Designing and Evaluating Buster – an Indexical Mobile Travel Planner for Public Transportation

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ABSTRACT
This paper elaborates on previous research into the design and use of mobile information systems for supporting the use of public transportation. Contributing to this domain of HCI research, we describe the design and evaluation of a mobile travel planner, Buster, for the public city bus system of a large regional city in Denmark. Carrying on from on earlier research activities, we did contextual interviews, acting out of future scenarios in situ, and iterative paper prototyping to extend on previous design ideas and explore further the principle of indexicality in interface design for context-aware mobile systems. We then implemented a functional prototype application and evaluated it in the field.

Categories and Subject Descriptors
H5.2. [**Information interfaces and presentation (e.g., HCI)**]: User Interfaces - *User-centered design, Graphical user interfaces, Screen design*.

General Terms
Design, Human Factors.

Keywords
Mobile information system, context-awareness, indexicality, user study, acting-out in situ, field evaluation, public transport

1. INTRODUCTION
In large cities where traffic is often very dense, traveling by car can be highly time consuming and unreliable, necessitating much planning. Valuable time is often spent in traffic jams and searching for places to park. It is often difficult to predict the time of arrival and so travellers may arrive late for appointments. Planning for such uncertainties however may result in slack time at the destination. However, the use of public transport is often perceived as complex and inflexible, imposing predefined routes and timetables, and subject to uncertainties about operation and possible delays.

Extending on our previous research into mobile computing supporting the use of public transportation in city contexts [6] "Buster" supports people's use of the public city bus system of a large regional city in Denmark by means of a context-aware mobile travel planner application embedded into the calendar application of a PDA. Using multiple techniques for contextual enquiry and design, we explored current travel practices and possible future practices of city inhabitants as they travelled by means of public transportation between their homes and places of work and study in a large regional city of Denmark. We enquired into current practice through contextual interviews with people in transit on board busses, and we explored potential future practice through acting-out sessions with participants in situ. Informed by these activities, we elaborated further on previous design ideas for the "TramMate" system [6] through iterative paper prototyping, and implemented a new functional prototype application called Buster. Finally, this prototype was evaluated it in the field. Below, we describe these activities and their outcomes in detail.

Figure 1. Observing people's use of public transportation

2. INDEXICALITY
Indexicality is a concept from semiotics, which has been used to describe the inherently close relation between information representations in the interface of a mobile context-aware system and the surrounding context that the system is adapting to. From a semiotic perspective, information is viewed as representations of something else (their object) [2]. Faced with an interpreter, these representations cause a reaction or interpretation. In brief, semiotics operates with three types of representations: symbolic (conventional), iconic (similarity) and indexical (material/causal). Symbols and icons are ways of representing information independent of context like, for example, text and graphical illustrations. Indexes, on the other hand, are ways of representing information with a strong relation to, for example, their spatial and/or temporal context exploiting information present in the interpreter's surroundings. Indexical representations are, for example, used on signposts and information boards. Thus, for example, locating information in time and space, symbolic and iconic representations can be converted into temporal and spatial indexical representations [1]. As shown in [7] increasing the level of indexicality can lead to a reduction of required symbolic and iconic representations.

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The idea of applying indexicality to interface design for context-aware mobile information systems is that if information and functionality on a mobile device can be indexed to the user's situation, then information already provided by the context becomes implicit and does not need to be displayed. Hence, the user's environment becomes part of the interface. On the basis of this, the limited screen real estate of mobile devices can be streamlined to contain only the most vital content and the required user interaction with mobile devices can be reduced. As an example of this, an indexical mobile information service for patrons entering a cinema complex could be made temporally and spatially indexical by taking into account the time, location and social context of the user, providing only information about the upcoming movies playing within a limited frame of time (temporal indexicality) in that specific cinema (spatial indexicality) [7]. The concept of indexicality has been explored preliminarily in the design of the TramMate mobile prototype system supporting the use of public transportation in Melbourne, Australia [6] and has proven to be a promising, but still challenging approach to interface design for context-aware mobile systems. In this study, the concept of indexicality was explored further by explicitly including strong indexical references to the users physical surroundings, such as locations, landmarks, bus stops and busses.

3. ACTING-OUT IN CONTEXT

The design process of Buster was initiated through a series of acting-out sessions with prospective users [4] following the contextual interviews. The acting-out sessions took place on busses en route through the city of Aalborg, Denmark and involved 4 participants enacting future use of a mobile device represented as a non-functional prop (figure 1). Following a short introduction to the process of acting-out and the purpose of the props, the participants were accompanied on a bus journey, during which they used they used and explained imaginary functions and information of a mobile information system. Two researchers supported the acting-out sessions. One researcher helped the participants explicate the information and functionality that they imagined that the device would offer, and how they would interact with it. The other researcher recorded the sessions on video.

Figure 2. Device props used in acting-out sessions

The acting-out sessions were carried out in the same way for all participants but made to accommodate the participants' time schedule. The participants were recruited among university students and selected to include people with different levels of experience with using the city bus system, and from different districts of the city, which required them to use different bus routes to get to and from the university.

4. ENVISIONED FUNCTIONALITY

The acting-out sessions provided insight into the potential functionality and use of a mobile travel planner for the public transportation system of a large regional city. Overall, the functionality envisioned through the acting-out sessions was to:

- Allow pre-planning the journey (e.g. from home)
- Alert when its time to leave home in order to catch the bus
- Allow for automatic ticket payment
- Provide information about the journey when on the bus
- Alert when it is time to get off the bus
- Provide information about the locations of unknown bus stops

The participants wanted to be able to get ad-hoc information about upcoming bus departures from stops nearby their current location as well as being able to plan journeys ahead of time (i.e. working out the right bus route and when and where to get on and off the bus). After planning a journey, the participants wanted the system to automatically alert them when it was time to leave their current location in order to catch the bus, taking in to account the time it would take to walk to the bus stop. As a part of this, it was suggested, that the system would show the distance and expected walking time to the stop, as well as a timer counting down to departure of the bus. In case of missing a bus, the system should immediately suggest a set of alternatives.

When boarding the bus, the participants suggested that the system would automatically work out the correct cheapest fare based on planned destination, purchase an electronic ticket, and notify the driver (who currently sells and inspects tickets) of the purchase. In case of the user having a weekly or monthly ticket, the system should also automatically notify the driver of this.

When on board the bus, some participants suggested that the system would provide information about the duration of the journey, the current location of the bus (e.g. on a map or a satellite photo), the remaining time of the journey, and the estimated time of arrival (as is seen on many long-haul international flights). It was also suggested that the system would indicate expected delays and clearly guide the user through any planned and unplanned bus changes.

In preparation for getting off the bus at the right place, some participants suggested that the system would alert the user shortly before their stop through a ringing or vibration signal discrete enough not to annoy other passengers. Some also suggested that the device would provide a button for alerting the bus driver to stop at the next stop similar to pressing the stop buttons inside the bus or pulling the cord on a tram. Minimizing user interaction and avoiding having to pull the device out of their pocket, some participants suggested that the system would just automatically alert the bus driver to stop at their scheduled destination.

Finally, some participants suggested that, if needed, the system would be able to guide them to the location of unfamiliar bus stops and from any bus stop to their final destination.

5. PROTOTYPES

Elaborating on ideas of context awareness [e.g. 3], our earlier design ideas for the "TramMate" system [6], the explicit use of indexical references in mobile device interface design [7], and readings in geo-semiotics [9], the functionality envisioned through the acting-out sessions was included into the design of a paper prototype of "Buster". The paper prototype was developed

over 3 major iterations each involving a heuristic evaluation with an expert in HCI and mobile computing.

The basic idea behind of Buster was to make the bus-route planning tool an integrated part of the user's calendar application, providing dynamic route planning information directly related to the user's schedule for the day. In this way, Buster would require very little additional interaction beyond entering appointments. When a new appointment is made, the user is asked to specify its physical location. Based on this, Buster will automatically create a time slot for getting to the place of the appointment by bus from the user's current or scheduled previous location.

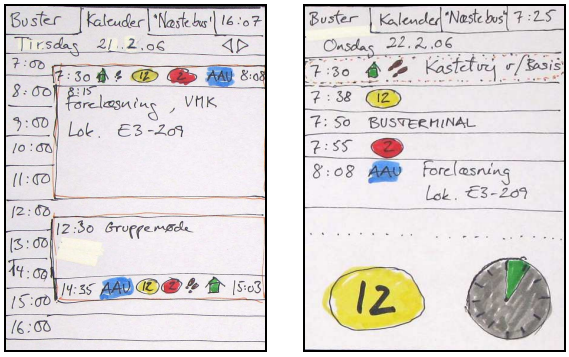

Figure 3. Paper prototype screens of Buster

Using the tabs on the top of the screen, the user can shift between calendar view (figure 3 left) and Buster view (figure 3 right). In calendar view, the bus route is represented through a minimalistic series of icons coloured to match the colour-coding of the bus system and located next to, and thus indexing to, the scheduled event. In Buster view, the current route is expanded and supplemented with detailed information about the next step to take in the form of a timer counting down to the next event and, for example, the number and colour of the next bus to get on. The bus number and colour-code index to busses in the user's physical surroundings while the countdown timer index to current time and the time of departure. The closer it gets to zero, the colour of the countdown timer changes to yellow and then to red.

The sequence of icons representing the route to follow in both calendar and Buster view were designed as a kind of rebus that conveys the information in less space than a textual expression because of their iconic, symbolic and indexical properties. Furthermore the icons are used to index to other elements in the interface. As an example, the information representation in figure 3 (right) reads: "you have to leave home at 7:30, which is in five minutes; catch the city bus number 12 at 7:38; you will arrive at the central bus station (busterminal) at 7:50 where you have to get off the bus; you should then change to metro bus number 2 departing at 7:55; this bus arrives at your bus stop at the university at 8:08; your lecture is in room E3-209".

Well ahead of an upcoming appointment, Buster notifies the user when it is time to leave in order to make it to the first bus stop on the route based on the estimated walking time to this stop from the user's current location. This reminder is similar to a conventional calendar reminder pop-up window on a PDA but extended with information about which bus to catch, where it leaves from, and how soon it leaves. During traveling to an appointment, the Buster timeslot continuously updates itself with information about the next step of the bus route. Thus normally the user will not have to interact directly with the system. When on the bus, Buster notifies the user when to get off and what next step to take. When arriving at the final bus stop on the route, an optional map provides the location of the appointment as well as the users current position.

As a third tab, the "Next bus" view gives access to a continuously updated list of upcoming bus departures the bus stop closest to the user's current location. This functionality was included in order to support ad-hoc use without having to enter an appointment. The information displayed in this view is indexical because refers implicitly to the user's location and the current time.

The final paper prototype design was implemented as a functional prototype (figure 4). Apart from a few adjustments, the functional prototype matched the description above. As a major graphical adjustment, the colour scheme of the functional prototype was modified to match the cooperate look of the bus company's printed timetables and their website.

Figure 4. Functional prototype screens of Buster

The functional prototype was developed in Macromedia Flash 8 with dedicated networking and file system components programmed in C#. Flash was chosen because it gave us a large degree of freedom over the look of the user interface. The Flash application was developed using Actionscript 2.0 to manipulate on-screen objects and to trigger events. Version 2.0 was chosen to support execution on a PDA in Macromedia Flash Player 6 for Microsoft Pocket PC. In order to edit, save and transport XML files from the Flash application, a number of supporting applications were developed in C#. Standalone and full screen execution was enabled using FlashAssist 1.3. Wizard of Oz simulation of context-awareness was enabled through a separate application running on a second PDA connected to the Buster prototype over WiFi and writing to a shared XML file. The city bus timetable was entered into XML file allowing for temporary changes and delays to be entered ad-hoc by the wizard.

6. FIELD EVALUATION

Due to the close relationship between the information in the system and the users physical surroundings, we evaluated Buster in the field. The field evaluations involved 11 participants using the prototype system while in transit between their homes and places of work or study (figure 5 left). Data collection for all evaluation sessions was done by means of a "field laboratory" allowing us to record high quality video images of the use context, the users using a camcorder, and their interaction with the mobile device using a small wireless camera (figure 5 right). For

simplicity, positioning and active context-awareness was simulated using the 'Wizard of Oz' technique [e.g. 5].

Figure 5. Field evaluation of Buster with wireless camera attached to the mobile device (right)

Each evaluation session involved two researchers and one test subject. One researcher had the role of test manager and interviewer with the responsibility for handing out tasks, encouraging the test subject to think aloud, and asking questions for clarification. This researcher also recorded the user and surroundings with a handheld camcorder. The second researcher had the role of wizard with responsibility for triggering events and entering data into the prototype system behind the scenes through a second PDA. This researcher was also responsible for operating the field laboratory's video recordings from the wireless camera. Evaluation data was analysed through affinity diagramming

7. FINDINGS

The findings from the evaluation were divided into two overall categories related to 1) experienced usability problems, and 2) perception of indexical references in the interface.

The first primary usability problem encountered was related to the pop-up messages on the PDA screen alerting the user when to get off the bus. Not surprisingly, most users wanted to put away the device while seated in the bus. Hence, they missed the on-screen alerts that it was time to get off. Sometimes the users did not see the pop-up messages until after they had left the bus, in which cases the messages did not make sense any longer, but was just confusing. In response to this, we found that it is necessary to work out an alert mechanism that does not require visual attention but at the same time is discrete enough not to attract the attention of the other passengers. We also found that pop-up messages pushed to the user on the basis of context should be designed to automatically disappear again when obsolete.

The second primary usability problem was related to bus delays and consequently information in the system and objects in the surrounding world getting out of sync. In response to this, we found that it is essential for this type of mobile systems to have access to real time information about the status of the bus system and not just to timetable information. In addition to these problems, some users experienced minor problems with the perception of specific user interface elements.

In terms of the perception of indexical references in the interface, we found that people were highly capable of making sense of the sometimes very fragmented pieces of information on the mobile device when using it in situ. This confirms findings from other empirical studies of indexical interaction design for context-aware mobile systems reported in recent HCI literature [e.g. 8]. Specifically, we found that people easily made the connection between the information in the system and the objects and locations in their surroundings it was indexing to. When faced with incomplete or ambiguous information, people *wanted* to put the pieces together. They want to connect the dots, and they are very good at it.

These findings verify that people easily understand indexing interface information to the user's current location and nearby objects, and that people usually find this type of context-awareness useful. We are all familiar with spatial indexicality through our experience of language and signage in the world that relates specifically to its location. Hence, it was easily accepted that an electronic "sign" (the PDA) would make use of the same kinds of implicit references to its location and be an annotation of peoples' physical surroundings.

8. CONCLUSIONS

We have presented the design of an indexical mobile travel planner for supporting the use of public transportation. Informed primarily by acting-out sessions conducted with participants in situ, the proposed design integrates context-aware route planning information into the calendar application of a PDA, and makes strong use of indexical references between representations in the interface and users surroundings. A functional prototype of our design ideas was evaluated in the field with prospective users. Through this evaluation, we confirmed our previous findings that people are highly capable of making sense of fragmented, indexical pieces of information in a context-aware mobile information system used in situ.

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