IMPACTS OF INTELLIGENT INFORMATION SYSTEMS ON TRANSPORT AND THE ECONOMY - THE MICRO-BASED MODELLING SYSTEM OVID

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Abstract
This paper gives an overview of the project OVID (http://www.ovid.uni-karlsruhe.de/) launched by the German Ministry of Research and Education (BMBF). The goal of the project is to evaluate the impact of advanced information systems on road transport in a micro-based way. A simulation platform is built up in order to simulate the reactions of consumers and firms on a micro-scale and to find out under which conditions a change of activity patterns or logistic routines occurs. An interim conclusion is, that the expected benefit from pre-trip information can lead to substantial changes of behaviour and improvements of the transport system.

1. Introduction
Transport is a complex system consisting of competing and complementary networks and demand patterns which are closely related to decisions in various sectors of the economy. Therefore, from a system’s point of view, self-organisation appears as the only principle to solve the manifold allocation problems. Self-organisation is widely accepted as a general principle to manage complex systems such as the market economy. Considering the transport system, in particular the road sector, it is often argued that it partly has lead to chaotic results because people are maximizing their individual benefits while neglecting social consequences of their behaviour for others. As a result, they generate undesired congestion and other kinds of external diseconomies in road networks.

Analyzing the reasons for failure of self-organisation in transportation networks three basic problem areas can be identified:

- Users take individually wrong decisions because they lack important information, e.g. on routes, on modes, or on better departure times for travelling.
- Users take socially wrong decisions because they lack information on the consequences of their behaviour for other actors in the system.
- Decision makers take wrong decisions because they do not realize the manifold indirect impacts of their decisions, e.g. the consequences of liberalisation policy in the transport sector without harmonizing the conditions for competition.

All problems mentioned correlate with incomplete information. Thus, de-central decision making in transport should be supported by providing the right information at the right quality to the right person at the right time and place. However, increasing the volume of information is not enough. Presumably, we will live in an environment of almost infinite information and pervasive computing opportunities in the near future. But one cannot expect that information will be homogenous and easily to be interpreted. Consequently, there are two basic aspects of information-based solution concepts in transport:
The German Ministry of Research and Education has launched the research project OVID. The acronym OVID stands for “Fostering Self-Organization of Transport Activities through Intelligent Telecommunication Systems”. The scope of the project consists of an organized interaction regime between human agents, transport models, transport data sources and software agents. The purpose is to analyse and evaluate the benefits of better information for de-central decision-making. A demonstrator platform is constructed which brings together all relevant elements of the system under study in a quantitative and computable manner.

2. Description of the Project OVID

There is a complex dependency between traffic information, road user and transport network. Since the user is not able to prove the quality of the received information, his compliance referring to information services is not predictable. The individual behaviour is influenced by the assessment of the traffic situation that the user can see and the quality of information the user receives from information services. Both aspects determine the individual acceptance, which influences the traffic situation and the real collective acceptance of all road users. The real collective acceptance has an effect on the prognosis, which is even influenced by the forecasted collective acceptance. The prognosis determines the quality of information. The loops of dependency are shown in Figure 1: Feedback loops between traffic information, user and transport network.

The research project OVID addresses individual user reactions on improved traffic information on a micro scale. In order to capture the feedback mechanisms between traffic information, road user and transport network a consistent platform combines different models.

While in the past studies on ICT have concentrated on the impact of on-trip information, the research in OVID includes also pre-trip information. Thus, it is possible to examine important effects such as the logistic changes in the freight sector, which might be induced by better information systems.

In a world of pervasive computing and heterogeneous information in terms of sources, reliability, quality, and technical standards, drivers as well as operators will not be able to filter out the relevant information. Thus, road users will need substantial technical assistance. In order to model such circumstances an agent-based approach is included in the micro-based simulation platform to study the paths of information processing and necessary conditions for the individual acceptance of ICT.

A simulation platform is built up in order to perform scenarios with complex relations between actors as decision makers and the transport system. It integrates without gap traffic demand, traffic flow and traffic forecast. The simulation is based on real time processes and consists of several software components. The study area is the upper Rhine region in the southwest of Germany between Karlsruhe and Mannheim, two cities with about 300,000 inhabitants each. Furthermore, there are five parallel artery roads such as three motorways and two national highways. About 200,000 vehicles move through the road network at the same time. The program mobiTopp simulates activity patterns of persons during the period of one week derived from the data base of the German mobility panel (MOP). Within the model learning processes can cause activity changes. Furthermore, mobiTopp contains information about the actors of the study area, which is divided in 99 traffic cells. Every actor is described by socio-economic attributes, weekly activity patterns and individual behaviour with reference to the use of traffic information. The simulation of single persons allows the integration of new empirical knowledge about behaviour of road users under different information conditions.

The micro-model VISSIM from PTV-AG [1] demonstrates the traffic flow. The tool allows the simulation of single drivers in real time and data collection to forecast future traffic states. Figure 2: Composition of the microscopic simulation platform shows the relations between the components of the simulation platform. The initial traffic state of the network including transit traffic is calculated with the assignment model VISUM from PTV-AG [2]. The output delivers the traffic load and travel times of the network within the study area. Furthermore, VISUM provides alternative routes for every origin –destination –pair (o-d-pair) that is filled in the travel demand matrix.

The microscopic simulation model mobiTopp from the Institute for Transport Studies [3] generates the traffic demand as an input for the micro-simulation of traffic flow with VISSIM. Finally, the approach of OVID represents a simulation platform, which contains all elements needed to get a real world picture of the impact of new information services on road transport.

3. Passenger Transport

In order to assess the impact of ICT OVID addresses individual user reactions on improved traffic information on a micro scale. Consequently, an activity-based modelling approach is applied. Activity-based approaches are...
causal models, which generate the transport demand based on personal schedules. Furthermore, the activity-based approach considers the intelligence of people by modelling each individual as an entity which is able to learn, make decisions and move through a synthetic environment.

### 3.1 Activity based Modelling – State-of-the-Art

In the last decades transport modelling has developed from trip-based to microscopic tour-based, also called activity-based models. A first milestone of the activity-based modelling was the statistical simulation approach, where artificial populations consisting of thousands of heterogeneous individuals are distributed in the planning area and every actor tries to execute its activity plan. A representative of this kind of models is the socio-ecological transport model by Zumkeller [4].

In the last years two types of agent-based simulation models have emerged. One group focuses on the activity scheduling process such as the model ALBATROSS [5] and the other group uses the possibility of agent based learning in order to find plausible solutions for unclear defined user equilibrium problems. An example is the large-scale multi-agent simulation of Balmer et al. [6].

### 3.2 Focus in OVID

In OVID an activity-based approach is used to simulate the effect of information services on road transport, especially in terms of pre-trip-information. According to a hypothesis of OVID pre-trip information has a broader influence on traffic demand patterns than on-trip information. The impact of on-trip information is reduced to route choice. However, to change modes and departure times during the trip is not possible anymore. Pre-trip information influences the choice of mode, route, departure time and activity. All personal decisions are made in the behavioural model. The behaviour model is sensible to the parameters of the information services simulated in OVID.

### 3.3 Model of User Reactions on Information Services

Transport information services have to be able to influence travel behaviour in order to control and to improve the quality of the traffic flow. Thus, user reactions are critical to success of information providers. Hence, major efforts were put into the development and integration of the model of behaviour describing ad hoc- and medium term reactions of road users on information.

Figure 3: Decisions of road users assisted by information services shows the user reactions relating to pre-trip as well as on-trip situations. Before starting a trip dynamic information services assist the road user to decide about the means of transport, the departure time and the route. During the trip information services provide route guidance. Corresponding to the assisted situations the model of user reactions intervenes in the trip generation, mode choice and route assignment relating to the classical four-step-model of transport planning.

For modelling user reactions it is important to determine and to quantify the impact of single factors on travel behaviour. Hence, an empirical study was carried out to get answers to the following questions:

1. What experience people already have made with transport information services?
2. In which pre-trip and on-trip situations do people use dynamic information services?
3. How do people comply with recommendations?

The core of the survey was a computer-based simulation game where 400 test persons had to react on transport information. In the empirical study as well as in the simulation three different types of transport information services were considered. As shown in Figure 4: Transport information services in OVID, there exists a classical radio service that provides collective information. The quality of the radio service is lower than the quality of the individual PDA services. A PDA is a small mobile computer that is called personnel digital assistant. The difference between the standard and the premium service is that the premium service automatically informs the user if traffic jams occur.

As a result of the study, the rate of utilization of information services and the rate of compliance on recommendations could be determined. In General, about 80% of the test persons used information services pre-trip and about 98% on-trip. Furthermore, the rate of compliance for e.g. the PDA premium service was about 87% pre-trip and about 81% on-trip. Due to the laboratory environment with low barriers to use information services the numbers are probably higher than they would appear in reality. In addition, according to the empirical study, socio-demographic parameters, trip purpose, geographic orientation, time pressure, travel time, and road pricing were factors that influenced user reactions.

The model consists of the following four steps with little differences in handling pre-trip and on-trip requests:

1. Choice of transport information service (Radio, Standard, Premium, or none)
2. Determining the request time
3. Choice of criterion of optimisation if an individual service was chosen (shortest, fastest, or less expensive route)
4. Choice of connection (including route, departure time and means of transport whereas the latter two issues are only considered for pre-trip requests)

At the beginning of a pre-trip request, some rules have to be checked in order to determine if a person is able to make a trip by car. For example, the person has to hold a driving licence and a car has to be available. Figure 5: Pre-trip and on-trip requests included in the activity schedule of a person illustrates how pre-trip and on-trip requests are included in the activity schedule of a person.

As shown in Figure 6: Pre-trip choice of transport information service, the pre-trip choice of a transport information service starts at the beginning of an activity and always concerns the following trip. It is divided into three binary logit models. The parameters of the utility function are estimated for each step using the data of the empirical study.

At first the person decides whether it wants to get information or not. If the decision is "no information", a classical mode choice is done. If the person would like to be informed the next step is to decide between the radio and individual services. Concerning the individual service, the road user can choose the standard or premium service. Subsequently, the request time has to be determined if a person wants to get information. Due to missing accurate empirical data, the model proceeds on the assumption of equally distributed pre-trip requests over the period of time within the current activity.

On-trip requests are triggered by traffic flow incidents that occur during the trip. For example, the road user will ask for information if it gets into a traffic jam. In such a case there are two binary logit models relating to the decision between radio and individual services on the first and standard and premium service on the second level. Before sending a request to the provider of individual services the road user has to set a criterion of optimisation. In the model the distribution of the criterion is directly taken over from the empirical study because of simplification. Then, it is assigned to pre-trip and on-trip requests by coincidence.

Figure 7: Pre-trip choice of travel connection gives an overview on the handling of pre-trip answers. Decisions are based on rules or binary logit models again. On the first level a person decides whether it wants to reject or accept the received recommendation. In the case of rejection the model checks if a suitable connection of public transport for the requested origin destination relation (o-d-relation or o-d-pair) is available. If there is no appropriate connection the person will choose its initial route driving the car. The initial route can be interpreted as individual geographic orientation or knowledge the person got by a map or signs. At the beginning of the simulation every person gets a primary route for all o-d-relations. Each route is taken from a set that was created by an initial route assignment. If a connection by public transport was found the person has to make a decision whether it wants to take the train or drive its car on the initial route.

The process of accepting an answer of a pre-trip request depends on the chosen service. The radio user gets a route provided by the service. In reality radio information does not always provide route recommendations in order to divert traffic but only locations of congestion. Thus, the received route can be interpreted in the model as recommended diversion by the radio or geographic orientation of the road user.

If the person has chosen an individual service it is possible that the service has found a better route with an alternative connection with a different departure time. If no suitable alternative route was found the person accepts the recommended route provided by the service.

The on-trip situation is much easier consisting of only one binary logit model. The road user has to decide whether he rejects or accepts the recommendation provided by the service.

4. Freight Transport

In freight transport the appraisal of effects caused by ICT requires a micro-based modelling approach because on a macro-level the effect cannot be identified. Considering existing approaches on freight transport modelling one can only detect macro-approaches and logistic optimisation tools for modelling company behaviour. Such tools are not able to produce tours of lorries because the freight transport system is characterised by multiple actors. Therefore a new approach has to consider the process of tour generation and the interaction between companies. Thus, ICT can be able to improve the coordination of connected actors participating in logistic subsystems. The multi-level demand structure in freight transport generates coupling constraints limiting the actors decision space.

4.1 State-of-the Art in Freight Transport Modelling

Traditionally, there has been a gap between two closely related topics such as shipper and forwarder behaviour research and freight transport modelling [7]. Firstly, Shipper behaviour research is mainly limited to non-representative case studies and to the application of optimisation models for mapping the supposed rational behaviour of selected company prototypes [8]. On the other hand, transport models based on the freight-variant of the four-step-model are criticised because they lack mapping the real decisions and the diversity of decisions makers [9] in an adequate way.
The state of the art in freight transport modelling is represented by aggregate approaches, which could be considered as variants of the four-step-model in passenger transport. A main characteristic common to all freight transport models is the trip generation in rather large traffic cells applying Cobb-Douglas regression functions. Because of the aggregation and loss of information at this step, microscopic simulation of freight transport with the standard approach is prevented already at this first step. In standard approaches, inner-regional commodity flows are disaggregated into shipment-size-classes and for each class a mode choice model is set up. Finally, a lorry model is required to determine average loading rates on different relations.

4.2 Challenges in Freight Transport Modelling

In order to assess the impact of ICT on freight transport decision makers, a microscopic and decision-based foundation of freight transport is required. Therefore, each step in macroscopic freight transport modelling should be replaced by a microscopic procedure. Figure 8: Obstacles and questions for a microscopic freight transport modelling shows the four steps of transport modelling. These steps can be modelled either by a macroscopic approach or it can be tried to identify the microscopic decisions at each step with regard to transduce them into decision rules, which can be simulated in a microscopic freight transport model.

The classical transport modelling starts with the generation step: Trip generation has to do a lot with industrial structures, which is supposed to change slowly. However, changes in logistic structures in some industries can happen very quickly, especially in the distribution of products. The first question associated with this observation is the re-organization of logistical networks in function of changed conditions and frameworks. In addition to this dynamic change, from a transport modelling point of view, the size of traffic zones, where transport is generated, is more and more decreasing in modern traffic planning models, so that output-rates instead of functional terms [10] have to be applied for generation. This is a second issue to be considered in micro-based freight transport models. Goods distribution is equivalent to the choice of an absorbing industry for the product. However, in industry the situation is rather inversely: companies select their supplier(s). In addition, these decisions are speeded up over the last years: production cycles become more and more dispersed in time and space and the “infelt” distance between companies is decreasing. This “dead of distance” is probably the main driver for the explosion of freight transport volume [11].

When modelling freight transport in a microscopic way, the changes of structures must be considered. However, freight transport models do generally not yet adequately map the structures themselves. When starting with generation rates, the question, to which consumer freight is transported, arises. From a macroscopic view this problem is related with operations basing on Input-Output matrixes.

In the distribution step, another problem is relevant. The question is whether shipment is really an atomistic decision object as the trip of a person or should choice functions rather map logistic decisions on a given microscopic freight flow [12]. The decisions concerning shipment-size, transport mode, transport-company and regional activity space are highly related with each other. Another difficulty of microscopic transport models is the so-called complimentarily between the logistic and transport systems: one carrier knows some shippers and one shipper knows many carriers [13]. Only in some selected markets (distribution, waste-collection, short-run inter-plant-delivery, economic travel), which count for about 30% of the transport volume, own-account transports still take place. It does not surprise, why microscopic and meso-scopic transport models have long-time only concentrated on these one-actor and round-trip segments, e.g. the WIVER-model [14]. The diversity of actors, their collaboration and competition is a further challenge in microscopic freight transport models.

4.3 Implementation of new approaches in Freight Transport Modelling

Because of the variety of challenges in freight transport with regard to ICT analyses, the freight transport researches in OVID are focusing on selected aspects and prepare a further development of freight transport modelling. The projects in OVID try to achieve a better understanding of transport related decisions. They contribute to the development of a microscopic freight transport-modelling framework, which is able to capture the e-Commerce and ICT-related effects with the following models:

- DIALOC of the strategic logistic consulting company LOCOM GmbH,
- Supply-chain modelling tool of the Institute for Logistics (IFL) at the University Karlsruhe (TH) on the basis of the SCOR-model,
- VISEVA-model [15] developed by Lohse and being applied at the PTV AG and
- Actor based freight market simulation with constraint-logic and network-economical elements at the Institute for Economic Policy Research (IWW) at the University Karlsruhe (TH).

Using these models, three types of analyses can be carried out, which allow a better understanding of the effects fostered by ICT. These are analyses of decision-making processes on different levels, attempts for trip-chain models in local transports and the development of an actor-based freight transport simulation system.
a) Analyses of decision-making processes on different levels

Decisions on several levels are distinguished: On the strategic level, whole strategy decisions of companies and location decisions are concerned. The tactical level describes the decision horizon over some months or years. At this level, one can also speak of operational routines. At last, also operational ad-hoc decisions (e.g. dynamic re-organization of production or dispatching processes) are treated. However, these decision processes and their support by ICT are considered mainly with regard to their impact on possible changes of the routines. The model DIALOG focuses on the long-term decisions while the SCOR-model is used for simulating stochastic production processes in order to find an optimal operational design at a tactical level.

DIALOG is a strategic planning tool for supply chains. If the shipment processes of a shipper (and also of a logistics network) are known, DIALOG supports the planning of distribution centres. The tool CARGO explicitly models dispatching processes for a given lorry category and its cost-components, an optimal consolidation and the tours are calculated. This supports the strategic software DIALOG. In OVID, the long-term changes of selected logistic system configurations are simulated with the two main LOCOM products. Following sectors are considered in detail: the home-delivery of white ware by a large retailer, the German-wide distribution of mineral wool to construction sites, a beverage-logistic company and a piece-good collection/delivery. The prototypes cover some 30% of the transport market in terms of transport performance. Following long-term effects concerning choice of location, re-organization of the division of processes over plants and the resulting traffic effect have been calculated: the introduction of a HGV-toll, the introduction of time-windows and an axle-weight limitation for city-deliveries. For one of the first times, these calculations have been made using real data concerning single shipments.

The SCOR model [16] is a time-discrete process-queue-model and a recognized tool for modelling complex production logistical networks. All imaginable processes in logistics are represented in simple process elements “source”, “make” and “deliver”. It is supposed, that there may exist a probability distribution for the duration of each process. Chains and networks constituted of the basic elements (e.g. large inter-company just-in-time logistic networks) can be modelled. When companies reduce Furthermore the buffering time at the interface between transport and production (i.e. reducing the time-windows), the traffic system as a process element becomes important. In the model, the traffic system is really also a resource with a probabilistic duration. The model is suitable to identify the limits of the observed acceleration in logistic process design during the last years. From a logistic point of view, this type of research concerning time-distributions especially in the context of traffic processes is relatively new and is the starting point for a new generation of decision support tools in order deal actively with the vulnerability of complex logistic processes.

b) Analyses of decision-making processes on different levels

VISEVA-W is a regional model for economic travel for dealing with round-trip like traffic patterns of people during their work [17]. VISEVA combines methods for solving the bilinear-distribution problem (e.g. the Furness-Algorithm) with activity-data (such as number of stops per roundtrip, attraction and generation rates of tours) in order to construct a macroscopic traffic flow picture, which is based on roundtrip-like movements in space. The pragmatic and applied research question in OVID is how to extend VISEVA, so that it is possible to deal in a better way with regional freight traffic. As already discussed in the context of Figure 3 one actual question in freight transport modelling is, lorry movements on the secondary road network can be determined, because the size traffic cells is continuing to shrink in modern applications and therefore companies are better treated in form of points of interest. By using output-rates for the traffic (tour) generation, a step towards an activity-based freight transport modelling is achieved. However, a segment “empty running” must be introduced in order to deal with the forwarder transports.

c) Construction of an actor-based freight transport simulation

The third activity in the freight transport modelling in OVID is the design of a completely microscopic and actor based freight transport simulation system, which is now realized in form of the InterLOG model. It focuses on one important aspect, which is not treated by the three models described above: the transport system is generally dominated by forwarders and carriers rather than by own-account round-trip-like tour-patterns and the market possesses some kind of relational-network topology. InterLOG merges principles of actor-based simulation and constraint-logic programming. Shippers and carriers are generated by a Monte-Carlo-algorithm, which creates synthetic production worlds. The simulation of industry patterns is carried out using information about company-size distributions and regional data. At a next step, microscopic commodity flows are simulated between the companies. For this purpose, different data sources are merged: production rates (tones/employee at a 3-digit CPA-level, trade, sale and wholesale statistics and I/O-matrices. The result – inter-sectoral commodity flows – are used to determine the attractiveness of another company as a potential supplier. Besides this attractiveness, the distance sensibility is important. It is extracted from the German lorry survey, which is clustered according to transport markets instead of NST/R classes.

The conversion of microscopic commodity flows into vehicle movements is carried out with an agent-based procedure. There is a functional separation between the tasks conveying and dispatching. Shippers try to
optimize their logistics regime, while forwarders perform vehicle dispatching. The forwarder’s decisions are supported with Constraint-logic methods, which are a successful tool for finding suitable decisions under complex (i.e. non-linear) constraints. Typical applications are transport, dispatching and scheduling problems [18]. However, generally, not the best solution is computed. Local-search algorithms are applied in order to improve the decisions. The interaction between both actor groups is managed with elements of the economics of networks, a branch in economic research that is designed for mapping market behaviour in network-like markets [19]. It is believed that the cargo segment is characterised by this type of market: Observations show a significant impact of human relations, behaviour patterns and resulting meso-structures (i.e. repeated complex tours combining several regular orders). These patterns change rather abruptly that continuously: on the microscopic side, the classical logit-choice-functions are not defined. As the described market segment is the largest in modern economies, InterLOG concentrates on the simulation this so-called general-cargo-segment (On the segmentation of the transport market for micro-modelling purposes cf. [20]. The concept bases on a market schema developed by [21]. First calculations show, that this solution-finding strategy in a simulation is very well suited for the market simulation: decisions are not undertaken each day, heuristics are involved and by mapping the restricted optimization horizon of individuals, the calculation time can be controlled when simulating some thousand “logistic” and “transport” agents undertaking local decisions. The simulation shall explicitly map the self-organization of the transport system in a middle-term time horizon. The individuals are mapped in a realistic, i.e. egoistic way, but profits are the result of cooperation, which is catalyzed by forwarders and self-stabilizing operations structures.

Each of the four different models contributes significantly to the filling the gap between optimization models, behaviour models and macroscopic, shipment-based transport models.

5. Scenarios
In order to show the impact of information services under varying boundary conditions five scenarios have been defined. At first there is a basic scenario (P0-case). It represents a reference point of traffic state in the study area. It is characterised by a daily recurrent congestion caused by a bottleneck such as a bridge over the river Rhine. But there is no unforeseen congestion. In the reference case there are no information services, even no collective information media like radio.
The second scenario (P1-case) is identical to the P0-case, but an unforeseen traffic jams occur on one main road about half an hour before the peak load hour in the morning. This is the “worst case” scenario, which causes the maximum time losses.
In the next scenarios different configurations of information services, pricing and organisational regimes are tested. The basic traffic situation is always the same like in the P1-scenario, which means:

- Every day recurrent congestion caused by a bottleneck,
- Unexpected congestion on one main road.

In addition, the described information services are tested under varying economical and organisational parameters. Further variations are prices of roads and the number of information providers.

6. Description of the Micro-Simulation
The micro-simulation is performed by a distributed system, running at three different locations. The communication between the components is organised by software agents. Thus, the software agents fulfil two main functions, which are quite different. Firstly, the software agents enable the communication in the distributed system and secondly they fulfil a service function for the road users. This is described in detail in the following chapters.
It is necessary to go through two simulation loops in order to describe all relevant steps of the simulation. In the first simulation loop all components of the simulation are explained with their basic functions. Figure 9: Simulation process in OVID illustrates the first simulation step. In the second loop additional functions of the software-agents are described.

6.1 First Simulation Loop
The simulation is divided into four steps:

1. Generation of route alternatives,
2. Request of the driver,
3. Real time traffic simulation,
4. Forecast generation.
The generation of route alternatives as well as the request of the driver for a route are pre-trip-actions. In a first step an initial route assignment with VISUM has to be done. The results are route alternatives for each o-d-relation, which are transmitted to the VISUM route agent.

The demand model mobiTopp contains all inhabitants of the study area with socio-economic, geographical data, and activity patterns. A person sends its driving purpose (departure time, o-d-relation) to the driver agent. The driver agent passes the request to the VISUM route agent. The VISUM route agent gives a route recommendation back to the driver agent, which passes the route recommendation to the driver. The driver decides the mode, route and the departure time based on the underlying decision model.

In this first simulation step the driver agent has the only job to pass on information. In the second and following simulation steps the driver agent fulfills additional functions.

The next step is the real time traffic simulation. The driver starts, the vehicle moves through the road network and reaches its destination. All relevant simulation data like floating car data etc. is stored in a database. The collected data serves as foundation to generate traffic forecasts. The prognosis algorithms compare the data of the real time simulation with the data of the initial assignment. When the difference between the actual and the expected state is bigger than a defined threshold a new assignment with VISUM is initiated.

Freight transport is integrated in the demand model in mobiTopp as a list of tours. With regard to the behaviour during the traffic flow simulation freight transport is treated nearly the same like passenger transport. The only difference is that truck drivers always comply with the recommendation because of the assumption of rational behaviour in business situations.

6.2 Second and following Simulation Loops

In a second and the following simulation loops the driver agent has additional functionalities. If a new assignment produces new route alternatives for o-d-pairs, the driver agent sends a request to the VISUM route agent. If there are significant changes in route alternatives, the driver agent compares the new route alternatives with its existing route recommendations and sends – based on a decision algorithm – new route recommendations to mobiTopp, if the new routes in terms of the optimisation criterion. This process exists to support the generation of pre-trip and on-trip-information.

7. Conclusions

A set of components for micro transportation modelling has been developed in order to simulate the impact chain following improved information supply in transport. An integrated software platform has been constructed to demonstrate the workability of the concept. The simulation of the upper Rhine area with 1.5 million inhabitants meets the requirements of future applications in practice. Information processing is substantially supported by software agents, which assist individual decisions of drivers as well as information suppliers. The whole system allows the performance of intelligent information system scenarios as a base for the assessment of the utility of advanced information services in road transport.

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Figure 1: Feedback loops between traffic information, user and transport network

Figure 2: Composition of the microscopic simulation platform
Figure 3: Decisions of road users assisted by information services

- General, collective information about traffic situations
- Pre-trip and on-trip information on request
- Information for free
- Lower quality level

- Shortest, fastest and less expansive route
- Recommendation of route and alternative departure time
- Pre-trip and on-trip information on request
- Price for information per request

Figure 4: Transport information services in OVID

Figure 5: Pre-trip and on-trip requests included in the activity schedule of a person
Figure 6: Pre-trip choice of transport information service

Figure 7: Pre-trip choice of travel connection
Figure 8: Obstacles and questions for a microscopic freight transport modeling

Figure 9: Simulation process in OVID