Efficient Microscopic Simulation of Large Scale Highway Traffic Flows

Sven Maerivoet and Bart De Moor

Katholieke Universiteit Leuven
Department of Electrical Engineering ESAT-SCD (SISTA)
Kasteelpark Arenberg 10, B-3001 Leuven
{sven.maerivoet,bart.demoor}@esat.kuleuven.ac.be
Phone: +32 (0) 16 32 17 09 / Fax: +32 (0) 16 32 19 70
http://www.esat.kuleuven.ac.be/scd

1. Introduction

As traffic policy makers get more and more confronted with increasing global congestion on the road networks, controlling the traffic flows becomes a corner stone in the optimal usage of the existing road infrastructure.

Today, a main challenge is the construction of macroscopic and microscopic models that lend themselves to a faithful representation of road traffic, as these models are used in several key aspects in the control of traffic flows [1].

Within this context, our research is aimed at assisting traffic engineers who wish to evaluate what-if scenarios and/or perform real-time control of traffic flows. Whereas the former requires a sufficiently detailed model, the latter calls for an efficient implementation that allows fast simulations. The challenge thus consists of the development of a flexible testbed environment that is capable of providing us with a detailed simulation model of a real-world road network (which is, in our case, the Flemish primary highway network) [2].

2. Microscopic traffic flow simulation

In our research, we consider traffic flow models as being microscopic in nature. Each vehicle in a traffic flow is modelled individually, resulting in a detailed description of the dynamical processes behind a traffic flow.

The class of microscopic traffic flow models that we employ, are the traffic cellular automata (TCA) models. They represent traffic flows using very simplified models that have, on a microscopic scale, a rather low accuracy [3]. This in turn has an important advantage: they provide an efficient and fast performance when used in computer simulations. TCA models explicitly describe local interactions between individual vehicles in a traffic flow, by means of rulesets that reflect the rule based behaviour of a cellular automaton evolving in time and space (i.e., the road network).

3. The quest for speed

Although these TCA models allow for fast computations, they are nevertheless computationally very expensive because they are based on behavioural submodels that need to be applied to each vehicle at each timestep. We thus need to find the most optimal solution in terms of time and space complexity. A logical step in this direction, is an efficient parallellisation scheme that lowers the computational overhead involved. This can be accomplished by using distributed computing, where we partition the road network in several distinct geographical regions that are assigned to different machines which run in parallel.

4. Practical implementation

We automatically gain platform independency using Java. The challenge now is to get reliable and efficient (i.e., faster than real-time) operation of a very heterogeneous computing environment. To this end, the simulator consists of one master, controlling several different workers that efficiently simulate local traffic flows.

Using this fast integrated simulation environment, we can evaluate different scenarios, or even use it as a mirror of the real-world when implementing traffic control measures.

References

[1] "*Sustainability Effects of Traffic Management Systems*", PODO-II / DWTC-CP/40 project, First Intermediary Scientific Report, ed. Sven Maerivoet, january 2003.

[2] Sven Maerivoet and Bart De Moor, "*Development of an Improved Traffic Cellular Automaton Model for Traffic Flows on a Highway Road Network*", Proceedings of the 10th World Congress and Exhibition on Intelligent Transport Systems and Services, Madrid, Spain, november 2003.

[3] Kai Nagel and Michael Schreckenberg, "*A cellular automaton model for freeway traffic*", Journal de Physique I France, vol. 2, pages 2221-2229, 1992.