Gábor SZŰCS

Optimizing and modeling methods of highly sophisticated systems by artificial intelligence controlled simulation, with special emphasis on the investigation of traffic systems

Ph. D. Thesis

Budapest University of Technology and Economics

Supervisor:
Professor András JÁVOR Ph.D., D.Sc.

Contents

- **Introduction**
- **Aim of the research tasks**
- **New scientific results**
- **Utilization of the new results**

Introduction

Simulation is a fast and efficient tool for analyzing sophisticated and large systems, besides it can help to determine optimal ones. The efficiency of the traditional simulation cycle can be improved by automating the long iteration process of model building, running simulation, data evaluation and model modification. It can be solved by intelligent demons (agents) monitoring the operational trajectory of the system during simulation, and modifying the model based on their reasoning algorithms.

Research tasks

- In the dissertation the methods and algorithms of artificial intelligence controlled simulation providing tools for problem solving in case of highly sophisticated systems have been discussed in order to find optimal solutions more effectively.
- In the development of algorithms searching solutions for complex problems instead of using conventional procedural algorithms, a structure constructed of modular objects based on the demon principle has been elaborated as a mechanism for solving problems in a wide range of applications. Monitoring, decision making, rule based and frame based knowledge bases with priority modules were integrated in this architecture in order to obtain a tool with easy adaptability for different tasks.
- In the procedure of searching models representing the optimal system beside structural and parametrical modifications the possibility of modifying the influence mechanisms between model objects is reviewed.

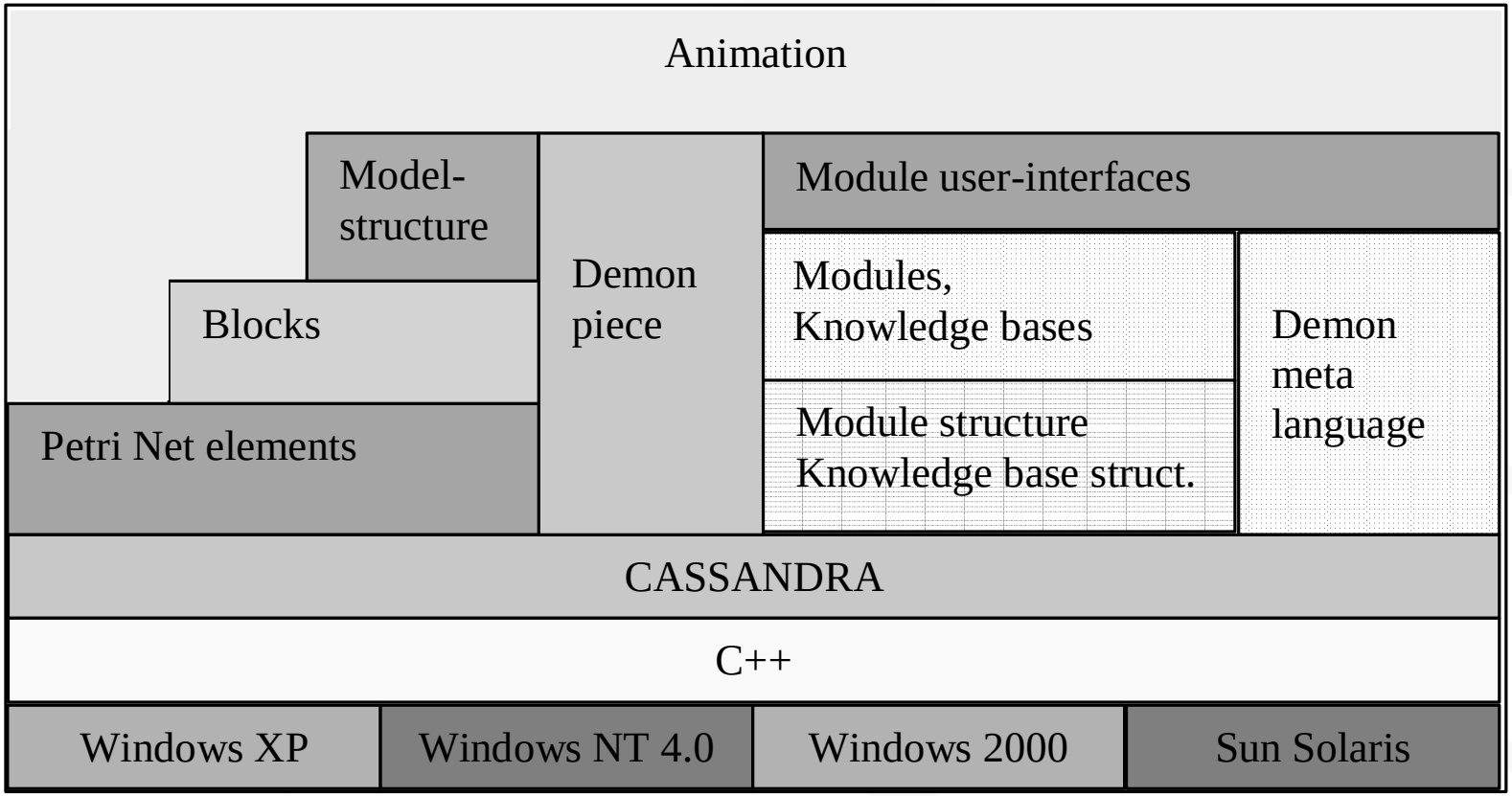
New scientific results

1) **A new structure to increase the efficiency of optimization tasks in discrete simulation has been elaborated.** To achieve this a new demon structure with flexible architecture based on the demon principle, with monitoring, decision making, acting and knowledge base modules has been developed. The new modules have search algorithms in several dimensions for optimization tasks, and provide for changing the effect-mechanisms among the model elements (beside structural, parametrical modifications) for determining the appropriate models.

2) **New model elements for traffic simulation have been elaborated.** A new place type element that can be used in Knowledge Attributed Petri Nets has been elaborated which made the representation of traffic systems more convenient. Furthermore a traffic emission line source has been developed for modeling the air-pollution caused by traffic.

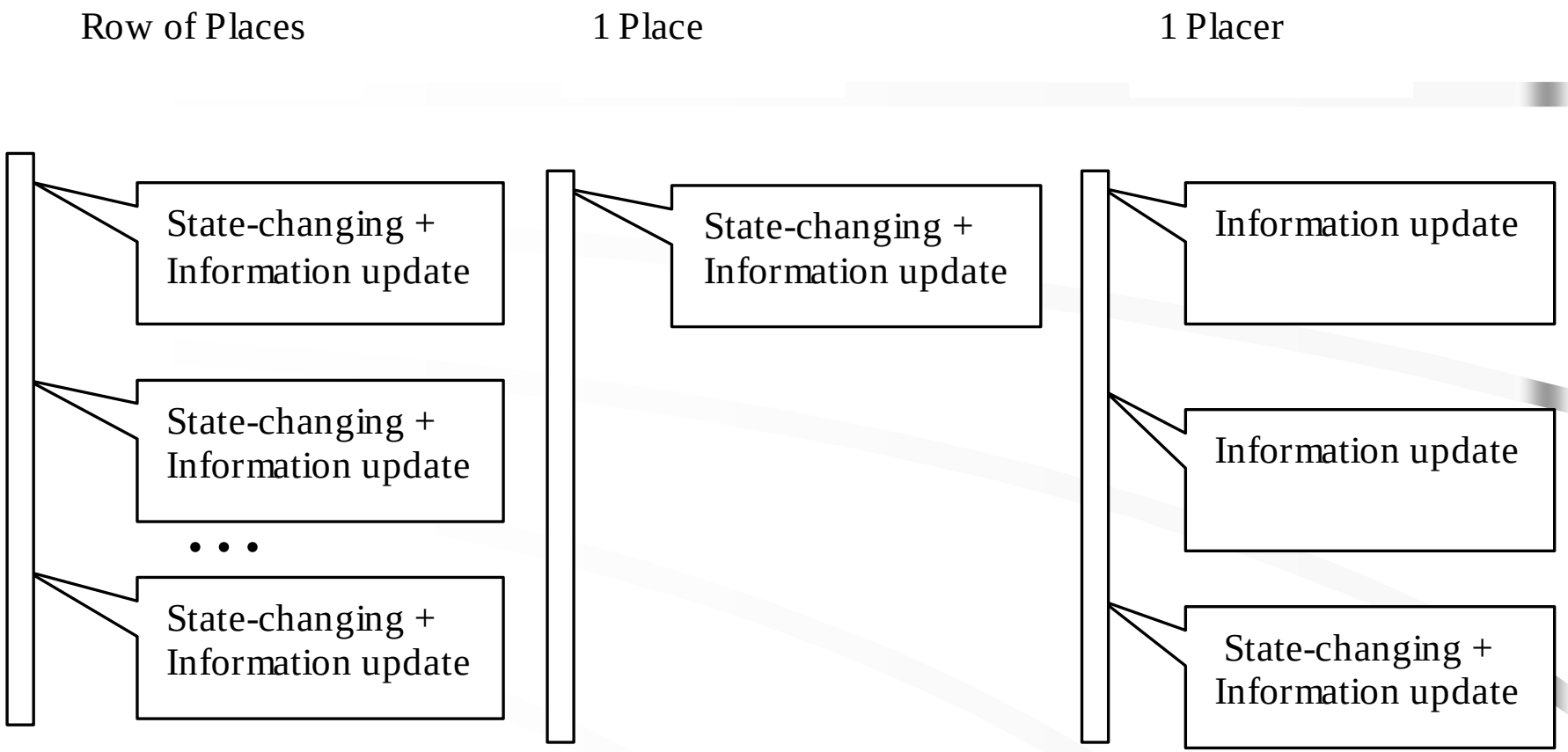
3) **The third group of the new scientific results contains new algorithms for run-length control of simulation.** An adaptive simulation run-length control based on given confidence level and confidence interval has been elaborated. The run-length control algorithm with several factors based on adaptive multistage procedure has been developed.

Modular demon structure



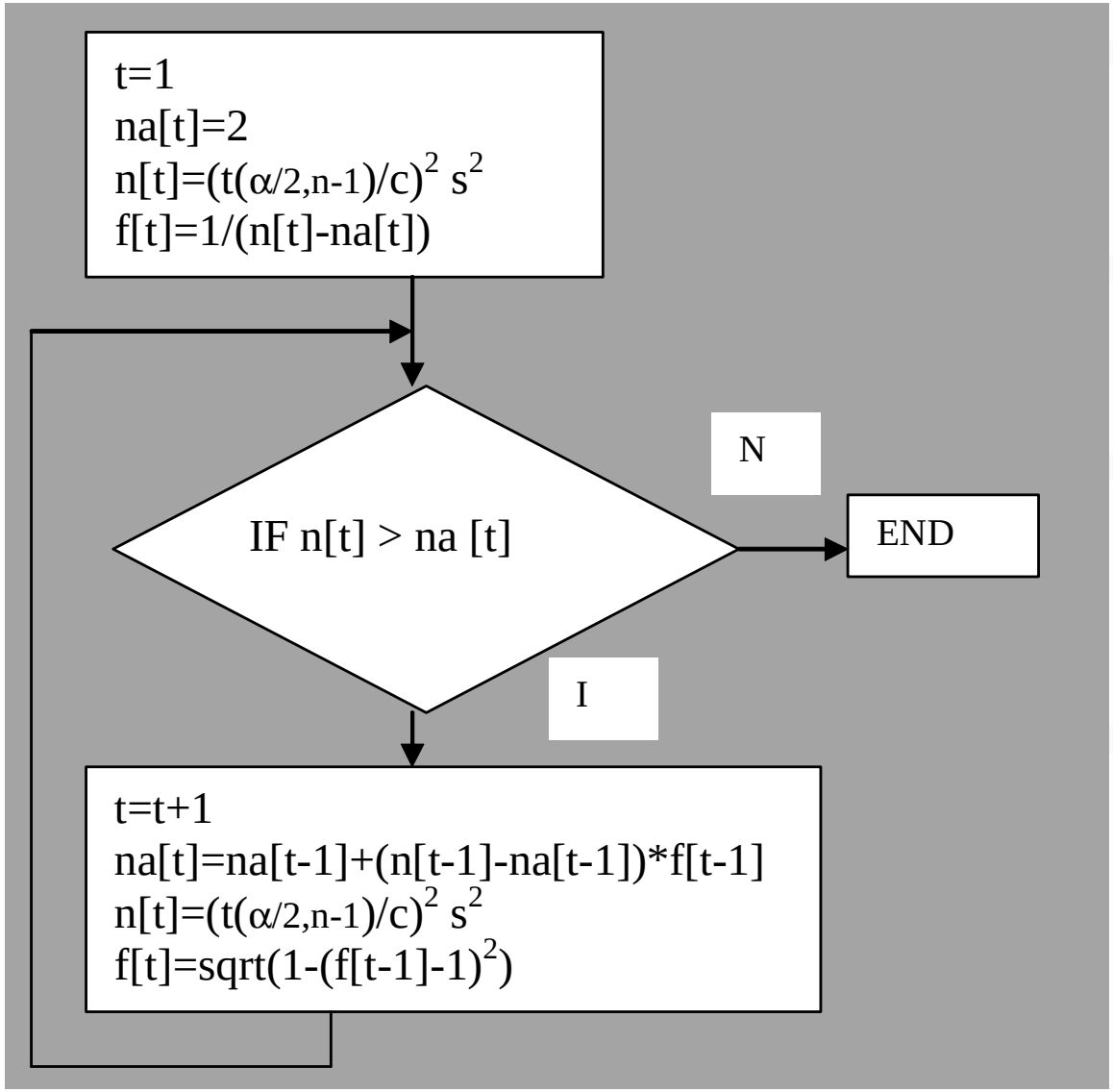
A new structure to increase the efficiency of optimization tasks in discrete simulation has been elaborated.

Placer method in the time control



New model elements for traffic simulation have been elaborated.

Adaptive Multistage Runlength Control (AMRC)

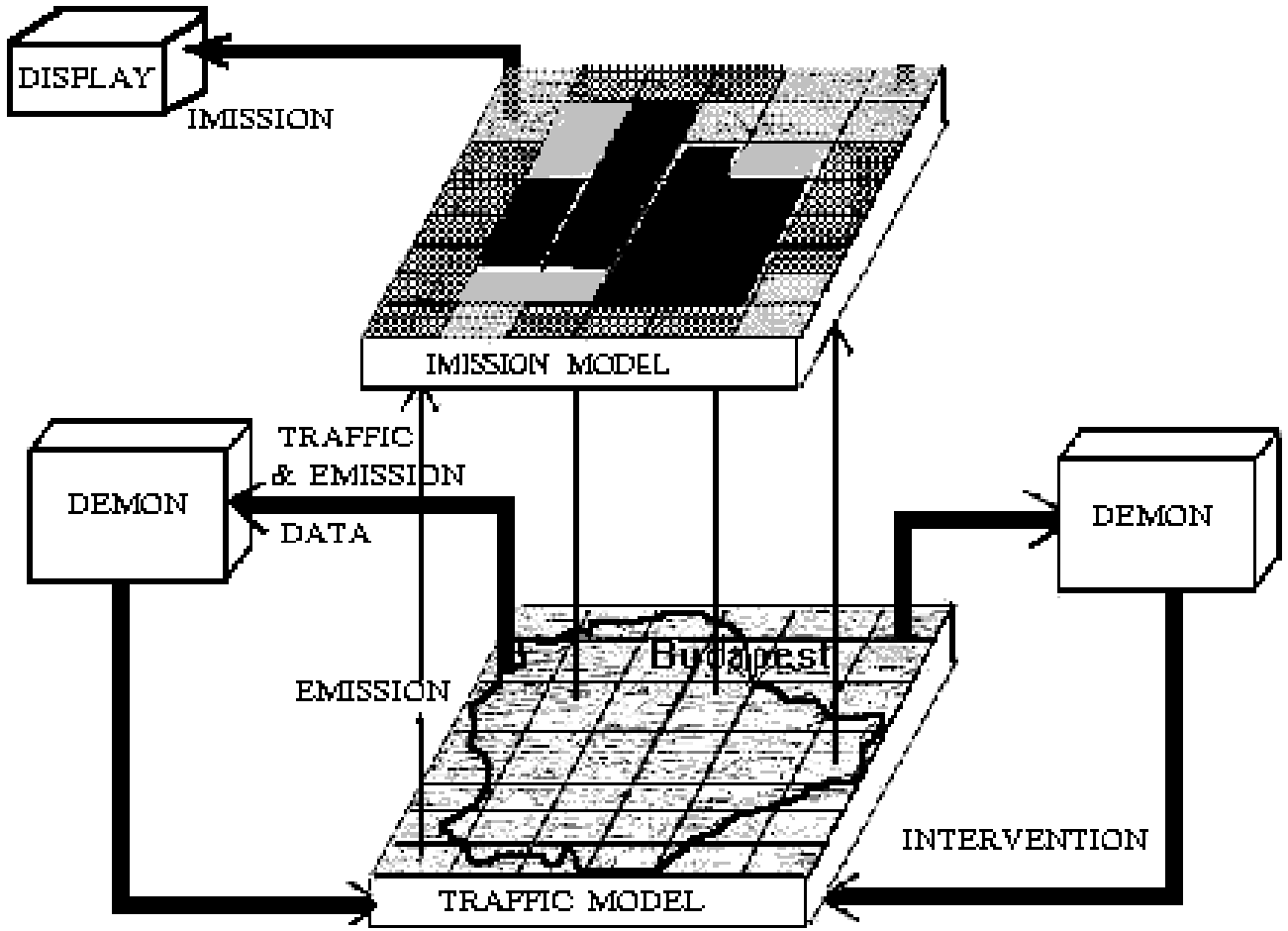


Main block of the new algorithm can be seen.

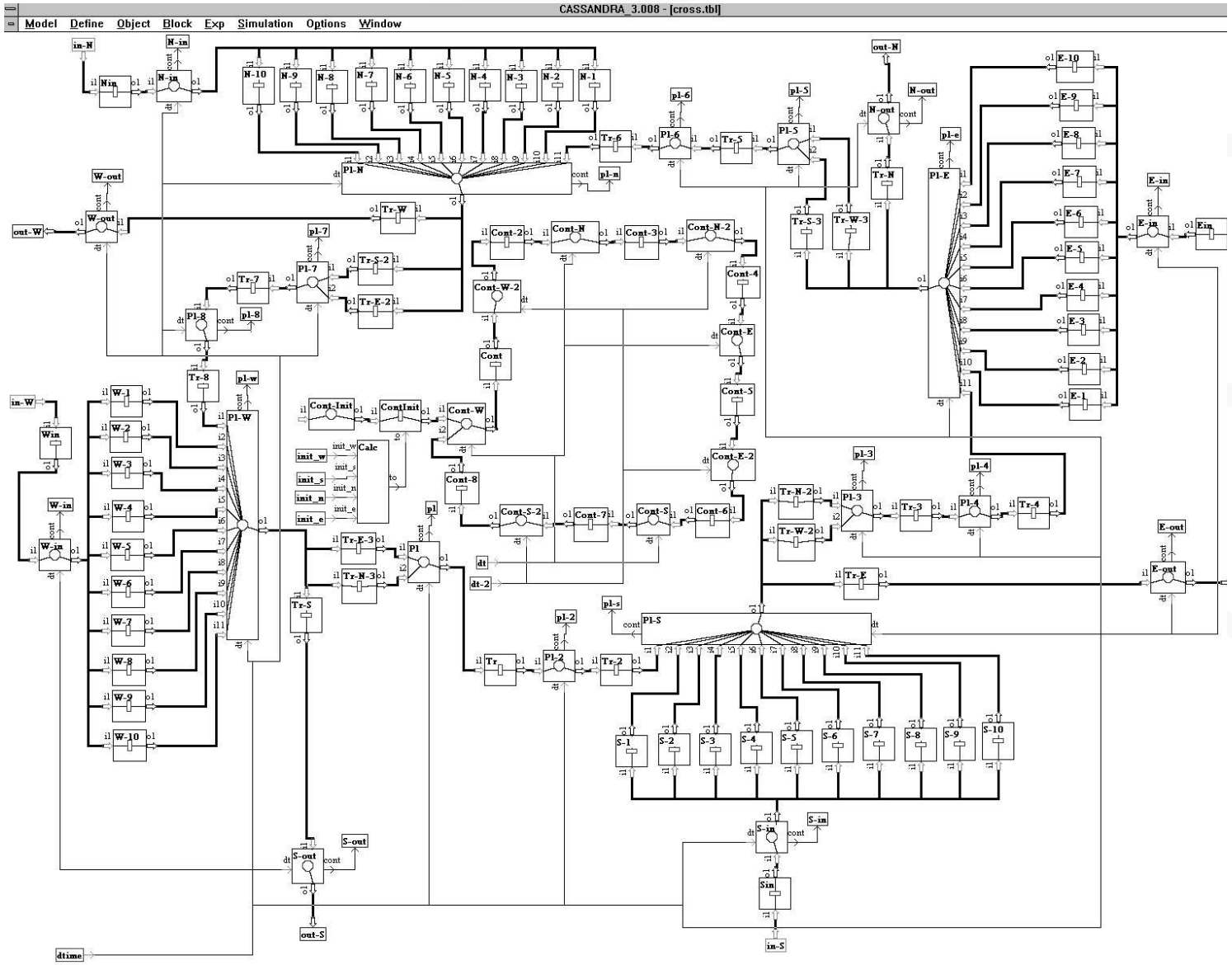
Application fields

The architecture presented in the dissertation can be applied in many fields, particularly in highly sophisticated systems, thus in the thesis transport systems are dealt with, where these methodologies can be used successfully. New methods are reviewed, which promote the development of multifacetted simulation models in road, urban and railway transport systems, as well as traffic caused air pollution models. In case of modeling traffic caused air pollution the traffic-emission line sources supply the air-pollutional emission values, and a user oriented place element has been implemented to be used in Knowledge Attributed Petri Nets.

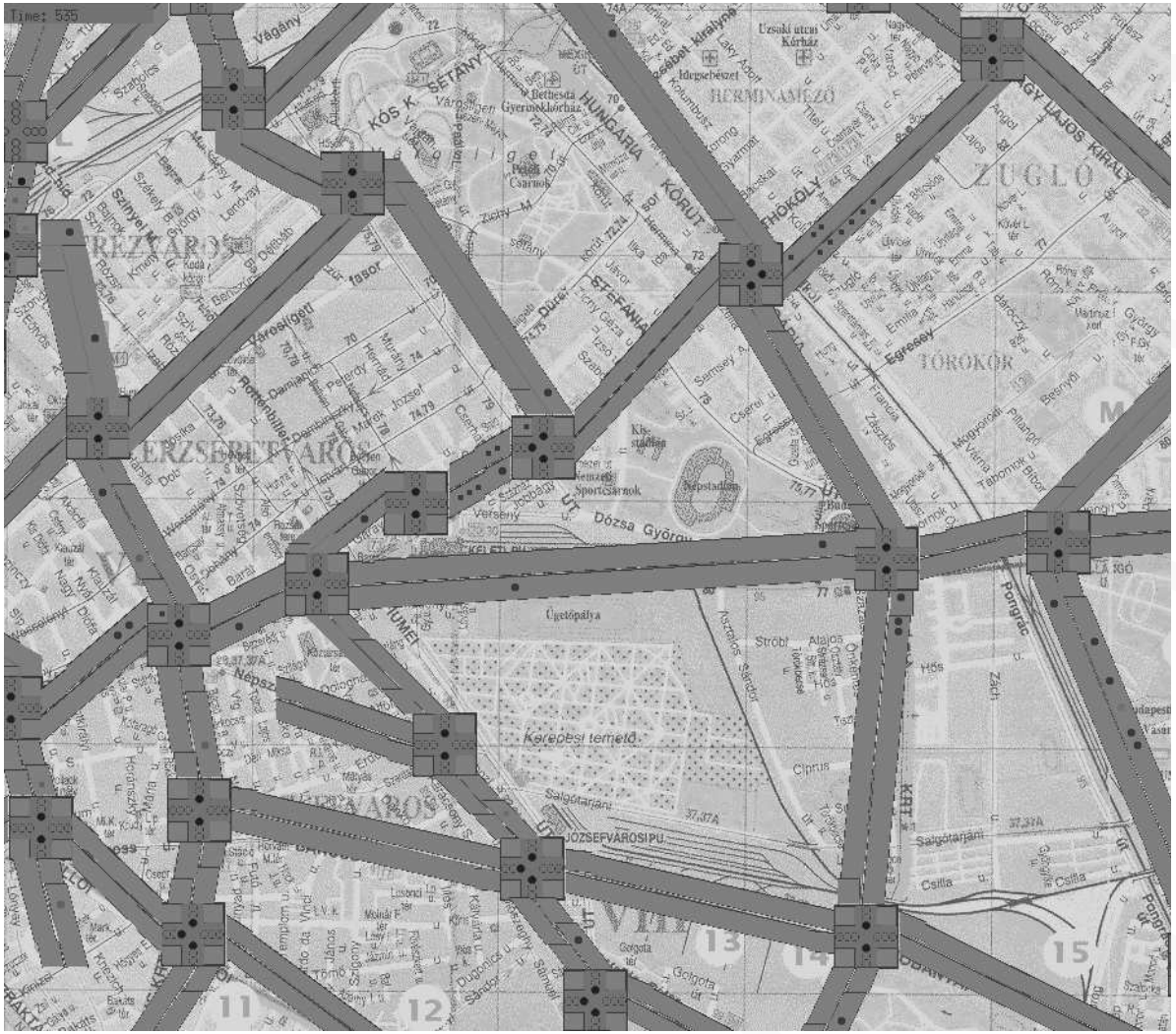
Complex traffic, air-pollution model



Inner architecture of a crossing by Placers



A part (segment) of traffic simulation of Budapest



Results utilized in projects

- "Qualitätssicherung bei Montageprozessen von Produkten mit hohem Sicherheitsanspruch (QUACAR)" (1994-1995) EUREKA-FAMOS
- Parallel Petri-Net Simulation for Traffic Control in Conurbations (PATRIC)" (1995-1997) COPERNICUS
- "Vasútvonal forgalmi folyamata szimulációs modelljének fejlesztése" Hungarian project (1998-1999)
- OSSA (Open Framework for Simulation of Transport Strategies and Assessment) (2000-2002)

The author would like to thank

- Professor András Jávor for supervisor instructions,
- Ágnes Vigh, Tiborné Benkő (research fellows) for helping techniques,
- Dr. István Prileszky (Széchenyi István University, Győr, Hungary) for helping traffic systems,
- Dr. Peter Albrecht (Prokon GmbH, Dresden) for inviting the research team of the McLeod Institute of Simulation Sciences (MISS) Hungarian Center to participate in the EUREKA-FAMOS QUACAR EU project,
- Prof. Achim Sydow (GMD FIRST, Berlin) for inviting the research team of MISS Hungarian Center to participate in an international EU project, COPERNICUS.