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Context-adoptive Mobile Applications for User Guidance with Standard Phones

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Abstract

Meanwhile, standard mobile phones are able to run applications which can be installed additionally to those provided by the network operators. These applications can be used for various purposes - one possibility is to use mobile phones for guiding persons on unknown territory. Mobile phones are especially suitable for guiding persons as mobile phones are often carried around in an active state, their usage is well-known to the user and local and remote data can be used for guidance. This working paper shows two prototypes developed at the Institute of Information Systems.

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List of Abbreviations

API	Application Programming Interface
CLDC	Connected Limited Device Configuration
CSS	Cascading Stylesheets
GPS	Global Positioning System
ISO	International Standardization Organisation
J2ME	Java 2 Micro Edition
JSP	Java Server Pages
JSR	Java Specification Request
MIDP	Mobile Information Device Profile
PC	Personal Computer
PDA	Personal Digital Assistant
PNG	Portable Network Graphics
POI	Point of Interest
SMS	Short Message Service
SOAP	Simple Object Access Protocol
SSL	Secure Socket Layer
SVG	Scalable Vector Graphics
UMTS	Universal Mobile Telecommunications System
VM	Virtual Machine
XHTML	eXtensible Hypertext Markup Language
XML	eXtensible Markup Language

1 Introduction

Meanwhile, standard mobile phones are able to run applications which can be installed additionally to those provided by the network operators. These applications can be used for various purposes - one possibility is to use mobile phones for guiding persons on unknown territory. Mobile phones are especially suitable for guiding persons as mobile phones are often carried around in an active state, their usage is well-known to the user and local and remote data can be used for guidance. This working paper shows two prototypes developed at the Institute of Information Systems.

Tourist guidance

The first part presents a context-adaptive mobile tourist guide which runs on standard mobile phones. The guide considers the user's situation to present relevant and interesting information about the currently attended city. It is designed especially for the use in common local buses. This prototype is based on a self-developed application framework which reduces complexity for the development of context-adaptive mobile applications [cf. Caus, Christmann and Hagenhoff 2008]. User acceptance, technical aspects and suitable business models have been investigated by an empirical study in Göttingen to deduce implications for framework and further applications [cf. Caus, Christmann, Klein and Hagenhoff 2009].

Mass-transit guidance

The second part presents the Hermes prototype which is an approach to assist persons in using mass transit systems and therefore to strengthen the acceptance of this more eco-friendly type of transportation. This prototype has been investigated in laboratory tests to show the general practicability of this concept [cf. Christmann, Caus and Hagenhoff 2008].

This working paper presents the implementation and technical issues of the two prototypes. Details of concepts and empirical results can be found in the referenced conference proceedings and journals.

2 Tourist guidance

Against the background of the worldwide deterioriation of the economic situation still growth in the tourism sector can be observed [Risi 2008]; in particular there is a high demand for short city breaks in Germany [Veldhues 2007]. According to experts, interest in city breaks will remain high in the short- and medium-term future. For example 36% of Germans plan to make a short trip to a major city in the next three years [Krüger, Rumpf and Warnholt 2007]. Furthermore, guided tour offers are going to be extended to meet the desires of tourists (e.g. more adventure during the visit). These trends are drivers for technological developments in the tourism sector. As a consequence, many major cities offer mobile, location based information systems to tourists [Halbach 2005].

On this issue increasing scientific research is done, especially investigating approaches with mobile end devices. Practical implementations seen so far are based on a walking scenario and require special mobile devices or technically advanced standard devices (e.g. PDA with UMTS and GPS) [Kramer, Modsching, and Ten Hagen 2005]. However, commercially available mobile phones are powerful, widespread and have a high level of standardization and thus are appropriate for mobile city guidance [Risi 2008][BITKOM 2006]. Tourists are familiar with their own mobile phone. In contrast to handling specialized equipment they are not supposed to have significant technical difficulties with their own mobile device. For these reasons, a location-based, personalized city guide for mobile phones has been developed prototypically. It is primarily designed for use in a bus, but also usable on foot.

It has been attempted for a long time to guarantee user-friendly access to mobile services through context-adaptive information provision. A certain plurality of academic concepts concerning this dilemma currently exists; these, however, find only restricted use in practice. Most examples of context-aware applications represent isolated solutions which are based on a ‘closed-world-assumption’ [Chen and Kotz 2007].

This is the reason why the city guide has been developed based on our Hydra framework that supports the development of different context-adaptive mobile applications [Caus, Christmann and Hagenhoff 2008]. We investigated the user acceptance, feasable business models and technical aspects of our mobile application and the framework in a user study [Caus et al. 2009].

The paper is structured as follows: the second chapter introduces the functionality and content of the mobile city guide system. Afterwards, the application architecture and components will be illustrated in Chapter three. Chapter four presents the context-adoption of the mobile city guide in terms of integrated personalization and localization.

2.1 Functionality and content

The mobile city guide presents interesting points of interest (POI) on the displays of mobile phones with respect to the current location. The system automatically checks what POI are in range. The content is presented in form of structured texts and images (cf. Fig. 1). Additionally, audio information about the current POI is played back. For some POI links to further information are provided. The user has the opportunity to control the process of the guided tour using hot keys: The pause key stops the audio streaming and the automatic search for new POI.

Fig 1: Exemplary screen shots of the Java-client component

The play key resumes the paused audio streaming and the automatic POI-search. Furthermore, it is always possible to manually check for new POI nearby. Presented POI can be switched by using a skip key. The application then automatically scans for unseen and interesting POI in range. Finding out interesting POI for the user happens before starting the guided tour. Therefore the user has the opportunity to select categories which are interesting to him.

Six categories have been defined to customize the city tour: (1) important facilities, (2) culture, (3) restaurants, (4) pubs and bars, (5) discos and (6) shopping. 41 POI have been chosen in Göttingen, which can be visited by bus and walking. Besides the content (texts, pictures and audio) for POI there are links to get further information. The content for the city tour has been created for the local bus number 12 in cooperation with the local bus company of Göttingen.

2.2 Architecture

From the technical point of view the mobile city guide is a service of a special mobile application. This application named MyLocalServices is based on the application framework Hydra, which works as an application layer between wireless transfer technologies and mobile applications [Caus, Christmann and Hagenhoff 2008]. It encapsulates important functionalities of mobile applications like personalization and localization. Furthermore, the communication processes are completely encapsulated by the framework. Functions for using mobile networks usually have to be implemented seperatly for each new application [Caus, Christmann and Hagenhoff 2008]. Based on the framework mobile applications can be installed and used on mobile end devices, given access to networks and the possibility to manage and use information about the user's context (e.g. personalization and localization) via the encapsulated functions.

The mobile application MyLocalServices as well as the Hydra framework consist of a server and a client component, which communicate via the short range radio technology Bluetooth. Basically, MyLocalServices enables the use of XHTML based services that use localization and features provided by the context-adoption functions of the Hydra framework (cf. Fig 2). The mobile city guide is a service that presents XHTML based content depending on the location and the interests of the user. The content is being accessed following the pull concept, because users can influence the process of the city guidance using the control buttons. A mobile end device automatically sends queries for POI to the server component in a regular periodic manner. Thus the user may have the impression to get information pushed by the application. If the server component detects a POI nearby which fits to the user's interests, appropriate XHTML content including information about the corresponding POI is sent to the requesting mobile device via Bluetooth.

As described above, these queries can be controlled manually by the user. Depending on type and content, many other services can be implemented based on MyLocalServices e.g. museum-, university- or exhibition guides.

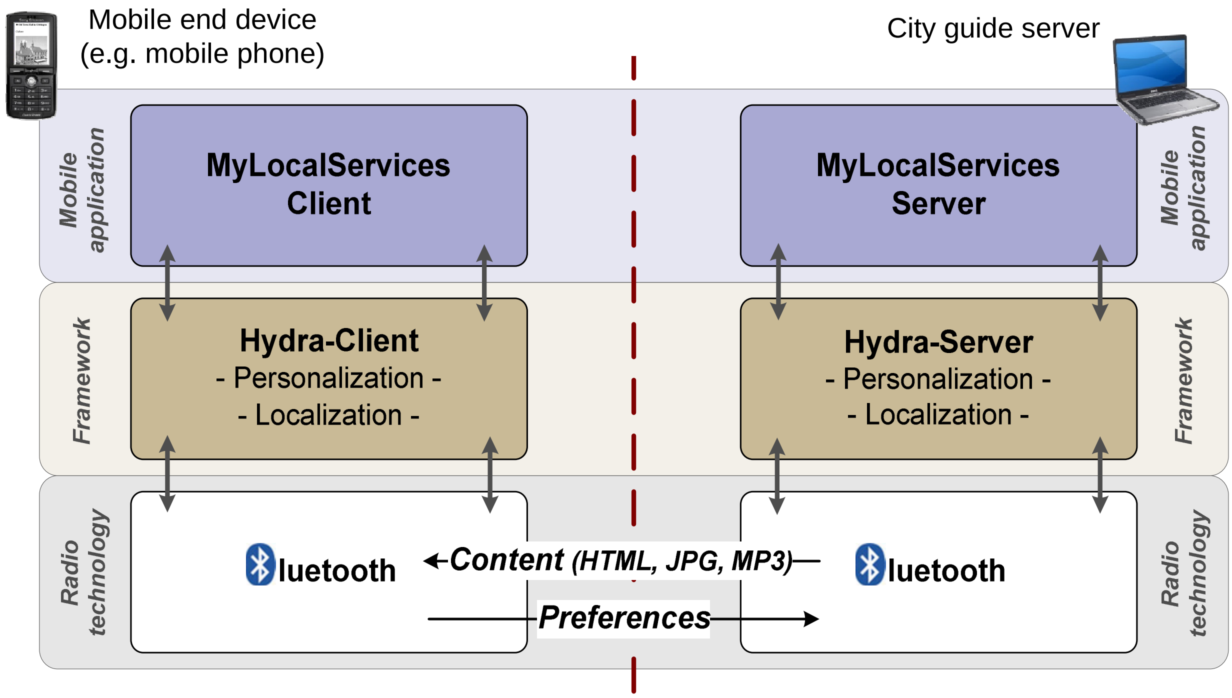

Fig 2: Architecture of the city guide prototype

2.3 Components

During the city tour, three components interact with each other: the user's mobile end devices, a city guide server and a GPS receiver (cf. Fig 3). The mobile end devices, in this case standard mobile phones, act as user clients of the mobile city guide.

On these devices the client component of MyLocalServices and the Hydra framework are installed. MyLocalServices can be used by the graphical interface of the framework and is responsible for the input of the user's individual attributes and preferences and the administration of that data in user profiles. Moreover, the wireless Bluetooth connection to the city guide server will be established and managed using the framework.

The application presents POI content in an integrated browser on the mobile phone and plays audio data simultaneously. Thus, the user can choose between a user controlled or an automatic city tour without active involvement. The city guide server is a computer, in this case a standard laptop, placed in a bus. Thereon the server component of the MyLocalServices application is installed. XHTML-contents of the city guide and according meta-data is stored in this component and being send as pull service via Bluetooth to the corresponding mobile phone.

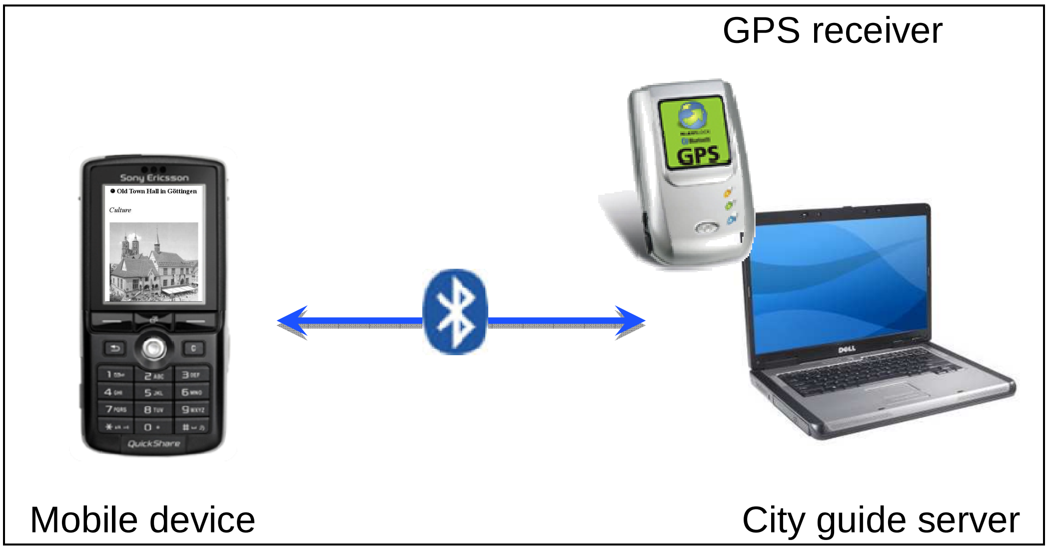

Fig 3: Components of the mobile city guide

All context-information provided by the personalization and localization functions of the framework are handled in this component. Additionally, a GPS-receiver is connected to the city guide server to enable localization. It receives geocoordinates in form of longitude and latitude from connected GPS-satellites at regular intervals. These coordinates are provided by the framework to the guided city tour for processing.

2.4 Context-adoption

As previously mentioned the city guide system adapts to the user's current situation and is therefore context-adaptive [Schilit, Adams and Want 1994][ThaeMin and JongKun 2007]. Two instruments are used in order to determine the context of the user: firstly a personalization mechanism to acquire and handle individual attributes and preferences and secondly a localization mechanism via GPS for detecting the current position [Caus et al. 2009].

Personalization

For the personalization of the mobile city guide data representing the user's context is gathered and implicitly evaluated during the usage of the city guidance. In this way only POI will be shown which are interesting for user. As context-adoption takes place on the content level an individualization rule system is used. The user model is retrieved and stored on the mobile phone in two parts. First a preference profile with preferred POI categories and secondly a user profile consisting of gender, age and preferred language is recorded. For the resource model all POI with title, category, images, texts, links and voice-recordings were collected. User model and resource model are combined and evaluated by the city guide server during a city tour.

Therefore the preference profile of the user is matched continuously with the meta-data of surrounding POI to only offer those, which are interesting to the user. Personalization is not only done implicitly by the city guide system but also explicitly by the user. By the use of the presented control functions the user is able to control the process of the application and can for instance skip presented POI. These control functions can therefore also be seen as personalization functions.

Localization

Localization provides further information about the user's context. In that way POI can be shown on the mobile device when the user is actually nearby. A satellite based positioning via GPS is used for the localization. GPS currently offers the best market penetration [Klein and Buchfelder 2007] and delivers meter-accurate position data. A GPS receiver is installed at the city guide server and not on every single mobile device. That means, not every user itself but the particular bus is located directly. Those geocoordinates are stored on the server and ensure efficient information about nearby POI. The city guide server processes the current coordinates of the bus at regular intervals by comparing them with the saved coordinates of the POI.

An ellipse around every POI determines if the user is nearby. This requires two saved coordinates in longitude/latitude form, for which a radius can be determined. The first coordinate describes the real position of the POI. In combination with the second coordinate and the radius, an ellipse is generated within the POI is shown. An algorithm, which handles the ellipse-data and the current position coordinate of the user detects if he is inside the ellipse. In this case, the POI is shown on the mobile device, if its categorization fits to the preferred categories of the user.

3 Mass-transit guidance

Mobility, understood as the opportunity to move around, is a vital principal for individuals and for society. Mobility plays an important role in our lives: We drive to work, to the supermarket, to the post office; we visit friends and go to the cinema. Multiple ways of satisfying mobility needs exist [Zemlin 2005]: individual or public transport, motorized or non-motorized transport or mixed forms. Even if transportation is important for society, the negative effects – especially of individual motorized transport – have to be considered. Traffic congestion and emissions of CO2, CO and NOX for example need to be lowered and therefore there is a general agreement in politics and society that mass transit should be strengthened and individual traffic should be reduced.

There are many reasons why persons use individual traffic rather than mass transit. One important effect is that mass transit usage is a complex process: Time schedules of vehicles need to be obtained and understood, connections must be combined, vehicles ordered or tickets purchased. These tasks are usually not a problem when a user is travelling on his daily route or if he has the opportunity to plan ahead, but unplanned movements usually pose problems as normally used planning tools may not be available in such situations.

A solution to this problem can be delivered by computer science: As a lot of travelers normally carry mobile end devices like PDAs, smart phones or mobile telephones with them, which are in fact small micro-computers and these can be used as personal guides. The named devices are especially suitable to support travelers because they can be used any time without booting. Most mobile telephones support the installation of additional software which can access local data and connect to remote data sources via a wireless network [Hess et al. 2005]. Additionally, more and more devices are equipped with localization technology. Such GPS capable devices give the possibility to support a user with information depending on his current location while using mass transit.

Existing mobile applications only cover parts of the necessary personal guidance [Christmann, Caus and Hagenhoff 2008]. The prototype presented in this paper shows how an application could support the user throughout the whole process of mass transit usage, in a context-adaptive and process-oriented manner. It is named after Hermes who, in Greek mythology, was not only the messenger of the Gods but also the protector of ways, traffic and ramblers [Burkert 1985]. In the future, maintainers of mass transit systems may provide such applications to their customers to increase system usage.

3.1 Requirements

A computer-based, personalized mass transit guidance system as described has various possible application situations. A mass transit usage can be seen as (1) a mobility need leading (2) a person to use (3) a mass transit system. All this three components can be sources for application situations: mobility needs can rise or change, persons can act erroneous or have insufficient knowledge and mass transit systems can have exceptions. To support a user in these situations, the application has to fulfill some functional and non-functional requirements.

Functional requirements

An application for mass transit guidance must be aimed at guiding a user from door to door. To raise the usefulness of the application it should be process-oriented: Mass transit usage must be seen as process with various activities to be carried out. The user should be supported in each process step, automatically in order of its occurrence. The system must process information, prepare activities and if applicable and desired accomplish them.

These process steps include the combination of means of transport, purchasing and paying tickets, ordering means of transport if necessary and guiding the user on foot to his target location or a stop. Additionally the system should provide information about the current location of the user and details about vehicles, e.g. forthcoming bus stops, remaining time until vehicle changes. It must be possible to change travel plans any time, whether caused by the user or by delays of mass transit vehicles. If an exception occurs, the user should by provided with information about possibilities to bridge waiting time and inform possibly waiting persons.

Non-functional requirements

As mobile end devices are used the limitations of those micro computers have to be taken into account. These are to be found especially in the input and output facilities and in the processing and storage of data. Different starting points to deal with these shortcomings exist. One possibility is to use context adaptation to make a great deal of user input unnecessary and therefore to make the application more easy to use. For this concept the user's social, technical and physical context [Samulowitz 2002] is acquired and used to adapt the applications appearance and recommendations. Most important are adaptations to preferences and characteristics of the user (personalization) and to his geographic location (localization). To do personalization a lot of information about a user (the user profile) is needed. This profile should be edited on a normal PC and then transferred to the device.

The strengths of mobile end devices should be used too as those devices often have functions that are useful for mass transit guidance. For example, the street address of a destination could be retrieved from the address book. It would also be possible to use the inbuilt calendar or text-messaging services (like SMS) as a means of communication. To find acceptance, the application must be easy to use. Therefore it has to be adequate for the task, capable of self-description, conducive to learning, steerable, conform to expectations, error-tolerant and individually adjustable (ISO 9241 Standard). A focus is to be laid on data security. Security on the level of device, transfer, transport and application have to be assured as the application deals with sensitive data due to the processing of the present geographical position, the geographical destination and personal characteristics and preferences of the user.

To reduce the costs of personalized mass transit guidance, usage of resources should be optimized. The most important cost factor in mobile applications is usually the network connection, and that is why data transfer should be minimized. Battery life time is another limitation, which must be taken into account. If battery life time is low, the application should reduce resource usage to extend operational readiness. A last non-functional requirement is that the application should be able to run on a maximum number of different devices in order to distribute it as widely as possible [Herden et al. 2004].

3.2 Architecture

Following the non-functional requirements it becomes clear that a mobile application for personal mass transit guidance cannot consist of just one software component. Giving the user the possibility to edit his profile data on a stationary PC requires a division of the functionality into at least two parts. This is also needed, as data should be adapted and compressed before transmission to the end devices to lower the use of wireless networks. Therefore a separation according to the client-server software architecture was chosen, as shown in Fig. 4.

On the client side, user as well as system administrator can use a simple web browser to initiate functions on the server. The browser only acts as a display software communicating with a web server. For mobile end devices there is an additional client software whose functionality goes beyond displaying information. The client can also do simple calculations (e.g. distances, remaining time) an save data on the end device permanently to ensure operation if the mobile network is currently unavailable.

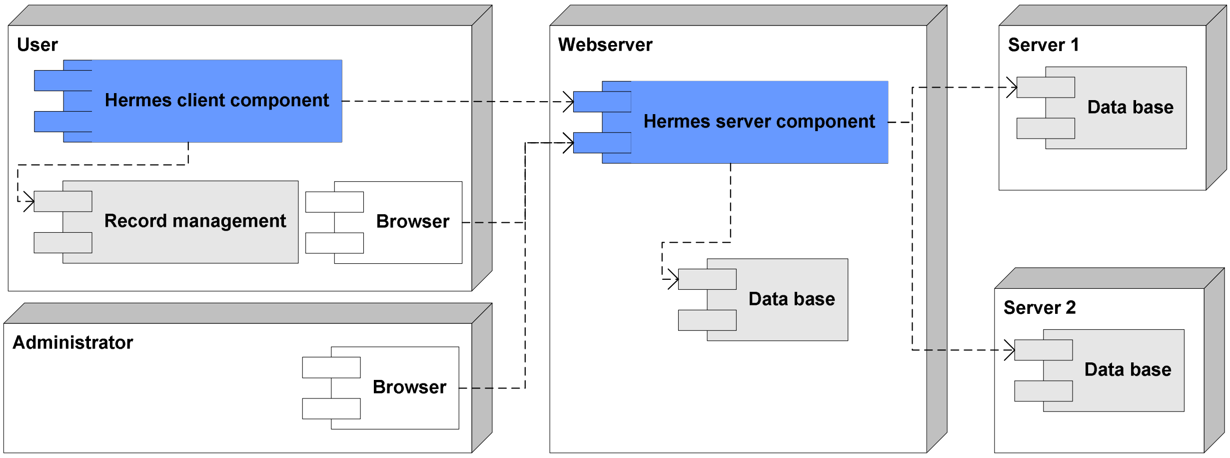

Fig 4: Architecture of Hermes prototype

The server software mainly works as a storage of profiles, and as a transcoding-proxy [Fox et al. 1996] for the adaptation of data to the user's context. When the client component requests data from the server it also transmits its context. The server component retrieves the requested data from its own data bases or from external server systems but before transferring them to the client, it adapts them to the client's context. External data available to the Hermes project are the data of the geographic information system Microsoft MapPoint® (OpenStreetMap and GeoNames could be used alternatively); the data of local transport companies also need to be integrated. Additionally to store and convert data the server acts as web server for the editing of profiles and the download of the client component to the mobile end device.

Due to the system architecture, a great amount of data needs to be exchanged between the client and the server component. For this interface web services based on XML- message formats like the widely used SOAP protocol [Weßendorf 2006] are most appropriate. As SOAP documents are transferred by HTTP, the transfer can be encoded using Secure Socket Layer (SSL) [Hansmann et al. 2003]. Graphics like maps can be added to these files as binary data, or additionally transferred using picture formats like Portable Network Graphics (PNG) or Scalable Vector Graphics (SVG). The latter format is especially suitable as it is XML-based and freely scalable on the device. A second interface is that between the server and additional data sources.

3.3 Implementation

Client and server components of Hermes have been developed in Java because of its platform-independency. The Hermes prototype is distributed as platform-independent bytecode which is interpreted on the mobile or stationary end device by a virtual machine (VM [Flanagan 2001]). On the mobile end device the Java-Edition J2ME ("Micro Edition") is used. It has been specially adapted to the memory size and capacity of mobile end devices [Mahmoud 2002]. The server component requires J2EE - the "Enterprise Edition" of Java and therefore its most complex version.

Server component

The server component runs on servers, personal computers and notebooks. To provide the web interface a web server software like JBoss® or the Apache Tomcat® Server is needed. These software products process Java Server Pages (JSP) and execute Java Servlets used to build the web interface. The server component generates an output in XHTML which can be displayed by web browsers like Mozilla Firefox® or Microsoft Internet Explorer®. The generated pages are formatted using Cascading Style Sheets (CSS) and JavaScript is used as scripting language on the client side. Furthermore a data base (like MySQL®, Oracle® or MSSQL®) is needed to store data on the server and provide it on request. The server component prototype includes a web page for user registration, profile editing and for the download of the application directly to the end device or indirectly to a computer. The design of the page can easily be changed by exchanging the CSS style sheet file, thus adapting it for example to the requirements of a mass transit company. Also there is a special design for the use on mobile end devices which uses less screen space.

Client component

On the client side normal mobile phones, PDAs and smart phones can be used as hardware. Running the application requires only a Java VM. J2ME, the Java edition on which the application is based, is further divided into configurations and profiles: CLDC version 1.1 and MIDP version 2.0 were used for the implementation of the prototype. Hermes is realized as a so-called MIDlet-Suite: a set of Java MIDlet programs which are combined to enable them to share resources and program codes.

Fig 5: Exemplary screen shots of the Java-client component

Exemplary screen shots of the Java-based client component can be seen in Fig. 5. All central functions (local traffic planning and implementation, local information, ticket purchase, payment, profile editing) were implemented prototypically. This enables a user to start a journey straight away or plan one for a later time. Destination addresses may be entered or retrieved from the address book; favorites may be administered. Distances to be covered on foot are displayed in graphical form and as text instructions.

The mass transit guidance can be interrupted at any time. The main menu of the application then changes and offers the alternative to continue or cancel the journey. Thus other functions of the application may be used before continuing the journey. If the journey is cancelled, several options are offered, e.g. calculating a new journey to the same destination. If means of transport were missed or delayed this is especially helpful. Similar to the server the client component can easily be adjusted to additional languages and other designs: all texts are stored in an initializing file and all designs in a style sheet file (CSS). Localization via GPS was integrated by using Location API (JSR 179). Orientation in the client application is made easy by using background pictures that are consistently the same for each function.

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