

## Chapter 3

# Scale and Topology Effects on Agent-Based Simulation: A Trust-Based Coalition Formation Case Study

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### **ABSTRACT**

*The exploitation of Agent-Based Social Simulation (ABSS) full capabilities often requires massive computing power and tools in order to support the achievement of breakthrough results in social sciences. Lately, this issue has been addressed by the release of several high-performance computing agent-based simulation tools; however, they have not been used for exploring critical issues, such as ABSS results invariance and universality. Hence, in order to advance this topic, this chapter provides an invariance analysis, considering scale and topology, of a model that incorporates the concepts of trust and coalition formation, in which agents are placed on a square lattice interacting locally with their neighbors and forming coalitions. By varying the environment size, its topology, as well as the neighborhood topology, it is identified in the experimental scenario that apparently the only parameter that affects the simulation dynamics is the neighborhood topology.*

## INTRODUCTION

Along the last decades, social sciences have been accepting gradually Agent-Based Social Simulation (ABSS) as an adequate approach for modeling social problems (Gilbert, 2008; Li et al., 2008). Although adequate, the exploitation of its full capabilities for facing the complexity of current social problems requires massive computing power and powerful tools endowed with features that allow the achievement of breakthrough results. The fulfillment of these requirements, for instance, would enable the simulation of large groups of agents rendering possible the study of more representative portions of the society. Additionally, it would enable the handling of the huge amounts of data recently made available by the increasing use of online tools in individuals' daily routines.

According to Murphy (2011), High-Performance Computing (HPC) is a good path to follow in order to fulfill such large-scale simulation needs. The term High-Performance Computing refers to any computational activity that aggregates computing resources in a way to deliver higher computing capabilities than one could get out of a single processor computer. HPC platforms are distributed systems composed of collections of independent processing units running in parallel. Their architectures are classified according to the coupling degree among their processing units. Some examples of HPC platforms are supercomputers, clusters, grids, clouds, and more recently GPU (Graphical Processing Units) computing (Fan et al., 2004). For an overview and a better understanding of the current HPC status, see (Dongarra & van der Steen, 2012).

Lately, several agent-based modeling and simulation (ABMS) tools, supporting different HPC platform architectures, have been freely released focused in fulfilling large-scale computing requirements: SWAGES (Scheutz, Schermerhorn, Connaughton, & Dingler, 2006), D-MASON (Cordasco et al., 2011), Repast HPC (Collier &

North, 2012), Pandora (Wittek & Rubio-Campillo, 2012) and FLAME (Coakley et al., 2012). Since this work is not focused on reviewing ABMS HPC tools, for a comprehensive review see (Collier & North, 2012).

Regardless of the availability of these tools, currently only few simulation models have been implemented using them. Moreover, their primary purpose is the demonstration of ABMS HPC tools functionalities rather than to explore more critical issues, such as ABSS results robustness (Cioffi-Revilla, 2002). Hence, the main contribution of this chapter is an invariance analysis, considering changes in scale and topology, of an ABSS model proposed by Nardin and Sichman (2011). This model is based on a square lattice, in which agents interact locally with their neighbors and form coalitions. Additionally, this chapter provides some practical challenges and drawbacks faced during this model's implementation in a HPC environment using the Repast HPC toolkit.

The remainder of this chapter is organized as follows. In the next section, we describe some related work. In the sequence, we present the conceptual description as well as the implementation of our model. Then, we describe the experiments' design. Next, we present the main questions concerning the model invariance and their corresponding answers, considering the effects of scale and topology change in the dynamics of the system. Finally, we present our conclusions.

## RELATED WORK

Among the few related work that approaches robustness, Flache and Hegselmann (2001) relaxed the assumption of rectangular grid structures and analyzed how the use of irregular (non-rectangular) structures, such as hexagonal or triangular cells, affects the migration and influence dynamics in cellular automaton models. They concluded that both dynamics are robust to structure variation.

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