User Requirements for Intermodal Mobility Applications and Acceptance of Operating Concepts

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Abstract. The mobility behavior of the European population has undergone significant changes in recent years. New services like bike, car and ridesharing are arising. The integrated use of different transport modes can be supported effectively by the features and services of sophisticated smartphones. This paper describes the methodology and research results concerning users' behavior, needs, and requests with regard to intermodal mobility applications.

Keywords: Intermodal mobility · Public transport · Mobility services · Mobile applications · User requirements · Preferences · Habit · Focus group · Operating concept

1 Motivation

Against the background of changing social values towards resource efficiency and environmental benefits today's mobility is less of a choice between different transport modes, but rather their intermodal integration during a trip. The advancing diversity of mobility services is combined by the users under very pragmatic aspects in order to get from A to B fast, reliably, conveniently and as cost effectively as possible. The resulting travel chains require a high level of information, routing, navigation, and guidance services including booking, smart ticketing and payment services, largely based on real-time data and reliable forecasts. This is supported by mobile applications.

As part of the research project "Dynamic Seamless Mobility Information" conducted by a consortium of different public transportation companies, service and IT companies as well as scientific institutions, the Technische Universität Dresden is investigating both the general user requirements for dynamic information services (step 1) and the operating concepts within the applications (step 2). In this article we present selected results of this research project.

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2 Status Quo of Mobility Application Development and Offered Services

Prevailing mobility applications already have a large number of features well established in terms of their technical feasibility. IT specialists are able to realize complex applications in the areas of information retrieval, route selection, favorite setting, navigation, travel companionship, alerts or ticket purchasing. However, the informational support of intermodal crosslinking as well as a seamless integration of different mobility services still has great potential. Figure 1 displays the result of a portfolio analysis of 35 mobility applications offered on the German market.

For the analysis, 22 functions were defined to characterize the information and service level of mobility applications along the travel chain. Following the approach of the Boston Consulting Group Portfolio Matrix [2], the vertical axis represents the degree of innovation and the horizontal axis displays the user satisfaction scores of each application. The innovation degree arose from the nature and scope of the different functions in combination with the number of highly innovative features. The user satisfaction scores were transferred from the application ratings found on the website of the iTunes App Store and Google Play Store respectively.

The result of the portfolio analysis shows that a variety of applications provides good functional core services but is improvable in terms of their innovation degree (cash cows). Far fewer applications (stars) offer very innovative features such as dynamic maps, augmented reality/3D function, voice navigation, proactive companion services, indoor routing, social network connections and crowdsourcing. Although some applications, such as Nokia HERE Transit, have a lot of innovative features, they are not able to convince the users with their performance (question marks) [1].

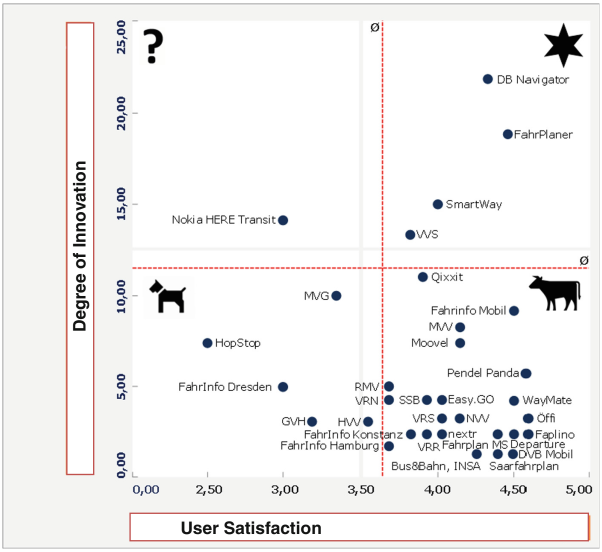

Fig. 1. Portfolio analysis of prevailing mobility applications in Germany [1]

Therefore, the aim of the research project “Dynamic Seamless Mobility Information” is to develop a highly innovative intermodal mobility application including trendsetting indoor navigation features in order to overcome the shortcomings of existing applications.

3 Identification of General User Requirements for Intermodal Mobility Applications

3.1 Methodology for User Requirement Identification

In order to investigate the general user requirements for intermodal mobility applications the empirical research based on two methodological approaches:

Qualitative Interviews. In focus group interviews, as a form of qualitative research [3], the participants were asked about their perceptions, opinions, needs, and attitudes towards using mobility applications in different pre-, on- and post-trip situations. Questions were asked in several interactive group settings encouraging participants to communicate freely with other group members.

The participants of the focus groups in Dresden and Frankfurt were selected specifically in accordance with relevant criteria. Prerequisite was the occasional or regular use of public transport. Furthermore, participants had already retrieved traffic information via stationary websites before, and possess a smartphone. In total, at least two subjects in each group had to be using mobility applications actively. In terms of socio-demographic characteristics, a balanced composition regarding age, sex, place of residence (urban, suburban and rural areas), employment status, stage of life, etc., was intended. People with mobility disabilities were explicitly included in each group.

The guideline supported focus group interviews covered four basic services: Routing & Navigation, Dynamic Trip Guidance, Social Media and Intermodal Crosslinking.

The objective of the qualitative focus group interviews was to analyze the user’s preferences and requirements for intermodal applications, especially with regard to

- their information needs and their pre-, on- and post-trip information behavior,
- the capabilities and requirements for their own orientation and guidance,
- their attitude towards social networks and how social networks can be helpfully integrated in mobility applications,
- the circumstances under which the subjects are willing to change the transport means and how the mobility applications could provide incentives to turn towards previously unused services such as car sharing or bike sharing,
- to develop a typology of different user groups.

Quantitative Interviews. In order to prove the plausibility of findings from the focus group interviews a broader online market survey with a larger sample was conducted. The principal user preferences concerning intermodal mobility applications were investigated using a standardized questionnaire [4]. The survey was conducted in the area of the Rhine-Main Transport Association in the German state of Hesse in the period of March to April 2014. The composition of the sample is shown in Fig. 2.

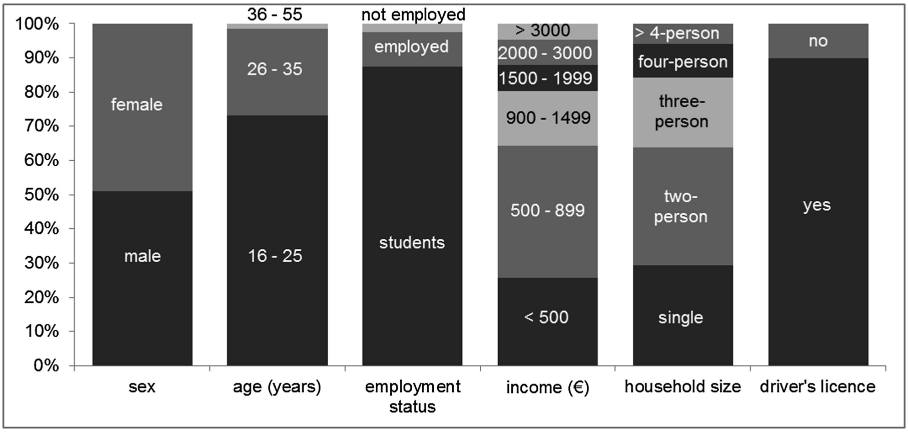

Fig. 2. Sample composition

The online questionnaire sent to 37,000 volunteers by e-mail accomplished a response rate of 5.3 % (i.e. 2000 fully completed questionnaires).

3.2 Selected Results of User Requirement Identification

The results of the qualitative and quantitative interviews described in Sect. 3.1 indicate:

- the **general user requirements** regarding the four basic services "Routing & Navigation", "Dynamic Trip Guidance", "Intermodal Crosslinking" and "Social Media"
- a **specific typology of user groups,** each of them in terms of their characteristics and user requirements for intermodal mobility applications internally homogeneous but clearly distinguishable from other groups externally.

General User Requirements. The following Table 1 summarizes the results of all focus groups as well as the online survey. It shows the most needed features and functions of mobility applications with reference to the four basic services. As an important result three user requirements could clearly be determined as the most needed and relevant ones across all phases of travel:

- automatic information about delays and disturbances of any kind
- calculation and display of alternative routes in case of disturbances
- automatic recognition of spontaneous target changes (or when entered manually) during the trip and recalculation of the route

User Typology. Based on the written and anonymized material of the focus group interviews a user typology was developed in four steps. Kelle's and Kluge's approach [5] served as methodological basis for the content analysis. As a result of this procedure four user types could be distinguished. They differ significantly from each other regarding the character traits "openness" and "level of structured behavior" (see Fig. 3).

The dimension "openness" includes a person's attitude towards recent technologies and the readiness to use or reject these. The dimension "level of structured behavior"

Table 1. Desired features and functions of basic services within mobility applications

Basic Service	Features	Functions
Routing & Navigation	route planning	• multimodal comparison of all transport modes with the possibility of intermodal linkage
	route planning and walking speed	• easy selection of walking speed "slow", "medium", "fast"; input of additional mobility restrictions such as luggage, bicycles, strollers etc. in order to calculate realistic transfer times • search options based on categories such as stations, POIs, addresses (auto-correction is must-have) • display of all available stops in the vicinity, not only the nearest
	details about stations, transfer hubs and whereabouts on the route	• to provide detailed information on station facilities such as ticket machines, lifts, stairs, restrooms, transfer spots, platforms, direction of travel etc. displayed by different symbols and signs
	indoor navigation	• to provide an overview about the complete building complex • navigation via images (also user-generated), landmarks, signs, and icons • use of augmented reality
	outdoor navigation	• in app-solutions desired (without using Google Maps) • synoptic view for related information (similar to Google Maps) • filter features for POI symbols, especially in case of augmented reality
Dynamic Trip Guidance	real-time data	• information about departure, scheduled and estimated time of arrival, delays, and disturbances in real-time • reliable information about assured connections
	storage of frequently traveled routes	• offline storage of the departure times for these routes • free choice whether information about disturbances are delivered via push or pull mode
	disturbance assistance	• reliable information about the cause and estimated duration of disturbances • planning of alternative routes • routing to the replacement station • information if the planned connection is at risk • automatic push message in case of deviation from schedule with respect to individual preferences
	inclusion of POIs in route calculation/rescheduling	• to take into account needed time for stopovers in the total routing • in case of delays, automatically finding and displaying alternative connections
Social Media	address transfer	• transferring start and destination addresses from social media (facebook, twitter, contact lists) • possibility of entering an address instead of a certain stop
	calendar	• link between the calendar and the mobility application to facilitate future trip planning • timely reminders • report of overlaps or disturbances on the planned route
	distrubance notifications via user networks	• relevance filter for notifications, only for important routes (routes with daily frequency, current route, interconnected route) • commuting features: Warning about disturbances on the daily route during the typical travel time causing tremendous delays • trouble notifications of users should be checked and verified by the transport operators
	complaints	• reporting complaints and irregularities (e. g. not working or damaged doors, windows, heating, air conditioners, ticket machines), gross dirt or lacking personnel services

Basic Service	Features	Functions
		• complaint forms allowing quick and easy information submission by predefined complaint categories • text editor to enter special incidents • quick response on complaints submitted
Intermodal Crosslinking	possible car and bike sharing services	• to provide notes for car/bike sharing services and appropriate information already during the initial setup of a mobility application • single sign-on for multiple service providers and offering "roaming" between different car and bike sharing providers
	taxi features	• display of different taxi providers • calculation of approximate price for selected trip • taxi request as an in-app solution
	ticketing	• ticket purchase on smartphones • to show the best ticket option • consideration of tariff zones and giving an alert when the valid tariff zone is left
	connection between public transport and use of private cars/ car sharing	• predictive journey time forecasting • display of P + R parking, including vacant capacities • calculation of additional time for searching parking space, transit times etc.
	choice and filter features	• display of available vehicles at car or bike sharing stations (vehicle type, state of charge, etc.) → car reservation and navigation to the station • reliable estimation of the route and arrival time should be given when shared vehicles are used on the route

describes the degree of personal planning needs, that is, whether a person acts more planned, structured and foresighted or rather spontaneously.

Subsequently, the main characteristics of the four user types are briefly described.

The Open-Minded Planner. The requirements of this user type are primarily aimed to his or her needs for structure. Those persons receive their needed security by planning. Statements such as "I'm not just going at random …" or "I always organize myself first before I leave…" are typical of this type of person. For the open-minded planner, the features and functions with regard to the basic service "routing and navigation" are most important, followed by the features of "dynamic travel guidance". His or her openness towards technical developments leaves a wide range for additional functions of mobility applications with a certain willingness to pay.

The Open and Flexible Type. This user type has the same enthusiasm for technology such as the open-minded planner, but requires much less structure and foresight. In extreme cases he or she is not even preparing for a journey. Statements like "and then I'll get from A to B somehow" are typical. He or she has much lower information needs and often makes spontaneous decisions. Therefore, the features and functions of "dynamic trip guidance" are most important for this person. The benefit for him or her using a mobility application is especially the retrieval of information, particularly in terms of real-time data. As a result, these users also have a great willingness to use sharing services (intermodal linkage), when access to these services is simple and straightforward.

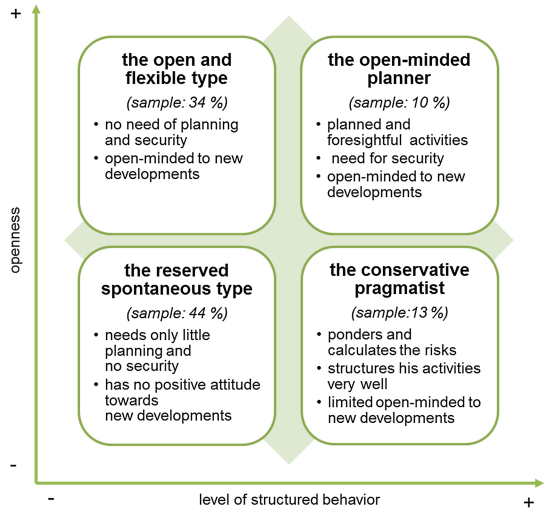

Fig. 3. User typology

The Conservative Pragmatist. Similar to the open-minded planner the decisions of this type are characterized by plans and structures. Information about the journey capabilities is searched at home on the Computer and frequently printed out for use while travelling. This type rarely falls back on smartphones or even mobility applications. The conservative pragmatist mostly uses his own vehicle and is only willing to switch to alternative transport means in case of incidents or unusual events. Then, car sharing options are taken into consideration as well as taxi features. These should be included in the application within the basic service “intermodal crosslinking”.

The Reserved Spontaneous Type. This type has the lowest scores regarding the two dimensions “openness” and “level of structured behavior”. In its spontaneity he or she is similar to the open-minded flexible type. In most cases, there is no time pressure and therefore no need to plan the routes carefully or to synchronize times. A typical statement is: “I always say, as long as the tracks are there, a train will come.” Furthermore, trips on unfamiliar routes and in foreign cities are often taken by surprise. Towards recent technical developments this type is not very open-minded. This may even extend to a total refusal of smartphones and services. Thus, the reserved spontaneous type is the user group that can be associated least with a mobility application. The requirements are mainly related to obtain clear and easy accessible information. Additional functions and features seem rather daunting.

As Fig. 3 shows, the shares of the “open and flexible type” (34 %) and the “reserved spontaneous type” (44 %) are the highest within the sample. Therefore, the features and functions of mobility applications supporting particularly pre-, on-, and post-trip spontaneity as well as information retrieval (see Table 1) have the best performance measures and are needed most.

4 Evaluation of Operating Concepts

The second part of the research project comprised the evaluation of eight operating concepts for mobility applications regarding their acceptance by potential users.

4.1 Methodology

1,884 oral interviews with public transport passengers were conducted in November and December 2014 during their trips or at public transit stations of the Rhine-Main Transport Association. In order to become interviewee the use of at least one mobility application was prerequisite. This way, a basic understanding of the topic could be ensured. The interview consisted of two sections: First, general questions concerning the mobility behavior, use of mobility applications as well as personal details and attitudes were included. Secondly, the interview subjects were due to assess their acceptance regarding the operating concepts of mobility applications, each by showing three different screen designs (e.g. Figs. 5, 6, 7). The participants were supposed to rate each screenshot on a scale from 1 (poor operating concept) to 7 (good operating concept).

The following operating concepts had to be scored: Menu design, route search, route options overview, route details, social media, mode choice, indoor navigation and map display. Moreover, in-depth questions concerning different aspects of each concept were included.

In order to validate the user typology mentioned in Sect. 3.2 a cluster analysis was conducted. The dimensions "level of structured behavior" and "openness towards technologies" were determined by calculating the mean of five relating items. A two-step cluster analysis was applied comprising the Ward-Method in order to find the optimal number of clusters as well as the K-Means Cluster Analysis [6] for allocating the interviewees to the right clusters.

4.2 Results

The cluster analysis found evidence for four groups of participants. Figure 4 shows their size and position within the two dimensions. Table 2 gives an overview of characteristics describing the identified groups.

Especially cluster 4 is located slightly apart from the rest. This group mainly consists of participants at the age above 65 years who use public transit regularly. This cluster is neither very open-minded concerning technical innovations nor plans its trips intensively.

Table 2. Cluster characteristics

Cluster	Openness	Level of structuredness	Public transit use	Age
1	+	−	often	younger
2	+	+	*(no result)*	middle-aged
3	++	++	very often	*(no result)*
4	−−	−	occasional and regular	above 65 years

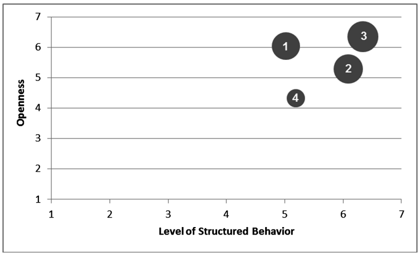

Fig. 4. Results of cluster analysis

Each of the eight operating concepts was analyzed separately. It has to be mentioned that the mean ratings are very close to each other. Therefore interpretation has to be done carefully. Generally, the existing operating concept from the Rhine-Main Transport Association was favored by the subjects. This effect must also be taken into account when assessing the results. Nevertheless, many differences reveal interesting preferences and attitudes. In the following, three selected operating concept evaluations will be presented

Operating Concept: Route Search. The results indicate the very classic operating concept for route searching is favored by the majority of interviewees (Fig. 5, screen 1). Especially frequent transit users, however, approve of the second screen which has a very modern design using only few buttons and additional options. Moreover, often used locations should be represented by shortcuts (e.g. photos) as seen in screen 3 (Fig. 5).

Operating Concept: Route Details. Generally, a design as seen on the second screen for displaying route details is barely accepted by the subjects. Tables seem to be a more appropriate format, especially for younger people. Further support regarding a better navigation than a simple route description is not desired (Table 4).

Cluster 4 rates screen 1 and 3 with very low values. Screen 2 however is favored by them. The higher average age in this group might cause a preference for less text.

Operating Concept: Indoor Navigation. Regarding indoor navigation, the most preferred solution uses augmented reality (Fig. 7, screen 1) in order to transfer the right instructions at the right time. Nevertheless, especially the elderly find written

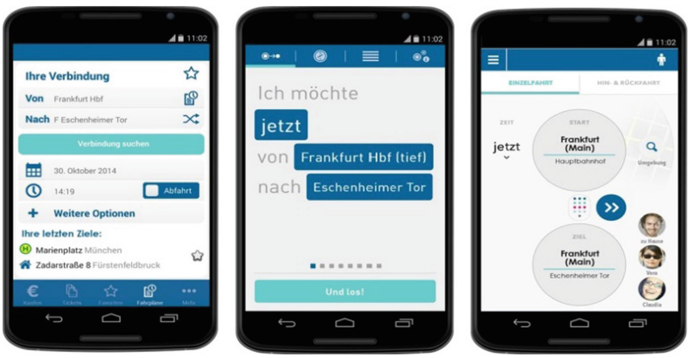

Fig. 5. Screenshots: Route search (screen 1, 2, 3 from left to right)

Table 3. Mean ratings for operating concept "route search"

Mean Ratings	Cluster				Total Sample
	1	2	3	4	
Screen 1	6.30	6.30	6.34	4.98	5.79
Screen 2	4.55	4.94	3.07	3.13	4.90
Screen 3	4.76	4.75	4.72	4.90	4.56

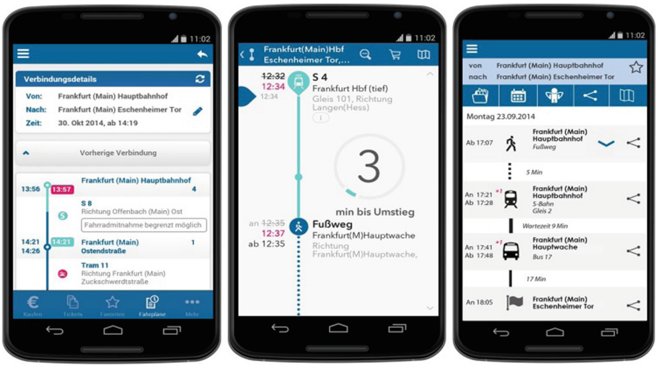

Fig. 6. Screenshots: Route details (screen 1, 2, 3 from left to right)

Table 4. Mean ratings for operating concept "route details"

Mean Ratings	Cluster				Total Sample
	1	2	3	4	
Screen 1	6.32	6.42	6.16	3.11	5.62
Screen 2	4.71	4.75	4.81	4.67	4.78
Screen 3	4.74	4.64	4.64	3.07	5.41

Fig. 7. Screenshots: Indoor navigation (screen 1, 2, 3 from left to right)

Table 5. Mean ratings for operating concept "indoor navigation"

Mean Ratings	Cluster				Total Sample
	1	2	3	4	
Screen 1	6,36	6,46	4,49	3,43	5,51
Screen 2	4,78	4,76	4,64	3,32	4,22
Screen 3	4,91	4,69	4,14	3,61	4,96

descriptions more helpful (Fig. 7, screen 3). Furthermore, intense public transit users have higher preferences for augmented reality than others (Table 5).

Cluster 3 and 4 gave low grades to all screenshots. Even though cluster 3 is open-minded concerning technical innovations, augmented reality elements could not convince these interviewees. On the contrary, the rather open-minded participants of cluster 1 and 2 show very high mean ratings for this operating concept.

5 Critical Assessment and Outlook

The investigation of detailed user requirements for mobile applications was very challenging. Every single user has specific requirements. Should these be implemented in one single application, it quickly becomes overloaded. Nevertheless, in order to successfully implement a "one design for all" approach the user requirements have to be balanced against each other. The developers should try to implement tailored packages of operating options for a few main user types.

Another problem was the identification of innovative future functionalities, as in most cases the subjects only had a limited knowledge and imagination. Therefore, it could be helpful to integrate research results from expert surveys.

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