Collaborative Management of Intermodal Mobility

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Abstract. Throughout the world societies are changing, so is mobility behavior. People are increasingly using multiple modes of transport; not only different modes for different trips but also combined use of different modes within one trip can be observed. Furthermore decisions for certain modes on specific trip stages depend on situational context (e.g. current traffic) and individual preferences. This trend can be supported by collaboration of mobility and service providers. Therefore information systems need to provide real-time data about traffic, provider status (of several mobility providers) and possible transfer points to enact context sensitive route adjustment. Alongside with customer preferences traffic flow can be optimized on individual and public level. In this article we strive to highlight challenges associated to this scenario. In addition we will present an architecture for intermodal information systems that offers services for individual planning, real-time route adjustment and provider cooperation.

Keywords: Intermodal Information Systems, Mobility, Public Transport, Collaborative Management.

1 Introduction

Throughout the world societies are changing, especially in urban regions mobility behavior of people is affected. In metropolitan areas individual motor car traffic is causing problems, e.g. traffic jam, overloaded parking space and air pollution. Therefore people are increasingly using multiple modes of transport, in order to accomplish mobility requirements. Not only different modes for different trips but also combined use of different modes within one trip can be observed. Furthermore decisions for certain modes on specific trip stages depend on situational context (e.g. current traffic) and individual preferences. In order to support and promote this development provider cooperation has to be strengthened. In addition new collaboration services are needed in order to cope with extended requirements,

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especially high load on demand side and dynamic reactions in real time (e.g. request for different kind of service or transport mode) based on a current situation. Thus providers have to offer services based on seamless ad-hoc collaboration, therefore two main adjustments have to be made to fulfill customer requirements. First of all a conceptual model that allows dynamic provider collaboration (including accounting) has to be developed. Secondly IT systems of providers have to exchange information regarding current state of operating vehicles as well as data to allow billing of performed services.

Alongside with given customer preferences traffic flow can be optimized on individual and public level. At customer level this means information systems have to provide real-time data about traffic, vehicle status and possible transfer points to enact context sensitive route adjustment. Additionally all mobility providers that collaborate to offer seamless mobility services have to offer information to allow billing of utilized services. In this article we strive to highlight challenges associated to this scenario. In addition we will present an architecture for intermodal information systems that offers services for individual planning, real-time route adjustment and provider collaboration.

2 Mobility Patterns

The travel behavior of the people is getting more and more heterogeneous. People use modes of transport which are convenient for them in specific situations. Contrary to some decades ago, people are less captive of one mode. Also, as displayed in **Fig. 1**, people use increasingly all modes during a longer period [1]. People reveal a multimodal travel behavior when they switch their main modes of transport for different trips in a longer period (e.g. in the course of one week). Just as the multimodal travel behavior the intermodal travel behavior is increasing. We define an intermodal trip as the usage of several transport modes during one trip, e.g. a trip with public transport in combination with bike or private car.

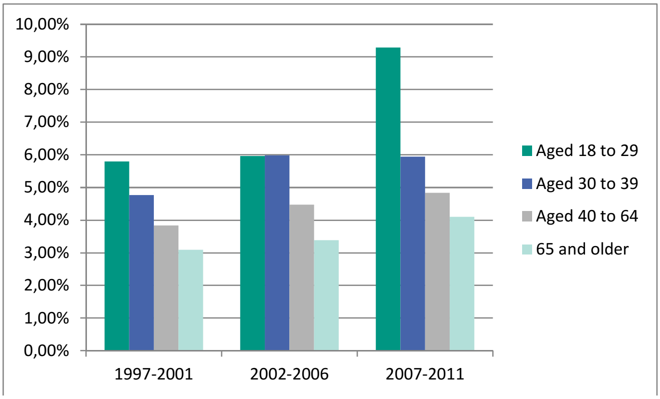

Fig. 1. Share of people with multimodal transport behavior [1]

This work aims on developing and evaluating innovative intermodal vehicle concepts and flexible vehicle sharing services in combination with public transport. Successful implementation of new mobility services in a certain region is driven by mobility needs of people. Therefore we analyzed the Rhine-Neckar-Region in order to get information about travel behavior and intermodal trip patterns of the inhabitants. A pre-existing study of this region was missing knowledge about the sequence of stages and their duration. Therefore we carried out a combined revealed preference (RP) and stated preference (SP) survey to collect intermodal trip information. The RP survey analyzed the revealed travel behavior including different stages, different modes and transfer points. In the SP survey participants could choose between several hypothetical but realistic mode choice situations based on reported trips including electric driven vehicles for the so called last mile (e.g. from public transport stop to work place). The SP survey is the empirical base to analyze acceptance of different electric vehicle concepts with a travel demand model which is under development. Both surveys together result in a model that reveals information about where and when a switch in transport mode is made or would be valuable. This can be utilized by providers to offer new services and extend collaboration to other providers.

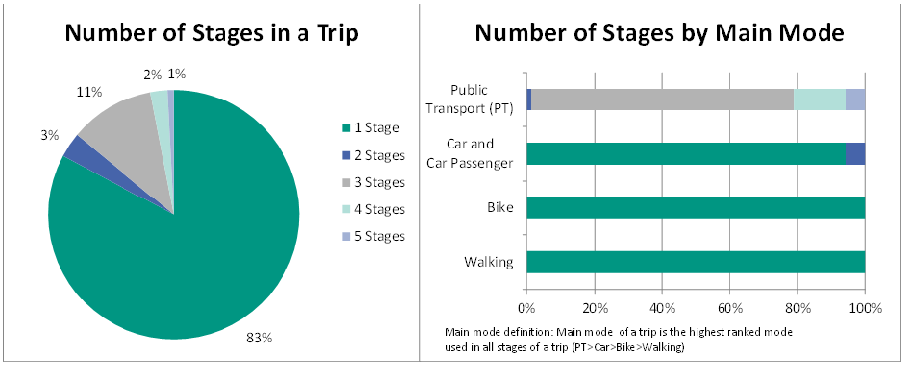

Fig. 2. Numbers of stages in a trip and by main mode in Rhine-Neckar-Region

As one result the RP survey the intermodal trip patterns of inhabitants including all stages are input for the design of information systems utilized by mobility providers. 17% of all trips include more than one stage (see **Fig. 2**). Almost all intermodal trips include at least one stage covered by public transport. Our results also reveal that there is a need for improved information on intermodal trips. Customers are especially seeking for real-time data and in certain situations information about backup services (including those of other service providers). Such enriched information will lead to profound knowledge of transfer possibilities for changing modes and to an increasing number of intermodal trips.

3 Mobility Management

As mentioned one reason for changing mobility behavior is the rising number of inhabitants of urban and metropolitan areas. In turn urban travel management is becoming more and more complex and has to respond to new challenges within high traffic density, lack of parking space and pollution. Furthermore urban inhabitants are more likely open to use environment-friendly mobility concepts, younger people also tend to prefer concepts of sharing over ownership (e.g. the rate of younger people not owning a car is growing). Taken together these trends can foster new intermodal mobility concepts. To turn the challenges mentioned above into opportunities, mobility providers have to cooperate and implement new business models including shared service concepts. However, mobility services in urban cities are currently far from fulfilling these requirements. State of the art services for intermodal mobility suffer from significant shortcomings. Expected real-time information during the trip as well as accurate route planning before and during the trip is currently unavailable or characterized by several media breaks. Especially planning and integrated ticketing of intermodal trips is still a major hurdle for customers, who have to cope with several provider specific information systems, applications and payment systems.

Mobility providers have realized that collaboration and networking are the key factors to solve these shortcomings. Hence first cooperation efforts between mobility providers can be observed in many German cities today. Three major types of cooperation can be observed:

- *Joint fee packages with special rates to each other's customers:* For example some car-sharing providers offer starting package deals over the first couple of months with special rates for public transport. Others offer general discounts for tickets of local public transport.
- *Integrated mobility offers through so called "Mobility cards"*: In some public funded pilot projects so called integrated mobility cards are being developed. The key idea is to combine various mobility and leisure services by a debit card. Thus customers can utilize one card as ticket different services (such as public transport or car sharing). The HANNOVERmobil-Card can serve as an example [2].
- *Joint sales and marketing activities:* A well-known and widely spread kind of cooperation is the establishment of joint sales and marketing activities. Cooperating partners advertise each other in own publications, point customers to partner offers or even negotiate contracts for partners.

These types of cooperation are first steps to improve support of intermodal trips, they, however, do not meet the needs and demands of today's mobility developments. On customers side only few aspects (primarily ticketing) to diminish the hurdle of intermodal trip planning are tackled. Regarding efficient provider collaboration all solutions suffer main drawbacks. Generally current approaches are operating on local level with pre-defined providers, which create rigid structures that are not designed to integrate new providers or new mobility services. Additionally on a technical level solutions focus information systems utilized by local providers and often neglect standards; thus further development of standards (e.g. VDV 452 [3] that cannot cope anymore with above mentioned requirements is also not promoted. Hence Intermodal Transport Control Systems (ITCS) that would enable efficient collaboration of providers and implement integrated mobility services with simple access for customers are still not established.

4 Intermodal Information Management

As elaborated, collaboration networks on business and IT level are required to implement ITCS. Thus information systems, interfaces, business processes and business models of the collaborating mobility providers have to be analyzed, aligned and integrated. This includes integration of pre-existing information systems of all participating partners; particularly the establishment of a collaborative integration platform is a major issue. To enable ad-hoc collaboration and integration of new services as well as providers, extendable open standards have to be developed and used. The most crucial nonfunctional requirement is, that the technical platform has to react in real-time under a high load (number of customers and status data delivered by mobility providers). In a public funded joint project we developed a four step approach to tackle these challenges:

1. Discover services and business processes offered by providers
2. Identify possible future services alongside intermodal trip support
3. Design platform architecture
4. Development of platform prototype with provider integration

At first we conducted several workshops with the participating mobility providers (Stadtmobil and RNV). Herein we identified, grouped and aggregated current use cases to derive relevant business process models. By process and interface analysis we identified interoperability opportunities and shortcomings. During this analysis we included several domain models such as [4] and a set of key performance indicators. As output an overall process map covering the relevant, aligned business processes of public transport and car sharing was generated. In a second step we went through further workshops to identify relevant target use cases for future intermodal mobility services. Taken together with identified mobility patterns (result of our surveys, see section 2) we could identify regional mobility demand and specify a set of service concepts prosperous to be implemented within provider business models. As stated a provider collaboration platform, that seamlessly links information and accounting systems, is essential to implement an overall and collaborative ITCS. The general architecture of such a platform is given in **Fig. 3**. The architecture is based on a mediator component, which acts as integrator for the collaborating partners. As collaboration participants **Fig. 3** displays a car-sharing provider, a public transport provider as well as a service provider (e.g. provider of routing and navigation technology). Routing and navigation technology is important to enable intermodal trip planning; the mediator can forward information of possible mobility related services. Further services and providers may be integrated in order to optimize planning of suggested intermodal trips. Furthermore the platform is designed with open interfaces to enact simple entry for further providers (mobility as well as additional services of other domains).

In our joint project all providers committed themselves to deliver real-time information (e.g. regarding state of vehicles, traffic situation, ticketing) to the mediator, which forwards them to customers. Customers can get access to information and ticketing by various clients (e.g. web-frontend, applications for desktop and smartphone). The data interface is currently based on standards utilized by providers. In this context standards such as VDV 452, 453 and 454 as well as CEN SIRI (see [3, 5]) are important, for enhanced provider collaboration. However, standard extensions are necessary, especially because their current main focus is providers of public transport. Thus we intend to suggest a meta-format that is flexible enough to integrate and extend several data standards and services beyond mobility. Therefore data transformation and coordination of interaction between all collaboration partners is a major task for the mediator component. Direct vehicle communication is out of scope of this architecture, since it has to be covered by collaborating mobility providers (e.g. car status is delivered from its on-board unit (OBU) to the car-sharing provider which forwards this information to the mediator if relevant). Thereby a load balancing mechanism is implemented implicitly.

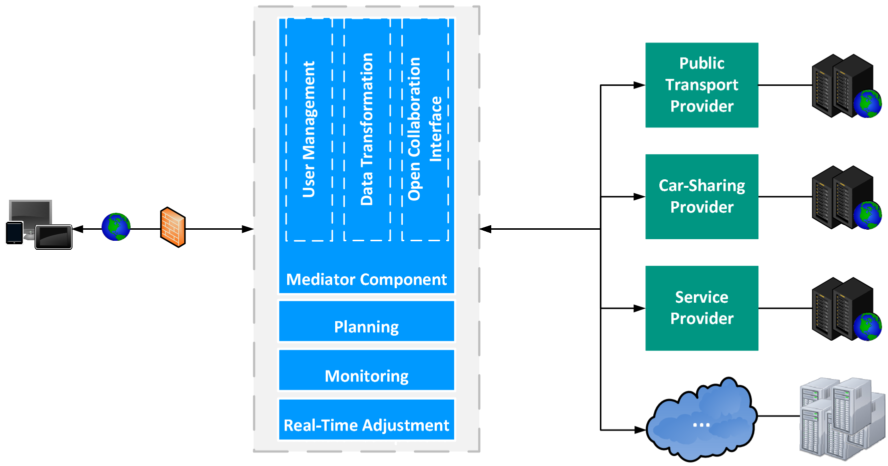

Fig. 3. General platform architecture to enact ITCS

The suggested architecture is implemented by an iterative approach. In a first stage we are implementing services for pre-trip planning and context based adaption of planned trips. Additionally to planning in general, we offer services to specify individual preferences in a user profile. This profile can also automatically be updated through the mobile app, if the user enables tracking of decisions and requests for mobility services. In order to create an interoperable implementation on customer level, we decided to offer these services by a web-based mobile application and a web-frontend. On provider level we integrated pre-existing information services based on their current API. Our implementation is based on extension and integration of systems of two mobility providers (RNV and Stadtmobil) and one service provider (PTV). Once a user requested a route, the mediator component communicates with PTV's xServer to get the results of the route calculation, additionally it coordinates interaction with the information systems of RNV and Stadtmobil. By integration of all results and customer preferences, the mediating component calculates an intermodal route which best fits to user and the current traffic situation. The current situation is retrieved through sensors of mobile devices and can be extended by third-party services (further collaboration partners of other domains such as weather forecasting). Results of this tactical route planning are presented to the customer.

As second iteration monitoring of the current situation will be implemented. This includes processing of incoming real-time information (traffic and provider related) in order to adapt trip stages, again this involve the planning steps described above. We plan to create push messages to keep the customer informed and suggest optimal mode switching (e.g. because an accident or a delayed tram). In a third iteration of implementation, the mediator will forward ticketing information to all affected providers in order to enable seamless ticketing based on booking through the known mobile app (thereby an additional debit card can be avoided).

5 Related Work

Only few research efforts have been taken on the coordination and cooperation of independent mobility and service providers in inter- and multimodal traffic. Some articles concerning intermodal freight transportation have been published, these mainly focus on methods derived from operations research in order to adjust planning along transport modes and handling of cargo [6–10]. Research regarding individual traffic is often not focused on intermodal traffic [11, 12]. Examples of cooperation between mobility providers can be found in Germany and Europe. In Barcelona, for instance, bike-sharing stations can easily be found nearby metro stations [4]. Holders of the "Mobil in Düsseldorf" season ticket can use public transportation as well as bike-sharing (240 minutes per day) and car-sharing (90 minutes per month). Comparable services are available in Hannover, Freiburg and Bremen [13]. Several research projects like Stuttgart Services [14] or BeMobility [15] deal with questions around integration and management of mobility concepts like car sharing, electrical vehicles and public transport in order to meet today's mobility needs. These projects consider implementing new intermodal mobility concepts with debit cards and specialized access points. However, initiatives are mainly local, based on rigid rate and cooperation concepts. Thus flexible integration of additional services is not covered conceptually. Furthermore optimization of route planning and adjustment is usually out of scope.

Also prosperous is development driven by automotive manufacturers that increase creation of new services, mobility concepts and investment in start-up companies with innovative mobility concepts. Daimler for instance is working on a consolidation of car-sharing services car2go and moovel supplemented by search services for parking space or load stations. Corresponding efforts can also be observed by other manufacturers such as BMW or Volkswagen. This strengthens the observation of increased importance of intermodal traffic and the combination of mobility and additional services. Nevertheless, currently an open integration platform across mobility providers which supports pre- and on-trip planning (including dynamical route adaption and real-time information across mobility providers) is still missing.

6 Conclusion

Traffic issues in larger cities require intelligent traffic control and lead to changed mobility behavior of people. Therefore demand for intermodal traffic and context-driven route adaption is increasing. The need for new services can be identified based on analysis of mobility patterns (as outlined in section 2). Implementation of these services can be supported by new forms of provider collaboration, which can be derived by analysis of pre-existing information systems, business processes and interfaces (as described in section 4). It should be noted that nowadays ad-hoc collaboration in general is not possible for providers because of two reasons: first of all common standard formats that allow exchange of real-time and accounting data are still not utilized, missing or under development; secondly a common architecture that enacts plug-n-play of providers is missing.

Throughout the article we presented a solution architecture that will enable mobility providers to create ad-hoc collaboration in order to fulfill customer demands based on individual preferences, route planning and current traffic situation. The architecture includes mechanisms for integration of supplementary services and providers. Currently we are implementing services within the proposed architecture to enact collaboration of providers of local public transport and car-sharing. To evaluate the proposed platform we are in cooperation with two major local providers. The implementation is driven be pre-existing systems and their extension. As a next step we plan to elaborate extension of current data standards to exchange provider and accounting information. Thereby we intend to widen the range of possible collaboration providers and lower the hurdle for integration (also of service providers of other domains). We are also planning to abstract general mobility patterns that might be relevant for all urban regions. The latter could be used to identify required services fast and easily.

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