Utilization Possibilities of Area Definition in User Space for User-Centric Pervasive-Adaptive Systems

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Abstract. The ability to let a mobile device determine its location in an indoor environment supports the creation of a new range of mobile information system applications. The goal of my project is to complement the data networking capabilities of RF wireless LANs with accurate user location and tracking capabilities for user needed data prebuffering. I created a location based system enhancement for locating and tracking users of indoor information system. User position is used for data prebuffering and pushing information from a server to his mobile client. All server data is saved as artifacts (together) with its indoor position information. The area definition for artifacts selecting is described for current and predicted user position along with valuating options for artifacts ranging. Future trends are also discussed.

Keywords: Prebuffering, Localization, PDPT Framework, Wi-Fi, Mobile Device, Area Definition.

1 Introduction

The usage of various mobile wireless technologies and mobile embedded devices has been increasing dramatically every year and would be growing in the following years. This will lead to the rise of new application domains in network-connected PDAs (Personal Digital Assistants) that provide more or less the same functionality as their desktop application equivalents. 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 in different context [1].

My recent research of context-aware computing has been restricted to location-aware computing for mobile applications using a WiFi network (LBS Location Based Services). The information about basic concept and technologies of user localization such as LBS, Searching for WiFi AP) can be found in my article [2]. On localization basis, I created a special framework called PDPT (Predictive Data Push Technology) which can improve a usage of large data artifacts of mobile devices [3]. I used continual user position information to determine a predictive user position. The data artifacts linked to user predicted position are prebuffered to user mobile device. When user arrives to position which was correctly determined by PDPT Core, the data artifacts are in local memory of PDA. The time to display the artifacts from local memory is much shorter than in case of remotely requested artifact.

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The prebuffering techniques may not be an only one application method for user position knowledge. I would like to describe a predictive position determination as well as area definition background in next chapter to give a reader more information about these themes to discuss new utilization possibilities in third chapter.

2 The PDPT Framework and PDPT Core

The general principle of my simple localization states that if a WiFi-enabled mobile device is close to such a stationary device – Access Point (AP) it may "ask" the provider's location position by setting up a WiFi connection. If position of the AP is known, the position of mobile device is within a range of this location provider. This range depends on type of WiFi AP. The Cisco APs are used in my test environment at Campus of Technical University of Ostrava. I performed measurements on these APs to get signal strength (SS) characteristics and a combination of them called "super ideal characteristic". More details can be found in chapter 2.3 [5]. The computed equation for Super-Ideal characteristic is taken as basic equation for PDPT Core to compute the real distance from WiFi SS. From this super ideal characteristic it is also evident the signal strength is present only to 30 meters of distance from base station. This small range is caused by using of Cisco APs. These APs has only 2 dB WiFi omnidirectional antenna. Granularity of location can be improved by triangulation of two or more visible WiFi 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 like Bluetooth, GSM or WiMAX. To let a mobile device determine its own position is needed to have a WiFi adapter still powered on. This fact provides a small limitation of use of mobile devices. The complex test with several types of battery is described in my article [4] in chapter (3). The test results with a possibly to use a PDA with turned on WiFi adapter for a period of about 5 hours.

2.1 Predictive Data Push Technology

PDPT framework is based on a model of location-aware enhancement, which I have used in created system. This technique is useful in framework to increase the real dataflow from wireless access point (server side) to PDA (client side). Primary dataflow is enlarged by data prebuffering. PDPT pushes the data from SQL database to clients PDA to be helpful when user comes at final location which was expected by PDPT Core. The benefit of PDPT consists in time delay reducing needed to display desired artifacts requested by a user from PDA. This delay may vary from a few seconds to number of minutes. Theoretical background and tests were needed to determine an average artifact size for which the PDPT technique is useful. First of all the maximum response time of an application (PDPT Client) for user was needed to be specified. Nielsen [6] specified the maximum response time for an application to 10 seconds [7]. I used this time period (10 second) to calculate the maximum possible data size of a file transferred from server to client (during this period). If transfers speed wary from 80 to 160 kB/s the result file size wary from 800 to 1600 kB. More details can be found in chapter 2.5 [5]. The next step was an average artifact size definition. I use a network architecture building plan as sample database, which contained 100 files of average size of 470 kB. The client application can download during the 10 second period from 2 to 3 artifacts. The final result of my real tests and consequential calculations is definition of artifact size to average value of 500 kB. The buffer size may differ from 50 to 100 MB in case of 100 to 200 artifacts.

2.2 The PDPT Framework Design

The PDPT framework design is based on the most commonly used server-client architecture. The PDPT framework server is created as a web service to act as a bridge between MS SQL Server (other database server eventually) and PDPT PDA Clients [Fig. 1].

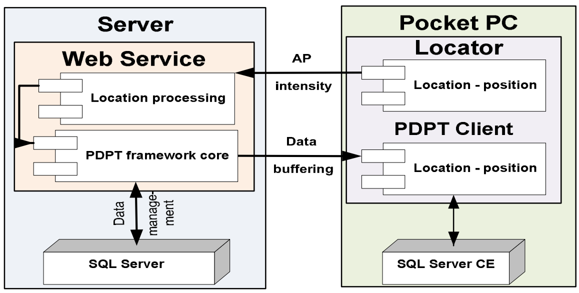

Fig. 1. PDPT architecture – UML design

Client PDA has location sensor component, which continuously sends the information about nearby AP's intensity to the PDPT Framework Core. This component processes the user's location information and it makes a decision to which part of MS SQL Server database needs to be replicated to client's SQL Server CE database. The PDPT Core decisions constitute the most important part of PDPT framework, because the kernel must continually compute the position of the user and track, and predict his future movement. After doing this prediction the appropriate data are prebuffered to client's database for the future possible requirements. This data represent artifacts list of PDA buffer imaginary image [Fig. 2].

2.3 PDPT Core – Static and Dynamic Area Definition

The PDPT buffering and predictive PDPT buffering principle is shown in [Fig. 2]. Firstly the client must activate the PDPT on PDPT Client. This client creates a list of artifacts (PDA buffer image), which are contained in his mobile SQL Server CE database. Server create own list of artifacts (imaginary image of PDA buffer) based on area definition for actual user position and compare it with real PDA buffer image.

The area can be defined as an object where the user position is in the object centre. I am using the cuboid as the object in present time for initial PDPT buffering. This cuboid has static area definition with a size of 10 x 10 x 3 (high) meters. The PDPT

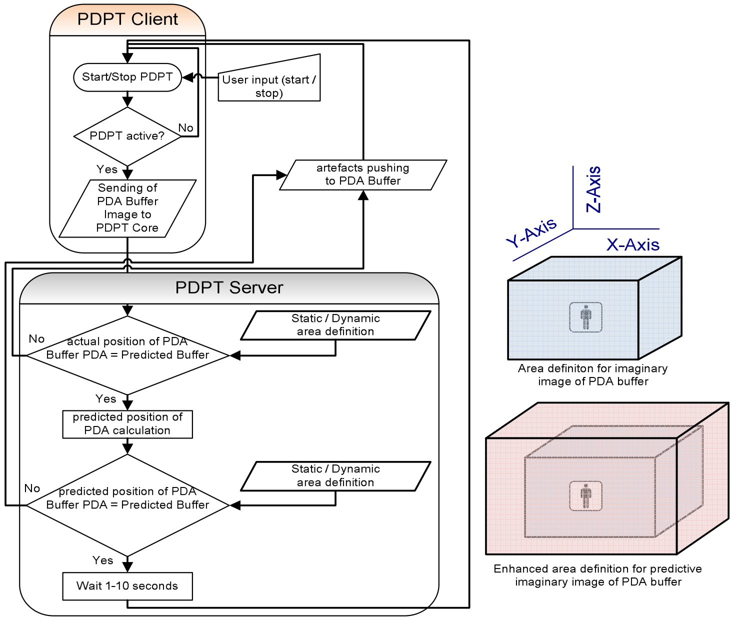

Fig. 2. Object diagram of PDPT prebuffering and predictive PDPT prebuffering. Right part shows the area definition for imaginary image of PDA buffer.

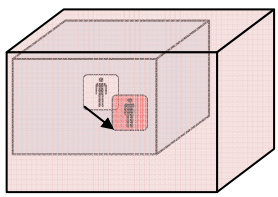

Fig. 3. Area enlargement to direction of predicted user position

Core will continue with comparing of both images. In case of some difference, the rest artifacts ale prebuffered to PDA buffer. When all artifacts for current user position are in PDA buffer, there is no difference between images. In such case the PDPT Core is going to make a predicted user position. On base of this new user position it makes a new predictive enlarged imaginary image of PDA buffer.

The size of this new cuboid is statically defined area of size 20 x 20 x 6 meters. The new cuboid has a center in direction of predicted user moving and includes a cuboid area for current user position [Fig. 3]. The PDPT Core compares the both new images (imaginary and real PDA buffer) and it will continue with buffering of artifacts until they are same. The process of selecting the artifacts for imaginary image of PDA buffer consists of finding and evaluating of artifacts inside the specified area in 3D environment [Fig. 4].

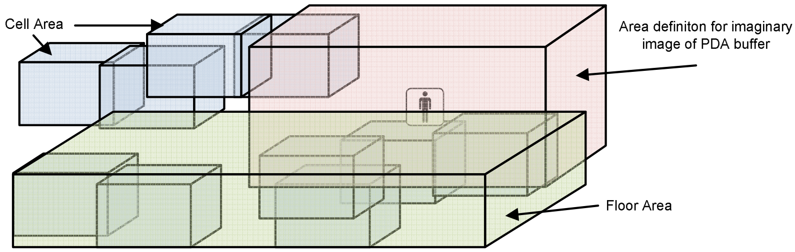

Fig. 4. Selecting artifacts which are included in area definition for current user position

1st, Corners numbering – Var. A: First possibility of evaluation is in corners numbering. The artifacts are stored in PDPT Server database along with position information of theirs corners. This information consists of six values: axis X, Y and Z, with the minimum and maximum values of artifact. First evaluation can be computed as a number of these corners inside the area.

2nd, Corners numbering – Var. B: Second one can be solve as intersection degree between the artifact and defined area. This way is more accurately, but it takes higher time consumption in most cases than previous one.

3rd, Priority counting: Third one possibility has a base in priority counting. Every artifact has own priority value which indicates a level of importance. The ranging of these levels can be made with all artifacts inside the area.

4th, Data types: Several types of data can be served as artifact. This property can be used as another way to valuating of artifacts.

First and third cases are used in PDPT Framework currently. The second case will be used in near future. The forth one cannot be currently used, because the only one type of data type is used for artifacts in sample PDPT database - the image type. Because of only two options are used and only a sample database exists, the static area definition is used now. In real case of usage is better to create an algorithm to dynamic area definition to adapt a system to user needs more flexible in real time.

2.4 The PDPT Client Application and Testing Results

The PDPT Client application realizes classical client to the server side and an extension by PDPT and Locator modules. Figure [Fig. 5] shows two screenshots from the mobile client. Figure [Fig. 5a] shows the classical view of the data artifact presentation from MS SQL CE database to user (in this case the image of Ethernet plan of the current area). The PDPT tab [Fig. 5b] presents a way to tune the settings of PDPT Framework. The middle section shows the logging info about the prebuffering process. The right side means measure the time of one artifact loading ("part time") and full time of prebuffering in millisecond resolution. More screens and details of PDPT Client can be found in chapters 2.7 and 2.8 [5].

I am focused on the real usage of the developed PDPT Framework on a wide range of wireless mobile devices and its main issue at increased data transfer. For testing purpose, five mobile devices were selected with different hardware and software capabilities. The high success rate found in the test data surpassed our expectations. This rate varies from 84 to 96 %. Please see the chapter 4 [5] for more info.

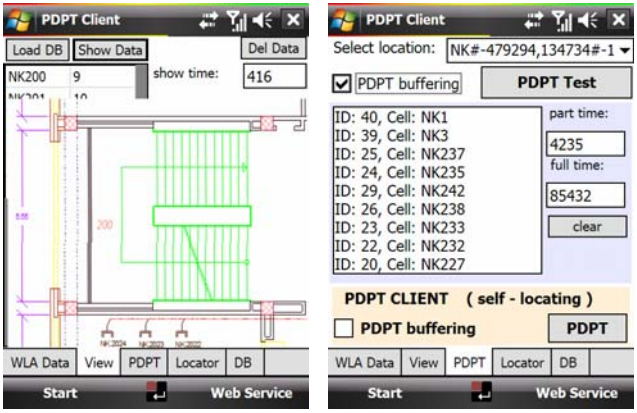

Fig. 5. PDPT Client – Left one figure 5a, Right one figure 5b

3 New Utilization Possibilities of Area Definition

The idea of user-centric pervasive-adaptive (UCPA) systems is in interaction between user and system throws his mobile device. Such interconnection can behold in the reaction on user's non declared requests. These requests include namely user current position, user future-predicted position, his movement and tracking (in case of my PDPT Framework). By the combination of these requests in conjunction with other sources of user’s knowledge and behaviors, the sophisticated information system can be developed as UCPA system. The user comfort or theirs performance can be found namely in predicting the user needs along with the pre-reacting on them.

The larger and larger data amounts are transferred throw the internet network nowadays. The needs of techniques to reduce its amount or preloaded them before user needs is still growing up. PDPT Framework idea can be applied in a variety of wireless network systems now and in future naturally. More usability of PDPT grows from Area Definition as well as from evaluation of artifacts or other user's behavior sources. I can imagine the use in area of botanical or zoological gardens systems. The user needs to be located continually by WiFi or GPS. From current user position will the user track be computed online to allow make a prediction of user move. Data artifacts can be preloaded to user device memory for future requests. When user request info about his location in context of zoo or garden (switching on the device is only needed), the client application will respond with a map of near surroundings and it will start to play a documentary about animals or vegetation around the user. User can act with direct requests to selected kinds of these. These preferred kinds will be taken into account to evaluate future objects/artifacts and preloaded only the most important ones for user. The type of artifact is also evaluable as well as his size because user may not wont to look at too long or micro presentation. From several statistic info obtained from users tracks, the most frequented ways in gardens can be found. By the help of some mentioned info sources a very sophisticated dynamical area definition can be developed.

4 Conclusions

The PDPT prebuffering techniques can improve the using of medium or large artifacts on wireless mobile devices in information systems. If we can transform the real data from information system to artifacts along with their positions information, we can improve the transfer rate of used wireless connection and have a better response to users. The localization part of PDPT framework is currently used in another project of biotelemetrical system for home care named Guardian to make a patient's life safer [8]. Another utilization of PDPT consists in use of Area Definition. This idea can be utilized inside the information systems like botanical or zoological gardens where the GPS navigation can be used in outdoor. In combination with multi data type artifacts and dynamic area definition the new complex adaptable systems as well as the user-centric pervasive-adaptive systems can grown from.

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