Microscopic real-time simulation of Dresden using data from the traffic management system VAMOS

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Abstract

In the city of Dresden the VAMOS traffic management system is developed to collect all available traffic-related data from numerous detectors and to process them for monitoring and decision making. In most cases aggregated traffic data is used to define traffic management interventions and strategies. In some cases, especially for choosing the strategy for the next time period, it is useful to reflect first on the current traffic situation, in order to examine the effects of different strategies. This is done by the microscopic traffic simulation software SUMO, which has a real-time I/O data interface. This means that an interaction during the simulation is possible, importing current detection data and traffic signal states from the field now, in order to obtain effects on e.g. delays, tailbacks, emissions and noise just a moment later. Based on these results an advice about which strategy is most efficient can be given. In this paper the system's setup is described, supplemented by two of the first examples of its use.

Keywords: Traffic Management System, Microscopic Traffic Simulation, Real-time Capability

1. Motivation

Traffic management systems are essential for operating sophisticated road networks in metropolitan areas. They combine on-line measured data from several data sources in the field to capture the current traffic state. The processed information supports the operator in order to recognize incidents and to fight congestion by applying one of the predefined strategies influencing the system's actuated elements like traffic signals, dynamic route advisory displays or variable speed signs. The challenge in that process is how to choose the best suiting strategy for the current situation, which is usually based on the experience of the operator. A taken decision can work out in the right way and clear the situation, or it can be wrong and even make it worse. The problem is the lack of possibilities to evaluate a strategy before applying it in the field. If at all, those strategies are only optimized one-time during the planning process of the management system by using a specific situation from the past to fit a set of parameters. When afterwards the detected and the underlying situation differ from each other the applied predefined strategy was implicitly not the optimal choice.

Focus of this work is to use the already existing on-line traffic data from a traffic management system for replicating the current traffic situation simultaneously in a traffic simulation. With this simulation it becomes possible to examine the effects of the system's different intervention strategies before applying them in the field. The operator can run a rapid benchmark to compare his available options on criteria e.g. optimizing vehicles' delay times, tailbacks, the number of stops or vehicle emissions and afterwards can choose the best one. Even immediate and automatic adaption of existing strategies or autonomous testing of new strategies like [4, 5] becomes feasible. The base for this research is the traffic management system VAMOS [3, 8] in the city of Dresden, mainly developed by the Chair of Traffic Control Systems and Process Automation at Dresden University of Technology and the microscopic simulation suite SUMO [2, 7], essentially developed by the Institute of Transportation Systems at the German Aerospace Center.

2. Real-time simulation system

2.1. System setup and requirements

For a simulative real-time replication of the current traffic situation the VAMOS management system must be connected with a server hosting the simulation program SUMO. On this SUMO simulation server the accurate model of the existing road network, the entire other infrastructure and the available management strategies must be modelled. Then the simulation needs to be permanently supplied with current traffic data from the VAMOS data base which is fundamental for achieving the objective of real-time capability. Due to this a special I/O data interface must be applied representing one of the project's main challenges. This setup consists of the three components VAMOS management system, SUMO simulation suite and I/O data interface and is depicted in figure 1. It will be specified in the following chapters.

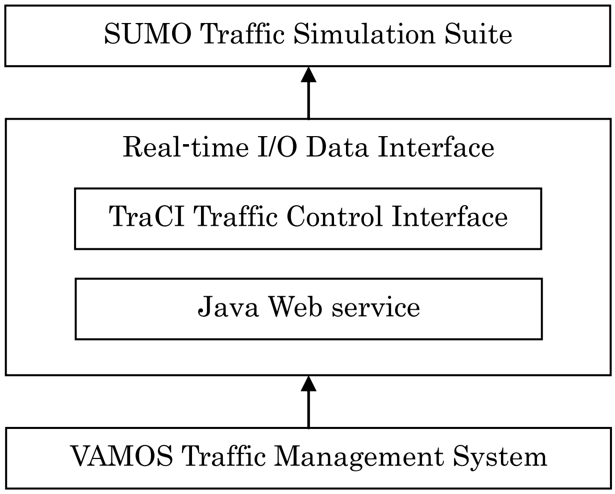

Figure 1 – Setup for the real-time simulation with its three major components

Obviously, there are some more requirements than the just mentioned I/O data interface to create a platform for real-time evaluation. Not only the I/O data interface needs to be real-time capable but the whole chain from measuring the traffic data in the field, storing it in the VAMOS data base, importing it to SUMO and running the simulation. In this context real-time capability means to keep the latency below 5 minutes which is an ambitious objective. The simulation itself must be able to handle several instances of one scenario, running at the same time for the comparison of the available strategies.

2.2. The Traffic Management System - VAMOS

The traffic management system VAMOS [3] is the technical base for the whole setup. It is founded on a mathematical model of the road network of the city of Dresden which contains about 7.000 nodes, 20.000 edges and at least 40.000 lanes. Data from various single and double induction loops, traffic eye universals, traffic signal controllers, floating cars (500 taxis), parking area detection and on-line cameras are gathered, processed and stored in various databases. The operator has the opportunity to analyse that data and set e.g. traffic signals or dynamic route advisory displays. Some fixed strategies are proposed by the system e.g. for an alternative routing when the motorway is closed, but they are not evaluated depending on the current traffic state. Figure 2 shows the VAMOS management center at Dresden University of Technology which is an exact duplicate of the city’s real management center. It acts as a client, receives the same traffic data, processes the same information and has implemented exactly the same intervention strategies but has no access to the system’s actuating elements. All available information like the traffic states on the road segments, the positions of the detection infrastructure or special POIs are shown on different layers. Further information about the VAMOS traffic management system is available on-line [8].

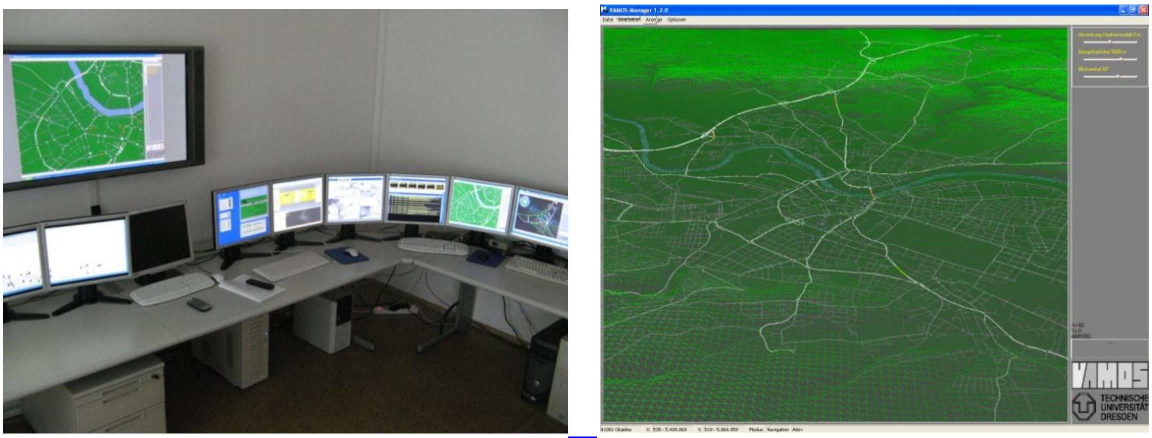

Figure 2 – VAMOS management center (left) and VAMOS user interface (right)

2.3. Simulation base SUMO

For modelling and simulation the open source simulation suite SUMO (Simulation or Urban Mobility) [2] is used. SUMO is a microscopic traffic simulator which includes network import e.g. from Open Street Map, VISUM, VISSIM or other sources, demand modelling and routing utilities supporting e.g. origin destination matrices or traffic counts. That means the import of the existing VAMOS road network model and of the continuously measured flows is possible. Each vehicle has a route which can be redirected during the simulation, a type to differentiate between e.g. cars, trucks, buses or trams and a set of other parameters to specify further characteristics. The parameters for the driving behaviour are required as input for the car-following model developed by Stefan Krauß which updates the position and the velocity of each vehicle in every second. The strength of SUMO is its high performance simulation which is usable for only few intersections or even for an extensive road network like in the city of Dresden. This is important for the required real-time feasibility of the system's setup. SUMO allows generating various outputs for a simulation run to compare numbers like delays, tailbacks, emissions and noise. These results are finally utilized to suggest the most efficient strategy to the operator in the traffic management center. The user interface of SUMO is depicted in figure 3, additional information about SUMO and the software itself can be downloaded [7].

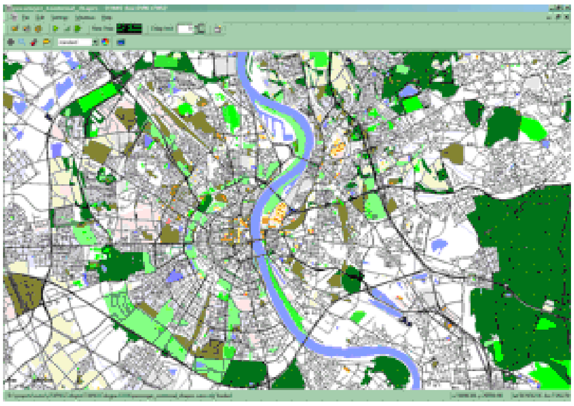

Figure 3 – SUMO simulation of a whole network (left) and a single intersection (right)

2.4. Real-time I/O data interface

A special real-time I/O data interface is applied to pass the gather traffic data from the VAMOS data base to the SUMO simulation. It consists of a Java Web service and an interactive simulation interface, so called TraCI (Traffic Control Interface). TraCI is already a tool in the SUMO simulation suite and gives access to a running simulation. On one hand current values of all objects in the simulation like vehicles, traffic signals or detectors are retrievable with TraCI, on the other hand it is also possible to change the states of these objects, which is important for the assessment of the available management strategies. With this function new vehicles can be imported to a running simulation as soon as they appear in the VAMOS data base e.g. when they were detected by an induction loop. To test the different strategies, all belonging interventions like modified traffic signal programs can be passed in the same manner. The data export from VAMOS via TraCI to SUMO is handled by the mentioned Java Web service. It was newly implemented to pull the stored traffic data from the VAMOS data base and to push it to TraCI for interacting with the simulation.

3. First use cases

3.1. Basic conditions and state of work

So far the concept is generally implemented but still not finished. All three components of the chain are connected with each other and the traffic data from the VAMOS management system can be passed to the SUMO simulation. The preliminary exchanged data are traffic signal states, public transport telegrams and vehicle counts. They are available for numerous signalized intersections, tram stops and counting points distributed all over the city. These data are aggregated and exported to data files which are parsed by the Java Web service. This intermediate step of export will be omitted in the future and replaced by straight database access but is still necessary for the improvement of the I/O data interface. In the following passages two first uses cases will be presented. They demonstrate the opportunity of system's setup on the whole and show the benefits of assessing some available intervention strategies.

3.2. Assessment of traffic signal coordination interventions towards traffic quality

In a first realistic simulation [1] an important arterial in Dresden with length about 10 kilometres was modelled. The model contains 15 traffic adapted signals with the opportunity to prioritize the public transport. In conventional simulations the entire control logic of all traffic signals needs to be implemented which is very time-consuming and difficult to calibrate in real-time Therefor another approach is chosen, here the VAMOS management system can pass the real signal states directly one-by-one to the running SUMO simulation. The benefit of that method is fact that the simulated and the real behaviour of the signal controllers in the field are equivalent. By using the online data from local detectors like double induction loops or traffic eye universals the traffic volume and the individual traffic composition can directly be passed into the simulation.

With a powerful I/O Interface various information about every part of the simulation e.g. vehicles, edges and lanes for every time period are available. The opportunity to detect congestions and traffic jams in front of traffic lights is part of an analytical process by using different kinds of Filters.

Figure 4 – Snapshot of the current traffic flow computed with SUMO (Dresden)

3.3. Assessment of public transport prioritisation interventions towards emissions

In a second realistic simulation [6] a single intersection was modelled and used to pass traffic demands and signal states from VAMOS to SUMO. In that case various kinds of emissions are calculated in real-time, depicted in figure 1. Measuring emissions is a true challenge; therefore it is very helpful to have a simulation-based assessment in order to choose the best suiting signal program to reduce these emissions. To increase the accuracy of the computed emission values double induction loops are used to get the current amount and the exact composition of the vehicles at a specific time. An algorithm decides which emission class fits the best to the recognized vehicle. This is done with help of the Handbook of Emission Factors for Road Transport (HBEFA).

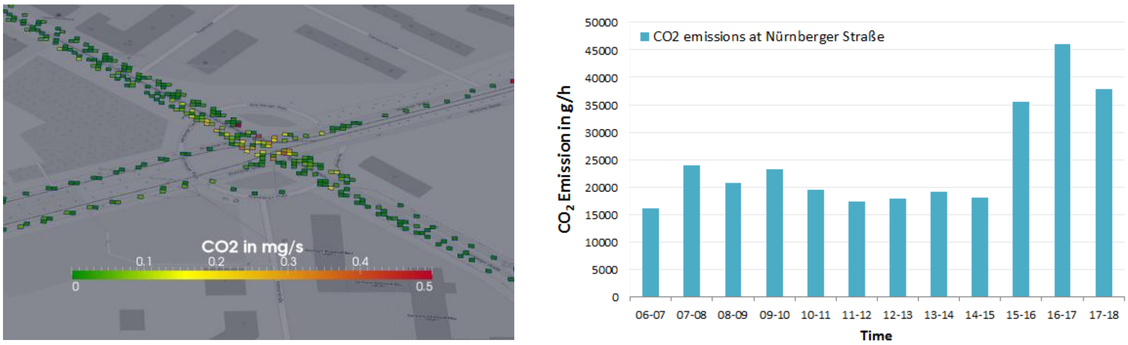

Figure 5 – Computed CO_2 Emission of vehicles (left) and aggregated for Roads (right)

4. Conclusions

In this paper a real-time simulation system is presented which makes it possible to first assess available intervention strategies of a traffic management system before setting them in the field. Thereby different strategies can be compared for a current traffic situation and the best suitable one can be suggested. This information supports the operator in the management center, it helps to avoid wrong decisions, and it can fight congestion efficiently. For that rapid benchmarking of the different strategies the simulation suite SUMO is connected with the VAMOS traffic management system via a special real-time I/O data interface. The gathered on-line traffic states are matched to the imported road network and the simulation is executed. As a result numerous output values e.g. delays, congestions, emissions and noise are offered for selecting an appropriate strategy. The two presented use cases of interventions towards traffic signalling and public transport prioritisation demonstrate the feasibility of this concept. After these first promising results the implementation of the described real-time simulation system will be continued to evaluate all available intervention strategies and to extend the VAMOS traffic management system by this valuable simulation feature in the future.

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