Towards Paperless Mobility Information in Public Transport

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Abstract. Following the integration of mobile applications into the mobility information system of public transport, public transport companies seek new opportunities to reduce paper-based information. A common example for these new opportunities is the so called 'paperless stop point'. This paper describes different expansion stages of public displays for mobility information at stop points, based on empirical evaluations with users and experts. Four stages are discussed, which range from static information screens to individual interactive displays. In addition, the widespread expectations of users and transport companies are described, which provide the base for the stage development, are described. As a result, this paper provides insight into typical challenges towards paperless mobility information at stop points in public transport.

Keywords: Public displays · Mobility information · Usability · Public transport

1 Introduction

Due to actual technological advances and new requirements, many transportation companies discuss new approaches in order to reach the passengers of public transport and fulfill their information needs [1]. While mobile applications are developed further and new functionalities are added continuously [2], other information systems are evaluated for optimizing potential as well.

Public transport already offers a wide range of information systems, from static, collective and stationary to dynamic, individual and mobile systems [3], which have been developed over the last decades and nowadays provide the information base for passengers. In the past, some of these systems have been modified and adapted to new requirements. Mobile tickets and e-ticketing have demonstrated the benefits and challenges of this adaption process [4].

However, with new mobile information systems and new technologies emerging, the contribution of traditional information systems to the mobility information system as a whole has to be questioned and a more drastic redesign has to be taken into account. One of these more traditional information systems is the paper-based information at stop points.

Enhancing the information quality and minimizing the costs e.g. for printing and manually updating the paper-based information, are two reasons for reducing the

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amount of paper-based information and for the development of paperless stop points in public transport.

Additional benefits of paperless stop points, based on the perspectives of transport companies, include e.g.:

- Actuality of information
- Readability of information
- Accessibility
- Multilingualism
- Consistency of information
- Additional information and functionality

On the other hand, the expected downsides are e.g.:

- Higher procurement and maintenance costs
- Hygiene issues
- Delays while waiting for other users to finish their interaction
- Higher repair costs caused by vandalism

Key elements of paperless stop points and stations involve the replacement of paper-based timetables, network plans, lists of transportation fees and maps of different content. While mobile applications already offer most of this information [5], the ownership of a smartphone, including the necessary public transport specific application, cannot be taken for granted.

At the moment, especially public screens and displays are used, to communicate real-time information on departures and to enhance the information quality [6]. Following this concept, it is only consequent to analyze further potential for transferring paper-based information to screens and displays. Due to the actual non-interactive and quite large presentation of paper-based information at stop points, the transfer raises several questions, regarding the user interface and the degree of interaction. This paper describes the different degrees of interactivity and the related typical challenges of public displays in public transport. The results are based on two usability evaluations as well as expert interviews, which are described in the following.

2 Method

The development of the user interface as well as the definition of the degree of interactivity, are primarily based on the goal of developing a product, which can be used with effectiveness, efficiency and satisfaction by different user groups [7]. The user-centered development process of the user interface consists of three concept stages and three evaluation stages and is based on preliminary consideration as shown in Table 1. These considerations integrate the requirements of public transport companies, the knowledge of experts and requirements of typical users of public transport and are

based on the initial usage analysis of two test systems implemented in Cologne and Stuttgart in Germany [8].
In addition, the context of use [9] provides challenges for

- Optimizing usage times to grant more users access in a short time
- Selecting and enhancing suitable content
- Merging dynamic and static information

A list of company requirements and the results of the usage analysis of the test systems [8] provide the base for the development, including the following elements:

- Information needs of passengers at stop points in different categories
- Design ideas for the segmentation of the display, e.g. for menus and information
- Added value functions, which are not included within paper-based information

Table 1. Development and evaluation phases

Development	Method	Details
Preliminary considerations	Usage analysis	2 test systems
	Company requirements	Best-practice-Analysis
Basic concept		
Requirements	Expert workshop	9 experts
Fine concept		
Interactive Prototypes	Usability Evaluation 1	7 test users
Detailed concept		
Final Prototype	Expert Evaluation	3 expert interviews
	Usability Evaluation 2	16 test users
Final concept		

In a first step, these preliminary considerations are used to design two basic prototypes, in order to discuss the segmentation of the screen as well as the functionality with public transport and usability experts. As a result, one basic concept is chosen to refine the concept with users in the next step.

The second step is based on a fine concept, which is derived from the preliminary considerations, the basic concept and the expert workshop. The usability evaluation is performed as a lab-based usability evaluation with seven typical users from the future destination of the first implemented test system. The evaluation focuses on the following topics:

- Degree of interactivity
- Workflow for typical user goals
- Usability and functionality
- Design of icons

Based on this evaluation, a detailed concept with only one degree of interactivity and solutions for the identified usability problems are developed. The third evaluation phase with an equal test setting and a final prototype focusses on the topics:

- Fulfillment of information needs
- Different task completion strategies
- Usage times
- Usability and functionality

Both usability evaluations are supported by an eye-tracking evaluation, in order to provide additional information to the video and audio recording as well as the used questionnaires. An expert evaluation with representatives of disabled rights organizations, service employees of a local transportation company and a designer, completes this evaluation phase. Based on this final evaluation, the results are integrated into a final user interface design concept, which is transferred to all parts of the user interface and a detailed description of the concepts is derived.

3 Results

Public transport is characterized through different users, tasks and contexts [3] and therefore provides challenges for the development of nearly all information systems. Table 2 shows the different user groups within the first and second usability evaluation. For both usability tests, typical tasks along the journey were chosen, which are typically performed at stop points.

Table 2. User characteristics within the two evaluations

	Evaluation 1	Evaluation 2
Participants	7 users in one test group	16 users in three test groups
Usage of public transport	at least several times each month	Commuters
		Casual users
		Tourists
Age	22–62 years	17-63 years
Body height	1,60–1,93 m	1,63–1,93 m
	5,25–6,33 feet	5,35–6,33 feet
Special characteristics	–	One user with mobility impairments

3.1 Requirements and Expectations of Transport Companies

The expert workshop with representatives from five public transport companies revealed the following, partially opposing, requirements and expectations. After the workshop, these requirements and expectation were analyzed and three categories identified.

Content. The expectations reach from identical transfer of paper-based information to new information concepts, which are more similar to the content of mobile applications. In general, the experts agree that typical tasks at stop points have to be addressed. These tasks are e.g.:

- Journey planning
- Path finding
- Information about tickets

Therefore, the expectations towards the presentation of the content differ as well. Traditional presentations provide a high conformity with the user's expectations. Nevertheless, new concepts can support users with low knowledge of a system and of a place.

Functionality. The basic functionality that all experts agree upon is the distribution of the content through software systems, which easily provide access to the public display. As a result, more up-to-date information can be provided. From that point forward, three major notions can be identified:

- No additional functionality
- Adding functions to reduce usage times and to include real-time information
- Functionality concept which mainly provides individual information

All experts provided comprehensible reasons for these notions. The question, how mobile applications will shape the whole information system in the next years, is still open and the main source for the different notions.

Equipment and Environmental Aspects. At the moment, paper-based information at stop points takes up a lot of space. The used space can only be reduced, if some sort of functionality is added to navigate through the content. Thereby, the equipment is strongly connected to content and functionality. Companies favoring the identical transfer of paper-based information will need at least the same space as before. With new functionalities, the space can be reduced and the available space can be used for advertisement or something similar. In addition, the number of displays has to be defined, depending on passenger figures and usage times.

3.2 Requirements and Expectations of Users

The usability evaluations with typical users from public transport revealed a differentiated perspective on public displays and paperless information as well. Figure 1 shows the widespread expectations of users regarding the need for a replacement of paper-based information, individual journey planning and waiting times.

All users can see at least some benefits of public displays, e.g. regarding the actuality and accessibility of information. But their opinion on the degree of interactivity varies. Again, the different requirements and expectations are grouped in the three categories: content, functionality and equipment and environmental aspects.

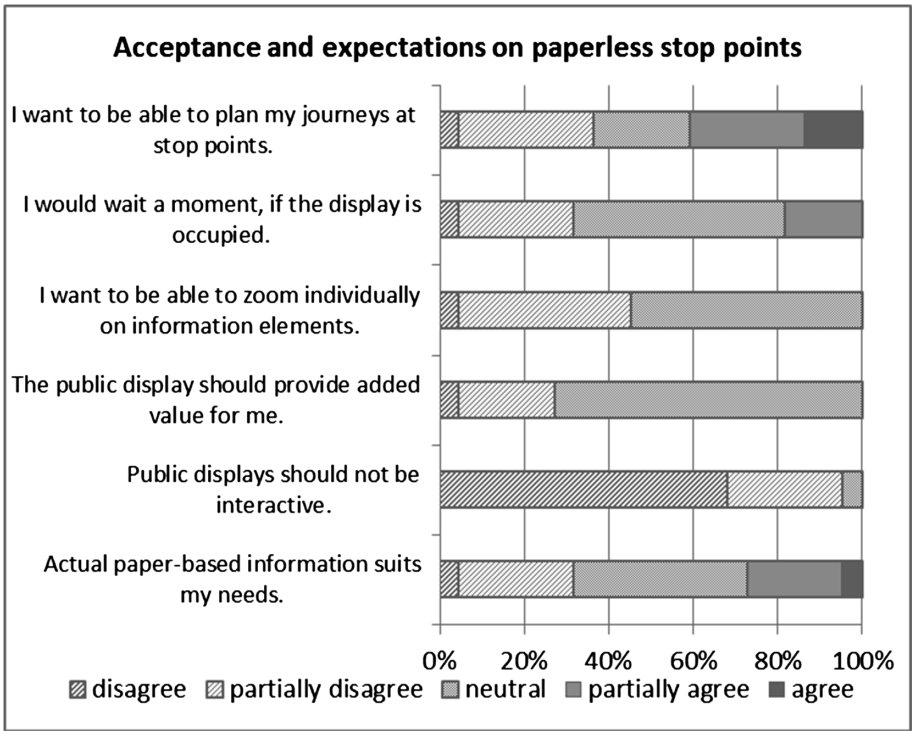

Fig. 1. Acceptance and expectations of users towards paperless stop points (n = 23)

Content. Users prefer a selection of paper-based information elements instead of a system providing all available paper-based information within an interactive system. This is mainly resulting from the already existing problem that users can hardly differentiate between the often very similar types of information elements, e.g. maps of different detail level.

The presentation of the content is important for the recognition of the system. For instance, timetables provide a well-known pattern for users. Therefore, the display is recognized even from a distance. Menus and icons support the recognition as well and signal interactivity. In contrast, advertisement reduces this recognition.

Functionality. Displays without any menus or dynamic elements are expected to provide less interactivity and functionality. However, even in this case users tested and searched for a zoom function. As soon as first dynamic or interactive functions are added, the expectation for more individual information rises.

Supporting functions are useful to ease the existing problems with paper-based information, e.g. complex maps and timetables. As a result, these support functions reduce the usage times and are very valid for an easy to use information system. Supporting functions are e.g.:

- Highlighting functions, e.g. in regard to the actual time, direct the users attention and minimize usage times

- Search functions, e.g. within maps, reduce the required knowledge of a place by directing the users attention

Equipment and Environmental Aspects. If interactivity is provided, the public display has to feature a high quality of touch recognition to support a fast change between information and typical gestures. As public transport often has to deal with vandalism, systems have to be designed more resistant and good touch recognition cannot be taken for granted. The positioning and design of the system has to suite all kind of users, especially with different heights and disabilities. In general, the requirements and expectations of users with disabilities can be better addressed with public displays, compared to paper-based information.

4 Expansion Stages

As a result of the expert workshops and usability evaluations, it can be stated, that different expansion stages of public displays for paperless information at stop points are considered and the advantages of these stages are discussed controversially. As a result of our evaluations, we identified four different expansion stages, as shown in Table 3, which themselves vary in their:

- capability to provide dynamic information,
- degree of interactivity,
- capability to provide individual information.

Table 3. Expansion stages of public displays in public transport

Stage		Dynamic information	Interactivity	Individualization
1	Static information	low	no	no
2	Dynamic Information	middle	no	no
3	Interactive Information	middle	yes	no
4	Interactive Individual Information	high	yes	yes

All stages provide different challenges about usage times, content and interface design. Nevertheless, they are based on the same goal, to support the user's tasks at stop points.
Static Information. This stage provides similar information to the paper-based information and therefore is characterized by a comparable usability and usage time as well as an at least identical need for information space. For public transport companies, this stage provides a faster way to update the information e.g. on a monthly or daily basis. As a result, this stage provides at least more actual information than paper-based information, which results in better information for users.

Dynamic Information. As an extension of the static information, this stage provides more actual information by integrating support functions and real-time information. This aspect and the integration of disturbance and event information are the most

valuable additions for users. Through these measurements, the usage times can be reduced compared to stage one. As an example, Fig. 2 shows the search duration for a

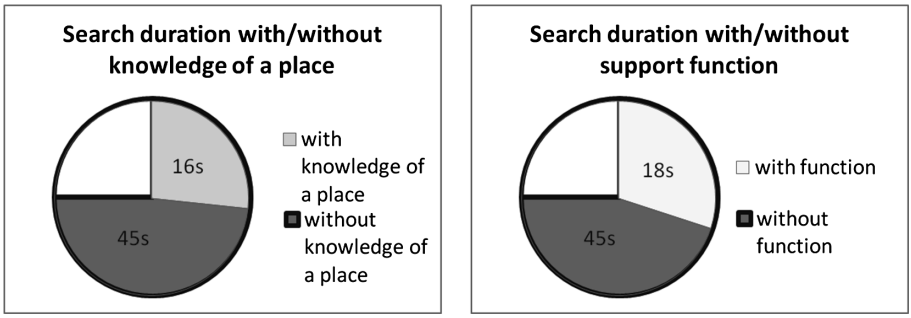

Fig. 2. Search duration with/without knowledge of a place and with/without support function

stop point on a map with knowledge of a place and without compared to the search duration with and without support function for users without knowledge of a place.

Interactive Information. One of the major disadvantages of the prior stages, the large screen size for parallel presentation of all information, is addressed in this stage by reducing the parallel information and introducing interactivity. As a result, not all the information is visible and the system can only be used by a single user, which may require more than one display at a stop point. Additionally, questions regarding the screen size, menu structure, usage times and overall usability have to be considered. This stage still focuses on the original paper-based information which can be supported with functions as mentioned in stage two and additional real-time information.

Interactive Individual Information. While stage one to three focus on collective information quite close to the original paper-based information, this stage focuses on individual information, based on basic public transport data. Therefore, stage four is able to fulfil the individual needs of different types of users and tasks with less need for specific knowledge of the system and of the place. An integration of real-time information as already known from mobile applications and websites in this stage is highly recommended.

5 Discussion

Our results show that compared to actual paper-based information at stop points, stage one can already provide sustainable benefit for the users, e.g. by providing more up-to-date information. The majority of test users welcome the development from paper-based information to public displays, but the expectations are widely spread. In addition, the question arises: whether a public display should provide the same functionality as a smartphone application, or if a combination can be found, which serves the different users' needs best. A public display could provide the collective and always available information while the mobile application carries the individual information.

Previous studies show [10], that a mix of different information systems enables the passengers to compare and recheck information, and therefore, provides security along the journey. This indicates that an answer to this question can only be found when the whole information system at a stop point and along the journey is considered.

Following the described lab-based usability evaluations, a future field study has to evaluate these questions and other challenges, e.g. regarding the accessibility, as well as the connection between the expansion stages and the interaction phases described by Vogel and Balakrishnan [11]. These phases could provide an additional framework, to refine the functionality of the described stages.

The described stages allow transport companies to decide what kind of system they want to develop and provide these companies with an overview of solutions and related challenges. In addition, the stages can be used as a communication base between all stakeholders involved into the development process. Considering the described heterogeneous expectations, this is vital to follow the same basic idea within the development.

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