Parallel simulation of large population dynamics

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Introduction

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.

Agent-based modeling and simulation

Agent-based models are formed by a set of autonomous agents that interact with their environment (including other agents) through a set of internal rules to achieve their objectives. They are used to represent a real world system to help us understand the system and make decisions.

Agent-based modeling is encouraging the introduction of computer simulations to examine behavioral patterns in complex systems. ABM simulation allows the implementation of experiments and studies that would not be feasible otherwise [1].
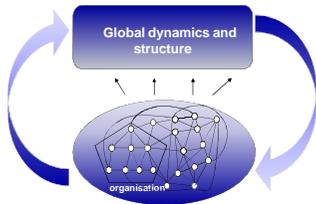

Size matters

Agent-based modeling is commonly used for small scenarios because the number of agents and interactions between them can be extremely large in some of case studies. Thus forcing the scientist to limit its number in order to execute the simulation in a standard computer. However, in the case of real-world policy models, both the amount of compute power required and detailed micro-level data are significant. The limitation on computer capacity can be overcome running the simulation model with parallel computation.

A parallel simulator for demographics

We developed **Yades**, a parallel agent-based demographic simulation tool [2][3]. Yades runs on top of a discrete-event simulator. Yades is implemented using μsik parallel simulation library [4], where a model is formed by:
- a set of interacting logical processes (LP), implemented as μsik processes which communicate through events.
- Multiple LPs are mapped onto a physical process (μsik kernel) that is run on top of a processing element (PE). A machine can have more than one PE (e.g., in multi-core architecture).
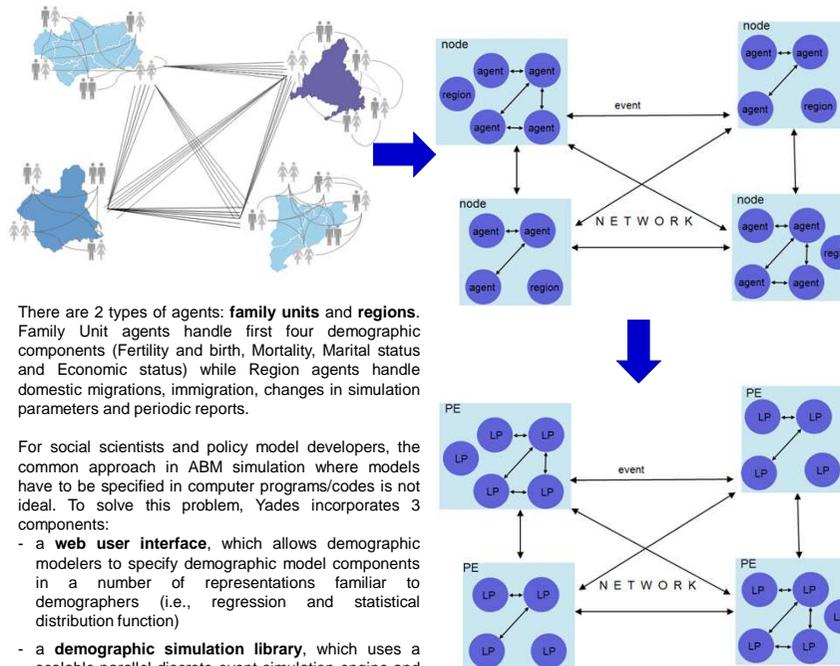
There are 2 types of agents: **family units** and **regions**. Family Unit agents handle first four demographic components (Fertility and birth, Mortality, Marital status and Economic status) while Region agents handle domestic migrations, immigration, changes in simulation parameters and periodic reports.

For social scientists and policy model developers, the common approach in ABM simulation where models have to be specified in computer programs/codes is not ideal. To solve this problem, Yades incorporates 3 components:
- a **web user interface**, which allows demographic modelers to specify demographic model components in a number of representations familiar to demographers (i.e., regression and statistical distribution function)
- a **demographic simulation library**, which uses a scalable parallel discrete-event simulation engine and supports both sequential and parallel execution of the simulation model [2] and a good performance [3]
- the simulation code generator, which produces the corresponding C++ code ready to be compiled.

With this design, users should be able to reap the performance offered by parallel computers transparently.

Conclusions

We showed 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

We demonstrated how **agent-based simulation can be run using a scalable parallel discrete-event simulation engine**.
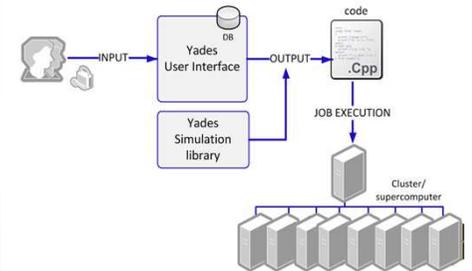
Future research directions

- To allow **multiple regions** to be run **on a processing element**
- introducing the concept of **household** which would allow one or more members of the same family unit to live in separate regions,
- to **enrich the agent-based model** with macro variables such as IDH, GPD and economic trends on regions
- test it with **real case studies**.

Literature cited

[1] J. Pavon, M. Arroyo, S. Hassan, and C. Sansores, "Agent-based modelling and simulation for the analysis of social patterns", *Pattern Recognition Letters*, vol.29, n.8, pp.1039–1048, 2008.
[2] Onggo, B.S.S. 2008. "Parallel discrete-event simulation of population dynamics". In *Proceedings of the 2008 Winter Simulation Conference*, S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, J. W. Fowler (Eds.), 1047–1054. IEEE Computer Society Press: Piscataway, NJ.
[3] Onggo, B.S.S., Montañola-Sales, C. and Casanovas-Garcia J. 2010. "Performance Analysis of Parallel Demographic Simulation". In *Proceedings of the 24th European Simulation and Modelling Conference*, 142-148. Eurosis-ETI: Ostend, Belgium.
[4] Perumalla, K.S. 2005. μsik – a micro-kernel for parallel/distributed simulation systems. In *Proceedings of the 19th Workshop on Principles of Advanced and Distributed Simulation*, 59-68. ACM Press: New York, NY.

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