Cascading Information for Public Transport Assistance

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Abstract: Over the last years, public transport has become both more prominent and more diverse. Because of the complex structure of today's public transport networks, an electronic guidance is effectively required. Usually different transport modalities and service providers offer their own application to which the traveler has to adapt after changing between services. Additionally a current trend in mobile applications is the customization of GUI elements which leads to appealing looks but usually also to cluttered presentation of information. Both these problems cause a high cognitive stress on the traveler using the mobile application, especially while conducting other activities at the same time. Our approach to mitigate these issues is to create a mobile application applying the Gamification principle *Cascading Information Theory* to simplify the usage and additionally to use a back-end which allows to integrate data from various services hereby unifiying the presentation. A prototype of the application was evaluated in an initial user test for comparing our approach to the most popular mobile travel application in Germany.

1 INTRODUCTION

Global trends like urbanization, climate change, and peak oil enforce and accelerate the change of people's mobility; the focus shifts back from individual transport to public transport. Traditional public transport networks, like subways and bus networks, have grown in size and new forms of transport systems like carsharing have been introduced. Consequently, the number of potential itineraries from one point to another raises, each with specific features, e.g., different prices and comfort levels. To use public transport efficiently, meaning to decide on the most suitable itinerary and to follow it closely, the traveler requires effective electronic assistance. To do so a large number of more or less appropriate travel information systems have been established. Such travel information vary from traditional web platforms used for plane or train ticket booking to modern mobile applications for sharing rides.

1.1 Motivation

From our continuous work on travel information, indoor navigation, diversity, and mobile applications we recognized that most current mobile applications for public transport are flawed in terms of usability under cognitive stress. Current applications (see Section 2.1) shine with a fancy Graphical User Interface (GUI), many configuration options and a high amount of information. Such applications perform well in situations where the traveler can direct all of her cognitive capacity to the application, but fall back in terms of usability in stressful situations. Stress can be introduced by noise, time pressure, unknown surroundings, or required multitasking (e.g., walking and using a device at the same time).

To improve the usability under stress we wanted to create a concept and a prototype which simplifies mobile travel assistance compared to already existing applications. While creating a concept based on our experience in indoor navigation (Heiniz et al., 2012) we realized that the initial GUI layout and interaction pattern is strongly related to archetypical Massively Multiplayer Online Role-Playing Games (MMORPGs) like World of Warcraft (Corneliussen and Rettberg, 2008). World of Warcraft, for example, uses non-intrusive, still useful indicators/descriptions for the next waypoint in a quest. The user has access to exactly the required information she needs to ful-

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fill the given task (e.g. travel to a specific location) at one glance. This principle of providing exactly the required information in the current context is called Cascading Information Theory. We wanted to transfer this principle to a real world application.

1.2 Cascading Information Theory

In his 2010 blog entry[1], Erick Schonfeld issued his company's "playdeck" of game dynamics terms which included most if not all of the currently employed elements of gamification. Gamification is a term which was coined by Nick Pelling in the early 2000's. Since then many different interpretations of the term have surfaced, making its exact meaning hard to conceive. Recently, there have been efforts by several researchers to reach a mutually agreed on definition. One of the more elaborate and most cited versions originates with (Deterding et al., 2011). They define gamification as: "The use of game design elements characteristic for games in non-game contexts." Elements of games are components or interaction patterns that, in combination, create the game experience. By abstracting these elements from their game implementation and employing them in another context (e.g. business software etc.) the developer makes use of people's play instinct. If a user is familiar with the ported game element there is a high probability that she will associate it with its original purpose and therefore be able to correctly utilize it.

Along with well known Gamification components like achievements, Schonfeld lists the principle of *Cascading Information Theory*. Cascading Information Theory suggests to unveil information about the game in as small amounts as possible to ensure the user's focus exactly on the desired objective. Thereby, confusion and misdirection of players by providing excess information is prevented and each iteration of new data can be applied directly.

The remainder of this paper is structured as follows: In Section 2, existing applications and related research are discussed. Section 3 describes our approach to the problem on an abstract level, whereas Section 4 demonstrates the actual prototype implementation. The evaluation is presented in Section 5 and Section 6 concludes the paper.

2 RELATED WORK

This section lists popular related applications and recent research.

[1] http://techcrunch.com/2010/08/25/scvngr-game-mechanics/

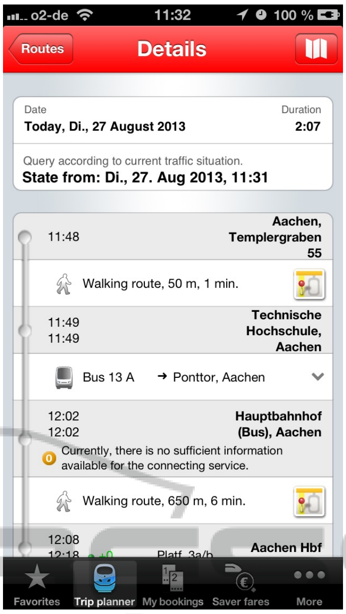


Figure 1: The DB Navigator application includes all trip data plus additional texts and various buttons in one view which impedes traveler orientation.

2.1 Public Transport Applications

The following part exhibits commonly used and high rated mobile applications for public transportation in Germany, not only explaining the benefits but also elaborating on flaws and drawbacks of the individual application, in order to convey the motivation for a new interface design. We considered only European applications because travel information applications are only meaningful applicable in the area for which they are created.

DB Navigator

Figure 1 shows a screenshot of the most popular (Statista GmbH, 2012) application for public transport in Germany, the DB Navigator. The DB Navigator is developed by HaCon AG on behalf of Deutsche Bahn. Therefore the assumption that its prevalence is due to the fact that its publisher is the main German provider of inter-regional public transportation suggests itself. The application also features fully compatible intermodal trip planning and supports real-time information about delays and arrival times. In addition to these functions there is also support for rudimentary walking directions and direct online purchase of tickets.

Despite its vast amount of features, the decent appearance, and the possibility of providing the company's own data the application has a few drawbacks.

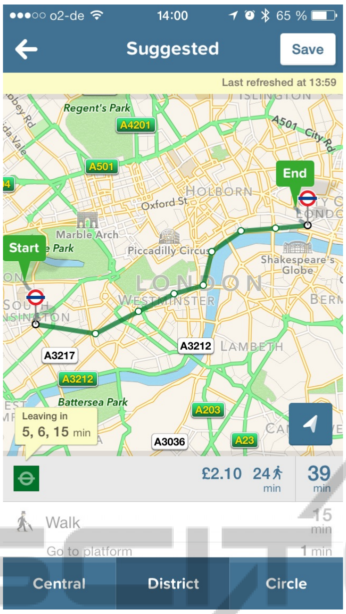


Figure 2: The London Citymapper is a very advanced application which is specifically adjusted to the needs of the London inhabitants.

The trip view shows the complete trip information in one tabular environment which requires the traveler to scroll vertically if the trip involves more than one change. To get walking directions the traveler has to press the button which resembles a map. The high number of GUI elements, the inconsistent coloring and required interaction complicate the interpretation and filtering of the needed information for the traveler and might delay the usage especially in a high stress situation.

Citymapper

The Citymapper application (London version tested) is well-known in England. The application includes a broad range of features such as generating intermodal trip plans using real-time information. Having selected the departure and destination locations the application suggests a variety of different possibilities to reach the desired spot. In addition to the intermodal route suggestions the user is presented with variations like routes only involving buses or rain safe ones and information about the current context such as the weather at the destination. The route detail view consists of a large map view displaying the selected trip itinerary and a table below it listing the individual parts of the journey (see Figure 2).

The Citymapper application addresses many of the crucial, common issues of public transportation and is appealing. However, it is specifically designed to match the London network transportation. This is a major drawback, adapting to a different application based on the whereabouts requires cognitive resources. This issue is exacerbated by the quantity of features which might be difficult to comprehend in a short amount of time.

2.2 Existing Research Work

This section presents recent work in the area of public transportation and mobile navigation systems and aims to give a short insight into the current state of research.

An attempt to create a multimodal routing service with directions for pedestrians is made in (Yu and Lu, 2012). In addition to evaluating travel modes by the criteria of distance, time, fare, and transfer, they use dynamic information about real-time and historic traffic data to enable accurate estimations. The computation of transit routes is aided by a high priority mode expansion strategy which incrementally generates parts of the most suited path. Similarly, the sophisticated algorithm developed by (Zheng and Xie, 2011) allows for accurate generic and personalized recommendations solely based on the analysis of user GPS traces. By correlating the travel behavior of users with their locations they are able to estimate user interests.

(Baus et al., 2002) introduce their concept of a pedestrian navigation system with a hybrid solution titled Project REAL. Already accurately predicting the evolution of personal navigation systems ("Personal navigation systems that extend beyond today's use in cars will play a major role in the future.") they present their approach featuring a combination of indoor and outdoor navigation. The system is capable of automatically adapting to location changes and presenting directions to the traveler on a variety of different devices.

Since the primary instruments for outdoor navigation are geolocation services, accomplishing indoor navigation is an incomparably more difficult task because exact positions are hard to determine. Nevertheless, considering the topic is crucial for any attempt at implementing a complete navigation system. In (Rehrl et al., 2005) a solution for the guidance of pedestrians inside transport interchange buildings is proposed which relies on generating a hierarchical model of the complex and providing instructions augmented with map views. (Chowaw-Liebman et al., 2010; Heiniz et al., 2012) present a turn-by-turn approach to manage navigation inside large, complicated buildings using landmark representations for orientation rather than street names. The work is based on the idea that pedestrians mostly rely on landmarks as navigation cue (May et al., 2003).

The TransitGenie project (Biagioni et al., 2009) aims at implementing a public transportation navigator with a transit tracking service which consists of an activity classification algorithm to determine user context as well as trajectory matching to enhance vehicle tracking. In their later work, (Biagioni et al., 2011) further pursue the automatic real-time tracking of transit traffic and the computation and prediction of arrival times.

The UbiBus project started an attempt to create an ubiquitous system for public transport assistance using context information (Vieira et al., 2011). The authors incorporated access to an intelligent transportation system application in buses as well as web services and smart phone apps, so that passengers are enabled to receive information about the progress of their bus. (Pessemier et al., 2013) proposed a framework which is capable of extracting high-level information about user context. Initially the system recognizes and collects very basic data to create a foundation. Complex user activities are then broken down into smaller parts and connected via conditional relationships which are afterwards matched with the previously recorded basic contexts. If a complex context is identified this way, an application is capable of requesting detailed activity recommendations from a central server using a four-part scoring model. (Christoph et al., 2010) proposed an integrated context-detection service architecture which combines information from different approaches.

(Keller et al., 2011) observed that creating an ideal representation of public transit trip information on a mobile device is a difficult task. Using paper prototypes, the authors compare different approaches to display intermodal travel chains.

3 APPROACH

While working on public transportation information systems we identified parallels between real world navigation and navigation in, e.g., MMORPGs. Navigation elements in games are usually lean and unobtrusive as to not distract the player from her main task, but still are easy to comprehend. In a real world environment full of distractions, noise, and confusion the traveler's concentration can rarely be focused entirely on operating her mobile device. When traveling on a bus, entering a rail station, or even just walking towards a bus stop the traveler needs to be capable of checking her itinerary as quickly as possible. Therefore, an assistant application is required to be uncomplicated and easy to use. In order to minimize the amount of cognitive resources needed by the navigator, the user interface needs to be plain and responsive, similar to navigation elements in MMORPGs.

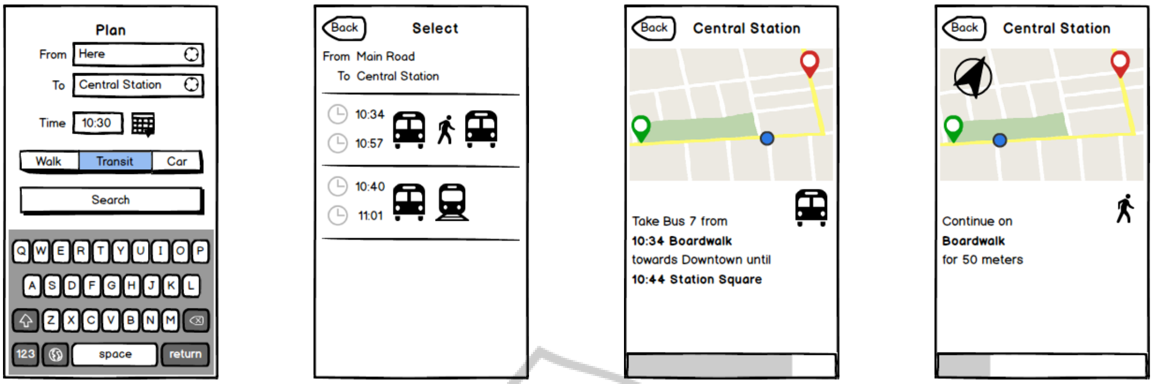
Following the general principle of Cascading Information we divided and analyzed information presented by mobile travel information applications regarding necessity. We only considered essential information for inclusion in our GUI concept. For every piece of essential information we assigned a time span at which it is required, and an order of priority (results in Section 3.3). Information will be presented if and only if it is required at this particular point in time and is shown in descending order of priority.

This is achieved by creating a turn-by-turn-like interaction. Travelers continuously progress through the trip by steering from intermediate target to target and ultimately arrive at the destination. Only information required to reach the next intermediate target is conveyed to the user. The design of the GUI is intended to noticeably enhance users' public transport navigation experience in comparison with existing applications. It is supposed to aid the traveler's navigation and make processing routing information as easy as possible. Device-independent mockups presented in Figures 3(c) and 3(d) show an early stage of design.

3.1 Planning the Trip

A trip is the journey from a specified starting point (usually in the vicinity of the traveler's current location) to a destination point in a previously set time frame, using one or several different modes of travel. Although it is possible to add numerous other parameters to the plan, they are not included in the application for the sake of simplicity. Conceivable additional options for planning the trip, although increasing complexity, include specifying the desired date/time of arrival instead of departure, preference of direct connections or favored traveler profiles. Users of public transport navigation aids often are in need of public transit information regarding their current location, such as to quickly return home from a friend's house or when to take the train to get to university. Therefore incorporating the latest position update as a location parameter for the trip request is deemed appropriate.

Figure 3(a) shows the first depiction of the initial planning view to input the desired trip parameters. The time of departure is shown in a textual representation and changeable by using a mechanism or by input via a (virtual) keyboard. Finally, the modes of travel are to be chosen using a multiple-selection segmented control which lists all possibilities and in-



(a) Planing view. (b) Trip list view. (c) Trip view (bus). (d) Trip view (walking).

Figure 3: Early development sketches.

dicates their selection state. The bottom-most button labeled "Search" will then issue the request and fetch one or more trip plans. One reasonable improvement to the interface might be the use of meaningful icons instead of the textual description of the travel modes in the segmented control. This is due to the fact that reading a piece of plain text usually takes longer than recognizing a commonly used icon.

3.2 Selecting a Trip

After submitting the trip inquiry, the traveler has to be presented with the trips suggested. The mockup in Figure 3(b) depicts an early version of a table view whose rows each contain one of the provided itineraries. The times of beginning and arrival of the journey are mandatory attributes for people to judge the expediency of a proposed trip plan. Especially if there are multiple possibilities for the modal composition of a route, displaying the different transport modes during the selection progress distinguishes any unique features of the trip. Displaying icons unambiguously depicting the travel modes not only saves screen space but also makes it easier to comprehend the complete routing process at a glance. In addition the starting and destination locations which the traveler had previously specified are presented on top of the table.

3.3 Assisting the Trip

The trip view shown in Figures 3(c) and 3(d) represents the most significant component of the interface and is also where the traveler is likely to spend the highest amount of time while actually using the application. Being the main source of detailed information about the journey, the trip view needs to fulfill certain requirements. Most importantly, all required information needs to be quickly accessible and easily comprehensible. A traveler should be able to capture the information which is necessary for her navigation at one glance without any interaction. Following the principle of *Cascading Information* introduced in Section 1.2, it is assumed that the traveler does not require the complete trip information during her navigation process. Therefore, the whole trip plan can be subdivided into small entities containing only the features of a single step along the route. Using this distinction allows displaying these entities individually. A type of view is needed which enables comfortable progression through the route and is easy-to-use. Consequently, the interface will not feature a vertical scrolling view. Instead, it is intended all the data necessary for the corresponding stage of the trip are visible at once, eliminating any need to perform time-consuming repositioning of screen elements or going through all the information to find the respective piece of information.

Using Context Awareness

To present exactly the required information for the current situation, respectively the current step, knowledge about the current situation is required. The multitude of sensors included in current mobile devices allows for precise determination of user contexts and their surroundings, and therefore the situation of the traveler. By using the context data, e.g., time and date, the location and the type of transportation vehicle the application is enabled to ascertain whether a user has entered the vehicle she was headed for on her itinerary. Using this information we can automatically deduct which step of the planned route should be presented.

Since one step in the plan has a variety of attributes, which are potentially subject to change, the possibilities of how to visualize them are manifold. In general one can distinguish between purely textual and graphical representations of data. As depicted in Figure 3(d), the mockup GUI contains a combination of both methods in order to take into account different user habits. Independent of the type of transport the general interface layout stays the same. The information is always displayed at the same area to enable the traveler to recognize relevant information at a glance.

Textual Elements

There are a few characteristics which are essential to the navigation procedure and therefore any major change to them is improbable. If the step required public transportation, the required characteristics, in descending order of priority, are (also shown in Figure 3(c)):

Departure and Arrival Stations. Naturally, the traveler needs to know the stations of the transit vehicle she intends to travel by. The description of the stop should not only include its name, but also some kind of information about which platform to enter. This holds especially true for large buildings like central stations or coach terminals.

Vehicle Information. Public transport vehicles are usually identified by a line number and direction headsign. Both are displayed to enable the traveler to find the vehicle easily.

Departure and Arrival Times. Knowing the respective departure and arrival times is a crucial factor for the traveler to catch the vehicle and leave it at the right time.

When providing on-foot navigation important characteristics include (shown in Figure 3(d)):

Direction. Walking navigation thrives on supplying the traveler with the direction she is supposed to walk in. While people usually tend to use relative directions like "left" or "slightly right" absolute directions based on points of the compass are a possible alternative.

Distance. Information about how long the current step will take is generally of great interest to a traveler. Since the individual walking speed may differ significantly between people, the better alternative is displaying the distance that has to be traveled.

Street Names. The traveler requires identifiers to exactly recognize the planned walking route she is supposed to follow. This is most easily accomplished by providing either the name of the street or an identifier of a nearby junction or a well-known public place.

Also, the final destination of the journey should always be visible so that the traveler is reassured she is traveling in the right direction. The top area provides sufficient space to display a text which slightly resembles the head sign of a bus or tram and therefore seem familiar to the traveler.

Graphical Elements

The graphical representation of trip data is primarily performed by a map view which displays the surroundings of the traveler and her route using an online map service as data source. All of the steps which are transmitted in the planned route are marked on the map and a path overlay approximately indicates the track that will be traversed during the journey. The traveler's progress on the route is shown by highlighting the map marker which corresponds to the current step. A compass is shown on the map to add an additional easy to follow navigation cue. For the traveler to always be aware of her advancement we added a progress bar at the bottom of the display. To prevent distraction, all graphical elements should be kept simple and lean.

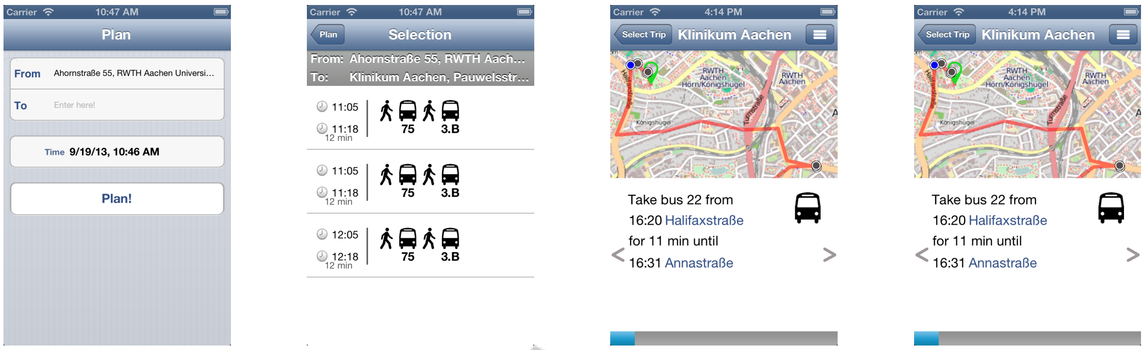
3.4 Back-end Requirements

Since the application is to be extensively evaluated in a user study, it would greatly benefit from real functionality instead of mockup-like dummy behavior. Therefore, the decision was made to employ a real back-end service capable of providing intermodal routing information for public transportation. Ideally, this service needs to include a variety of different travel modes as well as the possibility of extending the system. Most importantly the server is required to allow effortless import and use of own map and transit data in a standardized format so that user testing may be performed regionally with the appropriate information.

4 IMPLEMENTATION

This section describes the actual implementation based on our previously introduced approach. We begin with the process of drafting and assembling the prototype, including detailed explanations of the GUI followed by a brief description of the used back-end.

In the following we address the realization of the views of the prototype GUI. Since there was relatively little time between the creation of the mockups and the implementation of the application, and also because of the sophistication of modern mockup tools,



(a) Plan view. (b) Selection view. (c) Assistance view (bus). (d) Assistance view (walking).

Figure 4: Screenshots showing the prototype implementation.

the differences are not always apparent. Because of its popularity, stability, and the great amount of well-written documentation, Apple iOS 6 became the platform of choice for the development of the application prototype. In order to fully ensure compatibility with a real device, the application was also regularly tested on an iPhone 4.

4.1 The Planning View

The trip planning view presented in Figure 4(a) consists of *from* and *to* text fields, a date selector, and a *Plan!* button. Upon beginning text input a virtual keyboard is displayed alongside several possible text buttons. These buttons include a green position marker which resembles the traveler's position. By tapping it, the traveler starts a positioning process which uses the current geolocation, coordinates supplied by the device sensors to look up the current address using reserve geocoding. This trip planning may be used in two different scenarios: Either a traveler wants to make a request for an entirely new route, or she issued the command to reschedule an active trip. In the first case, the next step in the navigation chain is displaying the list of feasible itineraries provided by the backend server. If, on the other hand, a reschedule is supposed to happen, the application skips displaying the trip list and selects the first itinerary, optimistically assuming that it embodies the temporally closest possibility.

4.2 The Selection View

After receiving a response from the back-end server the trip information needs to be conveyed to travelers using the selection view in Figure 4(b). The shown table contains a variety of information; on the top of the list, the full description of both the origin as well as the destination location is presented. Each following row sums up the trip, containing on the left hand side the time of departure and arrival. Furthermore the full duration of the trip is written below. Next to the times the utilized modes of transportation are listed in an array of icons. Below the icons the line identifier (e.g., line number) is shown. To maintain consistency the icons from the planning view are reused throughout the application. By reducing the icon size after reaching a certain threshold an overflow is prevented.

4.3 The Assistance View

Presenting the stages of the trip to the traveler was one of the main challenges in designing and implementing the prototype GUI. Therefore drafting it included devising the functions which had to be employed in order to satisfy user needs while keeping a plain profile. The view grew in functionality and its features matured during the process of implementation.

Since the trip is split into several parts, a similar graphical representation is an obvious consequence. The trip plan is segmented into a number of steps which have to be subsequently completed in order to arrive at the destination. These steps are visualized on the map view by adding a position marker to the map layer at the geographical coordinates of the starting point of each step.

In addition to showing the route path and progress on the map, a *compass* was incorporated into the view. Using a rotatable image of a green arrow in the upper left corner, the traveler ought to always be aware of the direction in which her destination lies. This is achieved by computing the angle (i.e., the bearing) between the traveler's location and her destination. Utilizing iOS ability to not only monitor the position but also the heading, the application uses the bearing and the travelers heading to create and apply an affine transformation to the arrow image, thus rotating it. As a result, travelers are able to discern the correct direction of their destination at any given moment which is especially beneficial for walking directions. The concept of this orientation aid is derived from games, which often provide navigation instructions by displaying a compass. As the compass is only relevant for walking directions, it is disabled for other modes of transportation.

The part of the GUI displaying the textual representation presents either a step of the walking directions or a transit stage of the trip and contains a number of labels and one image view for depicting the current mode of the step, again reusing the mode icons from the planning view. If the step is part of the turn-by-turn walking directions it includes information about the absolute and relative direction, the street the traveler is supposed to follow, and the distance that will be traversed during this part of the journey (shown in Figure 4(d)). If, on the other hand, the view shows a transit stage, it contains details regarding the type of vehicle, the transit route, departure times and station as well as arrival time and name of the destination (Figure 4(c)).

At the bottom of the view, a progression indicator is placed which uses a bar style and is filled according to the progression in the trip. However, merely iterating over the steps does not accurately resemble the progression through the trip plan, because the route is generally not of a linear nature. Instead, the various parts of the journey each consume different amounts of time and therefore the advancement of the progress view was adjusted to precisely mirror the traveler's progress.

4.4 Back-end Realization

In order to generate some real functionality for the application prototype an existing routing solution was required. The optimal candidate in this scenario is an open source complete planning service to serve as a back-end which is capable of autonomously computing a route between two arbitrary locations. Also favorable are the possibilities of freely integrating a variety of maps sources as well as a fully compatible API to address the back-end server.

The OpenTripPlanner (OTP) project[2] is an open source platform which has developed a rather large community since its launch in 2009. While still in development, it already features intermodal trip planning with special support for bikes, allows the import of several internationally popular data types and offers a RESTful web API. OTP is mainly Java-based and consists of a server which performs routing and supplementary services, and a basic but effortlessly extensible web application enabling users to search for a route via their web browsers. Furthermore, the RESTful API is able to provide the same experience using either XML or JSON formatting, enabling access to the service with mobile clients.

The project employs the established A^* search algorithm for path finding when walking and the MOA^* algorithm for intermodal trips after the provided raw map data has been indexed by OTP's own map builder application. By default, all maps are obtained from the well-known OpenStreetmap (OSM) project, which distributes very up-to-date maps on an open source basis. To ensure compatibility, the developers use Google's General Transit Feed Specification (GTFS)[3] format for moving and importing transit data. The project includes a graph builder tool which is capable of analyzing any provided GTFS data feed and determining the required map excerpt, and automatically downloading the corresponding data from OSM. Afterwards, the program computes a large graph object containing all the correlated data ready to be used by OTP.

5 EVALUATION

For evaluating the prototype a user-oriented evaluation was applied.

Figure 5: Participant interacting with application prototype.

5.1 Methodology and Test Participants

The prototype application and the DB Navigator were evaluated in a lab user test (see Figure 5) in order to identify usability problems and have an insight in prospective users' assessment. The test encompassed a leading scenario and three tasks which had to be solved by interacting with the applications. The purpose of the leading scenario was to give the test tasks a contextual framing for supporting test participants in understanding the whole point of the test.

[2] http://opentripplanner.com

[3] https://developers.google.com/transit/gtfs

Scenario:

> You are a student in Aachen and you have a student ticket, which allows you to use all public transportation in your state. For this reason, you are a frequent user of Aachen's public transportation. You own an iPhone and use trip assistant apps to inform yourself about departure times.

After reading this, test participants were given the task instructions which focused to test the app's main functionality routing. To reduce the cognitive load and concentrate on the task processing, instructions for the next task were handed out after finishing the current one.
Task 1 was about routing from the actual location to a bus stop:

> It is 09:18 a.m. at the 3rd of August 2013. You are running through an unknown street. You have to go to the Audimax, a university building, to write an exam. The exam will start at 10:00 a.m. Use your app to find information about a bus ride to your exam. Use the integrated functionality to find your actual location.

Task 2 was about routing from a bus stop to an address:

> It is 03:03 p.m. at the 3rd of August 2013. Your performance during the exam was more or less successful. You are having a late lunch with your girlfriend Claudia and have to plan a trip from the Pontstrasse, Aachen to the home improvement store because you have to buy material for fixing a shelf for Claudia. The home improvement store is located in Roermonder Strasse 177, Aachen. You are again pressed for time because later you have an important appointment. Use your app to reach your destination by bus as quick as possible.

Task 3 was about routing from one address to another:

> It is 5:13 p.m. at the 3rd of August 2013. After you have carried out all tasks you have promised to Claudia you have to go quickly to your family for helping them to prepare a birthday party. At the moment, you are at Claudia's place in Oppenhoffallee 143, Aachen. Your parents live in Burtscheid, a suburb of Aachen, in the street Birkengrund 10. Aachen. You have to be there at 06:00 p.m. to set up a pavilion for the guests. You have to hurry to do this because the weather forecast has announced 88% rain probability. Use your app to reach your destination by bus as quick as possible.

The experimental design was varied for controlling position effects: Half of the test participants carried out the test tasks first with the prototype and then again with DB Navigator, the other half of test participants vice versa. During the test the test participants were instructed to apply the thinking aloud method which means to comment on their interaction with the apps. Verbal comments were recorded via audio and video. In addition, the interaction with the apps was recorded by a screen record software. The feedback of participants was collected with a questionnaire consisting of six sections:

Section 1 Demographic Data. Age, gender, profession, education.

Section 2 Mobility Profile. Possession of driver's license, use of means of transportation.

Section 3 Technology Use. Possession of electronic devices, frequency of use of devices, perceived ease of use of, electronic devices, experience with trip assistant apps.

Section 4 Assessment of the Prototype. Positive and negative comments, Additional questions about icons, size of map, visualization of progress.

Section 5 Final Rating. Application preference.

Ten test participants took part in the user test. Five were male, five female. Their age was $M = 23.9$ years, $SD = 3.03$ years. All of them were students. About their daily mobility profile they stated to go by foot (10), to ride the bus (5), to cycle (2), and to use the train (1). They were all using a smartphone (six iOS, one Android, one unknown, two others). Concerning mobility apps, nine used the DB Navigator, eight Google Maps, and three Navigon. Participants' experience with the DB Navigator was assessed as problematic because it impacts results of performance tests. However, this experience with several mobility apps could also be helpful for assessing the prototype's quality and utter specific optimization proposals.

5.2 Evaluation Results

The expenditure of time for solving tasks varied (see Table 1). According to the measured data, the processing of the tasks with the application prototype took longer than with DB Navigator. As mentioned before, nine of ten participants know and use DB Navigator and have learned to use the application to a certain extent. Therefore the result of the final rating for one app was predictable: seven participants preferred DB Navigator, two the prototype application, one neither of both apps.

Table 1: Mean of required time for solving tasks.

Application	Task 1	Task 2	Task 3
DB Navigator	1:13	2:44	4:22
Prototype	2:26	3:24	5:55

5.3 Participant Feedback

Participants gave very detailed feedback about the prototype visualization and features. They assessed positively that prototype was clearly and simply designed. For them it seemed to be easy to manage. No unnecessary gimmicks or icons were integrated. Furthermore, they appreciated the presentation of the map and the step-by-step support during the whole trip. The choice of means of transportation by marking icons was also a pro argument for the protoype application. Negative comments were predominantly related to missing features or information. For instance, participants missed the feature for defining the time of arrival/departure, choosing a bus stop from a selection, and a default setting of the territory, which should be considered (e.g. data for town, not for whole country). Moreover, information such as details of vehicles (e.g. bus number) was absent.

Technical problems were mentioned in connection with the GPS-based definition of the actual location. The range of participants' assessments concerning the size of the map was from "too small" to "ok". Also zooming was a little challenging for test participants. In general, the quality of icons rated as comprehensive. Two icons, bus and train, were named as too similar. The visualization of process progress within the app was also questioned. Three participants opted for page control dots, seven for a progress bar, two for displaying the percentage (multiple answers possible). Two participants stated that it was not clear, which kind of progress was visualized in the prototype distance, time, or steps within the step-by-step assistance.

5.4 Discussion

Based on the presented results our prototype application can be considered slightly inferior to the reference application DB Navigator. This outcome was expected; the majority of the test subjects had previous experience with the DB Navigator application. While this allows for potentially increased competence in operating the applications, it may have caused a biased outcome of the evaluation. The feedback highlighted the core usability issues of the interface, which severely influence the performance and satisfaction of users. While any problems identified by users during the tests are unfortunate, designing a flawless user interface right from the start is close to impossible. Last but not least, the employed lab test enviroment misses congnitive stress, which we believe will change the outcome.

6 CONCLUSIONS AND FUTURE WORK

This section discusses options of extending the prototype and the research topic in general and afterwards draws the conclusion of this paper.

6.1 Future Work

The presented mobile application is the foundation for a possibly holistic mobile application. However, the developed application is merely a prototype and therefore does not aspire to be complete or even a valid competitor on the market. During the process of implementation and beyond, many opportunities for extending and improving the design as well as the application itself were discovered or proposed by others. This section presents the most promising ideas and the circumstances of a possible realization.

Context Awareness

Although an approach to employ automatic context detection was described in this work, it was not included in the prototype. Instead, we opted for a manual selection of the current waypoint, respectively the current context as the focus of this work lies on the presentation of information. To reach the goal of a full-fledged mobile travel assistance solution, integrating an existing framework for automatic context is highly desirable. This would spare the user the need to manually select the next step of the journey by performing input on the device.

Indoor Navigation

A transit trip plan usually consists of many different stages with a multitude of varying transportation modes and changes of location. People often travel with one transit vehicle to a certain station and afterwards have to transfer to another vehicle. This happens especially often at stops in large facilities like central train stations or airports. Depending on the size of these buildings, the number of different transit modes they support travelers may be overwhelmed by their complexity. Users who visit the station in question for the first time are particular at risk of going astray in the building complex and therefore missing their connection. As GPS positioning is only available outdoors, the traditional means of locating the user fail to operate properly. In addition to this, there usually is no map data available for indoor navigation. Therefore we plan the incorporation of our previous work supporting pedestrian indoor navigation into the prototype.

Social Networking

Social networking is an aspect which increasingly finds its way into many everyday activities and often manages to make ordinary tasks more appealing. By adding social components like interaction with friends by e.g., sharing, commenting or recommending itineraries, the application might enhance the user experience and consequently create a new incentive for repeatedly using it.

Real-time Transit Data

Because the application is supposed to aid the traveler during her trip and guide her through problematic situations, using and providing real-time information about transit schedules is a crucial extension. By including this data in the application it would become possible to inform travelers of any unforeseen circumstances like delays or even cancellations. Using the application, the traveler could then react to the delay and try to search for an alternative way.

Field Test

After discerning and correcting a large amount of the design errors during the first user test in the laboratory, the logical consequence is a new iteration of usability testing. The initial user study was mainly intended to be a first step towards adjusting the application to user needs. However, the testing environment was unnatural considering the performed tasks, because people normally use public transit navigation either on the road or before starting a journey.

In order to further evaluate the application prototype more realistically a field test will be performed, which requires users to actually embark on a real trip. During this pre-planned journey the users and their reactions will be closely monitored in order to determine the amount of cognitive capacities that is actually consumed by using the application for orientation in a realistic scenario.

6.2 Conclusion

This paper presented the attempt to design a novel Graphical User Interface for planning and routing through multimodal transit trips. The interface prototype was designed to alleviate the issues of travelers and guide them while they embark on their journey. The first draft of the GUI was produced employing the principle of cascading information and classic user interface design methods, determining the scope of this work.

Based on the derived concepts and drafts, a prototype mobile application was developed for Apple iOS. The trip planning was based on a backend server running OpenTripPlanner. The developed application was finally evaluated in a laboratory test user study in order to obtain information about usability, design issues and the comparability of the prototype with established applications for public transport navigation. The results of this study revealed the crucial usability problems and provided detailed feedback about the aspects of the GUI. While the prototype lacks the developmental stage of a commercial application and offers room for improvement, the positive user feedback showed that presented approach is reasonable and worth further attention.

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