Implementation of traffic effect estimations
for intermodal dynamic routing services on VIELMOBIL -
an ITS-platform for the RheinMain region

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Abstract
Rising mobility of people and goods will increase current traffic volumes and cause more and more infrastructural bottlenecks and congestions within the traffic networks. Besides expanding the public transport service, one main goal is to improve the overall traffic information regarding specific traffic conditions in order to achieve a temporal, spatial and modal shift of trips based on the available network restraints. In order to use the available network capacities effectively and constantly; optimized traffic flow, new innovative mobility and information services need to be developed. The following paper describes the development of an integrated intermodal routable network graph, related quality management procedures and the implementation of a new dynamic routing approach using real-time traffic data provided by public authorities to operate VIELMOBIL - an innovative intermodal mobility information service for all modes of transportation.

Keywords: Intermodal Routing, Dynamic Routing, Traffic Message Detection, Traffic Model, Congestion And Traffic Disruption Effect Estimation, Dynamic Routing Strategies

1 Background

Our society is increasingly mobile and the traffic volume is continuously growing. Hessen with its metropolitan area RheinMain is a traffic hub in Central Europe. Mobility in Hessen also means mobility in rural areas. This is where the majority of the citizens of Hessen live - people who often have to travel long distances on their daily routes. There are numerous approaches for sustainable mobility. They require complex changes on many levels including behaviour, technology, organization and cooperation. One approach towards sustainable mobility is to improve information about the available alternative forms of mobility. Existing
information services usually do not cover characteristics such as situation and position-depending information or ad-hoc information and realistic intermodal alternative route suggestions. Providing this information within one single service is the key to a lasting change in mobility behavior of the population. To achieve this objective the Hessian state government co-financed VIELMOBIL; an intuitive and easy to use information platform for pre-trip planning and on-trip pilotage. VIELMOBIL sets a new standard of mobility services on the internet and on mobile devices. The bases of an improved information service are quality assured real-time data-sets for public transport services and individual traffic as well as historical traffic flow data. In addition VIELMOBIL also processes regional and local traffic management strategies similarly to information about road works and parking capacities (BERNHARD).

2 Avoiding information overflow - supporting intuitive planning

It is the aim of VIELMOBIL to deliver only as much information as necessary to support a targeting pre-trip planning and on-trip pilotage. It is not about accommodating as much different information about all possibly available modes of transportation in one information service. Rather, VIELMOBIL is designed to assist the user in the preliminary planning and accomplishment of his mobility. Studies surveying potential users of routing services clearly showed that travel planning is done in successive way step by step getting more and more accurate by using further information. Users do not expect the only recommendable route to be delivered by a mobility information service. They expect an information platform that delivers a reasonable set of alternative connections to choose from and the necessary information to gradually customize one or the other suggested route. Therefore, VIELMOBIL does not need a long list of personal preferences unclear how the individual input would influence the further routing results. Right after the entry of start and destination, VIELMOBIL offers a manageable number of route suggestions, displayed in a list to choose from and a large map to be adjusted to personal preferences. Moving a waypoint to one of the displayed bike-and-ride facilities will promptly create a route using the bike and public transport. Deactivating or reactivating one transportation mode will change the number of suggested routes and possible intermodal connections. Users request to use different communication channels depending on the time of their planning (pre-trip or on-trip) and their technical skills. Therefore, VIELMOBIL will use the advantages of the different communication techniques according to their individual strengths and will support the alternating use of stationary and mobile systems. Intensive pre-planning will then rather be done on a PC enabling to comfortable interact with mouse and keyboard. On-trip pilotage of a previous planned trip uses the advantages of a smartphone - always on, fast, and personalized.
3 Traffic information as a part of regional traffic and mobility management

Increasing mobility costs, growing demand for mobility and differentiated mobility services as well as the growing availability of internet-based and mobile information services, particularly in metropolitan areas, make traffic information a necessary and meanwhile natural planning instrument for individual mobility. However, the demands on these information services also increases. Actuality, completeness and the linkage of the available information to individual tailored services are often mentioned by users as a potential improvement of the already existing services. Information must also reflect the users every day ”experiences” - route recommendations need to consider the actual and expected traffic situation, account intermodal changes (e.g. parking search time) as realistic as possible and need to take the availability of the transport network due to road works or events into consideration. Traffic information is also an important tool for municipalities to manage their traffic network. Especially for communities without technical actuating elements like dynamic variable message signs, traffic information is a way to implement their mobility policy, traffic planning goals and concepts. This is where most of today’s commercial information and routing services fail. As they usually propose the optimal route for the user and sometimes ignore the opposing interests of municipal traffic planning, they inhibit the optimized use of existing traffic infrastructure and mobility services. However, individual mobility does not act independently in an overall transportation network. The demands for quality and reliability in future mobility will decide to what extent individual needs can be fulfilled in the transport system. With VIELMOBIL an opportunity will be given to the local authorities to constitute their local strategies regarding traffic and mobility management. VIELMOBIL is a tool to support the participation of various municipalities of differing sizes and a successful method to enforce the consideration of their strategies within information and routing services. Therefore, VIELMOBIL is a major step towards a regional integrated traffic management. Thus, a platform that promotes regional cooperation in transport and mobility management is an essential task of ivm in the Region Frankfurt RheinMain - namely the establishment of an integrated regional transport and mobility management. The integration and cooperation of different regional partners within VIELMOBIL is based on a task sharing model. There is a shared responsibility between regional actors. Each partner is responsible for particular services and for the delivery of data or information in a prescribed quality. For the further development of VIELMOBIL common goals and further steps that need to be realized by each partner will be defined. This task sharing model ensures the long-term use of the existing components and the sustainability of developments and investments that have been made or will be made in the future. Regional traffic management, especially the integration of different regional partners and their services require a new form of cooperation. A technical integration of the available data is also necessary. This technical integration is realized by an intermodal
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network graph. Based on standardized data form NAVTEQ and ATKIS the network graph can be edited and adapted to temporary or permanent changes in the road network. The different dynamic and static data is referenced to the network graph and will be the basis not only for VIELMOBIL, but also for other regional information services. Information is not only displayed on a map but already considered in the intermodal routing. Considering historical and real-time traffic flow as well as road works and traffic management strategies require new routing algorithms (BOHLINGER). In addition, powering an intermodal information service, this routing algorithm needs to be fast and effective. To realize these requirements, it was decided to design and build a specific routing engine – free to be used and adjusted for other routing services.

4 Generation of an intermodal routable network graph

The generation and later update of a routable network graph is a general task for each routing and traffic information service. Different approaches for this problem have been implemented in diverse projects

- direct use of a commercial graph (E.g. Teleatlas or NAVTEQ)
- use of open data, i.e. Open Street Map
- use of data generated by authorities.

All of these alternatives have been used at ivm in different projects and each of them has shown clear shortcomings. The bicycle network data is based on ATKIS (provided by the surveying authority) and shows high geometry precision, it is up to date but lacks many attributes relevant for routing (e.g. speed limits). The routing of motorised traffic is based on commercial network data, which are fully attributed but show inconsistencies in geometry alignment and are not fully up to date (especially in the lower level road networks).

For this reason a new model of network fusion was developed. It is based on a stepwise special algorithm, which allows a continuous refinement and improvement of the matching rate between the two networks. It starts with an automatic detection of junction features and matches these junctions. In the next steps network routing is used to collect the matching network edges and relate them to each other. As a result both (or more) networks are integrated in one database and referenced to each other, without losing any information available in either network.

A web-based editing client allows updates to routing attributes as well as adding new edges and changing edges. All these changes are automatically integrated in both networks in parallel, thus securing data consistency and reducing redundant editing efforts. In order to allow high quality information services the network information is enhanced with navigation relevant information. The resulting data pool consists of
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- Integrated network data as routing basis. TMC location codes are referenced to the network in order to allow direct integration of traffic messages provided via TMC.

- Points of Interest used as potential navigation points, including park & ride information. A specific editing client was developed for continuous update.

- Address data for location searches. Integrated regularly from public authorities as information source.

- Traffic messages, integrated from national and federal official information sources

- Travel times and Level-of-Service (HCM) from Floating-Car Data (KRAMPE)

In the first phase of system definition, the data listed above were integrated and referenced to each other. The tools for continuously enhancing the data were created by developing dedicated easy to use editing clients. The update of the network base information is an additional challenge, since the data are edited externally and additional internal edits are available, which shall not be lost in case of updating. A complex procedure for updating the network base information was devised for solving this issue.

Figure 1: Matching system architecture
The resulting data pool is intermodal and includes information about different modes of transport equally. Traffic data are permanently updated in order to generate the dynamical traffic situation. The synthesis of these manifold traffic data is the dynamical traffic situation information. It integrates a number of different information sources about current traffic information, like traffic messages, roadworks, roadside events, park and ride information and many more. All these information sources are integrated on the basis of the integrated graphs, which serve as the reference platform for the information and the services of VIELMOBIL based on them.

5 Traffic information message client

In order to maintain the road network and VIELMOBIL traffic incidents, a message client was developed to manage the acquisition of obstacles such as construction sites, accident or events that lead to a restriction of the traffic flow. This dedicated messaging client is used for adding more specific information, especially related to up to date construction site information. Beside the client supports spreading traffic information via other interfaces to coupled components like the VIELMOBIL routing platform. The end product is a comprehensive multimodal transport information client enabling the following core functionalities (figure 2).

- Real-time exchange of traffic messages allowing high performance information integration and information provision (using standard formats like TMC and DATEX2)
- Create a traffic message and definition of traffic impacts for all means of transport
- Edit, and edit existing traffic events, and define strategic alternative routes (BUDDE)

![Traffic message client](image)

Figure 2: Traffic message client
6 Dynamic Traffic Route Model

As a core function the operating module provides a routing engine for all transport modalities (road, bicycle, pedestrian). In the first stage these three routers (individual transport, cycling and walking) are static and implemented with the Dijkstra algorithm (see figure 3). Since maps and provided information differ for each routing result according to individual requirements, the routing modules are implemented entirely separated. The intermodal logic is capable to request results from the modal partial routers in order to set up an intermodal route. Possible transition points can be considered either by the intermodal logic or the user. The parameters strongly depend on the user’s needs and purpose of travel, and can be optimized by a variety of criteria. The goal is to provide a workable mixture of recommendation (= optimum system) and user intervention through interaction. The transport mode of choice is implemented by setting intermodal heuristics to define the individual route attractivity (number of inter-changes, arrival- departure time, max. car distance, max. footway distance, max. cycleway distance, P + R capacity, public transport frequentation, last connection with public transport). The graph network contains edge attributes defining the characteristics of road segments. The algorithm calculates the optimal route between two places and possible “via” nodes considering the attributes and criteria of individual road sections. Besides displaying the shortest and fastest route connecting to the road network topologies, more complex routing constraints such as environmental zones, turn restrictions and direction-specific attributes are considered as well (figure 3). The basic dynamic routing concept is based on a multi-criteria cost function (VORTISCH). The routing path travel time calculations depend on daytime or traffic conditions (construction, events, accidents, diversions, traffic management strategies) with the resulting segment specific resistant.
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Within the dynamic route calculation, depending on the daytime, segment-specific capacity restraints are merged with the reduction factor to reflect and differ between peak hours and periods of low traffic intensity. The user can see different alternatives in the graphical web interface for a requested route. As shown in Figure 4 there is a convenient overview of the different route results.

![Figure 4: Intermodal information services VIELMOBIL based on dynamic traffic data (www.vielmobil.info)](image)

There are also symbols for the used transport methods in each result. Since the duration for routes can change depending on daytime and traffic conditions, a slider at the top of the menu to change start or arrival time, will be implemented in the near future. Changing the time will then result in a change of suggested routes simultaneously. This provides intermodal dynamic routing considering different restraints which are implemented by the reduction factor. The reduction factor (RF) automatically reduces segment speeds proportional to the amount and density of traffic situations on the route (figure 5). The general attenuation of network graphs is based on traffic information and control strategies derived from public authorities (Landesmeldestelle Hessen) using DATEX II format. Dynamic routing results depend on Datex II format coded types of traffic messages which have different effects on the network (HELLING). The combined traffic reports inside RheinMain region are geocoded with a traffic message client into different categories according to the Datex II standardized format. Weather-related effects on the segment specific capacities are generally described in six state categories. These are equivalent to the Datex II format (normal, ice, snow, water, precipitation, etc.). The reduction factor simulates the expected capacity minimization of a network segment. Weather conditions also have different effects on certain incident categories and reduce separately.
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Figure 5: Segment resistors visualized in 3D (red – high, green – low)

For example an accident (Accident) in combination with icy precipitation gives the reduction factor 1 and thus corresponds to a complete blocked road. The dynamic traffic route model considers hourly, daily and seasonal fluctuations of the traffic flow as well as the effects of incidents, their extension, duration and expected frequency (KESTING&TREIBER). More complex models like multiple interfering traffic events are correlated and processed as segment-specific reduction factors as well.

7 Conclusion

The acceptance of any public information service depends strongly on the quality of the information provided: up to date, accurate and problem specific. For this reason the development of the new service VIELMOBIL was strongly coupled with a new approach for data management. The innovative network fusion and editing concept allows a combination of the advantages of commercial network data with those of public authority data. As a future development process it is planned to sequentially integrate municipalities into the data generation and updating process, thus further improving the information quality. The high performance framework easily allows integrating and combining additional traffic information from floating car data (FCD) or static sensors to calibrate the dynamic routing engine input parameters. The dynamic traffic route model provides realistic route related travel times based on traffic effect estimations and could help to significantly improve mobility and intelligent transportation systems (ITS) for all road users in the RheinMain region.

\[ RF = 1 - (A_1 + A_2 + \ldots + A_n) \times (1+g) \times pS_j \]

- RF = Reduction factor
- \( A_1 \) = derating factor 1 (e.g. accident)
- \( A_2 \) = derating factor 2 (e.g. weather)
- \( g \) = saturation level (daytime related)
- \( pS_j \) = probability based occurrence factor
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