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PARALLEL SIMULATION OF LARGE POPULATION DYNAMICS

Cristina Montañola-Sales
Josep Casanovas-Garcia
Jose Maria Cela-Espin

Universitat Politècnica de Catalunya-BarcelonaTech
Barcelona Supercomputing Center
Barcelona 08034, SPAIN

BAdriana Kaplan-Marcusan

Universitat Autònoma de Barcelona
Bellaterra 08193, SPAIN

B.S.S. Onggo

Lancaster University
Lancaster LA1 4YX, UK

ABSTRACT

Agent-based modeling and simulation is a promising methodology that can be used in the study of population dynamics. We present the design and development of a simulation tool which provides basic support for modeling and simulating agent-based demographic systems. Our results prove that agent-based modeling can work effectively in the study of demographic scenarios which can help to better policy planning and analysis. Moreover, parallel environment looks suitable for the study of large-scale individual-based simulations of this kind.

1 INTRODUCTION

Agent-based modeling (ABM) and simulation has been applied to many areas, from the physical sciences to the social sciences (Macal and North 2007). As a result, many agent-based simulation tools have been developed in the last years to explore the complexity of population dynamics. The object of study in social disciplines, human society present or past, is difficult to analyze through classical analytic techniques due to the unpredictable and changing (dynamic) nature. In this context, ABM is encouraging the introduction of computer simulations to examine behavioral patterns in complex systems.

ABM is commonly used for small scenarios because the number of agents and interactions between them can be extremely large in some of case studies. Having a large number of variables in an ABM might not only encounter difficulties on model calibration and validation but also might require high computational resources. Thus, scientists are forced to limit model size or agents' complexity in order to execute their simulations in a standard computer. However, in the case of policy models, both the amount of compute power required and detailed micro-level data are significant. To deal with complex social models we can take advantage of parallel computation. Nevertheless, the number of applications of parallel simulation in the social sciences is scarce. One of the reason is the challenge of making agent-based simulation scalable, which mainly depends on model size, the complexity of agents and the importance of the environment.

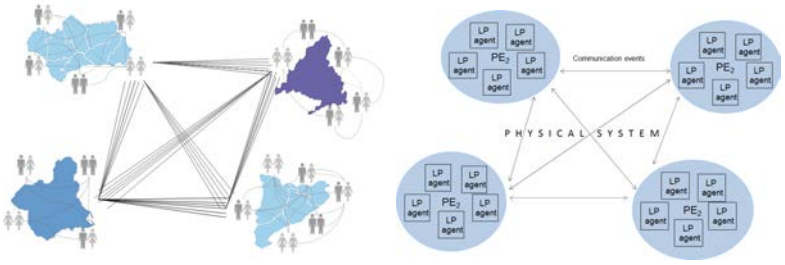
Our research has two main goals: (1) to show how ABM can be used for simulating the demographic evolution of a society, and (2) to find a scalable solution for large population dynamics profiting high-performance computing infrastructures. Therefore, we present our work-in-progress in developing a tool

for simulating the interactions of individuals in a society running ABM on top of a scalable parallel discrete-event simulation engine.

2 PARALLEL AGENT-BASED SIMULATION FOR DEMOGRAPHICS

Yades is a parallel demographic simulator. It was implemented using μsik parallel simulation library (Onggo 2008), which supports multiple synchronization algorithms such as: lookahead-based conservative protocol and rollback-based optimistic protocol (Perumalla 2005).

There are two types of agents in Yades: *families* and *regions*. Families are subject to five demographic components that may change their state: fertility, a change in economic status, a change in marital status, migration and mortality. Regions handle domestic migrations, immigration, changes in simulation parameters and periodic reports. Figure 1 shows how the demographic scenario is mapped on the architecture of Yades.



(a) Demographic scenario (b) Simulation architecture

Figure 1: Corresponding architecture of the demographic scenario to simulate

The scalability of our tool has been studied already in high performance computing systems and has shown good scalability (Onggo, Montañola Sales, and Casanovas-Garcia 2010). Hence the main contributions of our work are (1) to show an innovative application of parallel simulation in demography, an important field in social science that is increasingly used as the basis for policy planning and analysis, and (2) to demonstrate how agent-based simulation can be run using a scalable parallel discrete-event simulation engine.

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