Using open-source tools for the simulation of urban transportation systems

Authors

- **Quoc Tuan Nguyen**, L3I laboratory - university of La Rochelle, *France*
- **Alain Bouju**, L3I laboratory - university of La Rochelle, *France*
- **Pascal Estraillier**, L3I laboratory - university of La Rochelle, *France*

KEYWORDS : Intelligent transportation systems, Multi-agent, Regulation, Adaptive, Software architecture, Open-source software, Geolocation

Urban transportation systems are defined by means of urban transport plans and territorial coherence schemes. Organizational and regulatory policies concerning urban transportation systems are governed by general principles corresponding to strategic direction and policies and integrate infrastructure constraints. Transportation systems are increasingly complex and must evolve to incorporate components of sustainable development. It has become appropriate to develop high-level simulation tools for urban transportation policy makers so that they can analyze the potential consequences of their choices.

Nowadays, the open-source tools are used increasingly in many fields especially in the education, the research and applied domains. They have many advantages such as the availability of the source code and the right to modify it, the right to redistribute modifications and improvements to the code, the right to use the software in any way, etc.

In this paper, we propose a decision-maker simulator intended to define and tune urban transportation policy (travel, parking and transportation

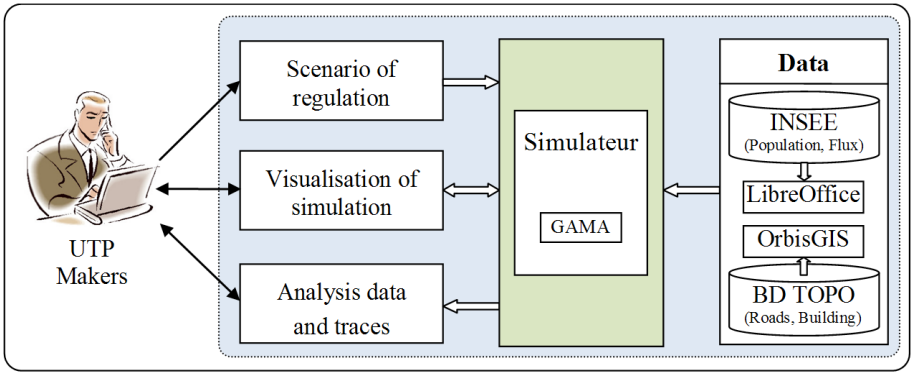
strategies) using exist open- source tools such as LibreOffice, OrbisGIS and GAMA platform.
Currently, there are simulators that deal with concrete problems in the urban transportation system such as the simulation of movement of individuals [1, 2, 3, 4], driver's behavior [5], the transportation flow [6] , etc. However, there are very few simulators that address the problems of the organization of transportation systems and in particular the problem of analyzing the impacts of regulatory strategies for the transportation system.

The main objective is to provide a simulation tool to help urban transportation policy (UTP) makers to analyze and evaluate the impacts of regulatory strategies. The simulator consists of modules that contain information describing the infrastructure of transportation systems, means of transport, signaling, individuals' behavior etc. The Figure 1 illustrates the interaction between the urban transportation policy maker and simulator components and presents an overview of our system. The simulator must then take into account the following features :

- Support scenarios of regulation: this feature allows the decision maker to define scenarios of regulation strategies (set indicators for the strategies of regulation).

FIGURE 1

Overview of the system (UTP – Urban Transportation Policy)



- Simulate movement of individuals in the context of multi-modality of transport: this feature simulates multimodal travel corresponding to a plan of activities (work, school, leisure, shopping, services, etc) of individuals on the infrastructure of the transportation system. The simulation must be multi-scale time and space.

The problems of our research contribute to:

- the development of transportation systems: a theoretical framework for modeling, software architecture supporting configuration and adaptive regulation and integration of temporal and spatial aspects.
- the development of a decision support simulator: modeling of transportation infrastructure, simulation of user's behavior and analyzing the impacts of regulatory strategies.

In terms of performance, simulators organizing transportation systems based on the multi-agent systems paradigm are well suited to complex dynamic systems and can describe the behavior of real systems for which equation models are not always satisfactory, particularly when an algorithmic approach is preferred to a probabilistic approach.

In terms of system architecture, we adopted a "system of systems" approach [7, 8], mainly structured in layers, in order to the main elements of the system. In our proposal, each layer plays a role as a system. We represent explicitly, for example, a layer of roads, lights, parking, means of transport, etc. Our system uses an agent-based simulation incorporating spatial and temporal information. It must support the regulatory scenarios to simulate the effect of regulatory strategies on transportation systems.

The input data of the simulator are geographic data for the study area, infrastructure of the transportation network (land, roads) provided by the BD TOPO 2 from IGN (the French National Geographical Institute), the results of surveys and the general census of the population provided by INSEE that contain the information to set individual's behaviors. The advantages of this INSEE (the French National Institute of Statistics and Economic Studies) source consist in the fact that this is a database with large sample, which ensures accurate data and provides a spatial presentation of the population, and data movements of individuals.

In addition, we implemented the mechanism of «traces»; the trace files contain the result of simulation. Travel surveys, census and traffic measurements were used. Analysis of available data and traces were used to evaluate the suitability of our simulations according to different regulatory strategies.

Finally, we implemented a prototype for the movement of people in the city of La Rochelle – France with data from INSEE 2006 and BD TOPO 2 (delivered on 22/10/2011).

LibreOffice is the power-packed free, libre and open source personal productivity. We used Calc and Base tools of LibreOffice to analyze and manipulate the data of INSEE in order to categorize individual's profile and the mobility flux.

OrbisGIS is a Geographical Information System dedicate to scientific modeling and simulation. OrbisGIS is developed by the Institute on Urban Sciences and Technics – France (IRSTV - CNRS/FR-2488), it is an open-source software. We used the OrbisGIS to process the geographical data of BD TOPO 2 for system infrastructure (roads, paths), attraction points (home, work, school, etc.).

GAMA [9, 10] is a simulation platform which aims at providing field experts, modelers, and computer scientists with a complete modeling and simulation development environment for building spatially explicit agent-based simulations. It is developed with the Java programming language and is open source. Geographic information is well integrated. It has implanted example models and has a language for defining models.

We installed a simulation of individual movements using the GAMA simulation platform version 1.4. System infrastructures (roads, paths, buildings) were stored in shapefiles (Esri ref). Each section of road or path was represented by an agent, each building was also represented by an agent and all these manipulations were performed automatically from a shapefile. The number of individuals in this simulation was 10000 (the actual population of La Rochelle is around 76000). Each individual was represented by an agent, it had a place of residence and a place of work or study, its activity plan consisted only of the round trip from home to work or study. The individual movements were determined by the shortest path algorithms. The results

obtained proved the feasibility of our choices for the design of our simulator and for the integration of geographic information (roads, buildings) in the simulation.

[1] LANG, C., BANOS, A. AND THEVENIN, T. *Représentation dynamique et visualisation interactive de données spatio-temporelles dans le projet MIRO*. Projet MIRO, 2006.

[2] LANG, C. AND al. MIRO, *Rapport Final Septembre*, 2007.

[3] KOOHBANANI, M. J. *Enhancements to Transportation Analysis and Simulation System (TRANSIMS)*. PhD thesis, 2004.

[4] NAGEL, K. Multi-modal traffic in TRANSIMS. *Traffic* (2001).

[5] ESPIE, S. ARCHISIM : Collaboration MSIS / LPC modélisation et simulation du comportement des conducteurs. MSIS, 2004.

[6] BEHRISCH, M. et al. 2011. SUMO – Simulation of Urban MObility. SIMUL 2011: *The Third International Conference on Advances in System Simulation* (Barcelona, Spain, 2011), pp. 63-68.

[7] LUZEAUX, D., & RUAULT, J.-R. *Ingénierie des systèmes de systèmes - concepts et illustrations pratiques.* Hermes Science. 2008.

[8] MAIER, M.W. Architecting Principles for Systems of Systems. *Systems Engineering 1* (1998), pp. 267-284.

[9] DROGOUL, A. *An introduction to GAMA Reasons for developing GAMA Original purpose of GAMA*. Training session on agent-based modeling, Hanoi, VietNam, 2009.

[10] TAILLANDIER, P., DROGOUL, A., VO, D.A. AND AMOUROUX, E. GAMA: a simulation platform that integrates geographical information data, agent-based modeling and multi-scale control. In *'The 13th International Conference on Principles and Practices in Multi-Agent Systems (PRIMA)'* (India, Volume 7057, 2012), pp. 242-258.