52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | **10 - 13 September 2007**

FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

TECHNISCHE UNIVERSITÄT
ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	 Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

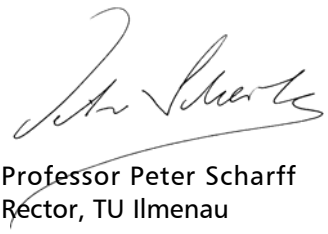
- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

Table of Contents

C O N T E N T S

Paper submitted after copy deadline

2 Advances in Control Theory and Control Engineering

52nd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10 – 13 September 2007

M. Abel / Th. Lohfelder

Simulation of the Communication Behavior of the German Toll System

Introduction

In Germany, toll is collected on all motorways and some selected national roads by the company *Toll Collect* [1] for vehicles heavier than 12t. In the following we will use "truck" for all toll-relevant vehicles. A truck driver can either use the automatic system, or book his journey manually before entering the toll-roads. Roughly, the automatic system consists of a central part, the computer centre and the OBUs as mobile components. About 540,000 trucks are equipped with this innovative device which determines its position by using Satellite technique (GNSS), and autonomously calculates the toll to be paid dependent on the distance travelled. The toll information is sent by mobile communication to the computer centre, and the logistics enterprise is billed for it. Taking into account the intricate data processing and spatio-temporal interdependencies of the sub-units of the computer centre, the system is among the most complex communication networks in the world. In this paper, we present simulations concerning the part of the automatic system occupied with remote device management: the update of the On-Board Units (OBU s) by mobile communication (GSM).

The key technology for the positioning is the Global Navigation Satellite System (GNSS), similar to the systems for personal use in cars. Of course, higher standards apply for toll collection with respect to availability, accuracy and reliability. Additionally, the OBU has to keep account about the distances driven, the tariffs in use and vehicle related information, like emission class, and number of axles. When an OBU drives on a toll-road it accounts for the toll and stores the amount to be paid encrypted on a smart card, similar to credit cards. When a certain limit is reached the amount is communicated by GSM services to the computer centre; from there the user receives a bill on a monthly basis.

Apart from money transfer, up-to-date information about new geo data (e.g. roads),

new tariff data and software (the “components”) has to be provided for and distributed to the OBUs. This distribution is highly nontrivial: the OBU is conceived in such a way that it many functions can be fulfilled autonomously, especially with respect to the process of updating information: it asks the centre, if any updated information is available. The centre communicates the state of the OBU data and the data present at the centre, this includes a timestamp after which the OBU information expires. Based on this procedure, the key requirements for a smooth update process are formulated: All OBUs should ask within the validity of the stored data for new information to ensure that no toll is lost due to missing geo or tariff data. Secondly, the OBUs should not ask all at the same time, otherwise mobile stations and central units would be unnecessarily overloaded. Thirdly, the distribution of the different components shall be independent from each other. To fulfill these requirements, Toll Collect has developed an intelligent distribution and monitoring system.

To obtain detailed predictions on the expected behavior of all registered OBUs, a simulation is of immense help. There are several advantages of the simulation approach: one can easily scale the system up or down in number, study worst-case scenarios, and finally one has the possibility to control efficiently the driving mechanism for the simulation, namely the activity of the trucks on the roads. This is a crucial factor, because a truck which is switched off most of the times obviously cannot communicate to the computer centre and thus needs special treatment for updates.

The modeling of the activities results from data mining; we use the unique data base of Toll Collect, where statistical analyses are run [2]. For our considerations, it is sufficient to model the temporal activity of the OBUs, i.e., on/off behavior, we do not need the spatial information on where the trucks drive.

Simulations have been carried out using MLDesigner [3], a very flexible next-generation system level design tool that combines the capabilities to model and analyze the architecture, function and performance of complex high-level systems. Different levels of abstraction can be accessed with most-common modelling domains like Discrete Event, Finite State Machine and Dataflow.

In the following section we describe some details of the update process, as used in the simulation. We explain our simulation strategy and show some graphs concerning programming and the final results. In the last section we conclude with a short discussion and outlook.

Simulation

The basic modules of the simulation are Driving, OBU, and Computer Centre, cf. Fig. 1. In these modules, the complex logic of the OBU and the computer centre is modeled and communication processes are worked out as detailed as needed. For the communication OBU-centre, the GSM service is used for a TCP/IP secure connection there are elaborate cryptographic algorithms in use which ensure that the data cannot be corrupted. The centre provides a certain number of ports which, of course, should be used in an optimal way. For toll collection all active OBUs must receive their update until validity expires, another task is the determination of the load on the ports. For the first, it is clear that a too short window for the distribution of updates yields a loss of the OBUS which have not been active in that window. On the other hand, geo-data must be up-to-date, such that distribution takes typically place within short time intervals. An obvious question for optimization concerns the number of ports necessary to communicate updated information to the OBUs reliably within a given time interval. Such questions are studied by means of our simulation.

.

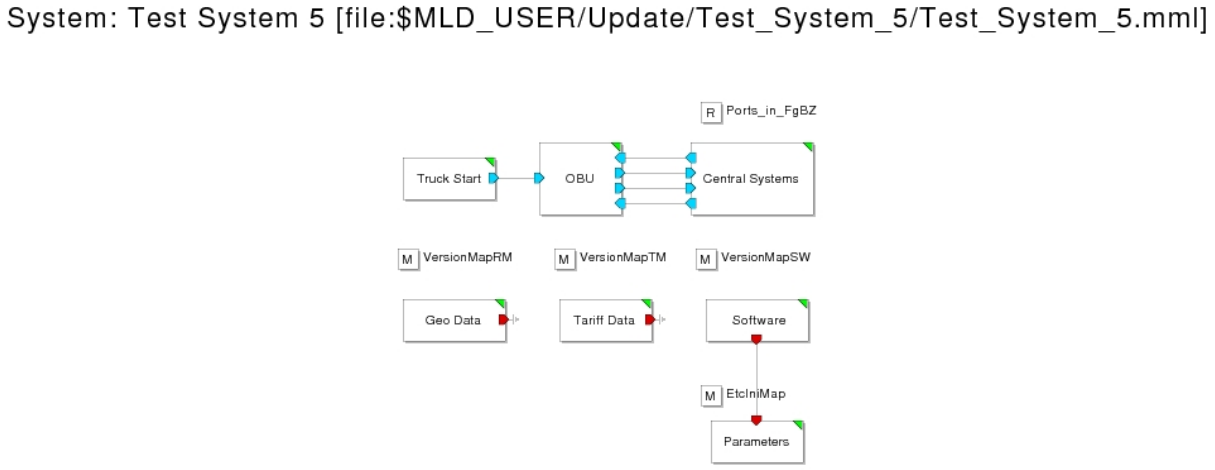


Figure 1: Schematic picture of the simulation with MLDesigner. The lower Modules provide the data relevant for the timing of the update process and other system parameters.

Results

To simulate the system, we create for each OBU a data structure containing the individual state of the OBU. The activity of the OBU is modeled by a hierarchical stochastic driver such that the important statistical properties, like number of daily journeys and recurrence rates are reproduced. Since our programming was optimized for storage (and speed of course), we can run easily up to 700,000 trucks on a computer with 1 GB RAM, to be compared with the current number of OBUs of ca. 600,000. A typical simulation yields the number of OBUs with updated information for each component. For this publication we simulated 50,000 OBUs with stochastic activity over 200,000 min, i.e., ca. 140 days. This is sufficient because traffic systems are scaling, i.e., apart from statistical outliers the main properties can be represented by a fraction of the real system [4]. The activity curve is shown in Fig. 2. One recognizes the weekly activity with gaps on Saturday and Sunday.

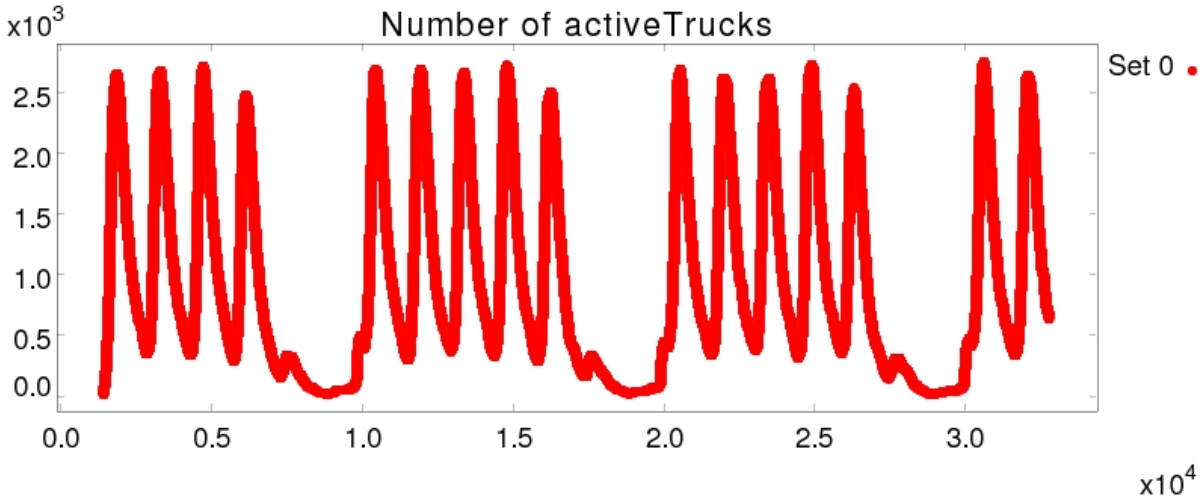


Figure 2: Activity output of our stochastic generator. The values correspond well to the activity observed by the Toll Collect data base. Saturday and Sunday evening activity (after the driving ban on German motorways) is seen by small peaks.

The time is given in minutes, the first 20,000 minutes (ca. 14 d) are transient. From 120,000 min to 167520 min (83 to 136 d) an update for geo and tariff data must be downloaded by the OBUs, software version 1 must be downloaded between 50,000

and 100,000 min, (35 to 69 d) another version from 120,000 to 180,000 min (83 to 125 d). In Figs. 3 and 4 the results are displayed. We see that the statistical distribution algorithm fulfills the requirements almost perfectly. In reality typical update intervals lie between 15 and 30 days.

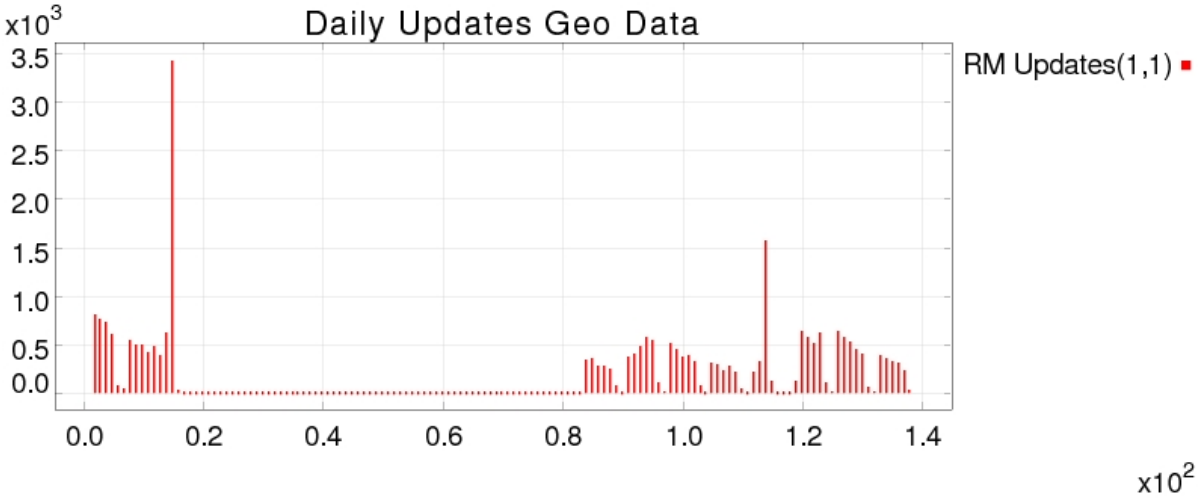


Figure 3: Update for the geo data, the x-axis unit is days. After a transient, the distribution of geo data is in the interval 83 to 136 d. Built-in, a security mechanism guarantees that a truck which otherwise might not obtain its update requests data briefly before validity of current data expires, this is seen as a peak. Fluctuations occur due to the irregular journeys of the trucks, as in reality. The tariff data are run with identical parameters, so the curve is almost identical and not shown here.

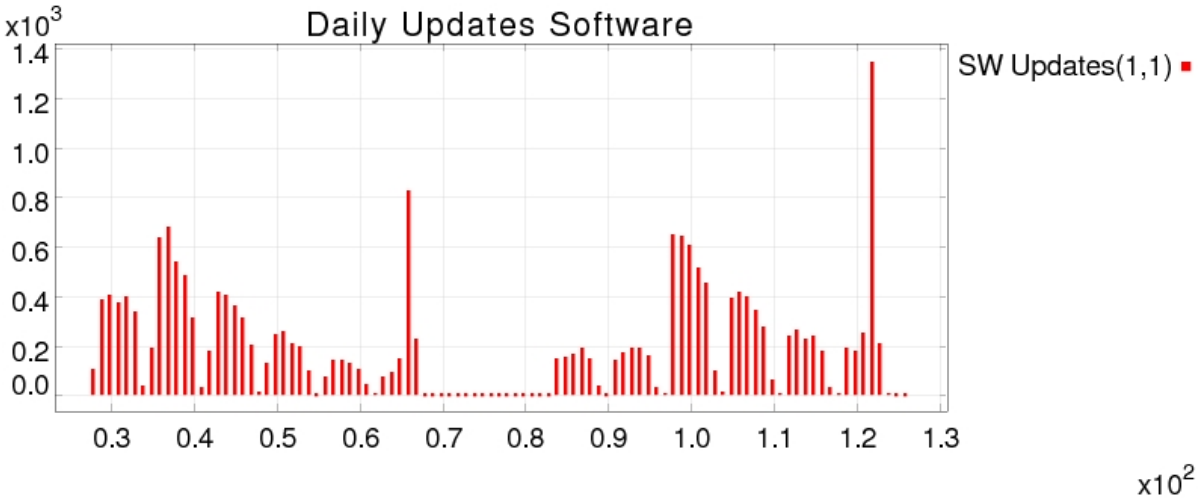


Figure 4: Update of software, x-axis units are in days. The distribution takes place over two large intervals from 35 to 69 days and from 83 to 125 days. Fluctuations occur due to the irregular activity of trucks.

Summary and Conclusions

We have demonstrated the great possibilities for the use of numerical simulation for telematic services in general and toll related tasks in particular. The tool – MLDesigner is a highest-level programming tool with strong object orientation and graphical support for modeling complex systems. The model displays the capabilities of remote device management in the Toll Collect fleet. Even though no detailed parameter studies are shown here to keep the paper short, the reader should have obtained an impression on the technological possibilities which result from the combination of high-level system design for communication and modern programming strategies.

The model as shown here is integrated in the routinely planning of update and information distribution, or the communication between central parts and mobile parts of the system, respectively. All procedures are highly optimized for toll collection. Of course, in full generality they are applicable to any system which requires remote device management. We think that the algorithms used and optimized by our work to be interesting for future applications involving communication between a central unit and mobile agents of arbitrary kind.

[1] www.toll-collect.de

[2] Statistics of the Truck Activity on German Motorways. K. Lüttkopf, M. Abel, and B. Eylert. This conference proceedings

[3] www.mldesigner.de

[4] M. Balmer, K. Nagel and B. Raney (2004) Large scale multi-agent simulations for transportation applications, Journal of Intelligent Transport Systems, 8 (4) 205-221.

Authors:

Dr. Markus Abel,
Toll Collect GmbH,
Linkstr. 4,
10875 Berlin
Phone: +49 (0)30 74077 4913
Fax: +49 (0)30 74077 5554
E-mail: markus.abel@toll-collect.de

Thomas Lohfelder,
Mission Level Design GmbH,
Ehrenbergstrasse 11,
D-98693 Ilmenau
Phone : +49 3677 4625-46
Fax : +49 3677 4625-11
Email: lohfelder@mldesigner.com