Chapter 11
A Unified Framework for Traditional and Agent-Based Social Network Modeling

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ABSTRACT

In the last sixty years of research, several models have been proposed to explain (i) the formation and (ii) the evolution of networks. However, because of the specialization required for the problems, most of the agent-based models are not general. On the other hand, many of the traditional network models focus on elementary interactions that are often part of several different processes. This phenomenon is especially evident in the field of models for social networks. Therefore, this chapter presents a unified conceptual framework to express both novel agent-based and traditional social network models. This conceptual framework is essentially a meta-model that acts as a template for other models. To support this meta-model, the chapter proposes a different kind of agent-based modeling tool that we specifically created for developing social network models. The tool the authors propose does not aim at being a general-purpose agent-based modeling tool, thus remaining a relatively simple software system, while it is extensible where it really matters. Eventually, the authors apply this toolkit to a novel problem coming from the domain of P2P social networking platforms.

INTRODUCTION

In the last sixty years of research, several models have been proposed to explain (*i*) the formation and (*ii*) the evolution of networks, or, more in general, (*iii*) various kinds of processes over networks.

Such models have been developed and studied by researchers coming from many different areas, such as computer science, economics, natural sciences, meteorology, medicine, pure or applied mathematics, sociology and statistics. As a consequence, a lot of material exists on the subject and it is beyond the scope of this work to review

DOI: 10.4018/978-1-4666-5954-4.ch011

and analyze it thoroughly (Bergenti et al., 2012; Franchi & Poggi, 2011); we refer to Jackson (2010) for the economic and game-theoretic point of view, and to Snijders (2011) for a complete review of the state of art of statistical models. Newman (2010) provides an accurate presentation of the approach developed in the computer, natural and physical sciences.

Several agent-based models have also been successfully developed in order to study specific problems that, because of either (*i*) the complexity of the agent to agent interactions, or (*ii*) the richness of the underlying environment, were relatively impervious to analysis using traditional techniques (Arthur, 1996; Axtel et al., 2004; Bagni et al., 2002; Carley et al., 2006; Dean et al., 2000; Epstein & Axtell, 1996; Folcik et al., 2007; Hill et al., 2006; Ilachinski, 2000; Kohler et al., 2005; Moffat et al., 2006; North et al., 2010; Lucas & Payne, 2014).

However, most agent-based models address very specific phenomena and, as a consequence, they have relatively low reusability. On the other hand, many traditional models focus on elementary interactions that are often part of several different processes, and, consequently, the effects of these elementary interactions have been thoroughly studied. Nardin, Rosset and Sichman (2014) present a more detailed discussion regarding how to obtain more universal conclusions from agent-based modeling.

We believe that such interactions should be introduced as basic building blocks even for agent-based models, enriched with more "agent-ness" when it is the case. However, several assumptions that are perfectly legitimate in a stochastic process are not well rendered in an agent-based model. Moreover, many considerations that we derive from the conversion from traditional stochastic to agent-based models are similar to the ones that should be made by implementing the stochastic model in a generic non agent-based concurrent environment.

Considering the relevance that social networking platforms have gained in our lives, either directly or indirectly, one of the most interesting applications of agent-based models for social networks is to social networking platforms.

The structure of this Chapter is as follows: (*i*) some considerations over the epistemology of agent-based modeling are given; (*ii*) our proposal for a meta-model for social network processes is described, and also a working toolkit built over such ideas is presented; (*iii*) as an example, our platform is used to model a problem coming from the implementation of P2P social networking platforms.

AGENT BASED MODELING FOR SOCIAL SCIENCES

ABM is a very powerful technique that has been applied increasingly often in the last years in a variety of different contexts. Examples of those contexts are (*i*) social sciences (Axelrod, 2003; Axelrod & Tesfatsion, 2006; Epstein, 1999, 2002, 2006; Kohler & Gumerman, 2000; Castelfranchi, 2014), (*ii*) economy (Arthur et al., 1997; Axtel et al., 2004; Epstein & Axtell, 1996; Arciero et al., 2014; Carbonara, 2013; Magessi & Antunes, 2014; Santos et al., 2014; Trigo, 2014), and marketing (North et al., 2010), (*iii*) epidemics and medicine (Bagni et al., 2002; Carley et al., 2006; Folcik et al., 2007), (*iv*) archeology (Dean et al., 2000; Kohler et al., 2005), (*v*) Philosophy (Coelho, da Rocha Costa & Trigo, 2014), (*vi*) energy distribution (Mota, Santos, Dimuro & Rosa, 2014), (*vii*) Game Theory (Georgalos, 2014) and (*viii*) warfare (Hill et al., 2006; Ilachinski, 2000; Moffat et al., 2006).

In ABM the subject of the modeling is described in terms of a collection of autonomous decision-making units, called agents, that are grouped together to form an agent-based model. Each agent individually assesses the situation and makes its own decision. A model consists of