VIRTUAL CITY AND TRAFFIC SIMULATION GAME BASED ON SCIENTIFIC MODELS

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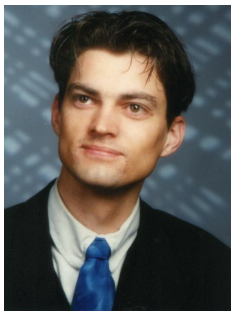
Abstract

This paper is about the development of the traffic simulation game MOBILITY and the forthcoming extended version "virtual city simulation dein|t|o|w|n|" and their usage in education. In 1998 the German BMBF (Federal Ministry of Education and Research) has supported the development of a computer game called "MOBILITY" within the framework of the research programme "Better understanding of mobility and traffic". With the assistance of this kind of software teenager and young adults should learn about traffic related connections, urban development and new concepts of mobility. The experience, which the user gains while playing MOBILITY or dein|t|o|w|n|, should set new impulses for his own mobility behaviour in "real life". The pedagogical idea behind is that the actor learns by experimentation what works and what doesn't. With this requirement it was necessary to model the virtual world as realistic as possible. So the integration of scientific algorithms from traditional traffic based modelling into a game-based environment was the mission to be solved. On the base of the classical urban transportation planning system model or also known as the "four-step model" the overall simulation model of MOBILITY was extended in particular by a network of interactions. This network of interactions describes realistic situation of the traffic in a typical German city.

Keywords: mobility, computer game, effect structure, traffic, deintown.

Presenting Author's biography



Raimo Harder is a traffic and transportation engineer based in Weimar, Germany. Since his study at the University of Hanover the main concentration has been on the alliance of traffic engineering and the helpful usage of computer and software in this field. In the late 80's he was involved in the development of a traffic assignment software called AVUS. Since 1998 he is employed at the Bauhaus-University Weimar mainly as a project manager for the traffic simulation game MOBILITY and the virtual city simulation dein|t|o|w|n|. He is involved in some smaller projects of the EU and since 2001 he heads the engineering office for transport planning and software development called JAVIDO.

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1 Introduction

Traffic is an immediate consequence of the social and economical activities of the people. Based on social, economic and technological factors, the activities of the people constantly change and therefore the traffic volume is varying permanently. The demand for mobility is still increasing. This is one of the reasons for the accumulation of traffic problems particularly in conurbation. In the competition for the use of the transport infrastructure, many different mobility needs clash with the demands of the population for quality of life, which is impaired by air pollution, noise, accident risks and land use (e.g. traffic areas versus green areas).

The widespread environmental awareness and the basic willingness to behave in a more environmentally and sociologically compatible way are not always congruent with people's actual mobility behaviour. This is also attributable to a lack of knowledge of the real consequences of common mobility decisions and of more acceptable alternatives. Therefore, the knowledge of advantages and disadvantages of individual means of transportation and new concepts of mobility (e.g. car sharing, car navigation systems, or prioritizing public transportation) is a requirement for achieving non-polluting traffic behaviour.

In order to reduce that lack of knowledge, educational institutions like grammar schools and universities are required to set up for these challenges and to perform explanation work. However, suitable tools, providing the complex and often complicate matter in intelligible form, are missing up to now.

The German Federal Ministry of Education and Research (BMBF) has noticed this need and therefore it has started the research initiative "Better understanding of mobility and traffic". Integrated research in the fields of transportation, sociology, and economics intend to close these knowledge gaps and prepare results in such a way that they can be translated into generally understandable target group-related information, which will be accessible to all road users and decision-makers.

Within the framework of this research initiative the German BMBF supported the development of a computer game called MOBILITY for the target group "young adults" (aged sixteen to thirty). With this multimedia computer game, they want to start new ways to promote “cross-linked thinking” to clear up the complex connections between mobility causes, traffic formation and traffic orders.

2 Simulation game like SimCity

On the one hand MOBILITY is designed as a city-building simulation game like SimCity. On the other hand it has some characteristics of a business game or also called “gaming simulation” (German: Planspiel).

A simulation game, or sim game, is a game that contains a mixture of skill, chance, and strategy to simulate an aspect of reality. In the case of MOBILITY the objective is to build and design a city, without specific goals to achieve (except in the scenarios). The player can mark land as being zoned as commercial, industrial, or residential, add special buildings, change the tax rate, build transportation systems and many other actions, in order to enhance the city. In contrast to SimCity the main focus is to manage the traffic in the town. So public transport, road construction, parking, and traffic lights, are the centre stage of the game.

Some of the characteristics that are elements of a business game (German: Planspiel) are also part of MOBILIY. It is an operating model of a real life system in which the actors in roles partially recreate the behavior of the system. He has predefined possibilities to influence the system. As a general rule the actor makes a single decision and then he finds out the consequences and reactions of a complex cross-linked system.

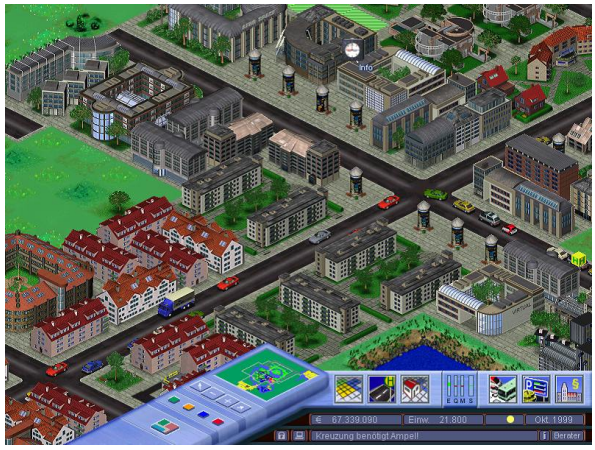

Fig. 1 Traffic simulation game MOBILITY (1999)

3 Network of interactions

The network of interactions describes realistic situations of the traffic in a (German) city. The integrated description of this subject is achieved with the aid of structured, cross-linked subsystems. The interactions are generally modelled in a macroscopic view.

At the beginning the problem was to collect and to describe the relevant variables for the network of interactions. Finally, more than 80 variables were found, which were divided into five subsystems (Tab. 1).

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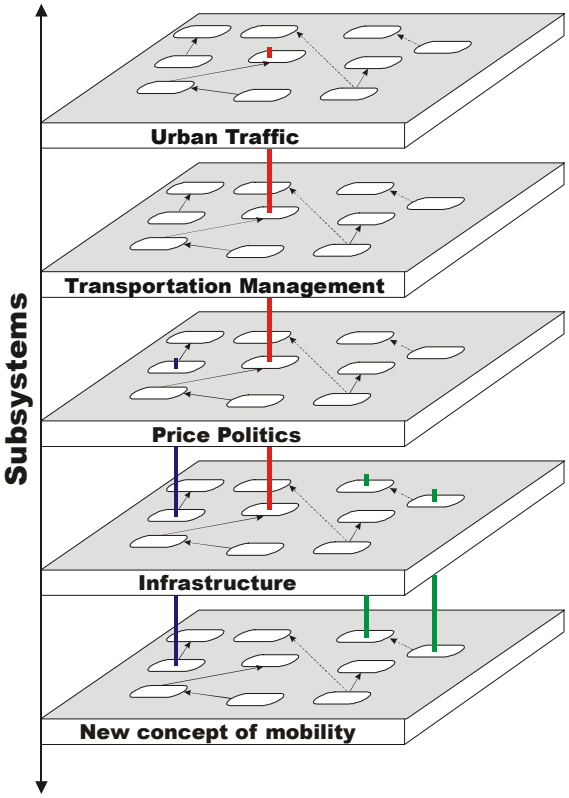

Fig. 2 Network of interactions - figure of subsystems

Tab. 1 Subsystems and a choice of variables

Subsystem	Choice of variables
Urban Traffic	– environmental choice of transportation mode – mobility
Transportation Management	– total kilometers travelled – park-and-ride
Price politics	– tax for motor vehicle – fare for public transportation
Infrastructure	– upgrading of the street network – installation of traffic lights
New concepts of mobility	– contingent of microcars (e. g. smart) – PTA (Personal Travel Assistant)

Accordingly all direct bilateral dependences of two variables are to be detected by a matrix. So more than 160 single relationships were found (Fig. 2). A plus sign in the matrix means that an increase of the source variable effects an increase of the target variable. The minus sign means the reverse: the increase of the source variable will effect a decrease of the target variable.

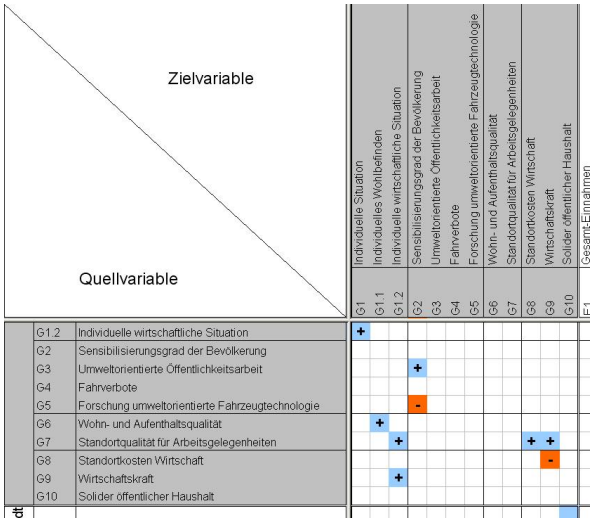

Fig. 3 Extract of the matrix of variables

As a result, a quantitative context was defined for each effect relationship. Furthermore, it was apparent that a temporal dependence must also be considered. For example, the reduction of the fare for local public passenger transportation will result in an increase in public transportation. However, this change is not expected to occur by today or tomorrow. Rather, this process will happen within several months.

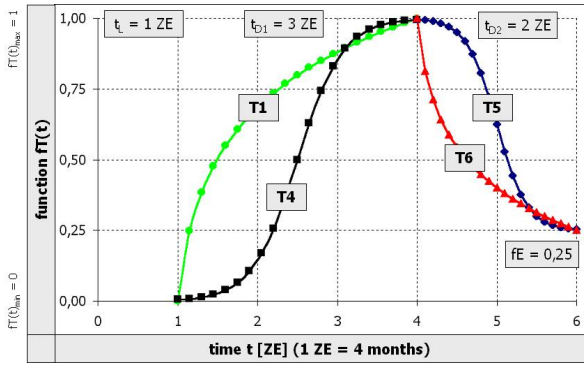

Fig. 4 Predefined function of time

4 Theoretical description of the model

The network of interactions is a directional graph with source and goal relations. Over the exchange of information, the network of interactions works as a time-discrete and event-oriented transceiver-model, in his nodes execute isolated processes sectional with individual process dynamics.

Each node of such graph is both, transmitter as well as receiver. Exceptions are the variables changeable by the user and the indicator variables that form the start points and final points of effect-chains.

The qualitative or also quantitative changes of the beginning state leads in the form of a "snowball-

system" resulting in the spread of the effects in the entire network and finally ends in a new state of the system. Thus, new state orders form, enabling the simulation of the development of a city and its traffic over time.

In most cases, the term "variable" is not only understand as a simple variable. The term has its own time-afflicted processes with its own devolution. These processes activate time-delayed reactions against each other. In this case, moving connections occur repeatedly.

Based on the complex network of interactions, a network of parallel processes originates. The reconstruction of dynamic structures necessitates the use of special methods and tools of modelling. These tools should have a component to simulate time and a component to calculate parallel processes.

The authors have decided to use the simulation tool called "PACE" [2]. This theory behind this tool of advanced "Petri Nets" is a formal and graphical appealing language, which is appropriate for modelling systems with concurrency. Petri Nets has been developed since the beginning of the 60'ies, where C. A. Petri defined the language. It was the first time a general theory for discrete parallel systems was formulated. The language is a generalization of automata theory such that the concept of concurrently occurring events can be expressed.

With the simulation of complex connected systems, the calibration and validation of the model is very important. From experience the evidence of a realistic behaviour of the model arranges itself with complexity. Alternatively, plausible demands are apparent which give cause for the simulation to be criticized. For a comparability of the results it is important that the starting point of the calibration is a reproducible situation.

After the implementation of different types of test procedures, it is determined that the model sufficiently reacts realistically.

5 Overall model MOBILITY

The network of interactions, which is described in the previous chapter, is the main of six complete modules (see figure 3). It is connected to all of the other modules and the effects of all player-decisions are determined here. For example, if the variable "choice of transport mode" changes, that has effects to the module "demand of traffic." On the other side results of the module "traffic assignment" have effects to the network of interactions.

The city-development-model is responsible for the growth of the city, the finance-model calculates balances and the model of infrastructure describes the whole band of infrastructure.

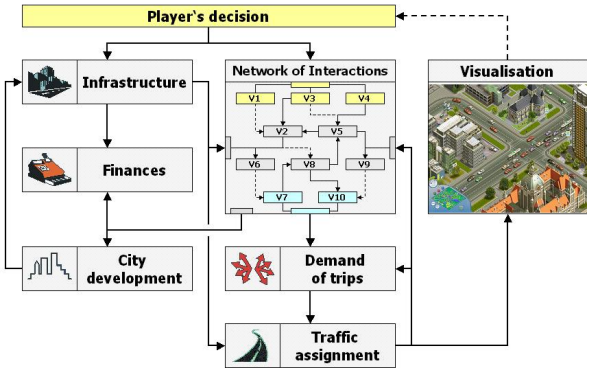

Fig. 5 Sub systems of MOBILTY

6 Dissemination and feedback

MOBILITY is a Software for Windows PC. It is a very popular simulation game in Germany but also in other countries. Up to now MOBILITY has been handed out 500,000 times. Those are 80,000 ordered CD-ROMs as well as 420.000 download over the Internet. With the assistance of bundled CD-ROMs in three German computer magazines (c't, Computer Bild Spiele, PC Pr@xis) the game has reached a wide dissemination of more than 1.000.000 copies.

MOBILITY gets many positive comments in German magazines, newspapers and in the Internet. Some comments from the Internet are: "best simulation game for free ever", "a great traffic simulation", "Mobility is much more ambitious than other games of this kind". For the computer magazine c't it was one of the best simulation game of the year 2000 [7].

After the first release of MOBILITY in the end of 1999 the software was published for free (except postage for delivering the version on CD-ROM). The actual version 2.20 of MOBILITY is published as Shareware and it is available for Windows as well as for LINUX. MOBILITY is trilingual German, English and Italian. More details can be found in the Internet at www.mobility-online.de.

7 From MOBILITY to dein|t|o|w|n|

The next version of MOBILITY will be published in 2007 and it is called dein|t|o|w|n|. It is a new kind of learning software not only for teenager in school but also for students at university. It can be used under survey of a teacher during the regular lessons or by self-study learning.

dein|t|o|w|n| has two main parts. The first part is similar to a class book with aspects to transfer the knowledge via text, figures, pictures, and animations. There are 13 learning units separated in three subject areas A, B, and C. It also contains different kind of tests and questions to measure the student's knowledge: single-choice, multiple-choice, free-response question, right-or-wrong sentences and so on. Furthermore it contains a glossary and all shown figures are exportable in print quality.

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The second part of dein|t|o|w|n| uses the traffic simulation module from MOBILITY but with additionally functions and a modified graphic engine. Every learning unit ends with a small simulation exercise with reference to the learning unit. The possibilities to interact the simulation are reduced to the minimal necessary features to solve the exercise. In general for this exercises the time is limited to five or ten minutes.

Moreover the traffic simulation module is used for more comprehensive exercise for about 20 minutes. And there are some city scenarios where the actor can use the whole functionality of the simulation with no time limit and no special exercise.

dein|t|o|w|n| will be a commercial software because the development of the programme is only partially financed by the government and third parties. The release is scheduled for the late summer of 2007 and the distribution will be handled on the website www.deintown.de.

Fig. 8 Overview of the content of dein|t|o|w|n|

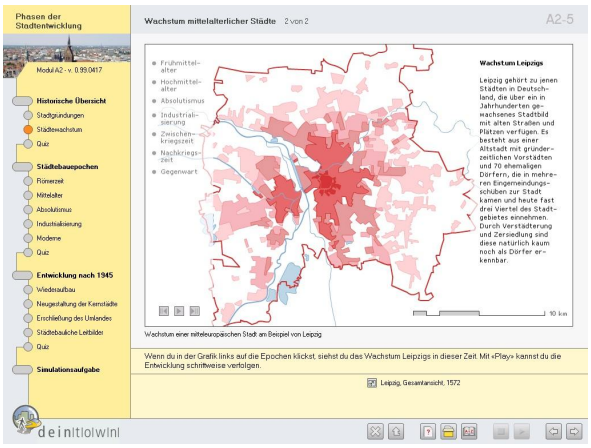

Fig. 8 Sreenshot of a page with an Adobe Flash animation (previously "Macromedia Flash") in dein|t|o|w|n|

Fig. 9 The new graphic engine of the traffic simulation module in dein|t|o|w|n|

Fig. 10 Beta testing: a lecture for students with dein|t|o|w|n|

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