Chapter 7
Large-Scale Social Simulation, Dealing with Complexity Challenges in High Performance Environments

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ABSTRACT

Advances on information technology in the past decades have provided new tools to assist scientists in the study of social and natural phenomena. Agent-based modeling techniques have flourished recently, encouraging the introduction of computer simulations to examine behavioral patterns in complex human and biological systems. Real-world social dynamics are very complex, containing billions of interacting individuals and an important amount of data (both spatial and social). Dealing with large-scale agent-based models is not an easy task and encounters several challenges. The design of strategies to overcome these challenges represents an opportunity for high performance parallel and distributed implementation. This chapter examines the most relevant aspects to deal with large-scale agent-based simulations in social sciences and revises the developments to confront technological issues.

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INTRODUCTION

Computer modeling and complex systems simulation have dominated the scientific debate over the last decade, providing important outcomes in biology, geology and life sciences, and resulting in the birth of entirely new disciplines (e.g. bioinformatics, geoinformatics, health informatics, etc.). In social sciences research in this direction is increasing. The reason is the object of study in these disciplines, human society present or past, is difficult to analyze through classical analytical techniques. Social phenomena are unpredictable and changing (dynamic). Thus, other methodological techniques are needed to more adequately study this field. Computer simulation can actually be used as a virtual lab to explore different hypotheses capable of explaining patterns of phenomena and validate them.

In this context, Agent-Based Modeling (ABM) is one of the most widely used simulation techniques, from the physical sciences to the social sciences (Macal & North, 2007). ABM is particularly well suited with the concept of entities with individual decision-making processes interacting within a common environment which can show emergent behavior[12]. Given the inherent complexity of population dynamics and structures, agent-based simulation allows the implementation of experiments and studies that would not be feasible otherwise (Pavon et al., 2008). As a result, many agent-based simulation tools have been developed over the last years to explore the complexity of social systems. Agent-based simulation is recognized as one of the techniques which could contribute more to develop useful simulations of complex social interactions (Gilbert, 2008).

In the real-world social dynamics are very complex, containing billions of interacting individuals and an important amount of data (both spatial and social). That is the reason why a desktop computer or a small cluster might not have enough capacity to manage realistic models. For example, the study of past societies scientists may require an important number of simulations to validate their models against archaeological records (Rubio & Cela, 2010). One solution is to run simulation models on high performance distributed and parallel environments such as big computer clusters, supercomputers, clouds or grids. However, the performance analysis is a difficult task in parallel and distributed simulation (Fujimoto, 2000), especially when the system is as dynamic as human populations. Scalability (the capacity of a system to handle a higher amount of work as hardware grows) needs to be addressed, although there is no consensus on dealing with the difficulties it encounters on ABMs (Hybinette et al., 2006; Tesfatsion, 2002).

With this chapter we want to address some of the technological challenges social researchers could expect of the future of social simulation. Specifically, we explain the most relevant aspects on dealing with large-scale agent-based simulations in social sciences and humanities. The chapter approaches advanced computer science techniques to social researchers interested to take advantage of simulation for virtual experimentation of social phenomena. In the background section we will provide a general description of Parallel and Distributed Simulation (PADS) and the current computer architectures to run simulations. We will also discuss some advantages and challenges when dealing with High Performance Computing (HPC) systems. We will then point at some reasons why HPC are suitable for large social simulations. Later we will review specific challenges and solutions to perform social simulations in HPC architecture. After revising some of the available tools for large-scale agent-based simulations in social sciences, we will conclude our chapter discussing why technology advances matter and how social simulation community can get advantage of them.