Workflow-Based Passenger Information for Public Transport

Cindy Mayas(✉), Stephan Hörold, and Heidi Krömker

Technische Universität Ilmenau, Ilmenau, Germany
{cindy.mayas, stephan.hoerold,
heidi.kroemker}@tu-ilmenau.de

Abstract. This paper presents a workflow-based concept of passenger information in public transport, in order to ensure a more intuitive and effective usage of mobile passenger information systems. The workflow-based navigation concept is derived from a pattern analysis and a field test of current mobile applications of passenger information, which mainly provide a function-based navigation. The results of a comparative usability test of workflow-based and function-based navigation concepts show, that workflow-based navigation can reduce the number of required tap actions in relation to function-based navigation concepts.

Keywords: Usability · Mobile applications · Workflow · Public transport

1 Introduction

Nowadays, passenger information systems not only include timetable and static trip information, but also real time and context specific information, for instance about interchanges, getting on and off the vehicle and disturbance information. Based on this information, most mobile applications provide a variety of functions [1]. Function calls within these applications are mainly available by menu and additional option buttons.

The resulting navigation process requires detailed foreknowledge of users about the system of public transport, for instance available functions of passenger information, labels, and situation specific benefits [2]. Especially, novices and occasional users of public transport are often not familiar with passenger information applications and their range of functionalities. Consequently, untrained users either require some time for exploring or never take advantage of the full range of functions. As a result, the usability of mobile passenger application systems in public transport is reduced for some user groups.

The objective of this paper is to increase the usability of mobile passenger applications, regarding the adequate access to functionalities. By replacing the function-based navigation by a workflow-based navigation, which is based on the context of the journey and the different means of transport, the access and the visualization of the functionalities are adapted to the relevant tasks and the relevant user needs along the journey [3].

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In particular, the complexity and diversity of information for travelers will increase, regarding the future of intermodal mobility, which combines public transport with individual transport and shared mobility services. Therefore, new strategies of integrated and holistic passenger information are required.

2 State of the Art

2.1 Best Practice: A Pattern Analysis of Mobile Applications

Based on the concept of Alexander [4], successful and established solutions for recurring challenges can be described as so called patterns for a specific area of application. While Alexander introduced the concept of pattern to the area of architecture, the pattern concept has been already adapted to other scientific areas, for instance software development [5], music and neuroscience [6], as well.

The design patterns, which are analyzed in this study, refer to the user interface of mobile applications for public transport, regarding the navigation functions and design. The revealed patterns give an overview of predominant navigation schemes within the development of mobile information systems in public transport. Although the design patterns do not describe rigid rules or regulations, limiting the development, design patterns are often applied by developers as tested and inspiring suggestions for solutions of interface design problems [7].

The analysis included 30 mobile applications for passenger information [8]. This variety of applications from different countries revealed the three following popular design concepts of navigating in mobile passenger applications:

- Bar navigation (cf. Fig. 1);
- Navigation on the main screen (cf. Fig. 2);
- Foldable navigation (cf. Fig. 3).

Bar navigation

Description of the pattern
The menu items are displayed as a bar-navigation-graph. This bar navigation is provided permanently and allows rapid switching between the functions. Selected sections are highlighted as the current position, in order to facilitate the orientation within the application.

Description of the problem
The items of the navigation bar have to be available for the users at all the screen of the application. These items have to be provided permanently and efficiently during the usage.

Example

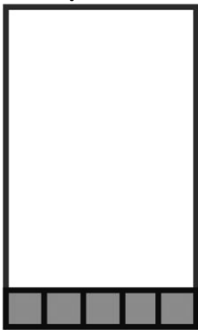

Fig. 1. Pattern “bar navigation”

Navigation on the main screen

Description of the pattern
The menu items are displayed on a separate main screen. The application permanently includes one button to get back to this screen, in order to change the used function. The currently selected function has to be marked at an appropriate place on each screen additionally.

Description of the problem
Users have to be able to switch between different functional sections of the application.

Example

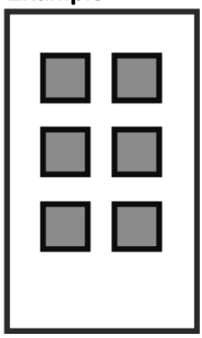

Fig. 2. Pattern "navigation on the main screen"

Foldable navigation

Description of the pattern
The menu items are not displayed permanently. The menu items are shown as a result of a defined action, for instance tapping at the right upper corner or sliding from the left margin. Subsequently, the menu bar is presented as an overlay of the current content.

Description of the problem
The menu items have to be easily available for the users, but they need to much space to be displayed permanently.

Example

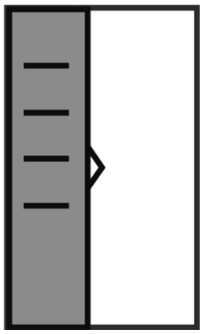

Fig. 3. Pattern "foldable navigation"

Next to these design patterns, the content of all analyzed navigation items is related to the same conceptual system, in which the names of the items always refer to a function or mobility specific content. The most common navigation items, which are used in more than 50 percent of the analyzed applications, are "planning", "departures/timetables", "favorites", and "position and surrounding". Furthermore "tickets", "messages" and "more functions" are used in more than 25 percent of the applications. A few applications also integrated the items "home", "options", "network maps" or other "services" into the navigation (cf. Fig. 4).

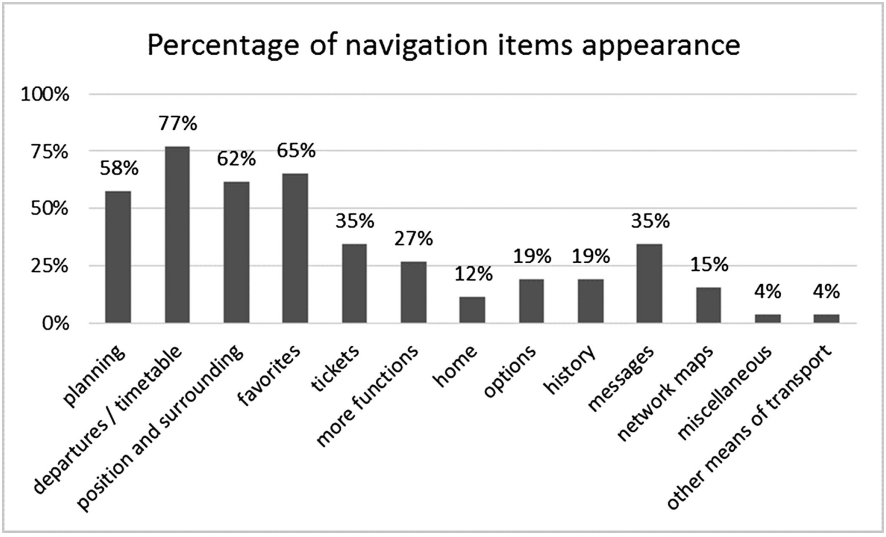

Fig. 4. Overview of navigation items

All of these items have in common, that the name and the distinction of the navigation items are characterized by the functions or content, which are included. Therefore, the optimal usage of the navigation requires foreknowledge of the functions and their benefits. While expert users have a lot of experience-based knowledge of the mobile applications and the structure of public transport, novice or occasional users, for instance tourists or ad hoc-users, cannot draw on that kind of knowledge. As a consequence, these users are not able to use all benefits of these mobile applications for passenger information intuitively.

2.2 Theoretical Approach: Information Needs Along the Journey

In contrast to the conceptual systems of the navigation items, the journeys of travelers consist of several recurring travel phases, for instance, trip planning, starting the journey, waiting for the vehicle, entering the vehicle and so on [9] (cf. Table 1). According to these travel phases, the information needs of the passengers vary [10] and the required kind of visualization differs correspondingly.

Table 1. Travel chain in public transport [10]

Phase	Preparation	Travel						
	Dealing with disturbances							
Step	1	2	3	4	5	6	7	8
	Planning the journey	Starting the journey	Waiting for the vehicle	Entering the vehicle	Travel with the vehicle	Transfer to another vehicle	Alighting from the vehicle	Heading towards the destination

The travel chain in public transport consist of different means of transportation, for instance busses, trams, or trains. Intermodal trips combine public, individual, or shared mobility services and consequently increase the complexity of the journey. The variety of means of transport implicates different information needs of the users and different information functions to fulfill them. For instance, the information need for travelling within a vehicle of public transport is characterized by the remaining travelling time and the destination station. In contrast, information on using a bike along the journey requires extra information on navigating in the streets.

3 Concept and Evaluation of the Workflow-Based Navigation

3.1 Design of the Workflow-Based Navigation

The increasing complexity of information requires a change to a more intuitive navigation in mobile applications for passenger information. The concept of workflow-based navigation [11] was especially developed for business applications and is orientated on the sequence of user tasks. The transfer of this concept allows an orientation for workflow-based navigation along the travel chain with specific user tasks, instead of the system's functions.

In order to reveal the required information and functions, according to the travel phases, a hierarchical task analysis (HTA) [12] of intermodal journeys with different mobility services was conducted. The HTA detailed the concept of a workflow-based navigation by assigning the relevant tasks. The necessity of parallel and sequential functions is systematically analyzed and ordered, in respect to the tasks of a journey. The results of the HTA revealed, that "trip preparation", "being on a trip section", and "changing between trip sections" are the most relevant stages of a trip with characteristic information needs. The task "handling disturbances" is considered as a subtask of all stages.

Finally, the relation between information and the stages of a trip is derived from a systematical analysis of the information needs along the journeys [10] and the results of a field study about the usage of mobile applications in public transport [13]. This field study of mobile applications for passenger information was conducted with 36 participants along a representative journey with one change of the vehicle. The number of intended function calls was gathered by analyzing the screencast of the smartphone and video data of a focus camera. Especially, the situation with functions switching within one task was analyzed, concerning the reasons of actions in a retrospective thinking aloud interview. Based on the results of this field study and a statistical analysis of intermodal travel behavior, the approach of the workflow-based navigation of mobile passenger information systems in public transport was developed.

3.2 Evaluation Method

The study compares the two conceptual navigation schemes function-based and workflow-based navigation in a usability test, which is conducted with users of mobile passenger information systems.

Test Method. The usability test [14] is based on a typical scenario in public transport. The scenario consists of a route planning task in combination with the first orientation tasks for travelling:

- Identifying the line, which has be chosen first;
- Identifying the destination station;
- Identifying the number of stop points to the destination station.

The interviewer accompanied each test session next to the test person, in order to answer questions and comments. The interactions with the mobile phone in each test session were video-taped and analyzed, in regard to the number and kind of user interactions. In order to ensure comparable results and reduce the learning effects, each user conducted the test either with the function-based or with the workflow-based navigation.

Test Persons. The test was conducted with 10 male test persons between the ages of 18 and 35 years of age. Every test person had medium knowledge of the public transport system and limited knowledge of the scenario place. All users were very experienced smartphone users.

Test Objects. For this study two functional prototypes of mobile applications for passenger information were developed. Due to a better comparability, both prototypes were designed according to the pattern of bar navigation (cf. Fig. 5). Thus, both navigation concepts were permanently present at the screen during all test tasks.

(1) *Function-based navigation.* The prototype with the function-based navigation includes the most popular navigation items “planning”, “departures/timetables”, and “favorites”, which provide detailed information of a planned journey. In addition, “messages” of disturbances and a vehicle information function are included.
(2) *Workflow-based navigation.* The developed workflow-based navigation is orientated towards the stages of a trip, instead of the functions. The concept provides different levels of detail: a planning overview for the preparation, a journey overview, and detailed trip section views for the travel. The available information and functions are displayed at the according stages of the trip.

3.3 Evaluation Results

The user interactions were counted and documented in connection with the purpose and the kind of interaction, by the reference of the video material.

The first analysis criterion is the total number of user interactions. In contrast to the hypothesis, that a workflow-based navigation could decrease the total number of interactions, the results revealed only negligible differences for the mean value of the total number of interactions (cf. Table 2). But the single results of the test persons show a higher dispersion for the function-based navigation from a minimum of 7 interactions to a maximum of 12 interactions. Opposing these results, the workflow-based navigation shows a lower dispersion from 6 to 9 interactions.

Fig. 5. Screenshots of the prototypes with function-based navigation (left) and workflow-based navigation (right).

Table 2. Number of interactions in comparison

	Total number of interactions	Number of tap actions	Number of swipe/slide actions
Functions-based navigation concept	$\bar{x} = 9$	$\bar{x} = 5.4$	$\bar{x} = 3.6$
	$\sigma = 1.9$	$\sigma = 1.34$	$\sigma = 0.89$
Workflow-based navigation concept	$\bar{x} = 8.4$	$\bar{x} = 3.2$	$\bar{x} = 5.2$
	$\sigma = 1.3$	$\sigma = 0.44$	$\sigma = 1.30$

$\bar{x}$ = mean; σ = standard deviation

The detailed analysis of the kind of interaction reveals more differences regarding the purpose and the actions. Both prototypes required the usage of tap actions, in order to reach the visualization screen for the next task, and swipe or slide actions, in order to compare the information of different trips or trip sections within one visualization screen. The mean value of the tap actions, which are the basic required actions to solve the tasks, are distinctively reduced from 5.4 tap actions in the function-based navigation to 3.2 tap actions in the workflow-based interactions, which nearly meets the minimum of three required tap interactions.

None of the interactions of the workflow-based navigation referred to the navigation bar, because all interaction steps could be clearly followed by interaction buttons in the visualization area, without returning to previous screens. The navigation buttons were highlighted, according to the next step of visualization, and were used as orientation by the users.

The lower number of tap interactions in the workflow-based navigation were equalized by the higher number of slide and swipe actions. Due to the vertical visualization of the trip results, the test persons used more slide actions to compare the results than for the horizontal visualization in the function-based navigation. Moreover, the lower mental workload to orientate and navigate between the functions in the workflow-based navigation might have encouraged the test persons to spend more time for comparing actions.

4 Discussion

The approach of the workflow-based navigation provides an intuitive and task-oriented concept for mobile information systems along the journey. The usage and benefits of mobile passenger information are related to the appropriate phases of a journey and the appropriate pre- and post-tasks. By this means, mobile passenger information systems can be used more intuitively and efficiently, especially by novice and occasional users.

In addition, mobile application systems also refer to the context, in which they are used. Krannich [15] describes influences of the situational dimension of the environment and the cognitive dimension of the user on the interactions with mobile applications. Some of these influences can be recognized sensor-based, for instance physical movements, temperature or the loudness of the environment. According to these data, travel phases can even be differentiated and the visualization screen can automatically be adapted to the workflow of the user. This development might decrease the number of required tap actions.

The revealed workflow-based navigation concept of mobile passenger information systems is validated in lab-based usability tests. As a next step, the results should also be validated in the field, using fully operative mobile applications as test objects, in order to compare the usage of function-based and workflow-based navigation, considering the different contextual influences of travelling. Further evaluation should also include individual mobility and shared mobility services, in order to evaluate the benefits of a seamless mobility information for integrated and intermodal journeys.

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