Heterogeneous Travel Information Exchange

Markus C. Beutel, Sevket Gökay(✉), Wolfgang Kluth, Karl-Heinz Krempels, Christian Samsel, Christoph Terwelp, and Maximilian Wiederhold

Information Systems, RWTH Aachen University, Ahornstr. 55, 52074 Aachen, Germany
goekay@dbis.rwth-aachen.de

Abstract. Travel information brokers are complex systems, dealing with a large amount of heterogeneous data from various sources. The exchange and integration of such data is therefore demanding, particularly for small mobility service providers with few IT resources. To face this problem, this work illustrates a key tool to support information and service integration. On a conceptual level, we present a travel information broker system architecture and respective information flows. Additionally, we describe data exchange related to system components, e.g., intermodal routing, pricing and accounting. On this basis, we developed and tested a communication adapter that enables and eases communication between the core system and second party service providers. Furthermore we outline the method of extending public transportation routing with information about sharing services. This enables travelers to query combined information about public transport, bikesharing as well as carsharing services using a single application.

Keywords: Bikesharing · Carsharing · e-mobility · Intermodal travel · Smart mobility · Travel information

1 Introduction

Combining diverse travel services (e.g., traditional public transport, parking services, carsharing, ridesharing) results in better offers and better service coverage compared to individual services [1]. Eventually this leads to a higher acceptance of alternative (compared to using a private car) services among travelers and therefore better sustainability. Because of the complexity and amount of these services, a supporting information system serving as single point of contact for travelers is required. Unfortunately, integration of diverse travel information is a demanding task. On the one hand, mobility modes differ significantly in structure, i.e., individual transport vs. train schedule, and payment model, i.e., single ticket vs. subscriptions. On the other hand, travel information systems vary in extent and functionalities. Either way, the respective data is heterogeneous and has to be integrated effectively. Hence, this work focuses on the technological data integration of different data sources and data types, to subsequently lower the burden for mobility providers to join a collaborative service offering. For this

B. Mandler et al. (Eds.): IoT 360° 2015, Part II, LNICST 170, pp. 181–187, 2016.
DOI: 10.1007/978-3-319-47075-7_23

purpose, we hereby refine the conceptual travel information broker architecture introduced in [2] and illustrate the workings and interaction of key components. We describe a communication adapter which enables optimized data exchange between mobility service providers and the core system. This solution allows second party providers to join the system and use its resources, e.g., intermodal routing and accounting, with little individual integration efforts.

2 Related Work

In general, travel information provision via information systems has been investigated and improved in several areas in the last years. Crucial for the success of these information systems are two main factors: (a) the quality of the provided information in terms of comprehensiveness and completeness and (b) the systems' usability. In [3] a technology acceptance model is applied to evaluate the usability of mobile passenger information systems. According to [4] travelers are highly frustrated when using public transportation because of lacking information provided whereas [5] also underline the importance of real time data provision. As a consequence, providing better information by integration of heterogeneous mobility services is a prominent research field.

Modern travel information applications like Transit App or Qixxit[1] differ in extend and functionalities. Above that, different research projects investigate issues related to travel information integration: For example the IMA System is an open agent based mobility platform, that combines heterogeneous mobility services, e.g. ridesharing [6]. The European research project SUPERHUB is another open platform for urban mobility, that enables multimodal journey planning. The system incorporates intermodal routing [7] and encourages sustainable travel behavior by a behavior management component [8]. Another example is the B2B platform OLYMPUS[2], which provides flexible multimodal transport solutions with focus on electric vehicle sharing [9] and the Integrated Mobility Platform (IMP)[3].

3 Use Cases

Using the integration method presented in Sect. 4, a platform is enabled to offer continuous intermodal travel in terms of planning, booking, ticketing and assisting. The following use cases exemplify the advantages of information exchange and integration.

[1] http://transitapp.com, http://www.qixxit.de (German).
[2] http://www.proeftuin-olympus.be/en.
[3] http://www.mobility.siemens.com/mobility/global/en/integrated-mobility/imp/pages/default.aspx.

Traditional Travel Without Data Integration. Adam has a business meeting with a project partner in St. Augustin (a suburb of Bonn), Germany in the afternoon. Currently he is planing his trip in his office in Aachen, Germany. He queries the website of Deutsche Bahn which returns an itinerary from Aachen Main Station to Bonn Main Station. To get to Aachen Main Station he asks a colleague which bus to take and to get from Bonn to St. Augustin he is thinking of taking a cab. Because the meeting is important and Adam knows neither the overall duration of the travel nor the price and also feels insecure about changing buses and trains, he opts for a rental car instead.

New Generation of Travel Supported by Data Integration. Bella is Adam's deputy and is in the same situation one day later. She queries a travel information system which integrates data of multiple mobility services. The system returns an itinerary involving a rental bike from the office to Aachen Main Station, trains from Aachen to Bonn and finally a reserved carsharing vehicle to St. Augustin. The system also shows the exact price and travel duration and allows to book the complete itinerary with a single click. After booking, the itinerary as well as tickets are transferred to her mobile device so she can check for train departure information easily and therefore feels secure to reach the destination in time.

Bella's travel costs less than half of Adam's and is almost as fast, while being more environment-friendly.

4 Heterogeneous Data Integration

This section outlines the technical infrastructure proposed for data integration and the required technology.

4.1 IT Architecture and System Components

Based on the general architecture presented in [2] we created a technical system infrastructure to support intermodal travel. The current architecture is depicted in Fig. 1. The traveler interacts with the system using a mobile application or a web portal which connects to the backend using the standardized APIs, URA2 and URA3. The URA interface family is widely used, i.e., by Transport for London[4].

The architecture of the backend resembles a distributed system consisting of different functional components and multiple internal and external endpoints. The following components represent existing functionality: The *Dispatcher* component serves as a single endpoint for all API calls from mobile applications and the web frontend. The dispatcher re-routes and combines requests, responses and push notifications to their respective receivers. The *Intermodal Router* serves exhaustive door to door routing queries and serves as a merger of the different routing

[4] http://www.tfl.gov.uk/info-for/open-data-users/.

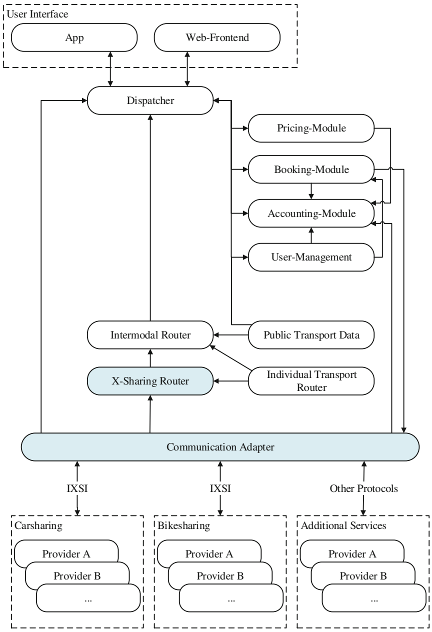

Fig. 1. Technical architecture.

techniques. It is invoked by the dispatcher. The Intermodal Router is based on the Raptor algorithm [10] for fast public transportation routing, using real time timetable data. The *Individual Transport Router* serves pedestrian and (private) bicycle routing queries. It uses established routing algorithms for finding shortest paths in networks. The *Pricing* module augments routing information supplied by the Intermodal Router with pricing information. The overall journey price is composed of a price per route segment which is handled individually. Prices for public transportation are modeled locally in the pricing module and can be calculated via stop numbers, distance, areas, daytime etc. Season tickets are also considered if specified in the request. For sharing service fees, the external sharing system is inquired via the communication adapter. This allows service providers to handle pricing corresponding to their individual tariff systems. The *Booking* module is responsible for forwarding booking requests to the respective mobility service and delivering the resulting ticket to the client. Price information is delivered to the billing module. The *Accounting / Billing* module collects all billing information from service providers to allow a real time cost check as well a monthly billing. The *User Management* component is responsible for creating and modifying user accounts and user authorization. If required, user data is also exchanged with external data using the Communication Adapter.

In addition, the Communication Adapter and X-Sharing Router are introduced in this work: *Communication Adapter* is responsible for all the communication with second party mobility providers. It supports communication via all noteworthy transport protocols: RESTful (using JSON or XML), SOAP and WebSocket (also using JSON or XML). The adapter exchanges travel information using a variety of open protocols i.e., IXSI (Interface for X-Sharing Information). IXSI [11] allows asynchronous exchange of vehicle sharing information, i.e. availability. The *X-Sharing Router* component extends the Intermodal Router with specific routing using sharing services. It employs real time vehicle availability data to calculate route segments. For faster query times, legs connecting sharing places are precalculated and cached. In order to calculate feasible path towards the destination using individual transport, several restrictions about a realistic routing alternative must be considered. Regular carsharing for example, usually requires the rented vehicle to be returned to exactly the same place it was taken from, which automatically prohibits this mode of transport from appearing in the middle of the journey.

4.2 Information Flow

To clarify how the components interact, consider the information/data flow of an intermodal travel query: Before the actual user interaction, the system has been initialized; all mobility service providers exchanged their availability as well as time table information and the user is registered. The user queries the system for an intermodal itinerary from location A to location B using a mobile app. The Dispatcher forwards the requests to the Intermodal Router which constructs multiple possible itineraries. Simplified, it does so by finding all stops and sharing places in the vicinity of both locations using the Individual Transport Router and finding the best connections between these places using both public transport and sharing service (calculated by the X-Sharing Router). In the next step, these itineraries are forwarded to the Pricing Module which calculates and annotates prices for every route segment. The list of itineraries, including prices, is then supplied to the app, respectively to the user. If the user opts to book a specific itinerary, he or she has to authenticate him or herself which is handled by the User Management (requests are again handled by the Dispatcher). Using the authentication token (supplied by User Management) and unique identifier for desired itinerary (supplied by the Routing), the booking commences: The Booking Module informs mobility services via the Communication Adapter to book the service and forwards the resulting billing information to the Accounting Module and the booking confirmation/ticket to the client. Now all preparation steps for the travel are complete and the user can conduct the travel. During the travel, he or she is notified about changes/updates in her subsequent route segments. Directly after the travel or alternatively at the end of the accounting period, the customer is billed by Accounting Module with the assistance of the User Management (for billing information).

5 Results and Discussion

We contributed a conceptual architecture and depicted the functional information exchange between system components. The solution allows system participation and service provision, based on standardized interface specifications.

We currently have a working instance of the architecture and most components presented in Sect. 4. Travelers are able to query time table information for public transport (buses and trains) and availability information for offered bikesharing pedelecs as well as carsharing vehicles and also book the services. This can be done via a single platform, respectively a single application. The information shown represents real world services/vehicles and by that demonstrate the functionality of the information exchange between systems. The respective services are provided by multiple independent mobility service providers, who operate their own business and IT infrastructure.

Main advantage of this solution is the technological accessibility of the core system towards second party providers with limited integration efforts. These providers can benefit from centralized user interfaces, intermodal routing and accounting functionalities without implementing them individually. Moreover, users benefit from a centralized information system that allows convenient and comprehensive intermodal travel information provision.

Some drawbacks might occur concerning the data management. Sensitive data, e.g., user information is located and aggregated at the centralized core system - instead of separated provider databases. Although standardized interfaces and architectures simplify data exchange, the implementation may be demanding for mobility service providers, especially if they are currently using old-fashioned IT systems.

Future Work and Outlook

The presented IT architecture was continuously refined during development and implementation and probably will be refined and possibly extended even more as required.

The implementation of the Communication Adapter is mature and ready for productive operation, only minor feature enhancements are anticipated. Such enhancements could include support for additional, potentially proprietary, protocols for even more mobility services. Specifically booked parking and/or charging of an electric vehicle appear worthwhile. The X-Sharing Router is currently being implemented. Depending on the initial results, further performance optimization to keep the whole system sufficiently interactive might be required. Besides performance, a specific route's feasibility from a user perspective might also be required to improve (i.e., avoiding slopes for rental bikes).

The overall system is currently partly working and operates in test mode with few test participators. After completion of pending functionalities, specifically full intermodal routing, a holistic field test will be conducted. This field test is supposed to, besides showing the technical feasibility, answer questions regarding the acceptance of such an intermodal travel information system, from providers as well as user perspective.

Acknowledgments. This work was funded by German Federal Ministry of Economic Affairs and Energy for project Mobility Broker (01ME12136).

References

1. Huwer, U.: Public transport and car-sharing - benefits and effects of combined services. Transp. Policy **11**, 77–87 (2004)
2. Beutel, M., Gokay, S., Kluth, W., Krempels, K.H., Samsel, C., Terwelp, C.: Product oriented integration of heterogeneous mobility services. In: IEEE 17th International Conference on Intelligent Transportation Systems, pp. 1529–1534 (2014)
3. Obermeier, M., et al.: Usability evaluation of mobile passenger information systems. In: Marcus, A. (ed.) DUXU 2014, Part I. LNCS, vol. 8517, pp. 217–228. Springer, Heidelberg (2014)
4. Papangelis, K., Sripada, S., Corsar, D., Velaga, N., Edwards, P., Nelson, J.D.: Developing a real time passenger information system for rural areas. In: Yamamoto, S. (ed.) HCI 2013, Part II. LNCS, vol. 8017, pp. 153–162. Springer, Heidelberg (2013)
5. Garcia, C.R., Candela, S., Ginory, J., Quesada-Arenciba, A., Alayon, F.: On route travel assistance for public transport based on android technology. In: 6th International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing (2012)
6. Keiser, J., Masuch, N., Lutzenberger, M., Grunewald, D., Kern, M., Trollmann, F., Acar, E., Avci Salma, C., Dang, X.T., Kuster, C.: IMA-an adaptable and dynamic service platform for intermodal mobility assistance. In: IEEE 17th International Conference on Intelligent Transportation Systems (2014)
7. Hrncir, J., Jakob, M.: Generalised time-dependent graphs for fully multimodal journey planning. In: 16th International IEEE Conference on Intelligent Transportation Systems, pp. 2138–2145 (2013)
8. Wells, S., Forbes, P., Masthoff, J., Gabrielli, S., Jylha, A.: SUPERHUB: integrating digital behaviour management into a novel sustainable urban mobility system. In: 27th International BCS Human Computer Interaction Conference (2013)
9. Buchinger, U., Lindmark, S., Braet, O.: Business model scenarios for an open service platform for multi-modal electric vehicle sharing. In: The Second International Conference on Smart Systems, Devices and Technologies (SMART 2013), pp. 7–14 (2013)
10. Delling, D., Pajor, T.: Werneck, R.F.: Round-based public transit routing. Transp. Sci. 1–14 (2014)
11. Kluth, W., Beutel, M.C., Gökay, S., Krempels, K.H., Samsel, C., Terwelp, C.: IXSI - interface for X-sharing information. In: 11th International Conference on Web Information Systems and Technologies (2015)