processes (Keyser, 2000). An emerging research area is the application of complexity theory to study organizations (e.g., Ballot & Weisbuch, 2000; Bar-Yam, 2000; Dent, 1999; Goldstein, 1999; McKelvey, 1999). Many researches give recommendations for organization development (Seel, 1999), draw lessons for organizational leaders (Kupers, 2001), or suggest to managers practical applications of metaphors of complexity (Lissack, 1999).

Our research focuses on using agent-based modeling and simulation to support designing new socio-technical systems in general and networked virtual organizations in particular. More specifically, we describe two studies we have conducted concerning two different socio-technical complex situations: large-scale emergency rescue and space mission design.

BACKGROUND

Designing virtual organizations is becoming more than ever a big challenge. Multi-disciplinary teams have to collaborate extremely, design alternatives, and compare rationally solutions.

Given the market demands and the high concurrency, it is required that such design teams first reduce time to implementation, second reduce costs, and finally design and implement for usability.

Organization design can be considered as the art of developing “new” organization by defining, according to the objective and according to the context, the suitable combination of the “elementary” entities which are mainly interwoven networks of people or groups or organizations and technologies.

Traditionally, science has had two methods of investigation: theory and experiment. In the postwar years, the computer erupted on the scene and with it an entirely new way of doing science: theory and experiment where joined by simulation; a problem that was too complex to understand theoretically or understand through experiments could be simulated on a computer (Kupers, 2001). For an organizational complexity science to avoid faddism and scientific discredit, it must become model-centered (McKelvey, 1999).

While *modeling* can be considered as “an abstract representation of a system from the modeler’s viewpoint” (Model, 2006); “*simulation* means *driving* a model of a system with suitable inputs and observing the corresponding outputs” (Bratley, Fox, & Schrage, 1987; quoted in Axelrod, 2005). Simulation is also “an attempt to model a real-life situation on a computer so that it can be studied to see how the system works” (Simulation, 2006).

Before computer simulations, *live simulations* have been practiced; they are sometimes used to support organizational design. *Live simulations* involve humans and/or equipment and activity in a setting where they would operate for real. An example of live simulation is testing emergency rescue plans with simulated victims (people playing this role) and rescuers (real fire-fighters and medical teams) in a “quasi-realistic” incident field (with a real fire, for example). For large-scale organizations, preparing and performing such live field simulations is becoming increasingly difficult, time consuming, and expensive. Such simulations are also of limited value since they allow only few scenarios to be re-enacted. Nonetheless, live simulations are fundamental for understanding the characteristics, the interactions, and the cooperative activities of actors involved in a shared environment. Compared with experiments using human subjects (i.e., live simulation), computational models are generally less noisy, easier to control, more flexible, more objective, and can be

used to examine a larger variety of factors within less time (Prietula, Carley, & Gasser, 1998).

In fact, agent-based modeling and simulation are recognized as valuable tools for investigating complex organizational systems. *Agent-based modeling* is a mindset more than a technology; it consists in describing a system from the perspective of its constituent units (Bonabeau, 2002). In agent-based modeling, a system is modeled as a collection of autonomous decision-making entities called agents. Each agent individually assesses its situation and makes decisions on the basis of a set of rules. Agents may execute various behaviors appropriate for the system they represent (Bonabeau, 2002).

To date, numerous agent-based simulations have been developed in many domains (e.g., Carley et al., 2006; Kreft, Booth, & Wimpenny, 1998; Strader, Lin, & Shaw, 1998; Terano, 2000). In particular, several studies have shown that this approach can be used for the design of complex organizational systems in a crisis situation (Bellamine-Ben Saoud, Pavard, Dugdale, Ben Mena, & Ben Ahmed, 2005; Dugdale, Pavard, & Soubie, 2000). Simulation studies have also been done to understand information technology in organizations (Kaplan & Carley, 1998) and to support organizational (re)engineering (Kunz, Levitt, & Jin, 1998), or to study work practices (Sierhuis & Clancey, 2002).

SIMULATIONS FOR ORGANIZATION DESIGN

The aim of this section is to defend, first, how agent-based simulation environment supports design of organization in general and more particularly virtual ones, to present, second, an agent-based approach which may be followed for such purpose, and to prove finally these claims by presenting two case studies.

How to Design Virtual Organization and How Agent-Based Simulation Would Support Such Activity?

Designing virtual organization consists either in starting from existing situation(s) and study its (their) modification(s) or by designing new organization by creating all its components and their connecting links. In all cases, humans as well as technological

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