PREBUFFERING AS A WAY TO EXCEED THE DATA TRANSFER SPEED LIMITS IN MOBILE CONTROL SYSTEMS

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Keywords: Wi-Fi, 802.11b, PDA, Localization, Framework, Predictive, Buffering.

Abstract: The proliferation of mobile computing devices and local-area wireless networks has fostered a growing interest in location-aware systems and services. Additionally, the ability to let a mobile device determine its location in an indoor environment supports the creation of a new range of mobile control system applications. Main area of interest is in model of radio-frequency based system enhancement for locating and tracking users of our control system inside buildings. The developed framework described here joins the concepts of location and user tracking as an extension for new control system. The experimental framework prototype uses a Wi-Fi network infrastructure to let a mobile device determine its indoor position. User location is used to data pre-buffering and pushing information from server to user's PDA. All the server data are saved as artefacts with their position info in building. These technique allow to exceed the data transfer speed limits in mobile control systems.

1 INTRODUCTION

The usage of various wireless technologies has increased dramatically and will continue for the coming years. This will lead to the rise of new application domains each with their own specific features and needs. Also, these new domains will undoubtedly apply and reuse existing (software) paradigms, components and applications in information and control systems. Today, this is easily recognized in the miniaturized applications on network-connected PDAs that provide more or less the same functionality as their desktop application equivalents. It is very likely that these new mobile application domains adapt new paradigms that specifically target the mobile environment. We believe that an important paradigm is context-awareness. Context is relevant to the mobile user, because in a mobile environment the context is often very dynamic and the user interacts differently with the applications on his mobile device when the context is changed. While a desktop machine usually is in a fixed context, a mobile device goes from work room, cross the building in company area, to work in-a-meeting, etc. Context is not limited to the physical world around the user, but also incorporates the user's behaviour, and terminal and network characteristics. Context-awareness concepts can be found as basic principles in long-term strategic research for mobile and wireless systems such as formulated in (WWRF, 2007). The majority of context-aware computing to date has been restricted to location-aware computing for mobile applications (location-based services). Our focus here is on position determination in an indoor environment. Location information is used to determine an actual user position and his future position. We have performed a number of experiments with the control system, focusing on position determination, and are encouraged by the results.

2 BASIC CONCEPTS

The proliferation of mobile computing devices and local-area wireless networks has fostered a growing interest in location-aware systems and services. A key distinguishing feature of such systems is that the application information and/or interface presented to the user is, in general, a function of his physical location. The granularity of location information needed could vary from one application to another. For example, locating a book in a library would require fine-grained information whereas locating a nearby room in company buildings area requires fairly coarse-grained location information. While much research has been focused on development of

Krejcar O. (2008).
PREBUFFERING AS A WAY TO EXCEED THE DATA TRANSFER SPEED LIMITS IN MOBILE CONTROL SYSTEMS.
In *Proceedings of the Fifth International Conference on Informatics in Control, Automation and Robotics - RA*, pages 111-114
DOI: 10.5220/0001494401110114

services architectures for location-aware systems, less attention has been paid to the fundamental and challenging problem of locating and tracking mobile users, especially in in-building environments. In RF area we focus mainly on RF wireless networks in our research. Our goal is to complement the data networking capabilities of RF wireless LANs with accurate user location and tracking capabilities for user needed data pre-buffering. This property we use as information ground for extension of mobile control system to exceed the data transfer speed limits.

2.1 Data Collection

A key step in the proposed research methodology is the data collection phase. We record information about the radio signal as a function of a user's location. The signal information is used to construct and validate models for signal propagation. Among other information, the WaveLAN NIC makes available the signal strength (SS), which is reported in units of dBm. A signal strength of Watts is equivalent to 10*log10(s/0.001) dBm. For example, signal strength of 1 Watt is equivalent to 30 dBm. The WaveLAN driver extracts the SS information from the WaveLAN firmware each time a broadcast packet is received. Then the information is make available to user-level applications via system calls. It uses the wlconfig utility, which provides a wrapper around the calls, to extract the signal information.

2.2 Localization Methodology

The general principle is that if a Wi-Fi-enabled mobile device is close to such a stationary device – Access Point (AP), it can "ask" the location provider's position by setting up a Wi-Fi connection. If the mobile device knows the position of the stationary device, it also knows that its own position is within a range of this location provider (100 meters app.). Granularity of location can be improved by triangulation of two or several visible Wi-Fi APs. The PDA client will support the application in automatically retrieving location information from nearby location providers, and in interacting with the server. Naturally, this principle can be applied to other wireless technologies. The application (locator) is now implemented in C# using the MS Visual Studio .NET 2005 with .NET compact framework and a special OpenNETCF library enhancement (OpenNETCF, 2007). Schema on figure 1 describes a runtime localization process. The stars points are exactly measured and computed points of suppose user position. The real track on figure presents real movement of user during the time. The exact track mean computed track from measured Wi-Fi intensity level.

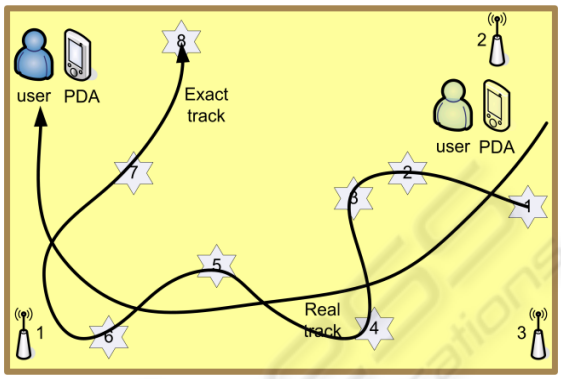

Figure 1: Localization principle - triangulation.

2.3 Predictive Data Push Technology

This part of project is based on a model of location-aware enhancement, which we used in debug control system. These info-data are used in developed framework to increase real dataflow from wireless access point (server side) to PDA (client side). Primary dataflow is enlarged by data pre-buffering. These techniques form the basis for predictive data push technology (PDPT). PDPT push data from information server to clients PDA to be on hand when user comes at desired location. The benefit of PDPT consists in reduction of time needed to display desired information requested by a user command on PDA. Time delay may vary from a few seconds to number of minutes. It depends on two aspects. First one is the quality of wireless Wi-Fi connection used by client PDA. A theoretic speed of Wi-Fi connection is max 687 kB/s. However, the test of transfer rate from server to client's PDA, which we have carried out within our Wi-Fi infrastructure provided the result speed from 43 to 160 KB/s on three various type of PDA (HTC Roadster, Blueangel and Universal). The second aspect is the size of copied data. We advice to use partitioned blocks from original data files or blocks.

2.4 Data Artefact Management

The PDPT Server SQL database manages the information (for example data about Ethernet hardware such as Ethernet switch, UTP socket, CAT5 cable lead, etc.) in the context of their location in building environment. This context

information is same as location information about user track. The PDPT core controls the data which are copied from server to PDA client by context information (position info). Each database artefact must be saved in database along the position info belongs to. The data artefact manager is used to manage these information.

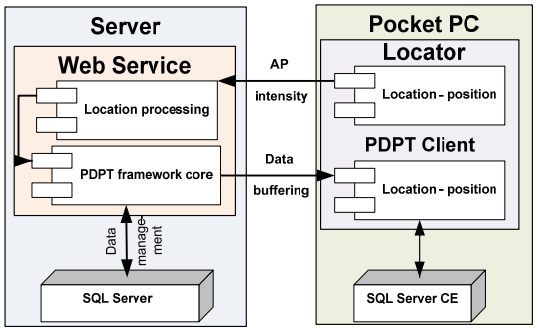

Figure 2: System architecture – UML design.

2.5 Framework Design

PDPT framework design is based on most commonly used server-client architecture. To process data the server has online connection to the control system. Data from technology are continually saved to SQL Server database (Tiffany, 2003) and (Reynolds, 2003). The part of this database (desired by user location or his demand) is replicated online to client's PDA where it is visualized on the screen. User PDA has location sensor component which continuously sends to the framework kernel the information about nearby AP's intensity. The kernel processes this information and makes a decision if and how a part of SQL Server database will be replicated to client's SQL Server CE database. The kernel decisions constitute the most important part of whole framework because the kernel must continually compute the position of the user and track and make a prediction of his future movement. After doing this prediction the appropriate data (part of SQL Server database) are pre-buffered to client's database for future possible requirements. The PDPT framework server is created as Microsoft web services to handle as bridge between SQL Server and PDPT PDA Clients.

2.6 PDPT Client

For testing and tuning of PDPT Core the PDPT Client application was created. This client realizes classical system and extension by PDPT and Locator module. Figure 3 show classical view of data presentation form SQL CE database to user (in this case the image of Ethernet network in company area.

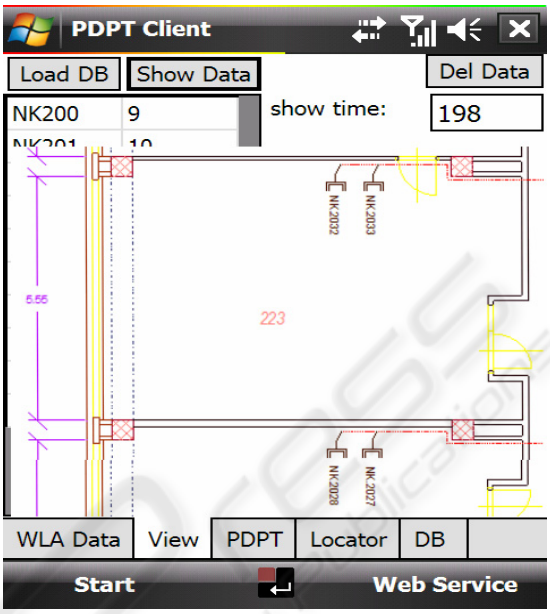

Figure 3: PDPT Client – Windows Mobile application.

3 EXPERIMENTS

We have executed a number of indoor experiments with the PDPT framework, using the PDPT PDA application. Wi-Fi access points are placed at different locations in buildings, where the access point cells partly overlap. We have used triangulation principle of AP intensity to get better granularity. It has been found that the location determination mechanism selects the access point that is closest to the mobile user as the best location provider. This technique partially uses a special Radius server (Radius, 2007) to realize "roaming" known in cell networks. Currently, the usability of the PDPT PDA application is somewhat limited due to the fact that the device has to be continuously powered. If not, the Wi-Fi interface and the application cannot execute the location determination algorithm, and the PDPT server does not receive location updates from the PDA client.

3.1 Data Transfer Tests using PDPT

The result of utilization of PDPT framework is mainly at data transfer speed reducing. The second test is focused on real usage of developed PDPT Framework and his main issue at increased data transfer. At table 1 are summary of eighteen tests

with three type of PDA and three type of data transfer mode. Each of these eighteen tests is fivefold reiterated for better accuracy. The data in table are average values from each iterations.

Table 1: Data transfer tests results.

no	Type	Mode	Data	Time	Speed
1	HTC Blue-angel	Sql CE	257	0.4	643
2		Sql CE	891	0.4	2228
3		Sql	257	5	51
4		Sql	891	13	69
5		PDPT	257	1.1	234
6		PDPT	891	3.2	278
7	HP iPAQ h4150	Sql CE	257	0.5	514
8		Sql CE	891	0.5	1782
9		Sql	257	5	51
10		Sql	891	14	64
11		PDPT	257	1.2	214
12		PDPT	891	3.7	241

The data mode column has three data transfer mode. The SQL CE mode represents the data saved at mobile device memory (SQL Server CE) and the data transfer time is very high. The second mode SQL means data which are stored at server (SQL Server 2005). Primary the data are loaded over Ethernet / Internet to SQL Server CE of mobile device and secondary the data are shown to user. The data transfers time consumption of this method is generally very high and the waiting time for user is very large. The third data mode PDPT is combination of previous two methods. The PDPT mode has very good results in form of data transfer acceleration. Realization of this test consists at user movement from location A to B at different way direction. Location B was a destination with requested data which are not contained at SQL CE buffer in mobile device before test.

4 CONCLUSIONS

The main objective of this paper is in the enhancement of control system for locating and tracking of users inside a building. It is possible to locate and track the users with high degree of accuracy. In this paper, we have presented the control system framework that uses and handles location information and control system functionality. The indoor location of a mobile user is obtained through an infrastructure of Wi-Fi access points. This mechanism measures the quality of the link of nearby location provider access points to determine actual user position. User location is used in the core of server application of PDPT framework to data pre-buffering and pushing information from server to user PDA. Data pre-buffering is most important technique to reduce time from user request to system response. The experiments show that the location determination mechanism provides a good indication of the actual location of the user in most cases. The median resolution of the system is approximately five meters. Some inaccuracy does not influence the way of how the localization is derived from the Wi-Fi infrastructure. For the PDPT framework application this was not found to be a big limitation as it can be found at chapter Experiments. The experiments also show that the current state of the basic technology used for the framework (mobile device hardware, PDA operating system, wireless network technology) is now at the level of a high usability of the PDPT application.

ACKNOWLEDGEMENTS

This work was supported by the Ministry of Education of the Czech Republic under Project 1M0587

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