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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:

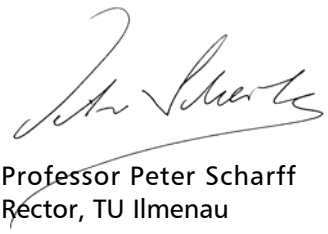
- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, 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.



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Head of Organisation

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Kai Lüttkopf / Markus Abel / Bernd Eylert

Statistics of the truck activity on German Motorways

Introduction

In this contribution, we present results on data mining the data base of Toll Collect, the company operating the German toll system [1]. When using German motorways, 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 traveled. The toll information is sent via mobile communication to the computer center of Toll Collect, and the logistics enterprise will be billed for it.
According to the German Data Protection Act (BDSG), Toll Collect stores the journey data for a certain time, after that time data will be deleted. One measure for the optimization of the operational procedures includes the statistics of the time an OBU spends on the German motorways, or the charged roads, respectively. This is important not only for operational questions. Furthermore it is a valuable basis to validate modern research on transport and logistics, not only for German roads.In this paper we present results only on the temporal behaviour, or activity, of the OBUs monitored in the Toll Collect data base. In a first step the data are anonymised in order to obey the data protection rules. In a second step we collect data pertaining to the OBUs. Thirdly, we identify journeys with and without breaks according to certain rules, specified below. Based on this classification we gather statistics on the start times and the duration of the OBU journeys with distinction of the weekdays. The statistics of the breaks between two subsequent journeys yields a clustering into two categories with clearly different activity.
The direct impact on the operational conditions of Toll Collect lies in the optimization of the communication processes of the computer centre with the OBUs: we use the results as input for a simulation of the intelligent update process developed for the Toll Collect system [2].

Data Analysis

Storage of data in the Toll Collect data base is limited to a certain amount of time (120 days). The use of the data is restricted to toll-relevant events, as e.g., billing or system maintenance. In particular, individual-related data cannot be used for any further analysis. The analysis presented here serves as input to a simulation of the communication dynamics occuring when trucks receive new geo data. So, we had to use statistical procedures without access to personal information. We therefore worked with anonymized, and accumulated data to obtain a picture of the on-off behaviour of trucks on German motorways. Especially, we did not use any location-based information in the data.

You can try to figure out criteria to divide the trucks into clusters of different activity. One cluster could be day and night activity, another heavy or light trucks, or short-distance or long distance journeys, etc. Please note that the latter translate into short-time and long-time journeys in our analysis, since we do not access the spatial information. When running analyses in these directions, you quickly recognize that these typical categories are hard to apply. Let us consider day and night journeys: the trucks can depart in the afternoon and arrive late at night. When a break lies in between – you can ask whether it is a day journey, because of its early start, or is it a night journey, because the arrival is late. Or the short-time and long-time criterion: indeed, we find a continuum of durations for a journey, where it is virtually impossible to identify a particular scale on which you could speak of a “short” or a “long” journey. Further, to determine the duration of a journey, you are faced with the problem to identify breaks, which have to be taken at the latest after 4 hours of driving. If a truck stops on the motorway with the restrictions of the data we analyzed it is not possible to identify it as a resting truck.
Instead, we compare the duration of the journey with the typical duration of a similar journey, which is stored in a so-called distance matrix [3]. This matrix contains typical durations of truck journeys within the web of German motorways. If a truck takes much longer time for its travel, we assign a break to this journey. This is often found at night, when goods have to be delivered on schedule in the morning. Then trucks drive close to their destination and stay overnight on a nearby location on the motorway. Open questions are simply left out in our analysis and will be subject to more detailed investigations. Having corrected the journeys for the breaks we can proceed with the analysis. Basically, from the points made before we can determine three necessary identifiers of a journey: Start, duration and idle period between one journey and the next one. In addition, it is useful to divide the journeys further according to daily activity: If a truck drives once a day, most probably it has one driver who starts work, delivers and then takes a rest until the next day. If, however the On-Board-Unit is mounted in a truck where the drivers can change, there can be more journeys on one day. Then we have no means to distinguish the journeys, this results in journeys all around the day. An example for this are local delivery trucks which circle around without observable longer breaks, as e.g. for a company providing spare parts, or mail service in a populated region. If however, a single driver starts his truck twice a day, with a break of at least 8 hrs in between, two entries onto the motorways could be detected (in some rare cases even three – 3x8 hrs). In the following section we refer to these journeys as twice-a-day journeys.
Based on this classification, we define three categories: Once-a-day journeys, twice-a day journeys and all-around the clock profiles. The division into these sets is not unique: a truck can drive one day according to the once-a-day rule, and another day it is found in the twice-a-day category. In companies with many trucks, the vehicles are used on demand, with changing drivers, such that the switch between the groups is a usual process. A sketch of the classification is given in Fig. 1.

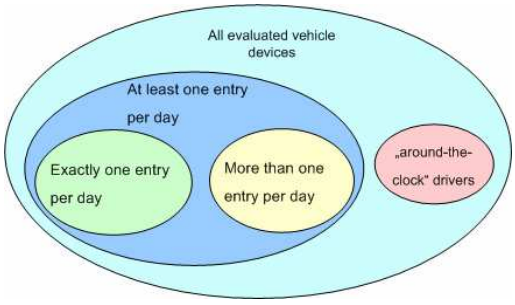

Figure 1: Composition of the categories.

Hereafter we consider a representative sample of 94,422 vehicles. For each category we analyze the start and duration of the journeys in statistical terms. The journeys have been corrected for the break duration as explained above. Let us consider the group with one, two or three journeys a day. All following analyses are done with SPSS [4]. We find the following histogram (all times in UTC).

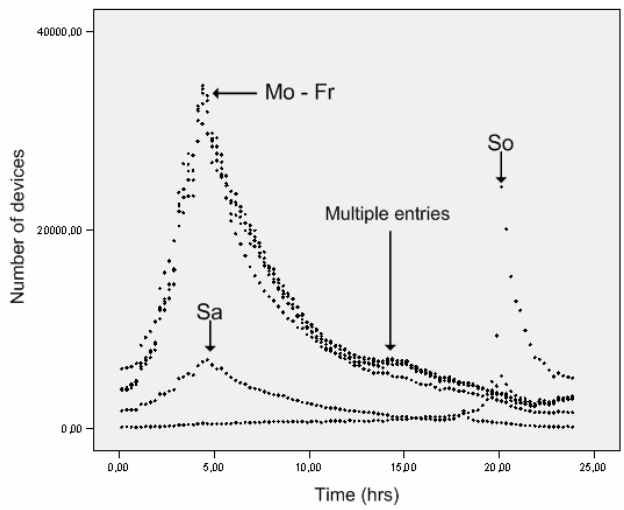

Figure 2: Distribution of start times of the journeys for each weekday. For working days, Monday to Friday, quite similar behavior are observed, on Saturday the activity is almost identical to the workdays, scaled by a factor 1:10. Sundays driving is banned before 20:00 UTC, this is seen as a sharp peak. Characteristic for the trucks with two journeys a day is the peak labeled "multiple entries".

The major activity lies about 05:00 hrs UTC, then regular business hours start. In addition, trucks starting in the afternoon give rise to a small kink at 15:00 UTC. For Saturday, the same activity as for a working day is recovered, whereas the ban on driving on Sunday causes a completely different distribution with a peak at about 20:00 UTC, indicating the end of the ban. Of course, absolutely there are more trucks on the road during the night from Sunday to Monday.

One motorway entry per day

To get rid of the multiple daily journeys, we simply took out the respective trucks with 8 hrs break. As a result, the kink at 15:00 UTC disappears, as seen in Fig. 3. We conclude that this peak is due to multiple journeys.

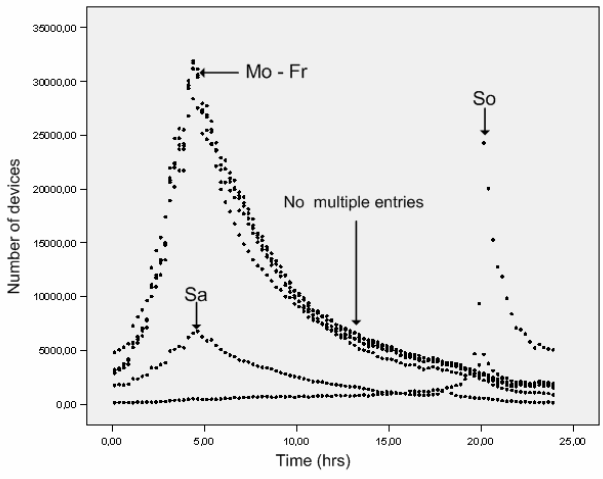

Figure 3: Same as Fig. 2, with multiple journeys per day subtracted.

Two motorway entries per day

Let us consider the multiple journeys alone, i.e., basically trucks driving twice a day with a break of at least 8 hrs in between. The distribution of entries over the day is displayed in Fig. 4. Clearly, there are two very distinct peaks at about 05:00 UTC and 15:00 UTC. Remarkably, you can notice another, peak at midnight. The dominant peak is at 05:00 UTC, and the other two approximately sum up to the height of the main peak. This means that the trucks typically enter in the morning and then wait either until afternoon or until midnight to start again.

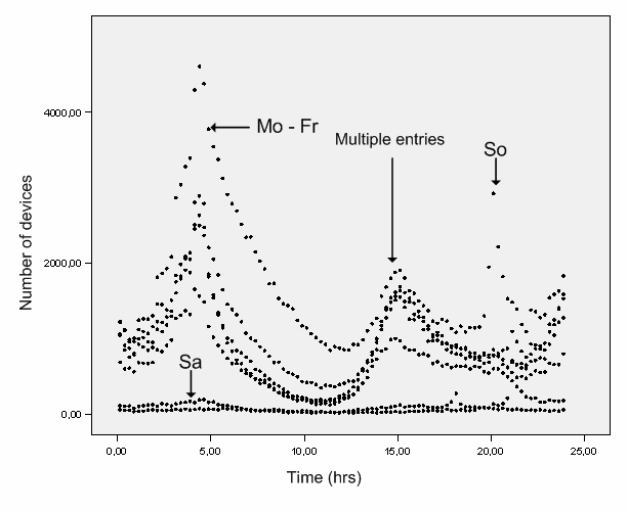

Figure 4: Twice-a-day entries. Trucks typically start in the morning and have a second journey starting the afternoon or at about midnight.

All-around the clock journeys

The last group, identified by us are all-around-the-clock journeys. They seem to drive locally or with two drivers in the way that no distinct break can be identified. The corresponding histogram is displayed in Fig. 5:

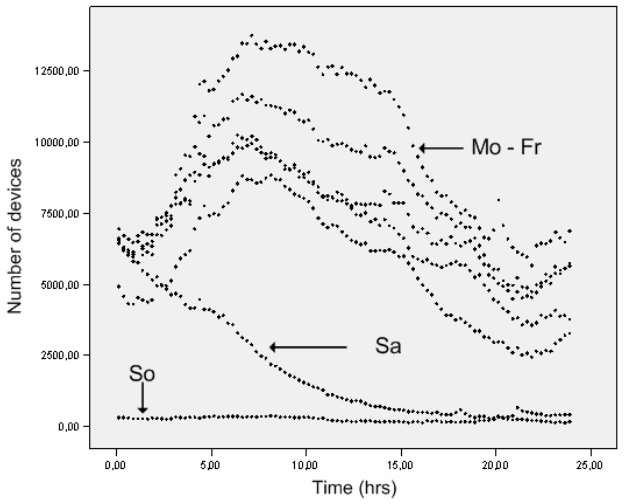

Figure 5: All-around-the-clock journeys show no peaked structure. Rather they are active during the normal working hours with slightly decreasing frequency. Late afternoon and night, the activity decreases to a smaller level, which arrives at a flat minimum at about 22:00 UTC.

Interestingly, the-all-around-the-clock journeys do not show the Sunday evening peak, neither do they show similarity on Saturday. This could indicate that the majority of the trucks in this category deliver locally, therefore no long-time journeys are necessary which would require a start at Sunday night.

Summary

In this paper, we present first results on data mining using the Toll Collect data base. In accordance with the data protection law, only accumulated, statistical analyses are possible on anonymized data without access to spatial information. Nevertheless we can obtain interesting results on the temporal activity of truck journeys for different weekdays. The statistics are used for the simulation of the communication of On-Board-Units for updating information in the devices. This is a regular task of Toll Collect which shall be controlled frequently. As a side product we get at a new division of truck activity suitable for the investigation of communication processes. We consider our work as important not only for toll collection. It rather shows that you can reach very interesting results on logistic processes with statistical evaluations.

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[3] D. Lohse, Verkehrsplanung. Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung, Verlag Bauwesen, 1997.
[4] www.spss.com

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