Development of a Concept for Evaluation User Acceptance and Requirements for NFC Based E-ticketing in Public Transport

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Abstract. In frame of OPTIMOS project (Open, Practical Infrastructures for Mobile Services) an open practical ecosystem based on Near Field Communication (NFC) will be developed and demonstrated by different implemented use cases in the field of public transport services in two German regions. One of the main objects is e-ticketing. For the generic definition of the OPTIMOS application (APP) user requirements are surveyed among the recruited friendly user group. Based on the results of different research studies and a conducted pretest among a student group an evaluation concept with a user-centred approach is developed and discussed.

Keywords: Mobility application · User requirements · Usability · Public transport · Evaluation concept · User-centered design

1   Motivation

Digital applications and services increasingly determine economic, social and personal life. Nowadays the smartphone as a personal device acts more and more as key and access for all kind of digital services, so also in public transport. Already in 2013, more than 50% of public transport passengers used mobility APPs on their smartphones searching for travel information or purchasing e-tickets [14]. They can enable an easy and comfortable way to navigate through the public transport network, because users do not have to deal with complex timetables or complex tariff information. The German public transport sector is traditionally organized regionally by some hundreds transport operators with different pricing schemes, fare conditions, e-ticket infrastructure and systems. For users it is nearly impossible to know all the regional specifics and to use public transport services on the spot without studying detailed information and to purchase ticket in advance. Till now passengers are used to be provided with real time schedule information, routed and navigated to a destination, or informed about ticket purchase. In 2015 the Innovation Centre for Mobility and Social Change in Germany tested 74 mobility APPs available at Google Play Store or at Apple Store. Almost all provide information about intermodal transport connections

but only half could calculate ticket fares [9]. Purchasing and paying electronic tickets via a personal access by smartphone application has been established in different regions but is still not realized as an unique service in public transport all over Germany. To increase customer acceptance for public transport services it is necessary to implement an open ecosystems for mobile services, which can be used without discrimination by service and technology providers as it has been well-known and used for airline or railway services for years. NFC mobile devices are seen as generic platforms that should support Public Transport e-ticketing worldwide.

With respect to usability and user experience for mobility APPs different problems can be assumed e.g. users are often not sufficiently supported in their current context and too many concepts from the desktop area are still used for mobile applications. One challenge for the accompanying research is to actively involve the potential users in the development process of the mobile APPs in order to communicate their requirements and feedbacks in the development process of the open system.

Therefore friendly users in two German test regions are recruited and provided with NFC mobile devices or NFC Universal Integrated Circuit Card (UICC). For testing the new implemented services the specific APPs in the test regions have to be defined and developed. In this context TU Dresden surveys user requirements for generic definition of the OPTIMOS APPs and will afterwards evaluate the user acceptance in field tests with the friendly user group. Based on desktop research results and a conducted pretest among a student group an evaluation concept is developed.

2 Project Presentation

OPTIMOS research project defines an open, practical ecosystem connecting the world of public transport with the world of mobile communication. It will be developed, tested and defined use cases will be evaluated. This approach uses open standards. Therefore the project collaborates with international standardization bodies like the European Committee for Standardization (CEN), GSM Association (GSMA), NFC-Forum to ensure acceptance for passengers, public transport provides and device manufacturers. The project work is funded from the German Federal Ministry of Economic Affairs and Energy and includes relevant stakeholders and associated partners from all parts of the ecosystem like IT-system and -security provider, mobile network operators, handset makers, public transport industry.

3 Desktop Research on Customer Requirements on Digital Services and Mobility Application

For analysing public transport passengers' needs and requirements on digital services and especially on mobility APPs a desk top research was carried out

by focusing on two different objectives. First we reviewed four general mobility studies in Germany and secondly the results of customer requirements on mobility APPs, evaluated in the frame of four research project.

By summarising the result of four general mobility studies [4–6,15] we detected that digital services and digital cross linkage between different transport modes will be more and more important for realising public transport in the next decades and will influence the user behaviour. Multi- and intermodal services need mobility platforms with digital information, routing, navigation and e-ticketing services supporting the individual transport chains. A big challenge is the creation and the commitment on interoperability by creating technical standards and interfaces for digital services. Implementing improved information and communication technology (ICT) access barriers to public passenger transport can be reduced. At the same time additional mobility offers can develop the public transport system as the backbone of the future multimodal system supporting the digital service chain: information – navigation – ticket purchasing – ticket control.

As the result of the further four research studies [1–3,17] concerning user requirements on mobility application five usability meta-categories [1] could be underlined with the aspects shown in Table 1.

It can be clearly seen users expect simple and intuitive mobile applications with clear and comprehensible visualization and reliable real-time information.

Those results are going to be validated for definition the OPTIMOS APPs. Therefore, a workshop concept is developed by the principles of Design Thinking with the tools personas, scenarios and journey mapping.

4   Pretest

In preparation of the usability study for definition a generic concept for the OPTIMOS APP a pretest was conducted with a non-representative student group. Aim was to collect first ideas about specific requests on mobility APPs. On the one hand we get first impressions what kind of functions are known, often used and appreciated. On the other hand we wanted to find out, which additional functions could be useful or even requested.

4.1   Brainstorming

We started with a brainstorming session about general requirements on APPs and on specific requirements in the field of mobility APPs. Mobility APPs are generally seen as a good and useful door opener for public transport services. A trustworthy issuer of a mobility APP is even very important for the purchase decision and using the APP for information, planning, navigation or ticketing services in context of transport services.

In Fig. 1 we structured the collected results into a mind map. Students wish generally simple, intuitive, fast, well-structured and smooth applications. Mobility APPs should not be overloaded but customisable e.g. with a user profile.

Table 1. User requirements surveyed for mobility application of public transport services

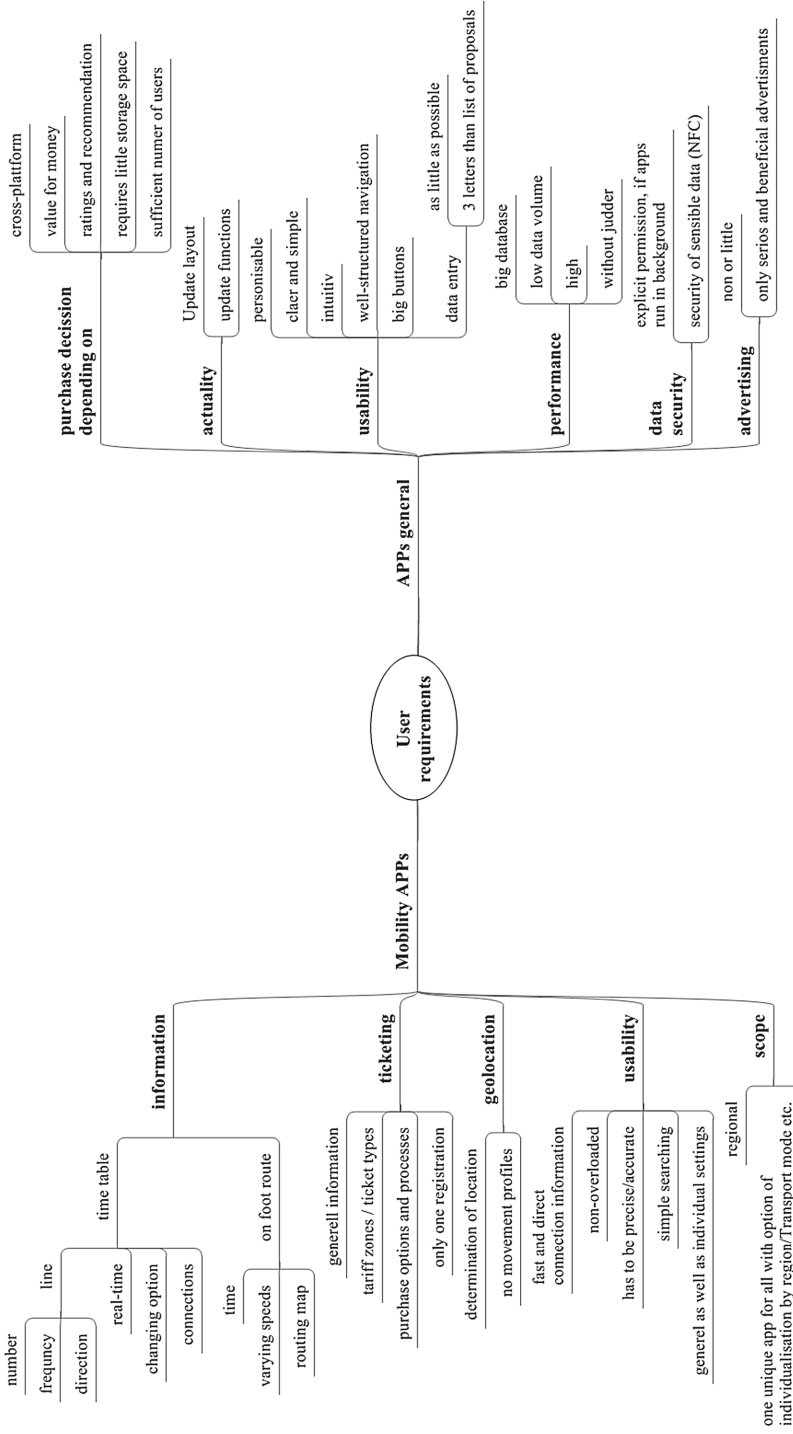| Function	User requirements
Technical usability	– Fast and easy menu-driven handling
	– Comprehensibility
	– Reliability
	– Consistency
	– Realistic mapping of real transport and mobility situation by high quality
	– Unique and comparable information provision across all media

Wording	–Consistency of terms between digital and real services, wrong choice of words could lead to irritation, e.g.:
	    • Searching connection vs. timetable
	    • Travel companion not used in regional public transport only in long-distance travel

	–Interpretation of real time
	– Descriptions or words in foreign language
	–Textual information
Structuring	– Simple and intuitive navigation
	– Traceability and transparency
	– Visibility of navigation options
Visualization/Frontend design	– Clear presentation (preference of symbols instead of text)
	–Legibility
	– Intelligible icons and symbols
	–Well-structured and designed forms of presentations
	–Appropriate size of the several elements
	–Assembling elements according to use routine
	–Appropriate contrast between text, symbol, background
Interactive elements	– Expedient error messages
	–At sensible points out-put with two-step function, e.g. "Are you sure you want to quit the app?"
	–Visible interaction elements

Fig. 1. User requirements - results of brainstorming process

The main function of mobility APPs are seen in connection information added by the option of electronic ticket purchase. By using public transport also the location function is appreciated. At the same time, there are concerns about data protection, the creation and misuse of personalized movement profiles and the misuse of the NFC interface concerning e-ticketing and mobile payment services. No clear picture was seen, if there is a preference for a unique Germany-wide application or for different regional ones. A solution could be a unique APP with the option for regional customization especially under the focus of the desired preselection list of starting point and destination input.

During the brainstorming process only known and already used aspects and application functions were mentioned. Barriers or problems were actively communicated, but not additional requirements and wishes. Even by encouraging the group to think about new aspects, approaches or issues to be taken in consideration for better usability and function design, no creative and innovative ideas were given.

This brainstorming method provided first insights for the researcher about customer behaviour and gives the basis for further research and analyses.

4.2   Conjoint Analysis

In the second step we carried out a conjoint analysis among the non-representative student group with the goal to understand customers' preferences of different product features. For this purpose product bundles were evaluated to determine user benefits by decomposing the values of the different functions and their attributes [11].

Since OPTIMOS project especially focusses on e-ticketing for public transport via NFC media such as smartphones or smartcards we chose the following four application functions: registration process, login procedure, payment system, and payment process. In Table 2 the function with different attributes are indicated.

16 different product bundles were created and 27 students were asked to rank them, according to their preferences with the results shown in Table 3.

The login procedure as well as the payment system seem not to be very important. The attributes of those function shown negligible values even taken in account the standard error. The highest benefit for the pretest group is the registration process by manual data input followed by the payment process by direct withdrawal at public transport operator and payment via financial service provider.

The quite high utility estimate for the attribute direct withdrawal at public transport operator by the function payment process underlines the importance of data security and provider confidence. By analogy of brainstorming the conjoint results show that those attributes were ranked best, which the study participants are most familiar with.

Nevertheless the results must be questioned critically, because we did not rotate the product bundles. All test persons valued all product bundles with the

Table 2. User requirements surveyed for mobility application of public transport services

Function		Feature attributes
Registration process		Electronic transmission of the personal data by eID of the ID card
		Manual entry of personal data
		Transfer of personal data from external service providers (Facebook, Google, ...)
Login procedure		Login once and stay logged in
		Re-login for each session
Payment system		Prepaid (using previously charged credit)
		Pay-per-Use (on each trip)
		Postpaid (billing weekly, monthly, quarterly)
Payment system		Cash (ticket machines, selling point, ...)
		Payment via mobile phone (carrier-billing)
		Financial service provider (credit card, paypal, ...)
		Direct withdrawal at public transport operator

same choice set order. So there might be a bias in favour on the first positioned registration process.

Considering the results of the brainstorming and the conjoint pretest we conclude that both methodologies are suitable for validation already known and experiences features, but not for detecting user requirements which are not yet explicitly known by customers. Those ones are difficult to communicate and to rank. Therefore we assume a different study design for evaluating user requirements for application usability.

5 Development of a Concept for User Acceptance and Requirement Research

In our pretest we detected difficulties for test persons to express and to evaluate specific feature requirements which are not yet used or the persons are not familiar with as it is with mobile payment services on German public transport market via NFC technology today. Because of this a multi-perspective approach by a user-centered design in four steps should be followed (Fig. 2).

5.1 Defining Personas

First, we create ideas of different target groups by defining personas. They are created on the basis of primary research, taking into account that they are not an average person, but hypothetical, specific individuals with desires, goals and expectations [12]. Personas describe a typical representative of a specific target group as "archetypical user, whose needs are determined as close as possible to reality" [10]. However they allow study participants to empathize and understand different target groups.

Table 3. User requirements surveyed for mobility application of public transport services

Function	Feature attributes	Utility estimate $\hat{\beta}$	Standard error
Registration process	Electronic transmission of the personal data by eID of the ID card	$-0,167$	$0,204$
	Manual entry of personal data	$3,296$	$0,174$
	Transfer of personal data from external service providers (Facebook, Google, ...)	$-3,130$	$0,204$
Login procedure	Login once and stay logged in	$0,111$	$0,131$
	Re-login for each session	$-0,111$	$0,131$
Payment system	Prepaid (using previously charged credit)	$-0,432$	$0,174$
	Pay-per-Use (on each trip)	$0,272$	$0,204$
	Postpaid (billing weekly, monthly, quarterly)	$0,160$	$0,204$
Payment system	Cash (ticket machines, selling point, ...)	$-1,426$	$0,226$
	Payment via mobile phone (carrier-billing)	$0,019$	$0,226$
	Financial service provider (credit card, paypal, ...)	$0,685$	$0,226$
	Direct withdrawal at public transport operator	$0,722$	$0,226$
Absolute term		$7,784$	$0,144$

Designing personas within the scope of the OPTIMOS project we make use of the defined ones of IP-KOM-ÖV project. They had been created by an extensive research with regard to mobility APPs by combining statistical analyses, expert interviews, focus groups and interviews reflecting the classification and the behaviour of public transport passengers adequately [13]. Those seven personas will be analysed, refined and if necessary complemented. Therefore it is necessary to check whether IP-KOM-ÖV-personas correspond to OPTIMOS target groups. A division into primary, secondary, complementary and non-personas (explicitly not considered target groups) can be helpful taking in consideration the different defined project use cases. The personas should focus specific user groups and prioritize their requirements by designing the OPTIMOS APP [8].
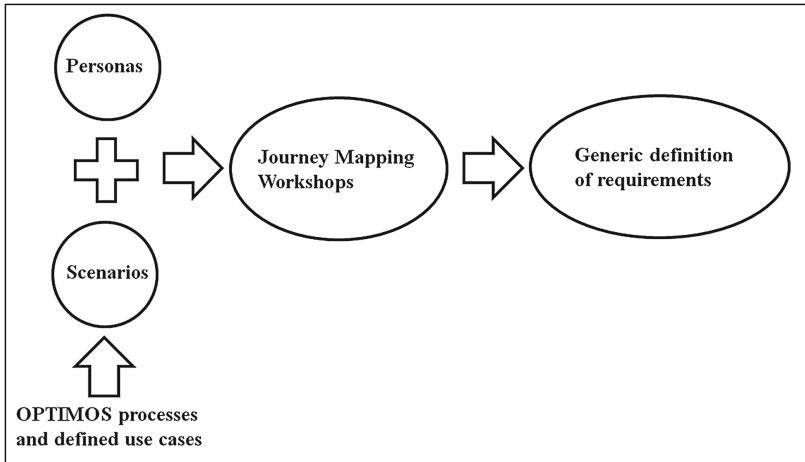
Fig. 2. User requirements - results of brainstorming process

5.2   Development of Scenarios

In a second step user scenarios must be developed based on the different defined personas. They are dependent on detailed research questions. Use cases are already developed during the OPTIMOS project. They focus on the following different processes:

– Mobile management of the personal account
– Classical sales and maintenance
– Mobile authentication
– Mobile sales and maintenance
– Personal point of sales
– Registration of customer media

The scenarios are the basis for the user-centered design discussion, analyses and evaluation in the workshops. According to Richter and Flückiger [8] user scenarios have to show the following features:

– Design for a specific user group
– Representation a specific case of an APP
– Showing deployment in real environment
– Illustrating the aspects relevant to the development of the new solution
– Describing exemplary exceptional and fault situations.

5.3   Workshop Journey Mapping

Based on the developed personas and scenarios workshops are being prepared in two test regions. Therefore potential workshop participants out of the project's friendly user group will be invited. Aim of the workshop is to work out and to

define user requirements for the OPTIMOS APP by using the Journey Mapping (also called Customer Journey) methodology. "The Customer Journey is a systematic approach designed to help organizations understand how prospective and current customers use the various channels and touch points, how they perceive the organization at each touch point and how they would like the customer experience to be. This knowledge can be used to design an optimal experience that meets the expectations of major customer groups, achieves competitive advantage and supports attainment of desired customer experience objectives." [7].

Under consideration of the different use scenarios a workshop guideline has to be developed for possible touch points by using the OPTIMOS APP. The workshop participants are asked to put themselves in the situation of a specific persona and scenario. By going through the different touch points needs, specific requirements but also fears will be communicated. On the one hand the workshop guideline allows a target-orientated moderation to ensure that the participants are aware of important issues and take note of them. On the other hand the participants can easily move into the process flows from the perspective of their persona [16]. For visualisation and structuring the discussion poster-templates with two dimensions are prepared. The horizontal shows the different touch points and the vertical the potential function fields regarding the specific scenario and use case. Furthermore, prepared facilitation cards with typical features of the individual situations and functions will help to complete the posters by the individual workshop participants respective their persona. Thereby it is desired to communicate what the persona might think, feel and actually do, and what opportunities and risks are seen.

The workshop leader moderates the process by asking target-oriented questions for user requirements regarding APP functionality and usability. It should be also examined which symbols, terms and error messages are understood in which way. These questions could be as follows:

– What information is expected?
  • Absolutely
  • Nice to have
  • Superfluous
– How should this information be presented?
  • Words
  • Figure
  • Icon
  • Image
– What kinds of processes are accepted?
  • Accepted best
  • Still accepted
  • Not accepted
– What could particularly interfere the usability of the APP in a particular situation?
– What are the chances of the APP in a particular situation?

As a result, a Customer Journey Map is created for each scenario, which takes into account all areas deemed to be relevant. In addition, the spoken word as well as specific questions can be used to extract the user requirements and required functions at each touch point.

5.4   Generic Definition of Requirements

Based on the workshop results and in consideration of the general usability categories guidelines and style guides for test regions' APPs will be developed and surveyed by iterative acceptance tests using generic mock-ups among the friendly user groups. Up to three innovation cycles are planned. The survey will take place by online-tool as well as in a moderated user workshop in the test regions. This will lead to develop the generic concept supporting all use cases and processes tested in OPTIMOS in order to ensure a user-friendly mobile APPs.

6   Conclusion

The described concept will ensure a generic user-centered approach by developing and designing user friendly mobile APPs for the open NFC-based system in frame of OPTIMOS project. In the subsequent field tests the APPs will be proved by the friendly users and their acceptances surveyed with the aim of identifying usage and acceptance barriers and potentials for improvement as well as to indicate best case scenarios.

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