EFFICIENT INFORMATION ACCESS FROM CONSTRAINT WIRELESS TERMINALS
Exploiting Personalization and Location-Based Services

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Abstract: Today, the success of data services used from small mobile devices, like digital phones or PDAs, appears very limited. Different reasons can be identified, which prevent the average customer from broadly using wireless data services. At first, the user has to deal with very uncomfortable devices in terms of UI ergonomy, and on the other hand, the costs for wireless data communication are extremely high. These restrictions can be overcome by employing a system concept, which is built up on two main components: A personalized display software allows simplifying the information access on the wireless terminal, while an intermediate agent residing on the Internet takes care of mining the desired contents from the open Web. In addition to the improved UI handling, this concept offers a reduction of access costs and an increase in retrieval speed. Real-world experiments with an information system on actual train departures are reported for measuring and demonstrating the benefit of the described system concept.

1 INTRODUCTION

Up to now, a common use of data services accessed from mobile terminals could not establish very well. Due to their broad market distribution, digital mobile phones for cellular networks would yield a very interesting platform for data services, e.g. information retrieval on traffic situation on lanes and public transportation. Unfortunately, the user of these devices today faces a couple of constraints, which prevent a wide acceptance of such wirelessly accessed data services.

Considering first the handling of mobile devices, it has to be stated that software tools are usually very uncomfortable. Most tools do not sufficiently respect the constraints of small mobile devices (Johnson, 1998), because the user often has to enter information, e.g. lengthy Web paths, account information, or selection information. The costs for the wireless transfer of data contents represent another critical aspect. For instance in Germany, a comparison of the tariffs of land line networks (e.g. ADSL technology) and cellular phone networks shows that transferring data amounts wirelessly is roughly 10^4 times more expensive.

Furthermore, the wireless data rates are slower in the order of 10^2 – 10^3. WLAN (Riezenmann, 2002) seems to be an alternative wireless access technology, which can overcome these back draws. Unfortunately, it is not truly feasible for a seamless information retrieval, because it does not supply roaming and requires more complicate hardware. E.g., a laptop computer linked to a WLAN hot spot is good for reading e-mails in a restaurant or at an airport terminal, but it cannot conveniently be used for accessing current departure information on, e.g., trains or planes while walking or traveling to the station or airport.

A system concept, which was developed and reported during the recent years (Weghorn, 2003; Weghorn, 2004-1), is presumed to overcome these restrictions. The concept bases on two components (Fig. 1): One part is personalized display software for the wireless terminal, which minimizes the required inputs from the user and which optimizes the presentation of the results. And the other part is a data-mining agent running on a central server on the Internet, which appropriately collects, examines and prepares the desired information content for a transfer to the wireless display terminal, as soon as the user remotely commands this. Since this system collects customer specific contents on base of customized tools, the name C2C was defined for this mechanism.

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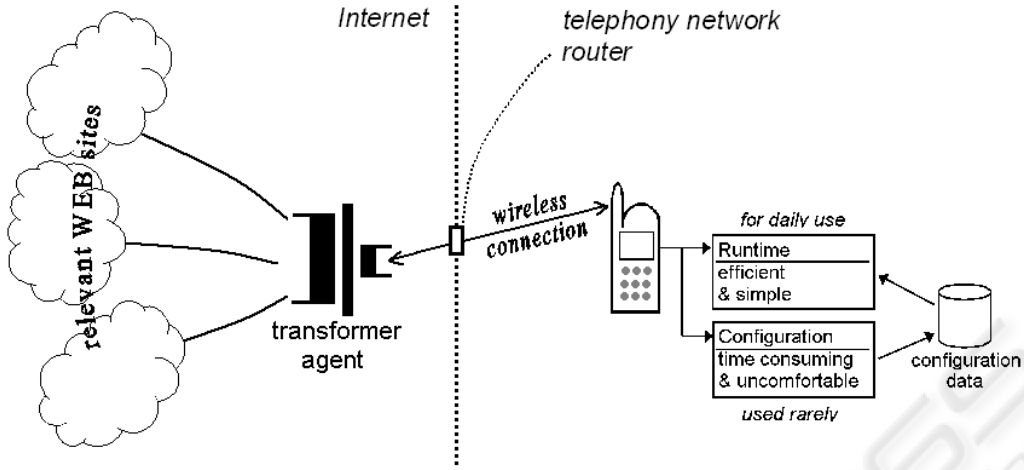

Figure 1: Construction concept of the customized information service

The user interacts with the C2C information retrieval system through the wireless terminal (Fig. 1). During this, the terminal executes specialized display software, which directs information queries to a central service agent residing on the Internet. The display software has to be constructed in the following manner:

- The required user input actions have to be minimized.
- The results have to be output in a reasonable presentation.
- Preferences of the user (e.g. passwords, account information) have to be remembered automatically, or should be editable by the user.
- The terminal software retrieves the desired information from the Internet agent by its activation with the appropriate settings and user preferences

The counterpart to the display tool is the mining agent. The agent has to be permanently available on the Internet, and it is in charge of sourcing the addressed contents – in many cases from the open Web. For instance, there exist many Web sites, which provide current information on traffic situation on highways and other main routes, and these could be used for a traffic information system. As other example, a mining agent could be employed to collect e-mail messages (or concise parts of it) for a remote display.

This kind of middleware should be a more generalized approach than wrapper or mediator services, which were reported earlier (Mahmoud, 2002; Wang et al., 2003), because in the new concept here the mining agent sources information from different sites in parallel, and retrieves by that a measure of the quality of information (Weghorn, 2004-2). Depending on the situation, the agent can already decide which information finally should be the correct one. In the end, the user will receive on the terminal the desired output together with a reliability score.

Clearly, for many cases, the user could do the same actions through WAP browsing manually, but of course, the automation of these procedure speeds up the information access, reduces the access costs, offers the user a very compact and efficient handling, and allows finally an appropriate display of the querying results. The fully programmed solution (instead of the manual use of standard tools like WAP browsers) allows also to apply compacted coding schemes on the expensive and slow wireless data link between the mobile terminal and the mining agent, which should additionally increase access speed and the effect of cost saving. In the reports about the different development stages of the C2C concept (Weghorn, 2004-1) the investigations mainly were derived from computer simulations of the wireless access. A considerable advance of this research presented in the following sections here is an extended real-world application for a specific information access system on public transportation.

2 KEY TECHNOLOGIES FOR EFFICIENCY IMPROVMENTS

2.1 Personalization

Personalization can be used as key for simplifying the user handling of wireless terminals. For instance, if the user wants to access e-mail from a handheld device, all account information (server settings, user name and password, filter definitions for mail retrieval) need to be entered only once into the terminal software, and these settings can be used

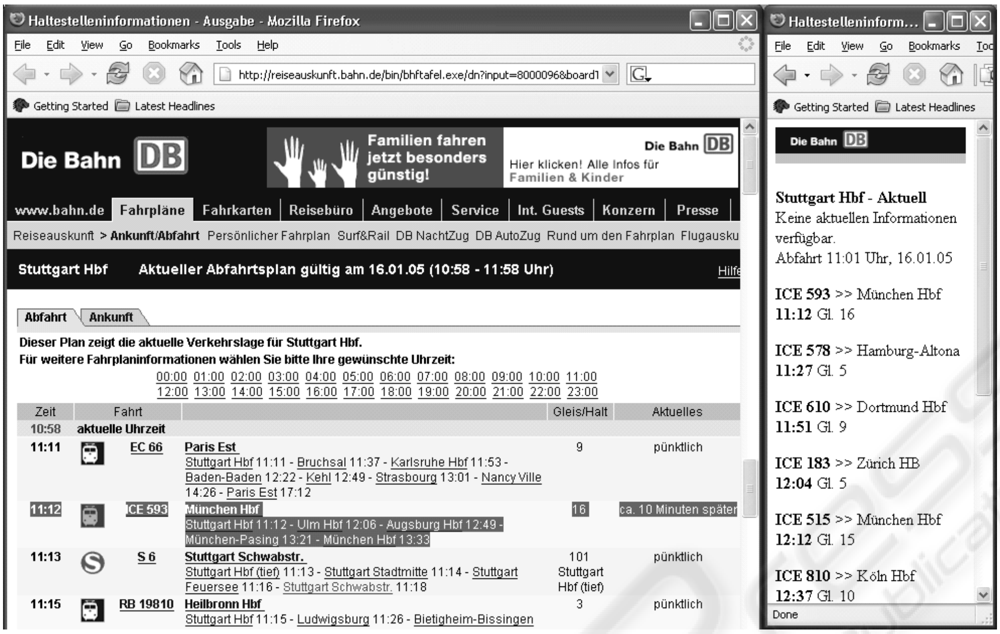

Figure 2: The railway company, which is used for the investigations, provides a Web site, from which departure tables for all main stations can be downloaded (left browser frame). In parallel to that, also information pages for WAP download are available, but the herein contained information is reduced for size reasons (right frame). Both content pages were retrieved at the same time, and as seen in this sample, the WAP service also is not accurate, because it does not report the information about the delayed train to Munich ("München")

automatically from this point. After initial configuration, the user can launch the e-mail inspection efficiently by pressing only a few buttons or – depending on the capabilities of the terminal – even by one single press of a so-called hot key. This concept renders possible, because handheld devices usually are treated as personal belongings. This means that a mobile phone rarely is lent to a colleague or another person, and hence, the information on these mobile devices can be considered as protected contents.

People, who are daily commuting between their living home and their working place (office, school place, University, or similar) are also prospective candidates for using this kind of personalized information systems, because most societies today face continuous traffic problems in terms of delays of public transportation or traffic jams. For a person, who is using public transportation like trains, the information query parameters, which have to be defined once, would be the departure, changing and destination stations, and probably the kind of train that is used. Another person, who usually goes by car to the office, will drive on a certain routing of roads and highways, and exactly this routing list of streets will represent the configuration set for an information query on traffic jams or other traffic messages.

2.2 Automated Personalization with Location-based Services

One very recent research topic is the application of location-based services (Schiller, and Voisard 2004). This could be used in the here described information systems as well, since for the commuting sample, the travel direction changes each day. Hence, the direction represents also a parameter for the information collection. Introducing the geographical location into the information retrieval process, allows the system automatically detecting the travelling direction: When a commuting person is inside or close by the office, the information system knows implicitly, which station the next departure place of the daily used train link will be.

Unfortunately, accessing this geographical information in general will require additional high efforts, for instance a GPS receiver inside the handheld terminal. Theoretically, each cellular phone terminal knows the communication cell, where it is registered, and this cell, which is identified by some kind of index value, could be resolved into a geographical location. How such a translation process can be implemented is discussed, e.g., in (Roth, 2003). The inconvenience today in the software structure of wireless devices is that this cell broadcast content (its regularly broadcasted

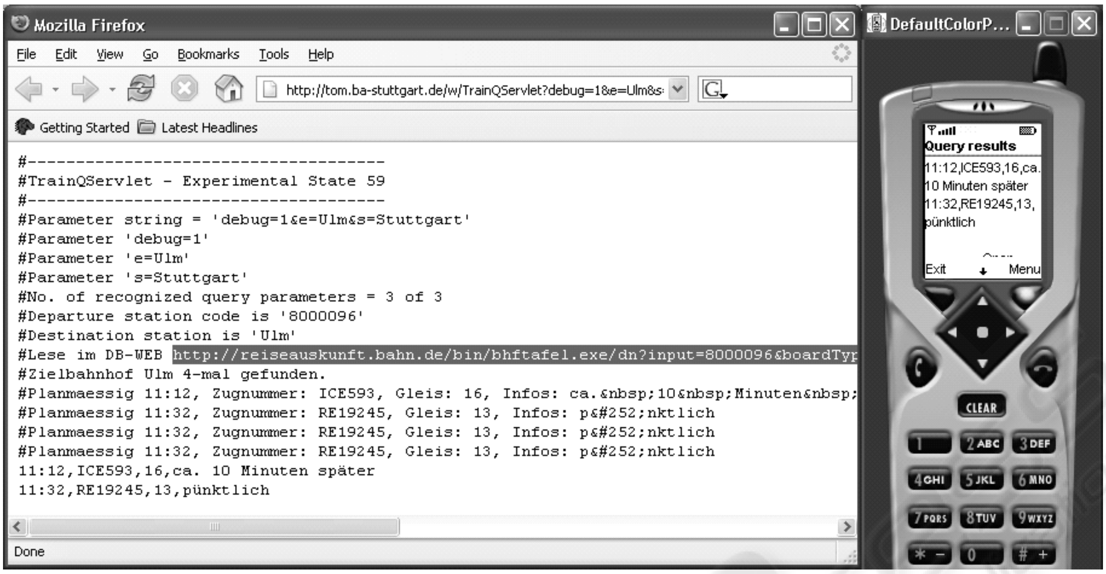

Figure 3: The personalized service filters all connections of interest out of the generalized Web departure table, which is seen in Fig. 2. The debug mode of the mining agent (left browser frame) shows the intermediate steps of this analysis, and the result will be displayed by the terminal software part (right frame) of the described information system

information, which does not require any retrieval costs) is not always accessible from add-on wireless application software. The chance is that all cell broadcast information will be available in future through standardized APIs, and then the location-based concepts can directly help to improve the described information systems without introducing new restrictions or requirements.

More recent communication technologies also would allow location-based control of information retrieval. Again for the commuting sample, Bluetooth communication can be applied for automatically determining the position of user: In particular, when the user is inside the office, the fact that the wearable device is registered in a local Bluetooth communication cluster can be used as location measure. For this, no application communication with the wireless device is required, but only the presence of the hand held terminal in the Bluetooth cell has to be detected, which can be done automatically and periodically from a host computer inside the office. If the user enters during the day once the office, this method provides already a feasible indicator for switching the travelling direction in the information system. As other example, an e-mail forwarding concept was reported already at a time (Weghorn, 2001), when programming of handheld devices was not available for cellular phones openly to the market. Today due to the before described technologies and applicable development systems like wireless JAVA programming (Piroumian, 2002), also this forwarding of important e-mail contents can be automatically controlled by the before described location detection mechanisms.

3 SAMPLE SYSTEM FOR TRAIN DEPARTURE QUERYS

3.1 Information retrieval mechanism

After some prior concept design and simulation of an information system on train actual departures, an information access system was developed, which is truly executable on JAVA-enabled wireless devices (Piroumian, 2002). The intermediate agent is implemented as JAVA servlet (Hall, and Parr 2001), and it handles a query about a certain train connection route. This tool uses a public Internet page, which is operated by the railway company (Fig. 2), and translates the Web coded contents into a format (Fig. 3) that is feasible for transfer and display on a wireless terminal (Fig. 3). Depending on the query parameters, the original information source will have sizes of 300 kilobytes and more, which obviously shows that a direct access to this information by mobile browsing does not make any sense. Truly, the same railway company operates a WML page server for WAP access to the information (Fig. 2), but the contents presented there are only a fraction of the Web version; in particular, if the reader doesn't know the train code, the system

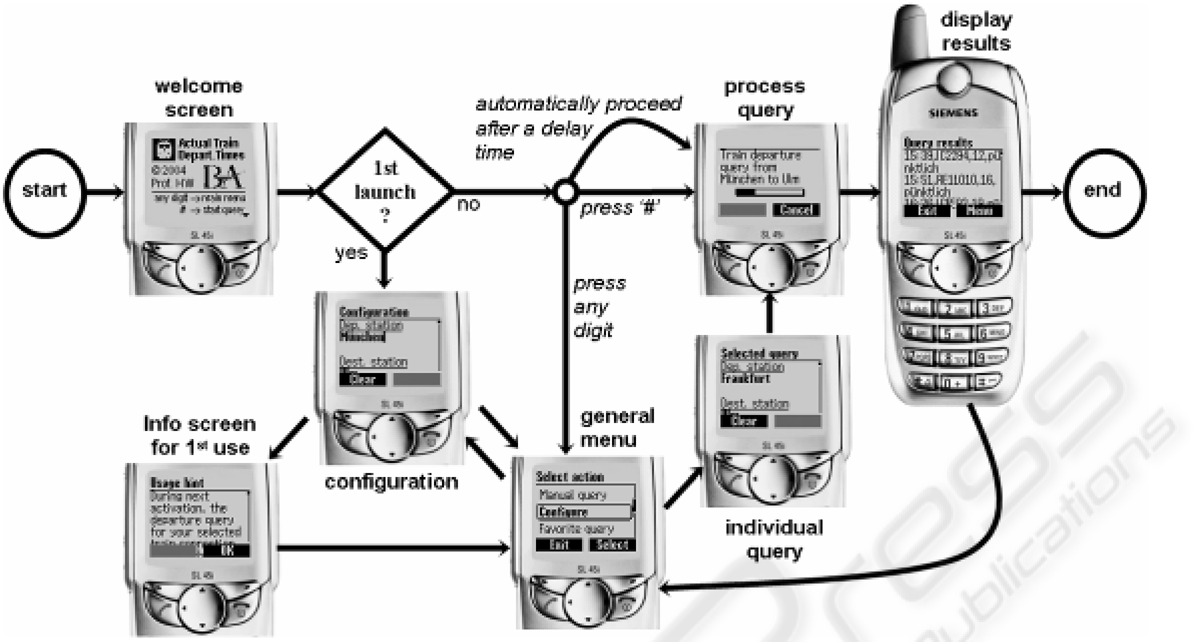

Figure 4: UI chart of the information channel on actual train departure times for a certain (personalized) travelling route. The direction of travelling is determined by a configurable switching time. If the user doesn't interfere, the query process proceeds automatically through the direct path between the markers for "start" and "end". This sample shows that this kind of application is feasible for a use on simple-styled phones, which are equipped with small B+W screens only

is more or less worthless, because intermediate train destinations are not displayed. For a personalized application, the WAP solution provides the wrong subset of information, at least for the indicative sample of daily commuting. Another problem is that it is obviously working incorrectly (Fig. 2), but this is not a fundamental problem.

3.2 UI design for the terminal client

The minimization of required inputs is one aim for the proposed information system. Therefore, the normal operation mode in the train departure query application is that after launching the terminal software, the information retrieval will start automatically. For overcoming the necessity of an additional configuration tool, the train query application starts with a welcome screen, which dismisses after a defined short time delay (Fig. 4). If the user doesn't want to run the default query, the welcome screen can be interrupted by a keyboard press. In this case a selection menu will appear next, and the user can modify the configuration for the favourite query, or place a manual query. The latter feature of performing individual queries shall make the information system more flexible, and it can casually be of interest, e.g., for use during business travels. The first launch of the application after its installation on the terminal requires one special additional UI mode: During this, the customer is informed about the regular behaviour of the information tool, and is then directly switched to the configuration menu.

The system was tested on six different physical devices: First, a Palm IIIc PDA computer, and a Siemens SL45i with B+W display screen belong to the first generation of JAVA-enabled handheld devices, which appeared on the market; next, the devices Erricson T630, Erricson P900, Nokia 6600, and Siemens SX-1 represent the recent generation on the market, while the latter three smart phones are based on the open operating system Symbian (www.symbian.com). The implementation and the tests showed that the different phone vendors do have individual interpretations about the operation of the standardized JAVA API. Therefore, several adoptions were required to produce terminal software, which is sufficiently working on all the test devices, although the first implementation was working cleanly in Sun's simulation environment.

To give samples of this disturbing behaviour, four of the devices do not display the defined program icons, which would make the handling more convenient for the non-technical user. Another of the devices couldn't display graphical images, which were produced with standard UNIX imaging tools. The alternatively used desktop software produced images files, which were displayed correctly on all devices, but the coding length of these images was bigger, which leads to a waste of memory on the terminal.

For automatically determining the travelling direction, an additional time parameter is defined and used in the system. The user can set a time, e.g. noon, from which the system assumes that the user will travel home, which means that the departure and the destination stations are exchanged for the departure table query. This sample shows how the requirement for knowing the geographical location can be overcome. Although this doesn't represent always an accurate measure, it will in most cases be a feasible strategy for replacing the detection of the geographical location.

With the P900 smart phone it can be demonstrated how convenient the use of the proposed information tool can be, because on this device JAVA applications can be placed for a quick start on top menu level. The actions for running the tool are opening first the keyboard cover, and next pressing with the touch pen the appropriate icon. Following this, the query launches automatically, and the user can read after a few seconds delay the result about the train connections of interest.

3.3 Performance measurements in phone networks

The train information system was used with different network operators and networking modes for investigating the efficiency of the tool. In general, in Europe data services can be used through the wireless telephony network (GSM) as traditional modem connection and with GPRS with enhanced data communication. Understanding the tariffs of the different network operators is not straight forward, and hence the produced costs for the information retrieval were also measured (Table 1).

In the standard GSM data link, the customer has to pay for the time duration of the connection, while with GPRS the customer has to pay theoretically for the transferred data amount. The latter paying method was too low for the network operators, and they invented additional charges for GPRS, some are billing an extra monthly charge of five Euros for using GPRS, others bill for each day of use an additional service charge (e.g. 19 Eurocents). This all complicates the calculation, what the retrieval of a dedicate information will cost, but exactly this confusion may be of strategic business interest for the network operators. As consequence, it is in general not possible to specify the precise billing amount for a single information access, e.g., one retrieval on train departures.

In summary, it can be derived that running one information query can in average cost down to 10 Eurocent with GPRS, while with the old modem connection at least twice this amount is charged. The required time for retrieving the information is an important factor for the user handling. With the GSM standard data link, the entire access will take approximately one minute. With GPRS the overall time depends on the fact, whether the mobile terminal has already registered the GPRS link. In this mode, most time is consumed for setting up the data link (~ 15 sec), while the information transfer from the application takes only a few seconds.

4 CONSIDERATION OF EXPERIMENTAL RESULTS

4.1 Discussion of benefits for the customer

For qualifying the benefit of the proposed information access concept, its handling has to be compared to alternative methods. Traditionally, one could use a desktop computer with an Internet connection or a phone voice service. Due to the structure of current operating systems, the use of a desktop computer will consume much more time, because it has to be booted, the user has then to log on to the operating system, and afterwards to launch the Internet connection. After this, the information retrieval can be invoked, and finally the whole computer system has to be shut down. This will take several minutes, and of course, the data terminal is not wearable. With a laptop computer this process can be accelerated, but in the end it will also take considerably longer for accessing the information. In addition to that, the laptop computer solution is not conveniently applicable in many situations, e.g. walking, going by public bus, or driving in a car.

With voice telephony services, it is like there is no possibility of personalization. Hence, if the user wants to obtain information about current train departure, always a voice-controlled navigation through an access tree will be required, which consumes time and produces network costs. The situation is comparable to Web browsing without bookmark links. Summarizing, it can be stated that the personalized access is much more efficient than traditional alternatives, because it can be performed in almost any situation and it will take one minute or with the proper configuration only a fraction of a minute. Each information access typically will cost around 10 Eurocent, which may be more expensive than with other systems.

Table 1: Representative measurements of information access time and costs for different networking modes

Experiment no.	Network Operator	Mode	Open URL	Time for content transfer	Costs	Remarks
1	T-Mobile	GPRS	9,2 sec	31 ms	19 ct	
2	T-Mobile	GPRS	3,5 sec	<1 ms	19 ct	
3.1	T-Mobile	GPRS	16,28 sec	<1 ms	28 ct	one GPRS session
3.2	T-Mobile	GPRS	3,00 sec	<1 ms		
3.3	T-Mobile	GPRS	3,39 sec	15 ms		
3.4	T-Mobile	GPRS	3,44 sec	31 ms		
4	Vodaphone	GSM std	22,25 sec	7564 ms	19 ct	
5	Vodaphone	GSM std	17,56 sec	5377 ms	19 ct	
6	Vodaphone	GSM std	20,96 sec	5146 ms	35 ct	
7.1	T-Mobile	GPRS	9,70 sec	31 ms	28 ct	one GPRS session
7.2	T-Mobile	GPRS	3,11 sec	<1 ms		
8.1	Vodaphone	GSM std	20,87 sec	6770 ms	35 ct	performed at the same time
8.2	T-Mobile	GPRS	3,47 sec	<1 ms	n/a	
8.3	T-Mobile	GPRS	3,50 sec	140 ms	n/a	

4.2 Run-time behaviour of J2ME devices

Besides the above-discussed difficulties with the operation of J2ME standard UI elements, there arise also problems with networking on the J2ME-enabled devices manufactured by different companies. This applies especially when using the standard GSM data link instead of the enhanced GPRS mode. On some devices, a network data link can be established from the J2ME application, but it cannot be terminated under application control. It is closed down only after exiting the JAVA sub menu in the phone UI. The consequence is that the user is charged in background additional costs, e.g., when the results of an information query are displayed, although no data needs to be transferred any more. Methods for closing down the physical layer connection, which are available in the standard JAVA system, are missing in J2ME. Interestingly, this kind of operation is present in Sun's sample implementation for Palm OS handheld computers, and it seems to be inherited by other devices. Even worth appears the fact that some newer devices are incapable at all of establishing a HTTP connection with the standard data link. These devices are working well with GPRS, but it depends on the phone contract, whether GPRS mode is available. For cost control reasons, and for reliability reasons the recommendation for a non-technical customer can only be using J2ME data networking only with GPRS.

In general, the data networking configuration is non-trivial, and therefore most devices are delivered today with all possible configurations for the different network operators. Unfortunately, it can be observed that on some devices these settings interfere with each other, and in the end there were several cases detected, for which the data networking was non-functional. After removing the unusable configurations, these devices started working correctly, but form this experience it can be derived that also in GPRS mode non-expert customers might be incapable of using the information access software due to general constraints of the device handling

4.3 SW engineering and XML coding of contents

The original approach of the concept was that low level coding (= binary exchange of information contents) should improve the overall performance of the wireless information system. From the experiments (Table 1), it can be deducted that this is not fully true, because in particular the transfer of the content in the data communication consumes only a small fraction of the overall access time. Hence, coding the data packet according to established software engineering philosophies (in particular in XML: Bradley, 1998) would be acceptable with GPRS for the transfer time and costs as long as the content packet size remains in the order of one kilobyte. Despite these measurement results, there arises still some impact of inefficiency on the terminal side, since XML coded contents will require a more complicate parsing in the wireless software part. Of course, this can be obtained by using standard library packages (Setiawan, 2001), but this will increase considerably the code size of the handheld application.

On the other hand, thinking forward of PUSH technologies (Ortiz, 2003), XML coding of contents still is not recommended, because an SMS, which can be used for this technology, will not be capable of carrying that content size.

5 CONCLUSION

A new information access system for truly mobile access was conceptually designed and developed during the recent years. In our former investigations on this, the concept, which shall customers provide an efficient and convenient access, was tested and developed mainly on base of simulations. The advance of the work presented here is the application of the information retrieval system in true networks under real conditions. On base of these experiments, it can be derived that the claimed properties, like increased access speed and improved handling, can be achieved with the proposed kind of information access structure.

Future work will stepwise regard quality of information by means of AI, and it shall further aim to reduce the information access costs, e.g. by applying AI controlled proactive PUSH mechanisms. Although the wireless JAVA platform defines a standard API, the experience with true devices is that it is not a straightforward task to develop applications, which are running truly sufficiently on all devices. Extra effort is required for achieving this, and therefore alternative technologies, e.g. C++-based software on Symbian devices, shall be investigated in future for obtaining best overall performance.

Also the application fields shall be expanded. Besides information on public transportation and car traffic, we are working in actual projects on weather channels for a customized retrieval of local recent information and forecasts. Furthermore, we are currently investigating how Web service technology (Aleksy and Gitzel, 2004) can contribute to an improvement of the described information access systems.

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