Parallel simulation of large population dynamics

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Introduction

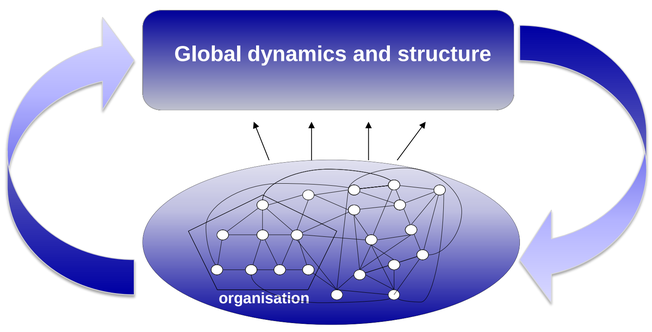
Agent-based modelling and simulation is a promising methodology that can be used in the study of population dynamics. One of the main obstacles hindering the use of agent-based simulation in practice is its scalability, especially if the analysis requires large-scale models. A possible solution is to run the agent-based models on top of a scalable parallel discrete-event simulation engine.

We present a modelling and simulation platform implemented to provide a basic support for modelling and simulation of agent-based demographic systems. We conducted a study to evaluate its performance with good results in a parallel environment: a supercomputer. A user interface was also designed to allow modellers to easily define models to describe different demographic processes and transparently run them on any computer architecture environment. Our results prove that agent-based modelling can work effectively in the study of demographic scenarios which can help to better family policy planning and analysis. Moreover, parallel environment looks suitable for the study of large-based individual-based simulations of this kind.

Agent-based modeling and simulation

Agent-based modelling (ABM) is a model that is 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.

ABM is used to represent a real world system to help us understand the system and make decisions.



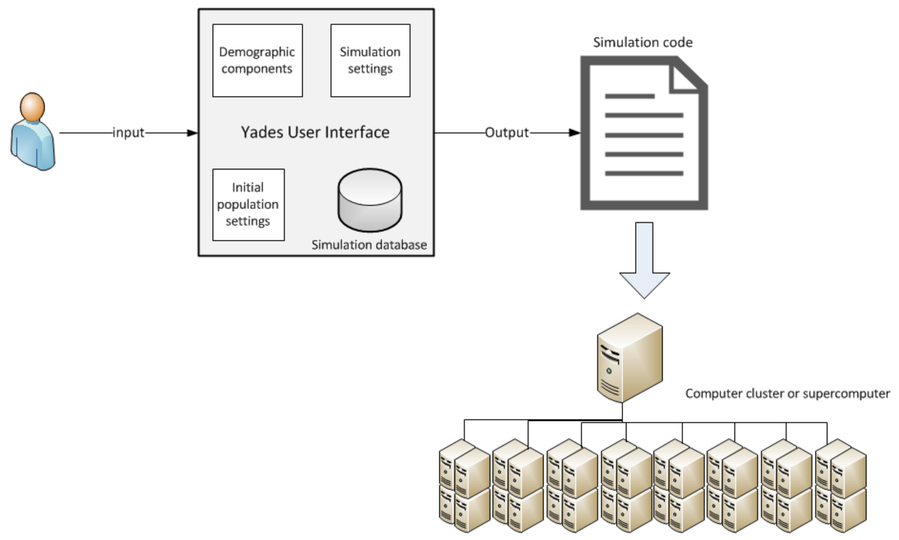
Social phenomena are unpredictable and changing (dynamic). ABM is encouraging the introduction of computer simulations to examine behavioural patterns in complex systems. ABM simulation allows the implementation of experiments and studies that would not be feasible otherwise [1].

Size matters

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. 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 agent-based simulator for demographics

We present the design and implementation of **Yades**, a parallel ABM demographic simulation tool. 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 an interface and it features automatic code generation for the simulation tool. In that way modellers can define the set of variables and components that will define the simulation model. They should be able to reap the performance offered by parallel computers transparently.



Yades has three components:

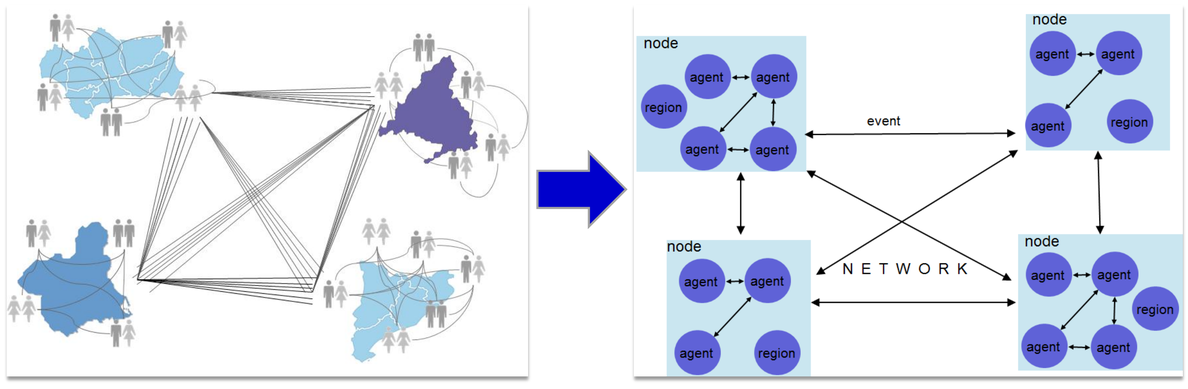
- a **web user interface**, which allows demographic modellers to specify demographic model components in a number of representations familiar to demographers (i.e., regression and statistical distribution function)
- a **demographic simulation library**, which uses a scalable parallel discrete-event 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.

Yades is a parallel agent-based demographic simulation tool that runs on top of a discrete-event simulator. Yades is implemented using µsik parallel simulation library [3].

The main core of a demographic simulation model is the life course of individuals. In general, a demographic simulation model is formed by a number of demographic components. Yades handles 5 demographic models:

- Fertility and birth
- Mortality
- Marital status
- Economic status
- Migrations (domestic migrations/emigrations and immigrations)

There are 2 types of agents: **family units** and **regions**. Family Unit agents handle first four demographic components while Region agents handle domestic migrations, immigration, changes in simulation parameters and periodic reports.



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

- Limitations and future works: introducing the concept of household which would allow one or more members of the same family unit to live in separate administrative areas, to enrich the agent-based model to add macro variables as IDH, GPD and economic trends on regions to improve scenario simulations and test it with real case studies.

Literature cited

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